Enterprise Service Bus (ESB)

Contents:

- Review Integration Approaches
- Influencing Technologies
- Infrastructure Reqs
- ESB Container
- Integration Services
- ESB MOM

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[From Chappell'04]

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Recent Past

- Recent past years significant technology trends, such as
  - Service-oriented Architecture (SOA)
  - Enterprise Application Integration (EAI)
  - Business-to-Business (B2B)
  - Web Services (WS)
- They attempted to address the challenges of integrated business processes

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Enterprise Service Bus

- The ESB concept is a new approach to integration
  - loosely coupled, highly distributed integration network
- Standards-based integration platform that combines:
  - messaging
  - web services
  - data transformation
  - intelligent routing
- Reliably connect and coordinate the interaction of diverse applications across (extended) enterprises with TX integrity

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Motivation

- Some large organizations have more than 1.000 distinct app types with more than 10.000 instances running
  - It is unrealistic to assume that all apps can use the same technology to participate in an integration environment

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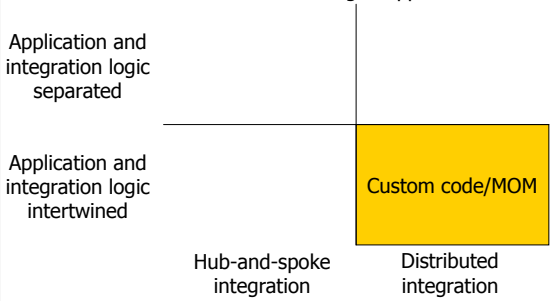
Integration Approaches

+ connect apps in a loosely coupled async fashion
- low-level coding in applications



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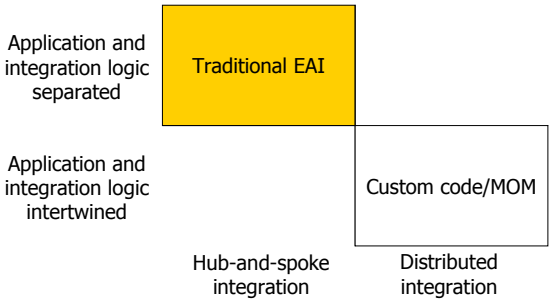
Integration Approaches

+ Centralized functions, e.g. management
+ separation of app and integration logic
- Does not scale well



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Integration Approaches

+ can interoperate through standard protocols
- Tightly coupled, does not scale well

	Hub-and-spoke integration	Distributed integration
Application and integration logic separated	Traditional EAI	
Application and integration logic intertwined	Application Server	Custom code/MOM

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Integration Approaches

+ configured instead of coded
+ highly distributed
+ clear separation of buz and integr. logic

	Hub-and-spoke integration	Distributed integration
Application and integration logic separated	Traditional EAI	ESB
Application and integration logic intertwined	Application Server	Custom code/MOM

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ESB - Origins

- ESB is not merely an academic exercise
- Born out of necessity!
  - Based on real requirements – difficult integration problems
- It's not just EAI + WS nor MOM + WS
  - A number of trends influenced on the evolution of the ESB
    - Both business- and technology-driven

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Influencing Technologies

- Enterprise Application Integration (EAI)
  - Good practices in data transformation and manipulation
- e-Marketplaces and vertical trading hubs
  - Recognition of a need for open standards for protocols and service discovery mechanisms
  - First to introduce the model of loosely-coupled, distributed federation of individual companies operating autonomously but collaborating together
- Java Message Service (JMS)
  - Standard API and behavioral semantics of MOM
- Application Servers
  - Nurtured the evolution of some important standards like servlets, JDBC, JCA, …

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Influencing Technologies (2)

- Y2K and post Internet-bubble economics
  - Caused major corporate reevaluation of big IT spending
  - Shift toward trying to make things work with the existing applications (and with a much smaller budget)
- Web services and SOA
  - Industry effort to provide platform-independent SOA
  - Relying on interoperable interface descriptions, protocols and data communications
- Evolution and maturation of standards
  - WS are important standards for XML, security and reliable messaging
- The "accidental" architecture
  - Nobody wants to create it but everybody has it

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Evolution

- The invention of the ESB was not an accident
  - The result of vendors working with forward-thinking customers
    - Trying to build a standard-based integration network using a foundation of SOA, messaging and XML
- Positive influences from its predecessor approaches and avoids the downsides

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Company Needs

- Various IT depts across business units needed to protect their investments in existing messaging and integration broker installations
- Be able to reach other corporate applications as shared services in a non-intrusive way
- Common API and event-driven service interfaces are a core part of the design of an ESB
  - Diversity in connectivity options is critical to the adoption of an integration strategy
  - Bring the infrastructure to the apps
    - Facilitating an incremental approach to adoption
  - core part of the definitions of an ESB, multiple…
    - client types
    - connectivity protocols
    - application adapters
    - MOM bridges

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Towards the Extended Enterprise

- EAI + evolution of Internet + App Servers
  - Clear separation between communications and app integration infrastructure
    - Driven by the capabilities and limitations of the technology
      - J2EE App Server: clear distinction between what's inside the firewall (EJB container) and what's outside (web container)
- Hub-and-spoke EAI brokers could get as far as the corporate boundaries
  - Not built for scaling beyond that
- Various Bridging Technologies designed for the "edge" of the network
  - Web services focused on this

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e-Commerce Trading Hubs

- Facilitates electronic commerce between buyers and suppliers in a supply chain
- A trading exchange acts as an intermediary, or semi-private business portal
  - "special" apps instead of browser-based
- Interaction between apps residing in a trading partner and the trading hub
- Trading hub provides value-added functions, such as dissemination of
  - Requests for Quote (RFQ) between buyer and multiple suppliers
  - Availability to Promise (ATP) data from suppliers to buyers

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e-Commerce Trading Hubs – Why?

- Move away from expensive EDI Value Added Networks (VAN)
- Use public Internet as means of communications wherever possible
- Lower the barrier of entry
  - According to the budget of small and medium enterprises
- Potential community could consist of thousands of trading partners

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Trading Hubs - Requirements

- Secure communications
  - Strict authentication and access control between entities connecting to the hub
- Asynchronous communications
  - "fire-and-forget"
- Reliable messaging
- Handle of large volumes of message traffic
- Need that segregated groups of backend apps expose and share their interfaces and data with other apps residing in other trading hubs
  - Maintaining their autonomy!
- BUT traditional MOM vendors did not have an infrastructure capable of spanning across Internet in a scalable and secure fashion

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Context (Comment #1)

- Different levels of trust when dealing with business partners
  - Reliable messaging requires a piece of MOM installed on either side of the communication link
    - BUT business partners are not always in a position to install software on the partner-side
    - If the relationship is not that close (or not that stable) you need to supply clear instructions on how to send business documents over secure HTTP

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Standards! (Comment #2)

- What do we mean when talking about standards?
  - In this context it refers to an specification or implementation that has gained enough traction in the industry with
    - Staying power
    - Open enough for multiple vendors

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Standard-based Integration

- Why adopting standards?
  - (in-house) IT professionals with expertise
    - e.g. XML-related technologies (SOAP, WSDL, XSLT, XPath, XQuery,…)
    - Allows developers to apply this knowledge across a variety of (integration) projects
  - Increases the ability to integrate with business partners using standard interfaces and protocols
    - E.g. Java standards (JMS, JCA)
  - Reduces proprietary vendor lock-in

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Towards the Integration Process

- Consider now …
  - Business Process definition
    - Represents a series of steps in a flow between apps
    - Steps can be mapped into service endpoints representing physical apps
    - Now it is possible to administratively insert additional steps into that path of control flow
      - Without modifying the apps directly
  - Content-based routing
  - Data transformation

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Towards the Integration Process (2)

- Complex integration tasks can be carried out through a sequence of inspection, routing and transformation combined with XML
- Greater flexibility in the coordination of development timelines of the apps that are driving the requirements

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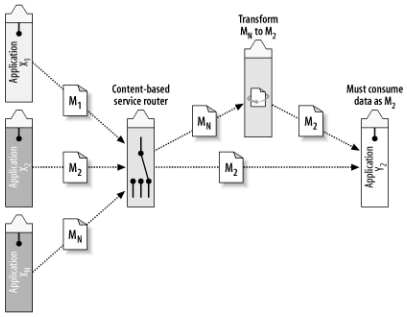
Towards the Integration Process (3)



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Towards a Generic Data Exchange

- When using specific point-to-point transformations between apps, the number of transformation instances increases exponentially with the number of apps
- Data translation to and from a Canonical format
  - A canonical, app-independent version of the data is key
  - Best-practice: decide on a set of canonical XML formats
    - Companies standardize the definition of common business entities
- The level of "format" is at the business-object level
  - e.g. the definition of a purchase order, or shipping address
  - Vertical dialects
    - Commerce relies mostly on xCBL
    - financial services rely on SWIFT
    - Healthcare on HIPPA or HL7

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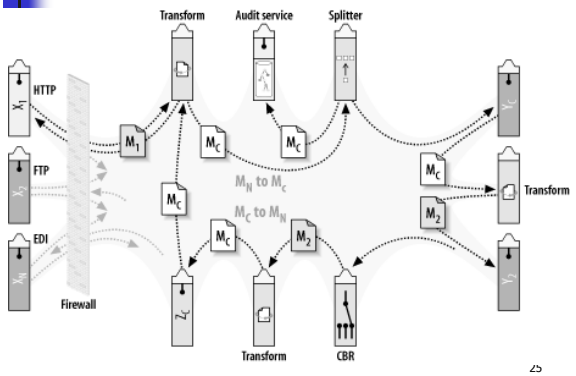
Towards a Generic Data Exchange (2)



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Canonical - Benefits

- Each app focus on only one type of transformation to and from a common format
- New apps can adopt the canonical format directly
  - Not anticipated apps can tap into the flow of messages
- Services can be written to use the canonical format
- Standard stylesheet templates and libraries can be created and reused throughout the organization

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ESB: Service Containers and Abstract Endpoints

Enterprise Service Bus (ESB)

- Provides a loosely coupled, highly distributed approach to integration
- An ESB consists (basically) of …
  - Message Oriented Middleware
    - Robust, reliable transport
    - Efficient movement of data across (abstract) channels
    - End-to-end reliability
  - Web Services
    - Service-oriented Architecture (SOA)
    - Abstract business services
  - Intelligent Routing
    - Based on content and context
    - Based on business process rules
  - XML data transformations
    - Based on XSLT and independent deployed services

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ESB Infrastructure Requirements

- Highly distributed, scalable service containers
- Event-driven service invocation
- Centralized management of distributed integration configurations
- Diverse client connectivity and support for multiple protocols
- Unified security and access control model
- Distributed configuration and caching of deployment resources
  - Such as transformation scripts, routing rules
- Scriptable and declarative environment
- Changeable behavior of integration components based on configuration and rules
  - Instead of compiling behavior into code

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An ESB …

- Can integrate apps built with .NET, C#, …
- Can utilize J2EE components (JMS, JCA,…) and the J2EE WS APIs
- XML standards
  - XSLT for data transformation
  - XPath for data access and intelligent routing
  - XQuery for querying "in-flight" data
- All these provide an open-ended, pluggable, service-oriented architecture
  - Supporting both industry-standard integration components as well as proprietary elements (through standardized interfaces)
- Three key elements, the use of:
  - Abstract endpoints (for representing remote services)
  - Internet-capable MOM
  - Distributed lightweight service container

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Abstract Endpoints

- For the integration architect all applications and services are treated as abstract endpoint
- Logical abstractions of services that are plugged into the bus
- Endpoints represent diverse things
  - a single, monolithic app (like payroll system)
  - a suite of applications
  - an ERP
  - an integration broker
  - a business unit
  - an interface to a business partner

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Abstract Endpoints

- All service endpoints are equal participants in an event-driven SOA
- Building out an integration network involves:
  - tying together service endpoints,
  - applying choreography,
  - transformation and
  - routing rules … into process flows between apps
- This allows the use of high-level tools to assemble service endpoints into process flows

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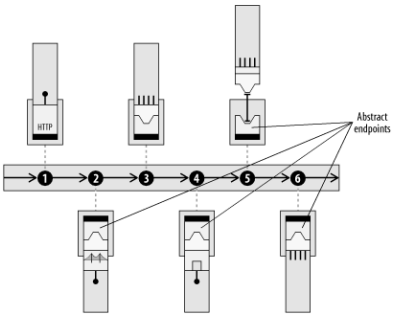
Endpoints – Abstract View



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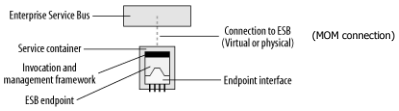
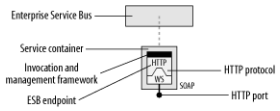
(Notations)

- Generic ESB endpoint



- SOAP or web service endpoint



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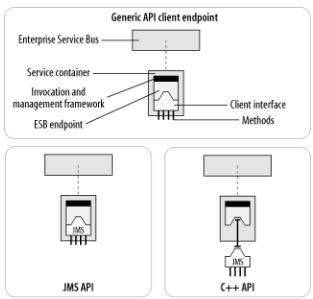
(Notations)

- ESB client API endpoint



Exposes methods that an app or service would use to plug into the bus

Pure java, relying on JMS

separation between the physical implementation of the C++ client and the endpoint.

Java and C++ via JNI or network layer

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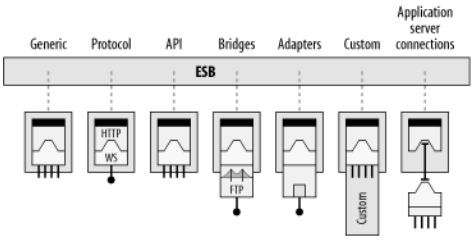
(Notations)

- Various client types and protocols



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Connectivity at the Core

- Highly scalable enterprise messaging backbone is key!
  - Capable of asynchronously transporting data as messages in a secure an reliable fashion
- The messaging core could be:
  - A proprietary MOM
  - a MOM based on JMS
  - a MOM based on WS-ReliableMessaging
  - a generic messaging engine

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Connectivity at the Core (2)

- The endpoint provides an abstraction away from the underlying protocol
  - Allowing the underlying protocol to vary depending on the deployment situation and the QoS requirements
- It is responsibility of the ESB to map the high-level process flows into individual service invocations across the designated transport

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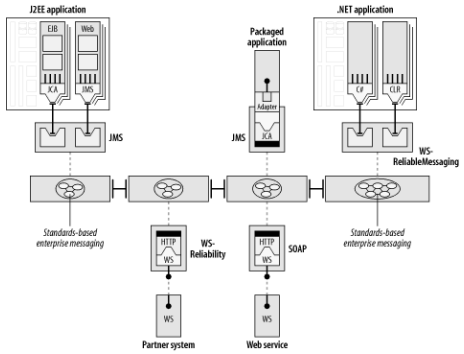
Connectivity at the Core (3)



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A diversity of connection choices

- Context
  - IT departments cannot adapt significantly legacy apps
  - At least it may be capable of dumping and loading flat files and transmitting them over FTP
  - The app in question may have never been intended to interface with anything
  - The app my have exposed a low-level, network socket-level interface as part of a point-to-point integration project
  - The app may reside at a business partner's site, being able to interoperate by using SOAP/HTTP
  - The app may rely on EDI
- Applications that want to connect to the ESB do not require drastic changes
  - It is the bus (not the apps) that provides the flexibility in connection technologies

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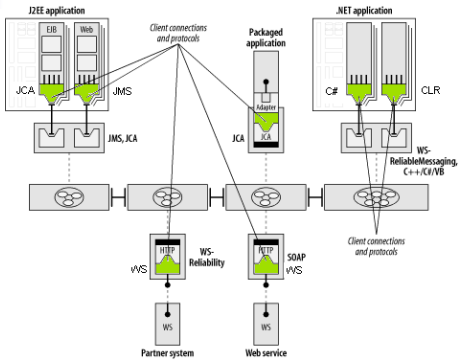
A diversity of connection choices



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Integration Services

- These services allow apps easy interoperability, for instance
  - Transformation service
    - Applies a transformation from one format/context/data structure to another
      - an XSLT stylesheet to convert in-flight XML messages from one XML dialect to another
  - Routing service
    - Evaluates expressions against in-flight messages to determine where to send it next
      - Applies an XPath expression to look into the XML document to decide destination
  - Logging
    - Copy the message for auditing and tracking purposes

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Integration Services (2)

- They can be independently deployed anywhere within the network
  - Precise deployment of integration capabilities at specific (demanding) locations.
  - Can scale independently
- As a result services can easily be
  - upgraded,
  - moved,
  - replaced or
  - replicated …

  without affecting cooperating apps

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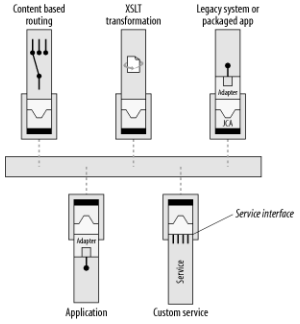
Integration Services (3)



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ESB Service Container

- Physical manifestation of the abstract endpoint
- Provides the implementation of the service interface
- Is a remote process that can host software components
  - With the goal of hosting integration services
- Simple and lightweight

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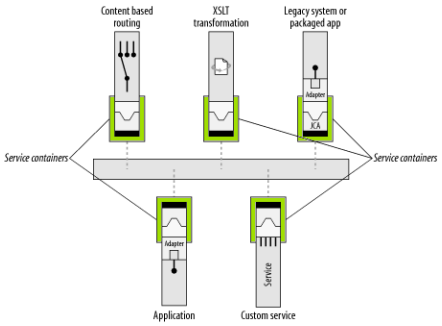
ESB Service Container (2)



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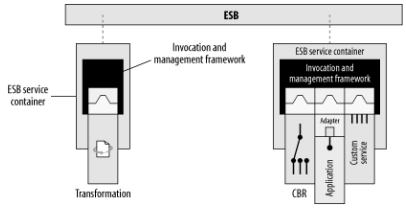
ESB Service Container (3)

- Can host a single service or can combine multiple services



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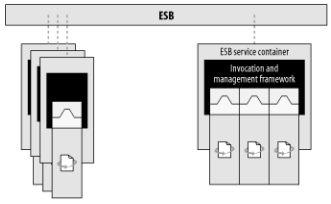
ESB Service Container (4)

- Services may be scaled within a container, and several containers may be scaled across multiple machines



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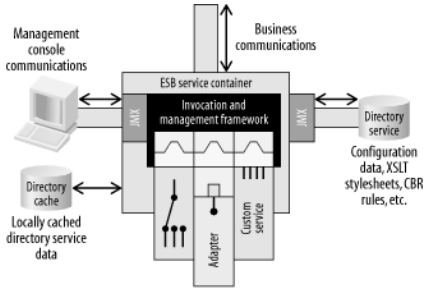
Anatomy of a Service Container

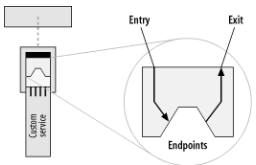
- Supports the retrieval of configuration data from a directory service
  - including a local cache of configuration data
    - If directory service becomes temporarily unavailable it can continue to operate
- Management input data includes
  - Start
  - Stop,
  - Shutdown and
  - Refresh cache
- Management output data consists of event tracking
  - e.g. successful execution of a service or a failure occurred
- Management console (or some other mgmt tool)
  - To manage input and output data
  - Relying on standard protocols as SNMP

Anatomy of a Service Container



The ESB Service Interface

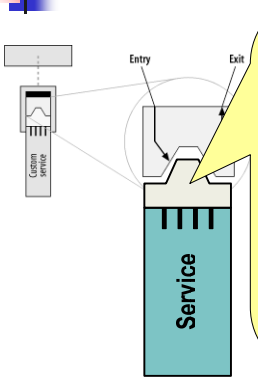
- A container manages an entry endpoint and an exit endpoint
  - Used by the container to dispatch a message to and from the service



The ESB Service Interface (2)

- (XML) messages are received by the service from a configurable entry point
- Upon completion of its task, the service implementation simply places its output message in the exit endpoint
  - The exit message may be based on the input or on a completely new one
  - In sophisticated cases, one input message can transform into many outputs

The Service Interface (3)




```
public void service(ESBServiceContext ctx)
throws ESBServiceException {

   // Get any runtime process parameters.

   Parameters params = ctx.getParameters( );

   // Get the message.
   ESBEnvelope env = null;
   env = ctx.getNextIncoming( ); // entry
   if (env != null) {
      ESBMessage msg = env.getMessage( );
      ...
     //  Perform the service
      //  Operate on the message
}
// Put the message to the Exit Endpoint
ctx.addOutgoing(env); // exit
}
```

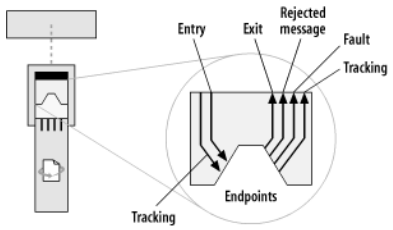

Auditing, Logging and Error Handling

- Important business function within an integration strategy
- Allow to track the exchanged data at a business level
- An ESB container provides an auditing and logging facility
- Multiple sources for tracking data
  - System-level
    - Info about the service itself
    - The flow of messages can be tracked and monitored
  - Application-level auditing, logging and fault handling
    - Accomplished through additional endpoints

Auditing, Logging and Error Handling

- Additional endpoints:
  - Tracking endpoint
    - A service can place a message in the tracking endpoint in addition to the normal exit endpoint
  - Rejected-message endpoint
    - Can be used for system-level errors, e.g. malformed XML documents or a service throwing exceptions
  - Fault endpoint
    - Any app-level errors or faults
- The service implementation has these endpoints available
  - It simply places data/messages in the corresponding endpoint
- Endpoints can be configured separating the implementation of the service from the details about e.g. a fault handling

Auditing, Logging and Error Handling



Auditing, Logging and Error Handling

- Tracking can be handled at both
  - the individual service level
    - Faults and auditing can be tied to the context of the greater business process
  - the business process level
    - May make use of different implementations of individual services over time
- Auditing and logging can be also done at the ESB level
  - e.g. placing a persistence service in the path of messages in a process flow
    - Less intrusive to each individual service implementation

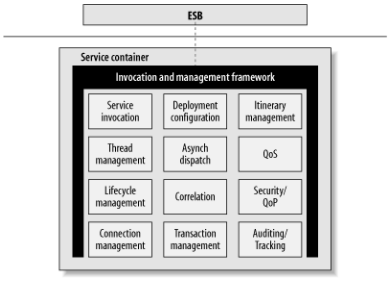
ESB Service Container Facilities

- The ESB provides a variety of facilities that a service implementation may use
  - Location
  - Routing
  - Service invocation
  - Management
  - Lifecycle management
    - Startup, shutdown, resource cleanup
  - Transaction service
  - Thread pooling
  - Connection management
    - Bindings to the underlying MOM
    - Fault tolerance and retry logic
  - Quality of Protection (QoP) and security
  - Quality of Service (QoS)

ESB Service Container Facilities

- Some of these are (best) delegated to the underlying MOM
- The container facilities represent an agreement between the container and the underlying middleware
  - Each facility has its own configuration that can be dealt with relying on an administrative tool (part of the ESB)
    - e.g. QoS for exactly-once delivery would be set as an administrative property of a service (not coded into the service)

ESB Service Container Facilities



Administration of ESB Facilities

- Full-blown GUI
- Command-line interface
  - For those accustomed to automating processes by building scripts
- API
  - There may be a legacy administrative tool in place

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ESB Service Invocation

- The traditional find/bind/invoke model requires writing the routing and flow logic into the apps that need to be connected
- In ESB basic design a service is not invoked directly by another service, but is part of a larger event-driven process flow
  - Find/bind/invoke occurs as part of the ESB mechanism, but it is separated out from the business logic
    - The implementation of a service:
      - Simply deals with an entry/exit endpoint metaphor
      - Focus only on the implementation logic of a service

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ESB Service Invocation

- A service receives a (XML) message (request) from an entry endpoint
- Upon completion of its task, the service implementation places its output message (reply) in the exit endpoint
- Find/bind/invoke are not defined by written code but through configuration and deployment tools

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Message Routing

- Service definition is separated from the mechanism for locating and invoking services
- The integration architect administratively defines a composite business process flow by plugging services together into a message itinerary
- Message itinerary are to enabling a highly distributed SOA across an ESB
- Details of the itinerary…
  - are stored as metadata on the message (header)
  - carried with the message as it travels across the bus
- The ESB service container knows how to evaluate the itinerary of messages combined with configuration knowledge

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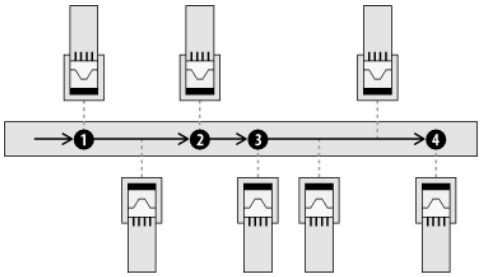
Itinerary-based Routing



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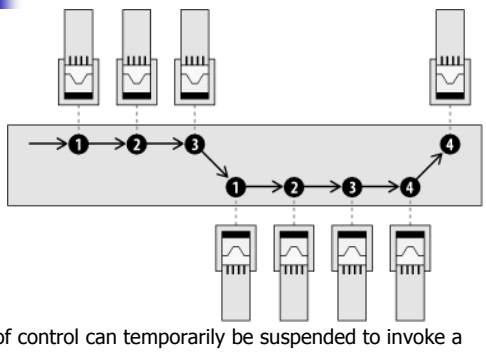
Itinerary-based Routing



Flow of control can temporarily be suspended to invoke a subprocess, and then resumed when the subprocess returns

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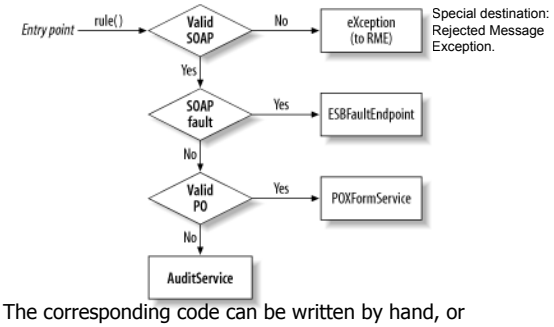
Content-based Routing

- The routing service relies on the invocation of a rule() method to perform routing logic
  - a validation step may be included
- Routing rules can be expressed and processed with different technologies
  - XML, javascript, java, BPEL, …
- A destination may be:
  - another service,
  - another process itinerary,
  - a MOM endpoint,
  - or an external web service
- Metadata and rules processed at the remote container (not by the centralized rule engine)
  - As opposed to the traditional hub-and-spoke EAI broker

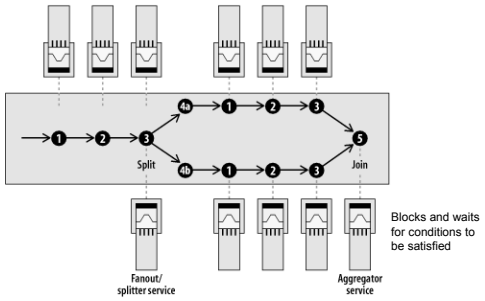
Content-based Routing



The corresponding code can be written by hand, or generated from a GUI interface.

Sophisticated Routing Strategies

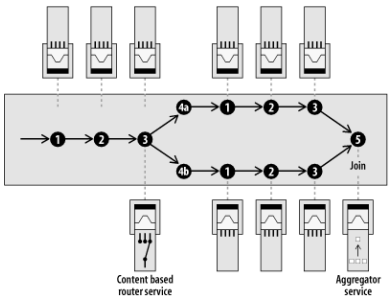
- Multi-itinerary splitter pattern



Multiple paths of execution to happen in parallel

Sophisticated Routing Strategies

- Multi-itinerary CBR pattern

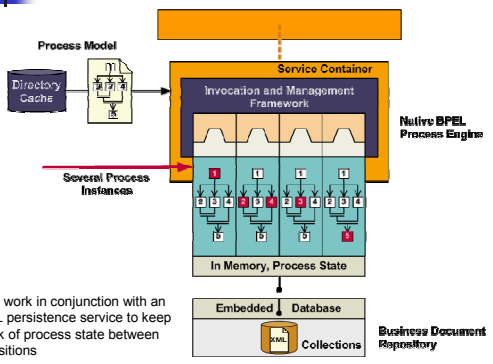


Choose between multiple possible paths

Sophisticated Process Flow

- Branching conditions could be also described using BPEL4WS
- BPEL can handle more complex situations than itineraries
- Requires an orchestration service
  - Can manage stateful information about a business process that spans a length of time
  - Business processes may include human interaction (e.g. approvals, …)
- Itineraries can carry state and recover from failures

Process Flow – BPEL



Can work in conjunction with an XML persistence service to keep track of process state between transitions

Routing – Handling Failures

- Routing rules are not treated in a centralized way
  - No single point of failure
  - Partial unavailability of the ESB network does not affect everyone
  - Configuration info can be also cached locally
- What to do with a RME message?
  - Handled by an error-handling service
  - Incorporated into an auditing and logging
  - To custom logic applied to the message based on more business rules

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XML Storage Service

- Storage
  - Could be implemented using a RDBMS with XML2Rel mappings
  - Native XML may be best suited
- Storage service can be used to collect data from multiple data sources
  - Can enable BAM functionality

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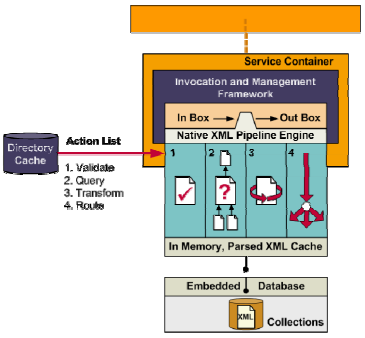
XML Server



- Multi-steps operating on the same instance of an XML doc
- Parsed only once
- Forming an XML processing pipeline

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The ESB MOM Core

- Capable of supporting a variety of industry-standard access mechanisms and protocols
- Multi-protocol messaging bus
  - Supports async delivery of messages with configurable QoS options
  - Primary means of getting into and out of the ESB
- Scalable clustering
- Physical topology is independent of the service-oriented view of an ESB process flow
- Routing details are not exposed to the application level or the ESB process level

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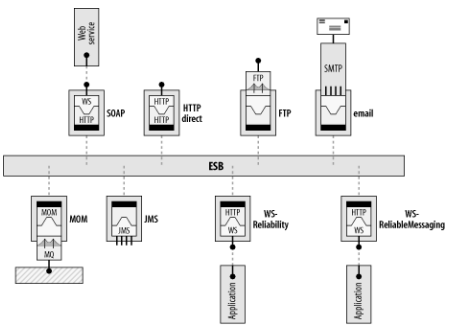
The ESB MOM Core



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The ESB MOM Core – Benefits

- Consistent QoS levels
- Consistent management
- Metrics and monitoring
- Consistent troubleshooting techniques
- Consistent scalability methodology
- Consistent performance tuning techniques
- Consistent security and ACL model
- Publish/Subscribe broadcast of information
- Message persistence and reliability of message delivery

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MOM Interoperability

- JMS is the only adopted standard for MOM
  - But it does not define interoperable on-the-wire format
    - The wire protocol is proprietary of a MOM vendor for providing highly efficient reliable delivery of messages
- WS-Reliability and WS-ReliableMessaging are industry efforts that define an open interoperable wire protocol for reliable messaging
  - Based on the SOAP protocol

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MOM Interoperability (2)

- Having an open protocol means that the MOM piece of software on either side of the conversation can be provided by different vendors
  - Less room for innovation on efficient delivery and reliability
- 80/20 Rule (domain dependent :)
  - 80% you need just one MOM vendor
  - 20% you'll be mixing MOM vendors via bridging technology

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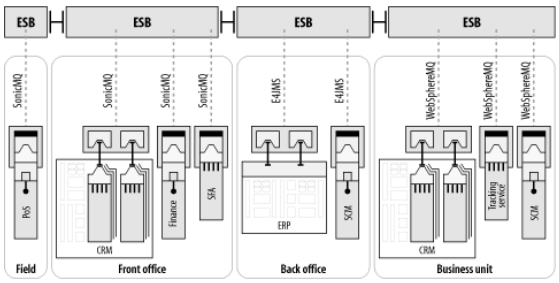
MOM Interoperability



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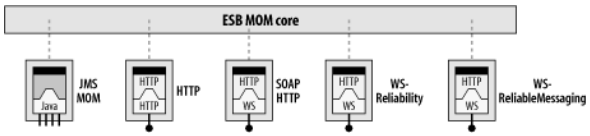
Direct Protocol Handlers

- The message broker itself provides the bridging, or mapping, between the external protocol and the internal MOM channel



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Direct Protocol Handlers – HTTP

- HTTP Invocation from an "external" client
  - ESB listen for inbound HTTP or SOAP requests
  - The protocol handler performs a mapping of the HTTP content into a JMS message
  - Places the JMS message into a queue or pub/sub destination
  - When the response arrives at the outbound queue it is sent back to the HTTP protocol handler

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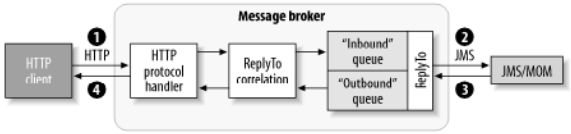
Direct Protocol handlers – HTTP



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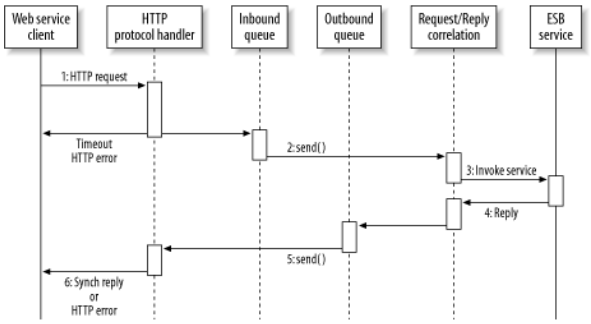
Direct Protocol handlers – HTTP



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Direct Protocol handlers – aHTTP

- Asynchronous R/R may be required since
  - The service represents an interface to an app with regular maintenance phases
  - The service represents an app that still relies on nightly batch processing
  - The process involves some human intervention

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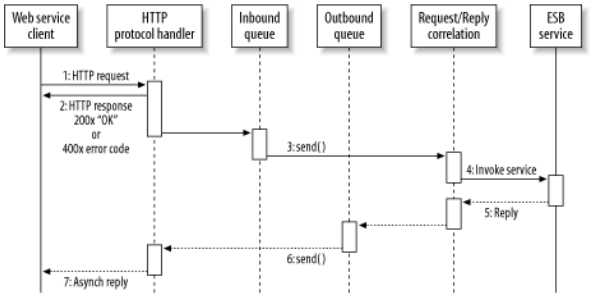
Direct Protocol handlers – aHTTP



The inbound request must contain a URI indicating where to send the reply

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Service Reusability

- In an ESB, services are meant to be reusable
- An ESB service is an instance of a service type
  - Reusability by instantiating a particular type and applying variable data and conditions through parameterization and configuration
    - e.g. transformation service

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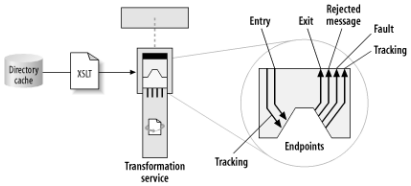
Service Reusability by Config.

- All the endpoints are configurable
- The nature of the transform can be determined by the docs that get fed into the service



Auditing capabilities may be introduced for certain documents

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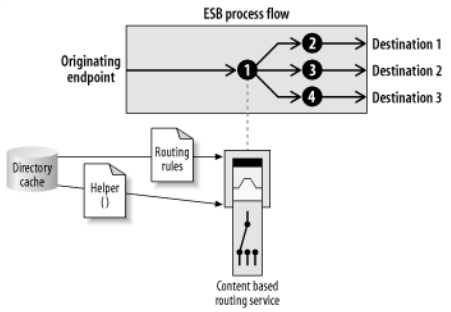
Service Reusability by Config.



Helper functions include validation and other kind of useful functionality that can be shared among rules

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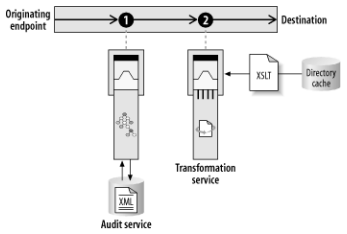
Service Reusability by Composition

- Specialized services may be connected to form a composite business process



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ESB Characteristics

- Pervasiveness
- Highly distributed, event-driven SOA
- Selective deployment of integration components
- Security and reliability
- Orchestration and process flow
- Autonomous yet federated managed environment
- Incremental adoption
- XML support
- Real-time insight

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ESB – Wrap up

- Integrate across a common backbone to gain real-time access to the business data that is flowing between participants
- An app can rely on the ESB to provide a uniform, consistent approach to sending and receiving data
  - An app plugs into the bus
  - It posts data to the bus
    - It is responsibility of the ESB to get it where it needs to be
    - In the target data format that it needs to be in

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ESB – Wrap up

- It separates the business process routing logic from the implementation of the apps that are being integrated
  - App owners do not need to worry about integration (e.g. routing, validation, …)
- Message itinerary very powerful and flexible
  - Through configuration and management tools, additional processing steps can be inserted as event-driven services
  - (processing pipeline)

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ESB – Wrap up

- ESB supports SOA across a series of abstract endpoints
  - Endpoints can represent apps and services of any size
- ESB is a managed environment
- ESB provides facilities that make the development, deployment and maintenance of integration services easy
- Unified view of security
- ESB MOM core as the basic infrastructure to build higher-level SOA
  - The details of creating and managing the messaging channels or setting QoS options are encapsulated in a contained-managed environment
    - Is configured instead of writing application code

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ESB – Wrap up

- Traditionally when dealing with MOM apps need to written code that
  - Establishes connection with the message server
  - Creates publishers, subscribers, queue senders and receivers, managing transactional demarcation and recovery from failures
- An ESB removes this complexity by delegating that responsibility to the ESB service container
  - Container relies on configurations

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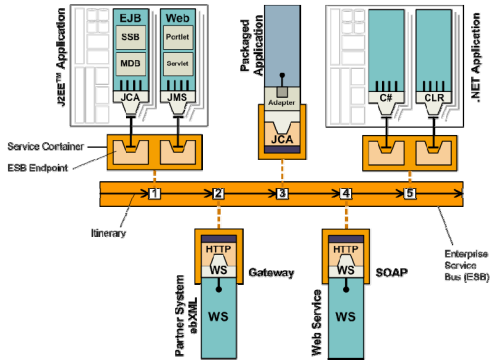
ESB – Big Picture



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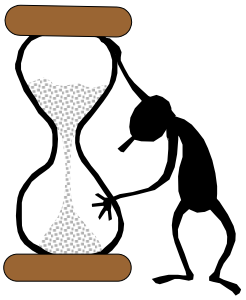

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