WS-CDL

Service Oriented Architectures

Module 1 - Basic technologies

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Agenda

Web Services Technology Stack

Aggregating Web Services

- Orchestration and BPEL4WS
- Choreography and WS-CDL

Collaboration Protocols

- Business Protocols
- Business Protocol Requirements
- Modeling Collaboration Protocols

WS-CDL in Detail

Aggregating Web Services

The inherent value of WS is realized by carefully planning how the various applications are modeled and how they interact with one another and with humans, when aggregated together

The operational semantics for accomplishing these goals are expressed through:

- Choreography & Orchestration
- Choreography complements Orchestration
  - –Choreography and Orchestration standards needed for next generation Web Services platform

Orchestration and BPEL

Orchestration focuses on the behavior of *a single participant*

- Hub/spoke based model, where a controller residing at a single location in a distributed system, locally enforces the progress of a process by following its definition

BPEL describes the computational logic of *a participant*

–control-flow (conditionals, sequencing, parallelism, loops)

–observable behavior of a participant, from the participant's own viewpoint

–variables and constructs for manipulating them

–event handlers

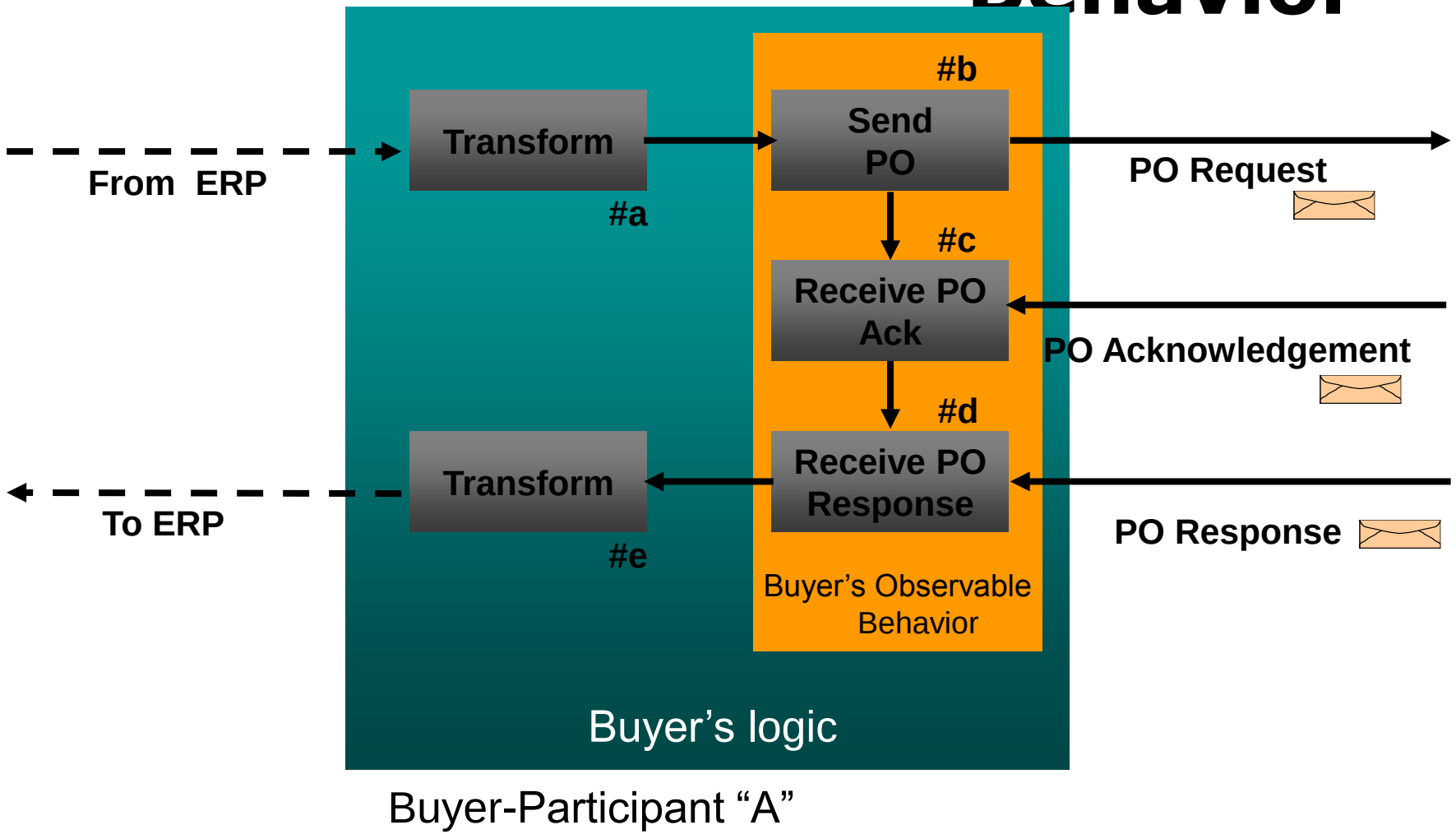
–timeout management

–exception and compensation handlers

Executable-BPEL/Abstract-BPEL

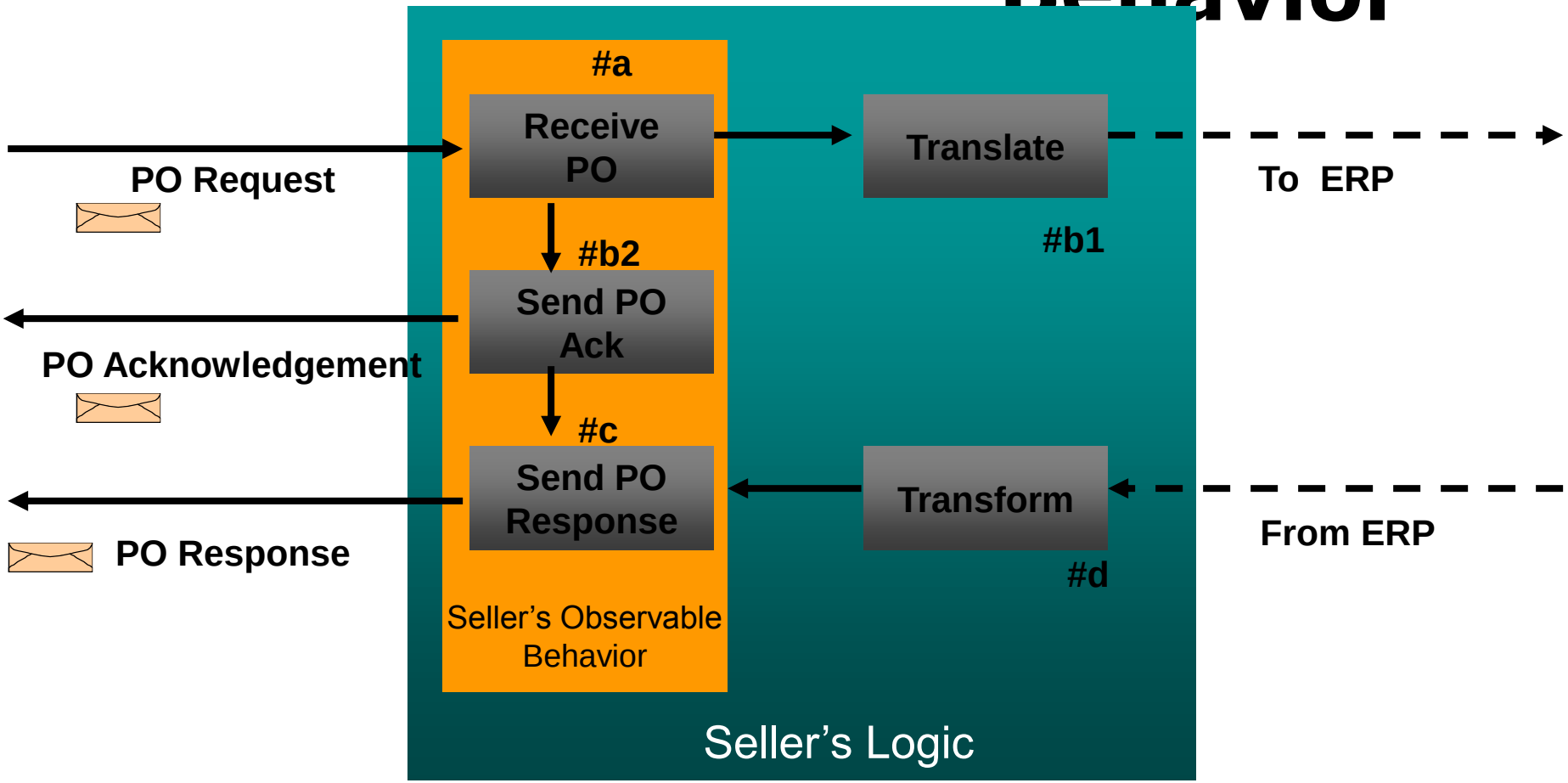
–They both possess the same computational expressiveness but with different syntactic rules, allowing specifying less process definition information when using AbsBPEL compared to ExecBPEL

Orchestration: *Buyer's* Logic, with its Observable Behavior



Buyer-Participant "A"

Orchestration: *Seller's* Logic with its Observable Behavior



Seller-Participant "B"

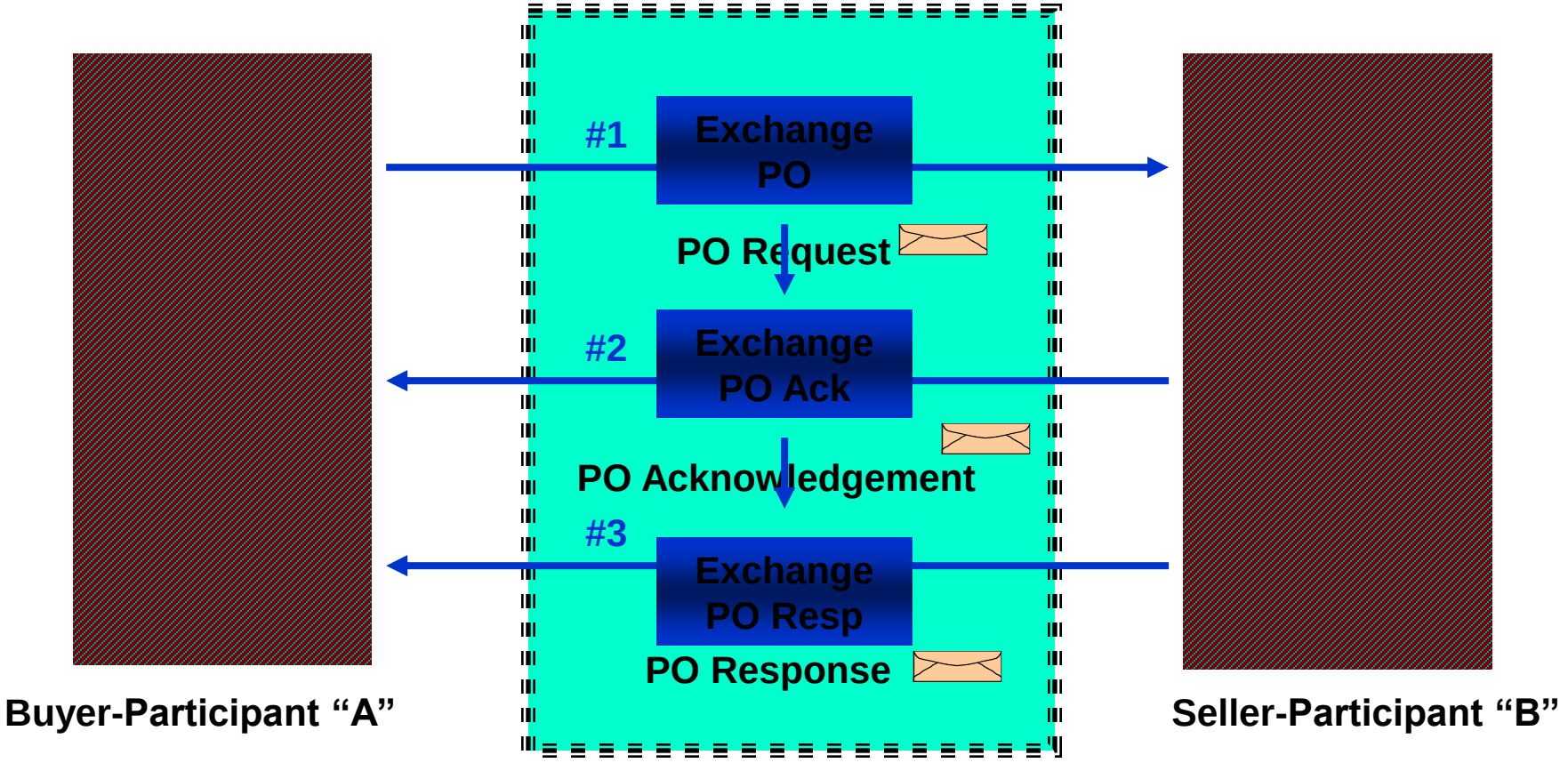
Choreography

Choreography is concerned with global, multi-party, peer-to-peer collaborations interoperable between any type of application components, regardless of the supporting platform or programming model used, being distributed within or across an organization's trusted domain

- Participants act as peers, interacting in long-lived, stateful and coordinated fashion

Choreography does not depend on a centralized controller

Choreography: Buyer and Seller Collaborate



Choreography of Buyer's & Seller's Collaboration

WS-Choreography Description Language (WS-CDL)

Choreography defines the common observable behavior of two or more participants, focusing on a global, participant agnostic viewpoint; where exchanges of information, with potential information alignment, occur when jointly agreed, information driven reactive rules are satisfied

WS-CDL is a language in which a Choreography description is specified

- Initially designed by Oracle and then submitted into the W3C Choreography WG in September 2003
- Standardization underway in the W3C Choreography WG with first Working Draft published in April 2004

WS-CDL Usage

Model a complex business protocol, such as Order Management, enabling interoperability between any type of application components, regardless of the supporting platform or programming model used

Generate computational logic of an individual collaborating participant

- ie. BPEL, Java, C#

WS-CDL Formalisms (1)

Global Model formalism **Based on a variant of pi-calculus [R. Milner, J. Parrow, D. Walker], the Explicit Solos calculus [P. Gardner, C. Laneve, L. Wischik], allows modeling a system from a global viewpoint**

Syntax:

Inf set *N* of names x, y, u and literals

x means x_1, …x_n (n>=0), loc means locations

Process P, Q, E, F ::=

	0	; inaction
|	?g !h P	; globalized trigger, replicated
|	loc:**x**.**#**$_l$ > u > loc':**y**.**#**$_r$	; globalized interaction: paired out||in, with only fusion
	# **y**	; continuations- reduces to loc:**#**$_l$ || loc':**#**$_r$ || loc:loc':**x**
|	(loc:x) P	; visibility
|	P || Q	; parallel composition
|	**loc**:**x** # **y**	; explicit fusion
|	P & Q	; globalized selection between alternatives
|	loc >> P	; projection of a process at a location
|	P @ E @ F	; choreography of: P normal, E exception, F finalizer

Guard g, h ::=

loc:u | loc:u # v | g + g | g g | h + h | h h

WS-CDL Formalisms (2)

- **Linear Typing to support safety/liveness properties in the presence of non-determinism & non-termination [K. Honda, N. Yoshida]**

Choreography vs Orchestration (1)

WS-CDL ➢ **Global declaration of visible information but also specifying a residing location**

BPEL ➢ Participant specific declaration of visible information

WS-CDL ➢ **Global Message Exchange (request and complementary matched accept) between 2 participants on a common Channel (w/ common reference and correlation)**

BPEL ➢ Send a message to a participant, Receive a message from a participant, with participant specific viewpoints of messageInformation/partnerLocators/correlations

WS-CDL ➢ **Global Reactive Rules for declaratively prescribing normal/abnormal progress, based on the flexible information driven model**

BPEL ➢ Participant specific viewpoints of control-flow (seq, flow, switch, controlLinks, exception/compensation handlers), based on the rigid imperative model

Choreography vs Orchestration (2)

WS-CDL ➢ **Common agreement of outcome (information alignment) across participants**

BPEL ➢ No agreement of outcome across participants

WS-CDL ➢ **Recursive Compositional model at the Choreography level and Templating allows reuse in different business contexts**

BPEL ➢ Compositional model at the WSDL level

WS-CDL ➢ **Generated computational logic of an individual collaborating participant can be BPEL, Java, C#, etc.**

BPEL ➢ Computational logic of an individual participant is BPEL

Collaboration Protocols

Business protocols, such as Purchase Order Management

- Involve creation of orders and change/cancel of in-flight orders
- Found in
  - –Financial protocols, such as the FIX, TWIST protocols
  - –RosettaNet PIPs

But can also be technical protocols, such as WS-Business Activity Protocol/WS-AtomicTransaction [Microsoft, IBM]

- Define a classic/extended transaction model

Collaboration Protocol Requirements (1)

Reusability in different contexts (industry, locale, etc.)

- Allow specifying varying degrees of details incrementally

Compositional model for enabling scalable modeling

- Build smaller choreographies first
- Combine them together to form a larger choreography

Collaboration Protocol Requirements (2)

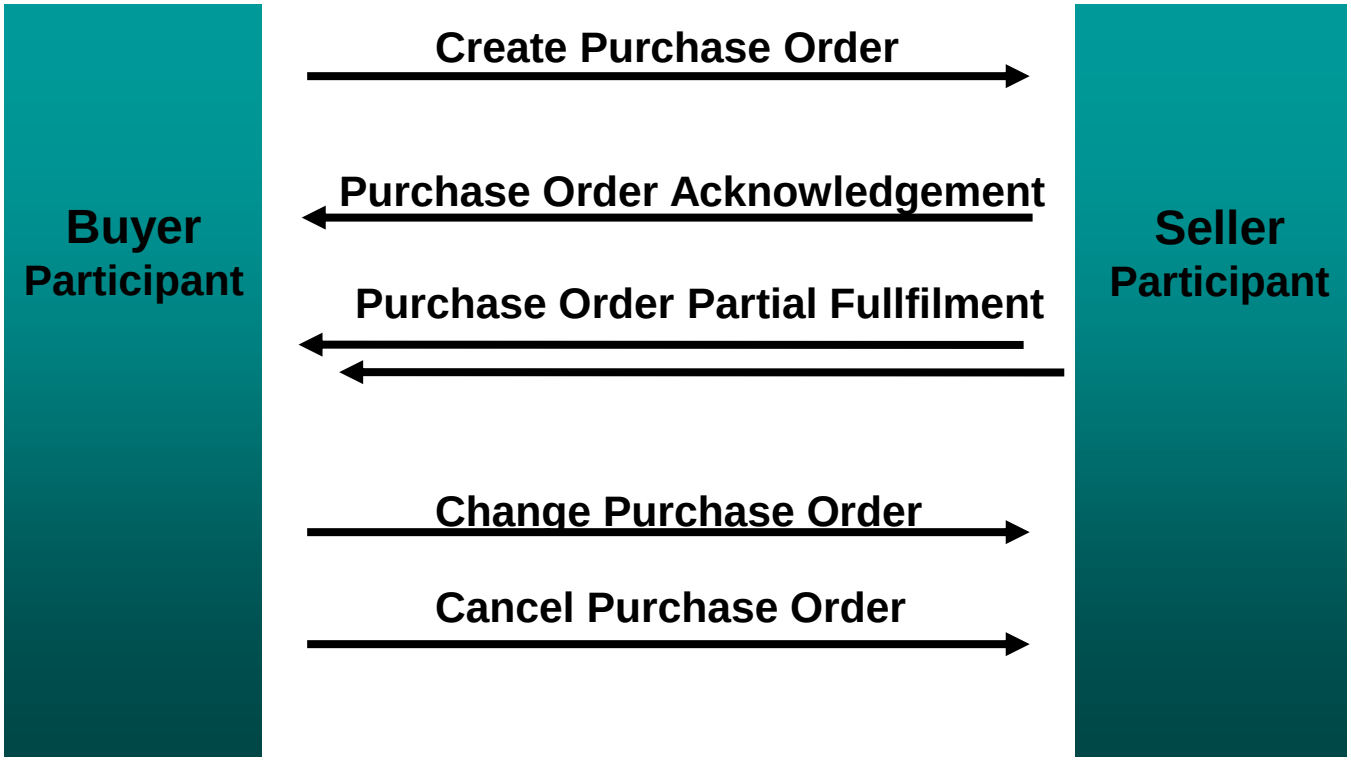
***Global model*, across two or more collaborating participants, of:**

- Stuck-free Message Exchanges (requests matched with complementary accepts)
- Channel-Passing, through 2 or more participants
- State Creation/Changes, Race Conditions capturing
- Common Reactive rules & Ordering Constraints (normal, exceptional), prescribing Information Driven computational progress in a declarative and flexible fashion
- Information alignment, guaranteeing common understanding of exchanged information and state changes
- Coordinated Progress (normal, exceptional)

With expressiveness greater than what CCS model offers

And guarantees of safety/liveness properties in the presence of non-determinism & non-termination

Real-life Business Collaboration Protocol: Order Management



Modeling a Collaboration Protocol with BPEL

Design individual puzzle pieces first and put them together later

Step 1: Design one piece

- Model the localized behavior of one participant: Buyer

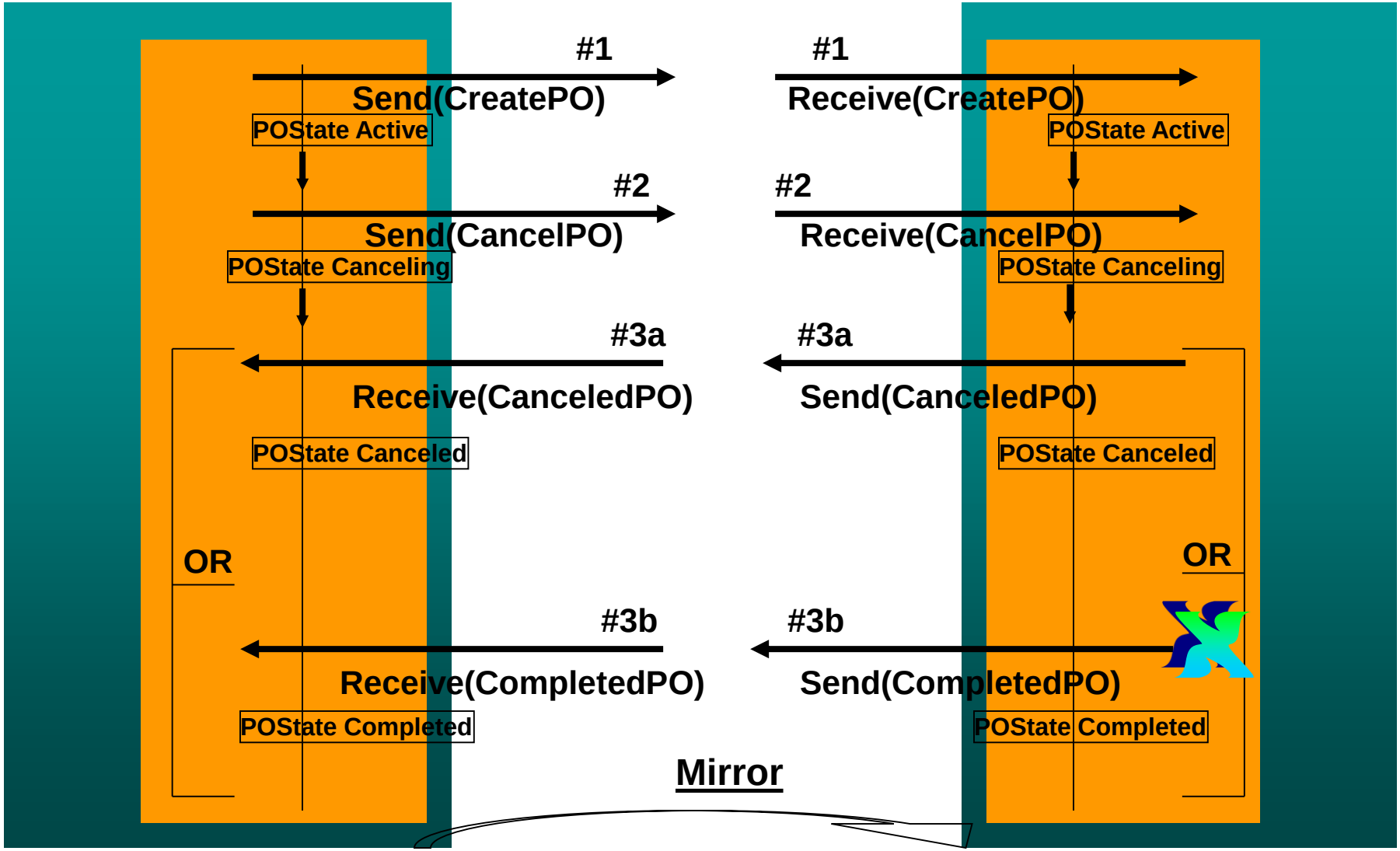
Step 2: Design another piece

- Model the localized behavior of another participant: Seller, Shipper, etc.

Oops! The individually designed pieces do not fit together

- The composed behavior of the individually modeled behaviors may capture an un-desired global system behavior (see #3b, Seller participant in the following slide)

Modeling a Collaboration Protocol with BPEL: *Undesired* Global Behavior



Modeling a Collaboration Protocol with WS-CDL

"Big-Picture" first and cut puzzle pieces later

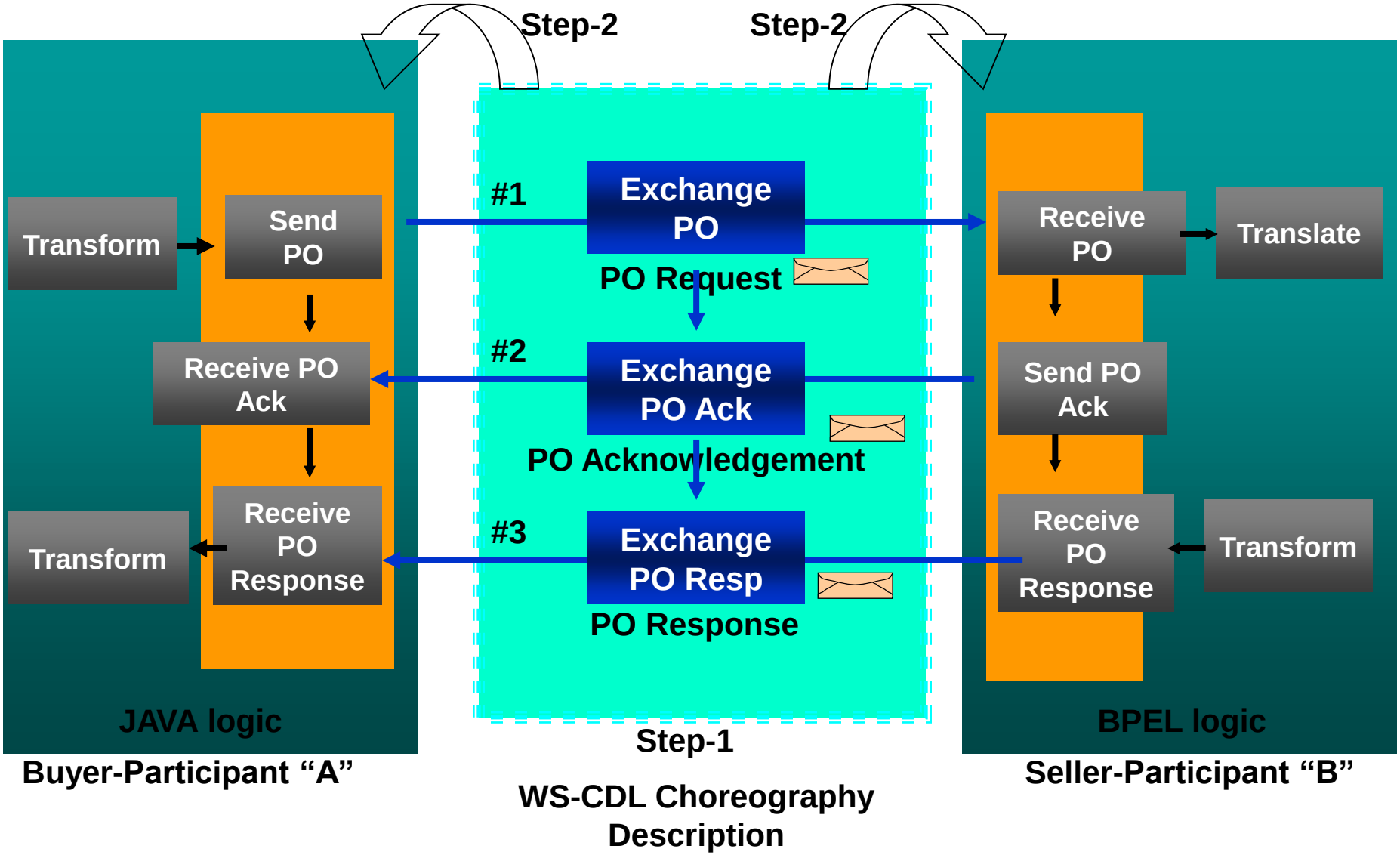
Step 1: Look one picture

- Start by modeling the collaboration between the Buyer participant and the Seller participant

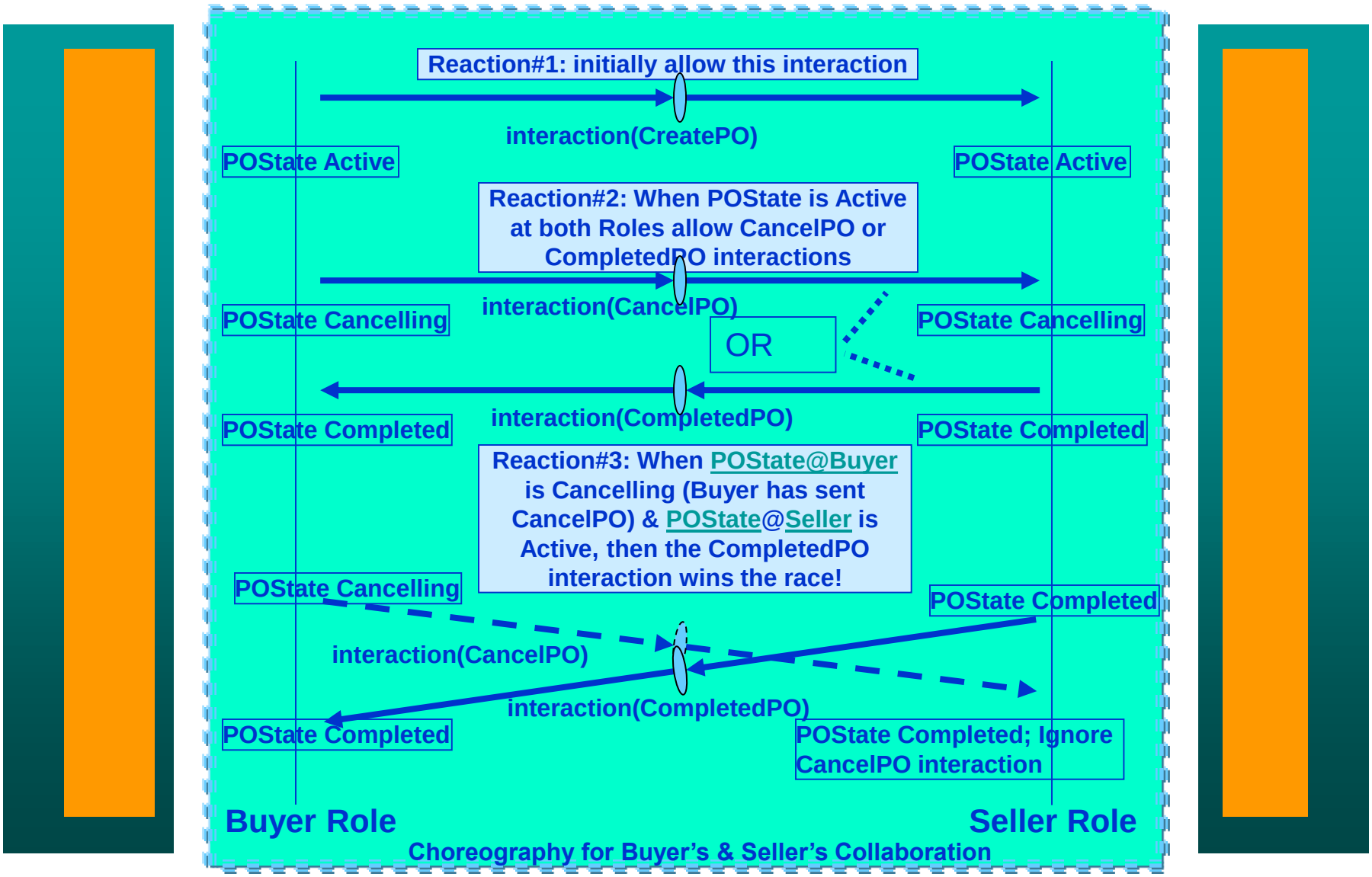
Step 2: Then cut the smaller pieces

- From WS-CDL we can generate BPEL/Java/C# logic for each participant, ie.
  - –Java logic for the Buyer
  - –BPEL logic for the Seller

Modeling a Collaboration Protocol with WS-CDL



Modeling a Collaboration Protocol with WS-CDL: *Desired* Global Behavior



WS-CDL in Detail

WS-CDL Concepts

Typing

- Information Type
- Token, Token Locator

Identifying & Coupling Collaborating Participants

- Role
- Relationship
- Participant

Information Driven Collaborations

- Channel Type
- Variable Definitions
- Activities
  - –interaction, perform, assign, noaction
- WorkUnit/Reaction
- Choreography
- Package, Import

Typing

Information type

- Aliases WSDL types, XSD type/element
- Supports other type systems

Token type

- Specify name and type as an alias to a piece of information within a document

Token Locater type

- Specify rules for selecting a piece of information within a document

Typing Syntax

```
<informationType  name="ncname"
                          type=”qname”? |
                           element=”qname”? />


<token  name="ncname"  informationType="qname" />

<tokenLocator  tokenName="qname"
      informationType="qname"
      query="XPath-expression"? />
```

Roles, Relationships, Participants

Role type

- Enumerate the observable behavior, specified by one or more Behavior type(s), a collaborating participant exhibits
- Behavior type specifies the operations supported
  - Optional WSDL interface type

Relationship type

- Specify the mutual commitments, in terms of the Roles/ Behavior types, two collaborating participants are required to provide

Participant type

- Enumerate a set of one or more Roles that a collaborating participant plays

Roles, Relationships, Participants Syntax

```
<role  name="ncname" >
  <behavior  name="ncname"
      interface="qname"? />+
</role>

<relationship  name="ncname">
  <role  type="qname"  behavior="ncname" />
  <role  type="qname"  behavior="ncname" />
</relationship>

<participant  name="ncname">
  <role  type="qname" />+
</participant>
```

Channel (1)

Realizes a *dynamic* point of collaboration, through which collaborating participants interact

- Where to & how to communicate a message
  - –Specify the *Role/Behavior* and the *Reference* of a collaborating participant
  - –Identify an *Instance* of a Role
- Identify an instance of a conversation between two or more collaborating participants
  - –A conversation groups a set of related message exchanges

Channel (2)

One or more channel(s) MAY be passed around from a Role to one or more other Role(s), possibly in a daisy fashion through one or more intermediate Role(s), creating new points of collaboration dynamically

- A Channel type MAY restrict the types of Channel(s) allowed to be exchanged between the Web Services participants, through this Channel
- A Channel type MAY restrict its usage, by specifying the number of times a Channel can be used

Channel Syntax

```
<channelType  name="ncname"
    usage="once"|"unlimited"?
    action="request-respond"|"request"|"respond"? >

  <passing  channel="qname"
        action="request-respond"|"request"|"respond"?
        new="true"|"false"? />*

  <role  type="qname"  behavior="ncname"? />

  <reference>
    <token type="qname"/>+
  </reference>

  <identity>
    <token  type="qname"/>+
  </identity>*
</channelType>
```

Variables (1)

Capture instance information about objects in a collaboration

Affect the progress of collaborations between collaborating participants

Variable types:

- Information Exchange Variables: define instances of exchanged documents between Roles in an interaction
- State Variables: define instances of state information at a Role
- Channel Variables: define instances of channel types

And their definitions:

- Specify the type of value a variable contains using informationType, channelType
- Specify the Role of the collaborating participant a variable resides in

Variables (2)

The value of a variable

- Is available to all the Roles by initializing them prior to the start of a Choreography. Common variables contain information that is common knowledge to two or more Roles
- Can be made available at a Role by populating them as a result of an interaction
- Can be made available at a Role by assigning data from other information. Locally defined variables that contain information created and changed locally by a Role. They can be Information Exchange, State or Channel Variables

- Can be used to determine the decisions and actions to be taken within a Choreography

Variable Syntax

```
<variableDefinitions>
   <variable   name="ncname"
      informationType=”qname”|channelType="qname"
      mutable=”true|false”?
      free=”true|false”?
      silent-action=”true|false”?
      role="qname"? />+
</variableDefinitions>
```

Activities: Interaction (1)

Enable collaborating participants to communicate and align information

Message exchange(s) between two Roles within a Relationship

- Request & Accept of an operation through a common channel
  - –one way or request-response operation
  - –information flow
    - request direction: fromRole towards toRole
    - response direction: toRole towards fromRole

Activities: Interaction (2)

State recordings at a Role

- Create new, modify existing variables at a Role

Information Alignment: agreement on their common understanding of the

- State changes of variables that reside in one Role with the state changes of variables that reside in the other Role
- Values of the exchanged messages from one Role to the other Role

Interaction Syntax

```
<interaction  name="ncname" channelVariable="qname"
              operation="ncname"
              time-to-complete="xsd:duration"?
              align="true"|"false"?
              initiateChoreography="true"|"false"? >
  <participate  relationship="qname"
                fromRole="qname"
                toRole="qname" />
  <exchange  messageContentType="qname"
             action="request"|"respond" >
    <use  variable="XPath-expression"/>
    <populate  variable="XPath-expression"/>
  </exchange>*
  <record  name="ncname" role="qname" action="request"|"respond" >
    <source  variable="XPath-expression" />
    <target    variable="XPath-expression" />
  </record>*
</interaction>
```

Activities: Assign

State recordings at a Role

- Create new, modify existing variables at a Role

```
<assign  role="qname">
  <copy  name="ncname">
    <source  variable ="XPath-expression" />
    <target  variable="XPath-expression"  />
  </copy>+
</assign>
```

WorkUnit/Reaction

Information driven model, where a Reaction rule guards a set of activities, by prescribing the constraints on information that need, to be satisfied for making normal/abnormal progress

- Reaction Guard expresses interest on the availability of one or more variable information
- When the variable is/becomes available and the guard condition evaluates to true, the enclosed activities are enabled
- Guard condition may be on variables that reside on different Roles

Repeat: marks the re-enablement of a workunit

isAligned(var1, var2, rel) specifies interest on the alignment of variables in two Roles within a Relationship

WorkUnit/Reaction Syntax

```
<workunit  name="ncname"
       guard="xsd:boolean XPath-expression"?
       repeat="xsd:boolean XPath-expression"?
       block="true|false" >

       Activity
</workunit>
```

Enablement within a set of Activities

Sequential: specifies the enablement of activities in a sequential fashion

Parallel: specifies the enablement of activities in a parallel fashion

Choice: specifies the enablement of one activity from a set of two or more activities

```
<sequence>
    Activity+
</sequence>

<parallel>
    Activity+
</parallel>

<choice>
    Activity+
</choice>
```

Choreography

•Combines actions with common behavioral characteristics, forming a collaboration unit of work

- Enumerate all the binary relationships interactions act in
- Localize the visibility of variables
  - –Using variable definitions
- Prescribe alternative patterns of behavior
  - –Using workunits/reactions
- Enable Recovery
  - –Using workunits/reactions
  - –Backward: handle exceptional conditions
  - –Forward: finalize already completed activities

Choreography Syntax

```
<choreography  name="ncname"
   complete="xsd:boolean XPath-expression"?
   isolation="dirty-write"|
   "dirty-read"|"serializable"?
   root="true"|"false"? >

<relationship  type="qname" />+
     variableDefinitions?
     Choreography*

     Activity

<exception  name="ncname">
         WorkUnit+
</exception>?

<finalizer  name="ncname">
       WorkUnit
</finalizer>
</choreography>
```

Choreography Composition (1)

WS-CDL's compositional model allows scalable modeling

- Build smaller choreographies first
- Combine them together to form a larger choreography
- Then do participant projections to get a participant's viewpoint
  - –Composition makes participant projections easier
  - –Without the big-picture of a "business process" in perspective, participant projections do not make sense

Choreography Composition (2)

- **Choreographies can be recursively combined to form new Choreographies, using the perform activity**

```
<perform  choreographyName=”qname”>
  <alias  name="ncname”>
    <this  variable=“XPath-expression” role=“qname” />
    <free  variable="XPath-expression" role=“qname” />
  </alias>+
</perform>
```

Package, Import, Templates

Facilitate modularity, reusability

A Choreography package allows combining choreography types under a common namespace:

- informationType, token, tokenLocator
- role, relationship, participant
- channelType
- variableDefinitions
- Choreography

An import allows using choreography types defined in another Choreography package

Templating allows specifying varying degrees of details incrementally, enabling reusability of choreographies in different contexts (industry, locale, etc.)

Package, Import Syntax

```
<package
    name="ncname"
    author=”xsd:string”?
    version=”xsd:string”
    targetNamespace="uri"
    xmlns=”http://www.w3.org/ws/choreography/2004/02/WSCDL/”>
    importDefinitions*
    informationType*
    token*
    tokenLocator*
    role*
    relationship*
    participant*
    channelType*
    Choreography*
</package>

<importDefinitions>
    <import  namespace="uri"  location=”uri” />+
</importDefinitions>
```

Summary

Conclusions

- **Choreography complements Orchestration**

- **Choreography is concerned with global, multi-party, peer-to-peer collaborations, between application components, distributed within or across an organizations trusted domain**

- **WS-CDL is based on a formal model**

WS-CDL is currently under standardization in W3C Choreography WG

- Please download the latest working draft and comment