WEB APP ARCHITECTURES:
MULTI-TIER (2-TIER, 3-TIER)
MODEL-VIEWER-CONTROLLER (MVC)
REST ARCHITECTURAL STYLE
Overview

- Data Independence in Relational Databases
- N-tier Architectures
- Design Patterns
  - The MVC Design Pattern
- REST Architectural Style
Data Independence in Rel. DBMS
Database Architecture With Views

Each level is independent of the levels below

User1
View1
Conceptual Schema
Internal Schema
Disk
User2
View2

What users see
Tables and links
Files on disk
Logical and Physical Independence

Each level is independent of the levels below.

- **User1** and **User2**
- **View1** and **View2**
- **Conceptual Schema**
- **Internal Schema**
- **Disk**

Logical Independence

Physical Independence
Data Independence

- **Logical Independence**: The ability to change the logical schema without changing the external schema or application programs
  - Can add new fields, new tables without changing views
  - Can change structure of tables without changing view

- **Physical Independence**: The ability to change the physical schema without changing the logical schema
  - Storage space can change
  - Type of some data can change for reasons of optimization

**LESSON**: Keep the VIEW (what the user sees) independent of the MODEL (domain knowledge)
N-tier architectures
Significance of “Tiers”

- N-tier architectures have the same components
  - Presentation
  - Business/Logic
  - Data

- N-tier architectures try to separate the components into different tiers/layers
  - Tier: physical separation
  - Layer: logical separation
1-Tier Architecture

- All 3 layers are on the same machine
  - All code and processing kept on a single machine
- Presentation, Logic, Data layers are tightly connected
  - Scalability: Single processor means hard to increase volume of processing
  - Portability: Moving to a new machine may mean rewriting everything
  - Maintenance: Changing one layer requires changing other layers
2-Tier Architecture

- Database runs on Server
  - Separated from client
  - Easy to switch to a different database

- Presentation and logic layers still tightly connected
  - Heavy load on server
  - Potential congestion on network
  - Presentation still tied to business logic
3-Tier Architecture

- Each layer can potentially run on a different machine
- Presentation, logic, data layers disconnected
A Typical 3-tier Architecture

Architecture Principles

- Client-server architecture
- Each tier (Presentation, Logic, Data) should be independent and should not expose dependencies related to the implementation
- Unconnected tiers should not communicate
- Change in platform affects only the layer running on that particular platform
A Typical 3-tier Architecture

**Presentation Layer**
- Provides user interface
- Handles the interaction with the user
- Sometimes called the GUI or client view or front-end
- Should not contain business logic or data access code
A Typical 3-tier Architecture

**Logic Layer**
- The set of rules for processing information
- Can accommodate many users
- Sometimes called middleware/back-end
- Should not contain presentation or data access code

**Presentation tier**
The top-most level of the application is the user interface. The main function of the interface is to translate tasks and results to something the user can understand.

**Logic tier**
This layer coordinates the application, processes commands, makes logical decisions and evaluations, and performs calculations. It also moves and processes data between the two surrounding layers.

**Data tier**
Here information is stored and retrieved from a database or file system. The information is then passed back to the logic tier for processing, and then eventually back to the user.
A typical 3-tier Architecture

**Data Layer**
- The physical storage layer for data persistence
- Manages access to DB or file system
- Sometimes called *back-end*
- Should not contain presentation or business logic code

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The 3-Tier Architecture for Web Apps

- **Presentation Layer**
  Static or dynamically generated content rendered by the browser (front-end)

- **Logic Layer**
  A dynamic content processing and generation level application server, e.g., Java EE, ASP.NET, PHP, ColdFusion platform (middleware)

- **Data Layer**
  A database, comprising both data sets and the database management system or RDBMS software that manages and provides access to the data (back-end)
3-Tier Architecture - Advantages

- Independence of Layers
  - Easier to maintain
  - Components are reusable
  - Faster development (division of work)
    - Web designer does presentation
    - Software engineer does logic
    - DB admin does data model
Design Patterns
Design Problems & Decisions

- Construction and testing
  - how do we build a web application?
  - what technology should we choose?
- Re-use
  - can we use standard components?
- Scalability
  - how will our web application cope with large numbers of requests?
- Security
  - how do we protect against attack, viruses, malicious data access, denial of service?
- Different data views
  - user types, individual accounts, data protection

Need for general and reusable solution: Design Patterns
What is a Design Pattern?

- A general and reusable solution to a commonly occurring problem in the design of software
- A template for how to solve a problem that has been used in many different situations
- NOT a finished design
  - the pattern must be adapted to the application
  - cannot simply translate into code
Origin of Design Patterns

- Adapted to OO Programming by Beck and Cunningham (1987)
- Now widely-used in software engineering
The MVC Design Pattern
Design Problem

- Need to change the **look-and-feel** without changing the **core/logic**
- Need to **present data under different contexts** (e.g., powerful desktop, web, mobile device).
- Need to **interact with/access data under different contexts** (e.g., touch screen on a mobile device, keyboard on a computer).
- Need to maintain **multiple views of the same data** (list, thumbnails, detailed, etc.)
Design Solution

- Separate core functionality from the presentation and control logic that uses this functionality
- Allow multiple views to share the same data model
- Make supporting multiple clients easier to implement, test, and maintain
The Model-View-Controller Pattern

Design pattern for graphical systems that promotes separation between model and view

With this pattern the logic required for data maintenance (database, text file) is separated from how the data is viewed (graph, numerical) and how the data can be interacted with (GUI, command line, touch)
The MVC Pattern

- **Model**
  - manages the behavior and data of the application domain
  - responds to requests for information about its state (usually from the view)
  - follows instructions to change state (usually from the controller)

- **View**
  - renders the model into a form suitable for interaction, typically a user interface (multiple views can exist for a single model for different purposes)

- **Controller**
  - receives user input and initiates a response by making calls on model objects
  - accepts input from the user and instructs the model and viewport to perform actions based on that input
The MVC Pattern (in practice)

- **Model**
  - Contains domain-specific knowledge
  - Records the state of the application
    - E.g., what items are in a shopping cart
  - Often linked to a database
  - Independent of view
    - One model can link to different views

- **View**
  - Presents data to the user
  - Allows user interaction
  - Does no processing

- **Controller**
  - defines how user interface reacts to user input (events)
  - receives messages from view (where events come from)
  - sends messages to model (tells what data to display)
The MVC for Web Applications

- Model
  - database tables (persistent data)
  - session information (current system state data)
  - rules governing transactions

- View
  - (X)HTML
  - CSS style sheets
  - server-side templates

- Controller
  - client-side scripting
  - http request processing
  - business logic/preprocessing
MVC Advantages

- **Clarity of Design**
  - model methods give an API for data and state
  - eases the design of view and controller

- **Efficient Modularity**
  - any of the components can be easily replaced

- **Multiple Views**
  - many views can be developed as appropriate
  - each uses the same API for the model

- **Easier to Construct and Maintain**
  - simple (text-based) views while constructing
  - more views and controllers can be added
  - stable interfaces ease development

- **Distributable**
  - natural fit with a distributed environment
3-tier Architecture vs. MVC Architecture

- Communication
  - **3-tier**: The presentation layer never communicates directly with the data layer—only through the logic layer (linear topology)
  - **MVC**: All layers communicate directly (triangle topology)

- Usage
  - **3-tier**: Mainly used in web applications where the client, middleware and data tiers ran on physically separate platforms
  - **MVC**: Historically used on applications that run on a single graphical workstation (applied to separate platforms as Model 2)