

WEB APP ARCHITECTURES: MULTI-TIER (2-TIER, 3-TIER) & MVC

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Based on materials by Marty Stepp, M. Ernst, S. Reges, D. Notkin, R. Mercer, R. Boswell, Wikipedia

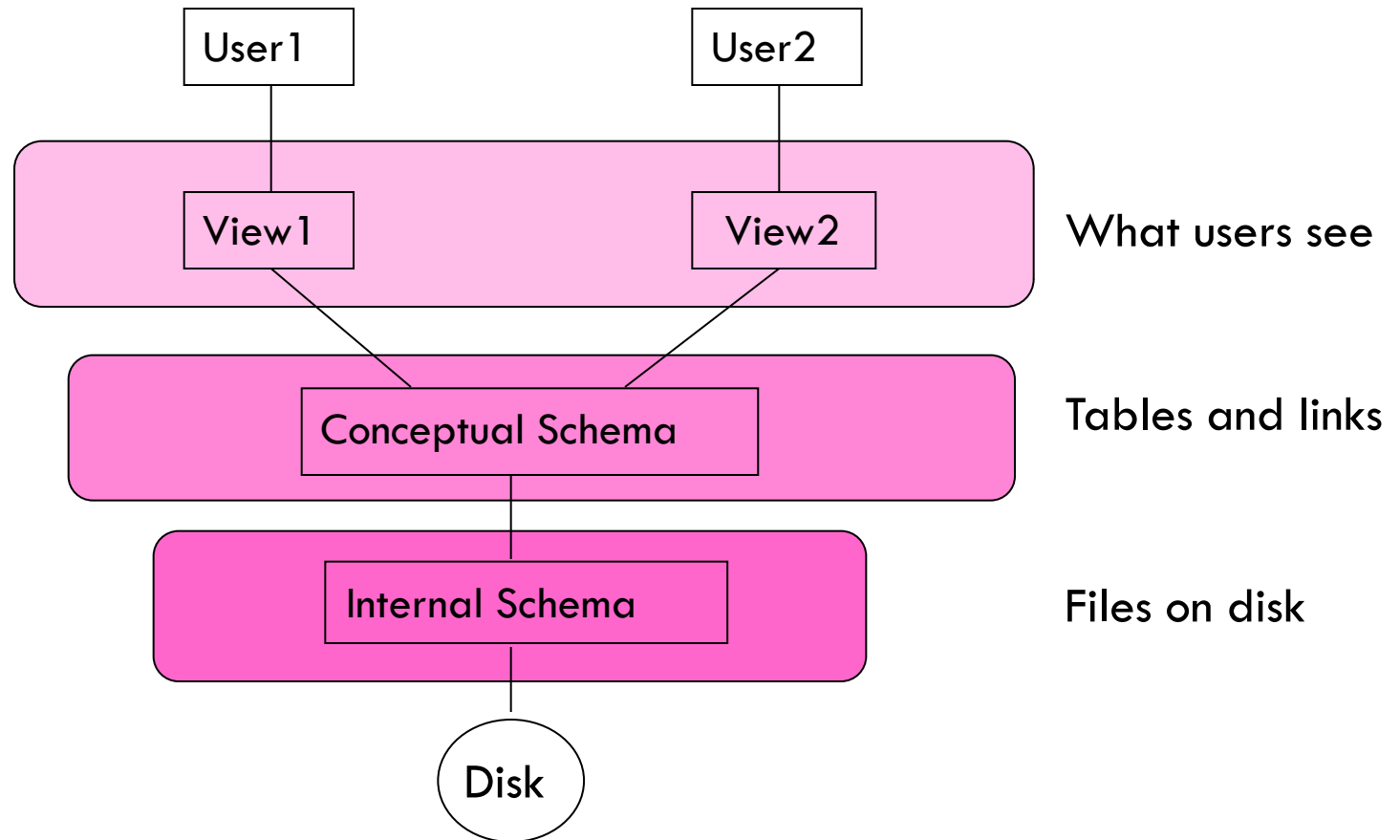
Overview

- Data Independence in Relational Databases
- N-tier Architectures
- Design Patterns
- The MVC Design Pattern

Data Independence in Rel. DBMS

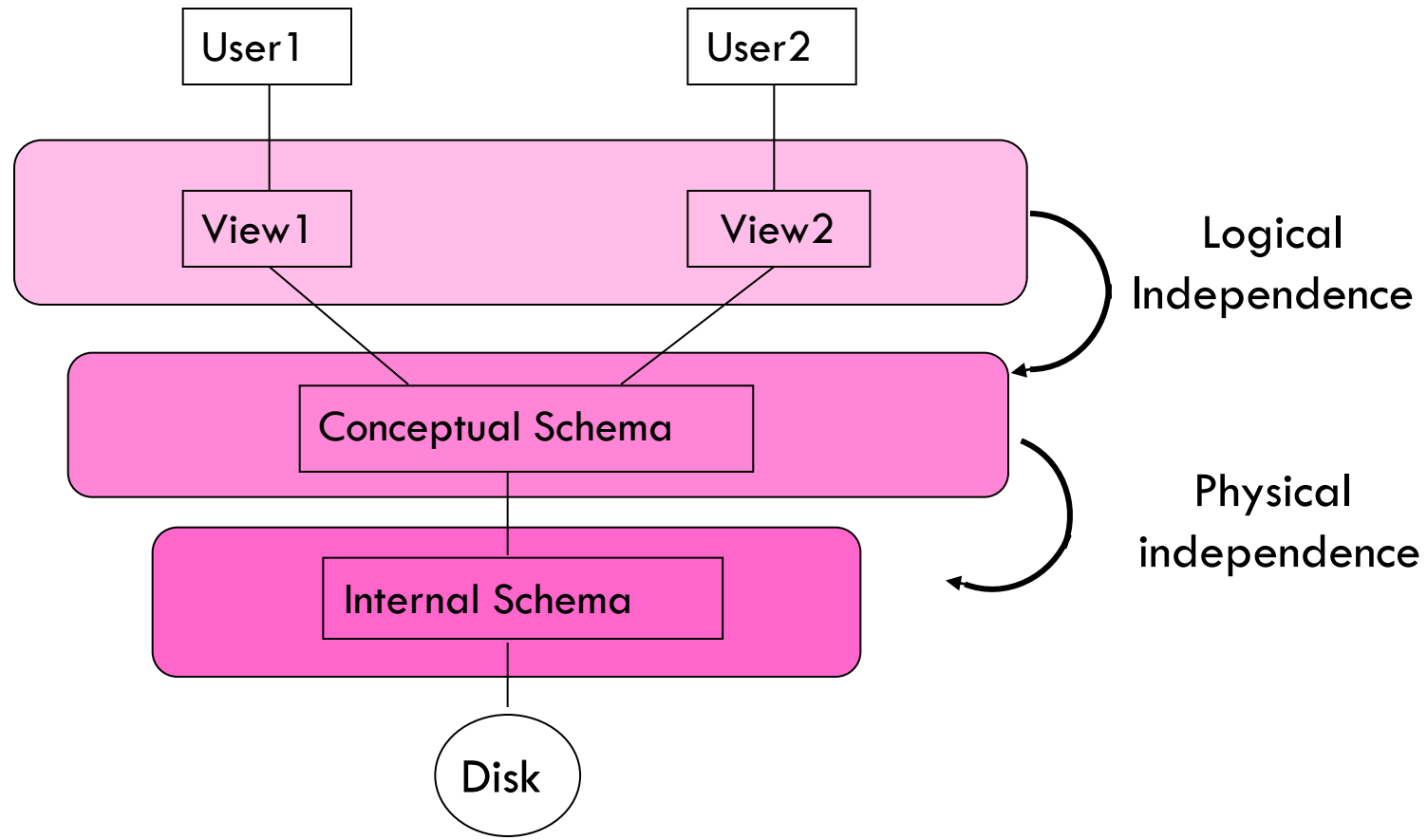
Database Architecture With Views

4



Each level is independent of the levels below

Logical and Physical Independence



Each level is independent of the levels below

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

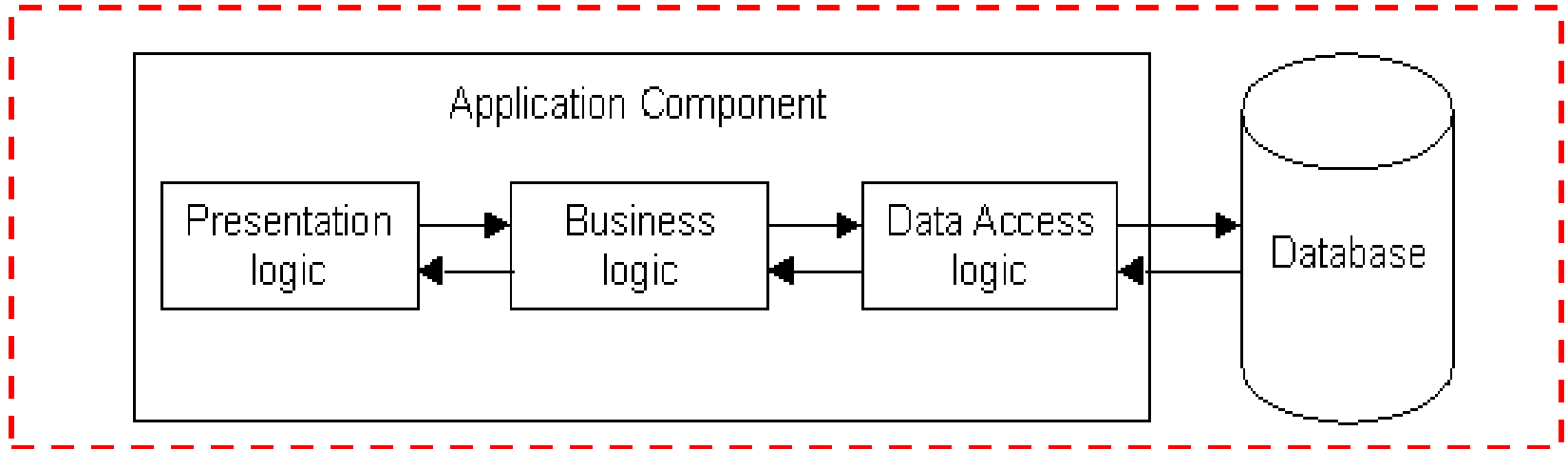
LESSON: Keep the VIEW (what the user sees) independent of the MODEL (domain knowledge)

N-tier architectures

Significance of “Tiers”

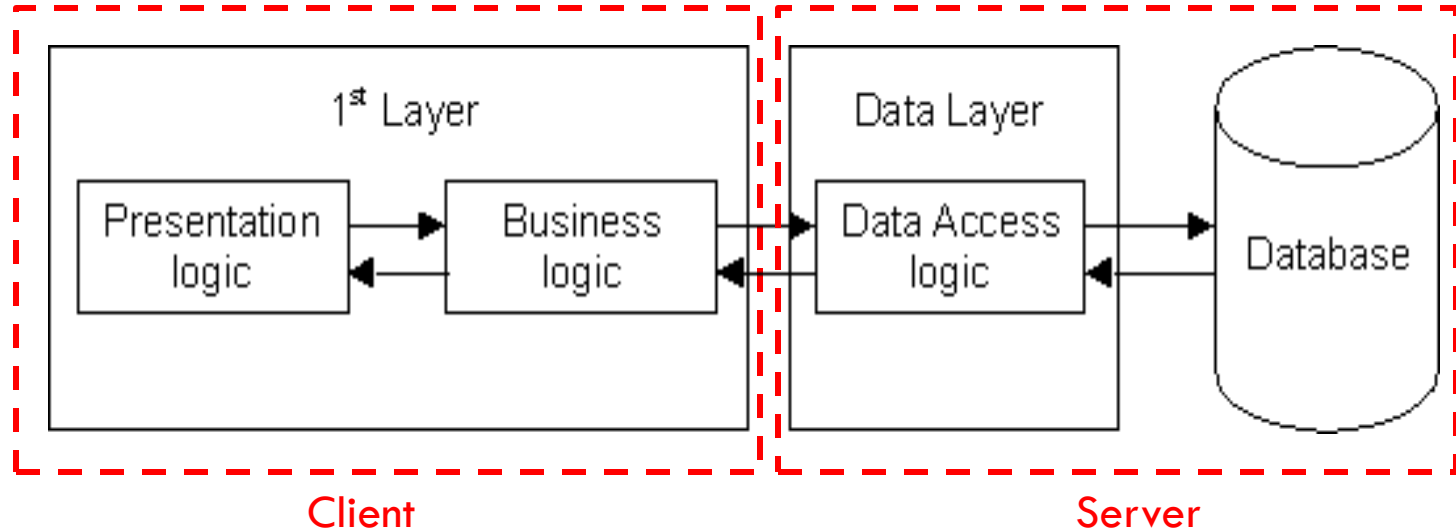
- N-tier architectures have the same components
 - ▣ Presentation
 - ▣ Business/Logic
 - ▣ Data
- N-tier architectures try to separate the components into different tiers/layers
 - ▣ Tier: physical separation
 - ▣ Layer: logical separation

1-Tier Architecture



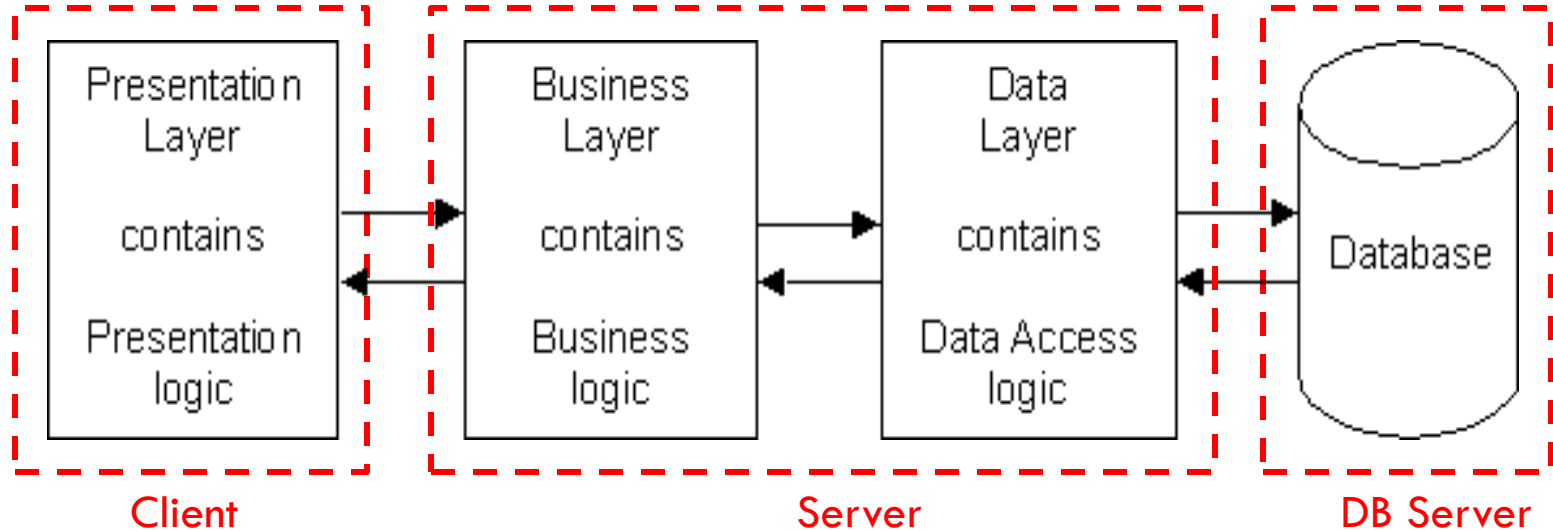
- All 3 layers are on the same machine
 - ▣ All code and processing kept on a single machine
- Presentation, Logic, Data layers are tightly connected
 - ▣ Scalability: Single processor means hard to increase volume of processing
 - ▣ Portability: Moving to a new machine may mean rewriting everything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

2-Tier Architecture



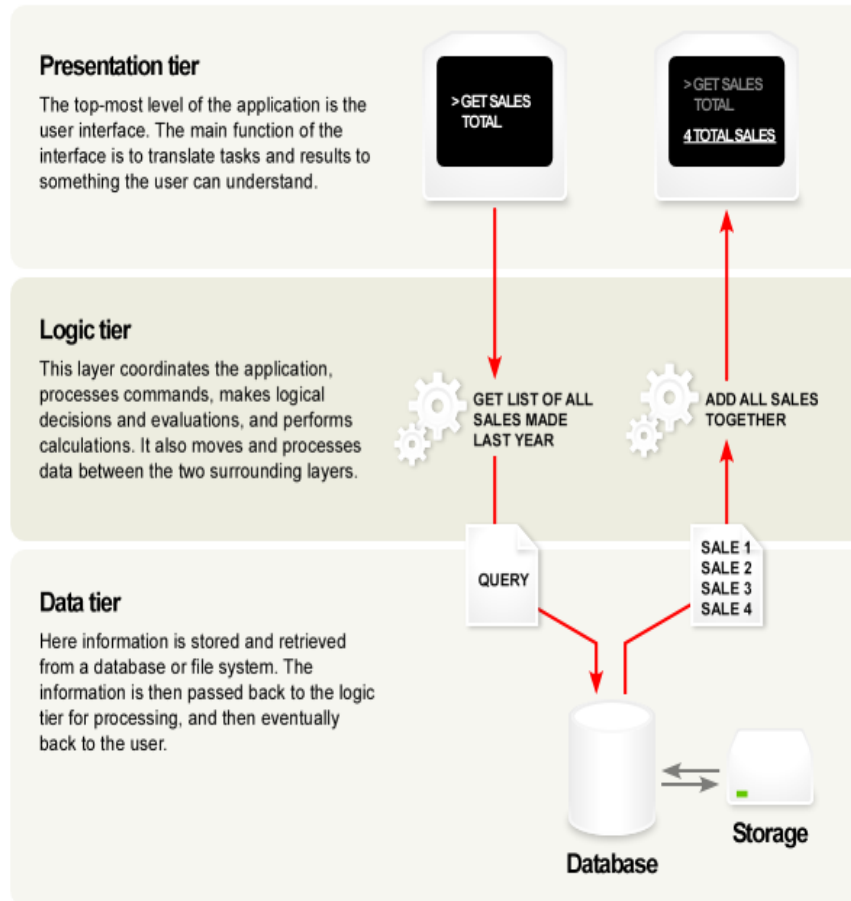
- ❑ Database runs on Server
 - ▣ Separated from client
 - ▣ Easy to switch to a different database
- ❑ Presentation and logic layers still tightly connected
 - ▣ Heavy load on server
 - ▣ Potential congestion on network
 - ▣ Presentation still tied to business logic

3-Tier Architecture



- Each layer can potentially run on a different machine
- Presentation, logic, data layers disconnected

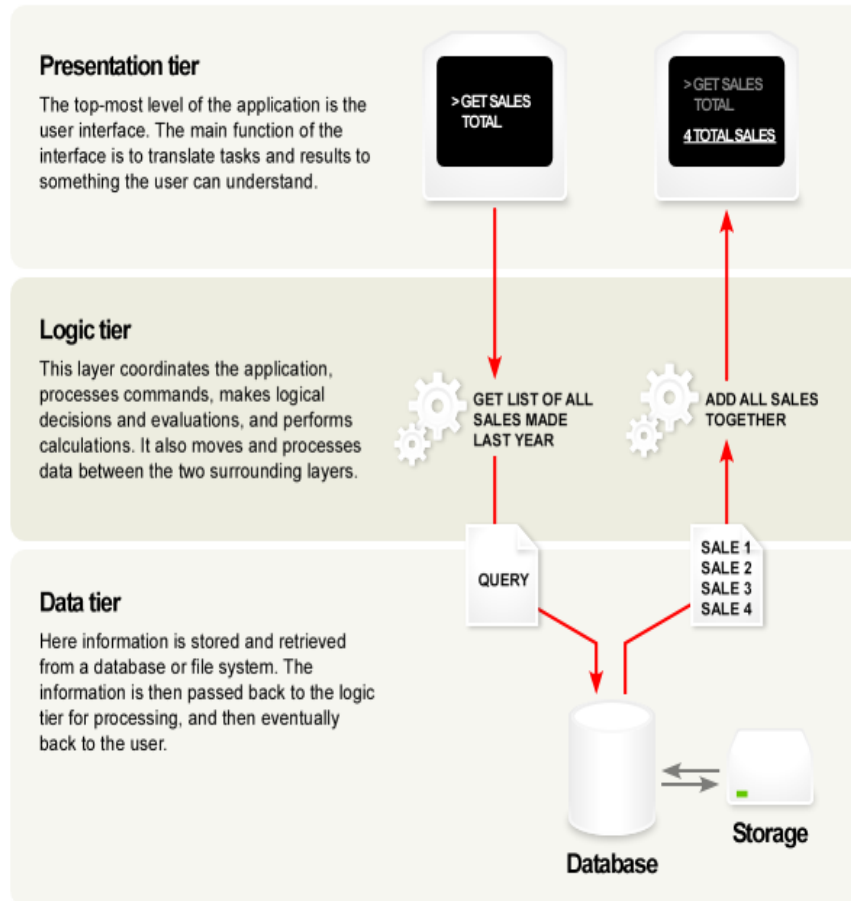
A Typical 3-tier Architecture



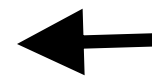
Architecture Principles

- 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

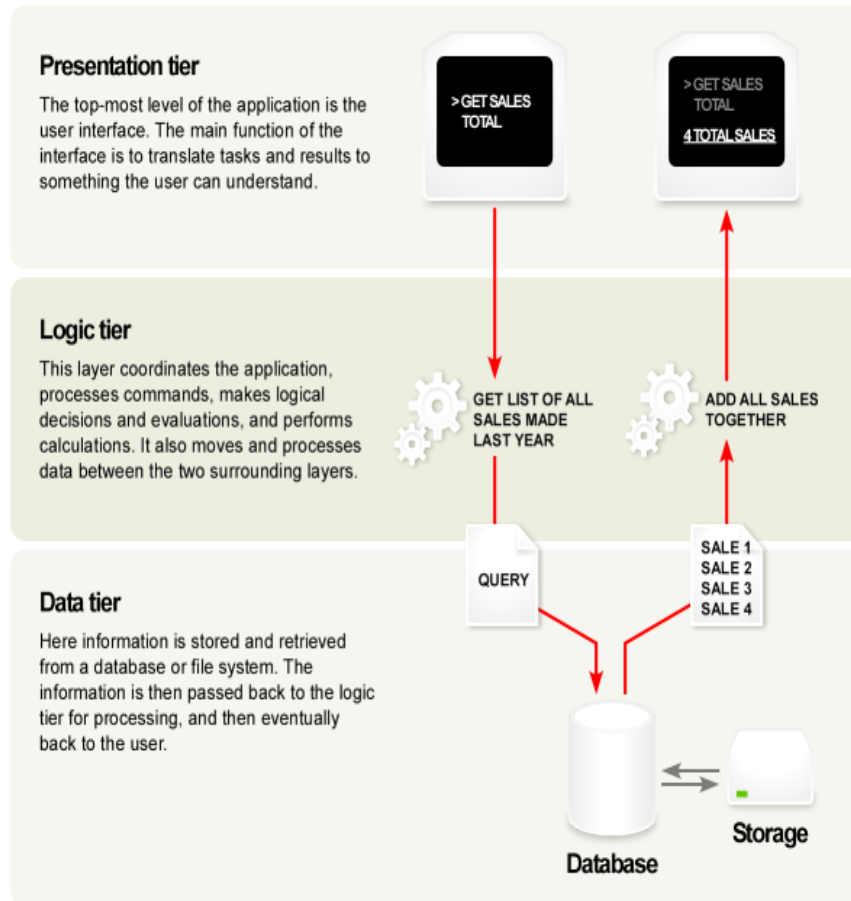


Presentation Layer



- 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

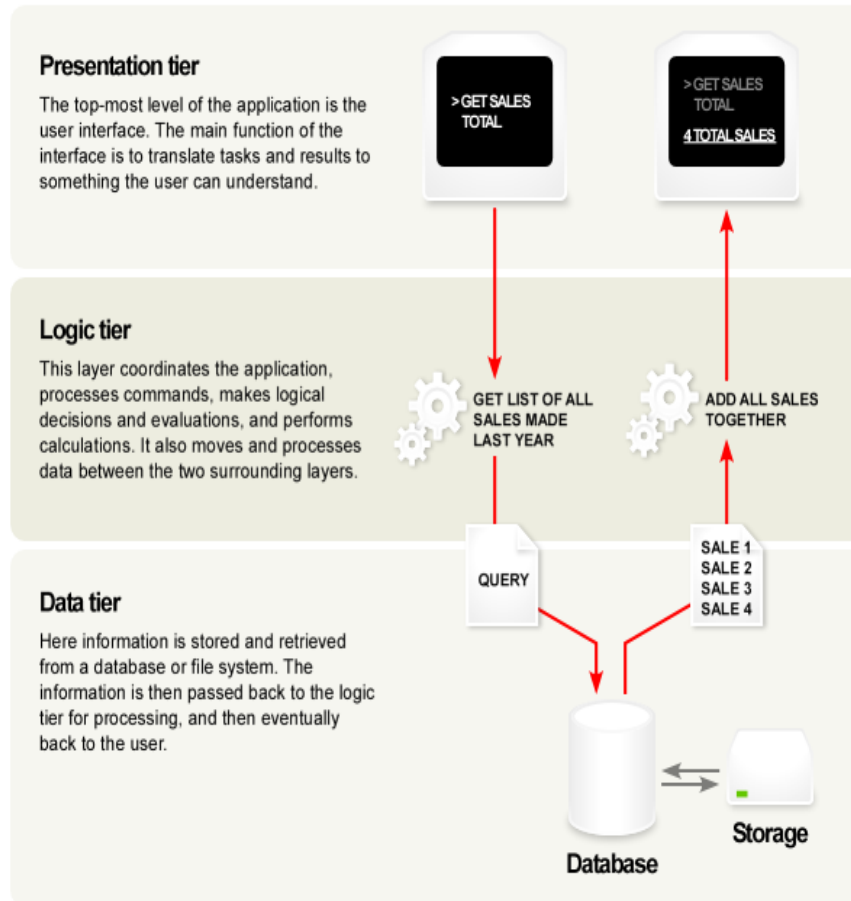
A Typical 3-tier Architecture



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

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

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

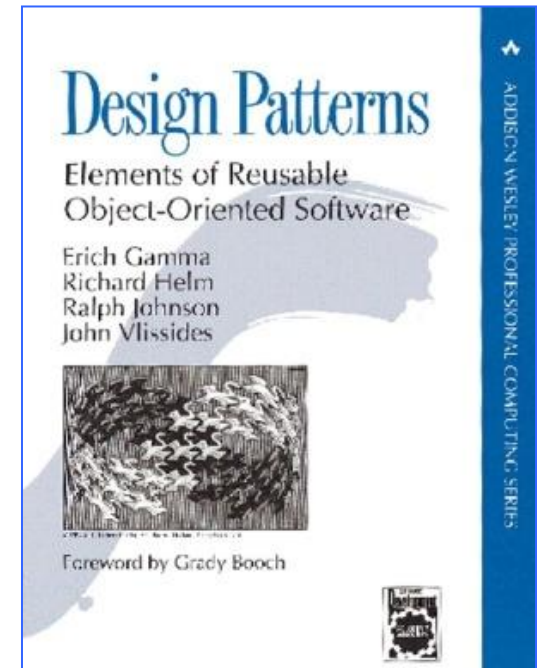
Need for general and reusable solution: **Design Patterns**

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

- Architectural concept by Christopher Alexander (1977/79)
- Adapted to OO Programming by Beck and Cunningham (1987)
- Popularity in CS after the book: “Design Patterns: Elements of Re-useable Object-oriented software”, 1994. Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides
- 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.)

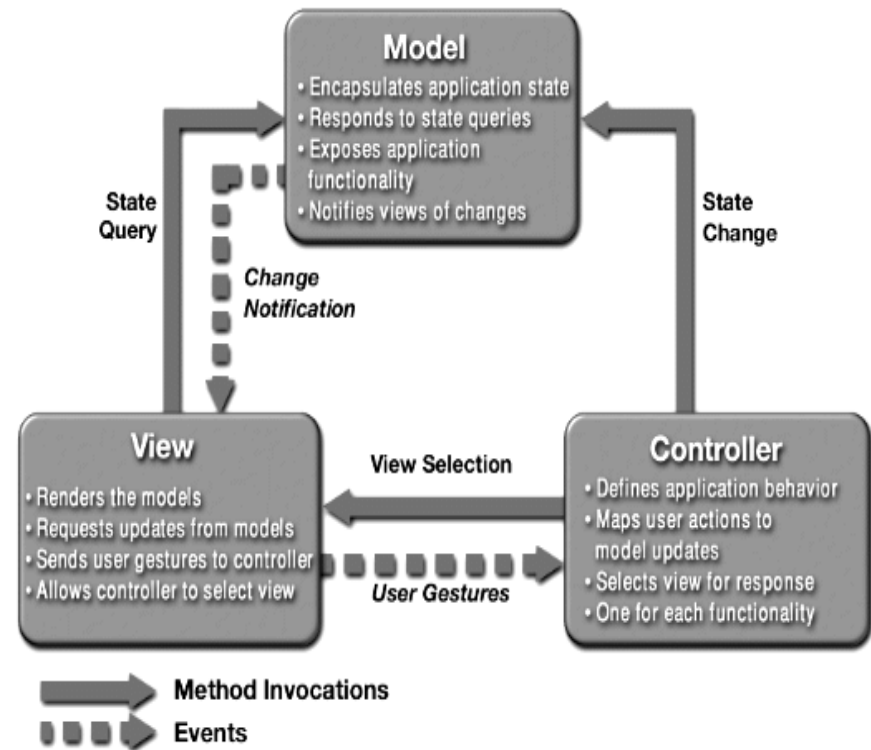
Design Solution

- 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

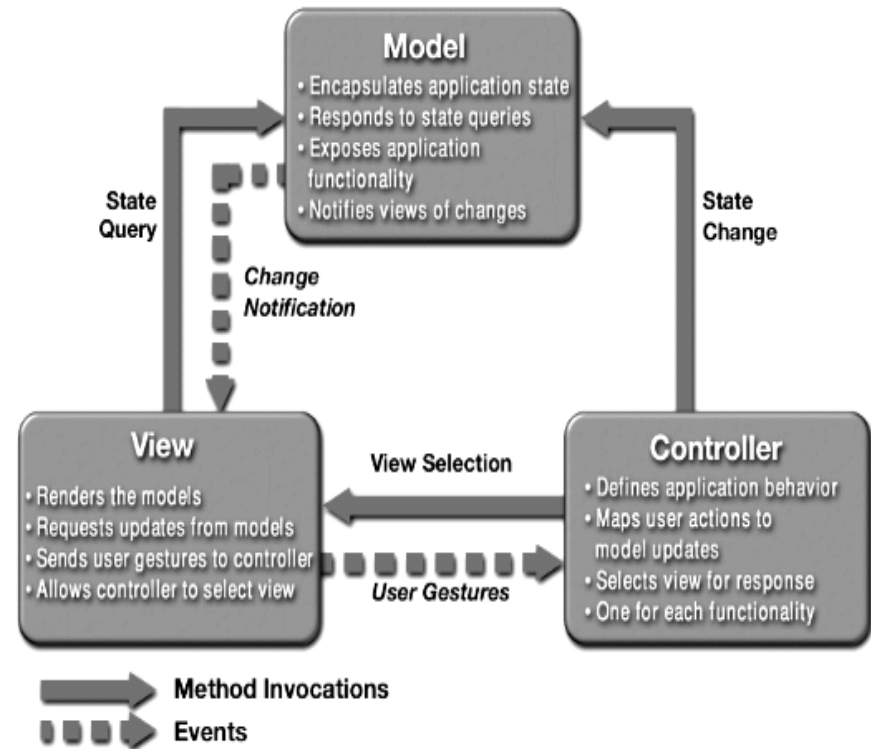
Design pattern for graphical systems that promotes separation between model and view

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)



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 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*)