DESIGN: ARCHITECTURE AND METHODOLOGY

Software Engineering
CS 130

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Content adapted from Essentials of Software Engineering 3rd edition by Tsui, Karam, Bernal Jones and Bartlett Learning

Design Topics Covered

1. Architectural .vs. Detailed design

2. "Common" architectural styles, tactics and reference architectures

3. Basic techniques for detailed design

4. Basic issues with user-interface design

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Design

- **Starts mostly from/with requirements (evolving mostly from functionalities and other non-functional characteristics)**
- **How is the software solution going to be structured?**
  - **What are the main *components* --- (*functional comp*)**
    - ***Often* directly *from Requirements' Functionalities (use Cases)***
  - **How are these *components related ?***
    - **possibly re-organize the components (composition/ decomposition)**
- **Two main levels of design:**
  - **Architectural (high-level)**
  - **Detailed design**
- **How should we depict design--notation/ language?**

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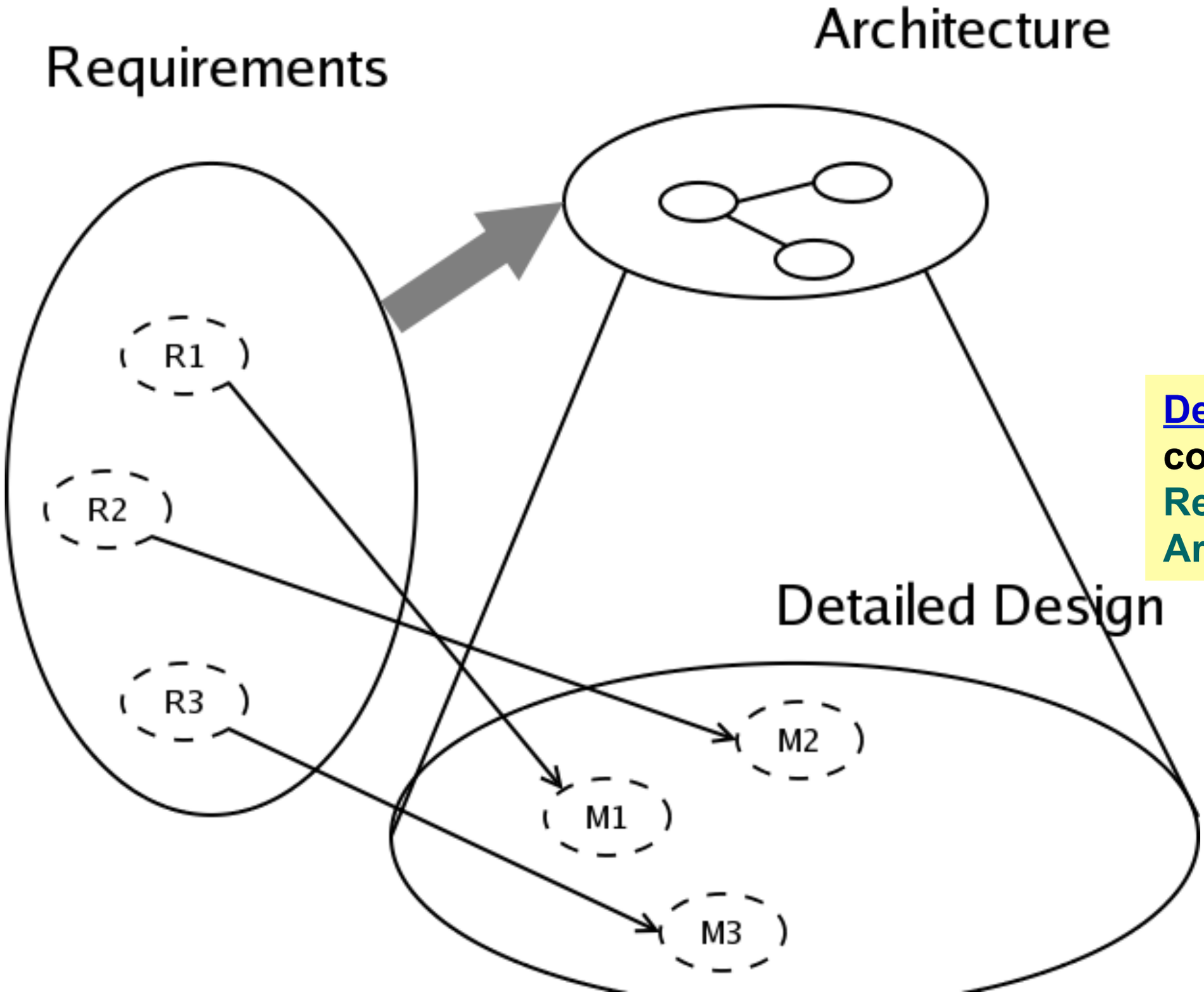
Relationship between Architecture and Design



Detailed Design come from **Requirements** & **Architecture**

Software Architecture

- **Structure**(s) **of the solution**, comprising:
  1. Major Software **Elements**
  2. Their externally visible **properties**
  3. **Relationships** among elements

- **Every software system has an architecture**

- **May have Multiple structures !**
  - multiple ways of organizing elements, *depending on the perspective*

- **External properties of components (& modules)**
  - ***Component (Module) interfaces***
  - ***Component (Module) interactions***, rather than internals of components and modules

Views and Viewpoints

- **View** – Representation of a system structure
- **4+1 views** (**by Krutchen**)
  - **Logical** (OO decomposition – key abstractions)
  - **Process** (run-time, concurrency/distribution of functions)
  - **Subsystem** decomposition
  - **Physical** architecture
  - **+1**: use cases
- **Other classification** (Bass, Clements, Kazman)
  - Module
  - Run-Time
  - Allocation (mapping to development environment)
- Different views for different people

Architectural Styles/Patterns

We discuss Architectural Styles/Patterns as "reusable" starting point for Design activities

1. **Pipes-and-Filters**
2. **Event-Driven**
3. **Client-Server**
4. **Model-View-Controller (MVC)**
5. **Layered**
6. **Database Centric**
7. **Three tier**

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Pipe-Filter architecture style

- **The high level design solution is decomposed into 2 "generic" parts (filters and pipes):**
  - ***Filter is a service that transforms a stream of input data into a stream of output data***
  - ***Pipe is a mechanism or conduit through which the data flows from one filter to another***

*** Reminds one of DFD without the data store or source sink ****

Problems that require *batch file processing* seem to fit this architecture:
e. g. payroll, compilers, month-end accounting

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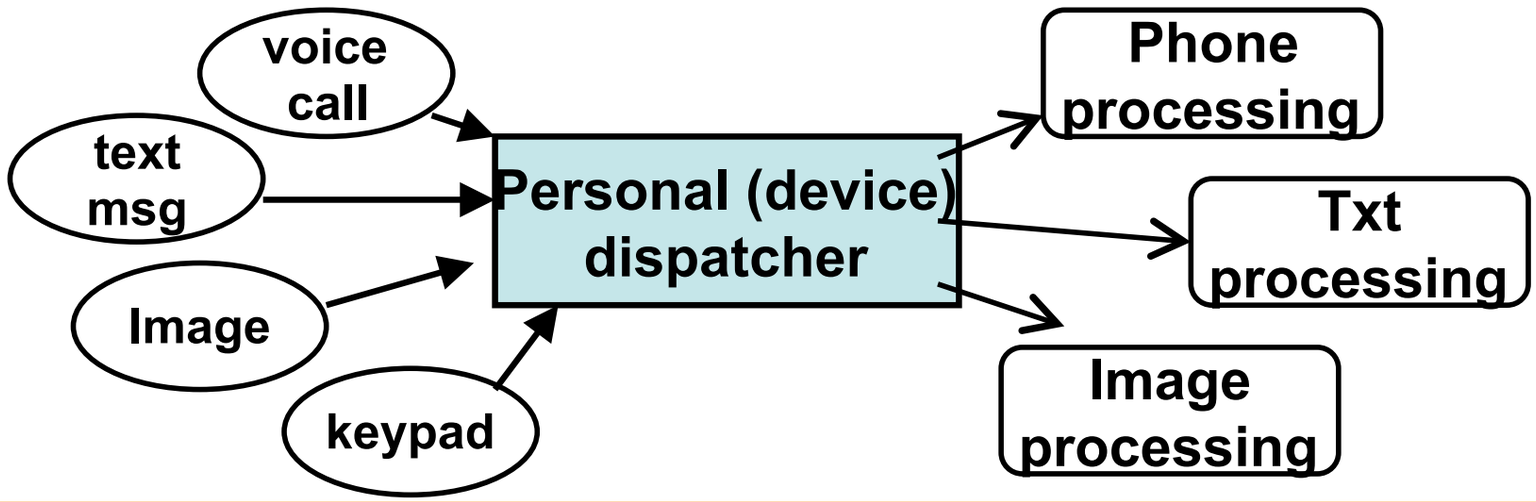
Event-Driven (Realtime)

- **The high level design solution is based on an *event dispatcher* which manages events and the functionalities which depends on those events. These have the following characteristics:**
  - **Events may be a simple notification or may include associated data**
  - **Events may be prioritized or be based on constraints *such as time***
  - **Events may require synchronous or asynchronous processing**
  - **Events may be "registered" or "unregistered" by components**

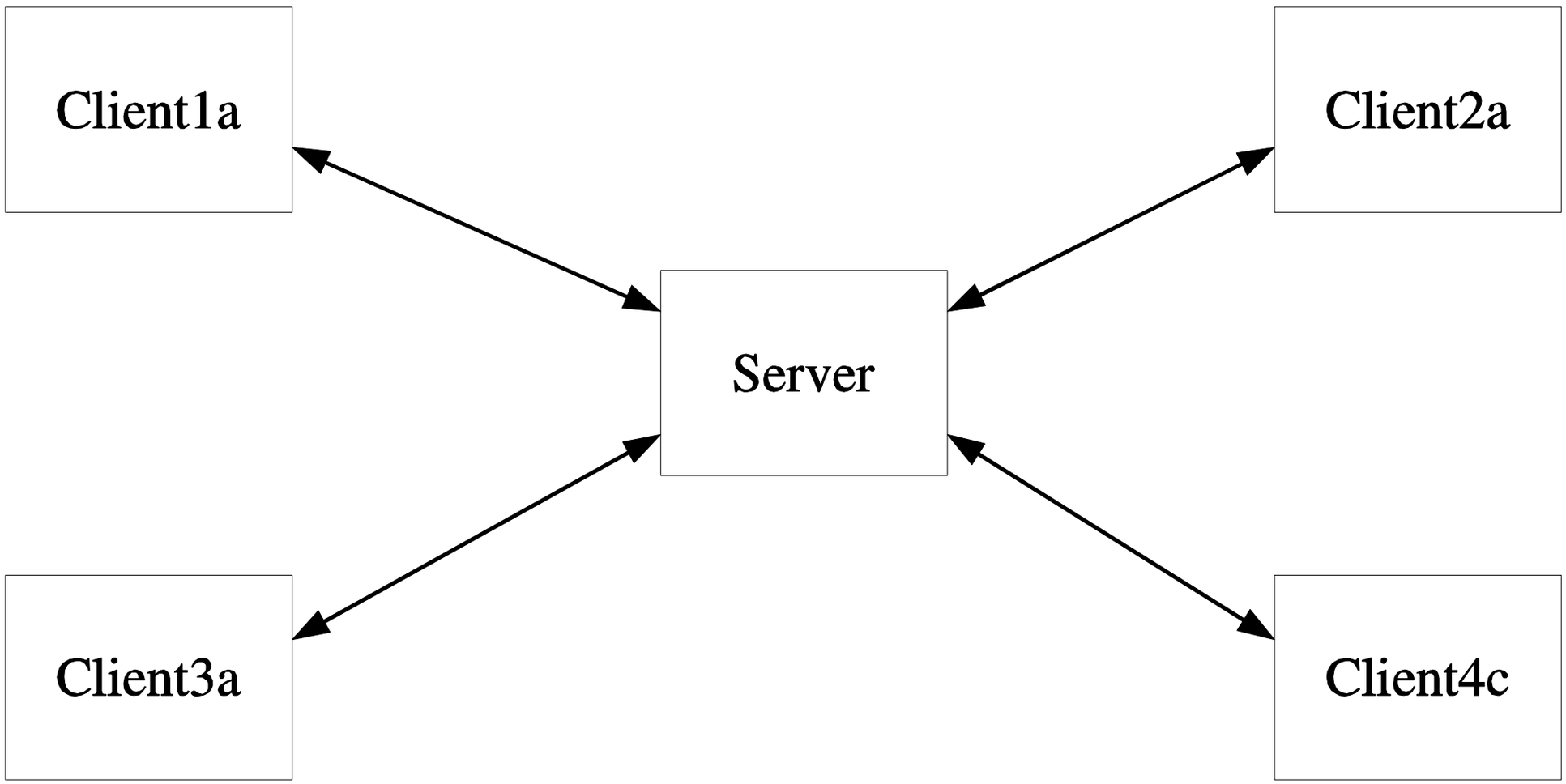


Problems that fit this architecture includes real-time systems such as: airplane control; medical equipment monitor; home monitor; embedded device controller; game; etc.

- - - try a commercial flight control system - - -

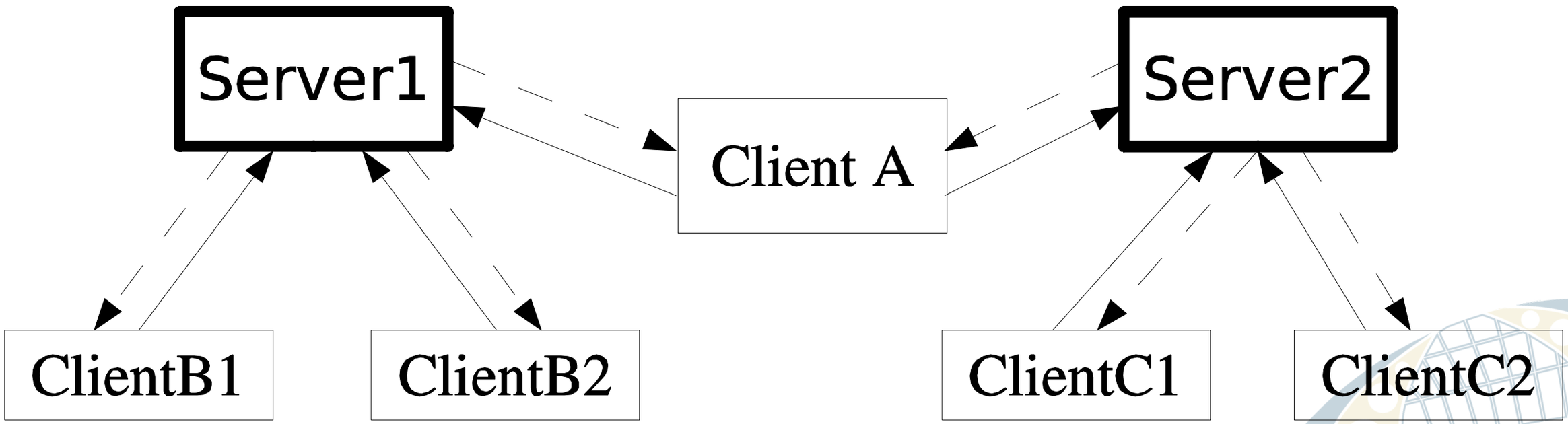
Basic Client-Server Style

Application split into client component and server component



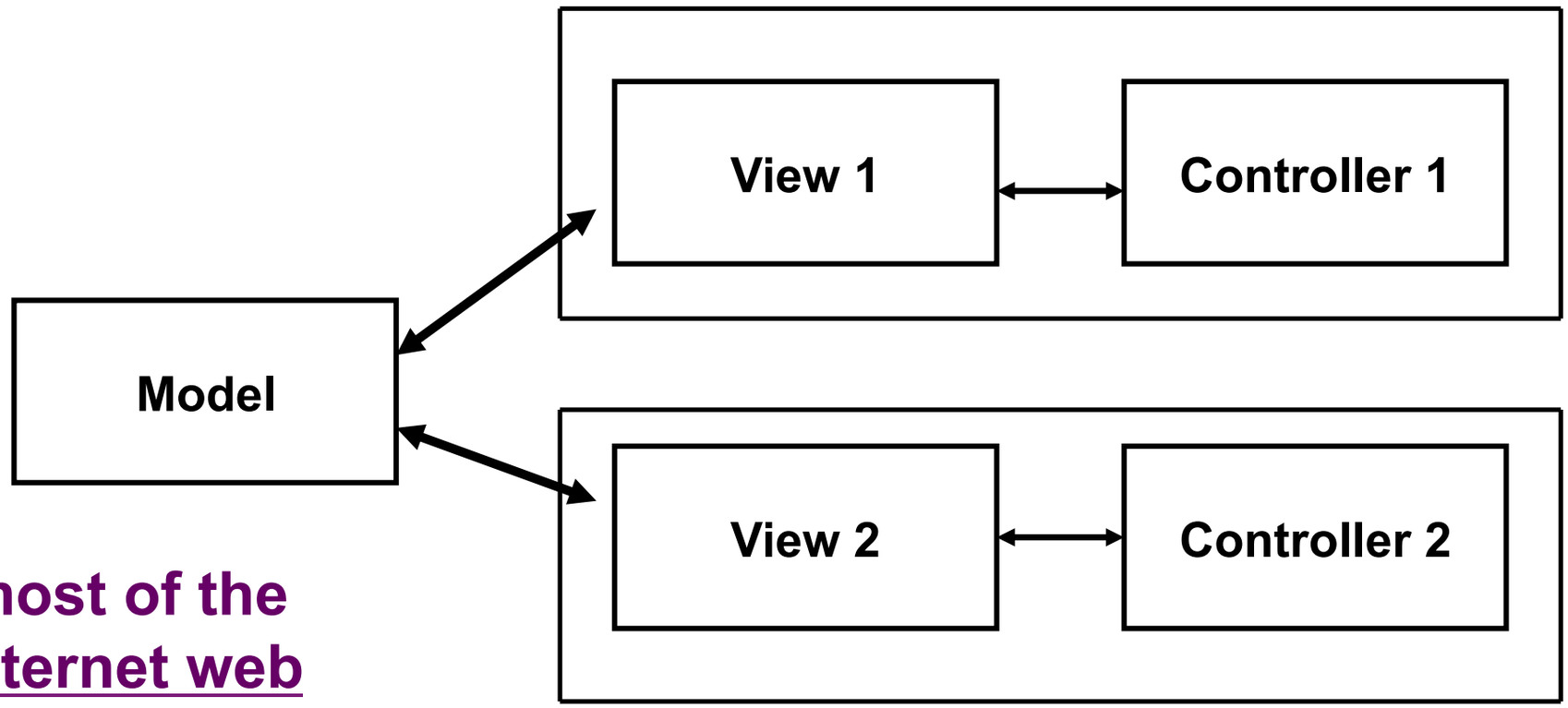
Client-Server Style

- **Client may connect to more than one server** (**servers are usually independent**)



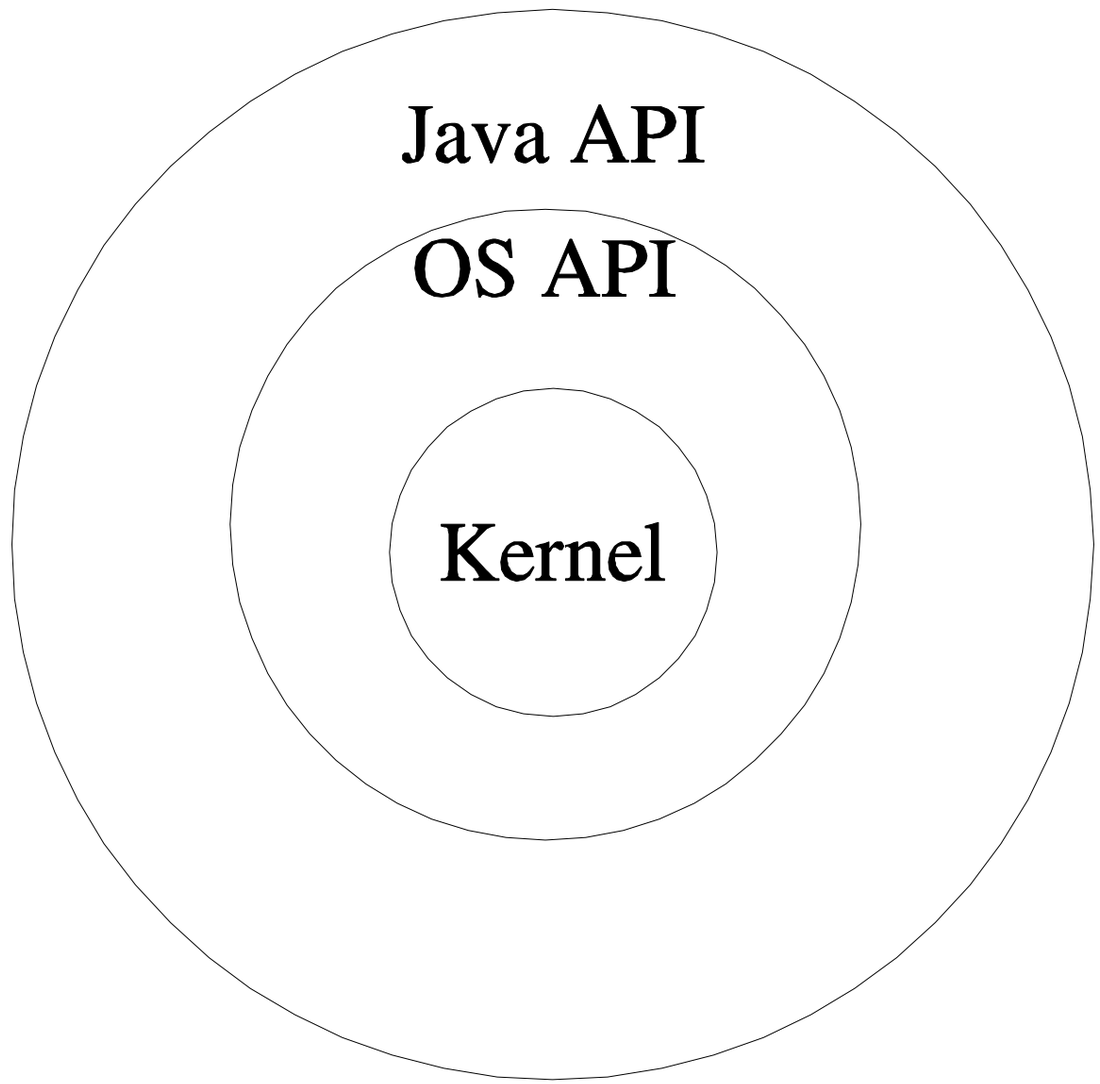
Model View Control (MVC) Style

- Separates ***model (data)*** from ***view***
- ***Controller*** often integrated with ***view*** nowadays



most of the internet web applications fall under this style

Layered Style



The "outer" layer can only ask for service from the "inner" layer or "upper" layer can only ask for service from "lower" layer.

- ***strict layering*----- only directly inside or below layers**
- ***relaxed layering*---- any inside or below layers**

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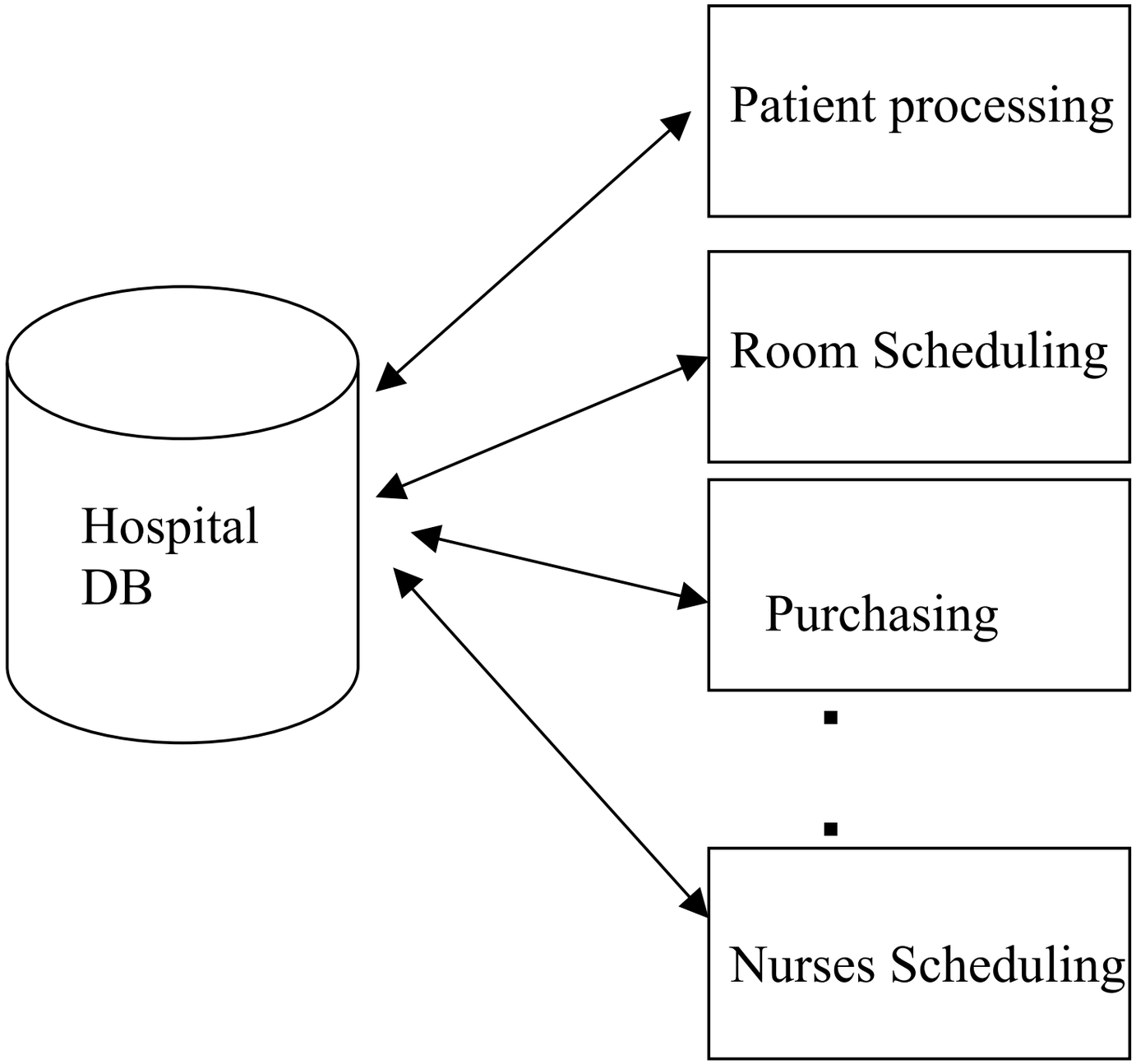
Shared Data (DB) centric style



Very popular within the business applications community

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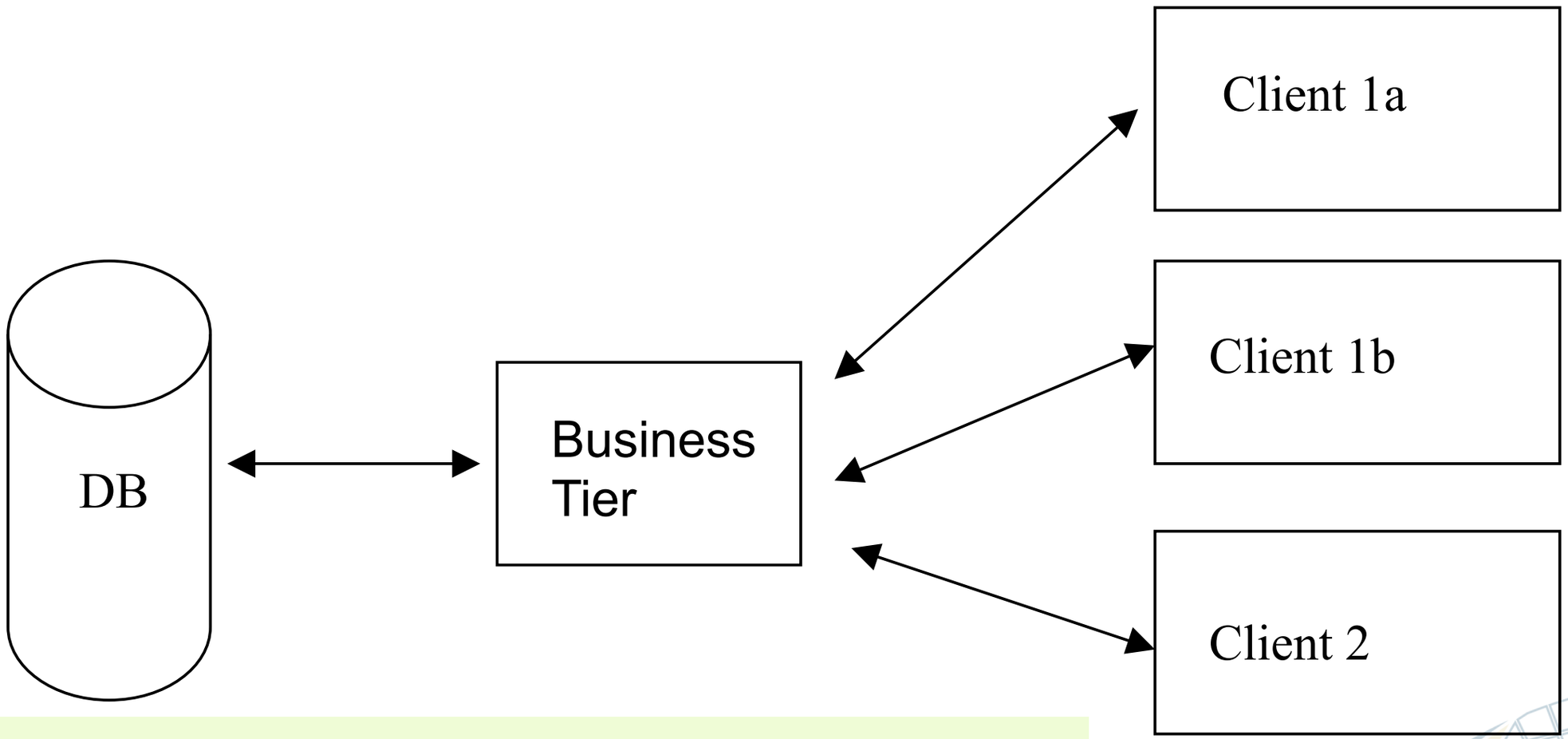
Three tier style (mixture)

- **Clients do not access DB directly**
- **Better Flexibility, integrity (why?)**



Reminds one of Client-Server or MVC ?

Architectural Tactics

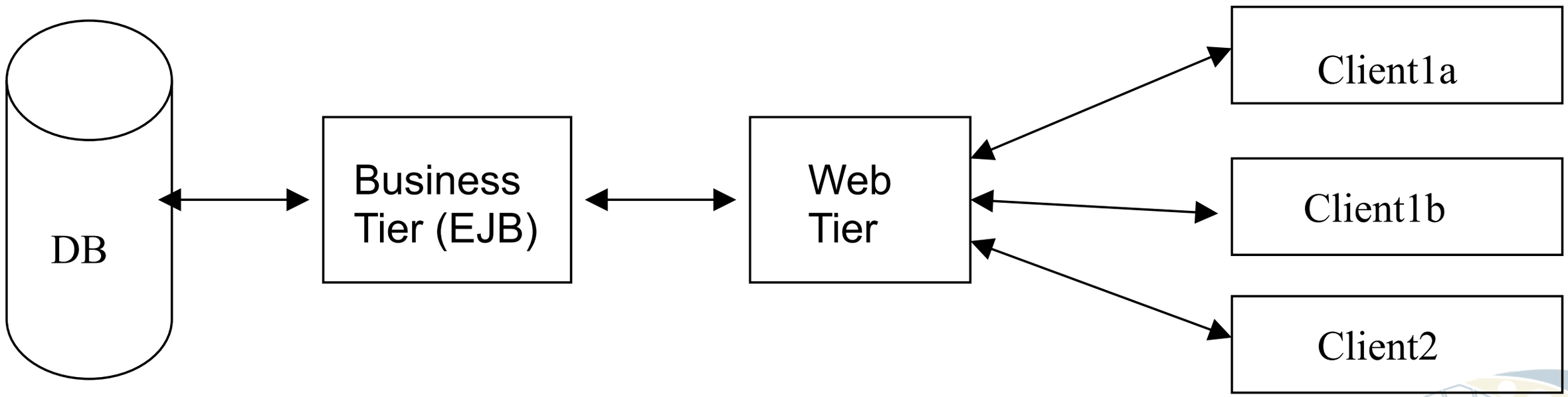
- **Tactics (in contrast to architectural style) are for solving "smaller, specific" problems**

- **Do not affect overall structure of system**

- **Example: we add specific functionalities or component (e.g. to increase reliability) in the design for fault detection ---- especially for distributed systems:**
  - ***heartbeat***
  - ***ping / echo***

Reference Architectures

- **Full-fledged architectures**
- **Serves as *"templates"* or as *"a reference"* for a class of systems**
- **Example: J2EE Reference Architecture (MVC2)**



There also are *"application domain specific"* reference architectures

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Detailed Design

- **Further Refine Architecture and match with Requirements**
- **How detailed ?**
- **How formal ?**
- **Maybe of different levels of detail for different views**

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Functional Decomposition Technique

- **Dates back to "structured programming" [now (non-OO)Web apps with PHP tool]**

- **Start with: main (task/requirements) -> module**

- **Refine into sub-modules**

- **There are alternative decompositions**

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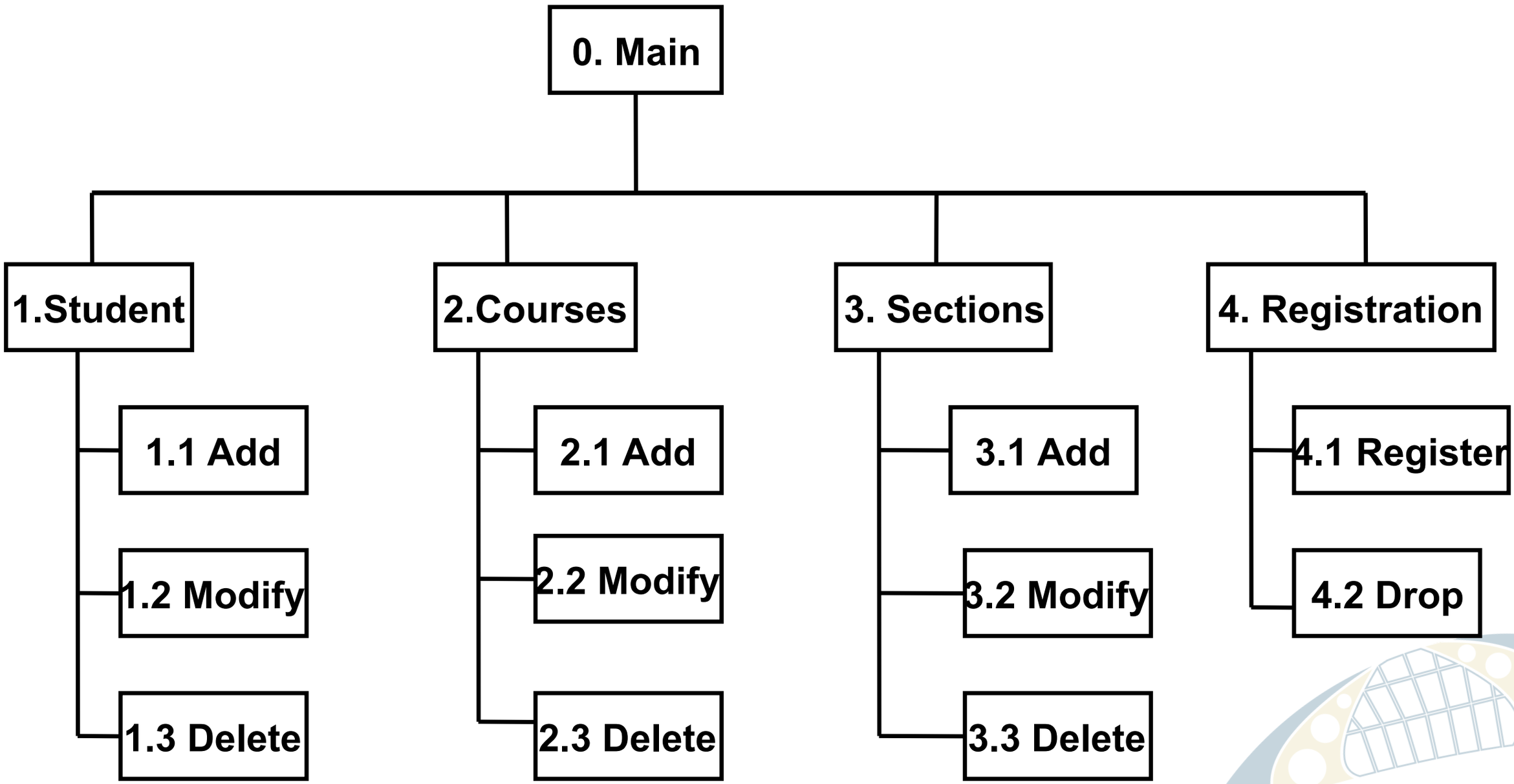
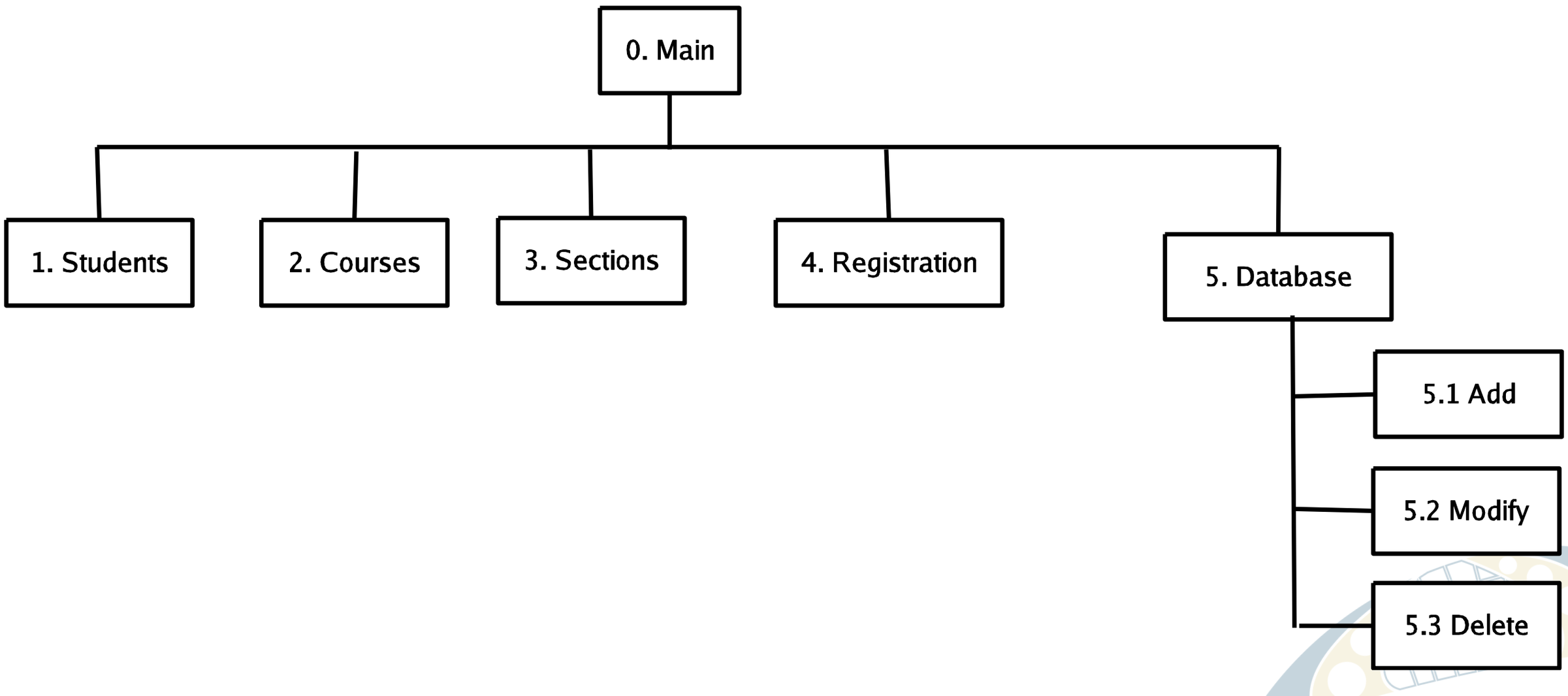
Possible Decomposition of (student- course management app)



"Alternative" Decomposition/Composition



Relational Database Design

- **Most databases use relational technology**
- **Relations (tables)**
  - **Two-dimensional sets**
  - **Rows (tuples), Columns (attributes)**
    - **A Row may be an entity, Columns may be relationship or attributes**
  - **Primary key (unique identifier) – for search**
  - **Foreign keys (connects tables)**

Database Design

- **Conceptual modeling** (done during analysis/requirement phase) produces ER diagram
- **Logical design** (to relational)
- **Physical design** (decide data types, etc.)
- **Deployment/maintenance**
  - Low-level physical (which hard-drive etc)
  - Adjustment of indexes

Entity-Relationship diagrams

- **Entities** (rectangles)
  - Weak – double lines
- **Relationships** (diamonds)
- **Attributes** (ovals)
  - Multi-valued - double lines
  - Identifying - underlined

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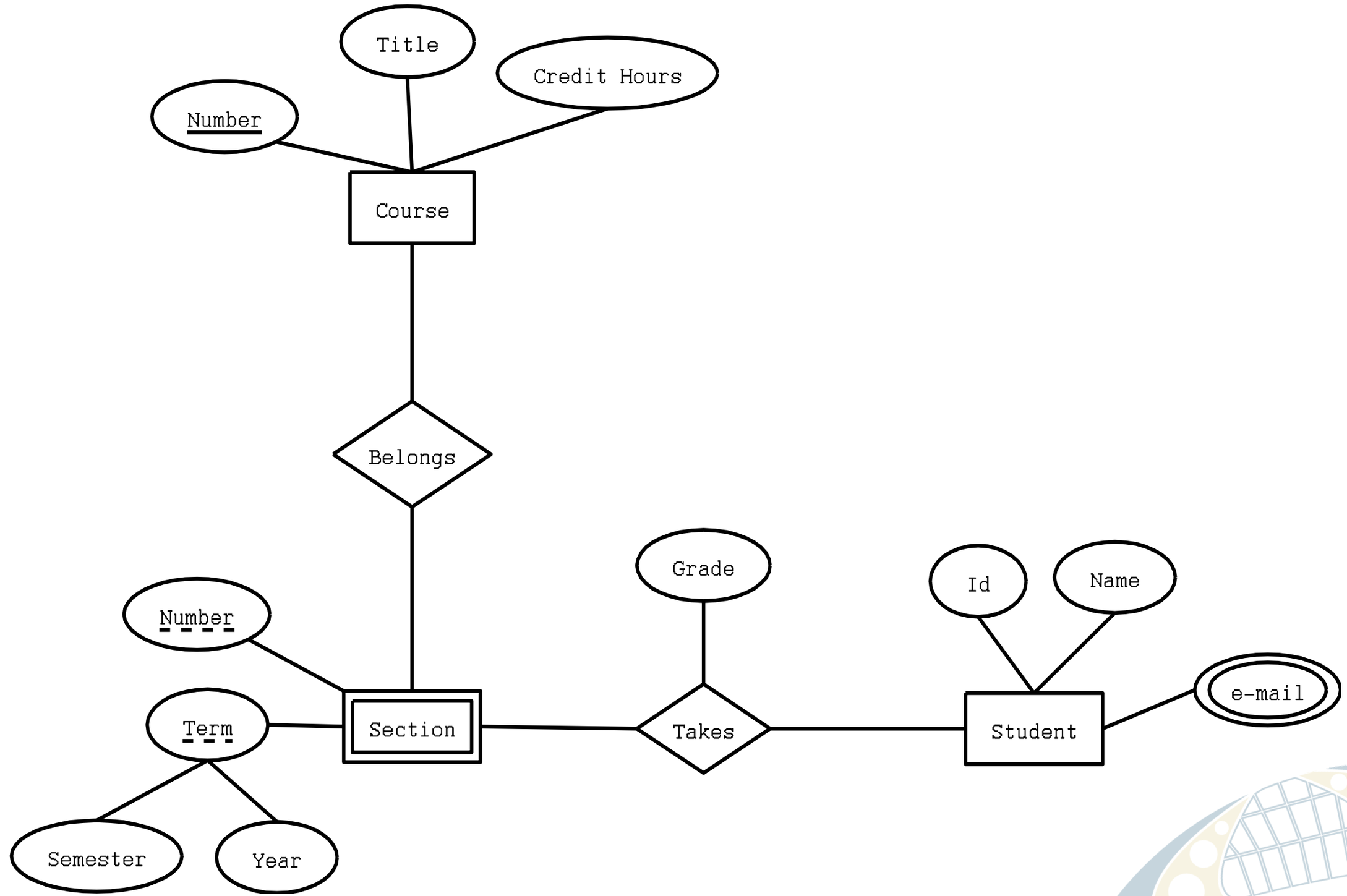
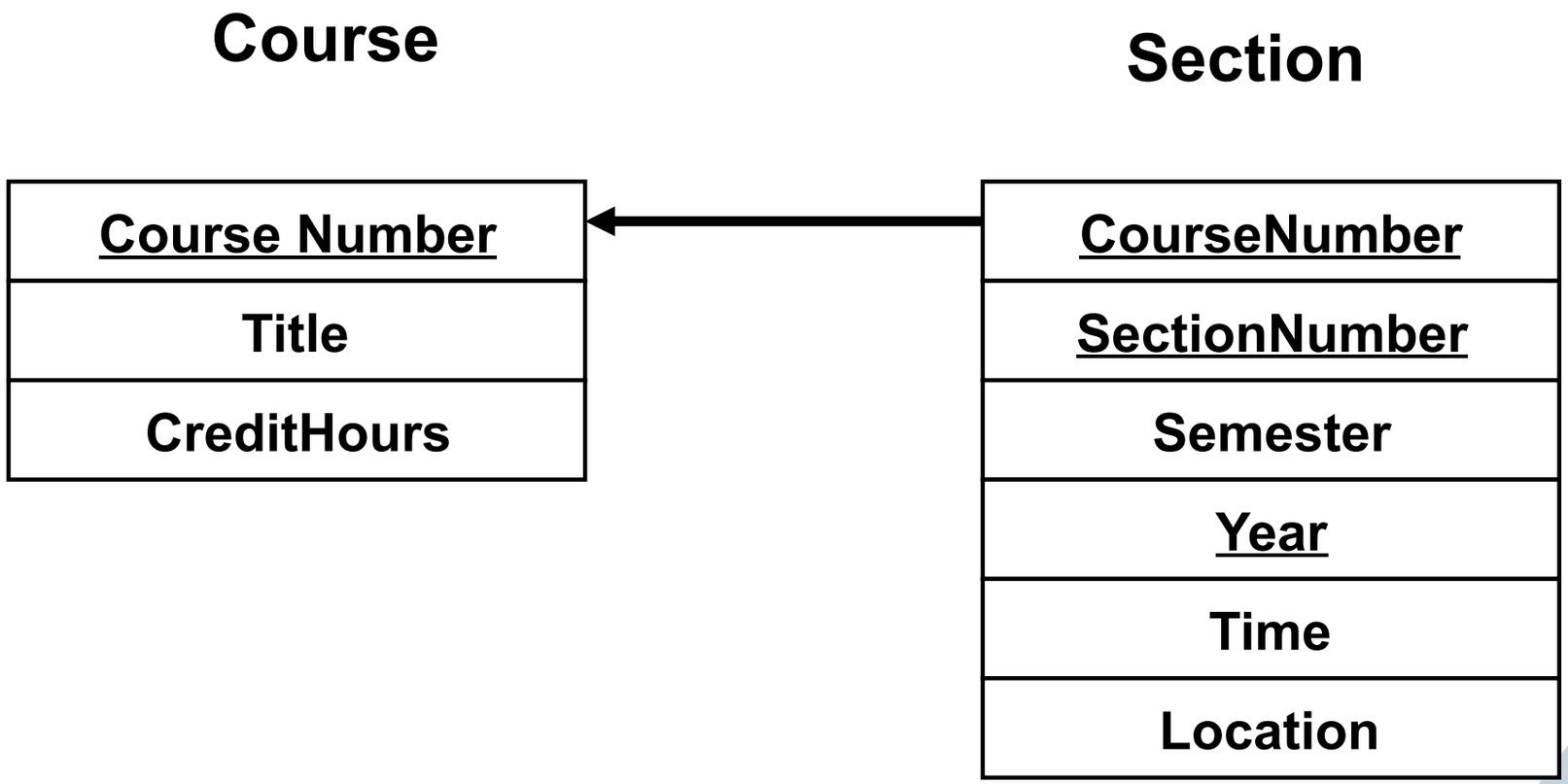
ER diagram



Logical DB Design- Entities

- Table per entity
- Flatten composite attributes
- For weak entities, add the primary key of the strong entity

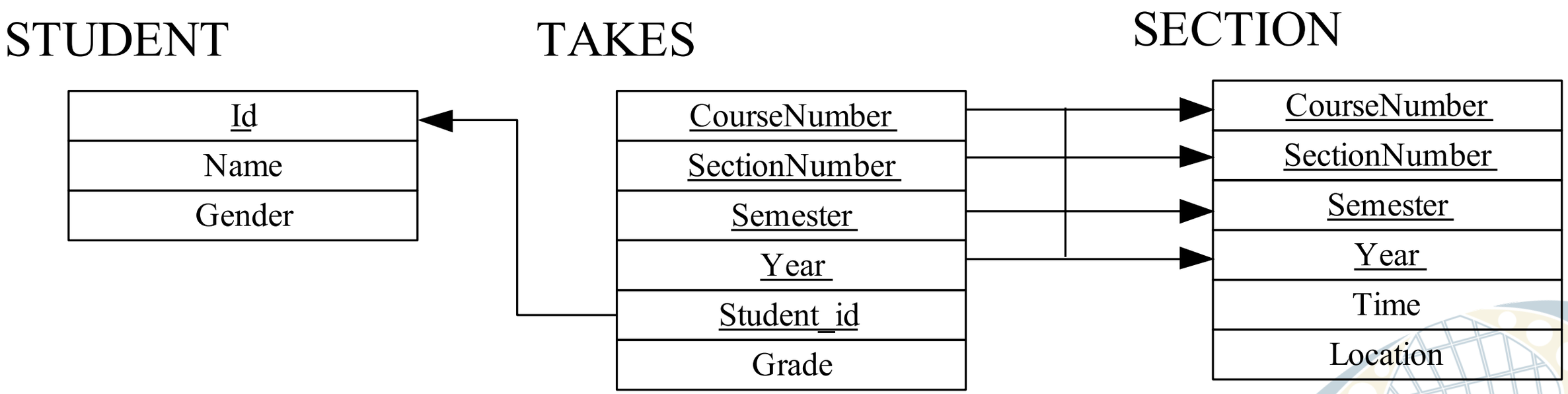


Logical DB Design – **Multi-valued**

- New table needed for multi-valued attributes

Logical DB Design - **Relationships**

- If one side related to just one entity, add foreign key to that side
- For many-to-many, need new table
- For ternary, need new table



Physical DB Design

- **Data types for each attribute**
  - Check which ones your DBMS support
  - Encoding
- **Decide on Indexes**
  - Searches are faster, updates are slower
  - Indexes consume space
  - Can always adjust during deployment
- Denormalization done sometimes (avoid)

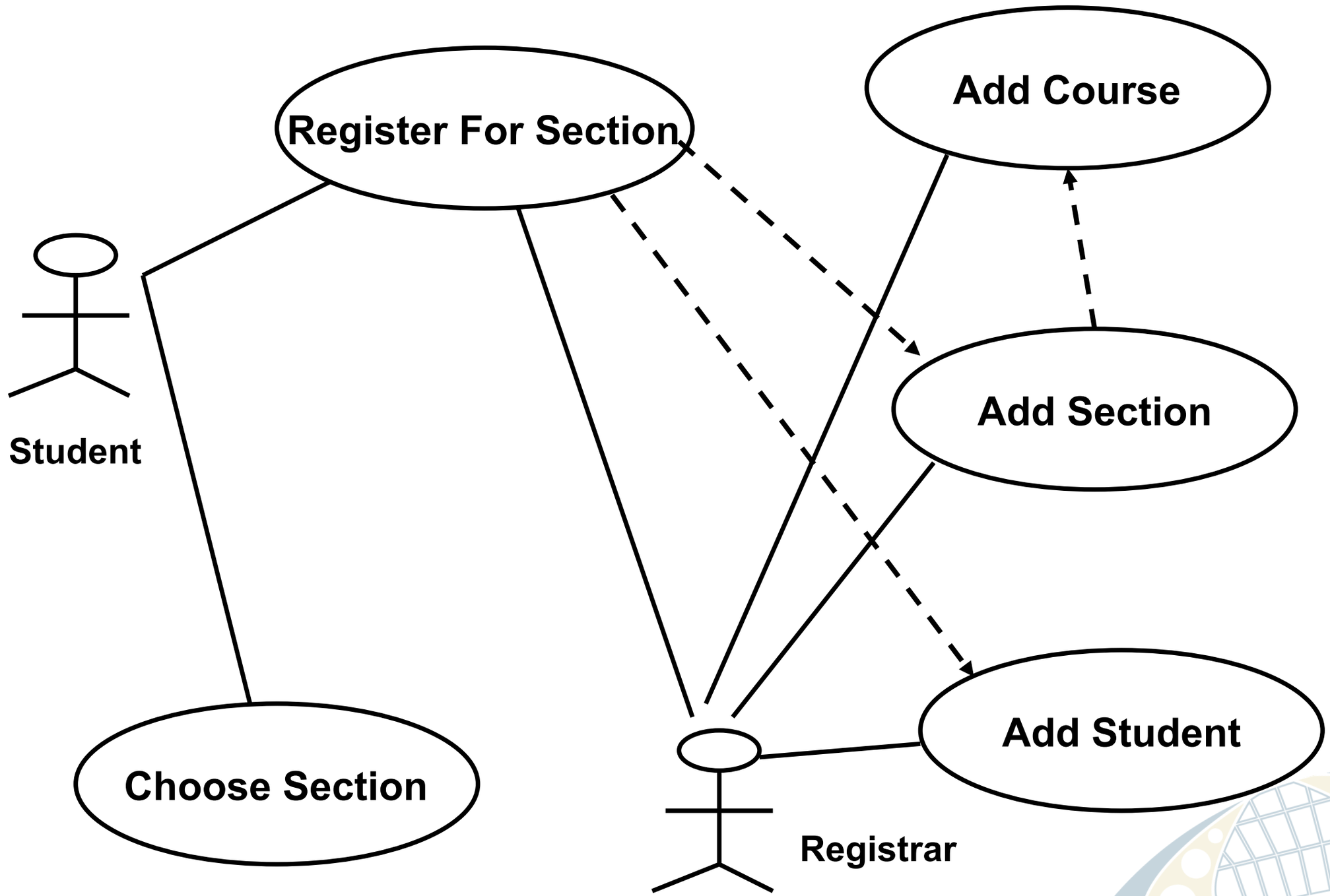
OO Design

- First step: Review & Refine use cases

- Decide
  - Which classes to create
  - How are the classes related

- Use UML as the Design Language

Use case diagram



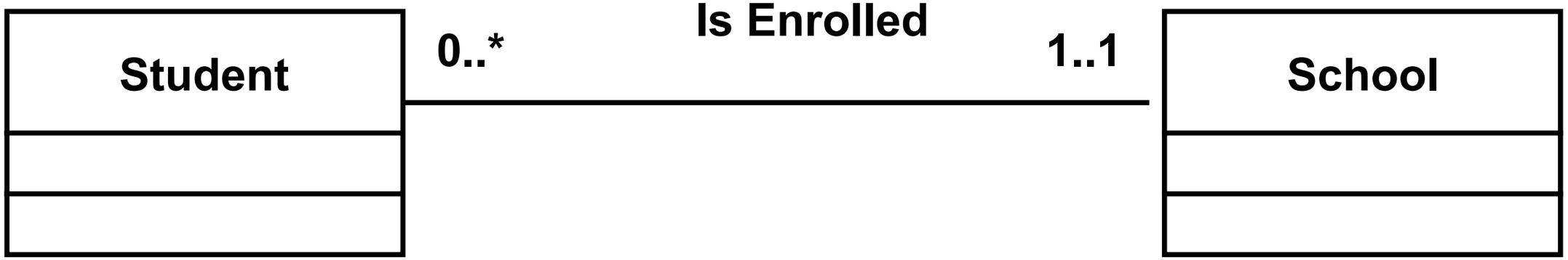
Class Design

- **Classes** represent real-world entities or system concepts
- Organized into **classes**: objects in a class have similar characteristics
- **Classes** have properties (attributes or data)
- **Classes** also have methods (performs functions)

Student
dateOfBirth : Date name : String
getAgeInYears() : int getAgeInDays() : int

UML Class diagrams

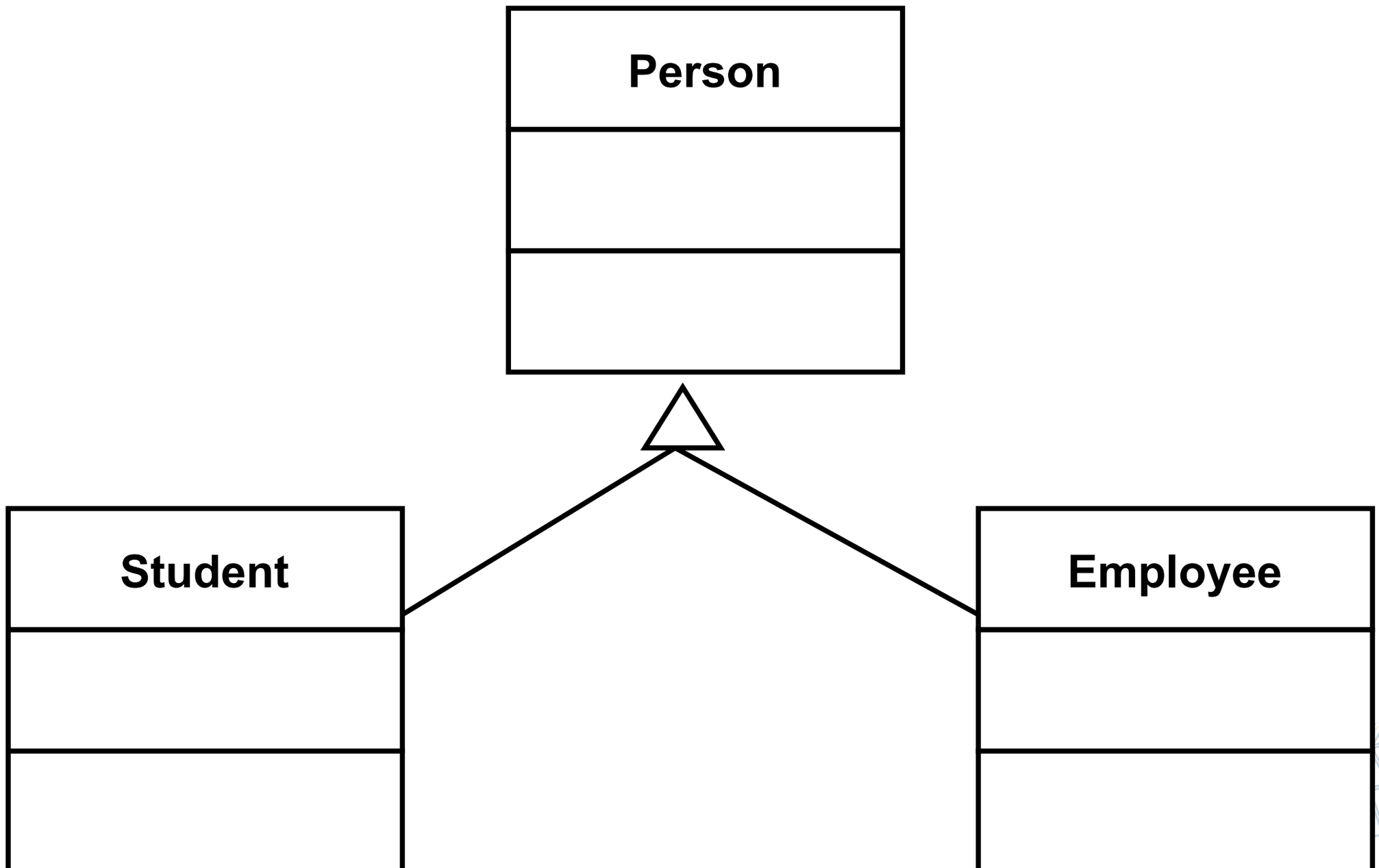
- ***Association***



- ***Composition***

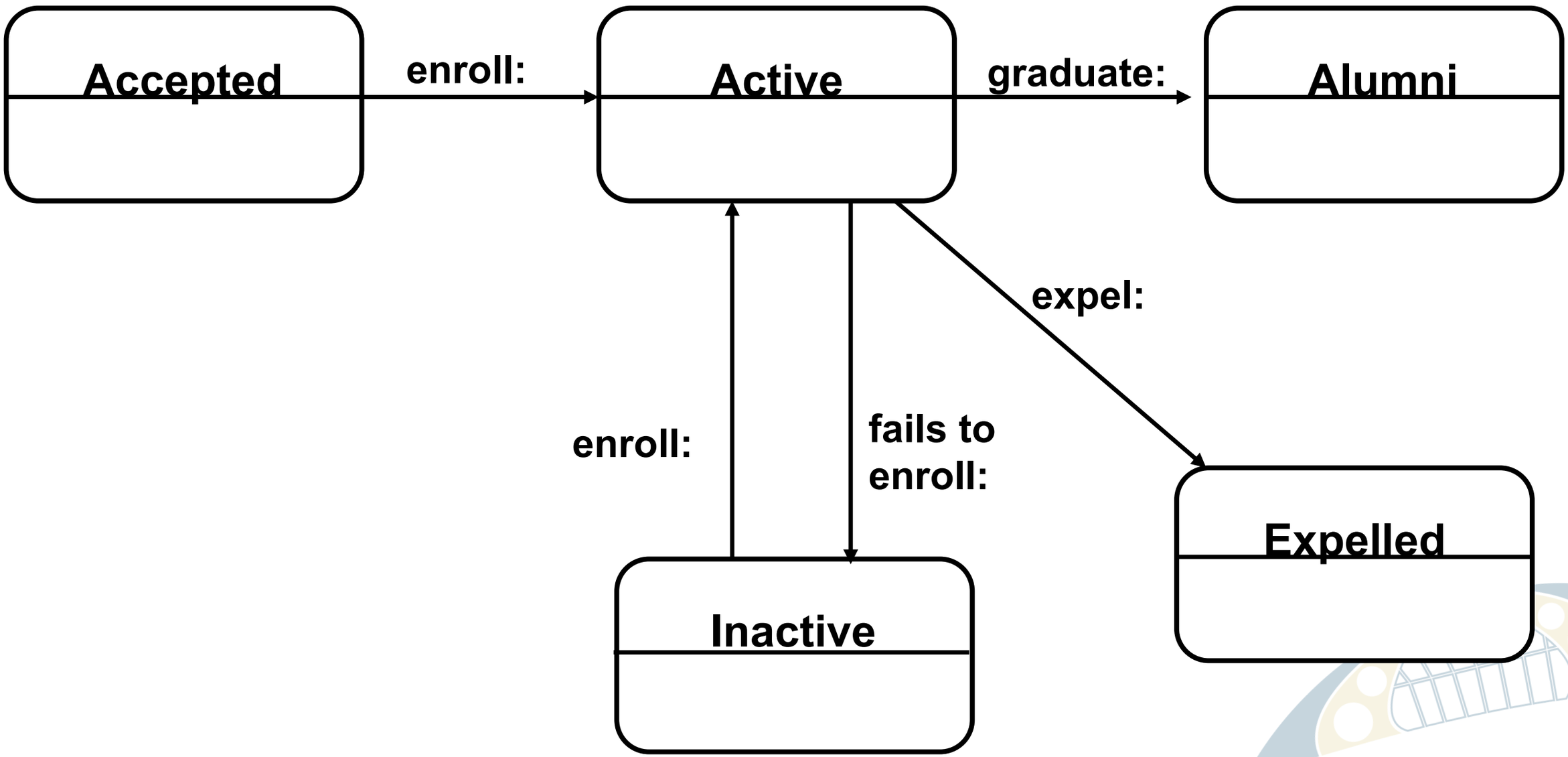
Use "no-fill" diamond for ***aggregation***

UML Class diagrams - Inheritance



UML State diagram

depicting a student's "status" in school



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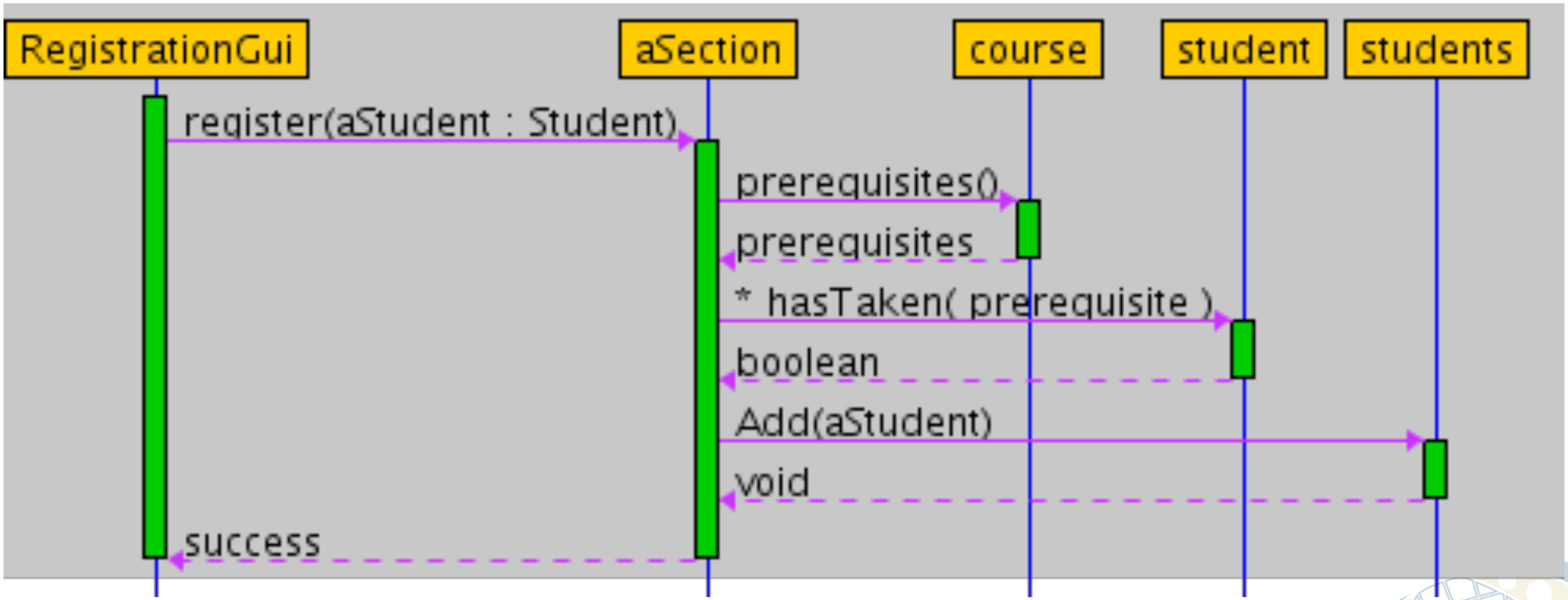
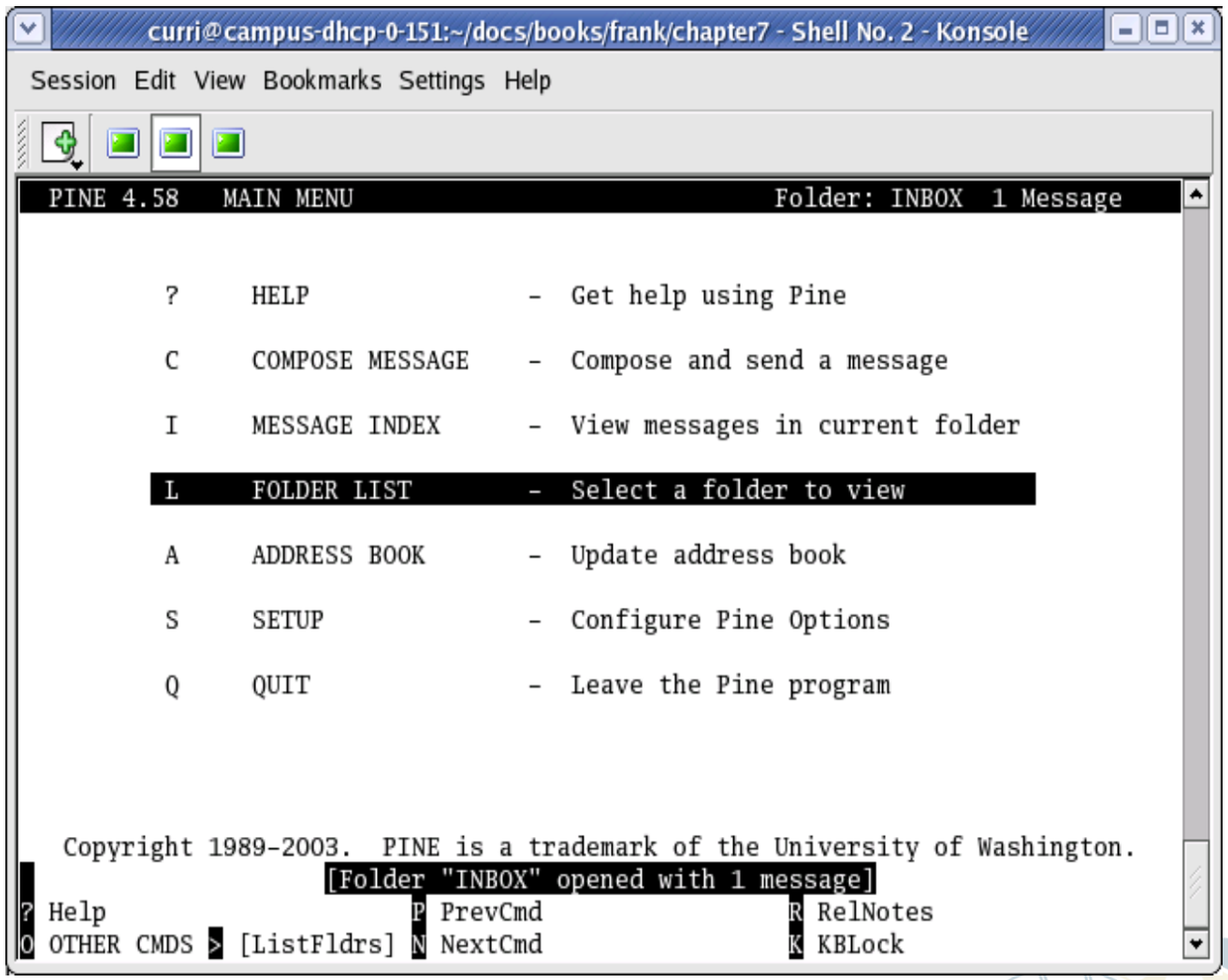
UML "Sequence Diagram"

used to depict a flow of interactions



User Interface Design

- **Most apparent to the user**
- **Two main issues**
  - **i) Flow of interactions**
  - **Ii) Look and feel**
- **Types of interfaces**
  - ***Command-Line***
  - ***Text menus***
  - ***Graphical (GUI)***



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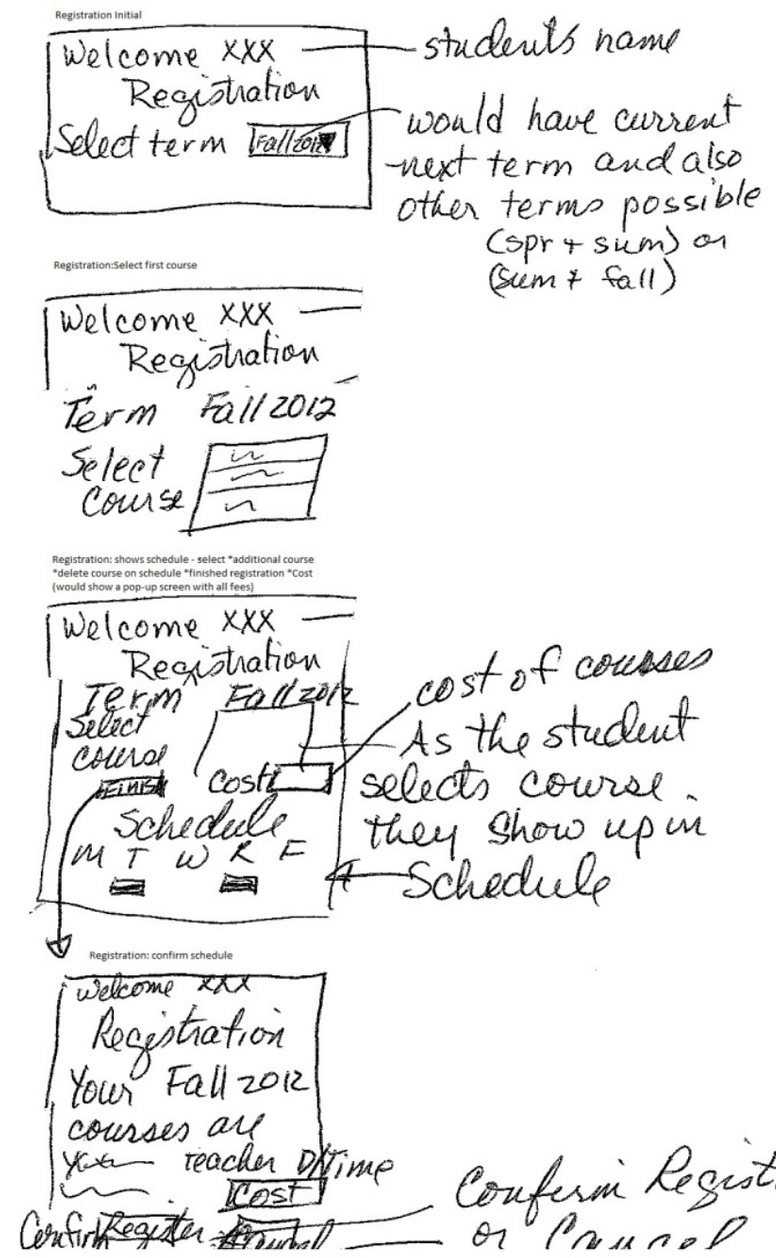
Flow of interactions

Prototype Screens

1. Registration:
   - Select term
2. Registration: shows term
   - Select first course
3. Registration: shows term, course(s) with schedule and cost
   - Select *Additional course; *Delete course; *Finish registration
4. Registration: shows final schedule
   - Select Confirm or Cancel



High Fidelity Prototype

Welcome UserName

Registration

School term to register SPR 2013

Help Cancel

Welcome aStudent

Registration

Desired School term to register - Spring 2012

Select course to add ALL Courses

Add Course Cancel Help

Welcome aStudent

Registration

Desired School term to register - Spring 2012

Desired Schedule:
SWE 2313 Intro to Software Engineering Delete course

Add another course Confirm Schedule Cancel Help

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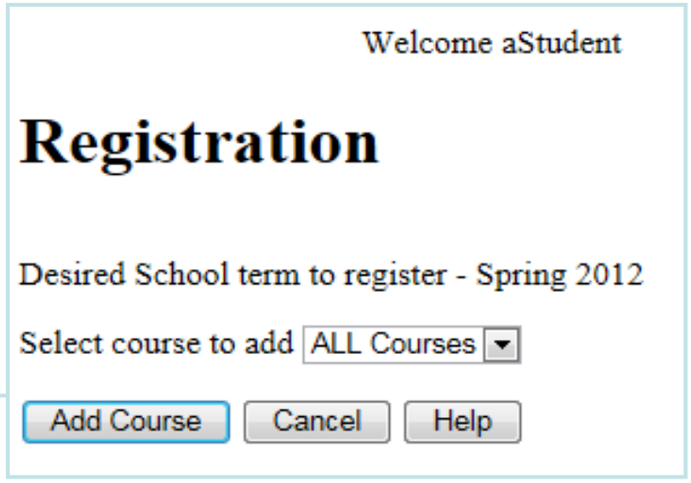
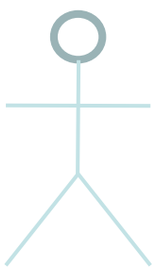
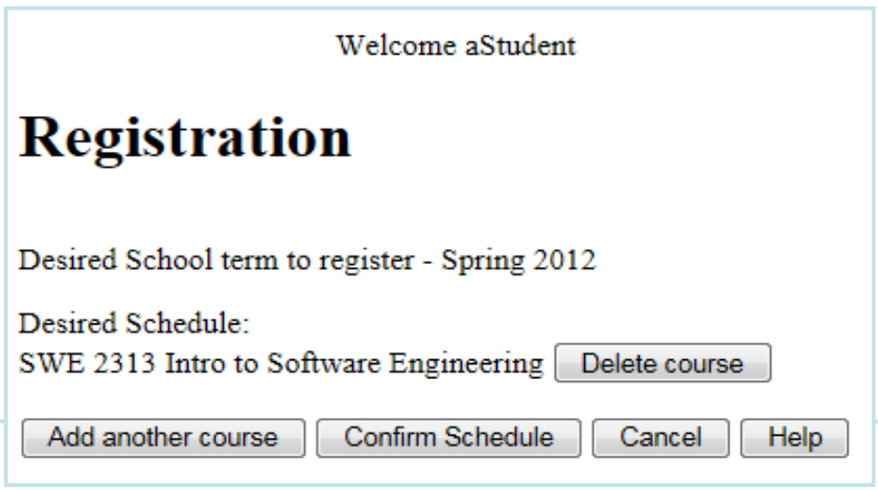
User: Screens: Process:

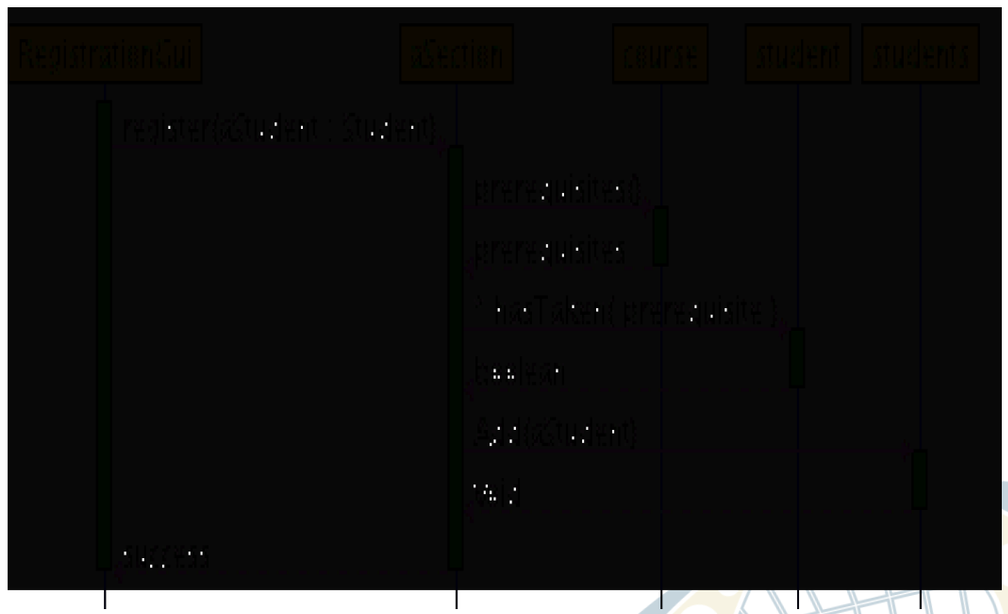




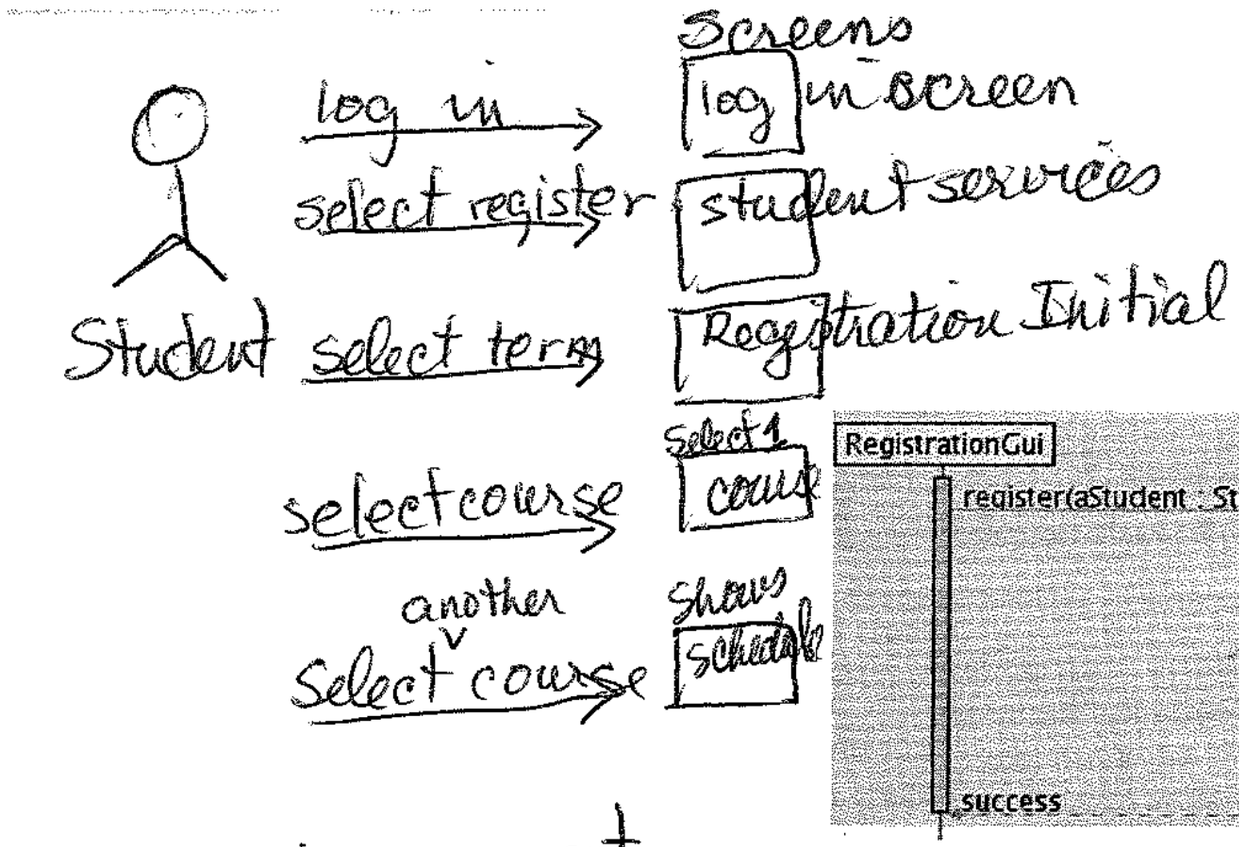
Student selects course and clicks “Add Course”

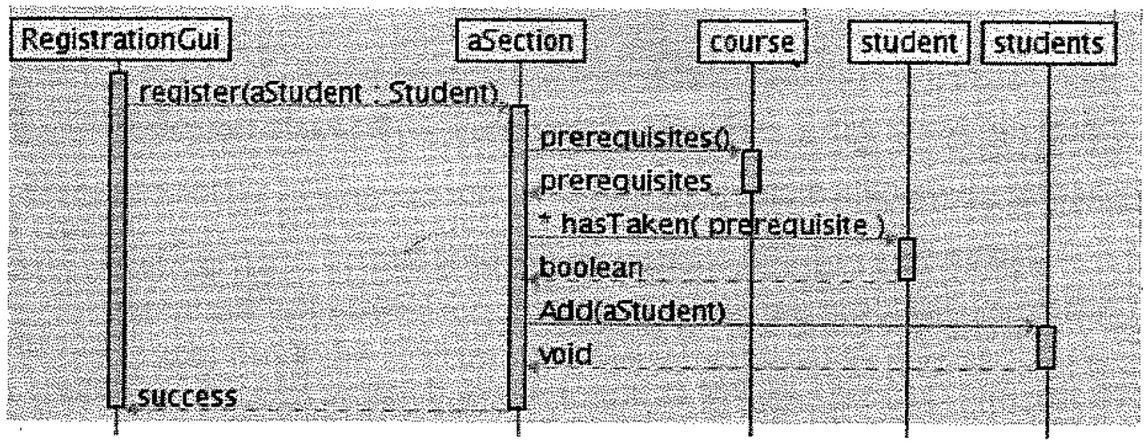
aStudent





User interaction added to the sequence diagram





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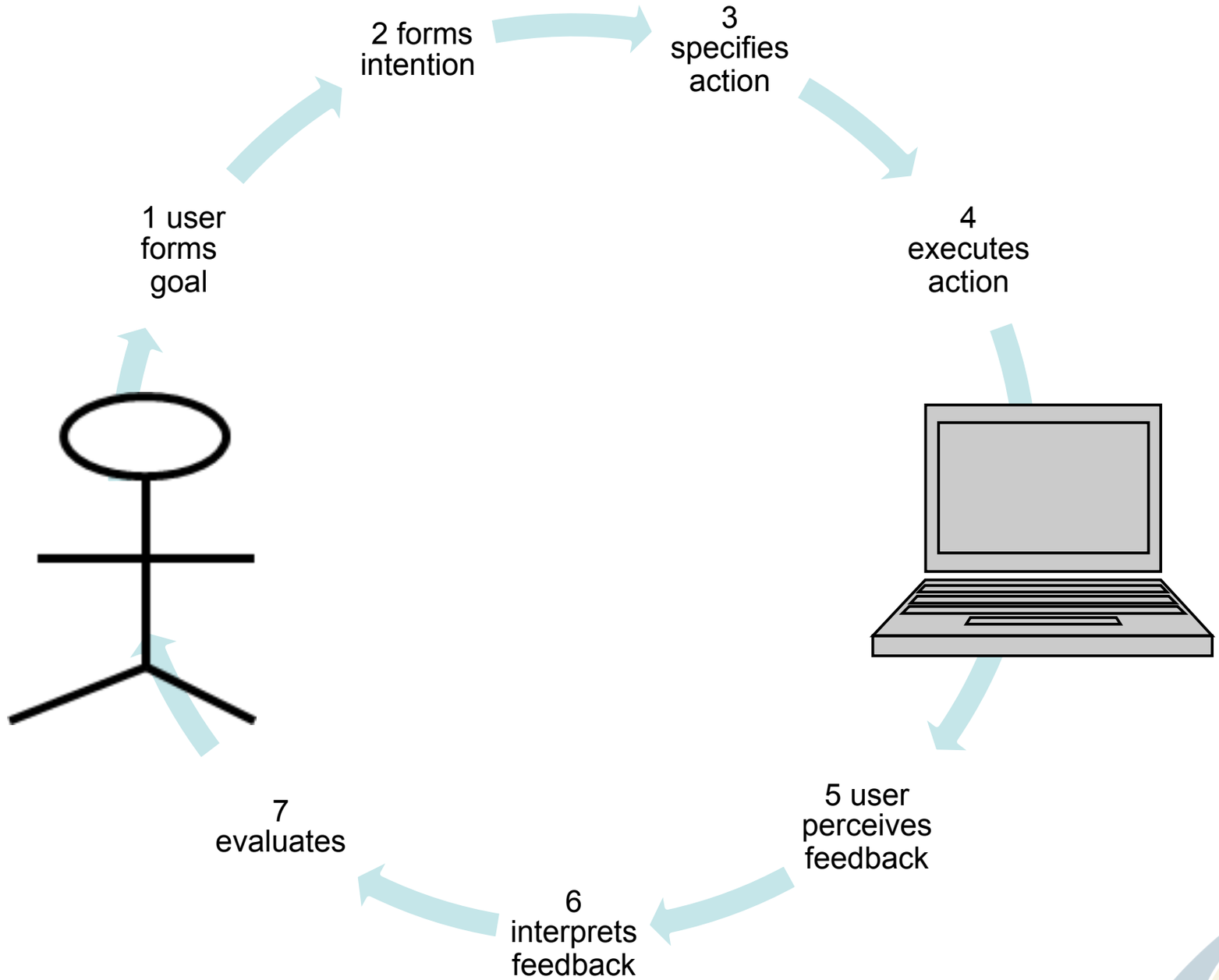
Norman's 7 Stage Model



The GOMS Model

(an "advanced" topic for UI)

- Consider **different kinds of users**

- Four factors **(for the kind of user)**
  - **Goals of the user**
  - **Operations provided by the system**
  - **Methods or the sequence of operations**
  - **Selection Rules for the methods**

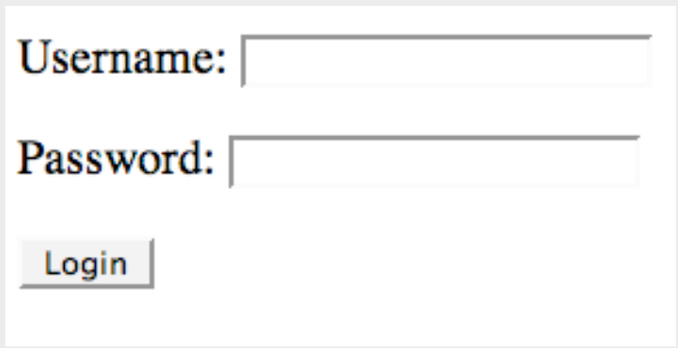
Other UI Issues

- **Kinds of users**
- **Heuristics**
- **UI Guidelines**
- **Multicultural issues**
- **Metaphors**
- **Multiplatform software**
- **Accessibility**
- **Multimedia Interfaces**

HTML-Script simple example

Sample HTML	Visual result (possible)

```
<form method="GET"
action="something.php">
<p>
  Username:
<input type="text" name="username">
</p>
<p>
  Password:
<input type="password"
name="password">
</p>
<input type="submit" value="Login">
</form>
```



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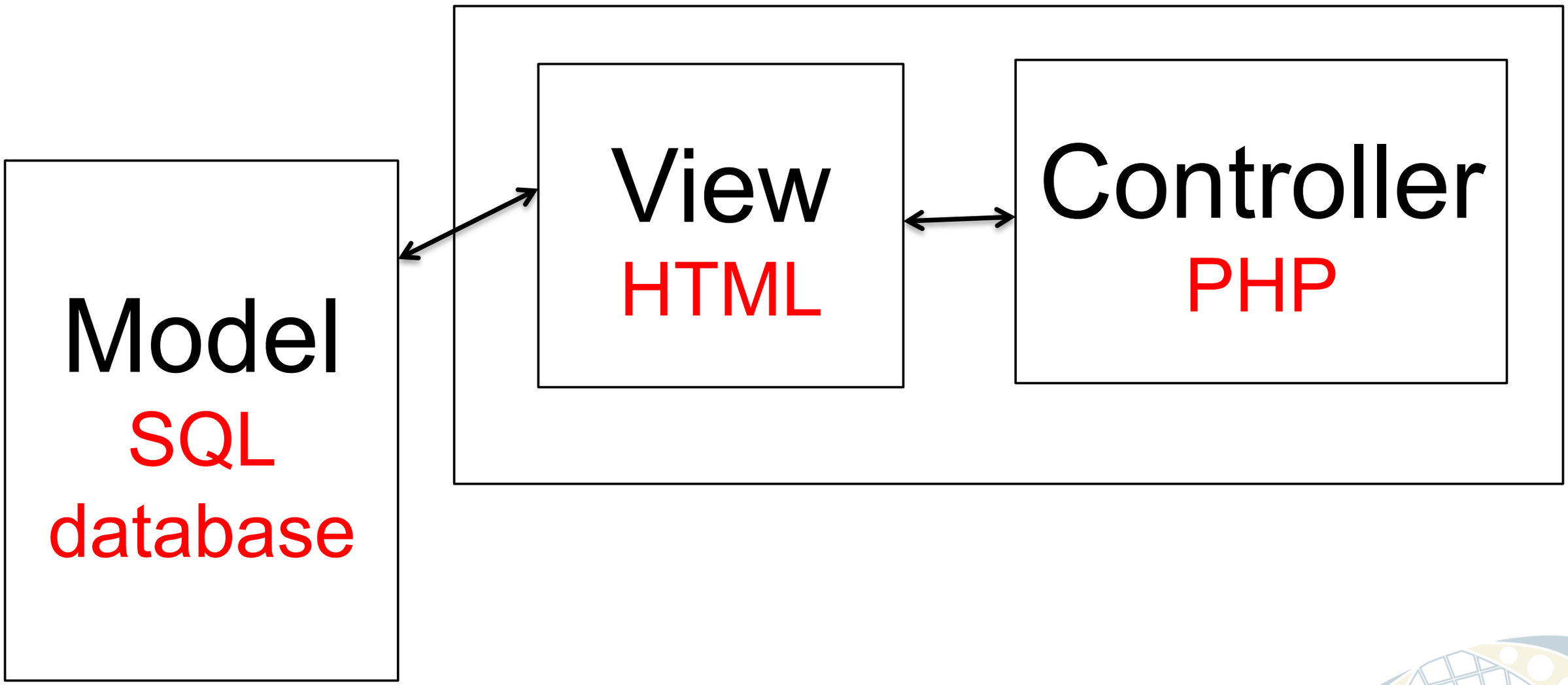
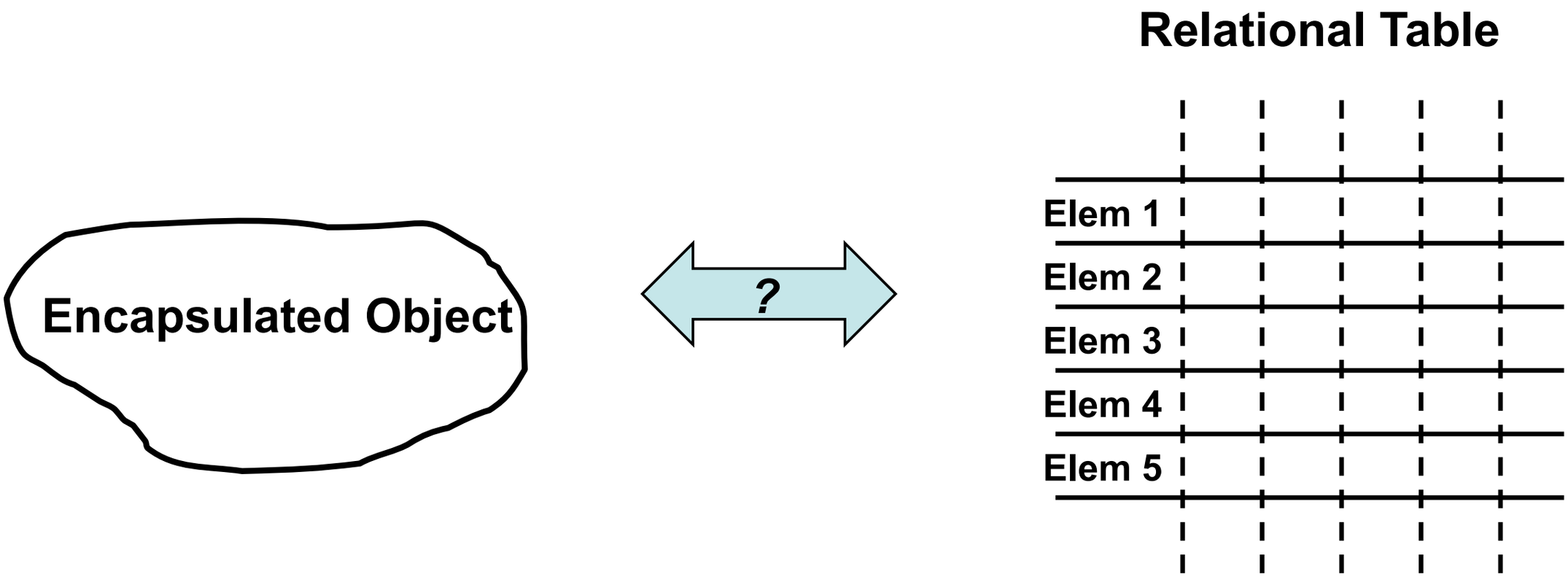
Model-View-Controller (MVC)

software project

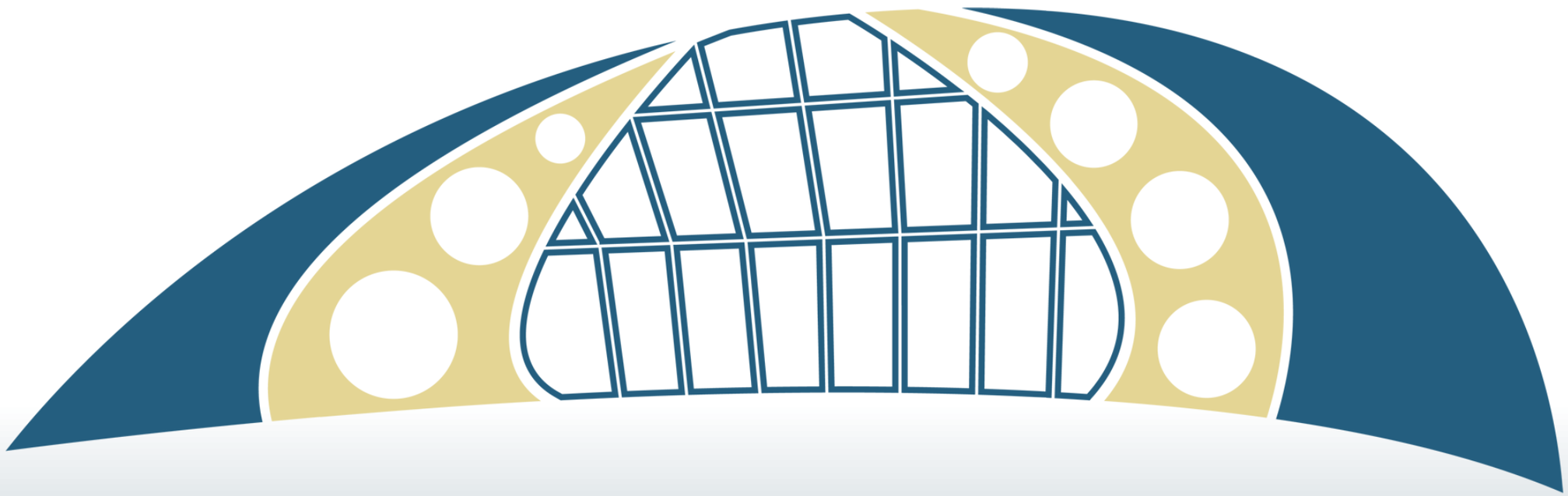


Object-Relational Impedance Mismatch
(an "advanced" topic)



How do we handle mismatches between object-oriented concepts and Relational DB such as :

- typing
- private and public
- inheritance and polymorphism
- nested structure versus table structure



WESTMONT INSPIRED

COMPUTING LAB