ICS 434
Advanced Database Systems

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Outline

1. The Relational Data Model: Version 2
2. **Advanced Data Modeling**
3. Databases on the Web
4. Client-Server Architecture
5. Client-Server Databases & Tools
6. The System Catalog
7. Query Processing and Optimization
8. Transaction Processing
9. Concurrency Control
10. Recovery
11. Administration & Security
12. Distributed Databases
13. Database Replication
14. Object-Oriented Databases
15. Data Warehousing and Data Mining
16. Other Emerging Database Technologies

2. Advanced Data Modeling

The Entity-Relationship (ER) Model

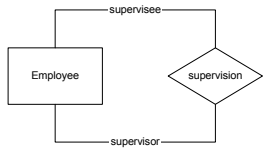
- Introduce by Peter Chen in 1976
- In 1988 ANSI chose ER model as the standard model for IRDS
- Elements of the the ER model:
  - Entities
  - Relationships
  - Attributes

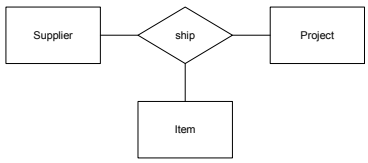
Entities

- Classes of real-world objects, represented by rectangles

Relationships

- Relate two or more entities represented by diamonds
  - Degree
    - recursive
    - binary
    - n-ary

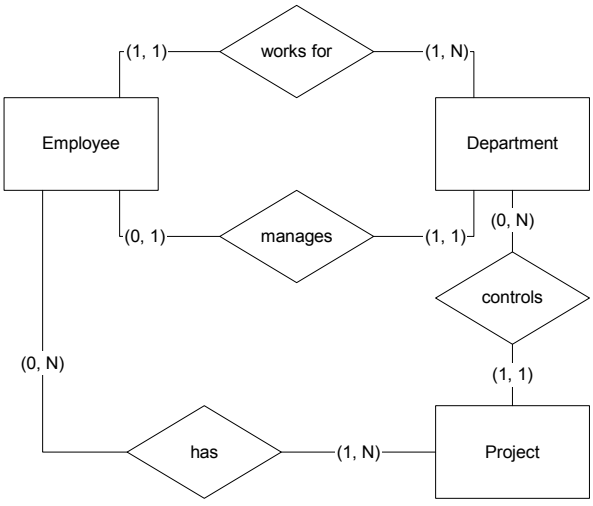




... Relationships

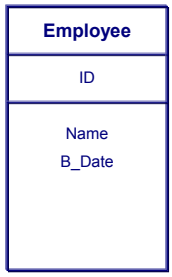
- Minimal and Maximal cardinality (min, max)
  - min-card (participation)
    - optional - 0
    - mandatory - 1
  - max-card (cardinality ratio)
    - 1 to 1
    - 1 to N
    - N to N

Example



Attributes

- Properties of entities or relationships
  - single-valued
  - multi-valued
  - simple
  - composite
  - domain



... Attributes

- minimal and maximal cardinality
  - min-card 0 optional
    1 mandatory
  - max-card 1 single-valued
    N multi-valued
  - (0, 1) is the default

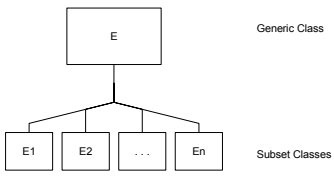
- Keys (identifiers)
  - simple or composite
  - internal or external
    (strong entity) (weak entity)

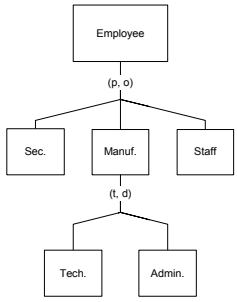
Problem with ER Model

- The Entity Relationship Model in its original form did not support the generalization abstraction
- Extended Entity-Relationship (EER) Model

Generalization Hierarchies

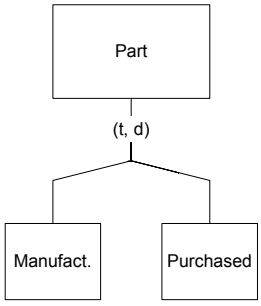
- Generalization vs. Specialization
- Coverage of generalization
  - total (t) or partial (p)
  - disjoint (d) or overlapping (o)





Inheritance

- Subset entities *inherit* all the properties of the generic entity



ER-to-Relational Mapping

- Entity → Relation
- 1:1 Relationship → Foreign Key
- 1:N Relationship → Foreign Key
- M:N Relationship → Relation
- Multi-valued Attribute → Relation
- Ternary Relationship → Relation

Generalization Hierarchy Mapping

- Superclass C with attributes {K, a1, ... ,an}
  m subclasses {S1, S2, ... ,Sm}
- Option A
  - relation L for C
  - relation Li for each subclass Si with attributes = {k} U {attributes of Si}
  - works for any constraints
- Option B
  - relation Li for each subclass Si with attributes = {K, a1, ... ,an} U {attributes of Si}
  - Works only with disjoint and total constraints

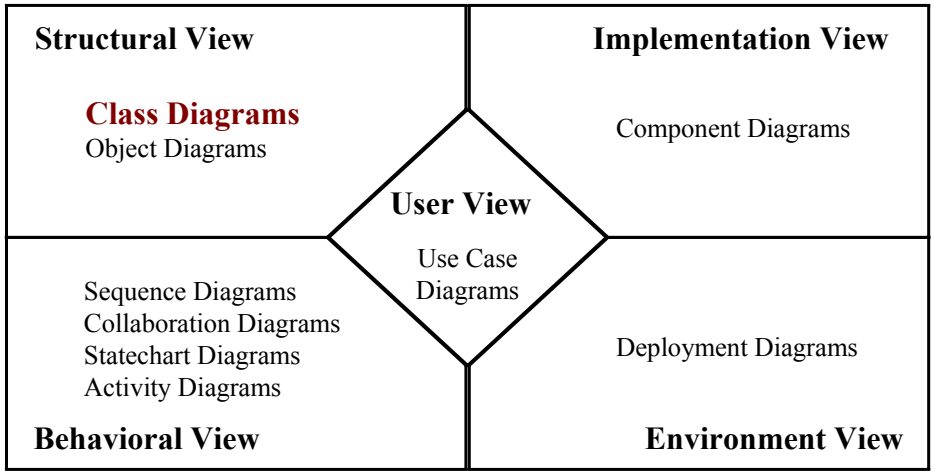
... Generalization Hierarchy Mapping

- Option C
  - a single relation with attributes = {$\underline{K}$, a_1, ... ,a_n} U {attributes of S_1} U .... U {attributes of S_m} U {t}
  - (t = type attribute to indicate the subclass, more than one is needed when overlapping)
  - Preferable if only few specific attributes exist

What is UML?

- UML (Unified Modeling Language)
  - An emerging standard for modeling object-oriented software
  - Resulted from the convergence of notations from three leading object-oriented methods:
    - OMT (James Rumbaugh)
    - OOSE (Ivar Jacobson)
    - Booch (Grady Booch)
- Supported by several CASE tools
  - Rational ROSE
  - Together
  - ...

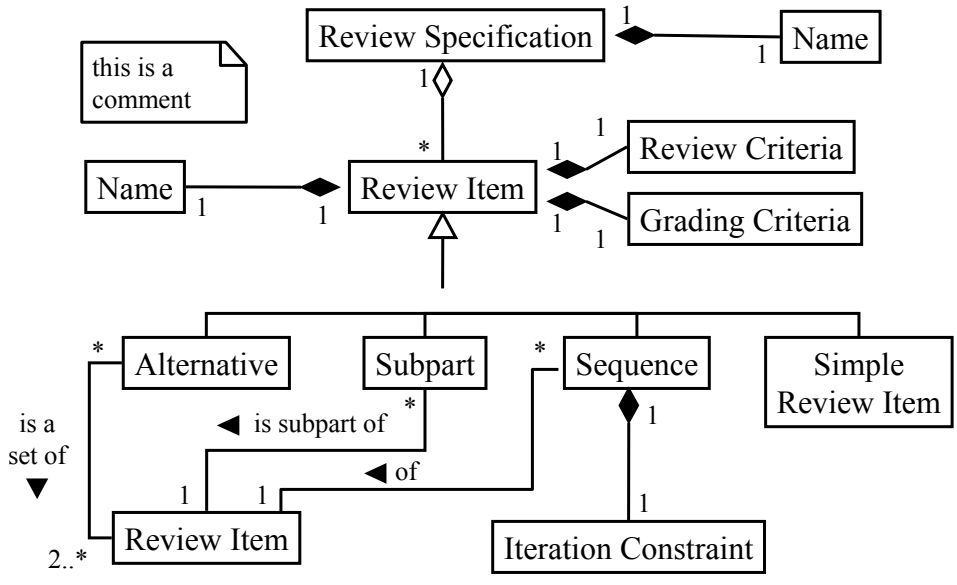
Different Views in UML



Class Diagrams: Static Structure

"A class diagram is a graphic presentation of the static view that shows a collection of declarative (static) model elements, such as classes, types, and their contents and relationships."

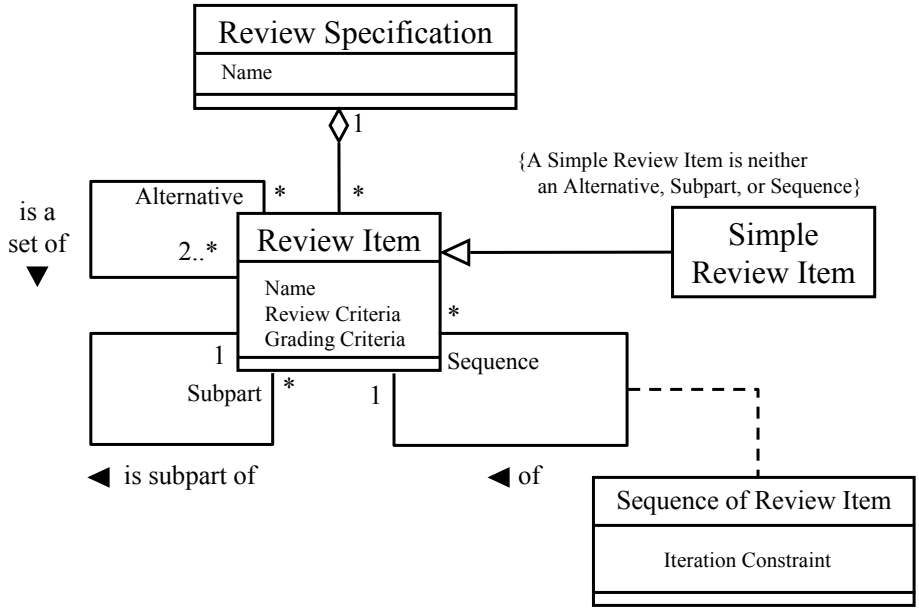
Class Diagrams: Example



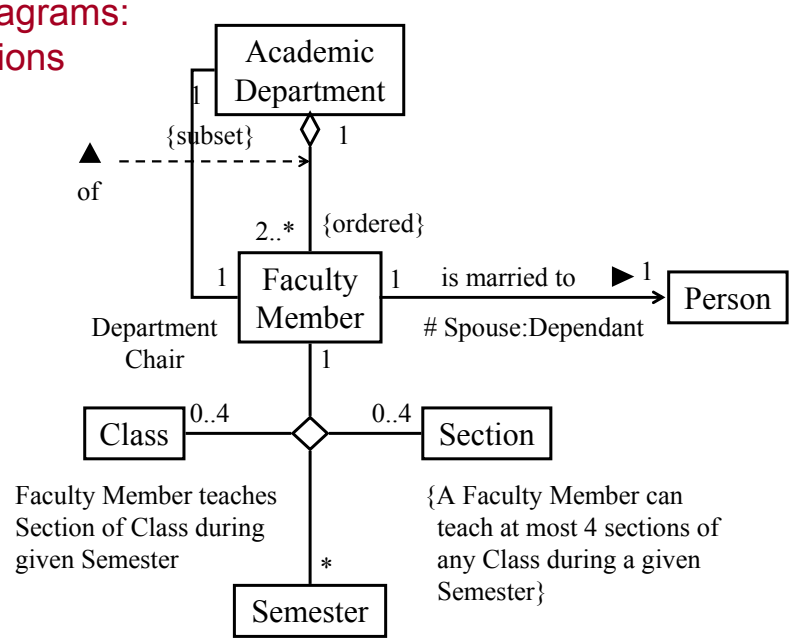
Class Diagrams: Multiplicity Constraints

- Denote a Set of Non-Negative Integers
- Common Forms
  - 0..1
  - 1..1 abbreviated as 1
  - 0..* abbreviated as *
  - 1..*
- General Form
  - i..j, k..l, m..n, … , z..*

Class Diagrams: Attributes

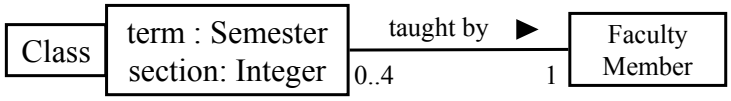


Class Diagrams: Associations

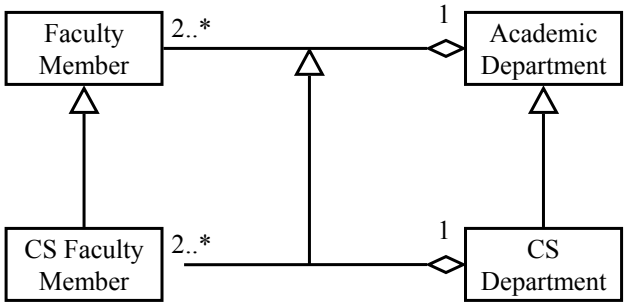


Class Diagrams: Associations

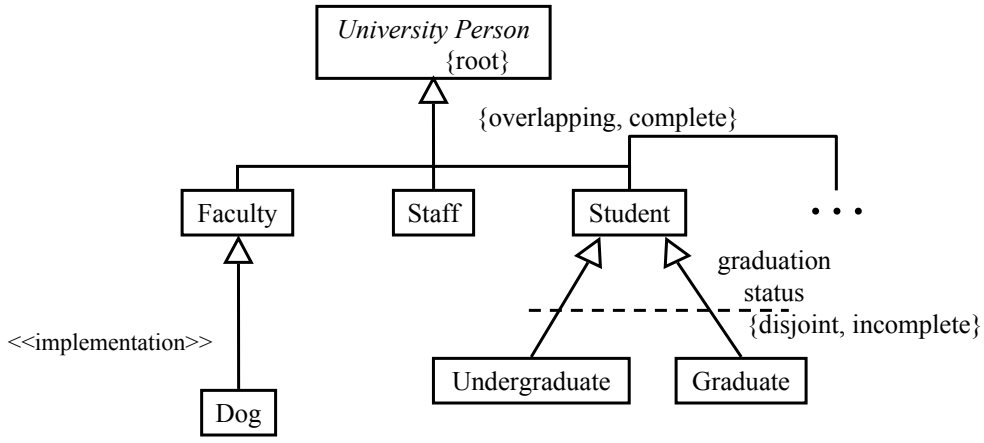
Qualified Association



Specialization between Associations



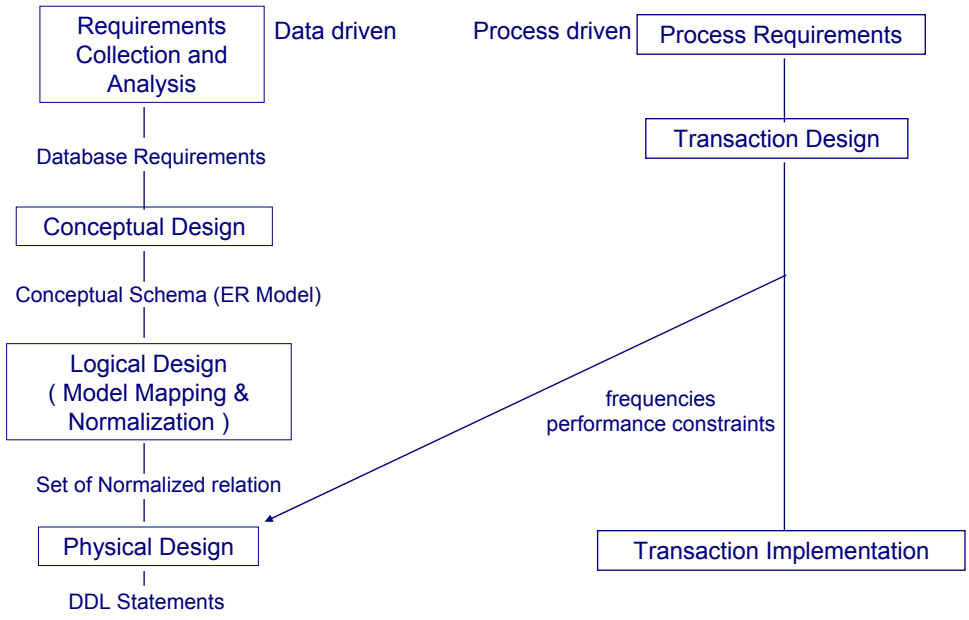
Class Diagrams: Generalization/Specialization



Database Application System Life Cycle

- System Definition
- Design
- Implementation
- Loading or Data Conversion
- Application Development or Conversion
- Testing and Validation
- Operation
- Monitoring and Maintenance

The Database Design Process



Requirements Collection and Analysis

- Identification of user groups and application areas
- Review of existing documentation
- Analysis of the operating environment and the processing requirements
- Questionnaires and interviews

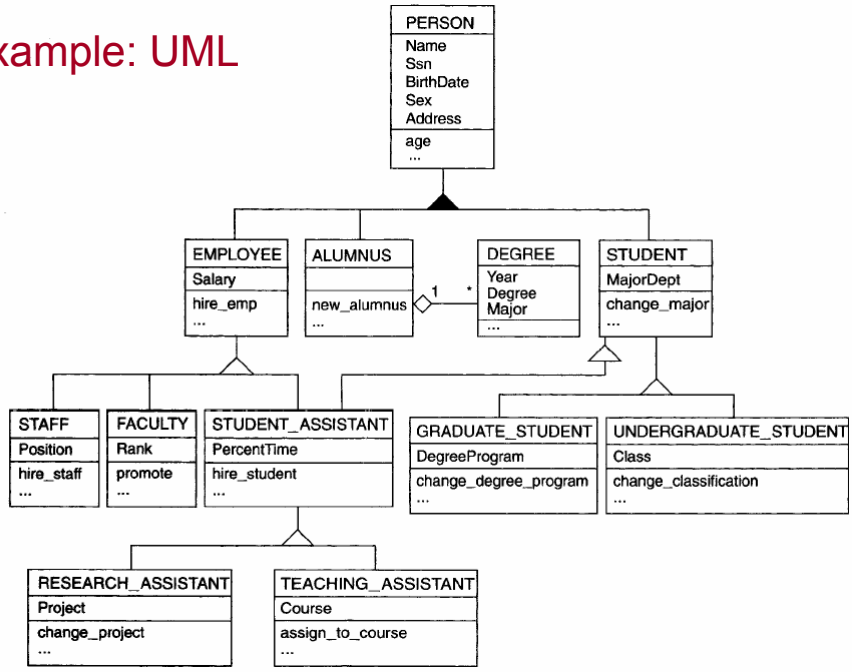
Conceptual Design

- A high-level data model (semantic data model) with the following characteristics:
  - Expressiveness
  - Simplicity
  - Minimallity
  - Diagrammatic Representation
  - Formality

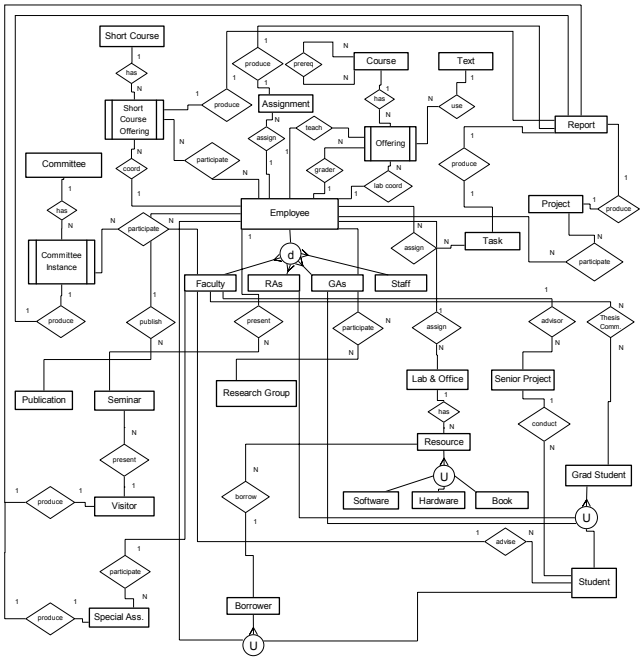
Approaches to Conceptual Database Design

- Centralized
- View integration
- View (schema) integration
  - Identifying correspondence and conflicts among the views:
    - Naming conflict
    - Type conflict
    - Constraint conflict
  - Modifying views to confirm to one another
  - Merging views
  - Restructuring
- Strategies

Example: UML



Example: EER



Example: Relational Database Schema

Student

ID	Name	BDate	Address	SupID	GPA	Dep
				↳ Faculty		↳ Department

Faculty

ID	Name	BDate	Office	Phone	Dep
					↳ DEPARTMENT

Department

Code	Name	Location	Phone	Chairman
				↳ Faculty

Some of the Currently Available Automated Database Design Tools

COMPANY	TOOL	FUNCTIONALITY
Embarcadero Technologies	ER Studio	Database Modeling in ER and IDEF1X
	DB Artisan	Database administration and space and security management
Oracle	Developer 2000 and Designer 2000	Database modeling, application development
Popkin Software	System Architect 2001	Data modeling, object modeling, process modeling, structured analysis/design
Platinum Technology	Platinum Enterprice Modeling Suite: Erwin, BPWin, Paradigm Plus	Data, process, and business component modeling
Persistence Inc.	Pwertier	Mapping from O-O to relational model
Rational	Rational Rose	Modeling in UML and application generation in C++ and JAVA
Rogue Ware	RW Metro	Mapping from O-O to relational model
Resolution Ltd.	Xcase	Conceptual modeling up to code maintenance
Sybase	Enterprise Application Suite	Data modeling, business logic modeling
Visio	Visio Enterprise	Data modeling, design and reengineering Visual Basic and Visual C++