301AA - Advanced Programming

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***AP-07**: JavaBeans*

Overview

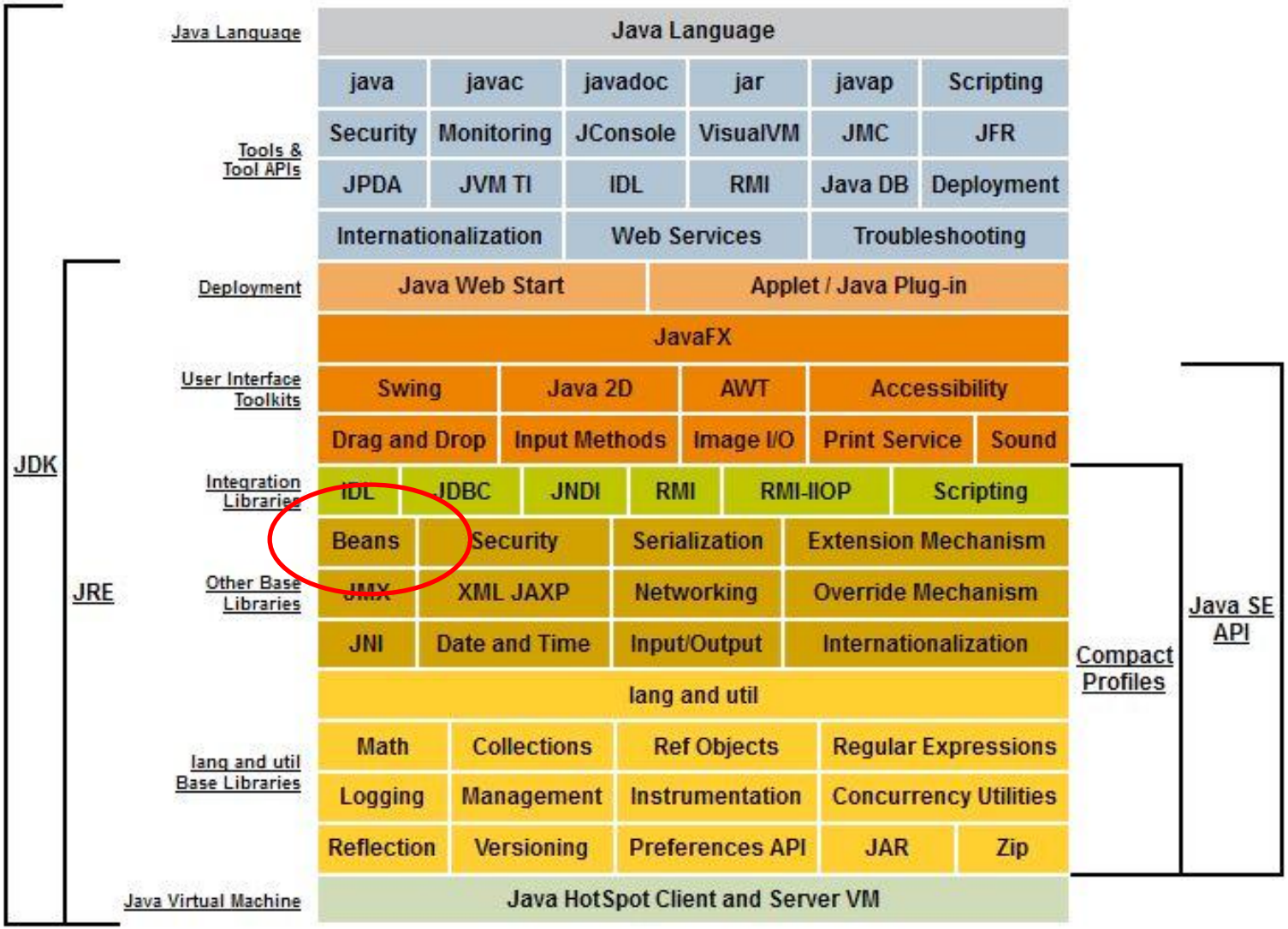
- Kinds of components in Java
- JavaBeans: design and deployment
  - Properties
    - Property design pattern
  - Events
    - Connection-oriented programming
    - Observer design pattern
  - Serialization
  - Jar
  - Introspection (InfoBeans)

➔ Chapter 14, sections 14.1, 14.3 and 14.5 of *Component Software: Beyond Object-Oriented Programming. C. Szyperski, D. Gruntz, S. Murer, Addison-Wesley, 2002*.

➔ The JavaBeans API Specification, sections 1, 2, 6, 7 and 8.

https://www.oracle.com/technetwork/java/javase/documentation/spec-136004.html

Components in Java SE (Standard Edition): Java Beans



Other Java Distributions

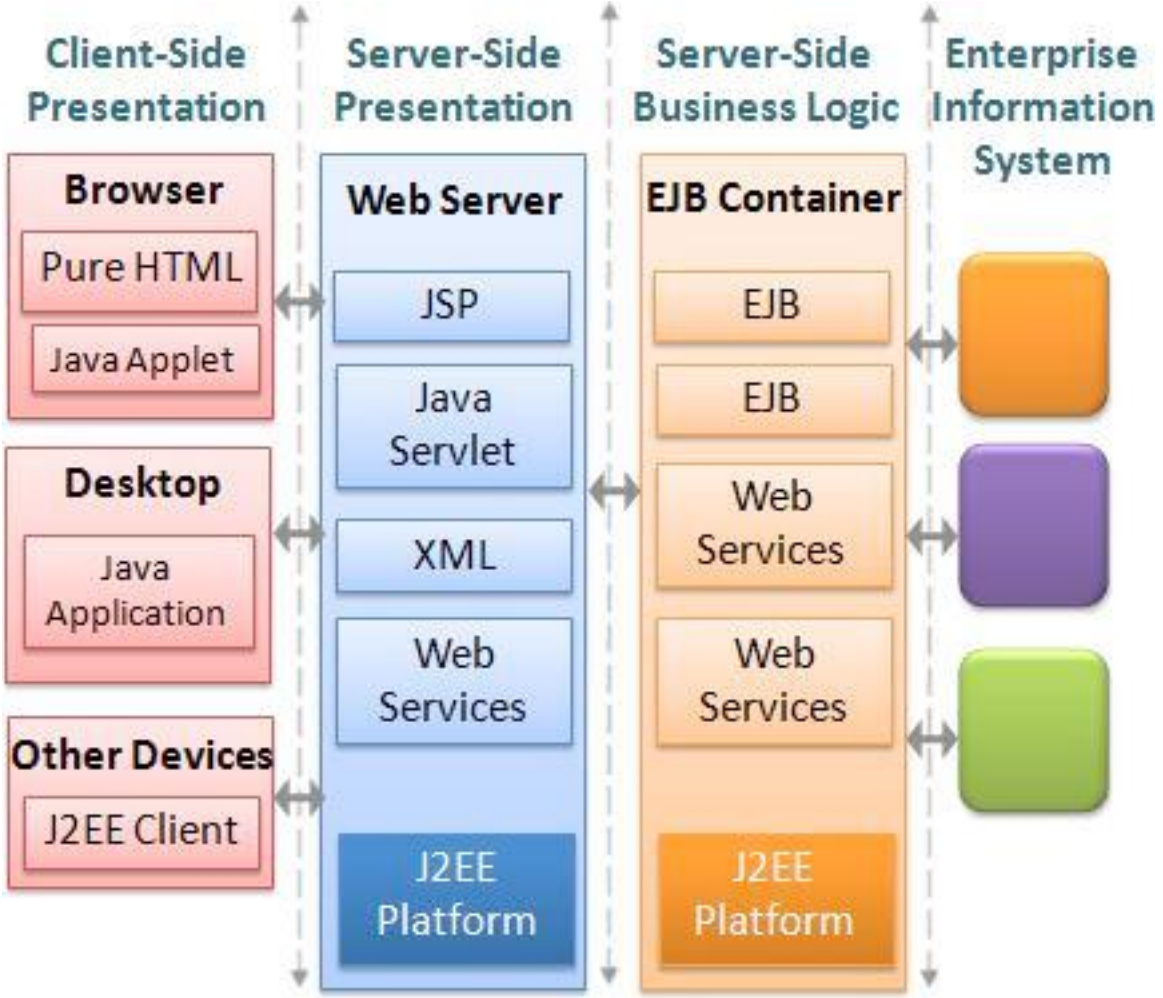
- Java/Jakarta EE (Enterprise Edition)
  - Suite of specifications for application servers
  - Around 20 implementations available
  - Reference implementation: Oracle Glassfish
- Java ME (Micro Edition)
  - embedded and mobile devices, e.g. micro-controllers, sensors, gateways, mobile phones, personal digital assistants (PDAs), TV set-top boxes, printers…

Components in Java EE (Enterprise Edition)

Client side
- JavaBeans
- Applets
- Application Components

Web server tier
- Servlets
- JSPs

Application tier:
- Stateless session EJB
- Stateful session EJB
- Entity EJB
- Message-driven EJB



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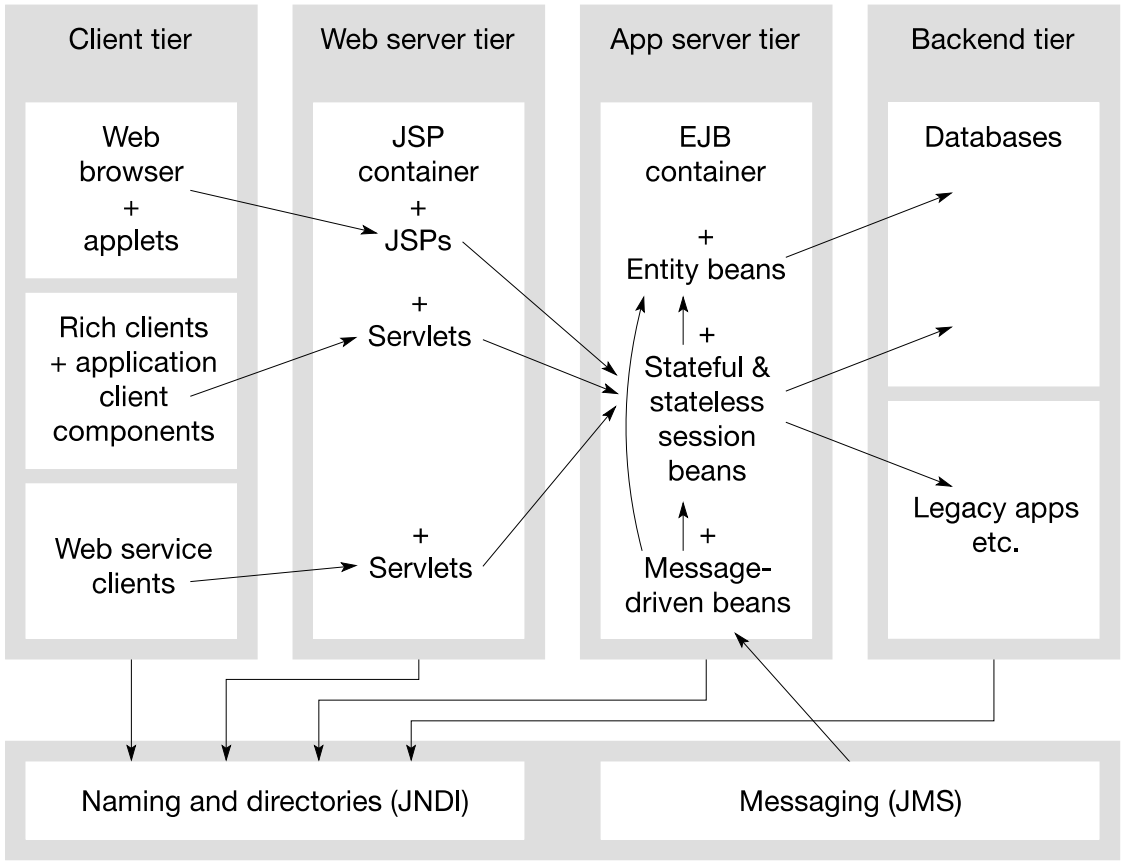


The JavaBeans API (1996)

Goal: to define a **software component model for Java**, allowing vendors to create and ship Java components that can be composed together into applications by end users.

Design goals:

- **Granularity**: from small (eg. a button in a GUI) to medium (eg. a spreadsheet as part of al larger document)
  - Similar to Microsoft's OLE Control or ActiveX APIs
- **Portability**: Ok in Java based application servers. Bridges defined to other component models (like OpenDoc, OLE/COM/ ActiveX)
- **Uniformity and Simplicity**: The API should be simple to be supported on different platforms. Strong support for small component, with reasonable defaults.

What are Java Beans?

"A Java Bean is a **reusable software component** that can be **manipulated visually** in a **builder tool**."

- **Sample tools:** builders for web pages, visual applications, GUI layout, server applications. Also document editors.
- A bean typically has a GUI representation, but not necessarily
  - Invisible beans
- Any Java class can be recognized as a bean in a tool provided that
  - It has a public default constructor (no arguments)
  - It implements the interface `java.io.Serializable`
  - It is in a **`jar`** file with *manifest file* containing

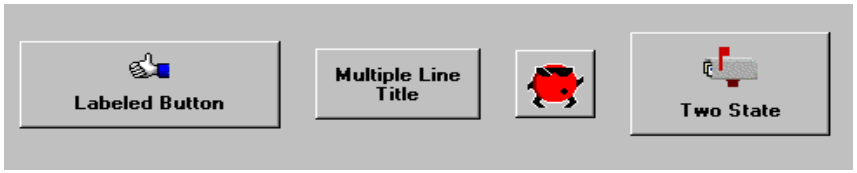
    `Java-Bean: True` (Really needed?)

JavaBeans as Software Components

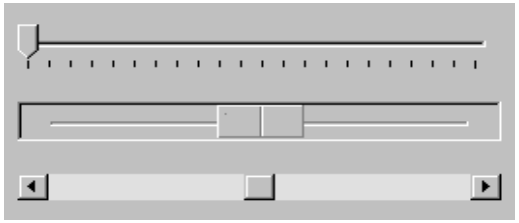
- Beans are binary building blocks (class files)
- Development vs. deployment (customization)
- Beans can be assembled to build a new bean or a new application, applet, … writing glue code to wire beans together
- Client side beans vs. beans for business logic process in MVC on server
- Beans on server are not visible

Sample Reusable Components

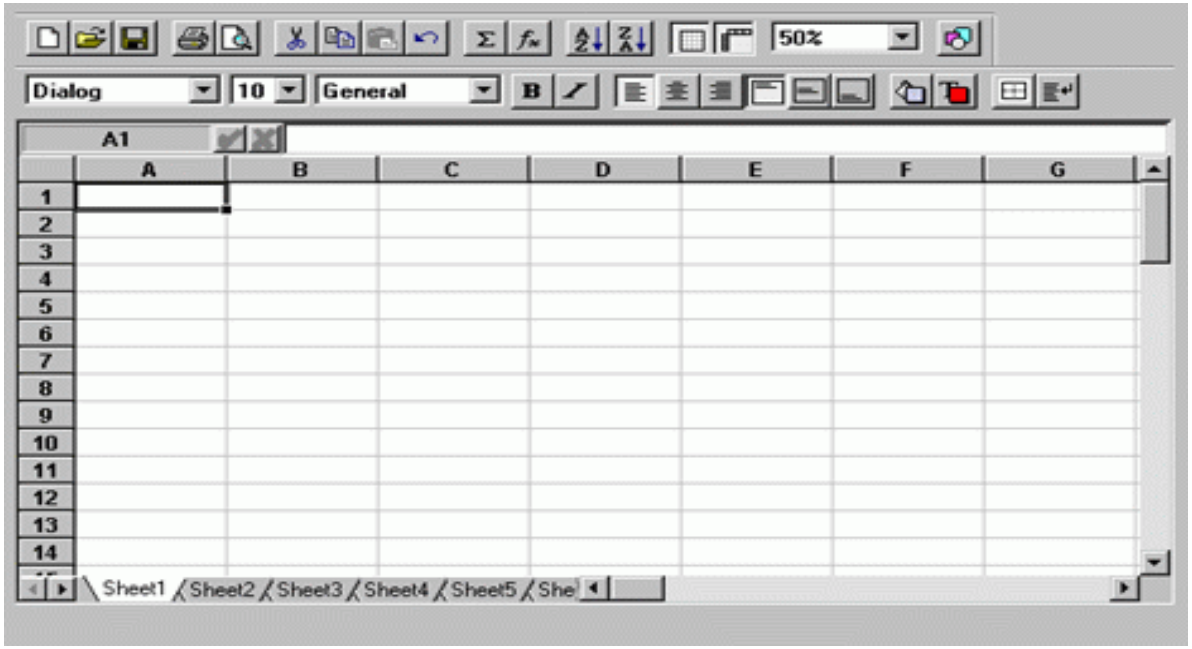
Button Beans



Slider Bean



An application constructed from Beans



JavaBeans common features

- Support for **properties**, both for customization and for programmatic use
- Support for **events**: simple communication metaphor that can be used to connect several beans
- Support for **customization**: in the builder the user can customize the appearance and behaviour of the bean
- Support for **persistence**: a bean can be customized in an application builder and then have its customized state saved away and reloaded later
- Support for **introspection**: a builder tool can analyze how the bean works

Emphasis on GUI, but textual programming also possible using the existing API

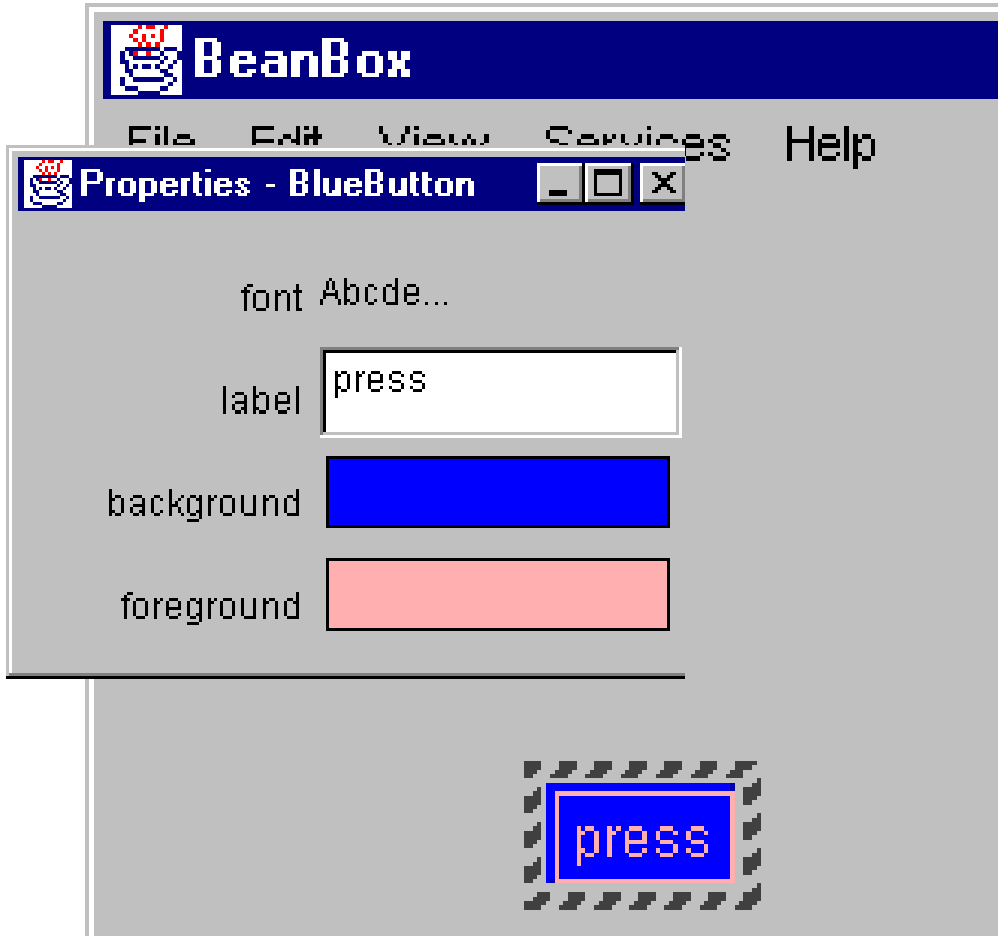
Design time vs. run-time

- A bean must be able to run in the *design environment* of a builder tool providing means to the user to customize aspect and behaviour
- At run-time there is less need for customization
- Possible solution: design-time information for customization is separated form run-time information, and not loaded at run-time
  - **<BeanName>BeanInfo.java class**

Simple Properties

- Discrete named attributes that can affect a bean instance's appearance or behaviour
- Property X (and its type) determined by public setter (setX) and /or getter (getX) methods
- Can be changed at design time (customization) or run-time (application logic)
- Example property: **background**

```
public java.awt.Color getBackground ();
public void setBackground (java.awt.Color color);
```



How can a builder identify the properties of a bean?

Introspection

- Process of analyzing a bean to determine the capability
- Allows application builder tool to present info about a component to software designers
- Implicit method: based on **reflection**, **naming conventions**, and **design patterns**
- Alternative: *<BeanName>BeanInfo* class to explicitly describe info about a bean for the builder tool

Using the BeanInfo class

With the BeanInfo class you can:

- Expose only those features you want to expose.
- Rely on BeanInfo to expose some Bean features while relying on low-level reflection to expose others.
- Associate an icon with the target Bean.
- Specify a **customizer** class.
- Segregate features into normal and expert categories.
- Provide a more descriptive display name, or additional information about a Bean feature.

Design Pattern for Simple Properties

- From pair of methods:

```
public <PropertyType> get<PropertyName>();
public void set<PropertyName>(<PropertyType> a);
```

infer existence of property **`propertyName`** of type **`PropertyType`**

- Example:

```
public java.awt.Color getBackground ();
public void setBackground (java.awt.Color color);
```

- If only the getter (setter) method is present then the property is read-only (write-only)

Pattern for Indexed Properties

- If a property is an array, setter/getter methods can take an index or the whole array

```
public java.awt.Color getSpectrum (int index);
public java.awt.Color[] getSpectrum ();
public void setSpectrum (int index, java.awt.Color color);
public void setSpectrum (java.awt.Color[] colors);
```

- From these methods, by introspection the builder infers the existence of property **spectrum** of type **java.awt.Color[]**

Bound and Constrained Property

- A ***bound property*** generates an event when the property is changed
- A ***constrained property*** can only change value if none of the registered observers "poses a veto"

➔ We discuss them after the event-based communication mechanism

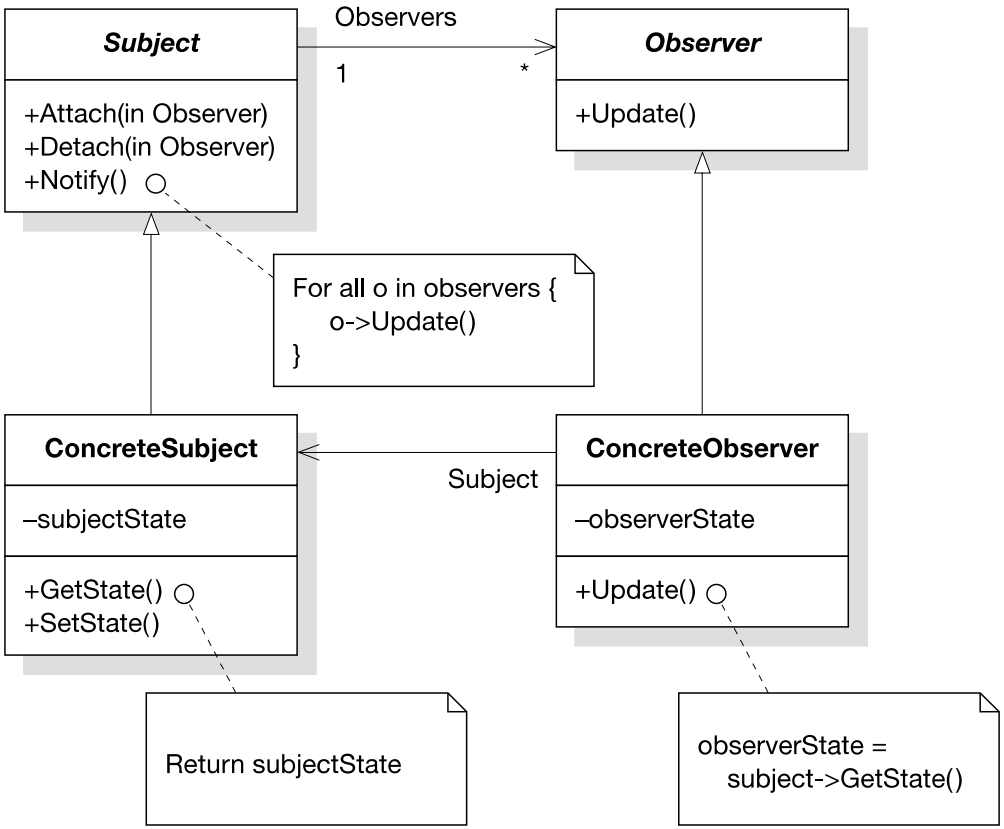
Connection-oriented programming

- Paradigm for gluing together components in a builder tool
- Based on the **Observer** design pattern
- Adequate for GUIs

Pattern: **Observer** (Behavioral) aka **Publish-Subscribe**

Name: Observer

Problem: Define a one-to-many dependency among objects so that when one object changes state, all of its dependents are notified and updated automatically.


Subject
Observers
1
*
Observer
+Attach(in Observer)
+Detach(in Observer)
+Notify()
+Update()
For all o in observers {
o->Update()
}
ConcreteSubject
Subject
ConcreteObserver
–subjectState
–observerState
+GetState()
+SetState()
+Update()
Return subjectState
observerState =
subject->GetState()

Events

- In Java the Observer pattern is based on Events and Event Listeners
- An **event** is an object created by an **event source** and propagated to the registered **event listeners**
- Multicast semantics by default: several possible listeners
- Unicast semantics (at most one listener) can be enforced by tagging the event source.

Design Pattern for Events

Based on methods for (un)registering listeners. From

```
public void add<EventListType>(<EventListType> a)
public void remove<EventListType>(<EventListType> a)
```

infer that the object is source of an event; the name is extracted from **`EventListType`**.

Example: from

```
public void addUserSleepsListener (UserSleepsListener l);
public void removeUserSleepsListener (UserSleepsListener l);
```

infers that the class generates a **UserSleeps** event

Unicast event sources

- Unicast sematics is assumed if the **add** method is declared to throw **`java.util.TooManyListenersException`**
- Example:

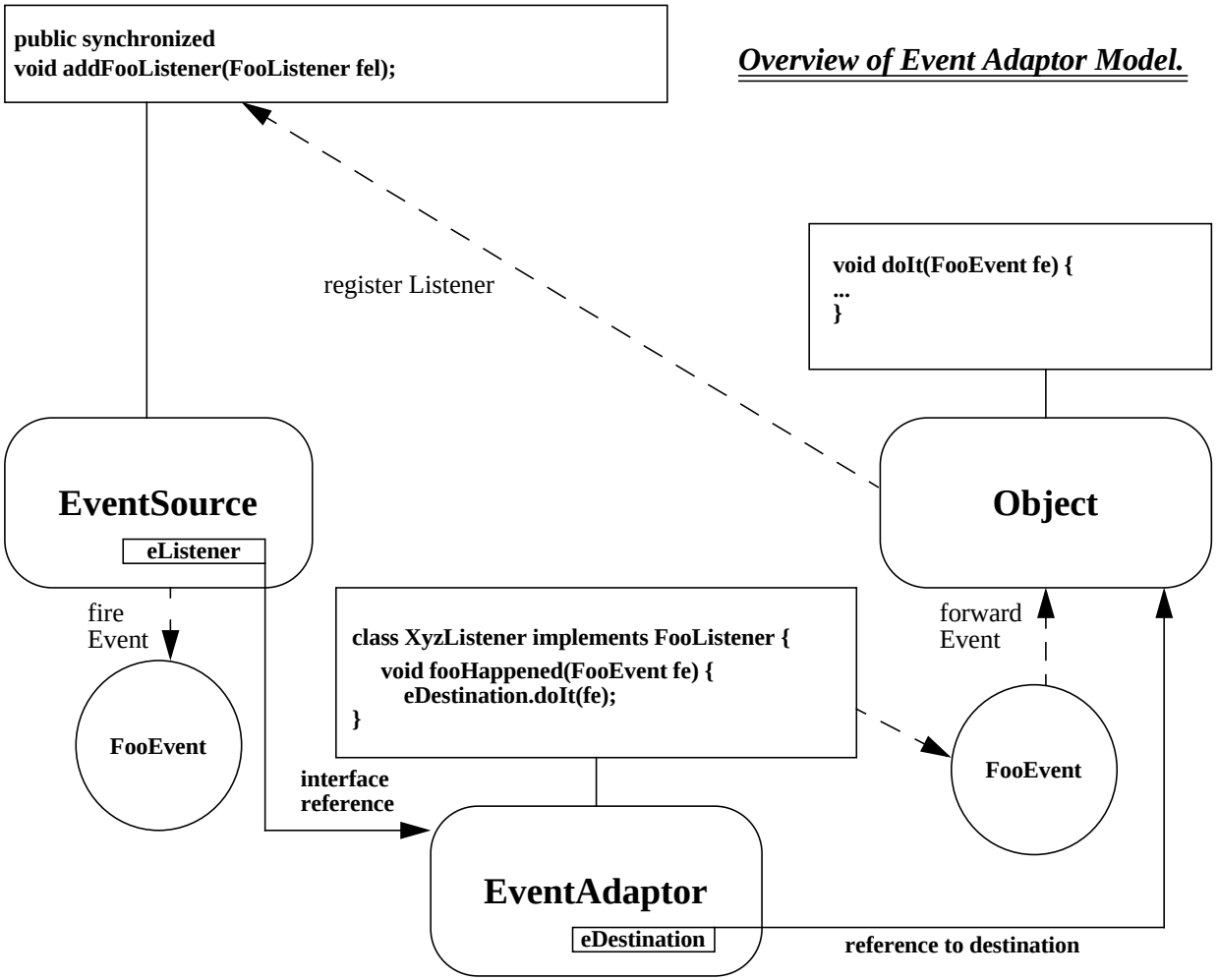
```
public void addJackListener(JackListener t)
throws java.util.TooManyListenersException;

public void removeJackListener(JackListener t);
```

defines a unicast event source for the "JackListener" interface.

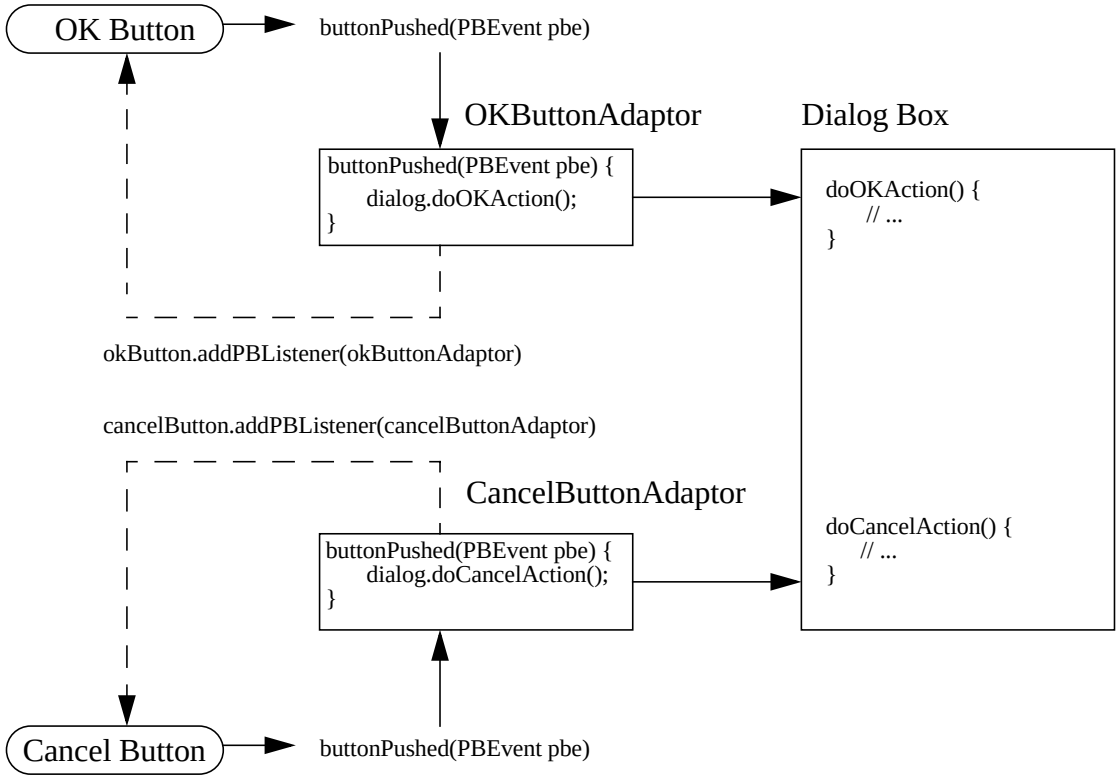
Event Adaptors

- Placed between the event source and a listener
- Is at the same time listener and source
- Examples of uses of adaptors:
  - Implementing an event queuing mechanism between sources and listeners.
  - Acting as a filter.
  - Demultiplexing multiple event sources onto a single event listener.
  - Acting as a generic “wiring manager” between sources and listeners.

Event Adaptors: general architecture



Event adaptors example: Demultiplexing multiple event sources



Back to Bound Properties

- Generate an event when the property is changed
- The event is of type **PropertyChangeEvent** and is sent to objects that previously registered an interest in receiving such notifications
- Bean with bound property: ***event source***
- Bean implementing listener: ***event target***
- Helper classes in the API to simplify implementation

Implement Bound Property in a Bean

1. Import **`java.beans`** package
2. Instantiate a **`PropertyChangeSupport`** helper object

```
private PropertyChangeSupport changes =
  new PropertyChangeSupport(this);
```

3. Implement methods to maintain the property change listener list:

```
public void
  addPropertyChangeListener(PropertyChangeListener l)
  { changes.addPropertyChangeListener(l);}
```

(also **`removePropertyChangeListener`** method is needed)

Implement Bound Property in a Bean (cont.)

4. Modify a property's setter method to fire a property change event when the property is changed.

```
public void setX(int newX){
    int oldx = x;
    x = newX;
    changes.firePropertyChange("x", oldX, newX);
}
```

Implement Bound Property Listener

1. Listener bean must implement the interface **`PropertyChangeListner`**

   ```
   public class MyLstnr implements
            PropertyChangeListener, Serializable
   ```

2. It must override the method

   ```
   public abstract void
      propertyChange(PropertyChangeevent evt)
   ```

3. Sample registration:

   ```
   Button button = new OurButton();
   MyLstnr lis = new MyLstnr();
   button.addPropertyChangeListener(lis);
   ```

Constrained Property

- It generates an event when an attempt is made to change its value
- The event type is **PropertyChangeEvent**
- The event is sent to objects that previously registered an interest in receiving such notification
- Those other objects have the ability to veto the proposed change by raising an exception
- This allows a bean to operate differently according to the runtime environment

Three Parts in Implementation of Constrained Property

1. Source bean containing one or more constrained properties

2. Listener objects that implement the **`VetoableChangeListener`** interface. These objects either accept or reject the proposed change. The change is rejected by raising a **PropertyVetoException**

3. **`PropertyChangeEvent`** object containing property name, old value, new value.

Implement Constrained Property in a Bean

The bean containing the constrained property must:

1. Import the **`java.beans`** package
2. Instantiate a **`VetoableChangeSupport`** object:

```
private VetoableChangeSupport vetos =
        new VetoableChangeSupport(this);
```

3. Implement methods to maintain the listener list:

```
public void
    addVetoableChangelistener(VetoableChangelistener l)
    {  vetos.addVetoableChangeListener(l);}
```

4. and similarly for **`removeVetoableChangelistener`**

Implement Constrained Property in a Bean (cont.)

5. Write a property's setter method to fire a property change event:

```
public void setX(int newX)
  {   int oldX = X;
      try{
          vetos.fireVetoableChange("X", oldX, newX);
          // if no veto there
          X = newX;
          // add here code to notify change, if needed
      } catch(PropertyVetoException e){
          // code to be executed if
          // change is rejected by somebody
      }
  }
```

Implementing Constrained Property Listeners

1. Implements the **`VetoableChangeListener`** interface which has an abstract method
   `void vetoChange(PropertyChangeEvent evt)`
2. Override this abstract method. This is the method that will be called by the source bean on each object in the listener list kept by the **`vetoableChangeSupport`** object
3. If the listener wants to forbid the change described in **`evt`**, it should raise a **PropertyVetoException**. Otherwise simply return.

Summary

- JavaBean is a platform-neutral component architecture for reusable software component
- It is a black box component to be used to build large component or application
- Property, method, event, introspector, customizer are parts of the JavaBean API