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Introduction to Middleware

Madhu Venkat

Guest Faculty
BITS, WILP

In this segment

Introduction to Middleware

- What is a Distributed Transaction ?
- What is Middleware ?
- Middleware in Distributed computing
- Different forms of Middleware

What is a Transaction ?

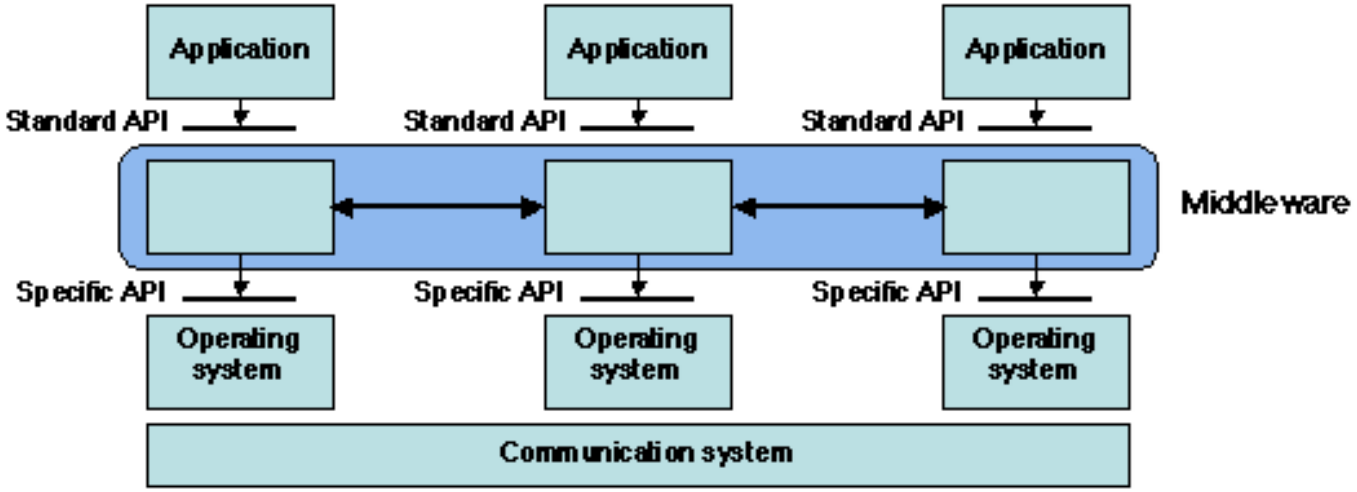
Transaction

- “A transaction symbolizes a unit of work performed (comprising of multiple operations if needed) within a system (distributed or monolith) and treated in a coherent and reliable way independent of other operations.”
- Properties of a Transaction:
  - Atomic
  - Consistent
  - Isolated
  - Durable
- All or Nothing mode of operation
- Ex: Funds transfer (debit remittance account and credit beneficiary account)

What is Middleware ?

What is it ?

- “Middleware is the software that connects software components or enterprise applications in a distributed system”.
- Examples: Enterprise Application Integration software, telecommunications software, transaction monitors, and messaging-and-queueing software.



Middleware in Distributed computing

What does it do ?

- Lies between the operating system and the applications on each side of a distributed computer network
- Hides the intricacies of distributed applications
- Hides the heterogeneity of hardware, operating systems, and protocols
- Provides uniform and high-level interfaces used to make interoperable, reusable and portable applications
- Provides a set of common services that minimizes duplication of efforts and enhances collaboration between applications

Middleware – common forms

Commonly used Architectures of Middleware

- Sockets
- Remote Procedure Calls
- Distributed Object Oriented Components (Ex: ORB)
- Message Oriented Middleware (Message Queues/ Enterprise Message Bus etc.)
- Service Oriented Architectures
- Web services (Arbitrary / RESTful)
- SQL-oriented data access
- Embedded middleware
- Cloud Computing

Thank You!

In our next session:

Socket Data structures

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Introduction to Enterprise Application Integration (EAI)

Madhu Venkat

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In this segment

Introduction to Enterprise Application Integration

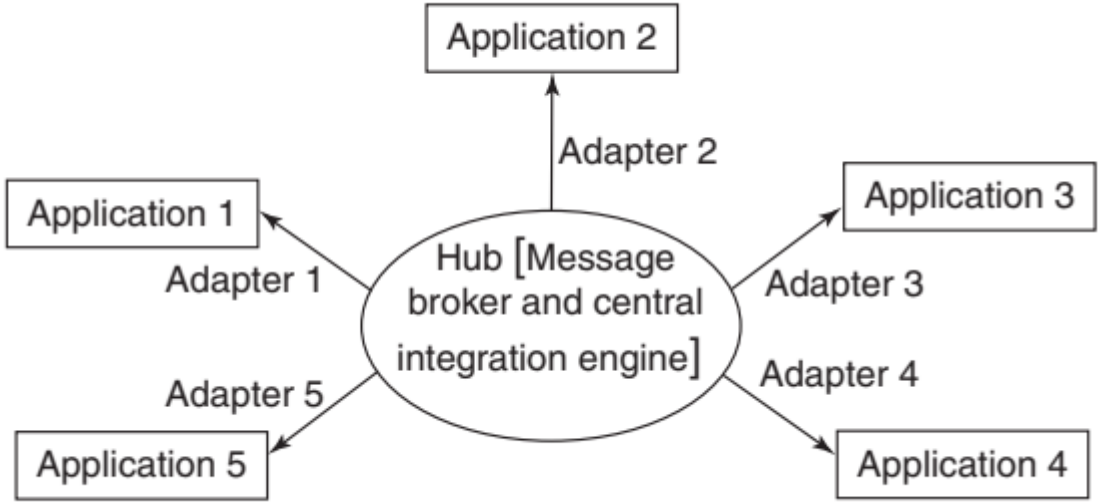
- EAI – Overview
- Message Channels
  - Point to Point messaging
  - Publish-subscribe model

Introduction to EAI

- Enterprise application integration allows diverse applications in an enterprise to communicate with each other to achieve a business objective in a seamless reliable fashion irrespective of platform and location of these applications.
- EAI comprises message acceptance, transformation, translation, routing, message delivery and business
- To achieve this,either Hub/Spoke or Bus Architecture can be used.

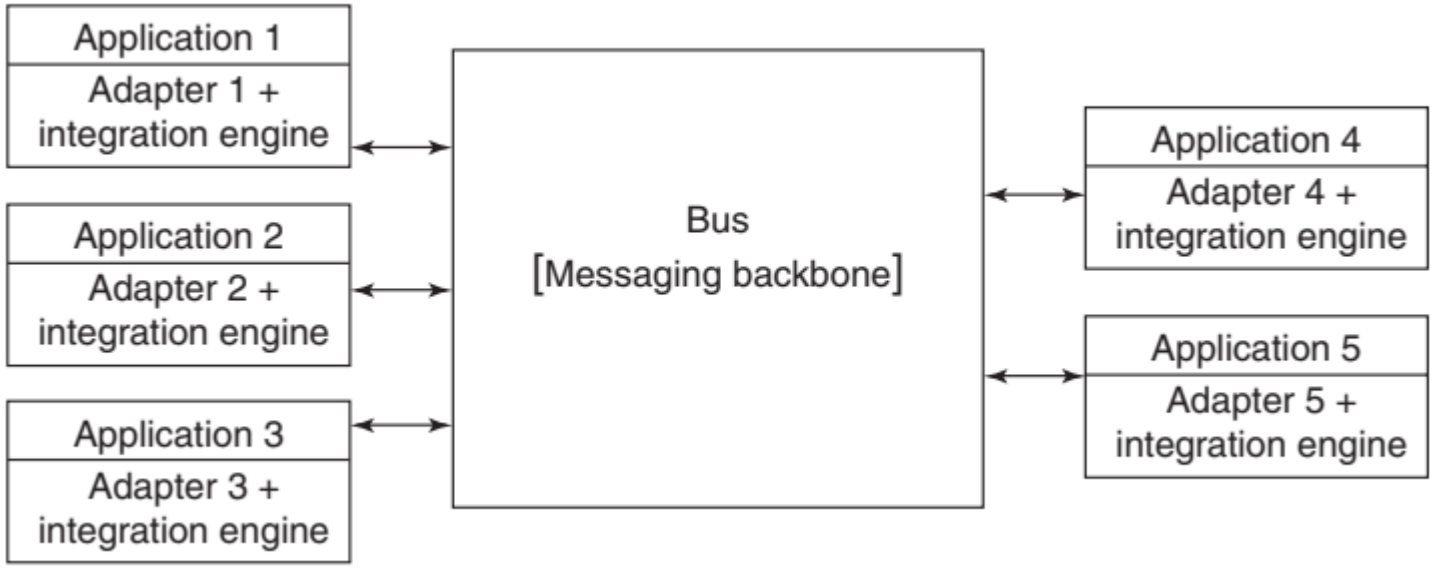
Hub/Spoke Architecture

- Hub has the centralized integration engine, which makes system with this architecture easy to manage and maintain but loses on scalability.



Bus Architecture

- In the bus architecture, adapters have integration engine and run on the same platform on which source and target applications run; and therefore it scales better but it is difficult to maintain.



Enterprise Application Integration (EAI)

Introduction

- An integration framework composed of a collection of technologies and services which form a middleware or "middleware framework" to enable integration of systems and applications across an enterprise
- *"unrestricted sharing of data and business processes among any connected application or data sources in the enterprise" - Gartner*
- Application of EAI
  - Data integration
  - Vendor/3rd party independence
  - Common façade
- Patterns
  - Mediation
  - Federation

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Introduction to Enterprise Bus (EB)

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In this segment

Introduction to ESB

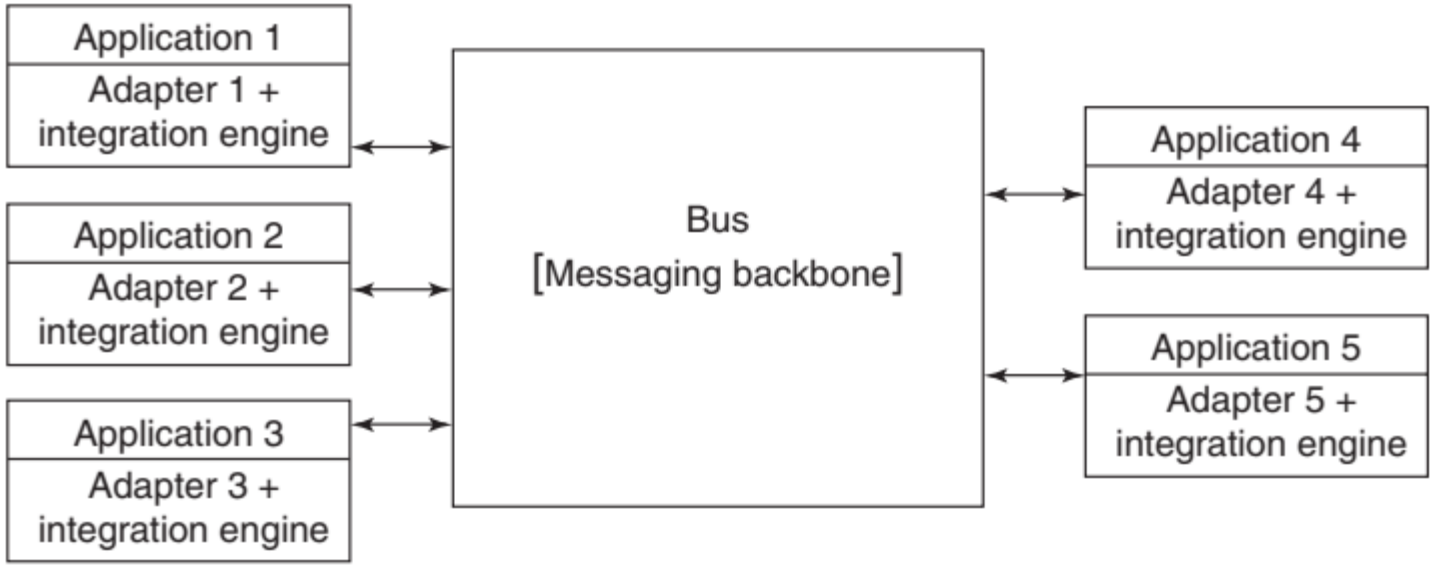
- ESB – Overview
- Capabilities of an ESB
- Why ESB is important?
- ESB challenges

Defining the ESB

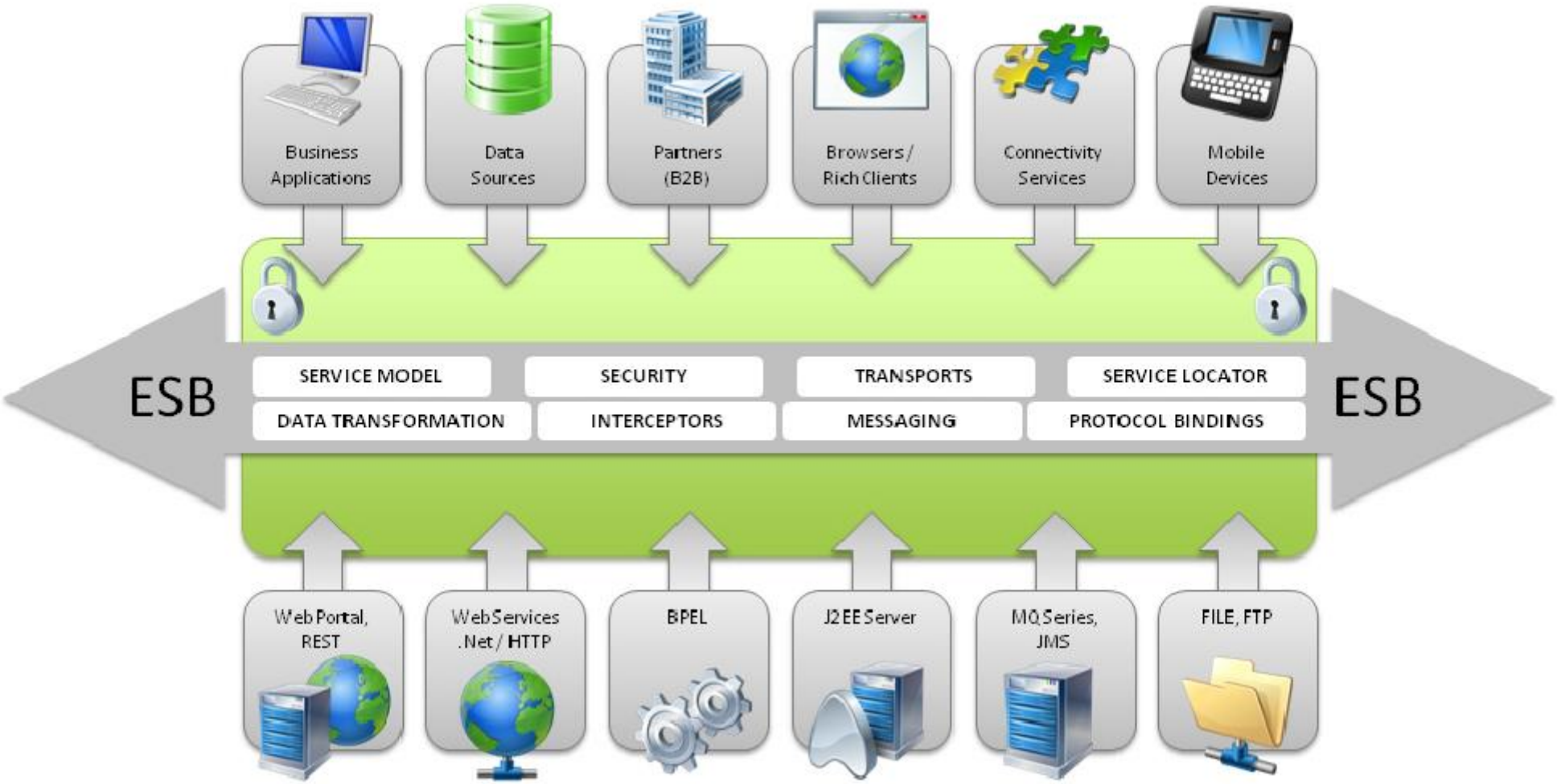
- "A style of integration architecture that allows communication via a common communication bus that consists of a variety of point-to-point connections between providers and users of services."
- "An infrastructure that a company uses for integrating services in the application landscape."

What is an ESB?

- A bus based architecture to enable integration of multiple heterogenous systems in an efficient manner.
- A sophistication over traditional P2P integrations
- ESB acts as an intelligent middleware to enable communication among different systems/application.



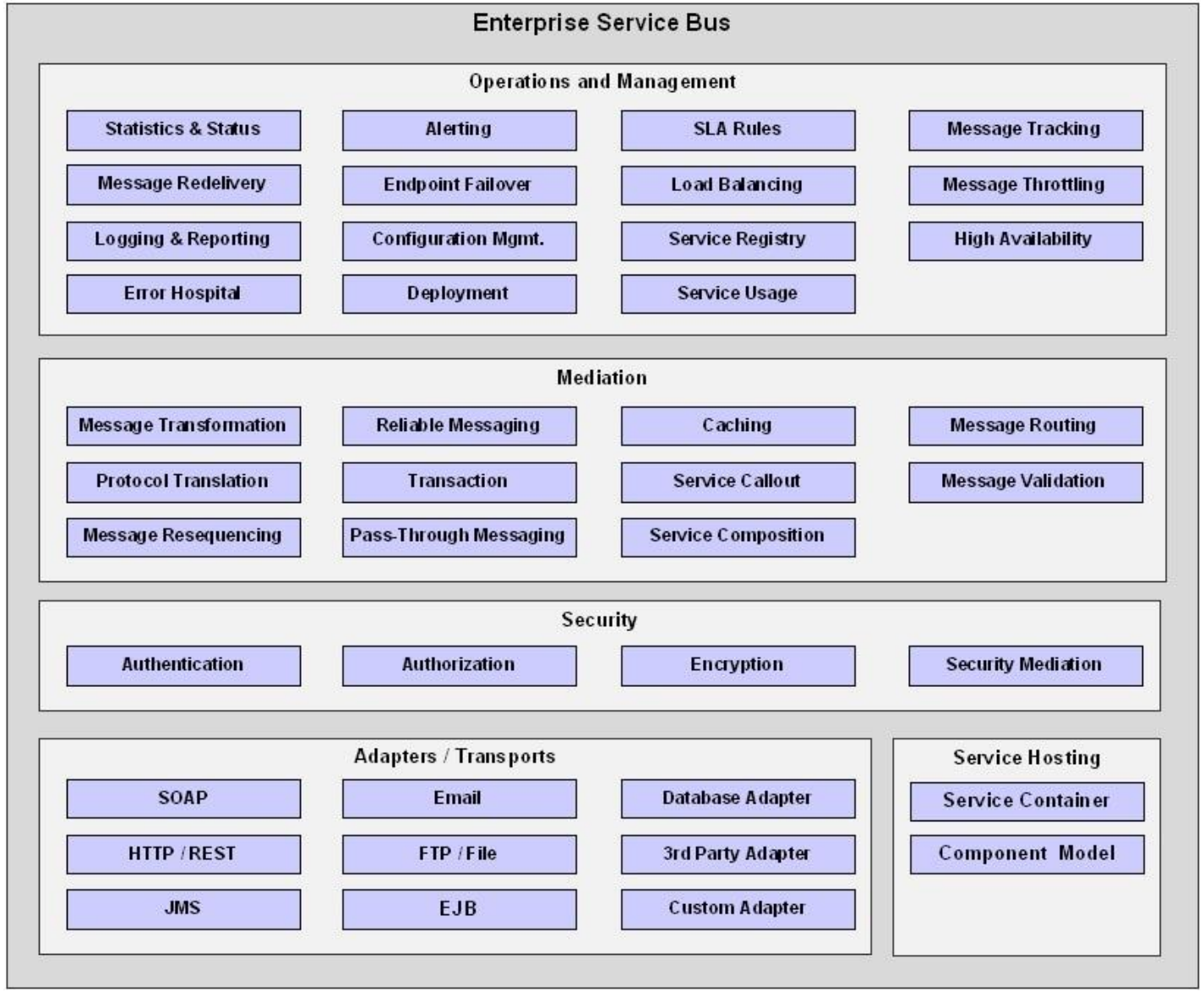
ESB Architecture



Capabilities of ESB

- **Routing** – Logically route data to different integrated servers/applications.
- **Orchestration** – Combining functionalities of discrete services to provide aggregated services.
- **Transformation/Translation** – Data formats transformations and translations as per connected application needs. Example (SOAP to Rest , JSON to XML conversions)
- **Mediation/Message Enrichment** – Customize, enrich, re-format messages as a middleware/mediator.
- **Transportation/Protocol conversions** – Transportation of data between connected systems as per supported transport protocols.
- **Non-Functional Consistency** – Enforcement of security policies, monitoring, management , HA/FT

ESB Blueprint



When Should an ESB be used?

- The use of an ESB is worth considering when three or more applications or services need to be integrated.
- A simple point-to-point integration is significantly easier and much more cost-effective when connecting two applications.
- An ESB can also be worthwhile if services are going to be incorporated from external service providers over which the company has no control.
- The ESB can then be used to monitor the service level agreements that the external provider guarantees.
- If many different protocols, such as HTTP, SOAP, and FTP, are to be used and standardized to one protocol like SOAP, the ESB can perform the necessary protocol transformation.
- If services are to be consistently incorporated into an architecture to be able to receive, process, and produce messages, then the use of ESB is also suitable.

Why ESB is important?

- Efficient decoupling of multiple systems/applications.
- Better use of integration capabilities.
- Improved time to market and conditions.
- Better synchronization for upgrades, monitoring and management of integration layer

Challenges with ESB

- ESB itself can become a bottleneck and a single point of failure.
- ESBs have associated regression of risks with dozens of heterogenous systems/applications connected.
  - Changes/upgrades to a single fat middleware may have ripple effect on many functionalities.
- ESB products have a learning curve involved and lack of professionals in the market.

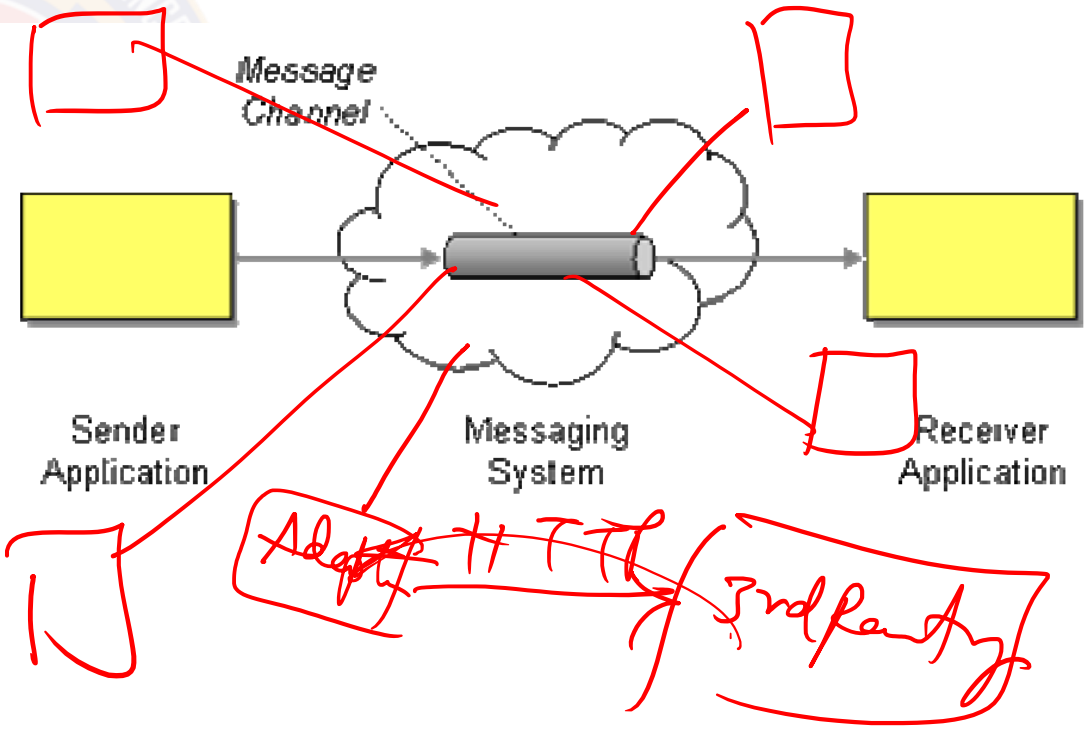
ESB tools

- IBM Websphere
- Microsoft BiZtalk
- Oracle ESB
- Mule ESB
- RedHat JBOSS Fuse

Enterprise Application Integration (EAI)

Message Channels - Overview

- Message Channel works as a logical addressing system in Messaging
- Messaging Channel acts as a medium of communication between two specific applications in a complex enterprise, where in the sender application selects which particular ”channel” of the messaging system to use, that designates the target application/ group of applications.
- Design challenges
  - One to one or one to many
  - Data type channel
  - Invalid and dead message handling
  - Crash proof design / Guaranteed delivery
  - Non-messaging client access - Channel adapter
  - Communications backbone – Message bus



Enterprise Application Integration (EAI)

Message Channels – Example (JMS)

- Configuring Message channels (Queues and Topics)

```
j2eeadmin -addJmsDestination jms/mytopic topic
j2eeadmin -addJmsDestination jms/myqueue queue
```

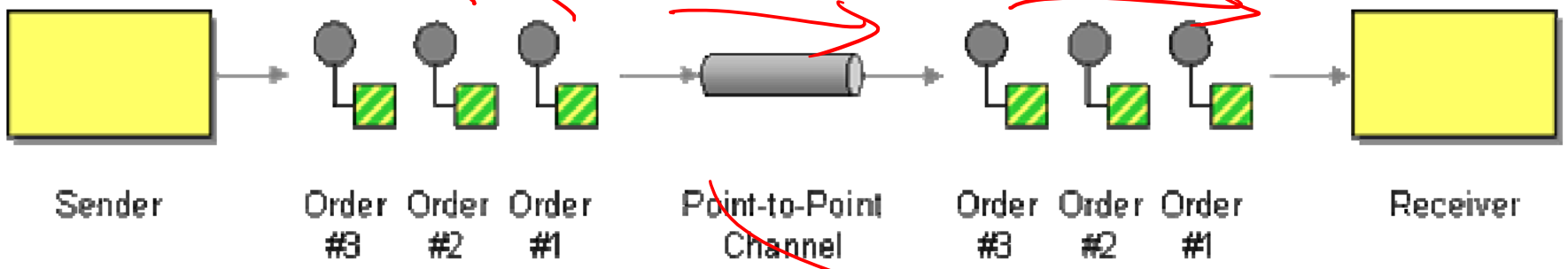
- Accessing Message channels

```
Context jndiContext = new InitialContext();
Queue myQueue = (Queue) jndiContext.lookup("jms/myqueue");
Topic myTopic = (Topic) jndiContext.lookup("jms/mytopic");
```

Enterprise Application Integration (EAI)

Point to point channel

- Point-to-Point Channel ensures that only one receiver consumes any given message, irrespective of number of receivers in that channel
- Increases scalability in multi consumer applications
- JMS Implementation uses 'Queue' interface to implement Point to point channel
  - QueueSender – send messages
  - QueueReceiver – receive messages



Enterprise Application Integration (EAI)

Point to point channel – Example (JMS)

- Sending message

```
Queue queue = // obtain the queue via JNDI
QueueConnectionFactory factory = // obtain the connection factory via JNDI
QueueConnection connection = factory.createQueueConnection();
QueueSession session = connection.createQueueSession(true, Session.AUTO_ACKNOWLEDGE);
QueueSender sender = session.createSender(queue);

Message message = session.createTextMessage("The contents of the message.");

sender.send(message);
```

Enterprise Application Integration (EAI)

Point to point channel – Example (JMS)

- Receiving message

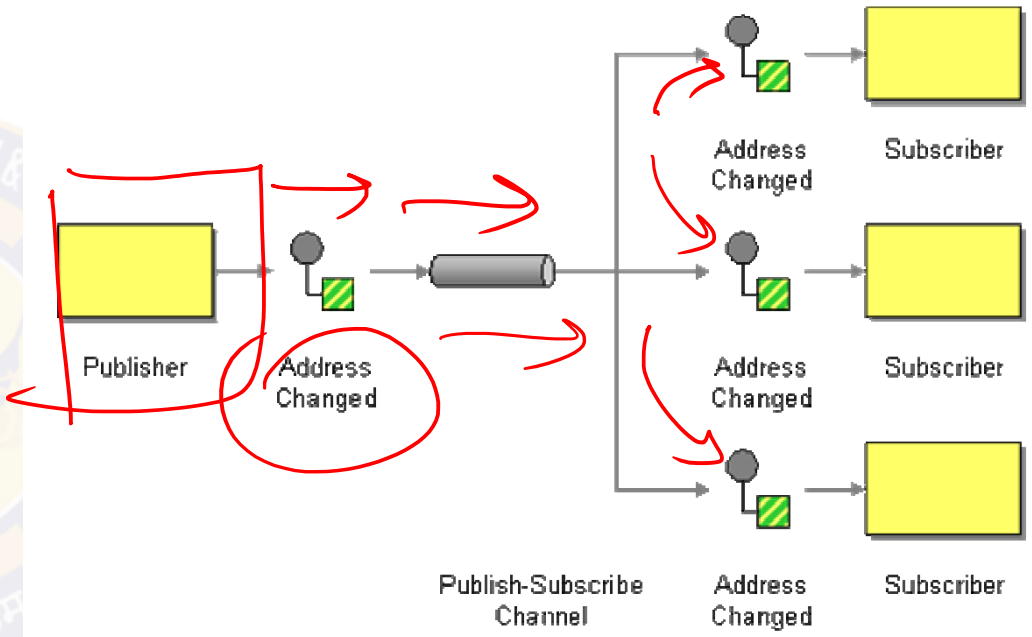
```
Queue queue = // obtain the queue via JNDI
QueueConnectionFactory factory = // obtain the connection factory via JNDI
QueueConnection connection = factory.createQueueConnection();
QueueSession session = connection.createQueueSession(true, Session.AUTO_ACKNOWLEDGE);
QueueReceiver receiver = session.createReceiver(queue);

TextMessage message = (TextMessage) receiver.receive();
String contents = message.getText();
```

Enterprise Application Integration (EAI)

Publish - subscribe channel

- Used for broadcasting messages to each recipient in the channel
- Ensures that each recipient gets only one copy of the message
- Helps in debugging channel without disturbing traffic
- JMS Implementation uses 'Topic' interface to implement Point to point channel
  - TopicPublisher – send messages
  - TopicSubscriber – receive messages



Enterprise Application Integration (EAI)

Publish - subscribe channel – Example (JMS)

- Sending message

```
Topic topic = // obtain the topic via JNDI
TopicConnectionFactory factory = // obtain the connection factory via JNDI
TopicConnection connection = factory.createTopicConnection();
TopicSession session = connection.createTopicSession(true, Session.AUTO_ACKNOWLEDGE);
TopicPublisher publisher = session.createPublisher(topic);

Message message = session.createTextMessage("The contents of the message.");
publisher.publish(message);
```

Enterprise Application Integration (EAI)

Publish - subscribe channel – Example (JMS)

- Receiving message

```
Topic topic = // obtain the topic via JNDI
TopicConnectionFactory factory = // obtain the connection factory via JNDI
TopicConnection connection = factory.createTopicConnection();
TopicSession session = connection.createTopicSession(true, Session.AUTO_ACKNOWLEDGE);
TopicSubscriber subscriber = session.createSubscriber(topic);

TextMessage message = (TextMessage) subscriber.receive();
String contents = message.getText();
```

Thank You!

In our next session:

Middleware Security

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Message Construction

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In this segment

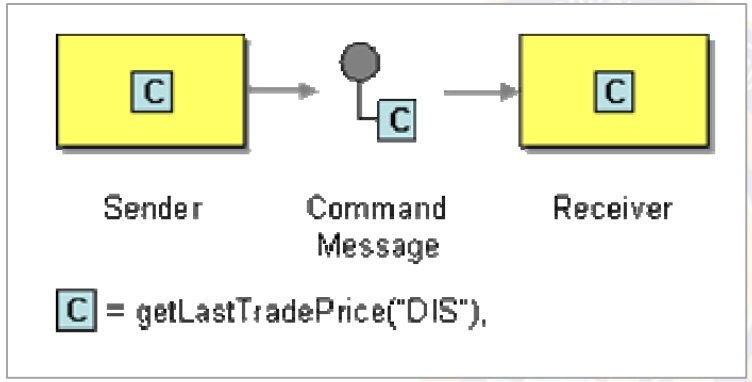
Message Construction

- Command Message
- Document Message
- Event Message
- Request-Reply
- Return Address
- Correlation Identifier
- Message Sequence
- Message Expiration
- Format Indicator

Message Construction

Command Message

- Command Message is used to invoke a procedure in another application, reliably.
- Asynchronous invocation of procedures, as opposed to RPC

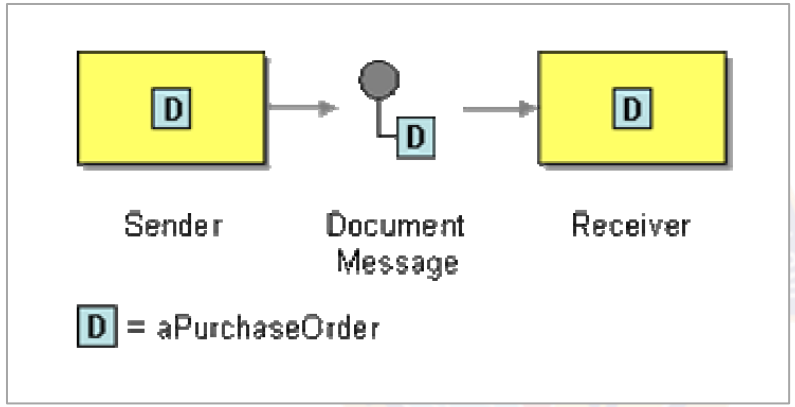


- Message contains command for the other application, there's no other specific indication on message
- Usually sent on point-to-Point channel
- Ex: SOAP messages

Message Construction

Document Message

- Document Message is used to reliably transfer a data structure between applications

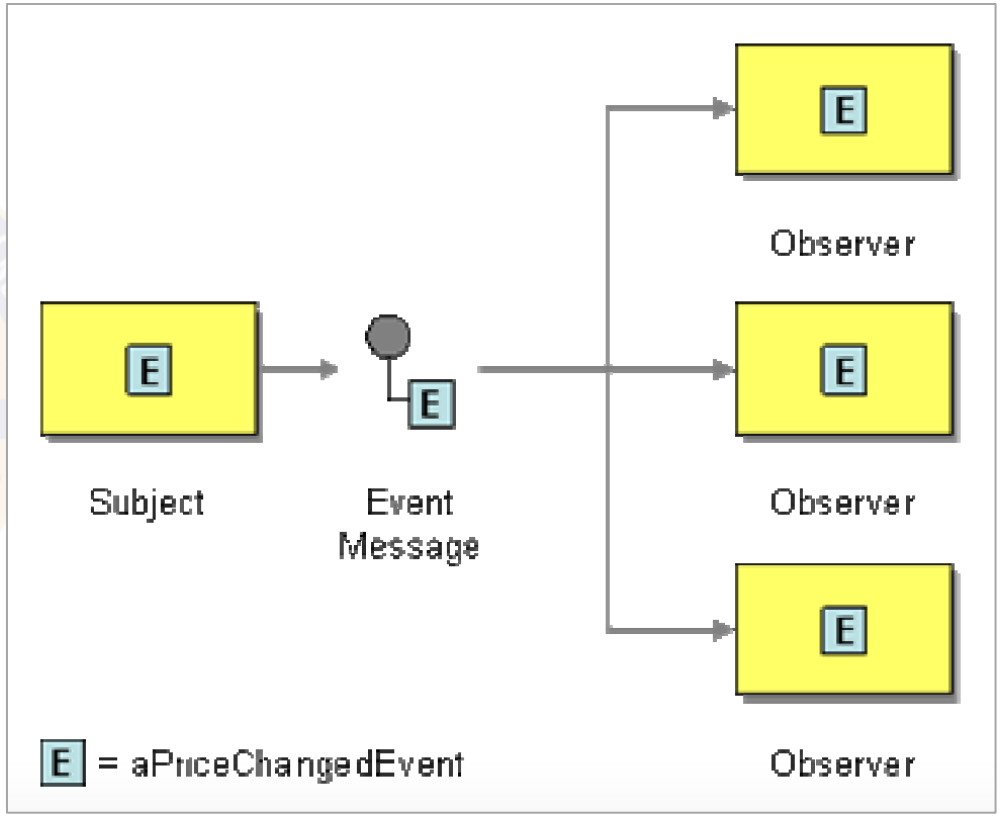


- Can contain any kind of message in the system, except that it represents a data object
- Usually sent on a point-to-point channel
- Ex: XML documents sent across the network

Message Construction

Event Message

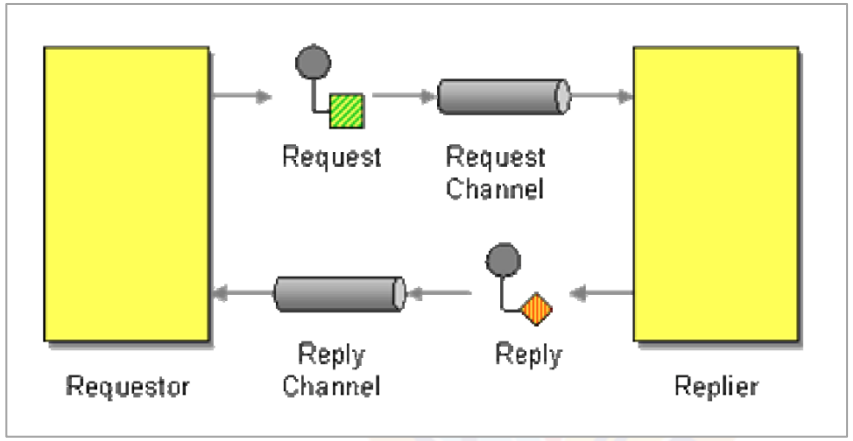
- Document Message is used to reliably send event notifications between application
- Sender will create an event object and sends it in a message (no special indicator used)
- Push model – sends event and the related state change info
- Pull model – sends only the event details and optionally additional info to obtain state details
  - Update
  - State Request
  - State Reply



Message Construction

Request-Reply

- Facilitates two way communication between sender/receiver using two-way channel

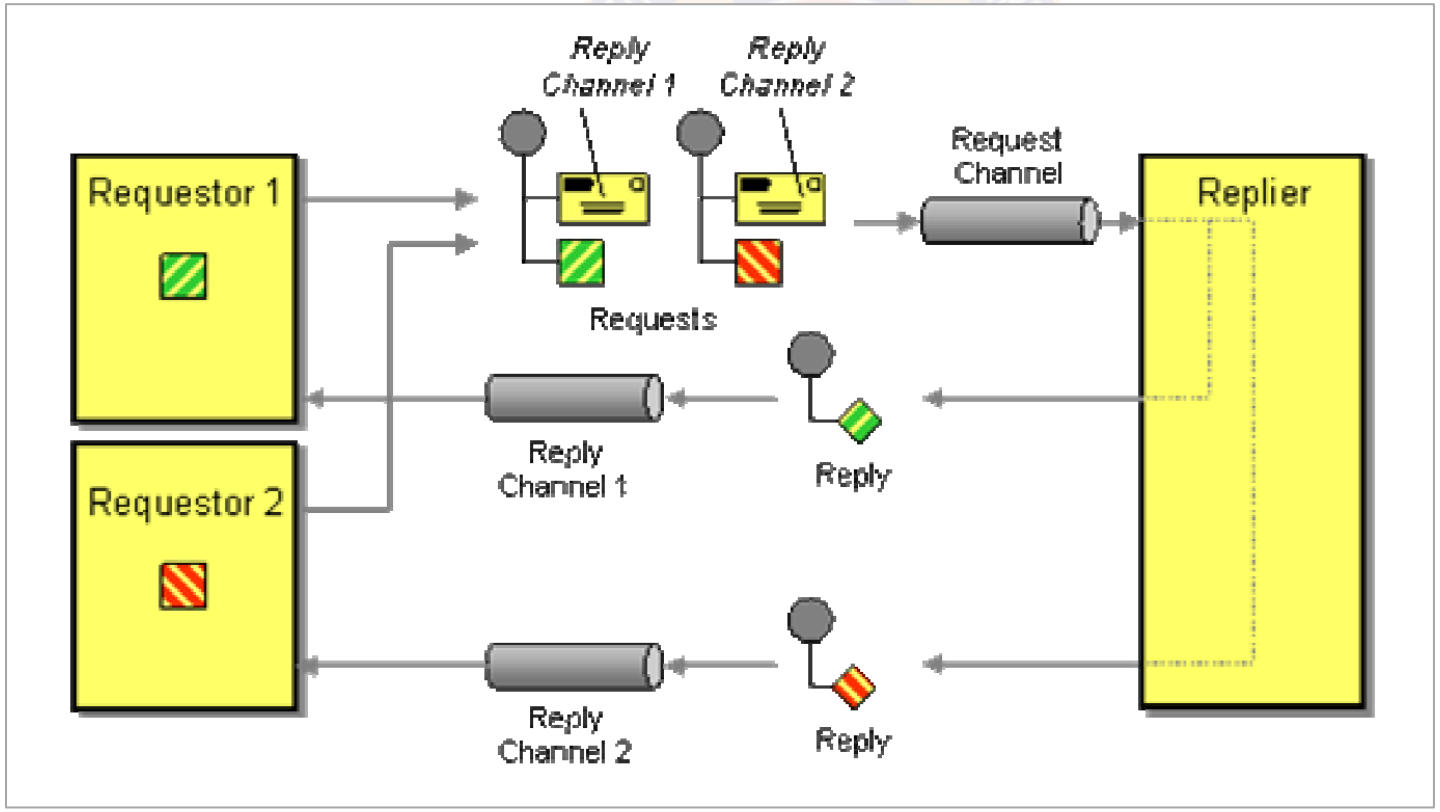


- Requestor – sends request message and waits for reply
- Replier – receives request message and sends the reply
- Request channel could be point-to-point or publish-subscribe
- Reply channel is almost always point-to-point
- Reply can be:
  - Synchronous (blocking)
  - Asynchronous (callback)

Message Construction

Return Address

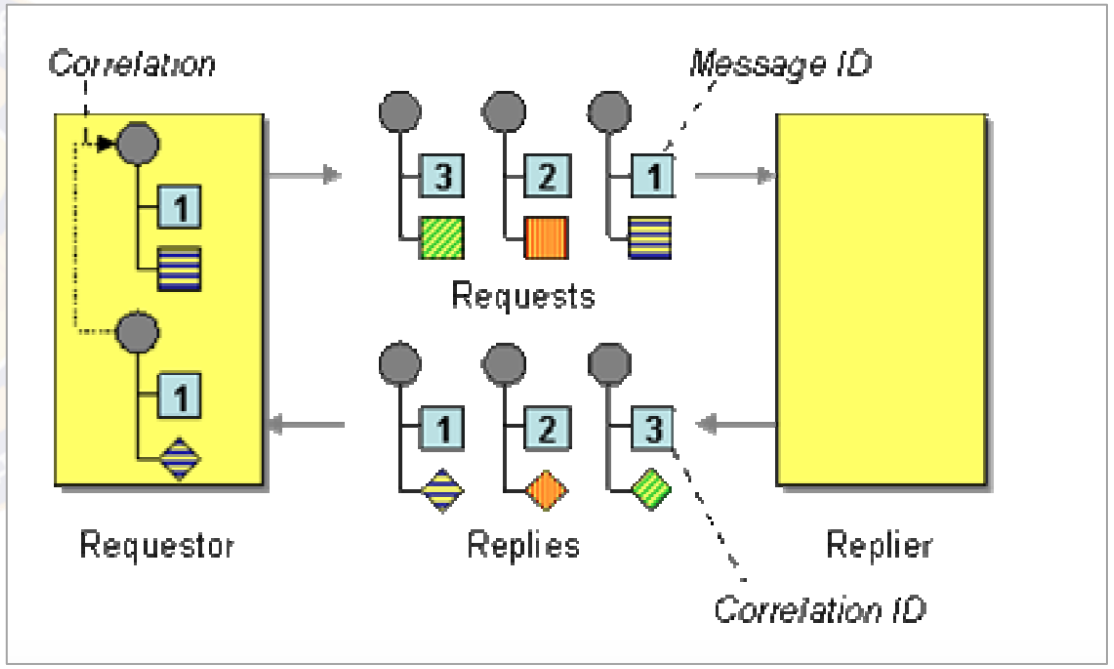
- Asynchronous request-reply model has callback mechanism, which needs the receiver to know where to send the response, especially with multiple senders in question
- Return Address is supplied along with the Request Message, that will be used by receiver to send the reply back (Ex: JMS – JMSReplyTo field on request object)



Message Construction

Correlation Identifier

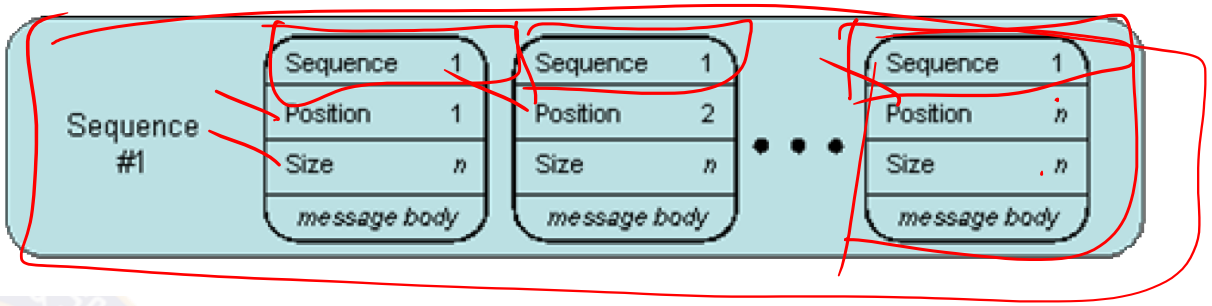
- Each reply in request-reply model should contain a Correlation Identifier that uniquely indicates a which request this reply is for.
- Correlation Identifier has 6 parties to it:
  - Requestor – Sender App
  - Replier – Replier App
  - Request – Contains Request ID
  - Reply – Contains Correlation ID
  - **Request ID – A unique token from the request**
  - **Correlation ID – Unique token in response copied from Request ID**
- Correlation ID (and even Request ID) are specified in respective message headers
- Ex: JMS - JMSCorrelationID and JMSMessageID

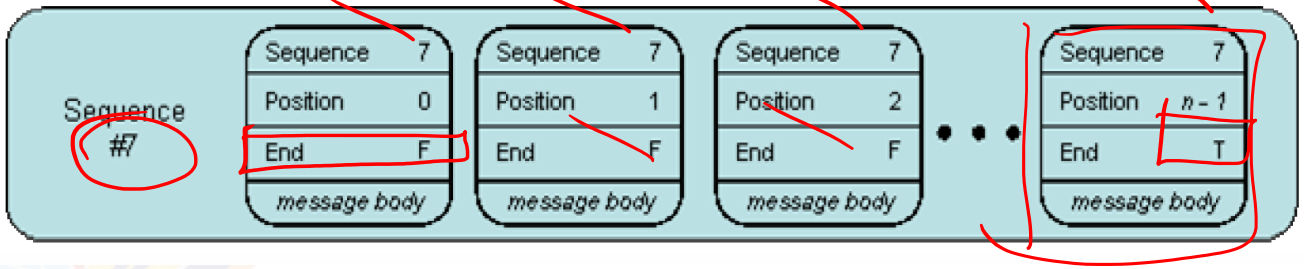


Message Construction

Message Sequence

- Message Sequence is used whenever a large set of data may need to be broken into message-size chunks
- Each message in Message Sequence is marked with sequence identification fields
- Message Sequence identification fields
  - Sequence identifier
  - Position identifier
  - Size or End indicator
- Example Use cases:
  - Large document transfer
  - Multi item query
  - Distributed query

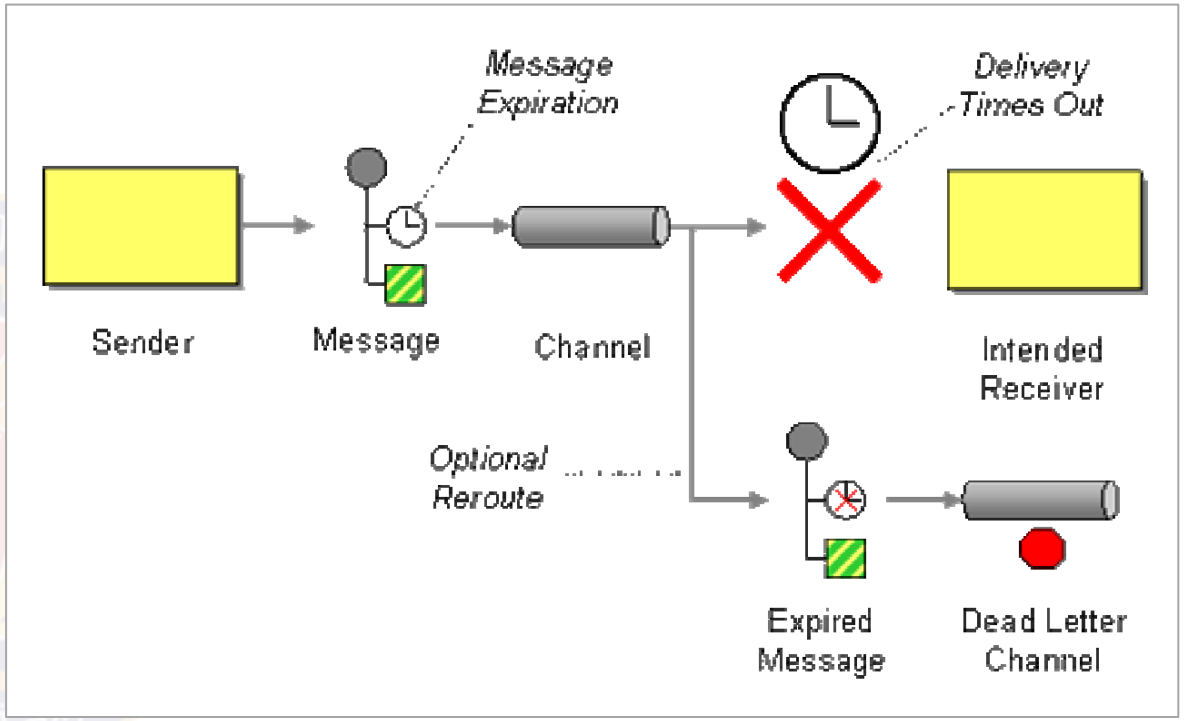




Message Construction

Message Expiration

- Message Expiration sets the time limit after which the message becomes stale
- One the time limit expires, the message is not considered by consumers for processing, moved to Invalid Message Channel
- It could be configured to be rerouted to Dead Letter Channel for further handing
- Message Expiration is a timestamp
  - Relative (longevity), using sent time property
  - Absolute
- JMS implementation - MessageProducer.setTimeToLive(long)



Message Construction

Format Indicator

- The format indicator enables the sender to tell the receiver the format of the message
- This handles versioning and future changes
- Format indicator can be implemented as:
  - Version Number
  - Foreign Key
  - Format Document

```
<?xml version="1.0"?>
```

```
<!DOCTYPE greeting SYSTEM "hello.dtd">
```

```
<!DOCTYPE greeting [
  <!ELEMENT greeting (#PCDATA)>
]>
```

Thank You!

In our next session:

Message Routing

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Message Channels

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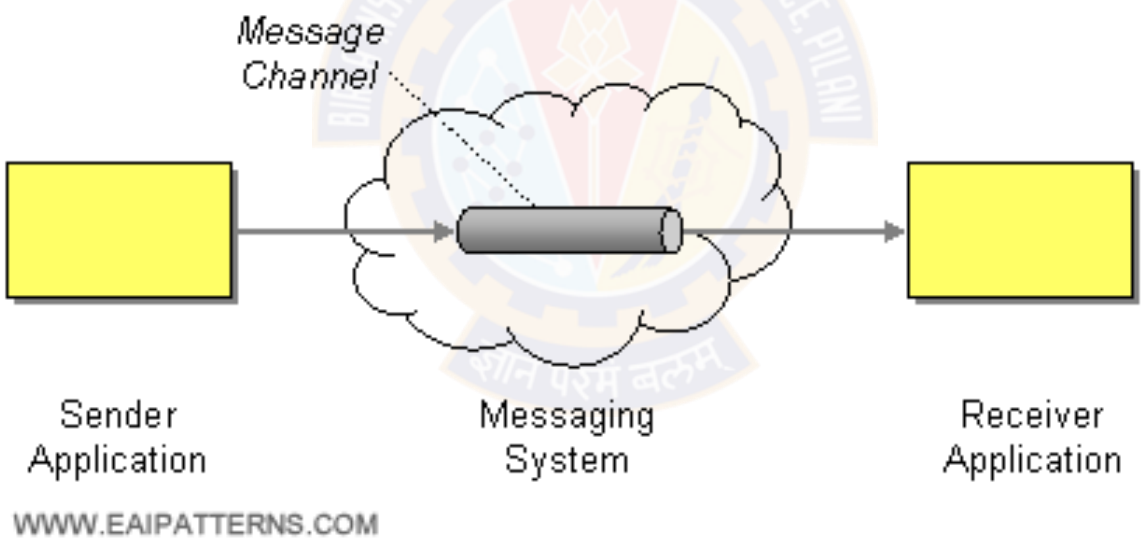
In this segment

Message Channels

- Message Channel
- Point to Point Channel
- Publish-Subscr Channel
- Data Type Channel
- Invalid Message Channel
- Dead Letter Channel
- Guaranteed Delivery
- Channel Adapter
- Messaging Bridge
- Message Bus

Message Channel

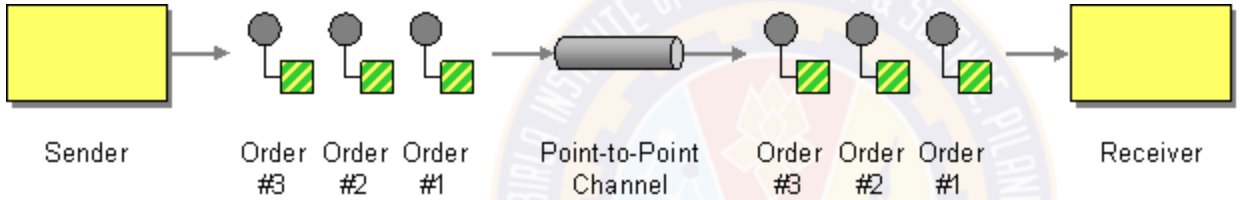
- A Message channel is a basic architectural pattern of a messaging system and is used fundamentally for exchanging data between applications. An application can use a channel to make a specific type of data available to any receiver applications that need to consume that type of data.

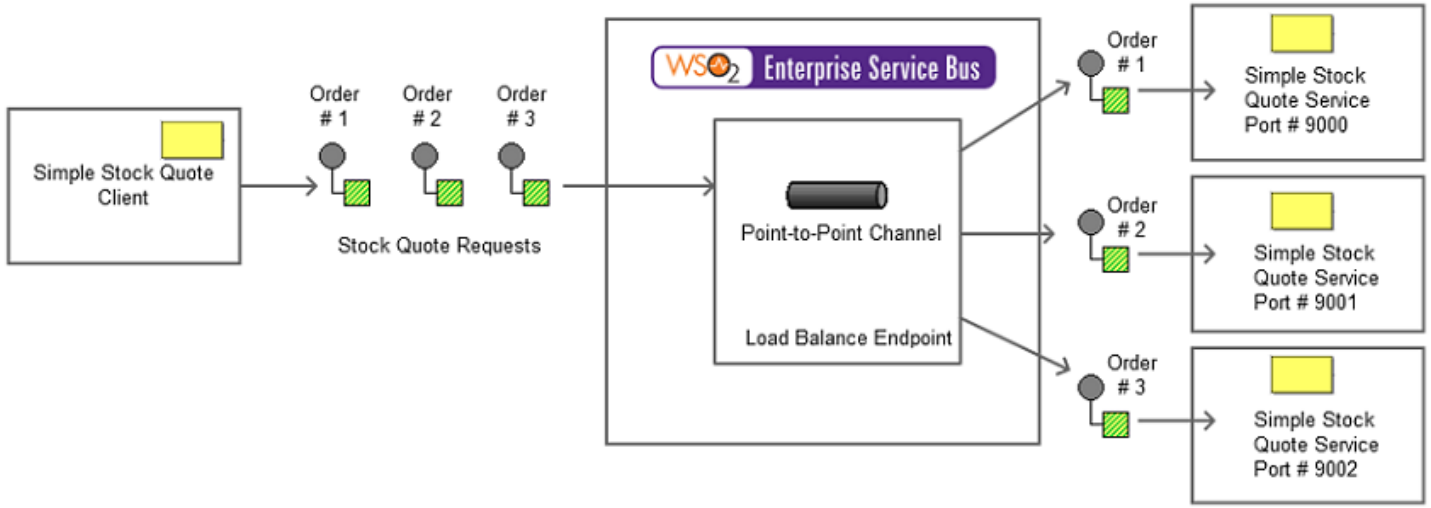


Message Channel

Point to Point Channel

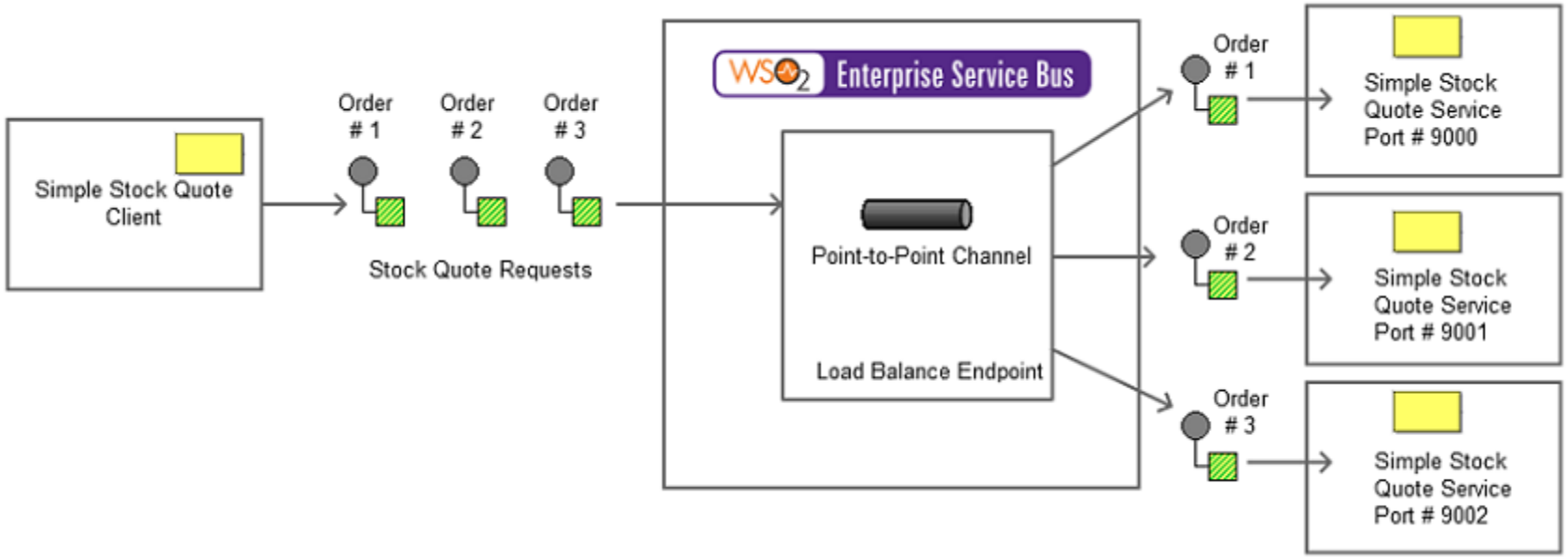
- The Point-to-Point Channel EIP ensures that only a single receiver consumes a message (when there are multiple receivers waiting to consume the message).





Message Channel

Point to Point Channel – Example



Message Channel

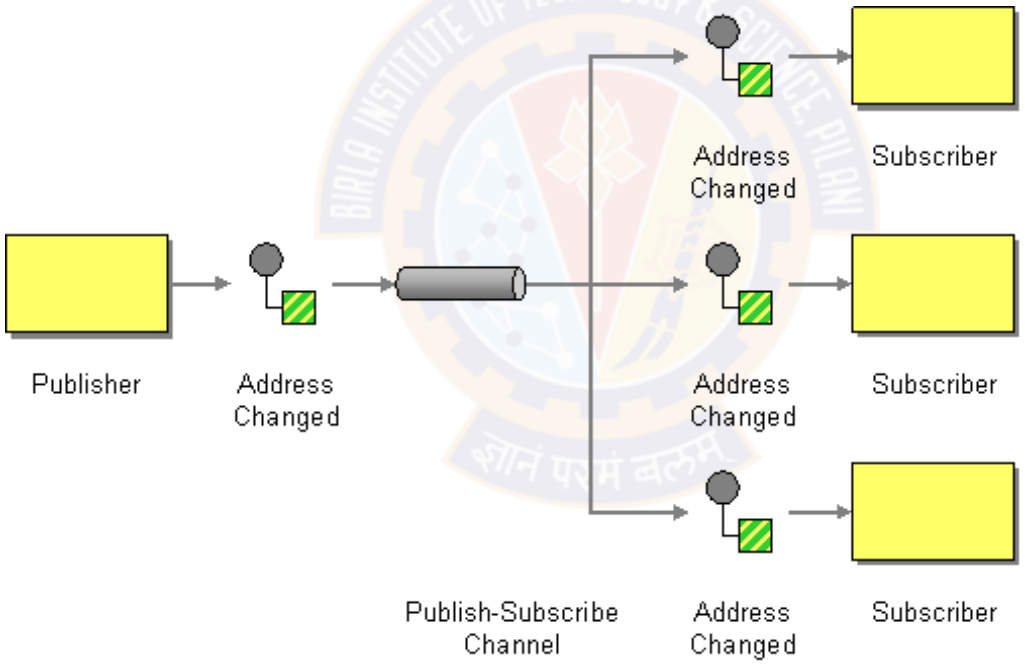
Point to Point Channel

Point-to-Point EIP (Figure 1)	Point-to-Point Channel Example Scenario (Figure 2)
Sender	Stock Quote Client
Receiver	Three instances of the Stock Quote service
Point to Point Channel	Load-balance Endpoint
Order	Stock Quote Requests

Message Channel

Publish-Subscribe Channel

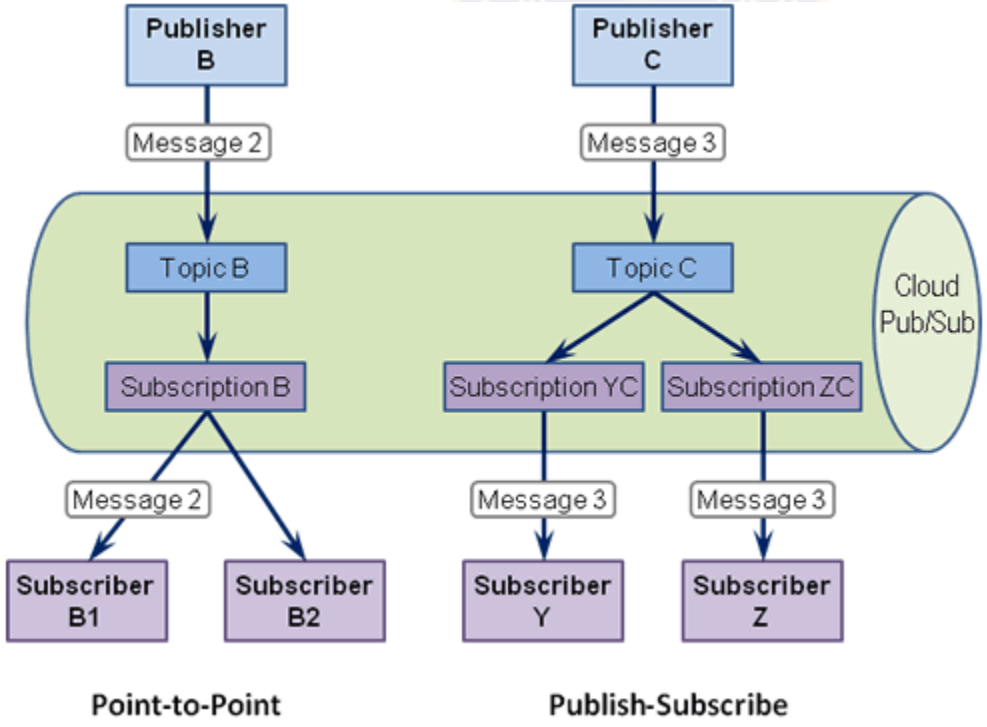
- The Publish-Subscribe Channel EIP receives messages from the input channel, and then splits and transmits them among its subscribers through the output channel. Each subscriber has only one output channel.



Message Channel

Publish-Subscribe Channel - Example

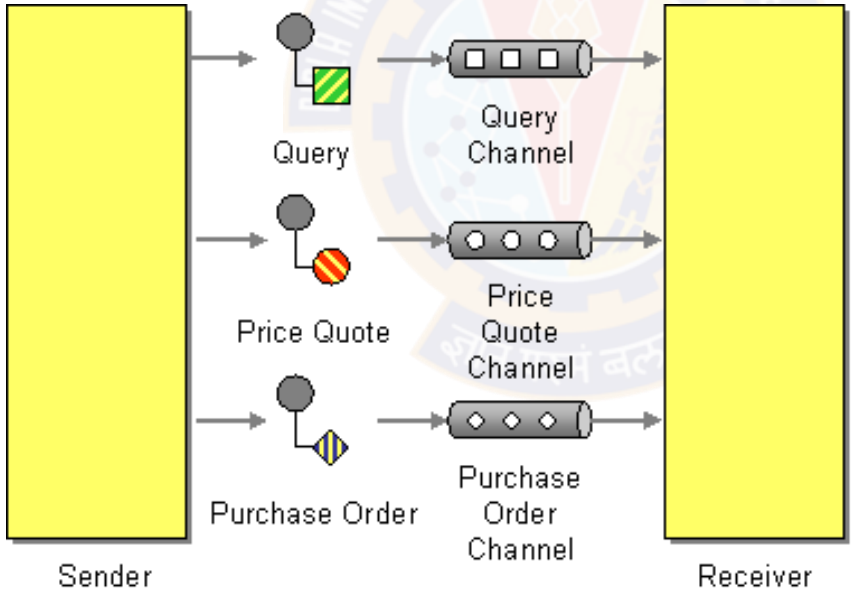
- In this example, both *Subscriber Y* and *Subscriber Z* each receive a copy of *Message 3* as they are subscribing to the same *Topic C*, but through separate subscriptions.



Message Channel

Datatype Channel

- This EIP creates a separate channel for each type of data so that all the messages on a given channel will contain the same data type. The sender, who knows the data type, should select the appropriate channel on which to send the message. The receiver identifies the type of data a message contains, based on the channel in which it is received.

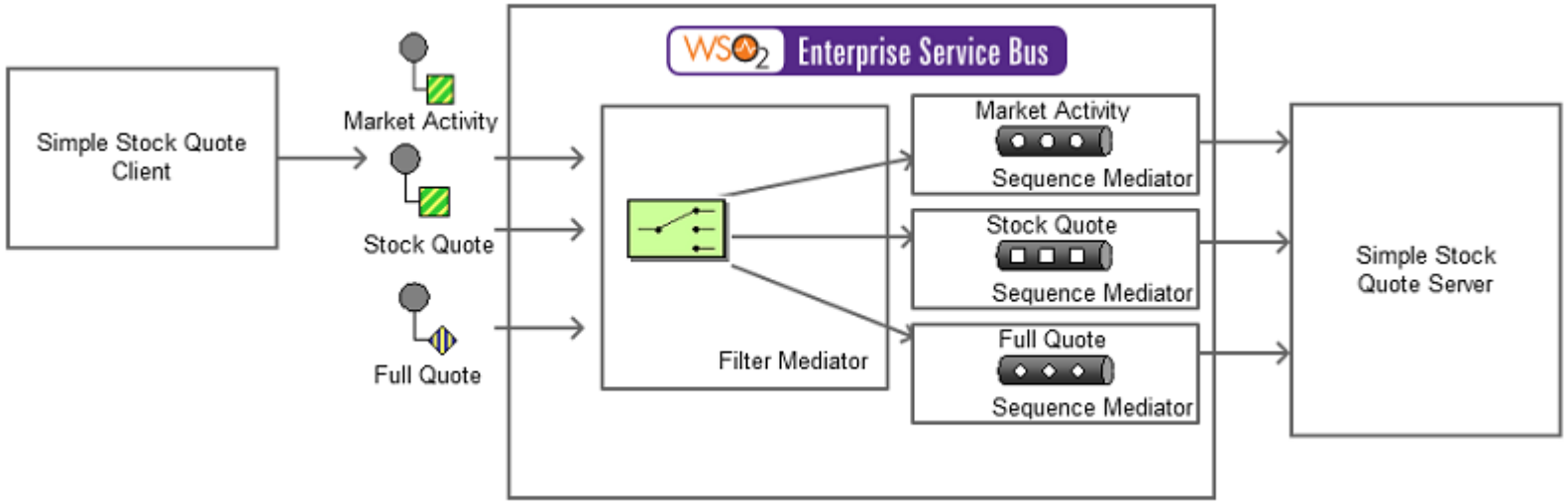


This example scenario depicts a Stock Quote service deployed in Axis2 server. It offers several service operations to the user. The ESB uses the filter mediator to identify each actio

Message Channel

Datatype Channel - Example

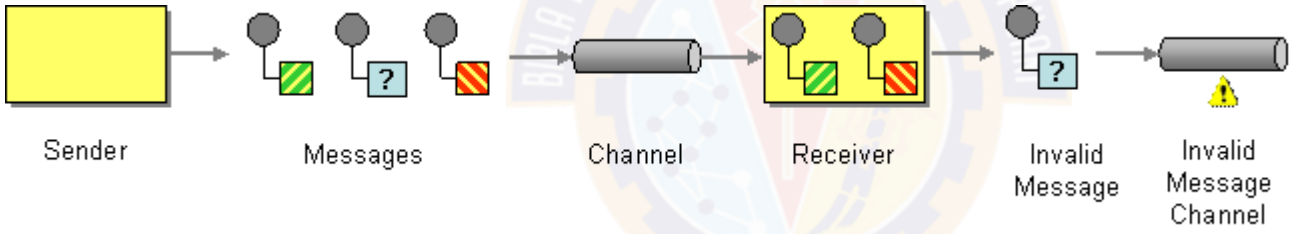
- This EIP creates a separate channel for each type of data so that all the messages on a given channel will contain the same data type. The sender, who knows the data type, should select the appropriate channel on which to send the message. The receiver identifies the type of data a message contains, based on the channel in which it is received.



Message Channel

Invalid Message Channel

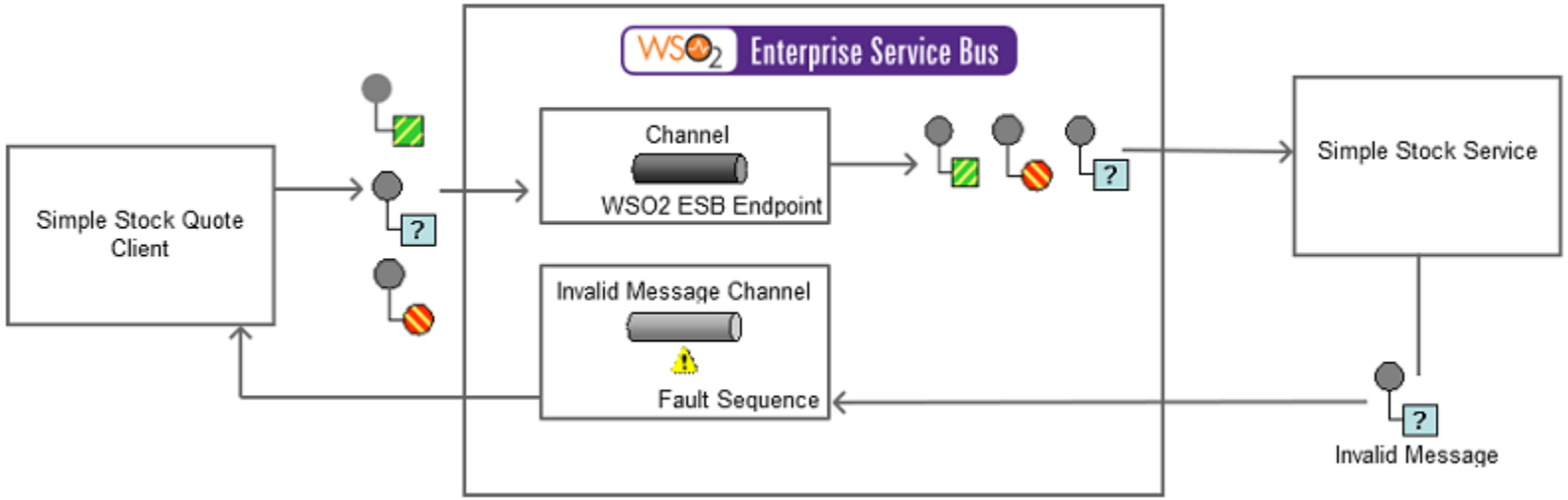
- The Invalid Message Channel EIP pattern allows administrators to define an error indication that appears when an endpoint fails to process a request.



Message Channel

Invalid Message Channel - Example

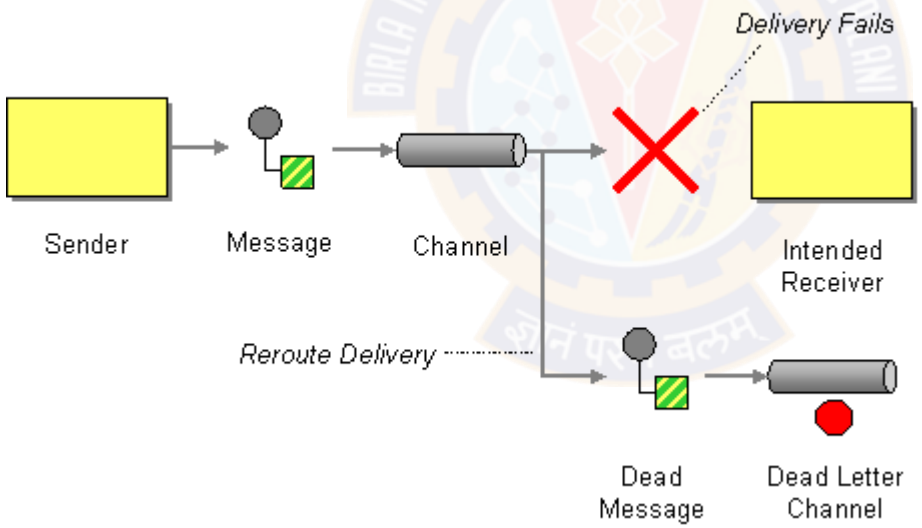
- The example scenario creates a deliberate error situation to demonstrate how the ESB handles errors on message failures.



Message Channel

Dead Letter Channel

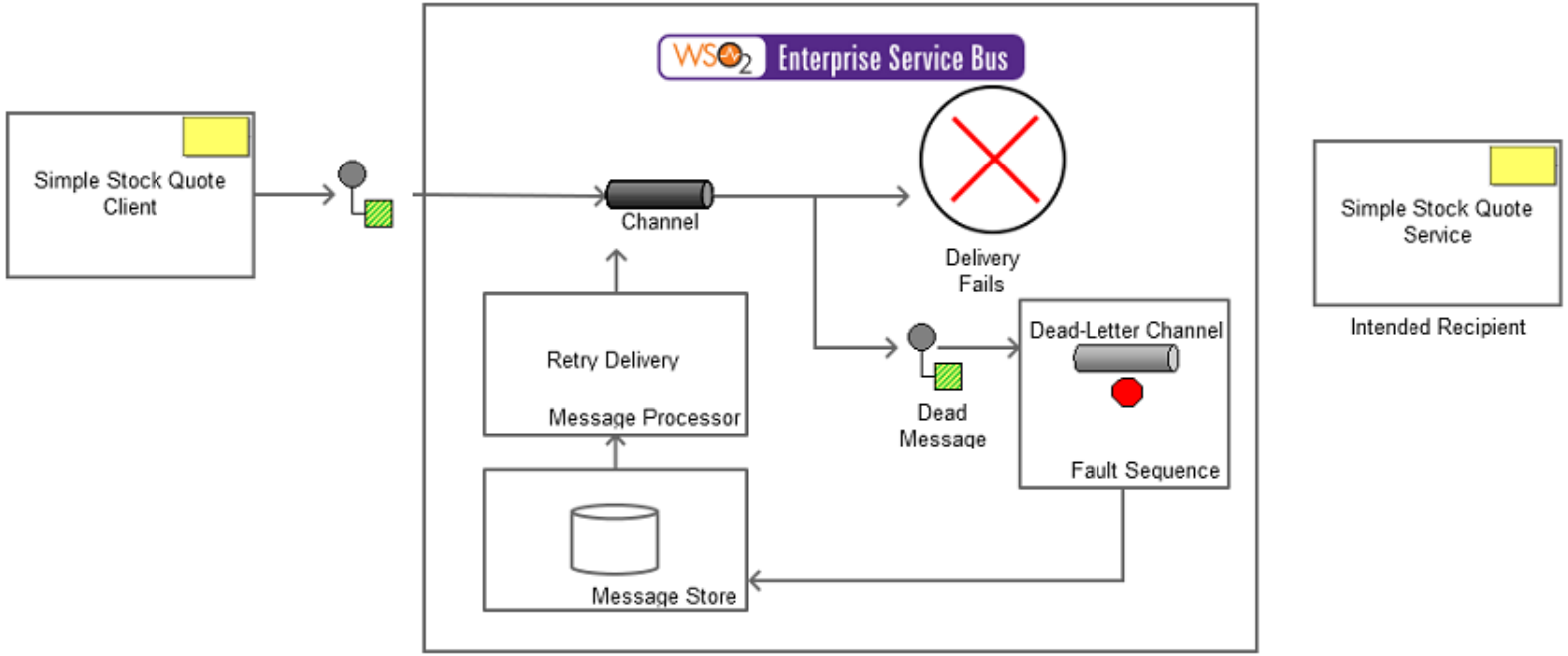
- The Dead Letter Channel (DLC) EIP outlines how messaging systems can handle messages that cannot be delivered to the recipient. Due to system/network failures or failures at the recipient's end, messages sometimes do not get delivered to the target. In such cases, the messaging system can deliver the message to a DLC.



Message Channel

Dead Letter Channel - Example

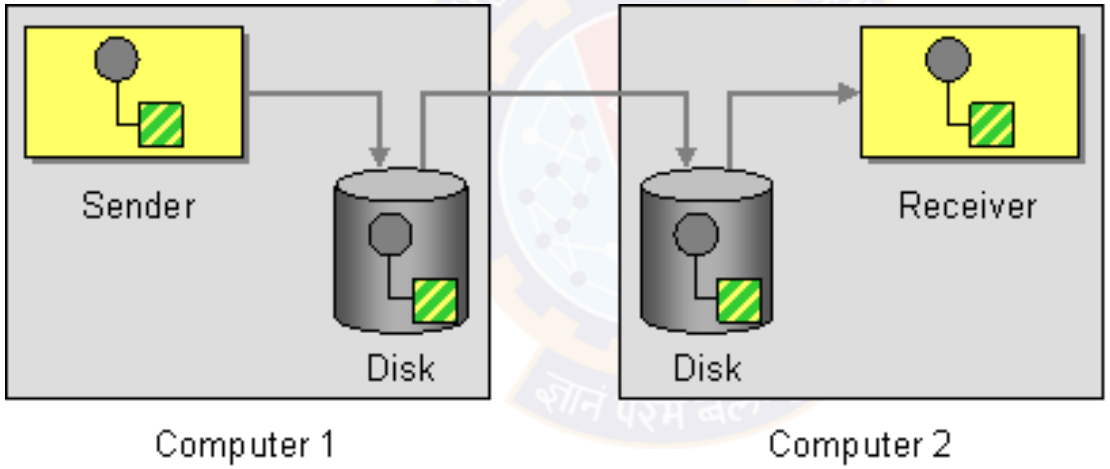
- This example takes a proxy service called StockQuoteProxy, which fronts a service by the name SimpleStockQuoteService. As long as the SimpleStockQuoteService is running, the clients calling StockQuoteProxy service got response. But if the SimpleStockQuoteService is down or a failure occurs while trying to send message to the SimpleStockQuoteService, the faultsequence will get involved and the message will be delivered to the dead letter channel.



Message Channel

Guaranteed Delivery Channel

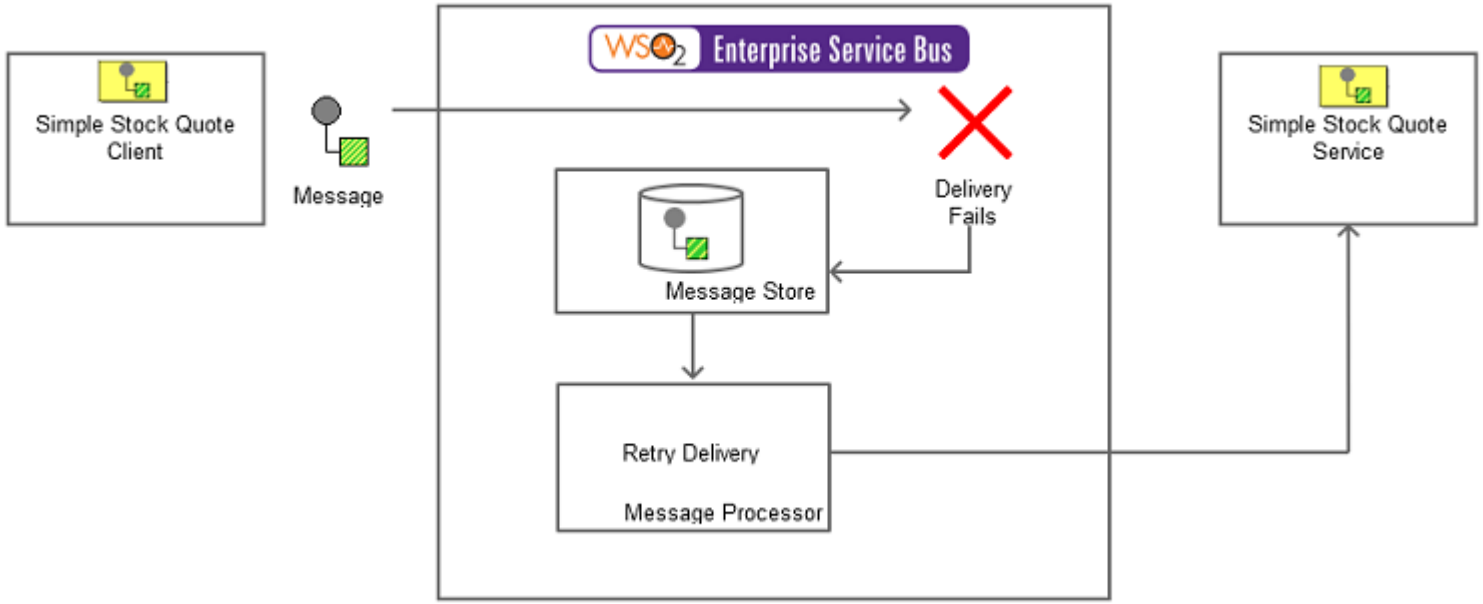
- The Guaranteed Delivery EIP ensures safe delivery of a message by storing it locally and transmitting it to the receiver's data store. Even when the receiver is offline, the EIP ensures that the message goes through when the receiver comes online.



Message Channel

Guaranteed Delivery Channel - Example

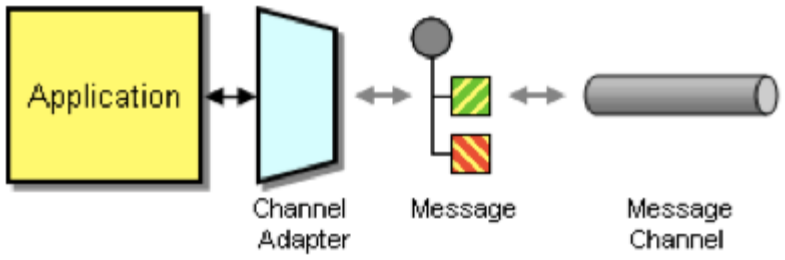
- This example is a stock quote service where a stock quote request is sent to a specific endpoint when the receiver is offline. An Axis2 server acts as the receiver. The ESB stores the request message in a JMS message store provided by the ESB. In this scenario, a Message Broker acts as the JMS message store. Here, the Message Broker can either be the WSO2 Message Broker or ActiveMQ.



Message Channel

Channel Adapter Channel

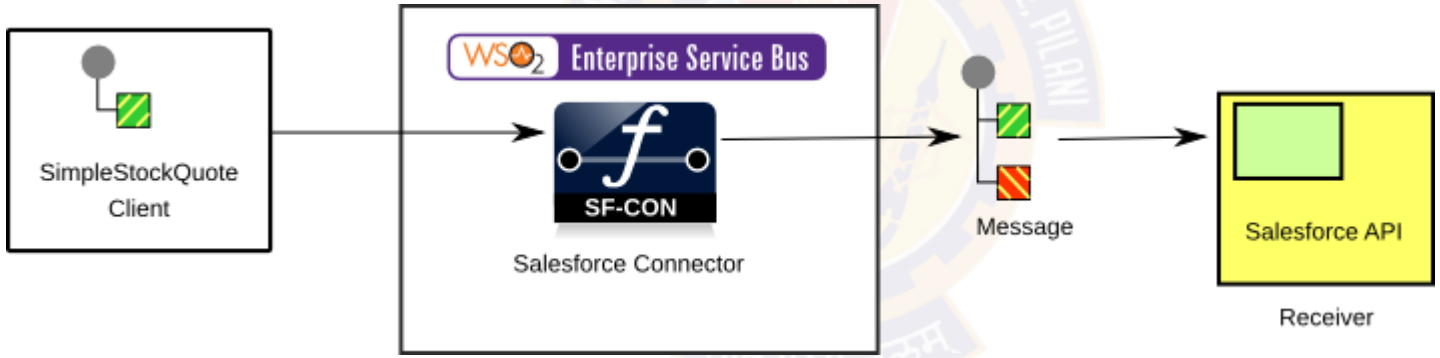
- Channel Adapter accesses an application's API or data and publishes messages on a channel based on this data. Also, it receives messages and invokes functionality inside the application.



Message Channel

Channel Adapter Channel - Example

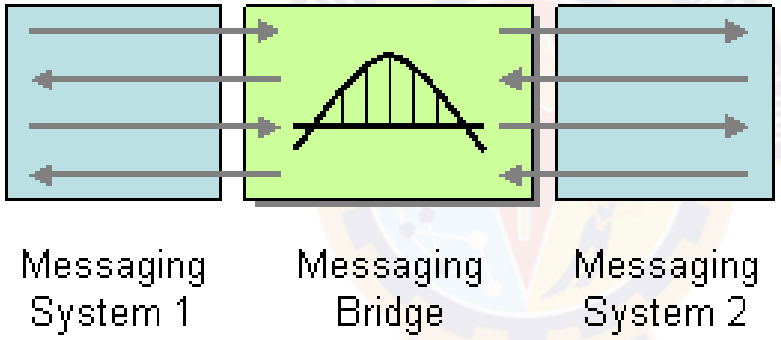
- This example demonstrates WSO2 ESB's Salesforce connector transferring a message coming from a stock quote client to Salesforce API and then sends the queried response that comes from Salesforce back to the client.



Message Channel

Messaging Bridge Channel

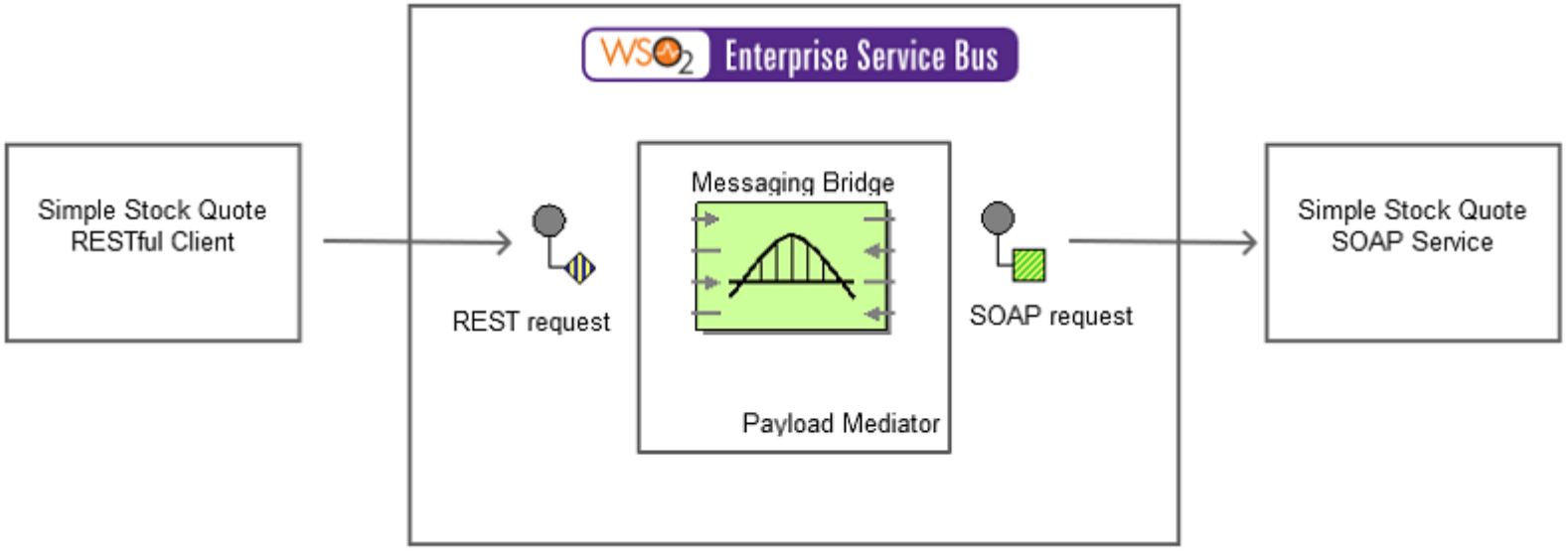
- The Messaging Bridge EIP facilitates the connection between messaging systems and replicates messages between them by transforming message formats from one system to the other.



Message Channel

Messaging Bridge Channel - Example

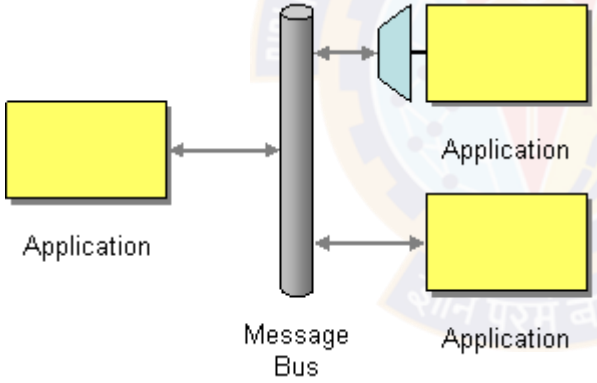
- This example illustrates the ESB as a message bridge, which accepts a REST message from the client, transforms the REST message to SOAP format, and sends the SOAP message to the back-end Axis2 server.



Message Channel

Messaging Bus Channel

- The Message Bus EIP enables separate applications to work together in a decoupled manner so that applications can be easily added or removed without affecting each other. This approach makes maintenance and testing smoother, since editing or removing an application will not affect the functionality of any other application.



Thank You!

In our next session:

Message Routing

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Message Routing

Madhu Venkat

Guest Faculty
BITS, WILP

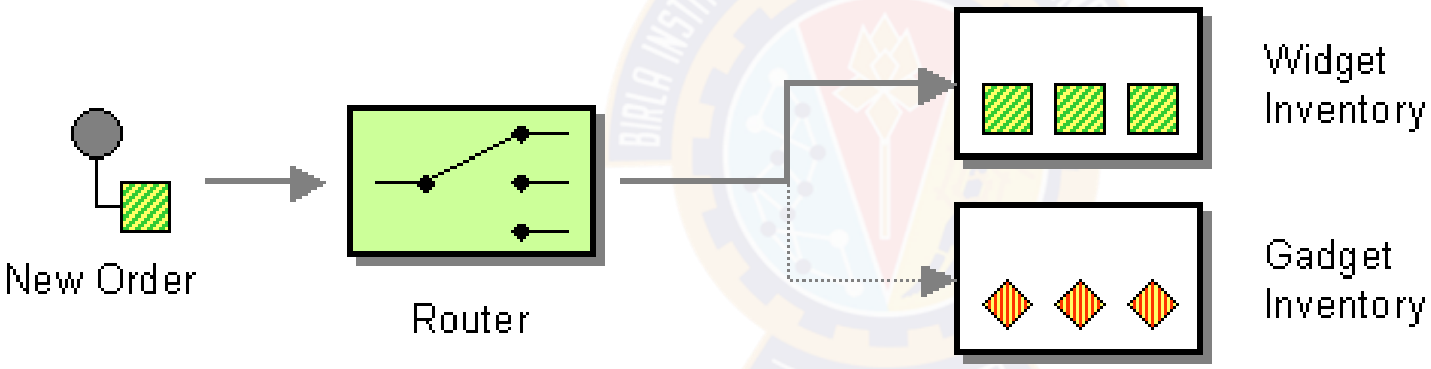
Message Routing

- Content-Based Router
- Message Filter
- Dynamic Router
- Recipient List
- Splitter
- Aggregator
- Resequencer
- Composed Msg-Processor
- Scatter-Gather
- Routing Slip

Message Routing

Content-Based Router

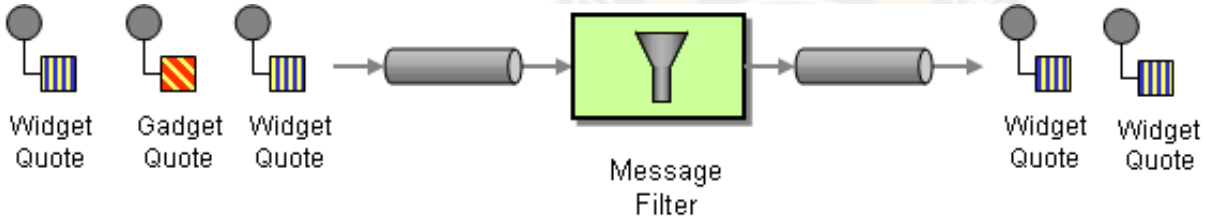
- The *Content-Based Router* examines the message content and routes the message onto a different channel based on data contained in the message. The routing can be based on a number of criteria such as existence of fields, specific field values etc.



Message Routing

Message Filter

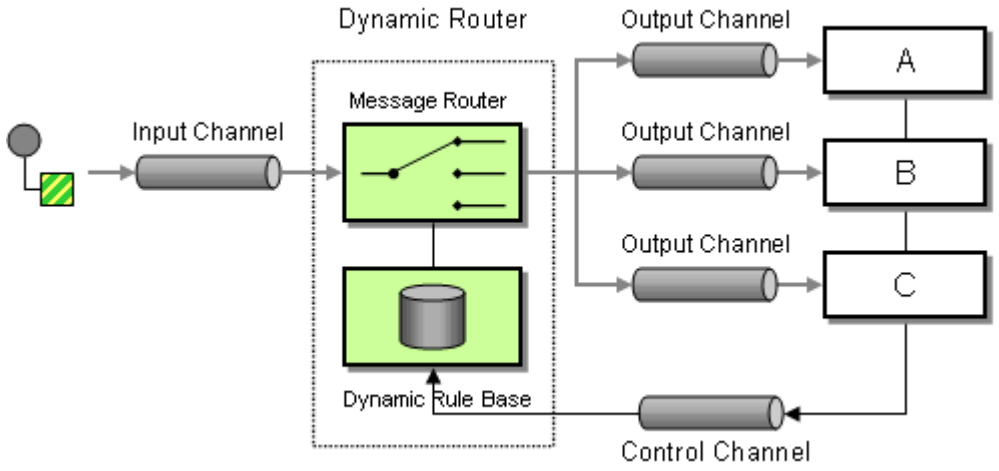
- The *Message Filter* has only a single output channel. If the message content matches the criteria specified by the *Message Filter*, the message is routed to the output channel. If the message content does not match the criteria, the message is discarded.



Message Routing

Dynamic Router

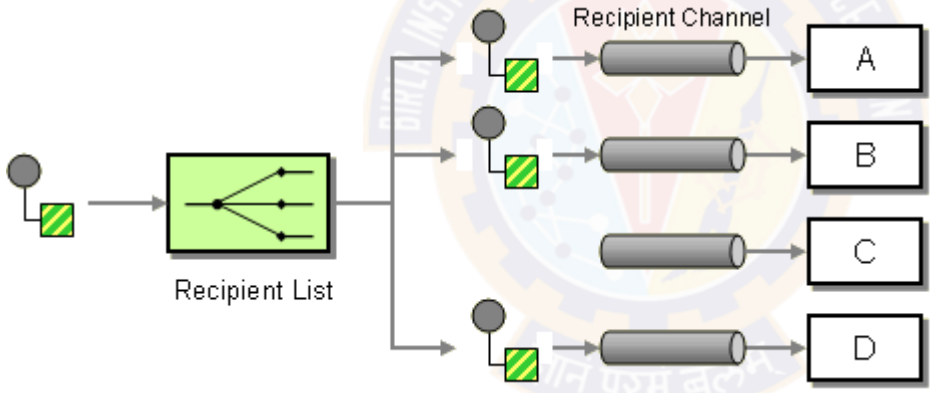
- Use a *Dynamic Router*, a Router that can self-configure based on special configuration messages from participating destinations.



Message Routing

Recipient List

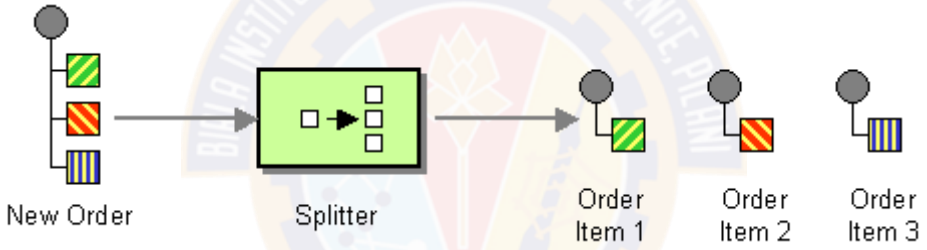
- Define a channel for each recipient. Then use a *Recipient List* to inspect an incoming message, determine the list of desired recipients, and forward the message to all channels associated with the recipients in the list.



Message Routing

Splitter

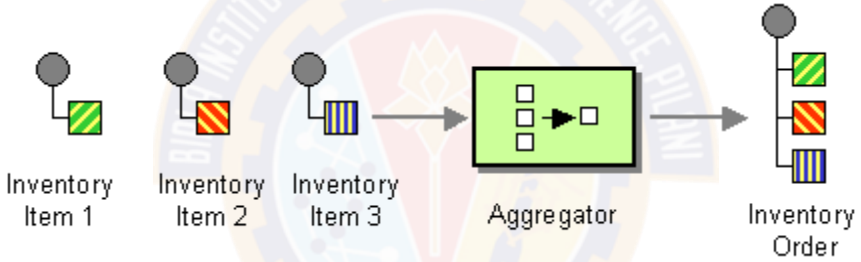
- **Use a *Splitter* to break out the composite message into a series of individual messages, each containing data related to one item.**



Message Routing

Aggregator

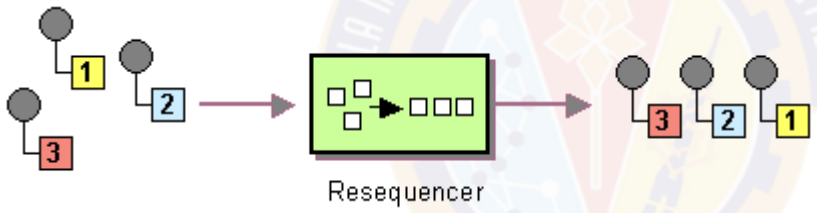
- **Use a stateful filter, an *Aggregator*, to collect and store individual messages until a complete set of related messages has been received. Then, the *Aggregator* publishes a single message distilled from the individual messages.**



Message Routing

Resequencer

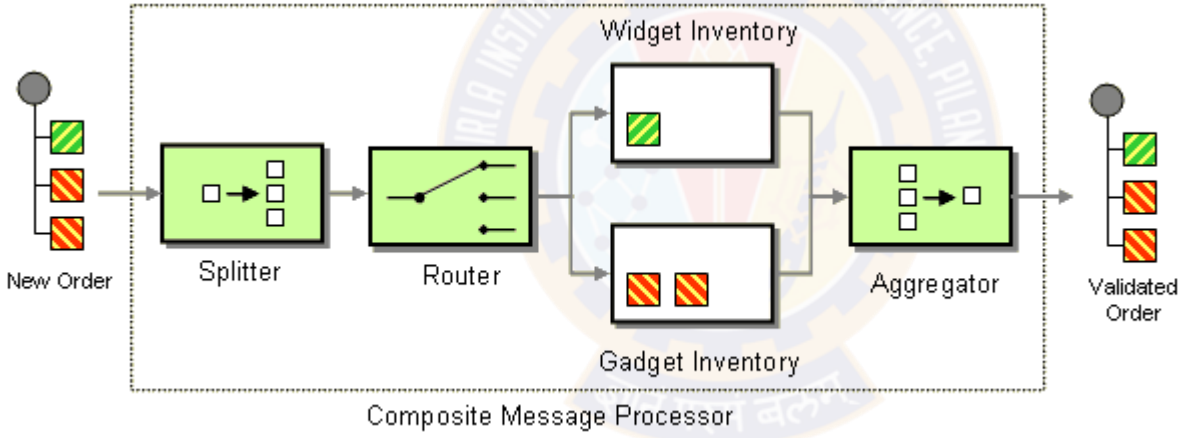
- **Use a stateful filter, a *Resequencer*, to collect and re-order messages so that they can be published to the output channel in a specified order.**



Message Routing

Composed Message Processor

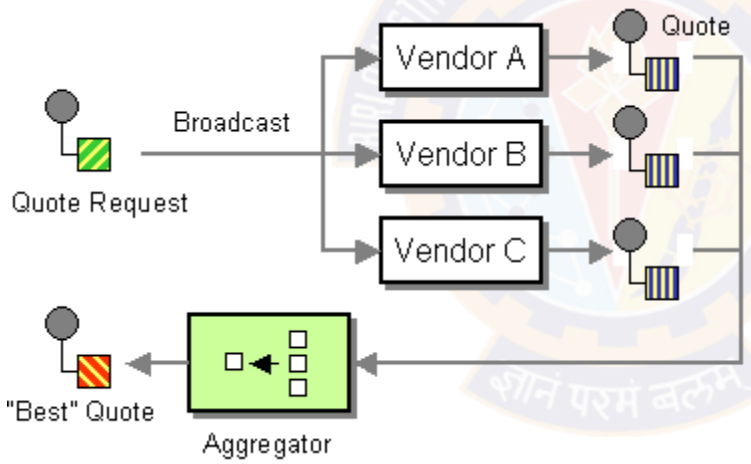
- **Use *Composed Message Processor* to process a composite message. The *Composed Message Processor* splits the message up, routes the sub-messages to the appropriate destinations and re-aggregates the responses back into a single message.**



Message Routing

Scatter-Gather

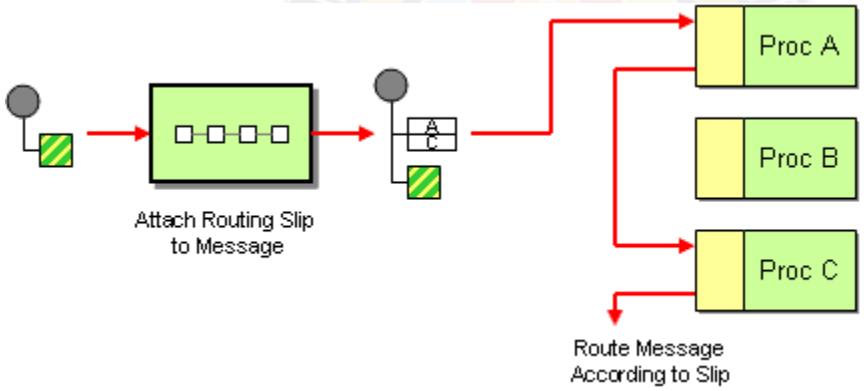
- **Use a *Scatter-Gather* that broadcasts a message to multiple recipients and re-aggregates the responses back into a single message.**



Message Routing

Routing Slip

- **Attach a *Routing Slip* to each message, specifying the sequence of processing steps. Wrap each component with a special message router that reads the *Routing Slip* and routes the message to the next component in the list.**



Thank You!

In our next session:

Message Transformation

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Middleware Web Technologies - Overview

Madhu Venkat

Guest Faculty
BITS, WILP

In this segment

Middleware Web Technologies - Overview

- Middleware technologies so far – recap
- Limitations of early middleware
- Middleware using Web services – Overview
- Service Oriented Architecture – Overview
- SOA vs ESB
- Service Orchestration
- Web services
  - RESTful Web services
  - Arbitrary (Non-REST) Web services

Middleware Web Technologies - Overview

Middleware technologies so far – recap

- Distributed systems and Middleware
- Evolution of Middleware technologies
- Early Middleware Technologies
  - Sockets
  - Remote Procedure Calls
  - Distributed Object Oriented Middleware
    - CORBA
  - Message Oriented Middleware
    - EAI Overview
    - Middleware Security
    - Messaging Systems
      - Channels and Formats
      - Routing, Transformations and Endpoints
      - Message Protocols (Apache Camel / Fuse ESB)
    - Performance and Availability

Middleware Web Technologies - Overview

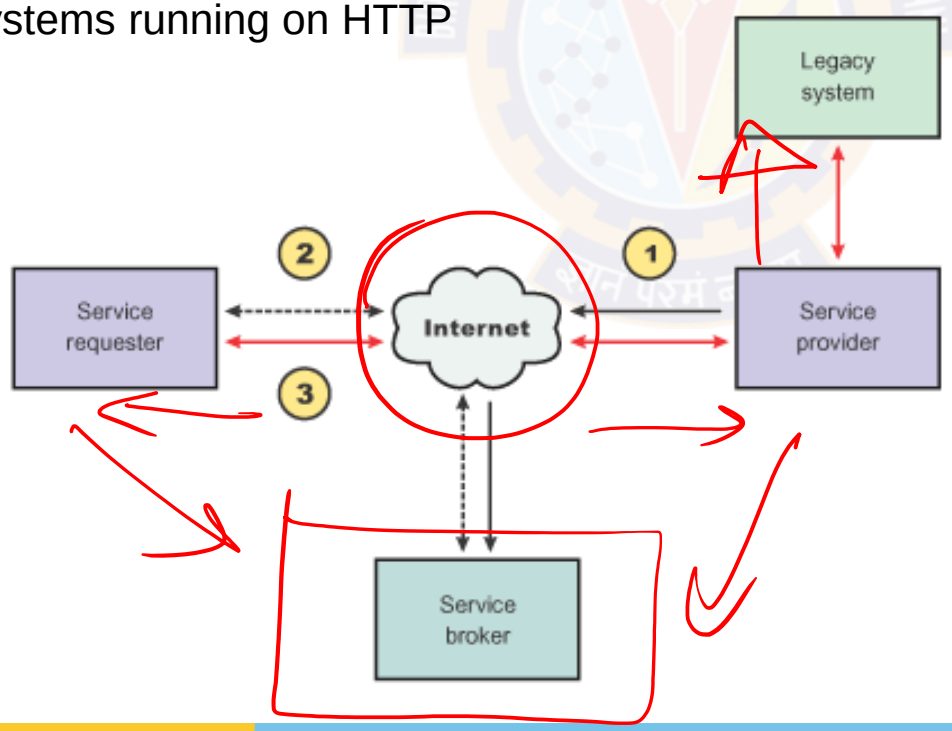
Limitations of early middleware and message oriented middleware

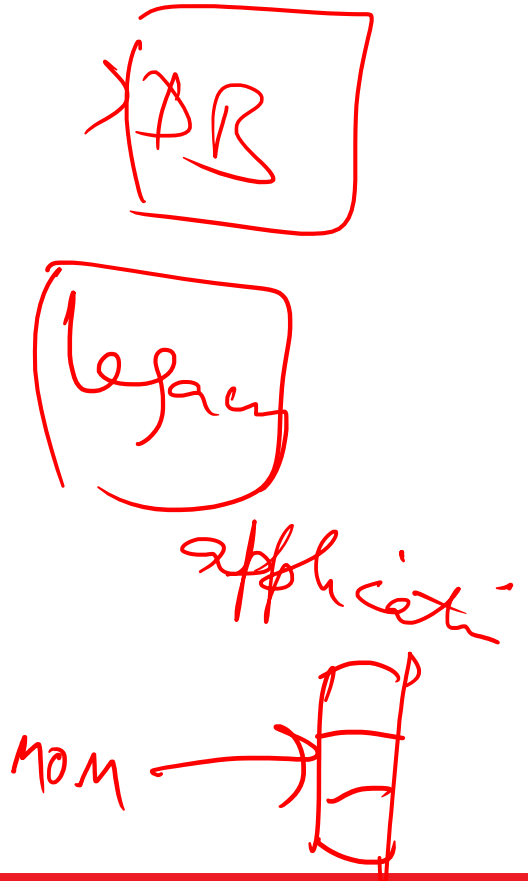
- Performance of legacy components (sockets/RPC) with the explosion of web
- Messaging middleware needs an extra hop in the architecture, adding another point of failure
- Most of web applications are synchronous, while MOM is designed for asynchronous apps primarily
- Interoperability issues with applications and architectural styles
  - Tight coupling with RPC/DOOC

Middleware Web Technologies - Overview

Middleware using Web Services - Overview

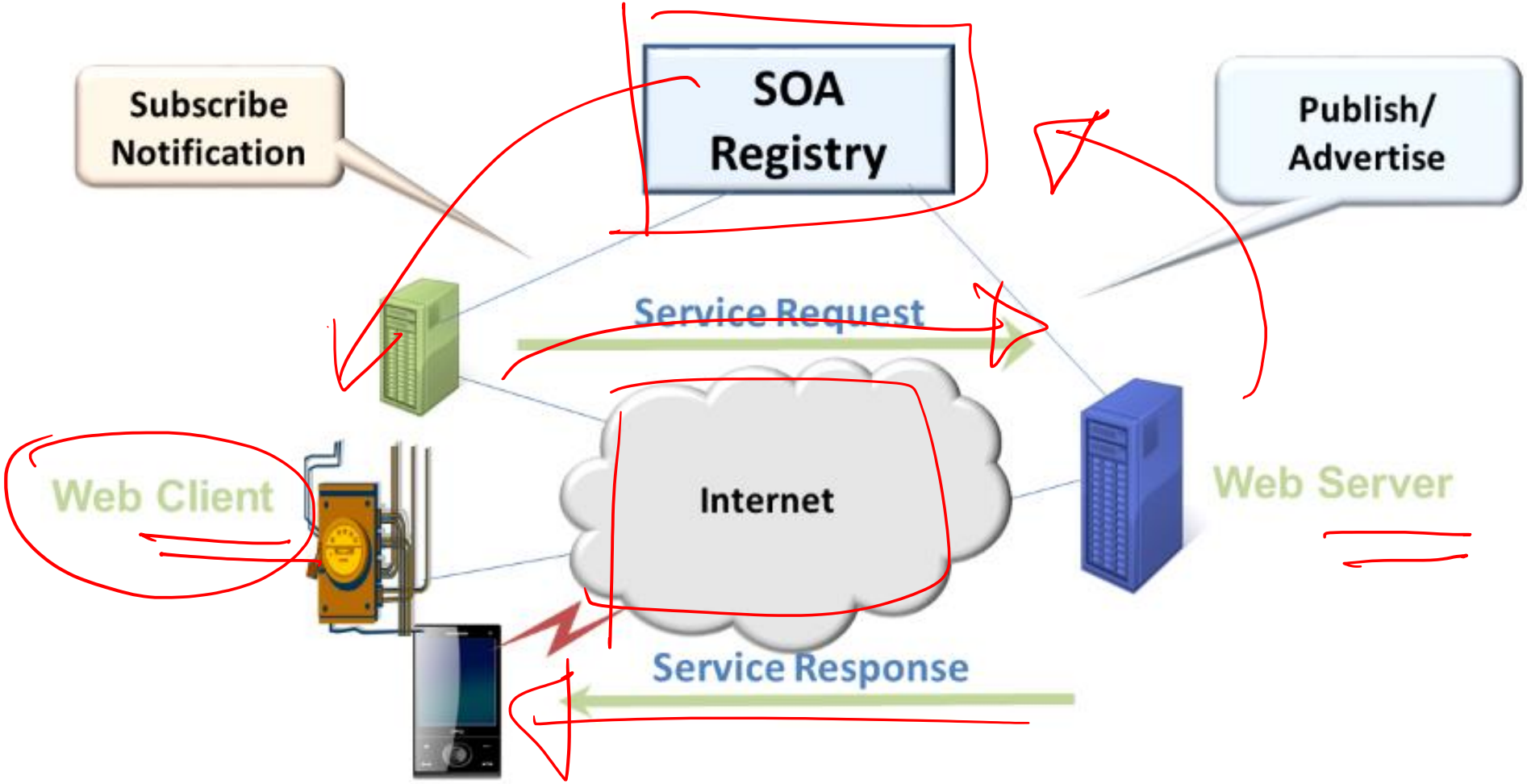
- Applications and architectures that are deployed in WWW / HTTP
- Middleware provides web interfaces to application services (legacy applications)
- Exposing legacy applications to web topologies by making them web-services
- Promotes interoperability between applications
  - Loose coupling
  - Distributed systems running on HTTP





Middleware Web Technologies - Overview

Service Oriented Architecture - Overview



Middleware Web Technologies - Overview

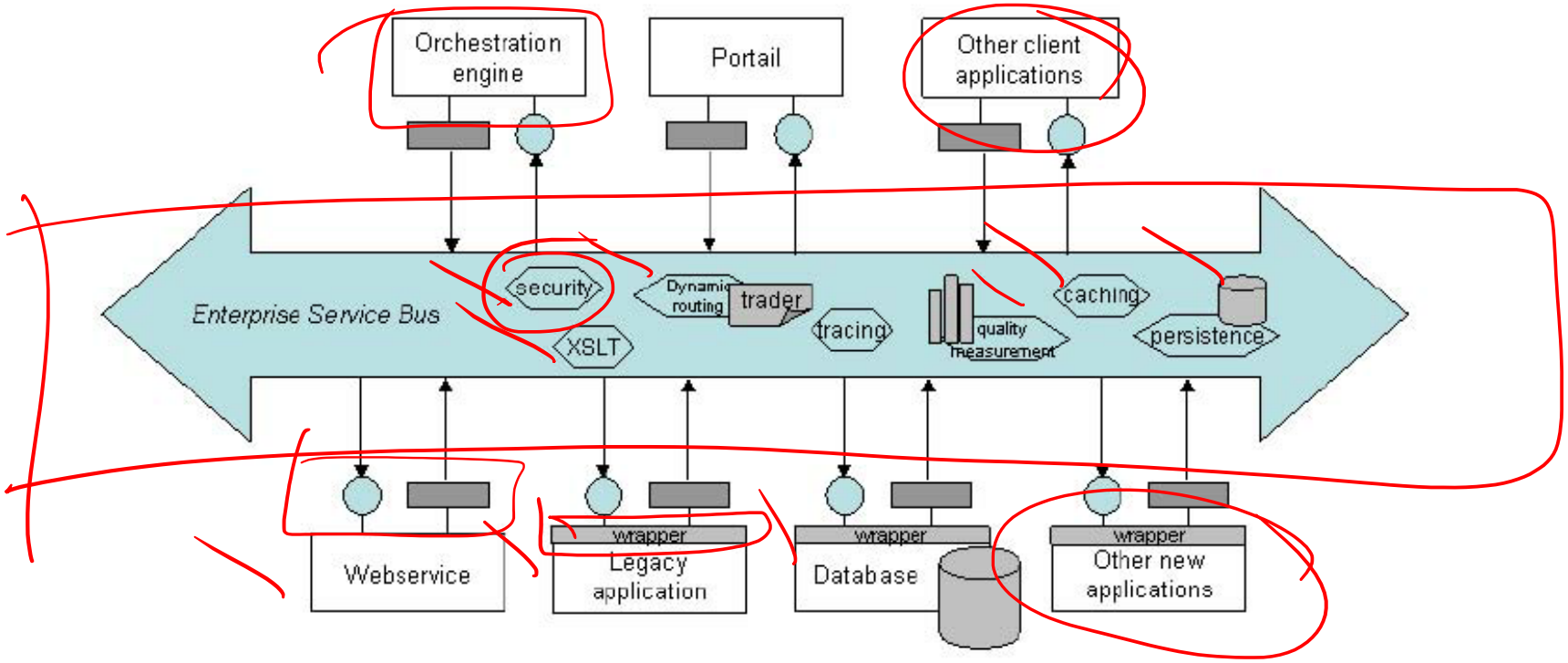
Service Oriented Architecture - Overview

- A Service Oriented Architecture (SOA) is a form of distributed systems architecture that is typically characterized by the following properties
  - Logical view
  - Message Orientation
  - Description Orientation
  - Granularity
  - Network Orientation
  - Platform Neutrality
- Implementation of SOA
  - Arbitrary Web services (SOAP/XML) → Non-REST
  - RESTful Web services
  - Apache Thrift → Protobuf

Middleware Web Technologies - Overview

SOA vs Enterprise Service Bus (ESB)

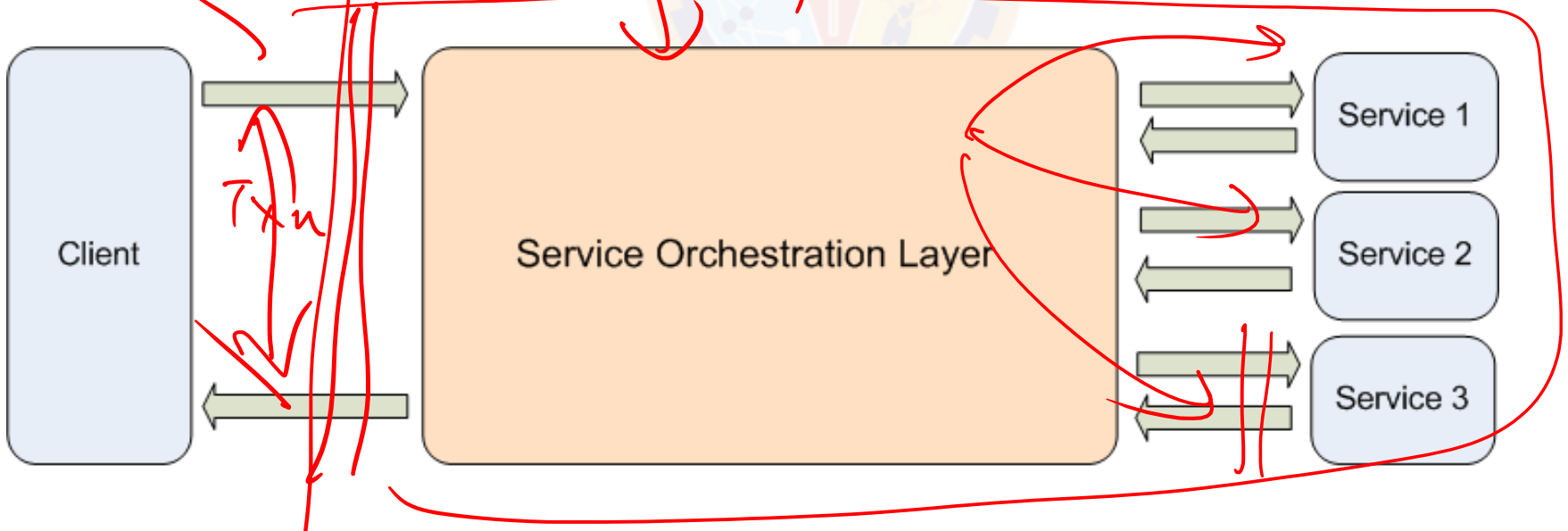
- ESB - Implements a communication system between mutually interacting software applications (including SOA components)
- Can be used to integrate SOA apps with non-SOA apps
- Acts as service orchestrator, API gateway, security manager etc.



Middleware Web Technologies - Overview

Service Orchestration

- Process of integrating two or more applications and/or services together to automate a process, or synchronize data in real-time
- Service orchestration is the combination of service interactions to create higher-level business services
- Service Orchestration involves connecting various applications, web services and legacy components in a business flow
- Examples of Orchestrators: Business Process Modeling engines, ESB etc.



Middleware Web Technologies - Overview

SOA Maturity Levels

- Analogous to CMM definition for process maturity
- Levels
  - Initial
  - Managed
  - Defined
  - Quantitatively Managed
  - Optimized

Maturity level	SOA view	Benefits and metrics	Business involvement	Methodology	Service sourcing	Governance
Initial	Fine-grained software components	Promise of reuse; no metrics	Hidden from business	Minor adaptation of current software methods	Largely derived from existing application programming interfaces	Basic service definition policies at project level
Managed	Emerged software architecture	Standardization of data and resources	Services exposed as part of project cost	Project-level service definition methods	In-house development of new fine-grained software components	Service policies managed by registry monitors
Defined	Business process support	Business process redesign	Services part of requirement capture	Business service definition methods	External sourcing possible by defined function	Full set of service policies and metrics in place
Quantitatively managed	Enterprise service architecture	Agility and flexibility	Organizational "service thinking"	Intra- and inter-organizational service definition	Enterprise service bus to coordinate services	Business and IT governance metrics aligned
Optimized	Adaptive architecture	Autonomic systems	Value-stream "service thinking"	Value-chain service optimization	Full integration up and down the stack	Policy feedback used to adjust delivery

Middleware Web Technologies - Overview

Web Service – Initial Definition

- "A web service is a software system designed to support interoperable machine-to-machine interaction over a network." – W3C glossary
- "It [Web Service] has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the web service in a manner prescribed by its description using SOAP-messages, typically conveyed using HTTP with an XML serialization in conjunction with other web-related standards." – W3C basic definition, 2002

W3C → SOAP WS

WSDL → XML/SOAP

Middleware Web Technologies - Overview

Web Service Redefined – REST + Non-REST

"An even more constrained architectural style for reliable Web applications known as Representation State Transfer (REST) has been proposed by Roy Fielding and has inspired both the W3C Technical Architecture Group's architecture document [Web Arch] and many who see it as a model for how to build Web services [Fielding]. The REST Web is the subset of the WWW (based on HTTP) in which agents provide uniform interface semantics -- essentially create, retrieve, update and delete -- rather than arbitrary or application-specific interfaces, and manipulate resources only by the exchange of representations. Furthermore, the REST interactions are "stateless" in the sense that the meaning of a message does not depend on the state of the conversation.

We can identify two major classes of Web services:

- REST-compliant Web services, in which the primary purpose of the service is to manipulate XML representations of Web resources using a uniform set of "stateless" operations; and
- arbitrary Web services, in which the service may expose an arbitrary set of operations."

-W3C extended definition, 2004

Middleware Web Technologies - Overview

Non-REST Vs RESTful Web services

Non-REST Web services (SOAP WS)	RESTful Web services
Exposes services as individual operations, each to achieve a specific business objective.	Representational State Transfer is an architectural style for defining interoperability in terms of resources or concepts
Introduced in W3C draft for web services in 2002	Introduced in W3C extended revision in 2004
Uses Simple Object Oriented Protocol (SOAP), a variant of XML for data transfer	REST supports SOAP/XML/JSON or any other data protocol supported by HTTP
Service contract definition is specified via Web service description language (WSDL)	Service contract is defined via resource or concept endpoints and HTTP methods (POST/ GET/ PUT/ DELETE) defined on them
JAX-WS is the binding protocol used	**JAX-RS** is binding protocol used
Imposes a rigid structure for service definition and request/response	Does not impose any specific structure – any format supported by HTTP is accessible
Requires more footprint and bandwidth, resulting in performance issues at large scale	Light-weight formats (like JSON) require less footprint there by improving performance
Defines its own security, as defined by SOAP-WS security	**Inherits security measures** from the underlying transport protocol (TCP, UDP etc.)

Thank You!

In our next session:

Non-REST (SOAP) Web Services

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Understanding RESTful services

Madhu Venkat

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BITS, WILP

REST Web Services

- Architectural Style
- Utilizes web standards
- Stateless communication protocol
- Standardized interface and protocol

Advantages of Web services

- Resource Identification – Data and functionality are considered resources.
- Uniform interfaces – Resources are manipulated using a fixed set of operations (GET, PUT, DELETE, POST)
- Self Descriptive – A resource can be represented in multiple formats.
- Stateful interaction – Communication between the client and the endpoint is stateless.

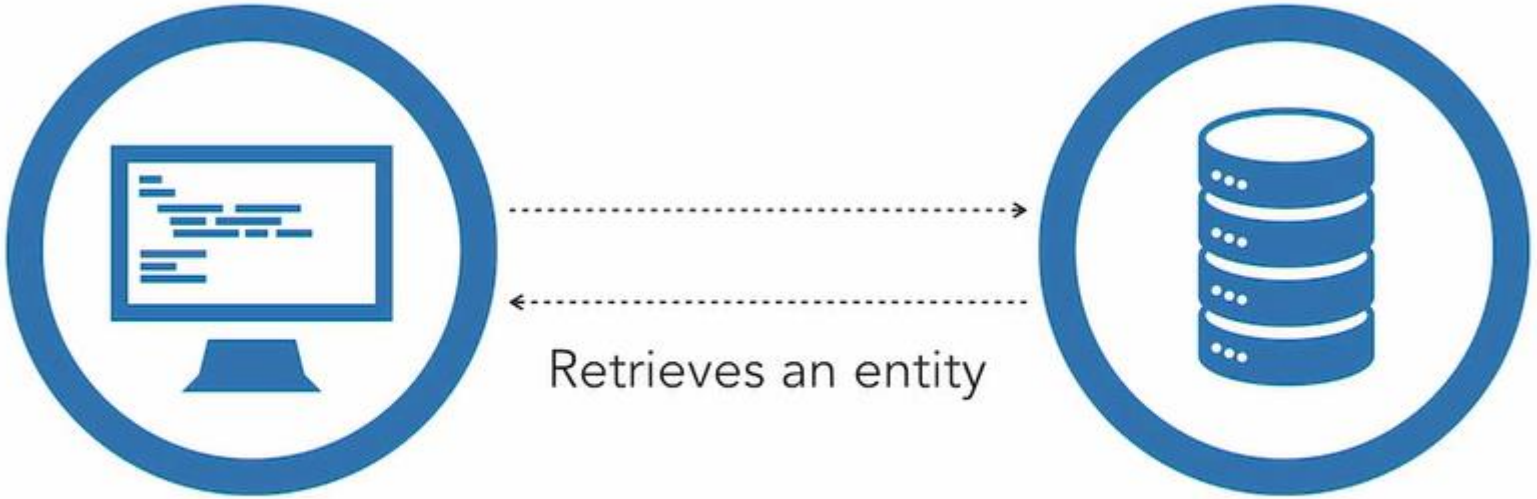
JAX-RS Specification

- Set of Interfaces and annotations
- Implementation of specification

JSON Methods

- HTTP GET
- HTTP POST
- HTTP PUT
- HTTP DELETE

HTTP GET Resource



HTTP GET Resource - Example

- http://localhost:8080/javaee-7.0/rest/applications

```
@GET
public Response getAll() {
...

}
```

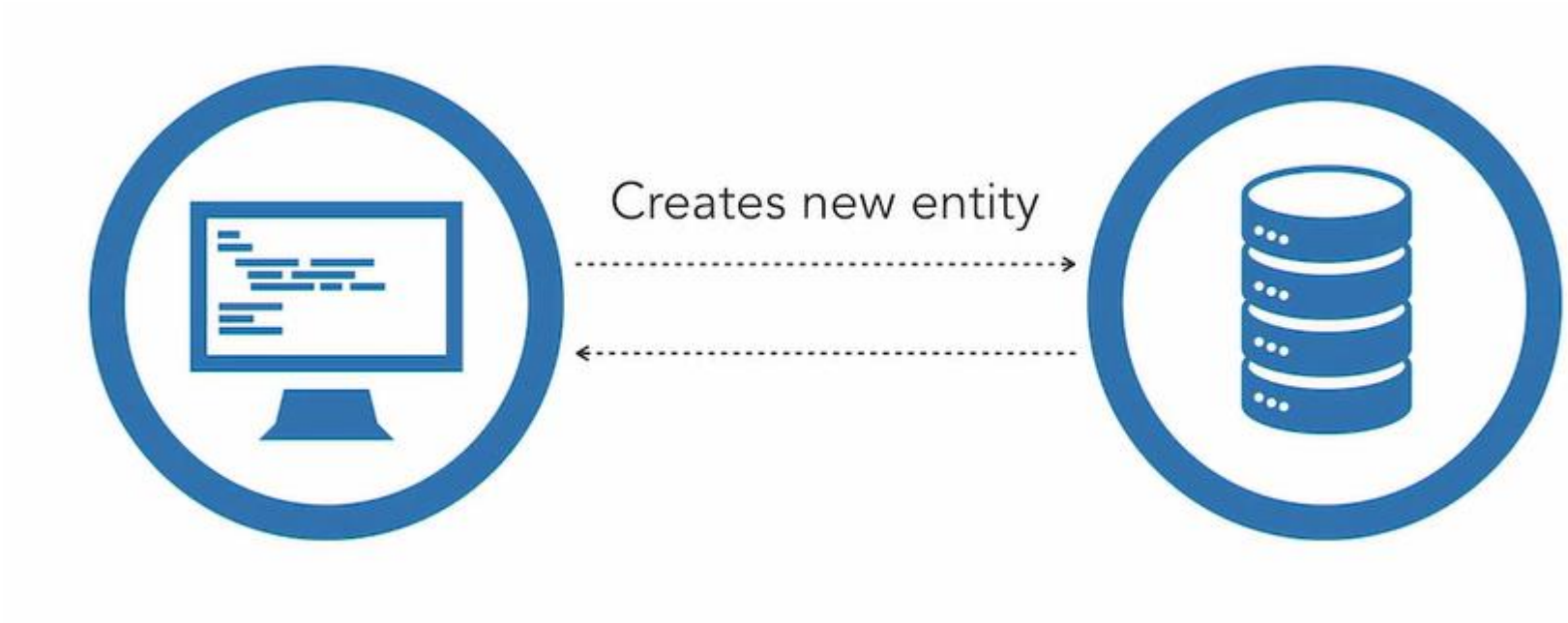
GET Resource with parameter

- http://localhost:8080/javaee-7.0/rest/applications/1

```
@GET
@Path("{id}")
public Response getApplication(@PathParam("id") int id)
{

  ...
}
```

HTTP Post

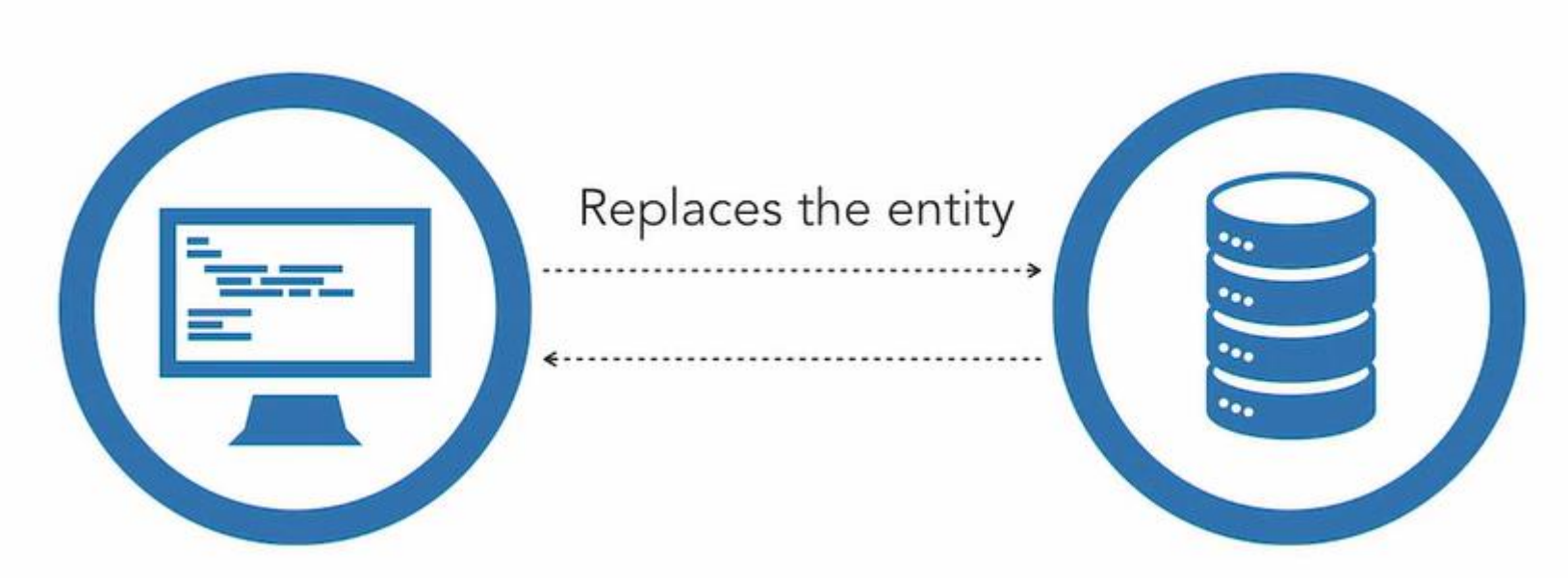


POST Request

- http://localhost:8080/javaee-7.0/rest/applications

```
@POST
public Application addApplication(Application application)
{
   ...
}
```

HTTP PUT Resource

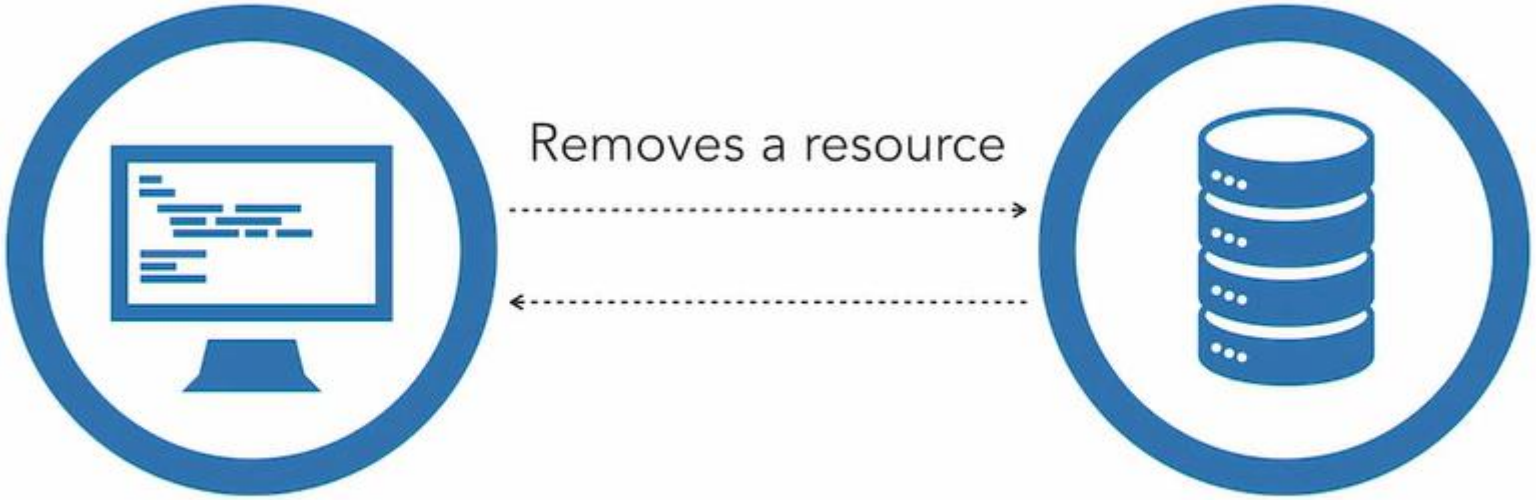


HTTP PUT Resource - Example

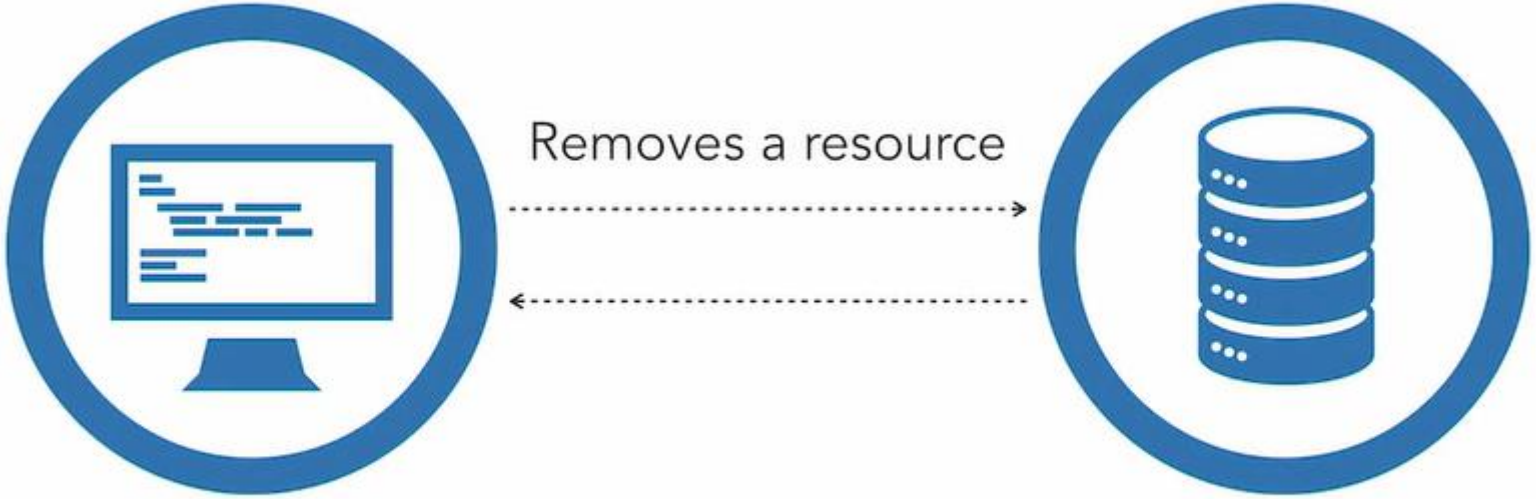
- http://localhost:8080/javaee-7.0/rest/applications

```
@PUT
public Response updateApplication(Application application)
{
  ...
}
```

HTTP DELETE Resource



HTTP DELETE Resource - Example



HTTP Delete Resource - Example

- http://localhost:8080/javaee-7.0/rest/applications/3

```
@DELETE
@Path("{id}")
public Response deleteApplication(@PathParam("id") int id)
{
   ...
}
```

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Understanding Web Services

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Web Service

- A Software Application
- Means of Communication
- Variety of Platforms
- Communicate with Other Programs

Web Service

Systems

- Windows or Linux servers
- Mobile devices
- Mainframe computers
- Desktop computers
- Smartphones
- Another web service

Communication

Two types of Web services

- SOAP – SOAP is an XML-based web service protocol for accessing web services.

- REST API – REST is an architectural style and approach to communications often used in web services development.

Two key entities

- Provider – the device, system or organization providing the data or information

- Client – the device , system requesting the data or information

Data exchange Formats

- XML – Extensible markup language is a popular way to structure data.

- JSON – Java script object notation (JSON) is a text based data interchange format derived from the Javascript language.

Web services provides

- Language Transparency
- Service provider in one language
- Service client written in another
- Common Language

Benefits

- Exposes business logic and data to other systems in a secure fashion.
- Provides a small reusable component that can be used by multiple systems.

Web service example in .NET

```
using System;
using System.Collections.Generic;
using System.Web;
using System.Web.Services;
///<summary>
/// Summary description for UtilityWebService
///</summary>
[WebService(Namespace = "http://tempuri.org/")]
[WebServiceBinding(ConformsTo = WsiProfiles.BasicProfile1_1)]
// To allow this Web Service to be called from script, using ASP.NET AJAX, uncomment the
// [System.Web.Script.Services.ScriptService]
public class WebService: System.Web.Services.WebService
{
    public WebService()
    {
        //Uncomment the following line if using designed components
        //InitializeComponent();
    }
    [WebMethod]
    public int converttodaysweb(int day, int month, int year)
    {
        DateTime dt = new DateTime(year, month, day);
        int datetodays = DateTime.Now.Subtract(dt).Days;
        return datetodays;
    }
```

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Understanding SOAP Serivces

Madhu Venkat

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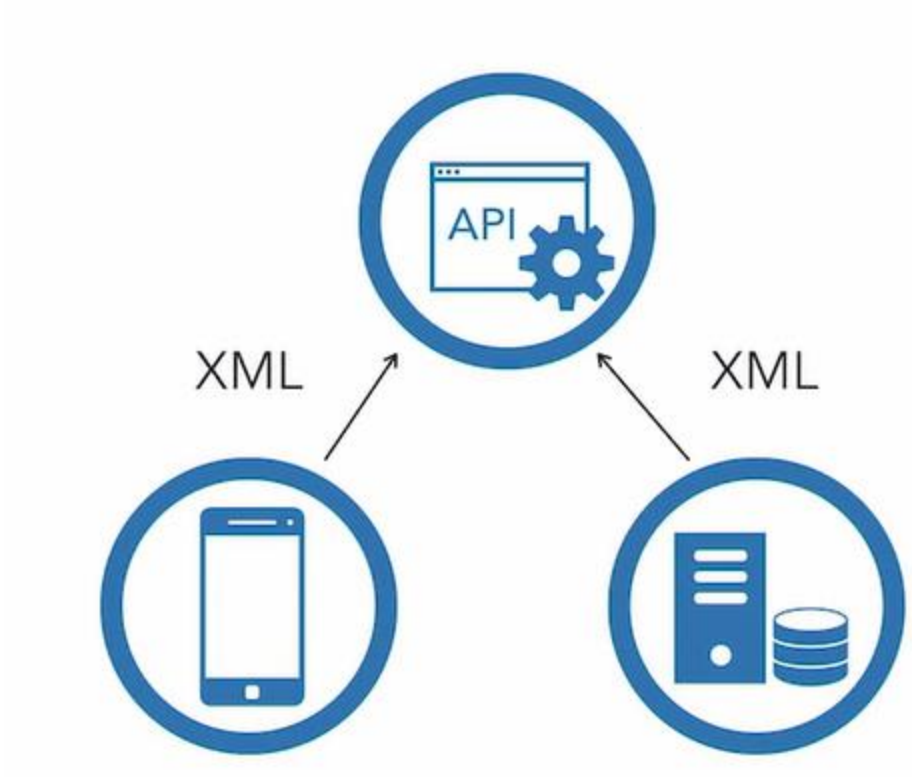
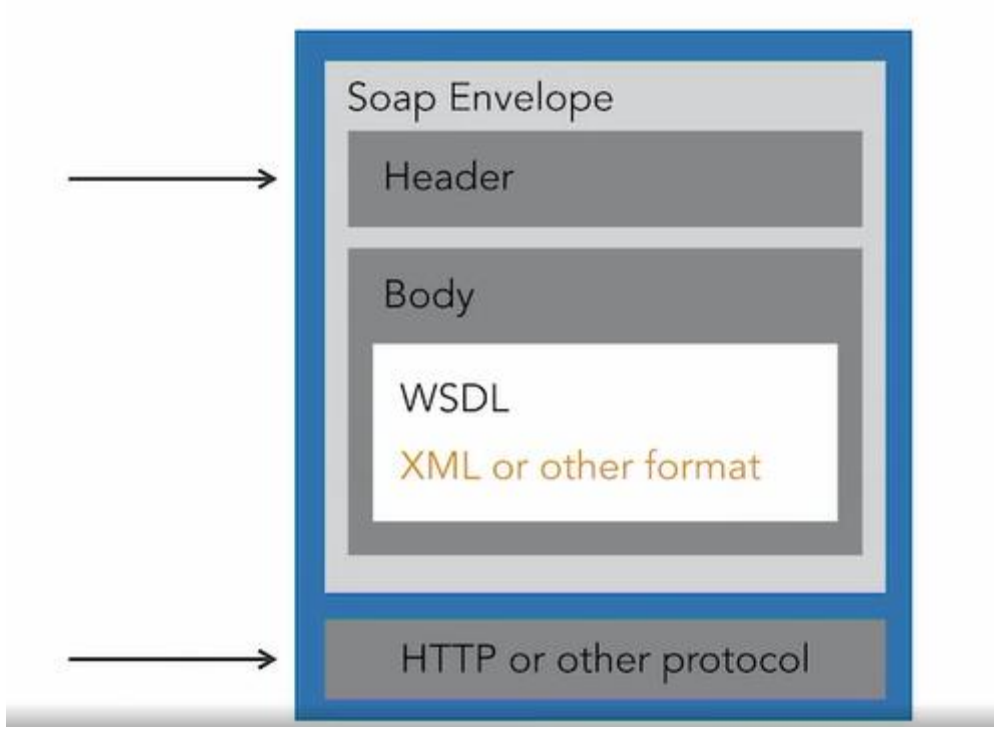
SOAP

- Simple
- Object
- Access
- Protocol



SOAP Message

- Structure
- Encoding rules
- Invocations
- Responses



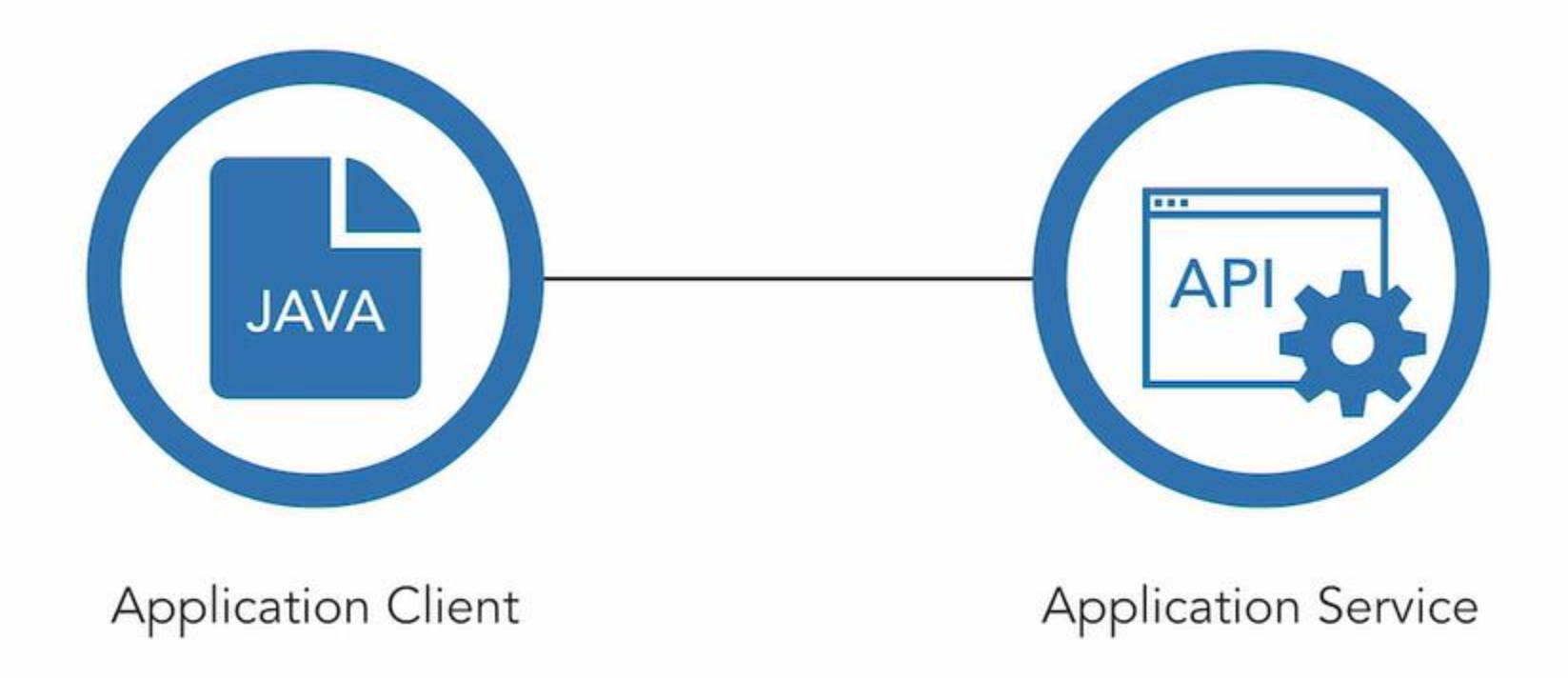
JAX-WS

- Java API for XML Web services
- Simplifies SOAP API
- Simple API

How it works?

- JAX-WS publishes web service and WSDL
- A Proxy generated allowing clients to invoke the service
- API Call converted to SOAP messages and sent out HTTP

How to implement SOAP web service?



SOAP Web Service Example

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Web;
using System.Web.Services;
namespace webservice.asmx
{
    [WebService(Name="Guru99 Web service")]
public class TutorialService : System.Web.Services.WebService
{
        [WebMethod]
        public string Guru99WebService()
        {
            return "This is a Guru99 Web service";
        }
    }
}
```

1 Name for the web service

2 Class which encapsulates all the web methods

3 Define the web method

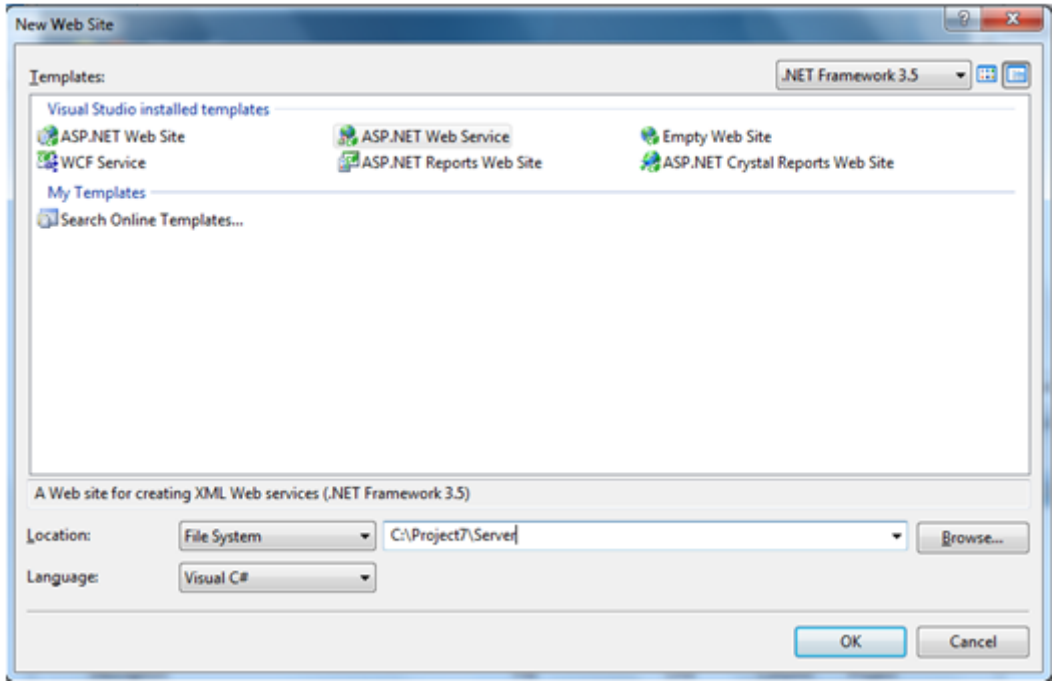
4 Create a function

5 Return a string

SOAP API vs REST API

SOAP API	REST API
Relies on SOAP (Simple Object Access Protocol)	Relies on REST (Representational State Transfer) architecture using HTTP.
Transports data in standard XML format.	Generally transports data in JSON. It is based on URI. Because REST follows stateless model, REST does not enforces message format as XML or JSON etc.
Because it is XML based and relies on SOAP, it works with WSDL	It works with GET, POST, PUT, DELETE
Works over HTTP, HTTPS, SMTP, XMPP	Works over HTTP and HTTPS
Highly structured/typed	Less structured -> less bulky data
Designed with large enterprise applications in mind	Designed with mobile devices in mind

Create SOAP API using .NET



Go to the *Service.cs* file and create the four needed methods by replacing:

C#

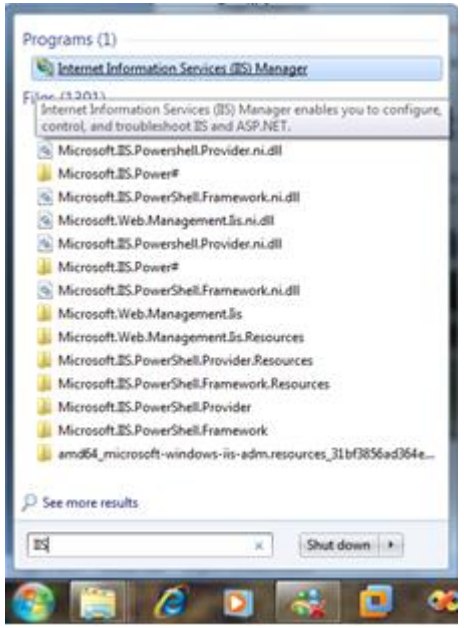
```
[[WebMethod]
    public int Add(int x, int y)
    {
        return x + y;
    }
    [WebMethod]
    public int Subtract(int x, int y)
    {
        return x - y;
    }
    [WebMethod]
    public int Multiply(int x, int y)
    {
        return x * y;
    }
    [WebMethod]
    public int Division(int x, int y)
    {
        return x / y;
    }
```

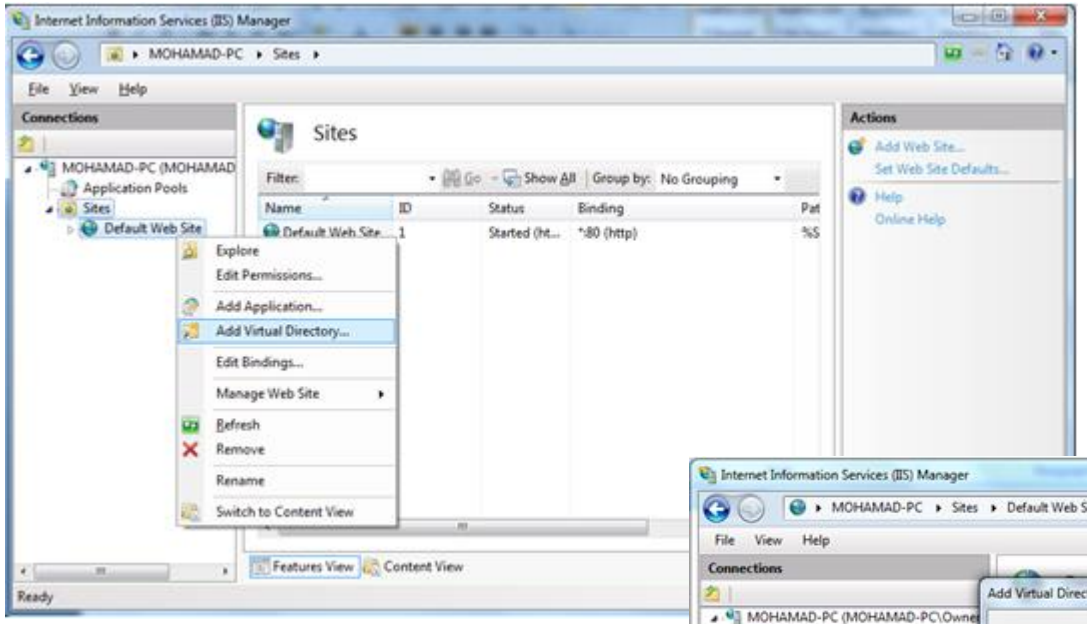
Accessing from External client - URL

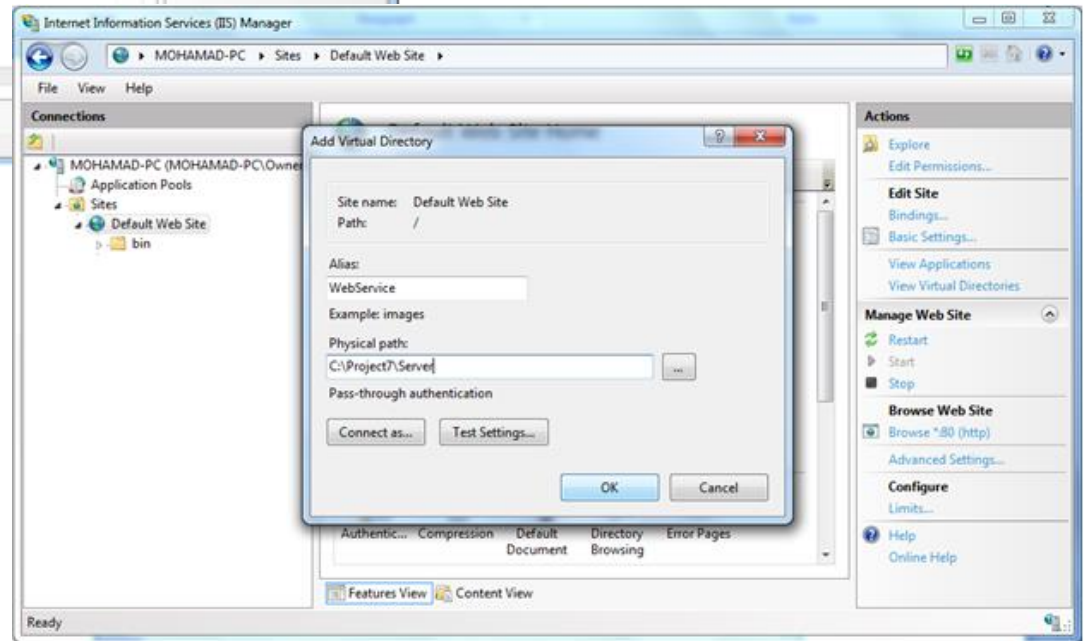
C#

```
[WebService(Namespace="http://tempuri.org/",
Description="A Simple Web Calculator Service",
Name="CalculatorWebService")]
```

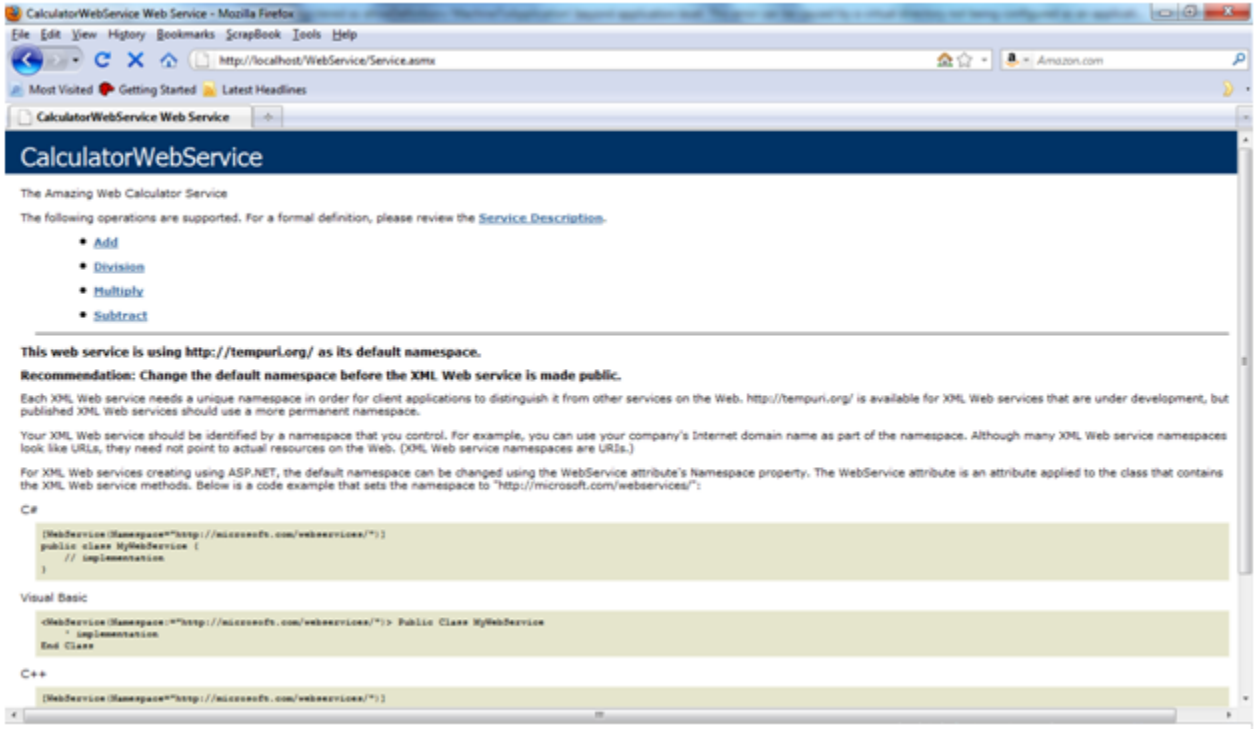
Installing in IIS



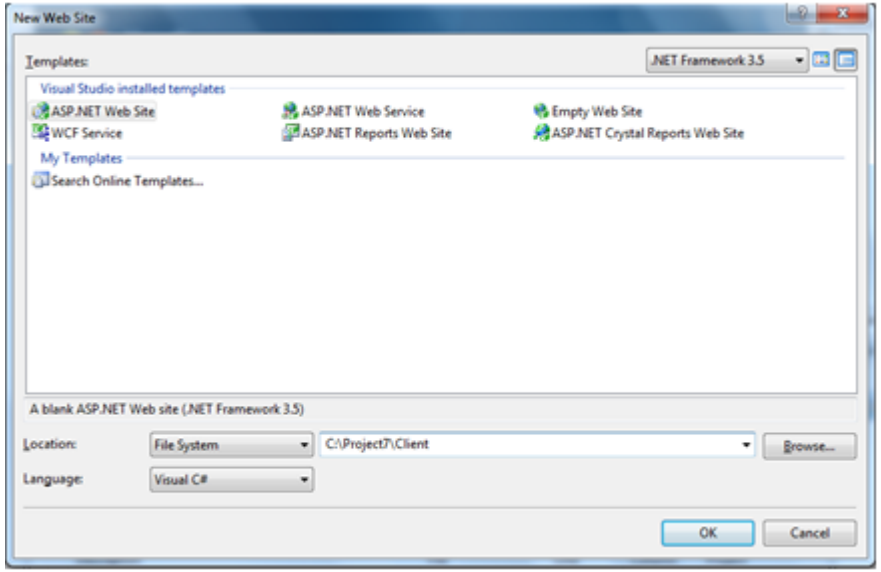


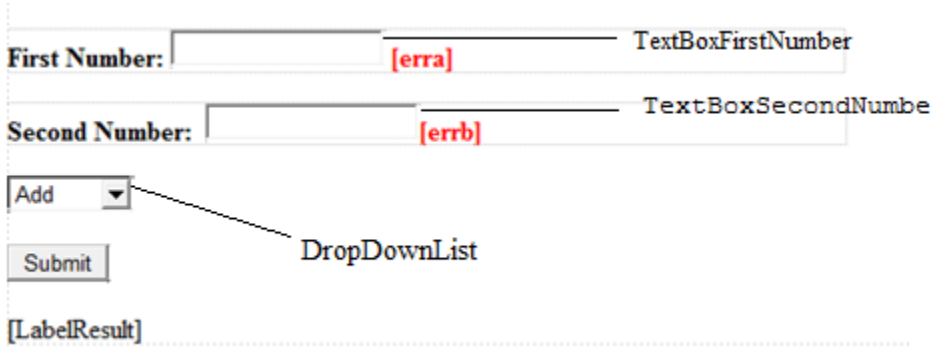


Now open your browser and goto *http://localhost/WebService/Service.asmx*, you should see a screen similar to this:

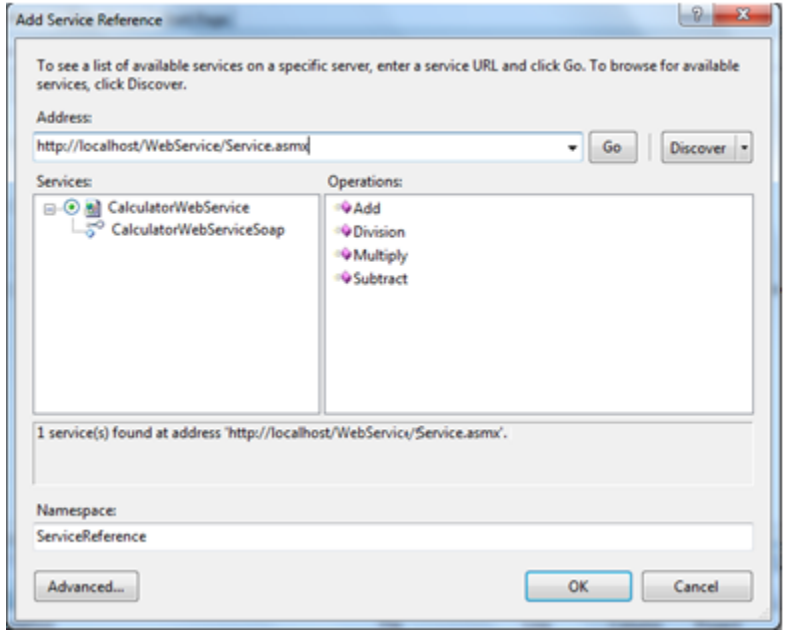


Testing the SOAP Web service from client





Right Click the Project in the solution explorer / choose *Add Service Reference* / enter *http://localhost/WebService/Service.asmx* in the address field /click *Go* to view the imported functions / choose *ServiceReference* as your namespace / click OK.



Submit button code to get results

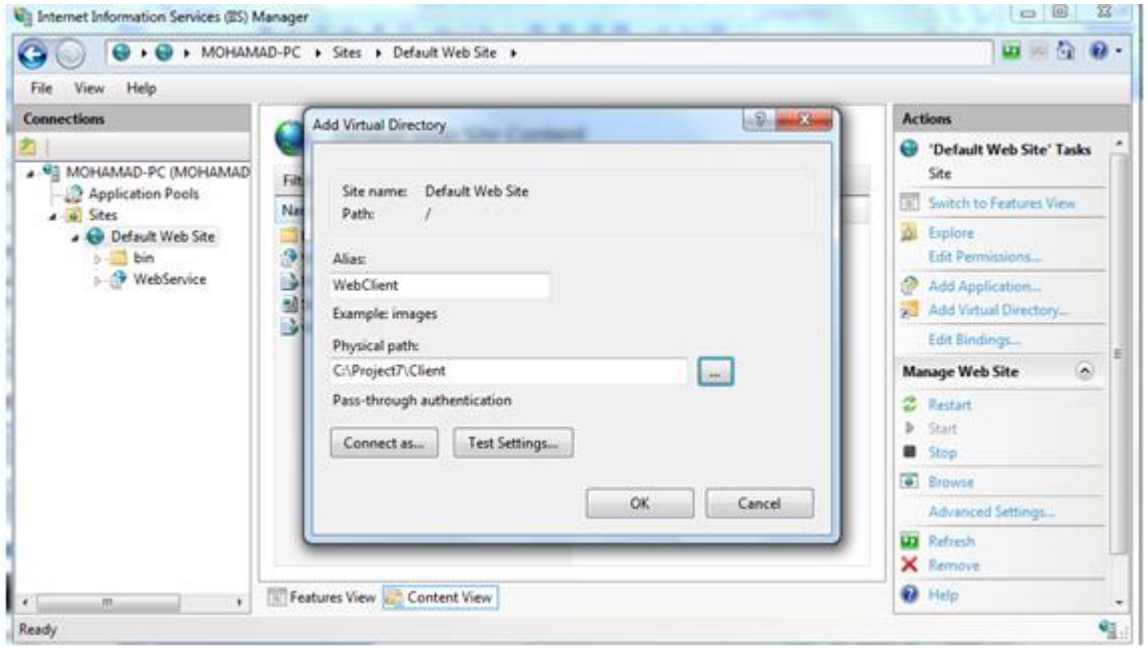
```
private string GetResult(string firstNumber, string secondNumber, int function)
    {
        ServiceReference.CalculatorWebServiceSoapClient client =
            new ServiceReference.CalculatorWebServiceSoapClient();
        int a, b;
        string result = null;

        erra.Text = "";
        errb.Text = "";

        if (!int.TryParse(firstNumber, out a))
        {
            erra.Text = "Must be a valid 32-bit integer!";
            return "";
        }

        if (!int.TryParse(secondNumber, out b))
        {
            errb.Text = "Must be a valid 32-bit integer!";
            return "";
        }

        try
        {
            switch (function)
            {
                case 0:
                    result = firstNumber + " + " + secondNumber +
            " = " + client.Add(a, b);
                    break;
                case 1:
                    result = firstNumber + " - " + secondNumber + " = "
                    + client.Subtract(a, b);
                    break;
                case 2:
                    result = firstNumber + " * " + secondNumber + " =
            " + client.Multiply(a, b);
                    break;
                case 3:
                    result = firstNumber + " / " +
                    secondNumber + " = " + client.Division(a, b);
                    break;
            }
        }
        catch (Exception e)
        {
            LabelResult.ForeColor = System.Drawing.Color.Red;
            result = "Cannot Divide by Zero!";
        }
        return result;
    }
```

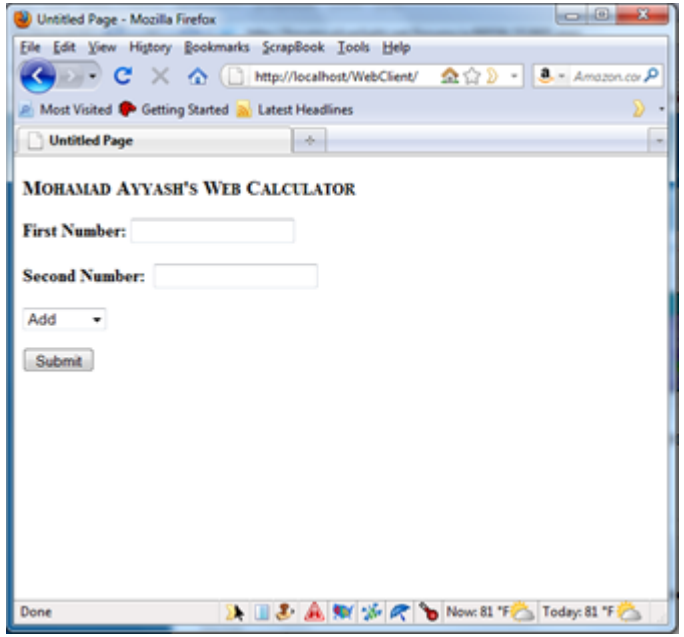
Invoke SOAP API

```
ServiceReference.CalculatorWebServiceSoapClient client =
        new ServiceReference.CalculatorWebServiceSoapClient();
```

```
protected void btnSubmit_Click(object sender, EventArgs e)
  {
      LabelResult.ForeColor = System.Drawing.Color.Black;
      LabelResult.Text = GetResult(TextBoxFirstNumber.Text,
      TextBoxSecondNumber.Text,
      DropDownList.SelectedIndex);
  }
```

Installing web client in IIS





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Middleware for Cloud Applications – AWS EC2 / Lambda

Srikanth Gunturu

Guest Faculty
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In this segment

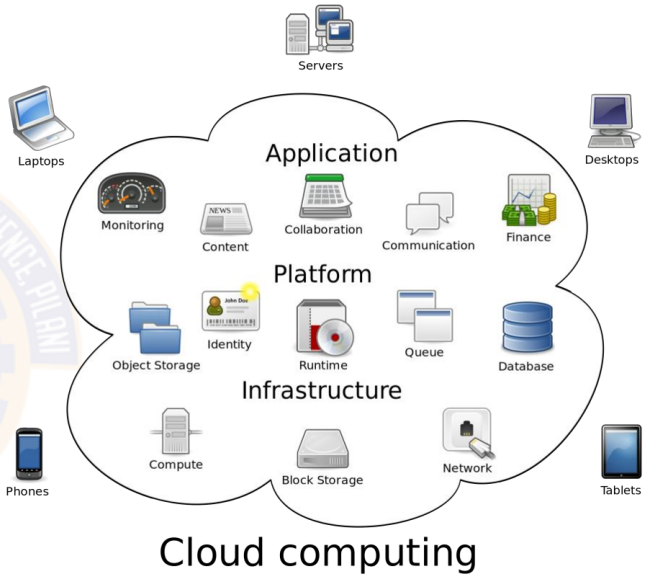
Middleware for Cloud Applications - AWS

- Cloud Computing Overview
- AWS Cloud Components
- Launching EC2 for Linux / Windows - Demo
- AWS Lambda

Middleware for Cloud Applications - AWS

Cloud Computing Overview

- Cloud computing is the on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user
- Cloud computing may be available:
  - Exclusively to one organization (enterprise / private cloud)
  - Multiple organizations (public cloud)
  - Combination (hybrid)
- Cloud computing relies on sharing of resources to achieve coherence and economies of scale
- Major cloud providers:
  - Amazon – AWS
  - Microsoft – Azure
  - Google – Google Cloud



Middleware for Cloud Applications - AWS

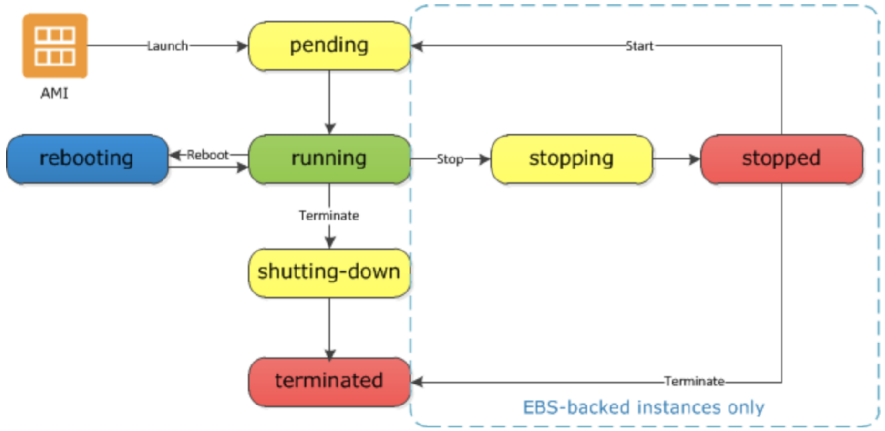
AWS Components

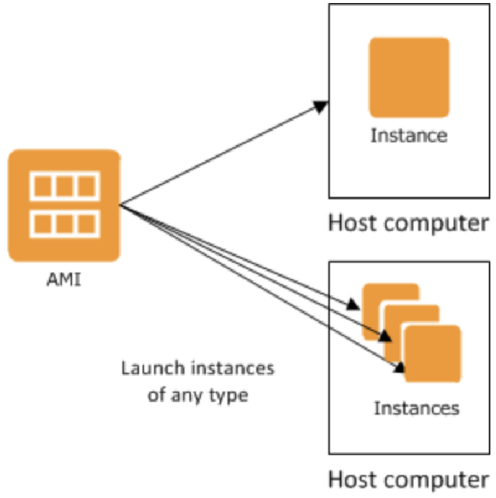
- *Compute – EC2, Elastic Beanstalk, Auto scaling*
- *Storage and Content Delivery – S3, EBS*
- *Database - RDS*
- *Networking – VPC, ELB*
- Analytics
- Enterprise Applications
- Internet of Things
- Mobile Services
- Developer Tools
- Management Tools
- Security and Identity
- Application Services
- Software (maintenance)

Middleware for Cloud Applications - AWS

EC2 – AMIs and Instances

- Amazon Machine Image (AMI) is the template for a software configuration (OS, application server etc.)
- Instance(s) is a virtual server in the cloud that's a copy of AMI template





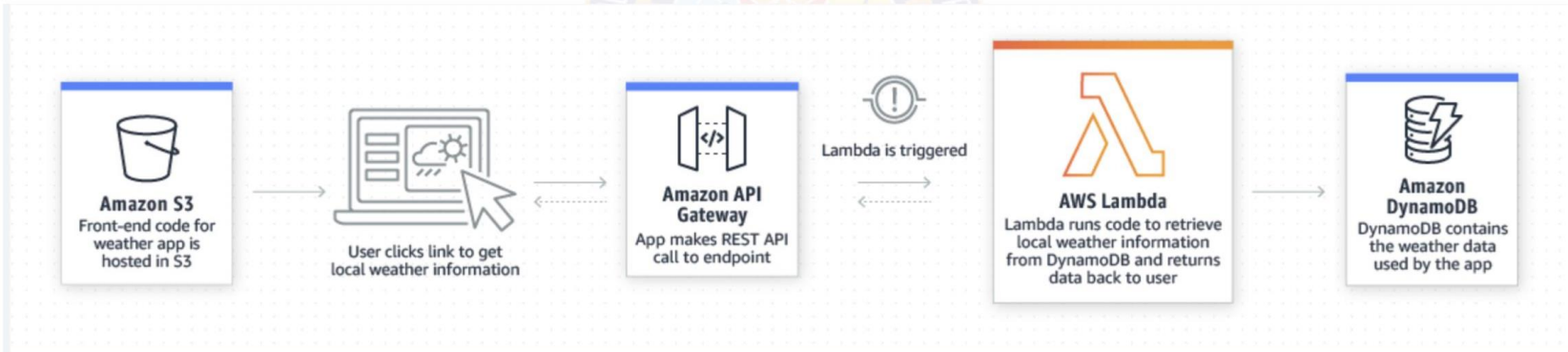
EC2 instance launch and connect

Demo from console

Middleware for Cloud Applications - AWS

AWS Lambda

- AWS Lambda is an event-driven, serverless computing platform provided by Amazon as a part of AWS
- The purpose of Lambda, as compared to AWS EC2, is to simplify building smaller, on-demand applications that are responsive to events and new information
- AWS Lambda supports securely running native Linux executables



Middleware for Cloud Applications - AWS

AWS Lambda - Demo

- Demo with ref-arch

Thank You!

In our next session:

Hybrid Cloud & Multi-Cloud architecture

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Hybrid Cloud & Multi Cloud Architectures

Srikanth Gunturu

Guest Faculty
BITS, WILP

In this segment

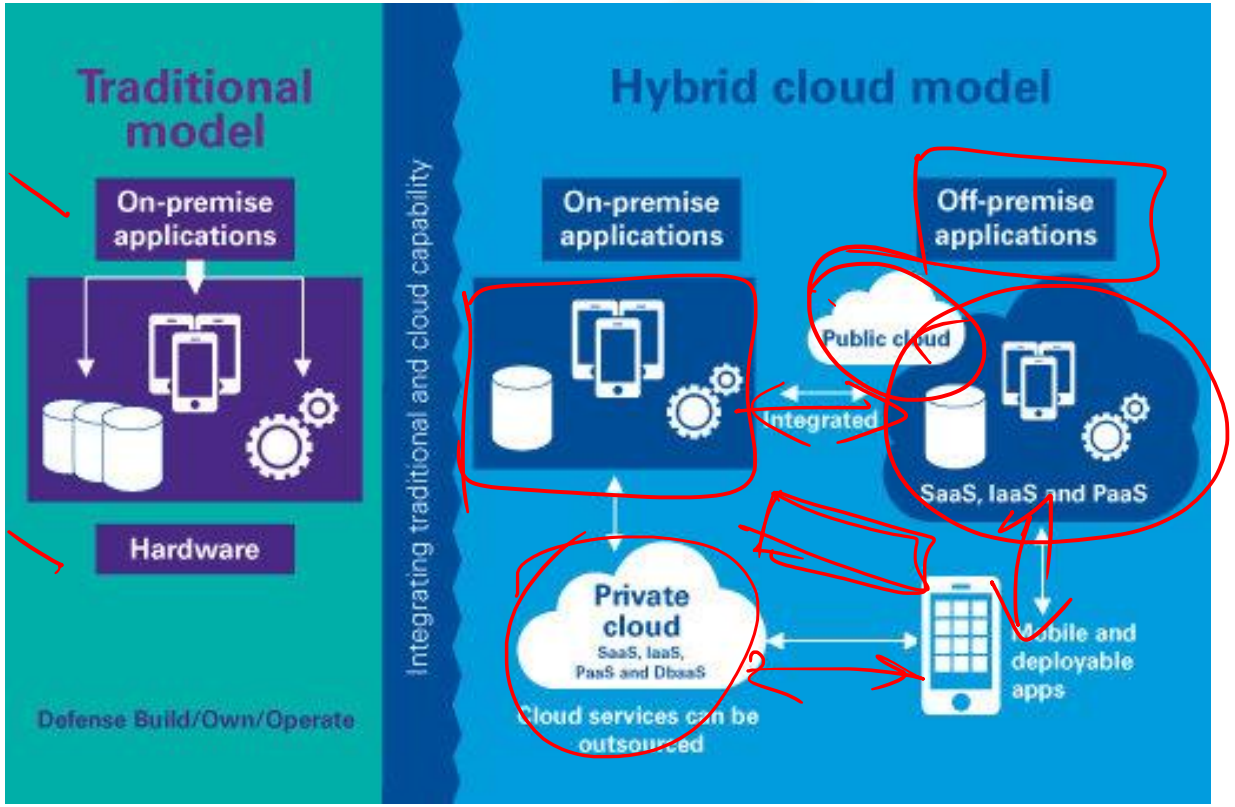
Hybrid Cloud & Multi Cloud Architectures

- Hybrid Cloud
- Multi-cloud architecture
- Load balancer in cloud - ELB

Hybrid Cloud & Multi Cloud Architectures

Hybrid Cloud

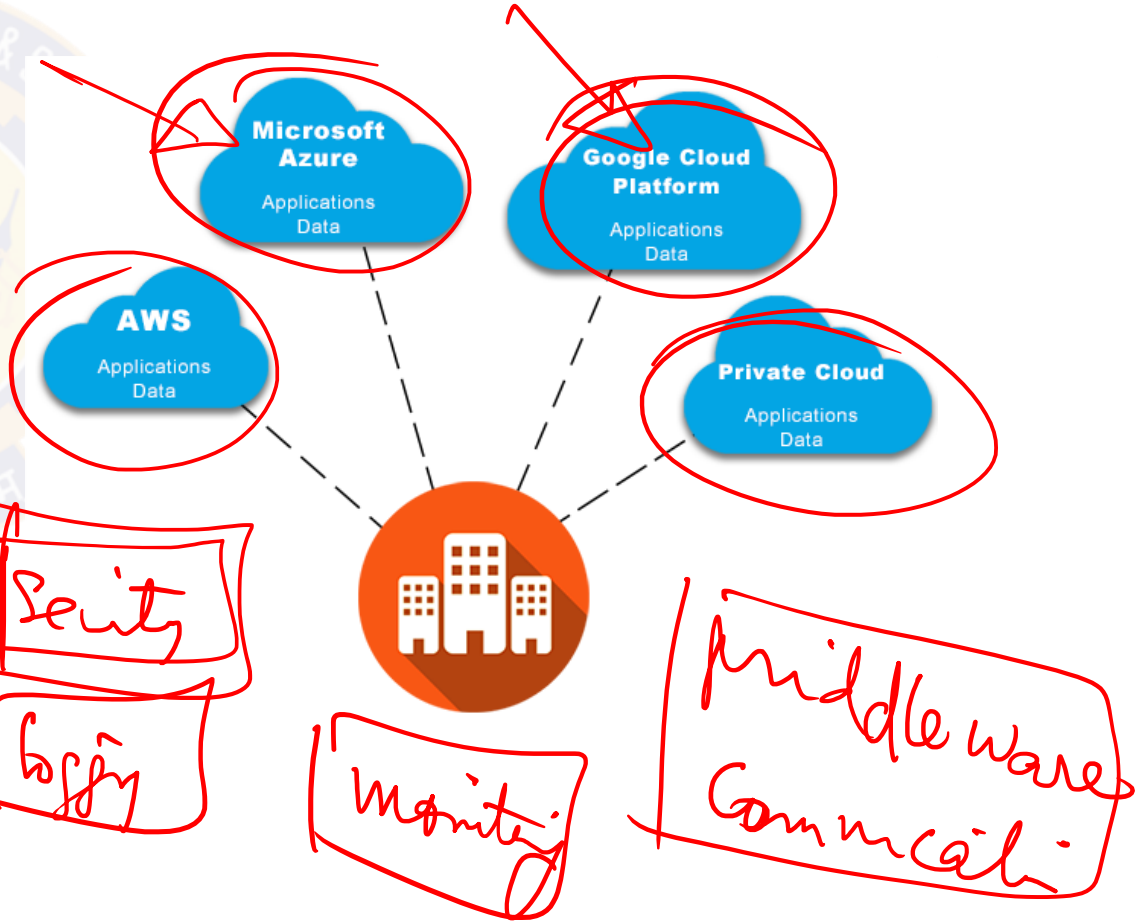
- Hybrid cloud has part of an enterprise's computing is provided by a separate cloud provider and part is done in house



Hybrid Cloud & Multi Cloud Architectures

Multi Cloud

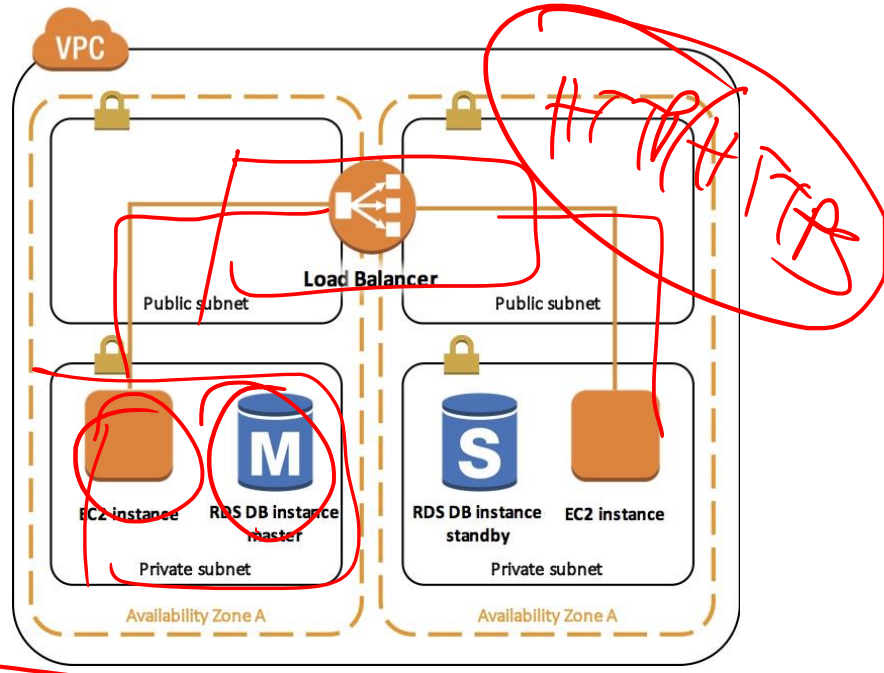
- Multi cloud setup has an enterprise utilizing services of multiple cloud service providers in tandem (optionally with their on-prem traditional infra or private cloud)
- Advantages
  - Cost effective
  - Independence from a single provider
  - Flexibility through choice
- Disadvantages
  - Complexity of managing affairs
  - Security is a challenge
  - Redundancy and High availability across providers

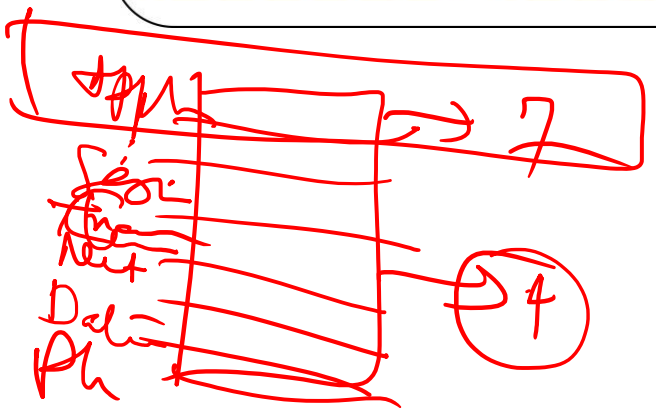


Hybrid Cloud & Multi Cloud Architectures

Load Balancing in Cloud – AWS Elastic Load Balancing (ELB)

- Elastic Load Balancing automatically distributes incoming application traffic across multiple targets, such as Amazon EC2 instances, containers, IP addresses, and Lambda functions
- AWS ELB has three types of loan balancing
- Application Load Balancer
  - Best suited for load balancing of HTTP and HTTPS traffic
  - Operates at request level (layer 7 of OSI
- Network Load Balancer
  - Best suited for load balancing of Transmission Control Protocol (TCP), User Datagram Protocol (UDP) and Transport Layer Security (TLS) traffic
  - Operates at connection level (layer 4 of OSI)
- Classic Loan Balancer
  - Provides basic load balancing across multiple Amazon EC2 instances and operates at both the request level and connection level





Hybrid Cloud & Multi Cloud Architectures

Load Balancing in Cloud – AWS Elastic Load Balancing (ELB) - Demo

- ELB Demo

Thank You!

In our next session:

Specialized Middleware – NoSQL Database