The Toolbox
工具箱

Vertical and horizontal contracts in large systems

Anders Kalhauge

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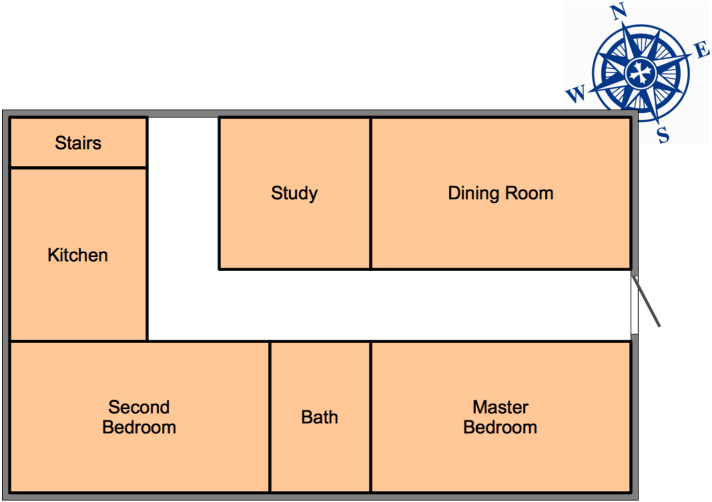
The goal of the day

- You all understand the toolbox as a sound alternative, somewhere between the extreme formalization in Design by Contract, and no formalization in natural language contracts.
- You will master the central elements in the toolbox.
- Understand and can use UML artifacts to define contracts between development groups working at the same level.
  - Vertical contracts
  - Horizontal contracts

Agenda

- Presentation of the details in a design contract
  - Table of content (template)
  - Evaluation criteria
- Introduction to the toolbox as a practical example to contract based software development
  - focus is on vertical contracts: front-end $\longleftrightarrow$ back-end
- Presentation of the toolbox
  - we might skip some of the slides ☺

Subsystems


N
E
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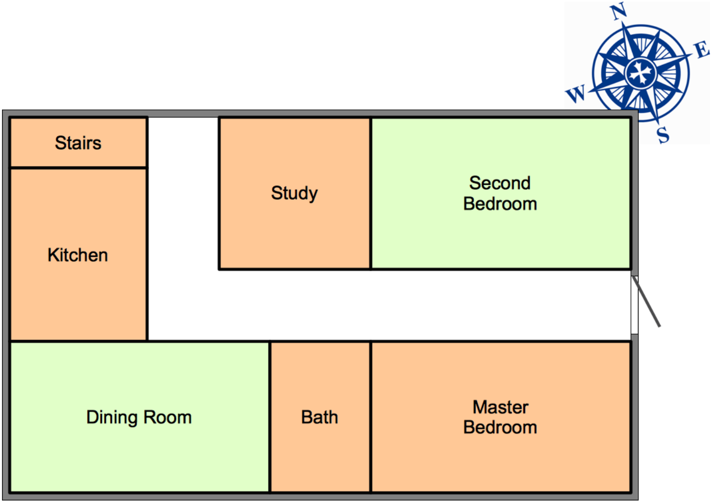
Stairs
Kitchen
Study
Dining Room
Second
Bedroom
Bath
Master
Bedroom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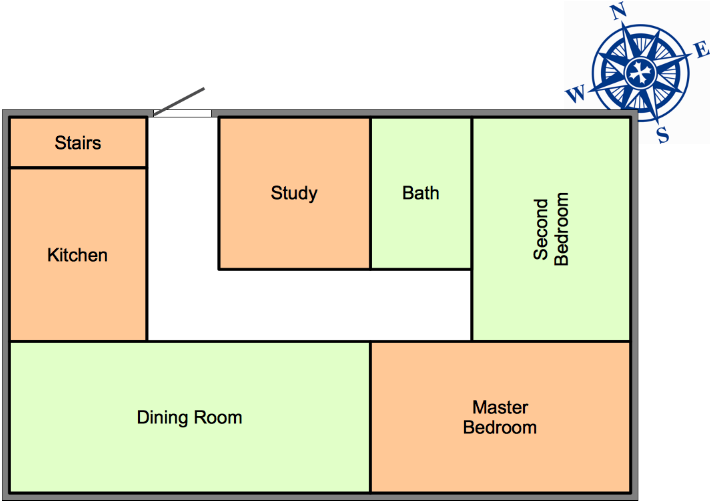
Subsystems


N
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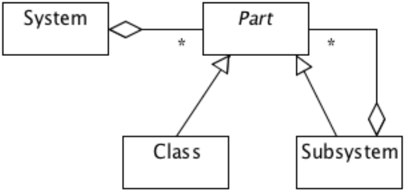
Subsystems

Table 6-1 Mapping of architectural and software engineering concepts.

	Architectural concept	Software engineering concept
Components	Rooms	Subsystems
Interfaces	Doors	Services
Nonfunctional requirements	Living area	Response time
Functional requirements	Residential house	Use cases
Costly rework	Moving walls	Change of subsystem interfaces

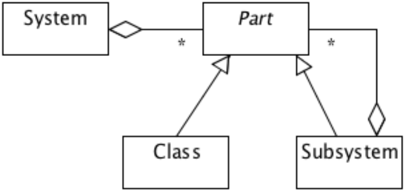
System design identifying large chunks of work that could be assigned to individual teams.

Object design specifying the boundaries between objects.



- Do you recognise this pattern?

Subsystems



- Do you recognise this pattern?
- What is the difference between a component and a subsystem?

Component Reusable encapsulated well defined software. Cannot stand alone.

Subsystem Encapsulated well defined stand-alone software. Might or might not be an application by itself.

Application An end-usable piece of software.

. . . seen this slide before?

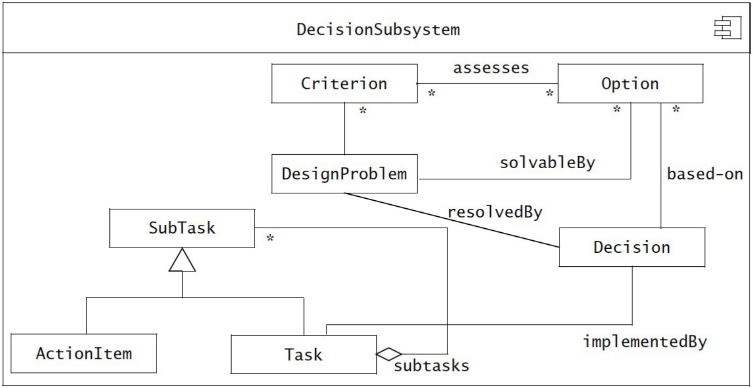


Figure 6-7 Decision tracking system (UML component diagram). The `DecisionSubsystem` has a low cohesion: The classes `Criterion`, `Option`, and `DesignProblem` have no relationships with `Subtask`, `ActionItem`, and `Task`.

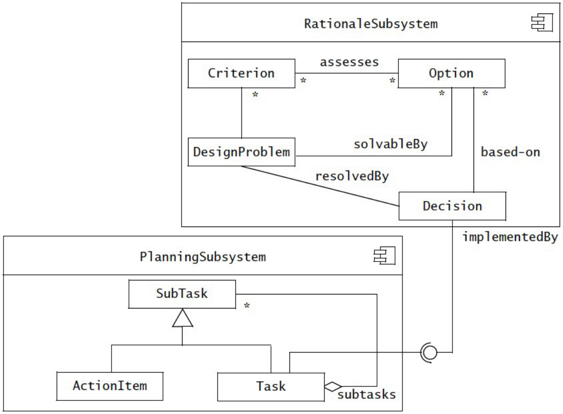
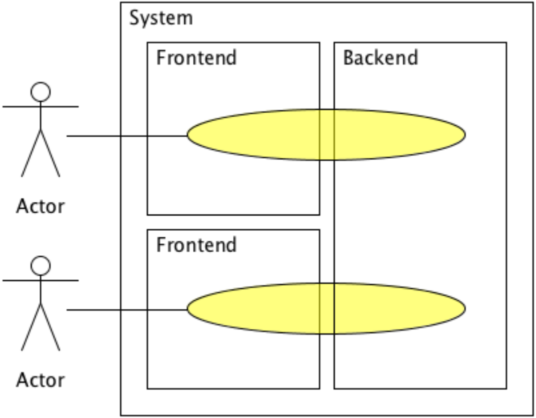


Figure 6-8 Alternative subsystem decomposition for the decision tracking system of Figure 6-7 (UML component diagram, ball-and-socket notation). The cohesion of the `RationaleSubsystem` and the `PlanningSubsystem` is higher than the cohesion of the original `DecisionSubsystem`. The `RationaleSubsystem` and `PlanningSubsystem` subsystems are also simpler. However, we introduced an interface for realizing the relationship between `Task` and `Decision`.

- Layered/functional sub-systems (High Cohesion)
  - Fit to competences between developers
    and/or
  - Fit to distributions on machines
- Use-case based sub-systemer (Low coupling – primary on data level)
  - Fits requirements owner (users)
- Mixed or balanced division
  - Front ends – use-cases - presentation logic
  - Back end - technology - business logic


System
Frontend
Backend
Frontend
Actor
Actor

Overview
What's in the box?

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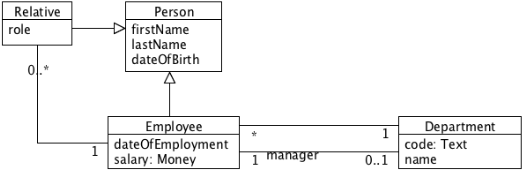
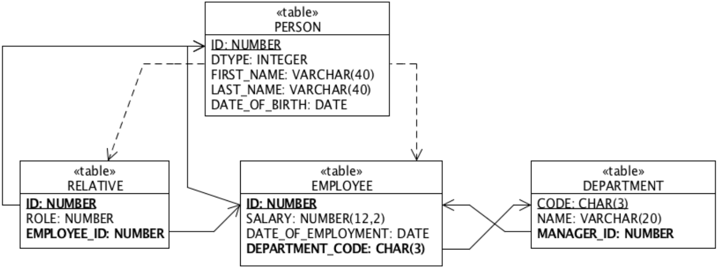
- Logical data model
- Use case model
  - Use case diagram(s)
  - Use case descriptions
  - System sequence diagram
  - System operation contracts
- Communication model
  - System operation contracts
  - Transfer objects
    - Data Transfer Objects (DTOs)
    - Exception Transfer Objects (ETOs)
- Verification strategy

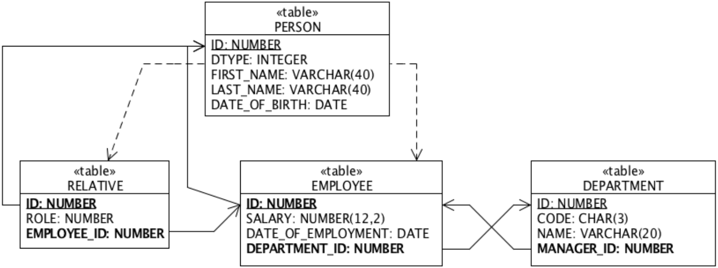
- It models the system state.
- Expresses valid pre- and postcondition states.
- Expresses possible system state changes.



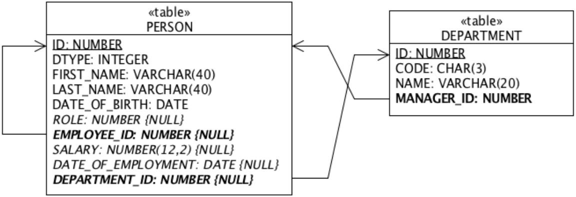
- What should be persisted
- Only entities
- No implementation details
    - No ids unless they contain data (not necessarily wise)
    - Only abstract types



- Primary (<u>underlined</u>) and foreign (**boldfaced**) keys shown.
- Joined tables inheritance strategy, `DTYPE` discriminates between types.

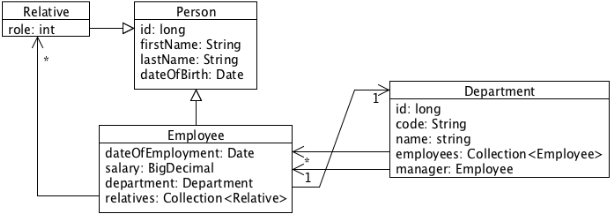


- Same as I, with no data bearing primary keys ☺



- Single table inheritance strategy
- "Irrelevant fields are nulled

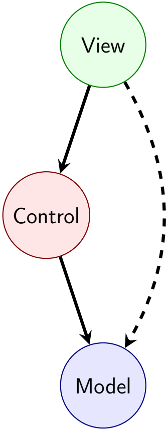
Logical data model
An implementation with objects



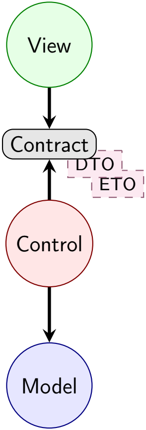
- No associations, only references
- Id's to support "Object Relational Mapping"

Example later...

- User stories
  - Written by users for developers
  - Incomplete by design
- Use cases
  - Written by deveopers for users
  - Intended to be complete



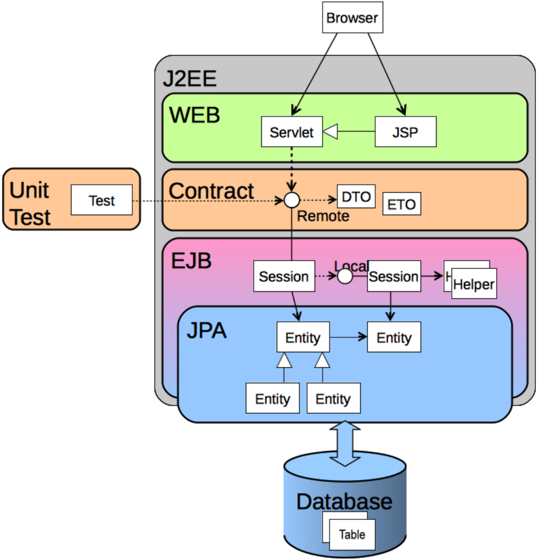
(a)



(b)

Communication model

System operation contracts - Layers in EJB



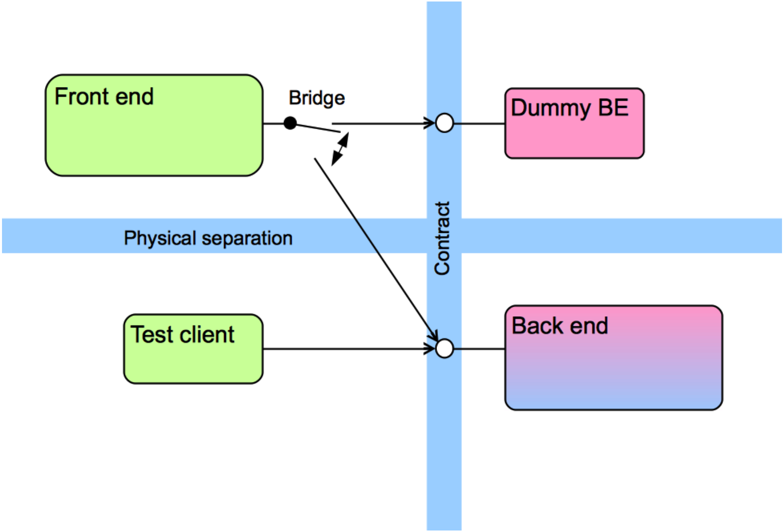
GUI design

Test cases

Use cases

Domain model

Communication model
Project setup with bridge



The interface is the code based operation contract.

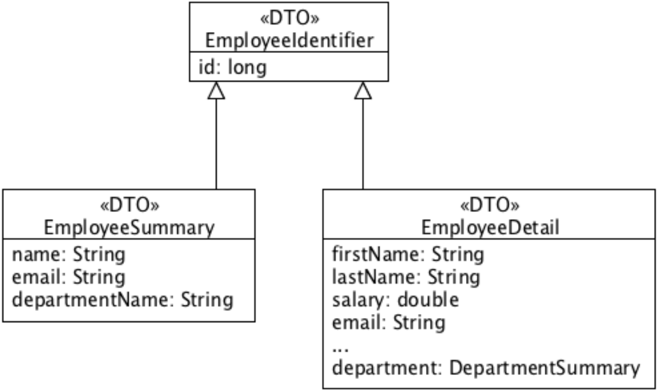
- Use strong typing.
  - use DTOs instead of simple data types.
- Make inline documentation (JavaDoc)
  - have documentation close to code - easier to update.
  - generates written code contracts.
- Implement the interface with a Remote facade in the "backend".
  - Changes to the backend code or to the interface will have less impact.
- Reference the interface from a Factory in the "frontend".
  - Change of backend can be done with practically no code changes in "frontend"

Data transfer objects should be as abstract as possible when still being concrete. Use DTOs for request and return values.

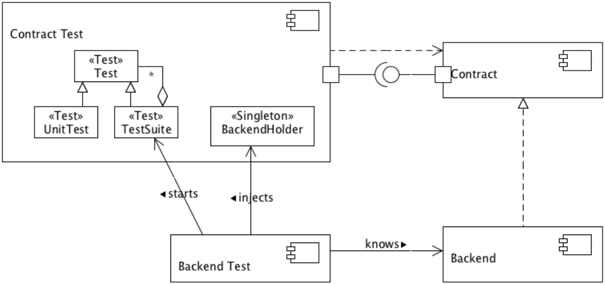
- Efficiency
  - Packing related data together
  - reducing calls - network calls are expensive to establish
  - reducing data - bandwidth is still an issue
- Encapsulation
  - by hiding irrelevant or secret data
  - **by hiding actual implementation**
- Serializable

Exceptions are as valid, even less happy, return values from operations.

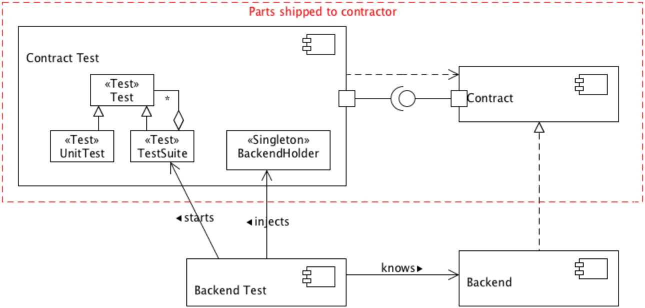
- User friendly - return only relevant information.
  - Preconditions: What precondition was violated (unchecked).
  - Postconditions: What went wrong (checked).
- Encapsulation
  - by hiding actual implementation
  - **revealing errors and their precise cause, is pleasing hackers**
- Serializable - in Java Exceptions are already Serializable

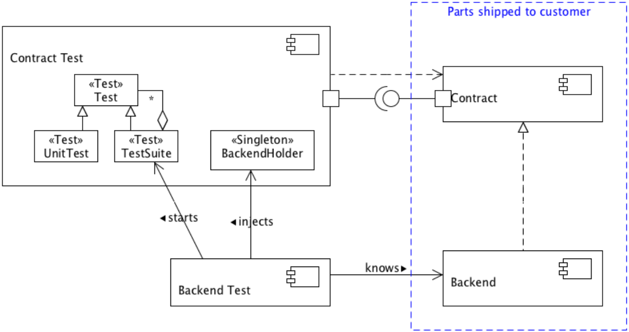


«DTO»
EmployeeIdentifier
id: long
«DTO»
EmployeeSummary
name: String
email: String
departmentName: String
«DTO»
EmployeeDetail
firstName: String
lastName: String
salary: double
email: String
...
department: DepartmentSummary

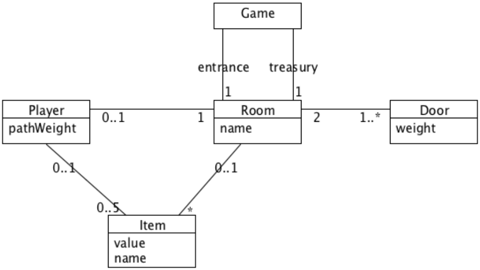

Contract Test
«Test»
Test
*
«Test»
UnitTest
«Test»
TestSuite
«Singleton»
BackendHolder
Contract
◂starts
◂injects
Backend Test
knows▸
Backend

Verification




Parts shipped to customer
Contract Test
«Test»
Test
*
«Test»
UnitTest
«Test»
TestSuite
«Singleton»
BackendHolder
Contract
starts
injects
Backend Test
knows
Backend

We want a Dungeon game. The scenario of the game is a number of connected rooms or dungeons in a mountain. The player enters the mountain from the entrance room, and he/she should travel from dungeon to dungeon until he/she reaches the treasury room. All dungeon has doors that leads to at least one other dungeon. A dungeon can contain an unlimited number of items. Items have values. When a player is in the room he/she can see the items in the room, and he/she can see the doors leading from the room to other dungeons. The player can pick up and lay down items when he/she is in a room. But he/she can keep at most five items at a time. The quest is to reach the treasury room with the most expensive items through the shortest path. The game should run on a central server, and played throug a mobile phone connected to the server.

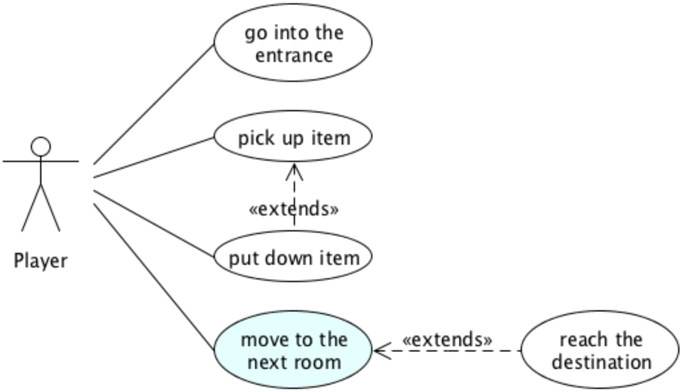


Again:

- Nouns from the requirements (glosary) are candidates
- What should be persisted
- Only entities
- No implementation details

Dungeon game example

Use Case Model - Use Case Diagram



- **Name** Move to the next room
- **Scope** System under design (SuD)
- **Level** Goal: Move to the next room
- **Primary Actor** Player
- **Precondition** The player is in a room
- **Main succes scenario** . . .
- **Success guarantees** The player is in a new room
- **Extensions** Reach the destination if room is treasury room
- **Special Requirements** NONE

- **Name** Move to the next room

  . . .

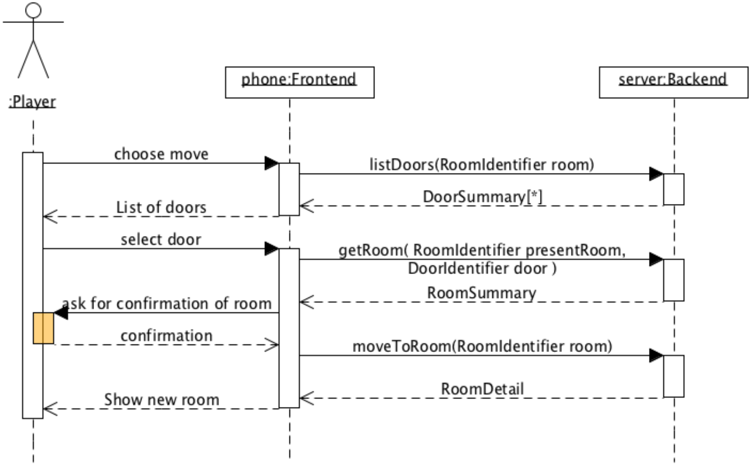
- **Main succes scenario**

  1. Player chooses “move”
  2. System shows a list with all doors to other rooms
  3. Player selects the door he/she wants to move through
  4. System shows the room name, and asks the player to confirm
  5. Player confirms the selection of door
  6. System moves the player to the room behind the selected door

  . . .

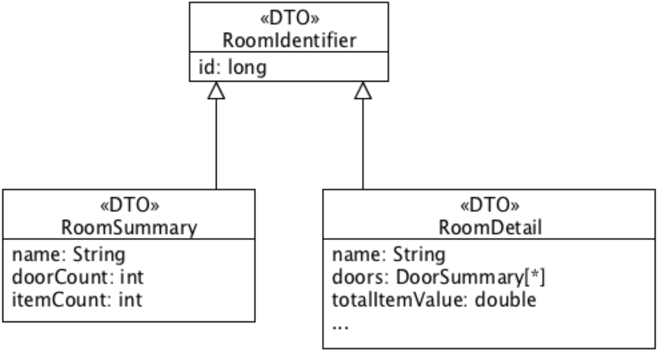
Dungeon game example

Use Case Model - System Sequence Diagram



```java
@Remote
public interface DungeonManager {
  ...
  /**
   * List the doors leading from a given room.
   * @pre the room cannot be null and must exist.
   *   @throws NoSuchRoomException room doesn't exist.
   *   @param room the given room.
   * @post the doors in the given room is returned
   *   @return A collection of door summaries.
   */
  Collection<DoorSummary> listDoors(
      RoomIdentifier room
      );
  RoomSummary getRoom(
      RoomIdentifier room, DoorIdentifier door
      );
  RoomDetail moveToRoom(RoomIdentifier room);
  }
```

Dungeon game example
Communication model - Data Transfer objects



```java
public class RoomIdentifier implements Serializable {
  private long id;

  public RoomIdentifier(long id) {
    this.id = id;
    }

  public long getId() { return id; }
  }
```

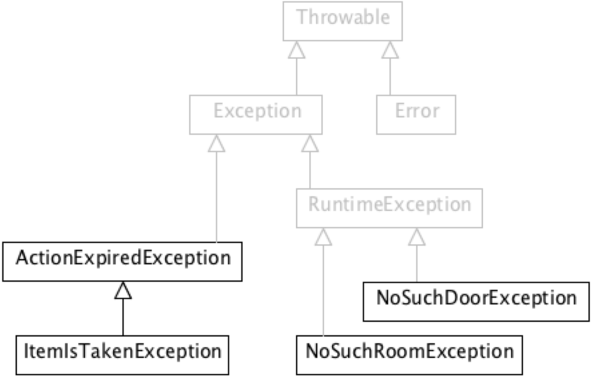
```java
public class RoomSummary extends RoomIdentifier {
  private String name;
  private int doorCount;
  private int itemCount;

  public RoomSummary(
      long id, String name,
      int doorCount, int itemCount
      ) {
    super(id);
    this.name = name;
    this.doorCount = doorCount;
    this.itemCount = itemCount;
    }

  public long getName() { return name; }
  public long getDoorCount() { return doorCount; }
  public long getItemCount() { return itemCount; }
  }
```

Dungeon game example

Communication model - Exception Transfer objects



```java
public class ActionExpiredException
             extends Exception {

  public ActionExpiredException(String message) {
    super(message);
    }

  }
```

```java
public class NoSuchRoomException
             extends RuntimeException {

  public NoSuchRoomException(String message) {
    super(message);
    }

  }
```