Web Service Composition Application Framework

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What is WS-CAF?

- Collection of 3 specifications designed to be used independently or together
  - WS-Context
    - Context service
  - WS-Coordination Framework
    - Framework for pluggable coordination protocols
  - WS-Transaction Management
    - Three transaction models for Web services

WS-Context

WS-Context

- Allows composite applications to share common information.
- Defines Notion of An “Activity”
  - An execution of a series of related interactions with a set of cooperating web services.
  - Operations correlated by a context associated with activity
- A Context
  - A way of doing correlation of messages
  - Context bound to one activity
  - Examples
    - Single-session sign-on
    - Transactions
    - Database session identifier

Context Structure

- An XML document containing a unique identifier and optional data specific to a related activity.
- Typically included in the SOAP header of messages to and from web services participating in an activity.
- Can be passed as a referenceable URI (by reference) or in its longer form (by value)

Context schema


```
<xs:complexType name="ContextType">
    <xs:sequence>
        <xs:any namespace="##other" processContents="lax" minOccurs="0"
                maxOccurs="unbounded"/>
        <xs:element name="context-identifier" type="tns:contextIdentifierType"/>
        <xs:element name="context-service" type="ref:ServiceRefType"
                minOccurs="0"/>
        <xs:element name="type" type="xs:anyURI"/>
        <xs:element name="context-manager" type="ref:ServiceRefType"
                minOccurs="0"/>
        <xs:element name="parent-context"   type="tns:ContextType"
                minOccurs="0"/>
    </xs:sequence>
    <xs:attribute name="timeout" type="xs:int" use="optional"/>
    <xs:attribute ref="wsu:Id" use="optional"/>
</xs:complexType>
```

Contains

- *Context identifier* - URI, MUST be unique
  - with optional wsu:Id attribute.
- *Context service* – ServiceRefType (OPTIONAL)
  - locate the authority having generated the context
  - ServiceRefType = Generic structure to deal with addressing
- *Type* – URI
  - the type of the protocol supported by the context,
- *Context-manager* ServiceRefType (OPTIONAL)
  - to get data associated with a context-identifier
  - if present, the context has been passed by reference
- *parent-contexts (*OPTIONAL)
- *timeout* attribute (OPTIONAL)
  - indicates for how long the context information is valid;
- *wsu:Id* attribute (OPTIONAL)
  - used to support signing or encrypting the context structure.

WS-Context Services

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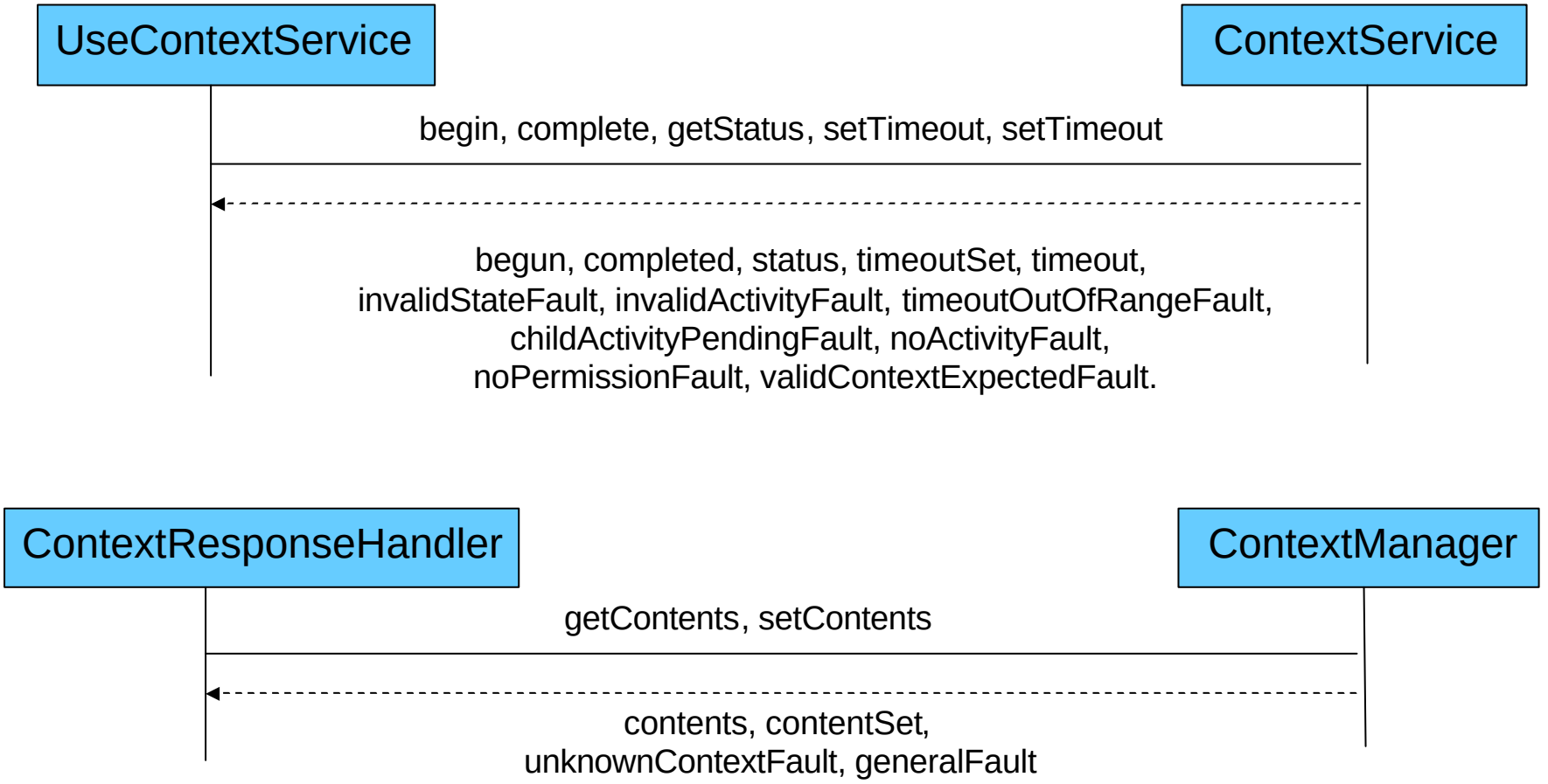
- Defines web services for maintaining contexts
- Ability to pass contexts by reference or by value.

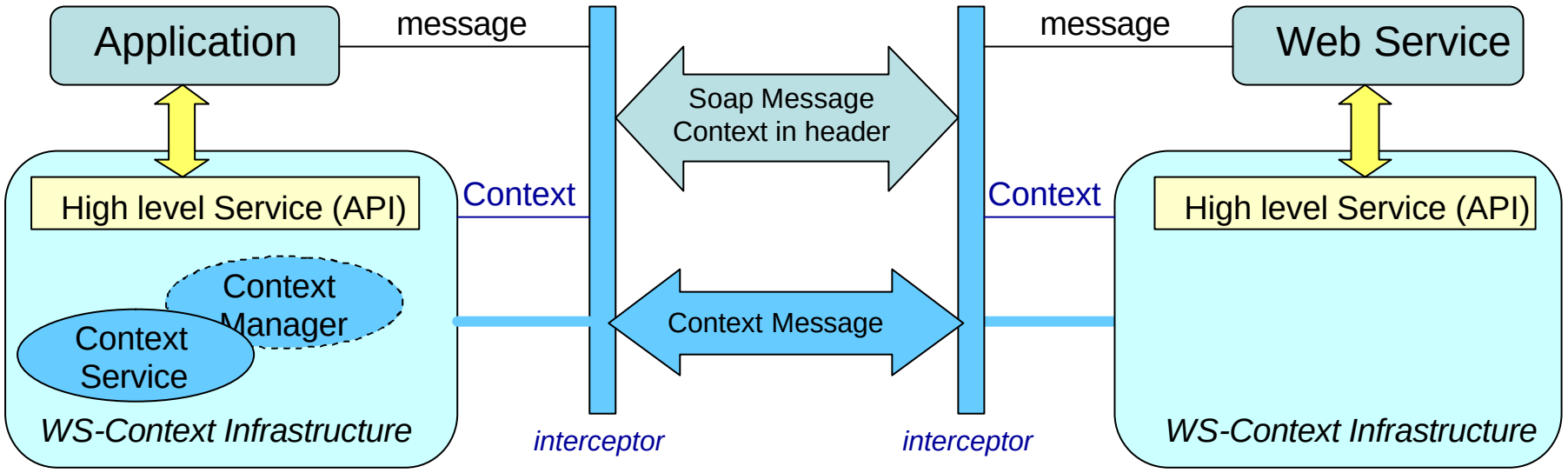
➢ Context Service
  - creating - *begin*
  - completing - *complete*
  - getting status of a context – *getStatus*
    - *ACTIVE, COMPLETING, COMPLETED, NO_ACTIVITY, UNKOWN*
  - Setting and getting timeout – *setTimeout*, *getTimeout*

➢ Context Manager Service
  - Obtaining/setting a content of a context got by reference – *getContents*, *setContents*

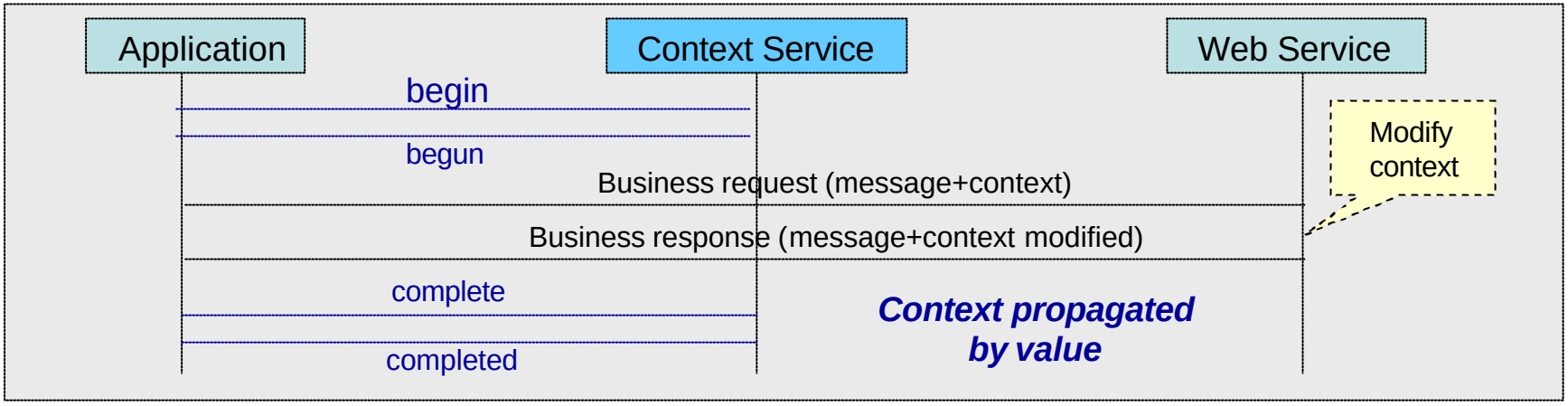
Interactions by Callback

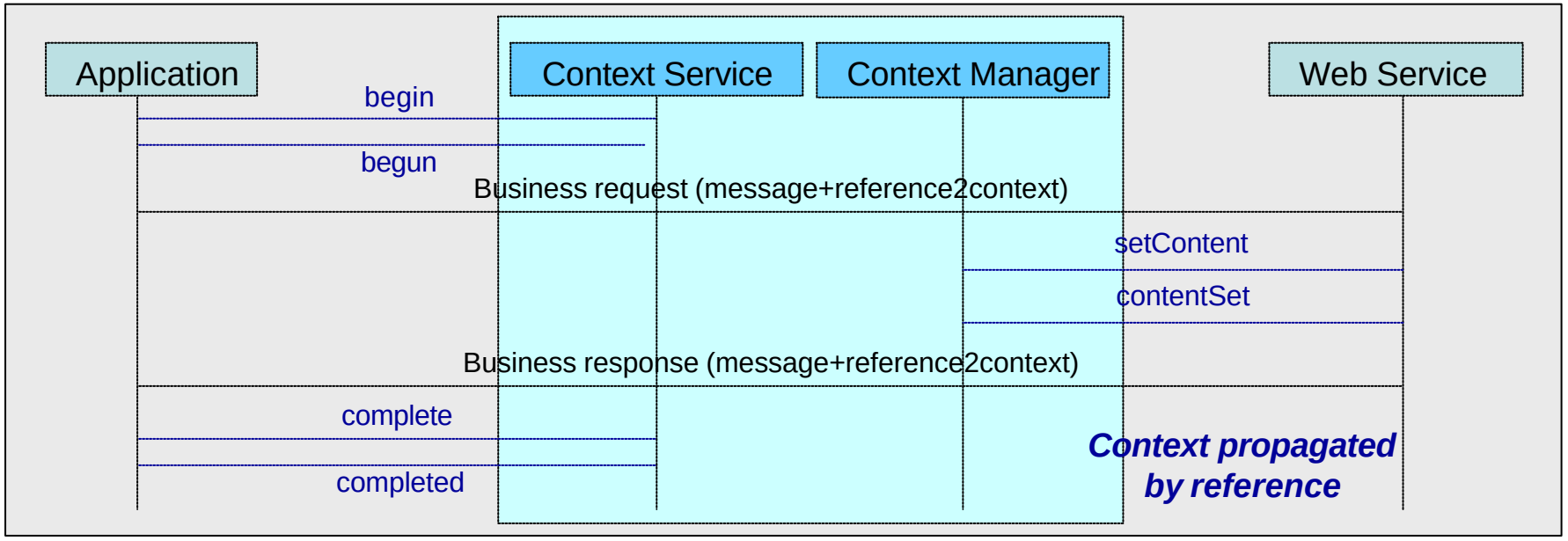


Architectural Overview



Interactions Overview





WS-Coordination Framework

WS-CF

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- Coordination is more fundamental than transactions
  - Security
  - Replication
  - Transactions
  - …
- Coordination could be seen as “disseminating information by a *coordinator* to a number of *participants* to guarantee that all participants obtain a specific message”.

Goals

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- Provide a general framework for coordination protocols
  - Existing implementations to be plugged in
  - New implementations can be supported
    - Defines coordinator and participant relationships
- Work with WS-Context
  - Augment context
  - ➢ Coordination Context
- Scope of activity becomes scope of coordination boundary

Context type


```
<xs:complexType name="ContextType">
  <xs:complexContent>
    <xs:extension base="wsctx:ContextType">
      <xs:sequence>
      <xs:element name="protocol-reference" type="tns:ProtocolReferenceType"/>
      <xs:element name="coordinator-reference" type="tns:CoordinatorReferenceType"
        maxOccurs="unbounded"/>
      <xs:any namespace="##any" processContents="lax" maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
```

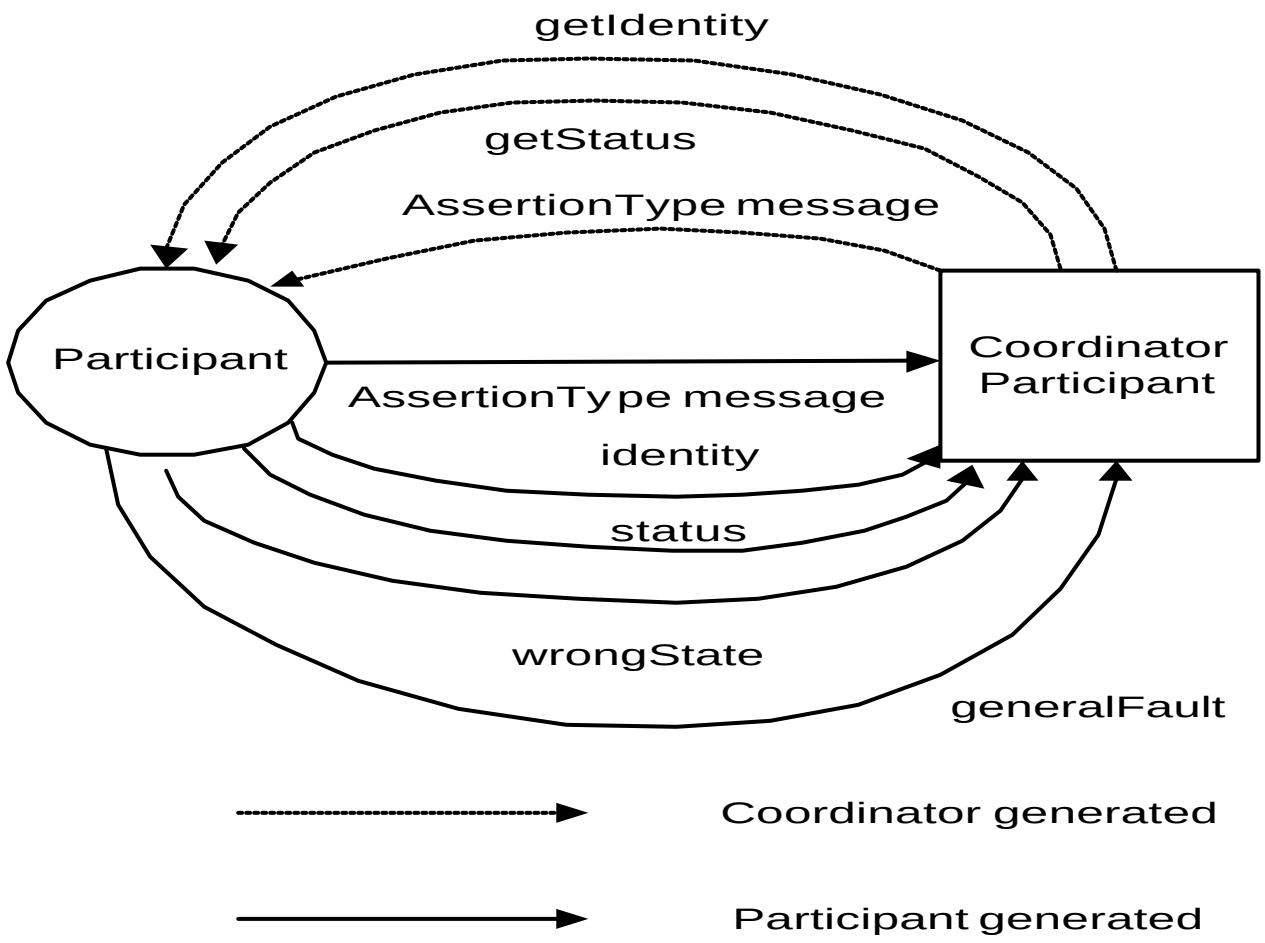
WS-CF
Main components

- *Coordinator*:
  - enable registration of participants triggered at *coordination point*s.
- *Participant*:
  - The operation or operations that are performed as part of coordination sequence processing
  - A *Coordination Service*: Defines the behavior for a specific coordination model.
- *Coordination Service:*
  - provides a processing pattern that is used for outcome processing.
  - For example
    - ACID (prepare, commit, rollback)
    - Sagas
    - Real-time transactions
    - …

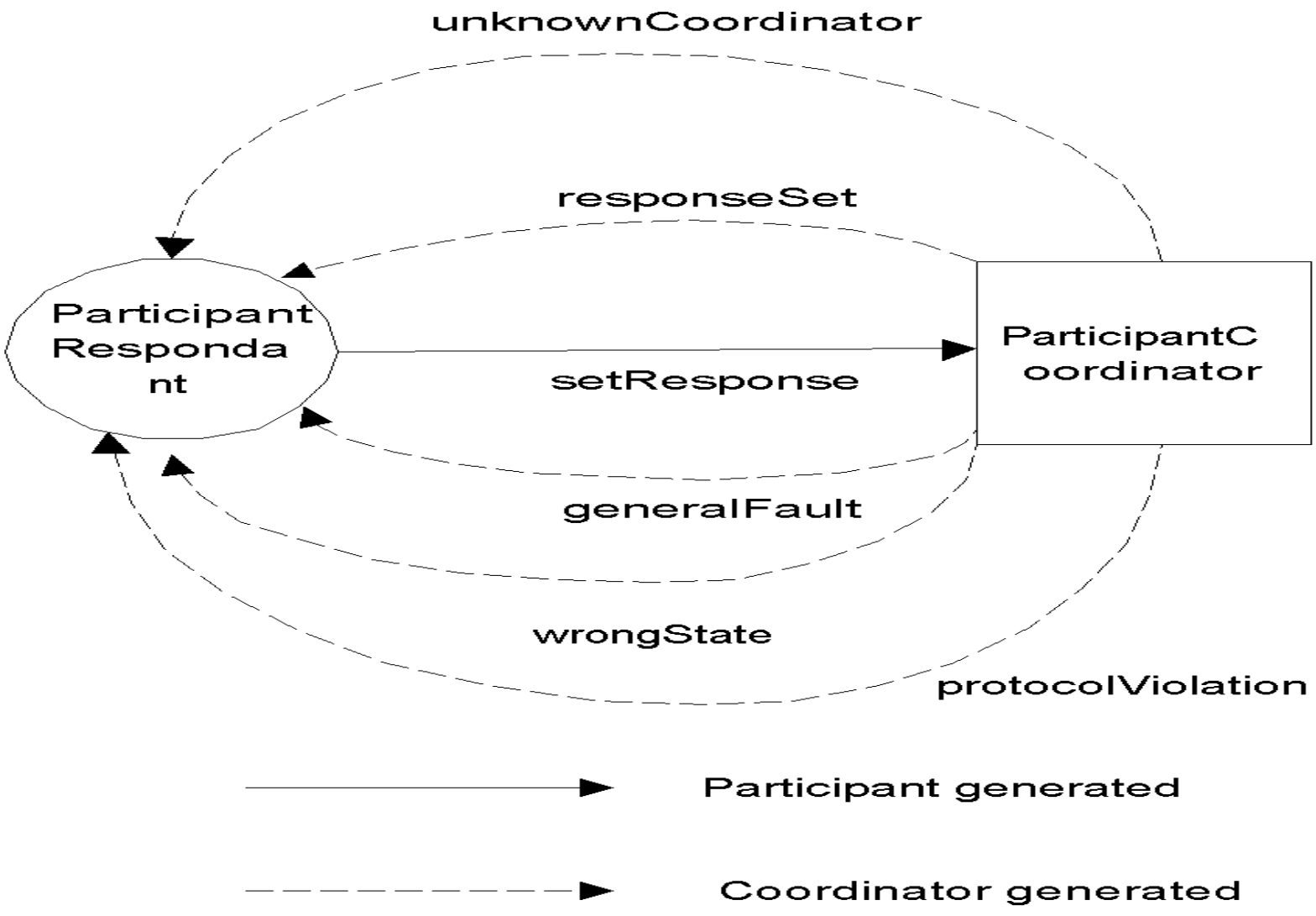
Coordination protocol

- Defined by message interactions between Coordinator and participants
  - Coordinator-to-participant
    - coordinator sends a protocol message to the participant and will eventually get a response.
    - Coordination status and identity
  - Participant-to-coordinator
    - a participant may autonomously communicate protocol messages to the coordinator.
      - Works in terms of AssertionTypes
- WC-CF protocol neutral
- Protocols Identified by URI

Coordinator-to-participant



Participant-to-coordinator



AssertionType

- “Base class” for all coordinator-to-participant message interactions
  - Requests and responses
- All protocol specific messages enhance this type
- One service (participant or coordinator) can accept multiple protocols

Qualifiers

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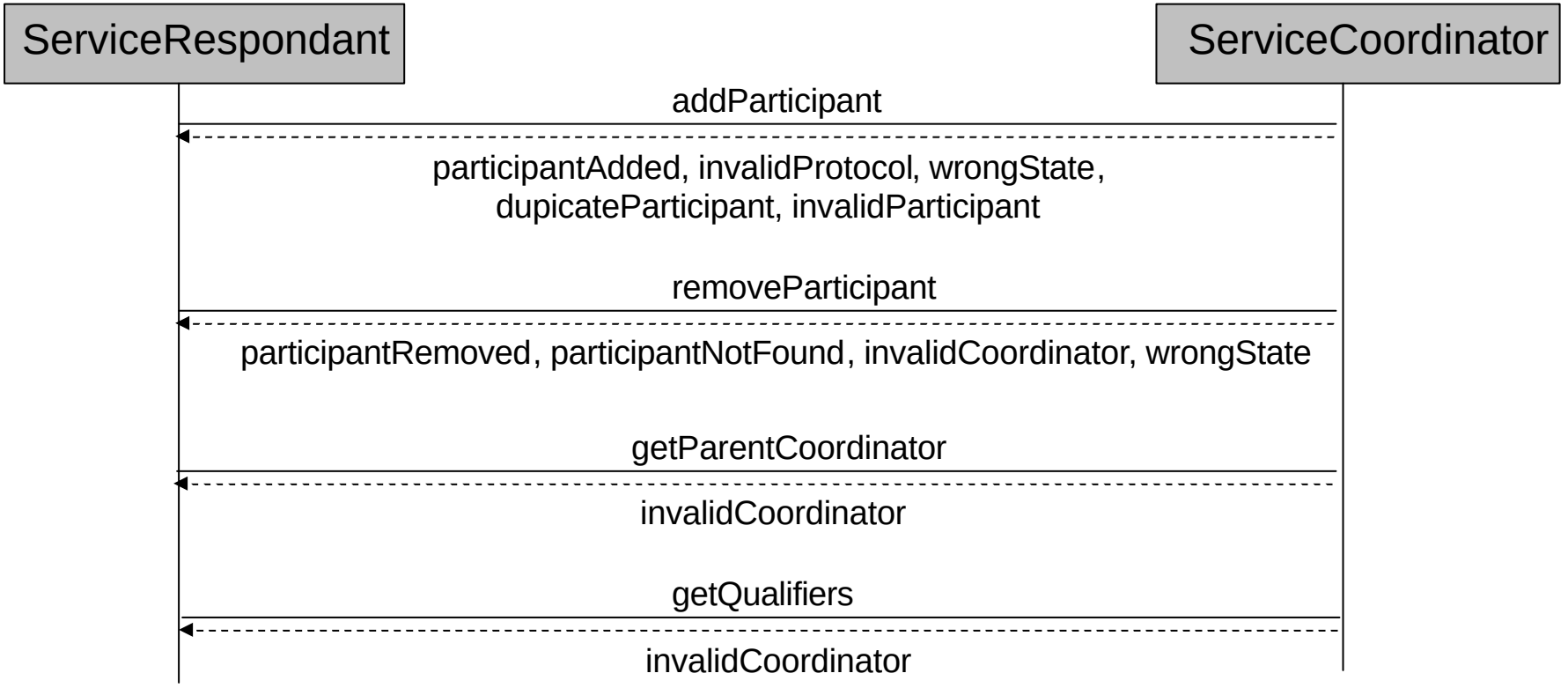
- Runtime protocol extensibility option
- Typically in enlist/delist
  - For coordinator/participant information
  - E.g., will cancel in 24 hours

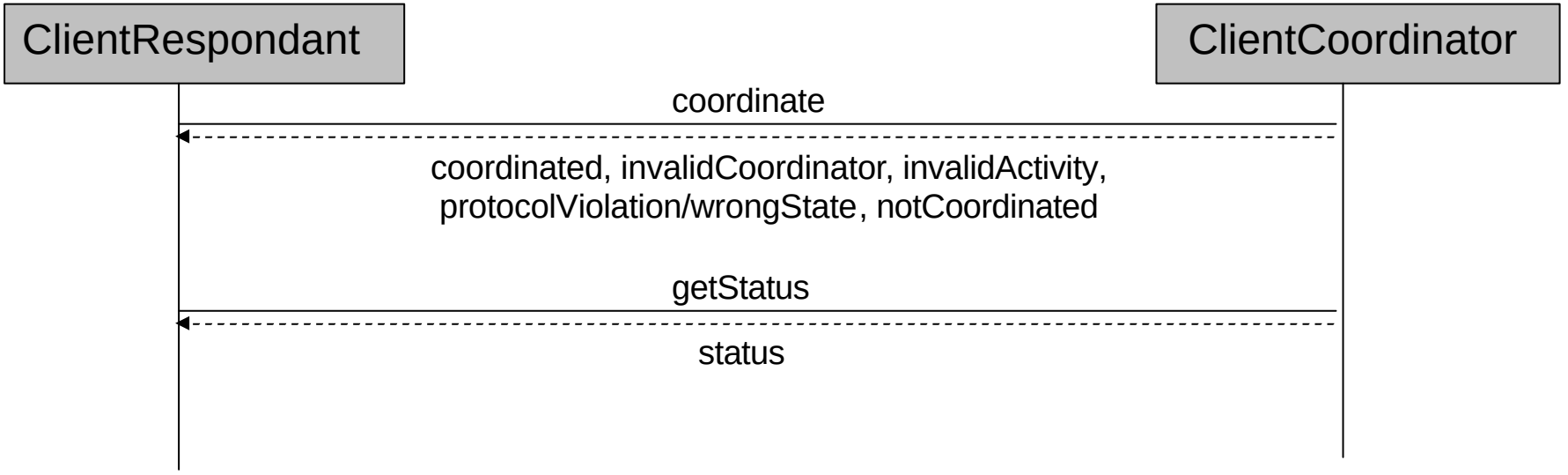
Service-to-coordinator interactions

- define how a service may enlist or delist a participant with the coordinator



Client-to-coordinator interactions

- Define how a client can obtain the status of the coordinator or ask it to perform coordination.



Architectural Overview

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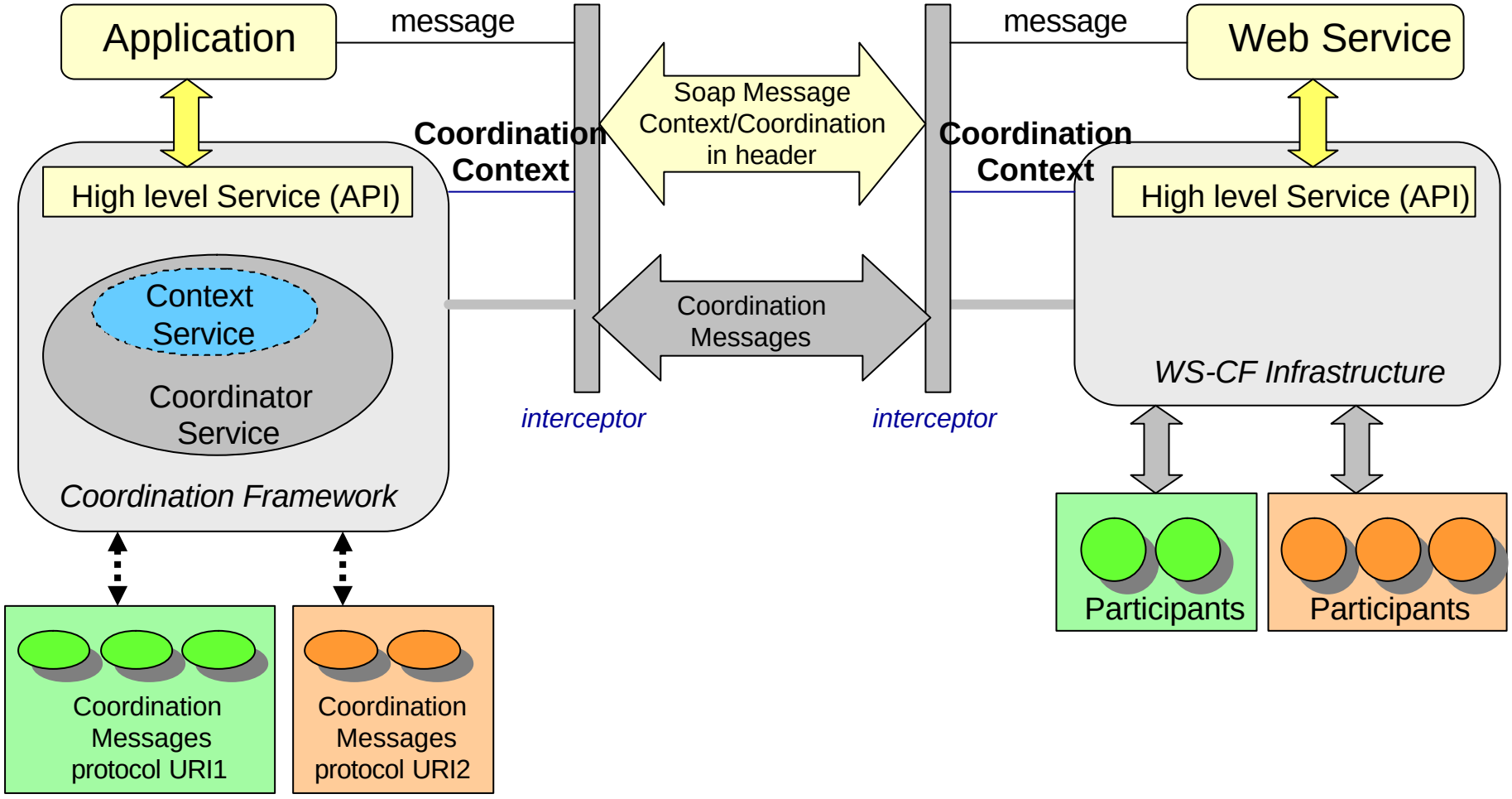

Interactions Overview

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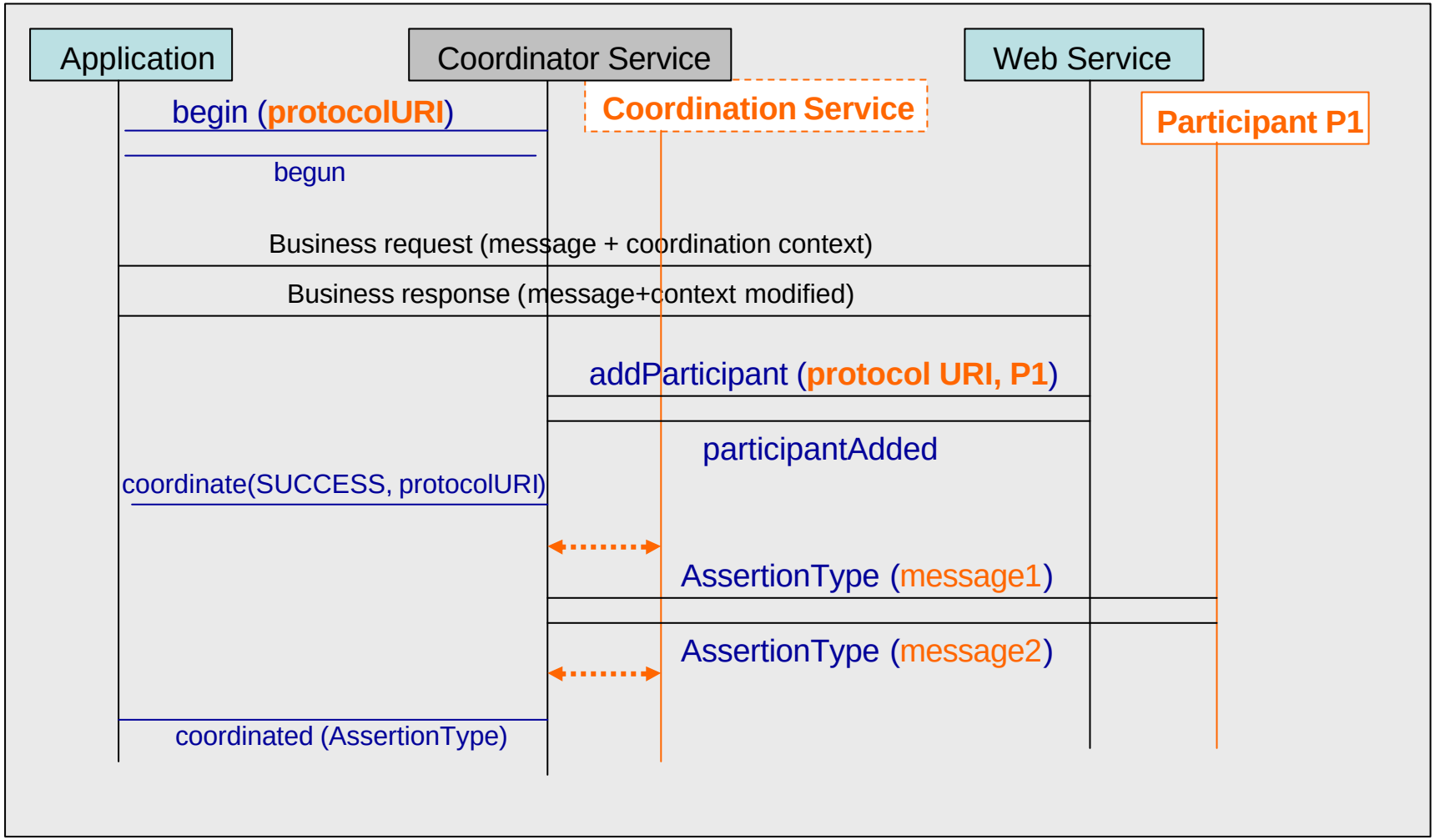

Interposition

- Important for security and performance reasons
  - Part of most distributed transaction protocols
- Subordinate coordinator
  - Participant as far as coordinator is concerned
  - Coordinator as far as participant is concerned
- Supported by WS-CF
  - Not mandated

Example

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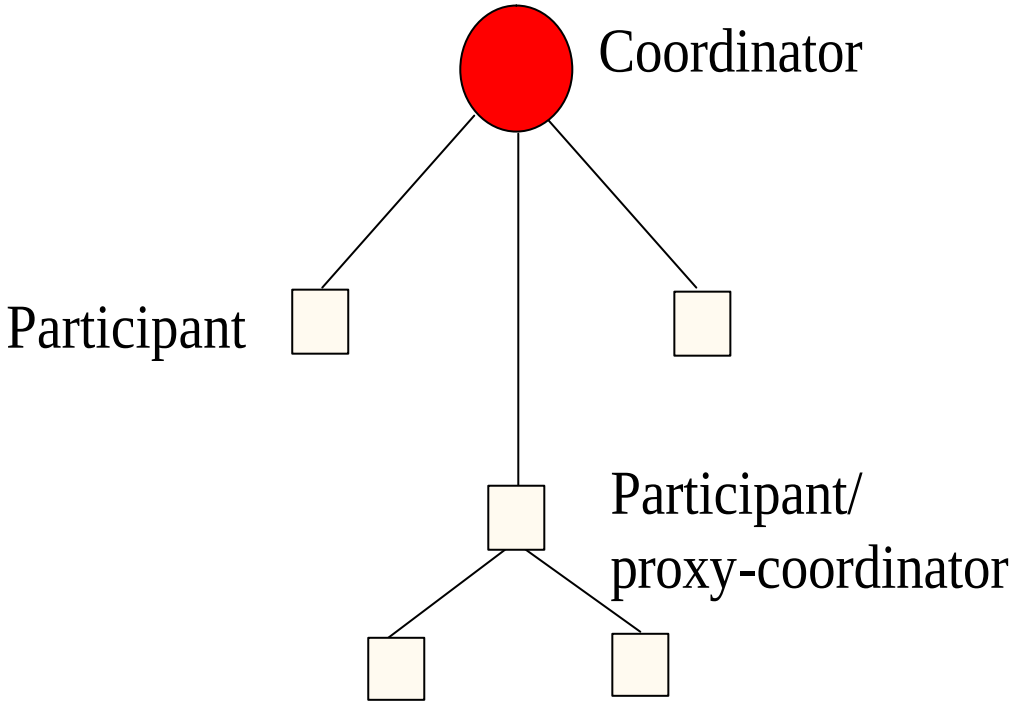

Recovery

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- Distributed application federated into natural recovery (admin) domains
  - Can’t mandate one specific recovery mechanism
    - Very application specific anyway
  - Have to allow administrative domains autonomy
- Therefore, support but not mandate

Recovery support

- RecoveryCoordinator
  - Drives recovery on behalf of participant
  - Participants may not be able to recover at same URI
    - Machine crash, domain migration, …
- Coordinator can replace one endpoint with another to continue protocol

WS-Transaction Management

WS-TXM

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- Goals
  - Support range of use cases
  - “One-size does not fit all”
  - Therefore a single protocol cannot cope with all requirements
  - All requirements aren’t “two-phase”
- Builds on WS-CF and WS-Context
  - Define specific coordinators and participants
  - Augment context

Defines

- Three transaction models
  - ACID transaction
    - For interoperability and high-cost services where ACID transactions are a requirement
  - Long running action
    - Loosely coupled, long duration work that uses compensations
  - Business process
    - For treating all steps in an automated business process as part of a single logical transaction

Architectural Overview

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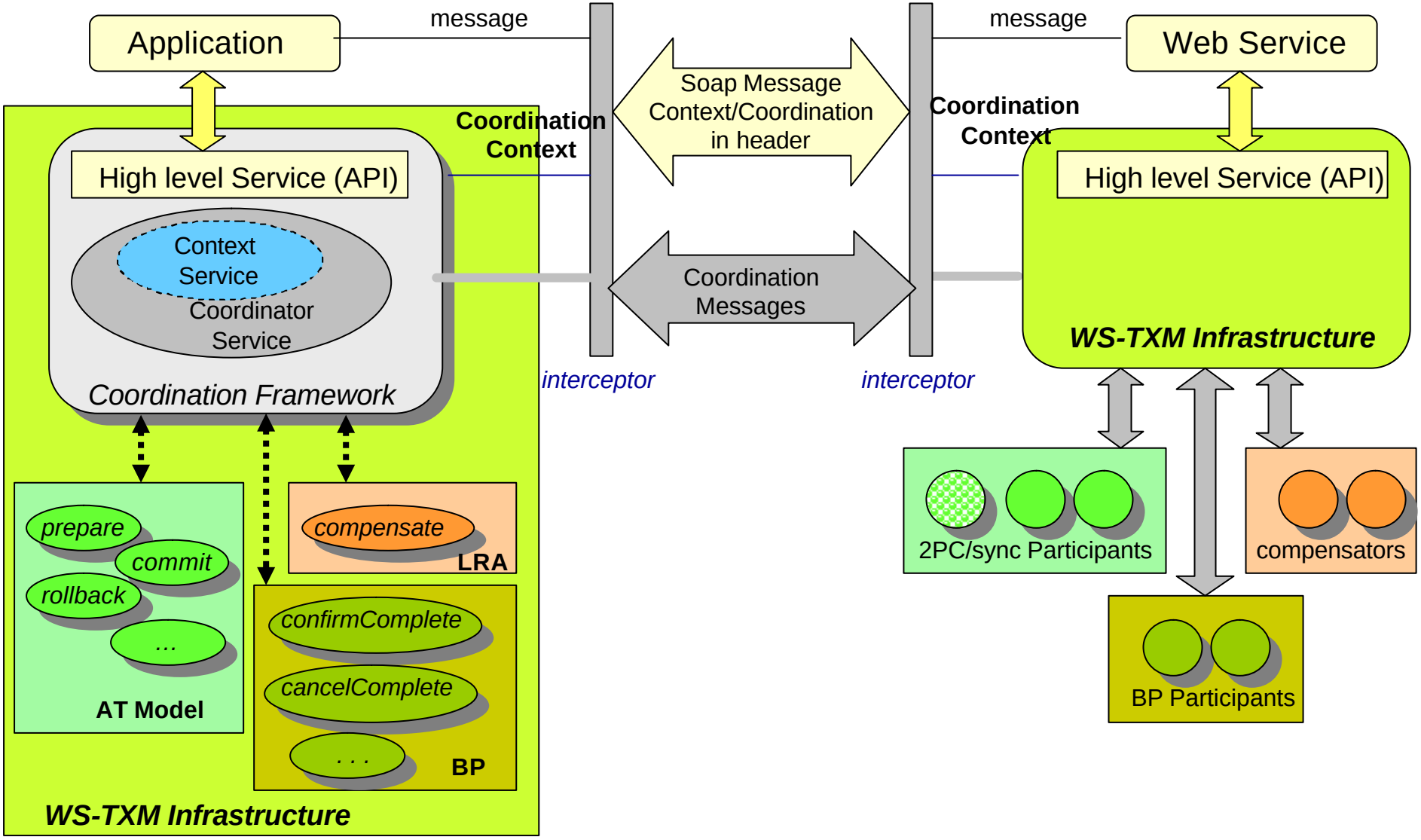

ACID Transaction (AT)

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- Coordination-type URI
  - *http://www.webservicestransactions.org/wsdl/wstxm/tx-acid/2003/03*
- Traditional *ACID transaction* with two sub-protocols (different URIs)
  - Two-phase commit
    - *http://www.webservicestransactions.org/wsdl/wsTXM/tx-acid/2pc/2003/03*
  - Synchronizations
    - *http://www.webservicestransactions.org/wsdl/wsTXM/tx-acid/sync/2003/03*
- Interoperability across different vendor implementations
  - *removeParticipant* illegal
    - wrongState returned by coordinator
  - *coordinate* cannot be used
    - Bind the scope of activity to the scope of transaction

Model (AT)

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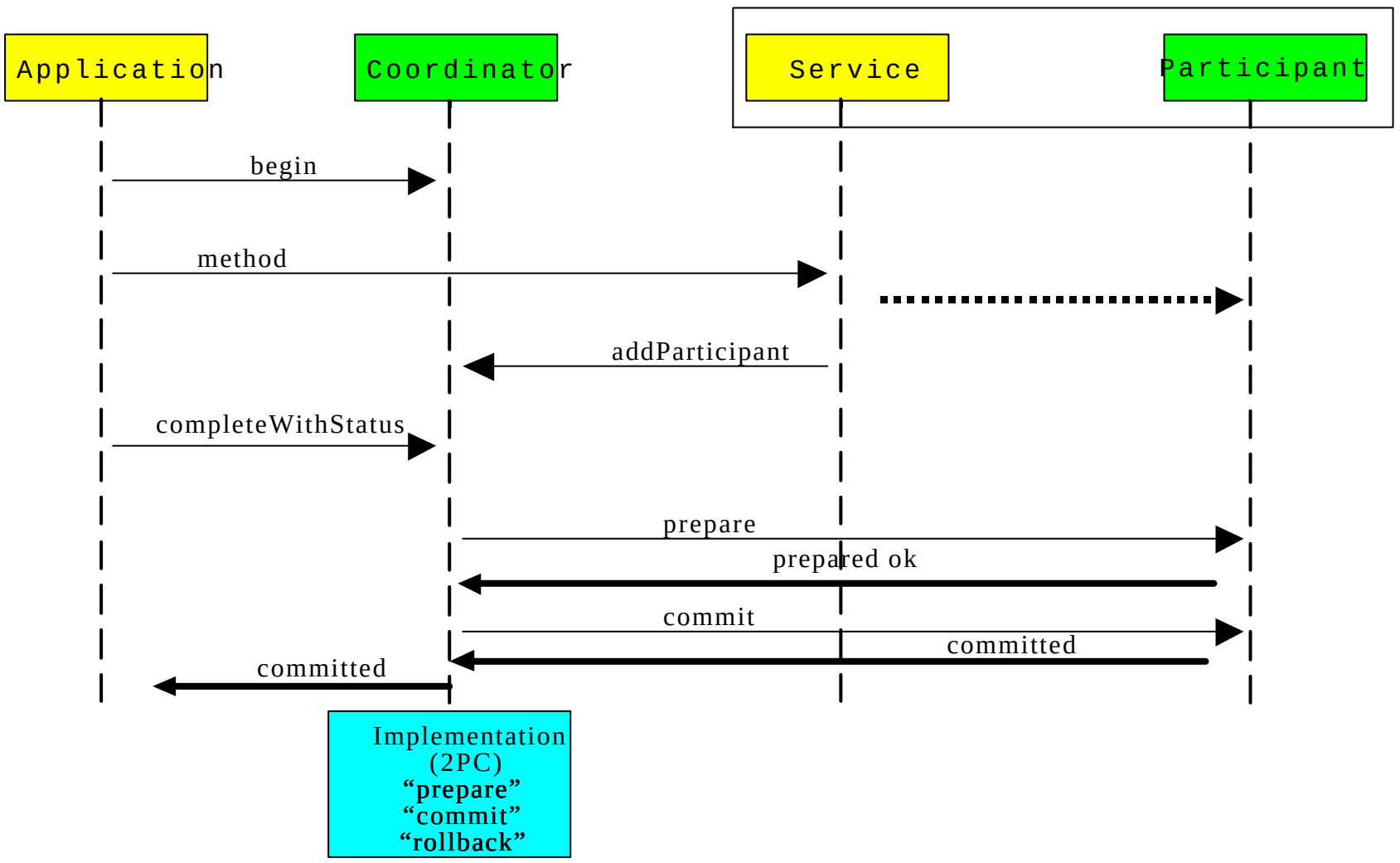
- ACID semantics explicitly required
- Presumed rollback
- One-phase optimization
- Read-only optimization
- Heuristics

Example (AT)


Application
Coordinator
Service
Participant
begin
method
addParticipant
completeWithStatus
prepare
prepared ok
commit
committed
committed
Implementation
(2PC)
“prepare”
“commit”
“rollback”

2PC protocol messages (AT)

- Usual for two-phase commit
  - prepare
    - voteReadonly, voteCommit, voteRollback
    - And heuristics
  - commit
    - Heuristics
  - rollback
    - Heuristics

Synchronization messages (AT)

- beforeCompletion
  - Runs before two-phase commit begins
- afterCompletion
  - Runs after two-phase protocol

Long running action model (LRA)

- Protocol URI
  - http://www.webservicestransactions.org /wstxm/tx-lra/2003/03
- Specifically for long duration interactions
- ACID transactions are not appropriate
  - Can’t lock resources for the duration
  - No assumed trust relationships
- Compensation actions used
  - Forward work to return the business state to consistency
    - E.g., credit your credit card and give you back interest payments

Relationship to context and coordination

- Activity becomes the scope of business interactions
  - Travel agent, computer construction, etc.
- How services do work is not important
  - Back-end implementation choice
- If work can be compensated then compensation is bound to the activity
  - Non-atomic behaviour
- Activities can be nested

Activities and compensators

- Each activity is a unit of compensatable work
- Work performed must remain compensatable for duration of activity
  - TimeLimit qualifier
- Nested activities imply nested compensators
  - Could be different compensator from child to parent

Travel agent example

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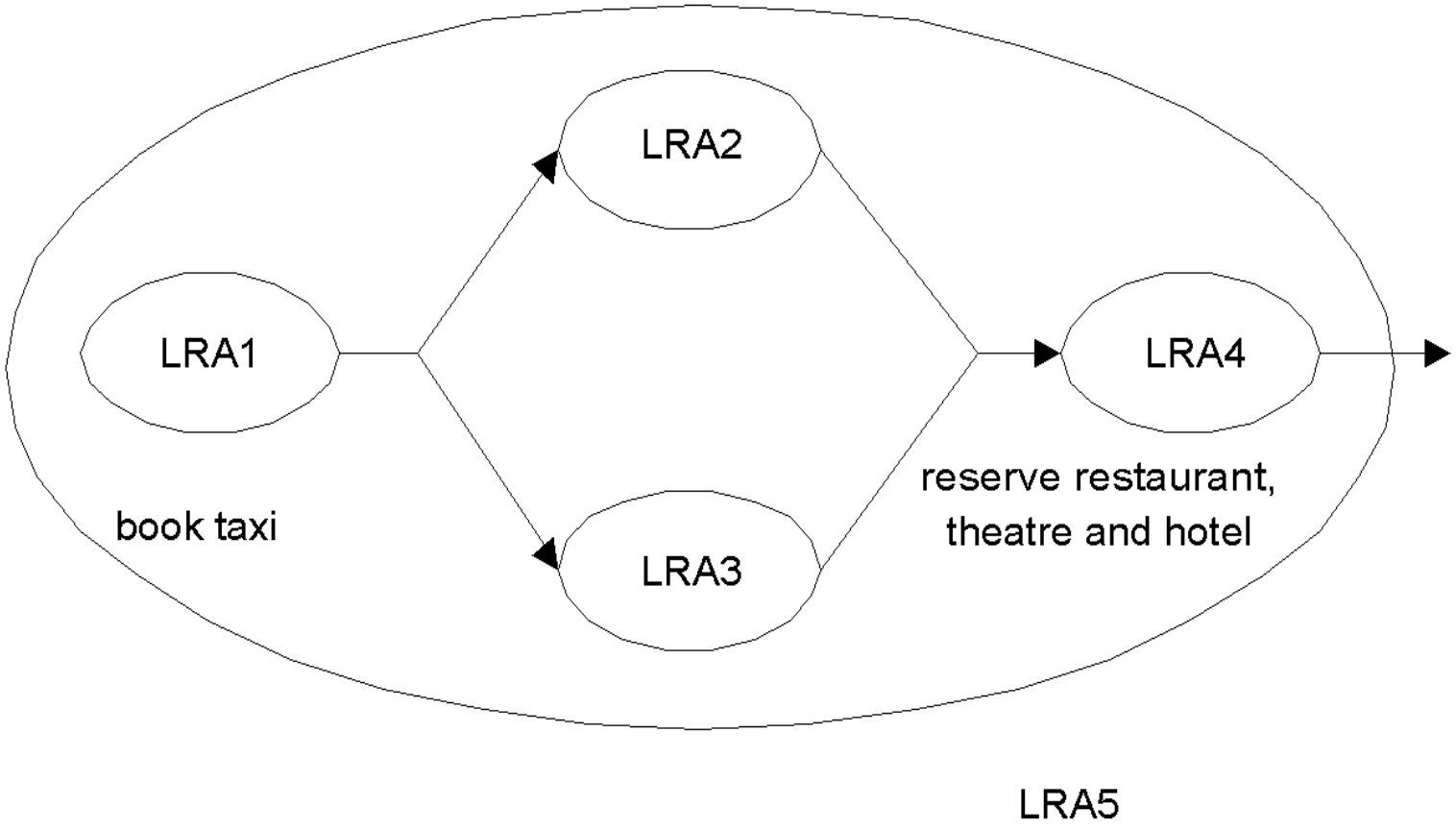

Context


```
<xs:element name="context">
  <xs:complexType>
    <xs:complexContent>
      <xs:extension base="wstxm:ContextType">
        <xs:sequence>
          <xs:element name="lra-id" type="xs:anyURI"/>
          <xs:element name="coordinator-hierarchy">
            <xs:complexType>
              <xs:sequence>
                <xs:element name="coordinator-location" type="xs:anyURI" minOccurs="0"
                  maxOccurs="unbounded"/>
              </xs:sequence>
            </xs:complexType>
          </xs:element>
        </xs:sequence>
      </xs:extension>
    </xs:complexContent>
  </xs:complexType>
</xs:element>
```

To compensate or not?

- Some services may not be able to compensate
- The user defines whether or not this is important
  - MustUnderstand
- Must be an explicit choice
  - Adverse consequences otherwise

Compensators

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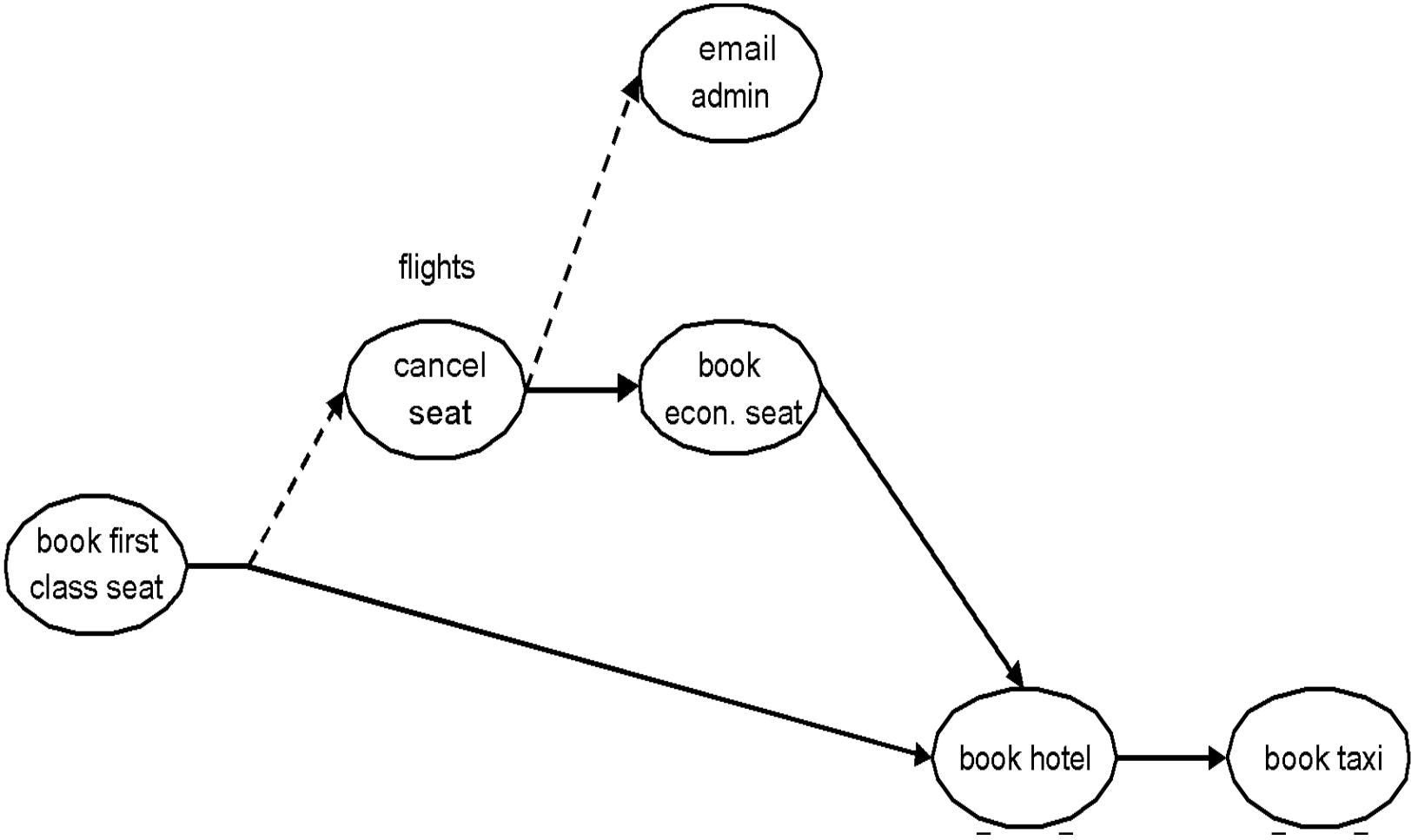
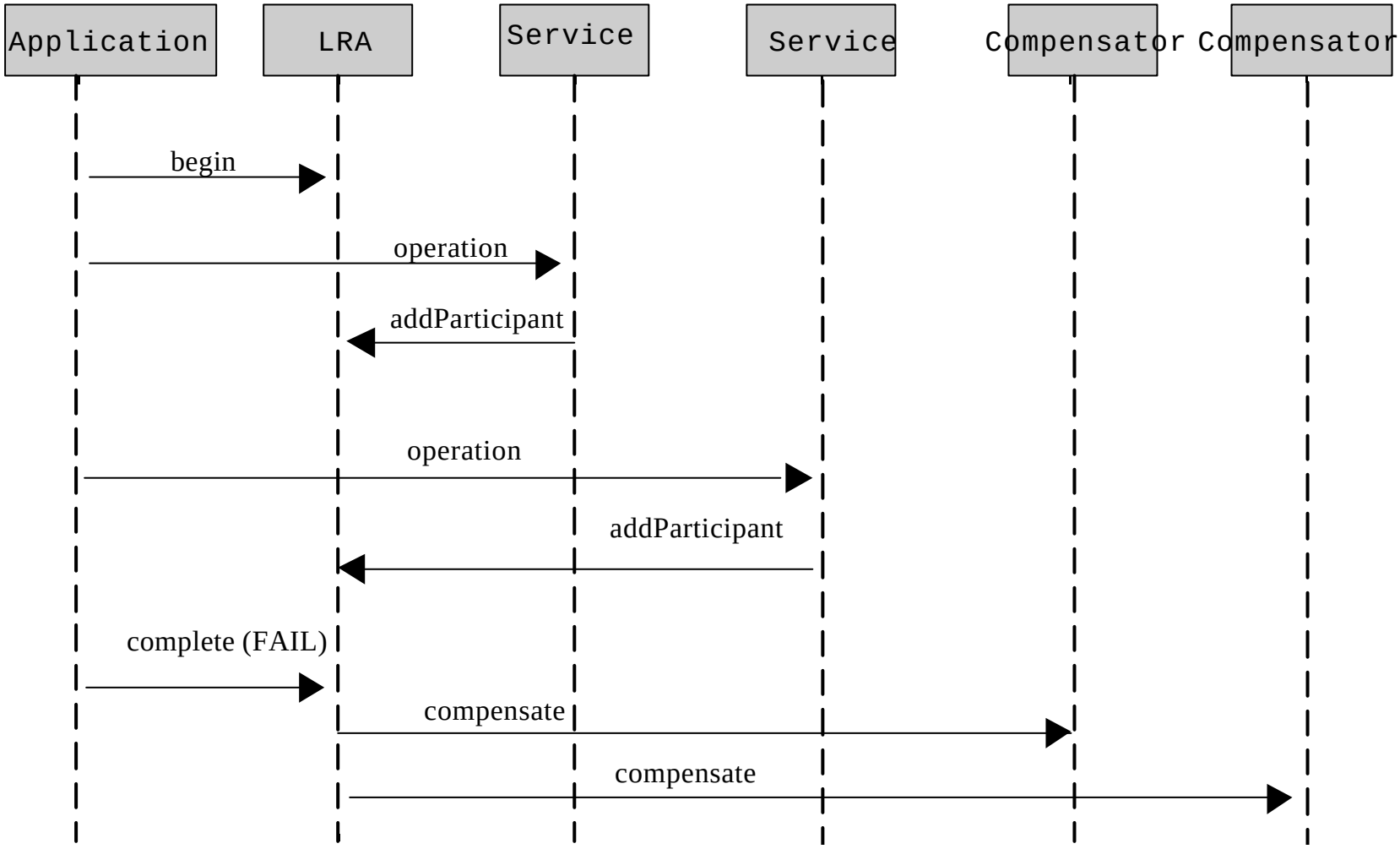


Example


Application
LRA
Service
Service
Compensator
Compensator
begin
operation
addParticipant
operation
addParticipant
complete (FAIL)
compensate
compensate

Concurrent LRAs

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- Activities can be concurrent
  - Therefore, LRAs can be too
- Allows selection of work within overall activity
  - E.g., choosing the cheapest flight

Selection of work

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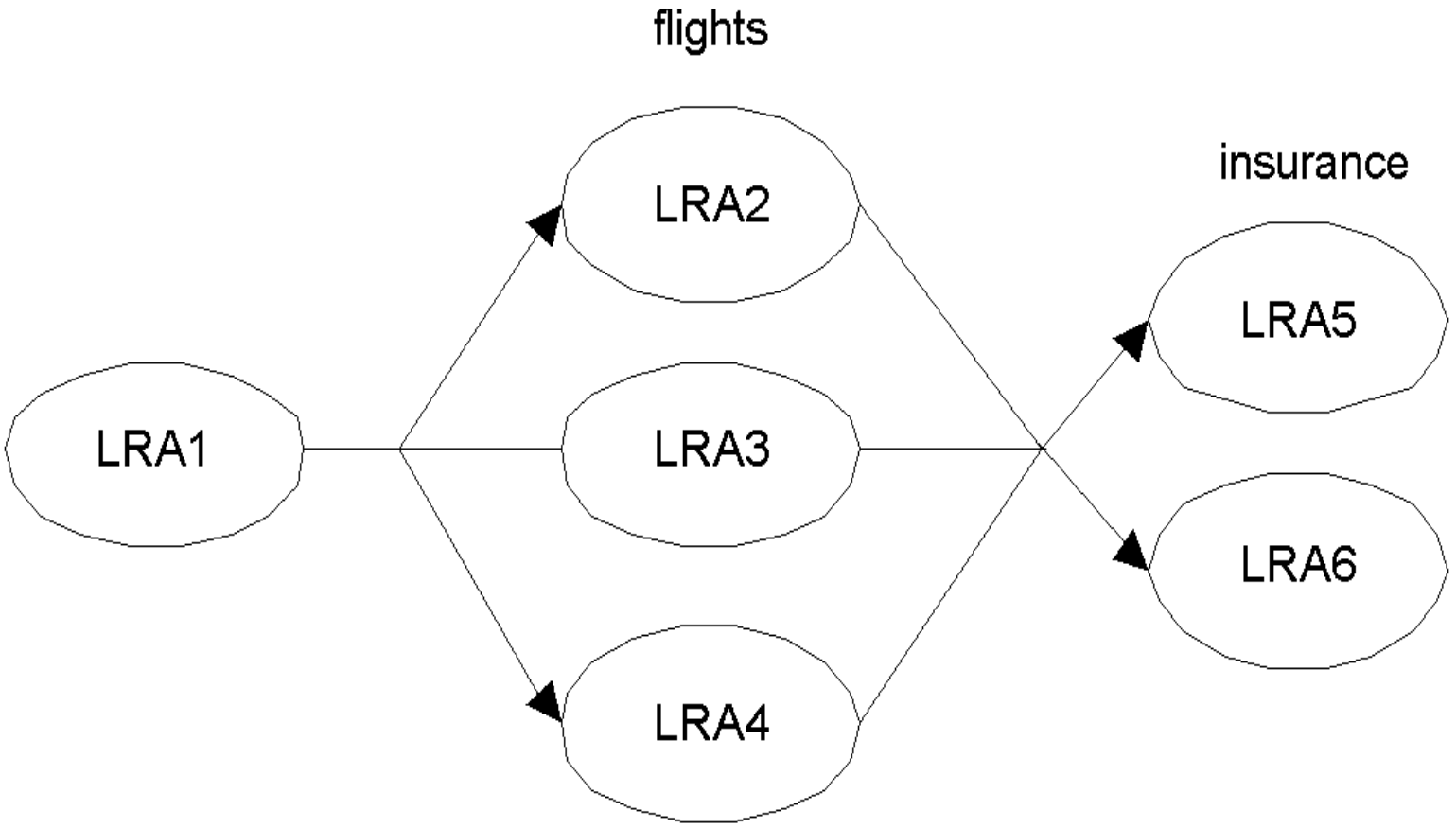

Business process model

- Aimed at *long running* interactions that span different domains *and* models
  - Workflow
  - Messaging
  - Traditional ACID transactions
- Federated systems that can't/won't expose back-end implementations

Domains

- All parties reside within *business domains*
  - Recursive structure is allowed
  - May represent a different transaction model
- Business process is split into *business tasks*
  - Execute within domains
  - Compensatable units of work
    - Forward compensation during activity is allowed
      - Keep business process making forward progress

Travel agent

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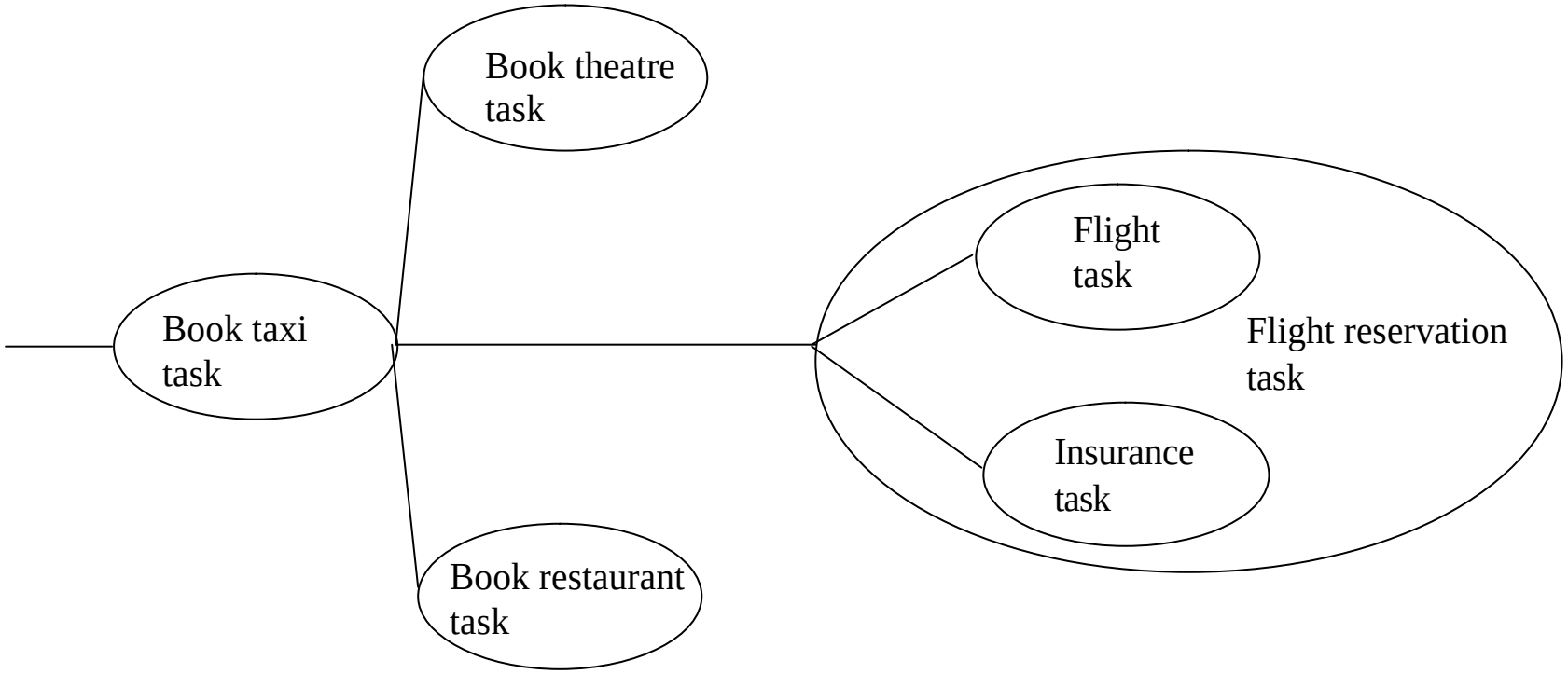
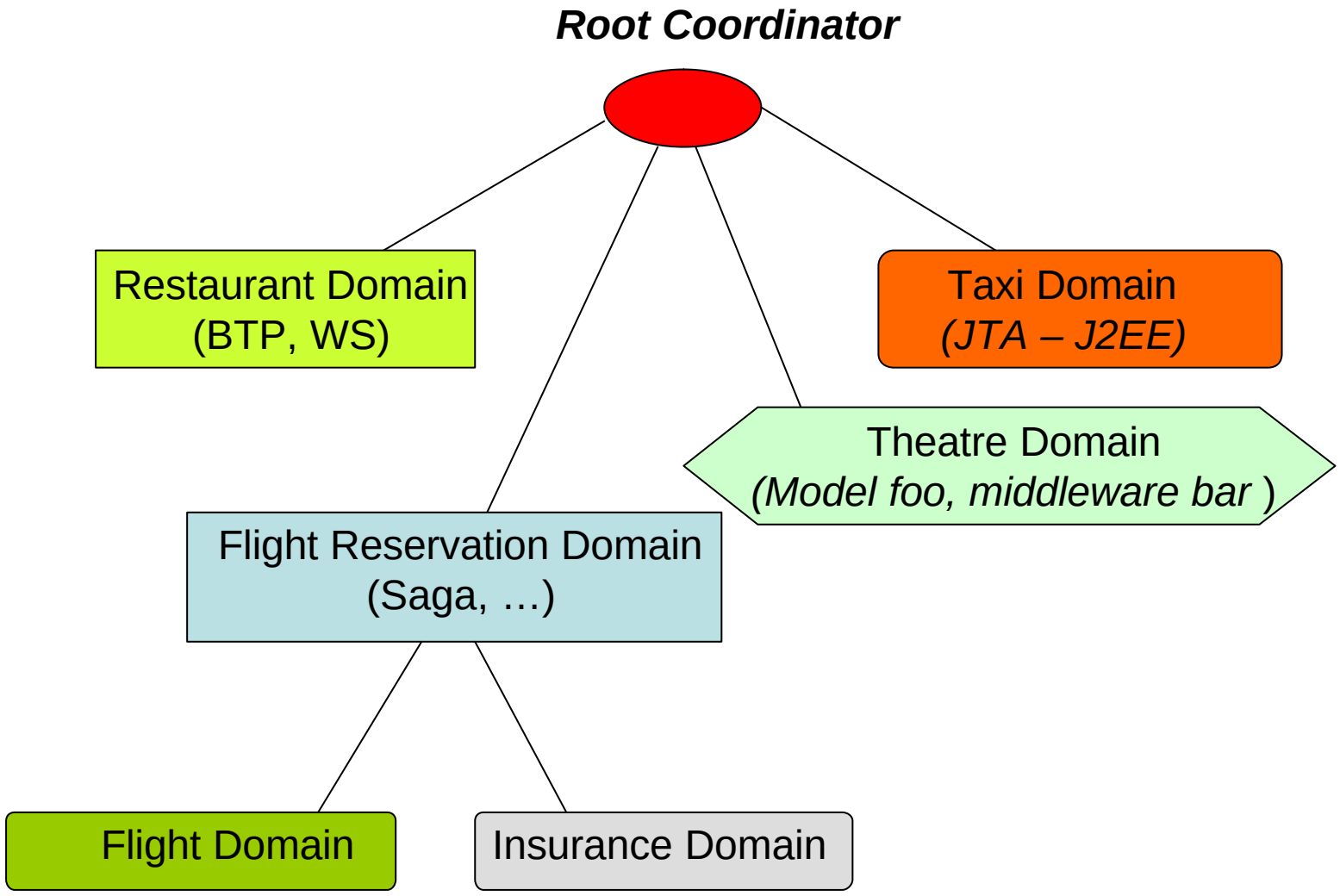


Business Process interposition



Model

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- Supports synchronous and asynchronous interactions
  - Users can submit work and call back later
  - Or interact synchronously (traditionally)
- Business Process manager
- Optimistic rather than pessimistic
  - Assumes failures are rare and can be handled offline if necessary

How does it work?

- Each domain is exposed as a subordinate coordinator
  - Responsible for mapping incoming BP requests to domain specific protocol
- Protocol messages
  - checkpoint, confirm, cancel, restart, workStatus

checkpoint/restart

- Application driven
  - E.g., via *coordinate* message
- Checkpoints are created across the domains
  - Uniquely identified
- Domains can then roll back to specific checkpoint

workstatus

- Domain calls back to coordinator to inform it of final status
- Or application can enquire
  - WorkCancelled
  - WorkCompleted
  - WorkProcessing

confirm/cancel

- BP termination protocol messages
- Map to success/failure of activity
- Because long-running, heuristics may occur
  - Mixed responses from domains
  - Sufficient information to allow administrative handling

Business Process Entities

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