WS-AtomicTransaction

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Introduction

• Coordinate agreement with ACID semantics
  – Atomic, Consistent, Isolated, Durable

• Tried and trusted model
  – Simple application model
  – Synchronized state changes
  – Correctness in the face of failures
  – Widespread adoption
  – Proven protocols
Model Assumptions

• Transactions are short lived
  – Resources isolated (locked) for duration
• Coordinator availability
  – Connected and responsive
  – Timely failure recovery
• Participants trust that the above are true
But why…?

• Web services are “for the internet”
  – B2B communication
  – Separate trust domains
  – Why WS-AT?

• Two reasons
  – Interoperability
    • Heterogeneous systems
  – Ubiquity
    • Vision of WS-* scale down
Core Scenarios

• Some services require ACID properties
  - Tight coordination of mission critical state
• Use with service-based resource managers
  – Example: Queue service
• Use within datacenter
  – Controlled environment
• Use with virtual datacenter
  – Between close partners
  – Contractual QOS
Protocol

- Defines WS-Coordination Coordination Type
- Activities are transactions
  - CreateCoordinationContext
    - Create transaction
    - Join transaction as subordinate
  - Register
    - Create subordinate enlistment
- Three coordination protocols
  - Completion
  - Durable 2PC
  - Volatile 2PC
- Simple message patterns
  - One-way messages
  - Correlation using WS-Addressing
- Full state machines for 2PC
The Actors

• Completion Initiator (I)
  – Signals coordinator to complete a transaction
    • Can request commit or rollback

• Coordinator (C)
  – Responsible for coordinating a single outcome
  – Drives 2PC with participants
    • Phase 1: Ensure all participants are prepared
    • Phase 2: Notify participants of outcome

• Participants (P)
  – Can vote to abort
  – Can vote “prepared to commit”
    • Must honor coordinator’s commit decision
WS-C and WS-AT

Application level

Service Requestor

Initiator

SOAP

UDDI/WSDL

XML Messages

Service Provider

Application Service

Response

Request

[application context]

Infrastructure level

WS-Coordination

WS-AT

WS-BA

Security

WS-AT

Security

Coordination Messages

[execution context]

SOAP

SOAP
Completion Protocol

Initiator (I) → Coordinator (C)
- Committed
- Aborted

Coordinator:
- Active
- Completing
- Committed
- Ended

Actions:
- Rollback
- Commit
- Aborting
- Aborted

Initiation:
- Coordinator generated
- Initiator generated
2PC Protocol

Prepared
ReadOnly
Aborted
Committed
Replay

Prepare
Rollback
Commit

Active
Preparing
Prepared
Committing
Committed
Ended

Rollback
Abort

Coordinator generated
Participant generated
Volatile versus Durable 2PC

• Two variants of 2PC protocol
  – One for volatile resources (e.g., cache)
  – One for durable resources (e.g., database)

• Phase 1 has sub-phases
  A) Prepare all volatile participants
     • This can cause more durable participant registrations
  B) Prepare all durable participants
WS-Addressing

• Specification uses WS-Addressing
  – Important for interoperability
• Different message classifications
  – Request messages
  – Reply messages
  – Notification messages
  – Fault messages
Commit message
Committed message
Policy assertions

- **Transaction flow assertion**
  - `<wsat:ATAssertion wsp:optional="true"/>
  - Operation Policy Subject
  - Used by applications to indicate willingness to accept incoming transactions
  - Wire format of serialized transaction is `<wscoor:CoordinationContext>` header

- **Atomic service assertion**
  - `<wsat:ATAlwaysCapability />`
  - Operation Policy Subject
  - Used by applications to indicate that a requester’s message will be processed transactionally
Resources

• WS-AtomicTransaction

• Web services whitepapers, specs, workshops
  – http://msdn.microsoft.com/webservices/
  – http://www.arjuna.com/library/
State tables (per participant)

<table>
<thead>
<tr>
<th>Inbound Events</th>
<th>States</th>
<th>Preparing</th>
<th>Prepared</th>
<th>PreparedSuccess</th>
<th>Committing</th>
<th>Aborting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register</td>
<td>None</td>
<td>Send RegisterResponse Active</td>
<td>Durable: Invalid State Aborting Volatile: Send Register Response Active</td>
<td>N/A</td>
<td>Invalid State PreparedSuccess</td>
<td>Invalid State Committing</td>
</tr>
<tr>
<td>Prepared</td>
<td>Durable: Send Rollback Volatile: Invalid State None</td>
<td>Invalid State Aborting</td>
<td>Record Vote Preparing</td>
<td>N/A</td>
<td>Ignore PreparedSuccess</td>
<td>Resend Commit Committing</td>
</tr>
<tr>
<td>ReadOnly</td>
<td>Ignore None</td>
<td>Forget Active</td>
<td>Forget Preparing</td>
<td>N/A</td>
<td>Invalid State PreparedSuccess</td>
<td>Invalid State Committing</td>
</tr>
<tr>
<td>Aborted</td>
<td>Ignore None</td>
<td>Forget Aborting</td>
<td>Forget Aborting</td>
<td>N/A</td>
<td>Invalid State PreparedSuccess</td>
<td>Invalid State Committing</td>
</tr>
<tr>
<td>Committed</td>
<td>Ignore None</td>
<td>Invalid State Aborting</td>
<td>Invalid State Aborting</td>
<td>N/A</td>
<td>Invalid State PreparedSuccess</td>
<td>Forget Committing</td>
</tr>
<tr>
<td>Replay</td>
<td>Durable: Send Rollback Volatile: Invalid State None</td>
<td>Send Rollback Aborting</td>
<td>Send Rollback Aborting</td>
<td>N/A</td>
<td>Ignore PreparedSuccess</td>
<td>Send Commit Committing</td>
</tr>
</tbody>
</table>
## Atomic Transaction 2PC protocol (Participant View)

<table>
<thead>
<tr>
<th>Inbound Events</th>
<th>States</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Register Response</td>
<td>Register Subordinate</td>
</tr>
<tr>
<td></td>
<td>Active</td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepare</td>
<td>Send Aborted</td>
</tr>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Commit</td>
<td>Send Committed</td>
</tr>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Rollback</td>
<td>Send Aborted</td>
</tr>
<tr>
<td></td>
<td>None</td>
</tr>
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<td></td>
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</tbody>
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Workshops

• March 2004 for feedback workshop
• January 2005 for interoperability workshop
• Several public endpoints, including …
  – http://mssoapinterop.org/ws/
Testing scenarios

- Explicitly tested WS-AT and WS-BA
  - Implicitly tested WS-C
- Many different test cases
  - Both for coordinator and participants
  - Included failures
General flow

Implementation A

InitiatorApp (IA)
CoordinatorProtocolService (CS)

Implementation B

ParticipantProtocolService (PS)
ParticipantApp (PA)

tns:Request()

wscoor:RegisterRequest()
wscoor:RegisterResponse()

tns:Response()

wsat:Protocol()
## Interoperability results

<table>
<thead>
<tr>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
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<tbody>
<tr>
<td><img src="image" alt="Interoperability results" /></td>
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