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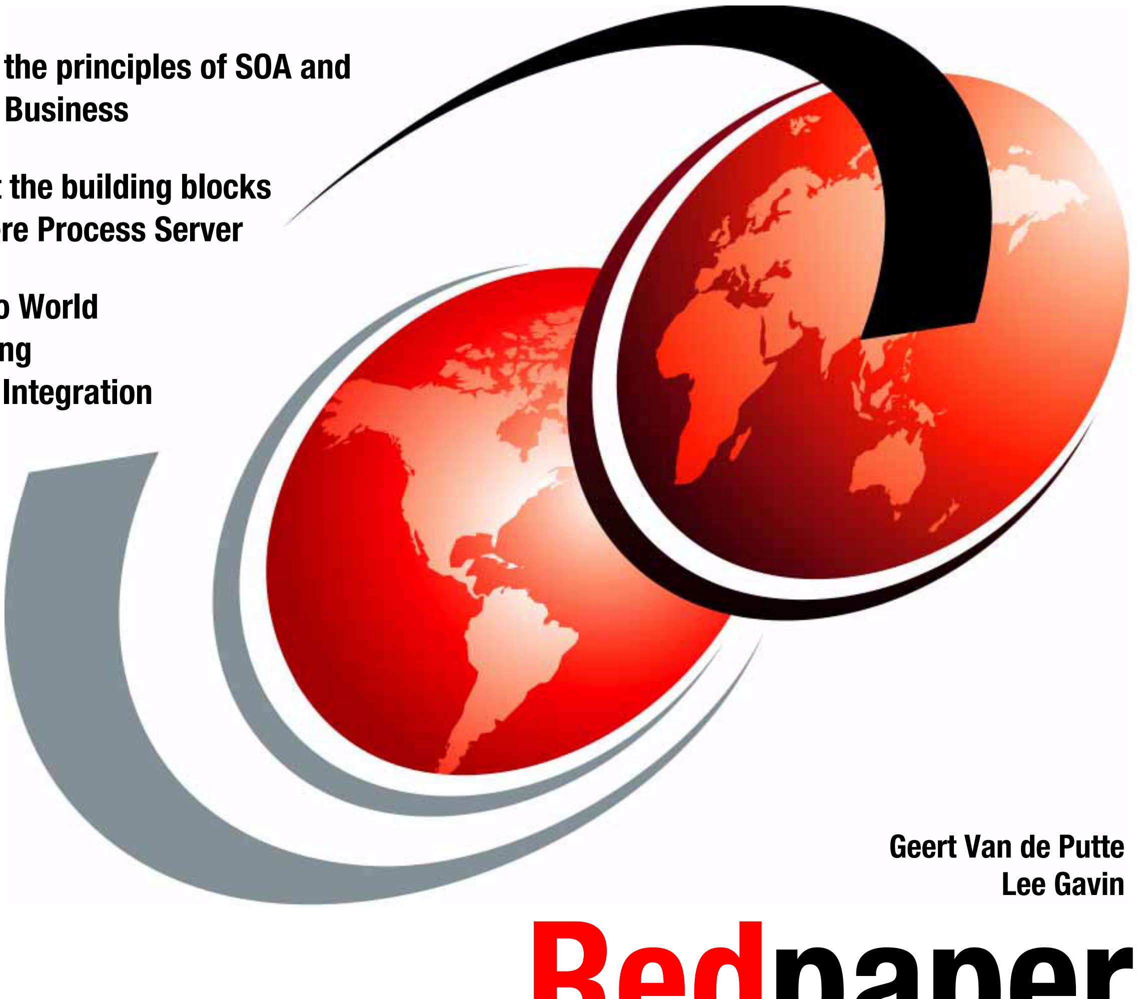
Technical Overview of WebSphere Process Server and WebSphere Integration Developer

Understand the principles of SOA and On Demand Business

Learn about the building blocks of WebSphere Process Server

Build a Hello World solution using WebSphere Integration Developer



Geert Van de Putte
Lee Gavin

Redpaper

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International Technical Support Organization

Technical Overview of WebSphere Process Server and WebSphere Integration Developer

December 2005

Note: Before using this information and the product it supports, read the information in "Notices" on page v.

First Edition (December 2005)

This edition applies to Version 6, Release 0, Modification 0 of WebSphere Process Server (product number 5724-L01) and WebSphere Integration Developer (product number 5724-I66).

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Preface

This IBM® Redpaper is a technical introduction to IBM WebSphere® Process Server and WebSphere Integration Developer. Part of the WebSphere Process Integration family of products, WebSphere Process Server and WebSphere Integration Developer provide the core functionality for implementing a Service-Oriented Architecture (SOA) in an On Demand Business environment.

In the first chapter, we introduce On Demand Business and SOAs, describing the requirements for runtime and the development tools for implementing an SOA. In the second chapter, we discuss the building blocks of WebSphere Process Server and WebSphere Integration Developer and demonstrate how these products allow you to develop services and how they can be mapped and assembled together.

While the first two chapters of this redpaper provide you with theoretical information about WebSphere Process Server and WebSphere Integration Developer, the last chapter is an introduction to building solutions using these products. We demonstrate how to develop and test a classic Hello World application to give you a head start for developing your own solutions.

The team that wrote this Redpaper

This Redpaper was produced by a team of specialists from around the world working at the International Technical Support Organization, Raleigh Center.

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Thanks to the following people for their contributions to this project:

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1

On Demand Business and service-oriented architecture

Increasing consideration is being given to the strategic initiative of On Demand Business. This chapter provides an overview of On Demand Business concepts and discusses the correlation with the service-oriented architecture (SOA). It then discusses the life cycle of an application for On Demand Business and the role of WebSphere Process Integration.

1.1 Overview of On Demand Business

The IBM vision of On Demand Business is to enable customers to succeed in an environment with an unprecedented rate of change.

Businesses want to focus on core competencies, reduce spending, and reuse existing information in new ways without a major overhaul of their existing infrastructures. There exists a constant pressure to juggle the often conflicting demands to provide flexibility, cost savings, and efficiency. The sections that follow outline the key business and technical attributes that provide the basis for the on demand message.

Figure 1-1 identifies the key components of On Demand Business.

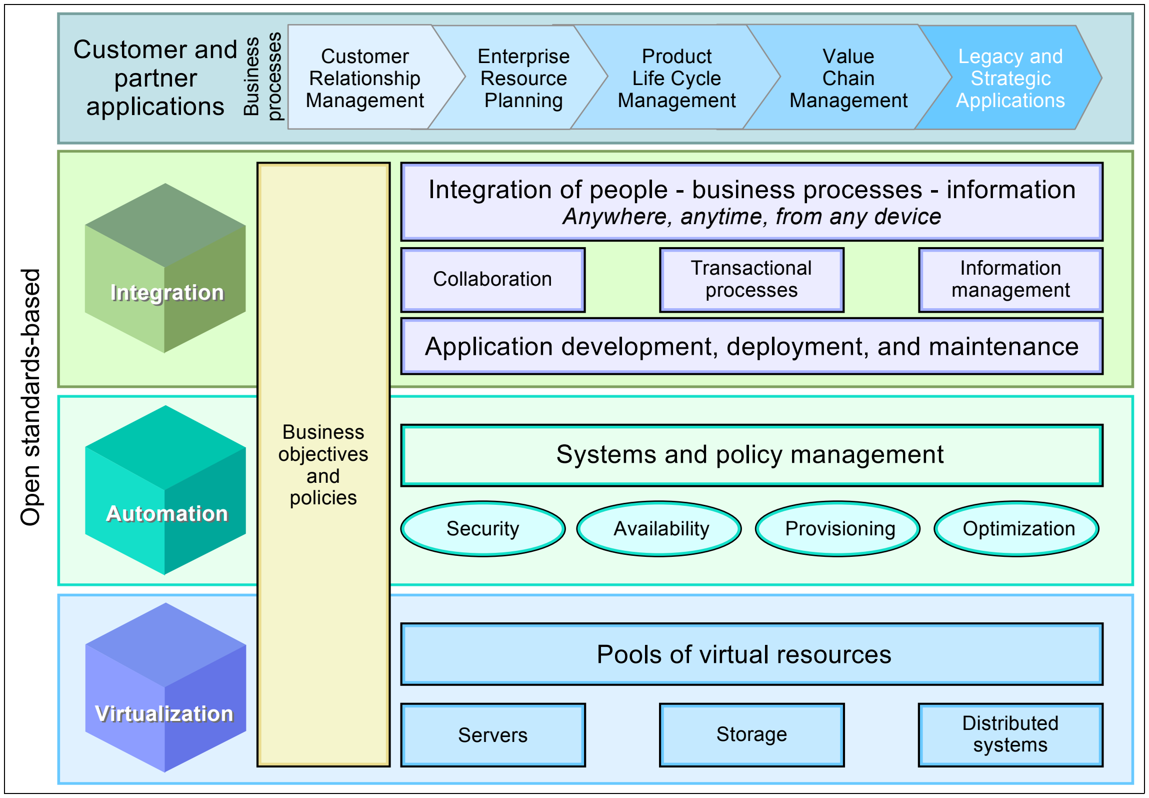

Customer and partner applications
Business processes
Customer Relationship Management
Enterprise Resource Planning
Product Life Cycle Management
Value Chain Management
Legacy and Strategic Applications
Open standards-based
Integration
Automation
Virtualization
Business objectives and policies
Integration of people - business processes - information
Anywhere, anytime, from any device
Collaboration
Transactional processes
Information management
Application development, deployment, and maintenance
Systems and policy management
Security
Availability
Provisioning
Optimization
Pools of virtual resources
Servers
Storage
Distributed systems

Figure 1-1 On Demand Business overview diagram

1.1.1 Key business attributes

From a business perspective, On Demand Business is about providing a way for companies to realign their business and technology environments to match the request for reusable business functionality.

Business drivers can be summarized with the following key elements:

- **Focused**

  The enterprise can focus on their core competencies: what makes them successful and what makes them unique. Strategic alliances are formed to provide needs external to these core competencies.

- **Responsive**

  The business can respond with agility to customer demands, market opportunities, or external threats. These decisions are guided through insight-driven decision management features.

- **Variable**

  The enterprise can achieve operational and business process flexibility and adapt variable cost structures (fixed to variable) to provide a high level of operational efficiency.

- **Resilient**

  The business can respond robustly to changes in both business and technical environments, managing changes and threats with predictable outcomes.

Companies can achieve these business imperatives by exploiting current technological developments while drawing on experiences that have been learned from past architectural builds.

1.1.2 Key technology attributes

The business drivers of On Demand Business must be supported by a well-defined technical infrastructure. The following key technological attributes deliver the flexibility, responsiveness, and efficiency that organizations require:

- Integration
- Virtualization
- Automation
- Open standards

Figure 1-2 on page 4 provides a high-level overview of the range of each On Demand Business attribute.

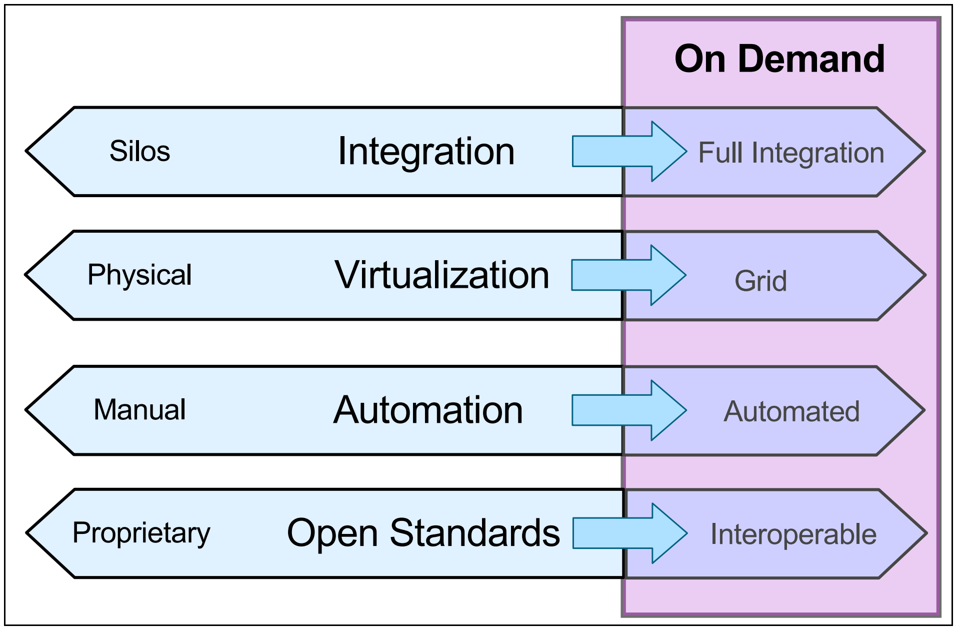


Figure 1-2 Four key technology attributes of On Demand Business

In the sections that follow, we describe these attributes as they apply to On Demand Business. Then, we expand these topics to demonstrate the correlation between On Demand Business and s.

Integration

The fundamental component of an infrastructure designed for On Demand Business is integration. In 2002, Sam Palmisano, Chief Executive Officer of IBM, defined On Demand Business as: “An enterprise whose business processes, integrated end-to-end with key partners, suppliers, and customers, can rapidly respond to any customer demand, market opportunity, or external threat.”

Integration can occur at various levels:

- People

  To function at an operating level that is suitable for On Demand Business, human-to-human and human-to-process interaction requires integration throughout the various levels that is not limited to those who use the finished products. Business partners, customers, and employees are all important resources for the value chain provided by On Demand Business. For example, integration can occur for developers through open tooling paradigms that are based on open standards, for business partners through the creation of horizontal processes, and for employees through collaboration.

- Process

  Recurring elements (security, service level, monitoring, and so on) can be shared by applications to provide horizontal services for decoupling these reusable application components. The use of SOA and Web services to implement these processes, including the emerging Business Process Execution Language for Web Services (BPEL4WS), is likely to facilitate more rapid changes in these processes so that the business can respond with agility to changing market conditions.

- Applications

  Organizations have invested enormous resources and capital into custom designed and off-the shelf applications. The application integration goal is to leverage, rather than replace, these assets by providing ways of connecting, routing, and transforming the data that is stored or shared among them. Applications sit on disparate systems in an enterprise or are installed throughout many enterprises.

- Systems

  Systems manage, process, and deliver data to the people and applications in the solution environment. An On Demand Business Operating Environment requires the system to be invisible to the elements that interact with it.

- Data

  Data is the primary business element of a system. The data is the source of the information and can more easily be shared through the adoption of standards specifications.

Virtualization

Various areas of technology in our lives exploit virtualization concepts, including cell phones, personal digital assistants, wireless connectivity, printers, and so forth. Aspects of virtualization draw on widely adopted architectural concepts, including object oriented design and development, Web services, and XML.

There is a spectrum of virtualization that begins with independent stand-alone systems on one side (a large mainframe system, perhaps) and grid computing on the other. In the middle are varying degrees of client-server implementations.

A grid paradigm, an absolute example of on demand virtualization, is a collection of distributed computing resources that are available over a local or wide area network and that appear to a user or application as one large virtual computing system.

The Internet, the most widely recognized example of virtualization, provides a virtual network that supplies access to content and applications.

The vision is to create virtual dynamic organizations with secure, coordinated resource-sharing between individuals, institutions, and resources. Grid computing is an approach to distributed computing that spans locations, organizations, machine architectures, and software boundaries.

Figure 1-1 on page 2 depicts virtualization as a set of virtualized resource pools based on:

- Servers

  This might include partitioning, hypervisors, VM OS, emulators, I/O virtualization, virtual Ethernet, and so forth.

- Storage

  Here, the focus is on the addition of intelligence and value in the network.

- Distributed systems

  This includes Web services, scheduling, provisioning, workload management, billing and metering, and transaction management.

The goal of grid computing, and thus on demand virtualization, is to provide unlimited power, collaboration, and information access to everyone connected to a grid.

Note: Open Grid Services Architecture (OGSA) is an important starting point for grid enablement. For more information about OGSA, refer to the article at:

`http://www-106.ibm.com/developerworks/grid/library/gr-visual/`

Automation

Autonomic computing addresses the need of an organization to limit the amount of time and cost that occurs as a result of:

- Overprovisioning
- New applications and highly skilled labor
- Disparate technology platforms even within one organization
- Focus on maintenance, not problem resolution
- Complexities in operating heterogeneous systems

So how can organizations begin to address these common concerns by using On Demand Business? This is where autonomic computing comes in. Autonomic computing can be summarized by four key components:

- Self-healing

  For a system to keep functioning, it must detect, prevent, and recover from disruptions with minimal or no human intervention. This requirement is directly proportional to increased business dependence on technical infrastructures. The need for self-healing is directly proportional to the organization's availability requirement.

- Self-configuring

  The system can adapt dynamically to changing environments, add and remove components to and from the systems, and change the environment to adapt to variable workloads.

- Self-optimization

  Configuration that maximizes operational efficiency, including resource tuning and workload management, alleviates the constant drain on resources to perform routine tasks. The goal is to tune systems to respond to the workload changes. Systems must monitor and self-tune continuously, adapting and learning from the environment around them.

- Self-protecting

  Security is one of the inhibitors of the adoption of SOAs as organizations prepare themselves to share data externally. Self-protection requires the system to provide safe alternatives for securing information and data. Self-protecting automation works by anticipating, detecting, identifying, and protecting systems from external or internal threats.

Open standards

Open standards affect the On Demand Business Operating Environment across the previously defined levels, including automation, integration, and virtualization. Each of these elements leverage open standards specifications to achieve their objectives. Open standards are the key element of flexibility and interoperability throughout heterogeneous systems.

The global adoption of a standard specification enables the disparate systems to interact with each other. The underlying platforms might be completely different and independent, but open standards enable processes to be built despite (or because of) these differences.

Open standards provide the On Demand Business Operating Environment with a standard, open mechanism to invoke system services.

1.1.3 Key requirements for integration flexibility

For the business integration that is required by On Demand Business while maintaining the maximum flexibility of implementation, the requirements shown in Figure 1-3 on page 8 must be met.

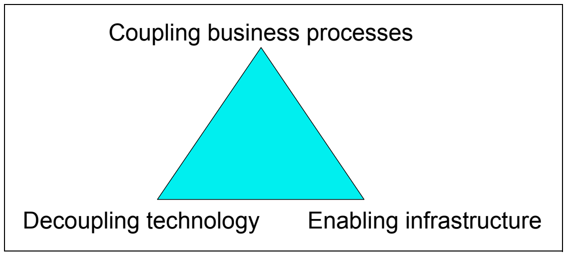


Figure 1-3 Key requirements for integration flexibility

Each requirement poses several questions:

- Coupling business processes:
  - How do we model the business?
  - How do we refactor the business into processes, components, and services that can interact dynamically and change in an agile manner?
- Decoupling technology:
  - How do we support business behavior with systems that can interact without joining them too tightly?
  - How can we change and evolve the systems and interactions on the time scales required by the business?
- Enabling infrastructure:
  - How do we build the technical infrastructure to support, execute, manage, and measure these interactions, services, components, and processes?

1.2 Introduction to SOA

SOA is an approach to defining integration architectures based on the concept of a *service*. It applies successful concepts proved by Object Oriented Development, Component Based Design, and Enterprise Application Integration (EAI) technology. The goal of SOA can be described as bringing the benefits of loose coupling and encapsulation to integration at an enterprise level.

To help you understand SOA, it is important that you first understand what is meant by “service” in this context. This is key because, unless you are confident that the services that you define really are *well designed*, you are not assured of achieving the promoted benefits of SOA.

The most commonly agreed-upon aspects of the definition of a service in SOA are:

- Services are defined by explicit, implementation-independent interfaces.
- Services are loosely bound and invoked through communication protocols that stress location transparency and interoperability.
- Services encapsulate reusable business function.

The use of explicit interfaces to define and encapsulate the function of services is important and is illustrated in Figure 1-4.

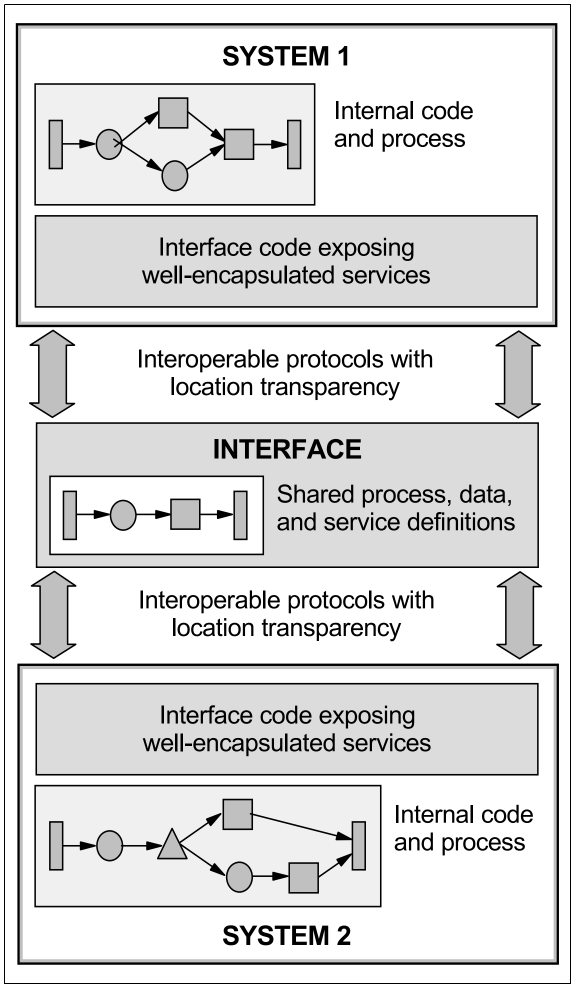

SYSTEM 1
Internal code and process
Interface code exposing well-encapsulated services
Interoperable protocols with location transparency
INTERFACE
Shared process, data, and service definitions
Interoperable protocols with location transparency
Interface code exposing well-encapsulated services
Internal code and process
SYSTEM 2

Figure 1-4 The key concepts of SOA

Note how the interface encapsulates those aspects of process and behavior that are common to an interaction between two systems, while hiding the specifics of each implementation. By explicitly defining the interaction in this way, those aspects of either system (for example, the platform that they are based on) that are not part of the interaction can change without affecting the other system.

After the function has been encapsulated and defined as a service in an SOA, it can be used and reused by one or more systems that participate in the architecture. For example, when the reuse of a Java™ logging application programming interface (API) is described as “design time” (when a decision is made to reuse an available package and bind it into application code), the intention of SOA is to achieve the reuse of services at:

- Runtime: Each service is deployed in one place and one place only and is remotely invoked by anything that must use it. The advantage of this approach is that changes to the service (for example, to the calculation algorithm or the reference data that it depends on) need only be applied in a single place.
- Deployment time: Each service is built once but redeployed locally to each system or set of systems that must use it. The advantage of this approach is the increased flexibility that is needed to achieve performance targets or to customize the service (perhaps according to geography).

Note that, in contrast to reusing service implementations at runtime, the encapsulation of functions as services and their definition with interfaces also allows the substitution of one service implementation for another. For example, the same service might be provided by multiple providers (such as a car insurance quote service, which might be provided by multiple insurance companies), and individual service requesters might be routed to individual service providers through some intermediary agent.

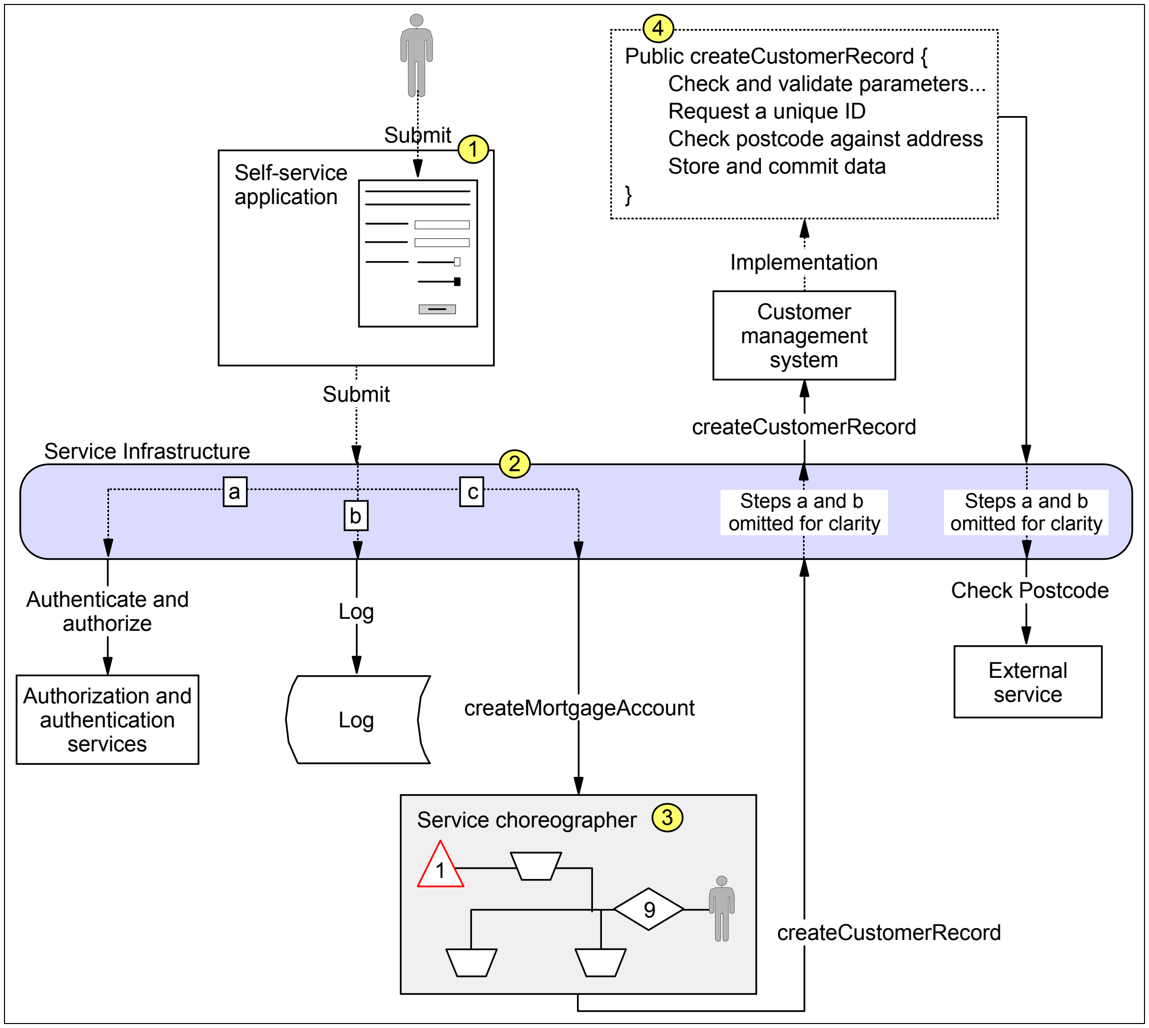
The encapsulation of services by interfaces and their invocation through location-transparent, interoperable protocols are the basic means by which SOA increases flexibility and reusability.

1.2.1 Service granularity and choreography

Many descriptions of SOA also refer to “large-grained” services. However, powerful counterexamples of successful, reusable, fine-grained services exist. For example, getBalance is a useful service that is not large grained. More realistically, there are many useful levels of service granularity in most SOAs:

- Technical functions (such as logging)
- Business functions (such as getBalance)
- Business transactions (such as openAccount)
- Business processes (such as applyForMortgage)

Some degree of choreography or aggregation is required between each granularity level. It is unlikely that all organizations share identical definitions of granularity, but each undoubtedly finds it beneficial to define their own. At each level of granularity, it is important that service definitions encapsulate function well enough that it is reusable. Figure 1-5 shows an example of service granularities and the choreographies between them.



Submit
1
Self-service application
4
Public createCustomerRecord {
Check and validate parameters...
Request a unique ID
Check postcode against address
Store and commit data
}
Implementation
Customer management system
Submit
createCustomerRecord
Service Infrastructure
2
a
b
c
Steps a and b omitted for clarity
Steps a and b omitted for clarity
Authenticate and authorize
Log
Check Postcode
Authorization and authentication services
Log
createMortgageAccount
External service
Service choreographer
3
1
9
createCustomerRecord

Figure 1-5 Service granularity and choreography

The interactions between services of various granularities (Figure 1-5) are:

1. A user submits a request to a self-service application to create a mortgage account. The self-service application submits the business process service request (createMortgageAccount) through the service infrastructure to a

service choreographer component, the purpose of which is to choreograph business transaction services into business process services.

2. When the service infrastructure receives the request for createMortgageAccount, the service infrastructure first invokes *authentication* and *authorization* technical function services to ensure that the request is valid, then a *log* technical function service, and, finally, createMortgageAccount in the service choreographer.
3. The service choreographer executes createMortgageAccount. If the request is valid, then, after the other process elements are finished, the choreographer invokes the createCustomerRecord business transaction service through the service infrastructure to store the details of the new customer. (Before doing this, it might already have invoked storeMortgageDetails.)
4. In the implementation of the createCustomerRecord service, it is necessary to validate the information for the new customer. Part of this validation is checking whether the post code and address match. To do this, a CheckPostCode business function service is invoked through the service infrastructure.

To summarize, three aggregations or choreographies are performed by distinct components for distinct granularity levels:

Service choreographer	Choreographs business transaction services into higher level business process services.
Service Infrastructure	Choreographs technical function services to control the invocation of business process services, business transaction services, and business function services (might be an Enterprise Service Bus).
Individual application components	Responsible for invoking business function services where they are required to implement business transaction services.

Of course, this is just one hypothetical example. Real organizations must formulate their own definitions.

1.2.2 Implications of SOA

The encapsulation of reusable business functions, the achievement of loose coupling, the definition of appropriate levels of granularity, and so forth are analysis issues as much as they are technology issues. They are difficult issues to grasp, so SOA cannot be successful without skilled architects and designers who understand and are able to articulate them. It is easy to see these concerns becoming hostage to time, skill, and cost issues, leading to another generation of isolated systems that require integration.

Widespread implementation of an SOA and infrastructure is a long-term endeavor that involves all of the usual hard business decisions, questions of data, and process ownership. Implementing SOA requires serious, long-term commitment by business and by the IT organization that supports it. The implementation might involve upfront costs, centralized costs, and many other challenges, such as:

- No specific technologies are ruled in or ruled out.
- Existing implementations are possible (for example, CICS® Transaction Server “super router” transactions with simplified, text-based interfaces).
- EAI implementations are common (for example, XML over WebSphere Message Broker).
- Web services are potentially a very good fit, but are still maturing.

1.3 On Demand Business and SOA

SOA is an approach to defining integration architectures based on the concept of a service. The business and infrastructure functions that are required to make an effective On Demand Business environment are provided as services. These services are the building blocks of the system.

Services can be invoked independently by either external or internal service requesters to process simple functions, or they can work together by choreographic implementations to quickly devise new functionality for existing processes.

SOAs can use Web services as a set of flexible and interoperable standards for distributed systems. There is a strong complimentary nature between SOA and Web services.

SOA touches on the four key attributes of On Demand Business as follows:

- Open standards
  - SOA provides a standard method of invoking Web services (business logic and functionality) for disparate organizations to share across network boundaries.
  - Web services use open standards to allow inter-enterprise connectivity through networks and the Internet:
    - Messaging protocols (Simple Object Access Protocol, or SOAP)

        - Transport protocols (including HTTP, HTTPS, JMS).
        - Security at the transport level (HTTPS), at a protocol level (WS-Security), or at both levels
    - Web Service Description Language (WSDL) allows Web services to be self-describing for a loosely coupled architecture.
    - Standards bodies, including WS-I, W3C, and OASIS, use technologists from industry leading software vendors (IBM, BEA, Oracle, and Microsoft®, for example) to accelerate and guide open standards creation and adoption.
- Integration
    - Interfaces are provided to wrap service endpoints for a system-independent architecture and to promote cross-industry communication.
    - SOAs can provide dynamic service discovery and binding, which means that on demand service integration can occur.
- Virtualization
    - A key principle of SOA is that services should be invoked by service requesters that are oblivious to service implementation details, including location, platform, and, if appropriate to the business scenario, even the identity of the service provider.
    - Grid services and the very framework it all rests on is very much like object-oriented programming.
- Automation
    - Grid technologies are applying SOA principles to implementing infrastructure services that provide an evolutionary approach to increased automation.

For more information about the topics that are covered in this section, visit:

- IBM Web services

  `http://www.ibm.com/webservices`
- IBM on demand Operating Environment

  `http://www-3.ibm.com/software/info/openenvironment/`
- IBM developerWorks®: SOA and Web services zone

  `http://www.ibm.com/developerworks/webservices`

1.4 The On Demand Business Operating Environment

To create truly successful On Demand Business, one must embrace the SOA, which helps businesses wrap functions (services) to provide loosely coupled accessibility to functions, flows, and applications.

So how does the Enterprise Service Bus address the IBM vision of On Demand Business? This section describes the way that the Enterprise Service Bus can help businesses create processes that meet the objectives of the capabilities of an On Demand Business environment.

Figure 1-6 shows the On Demand Business Operating Environment based on SOA.

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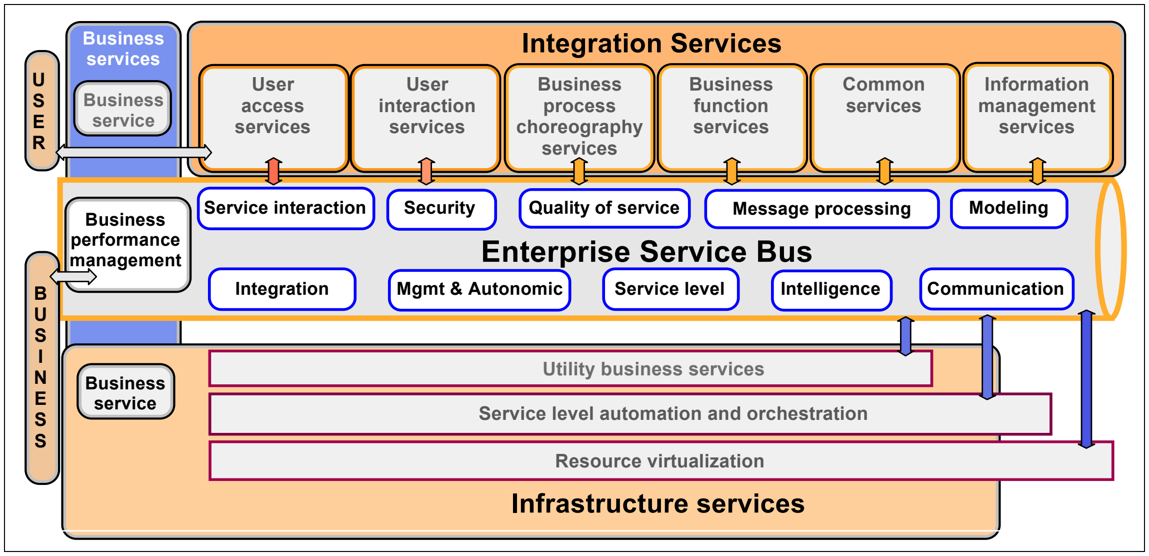


Figure 1-6 Operating environment architecture for On Demand Business

The three core components of the On Demand Business Operating Environment (integration services, Enterprise Service Bus, and infrastructure services) work together so that the operating environment can meet defined business objectives.

Business services leverage the application and infrastructure services, which are mediated by the Enterprise Service Bus, to provide real business processes to all users, including customers, employees, and business partners.

Business service management incorporates the policies and goals of the organization, such as service levels, metrics, and other measurable business guidelines.

Infrastructure services

The services in the infrastructure category provide and manage the infrastructure into which business services and their constituents are deployed. These include:

- Utility business services

  These services support functions such as billing, metering, rating, peering, and settlement and are commonly used, for example, when hosting On Demand Business services or their components.

- Service level automation and orchestration

  Service level automation and orchestration provide services that facilitate translation of service policy declarations that are associated with business services into reality. This is achieved by services that implement autonomic managers, which monitor the execution of services (more precisely, services that are instrumented to be managed elements) in the On Demand Business Operating Environment according to the policy declarations that they receive. They then analyze their behavior, and if the analysis indicates problems, plan a meaningful reaction to that problem and initiate execution of that plan. This closed feedback loop is called an *M-A-P-E* (Monitor, Analyze, Plan, Execute) *loop*.

  Several specializations of such services focus, for example, on managing the availability, the configuration, or the workload for the managed elements; provisioning resources; performing problem management; handling end-to-end security for services for the On Demand Business Operating Environment; or managing data placement.

- Resource virtualization services

  These services provide the instrumentation of server, storage, network, and other resources. Included is structured (relational) and unstructured information content that is held in a variety of data sources to allow management and virtualization of those resources that are under the control of operating environment resource managers for On Demand Business. Virtualization services include mapping requirements of business services and their components to available resources based on quality of service declarations of the service and knowledge about the current utilization of available resources.

Besides the fact that they implement very different capabilities that support a variety of patterns for the On Demand Business Operating Environment, the main difference between the two categories of services is which user roles build them and which use them. Infrastructure elements are built by middleware providers and Independent Software Vendors (ISVs), while integration elements are constructed by infrastructure and application builders.

One of the most important insights regarding the On Demand Business Operating Environment is that a common pattern supports both application services and infrastructure services. For example:

- Adapters enable integration of existing infrastructure components into the Enterprise Service Bus.
- Service choreography is often used for scripting of M-A-P-E execution plans.
- The Enterprise Service Bus provides the infrastructure for exchange of events between managed elements and autonomic managers.

Users interact with infrastructure services using portal user interaction services.

Enterprise Service Bus

The Enterprise Service Bus is emerging as a service-oriented infrastructure component that makes large-scale implementation of the SOA principles manageable in a heterogeneous world.

Applications for On Demand Business are business services built from services that provide a set of capabilities that are worth advertising for use by other services. Typically, a business service relies on many other services in its implementation. Services interact through the Enterprise Service Bus, which facilitates mediated interactions between service endpoints. The Enterprise Service Bus supports event-based interactions as well as message exchange for service request handling. One innovation of the Enterprise Service Bus is a common model for messages and events. All messages can become events if deploying the service binds the message to a topic in the event space.

For both events and messages, mediations can be used to facilitate interactions (for example, to find services that provide capabilities that a requestor is asking for or to take care of interface mismatches between requesters and providers that are compatible in terms of their capabilities). In this context, we use the term *service* in a very general sense.

It is worth noting that, although from the perspective of the bus all application components can be specified through WS-* standards (because the bus requires a normalized representation for efficient mediated, capability-based match making), this does not imply that they all communicate with SOAP or WS-* protocol standards. The Enterprise Service Bus supports a broad spectrum of ways to get on and off the bus, including on ramps for existing applications or business connections that allow external partners in business-to-business (B2B) interaction scenarios to participate in the service interaction game.

Although they all look the same from the perspective of the Enterprise Service Bus, services implement different facets of an overall application for On Demand Business, including:

- Realize interactions with people involved in the underlying business process.
- Provide adapters to existing applications that have to be integrated.
- Choreograph the interaction of several services to achieve a business goal.
- Watch for potential problems in the execution of the process, ready to take action to fix them if they occur.
- Manage resources that are needed to perform required business functions.

Therefore, in addition to providing the basic infrastructure for service interactions, the On Demand Business Operating Environment identifies a set of common patterns for construction of applications and supports the realization of distinct service categories that play particular roles in those patterns. The two distinct service categories are integration and infrastructure service.

The capabilities that are provided by the Enterprise Service Bus facilitate the interactions between the levels in the On Demand Business Operating Environment.

Integration services

The programming model for On Demand Business services is based on application development that uses component (service) assembly. The services in the integration category are used by the builders of applications for On Demand Business to create new business services; they include services that facilitate integration and services that provide functions to be integrated:

- User access services

  Handle adaptation from three orthogonal perspectives:

  – Endpoint form factor such as display size, memory, and processor limitations (ranging from desktop down to pervasive devices)
  – Modes of interaction, including conventional display-keyboard interactions, as well as speech-based interactions and combinations (multi-modality)
  – Connection types such as peer-to-peer or client/server across a range of reliabilty connections, including fully disconnected operations

- User interaction services

  Handle direct interactions with people involved in the business process; for example, processing work items that are spawned by choreography or collaborative process elements

- Business process choreography services

  Support the execution of other services that express their behavior using process flow or rule technology. Process flows, for example, are used to describe the interaction of other services (nearly any of the integration kinds, including other process flow services) to perform the tasks required to realize the functions offered by the new (combined or aggregated) business service

- Business function services

  Provide the atomic business functions (those that are not composed from other services) that are required by the overall business service; this includes adapters to packaged or existing custom applications and brand new application components that are created to realize a functional need that is not already covered by existing applications

- Common services

  Implement useful features, or helper functions, that are designed to be used by many business services; for example, services that implement personalization of user access and user interaction services, or for reporting status and progress of business services

- Information management services

  Help to integrate information hosted in a variety of data sources, such as databases or existing applications; to access (query, update, and search) that information; to analyze information from those sources in business intelligence scenarios; or to take care of metadata about information and services that are used and provided by the business services that are part of the On Demand Business Operating Environment.

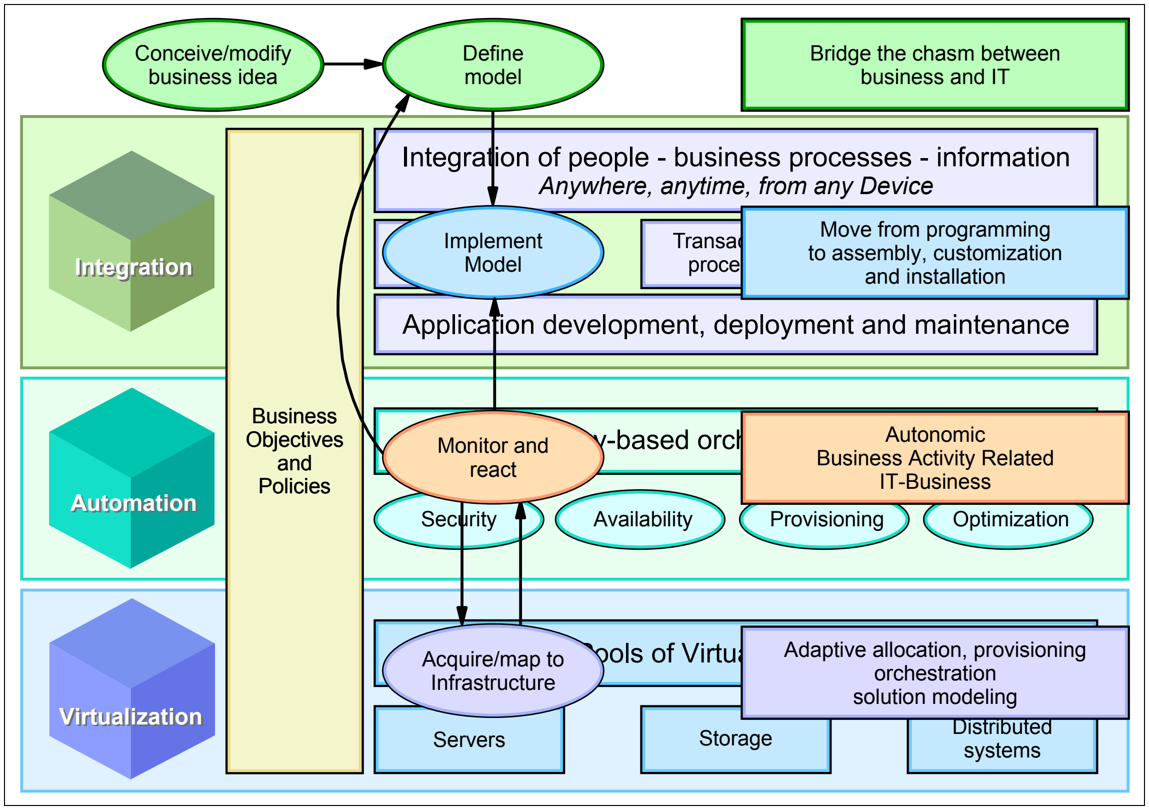
Integration services are hosted by application services that provide container facilities for simplifying their participation in interactions with other integration services and with the infrastructure services for the On Demand Business Operating Environment. Integration service developers focus on realizing the business logic that they care about, assembling integration services that provide required business function and declaring expected quality of service.

Programmers and administrators annotate their applications and services with policy declarations that specify quality of service. The application container (and the Enterprise Service Bus) automates the interactions with infrastructure services to achieve the expressed policies. An application container also provides generic facilities such as taking care of security or transaction management requirements for the services that it hosts, and kind-specific facilities such as generating the events reporting status and the progress of business process choreography services.

1.5 Life cycle of an On Demand Business application and the role of WebSphere Process Integration

WebSphere Process Integration plays a key role in the overall On Demand Business strategy.

Figure 1-7 illustrates the overall life cycle of an application in the On Demand Operating Environment.



Conceive/modify business idea
Define model
Bridge the chasm between business and IT
Integration
Business Objectives and Policies
Integration of people - business processes - information
Anywhere, anytime, from any Device
Implement Model
Transac proce
Move from programming to assembly, customization and installation
Application development, deployment and maintenance
Automation
Monitor and react
y-based orch
Autonomic Business Activity Related IT-Business
Security
Availability
Provisioning
Optimization
Virtualization
Acquire/map to Infrastructure
ools of Virtu
Adaptive allocation, provisioning orchestration solution modeling
Servers
Storage
Distributed systems

Figure 1-7 Life cycle of an On Demand application

WebSphere Process Integration plays a role in the green layer in Figure 1-7. This is where WebSphere Business Modeler and the concepts that it can capture fit in. Today, much of this work is done on napkins and using drawings that are created in Visio or similar products. Very little simulation is done and much is lost in the translation as you move from the *business idea* and associated *model* to the implementation phase. If you use a tool that captures the *model*, you can feed that down to the next layer in the process.

The blue implementation layer is where you accept the results of the modeling activity and transform them into an implementation that will run in your runtime. Abstract processes, for example, that are sketched out in WebSphere Business Modeler are finished in this layer.

A key goal of WebSphere Process Integration is to transform the activities in this later from writing code to scripting and assembly. This is achieved by building up the appropriate services and components that are concrete representations of the model. After these are available and they have interfaces at the correct level of granularity, the scripting and assembly can be done. Scripting is a synonym for flows and this is where BPEL-based choreography technology fits in. In this layer, you can build flows that represent a business process and have the runtime to execute them.

Assembly and customization is another aspect that is important. Here you wire together components. This is a not a flow concept, but more of an assembly idea, where high level components support specific interfaces and depend on other interfaces for implementation.

As we move to the red layer, WebSphere Business Monitor provides the business-level monitoring. You can build dashboards to see how the business is performing and register actions to take place based on business level events that are occurring in the system. WebSphere Business Monitor will work in conjunction with the other tools that provide monitoring of the infrastructure events. Because the IT and business events are both based on a Common Event Infrastructure, there is correlation between business and IT events, thus providing faster problem resolution because you can determine exactly what happened where and when, and fix things at a business and infrastructure level.

The final pink layer speaks to the core runtime that provides workload management across disparate resources and efficient utilization of all available IT resources. Solution Modeling and part of the WebSphere Business Modeler solution is a starting point for configurations and service level agreements (SLAs) and thus has some affinity at this layer.

WebSphere Process Integration is based on the WebSphere Application Server, which provides a number of the key technologies that otherwise would have to be re-implemented by WebSphere Process Integration. Examples are infrastructure services around transaction management and workload management.

WebSphere Process Integration also builds ideas upon the basic virtualizaton of resources that are being enabled and extended in the base application server. As the application server continues to enable On Demand Business, the process server benefits from these features as well.

The remainder of this paper focuses on the key concepts and components of WebSphere Process Server and WebSphere Integration Developer, two products that constitute WebSphere Process Integration. WebSphere Process Server allows the development and execution of standards-based business integration applications in an SOA. Based on the robust J2EE 1.4 infrastructure and associated platform services provided by WebSphere Application Server, WebSphere Process Server can help you meet current business integration challenges. This includes, but is not limited to, business process automation.

WebSphere Integration Developer delivers role-based development for integration projects based on the Eclipse 3.0 platform. WebSphere Integration Developer complements WebSphere Business Modeler and can be used in conjunction with other Rational® tools to create a unique, integrated, and powerful development platform. Each user has a tooling perspective based on their particular role (J2EE Developer, Business Analyst, or Integration Developer). This allows the user to focus on just the editors and tools that they need for their role, which leads to unparalleled productivity.

Figure 1-8 shows which products and tools could be used in which phase of a software development and deployment project.

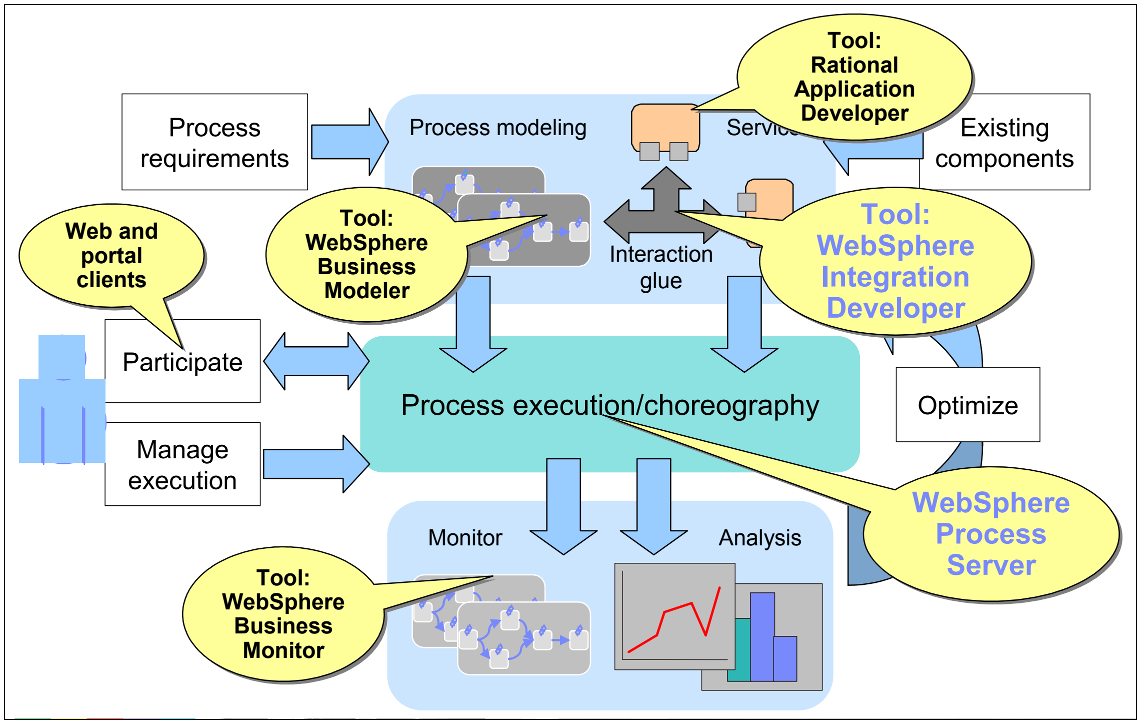


Figure 1-8 WebSphere Process Integration and related products

2

Building blocks of WebSphere Process Server

This chapter discusses the programming model and main building blocks of WebSphere Process Server, grouped around three concepts:

- Invocation
- Data
- Composition

2.1 WebSphere Process Integration programming model

Integration projects have long been very difficult because there is a myriad of technologies. There are many ways to represent or interact with data and there are many ways to describe or invoke existing application logic. Figure 2-1 shows only a few relevant technologies in this area.

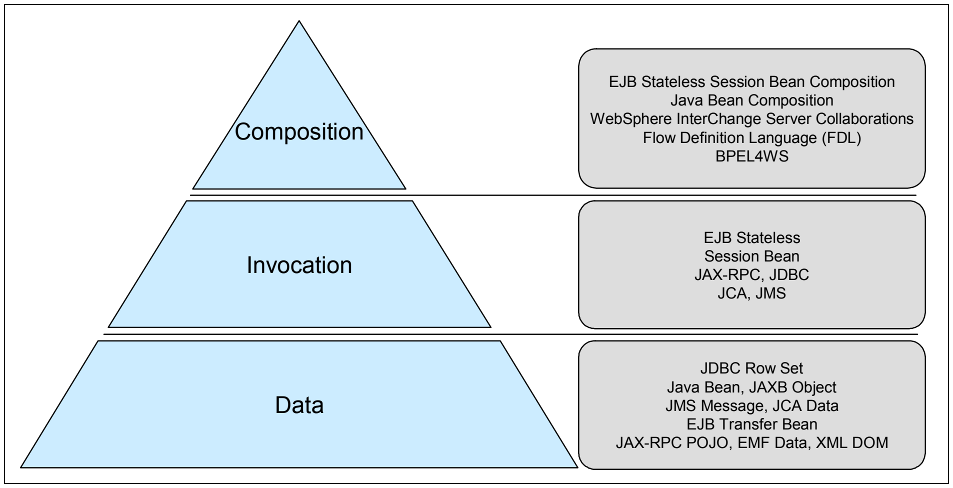


Figure 2-1 Traditional programming model

A third level in a typical integration project is composition. How do you combine several components together in an overall flow? Here, too, a number of technologies were in use in typical integration projects. These (and other) technologies are likely to be used in the future as well as today to build IT solutions.

WebSphere Process Server offers a new level of abstraction at each of these levels so that the task of integrating applications and services becomes much easier (see Figure 2-2 on page 25).

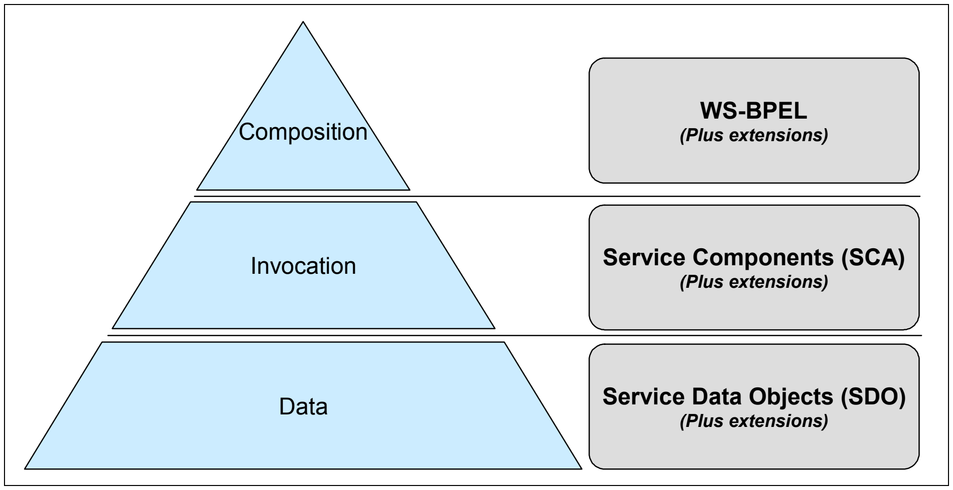


Figure 2-2 New programming model

At the data level, WebSphere Process Integration offers Service Data Objects (SDOs) as an abstraction level. SDO and a number of extensions are used to implement business objects. Extensions to SDO that are implemented in WebSphere Process Server include, for example, support for metadata, context information, and change history.

The term *business objects* is also used for WebSphere InterChange Server. However, in WebSphere Process Server, the term gets a much broader usage because it provides a universal means of describing and accessing data.

At the invocation level, WebSphere Process Server offers Service Component Architecture (SCA). SCA describes all integration artifacts as service components with well-defined interfaces. SCA also introduces the concept of a module, which groups together service components and provides further specification and encapsulation of services.

WebSphere Integration Developer provides an assembly editor where the developer groups service components into modules and specifies which service interfaces are exposed by the module to outside consumers. Services that are available include imported components such as Java Beans or Web services and service components that WebSphere Process Server provides. Modules are then connected to form complete integration solutions.

The concepts of SCA allow a developer to encapsulate integration logic within modules. This means that a change to service components within a module does not impact any of the other modules in the overall solution as long as the interface of the changed module stays the same. This concept has been applied throughout WebSphere Process Server. All integration artifacts in WebSphere Process Server (processes, business rules, human tasks, and so on) are represented as SCA service components. This creates an environment with great flexibility. It is possible, for example, to replace a human task for an approval with a business rule for automatic approval simply by replacing the service components in the assembly diagram without changing either a business process or the caller of the business process.

With SCA, you can invoke service components using synchronous and asynchronous programming styles. You can assemble modules into overall solutions where asynchronous channels between service components and modules can increase the overall throughput and flexibility of the system.

At the composition level, WebSphere Process Server offers business process execution language for Web services (WS-BPEL), sometimes also referred to as BPEL4WS.

2.2 WebSphere Process Integration architectural model

WebSphere Process Server is built on a robust J2EE runtime provided by WebSphere Application Server. The architectural model is illustrated in Figure 2-3.

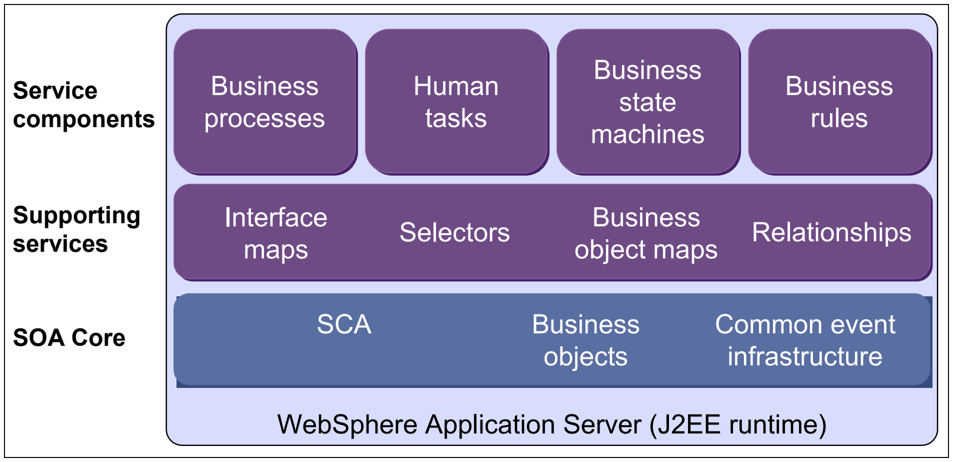


Figure 2-3 Architectural model for WebSphere Process Server

The J2EE runtime offers Qualities of Service that WebSphere Process Server exploits, such as clustering, failover, scalability, and security. The J2EE server also includes a built-in messaging provider that can be configured to connect to an existing WebSphere MQ network.

Also in the infrastructure layer is the Common Event Infrastructure, which is the foundation for monitoring applications. IBM uses this infrastructure throughout the IBM product portfolio; monitoring products from Tivoli® and WebSphere (WebSphere Business Monitor) exploit it. The event definition (Common Business Event, or CBE) is being standardized by the OASIS standards body so that other companies and clients can use the same infrastructure to monitor their environments.

On top of this infrastructure, WebSphere Process Server implements a layer called the SOA core. To do integration in an SOA properly, you must have a single invocation model and a single data model. SOA is this invocation model: every integration component is described using an interface. These services can then be assembled in a component assembly editor; the result is a very flexible, encapsulated solution. Business objects are the universal data description. They are being used as data going in and out of services and are based on the SDO standard.

SCA Bindings describe the physical description of components. Services that can be accessed include Plain Old Java Objects (POJOs), EJBs, Web services, JMS messages, and adapters.

On top of this SOA core layer, WebSphere Process Server implements a number of components and services that can be used in an integration solution:

- Business processes: The business process component in WebSphere Process Server implements a WS-BPEL compliant process engine. Users can develop and deploy business processes with support for long and short running business processes and a robust compensation model in a highly scalable infrastructure. WS-BPEL models can be created in WebSphere Integration Developer or imported from a business model that has been created in WebSphere Business Modeler.
- Human tasks: Human tasks in WebSphere Process Server are stand-alone components that can be used to assign work to employees or to invoke any other service. Additionally, the Human Task Manager supports the ad-hoc creation and tracking of tasks. Existing Lightweight Directory Access Protocol (LDAP) directories (and operating system repositories and the WebSphere user registry) can be used to access staff information. Of course, WebSphere Process Server supports multi-level escalation for human tasks, including e-mail notification.

  WebSphere Process Server also includes an extensible Web client that can be used to work with tasks or processes. This Web client is built based on a set of reusable Java Server Faces (JSF) components that can also be used to create custom clients or embed human task functionality into other Web applications.

- Business state machines: A business state machine provides another way of modeling a business process. Businesses can represent their business processes based on states and events that sometimes are easier to model than a graph-oriented business process model. One example is an ordering process where the order can be cancelled or modified at any time during the order process.
- Business rules: Business rules are a means of implementing and enforcing business policy through the externalization of business. This allows dynamic changes of a business process for a more responsive business environment. Business rule authoring is supported by an Eclipse-based desktop tool. WebSphere Process Server also includes a Web-based runtime tool for business analysts so that business rules can be updated as business needs dictate without affecting other SCA services.

These components can use the features of a number of supporting services in WebSphere Process Server. Most of these can be classified as some form of transformation, which is not surprising. A number of the transformation challenges in the process of connecting components and external services are addressed by a component of WebSphere Process Server:

- Interface maps: Very often interfaces of existing components match semantically but not syntactically (for example, updateCustomer versus. updateCustomerInDB2). This is especially true for already existing components and services. Interface maps translate these calls so that these components can be invoked. Additionally, business object maps can be used to translate the actual business object parameters of a service invocation.
- Business object maps: Used to translate one type of business object into another type, these maps can be used in a variety of ways (for example, as an interface map to convert one type of parameter data into another).
- Relationships: In business integration scenarios, it is often necessary to access the same data, such as customer records, in various back-end systems (for example, Enterprise Resource Planning and Customer Relationship Management). A common problem with keeping business objects in sync is that different back-end systems use different keys to represent the same objects. The WebSphere Process Server relationship service establishes relationship instances between objects in these disparate systems. These relationships are typically accessed from a business object map while one business object format is being transformed into another.
- Selector: Different services that all share the same interface can be selected and invoked dynamically by a selector. For example, a customer support process might use different human task implementations during different times of the day. Work is routed to different support centers (Americas, Europe, and Asia-Pacific) based on the time of day. WebSphere Process

Server offers a Web-based interface for dynamic updates to selection criteria and target services.

2.3 Invocation: SCA

Figure 2-4 shows a simple way to look at the important architectural constructs that make up an SOA. To build an SOA, three concepts quickly emerge. Specifically, there must be a way to represent the data that is exchanged between services, there must be a mechanism for invoking services, and there must be a way to compose services into a larger integrated business application.

In this section, we discuss the concept of invoking services in an SOA (Figure 2-4).

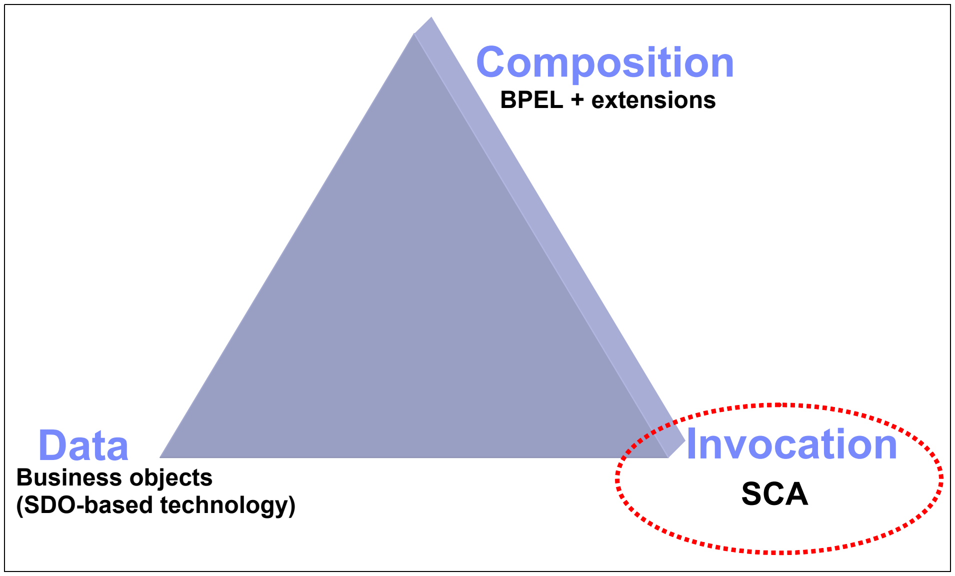


Figure 2-4 Invocation in SOA: SCA

Today, there are many different programming models for supporting each construct in Figure 2-4. This situation presents developers with the challenge of not only needing to solve a particular business problem, but also choosing and understanding the appropriate implementation technology. One of the important goals of the WebSphere Process Server SOA solution is to mitigate these complexities by converging the various programming models that are used for implementing service-oriented business applications into a simplified programming model.

2.3.1 Anatomy of the SCA

SCA is the service-oriented component model. It provides an abstraction that covers stateless session EJBs, Web services, POJOs, BPEL4WS processes, database access, Enterprise Information System (EIS) access, and so on. SCA separates business logic from infrastructure logic so that application programmers can focus on the business problem. SCA covers both the usage of services and the development of services. It provides a uniform model for application programmers and for tools.

SCA is a universal model for business services that publish or operate on business data. SDOs provide the universal model for business data. SDO is discussed in 2.4, “Data: Business objects and SDO” on page 37.

Figure 2-5 shows the main terms of an SCA component:

- Interface
- Implementation
- Reference

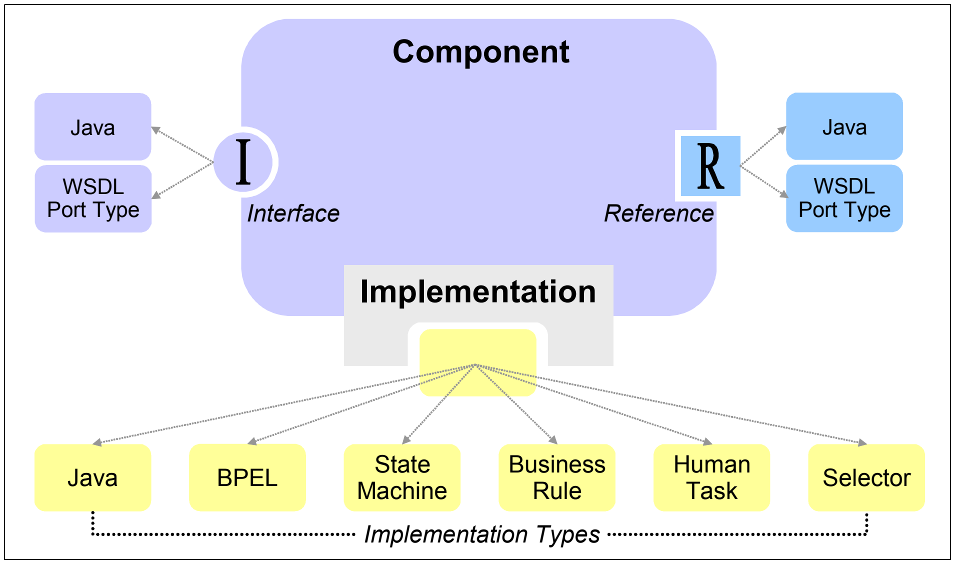


Figure 2-5 Service component: overview

A service interface is defined by a Java interface or WSDL Port Type. Arguments and return values are described with Java classes, simple Java types, or XML schema. SDO generated Java classes are the preferred form of Java class because of their integration with XML technologies. Arguments described in XML schema are exposed to programmers as SDOs.

A component exposes business-level interfaces to its application business logic so that the service can be used or invoked. The interface of a component defines the operations that can be called and the data that is passed, such as input arguments, returned values, and exceptions. An import and export also has interfaces so that the published service can be invoked.

All components have interfaces of the WSDL type. Only Java components support Java-type interfaces. If a component, import or export, has more than one interface, all interfaces must be the same type.

A component can be called synchronously or asynchronously; this is independent of whether the implementation is synchronous or asynchronous. The component interfaces are defined in the synchronous form and asynchronous support is also generated for them. You can specify a preferred interaction style as synchronous or asynchronous. The asynchronous type advertises to users of the interface that it contains at least one operation that can take a significant amount of time to complete. As a consequence, the calling service must avoid keeping a transaction open while waiting for the operation to complete and send its response. The interaction style applies to all the operations in the interface.

You can also apply a role-based permission qualifier to an interface so that only authorized applications can invoke the service with that interface. If the operations require different levels of permission for their use, you must define separate interfaces to control their access.

A service can be implemented in a range of languages (for example Java, BPEL, state-machine definitions, and so on). When implementing a service, the focus is on the business purpose and less on infrastructure technology.

SCA and non-SCA services can use other service components in their implementations. They do not hard code the other services they use. They declare soft links called service references. Service wires resolve service references. You can use SCA wiring to create SCA applications by component assembly.

Figure 2-6 on page 32 shows a service component and a number of references. When a component wants to use the services of another component, it must have a partner reference or simply a reference. We can consider an in-line reference, which means that the referenced service component is defined within the same scope of the referencing component. In other words, both components are defined within the same module.

Applications that are not defined as SCA components (for example, JavaServer Pages, or JSPs) can still invoke SCA components; they do so through the use of stand-alone references. Stand-alone references contain partner references that identify the components to call. Alone, stand-alone references do not have any implementation or interface.

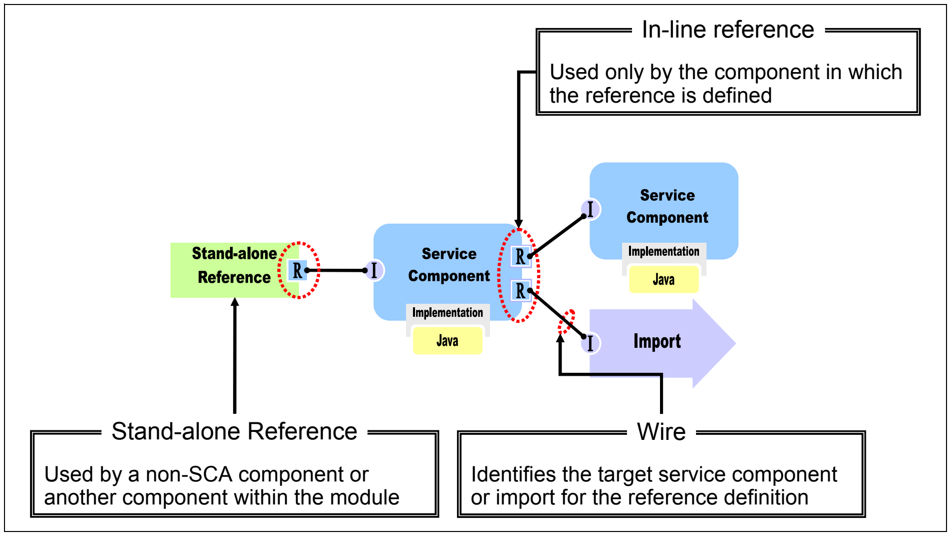

In-line reference
Used only by the component in which the reference is defined
Stand-alone Reference
R
I
Service Component
Implementation
Java
R
R
I
Service Component
Implementation
Java
I
Import
Stand-alone Reference
Used by a non-SCA component or another component within the module
Wire
Identifies the target service component or import for the reference definition

Figure 2-6 Service component and references

Components are assembled in a module (Figure 2-7), which is a basic unit of deployment in the WebSphere Process Server.

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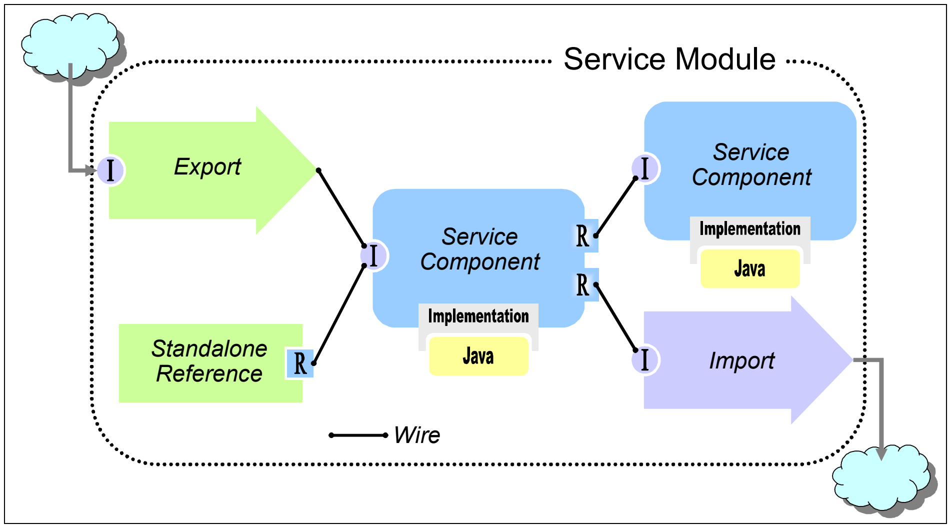


Figure 2-7 Service module: overview

The module assembly contains a diagram of the integrated business application, consisting of components and the wires that connect them. You use an assembly editor to visually compose the integrated application with elements that you drag from the palette or from the tree in the Business Integration view.

The implementations of components that are used in a module assembly might reside within the module. Components that belong to other modules can be used through imports, which are described later. Components in different modules can be wired together by publishing the services as exports that have their interfaces and dragging the exports into the required assembly diagram to create imports.

When wiring components, you can also specify quality of service qualifiers on the implementations, partner references, and interfaces of the component.

An import allows you to use functions that are not part of the module that you are assembling. Imports can be from components in other modules or non-SCA components such as stateless session EJBs and Web services. Available function (or business logic) that is implemented in remote systems (such as Web services, EIS functions, EJBs, or remote SCA components) is modeled as an *imported service* (Figure 2-8).

Imports have interfaces that are the same as or a subset of the interfaces of the remote service that they are associated with so that those remote services can be called. Imports are used in an application in exactly the same way as local components. This provides a uniform assembly model for all functions, regardless of their locations or implementations. The import binding does not have to be defined at development time; it can be done at deployment time.

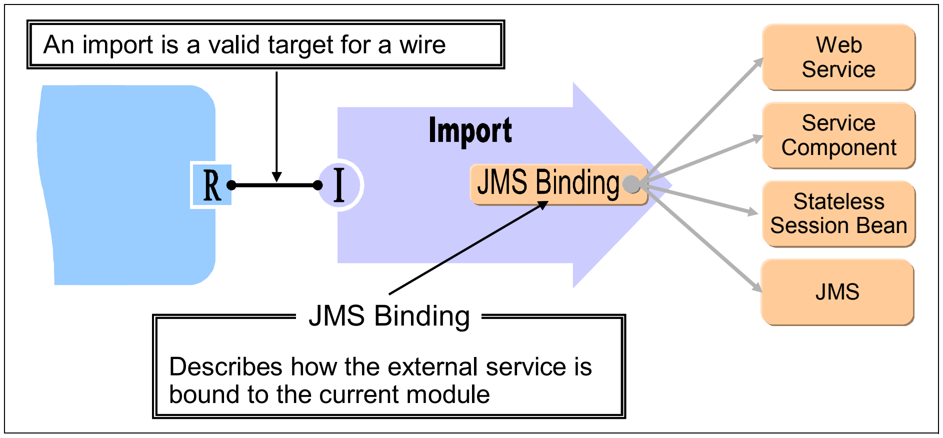

An import is a valid target for a wire
R
I
Import
JMS Binding
Web Service
Service Component
Stateless Session Bean
JMS
JMS Binding
Describes how the external service is bound to the current module

Figure 2-8 Service component and import

An *export* is a published interface from a component (Figure 2-9) that offers the component business service to the outside world, for example, as a Web service. Exports have interfaces that are the same as or a subset of the interfaces of the component that they are associated with so that the published service can be called. An export dragged from another module into an assembly diagram automatically creates an import.

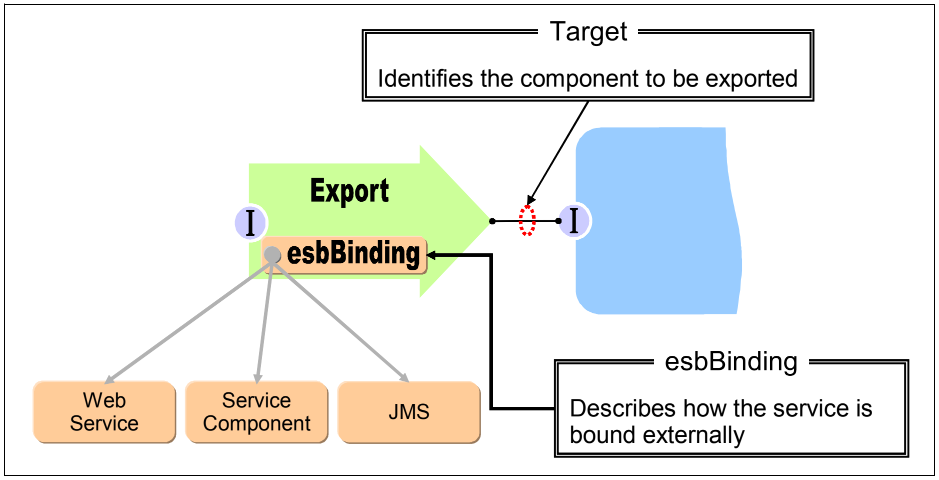

Target
Identifies the component to be exported
Export
I
esbBinding
I
Web Service
Service Component
JMS
esbBinding
Describes how the service is bound externally

Figure 2-9 Service component and export

The service component details are stored in an XML file (Figure 2-10 on page 35) using a new definition language: Service Component Definition Language (SCDL).

```
<?xml version="1.0" encoding="UTF-8"?>
<scdl:component xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:java="http://www.ibm.com/xmlns/prod/websphere/scdl/java/6.0.0"
xmlns:ns1="http://HelloWorld/HelloWorldInterface"
xmlns:scdl="http://www.ibm.com/xmlns/prod/websphere/scdl/6.0.0"
xmlns:wsdl="http://www.ibm.com/xmlns/prod/websphere/scdl/wsdl/6.0.0"
displayName="HelloWorld" name="HelloWorld">
  <interfaces>
    <interface xsi:type="wsdl:WSDLPortType" portType="ns1:HelloWorldInterface">
      <method name="sendMessage"/>
    </interface>
  </interfaces>
  <references>
    <reference name="HelloWorldInterfacePartner">
      <interface xsi:type="wsdl:WSDLPortType" portType="ns1:HelloWorldInterface"/>
    </reference>
  </references>
  <implementation xsi:type="java:JavaImplementation" class="sample.HelloWorldImpl"/>
</scdl:component>
```

Figure 2-10 Sample SCDL file

2.3.2 SCA client programming model

The SCA client programming model is designed to locate a service, to create data objects, to invoke a service, and to handle exceptions that are raised by the invoked component.

Clients locate services by using the ServiceManager class. There are a few ways to instantiate the ServiceManager class, depending on the desired lookup scope for the service. Once the ServiceManager is instantiated, you can use the method locateService(String interface) to locate the service that implements the requested interface.

The SCA supports both static (type-safe) and dynamic invocation. The following snippet of pseudo-code shows how the service is located and how the method `someOperation` is then invoked dynamically.

```
Service myService = (Service) serviceManager.locateService(“myService");
DataObject input = ...
myService.invoke(“someOperation”, input);
```

The dynamic invocation interface provides an invoke method for calling methods dynamically. The invoke method takes (as input) the name of the method to invoke and an input array of *Object*. The invoke method returns an array of

Object also. Ideally, the input is an SDO; however, ordinary Java classes can be used, too.

The following pseudo-code snippet shows the type-safe invocation:

```
MyServiceImpl myService =
   (MyServiceImpl) serviceManager.locateService(“myService");
myService.someMethod(“input”);
```

With SCA, services can be called synchronously or asynchronously. There are three types of asynchronous invocation models as shown in Figure 2-11.

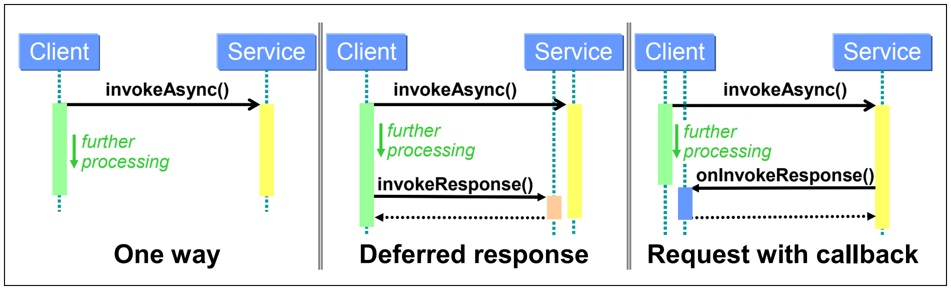
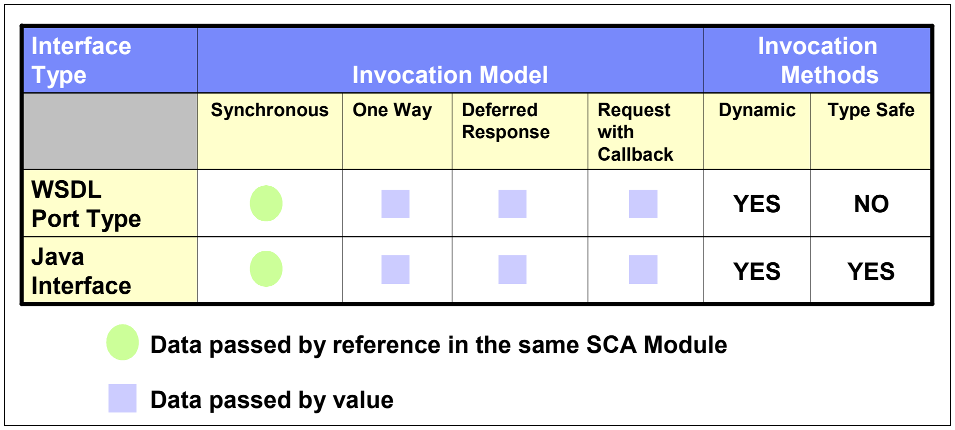


Figure 2-11 Three types of asynchronous invocations

The first option is a simple one-way operation. The invocation returns immediately and the client can continue further processing. The second option is the deferred response. In this case, the client retrieves the output later, using a ticket. The third option is the callback mechanism: the service calls a method on the client side to return the response.

SCA interfaces are always defined in the synchronous form. For each synchronous interface, one or more asynchronous interfaces can be generated. When a callback mechanism is chosen by the client, the client component needs to implement a class: <*interface name*>Callback.java. The interface of this class is derived from the interface of the actual component that the client wants to use.

Figure 2-12 on page 37 summarizes the different interface types, the supported invocation methods and models, and how data is passed between client and service.



Interface Type	Invocation Model				Invocation Methods	
	Synchronous	One Way	Deferred Response	Request with Callback	Dynamic	Type Safe
WSDL Port Type	●	■	■	■	YES	NO
Java Interface	●	■	■	■	YES	YES

● Data passed by reference in the same SCA Module

■ Data passed by value

Figure 2-12 SCA interactions

2.4 Data: Business objects and SDO

In the previous section, we discussed SCA and mentioned SDO briefly. We also discussed the concept of business objects, the second architectural construct of an SOA.

Business data that is exchanged in an integrated application in WebSphere Process Server is represented by business objects. The objects are based on SDO, which is a new data access technology (see Figure 2-13 on page 38). In this section, we discuss SDO in greater detail.

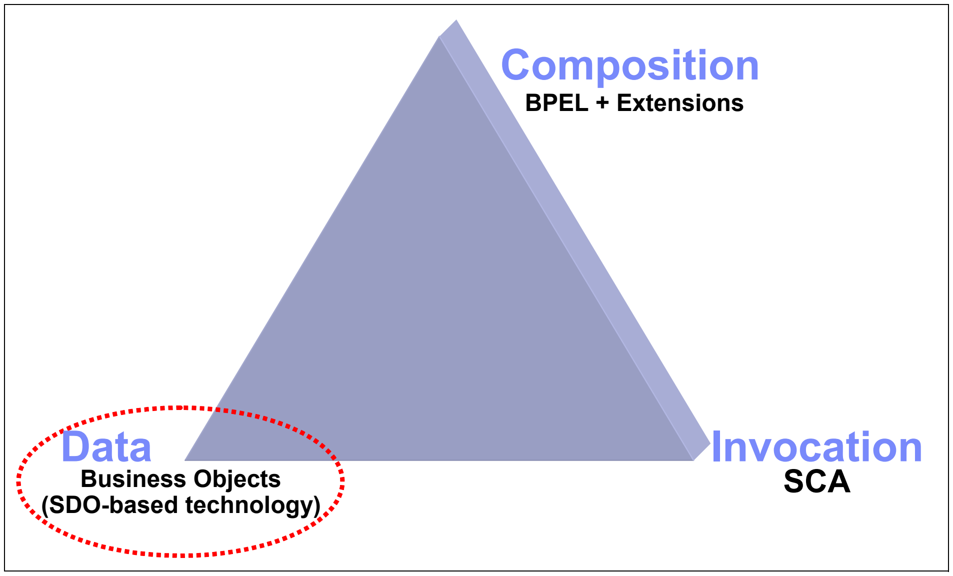


Figure 2-13 Data in SOA: SDO

2.4.1 SDO design points

When a programmer must access data, the programmer must select a programming model that is based on where the data is stored. For example, a Java programmer who wants to manipulate relational data can use the Java Database Connectivity (JDBC) API. That same API can also be used to query metadata. For an XML document, the programmer might use, for example, the Simple API for XML (SAX).

Basically, the programmer must know and write infrastructure code, and the business logic is tied to the location and type of data. If the data was first stored in an XML data source and is moved to a relational data source, the programmer needs to change the data access code in the program.

SDO changes all that. It unifies data representation across disparate data stores. It supports a disconnected programming model and is integrated with XML. SDO provides dynamic and static (strongly typed) data APIs. The SDO proposal was published jointly by IBM and BEA as JSR 235. SDO Version 1.0 support is introduced in WebSphere Application Server V6 and IBM Rational Application Developer V6. The SDO V2.0 specification is currently available.

Table 2-1 on page 39 lists a number of data-oriented Java APIs and adds the characteristics for SDO as well.

Table 2-1 Comparing data-oriented Java APIs

Technology	**Model**	**API**	**Data Source**	**Meta-data API**	**Query Language**
SDO	Disconnected	Dynamic and static	Any	SDO Meta-data API and Java Introspection	Any
JDBC Rowset	Connected	Dynamic	Relational	Relational	SQL
JDBC Cached Rowset	Disconnected	Dynamic	Relational	Relational	SQL
Entity EJB	Connected	Static	Relational	Java Introspection	EJBQL
JDO	Connected	Static	Relational, Object	Java Introspection	JDOQL
JCA	Disconnected	Dynamic	Record-based	Undefined	Undefined
DOM and SAX	Disconnected	Dynamic	XML	XML InfoSet	XPath, XQuery
JAXB	Disconnected	Static	XML	Java Introspection	N/A
JAX-RPC	Disconnected	Static	XML	Java Introspection	N/A

For each technology shown in the first column, the table lists some characteristics in the following areas:

- Model

  Connected or **disconnected** are the possible values. This refers to the requirement of some APIs for an active connection to the data source. Active connections are incompatible with SOAs.

- API

  Static or **dynamic** are the possible values. Static code is generated in advance while dynamic code has a reflective interface that avoids code generation. However, dynamic code lacks compile-time checking.

- Data source

  This refers to the intrinsic nature of the data. SDO works uniformly across all kinds of data sources.

- Meta-data API

  This refers to the API that can be used to obtain type information about the data itself.

- Query Language

  This column specifies what option is available for defining the data that is accessed by a service. SDO can handle any query language.

In addition to providing a programming model that unifies data access, there are several other key design features to note about SDO. First, built into the SDO architecture is support for some common programming patterns. Most significantly, SDO supports a disconnected programming model. Typically, with this type of pattern, a client might be disconnected from a particular data access service (DAS) while working with a set of business data. However, when the client has completed processing and needs to apply changes to a back-end data store by way of a DAS, a change summary is necessary to provide the appropriate level of data concurrency control. This change summary information has been built into the SDO programming model to support this common data access scenario.

Another important design point to note is that SDO integrates well with XML. As a result, SDO naturally fits in with distributed service-oriented applications where XML plays a very important role.

Finally, SDO has been designed to support both dynamic and static data access APIs. The dynamic APIs are provided with the SDO object model and provide an interface that allows developers to access data even when the schema of the data is not known until runtime. In contrast to this, the static data APIs are used when the data schema is known at development time, and the developer prefers to work with strongly typed data access APIs.

2.4.2 Some SDO concepts

There are a a few key SDO concepts that can provide a framework for understanding business object architecture, including the design and use of business objects in WebSphere Process Server.

The fundamental concept in the SDO architecture is the data object. In fact, the term SDO is often used interchangeably with the term data object. A data object is a data structure that holds primitive data, multi-valued fields (other data objects), or both. The data object also has references to metadata that provide information about the data found in the data object. In the SDO programming model, data objects are represented by the commonj.sdo.DataObject Java interface definition. This interface includes method definitions that allow clients to obtain and set the properties associated with DataObject.

As an example, consider modeling customer data with an SDO data object. The properties associated with the customer might be firstName (String), lastName (String), and customerID (long). The following pseudo code shows how you might use the DataObject API to obtain and set properties for the customer data object:

```
DataObject customer = …
customer.setString("firstName","John");
customer.setString("lastName","Doe");
customer.setInt("customerID", 123);
int id = customer.getInt(“customerID”);
```

Another important concept in the SDO architecture is the data graph (Figure 2-14). A data graph is a structure that encapsulates a set of data objects. From the top level data object in the graph, all other data objects can be reached by traversing the references from the root data object. In the SDO programming model, data graphs are represented by the commonj.sdo.DataGraph Java interface definition.

An important feature of the data graph is a change summary that is used to log information about what data objects in the graph have changed during processing. The change summary information is defined by the commonj.sdo.ChangeSummary interface.

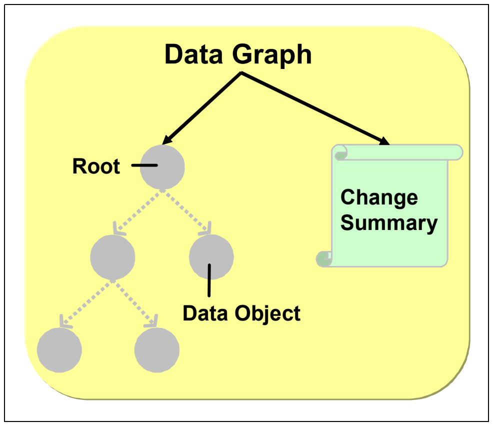


Figure 2-14 Data graph consisting of data objects and change summary

2.4.3 Business objects and the business object framework

The business object framework provides a data abstraction for SCA. For readers that have experience with WebSphere InterChange Server, the WebSphere Process Server business object framework provides capabilities similar to business objects as used in WebSphere InterChange Server. Business objects are based on SDO v1.0 technology but provide some additional functionality not found in SDO.

Both SCA and SDO (the basis of business objects) have been designed to be complimentary service oriented technologies. Figure 2-15 illustrates how SCA provides the framework to define service components and to compose these services into integrated applications, and it further shows that business objects represent the data that flows between each service. Whether the interface associated with a particular service component is defined as a Java interface or a WSDL port type, the input and output parameters are represented by business objects.

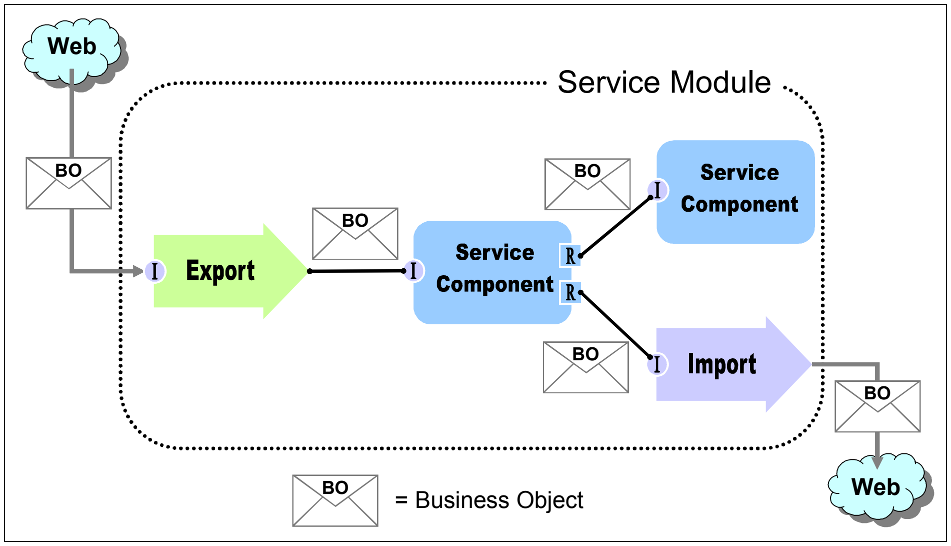


Figure 2-15 Exchanging data in an SCA runtime

The business object framework consists of the following four concepts:

Business object (BO)	Fundamental data structure for representing business data
Business graph (BG)	Wrapper for a business object or hierarchy of business objects to provide enhanced information such as change summary, event summary, and verb
BO Type Metadata	Metadata that provides the ability to annotate business objects with application specific information
BO Services	A set of services provided to facilitate working with business objects, available in addition to the capabilities already provided by SDO V1.0

Note: The term *business object* is occasionally used to refer to the entire framework. However, in this paper, the term refers to the fundamental data structure for representing business data and *not* to the overall architecture. For the overall architecture, the term *business object framework* is used.

The business object is directly related to the SDO data object concept discussed previously. In fact, business objects in WebSphere Process Server are represented in memory with the SDO type commonj.sdo.DataObject. Business objects are modeled as XML schema. Two types of business objects are found in the business object framework:

- Simple business objects, which are composed only of scalar properties
- Hierarchical business objects, which are composed of attributes that refer to nested business objects

In the business object framework, a business graph is used to wrap a top level business object and provide additional information that can enhance the data. In particular, the business graph includes the change summary for the data in the graph (similar to the SDO change summary information), the event summary, and verb information (used for data synchronization between EISs).

The business graph is similar to the SDO data graph. However, the event summary and the verb portion of the enhanced information is not included with the SDO data graph concept. Figure 2-16 shows how these concepts fit together.

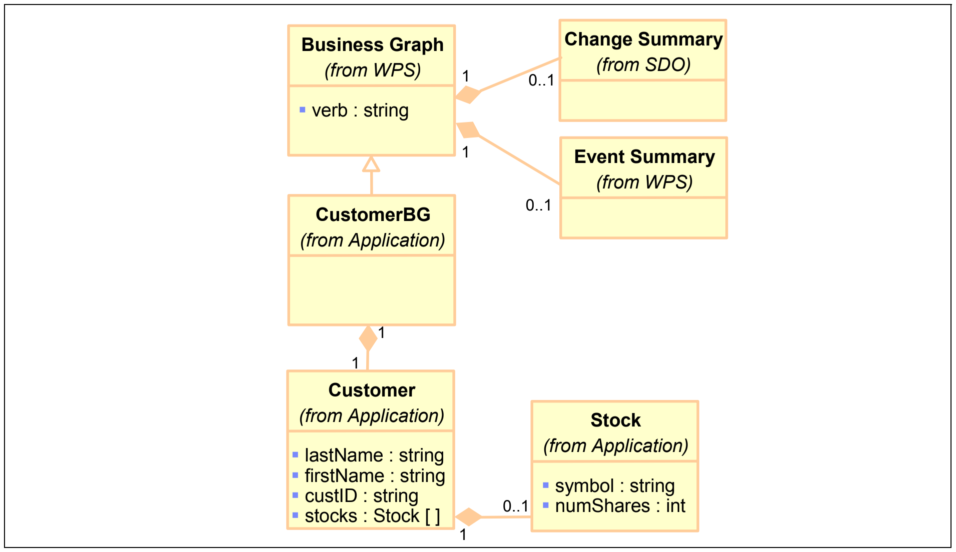


Figure 2-16 Business graph and business objects

At the bottom of the graph is the simple business object, *Stock*. This business object has only scalar attributes. The business object *Customer* is a hierarchical business object. It has scalar attributes, but it also has an attribute that is an array of business objects (BO Stock, in this case).

Business graph *CustomerBG* acts as a wrapper. It contains the top-level business object. Since CustomerBG is a business graph, it has the additional attribute verb and a reference to a change summary and event summary. The change summary concept is inherited from SDO, while the concept of a verb and event summary are provided by WebSphere Process Server itself.

2.5 Composition: BPEL

The third aspect of a process integration solution is composition. A process component orchestrates multiple service components to achieve a given business goal. A process component is described in BPEL, sometimes referred to as BPEL4WS or WS-BPEL 2.0. Figure 2-17 illustrates this concept.

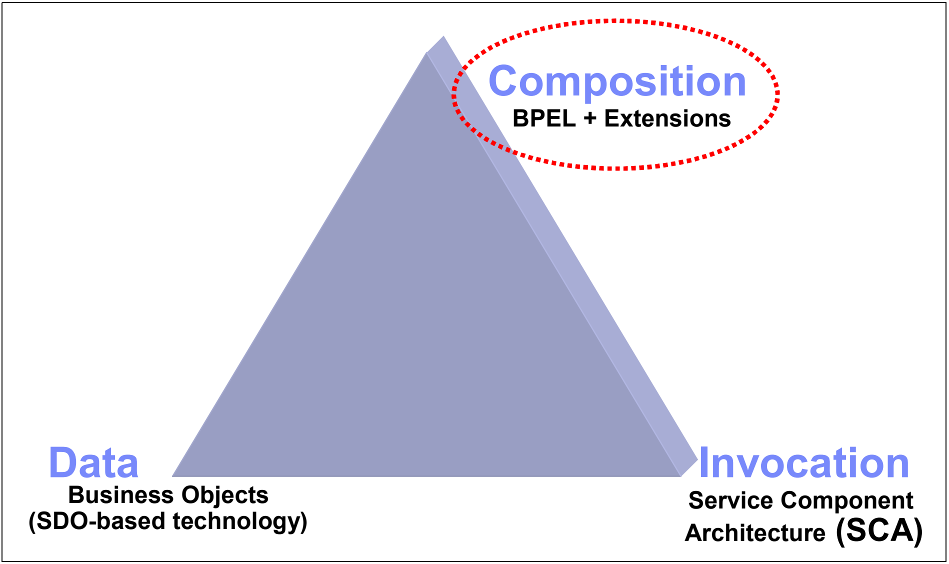


Figure 2-17 Composition in SOA: BPEL

Business processes are a unifying concept for integrating business-to-business and enterprise applications by exposing the appropriate invocation and interaction patterns. Processes are the building blocks for developing consistent distributed applications in heterogeneous environments. Process-based applications are composed of two distinct pieces:

- A process model that describes the logical order in which the different activities of the process are being executed
- The individual services/components that implement the specific activities

As a result, a business process is the set of business-related activities, rules, and conditions that are invoked in a defined sequence to achieve a business goal.

The purpose of the Business Flow Manager is to manage the life cycle of business processes, to navigate through the associated process model, and to integrate the appropriate business functions by invoking the appropriate services. WSPEL is used to define the process model that the Business Flow Manager navigates through.

2.5.1 WS-BPEL

WS-BPEL defines a model and grammar for describing the behavior of a business process based on interactions between the process and its interactions with external partners. It can be used to specify both the public interfaces for the partners and the description of the executable process. A partner can be any entity that provides a service, consumes a service, or both.

WS-BPEL provides the means to specify business processes that consist of service invocations and the ability to expose the actual business process as Web services. The interaction with each partner occurs through Web service interfaces, and the structure of the relationship at the interface level is encapsulated by partner links. The WS-BPEL process defines the sequencing of service interactions with partners. The process also provides the coordination to achieve a business goal, and the state management and the logic necessary for the coordination.

WS-BPEL provides systematic mechanisms for dealing with business exceptions and processing faults. WS-BPEL implements a framework for defining how individual or composite activities in a process are to be compensated in cases where exceptions occur or a partner requests the reversal of a scope of work.

WS-BPEL is founded on an XML notation for specifying business process behavior based on Web services. The standard is being directed through OASIS. Refer to the following Web site for more information:

http://www.oasisopen.org/committees/tc_home.php?wg_abbrev=wsbpel

The standard is based on WSDL 1.1, XML Schema 1.0, and XPath 1.0. WSDL messages and XML schema type definitions provide the data model used by WS-BPEL processes. XPath provides support for data manipulation. External resources and partners are represented as WSDL services. A WS-BPEL compliant process can be executed in any process execution environment that supports that standard. Therefore, WS-BPEL process models are portable.

The technical features of WS-BPEL are:

- Compensation (compensation handlers, compensate activity) for undoing process steps that have already been completed
- Event handlers for providing the ability to handle asynchronous event issues during process execution
- Support for XPath as query and expression language (for example, in conditions), which provides flexibility for modeling process conditions
- Explicit isolated scopes to allow for separation of internal error and event handling
- Fault handlers for advanced internal process error handling

2.5.2 A business process as an SCA component

A BPEL process provides operations by implementing them through Receive activities (for one-way operations) or Receive-Reply activity pairs (for request-response operations). These operations are available in the external interface of the process. A business process can be invoked as an SCA component through that interface (Figure 2-18). Business process interfaces, such as the Receive, Reply, and Receive Choice activities, are available to SCA through Export and non-SCA components from a stand-alone reference.

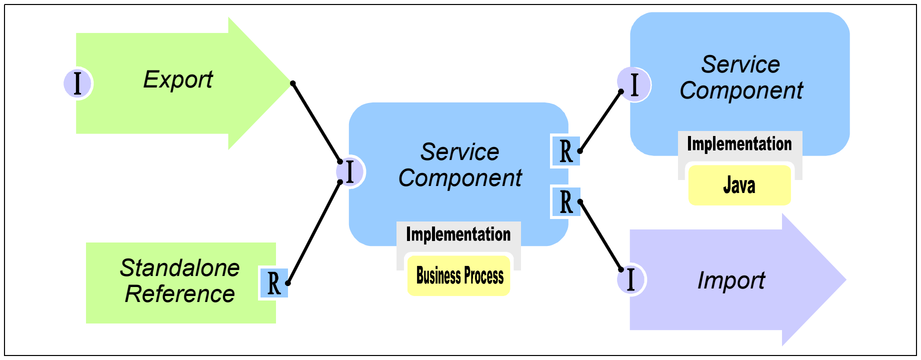


Figure 2-18 A business process as an SCA component

A business process can also invoke SCA components. BPEL partner links in the process are resolved to SCA components or external services using the assembly editor. Partner links in the BPEL process are wired to SCA and non-SCA components by an import. Partner links to SCA components in the same module are wired directly.

A BPEL process uses an invoke activity to invoke other services. That activity specifies the partner and the operation that is to be called on behalf of the process, the data that is used as the input message to that operation, and, in the case of a request-response operation, where the result data is to be stored.

BPEL processes can transparently handle one-way, request-response operations, and synchronous and asynchronous interaction modes, using the same syntax for all cases. The business flow manager dynamically detects the type of service implemented by the corresponding partner and uses the appropriate invocation. This allows the business process modeler to create processes that are independent from the physical realization of the involved services.

Business processes execute in a dedicated container, the Business Flow Manager component of Business Process Choreographer. This component persistently and reliably:

- Manages process state
- Routes incoming requests to the correct instance
- Executes BPEL statements
- Interfaces with the Human Task Manager for people interactions
- Produces the right logging events for the Common Event Infrastructure (CEI)
- Deploys and manages processes

2.5.3 Business process examples

Business processes are used to solve a wide variety of business problems. WebSphere Process Server implements functionality that maps to features that are available in WebSphere Business Integration Server Foundation, WebSphere InterChange Server, and WebSphere MQ Workflow. WebSphere Process Server provides techniques for building solutions that mimic the functionality that is available in each of these earlier products. This section briefly describes how these tools provide business process support to illustrate the advanced architecture of WebSphere Process Server.

WebSphere Business Integration Server Foundation

WebSphere Process Server is a direct evolution from WebSphere Business Integration Server Foundation. As such, the business process model that is available in WebSphere Business Integration Server Foundation is supported and extended in WebSphere Process Server.

Figure 2-19 on page 48 shows a simple WebSphere Process Server solution that represents a WebSphere Business Integration Server Foundation solution. On the left is a Web services export that exposes the service as a standard Web service. The business process is a WS-BPEL-based solution that integrates partner links that are exposed as references and implemented as Web services.

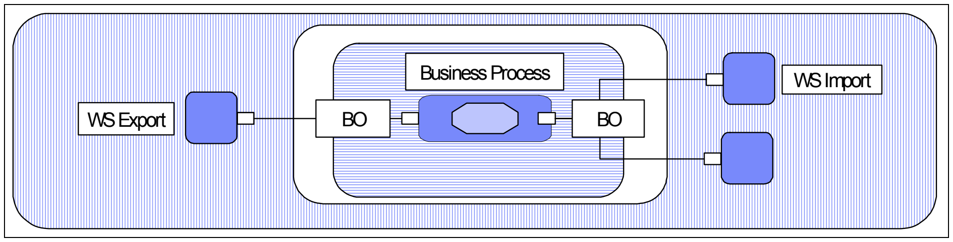


Figure 2-19 WebSphere Business Integration Server Foundation scenario

WebSphere InterChange Server

WebSphere InterChange Server solutions utilize a set of adapter-integration broker patterns for integration with source and target systems. WebSphere InterChange Server is often used for integrations that synchronize enterprise systems. WebSphere InterChange Server makes extensive use of transformations and complex manipulation of data through graphical tools. The underlying concepts of these solutions can be easily replicated in WebSphere Process Server with import-export functions that support source and target systems through Web services, JMS messaging resources, WebSphere Adapters, and other access patterns. WebSphere Process Server uses transformations to deliver the mapping functions needed for synchronization.

Figure 2-20 shows a WebSphere InterChange Server solution that was implemented in WebSphere Process Server. On the left, the adapter provides the source application specific business object. Using the transformation features of WebSphere Process Server (that are conceptually based on WebSphere InterChange Server concepts), the application-specific business object is converted to a generic business object. Optionally, the generic business object can be passed into a WS-BPEL-based business process for further enhancement or action. As a final step, the generic business object can be converted back to an application specific business object for output to target systems through another adapter.

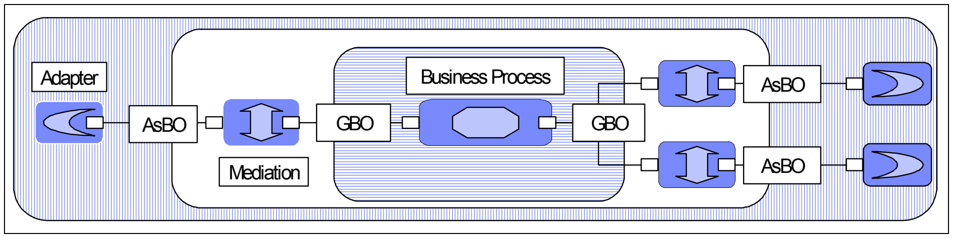


Figure 2-20 WebSphere InterChange Server scenario

WebSphere MQ Workflow

WebSphere MQ Workflow is a WebSphere MQ-based workflow solution. Many of the human-related features of the Human Task Manager are derived from WebSphere MQ Workflow. Figure 2-21 shows a simple example of a JMS export receiving a message and interacting with a process. This process can support multiple types of component interactions, including the Human Task Manager to support traditional workflow interactions. The Human Task Manager provides all the services to interact with the user and to manage that interaction. For more detail, see 2.6.3, “Human Task Manager” on page 52. After the process is complete, the output could be to another JMS location.

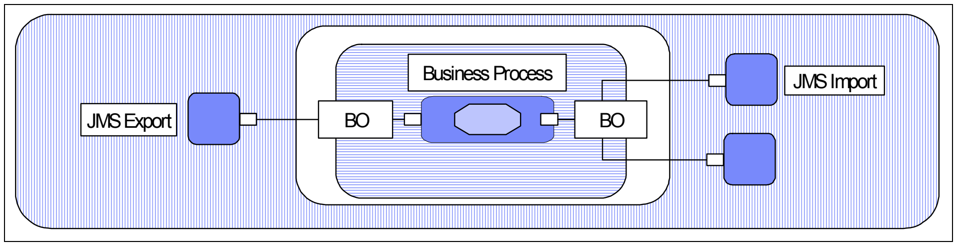


Figure 2-21 WebSphere MQ Workflow scenario

2.6 Other service implementation types

A BPEL business process is an important type of service implementation in SCA. A BPEL business process is also an important technology for composing a larger scale service by wiring together services. However, there are other types of service implementations.

2.6.1 POJO

A POJO can act as the implementation of a service. Such a service has an interface that is nothing more than a Java interface declaration. Figure 2-22 shows a simple Java interface called HelloWorld.

```
public interface HelloWorld {
   public String sendMessage(String message);
}
```

Figure 2-22 Java interface definition

A service is described in a service definition file that contains information about the services that are called, if any, and the exposed interfaces. Figure 2-23 on page 50 shows a simple service information file. The interfaces section describes the exposed interfaces, while the implementation section lists the Java class that implements this service.

```
<?xml version="1.0" encoding="UTF-8"?>
<scdl:component xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:java="http://www.ibm.com/xmlns/prod/websphere/scdl/java/6.0.0"
xmlns:ns1="http://HelloWorld/HelloWorldInterface"
xmlns:scdl="http://www.ibm.com/xmlns/prod/websphere/scdl/6.0.0"
xmlns:wsdl="http://www.ibm.com/xmlns/prod/websphere/scdl/wsdl/6.0.0"
displayName="HelloWorld" name="HelloWorld">
  <interfaces>
    <interface xsi:type="wsdl:WSDLPortType"
portType="ns1:HelloWorldInterface">
      <method name="sendMessage"/>
    </interface>
  </interfaces>
  <implementation xsi:type="java:JavaImplementation"
class="com.ibm.itso.sca.sample.HelloWorldComponent"/>
</scdl:component>
```

Figure 2-23 Service information file

Note that the interface type element in Figure 2-23 could also be:

```
<interface xsi:type=”java:JavaInterface” interface=”HelloWorldInterface”/>
```

For a POJO, you have the choice between a Java type of invocation or a WSDL type of invocation. In Chapter 3, “Developing a simple solution” on page 67, we discuss, in detail, the development of such a service.

2.6.2 Business state machine

A state machine model is a way to describe the dynamic behavior of an application or business process by focusing on the events that cause a transition from one state to another. A business state machine is an implementation of a business model that executes (that is, it moves from state to state) based on real time events. With a business state machine, you can model event-based processes easily and efficiently. States and state transitions form the basis of the process. Business logic is embedded in the transitions between two states. This means that WebSphere Process Server contains two types of business processes, BPEL and state machines.

You should use a BPEL process when:

- Steps in a process tend to happen in sequence.
- Some event handling and looping is present.

You should use a business state machine when:

- The business process is heavily event-driven.
- The reaction to these events is dependent on the process state.
- The process may revert to prior states.
- Some sequential steps are involved.

A good example of a business process that is easily modeled as a state machine is an ordering process where the buyer can cancel or modify the order at any time. The cancel or modify could become an event that can occur at any time in the state machine and that needs to be handled in the design. If an order cannot be modified or canceled again after it has been submitted, you might as well model the order processing as a generic BPEL process.

Note that at runtime, a process that is modeled as a state machine is still described as a BPEL process. The process is deployed to the same business process engine that is used for ordinary BPEL processes. The main difference between a business state machine and a BPEL process is noticeable at modeling time. One technology is better suited for a certain class of business processes than another. But at runtime, the difference is minimal.

When discussing state machines, a number of terms are often used and they have specific meaning in the context of state machines:

States	A state is one of several discrete individual stages that are organized in sequence to create a business transaction.
Composite states	A composite state is an aggregate of one or more states that can be used to decompose a complex state machine diagram into an easy to comprehend hierarchy.
Operations/events	An operation is an external prompt that attempts to trigger a movement from one state to another.
Transitions	A transition is the movement that occurs through the recognition of an appropriate triggering operation, the evaluation of the conditions necessary for execution to flow through it, and the determination of what actions can occur should execution be allowed.
Conditions	A condition guards the transition and only allows the transition to the next state if the incoming operation evaluates to *True*. Otherwise, the current state is maintained.
Actions	An action is an operation that is executed at one of three distinct locations in the business state machine: during a transition, when a state is entered, or when a state is exited.

Correlation	The state machine uses correlations to distinguish the parties in their initial interactions so that they can recognize each other in the future. A correlation is the record that is used to keep track of multiple participants in the same business transaction.

Events map to the operations that are available in the SCA component of the state machine. Business objects, primitives, or both can be used as I/O parameters. Part of the input parameter is used to correlate to a state machine instance.

A transition can be caused by a timeout. For example, a state transition can occur when a certain duration is exceeded (1 day, for example) or when the state becomes expired (for example, December 31, 2006).

If a transition has no event (operation) or timer, it is considered an automatic transition. Automatic transitions enable sequential processing. Automatic transitions in conjunction with conditions can provide default behavior.

A business state machine is an SCA component. The interfaces of such an SCA component are used to define the events of the state machine. Or, in other words, SCA operations are events in a state machine. The actions in a state machine can refer to other SCA components. Business objects can be defined and assigned to instance variables within the state machine.

2.6.3 Human Task Manager

Human interaction is key to many business integration applications. Human interaction can be required for input and initiation of a process or for review and approval of the business process. Human interaction can also be required to review and correct an error or exception situation in a process that is otherwise fully automated. This technique is sometimes called management by exception.

There are many challenges involved when you add human interaction to a process integration solution, such as:

- How to make sure that the correct people are involved
- How to add capabilities that model real-life human task management, where tasks are claimed, transferred, and completed or are overdue and need escalation
- How to make sure the human interaction provides a suitable interface without disrupting the flexibility to change the business process

The Human Task Manager provides different types of human tasks for different integration situations.

Participating Task	A service creates a work item for human interaction (for example, a service implemented in BPEL).
Originating Task	Human interaction invokes a service (for example, a business state machine).
Human Task	Human interaction invokes a service that creates a work item for another human to complete.

At runtime, human tasks are assigned to users based on mappings to a user registry, which could be an LDAP server, local operating system user registry, or a custom registry. When you model a human task, you can set a verb and a parameter that can be used to build a query to the user registry. Tasks are then created and assigned for all users in the result set of that query.

Figure 2-24 shows the link between modeling time and runtime. The attribute role of an activity is set to *Potential Owner*. The verb is set to *Group Members* and the parameter to *Approvers*. At runtime, this is used to build a *SELECT ALL* query. This query returns two users, John and Jane. John and Jane are members of the group Approvers and become potential owners of this new task.

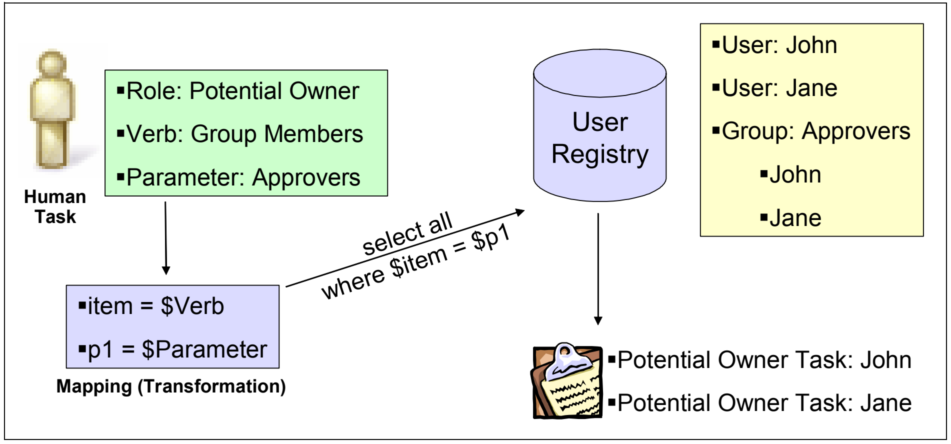


Figure 2-24 Assigning tasks to users at runtime

We can use Figure 2-25 on page 54 to review the runtime portion of assigning users to tasks. The Human Task Manager runs as a container within the application server. It is accessible through SCA or by way of specific APIs. These APIs or the client SCA interface can create a new task.

When a new task is created, the Human Task Manager retrieves information from its database to build the query. The Human Task Manager passes the query to the Staff Plug-in Provider using the Staff Service. The query is executed against the staff repository to retrieve a user or group of users. The query results are returned to the Human Task Manager. The new tasks that are created for the selected users are then stored in the database by the Human Task Manager.

Staff plug-in providers are managed as resources in the application server and are accessible through the Java Naming and Directory Interface (JNDI).

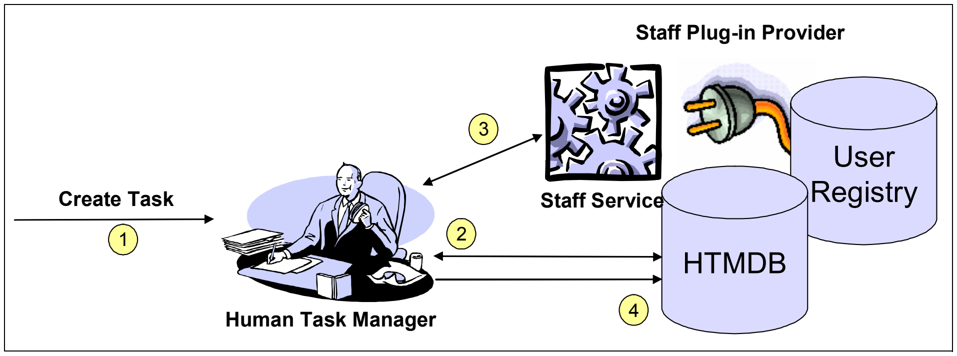


Figure 2-25 Interaction between Human Task Manager and User Registry

Human tasks themselves can be invoked as SCA components. Thus, integration with other SCA components, such as a BPEL business processes, becomes very easy (Figure 2-26). As with any SCA component, SDO provides the standard data format for passing data to and receiving data from human tasks.

A human task can also invoke SCA components and provides an invocation point for someone to invoke SCA components. At the same time, it adds escalation and notification to the invocation of any other SCA component, including non-human tasks.

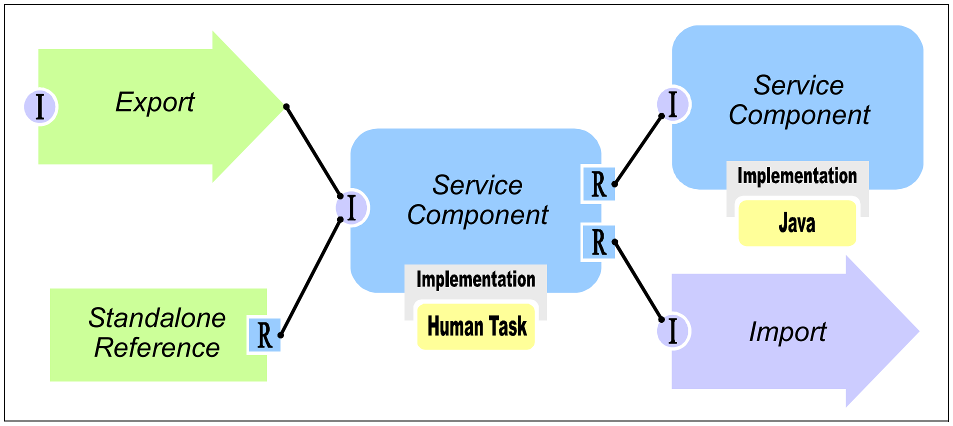


Figure 2-26 Human tasks in an SCA environment

2.6.4 Business rules

Business rule groups are a means of implementing and enforcing business policy through the externalization of business functions. Externalization allows the business rules to be managed independently from other aspects of an application. This independence provides dynamic updating capabilities to the business rules, which can result in a more agile business.

Often business analysts focus on business policy to describe guidelines that drive a business and can range from marketing heuristics, to accounting principles, to government regulations, to manufacturing standards, to supply management quality of service levels, or to any other aspect of the business that relies on specific conventions. Business rules represent a common way for implementing and enforcing these business policies.

There are two styles of business rules:

- If-then rule set
- Decision table

Business rules are invoked through a business rule group component. A business rule group component provides the interface for the business rule. Each operation defines a business need and not a specific rule implementation.

Business rules, by their nature, change over time to support, for example, changing business policy or changing government regulations. The ability to schedule rules to be in effect during specific time periods provides the flexibility for an organization to respond to changes. With the integrated effective dates, the operation can be implemented with more than one business rule with each implementation, which is effective for a specified period of time. Effective dates allow a client application to invoke the business rule group component as though it were a time in the past, present, or future.

WebSphere Integration Developer (for the developer) and a Web-based business rules manager to support rule management for runtime changes both support Business rule authoring. The business rule group component includes support for deploying, installing, dynamically authoring, and executing the business rules. Updated business rules can be exported from the runtime and re-imported into the development tool.

Business rules are invoked through a business rule group component, never directly. The business rule group component can be invoked as an SCA service. The client application does not have to be concerned with the type of implementation or which implementation is used to process the request. The client application simply interfaces with the SCA component type to meet a desired business need. This construct allows business rules to be encapsulated and invoked as a service from other consumers.

The business rule group component is the artifact used to interface and invoke rules. As mentioned previously, rule sets and decision tables (representing the two forms of business rules that are supported in WebSphere Process Server) are never invoked directly. The rule group component provides a means for the user to form logical groupings of the business rules. The integrated effective dates allow the user to build one interface (component) for their logical rule group and associate one-to-many implementations of a business rule with each operation on the component as shown in Figure 2-27.

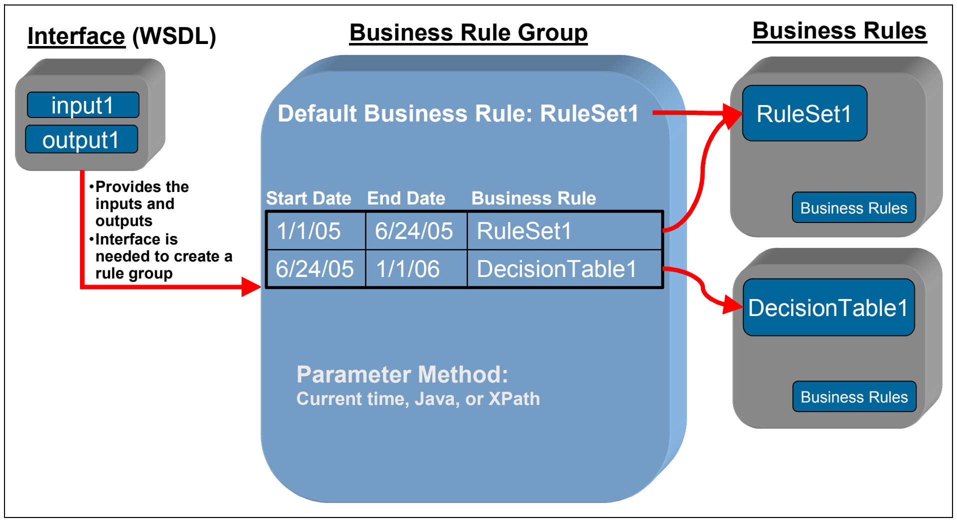


Figure 2-27 Business rule group as an SCA component

A rule set is a set of one or more if-then condition/action statements that are evaluated sequentially. Therefore, the first business rule listed is going to be the first one evaluated when called upon at runtime. The second is evaluated second, the third is third, and so forth until the last one is evaluated.

Rule sets hold any number of action/if-then conditions. To explain further, an action does not have an if-then condition; it simply initializes or sets variables. The if-then condition does all the decision work for a variable change. A rule set can evaluate multiple conditions and can fire multiple rules. This might be necessary when a rule is found true and fired, but more processing must be done to fire any other business rules in that rule set.

A decision table represents a multi-dimensional nested if-then structure. Think of it as a rule set that can handle more complex decisions than a simple if-then. The decision table is broken down into a tree decision structure, a set of “if” conditions with “then” actions that are defined at the intersection points of the table. Conditions are evaluated in a nested order (tree view). The decision table evaluates one or more conditions, but fires only one rule. Most rules fall under a decision tree because most business rules are called to fire one rule.

Use decision tables when:

- You have rules with multiple clauses/variables in the conditional statements.
- You want to fire only one rule.

Use rule sets when:

- You have rules with a few clauses/variables in the conditional statements.
- You want to fire multiple rules.

Templates provide the mechanism for supporting Web-based rule authoring at runtime. The templates provide a constrained method for a business analyst to author rules in real time in the application server. If a rule, condition case, or action is not characterized as a rule template, then the business rule cannot be exposed with the Web tools for rule authoring.

Templates allow application developers to:

- Control which aspects (conditions/actions) of a business rule can be modified by the Web user
- Define constraints (that is, valid discount range, customer status, gold/silver/bronze, and so on)
- Define the structure of an if-then rule and then create instances of this template
- Define the structure of a condition case, action, or both for a decision table
- Define a natural language string that is used in the Web-based tool for presenting the rule to the business analyst

Templates are applicable to both if-then rule set and decision table business rules.

Business rules are also important for supporting Business Process Management (BPM) because they help businesses of any size proactively change processes for future events or speed response to changing customer demand. Big businesses with a great deal of processes can move slowly when responding to customer demand changes. With business rules, processes can be changed in minutes so that the big business can turn the ship around quicker. Small businesses must be able to scale and grow fast, to add processes as needed, and change them fast. This is where business rules shine.

Businesses of all sizes are realizing how important IT flexibility and efficiency is. Business rules help keep IT flexible because developers are freed from tasks that a more business experienced person can do. In other words, a developer does not have to be bothered every time a simple rule needs to be changed. A business analyst who is more in tune to business needs can make that change swiftly. Another attribute of business rules that improve IT efficiency is the ability to have multiple processes call a business rule at the same time. This multi-threading allows multiple processes to run at the same time.

The developer and business analyst roles are separated by the red line shown in the middle of Figure 2-28. The more technical skills are assigned to the developer role. The developer uses WebSphere Integration Developer to create or manage the technical details of the business rules. The developer role works with the architect to implement the business process plan.

On the other side, there is the business analyst role. This person is more in tune with changing business needs. They use the business rule manager Web tool to change the business rules when necessary. The business analyst also works with the developer to update and create new business rules for the company.

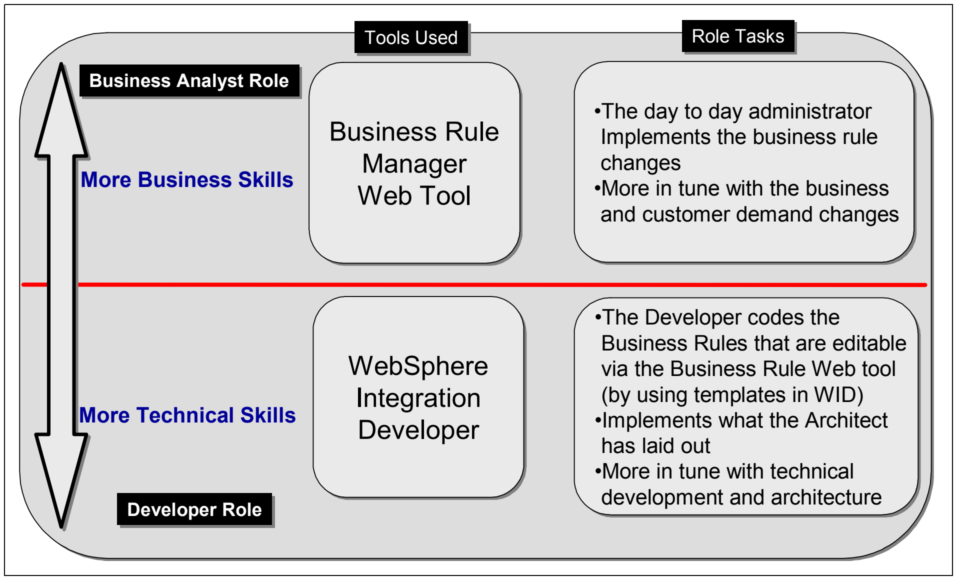
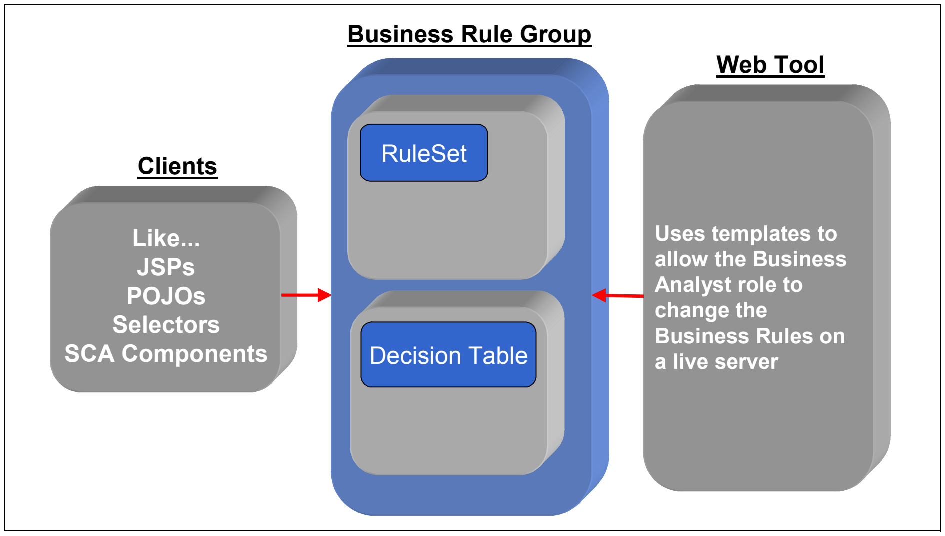

Tools Used
Role Tasks
Business Analyst Role
More Business Skills
Business Rule Manager Web Tool
•The day to day administrator Implements the business rule changes
•More in tune with the business and customer demand changes
More Technical Skills
WebSphere Integration Developer
•The Developer codes the Business Rules that are editable via the Business Rule Web tool (by using templates in WID)
•Implements what the Architect has laid out
•More in tune with technical development and architecture
Developer Role

Figure 2-28 Roles and tools when manipulating business rules

When a business rule is part of a running business process application, clients access a business rule group to find which implementation to use and to fire one to many business rules. These clients could be non-SCA components (called stand-alone references) like JSPs or other SCA components like POJOs, selectors, BPEL, or other business rules. While the business process is deployed, you can use a Web tool that is part of WebSphere Process Server to edit business rules that are created as templates.



Business Rule Group
Web Tool
Clients
Like...
JSPs
POJOs
Selectors
SCA Components
RuleSet
Decision Table
Uses templates to allow the Business Analyst role to change the Business Rules on a live server

Figure 2-29 Clients of a business rule group

2.7 Supporting services

Supporting services provide the transformation primitives for the WebSphere Process Server service components. This layer provides a common mapping and transformation service. The mapping of interface signatures is done through the interface map, and correlation and synchronization of key relationship interfaces between systems are accomplished with the relationship service. The selector component provides for dynamic component and target invocation with flexible administration control at runtime.

2.7.1 Interface maps

Flexible and scalable business integration and SOA-based solutions often require support for different types of transformations. WebSphere Process Server delivers flexible and powerful transformation capabilities through its interface map functions. The transformation capabilities in WebSphere Process Server can be used in different combinations to meet the transformation requirements of problem domains.

Interface maps can be applied to business objects or to events or requests (interfaces) that are associated with business objects. An interface map is an SCA component that is logically separate from the source and target components. Figure 2-30 on page 60 shows the high level view of the relationship between maps, imports/exports, and the business process.

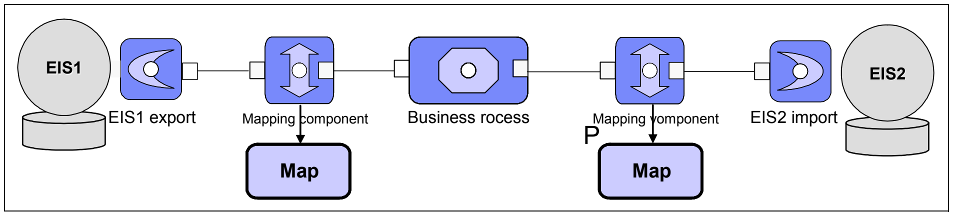


Figure 2-30 Role of mapping components in a WebSphere Process Server flow

Interface maps provide operation binding and parameter transformation between components. The data map provides the structural and semantic transformation of business objects. The relationship manager provides identity relationship maintenance and tracking and relationship lookup in custom transformations. Finally, the selector component supports dynamic determination of the target implementation or destination.

These technologies help developers connect components. For example, adapters produce events that have specific signatures (operation names and parameters). These events can be converted into different formats for downstream components in the overall solution.

2.7.2 Interface map: Bridging incompatible interfaces

The interface map component provides resolution and reconciliation of differences between interfaces found between SCA components. A map can be created that understands one interface (cancelOrder) and invokes another interface (updateOrderStatus) as shown in Figure 2-31. The interfaces can additionally map the data on these interface calls through a data map.

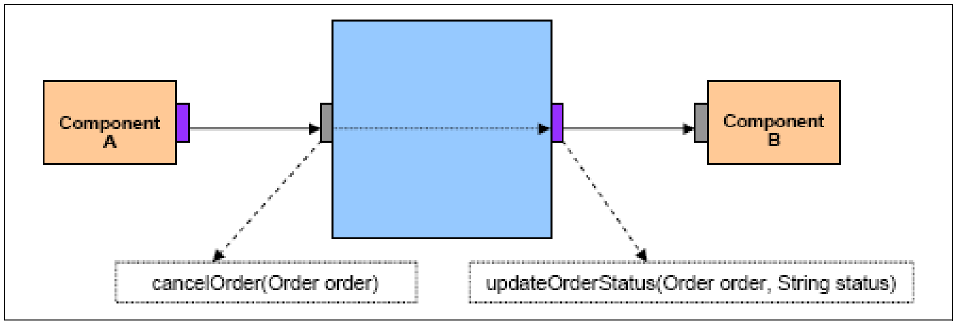


Figure 2-31 Interface mediation component

2.7.3 Data maps

WebSphere Integration Developer contains a rich graphical mapping tool that offers move, join, extract, and assign functionality for data fields and custom mapping (through custom activities or Java code). It also offers sub-maps for complex business object structures and relationship mapping.

In Figure 2-32, an adapter interacts with a back-end enterprise information system (for example, SAP) to create, read, update, or delete events of application specific business objects (for example, SAPCustomer and SAPOrder). The adapter publishes these events to a set of business processes that are modeled using generic business objects (for example, Customer and Order) for further processing. In this case, the data map, which is called from within the interface map, allows the request to be transformed into a canonical, or generic, format (generic business object) from an application specific format (application specific business object). The result of this built-in functionality is the transformation of the operation name (interface map) and the content and structure of the parameters that are being passed as part of the operation (data map).

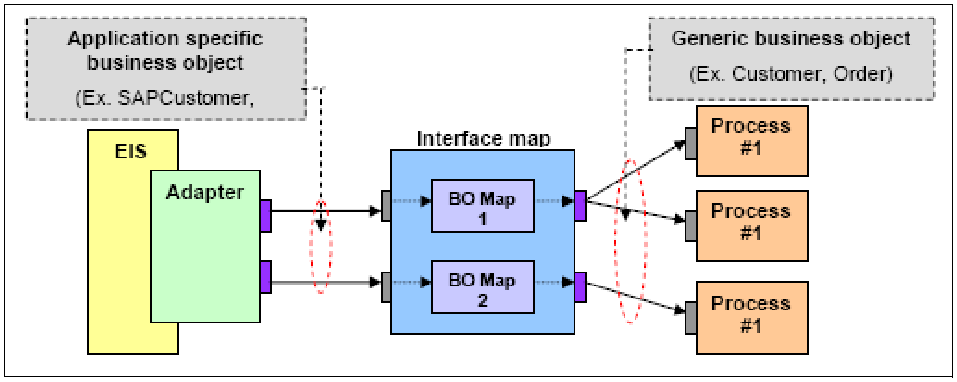


Figure 2-32 Data maps used by an interface map

2.7.4 Relationships

In business integration scenarios, accessing the same data (for example, customer records) in various back-end systems is often a requirement. A common problem for keeping data in sync is that different back-end systems use different keys to represent the same data. The relationship service in WebSphere Process Server is used to relate these disparate data sources. As a business object is converted from one application specific representation into another, WebSphere Process Server can dynamically maintain a database of keys, which enables the mapping of one data record into another between disparate back-end systems.

Figure 2-33 shows the concept of a dynamic identity relationship with a customer identifier being maintained in four different applications. These four systems use different identifiers and store customer information in a different format or object model. A typical integration requirement is to propagate new or changed records in all four systems. In conventional middleware solutions, this is an extremely difficult solution to develop and, more importantly, to manage continuously. WebSphere Process Server automates this activity through a set of capabilities that provide an integrated framework for managing dynamic relationships.

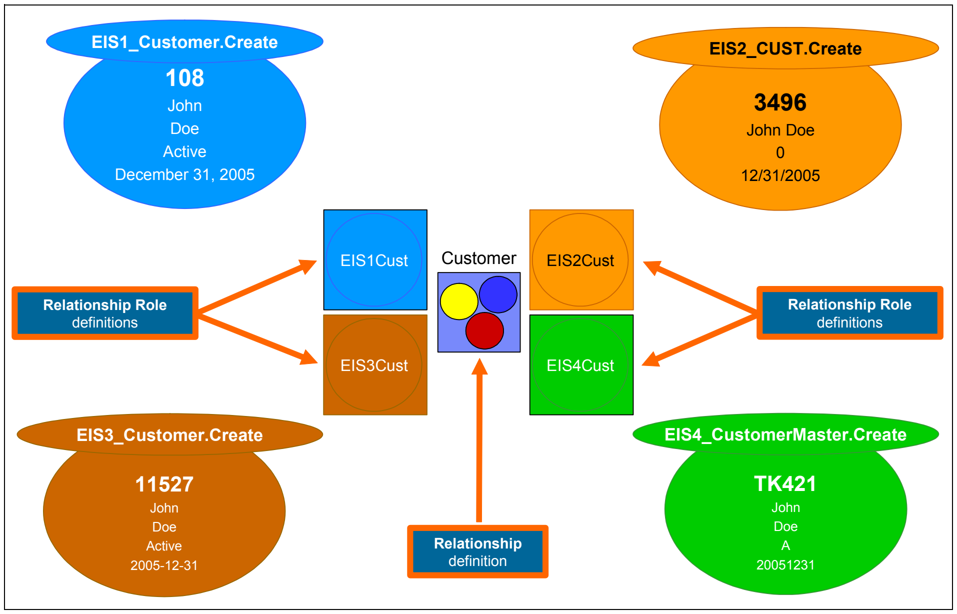
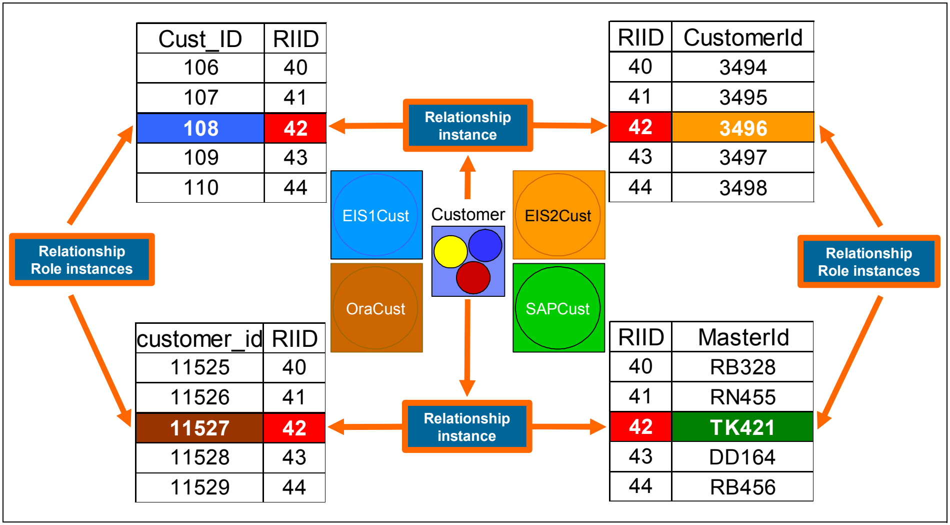


Figure 2-33 Multiple sources of customer record information

Figure 2-34 on page 63 shows us how WebSphere Process Server maintains information about each application. Basically, a new identifier is created for each customer and that identifier refers to the specific identifiers in each application. Thus, when information is received from the application that is carrying identifier 108, then that identifier is replaced with the generic identifier 42 during processing in WebSphere Process Server. When the business object is sent to one or more target applications, the generic identifier 42 is replaced with the appropriate identifier for that system, for example 3496 in the second application.



Cust_ID	RIID
106	40
107	41
108	42
109	43
110	44

RIID	CustomerId
40	3494
41	3495
42	3496
43	3497
44	3498

customer_id	RIID
11525	40
11526	41
11527	42
11528	43
11529	44

RIID	MasterId
40	RB328
41	RN455
42	TK421
43	DD164
44	RB456

Figure 2-34 Relationship instances linking multiple customer identifiers

Creating and maintaining these links between identifiers is completely automatic in WebSphere Process Server. Relationships are available directly from business object maps and simplify the management of disparate back-end data representations.

Consider the example shown in Figure 2-35 on page 64. A new customer is created in EIS1. This is an application event that is delivered to the integration solution. The business object that holds the new customer record contains the new identifier and the verb *Create*. Within the context of event delivery, the mediation component is called to transform the EIS1 specific business object to a generic object. The map then uses the services of the relationship manager. Given the context of event delivery and the verb, the relationship manager creates a new relationship instance and generates a new relational identifier. In other words, a new record is added to the relationship tables that link EIS1 customer 108 to generic customer 42.

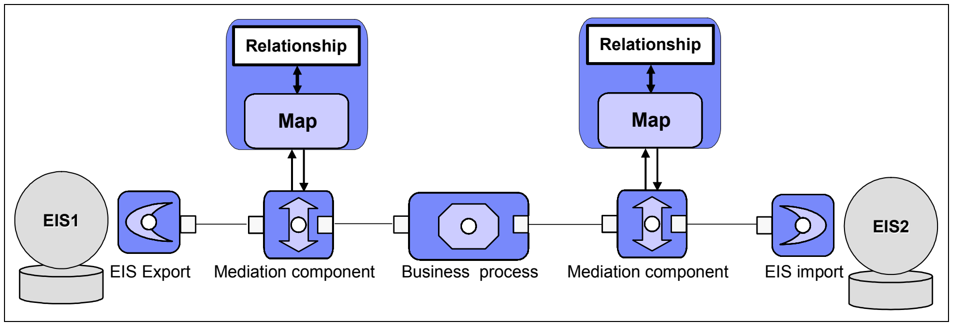


Figure 2-35 Relationship invoked during the execution of a map

After the business process is executed, the generic business object is transformed to the business object specific for EIS2. The creation of a new customer record in EIS1 should trigger the creation of a new customer record in EIS2. A service call request is issued to achieve this. Upon return, a new identifier for this customer record in EIS2 is passed back to the business process. The new customer record for EIS2 is mapped back to the generic object and during the mapping, in the context of the service call response, the relationship manager creates a new relationship instance to link the generic identifier to the newly created identifier for EIS2. That is, identifier 3496 is linked to the generic customer identifier 42. A similar process takes place when an event is passed to the business process for updated or deleted customer records.

Similarly, the relationship service could be called from a data map to perform a lookup of a value or other static information. In addition to dynamic identity relationship management, WebSphere Process Server also supports lookup, or static, relationships. This feature can be used to define static lookup tables where one entry always represents another entry and this relationship never changes (for example: LT = liter, KM = kilometer, and so forth).

Both dynamic and static relationships are created using the relationship editor in WebSphere Integration Developer. Relationships are stored in a database and are maintained automatically or administered through the relationship manager.

2.7.5 Selectors

The selector component provides a dynamic selection mechanism for invoking components at runtime. The objective of the selector component is to:

- Determine dynamically which implementation of a target destination to invoke based on some defined set of criteria, data, and logic (currently the selector component only supports selection based on date and time).

- Decouple the client application from a specific target destination implementation allowing for dynamic selection and invocation of a target destination.
- Allow new implementations of target destinations to be added to the system without requiring changes to the client application.
- Allow new SCA implementations of a target destination to be added to the selector component dynamically through a Web interface without requiring a restart of the application or server.

A selector is an SCA component itself and therefore has an interface as well (Figure 2-36). Note that the interface of the selector is the same as all the interfaces of the target components.

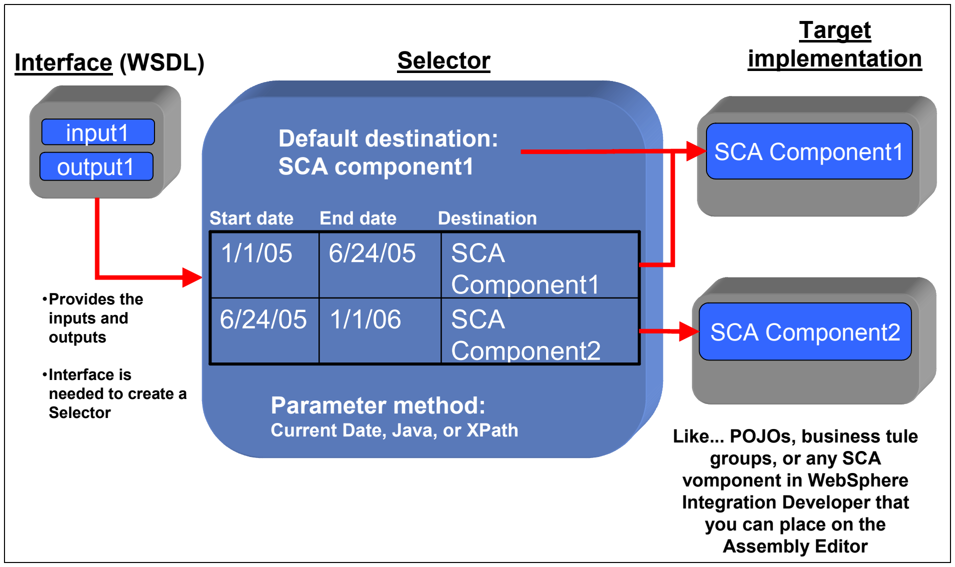
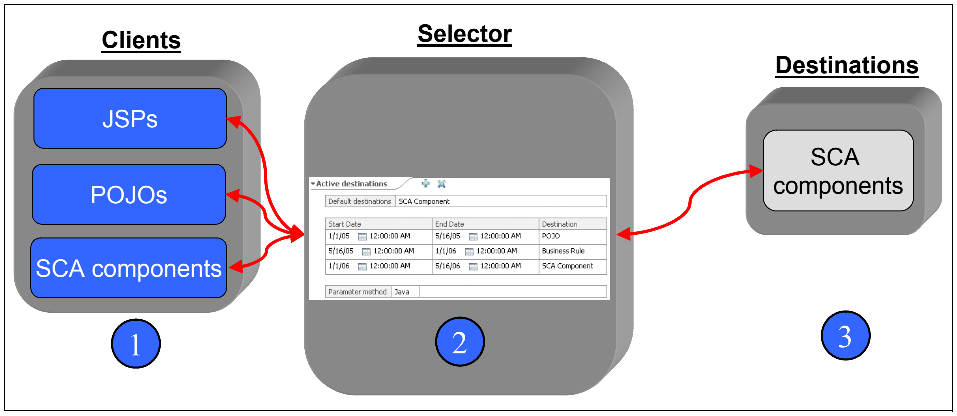

Interface (WSDL)
Selector
Target implementation
input1
output1
Default destination: SCA component1
Start date
End date
Destination
1/1/05
6/24/05
SCA Component1
6/24/05
1/1/06
SCA Component2
Parameter method:
Current Date, Java, or XPath
SCA Component1
SCA Component2
•Provides the inputs and outputs
•Interface is needed to create a Selector
Like... POJOs, business tule groups, or any SCA vomponent in WebSphere Integration Developer that you can place on the Assembly Editor

Figure 2-36 How selectors work

Figure 2-37 on page 66 illustrates the design of the selector component.



Active destinations

Default destinations	SCA Component

Start Date	End Date	Destination
1/1/05 12:00:00 AM	5/16/05 12:00:00 AM	POJO
5/16/05 12:00:00 AM	1/1/06 12:00:00 AM	Business Rule
1/1/06 12:00:00 AM	5/16/06 12:00:00 AM	SCA Component

Parameter method	Java

Figure 2-37 Participants of a selector

The selector component design involves three participants:

- Client: The client component makes a call to the selector component. A client can be anything that can access an SCA component.
- Selector: The selector component is a generated SCA component where each operation reflects a business need or task and the target destinations provide the implementation. The selector component chooses which target destination to invoke using a declared selection implementation.
- Destination: The selector component can choose any SCA target destination type. The destinations for each operation on the selector component are associated with the specific selector component.

3

Developing a simple solution

In Chapter 2, “Building blocks of WebSphere Process Server” on page 23, we introduced some of the major concepts and terminology that you need to be familiar with when starting to build a process integration solution. In this chapter, we go a little further and build a simple example to reinforce these concepts.

As with all good IT-related beginnings, we start with a classic Hello World application. In our example, we show how to use WebSphere Integration Developer to create a very simple application that is built upon SCA.

3.1 Getting started

The Hello World application in this example consists of a single service component that is associated with a simple WSDL interface definition. This definition includes a sendMessage operation. The service component in the application uses a Java implementation (POJO) to provide the sendMessage functionality.

Once the simple service component is built, we define a stand-alone reference that enables the HelloWorld service to be invoked by a service client (such as a JSP) using the SCA client programming model.

Figure 3-1 shows the Service Component Architecture module that is built in this example.

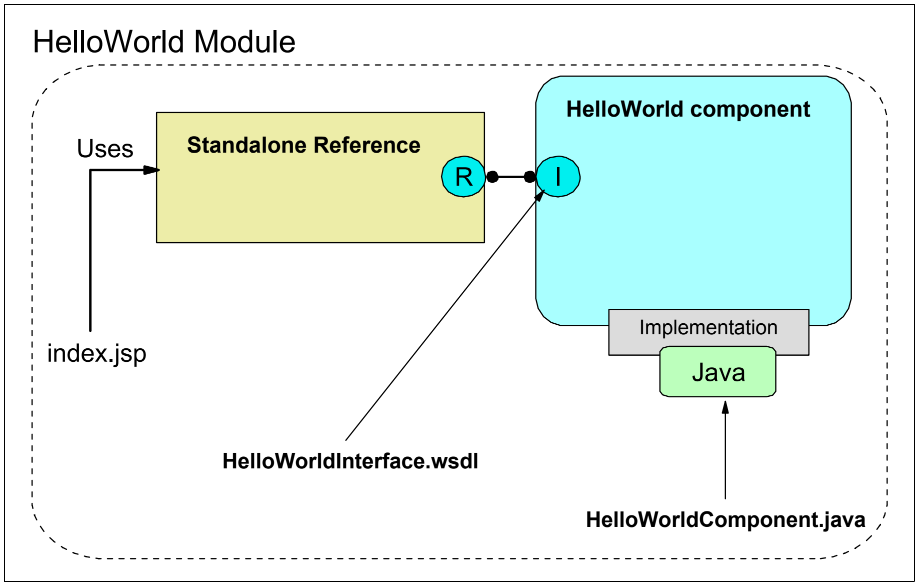


Figure 3-1 HelloWorld module

Our example consists of the following steps:

1. Set up the development and test environment.
2. Create a new business integration module.
3. Use the interface editor to define a simple WSDL interface.
4. Use the assembly editor to:
   - Define a simple service component with a single WSDL port type interface and a Java implementation.

   - Define a stand-alone reference to the simple service component.
   - Assemble a service module.
5. Use the SCA client programming model to invoke the service component from within a service client.
6. Test the service component invocation from:
   - A client JSP
   - The test framework

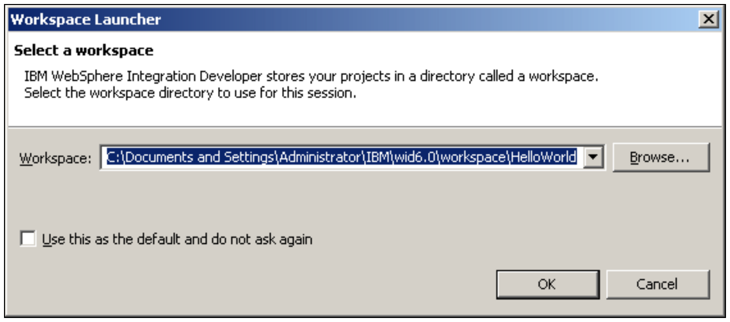
3.2 Setting up the development and test environment

The first thing to do before starting to build the solution is to start WebSphere Integration Developer and set up the environment to allow the WebSphere Process Server to be used as the WebSphere Test Environment.

1. Start the WebSphere Integration Developer by selecting:

   Start → **Programs** → **IBM WebSphere** → **Integration Developer V6.0** → **WebSphere Integration Developer V6.0**
2. When prompted, enter a location for your workspace (for example, HelloWorld) as shown in Figure 3-2. Or, you can accept the default location.

Tip: You can select **Use this as the default and do not ask again** (see Figure 3-2). Once this option is selected, you can still use other workspaces by selecting **File** → **Switch Workspace**.


Workspace Launcher

Select a workspace

IBM WebSphere Integration Developer stores your projects in a directory called a workspace.
Select the workspace directory to use for this session.

Workspace: C:\Documents and Settings\Administrator\IBM\wid6.0\workspace\HelloWorld

Figure 3-2 Workspace launcher

3. The Welcome page (Figure 3-3 on page 70) opens. You can close this tab in the window by clicking the cross icon.

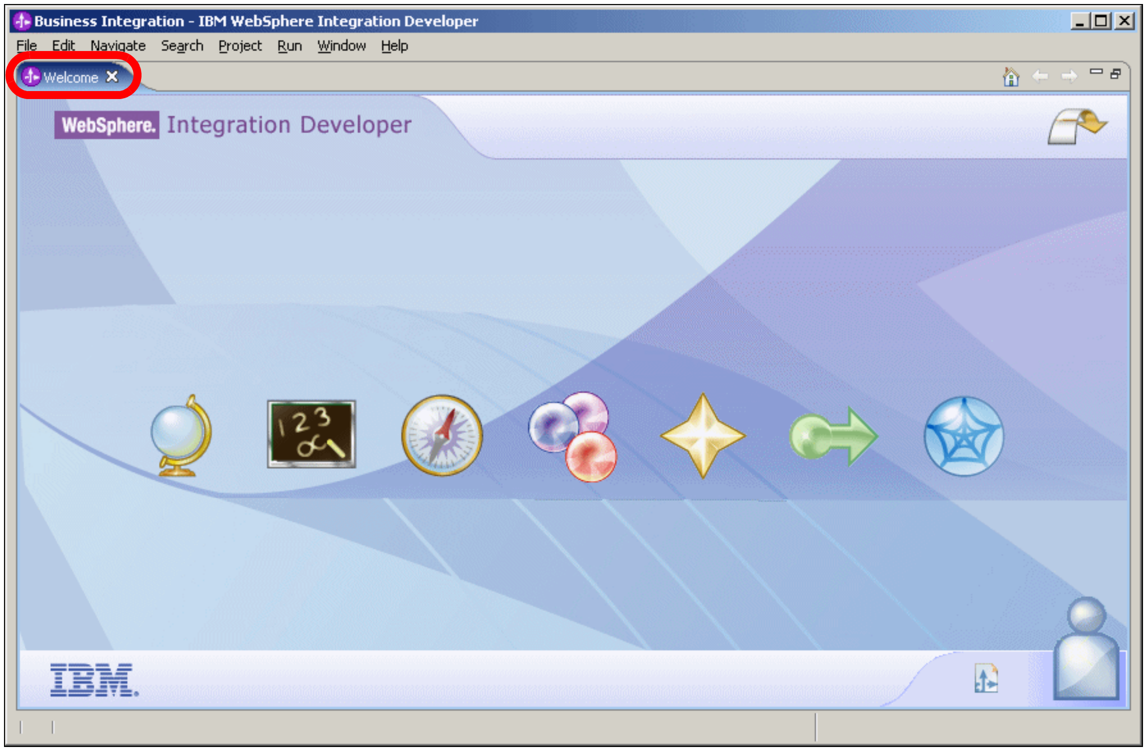
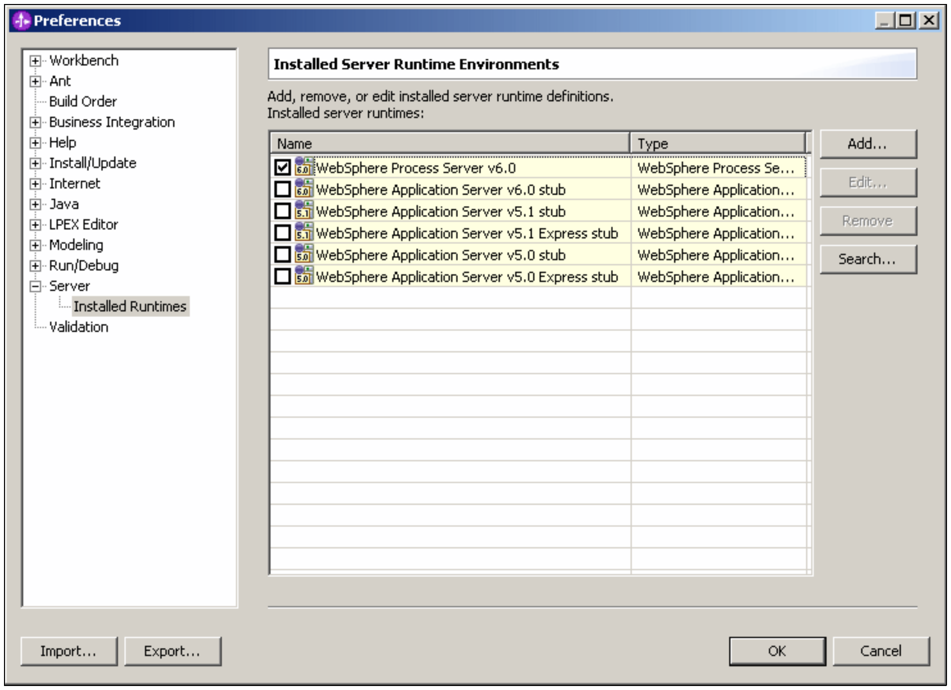

Business Integration - IBM WebSphere Integration Developer
File Edit Navigate Search Project Run Window Help
Welcome
WebSphere. Integration Developer
IBM.

Figure 3-3 Welcome page

4. Select the WebSphere Process Server V6.0 runtime as your target test server as follows:
   a. Select **Window** → **Preferences**
   b. Expand Server (in the left pane) and expand the list of installed runtimes.
   c. Select **WebSphere Process Server v6.0** as shown in Figure 3-4 on page 71.
   d. Click **OK**.



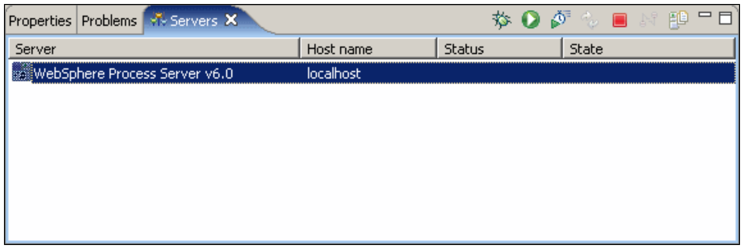
Installed Server Runtime Environments

Add, remove, or edit installed server runtime definitions.
Installed server runtimes:

	Name	Type
✓	WebSphere Process Server v6.0	WebSphere Process Se...
	WebSphere Application Server v6.0 stub	WebSphere Application...
	WebSphere Application Server v5.1 stub	WebSphere Application...
	WebSphere Application Server v5.1 Express stub	WebSphere Application...
	WebSphere Application Server v5.0 stub	WebSphere Application...
	WebSphere Application Server v5.0 Express stub	WebSphere Application...

Figure 3-4 Installed runtimes

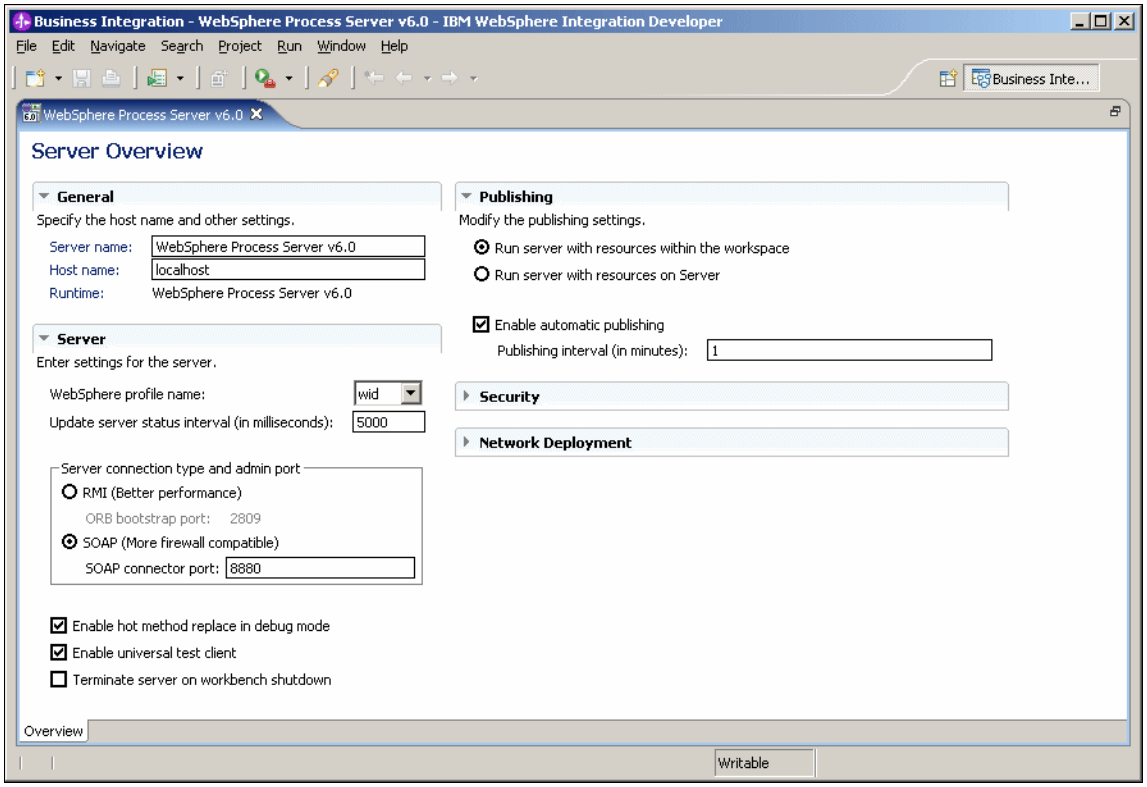
5. If it is not already open, open the Business Integration perspective. Select **Window** → **Open Perspective** → **Business Integration**.
6. Select the Servers tab in the pane at the bottom and to the right.



Server	Host name	Status	State
WebSphere Process Server v6.0	localhost		

Figure 3-5 Servers view

7. Double-click the server name to open the configuration editor.
8. In the Server setting, select **SOAP** as the Server connection type and admin port.
9. In the Publishing section, select **Run server with resources within the workspace.**


Business Integration - WebSphere Process Server v6.0 - IBM WebSphere Integration Developer
File Edit Navigate Search Project Run Window Help
Business Inte...
WebSphere Process Server v6.0

Server Overview

General
Specify the host name and other settings.
Server name: WebSphere Process Server v6.0
Host name: localhost
Runtime: WebSphere Process Server v6.0

Server
Enter settings for the server.
WebSphere profile name: wid
Update server status interval (in milliseconds): 5000

Server connection type and admin port
○ RMI (Better performance)
ORB bootstrap port: 2809
● SOAP (More firewall compatible)
SOAP connector port: 8880

[✓] Enable hot method replace in debug mode
[✓] Enable universal test client
[ ] Terminate server on workbench shutdown

Publishing
Modify the publishing settings.
● Run server with resources within the workspace
○ Run server with resources on Server

[✓] Enable automatic publishing
Publishing interval (in minutes): 1

Security

Network Deployment

Figure 3-6 Using the server configuration editor

10. Save these settings and close the configuration editor.

Tip: You can maximize the editor by double-clicking the title of the tab. To return to the previous size, double-click the title of the tab once more.

3.3 Creating a new business integration module

You are now ready to start building your HelloWorld module. The fundamental project type for building SCA applications is called a *module*. To begin building the Hello World application, create a new module called HelloWorld as follows:

1. Select **File** → **New** → **Other**.
2. Select **Module** as shown in Figure 3-8 on page 74.
3. Click **Next**.

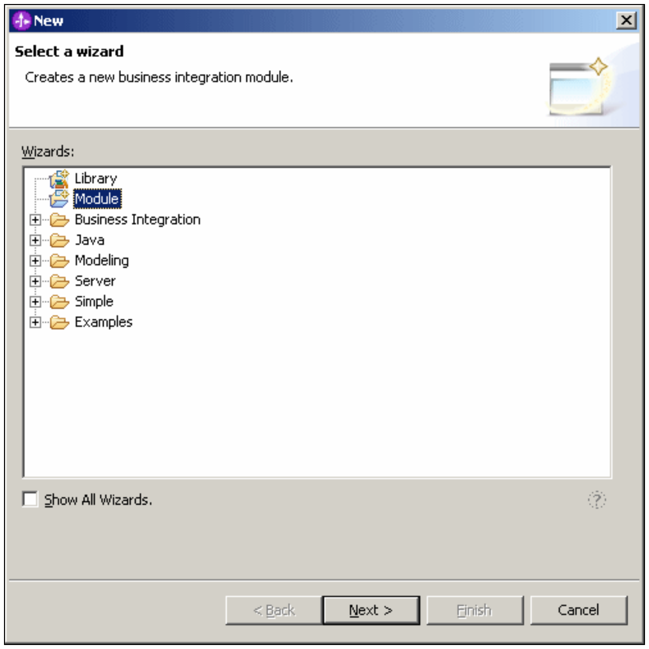
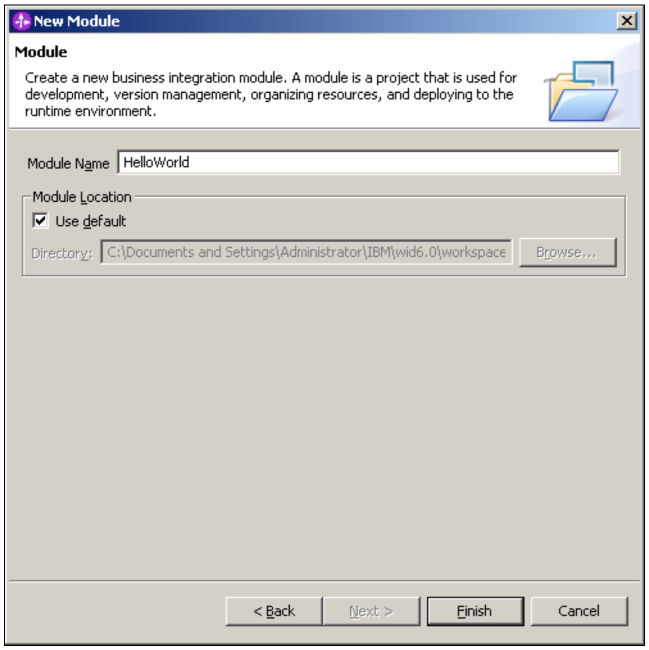


Figure 3-7 Wizard

4. Enter *HelloWorld* for the module name (see Figure 3-8 on page 74) and click **Finish**.



New Module

Module

Create a new business integration module. A module is a project that is used for development, version management, organizing resources, and deploying to the runtime environment.

Module Name: HelloWorld

Module Location

☑ Use default

Directory: C:\Documents and Settings\Administrator\IBM\wid6.0\workspace

Figure 3-8 New module

Note: As you can see in Figure 3-8, we used the default location.

5. Expand the HelloWorld module.

Figure 3-9 on page 75 shows the structure of the module and how artifacts are organized. The structure maps to the building blocks of WebSphere Process Server that we discussed in Chapter 2, “Building blocks of WebSphere Process Server” on page 23.

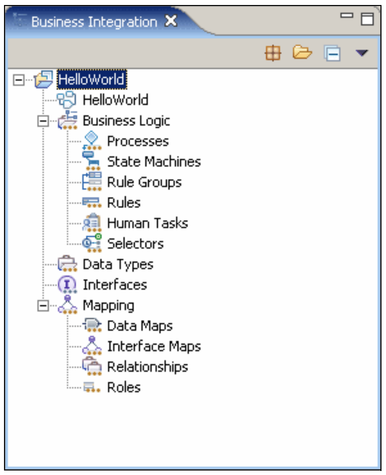
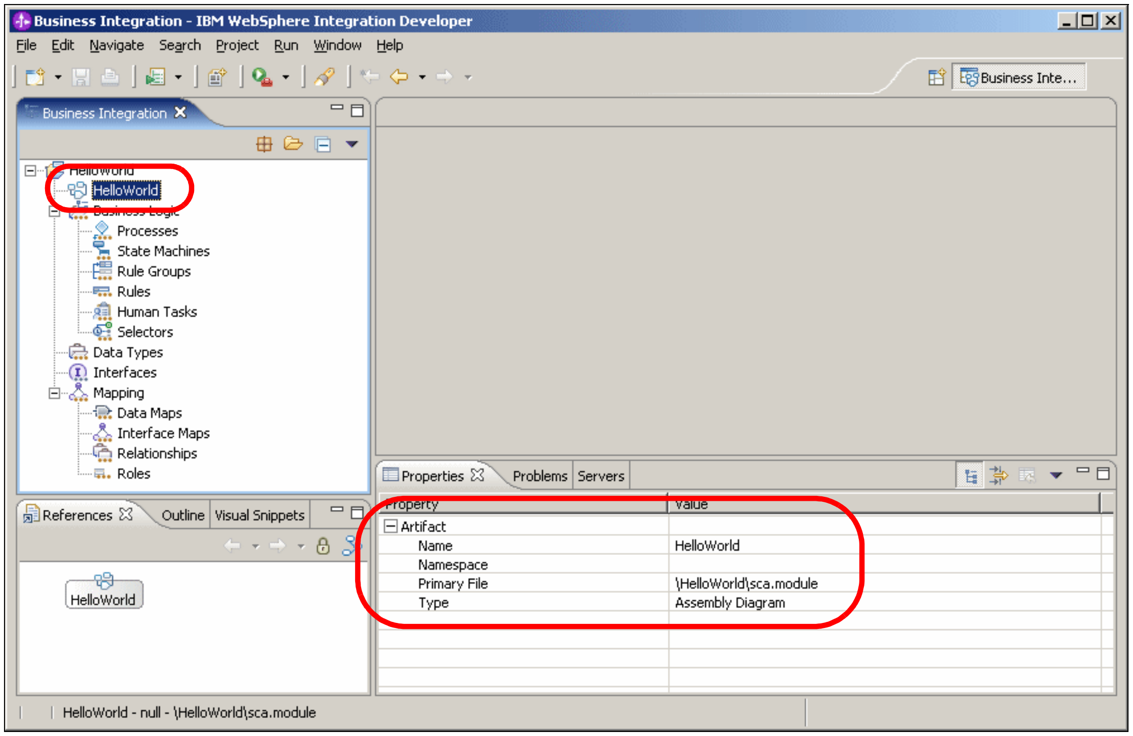


Figure 3-9 HelloWorld module

All artifacts belong to a certain category and are stored in their respective folders.

As shown in Figure 3-10 on page 76, at the top of the tree and below the module name, you have access to the assembly diagram for this module. In the assembly diagram, you can connect the different components together into a single SCA module called HelloWorld.



Property	Value
Artifact	
Name	HelloWorld
Namespace	
Primary File	\HelloWorld\sca.module
Type	Assembly Diagram

Figure 3-10 Properties of the assembly diagram

Components within the workspace are built automatically whenever a resource is edited. While this feature is handy for detecting errors quickly, it is often easier to take control of when a module or project is built or rebuilt yourself. To turn this option off or on, select **Project** → **Build Automatically**.

3.4 Using the interface editor to define a WSDL interface

The SCA component in this application is specified by a WSDL interface called HelloWorldInterface. To create such an interface, follow these steps:

1. In the expanded HelloWorld module, right-click **Interfaces** and select **New** → **Interface** as shown in Figure 3-11 on page 77.

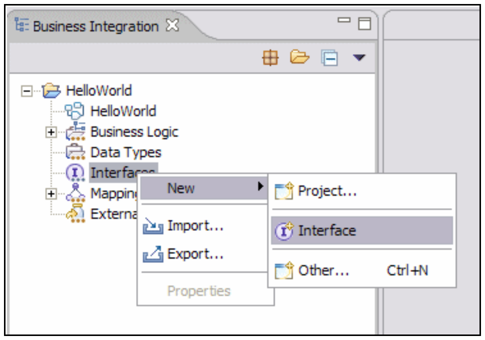
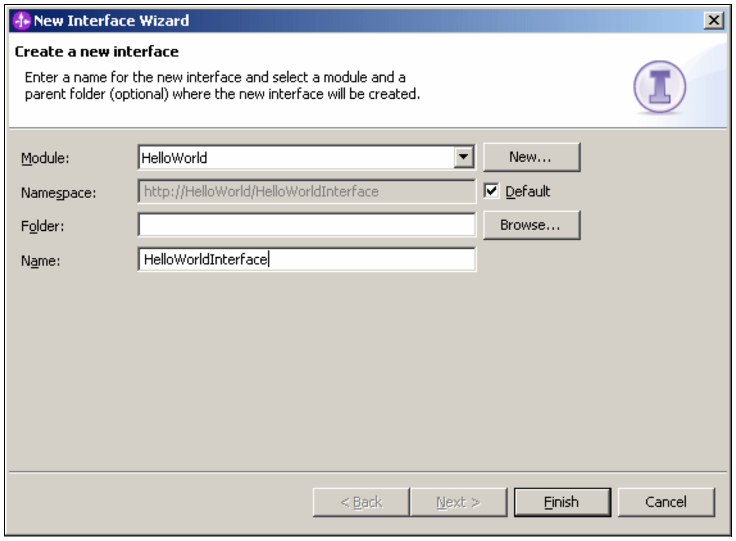


Figure 3-11 New interface

2. This starts the New Interface Wizard (Figure 3-12). Enter *HelloWorldInterface* for the name and verify that the selected module is HelloWorld.
3. Click **Finish**.


New Interface Wizard

Create a new interface

Enter a name for the new interface and select a module and a parent folder (optional) where the new interface will be created.

Module: HelloWorld

Namespace: http://HelloWorld/HelloWorldInterface [✓ Default]

Folder:

Name: HelloWorldInterface

Figure 3-12 New interface wizard

The HelloWorldInterface has a single operation called sendMessage that takes a string (message) as input and returns a string (status) as output.

4. After you use the wizard to create the new interface, the WSDL editor opens. Click the Add Request Response Operation icon in the WSDL editor as shown in Figure 3-13 on page 78.

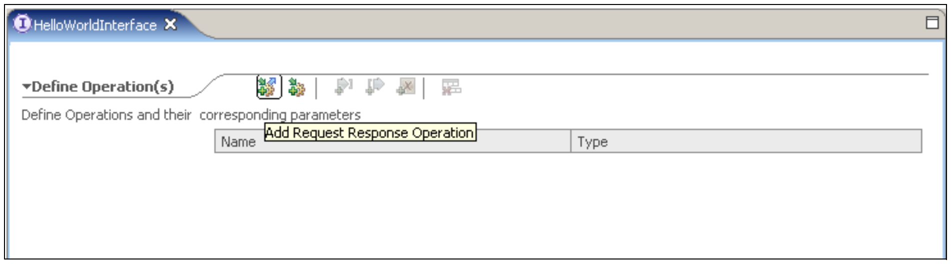

HelloWorldInterface
Define Operation(s)
Define Operations and their corresponding parameters
Add Request Response Operation
Name
Type

Figure 3-13 Add Request Response Operation action button

5. Change the operation name to *sendMessage* as shown in Figure 3-14.

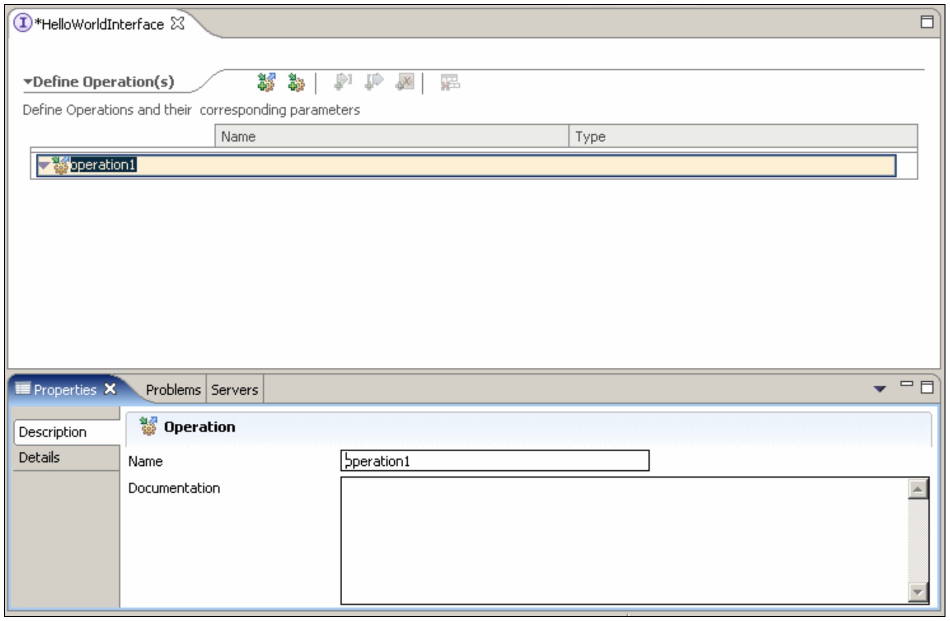
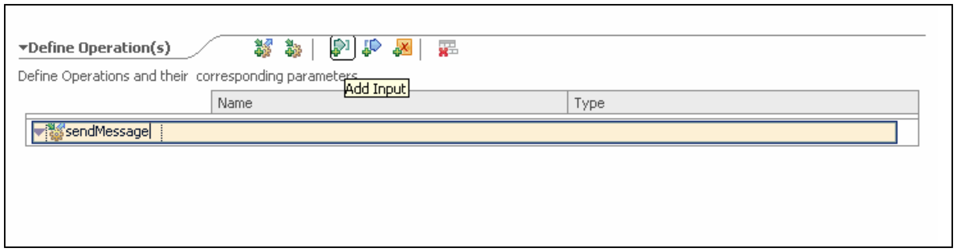


Figure 3-14 New operation

Note: The name of the operation can be changed from either the properties view or in the interface editor (see Figure 3-14).

6. Click the Add Input icon (Figure 3-15 on page 79).

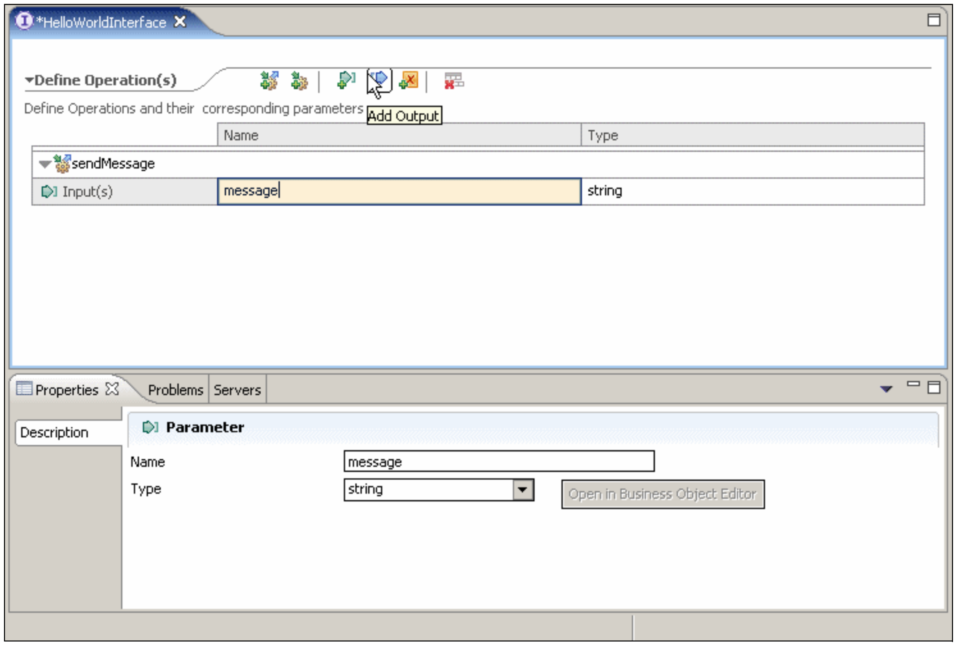


Define Operations and their corresponding parameters

Name	Type
sendMessage	

Figure 3-15 Add input

7. Change the input1 name to *message* and accept *string* as the type for the input parameter.



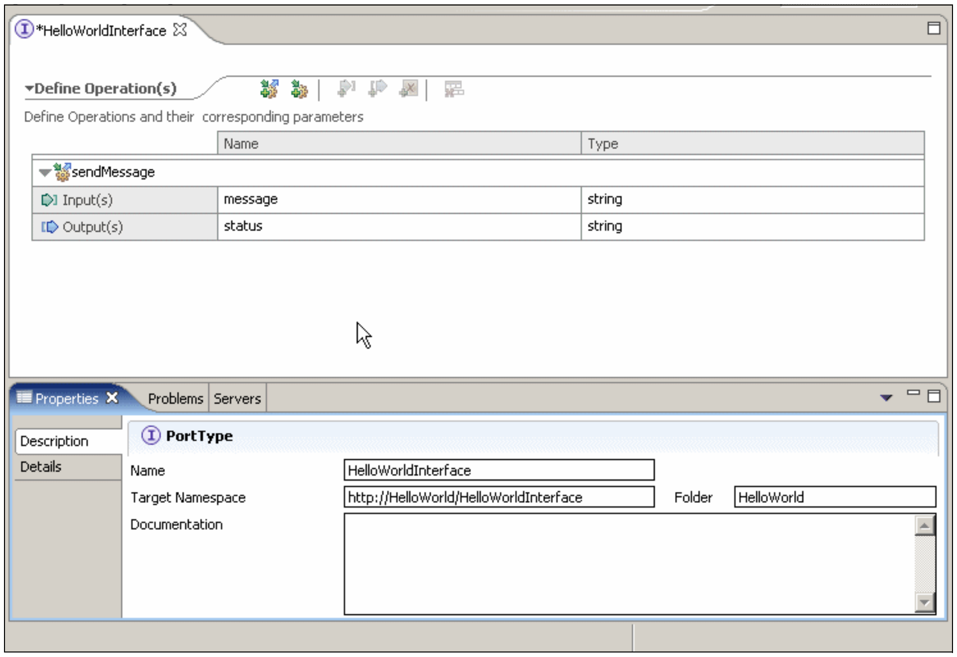
Define Operations and their corresponding parameters

	Name	Type
sendMessage		
Input(s)	message	string

Name: message
Type: string

Figure 3-16 Renamed input parameter

8. Click the Add Output icon.
9. Change the output1 name to *status* and accept *string* as the type for the output parameter. The resulting interface is shown Figure 3-17 on page 80.



Define Operations and their corresponding parameters

	Name	Type
sendMessage		
Input(s)	message	string
Output(s)	status	string

Name	HelloWorldInterface		
Target Namespace	http://HelloWorld/HelloWorldInterface	Folder	HelloWorld
Documentation			

Figure 3-17 Completed interface

10. Save and close the WSDL file.

3.5 Using the assembly editor

The assembly editor is the primary tool for composing an SCA based application. Now that you have created the interface called HelloWorldInterface, you can use the assembly editor to create the simple HelloWorld component with the HelloWorld interface as follows:

1. Return to the Business Integration view.
2. Expand the HelloWorld project.
3. Double-click the HelloWorld module.

   This opens the assembly editor (Figure 3-18 on page 81) in the workspace.

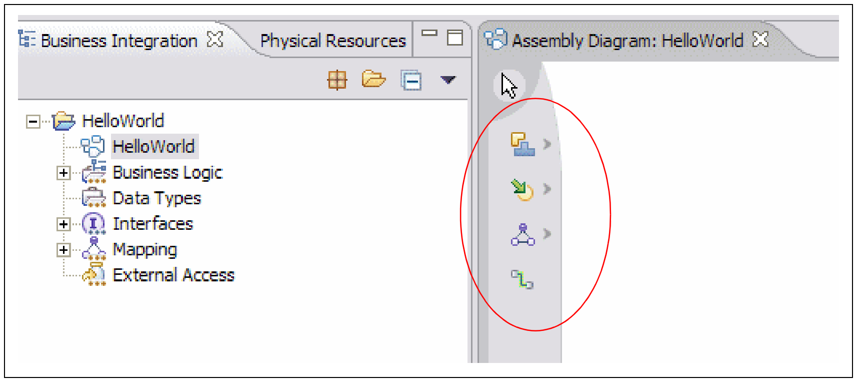
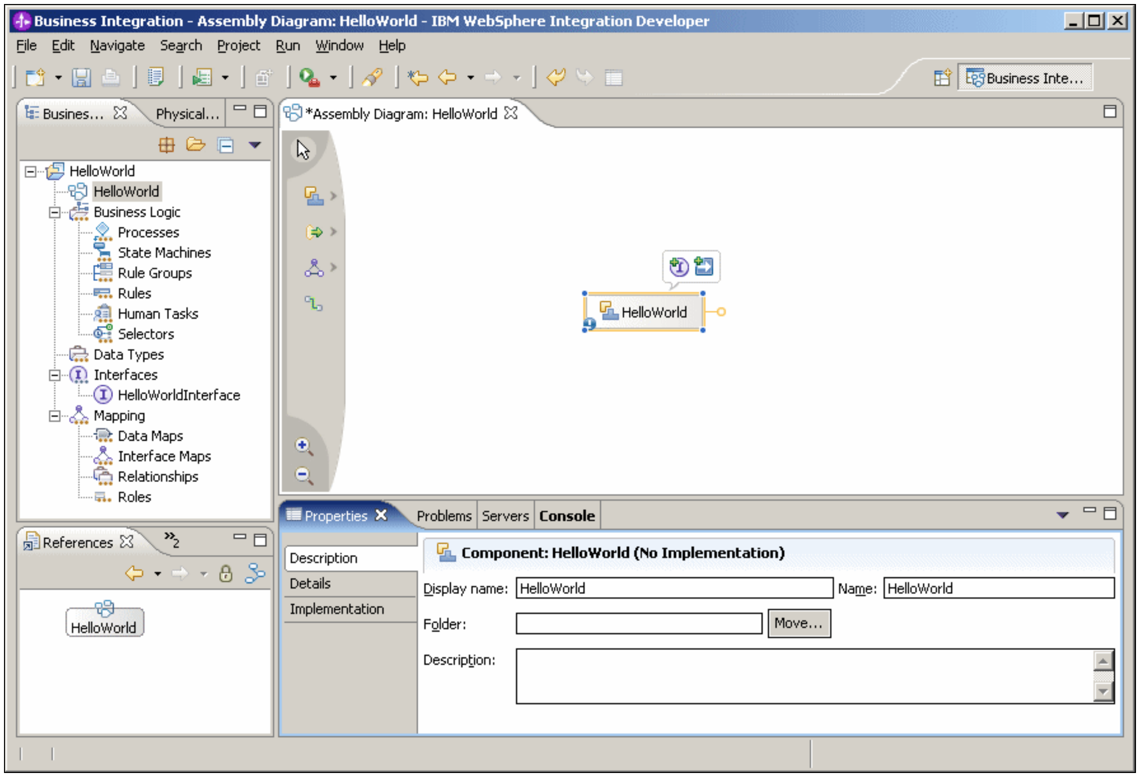


Figure 3-18 Assembly editor

Note: The assembly editor consists of a canvas area and a palette for selecting components to add to the diagram. The palette is located to the left of the canvas area. There are nested items within the palette; access these by clicking the grey > (greater than) symbol next to the parent item (see Figure 3-18).

4. Add a service component to the diagram by clicking the component icon and clicking anywhere in the canvas of the assembly diagram (Figure 3-19 on page 82).
5. Select the Properties view.
6. Change the Display name and Name to *HelloWorld*.
7. In the assembly diagram (Figure 3-19 on page 82), select the HelloWorld component and click the Add Interface icon .



Component: HelloWorld (No Implementation)

Display name: HelloWorld   Name: HelloWorld

Folder:

Description:

Figure 3-19   Properties of a component in the assembly editor

Tip: Select the HelloWorld component and position your mouse over it to see the icons shown in Figure 3-20.

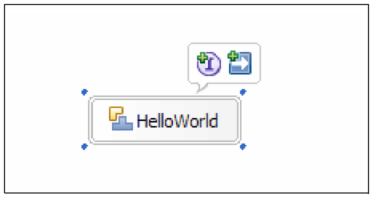
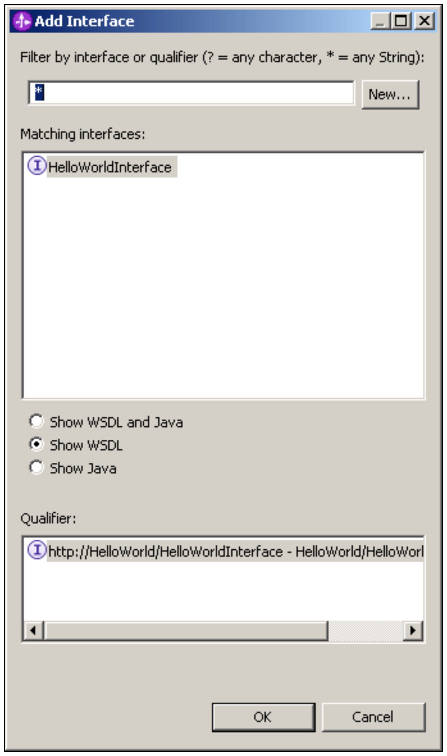


Figure 3-20   Interface icon

8. When the Add Interface dialog opens (Figure 3-21 on page 83), select **HelloWorldInterface**.
9. Click **OK**.



Filter: `*`

HelloWorldInterface

( ) Show WSDL and Java
[✓ Show WSDL]
( ) Show Java

Qualifier: http://HelloWorld/HelloWorldInterface - HelloWorld/HelloWorl

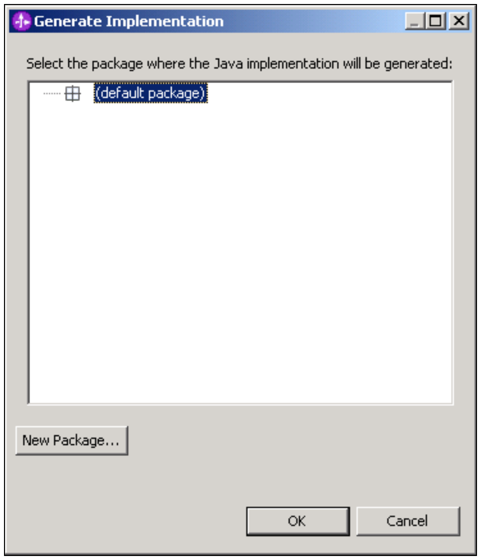
Figure 3-21 Add interface dialog

Tip: If you have many interfaces defined to your workspace, you can use the filter to narrow the list.

In this case, when the Add Interface dialog appears, begin typing HelloWorldInterface into the Filter by interface or qualifier field and select the HelloWorldInterface from the **Matching interfaces** list when it appears**.**

As we mentioned earlier in this chapter, our SCA component uses a Java implementation. The implementation does not yet exist at this time; however, you can ask to generate a skeleton as follows:

1. In the assembly diagram, right-click the HelloWorld component and select **Generate Implementation** → **Java**.
2. When the Generate Implementation wizard (Figure 3-22 on page 84) starts, you can select an existing package or ask to use a new package. Click **New Package**.

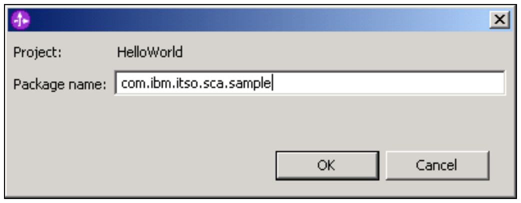


Select the package where the Java implementation will be generated:

(default package)

Figure 3-22   Select package for generated class

3. In the window that opens, provide the name of the new package (for example, com.ibm.itso.sca.sample) as shown in Figure 3-23.

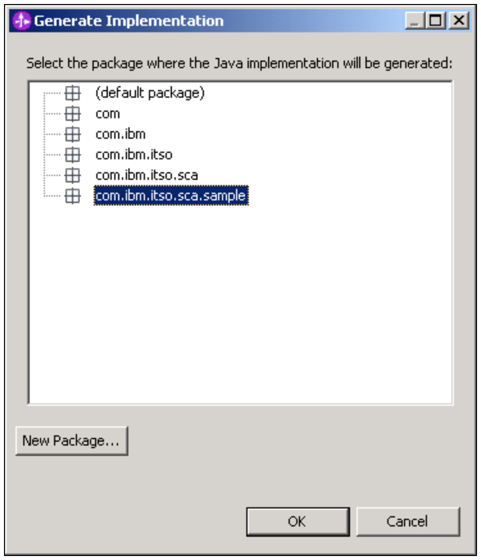


Project: HelloWorld

Package name: com.ibm.itso.sca.sample

Figure 3-23   Provide name of new package

4. Return to the Generate Implementation window (see Figure 3-22), select the newly created package as shown in Figure 3-24 on page 85, and click **OK**.

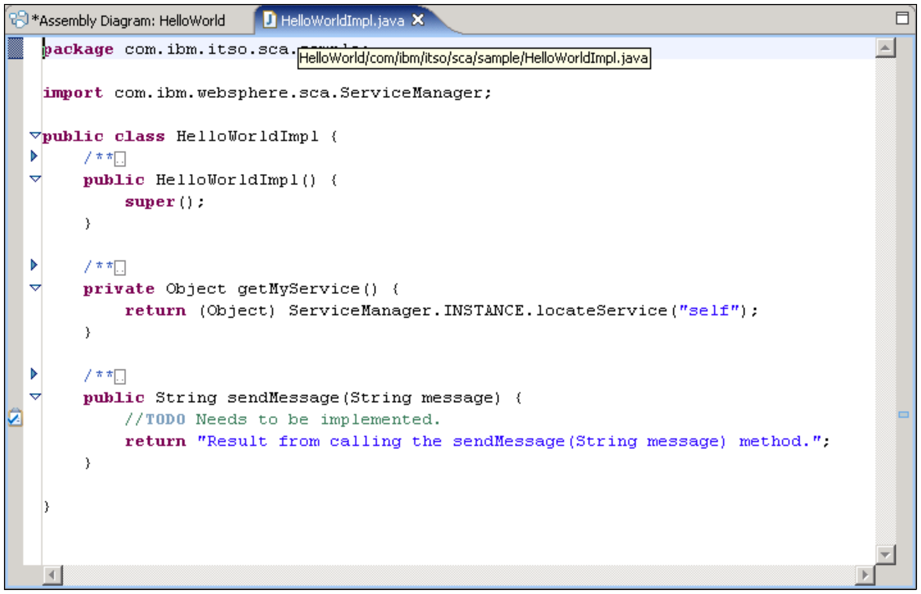

Generate Implementation

Select the package where the Java implementation will be generated:

- (default package)
- com
- com.ibm
- com.ibm.itso
- com.ibm.itso.sca
- com.ibm.itso.sca.sample

Figure 3-24 Select newly created package

The new class is now generated and is shown in the Java editor (Figure 3-25). This skeleton can be used to adapt the implementation of the sendMessage method.



```
package com.ibm.itso.sca.sample;  HelloWorld/com/ibm/itso/sca/sample/HelloWorldImpl.java

import com.ibm.websphere.sca.ServiceManager;

public class HelloWorldImpl {
    /**
    public HelloWorldImpl() {
        super();
    }

    /**
    private Object getMyService() {
        return (Object) ServiceManager.INSTANCE.locateService("self");
    }

    /**
    public String sendMessage(String message) {
        //TODO Needs to be implemented.
        return "Result from calling the sendMessage(String message) method.";
    }

}
```

Figure 3-25 Generated skeleton for HelloWorld interface

If you wish, you can alter the implementation of sendMessage to return a string that includes the original message. See Example 3-1.

Example 3-1 New implementation of sendMessage method

```
public String sendMessage(String message) {
   System.out.println("MESSAGE>> " + message);
   return "Did you say? " + message;
}
```

Figure 3-26 shows the current state of the assembly editor. You can see that the icon of the HelloWorld component has a character, *J*, added to it, indicating that the component is implemented by a Java class. In the Properties view and Details section, you can see that the interface has been added and that this interface has one single operation, sendMessage.

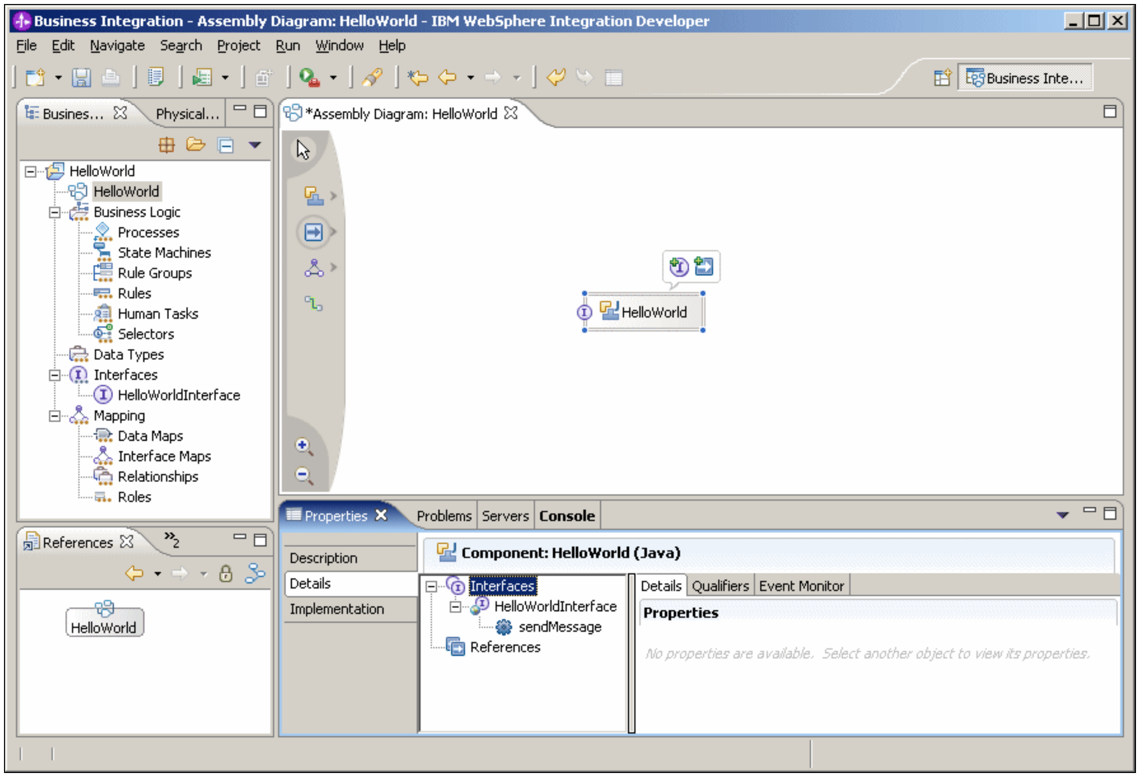


Figure 3-26 Assembly editor after selecting the implementation

The SCA component is called by a client implemented as a JSP. To allow this, you need to add a stand-alone reference to the component as follows.

1. Using the palette, select the stand-alone reference icon and add it to the canvas.

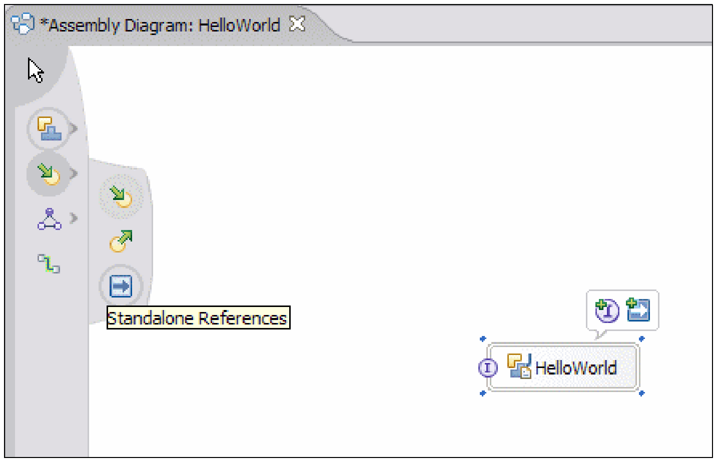
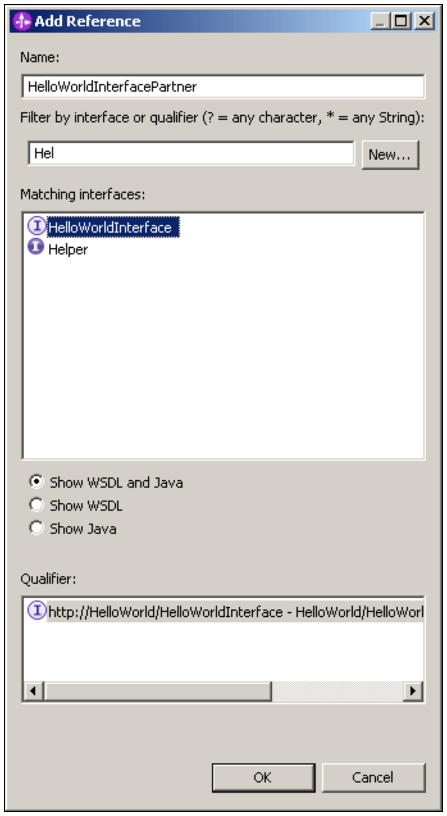


Figure 3-27   Stand-alone reference

2. In the assembly diagram, select the stand-alone references component and click the Add Reference icon from the menu that opens when you move your mouse over HelloWorld.
3. When the Add Reference dialog (Figure 3-28 on page 88) opens, enter *HelloWorldInterfacePartner* and select **HelloWorldInterface**.
4. Click **OK**.



Add Reference

Name:

HelloWorldInterfacePartner

Filter by interface or qualifier (? = any character, * = any String):

Hel

Matching interfaces:

HelloWorldInterface

Helper

(●) Show WSDL and Java

( ) Show WSDL

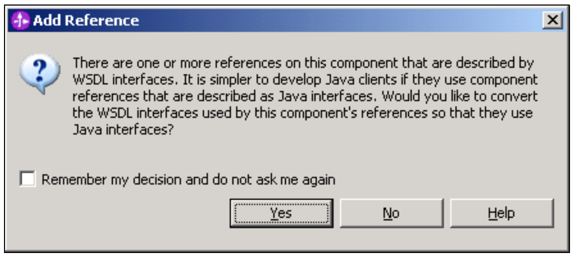
( ) Show Java

Qualifier:

http://HelloWorld/HelloWorldInterface - HelloWorld/HelloWorl

Figure 3-28 Add Reference

Depending on the settings of your workspace, you might see the message box shown in Figure 3-29 on page 89. Basically, you can always invoke a component by using the WSDL interface for that component. However, if the component is a Java component, you can also invoke it natively as a Java class. Invoking our component using the Java interface is likely to be quicker and easier. However, to demonstrate the generic case, we continue to use the WSDL method.


Add Reference

There are one or more references on this component that are described by WSDL interfaces. It is simpler to develop Java clients if they use component references that are described as Java interfaces. Would you like to convert the WSDL interfaces used by this component's references so that they use Java interfaces?

Remember my decision and do not ask me again

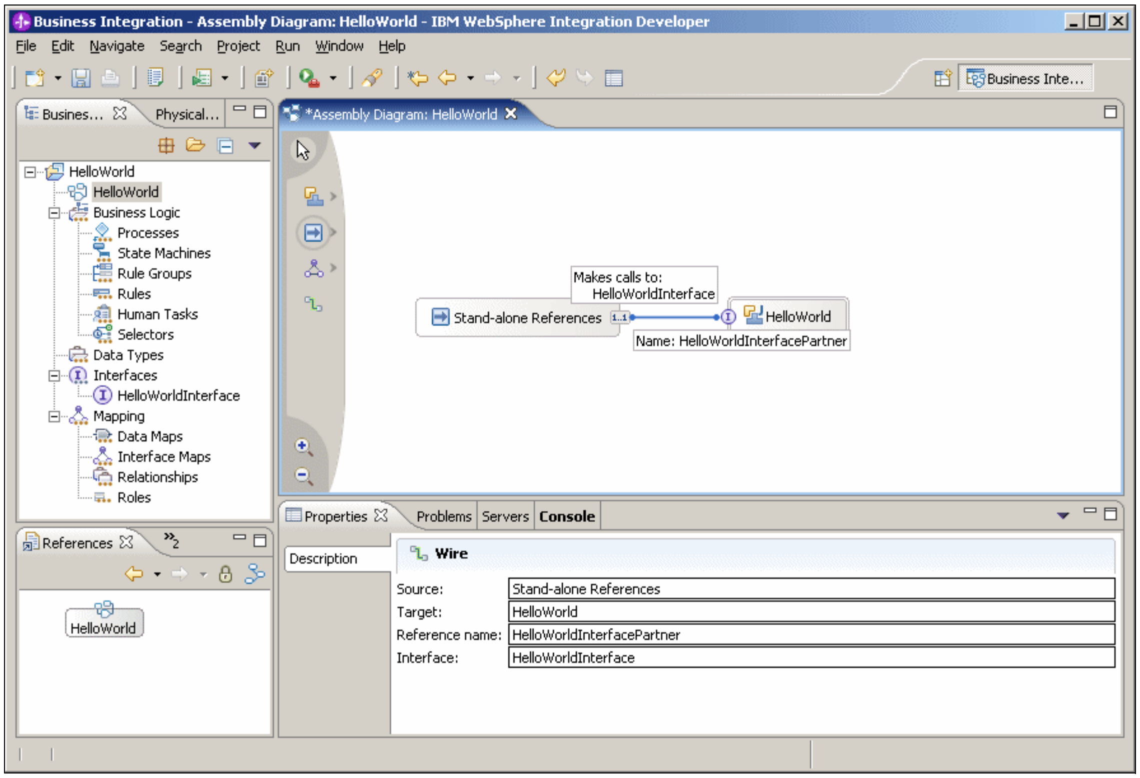
Figure 3-29 Select the type of reference, Java or WSDL

5. To choose the generic WSDL technique, click **No**.
6. Now you must connect the reference to the component. Select the wire icon from the palette.
7. Click the reference box icon on the stand-alone reference.
8. Now click the HelloWorld component.

Tip: You can also right-click the Stand-alone Reference component and select **Wire to Existing**. The assembly editor then searches itself for an interface that matches the reference. In our example, this target interface is obvious.

9. Your assembly diagram resembles that shown in Figure 3-30 on page 90. Click the wire that is now connecting the stand-alone reference and the HelloWorld component. From the Properties view, you can see the definition of the wire.

   In the assembly diagram itself, you can see that the stand-alone reference named HelloWorldInterfacePartner makes calls to the HelloWorldInterface (which we know is a single WSDL port type with a Java implementation; refer to Figure 3-1 on page 68 as a check point).



Source:	Stand-alone References
Target:	HelloWorld
Reference name:	HelloWorldInterfacePartner
Interface:	HelloWorldInterface

Figure 3-30 Completed assembly diagram

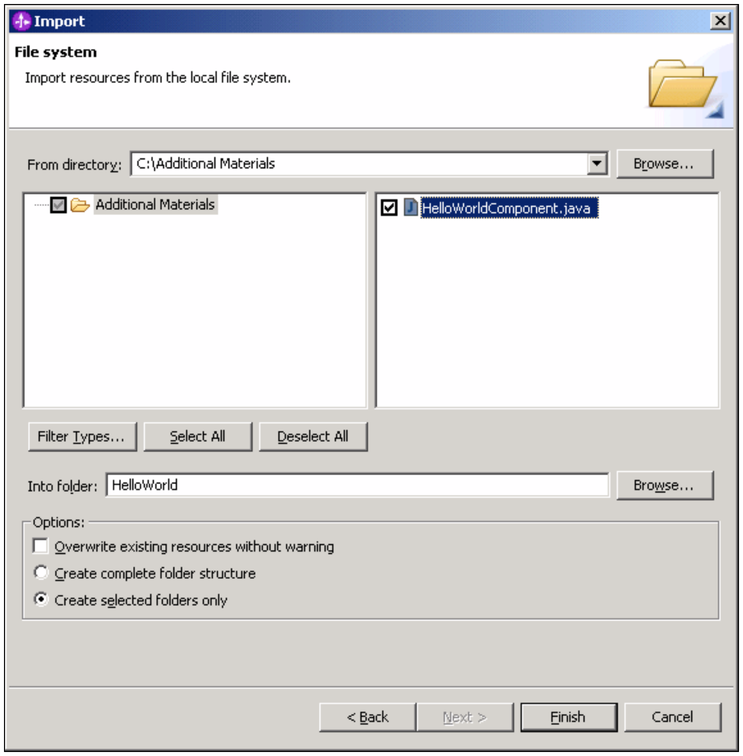
10. Save and close the assembly diagram.

3.6 Using your own implementation of the interface

In the previous section, we asked WebSphere Integration Developer to generate an implementation skeleton for a given interface. However, you might already have an implementation, possibly even with a different class name than the one that is used by the Java generator. In this section, we show how to use an existing class.

1. To make this existing class available to the project in WebSphere Integration Developer, you can import it by selecting **File** → **Import**.
2. Select **File System** as the source for the import.
3. In the next window (Figure 3-31 on page 91), click **Browse** to point to the directory that contains the Java source file.

4. After the directory has been identified, select the file that you want to import (HelloWorldComponent.java in our example in Figure 3-31).


Import

File system

Import resources from the local file system.

From directory: C:\Additional Materials

☑ Additional Materials

☑ HelloWorldComponent.java

Into folder: HelloWorld

Options:

☐ Overwrite existing resources without warning

○ Create complete folder structure

● Create selected folders only

Figure 3-31 Import a Java source file

5. Select the folder in the project where you want to import the Java source file (for example HelloWorld).
6. Click **Finish**.

Note: The Java source file used in this section is available for download as part of the additional materials for this redpaper. Refer to Appendix A, “Additional material” on page 111 to obtain it.

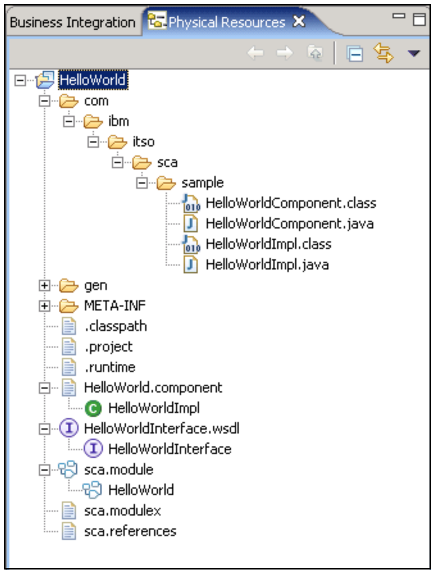
You might notice that the class name HelloWorldComponent is not the same as the name of the generated class. Also, if you look at the source shown in Example 3-2 on page 92, there is no reference to anything related to SCA. There is not even a reference to an interface.

Example 3-2 Implementation of the class HelloWorldComponent

```
package com.ibm.itso.sca.sample;

public class HelloWorldComponent {

   public String sendMessage(String message) {
      System.out.println("MESSAGE>> " + message);
      return "Did you say? " + message;
   }

}
```

The import of the Java class might not be immediately visible in the Business Integration view. To show the physical files associated with a module, right-click **HelloWorld** and select **Show Files**. Or, you can select **Window** → **Show View** → **Physical Resources**.

Figure 3-32 shows the new view (called Physical Resources). In this view, you can locate the Java class file that you imported.



```
HelloWorld
  com
    ibm
      itso
        sca
          sample
            HelloWorldComponent.class
            HelloWorldComponent.java
            HelloWorldImpl.class
            HelloWorldImpl.java
  gen
  META-INF
  .classpath
  .project
  .runtime
  HelloWorld.component
    HelloWorldImpl
  HelloWorldInterface.wsdl
    HelloWorldInterface
  sca.module
    HelloWorld
  sca.modulex
  sca.references
```

Figure 3-32 Physical resources view

To use this imported class as the HelloWorld component implementation, open the assembly for this module again and follow these steps:

1. Right-click the HelloWorld component and select **Select Implementation**.

2. In the Pick Implementation window (Figure 3-33), alter the selection filter until the Matching types list shows the HelloWorldComponent class.
3. Select the class and click **OK**.

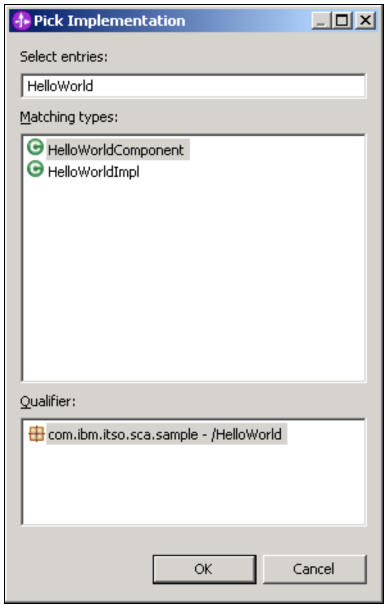


Figure 3-33 Pick implementation

4. Save and close the assembly diagram.

3.7 Building a client to invoke the service component

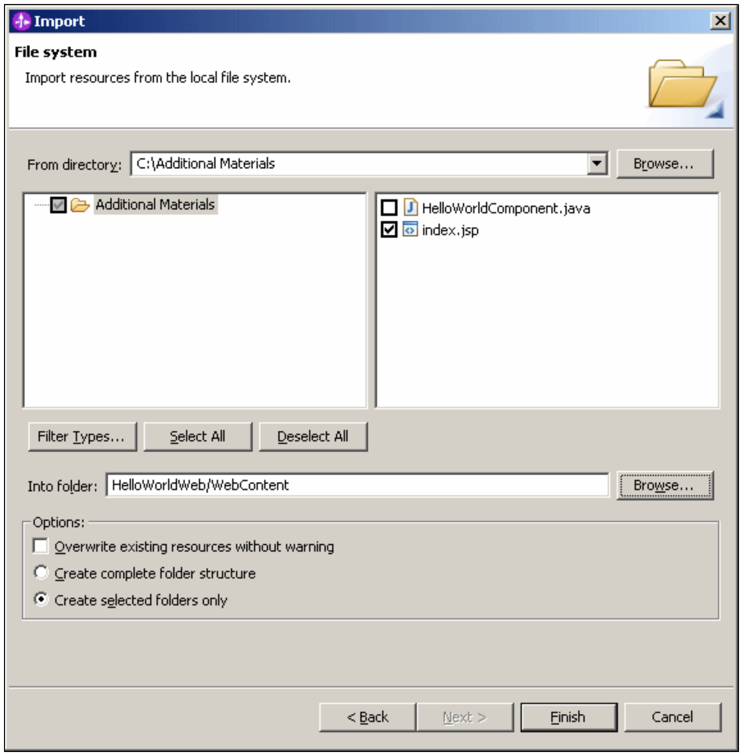
There are many ways to invoke the service component that we have developed in the previous sections. In this section, we discuss how to use a JSP Web page to invoke the Hello World application.

Note: The development of JSPs is beyond the scope of this book. A sample JSP is provided as part of the additional materials of this redpaper. To obtain the additional materials, please refer to Appendix A, “Additional material” on page 111.

To get started, import a client JSP file that includes the appropriate client code to invoke the HelloWorld service that you created previously:

1. Select **File** → **Import**.

2. Select **File System** and click **Next**.
3. Browse to the folder that contains the unzipped additional material.
4. Select the index.jsp file (Figure 3-34).


Import

File system

Import resources from the local file system.

From directory: C:\Additional Materials

Additional Materials

HelloWorldComponent.java

[✓] index.jsp

Into folder: HelloWorldWeb/WebContent

Options:

Overwrite existing resources without warning

Create complete folder structure

[●] Create selected folders only

Figure 3-34 Select the JSP file

5. Click **Browse** to provide the name of the destination folder (for example, **HelloWorldWeb/WebContent**) as shown in Example 3-35 on page 95.

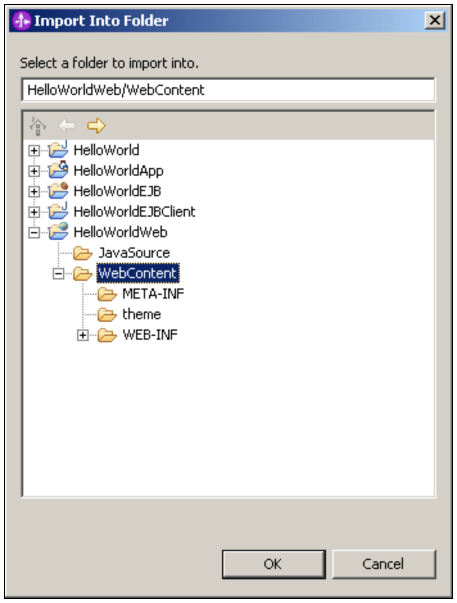


Figure 3-35 Import into folder

6. Click **OK**.
7. In the Import window, click **Finish**.
8. Open the Web perspective by selecting **Window** → **Open Perspective** → **Other**.
9. If you receive a prompt that requests confirmation for enabling the Web Development capability, click **OK** to continue.
10. From the Web perspective (Figure 3-36 on page 96), expand **Dynamic Web Projects** → **HelloWorldWeb** → **WebContent**.

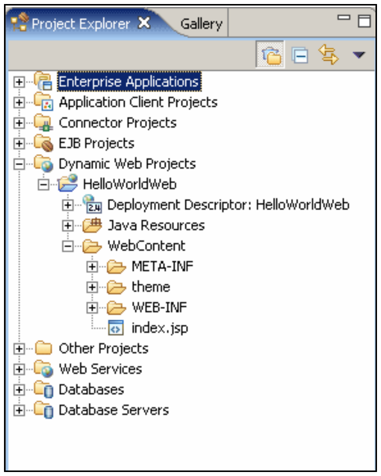


Figure 3-36   Find index.jsp

11. Double-click the index.jsp file. This opens the JSP editor (Figure 3-37).

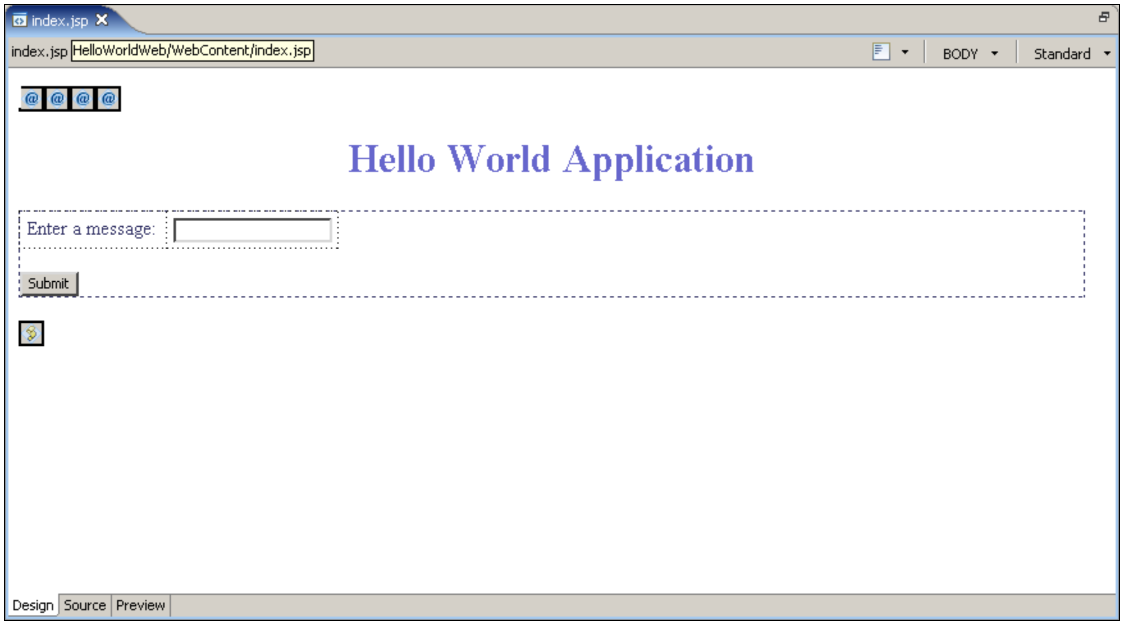


Figure 3-37   Design view of the JSP editor

12. Select the Source view in the JSP editor.

The portion of the JSP that actually invokes the component is shown in Figure 3-38.

```
<%
if (request.getParameter("message") != null) {
    try {
        ServiceManager serviceManager = new ServiceManager();
        Service service = (Service) serviceManager.locateService("HelloWorldInterfacePartner");
        BOFactory bofactory = (BOFactory)
serviceManager.locateService("com/ibm/websphere/bo/BOFactory");
        DataObject input = bofactory.createByElement("http://HelloWorld/HelloWorldInterface",
"sendMessage");
        input.set("message", request.getParameter("message"));

        System.out.println("Sending message: " + request.getParameter("message"));
        DataObject resp = (DataObject) service.invoke("sendMessage",input);
        System.out.println("Response: " + resp.getString("status"));
        if (resp != null) {
            out.println("<p>" + resp.getString("status") + "</p>");
        }

    } catch (Exception e) {
        System.out.println(e);
    }
}
%>
```

Figure 3-38 Service invocation

Note the following elements:

- Name of the stand-alone reference (HelloWorldInterfacePartner)
- The creation of the Data Object input
- Name space for the sendMessage input type in the WSDL (http://HelloWorld/HelloWorldInterface)
- The invocation of the service (service.invoke)
- Getting the status property from the output Data Object

3.8 Testing the service component invocation

Now that you have completed your service component, there are two ways to test the invocation from a service client:

- Using the end-to-end Test Framework
- From a Web interface

We start with the use of the end-to-end Test Framework.

3.8.1 Using the end-to-end Test Framework

The end-to-end Test Framework can be invoked on a service component from the assembly diagram.

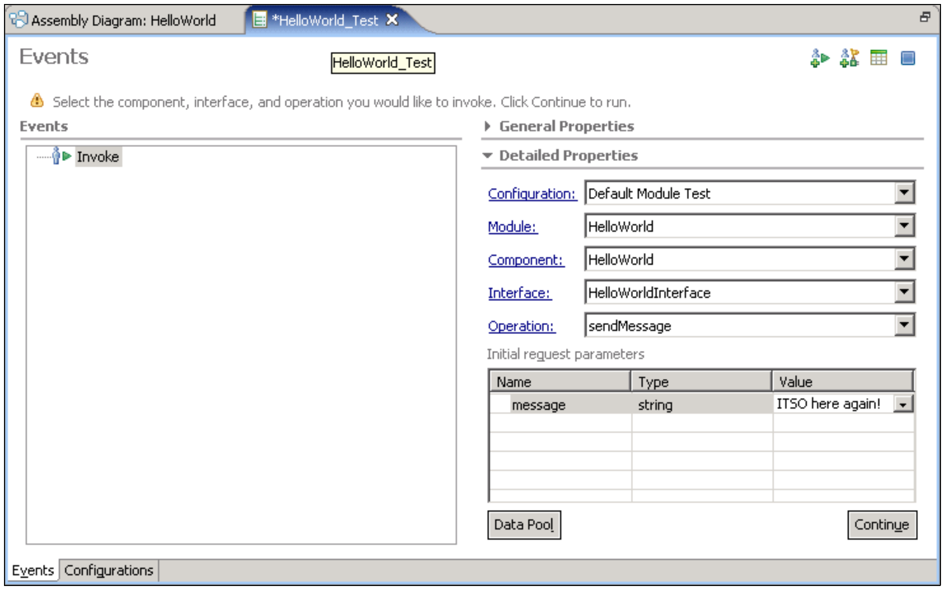
Start by opening the assembly diagram:

1. From the Business Integration perspective, expand the HelloWorld project.
2. Double-click the HelloWorld module to open the assembly diagram.
3. Right-click anywhere in the assembly diagram and select **Test Module** from the context menu.

> **Note:** You can also test a single component by right-clicking it and selecting **Test Component**. In our example, there is basically little difference because the module contains only one component.

   The test editor (Figure 3-39) opens. On the left, you can see that you are going to invoke something. On the right, you can select the module, component, interface, and operation that you want to invoke. Below that, there is the opportunity to provide values for the operation input message. Note also the Datapool option. You can save and reuse input data if you must test a component several times or to manage sets of test data.

4. Provide text as the input message and click **Continue**.



Select the component, interface, and operation you would like to invoke. Click Continue to run.

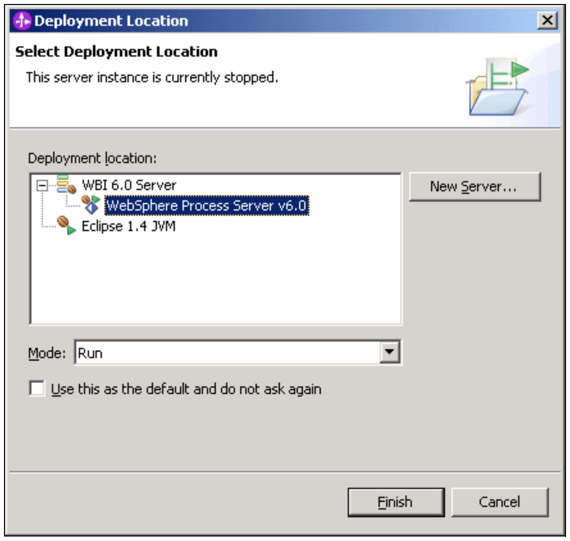
Configuration:	Default Module Test
Module:	HelloWorld
Component:	HelloWorld
Interface:	HelloWorldInterface
Operation:	sendMessage

Initial request parameters

Name	Type	Value
message	string	ITSO here again!

Figure 3-39 Test editor

5. In the Deployment Location dialog (Figure 3-40), verify that **WebSphere Process Server v6.0** is selected. Click **Finish**.


Deployment Location

Select Deployment Location

This server instance is currently stopped.

Deployment location:

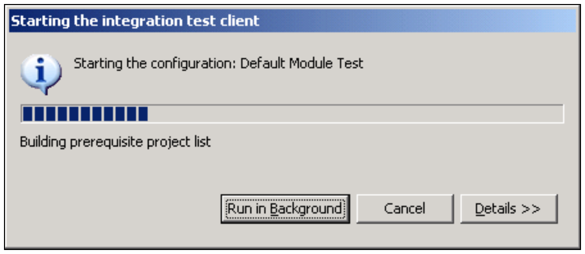
WBI 6.0 Server
WebSphere Process Server v6.0
Eclipse 1.4 JVM

Mode: Run

Use this as the default and do not ask again

Figure 3-40 Deployment location

The application is deployed to the test server and the application server starts (Figure 3-41).

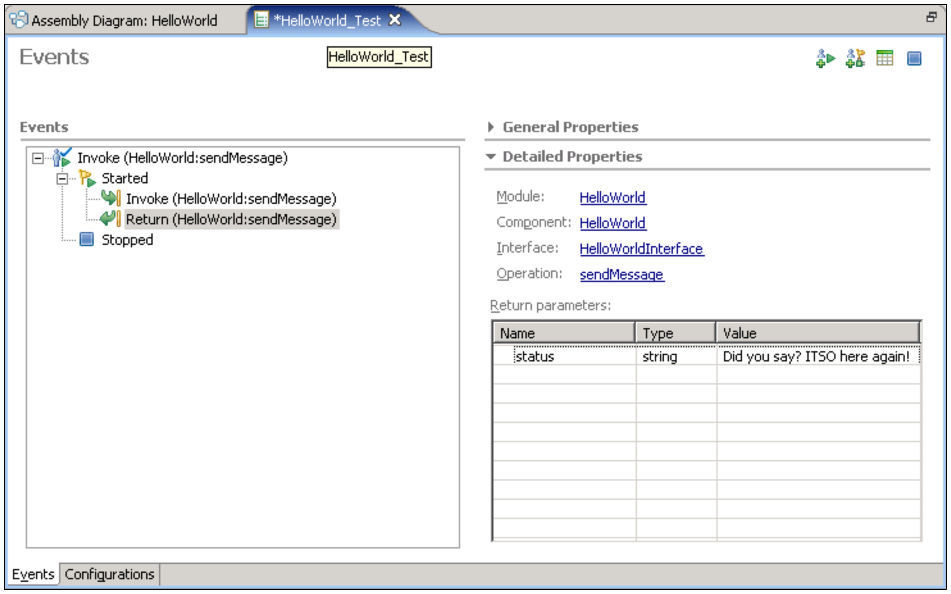

Starting the integration test client

Starting the configuration: Default Module Test

Building prerequisite project list

Figure 3-41 Starting the test client

Once the test has completed, you can see the response message in the Detailed Properties pane (Figure 3-42 on page 100) as *status*.


Assembly Diagram: HelloWorld | *HelloWorld_Test

Events HelloWorld_Test

Events
- Invoke (HelloWorld:sendMessage)
  - Started
    - Invoke (HelloWorld:sendMessage)
    - Return (HelloWorld:sendMessage)
  - Stopped

General Properties

Detailed Properties

Module: HelloWorld
Component: HelloWorld
Interface: HelloWorldInterface
Operation: sendMessage

Return parameters:

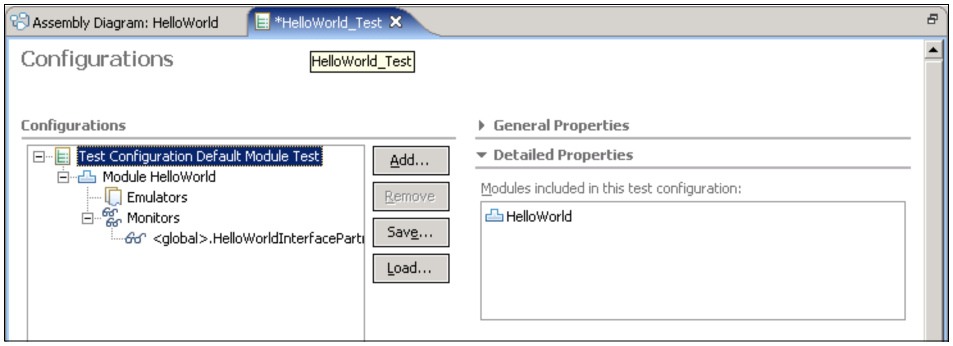
Name	Type	Value
status	string	Did you say? ITSO here again!

Events | Configurations

Figure 3-42   Result of test

In the events pane, you can see the successful invocation and response.

In the Configurations pane, you can see the details of the module that you have been testing (see Figure 3-43). Notice the concept of an emulator. If the module diagram contains interfaces for the implementation that are not yet ready for testing, you can ask to emulate that component. This gives the tester the option to provide output using the test facility, instead of invoking the actual implementation of that interface.


Assembly Diagram: HelloWorld | *HelloWorld_Test

Configurations HelloWorld_Test

Configurations
- Test Configuration Default Module Test
  - Module HelloWorld
    - Emulators
    - Monitors
      - <global>.HelloWorldInterfacePart

Add... | Remove | Save... | Load...

General Properties

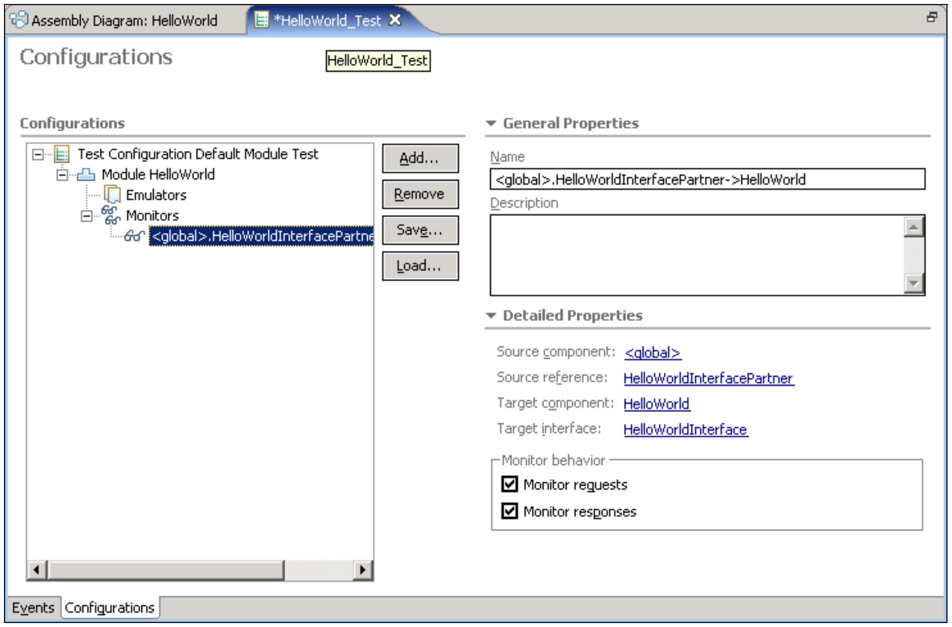
Detailed Properties

Modules included in this test configuration:

HelloWorld

Figure 3-43   Configurations pane

To see the details of what is being monitored for the test run, select **HelloWorldInterfacePartner** → **HelloWorld** (this matches the link between our stand-alone reference and the HelloWorld component in the assembly diagram). You can see the details in the Detailed Properties pane (Figure 3-44). Close the test editor without saving the data from this test run.



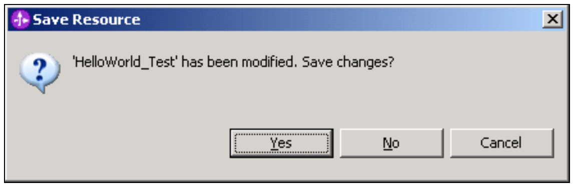
Name: <global>.HelloWorldInterfacePartner->HelloWorld

Source component: <global>
Source reference: HelloWorldInterfacePartner
Target component: HelloWorld
Target interface: HelloWorldInterface

☑ Monitor requests
☑ Monitor responses

Figure 3-44 Detailed properties

For more complex interfaces and multi-level business objects, saving and reusing test data and test configurations can be very helpful. Saving the test editor file (by clicking **Yes** in the Save Resource prompt shown in Figure 3-45) can help you re-run the test with similar data. There is, however, little value in saving the file for the Hello World example.



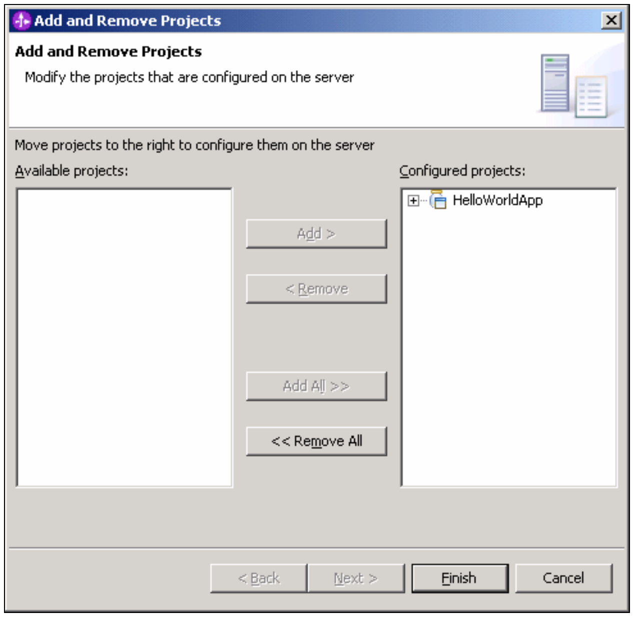
'HelloWorld_Test' has been modified. Save changes?

Figure 3-45 End test run

3.8.2 Testing from the Web interface

To test from the Web interface, you have to start the server and add the project to the server. If you used the test client option, this has already been done. If not, follow these steps:

1. From the Server view, right-click the Server and select **Start**.
2. After the server has successfully started, from the Server view, right-click the server.
3. Select **Add and remove projects** from the context menu.
4. Select **HelloWorldApp** from the list of available projects as shown in Figure 3-46.


Add and Remove Projects

Modify the projects that are configured on the server

Move projects to the right to configure them on the server

Available projects:

Configured projects:

HelloWorldApp

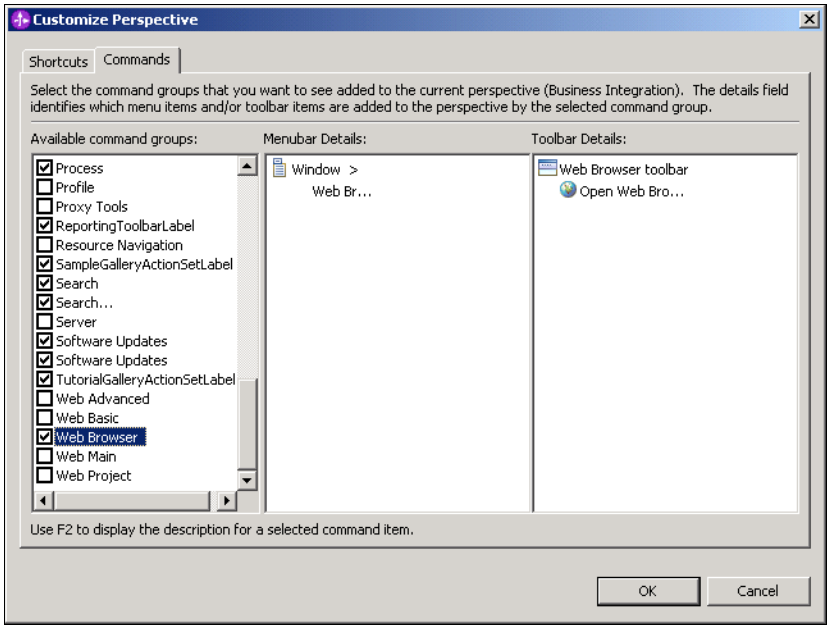
Figure 3-46 Selected project

5. Select **Add** and click **Finish**.

After the server has been updated successfully, you can test your service component. First, you must enter the URL of the client in a Web browser. There are a few ways to achieve this. One way is to locate the index.jsp file in the Web perspective and select the option **Run** → **Run on Server**, which launches the internal browser and goes straight to the requested Web page.

If you do not want to leave the Business Integration perspective, you can easily configure that perspective to open a browser from the tool bar:

1. Select **Window → Customize Perspective.**
2. In the Customize Perspective window (Figure 3-47), click the Commands tab.



Select the command groups that you want to see added to the current perspective (Business Integration). The details field identifies which menu items and/or toolbar items are added to the perspective by the selected command group.

Available command groups:

- ☑ Process
- ☐ Profile
- ☐ Proxy Tools
- ☑ ReportingToolbarLabel
- ☐ Resource Navigation
- ☑ SampleGalleryActionSetLabel
- ☑ Search
- ☑ Search...
- ☐ Server
- ☑ Software Updates
- ☑ Software Updates
- ☑ TutorialGalleryActionSetLabel
- ☐ Web Advanced
- ☐ Web Basic
- ☑ Web Browser
- ☐ Web Main
- ☐ Web Project

Menubar Details:

Window >
Web Br...

Toolbar Details:

Web Browser toolbar
Open Web Bro...

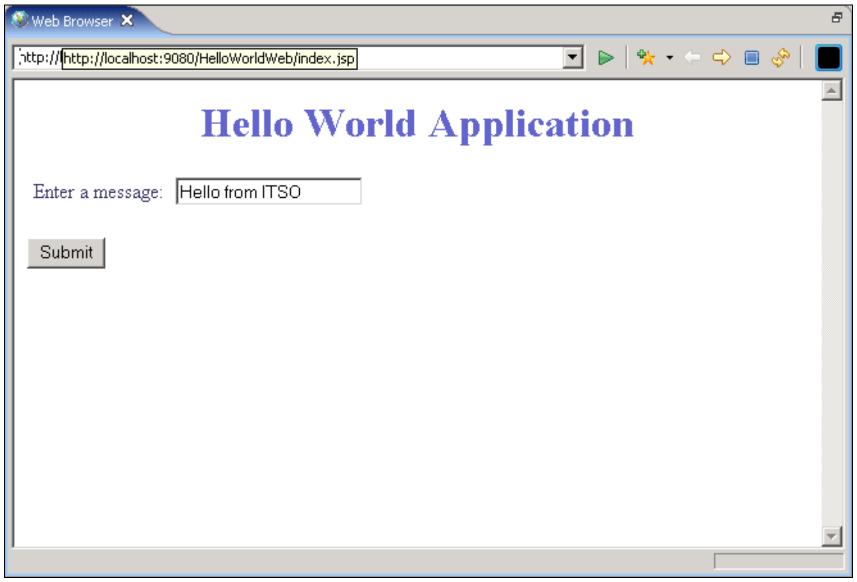
Use F2 to display the description for a selected command item.

Figure 3-47 Customize perspective dialog

3. Scroll to the end of the available commands.
4. Select **Web Browser**.
5. Click **OK**.
6. The Web browser icon is now visible in the tool bar. Click this icon to open the embedded Web browser.
7. Enter the following URL:

```
http://localhost:9080/HelloWorldWeb/index.jsp
```

8. Your browser should display a page similar to that shown in Figure 3-48 on page 104. Enter a message and click **Submit**.



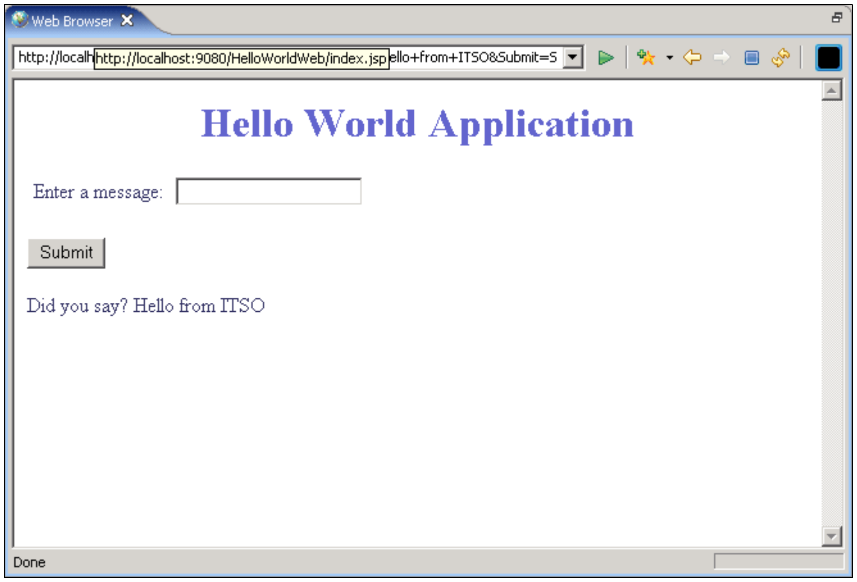
Hello World Application

Enter a message: Hello from ITSO

Submit

Figure 3-48 Enter a message

9. Verify that you received your original message, which is preceded by "**Did you say?**" (Figure 3-49).


Web Browser
http://localhost:9080/HelloWorldWeb/index.jsp
http://localhello+from+ITSO&Submit=S
Done

Hello World Application

Enter a message:

Submit

Did you say? Hello from ITSO

Figure 3-49 Response

3.9 Summary

Figure 3-50 shows the schematic overview of the application developed in this chapter. It includes the HelloWorld component, implemented in Java as HelloWorldComponent.java.

The component is formally described as an interface in HelloWorldInterface.wsdl. The stand-alone reference acts as a place holder for an external client, such as a JSP. We used the index.jsp sample.

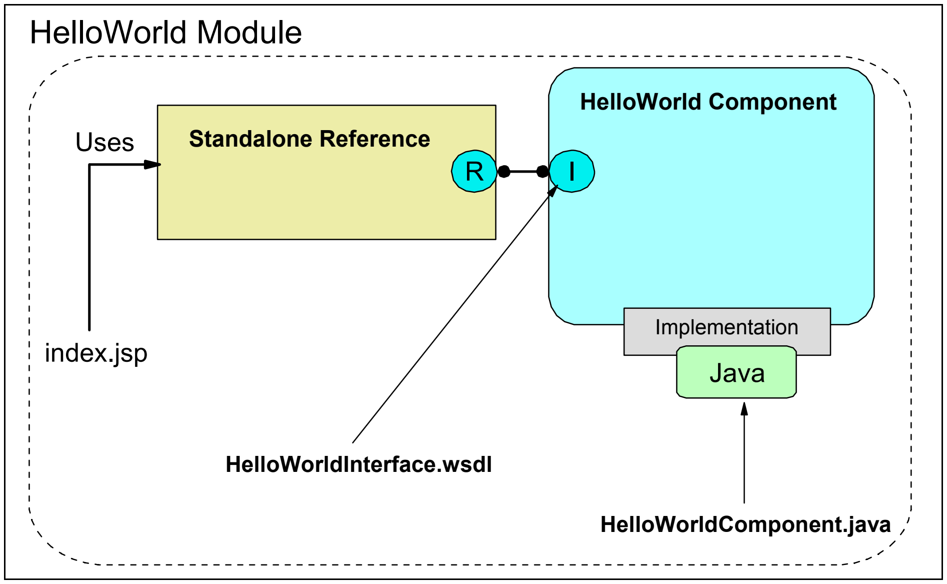
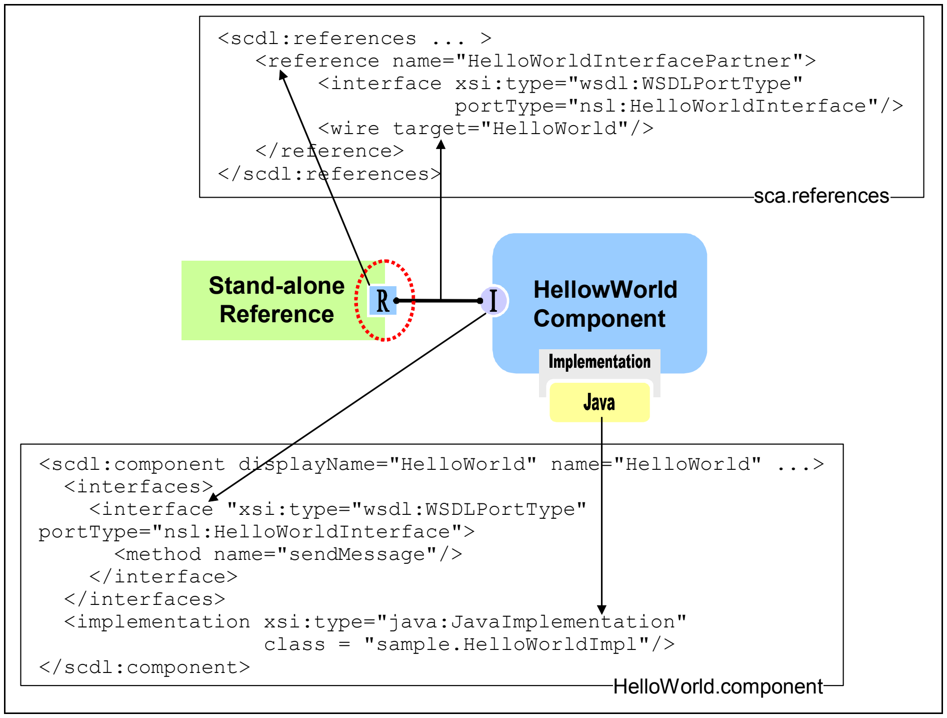


Figure 3-50 Schematical overview of files and components

The wiring of these components is done in the assembly editor, which stores elements such as references and wires in a file called sca.references. Part of that XML file (Figure 3-51 on page 106) shows that the reference is WSDLPortType (versus a Java reference). Information about the component is stored in another XML file, called HelloWorld.component.

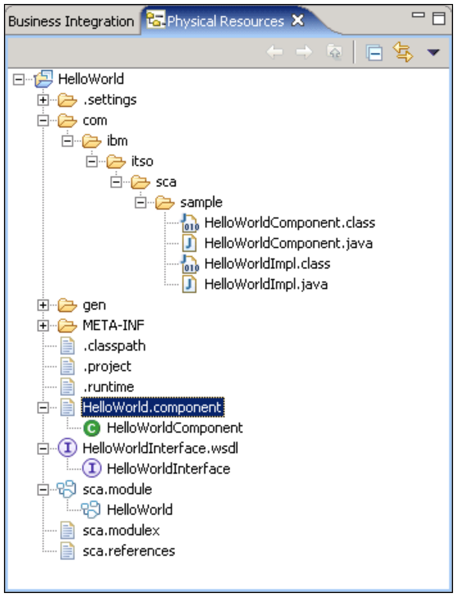


```
<scdl:references ... >
   <reference name="HelloWorldInterfacePartner">
        <interface xsi:type="wsdl:WSDLPortType"
                   portType="nsl:HelloWorldInterface"/>
        <wire target="HelloWorld"/>
   </reference>
</scdl:references>
```

```
<scdl:component displayName="HelloWorld" name="HelloWorld" ...>
  <interfaces>
    <interface "xsi:type="wsdl:WSDLPortType"
portType="nsl:HelloWorldInterface">
      <method name="sendMessage"/>
    </interface>
  </interfaces>
  <implementation xsi:type="java:JavaImplementation"
                  class = "sample.HelloWorldImpl"/>
</scdl:component>
```

Figure 3-51 XML files behind the assembly editor

While you should not edit these XML files by hand, it is good to know where these files are located. Using the physical resources view, you can see these and other files that are manipulated by the editors and wizards in the Business Integration perspective (Figure 3-52 on page 107).



```
HelloWorld
  .settings
  com
    ibm
      itso
        sca
          sample
            HelloWorldComponent.class
            HelloWorldComponent.java
            HelloWorldImpl.class
            HelloWorldImpl.java
  gen
  META-INF
  .classpath
  .project
  .runtime
  HelloWorld.component
    HelloWorldComponent
  HelloWorldInterface.wsdl
    HelloWorldInterface
  sca.module
    HelloWorld
  sca.modulex
  sca.references
```

Figure 3-52 Physical resources

Returning to the schematical overview in Figure 3-50 on page 105 and index.jsp, a portion of the source (Figure 3-53 on page 108) details clearly the generic steps for invoking a service:

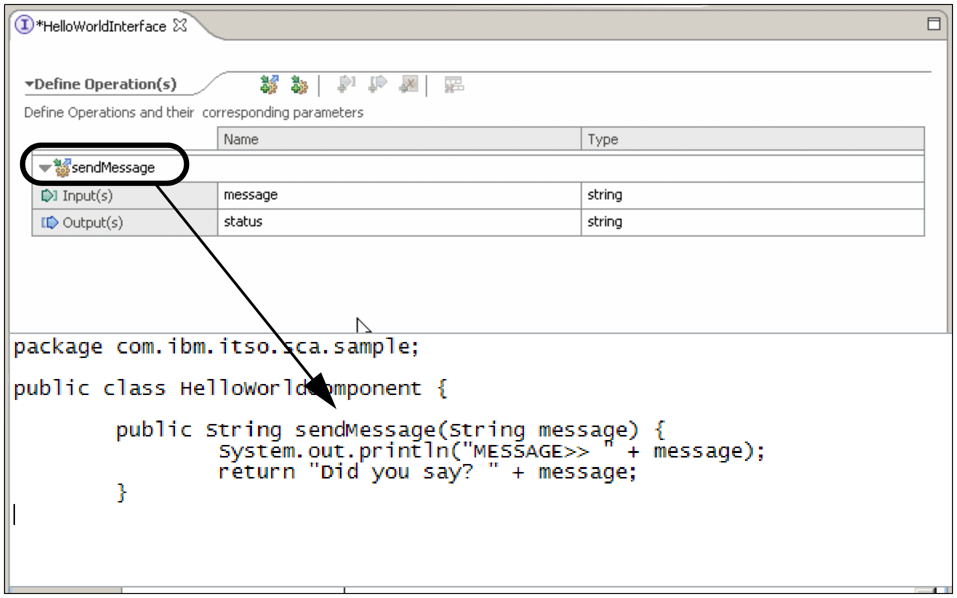
- Use the Service Manager to locate the HelloWorldInterfacePartner service, which is the name of the partner in the stand-alone reference.
- Create a data object and populate it.
- Invoke the required operation of the service.
- Retrieve the output value.

```
<%
if (request.getParameter("message") != null) {
    try {
        ServiceManager serviceManager = new ServiceManager();
        Service service = (Service) serviceManager.locateService("HelloWorldInterfacePartner");
        BOFactory bofactory = (BOFactory)
serviceManager.locateService("com/ibm/websphere/bo/BOFactory");
        DataObject input = bofactory.createByElement("http://HelloWorld/HelloWorldInterface",
"sendMessage");
        input.set("message", request.getParameter("message"));

        System.out.println("Sending message: " + request.getParameter("message"));
        DataObject resp = (DataObject) service.invoke("sendMessage",input);
        System.out.println("Response: " + resp.getString("status"));
        if (resp != null) {
            out.println("<p>" + resp.getString("status") + "</p>");
        }

    } catch (Exception e) {
        System.out.println(e);
    }
}
%>
```

Figure 3-53 Service invocation

Notice that the name of the operation, sendMessage, is actually the value of the first parameter of the method invocation. The object service does not inherit the interface of the component. Or, in other words, it is not some kind of proxy for the actual component.

Finally, consider the overlaid figure in Figure 3-54. At the top, you see the graphical representation of an operation and its input and output. Below that is the implementation of that operation as a public method in a Java class.



	Name	Type
sendMessage		
Input(s)	message	string
Output(s)	status	string

```
package com.ibm.itso.sca.sample;

public class HelloWorldComponent {

        public String sendMessage(String message) {
                System.out.println("MESSAGE>> " + message);
                return "Did you say? " + message;
        }
```

Figure 3-54 Completed interface and implementation

A

Additional material

This Redpaper refers to additional material that can be downloaded from the Internet.

Locating the Web material

The Web material associated with this Redpaper is available in soft copy on the Internet from the IBM Redbooks Web server. Point your Web browser to:

`ftp://www.redbooks.ibm.com/redbooks/REDP4041`

Alternatively, you can go to the IBM Redbooks Web site at:

`ibm.com``/redbooks`

Select the **Additional materials** and open the directory that corresponds with the redbook form number, REDP4041.

Using the Web material

The additional Web material that accompanies this Redpaper includes the files listed in Figure A-1 on page 112.

Table A-1 Provided Web materials

File Name	Description
HelloWorldComponent.java	Java class written by a developer
HelloWorldImpl.java	Generated Java class
index.jsp	Sample JSP invoking an SCA component
HelloWorld.zip	Project Interchange file

System requirements for using the Web material

The intended use of the Web materials is importing an installed copy of WebSphere Integration Developer. The system requirements for running this product are documented at:

`http://www-306.ibm.com/software/integration/wps/sysreqs/`

How to use the Web material

Create a subdirectory (folder) on your workstation, and unzip the contents of the Web material zip file into this folder. The use of each file is described in Chapter 3, “Developing a simple solution” on page 67.

The file HelloWorld.zip contains the completed sample and can be imported in WebSphere Integration Developer by selecting **File -> Import**. Select **Project Interchange** as the source for the import and point the wizard to the location of the downloaded zip file.

Abbreviations and acronyms

API	Application Programming Interface
BO	Business Object
BPEL	Business Process Execution Language
BPM	Business Process Management
CBE	Common Business Event
CEI	Common Event Infrastructure
CICS	Customer Information Control System
CRM	Customer Relationship Management
EAI	Enterprise Application Integration
EIS	Enterprise Information System
ERP	Enterprise Resource Planning
HTTP	HyperText Transfer Protocol
HTTPS	Secure HyperText Transfer Protocol
I/O	Input/Output
IBM	International Business Machines
ISV	Independent Software Vendor
IT	Information Technology
ITSO	International Technical Support Organization
JDBC	Java Database Connectivity
JMS	Java Messaging Service
JNDI	Java Naming and Directory Interface
JSF	Java Server Faces
JSP	JavaServer Pages
JSR	Java Specification Request
LDAP	Lightweight Directory Access Protocol
OASIS	Organization for the Advancement of Structured Information Standards
POJO	Plain Old Java Object
SAX	Simple API for XML
SCA	Service Component Architecture
SCDL	Service Component Description Language
SDO	Service Data Object
SLA	Service Level Agreement
SOA	Service-oriented Architecture
SOAP	Simple Object Access Protocol
UI	User Interface
URL	Universal Resource Locator
VM	Virtual Machine
WSDL	Web Service Description Language
WS-I	Web Services Interoperability
WSDL	Web Service Description Language
XML	Extensible Mark-up Language

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this Redpaper.

IBM Redbooks

For information on ordering these publications, see “How to get IBM Redbooks” on page 115. Note that some of the documents referenced here may be available in soft copy only.

- *Patterns: Serial and Parallel Processes for Process Choreography and Workflow,* SG24-6306
- *Patterns: SOA with an Enterprise Service Bus in WebSphere Application Server V6*, SG24-6494

Online resources

These Web sites and URLs are also relevant as further information sources:

- Business Process Execution Language (BPEL) Specification

  `http://www.ibm.com/developerworks/webservices/library/specification/ws-bpel`
- Service Data Object (SDO) Specification

  `http://www.ibm.com/developerworks/java/library/j-commonj-sdowmt/`
- WebSphere Process Server InfoCenter

  `http://www-306.ibm.com/software/integration/wps/library/infocenter/`

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IBM Global Services

ibm.com/services

Technical Overview of WebSphere Process Server and WebSphere Integration Developer

Redpaper

Understand the principles of SOA and On Demand Business

Learn about the building blocks of WebSphere Process Server

Build a Hello World solution using WebSphere Integration Developer

This IBM Redpaper is a technical introduction to WebSphere Process Server and WebSphere Integration Developer. Part of the WebSphere Process Integration family of products, WebSphere Process Server and WebSphere Integration Developer provide the core functionality for implementing a Service-Oriented Architecture (SOA) in an On Demand Business environment.

In the first chapter, we introduce On Demand Business and SOAs, describing the requirements for runtime and the development tools for implementing an SOA. In the second chapter, we discuss the building blocks of WebSphere Process Server and WebSphere Integration Developer and demonstrate how these products allow you to develop services and how they can be mapped and assembled together.

While the first two chapters of this redpaper provide you with theoretical information about WebSphere Process Server and WebSphere Integration Developer, the last chapter is an introduction to building solutions using these products. We demonstrate how to develop and test a classic Hello World application to give you a head start for developing of your own solutions.