CptS 322- Software Engineering Principles I

Software Design and Architecture Part-2

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WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

Architectural Patterns

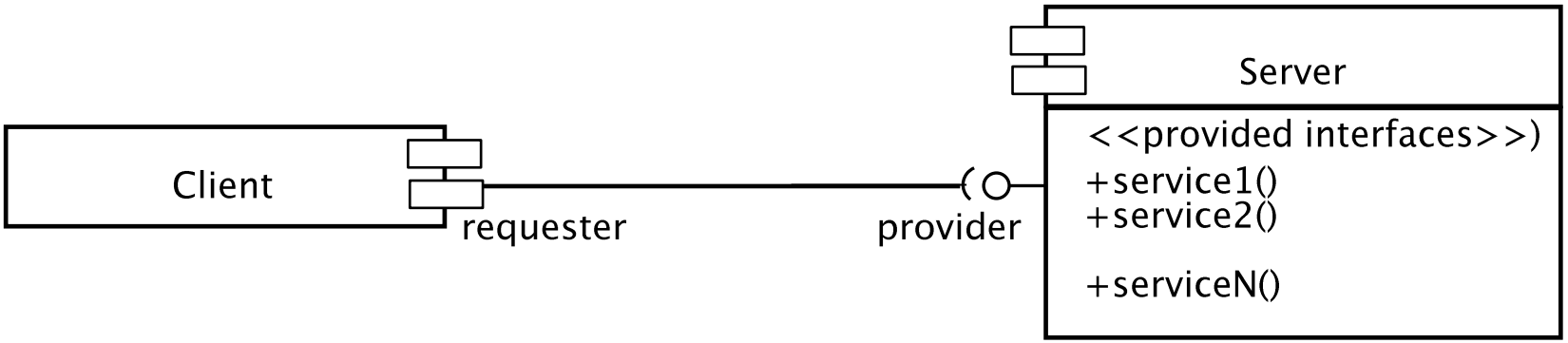
- The notion of patterns can be applied to software architecture.
  - These are called *architectural patterns* or *architectural styles*.
  - Each allows you to design flexible systems using components
    - The components are as independent of each other as possible.

The Client-Server Architectural Pattern

- There is at least one subsystem that has the role of server, waiting for and then handling connections.
- There is at least one subsystem that has the role of client, initiating connections in order to obtain some service.

The Client-Server Architectural Pattern

- Each client calls on the server, which performs some service and returns the result
  - The clients know the interface of the server
  - The server does not need to know the interface of the client
- The response in general is immediate
- End users interact only with the client.



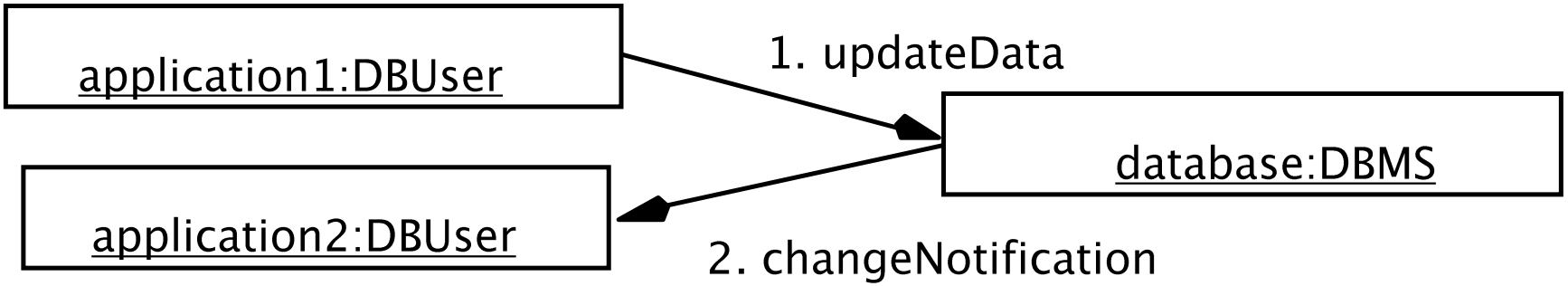
Client/server Architectural Design (UML Component Diagram)

The Client-Server Architectural Pattern

- Often used in the design of database systems
  - Front-end: User application (client)
  - Back-end: Database access and manipulation (server)
  - Functions performed by client:
    - Input from the user (Customized user interface)
    - Front-end processing of input data
  - Functions performed by the database server:
    - Centralized data management
    - Data integrity and database consistency
    - Database security

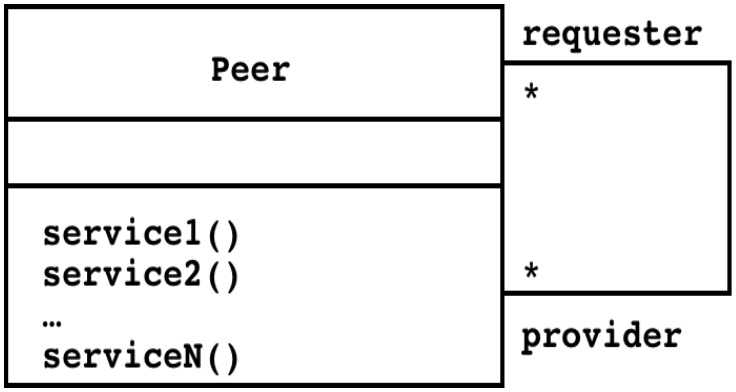
Limitation of Client/Server Architectures

- Client/Server systems do not provide peer-to-peer communication
- Example:
  - Database must process queries from application and should be able to send notifications to the application when data have changed



Peer-to-Peer Architectural Pattern

- Generalization of Client/Server Architectural Pattern
  - Introduction a new abstraction: Peer
  - “Clients and servers can be both peers”

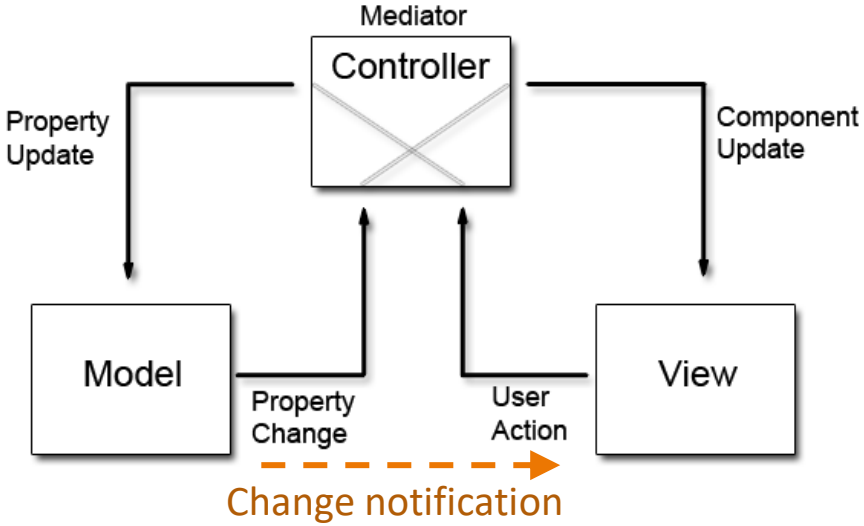


“A peer can be a client as well as a server”.

Model-View-Controller (MVC) Architecture

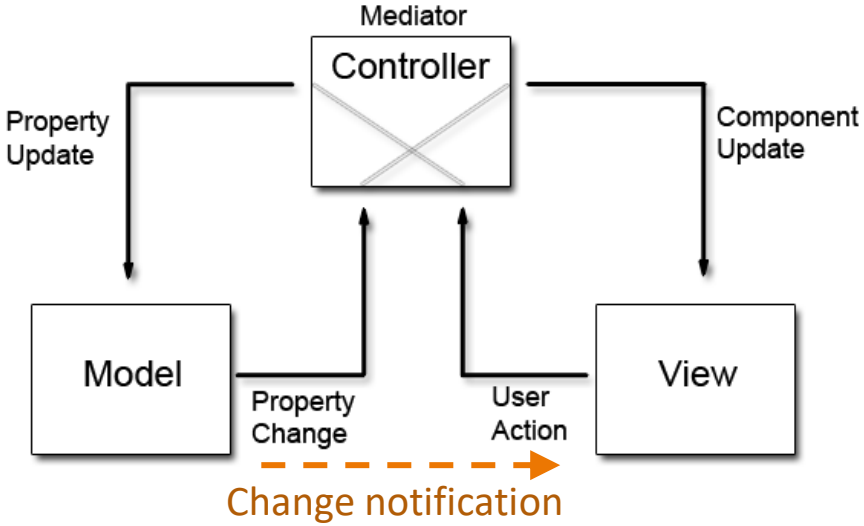
- Many applications follow this pattern:
  - iOS, Android, Web, Desktop applications
    - Receive commands/instructions
    - Read/compute/update state
    - Pick/update the presentation of the state

- A time-tested architectural principle:
  - Separate model (data and state management) from presentation (view)



Why MVC?

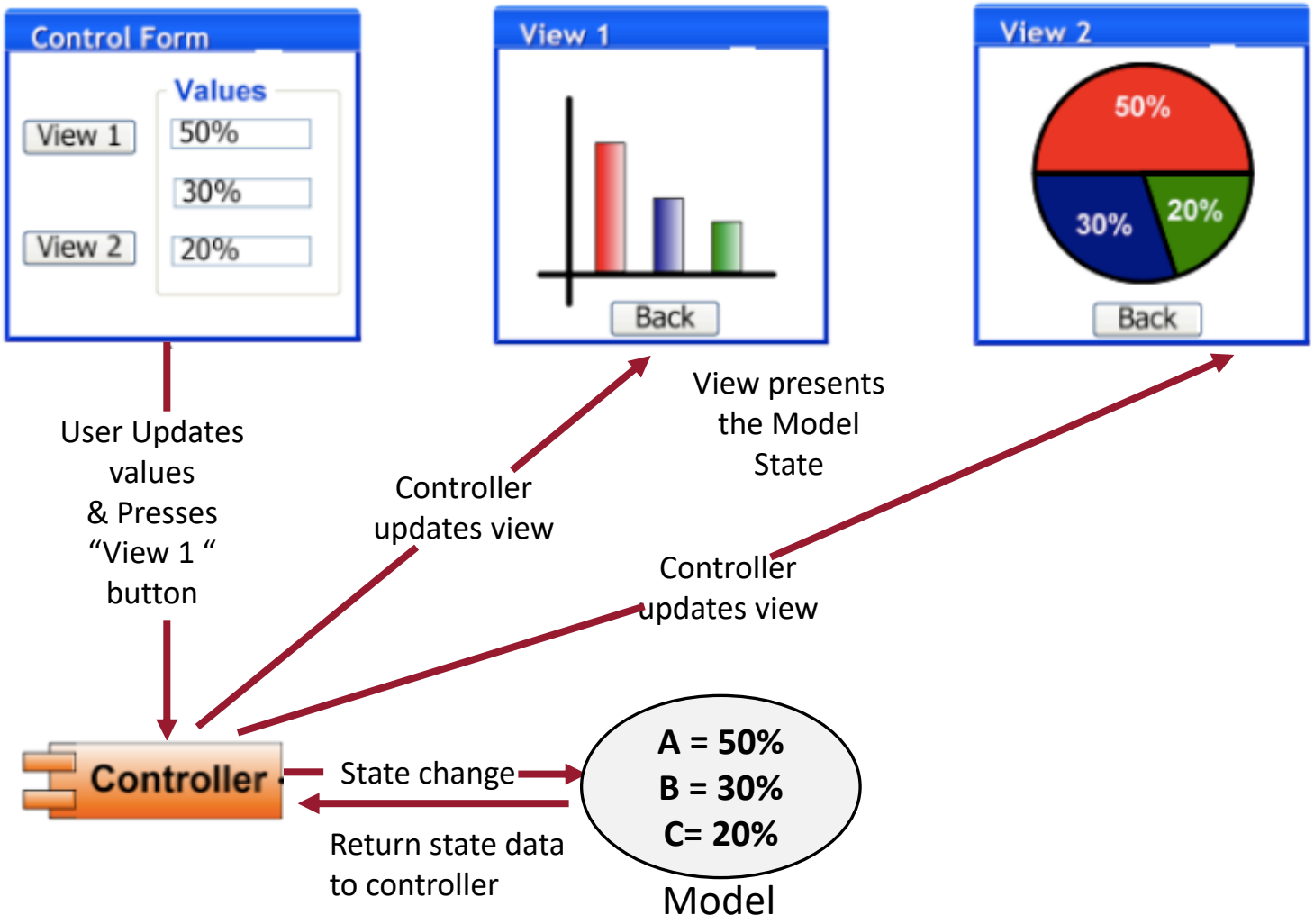
- The presentation and the data logic have different rate/risk for change
  - Isolate change
- Use different presentations for the same state
  - E.g., Google Drive presentations: browser, mobile, API
- Presentation is hard to test automatically
  - We want to at least test the state management easily



Model-View-Controller (MVC) Architectural Pattern

- An architectural pattern used to help separate the user interface from other parts of the system.
  - *Model* :
    - The state and data
    - Methods for accessing and modifying state and data
  - *View* :
    - Render the appearance of the state and data from the model in the user interface
    - When model changes, view must be updated
  - *Controller :*
    - Translates user actions (i.e. interactions with view) into operations on the model
    - Example user actions: button clicks, menu selections
    - When model changes controller should update the view

Example of MVC for GUI App



MVC Example

Step 1: Create the Model

```
public class MyData {
  private float A;
  private float B;
  private float C;

  public float getA() {
      return A;
  }
  public float setA(float A) {
      this.A = A;
  }
  public float getB() {
      return B;
  }
  public float setB(float B) {
      this.B = B;
  }
  public float getC() {
      return C;
  }
  public float setC(float A) {
      this.C = C;
  }
}
```

Step 2: Create the View

```
public class MyDataView {

   public void displayBarGraph(float, A, float B, float C) {
         g = barGraph(A,B,C);
   }

   public void displayPieGraph(float, A, float B, float C) {
         g = pieGraph(A,B,C);
   }

   public void printData(float, A, float B, float C) {
          System.out.println("A: %f" + A);
         System.out.println("B: %f" + B);
         System.out.println("C: %f" + C);
   }
}
```

Step 3: Create the Controller

```
public class MyDataController {
   private MyData model;
   private MyDataView view;

   public MyDataController( MyData model, MyDataView view){
      this.model = model;
      this.view = view;
   }
   public void setDataA(float A){
      model.setA(A);
      updateView("bar");
   }
   public void setDataB(float B){
      model.setB(B);
      updateView("bar");
   }
   public void setDataC(float C){
      model.setC(C);
      updateView("bar");
   }
   public float getDataA(){
      return model.getA();
   }
   public float getDataB(){
      return model.getB();
   }
   public float getDataC(){
      return model.getC();
   }
   public void updateView(String type){
      if (type=="bar") view. displayBarGraph(model.getA(), model.getB(), model.getC());
      else if (type=="pie") view.displayPieGraph(model.getA(), model.getB(), model.getC());
      else view.printData(model.getA(), model.getB(), model.getC());
   }
}
```

Step 4: Create the main program

```
public class MVCPatternDemo {
   public static void main(String[] args) {

      //Create the model
      MyData model  = new MyData();
      model.setA(0.5);
      model.setB(0.3);
      model.setC(0.2);

      //Create a view : to display data on graph
      MyDataView view = new MyDataView();

      MyDataController controller = new MyDataController(model, view);

      controller.updateView("bar");

      //update model data
      controller.setA(0.6);
      controller.updateView("pie");
   }
}
```

The Model

- The main goal of MVC is to separate the model from the presentation (view)

- Model is the functional core of the application:
  - Sometimes called business logic because this is the business layer in enterprise applications
  - Sometimes called domain logic
  - Encapsulates the state of the application
    - E.g., databases and data structures would be managed by the model

- Allows the controller to access application functionality encapsulated by the Model

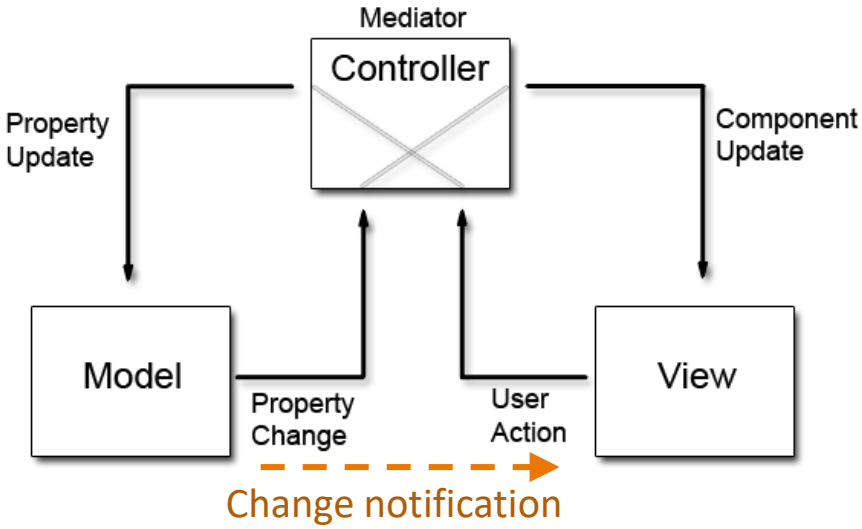
- Notifies views when the application state changes

The View

- Renders the contents of a model
- Forwards user gestures to the controller

MVC variants:

- When the model changes, the view must update its presentation
  - push model:
    - the view registers itself with the model for change notifications
  - pull model
    - the view is responsible for calling the model when it needs to retrieve the most current data

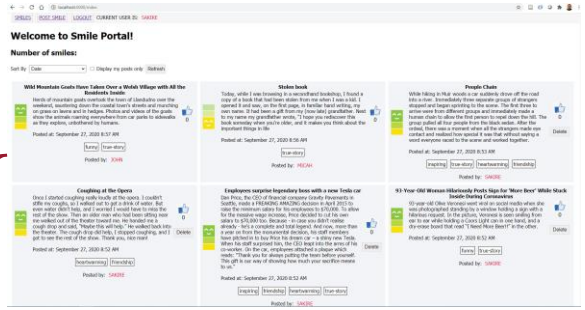


The Controller

- Orchestrates interaction of models and views
- Defines application behavior
- Interprets user gestures and maps them into actions
  - For the model to perform
  - In selecting a different view
    - E.g., a web page of results to present back to the user

- The Structure of the “Smile App”

Smile Application



HTTP

MODEL

Routes

Auth-Routes

VIEW

Error Handlers

CONTROLLER

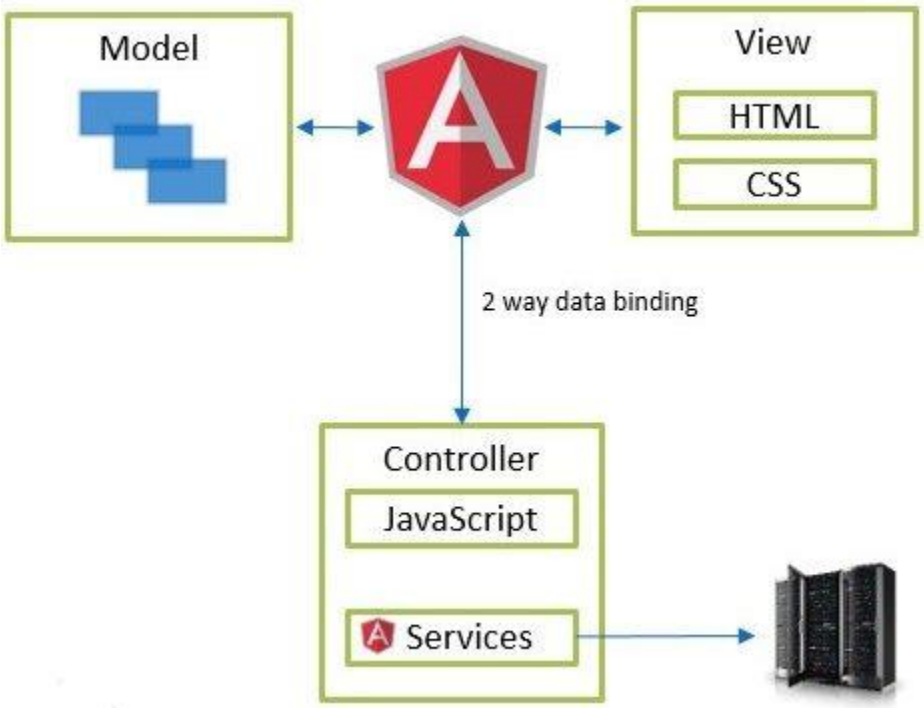
Database

https://selftaughtcoders.com/model-view-controller-mvc-web-application/

Smile Application – UML Component Diagram

- We will draw this in class.

Example of MVC for Angular JS

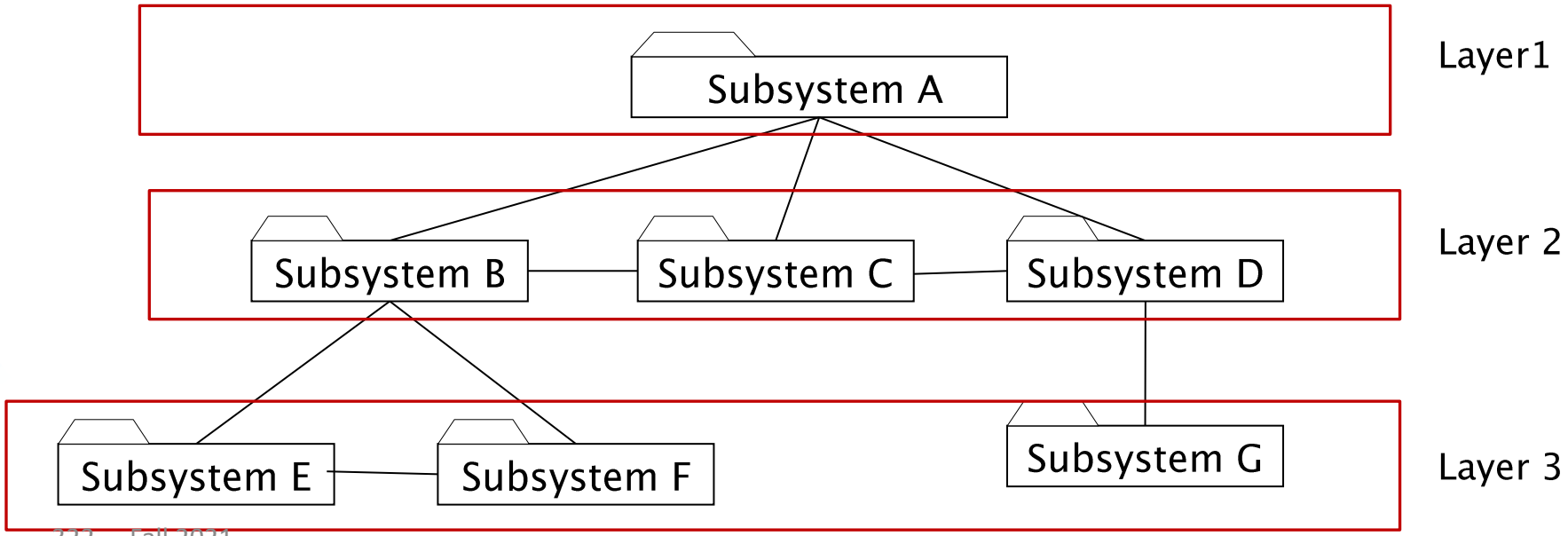


2-way binding – Angular.js keeps the data and presentation layer in sync.

- No need to write additional JavaScript code to keep the data in your HTML code and your data layer in sync. Angular.js will automatically do this for you.
- You just need to specify which control is bound to which part of your model.

The Multi-Layer Architectural Pattern

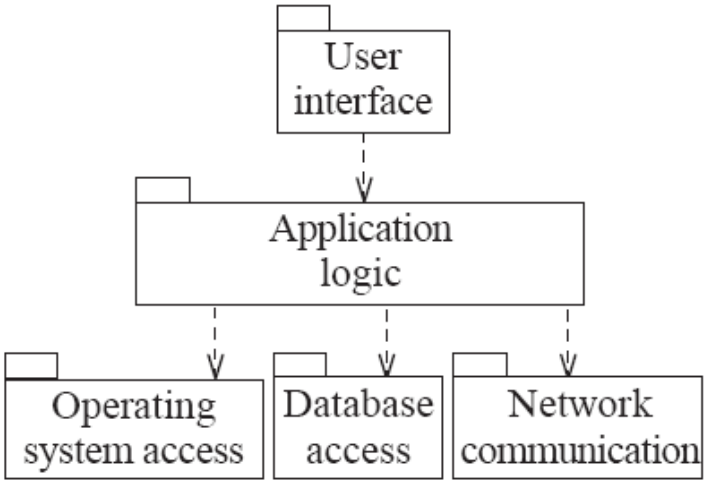
- Hierarchical decomposition of the system as an ordered set of layers.
- A layer is a subsystem that provides services to another layer:
  - A layer only depends on services from lower layers
  - A layer has no knowledge of higher layers



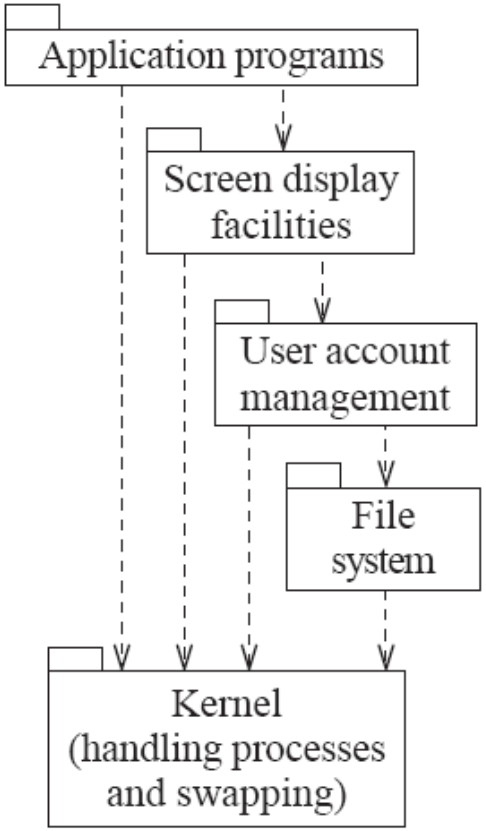
The Multi-Layer Architectural Pattern

- Each layer has a well-defined interface used by the layers above.
  - The higher layers see the lower layers as a set of *services*.
- A complex system can be built by superposing layers at increasing levels of abstraction.
  - It is important to have a separate layer for the UI.
  - Layers immediately below the UI layer provide the application functions determined by the use-cases.
  - Bottom layers provide general services.
    - e.g. network communication, database access

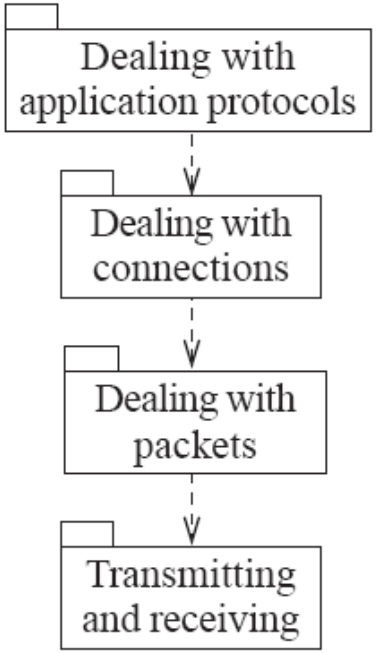
Example of Multi-layer Systems



(a) Typical layers in an application program



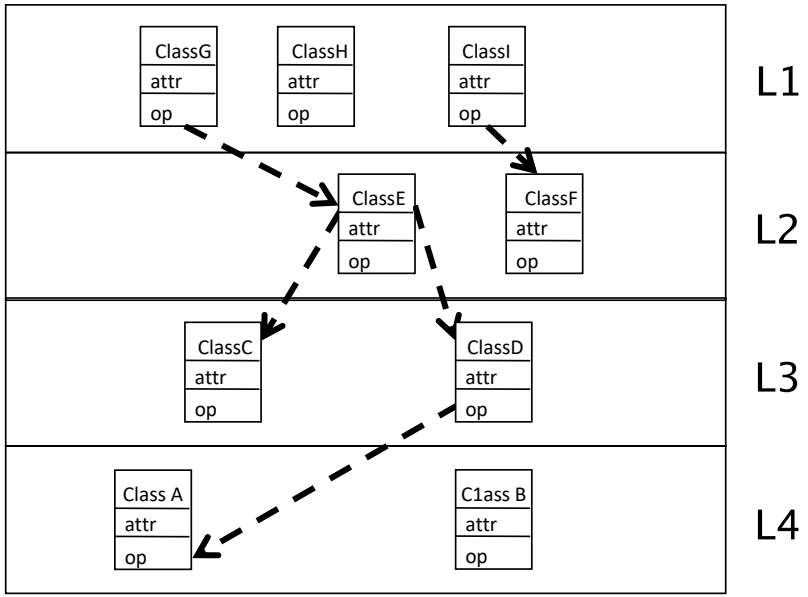
(b) Typical layers in an operating system



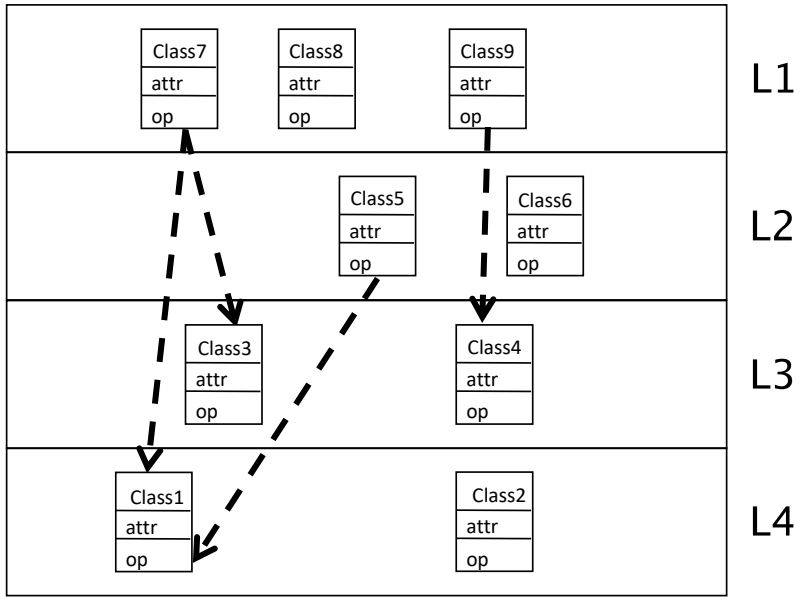
(c) Simplified view of layers in a communication system

Open vs Closed Layered Architecture

- Closed architecture: each layer communicates only with the layer immediately below it.
  - Design Goals: Maintainability, flexibility
- Open architecture: a layer can also access layers at deeper levels.
  - Design Goal: Runtime efficiency



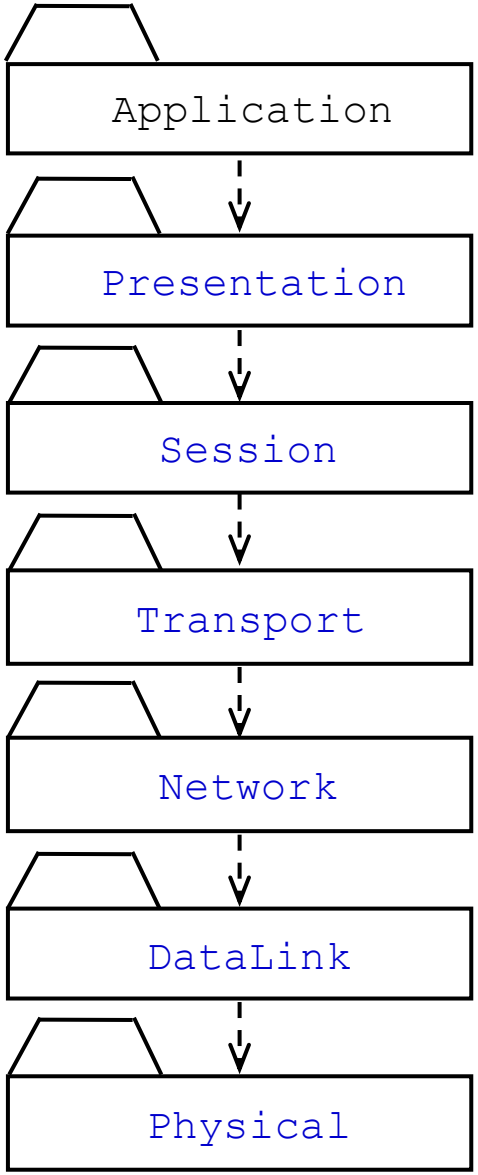
Closed Layered Architecture



Open Layered Architecture

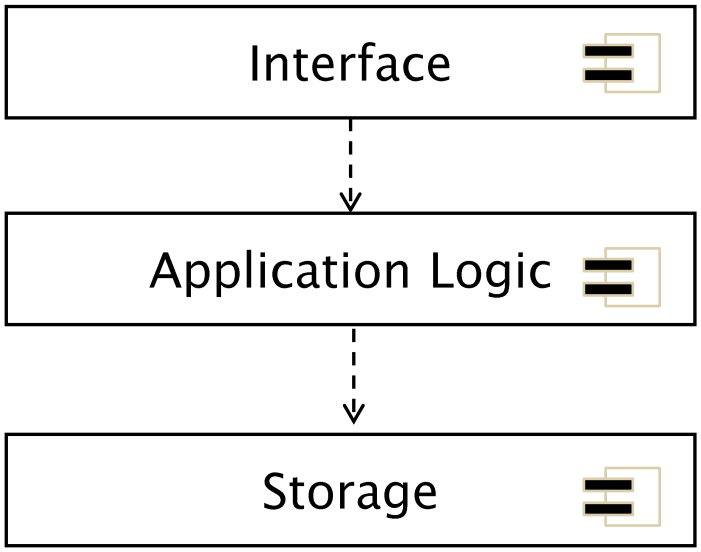
Example of Closed Layered Architecture: OSI Model Layers and their Services

- Presentation Layer
  - Services: data transformation (encryption, byte swapping)
- Session Layer
  - Services: Initializing and authenticating a connection
- Transport layer
  - Services: Transmitting messages
- Network layer
  - Services: Transmit and route data within the network
- Datalink layer
  - Services: Transmit data frames without error
- Physical layer
  - Services: Transmit bits over communication channel



Three-Tier Architectural Pattern

- An application consists of 3 hierarchically ordered subsystems
  - Interface layer: user interface
  - Application logic layer: middleware
  - Storage layer: database system



windows, forms, web pages, etc.

processing, rule checking, notifications

Storage, retrieval and query of persistent objects

Usually the 3 layers are allocated on 3 separate hardware nodes

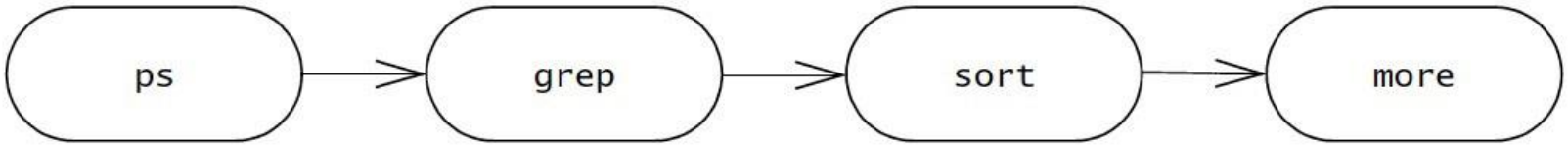
Example of a Three-tier Architecture

- Three-tier Architectural pattern is often used for the development of Websites:
  1. The Web Browser implements the user interface
  2. The Web Server serves requests from the web browser
  3. The Database manages and provides access to the persistent data.

The Pipe-and-Filter Architectural Pattern

- A pipeline consists of a chain of processing elements (processes, threads, etc.), arranged so that the output of one element is the input to the next element
- A stream of data, in a relatively simple format, is passed through these series of processes
- Each of which transforms it in some way.
- Data is constantly fed into the pipeline.
- The processes work concurrently.
- Example: Unix shell command

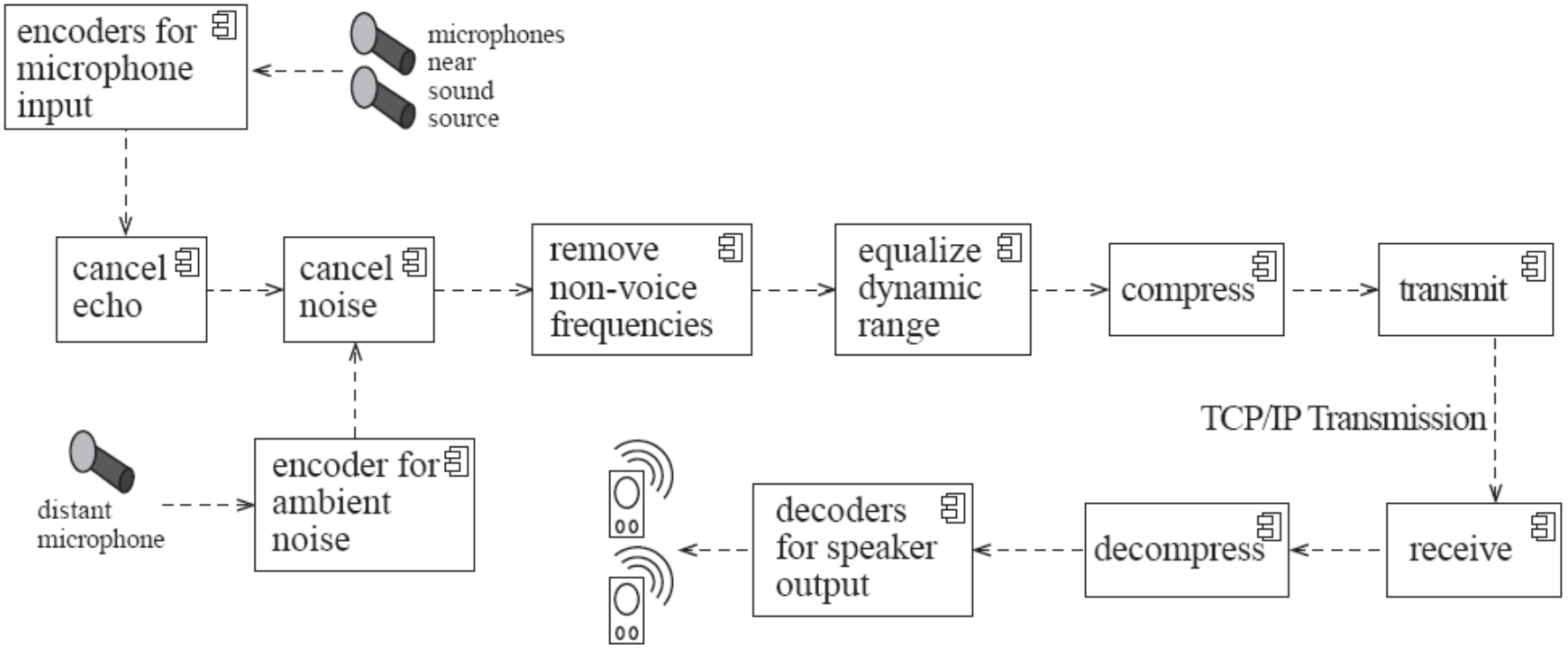
```
% ps auxwww | grep dutoit | sort | more

dutoit   19737  0.2  1.6 1908 1500 pts/6    O 15:24:36  0:00 -tcsh
dutoit   19858  0.2  0.7  816  580 pts/6    S 15:38:46  0:00 grep dutoit
dutoit   19859  0.2  0.6  812  540 pts/6    O 15:38:47  0:00 sort
```



The Pipe-and-Filter Architectural Pattern

- The architecture consists of subsystems (called pipes) and filters
  - Filter: A subsystem that does a processing step
  - Pipe: A Pipe is a connection between two processing steps
- Each filter has an input pipe and an output pipe.
- The data from the input pipe are processed by the filter and then moved to the output pipe
- The architecture is very flexible.
  - Almost all the components could be removed.
    - Components could be replaced.
    - New components could be inserted.
    - Certain components could be reordered.

Example of a Pipe-and-Filter System



Contents of a Good Architectural Model

- A system's architecture will often be expressed in terms of several different *views*
  - The logical breakdown into subsystems/classes ; The interfaces among the subsystems/classes
    - UML component diagram
    - UML class diagram
  - The dynamics of the interaction among components at run time
    - UML sequence diagram
    - UML state diagram
  - The data that will be shared among the subsystems
    - UML ER diagram
  - The components that will exist at run time, and the machines or devices on which they will be located
    - UML deployment diagram

Summary

- An architecture provides a highlevel framework to build and evolve a software system.
- Strive for modularity: strong cohesion and loose coupling.
- Consider using existing architectural styles or patterns.