Enterprise Applications

- Examples
  - E-Bay
  - Amazon
  - Testudo
- What distinguishes them from other applications? What do they have in common? How can building them be made easier?
Features of Enterprise Apps

• Persistent data
  – Databases store essential business information
  – Need to worry about integrity, transactions

• Many interfaces
  – Web clients
  – Web services
  – Legacy applications

More Features

• Distribution and scaling
  – Demands on successful app grow over time
  – Should be possible to scale up
    • Multiple machines
    • Geographic distribution

• Resiliency to failure
  – One machine failure cannot shut down app
  – …app failure = $$$ lost
Enterprise Apps and Java

- Extensive support enterprise apps in Java
  - EJB, JSP, JDBC, BMP, CMP, JDO, WSDP, …

- Focus of this lecture: How do we build these systems?

Multi-tier Architecture
Key Properties of a Database

• A transaction is a set of consistent changes to a database
  – Ex: balance := balance - $100; dispense $100
• ACID transactions
  – Atomicity -- actions all occur or none occur
  – Consistency -- respect domain invariants
  – Isolation -- no interference with other actions
  – Durability -- persistent even if system fails

Database Possibilities

• ACID transactions are well-understood
  – Hard to implement correctly
  – …but good implementations available
• Relational databases are the standard
  • Scale up to very large data sets
  • Handle transactions and failure well
• But don’t interact that well with Java
  • SQL for queries
  • Awkward to construct, use correctly
Persistent Objects

- Represent persistent state with objects
  - Reads and writes become actions on the database
  - Largely transparent to object client

```java
Foo foo = ...
foo.data = … // database write
… = foo.data; // database read
```

Enterprise Java Beans (EJB)

- A system for persistent objects
  - …and many other things
- A bean is a server-side class that encapsulates application business logic
  - AccountInfo, Order, ShoppingCart, …
- Beans live in containers
  - Containers often implement generic functionality such as security, persistence, etc
Kinds of Beans

- Entity beans (now Java Persistence API)
  - Lightweight persistence domain objects.
- Entities often represent tables in a relational database, and each entity instance corresponds to a row in that table.
- The persistent state of an entity is represented either through persistent fields or persistent properties.
- These fields or properties use object/relational mapping annotations to map the entities and entity relationships to the relational data in the underlying data store.

Kinds of Beans (cont’d)

- Session beans
  - Represent a single client in the App server
  - Stateful
    - Tracks conversational state across method calls
    - Useful when session involves multiple complex steps
      - Ex: Client logs in to app, so need to track client id
    - Not durable: Go away after timeout or crash
  - Stateless
    - Handles one, isolated request from client
      - Ex: Send an e-mail confirmation, verify credit card
    - Can be shared across multiple clients
Kinds of Beans (cont’d)

• Message-driven beans
  – Listens for asynchronous messages (observer)

• …we won’t talk about these

Assumptions

• We’ll assume all calls to EJBs are remote
  – In practice, people use entity beans locally

• Clients never talk directly to a bean
  – Instead they go through stubs (proxy pattern)
  – Enforces security, transactions

• Today’s examples use older EJB style.
  Newer style hides much of the details
Beans Provide Two Interfaces

- **Remote or component interface**
  - Actions for business logic

- **Home interface**
  - Factory design pattern (create, destroy, find)
You Provide

• Component and home interface
  – How clients interact with bean
• Bean implementation class
  – Does not implement component/home interface
  – Client cannot directly access bean; must use container
• Deployment descriptor (in XML)
  – Tells container how to manage the bean

Container Provides

• Home implementation and stubs
• Component implementation and stubs
• Deployment of beans with features specified by deployment descriptor
  – Reflection used to find bean methods
    • Ex: Will look for deposit() method in EJB
Example: Hello World

- Step 1: The Bean class

```java
import javax.ejb.*;
public class AdviceBean implements SessionBean {

    private String[] adviceStrings = {"test", "test1", "test2"};

    public String getMessage() {
        System.out.println("in get advice");
        int random = (int) (Math.random() * adviceStrings.length);
        return adviceStrings[random];
    }

    public void ejbCreate() { System.out.println("ejb create"); }
}
```

Example from Head-First EJB

Example: Hello World

- Step 2: The interfaces

```java
import javax.ejb.*;
import java.rmi.RemoteException;

public interface Advice extends EJBObject {
    public String getMessage() throws RemoteException;
}

public interface AdviceHome extends EJBHome {
    public Advice create() throws CreateException, RemoteException;
}
```
Example: Hello World

• Step 3: The deployment descriptor

```xml
<?xml version="1.0" encoding="UTF-8"?>
<ejb-jar xmlns="http://java.sun.com/xml/ns/j2ee" version="2.1"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://java.sun.com/xml/ns/j2ee
http://java.sun.com/xml/ns/j2ee/ejb-jar_2_1.xsd">
  <display-name>Ejb1</display-name>
  <enterprise-beans>
    <session>
      <ejb-name>Advisor</ejb-name>
      <home>AdviceHome</home>
      <remote>Advice</remote>
      <ejb-class>AdviceBean</ejb-class>
      <session-type>Stateless</session-type>
      <transaction-type>Bean</transaction-type>
      <security-identity><use-caller-identity/></security-identity>
    </session>
  </enterprise-beans>
</ejb-jar>
```

Example: Hello World

• Step 4: Put it together

  – Package up all files into ejb-jar.jar
    - `jar cMf ejb-jar.jar Advice.class AdviceBean.class
      AdviceHome.class META-INF/ejb-jar.xml`
  
  – Deploy it
    - `cp ejb-jar.jar ~/java/jboss/server/default/deploy`
Example: Hello World

- Step 5a: Write the client

```java
public class AdviceClient {

    public static void main(String[] args) throws Exception {
        new AdviceClient().go();
    }

    public void go() throws Exception {
        Context ic = new InitialContext();
        Object o = ic.lookup("Advisor");

        AdviceHome home = (AdviceHome)
            PortableRemoteObject.narrow(o, AdviceHome.class);

        Advice advisor = home.create();
        System.out.println(advisor.getMessage());
    }
}
```

Example: Hello World

- Step 5b: Specify some extra properties

File jndi.properties:

```
java.naming.factory.initial=org.jnp.interfaces.NamingContextFactory
java.naming.provider.url=localhost:1099
java.naming.factory.url.pkgs=org.jboss.naming:org.jnp.interfaces
```

- Step 6: Run it
  - java AdviceClient
XML

Alphabet Soup

XSL, JAX-RPC, SOAP, XPath, DTD, XML, HTML, W3C, XSLT, CSS, XPointer, JAXM, JAXB, UDDI, SGML, XLink, ebXML, JAXB, JAXP, XML, SAX, JAXR, JAXM, JAXB, UDDI, SGML, XLink, ebXML, JAXB, JAXP, XML, SAX, JAXR
**Background**

- Applications often represent data in proprietary internal formats
  - E.g., Word, Excel, Quicken

- Difficult to share data
  - Between different software versions
  - Between different applications
  - Between different platforms

**eXtensible Markup Language**

- Goal: Provide a universal external format for application data

- Siméon and Wadler:
  - “[T]he essence of XML is this: the problem it solves is not hard, and it does not solve the problem well.”
You’re probably familiar with HTML:

```html
<html>
<head><title>CMSC 433</title></head>
<body><p>Hello, world!</p></body>
</html>
```

Pretty good for display, but limited as a file format

---

Not extensible
- Fixed set of tags like `<a>`, `<p>`, `<h4>`, etc.

No semantic structure
- Divides document into headings, paragraphs, tables etc.
- ...which doesn’t match a lot of file formats
  - E.g., spreadsheets
XML Example

```xml
<?xml version="1.0"?>
<reading>
  <book>
    <title>Thinking in Java</title>
    <author>Bruce Eckel</author>
  </book>
  <book>
    <title>Program Development in Java</title>
    <author>Barbara Liskov</author>
    <authorwith>John Guttag</authorwith>
  </book>
</reading>
```

Notation

```xml
<Item optional="1">
  <Tag>
    Name
  </Tag>
  <Attribute>
    Name
  </Attribute>
  <Attribute>
    Value
  </Attribute>
</Item>
```

Attributes

• Tags can have attributes
  
  \[
  \text{<book binding="hardcover">...</book>}
  \]

• Attributes don’t add any expressiveness
  – Could also have
    
    \[
    \text{<hardcoverbook>...</hardcoverbook>}
    \]
  – But attrs sometimes make things easier

Syntactic Notes

• Begin with magic xml incantation
• Must have root element
• All elements need a closing tag
  – Shorthand:
    • Instead of \text{<Foo attr="value"/>}<\text{Foo}>
    • Can write \text{<Foo attr="value"/>}
• Elements must be properly nested
XML = Tree Structured Data

```
reading
title
Thinking in Java
author
Bruce Eckel

book

author
Barbara Liskov

Program Development in Java

book

authorwith
John Guttag
```

Parsing XML

- XML files are just text files
  - Can write with your favorite text editor
- Easy to parse XML into its tree structure
  - Can tell if a document is well-formed
  - But does it make sense?
    - Can’t have two <title>s in a <book>
    - An <author> outside of a <book> doesn’t make sense
  - Need to validate the document
Document Type Definition

- Defines a set of legal XML files
  ```xml
  <!ELEMENT reading (book*)>
  <!ELEMENT book (title, author, authorwith?)>
  <!ELEMENT title (#PCDATA)>
  <!ELEMENT author (#PCDATA)>
  <!ELEMENT authorwith (#PCDATA)>
  <!ATTLIST book binding CDATA "paperback">
  </<!ELEMENT reading (book*)>
  ```

- XML files can specify DTD
  ```xml
  <?xml version="1.0"?>
  <!DOCTYPE reading SYSTEM "reading.dtd">
  ```

XML Schema

- The replacement for DTDs
  ```xml
  <?xml version="1.0"?>
  <xsd:schema
    xmlns:xsd="http://www.w3.org/2001/XMLSchema"
    targetNamespace="http://www.cs.umd.edu"
    xmlns="http://www.cs.umd.edu">
    ... The tags we're defining are for this namespace
    <xsd:element name="reading">
    ... The default namespace for tags
  </xsd:schema>
  ```
XML Schema Example

```
<xsd:element name="reading">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="book" maxOccurs="unbounded">
        <xsd:complexType>
          <xsd:all>
            <xsd:element name="title" type="xsd:string"/>
            <xsd:element name="author" type="xsd:string"/>
            <xsd:element name="authorwith" type="xsd:string" minOccurs="0"/>
          </xsd:all>
        </xsd:complexType>
      </xsd:element>
    </xsd:sequence>
    <xsd:attribute name="binding" type="xsd:string" fixed="paperback"/>
  </xsd:complexType>
</xsd:element>
```

Advantages of Schemas

- Schemas are written in XML
  - So schemas can describe schemas

- Schemas have type information
  - Can introduce new named types

```
<xsd:simpleType name="ssnumber">
  <xsd:restriction base="xsd:string">
    <xsd:pattern value="\d{3}-\d{2}-\d{4}"/>
  </xsd:restriction>
</xsd:simpleType>
```

(Brill, CodeNotes for XML)
Design Goals of XML

1. XML shall be straightforwardly usable over the Internet.
2. XML shall support a wide variety of applications.
3. XML shall be compatible with SGML.
4. It shall be easy to write programs which process XML documents.
5. The number of optional features in XML is to be kept to the absolute minimum, ideally zero.

Design Goals of XML (cont’d)

6. XML documents should be human-legible and reasonably clear.
7. The XML design should be prepared quickly.
8. The design of XML shall be formal and concise.
9. XML documents shall be easy to create.
10. Terseness in XML markup is of minimal importance.