OBJECT ORIENTATION AND OBJECT PATTERNS

Design failures

- Rigidity
  - Hard to modify functionality without major re-work (e.g. fixed strings in menu items)
- Fragility
  - P(error) high after modification
- Immobility
  - Code hard to re-use on other projects (often due to coupling)
- Viscosity of design
  - Hard to modify code functionality and keep original design philosophy

Good design principles

- DRY
  - Don't Repeat Yourself
  - So
    - 1 version of (data, algorithm, document, image file, test plan)
    - Authoritative
    - Example for encryption algorithm use a code generator to generate javascript version from Java
  - Ok
    - To have cached copies, as long as they are generated from the original

Design principles

- Open Closed Principle (OCP) (Bertrand Meyer)
  - Definition
    - Open for extension
    - Closed from modification
  - In practise implemented using
    - Use of interface definitions (head, no body)
      - Dynamic polymorphism (run time type checking)
    - Use of generics
      - Static polymorphism (compile time checking)

Dynamic polymorphism

```
Interface Printable {
    public void doPrint();
}

Class Circle implements Printable {

Public void doPrint() {
    //
}
}

// If object is type Printable, doPrint implementation is determined at run time
```

Static polymorphism

- Generics/templates
  - One code base, but types can modify

```
public class Stack<E> {
        public <E> pop() {

        }
}

public class Main {
   public static void main(String argvs) {
      Stack <int> myStack; // type is fixed at compile time
   }
}
```

Liskov Substitution Principle (LSP)

Barbar Liskov

- Subclasses should be substitutable for their base classes
- Circle/(Ellipse) example
- Class Ellipes {
  - setFocus1(Point focus)
  - setFocus2(Point focus)
  - Point getFocus1()
  - Point getFocus2()
- }

LSP violation example

- Class Circle extends Ellipse {
  - setFocus1(Point center) {
    - super.setFocus1(center);
    - super.setFocus2(center);
  - }
  - setFocus2(Point center) {
    - super.setFocus1(center);
    - super.setFocus2(center);
  - }

LSP violation detection

```
public void (Ellipse e)
{
        Point a(-1,0);
        Point b(1,0);
        e.Focus1(a);
        e.Focus2(b);
        assert(e.GetFocus1() == a); // if e is type Circle
        assert(e.GetFocus2() == b);  // assertion will fail!!
}
```

Design by contract

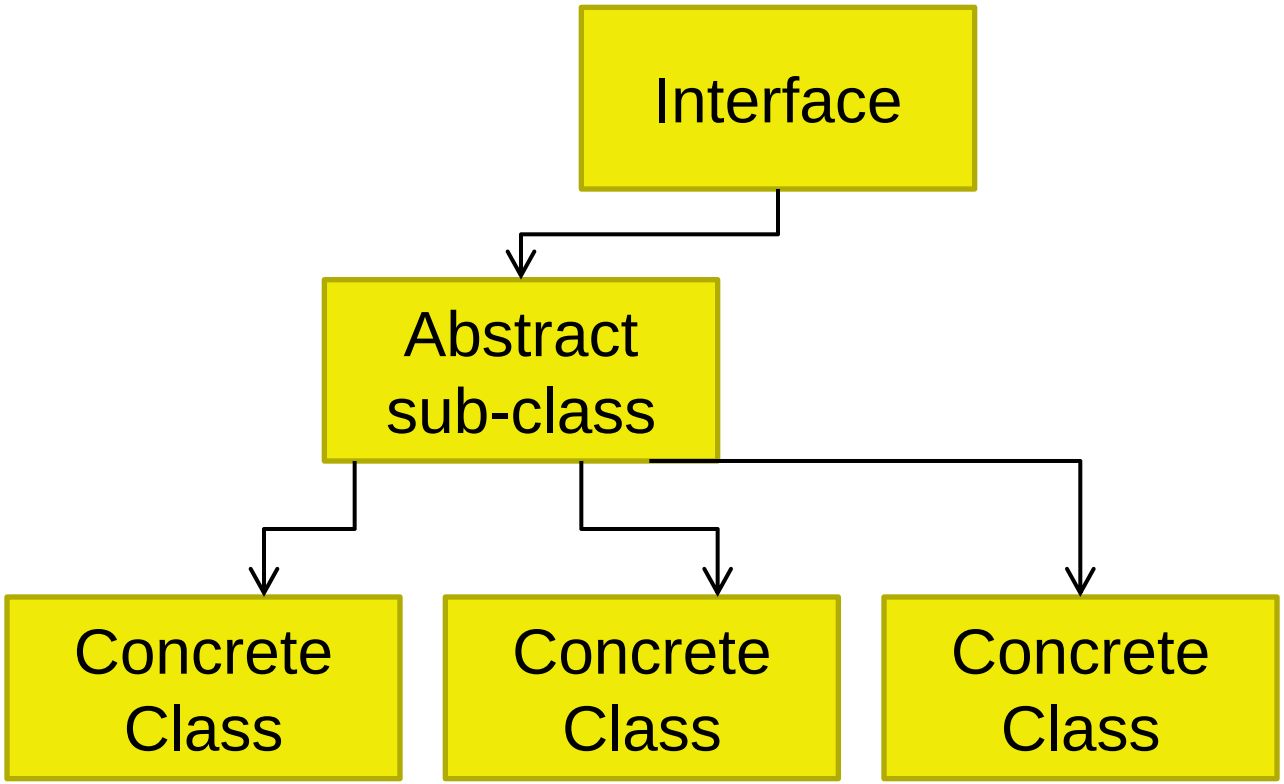
- Circle breaks the implicit contract of the Ellipse class and therefore violates LSP
- Design by contract
  - Can be defined in languages such as Eiffel, each method has a contract which is checked on each invocation
  - For other languages use assertions

Dependency Inversion Principle

- Tradition dependency
  - High level (application level) methods rely on lower detailed functions
  - Unreliable
    - Low level concrete functions are liable to change (e.g. ascii -- > unicode handling)
    - Changes in low level can break high level code

Dependency Inversion Principle

- With OO, concrete base classes depend on high level interfaces so…
- Depend upon Abstractions. Do not depend upon concretions.



Object creation and DIP

- When creating class instance, you often need to be dependent on a concrete class
- Image p=new Image(“fred.png”);
- Our code is now directly coupled to the constructor for image….
- To de-couple this interface it is common to use some form of abstract factory

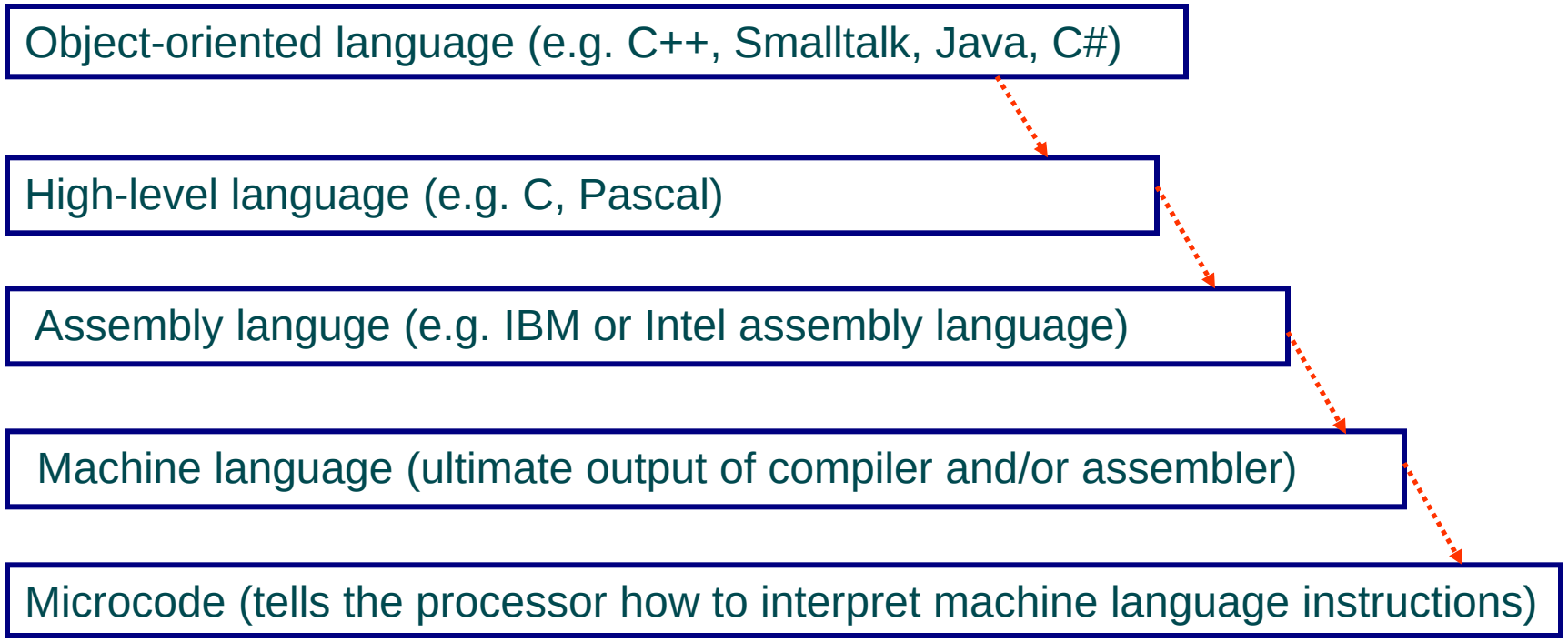
Interface Segregation Principle

- If a class has a large interface to a number of different clients, break it down into
  - Different interfaces for each client type
- E.g. SQL execution helper
  - Insert interface
  - Select interface
  - Delete interface

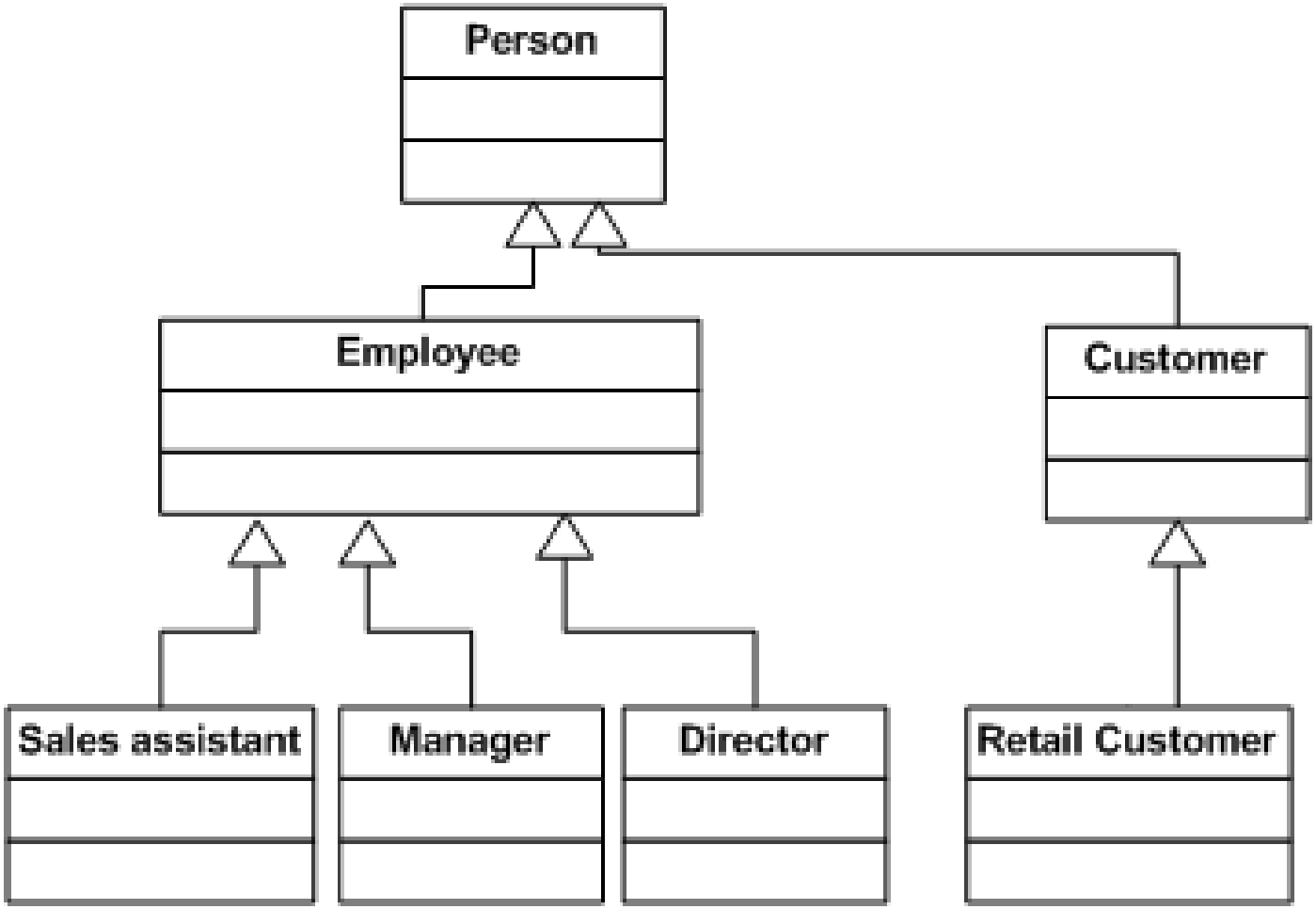
Class packaging principles

- Release Reuse Equivalency Principle
  - The granule of reuse is the granule of release. Only components that are released through a tracking system can effectively be reused. This granule is the package.
- Common Closure Principle
  - Classes that change together, belong together
- Common Reuse Principle
  - Classes that aren't reused together should not be grouped together
  - Consequence, keep packages as small as possible but which doesn't violate CCP

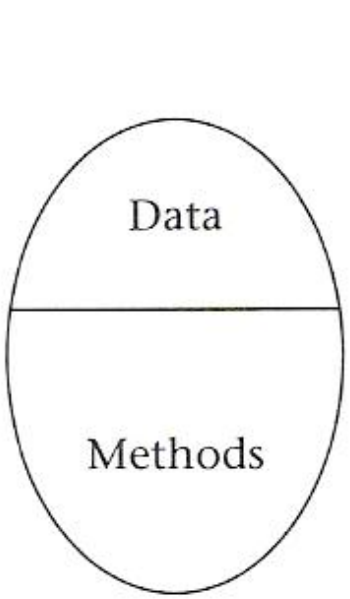
Language levels

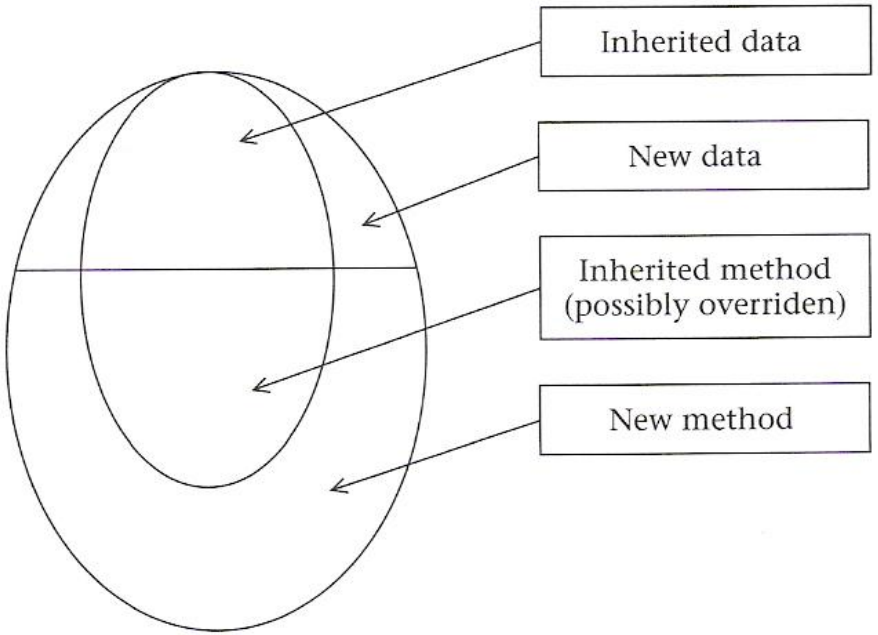


Classification



Encapsulation & Inheritance





Benefits of OO approach

- Inheritance - classes
- Encapsulation - classes + methods
- Polymorphism - function
- good Cohesion
- good Coupling

OO Analysis (!= OO design)

" … is figuring out how to arrange a collection of classes that do a good job of representing your real-world problem in a format which a computer programmer finds easy to deal with."

- Input
  - Thinking effort
  - Pencil, paper and Notebook
  - Observations
- Output
  - Answer to "which classes to use?"
  - UML diagrams

Object Orientated design

“ … *is about what kinds of data and method go into your classes and about how the classes relate to each other in terms of inheritance, membership and function calls.”*

- Input
  - Thinking effort + Pencil Paper, Notebook
  - OOA diagrams
- Output
  - UML diagrams
  - Header files (e.g. *.h files)

Role of documentation

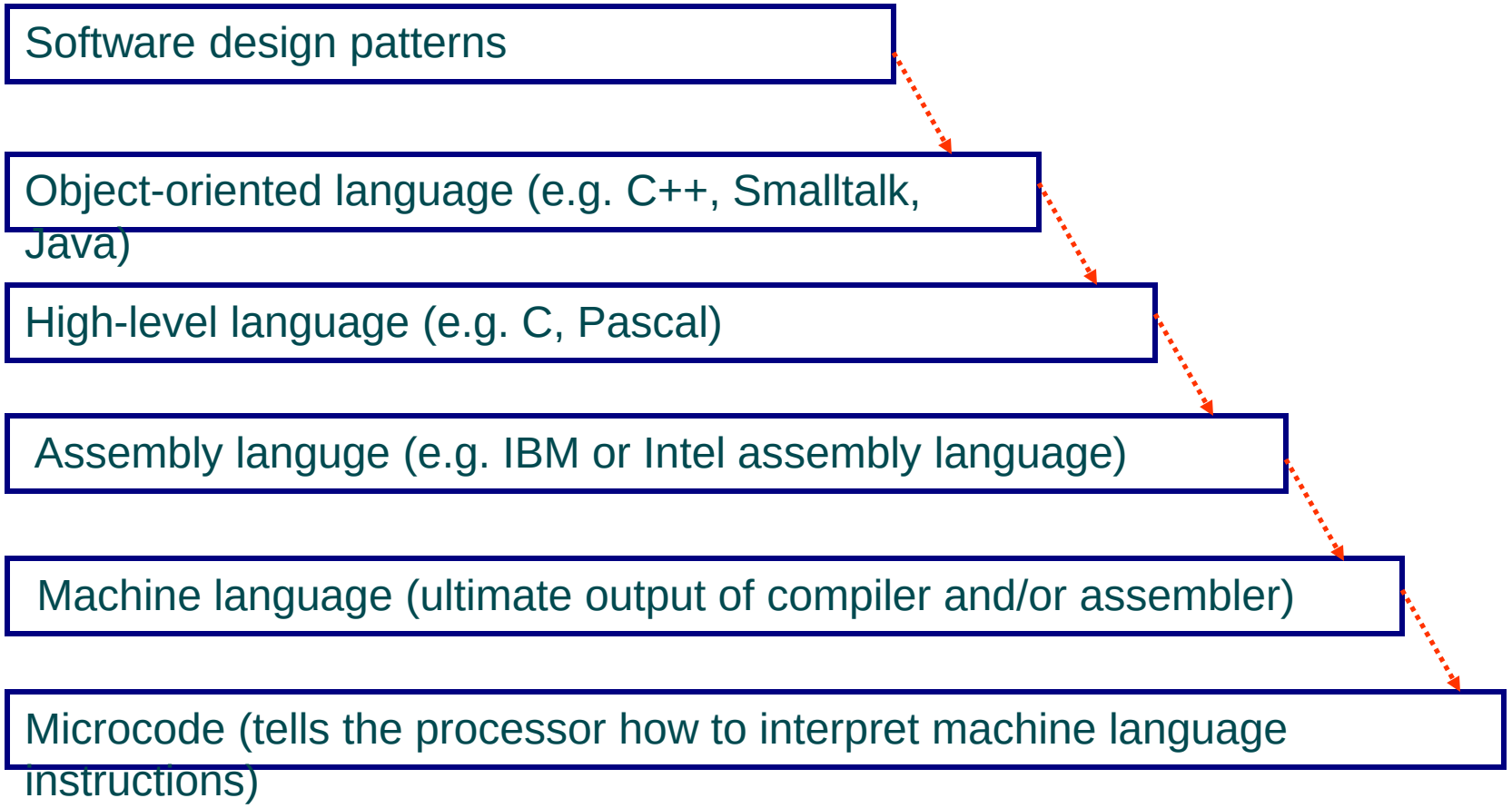
- Central communication
  - Cut down on communication overhead
- Control
  - If it's not in the specification, it won't be built
- Annotation
  - Particularly of code but also design
- Operational
  - User/system manuals

Types of Documentation

- UML diagrams
- User Guides
- System Guides
- Management documents
- Requirement and Specification
- Schedule and Budget
- Organisation and Planning

Design Patterns

Software Evolution → Patterns



Design patterns

- Repeatable approaches to problem solving in software design
- Not locked into any 1 language (but often use OO concepts)
- Speed up development
- Increase software flexibility
- Make software more readable
- Can be implemented as components which will move from reusable design to reusable code

Patterns and Components

- Patterns
  - Approaches to the problem
- Components
  - Re-usable code which solves approach

Design Pattern types

- Architectural (approach to designing the whole system) example MVC
- Creational
- Structural (one class/method wrapping another)
- Behavioural
  - Example : call backs, persistence
- Concurrency
  - Controls multiple threads

Model View Controller

- Problem
  - Many different GUI APIs
  - GUI code can be very complex and messy
  - Porting GUI code between platforms is hardwork

MVC Components

- Splits the code into
  - Model
    - Stores, retrieves and manipulates the data
  - View
    - Renders the data on the screen
    - View fetches data from model
  - Controller
    - Processes user input, passing events to model
    - Controller can instruct view to render

Model

- Provides the following
  - business logic, rules (e.g. who can access a student's transcript)
  - validation (can also be in controller)
  - persistence
  - application state (session)
    - shopping cart for user
    - address book, contact list
    - logged in user id

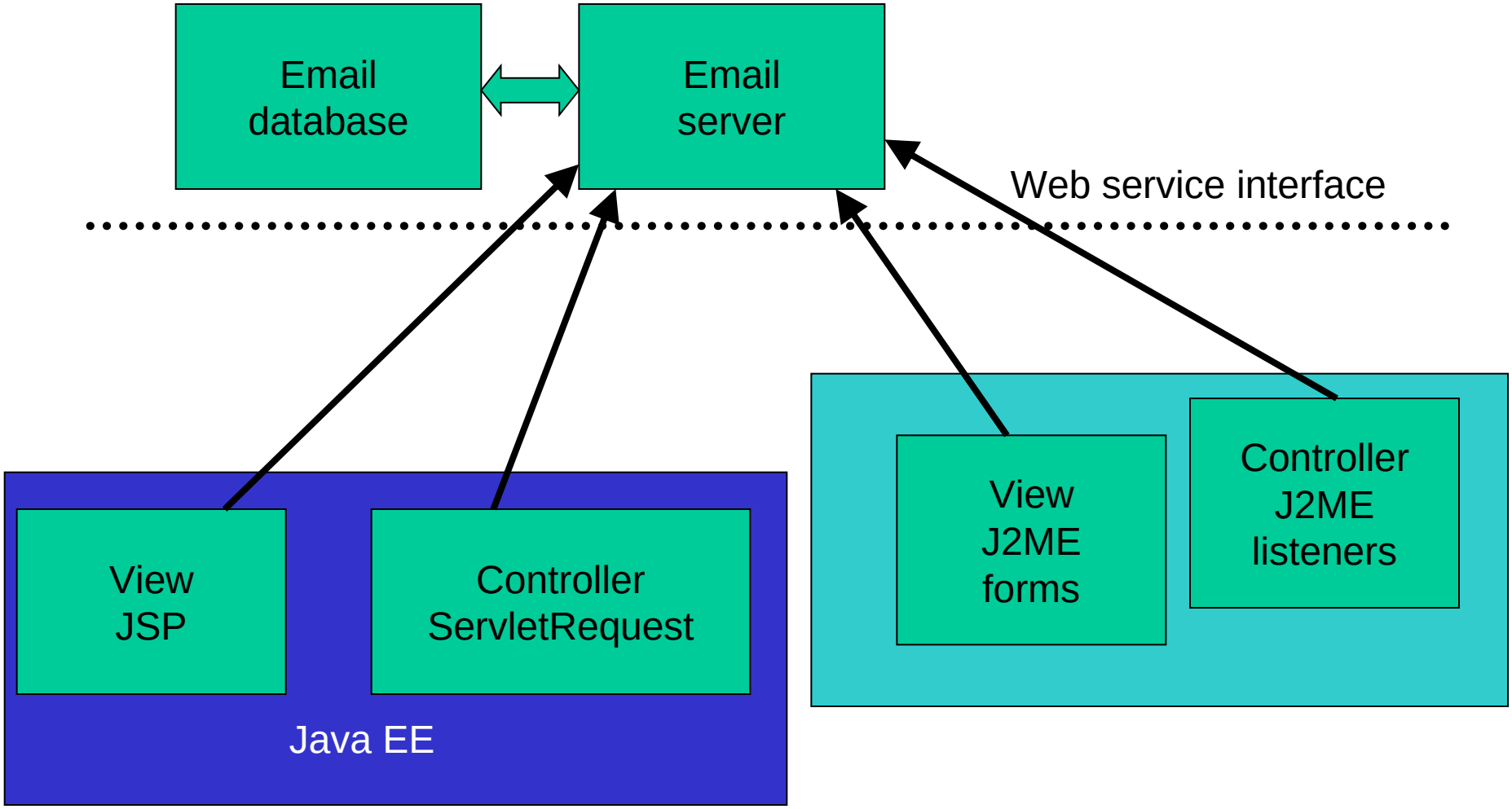
View

- Presents the information to the user
- Example View technologies
  - JSP allows user to use Java to generate web pages
  - CSS web page presentation
  - HTML/XML
  - .aspx Microsoft dynamic web technology

View/Controller options

- Java servlets and JSP (browser client)
  - Java EE (Tomcat or Glassfish)
- .NET aspx pages (browser client)
  - Microsoft Server
- J2ME MIDP
  - Mobile Java
- Java AWT/Swing
  - Java SE

MVC Example


Email database
Email server
Web service interface
View JSP
Controller ServletRequest
Java EE
View J2ME forms
Controller J2ME listeners

Model code example

Plain old Java class

```
class Customer {
    private String surname;
    private String forenames;
    private Date dateOfBirth;
}
```

Note this class can be ported to any platform that supports Java

View code example

```
Class CustomerForm extends Form {
    private TextField tfSurname; // text field input surname
    private TextField tfForenames; // forenames input
    private DateField dfDateOfBirth; // date of birth input
    private Command ok;
}
```

Controller Code (J2ME)

```
CustomerFormListener implements CommandListener {
  CustomerForm customerForm;
  public void commandAction(Command c, Displayable
    displayable) {
      if ( (c.getCommandType()==Command.OK)) {
              Customer customer=customerForm.getCustomer();
              customer.Save();
      }
}
```

MVC Model View Controller

- Benefits
  - Clear seperation of concerns
  - Easier to port software UI platform to UI platform
- VC code
  - Can be implemented by GUI specialist
- Team working
  - Web, Mobile App (iOS, Android), Mobile Web
  - Business logic

Command pattern

- Command
  - general abstraction for controller type interactions
  - allows controller API to change and keep business logic the same
- Code example

```
interface Command {
   void    OnExecute();
}
```

Command interface detail

```
public abstract class Command {
    private Hashtable <String,Object> callParameters=new Hashtable();
    private Hashtable <String,Object> returnParameters=new Hashtable();
    protected abstract void OnExecute();

    protected void setCallParameter(String name,Object object) {
        callParameters.put(name, object);
    }

    public void setCallParameters(Hashtable parms) {
        this.callParameters=parms;
    }

    protected Object getCallParameter(String name) throws
     ParameterNotFoundException {
        if (callParameters.containsKey(name)) {
            return(callParameters.get(name));
        }
        throw(new ParameterNotFoundException());
    }
}
```

CommandManager

```
public class CommandManager {
public void Execute(Hashtable parameters) throws
NoSuchCommandException,CommandNameMissingException {
        String packageName="patterns.commands";
         if (!parameters.containsKey("name")) {
            throw (new CommandNameMissingException());
        }
        String name=(String)parameters.get("name");
        String commandName=packageName+name;
        try {
           Class commandClass=Class.forName(commandName);
           Command commandObject=(Command)commandClass.newInstance();
           if (parameters!=null) {
              commandObject.setCallParameters(parameters);
           }
           commandObject.OnExecute();
        } catch (Exception exc1) {
            throw (new NoSuchCommandException(name));   // problem with command
class
        }
    }
```

HttpCommandManager extends CommandManager

```
 public void Execute(HttpServletRequest request) throws
NoSuchCommandException, CommandNameMissingException {
        Enumeration allNames=request.getParameterNames();
        Hashtable <String,Object> parameters=new Hashtable
<String,Object> ();
        while (allNames.hasMoreElements()) {
            String pname=(String)allNames.nextElement();
            String parmValue=request.getParameter(pname);
            parameters.put(pname, parmValue);
        }
        Execute(parameters);
    }
```

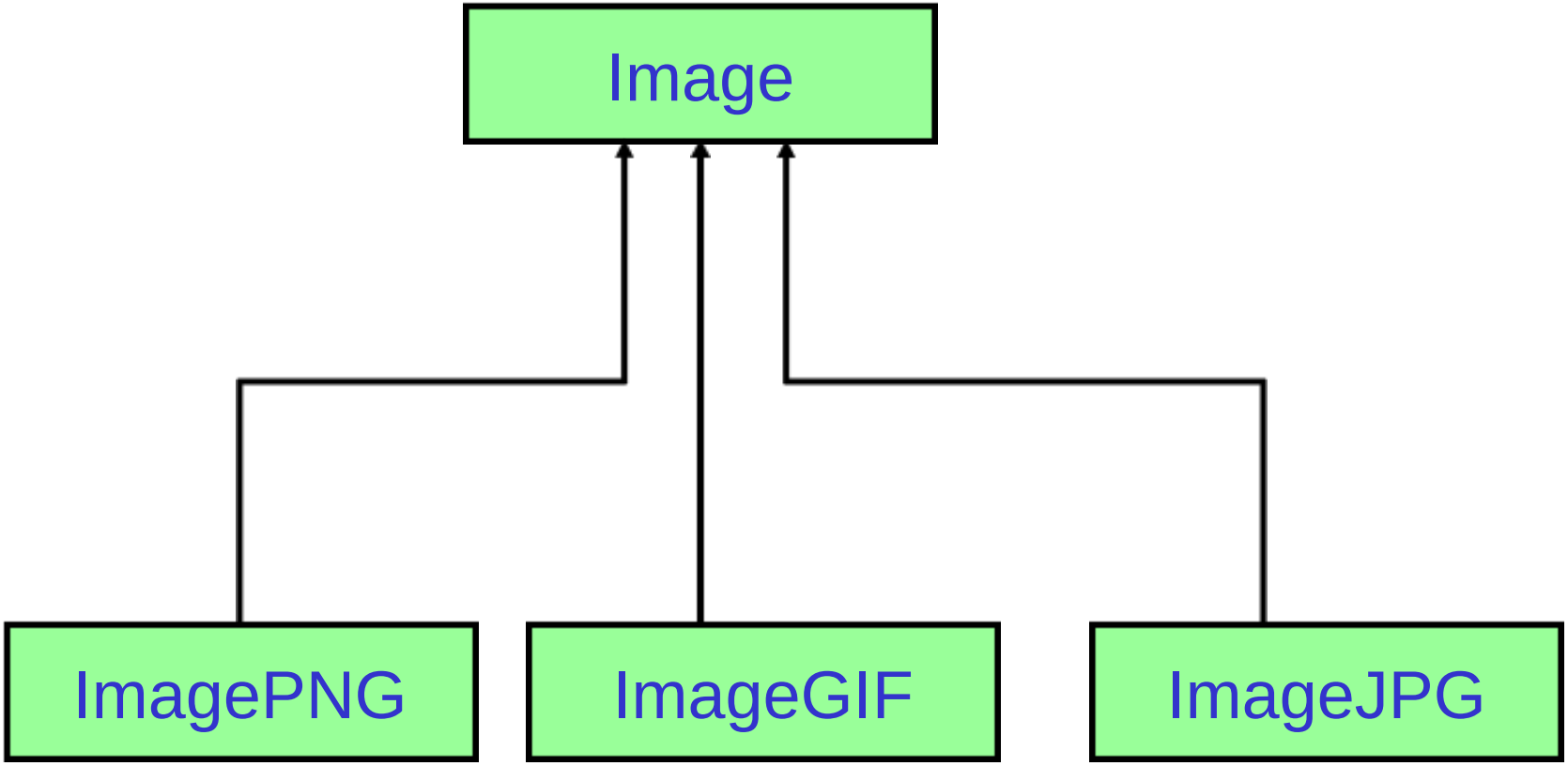
Factory class

- Factory method constructs instances of a class
- Problem
- Constructing a Image class
  - Image format could be png, gif, jpg
  - Each format could have different image class

  - Calling code needs to use different class depending on image type
  - ImagePNG image=new ImagePNG(“/picture.png”);
  - Type may not be know till runtime

Factory example

- Solution
  - Use inheritance from abstract class Image



```
public static  createImage(String fname) throws
Exception {
   if (fname.endsWith(“.gif”)) {
     return( (Image) new ImageGIF(fname) );
    }
    if (fname.endsWith(“.png”)) {
       return( (Image) new ImagePNG(fname) );
    }
    if (fname.endsWith(“.jpg”)) {
       return( (Image) new ImageJPG(fname) );
    }
    throw new Exception("Unknown image type
for file "+fname);
}
```

Singleton

- Single instance of class
- Constructor is private
- static final Class instance constructed when application loads
- or loaded only when need (lazy initialization)
- Examples of usage
  - to access database so that all threads go through one control point
  - Font class keeps memory load low

Singleton Example in Java

```
public class DbaseConnector {
    private static final DbaseConnector instance=new
    DbaseConnector();
    private DbaseConnector() {
            // database construction code…..
    }

    public static DbaseConnector getInstance() {
        return(instance);
   }
}
```

Singleton Example (lazy initialization)

```
public class DbaseConnector {
   private static DbaseConnector instance;
   private DbaseConnector() {
         // database construction code…..
   }
   public static DbaseConnector synchronized getInstance() {
      if (instance==null) {
         instance=new DbaseConnector();
      }
      return(instance);
  }
}
```

Wrapper classes

- **Problem**
  - **Different external technologies to connect to**
  - **Example for database connection**
    - **ODBC (Microsoft)**
    - **JDBC (Java standard)**
  - **Other examples**
    - **External Credit card payment**
    - **Network connection (Java and Microsoft)**
    - **Data structure libraries**

Wrapper classes

- **Problem with coding directly**
  - **Code will end up messy**
  - **Hard to port**
  - **Hard to understand**
- **Benefits of wrapping code**
  - **easier to swap modules (e.g. CC function)**
  - **easier to implement standard functions (e.g. accountancy, error logs)**

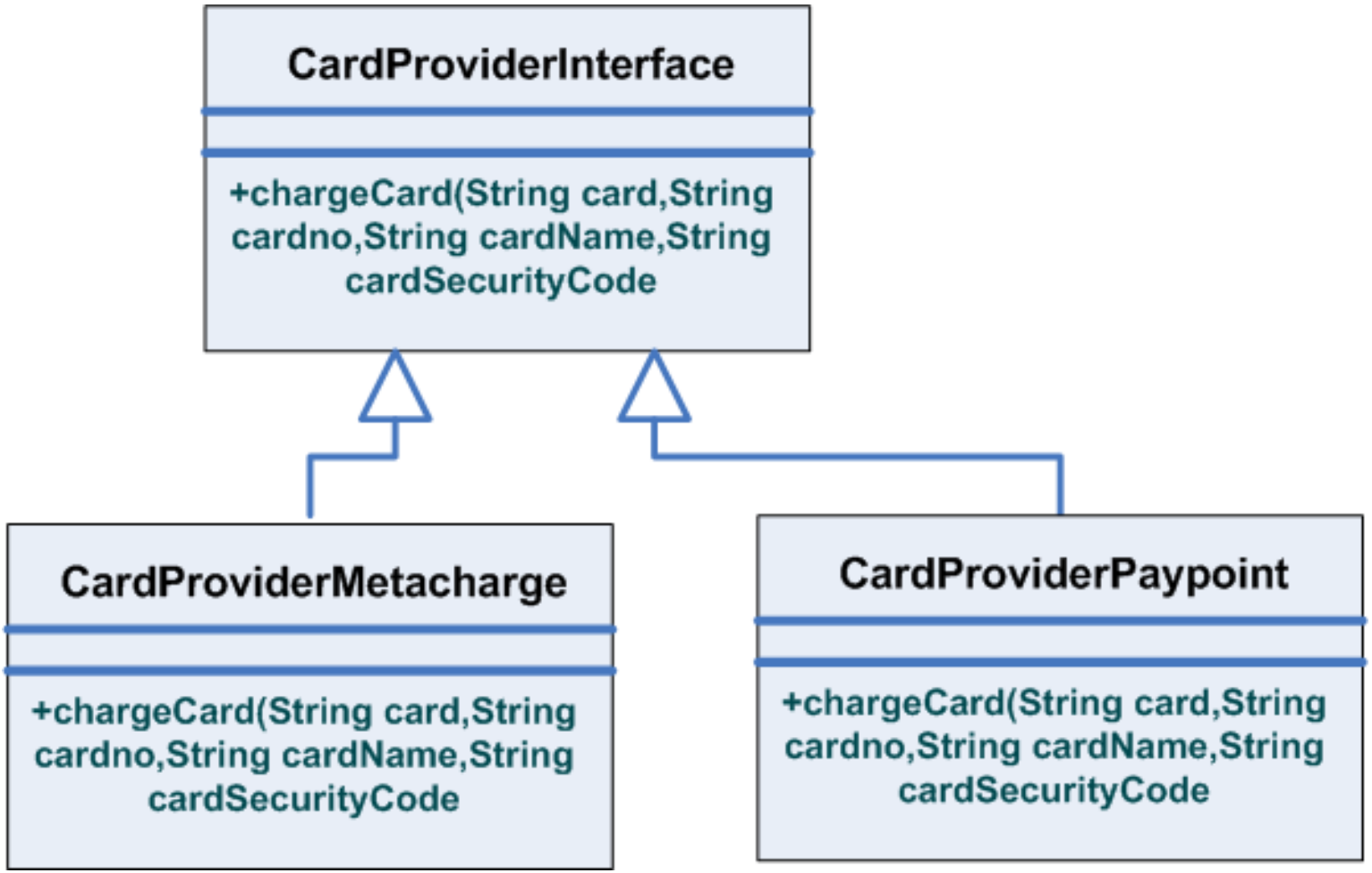
Wrapper example (unwrapped code)

```
String sql="select * from customers";
     try {
          java.sql.Statement
s=dbConnection.createStatement();
          int rows=s.executeUpdate(sql);

      } catch (Exception e) {
          status=sql+" "+e.toString();

      };
```

Wrapped code

```
public class SQLHelper {
   public void executeSQL(String sql) {
         try {
              java.sql.Statement
    s=dbConnection.createStatement();
              int rows=s.executeUpdate(sql);
         } catch (Exception e) {
           status=sql+" "+e.toString();
        };
}
}
```

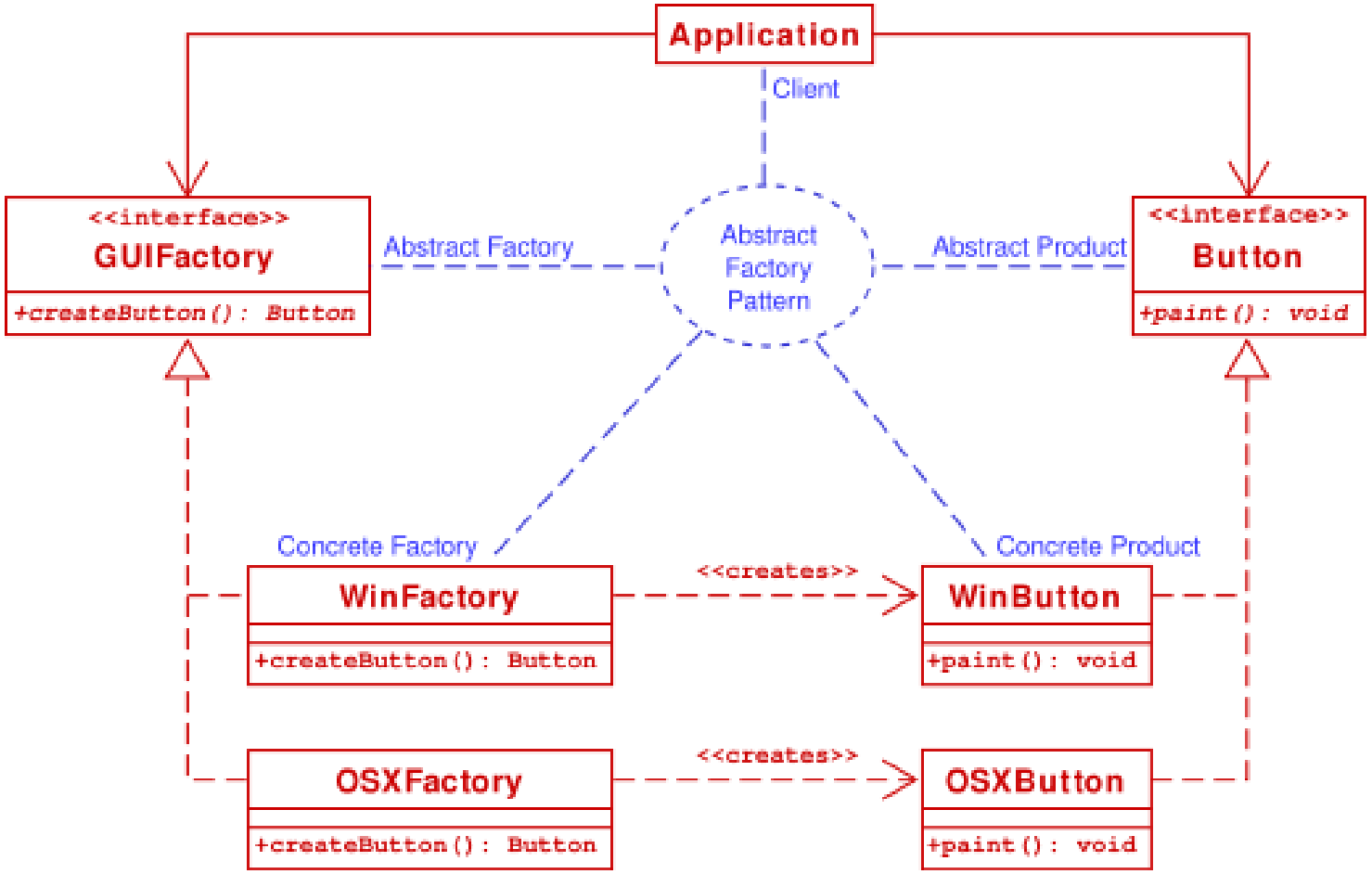
Adapter class diagram example



Abstract factory

- Used when you have an associated set of object types to create, but the actual class to create is decide at run time
- Example:
  - Sets of encryption algorithms from different providers
  - User interface components for different OS UI API

Abstract Factory class diagram



Abstract factory code example

```
interface SecurityFactory {
   public Encryptor createEncryptor();
}
class LowSecurityFactory implement  SecurityFactory {
    public Encryptor createEncryptor() {
          return(new ShortKeyEncryptor());
    }
}
class  HighSecurityFactory implement SecurityFactory {
    public Encryptor createEncryptor() {
          return(LongKeyEncryptor());
    }
}
```

Abstract factory example

```
class Application {
        private Encryptor encryptor;
        public Application(securityFactory sfactory) {
            encryptor=sfactory.createEncryptor();
        }
}

class Start {
   public static void main(String argsv[ ]) {
       Application application;
       if (professionalVersion) {
           application=new Application(new HighSecurityFactory());
       } else {
           application=new Application(new LowSecurityFactory());
       }
   }
}
```

Builder

Separates abstract definition of an object from its representation

Example

- Builder for SQL statements

Abstract interface

- Defines interface with appropriate elements (table names, columns, indexes)

Concrete definition

- SelectBuilder (for select statements)

Coding example

```
public interface ISQLBuilder {
    public void setTableName(String table);
    public String getTableName();
    public void setCommandName(String command);
    public String getCommandName();
    public void addColumnName(String columnName);
    public String toSQLString();
    public String getWhereClause();
    public void addWhereClause(String where);

}
```

```
public abstract class SQLBuilderBase implements ISQLBuilder {
    private String tableName;
    private String commandName;
    private StringBuilder whereClause=new StringBuilder();
    private Vector <String> columnNames=new Vector <String>();

    public String getTableName() {
        return tableName;
    }
    public void setTableName(String tableName) {
        this.tableName = tableName;
    }

    public String getCommandName() {
        return commandName;
    }

public void setCommandName(String commandName) {
        this.commandName = commandName;
    }
```

```
public void addColumnName(String columnName) {
    columnNames.add(columnName);
}

public int getColumnCount() {
    return(columnNames.size());
}

public String getColumnName(int index) {
    return(columnNames.get(index));
}

public void addWhereClause(String whereStatement) {
    this.whereClause.append(whereStatement);
}

public String getWhereClause() {
    return(whereClause.toString());
}
```

Coding example

```
public class SQLSelectBuilder extends
SQLBuilderBase {
    public SQLSelectBuilder(String tableName) {
        super.setTableName(tableName);
        super.setCommandName("SELECT");
    }
```

```
public String toSQLString() {
        StringBuilder sb=new StringBuilder();
        sb.append(this.getCommandName()+" ");
        if (getColumnCount()==0) {
            sb.append("(*)");
        } else {
            sb.append("(");
            for (int idx=0;idx<this.getColumnCount();idx++) {
                sb.append(getColumnName(idx));
                if (idx!=this.getColumnCount()-1) {
                    sb.append(",");
                }
            }     sb.append(")");
        }
        sb.append(" from "+this.getTableName());
        sb.append(" where "+getWhereClause());
        return(sb.toString());
    }
}
```

Builder coding example

```
public class Main {
    public static void main(String argvs[]) {
        SQLSelectBuilder builder=new
SQLSelectBuilder("customers");
        builder.addWhereClause("customerid=3");
        System.out.println("SQL string is "+builder.toSQLString());

    }

}
```

So why both with all this complexity?

```
SQLSelectBuilder builder=new SQLSelectBuilder("customers");
    builder.addWhereClause("customerid=3");
```

- Instead of
  - String sql="select (*) from customer where customerid=3"
- Reduces chance of syntax error
  - Fool proofing code
- Allows builder to generate code for other syntaxes (transparent translation) "limit v. top"
- Allows builder to introduce new layers in database complexity, for example sharding, security layer

Sharding

- Splitting data over more than 1 database or database table, based on a key index
- Data can be divided based on
  - Key index range
    - (0-99 table 1, 100-199 table 2 etc)
  - Hash function on key index

Sharding example

```
public String getTableName() {
        if (customer_id!=0) {
              return tableName+”_”+customer_id/1000;
        } else {
             return tableName;
        }
    }
```

Table validation

- Can debug to make sure table names are valid for the application

```
public void setTableName(String tableName) throws
BadTableNameException {
        if (!tableNames.contains(tableName)) {
            throw new BadTableNameException();


            };
        }
        this.tableName = tableName;
    }
```

More useful than run time SQL error, since error is caught earlier, better application control

Multiton

- Like a singleton, but
  - Produces a different singleton instance dependent on a key
  - Example
    - You want a singleton class instance for a CRM (Customer relationship manager) for each customer

Multiton code example

```
public class CRMHandler {
    private int customer_id=0;
    private int staffid=0;
    private java.util.Date lastContactTime;
    private static  Hashtable <Integer,CRMHandler> allHandlers =new Hashtable
<Integer,CRMHandler>() ;

    private CRMHandler(int customer_id) {      // private constructor
        this.customer_id=customer_id;
        System.out.println("Making handler for customer id "+customer_id);
    }

    public static synchronized CRMHandler getCRMHandler(int customer_id) {
        if (!allHandlers.containsKey(new Integer(customer_id))) {
            CRMHandler handler=new CRMHandler(customer_id);
            allHandlers.put(new Integer(customer_id), handler);
        }
        return(allHandlers.get(new Integer(customer_id)));
    }
}
```

Flyweight pattern

- Used to share memory allocation between objects with similar properties
- Example
  - A word processor could have a different font definition for each character
- Related to Multiton
  - Heavyweight resource will be often expressed a multiton

Flyweight example

```
public class FontDefinition {
    private static  Hashtable <String,FontDefinition> allFonts =new
Hashtable <String,FontDefinition>() ;
    private String name="";
    private java.awt.Font font;
    private FontDefinition(String name) {      // private constructor
        this.name=name;
        // TO DO
        // Code to create Font natively is here see AWT documentation
for Java
        //
    }
```

Flyweight example

```
public static synchronized FontDefinition getFont(String
name) {
        if (!allFonts.containsKey(name)) {
            FontDefinition definition=new
FontDefinition(name);
            allFonts.put(name,definition);
        }
        return(allFonts.get(name));
    }
}
```

Flyweight example

```
public class WPCharacter {
    private FontDefinition fontDefinition;
    private char letter;
    public void setFontName(String fname) {
        // Font definition is fly weight…
        fontDefinition=FontDefinition.getFont(fname);
    }

    public WPCharacter(char letter) {
        this.letter=letter;
    }
}
```

Chain of responsibility

- A number of classes work together to handle a message (call)
- If the class doesn’t want to handle the message, it passes the messages down to next class in the chain
- Example
  - System logging

```
abstract class Logger {
    public static int ERR = 3;  // highest priorty message
    public static int NOTICE = 5;
    public static int DEBUG = 7;
    protected int logger_level;
    private static Logger lastLogger;
    // The next element in the chain of responsibility
    protected Logger next;

    public Logger(int level) {
        this.logger_level=level;
        setNext();
    }

    private void setNext() {
        if (lastLogger!=null) {
            lastLogger.next=this; // add this into chain
        }
        lastLogger=this;
    }
```

```
    public void message(String msg, int priority) {
        if (priority <= logger_level) {
            writeMessage(msg);
        }
        if (next != null) {
            next.message(msg, priority);
        }
    }

    abstract protected void writeMessage(String msg);
}
```

```
class StdoutLogger extends Logger {
    public StdoutLogger(int logger_level) {
        super(logger_level);
    }

    protected void writeMessage(String msg) {
        System.out.println("Writing to stdout: " + msg);
    }
}


class EmailLogger extends Logger {
    public EmailLogger(int logger_level) {
        super(logger_level);
    }

    protected void writeMessage(String msg) {
        System.out.println("Sending via email: " + msg);
    }
}
```

Memento

- Used to restore object to previous state
- Features
  - Stores complexity of objects state
  - Does not allow external classes to view state
  - State is passed back to original object
- Classes
  - Memento stores the state
  - Originator, where the state comes from
  - Caretaker, handles the state, redo
- Application examples
  - Word processing, version control, financial

Memento example (bank account)

- Memento defined as inner class of originator class
  - Allows private sharing of data with originator
- In practise
  - All mementos should be persistent (stored to dbase)

Memento example

```
class BankAccount {
    class Memento {  // memento defined as inner class
        private String state="";
        public Memento(String state) {
            this.state=state;
        }
       private String getSavedState() {
            return(state);
       }
    }
```

Memento example

```
 private long lastTransactionID=0;
   private Vector <Transaction> allTransactions=new Vector  <Transaction>
();

   public Memento saveToMemento() {
      System.out.println("Originator: Saving to Memento.");
      return new Memento(""+lastTransactionID);
   }

   public void doTransaction(String description,int amount) {
      lastTransactionID++;
      Transaction transaction=new
Transaction(amount,description,lastTransactionID);
      allTransactions.add(transaction);
   }
}
```

Memento example

```
public synchronized void restoreFromMemento(Memento memento) {
        lastTransactionID =Long.parseLong(memento.getSavedState());
        for (int idx=0;idx<allTransactions.size();idx++) {
            Transaction transaction=this.allTransactions.elementAt(idx);
            if (transaction.getTransactionid()>lastTransactionID) { // remove
transactions after id
                allTransactions.remove(idx);
                idx--; // move back one position, }
        }
       String sql="delete from account_transaction where
transactionid>"+lastTransactionID; // remove all
        // TO DO
        // EXECUTE SQL
    }
```

Double-checked locking

```
class DbaseConnector {  // standard locking….
    private static DbaseConnector instance = null;
    public static synchronized Helper getConnector() {
        if (instance == null) {
              instance = new DbaseConnector();
        }
        return instance;
    }
}
```

Problem

Synchronizing a method can decrease performance by a factor of 100 or higher

Double-checked locking

```
public class DbaseConnector2 {
    private static DbaseConnector2 instance = null;
    public static DbaseConnector2 getConnector() {
        if (instance == null) {
            synchronized (DbaseConnector2.class) {
                instance = new DbaseConnector2();
            }
        }
        return instance;
    }
} // Look's good but is faulty?  Why?
```

Double-checked locking

```
public class DbaseConnector2 {

    private static DbaseConnector2 instance = null;
    /**
     * This method has a subtle bug
     * @return
     */
    public static DbaseConnector2 getConnector() {
        synchronized (DbaseConnector2.class) {
            if (instance == null) {
                instance = new DbaseConnector2();
            }
        }
        return instance;
    }
}
```