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Agent and **O**bject **T**echnology **Lab**
Dipartimento di Ingegneria dell'Informazione
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Business Process Modelling Languages

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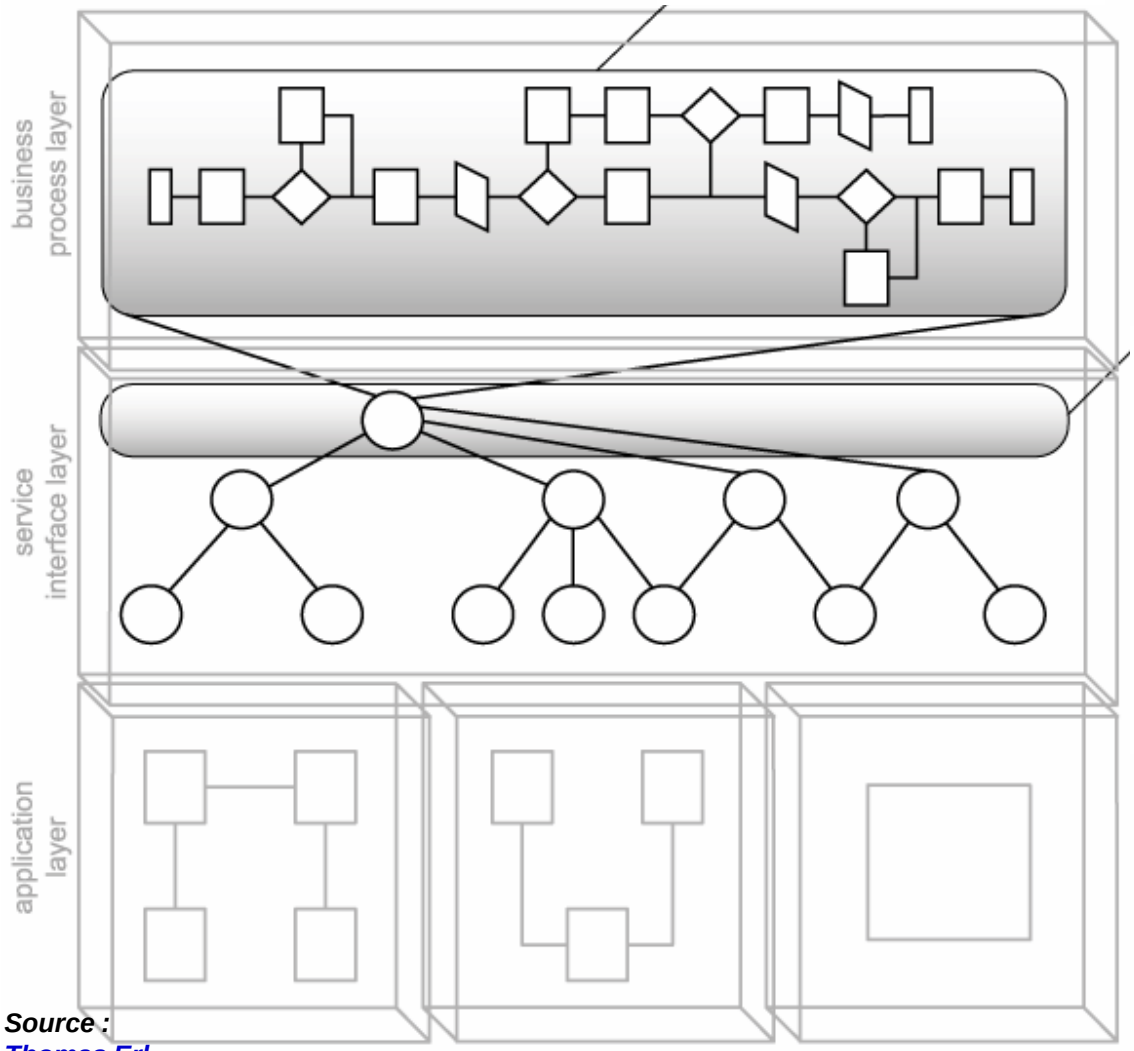
Business Process Modelling



- ***Business Process Modelling***
  - ***UML Activity Diagram***
  - ***BPMN***
  - ***WSBPEL***
  - ***Process Integration Languages***
- ***Integration issues and "traditional" approaches***
- ***Service-Oriented Architecture***
  - ***Service-Oriented paradigm***
  - ***Web Services***
    - ***Core Web Services Standards***
  - ***Semantic Web Services: SAWSDL***
- ***Enterprise Applications***
  - ***Overview***
  - ***Architectural solutions***
    - ***Patterns of Enterprise Application Architecture***

Source :
Thomas Erl
Service-Oriented Architecture: Concepts, Technology, and Design

Business Process

"The hardest single part of building a software system is deciding precisely what to build. No other part of the conceptual work is as difficult as establishing the detailed technical requirements ... No other part of the work so cripples the resulting system if done wrong. No other part is as difficult to rectify later".
Brooks [1987]

1. To understand what a software system is supposed to do, it is necessary to put it into the context of the business processes that it is supposed to support.
   - This support can range from storage and retrieval of business data to decision support or even to full automation.
   - In all cases, an understanding of the underlying business processes is required.
2. Understanding business processes enables business experts to analyze them, to identify potential weaknesses or inefficiencies, and to "reengineer them" to address those weaknesses.

Business Process Challenges

- Coordinate asynchronous communication between services
- Correlate message exchanges between parties
- Implement parallel processing of activities
- Manipulate/transform data between partner interactions
- Provide consistent exception handling
- Support for long running business transactions and activities
- . . .

***Source :** ORACLE, "BPELOverview"*

Process Abstractions

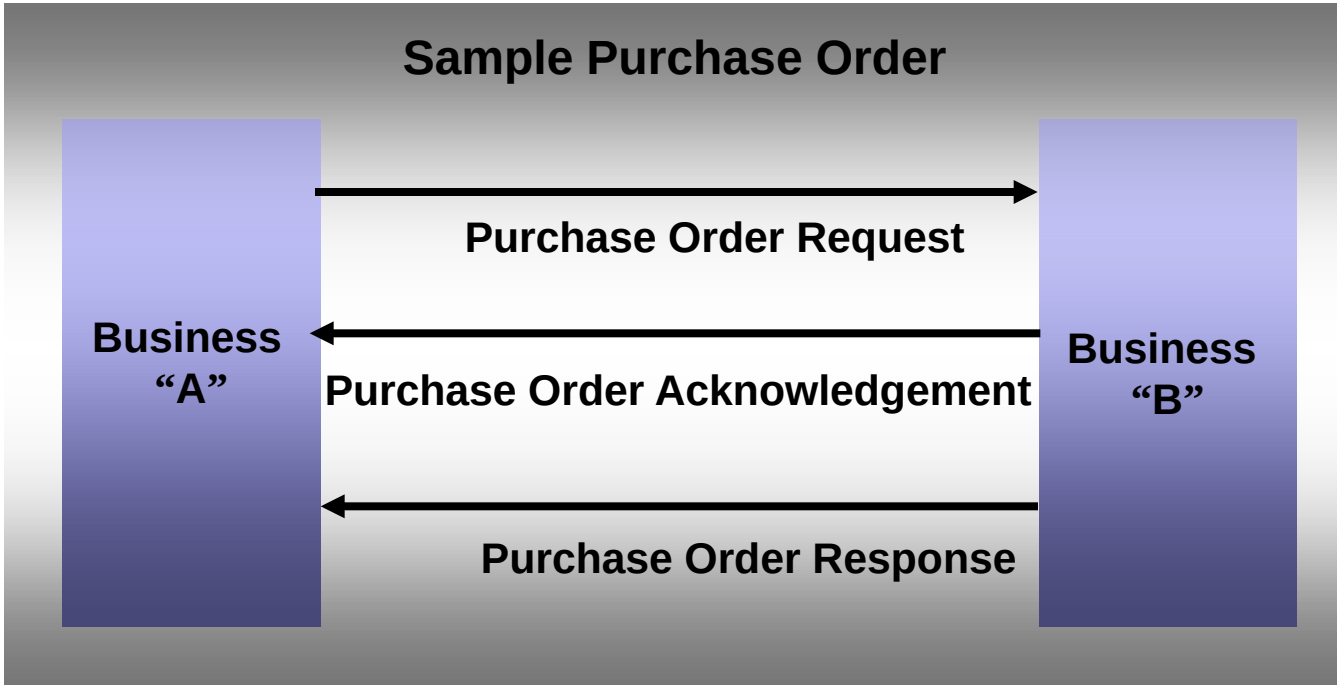
Orchestration: A process describing a flow from the perspective and under control of a single endpoint (akin to workflow)

➡ central

Choreography: A process is an exchange of messages, a set of rules of interaction and agreements between two or more business process endpoints

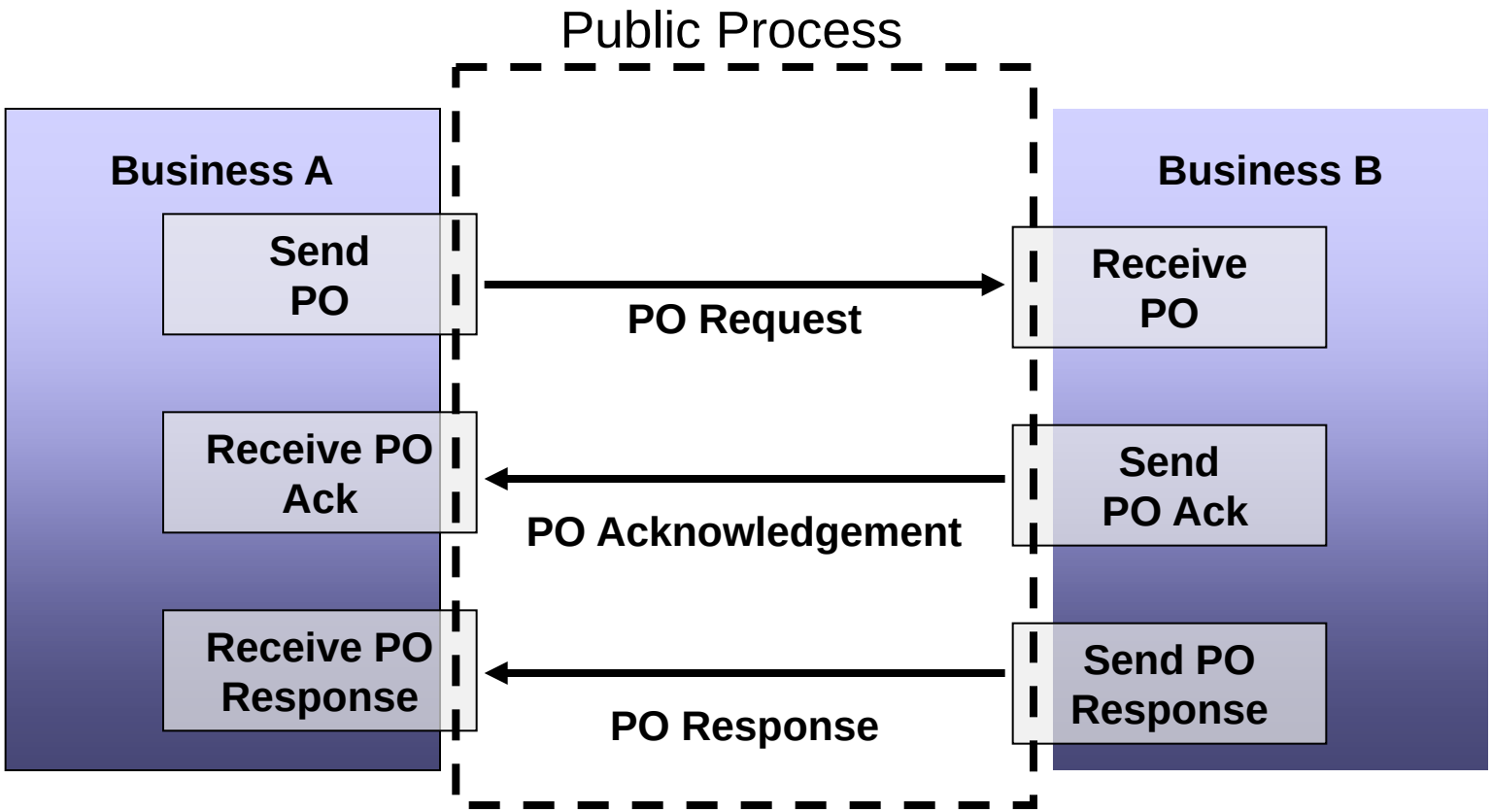
➡ distributed

Sample Business Process: Purchase Order



***Source :** ORACLE, "BPELOverview"*

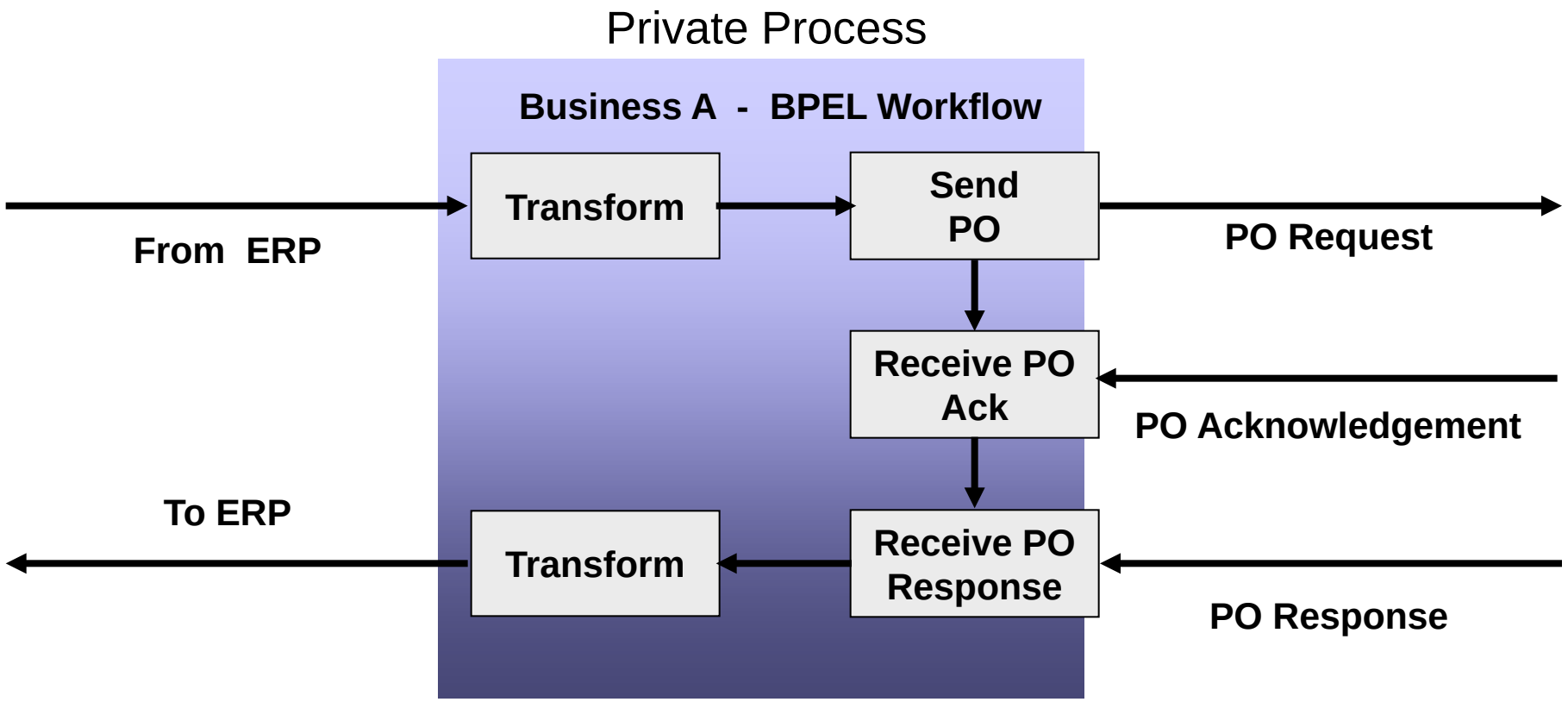
From a Choreography Perspective



Choreography – The observable public exchange of messages

Source : ORACLE, "BPELOverview"

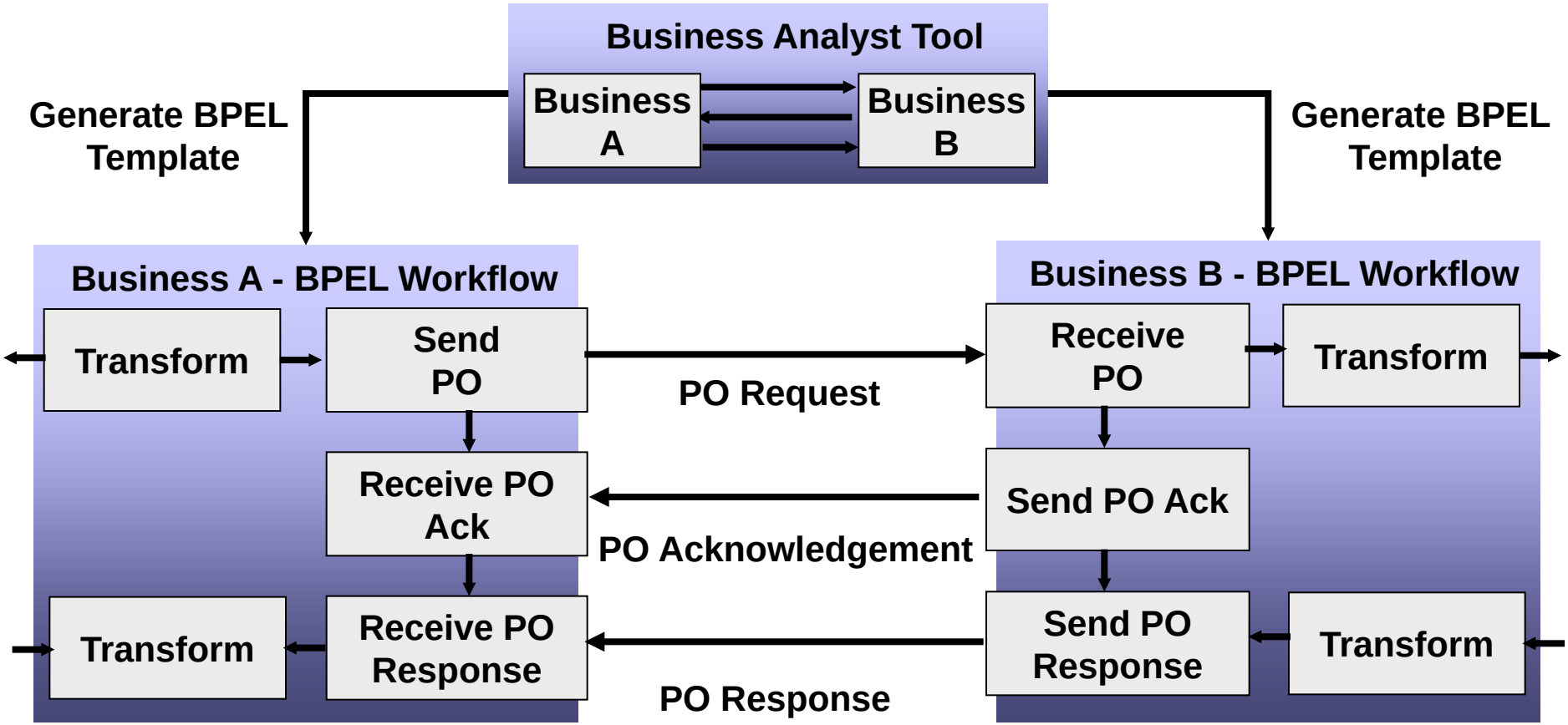
From an Orchestration Perspective



Orchestration – A private executable business process

Source : ORACLE, "BPELOverview"

Orchestration and Choreography Together



Two BPEL workflow templates reflecting a business agreement

Source : ORACLE, "BPELOverview"

Business Services and Orchestration

- The process manager resides at the top of the service layer hierarchy and is responsible for composing business services
- Essentially, the use of orchestration establishes the following structure in the services layer:
  - Workflow logic and process-specific business rules are embedded in a process definition. Orchestration composes business services (and possibly application services) according to this definition.
  - Business services compose application services to execute business logic.
  - Application services interact with underlying systems to process the required functions specified in the orchestration workflow logic

Source :
Thomas Erl
Service-Oriented Architecture: Concepts, Technology, and Design

Workflow

- A collection of processing steps (also called tasks or activities) organized to accomplish some business processes.
- Defines:
  - The order of task invocations or condition(s) under which tasks must be invoked (i.e. control-flow)
  - Data-flow between these tasks
  - Constraints, such as when the activities should be executed
  - Specification of who can or should perform each activity
  - Which tools and programs are needed during the activity execution

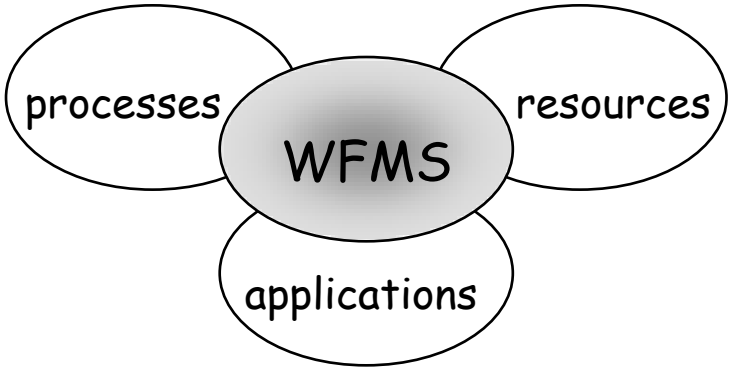
Workflow Management System

- Business Processes
  - Are becoming more important
    - Their effective setup, execution and evolution is of paramount importance to successful business operations
  - Are subject to frequent changes
  - Are becoming more complex

⇒ **Workflow Management System**

Workflow Management System (II)

- A software providing support for the definition, enactment, administration and monitoring of workflow processes
  - **Goal:** to manage the flow of work such that the work is done at the right time by the proper person.



  - Separation of processes, resources and applications
  - Focus on the logistics of work processes, not on the contents of individual tasks

Business Process Management

- *"True Business Process Management is an amalgam of traditional workflow and the 'new' BPM technology. It then follows that as BPM is a natural extension of – and not a separate technology to – Workflow. BPM is in fact the merging of process technology covering 3 process categories: interactions between (i) people-to-people; (ii) systems-to-systems and (iii) systems-to-people – all from a process-centric perspective. This is what true BPM is all about."* Jon Pyke, CTO Staffware*.
- *"…a blending of process management/workflow with application integration."* David McCoy, Gartner Group

**** Staffware, a leader in business process management software***

Business Process Modelling

- Identifying and documenting business activities and processes by employing a formal or human understandable BPM language.
- Current standard approaches for process modelling are based on workflow abstractions
  - UML, provides graphical constructs that can be used to describe actions and activities, and temporal precedence and control flows *(OMG)*
  - BPMN, flow-chart based notation for defining Business Processes *(OMG)*
  - WSBPEL, enables specification of processes as coordinated sets of Web service interactions *(OASIS)*

Business Process Modeling: Motivation

- Establishing a common organizational language
  - Improving communication between domain expert and IT expert
  - Increasing collaborations with business partners
- Contributing to product requirements and process automation
- Identifying functionality redundancy across the enterprise
- Creating process-centric composite services & applications

General Modelling Concepts

- A process is chronological
  - Accurate models should be oriented on a time line (in general, from left to right in sequence)
  - A process can be modeled in a hierarchical fashion (e.g., with Sub-Processes)
- Processes generally begin with triggering events
- Flow-of-control constructs (e.g. synchronization, decision, concurrency, …), determine which of all potential paths will be taken
- A complete model should display how objects or data (or both) are transferred
- All tasks or activities are assigned to roles that are meaningful to people in the business.

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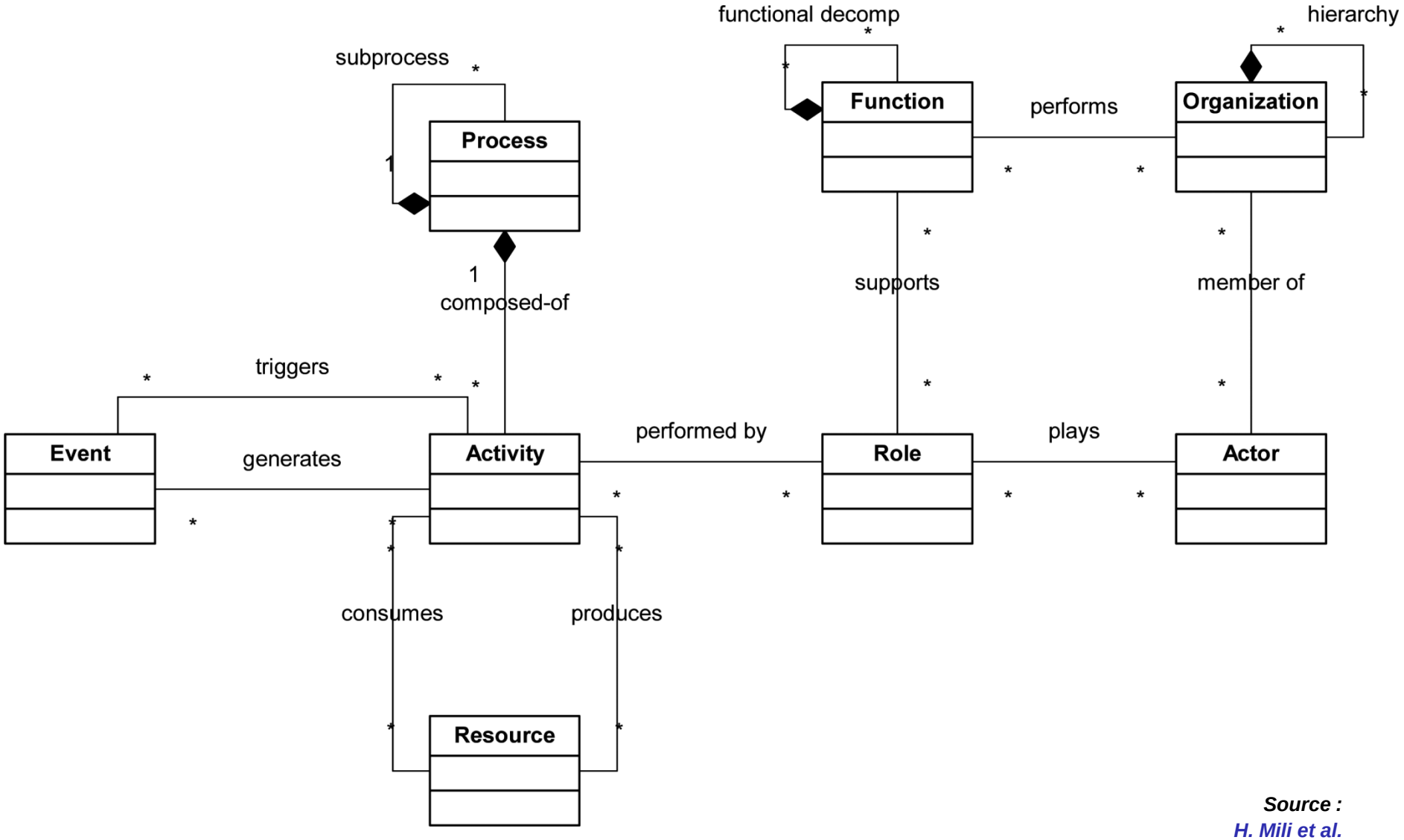
Business Process Metamodel

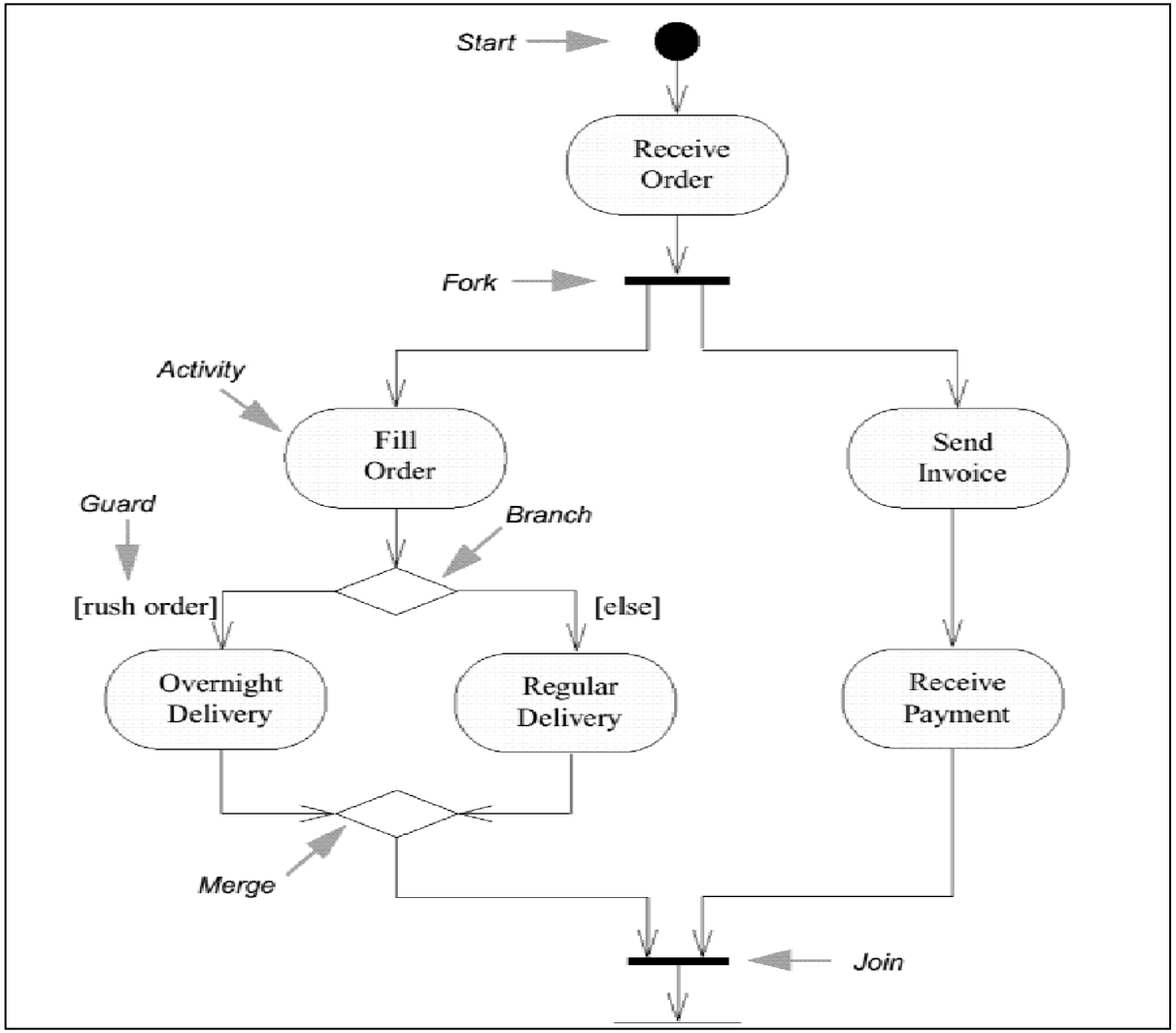


Source :
H. Mili et al.
Business Process Modeling Languages: Sorting Through the Alphabet Soup

UML 2.0

- Over the years, UML has been moving away from a modelling language for object-oriented software to a modelling language for “systems” in general
- UML Activity Diagram
  - Typically used for business process modelling, but also for modelling the logic captured by one or more use cases
  - Emphasizes the sequence and conditions for coordinating lower–level behaviours
    - Control flow and object flow model.
  - The actions coordinated by activity models can be initiated because other actions finish executing, because objects and data become available or because events occur external to the flow.

A Sample Activity Diagram



- A UML activity diagram for an order

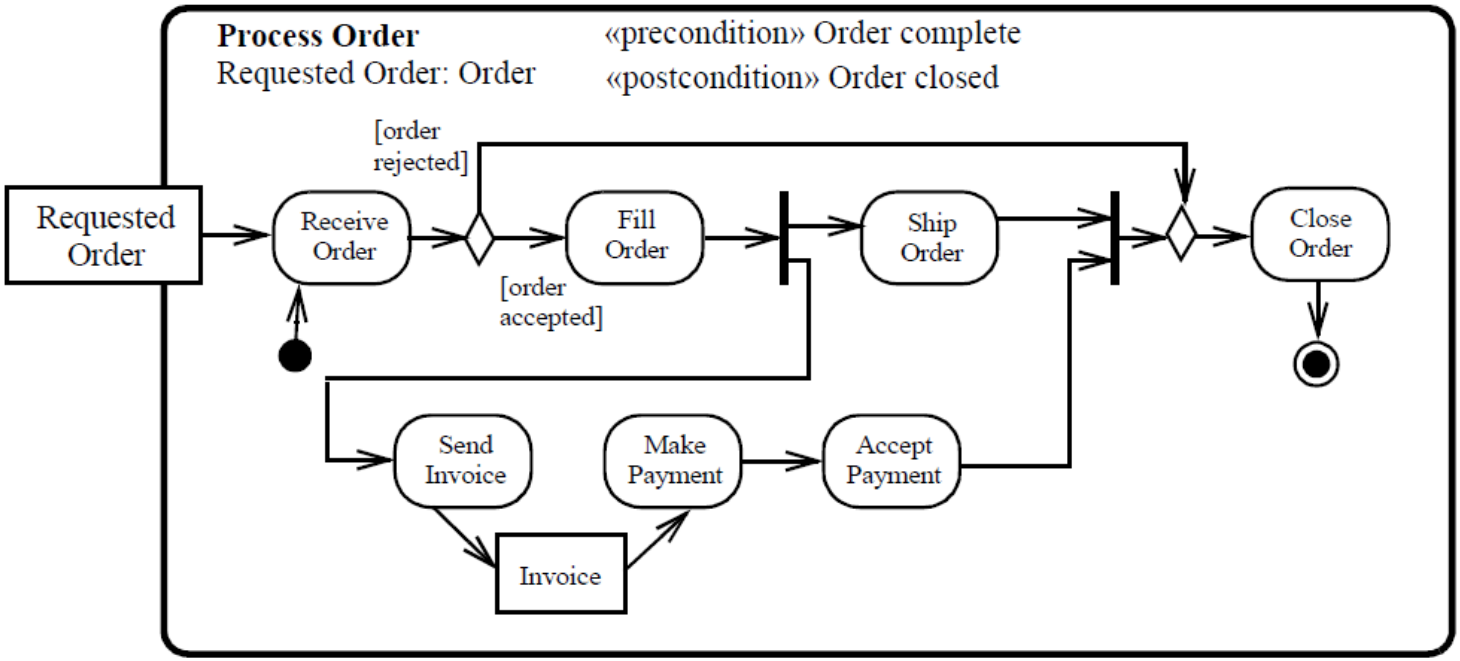
Source :
Fowler, Martin UML Distilled
Addison Wesley

Activity Diagrams - Semantics

- Conditional behavior is delineated by branches and merges.
  - A **branch** has a single incoming transition and several guarded outgoing transitions, mutually exclusive.
    - The [else] guard indicates that the transition should be used if all the other guards on the branch are false.
  - A **merge** has multiple input transitions and a single output. A merge marks the end of conditional behavior
- Parallel behavior is indicated by forks and joins.
  - A **fork** has one incoming transition and several outgoing transitions. When the incoming transition is triggered, all of the outgoing transitions are taken in parallel.
  - **join** is used to synchronize parallel behaviors. With a join, the outgoing transition is taken only when all the states on the incoming transitions have completed their activities.

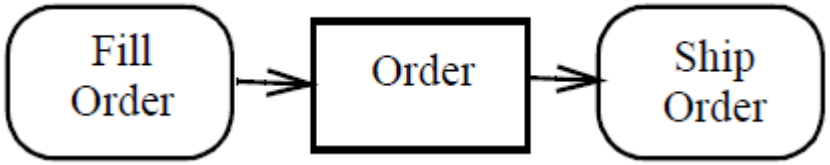
Activities and Actions

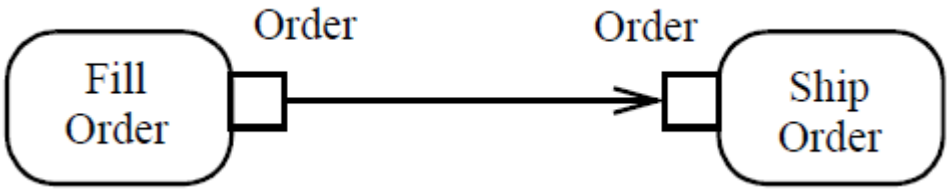
- An action is the fundamental unit of behaviour specification
- Actions are contained in activities, which provide their context



Object Flow

- An object flow is an activity edge that can have objects or data passing along it
  - For sequencing data produced by one node that is used by other nodes.





Source : *OMG UML*

Accept Event Notification

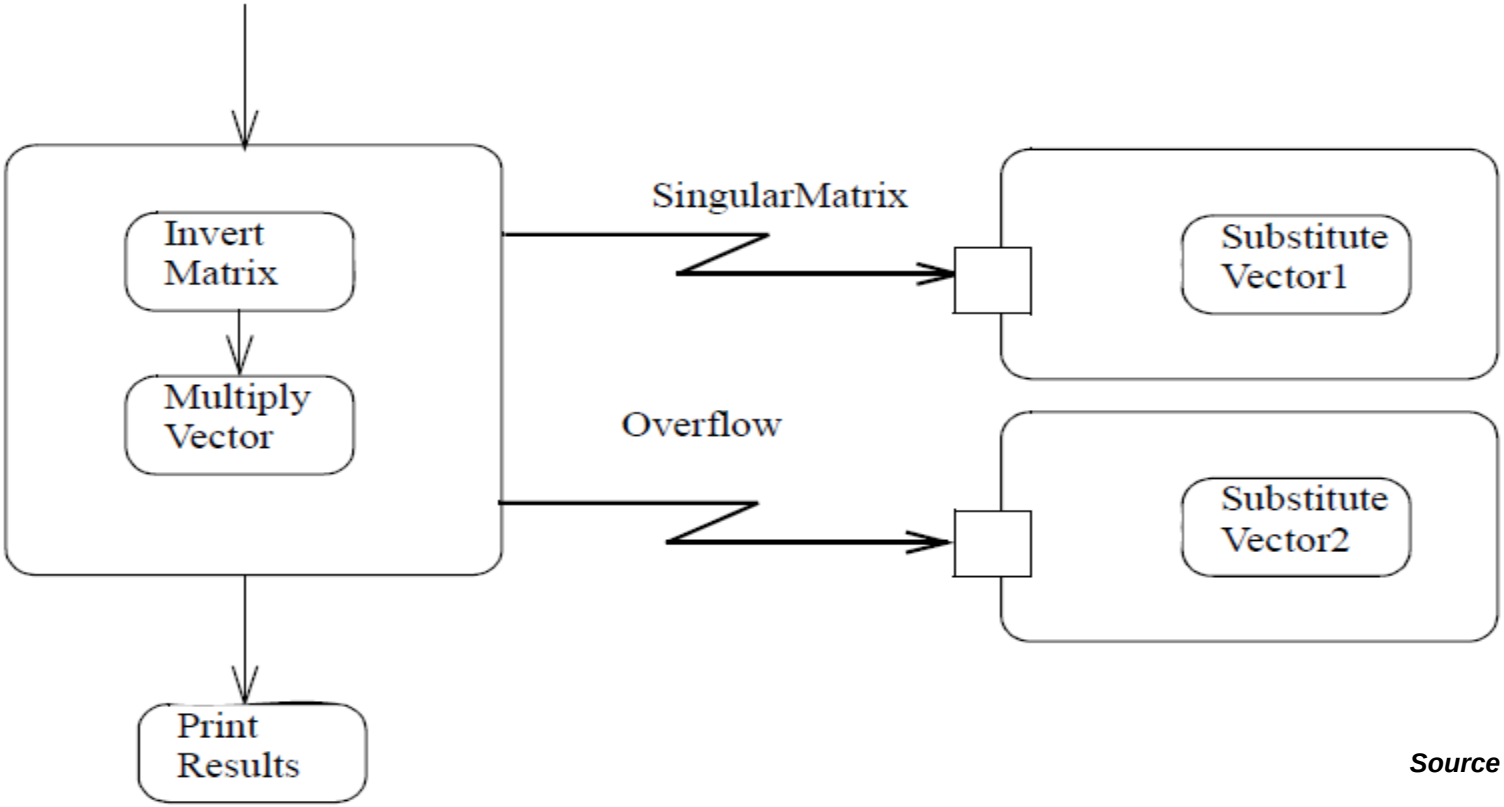
- An example of the acceptance of a signal indicating the cancellation of an order. The acceptance of the signal causes an invocation of a cancellation behavior

- A request payment signal is sent after an order is processed. The activity then waits to receive a payment confirmed signal. Acceptance of the payment confirmed signal is enabled only after the request for payment is sent. When the conformation is received the order is shipped.

- The end-of-month accept time event action generates an output at the end of the month

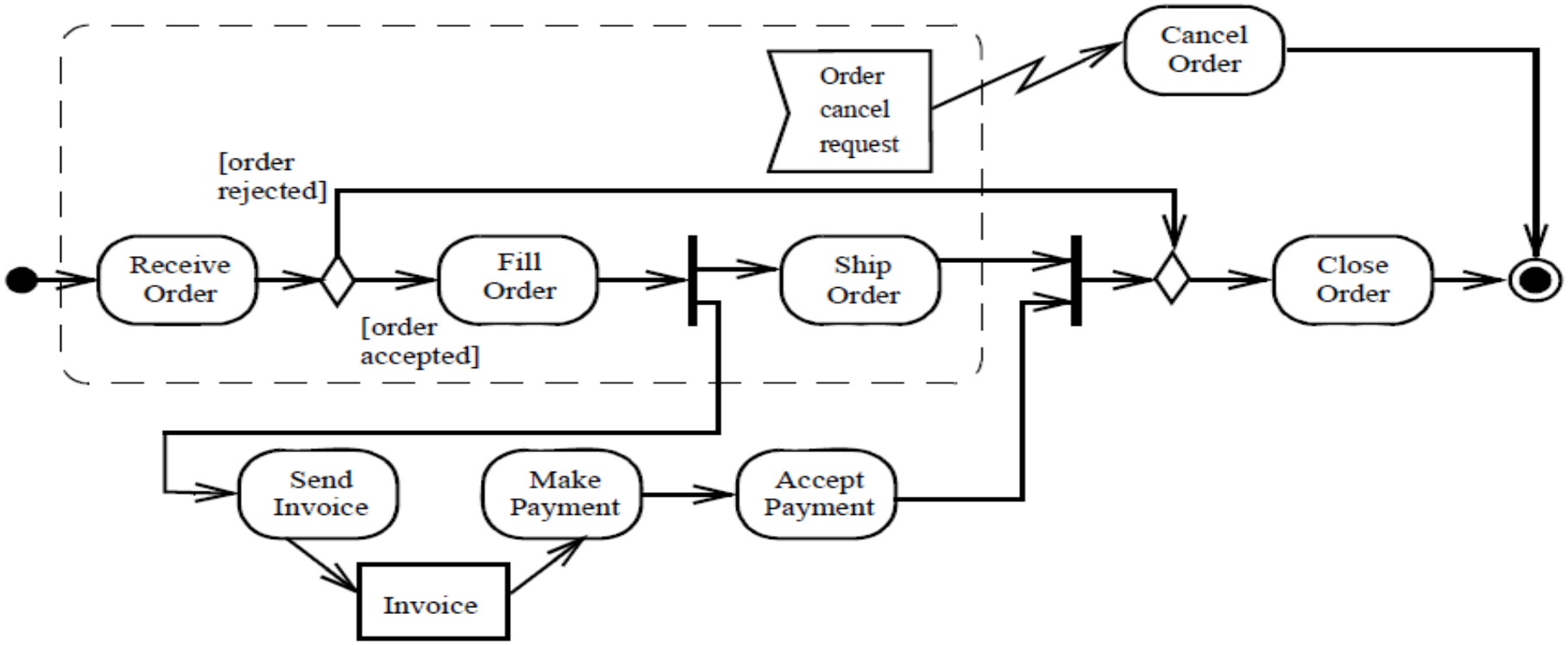
Exception Handler

- An element that specifies a body to execute in case the specified exception occurs during the execution of the protected node.



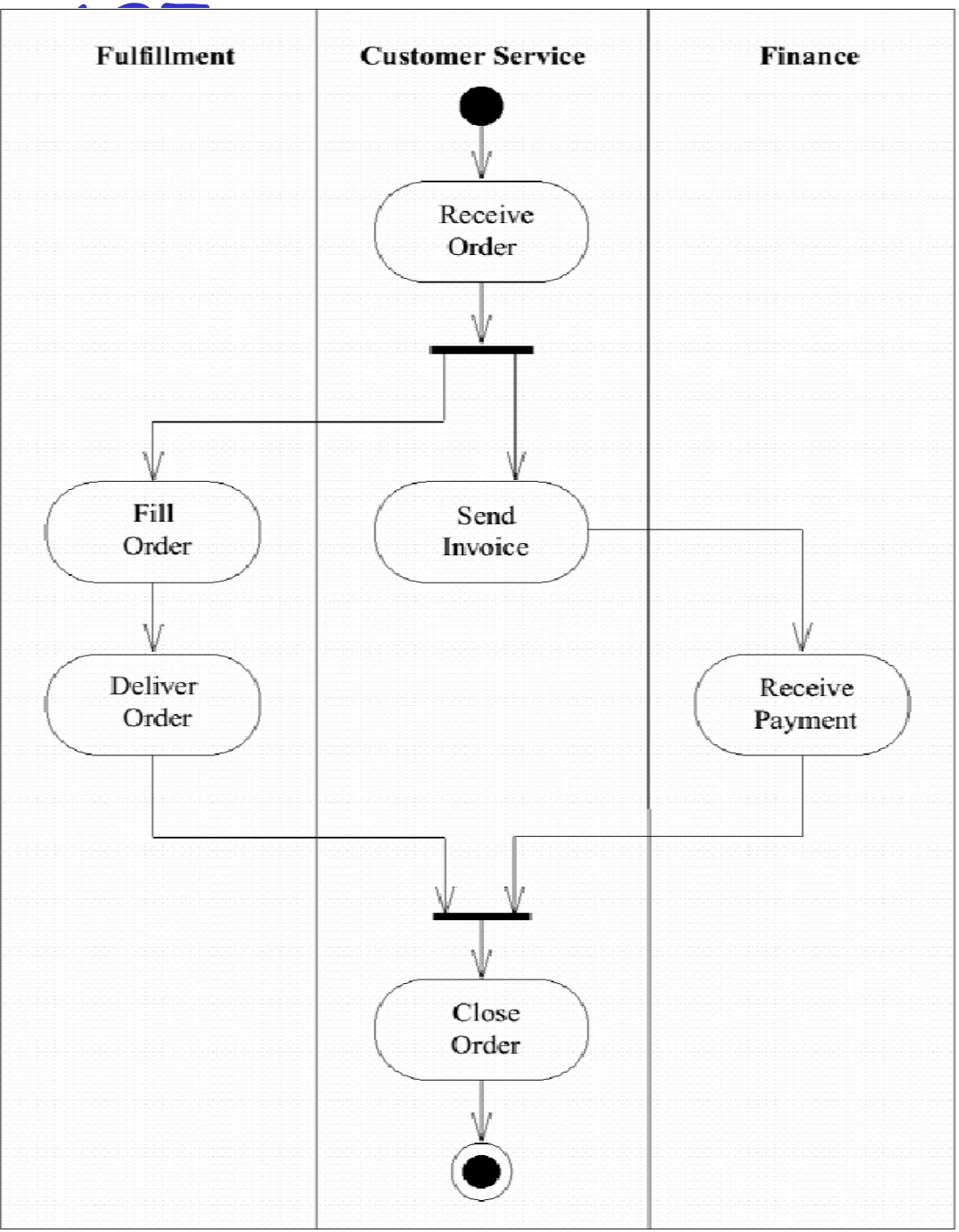
Source : OMG UML

InterruptibleActivityRegion



when an order cancellation request is made — only while receiving, filling, or shipping orders — the Cancel Order behavior is invoked.

Source : *OMG UML*



Partition Notation

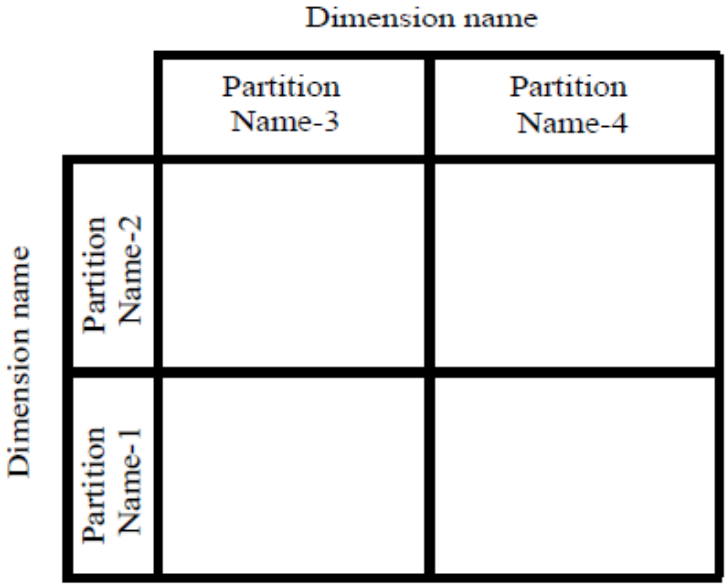
- To support the assignment of domain–specific information to nodes and edges
  - Activity diagrams are arranged into partitions separated by lines
    - Each partition represents the responsibilities of a particular entity or a particular department

Source : ***Fowler, Martin UML Distilled Addison Wesley***

Partition Notation II

a) Partition using a swimlane notation

b) Partition using a hierarchical swimlane notation



c) Partition using a multidimensional hierarchical swimlane notation

BPMN

- The Business Process Management Institute (BPMI—now a part of the OMG) develops BPML (an XML process execution language)
  - BPML was later replaced by BPEL as the target execution language
- August, 2001, the Notation Working Group is formed (need for a graphical representation). The group was composed of 35 companies, organizations, or individuals.
- BPMN 1.0
  - May, 2004, the BPMN 1.0 specification was released to the public.
  - February, 2006, BPMN 1.0 was adopted as an OMG standard
- BPMN 2.0, January 2011
- Currently, there are several companies that have implementations of BPMN

BPMN (II)

- Focuses on the ***dynamic (behavioural) view***
  - Provides sequencing and control information about the process; when activities are performed (timing, pre–conditions) and how they are performed (e.g., by describing the control logic).
- Three types of models that can be represented by BPMN.
  - *Private business processes* - processes internal to an organization, typically implemented by a workflow management system;
  - *Abstract public business processes* - interaction points between a process that is internal to an organization and the outside world; it shows the public interface of an internal process in terms of the message exchanges
  - *Collaboration processes* - describe the interactions between two or more organizations/business entities, each of which has its own internal process. Examples of collaboration processes include RosettaNet's Partner Interface Processes (PIPs)

BPMN - Business Process Modeling Notation 1.1

Gateways

Data-based Exclusive Gateway
When splitting, it routes the sequence flow to exactly one of the outgoing branches based on conditions. When merging, it awaits one incoming branch to complete before triggering the outgoing flow.

Event-based Exclusive Gateway
Is always followed by catching events or receive tasks. Sequence flow is routed to the subsequent event/task which happens first.

Parallel Gateway
When used to split the sequence flow, all outgoing branches are activated simultaneously. When merging parallel branches it waits for all incoming branches to complete before triggering the outgoing flow.

Inclusive Gateway
When splitting, one or more branches are activated based on branching conditions. When merging, it awaits all active incoming branches to complete.

Complex Gateway
It triggers one or more branches based on complex conditions or verbal descriptions. Use it sparingly as the semantics might not be clear.

Activities

Multiple Instances of the same activity are started in parallel or sequentially, e.g. for each line item in an order.

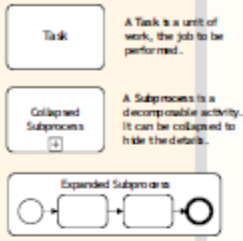
Loop Activity is iterated if a loop condition is true. The condition is either tested before or after the activity execution.

Ad-hoc Subprocesses contain tasks only. Each task can be executed arbitrarily often until a completion condition is fulfilled.

Sequence Flow defines the execution order of activities.

Conditional Flow has a condition assigned that defines whether or not the flow is used.

Default Flow is the default branch to be chosen if all other conditions evaluate to false.

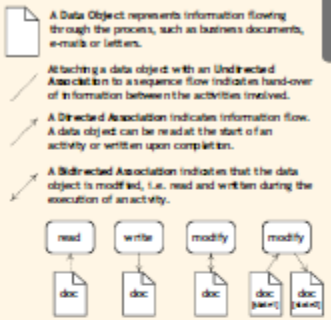


A Task is a unit of work, the job to be performed.

A Subprocess is a decomposable activity. It can be collapsed to hide the details.

An Expanded Subprocess contains a valid BPMN diagram.

Data



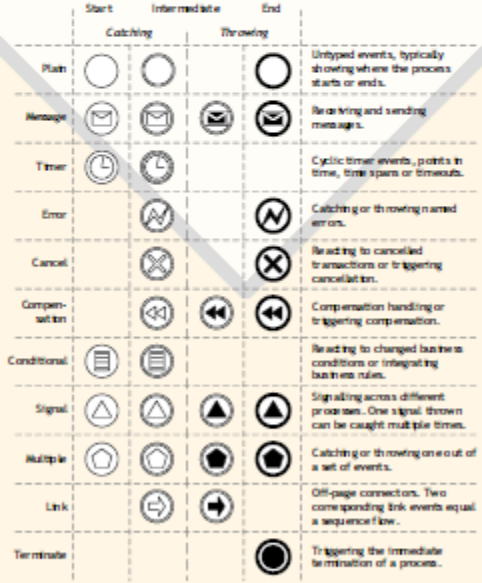
A Data Object represents information flowing through the process, such as business documents, e-mails or letters.

Attaching a data object with an **Undirected Association** to a sequence flow indicates hand-over of information between the activities involved.

A **Directed Association** indicates information flow. A data object can be read at the start of an activity or written upon completion.

A **Bidirected Association** indicates that the data object is modified, i.e. read and written during the execution of an activity.

Events



Catching

Start Event: Catching an event starts a new process instance.

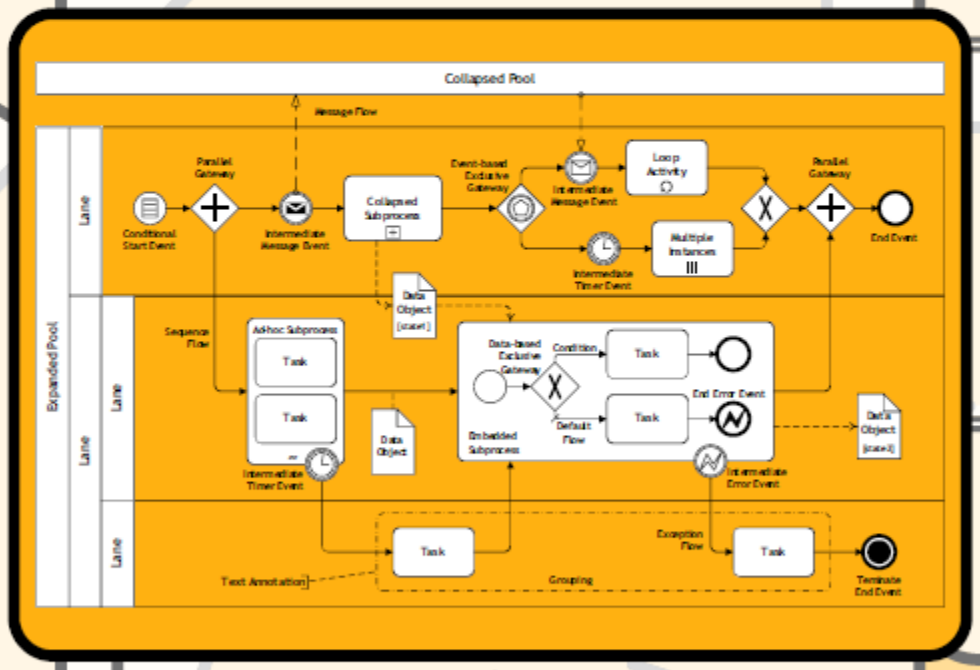
Intermediate Event (catching): The process can only continue once an event has been caught.

Throwing

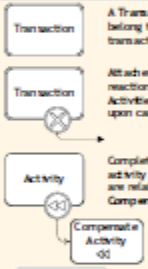
End Event: An event is thrown when the end of the process is reached.

Intermediate Event (throwing): An event is thrown and the process continues.

Attached Intermediate Event: The activity is aborted once an event is caught.



Transactions



A Transaction is a set of activities that logically belong together; it might follow a specified transaction protocol.

Attached **Intermediate Cancel Events** indicate reactions to the cancellation of a transaction. Activities inside the transaction are compensated upon cancellation.

Completed activities can be compensated. An activity and the corresponding **Compensate Activity** are related using an attached **Intermediate Compensation Event**.

Documentation

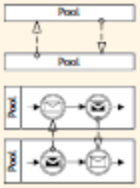
An arbitrary set of objects can be defined as a Group to show that they logically belong together.

Any object can be associated with a Text Annotation to provide additional documentation.

Swimlanes

Pools and **Lanes** represent responsibilities for activities in a process. A pool or a lane can be an organization, a role, or a system. Lanes sub-divide pools or other lanes hierarchically.

Collapsed Pools hide all internals of the contained processes.



Message Flow symbolizes information flow across organizational boundaries. Message flow can be attached to pools, activities, or message events.

The order of message exchanges can be specified by combining message flow and sequence flow.

Business Process Technology
Prof. Dr. Mathias Weske

Web: bpt.hpi.uni-potsdam.de
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Blog: bpmn.info

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BPEL4WS or WSBPEL

- A standard for orchestrating business process using web services (OASIS April 2007)
  - Joint IBM/Microsoft proposal, being standardized through OASIS
  - There are some competing languages
- Supported by more platform vendors than its predecessors that tried to achieve similar goals, such as ebXML
  - BPEL is supported by Microsoft, IBM, BEA, SAP, Hewlett-Packard, Oracle, Siebel, and others.
  - Choice of process engines
    - Standards lead to competitive offerings

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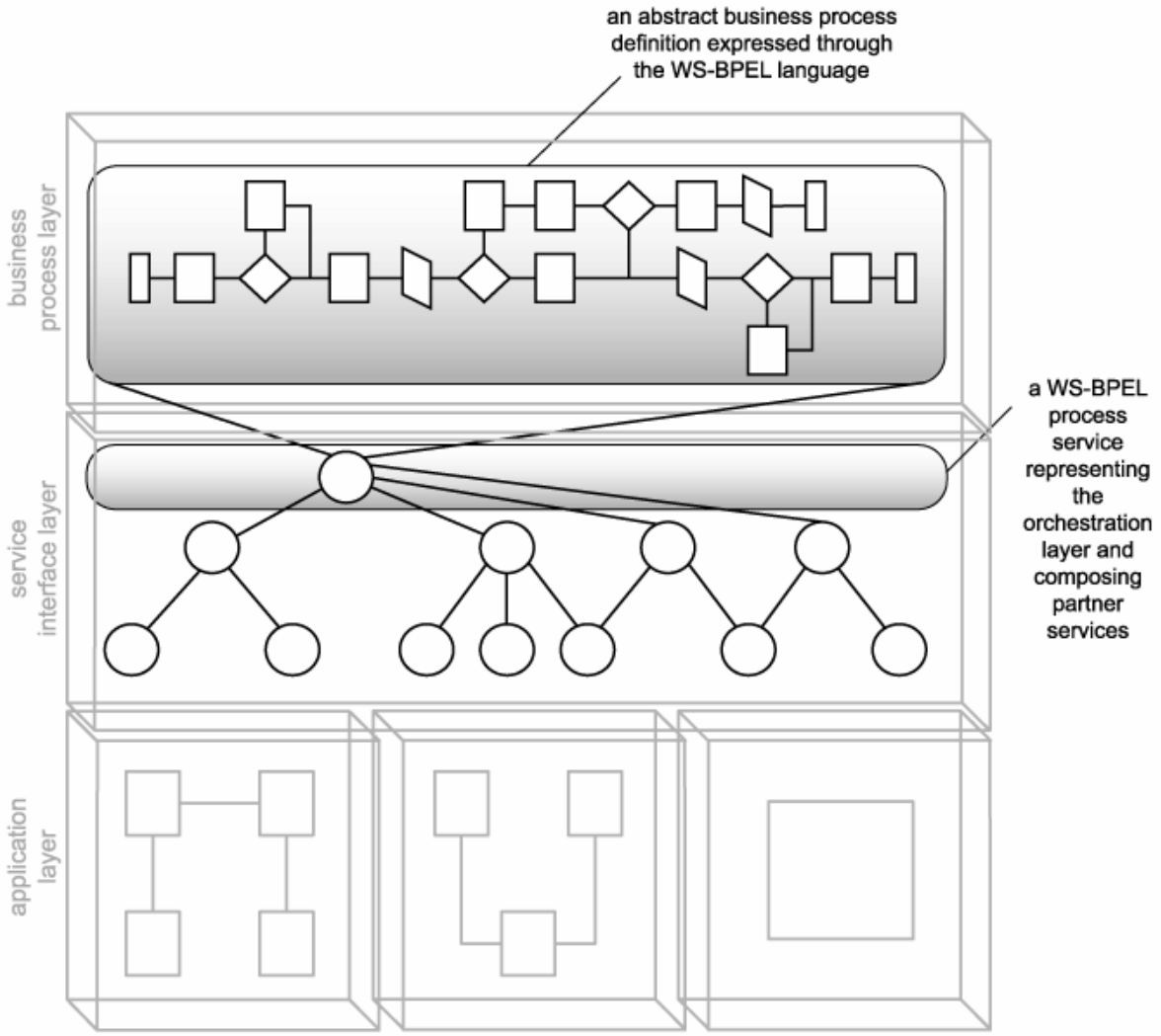
Orchestration Service Sub-layer within a Service Layer

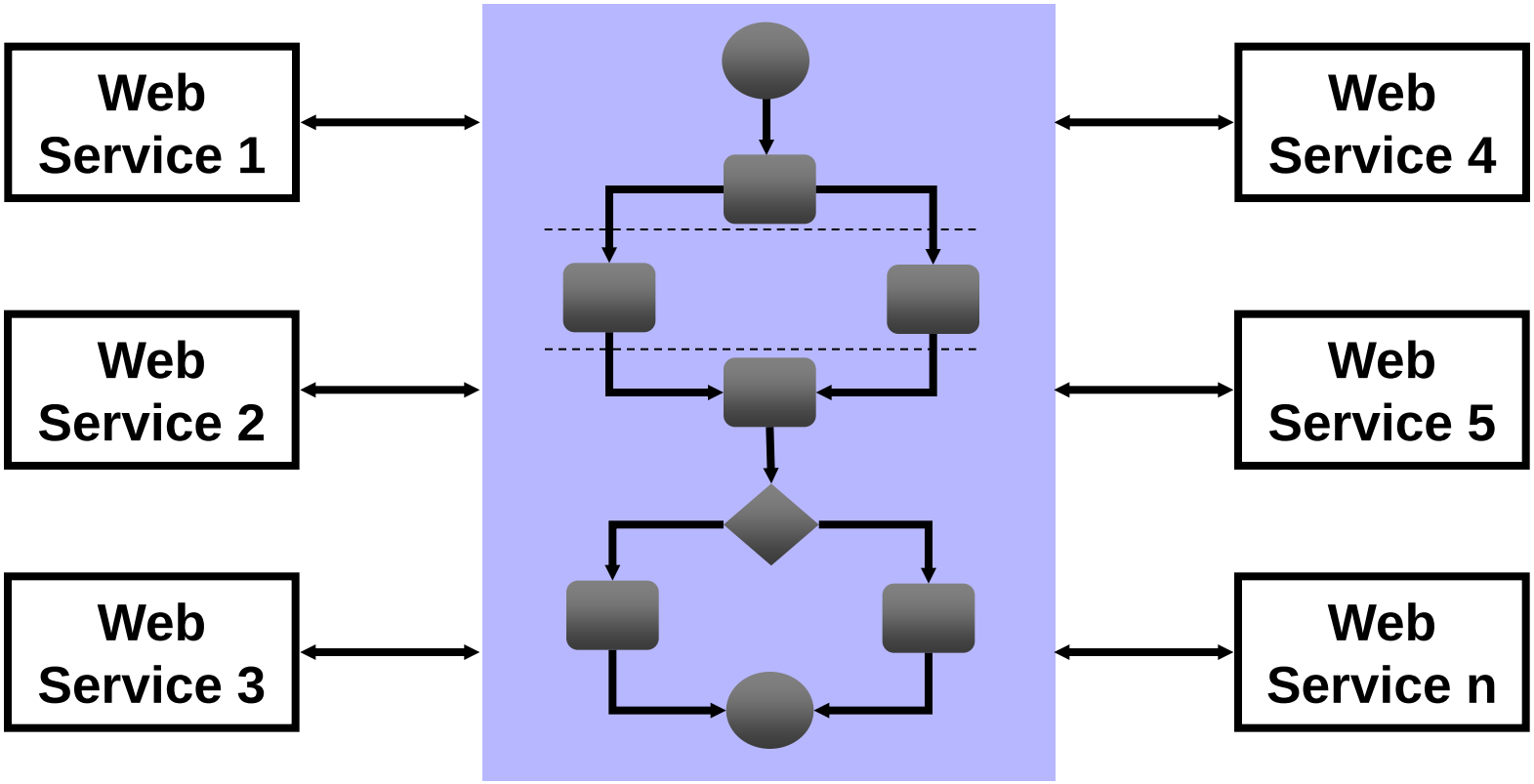


Source :
Thomas Erl
Service-Oriented Architecture: Concepts, Technology, and Design

WSBPEL 2.0 – Key Features

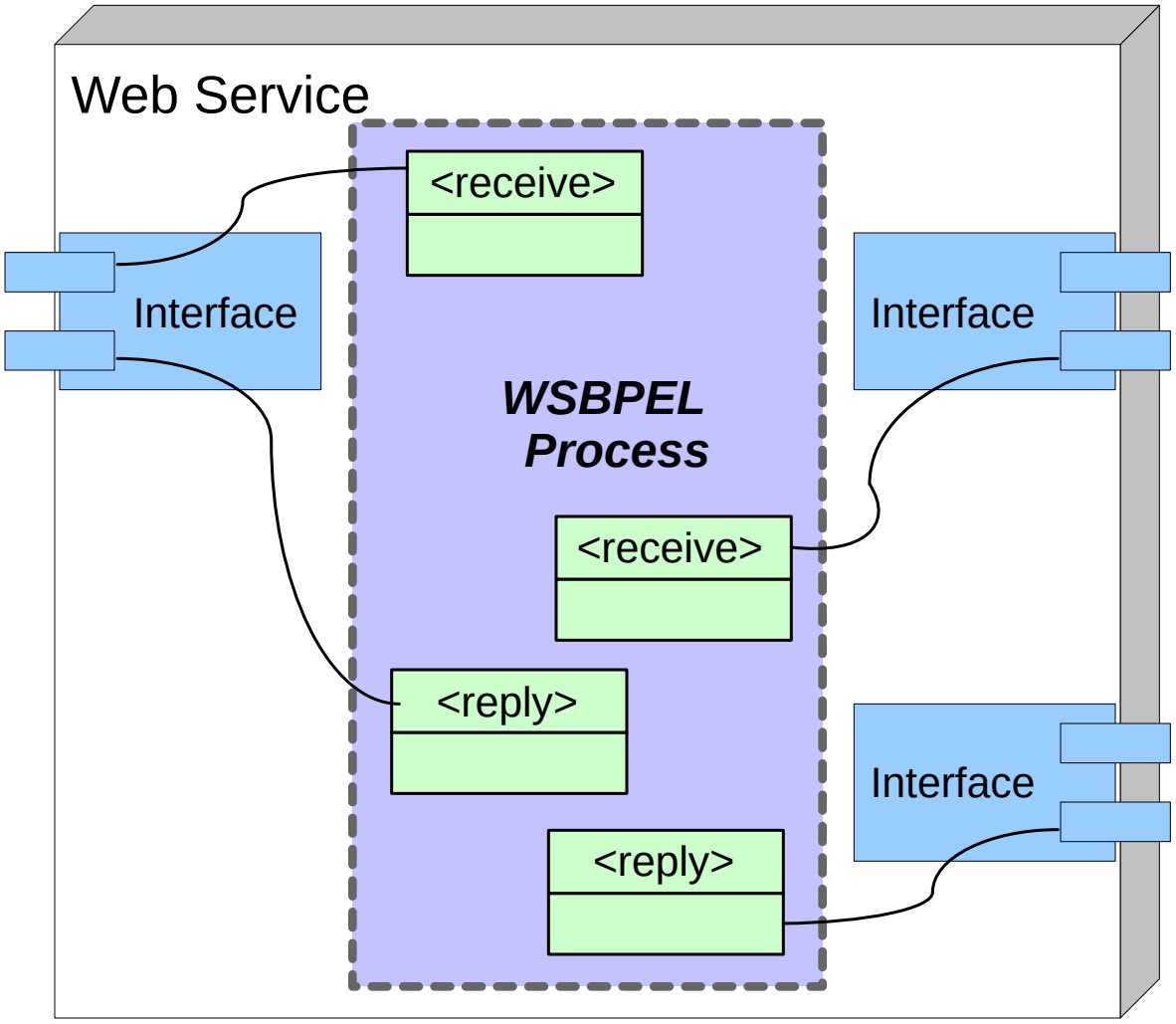
- Integrated into the Web services stack
  - Expressed entirely in XML
  - Uses and extends WSDL 1.1
  - Uses XML Schema 1.0 for the data model
  - Exposes itself as a Web service
    - Recursive: these new Web services can again be tied into other new Web services
- Portable across platform and vendor
  - Will run on any WS-BPEL-compliant engine
- Useful in defining both *concrete* and *abstract processes*
  - *Abstract process,* can describe just the business protocols
- Supports compensation model of transactions for long–running processes

Standards-Based Business Processes with Web Services



Source : ORACLE, "BPELOverview"

A WSBPEL Process



A composite Web service with a WSDL description

BPEL Process

- Once a WSBPEL process has been invoked, an instance of this process remains in existence until execution has completed.
- Two interaction scenarios exist between the process services and external partner services:
  - The partner service can invoke a new instance of a process
  - The partner service can interact with an existing process instance
    - Accomplished through message correlation.

BPEL Scenario Structure

```
<process>
   <!– Definition and roles of process participants -->
  <partnerLinks> ... </partnerLinks>
   <!- Data/state used within the process -->
   <variables> ... </variables>
   <!- Properties that enable conversations -->
   <correlationSets> ... </correlationSets>
   <!- Exception handling -->
   <faultHandlers> ... </faultHandlers>
    <!- Error recovery – undoing actions  -->
   <compensationHandlers> ... </compensationHandlers>
   <!- Concurrent events with process itself  -->
   <eventHandlers> ... </eventHandlers>
   <!- Business process flow  -->
   (activities)*
</process>
```

Context

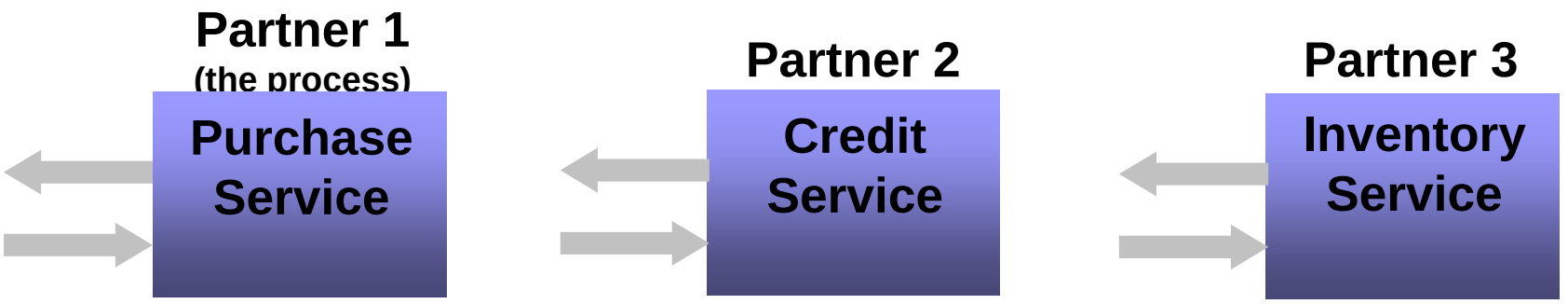
Business Logic

Source : ORACLE, "BPELOverview"

Partners

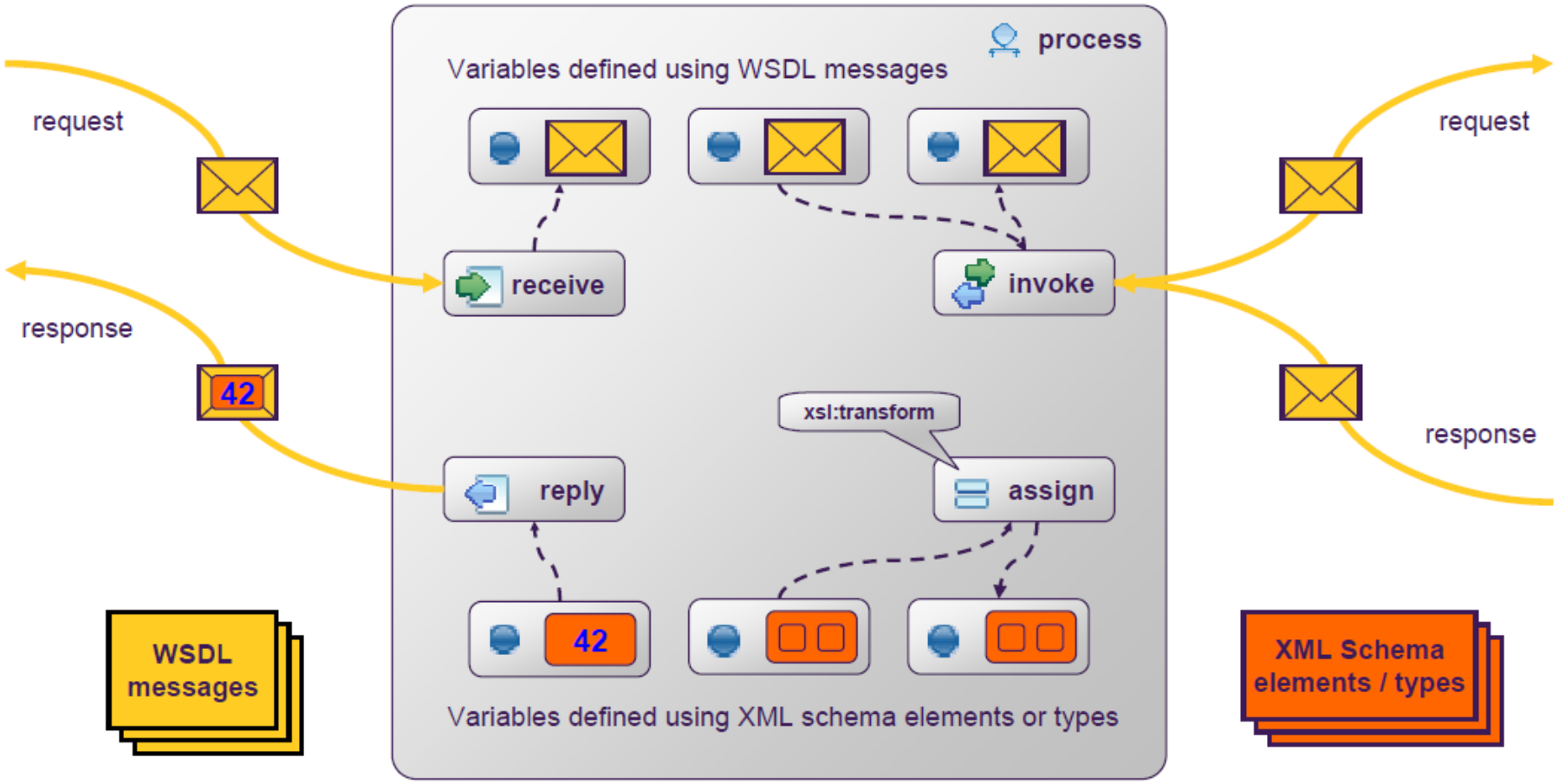
- Services that participate with a business process are referred to as partner services, and are defined within the process description
  - Assigns services a name used within the context of the process, and also allows for the allocation of roles

```
<partnerLinks>
 <partnerLink name="customer" partnerLinkType="lns:purchasePLT"
    myRole="purchaseService"/>
 <partnerLink name="inventoryChecker"
   partnerLinkType="lns:inventoryPLT"
    myRole="inventoryRequestor" partnerRole="inventoryService"/>
 <partnerLink name="creditChecker" partnerLinkType="lns:creditPLT"
    myRole="creditRequestor" partnerRole="creditService"/>
</partnerLinks>
```



Source : ORACLE, "BPELOverview"

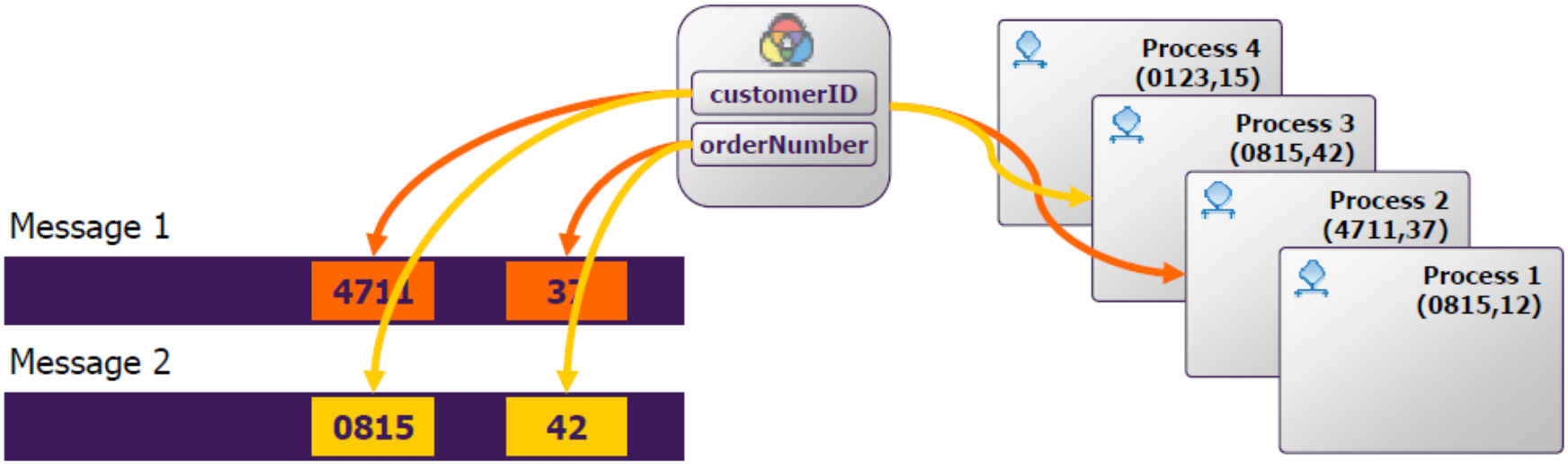
Variables



Source : *Web Service Orchestration and WS-BPEL 2.0*
Dieter König – IBM Senior Technical Staff Member –

Correlation Sets

- How to identify stateful instances via stateless WS interfaces?
- A process instance is assigned one or more keys
  - Business data is used as key, e.g., customerID
  - A key can be compound, e.g., (customerID, orderNumber)
  - WS-BPEL calls a key a correlation set – it is used to correlate an incoming message with a process instance



Source : *Web Service Orchestration and WS-BPEL 2.0*
Dieter König – IBM Senior Technical Staff Member –

Simple Activities

- Receive
  - Wait for a partner inbound message
  - Can be the instantiator of the business process
- Reply
  - Synchronous response to a receive activity
- Invoke
  - Issue a request synchronously *or* asynchronously
- Pick
  - Specify an inbound set of messages
  - Can be the instantiator of the business process
  - Activity completes when one of the messages arrives

Source : ***ORACLE, "BPELOverview"***

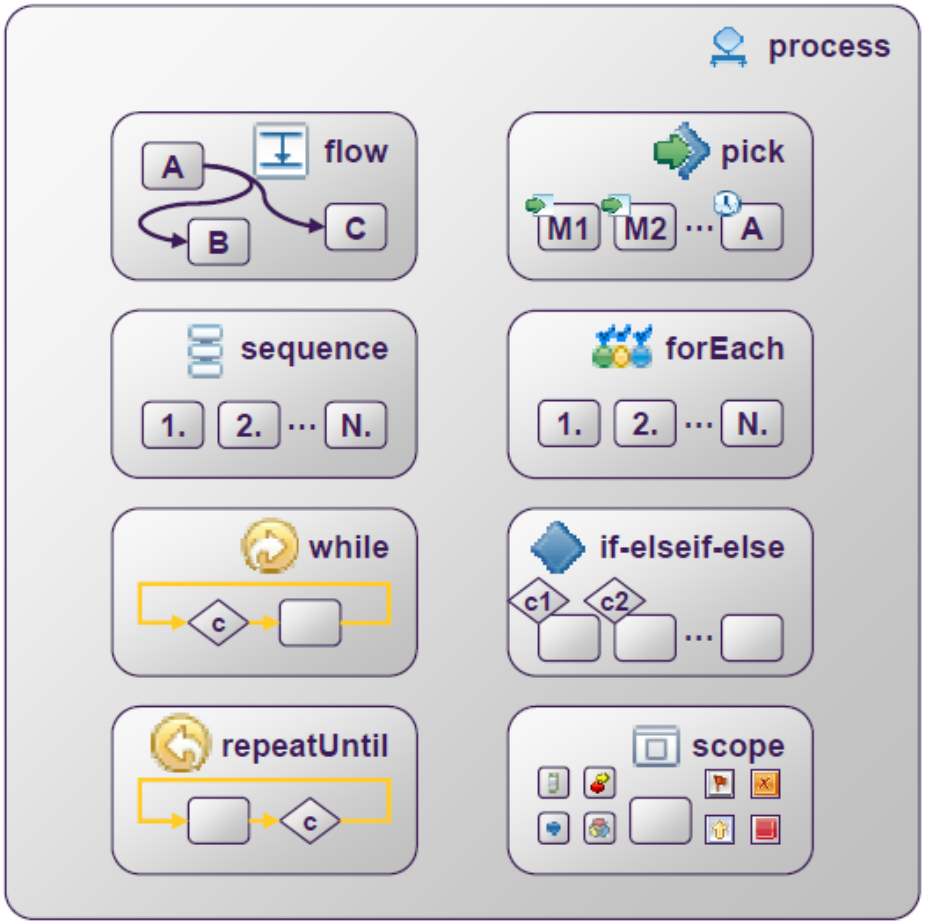
Structured Activities

Contained activities are executed in parallel, partially ordered through control links

Contained activities are performed sequentially in lexical order

Contained activity is repeated while a predicate holds

Contained activity is repeated until a predicate holds



Block and wait for a suitable message to arrive (or time out)

Contained activity is performed sequentially or in parallel, controlled by a specified counter variable

Select exactly one branch of activity from a set of choices

Associate contained activity with its own local variables, partner links, etc., and handlers

Source : *Web Service Orchestration and WS-BPEL 2.0*
Dieter König – IBM Senior Technical Staff Member –

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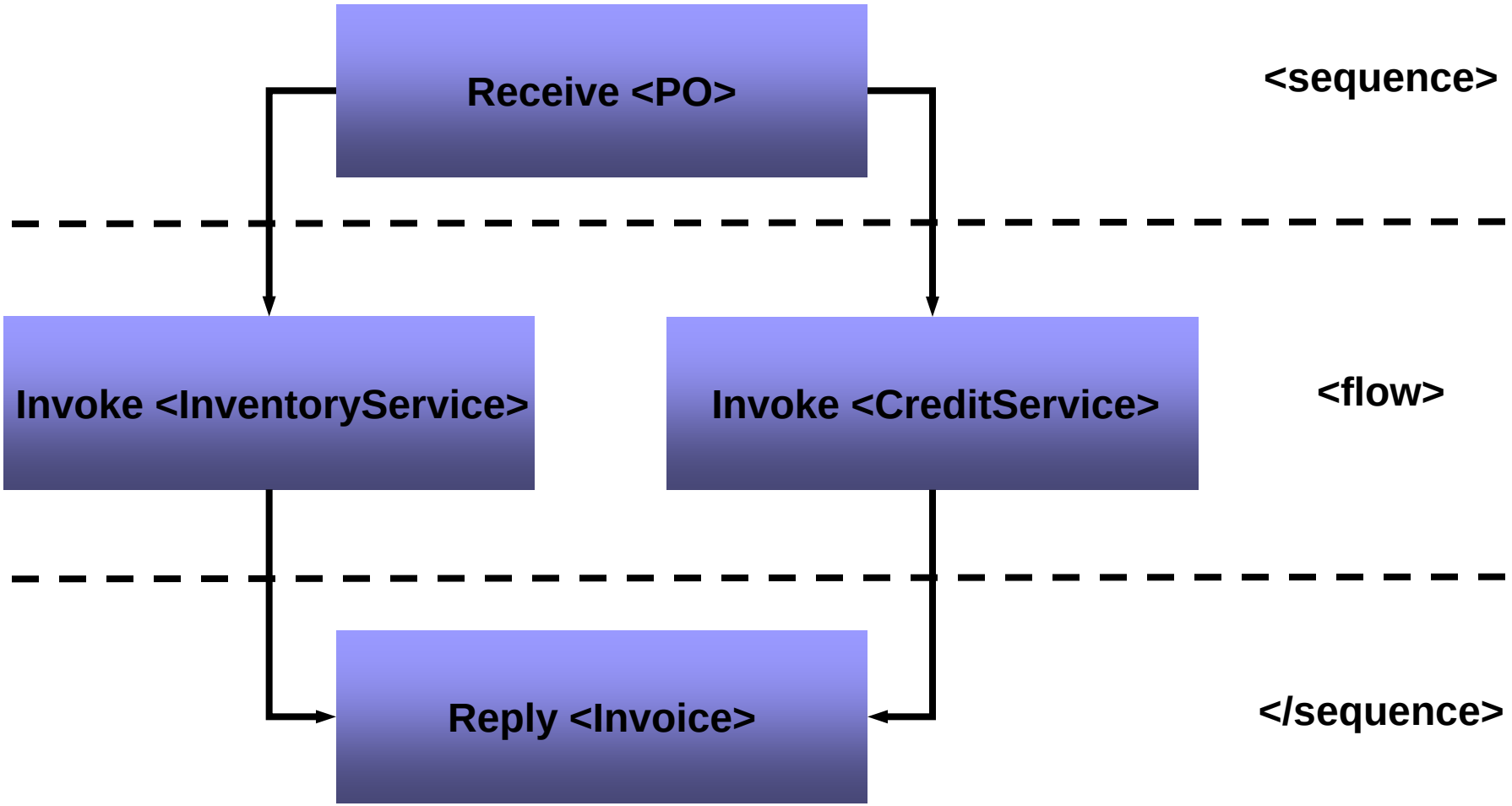
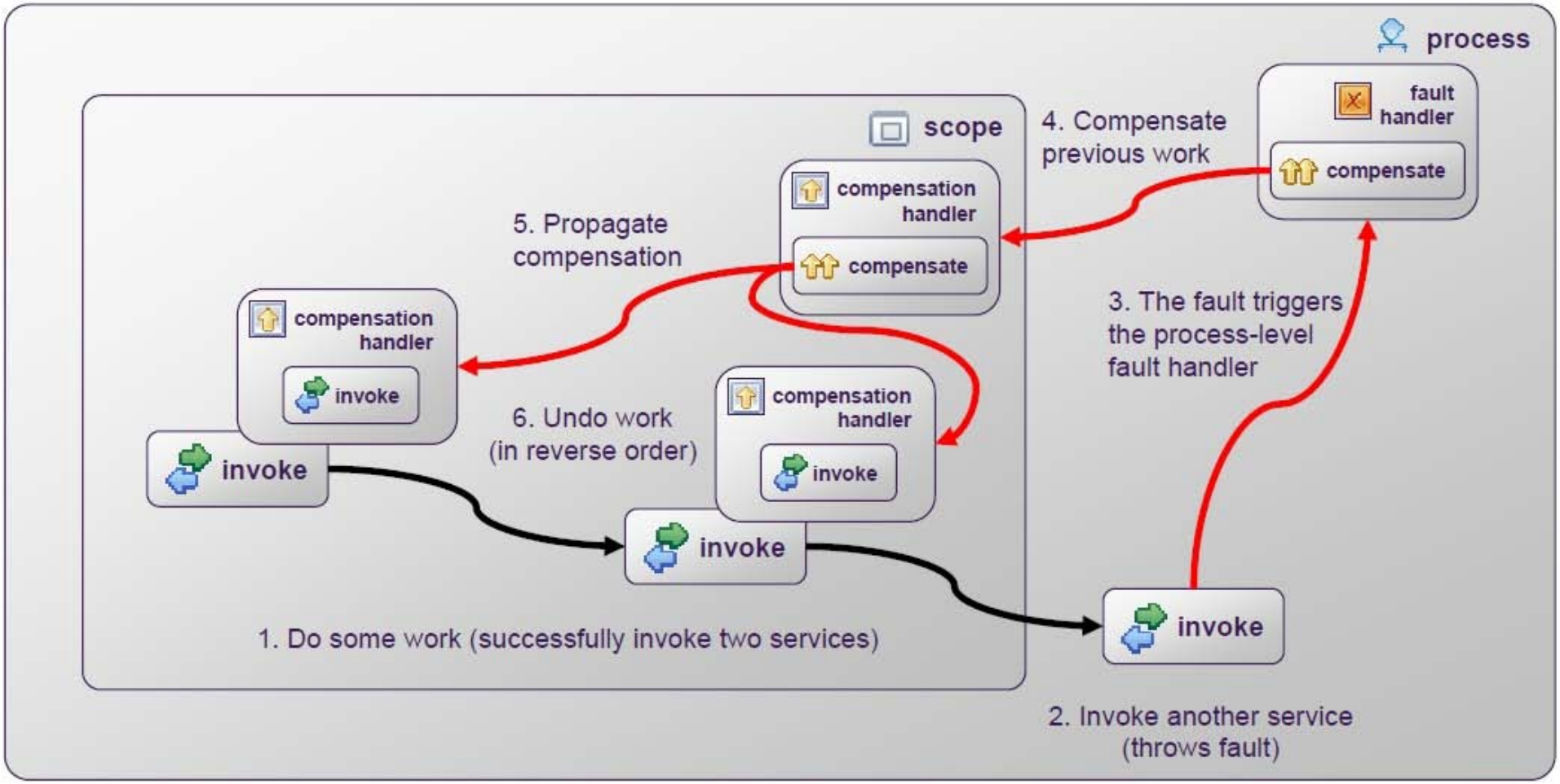
Simple Activities Combined with Structured Activities



Source : ORACLE, "BPELOverview"

Compensation Handling

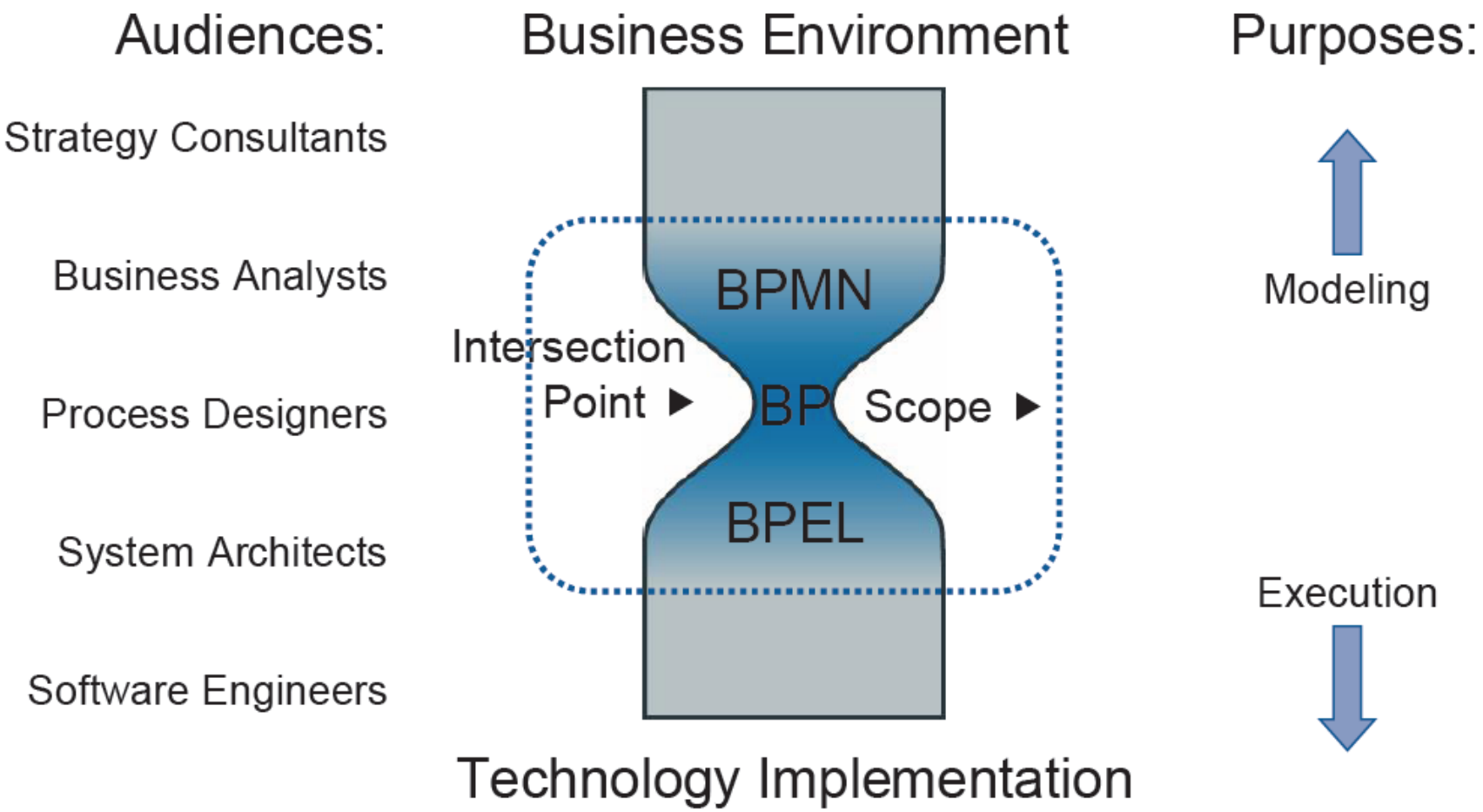


Source : *Web Service Orchestration and WS-BPEL 2.0*
Dieter König – IBM Senior Technical Staff Member –

WSBPEL & BPMN

- WSBPEL provides a formal mechanism for the definition of business processes
  - Optimized for the operation and inter-operation of BPM Systems.
  - Less suited for direct use by humans to design, manage, and monitor business processes
- The human level of “inter-operability” is not addressed by WSBPEL
- Business people are very comfortable with visualizing business processes in a flow-chart format
  - Technical gap between the format of the initial design of business processes and the format of the language, such as WSBPEL, that will execute these business processes
- BPMN
  - Provides businesses with the capability of understanding their internal business procedures in a graphical notation and gives organizations the ability to communicate these procedures in a standard manner
  - Provides a mapping of a BPMN model to WSBPEL
    - Not all BPMN orchestration processes can be mapped to WSBPEL in a straight-forward way. That is because BPMN allows the modeler to draw almost arbitrary graphs to model control flow

WSBPEL & BPMN (II)



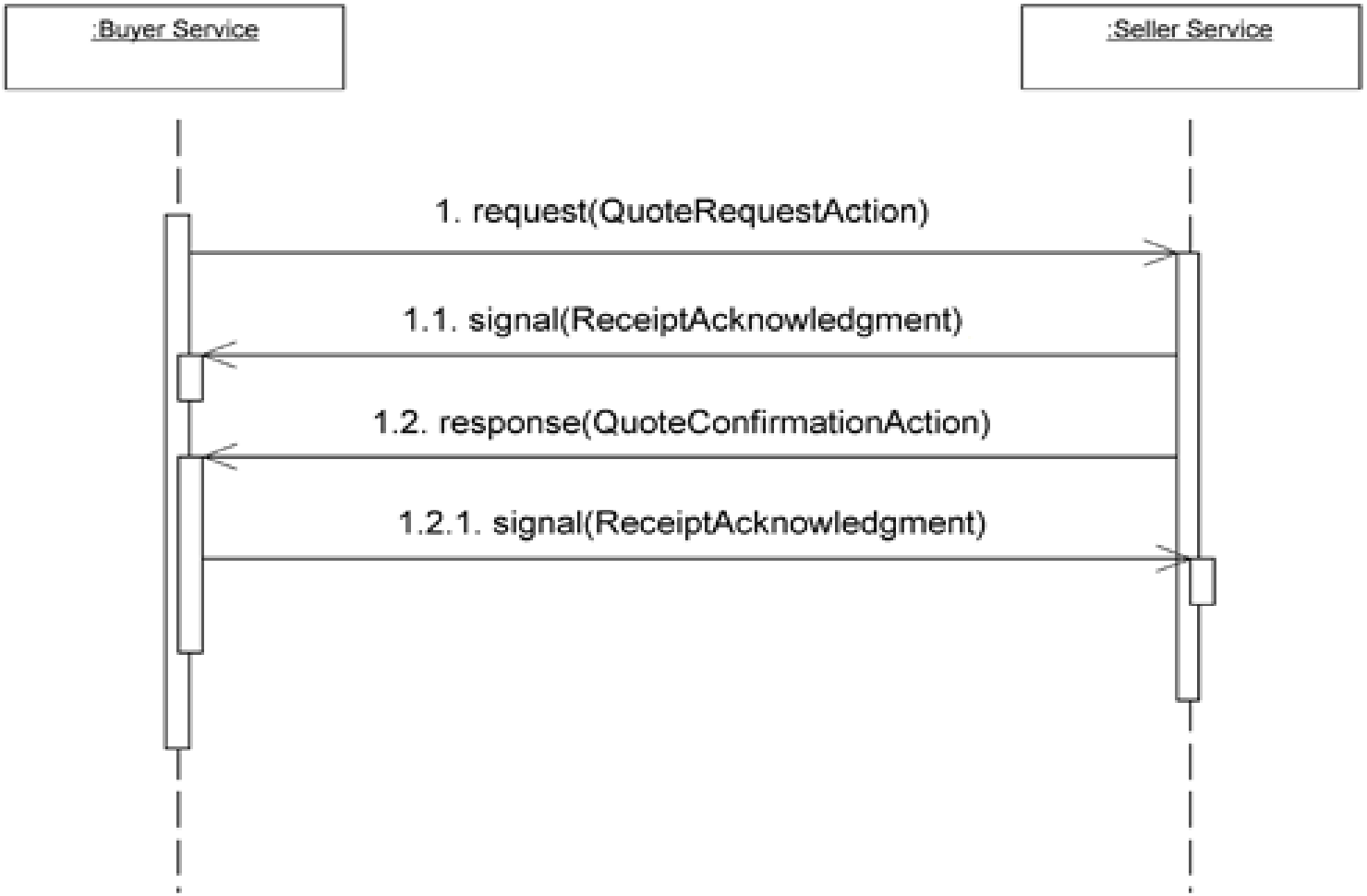
Process Integration Languages

- *The advent of interenterprise electronic business* (B2B) has spurred interest in process modelling languages for the purposes of integrating the processes of two or more business partners.
  - Such languages typically focus on the mechanics of the integration in terms of abstract, technology independent, programming interfaces and data exchange formats.
  - RosettaNet
  - ebXML
  - WS-CDL

RosettaNet

- Universal standards with the focus mainly on the supply chain and its optimization
- The standards cover the following areas:
  - RosettaNet Partner Interface Processes (PIPs), define business processes between trading partners
  - RosettaNet business and technical dictionaries
  - RosettaNet Implemantation Framework (RNIF)

PIP Interaction Diagram



The diagram shows the business roles, messages, and their sequence of exchange in the PIP

RosettaNet and Web Services

- Considering a public process in which a customer issues a request for a quote from a supplier
  - Using Web services alone to implement this step without a clearly defined dialog between trading partners, we would have a different implementation of this service for every trading partner
  - By ensuring our Web service implementation of this public process adheres to RosettaNet standards, we can request a quote from any number of trading partners

RosettaNet and Web Services (II)

- Public and private business processes
  - Private business processes can be implemented with any suitable technology including Web services
  - Public processes adhere to RosettaNet specifications which standardize B2B communications between trading partners
  - RosettaNet and Web services are therefore complementary, and Web services serve as an excellent implementation mechanism for the RNIF