Today: Middleware and Distributed Objects

- Case study: EJBs (Enterprise Java Beans)
- Case study: CORBA

Distributed Objects

- Figure 10-1. Common organization of a remote object with client-side proxy.
Distributed Objects vs. RPC

RPC: Remote Procedure Call
- Provides argument marshalling / unmarshalling
- Server handles invocation

Distributed Objects
- Remote methods on remote objects
- RPC + distributed object references

Distributed object operation:
- Server side: create object, register it (register with what?) (always in this order?)
- Client side: get object reference (from where?), invoke method

Distributed Objects through History

A brief and incomplete history of commercially used RPC and distributed object systems

The vision
- a Grand Distributed System

The reality
- Client/Server
Naming: Object References

CORBA object reference

- Interoperable object reference: language-independent techniques for referring to objects

Object references and Naming

- First versions of CORBA used **opaque** object references
  - How do you locate the object? Via a location service.
  - What is the interface to the location service?
  - How do you invoke the location service?

- Java (and CORBA 3.0) use **transparent** object references
  - Can be decoded at the client
  - Java reference can encode all information (e.g. code) needed to invoke an object.
Binding

- Static vs. Dynamic binding
  - What is the difference?
  - Advantages of static binding?
  - Of dynamic binding?

- What state is involved in client binding?
  - What happens if the client crashes?
  - The server?

Example: Enterprise Java Beans

- Figure 10-2. General architecture of an EJB server.
Parts of an EJB

- **Home interface:**
  - Object creation, deletion
  - Location of persistent objects (entity beans)
  - Object identifier is class-managed

- **Remote interface**
  - “business logic”
  - i.e. the object itself

- **Terminology differences**
  - Client/server -> web applications

Four Types of EJBs

- Stateless session beans
- Stateful session beans
- Entity beans
- Message-driven beans
Overview of CORBA

- Common Object Request Broker Architecture
  - Specification of a distributed middleware
  - Specs drawn up by Object Management Group (OMG)
  - http://www.omg.org
- Goal: Interoperability with distributed applications on various platforms

CORBA Overview

- Object request broker (ORB)
  - Core of the middleware platform
  - Handles communication between objects and clients
  - Handles distribution and heterogeneity issues
  - May be implemented as libraries
- Facilities: composition of CORBA services
Object Model

- Objects & services specified using an Interface Definition language (IDL)
  - Used to specify interface of objects and/or services
- ORB: run-time system that handles object-client communication
- Dynamic invocation interface: allows object invocation at run-time
  - Generic `invoke` operation: takes object reference as input
  - Interface repository stores all interface definitions

CORBA Services

- Collection service: group objects into lists, queues,..
- Query service: use query language to query for service(s)
- Concurrency control service: locking services
- Event service: interrupt upon a specific event
- Many more…

- Q: Do CORBA objects have a corresponding class?
## Corba Services

<table>
<thead>
<tr>
<th>Service</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection</td>
<td>Facilities for grouping objects into lists, queue, sets, etc.</td>
</tr>
<tr>
<td>Query</td>
<td>Facilities for querying collections of objects in a declarative manner</td>
</tr>
<tr>
<td>Concurrency</td>
<td>Facilities to allow concurrent access to shared objects</td>
</tr>
<tr>
<td>Transaction</td>
<td>Flat and nested transactions on method calls over multiple objects</td>
</tr>
<tr>
<td>Event</td>
<td>Facilities for asynchronous communication through events</td>
</tr>
<tr>
<td>Notification</td>
<td>Advanced facilities for event-based asynchronous communication</td>
</tr>
<tr>
<td>Externalization</td>
<td>Facilities for marshaling and unmarshaling of objects</td>
</tr>
<tr>
<td>Life cycle</td>
<td>Facilities for creation, deletion, copying, and moving of objects</td>
</tr>
<tr>
<td>Licensing</td>
<td>Facilities for attaching a license to an object</td>
</tr>
<tr>
<td>Naming</td>
<td>Facilities for systemwide name of objects</td>
</tr>
<tr>
<td>Property</td>
<td>Facilities for associating (attribute, value) pairs with objects</td>
</tr>
<tr>
<td>Trading</td>
<td>Facilities to publish and find the services on object has to offer</td>
</tr>
<tr>
<td>Persistence</td>
<td>Facilities for persistently storing objects</td>
</tr>
<tr>
<td>Relationship</td>
<td>Facilities for expressing relationships between objects</td>
</tr>
<tr>
<td>Security</td>
<td>Mechanisms for secure channels, authorization, and auditing</td>
</tr>
<tr>
<td>Time</td>
<td>Provides the current time within specified error margins</td>
</tr>
</tbody>
</table>

## Object Invocation Models

<table>
<thead>
<tr>
<th>Request type</th>
<th>Failure semantics</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronous</td>
<td>At-most-once</td>
<td>Caller blocks until a response is returned or an exception is raised</td>
</tr>
<tr>
<td>One-way</td>
<td>Best effort delivery</td>
<td>Caller continues immediately without waiting for any response from the server</td>
</tr>
<tr>
<td>Deferred synchronous</td>
<td>At-most-once</td>
<td>Caller continues immediately and can later block until response is delivered</td>
</tr>
</tbody>
</table>

- Invocation models supported in CORBA.
  - Original model was RMI/RPC-like
  - Current CORBA versions support additional semantics
What went wrong with CORBA?

- Where is it now?
  - Inside EJB, I think
  - Gnome desktop
  - Embedded CORBA?

- Design by committee
  - Competing commercial interests
  - … time to go teach….

Event and Notification Services (1)

- The logical organization of suppliers and consumers of events, following the push-style model.
Event and Notification Services (2)

- The pull-style model for event delivery in CORBA.

Messaging: Async. Method Invocation

- CORBA's callback model for asynchronous method invocation.
Messaging (2)

• CORBA's polling model for asynchronous method invocation.

Portable Object Adaptor (1)

• POA: Wrappers for server-side code (makes code look like objects)
  a) The POA supports multiple servants.
  b) The POA supports a single servant.
Portable Object Adaptor (2)

```
My_servant *my_object;     // Declare a reference to a C++ object
CORBA::Objectid_var oid;  // Declare a CORBA identifier
my_object = new MyServant; // Create a new C++ object
oid = poa->activate_object(my_object); // Register C++ object as CORBA OBJECT
```

- Changing a C++ object into a CORBA object.

An Example Architecture

- An example architecture of a fault-tolerant CORBA system.
Replication Frameworks (1)

- Invocations to objects are intercepted at three different points:
- At the client side just before the invocation is passed to the stub.
- Inside the client’s stub, where the interception forms part of the replication algorithm.
- At the server side, just before the object is about to be invoked.

Replication Frameworks (2)

- Figure 10-16. A general framework for separating replication algorithms from objects in an EJB environment.
Replicated Invocations (1)

Figure 10-17. The problem of replicated method invocations.

Replicated Invocations (2)

Figure 10-18. (a) Forwarding an invocation request from a replicated object to another replicated object.
Replicated Invocations (3)

- Figure 10-18. (b) Returning a reply from one replicated object to another.