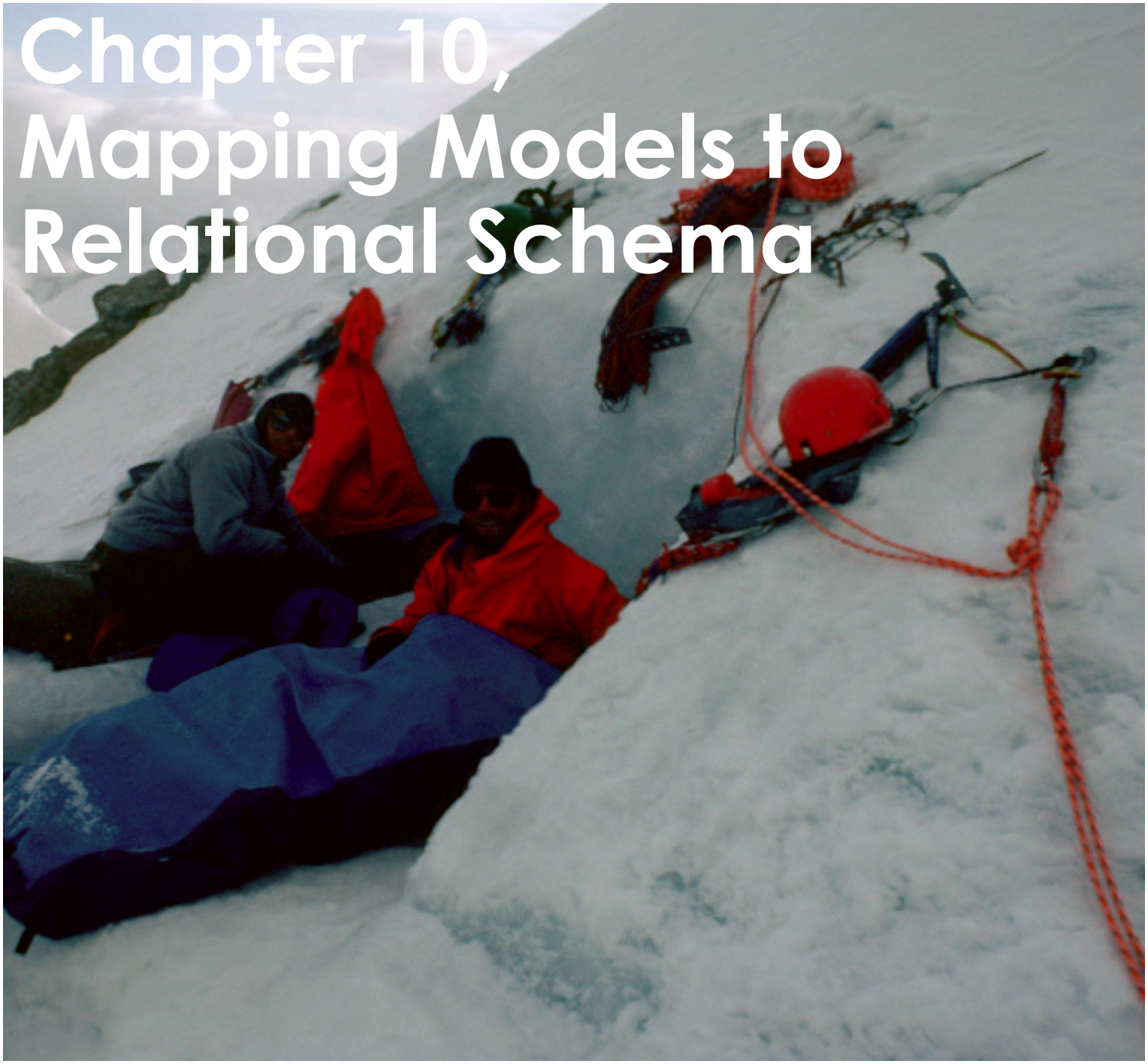
Object-Oriented Software Engineering

Using UML, Patterns, and Java

# Chapter 10, Mapping Models to Relational Schema



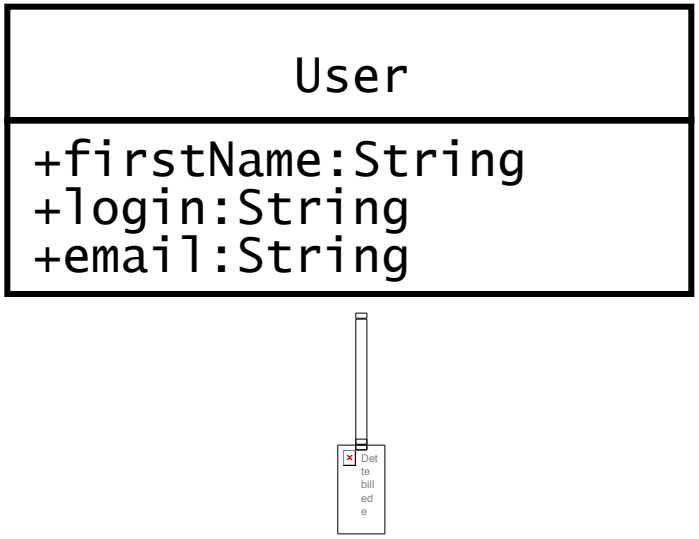
# Lecture Plan

- Last lecture:
  - Implementation of class model components:
    - Realization of associations
- This lecture:
  - Realizing entity objects based on selected storage strategy, in particular
  - Mapping the object model to a relational database
    - Mapping class diagrams to tables

# Mapping an Object Model to a Database

- UML object models can be mapped to relational databases:
  - Some degradation occurs because all UML constructs must be mapped to a single relational database construct - the table
- Mapping of classes, attributes and associations
  - Each *class* is mapped to a table
  - Each class *attribute* is mapped onto a column in the table
  - An *instance* of a class represents a row in the table
  - *A many-to-many association* is mapped into its own table
  - A *one-to-many association* is implemented as buried foreign key
- Methods are not mapped.

# Mapping a Class to a Table




**User table**

| id:long | firstName:text[25] | login:text[8] | email:text[32] |
|---|---|---|---|
| | | | |

# Primary and Foreign Keys

- Any set of attributes that could be used to uniquely identify any data record in a relational table is called a **candidate key**
- The actual candidate key that is used in the application to identify the records is called the **primary key**
  - The primary key of a table is a set of attributes whose values uniquely identify the data records in the table
- A **foreign key** is an attribute (or a set of attributes) that references the primary key of another table.

# Example for Primary and Foreign Keys

**User table**

Primary key

| firstName | login | email |
|---|---|---|
| “alice” | “am384” | “am384@mail.org” |
| “john” | “js289” | “john@mail.de” |
| “bob” | “bd” | “bobd@mail.ch” |

Candidate key Candidate key

**League table**

| name | login |
|---|---|
| “tictactoeNovice” | “am384” |
| “tictactoeExpert” | “bd” |
| “chessNovice” | “js289” |

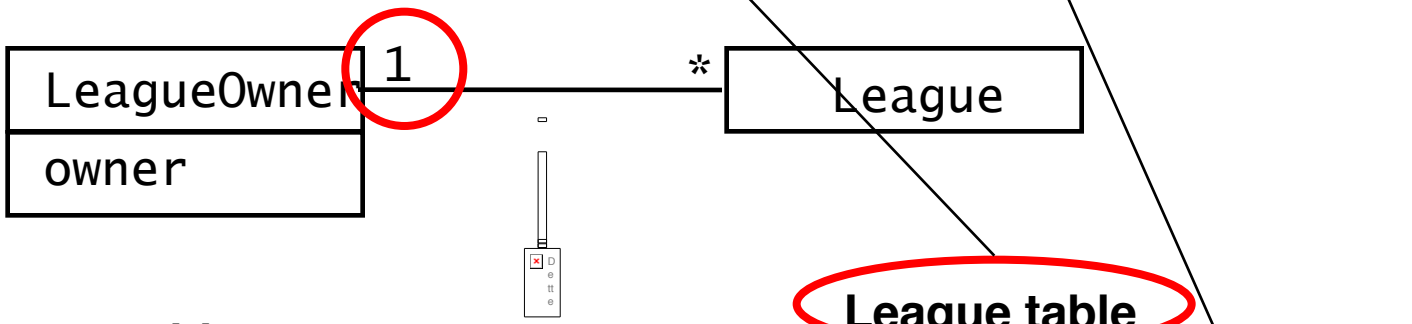
Foreign key referencing **User table**

# Buried Association

- Associations with multiplicity "one" can be implemented using a foreign key

For one-to-many associations we add the foreign key to the table representing the class on the "many" end.

For all other associations we can select either class at the end of the association.




**LeagueOwner table**

| id:long | ... |
|---|---|
| | |

**League table**

| id:long | ... | owner:long |
|---|---|---|
| | | |

# Another Example for Buried Association


**Transaction Table**

| transactionID | portfolioID |
|---|---|
| | |
| | |
| | |
| | |

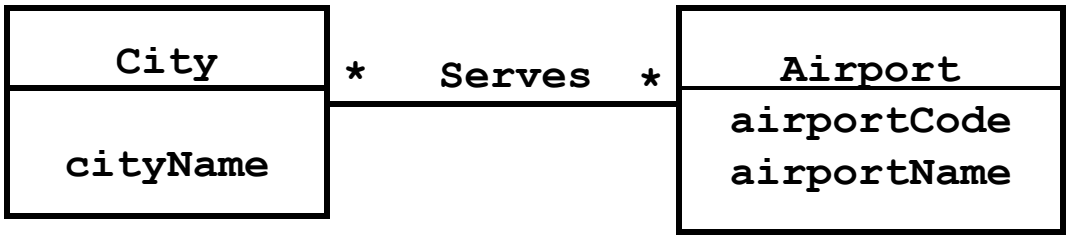
Foreign Key

**Portfolio Table**

| portfolioID | ... |
|---|---|
| | |
| | |
| | |

# Mapping Many-To-Many Associations

In this case we need a separate table for the association




Separate table for the association "Serves"

Primary Key

**City Table**

| cityName |
|---|
| Houston |
| Albany |
| Munich |
| Hamburg |

**Airport Table**

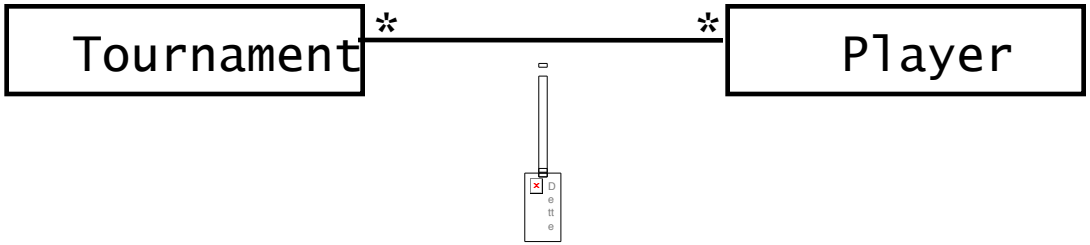
| airportCode | airportName |
|---|---|
| IAH | Intercontinental |
| HOU | Hobby |
| ALB | Albany County |
| MUC | Munich Airport |
| HAM | Hamburg Airport |

**Serves Table**

| cityName | airportCode |
|---|---|
| Houston | IAH |
| Houston | HOU |
| Albany | ALB |
| Munich | MUC |
| Hamburg | HAM |

# Another Many-to-Many Association Mapping

*We need the Tournament/Player association as a separate table*




**Tournament table**

| id | name | ... |
|---|---|---|
| 23 | novice | |
| 24 | expert | |

**TournamentPlayerAssociation table**

| tournament | player |
|---|---|
| 23 | 56 |
| 23 | 79 |

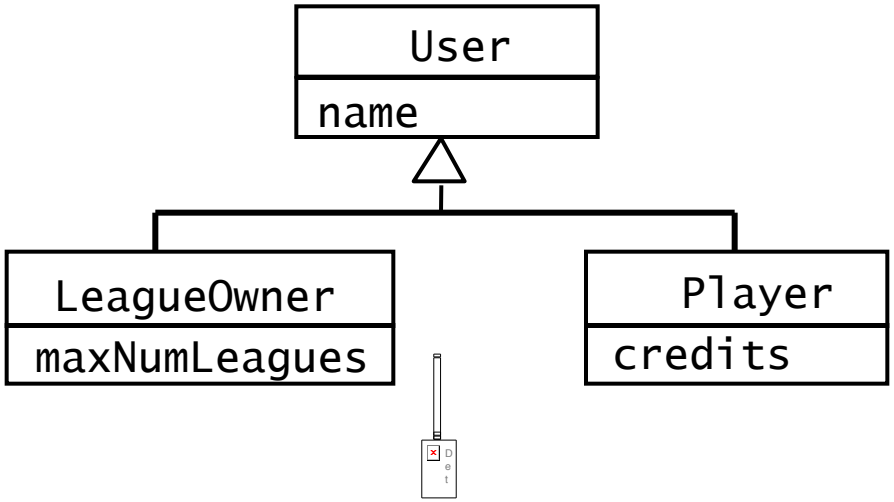
**Player table**

| id | name | ... |
|---|---|---|
| 56 | alice | |
| 79 | john | |

# Realizing Inheritance

- Relational databases do not support inheritance
- Two possibilities to map an inheritance association to a database schema
  - With a separate table ("vertical mapping")
    - The attributes of the superclass and the subclasses are mapped to different tables
  - By duplicating columns ("horizontal mapping")
    - There is no table for the superclass
    - Each subclass is mapped to a table containing the attributes of the subclass and the attributes of the superclass

# Realizing inheritance with a separate table (Vertical mapping)




**User table**

| id | name | ... | role |
|---|---|---|---|
| 56 | zoe | | LeagueOwner |
| 79 | john | | Player |

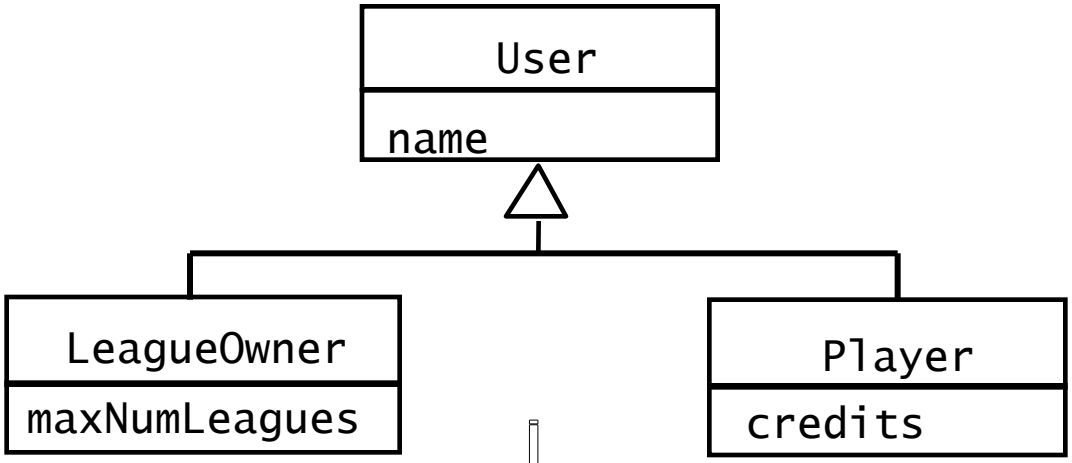
**LeagueOwner table**

| id | maxNumLeagues | ... |
|---|---|---|
| 56 | 12 | |

**Player table**

| id | credits | ... |
|---|---|---|
| 79 | 126 | |

# Realizing inheritance by duplicating columns (Horizontal Mapping)




**LeagueOwner table**

| id | name | maxNumLeagues | ... |
|---|---|---|---|
| 56 | zoe | 12 | |

**Player table**

| id | name | credits | ... |
|---|---|---|---|
| 79 | john | 126 | |

# Comparison: Separate Tables vs Duplicated Columns

- The trade-off is between modifiability and response time
  - How likely is a change of the superclass?
  - What are the performance requirements for queries?
- Separate table mapping  (Vertical mapping)
  - ☺We can add attributes to the superclass easily by adding a column to the superclass table
  - ☹Searching for the attributes of an object requires a join operation.
- Duplicated columns (Horizontal Mapping)
  - ☹Modifying the database schema is more complex and error-prone
  - ☺Individual objects are not fragmented across a number of tables, resulting in faster queries

# Summary

- Four mapping concepts (we did not cover all of them)
  - Model transformation improves the compliance of the object design model with a design goal
  - Forward engineering improves the consistency of the code with respect to the object design model
  - Refactoring improves code readability/modifiability
  - Reverse engineering discovers the design from the code.
- Model transformations and forward engineering techniques: (we did not cover all of them)
  - Optimizing the class model
  - Mapping associations to collections
  - Mapping contracts to exceptions
  - Mapping class model to storage schemas.