Software technology

07 – OOP Principles, Refactoring, Modeling

Dependency Injection

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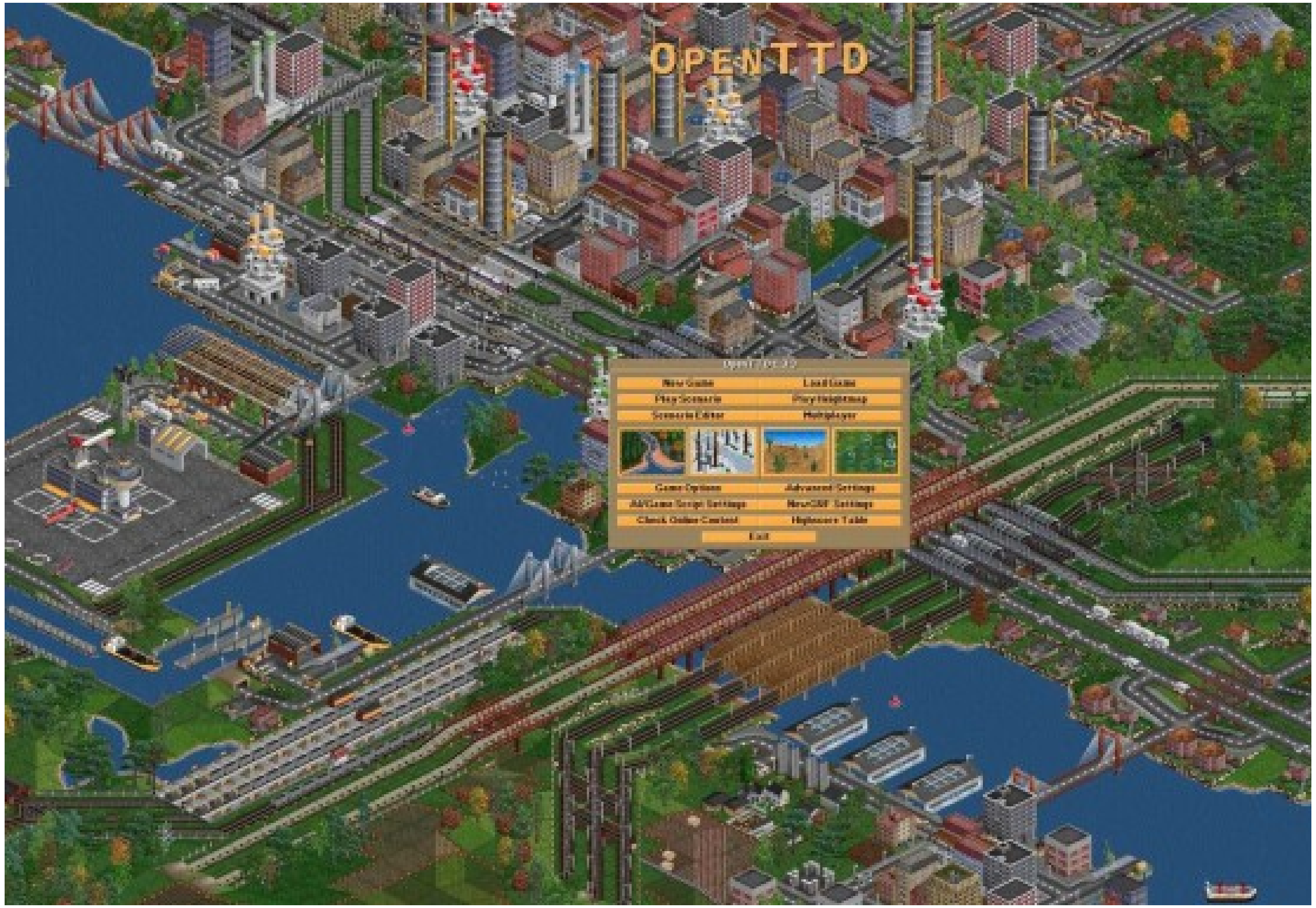
Why OOP? (Object-oriented programming)

- What is it?
- Why are we using OOP?
- What are the tools for OOP?
- What is a good OOP design?
    - How can we evaluate?
    - How can we generate?

OOP Example

How would you sketch up the object model of this game?



OOP Example

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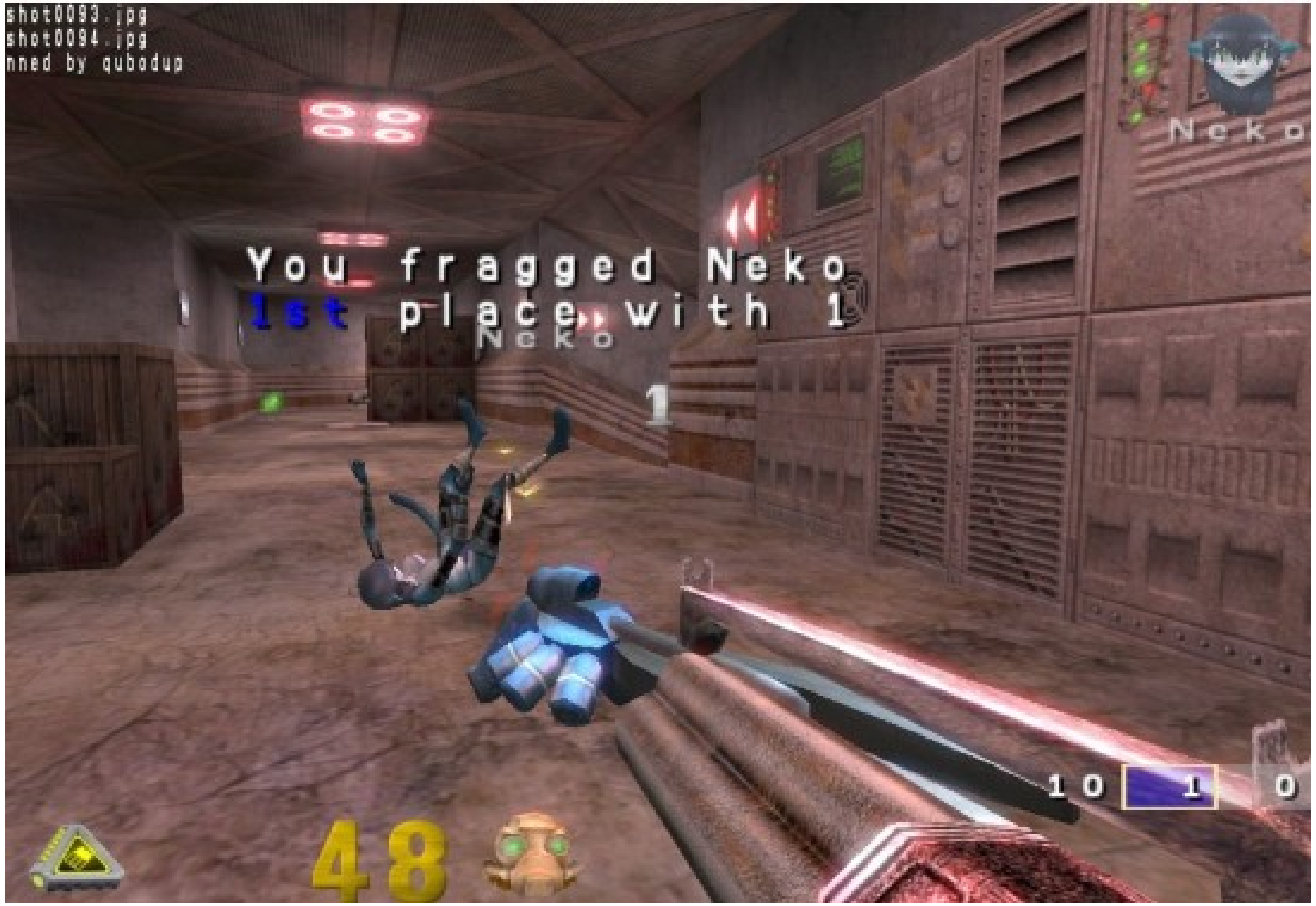
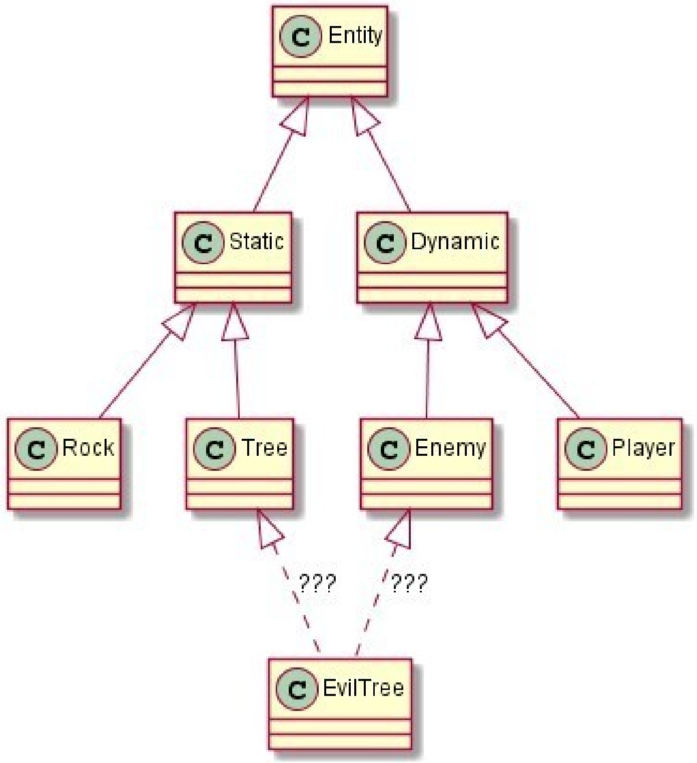


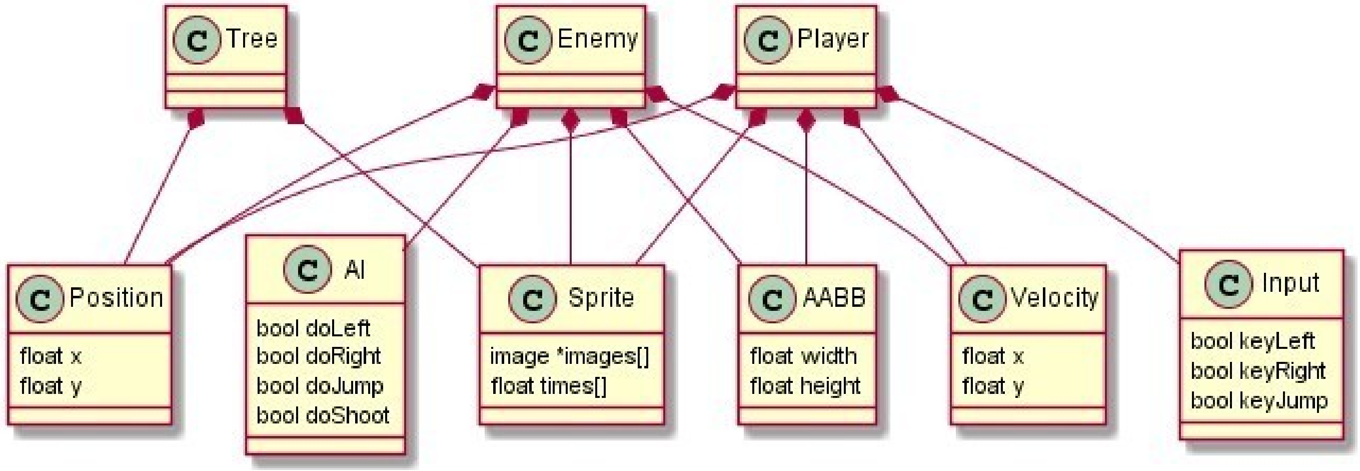
OOP Example

- Not everything can be solved by inheritance or classic OOP constructs (at least not in the classic way)



OOP Example

- Composition over inheritance → ECS (Entity-Component-System)
- ECS is a high-level compositional design pattern



OOP Tools

- Classes, Objects…
- Composition or inheritance or delegation?
- Dynamic dispatch (late binding) or message passing
  - What about static (parametric) polymorphism? (templates)
- Goals
  - Reusability
  - Maintainability
  - Support teamwork

OOP Tools

- Tools are not enough…
  - Design Patterns
  - Control flow vs Data flow
  - Responsibility-driven Design
  - Data-driven Design

OOP Tools

- Unlimited ways of code + data grouping
  → How to do encapsulation?
  → Which one is the best?
- Maybe: Think about
  - SW processes
  - Feature introduction
  - Agile
- *Just because I am using OOP Tools does not mean that my design is any good*

SOLID

- 5 principles of Object-Oriented Programming and Design
- Principles to remove Code Smells
- **S** – Single Responsibility Principle
- **O** – Open/Closed Principle
- **L** – Liskov Substitution Principle
- **I** – Interface Segregation Principle
- **D** – Dependency Inversion Principle

SOLID

- **S** = A class should have one responsibility. Encapsulate along responsibility lines.
- **O** = Classes should be closed for modification (they are whole, complete, functioning units), but open for extension (structural extension example via polymorphism)
- **L** = Objects can be replaced by their subtype without ruining correctness.
- **I** = Large interfaces should be broken up. If I use an interface, I depend on it. I don’t want to depend on many. (Maximal separation)
- **D** = Depend on abstractions only, not concrete implementations

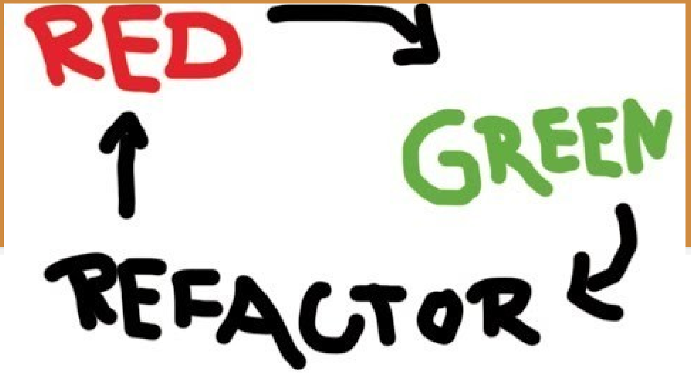
Architectural Improvements

1. Refactoring

2. Class Normalization

3. Design Patterns (and anti-patterns)

1. Refactoring



- No external behavior change, but
- Improve
  - Readability
  - Ease of understanding (lower complexity)
  - Extensibility
  - Maintainability

→ Improve all goals of OOP (teamwork)

1. Refactoring

- Program transformations
  - Rename (understanding – most important!!!)
  - Move
  - Break into components (new class or method)
    - Encapsulate
  - Generalize
  - Branching into Compound State or Polymorphic behavior
- Tools (…many IDEs)

refactor

engage ■ succeed ■ repeat

2. Class Normalization

- Comes from DB normalization
  - 1st object normal form (1ONF)
    - Encapsulate behavior of multiplicity >1
  - 2nd object normal form (2ONF)
    - Encapsulate any shared behavior
  - 3rd object normal form (3ONF)
    - Encapsulate one set of cohesive behavior per class
- Behavior = code, data or combination

3. Design Patterns

- *...coming soon! (next weeks)*
- Types
  - Creational
  - Structural
  - Behavioral
  - Concurrent
  - Architectural

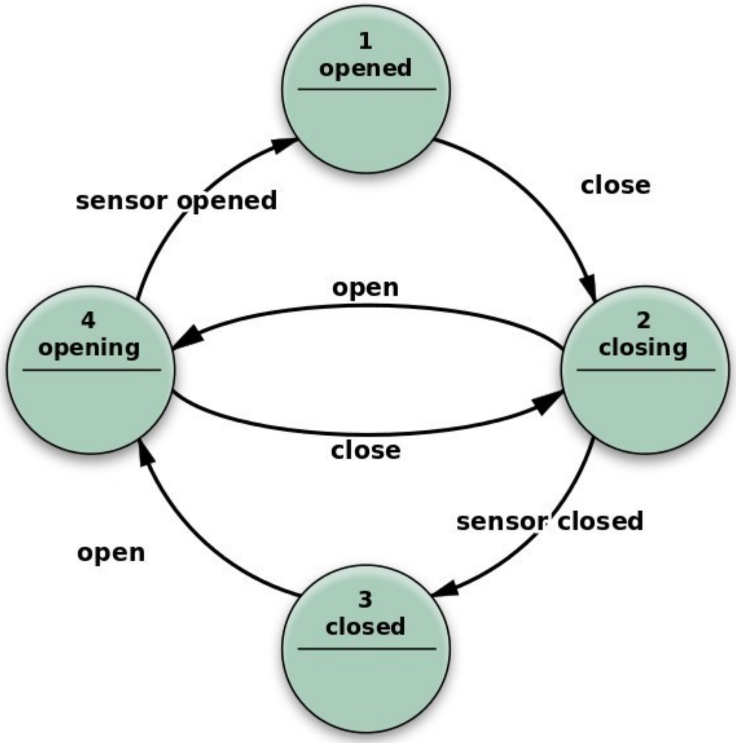
OOA (Object-Oriented Analysis)

- Structured analysis and design was something like
  - Sketch up system (to some level of detail)
  - Implement
  - Improve

- Instead do deeply precise analysis → OOA (Shlaer-Mellor Method)

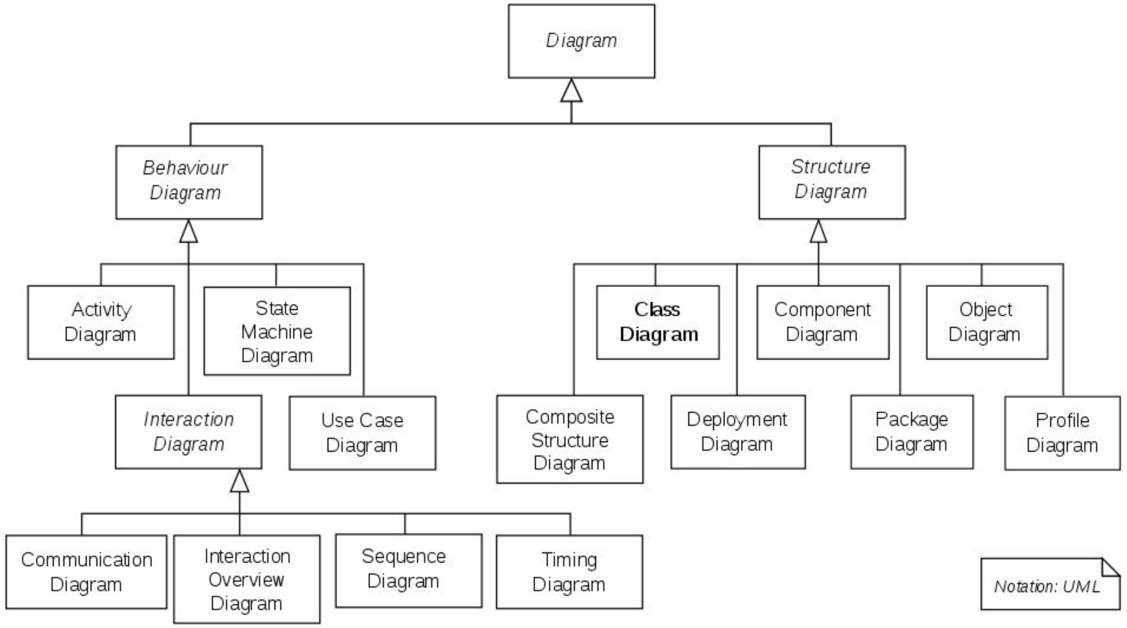
OOA (Object-Oriented Analysis)

- Translation instead of Elaboration
- Logic in Finite-State Machines
- Action Data Flow Diagram or Action Language
- Virtual Machine
- Cross language, Cross platform compilable
- Simulation
- Test

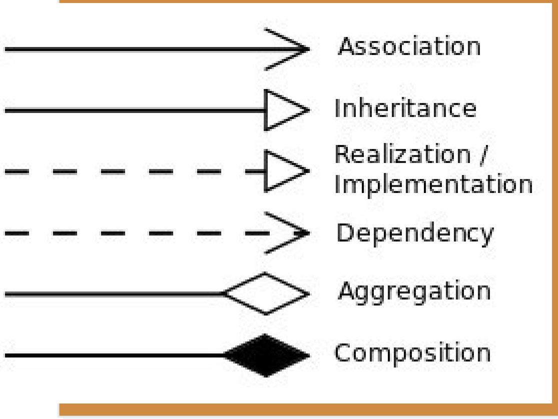


UML (Unified Modeling Language)

- Divided into 2 groups:
  1. Static (structural) view
  2. Dynamic (behavioral) view



UML
Class diagram



Association

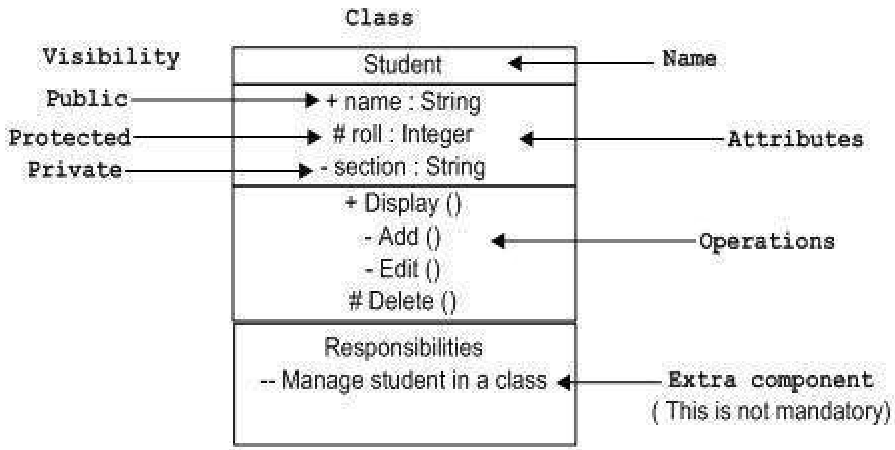
Inheritance

Realization / Implementation

Dependency

Aggregation

Composition



Class

Visibility

Student ← Name

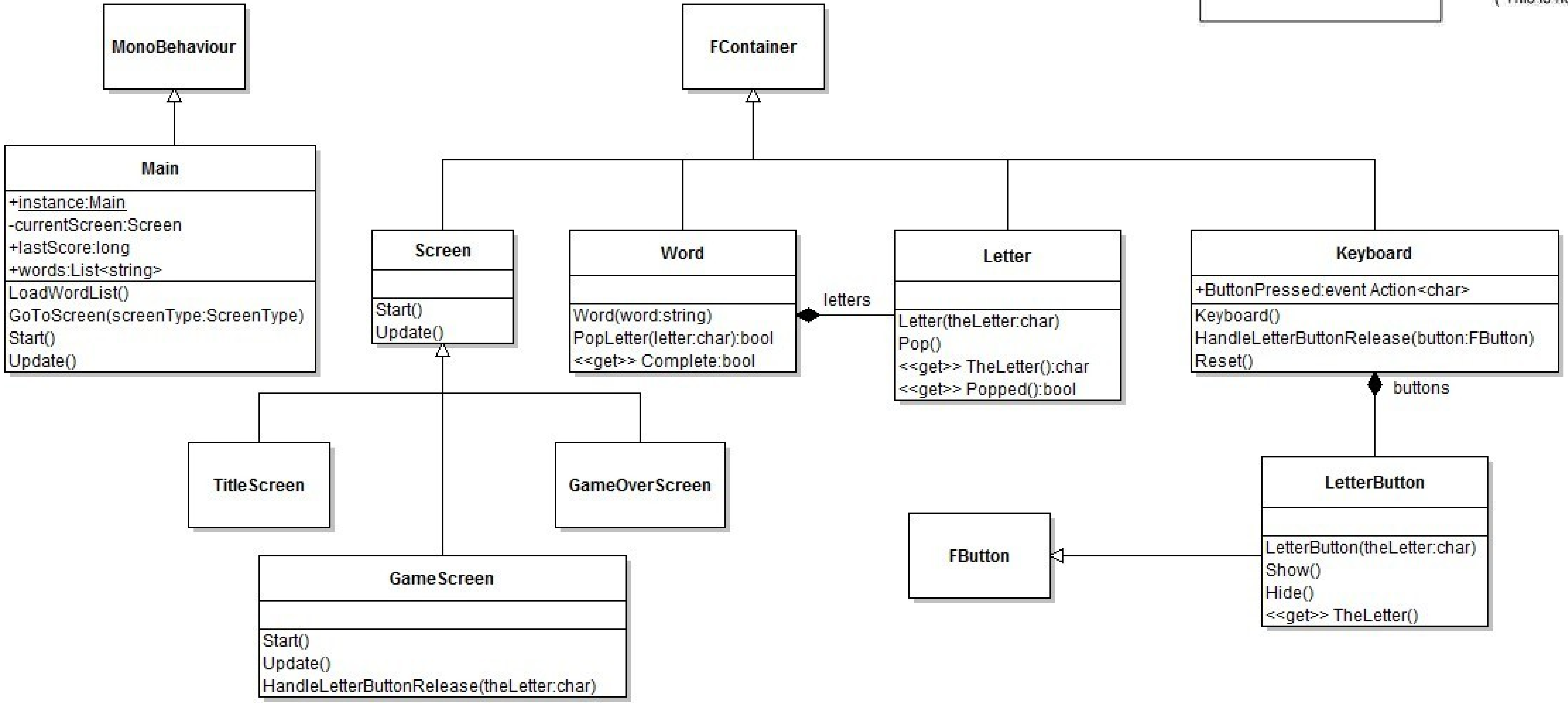
Public → + name : String

Protected → # roll : Integer ← Attributes

Private → - section : String

+ Display ()
- Add () ← Operations
- Edit ()
Delete ()

Responsibilities
-- Manage student in a class ← Extra component
(This is not mandatory)



MonoBehaviour

Main
+instance:Main
-currentScreen:Screen
+lastScore:long
+words:List<string>
LoadWordList()
GoToScreen(screenType:ScreenType)
Start()
Update()

FContainer

Screen
Start()
Update()

Word
Word(word:string)
PopLetter(letter:char):bool
<<get>> Complete:bool

letters

Letter
Letter(theLetter:char)
Pop()
<<get>> TheLetter():char
<<get>> Popped():bool

Keyboard
+ButtonPressed:event Action<char>
Keyboard()
HandleLetterButtonRelease(button:FButton)
Reset()

buttons

TitleScreen

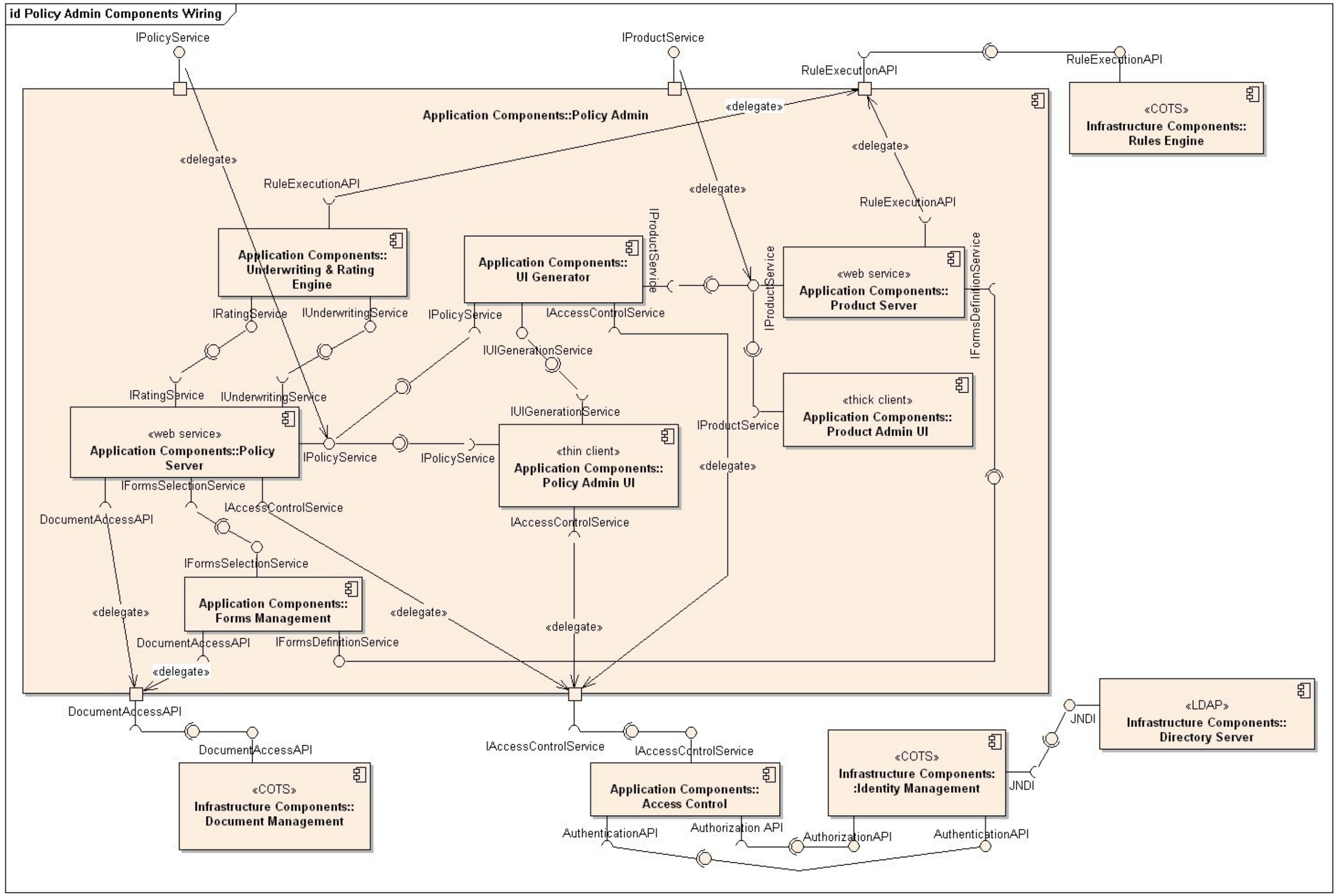
GameOverScreen

GameScreen
Start()
Update()
HandleLetterButtonRelease(theLetter:char)

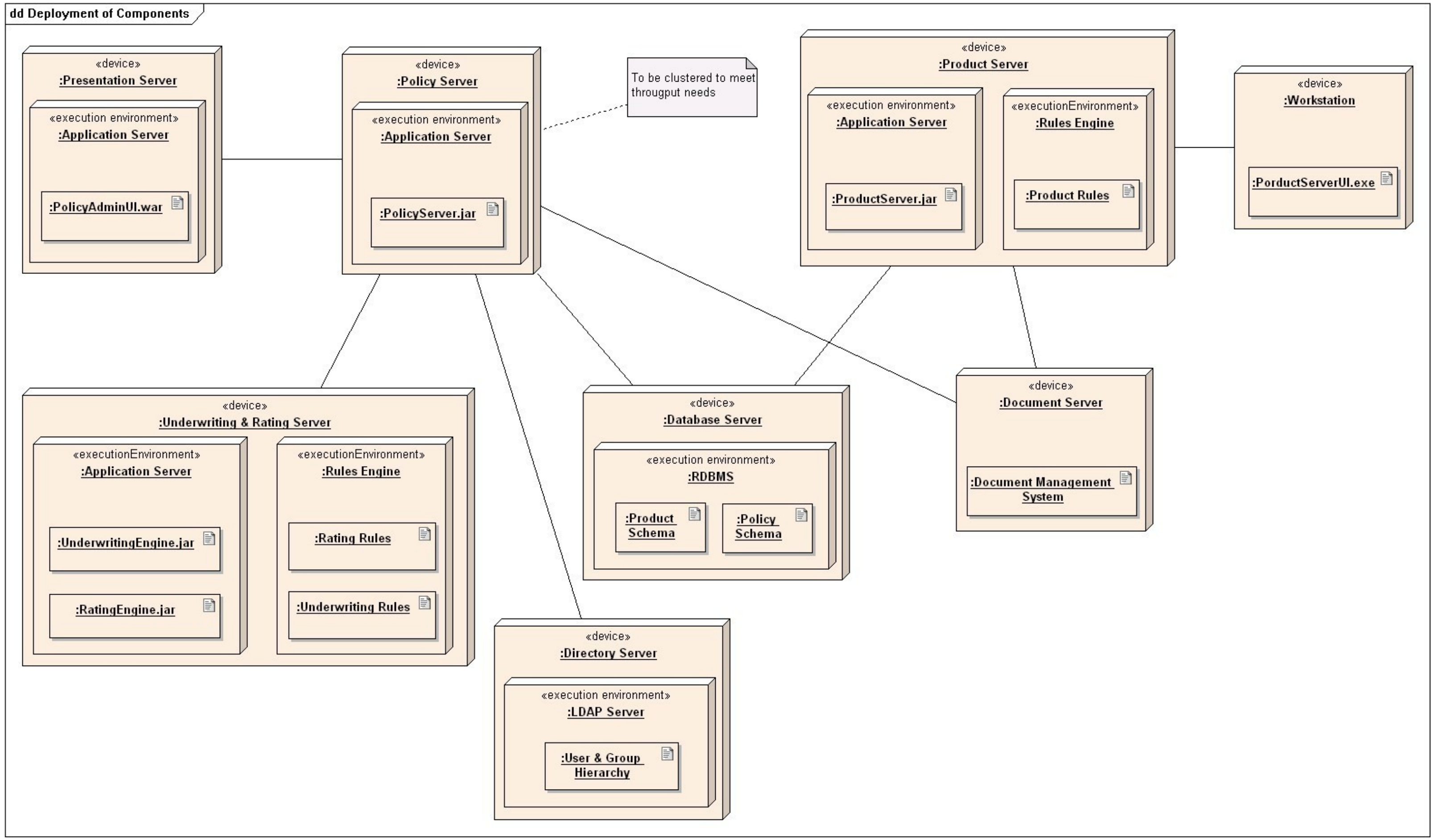
FButton

LetterButton
LetterButton(theLetter:char)
Show()
Hide()
<<get>> TheLetter()

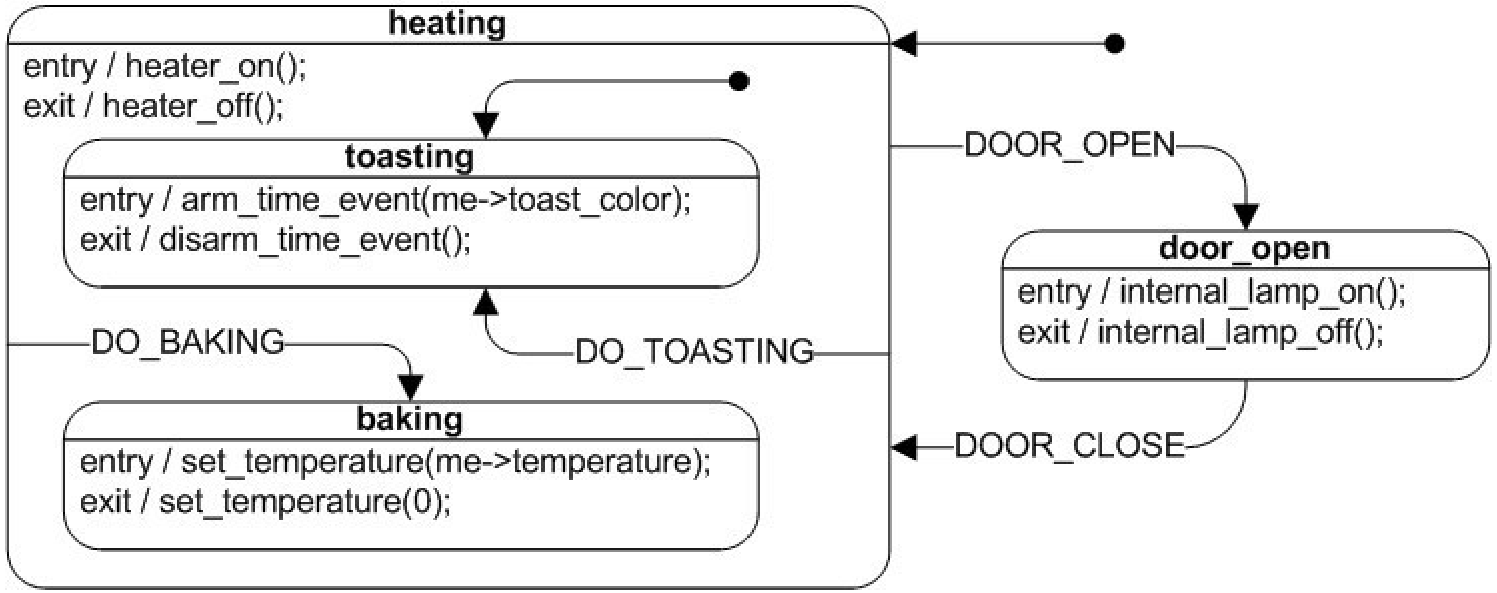
UML Component diagram



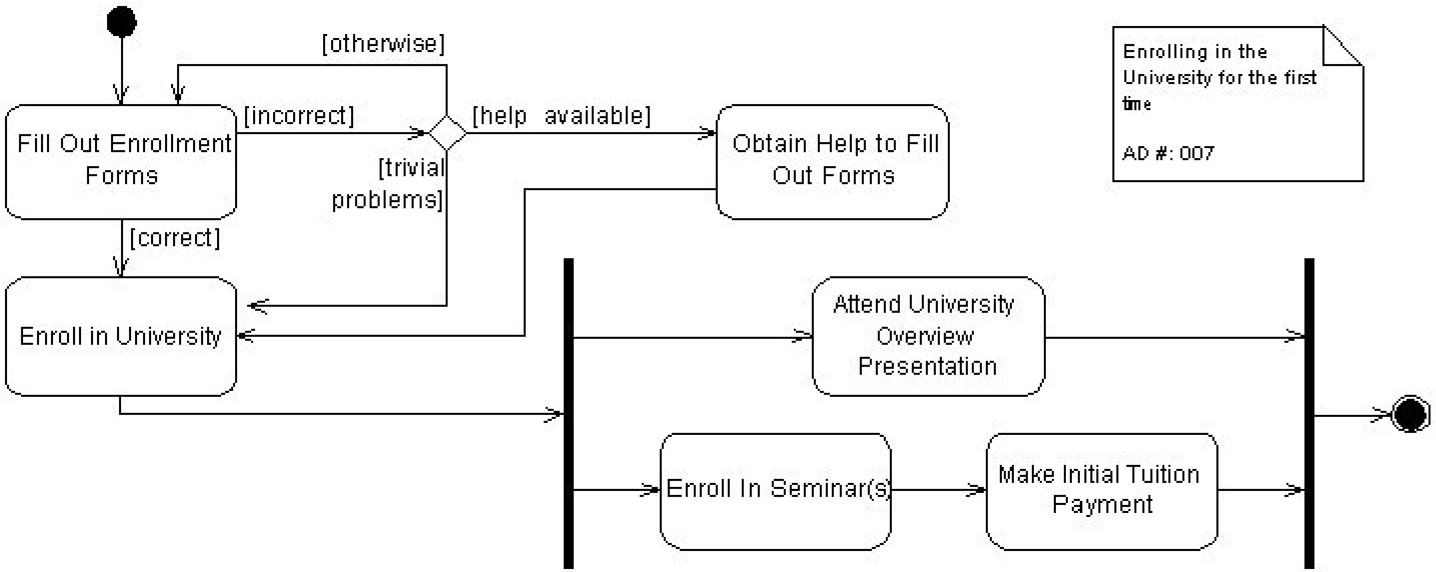
UML Deployment diagram



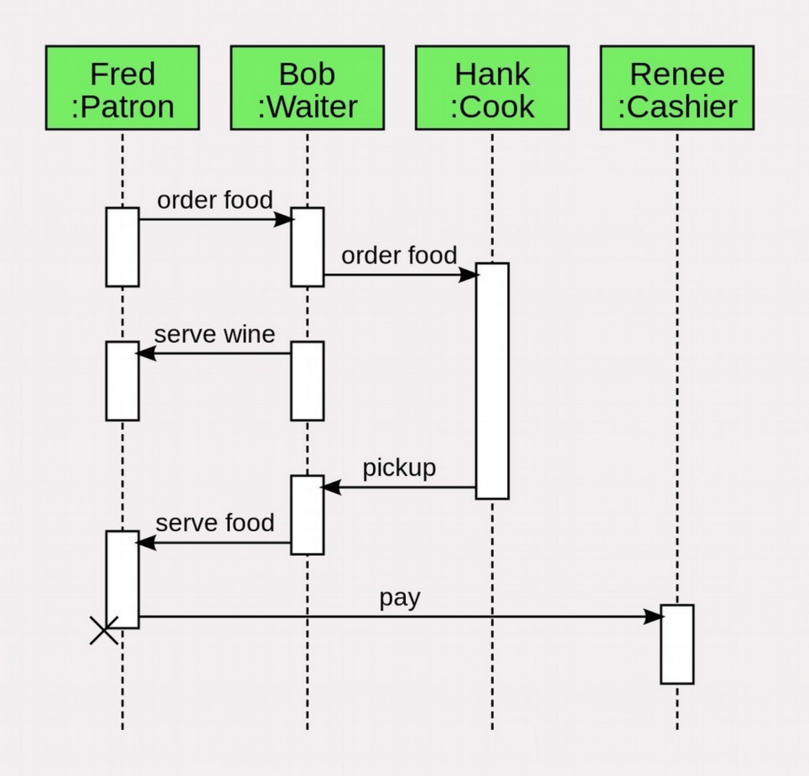
UML State Machine diagram


heating
entry / heater_on();
exit / heater_off();
toasting
entry / arm_time_event(me->toast_color);
exit / disarm_time_event();
DO_BAKING
DO_TOASTING
baking
entry / set_temperature(me->temperature);
exit / set_temperature(0);
DOOR_OPEN
door_open
entry / internal_lamp_on();
exit / internal_lamp_off();
DOOR_CLOSE

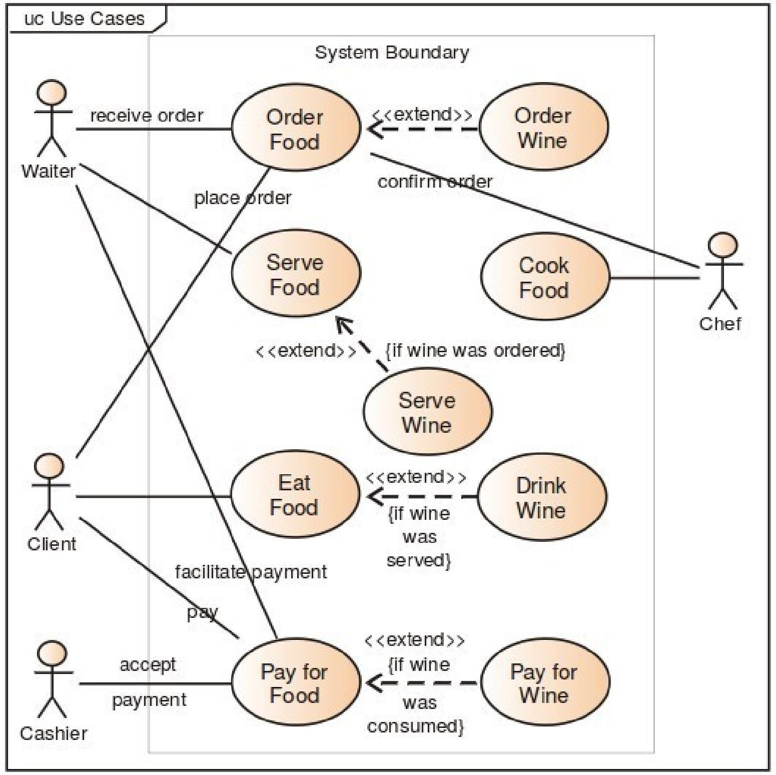
UML Activity diagram


[otherwise]
[incorrect]
[help available]
Fill Out Enrollment Forms
Obtain Help to Fill Out Forms
[trivial problems]
[correct]
Enroll in University
Attend University Overview Presentation
Enroll In Seminar(s)
Make Initial Tuition Payment
Enrolling in the University for the first time
AD #: 007

UML Sequence diagram



UML Use Case diagram



UML Criticism

- Good to visualize and present, but…
  - Nobody wants to program this way (creating diagrams)
  - Complex diagrams cannot be overseen
  - Simple diagrams are useless
  - Only program stub is generated
  - No round-trip editing

xtUML (eXecutable Unified Modeling Language)

- UML subsets (to make xtUML fully supported)
- Action Language
- Virtual Machine
- Testing, debugging (including state visualization), measurements are possible on original model without compilation
- Model Compilation
  - Into any language
  - On any platform
  - Possible optimization to target language / platform

MDD (Model-driven Development)

- Model-driven architecture design is useful for further development
- Model-driven Testing can be used independent of platform
- Model-driven Testing can give proof

Questions?

- ...
- Or write me an email to gla@inf.elte.hu

Dependency Injection

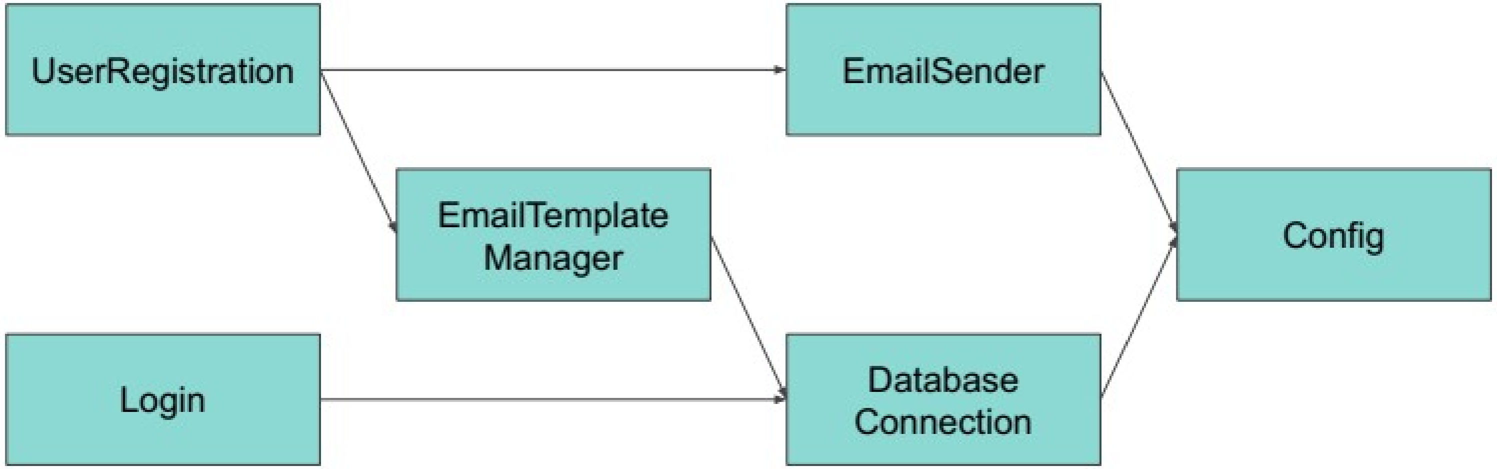
Class diagram

- During the semester, we work with the OOP and the imperative paradigm
- One of the basic principles of OOP is the class diagram, see:
  - https://en.wikipedia.org/wiki/Class_diagram
- Designing a program basically means to design the classes and the relations between the program operates with
- You basically define instance and class level relationships

Example
Who creates the Instances?

```
public void main(String[] args) {
   ConfigInterface config = new Config(“config.json”);
   EmailSenderInterface emailSender = new EmailSender();
   emailSender.setConfig(config);
   EmailTemplateInterface emailTemplate = new EmailTemplate();
   UserRegistratorInterface userRegistrator = new UserRegistrator();
   userRegistrator.setEmailSender(emailSender);
   userRegistrator.setEmailTemplateManager(emailTemplateManager);
   ...
}
```

Example on Class References



Manual Instantiation

- A lot of (centralized) code. Decentralization?
- Maybe a subtree is sufficient. No need for all the instances. Optimization?
- Redundancy (which should be eliminated in general, as it indicates a design flaw)
  - You define the new class
  - You define the new field that points to it
  - You create the instance
  - You set up a pointer
- Elimination of redundancy?

Dependency Injection

- Why not have a smart container which creates the instances on demand?
- The classes and the relationships are defined
- No instance is created manually
- The classes are annotated as injectables
- Some fields are annotated as inject targets
- The Context Dependency Injection framework creates the instances and also sets the references
  - See: https://en.wikipedia.org/wiki/Inversion_of_control

Annotations

- Classes annotated as **@Named** are to be created automatically
- Fields annotated with **@Inject** will be initialized automatically
- The method annotated with **@PostConstruct** is the initializer of the class. A constructor without parameters is necessary, so that the framework is able to create the instances. The parameters are passed as fields
- The context the instance is created in can be refined by the **@SessionScoped** and **@ApplicationScoped** (and similar) annotations
- You may take a look at:
  - https://en.wikipedia.org/wiki/Service_statelessness_principle

EmailService

```
@Named
public class EmailService implements EmailServiceInterface {
   public void sendEmail(String fromName, String fromEmail,
      String    recipientName, String recipientEmail, String subject,
      String html, String text) {

      <code that actually sends the email>

   }

   …
}
```

UserRegistration

```
@Named
public class UserRegistration implements UserRegistrationInterface {
    @Inject
    private EmailServiceInterface emailService;
    …
}
```

EntityManager

```
@Named
public class UserDao implements UserDaoInterface {
    @PersistenceContext(unitName = "<ProductName>EntityManager")
    protected EntityManager entityManager;
    protected CriteriaBuilder criteriaBuilder;
    @PostConstruct
    public void postConstruct() {
        criteriaBuilder = entityManager.getCriteriaBuilder();
    } …
}
```

ManagedExecutor

```
@Named
public class UserDao implements UserDaoInterface {
    // Do not create threads
    // Use the executor service instead
    @Resource(name = "DefaultManagedExecutorService")
    protected ManagedExecutorService executor;
    …
}
```

Scheduling

```
@Singleton
public class Worker {
   @Schedule(second = "*/10", minute = "*", hour = "*", persistent = false)
   public void run() {
   executor.submit(new FutureTask<Boolean>(new Callable<Boolean>() {
   @Override
   public Boolean call() throws Exception {
   // Do the job
   }
   }));
   }
}
```

Dependency Injection Dependency

- Advanced CDI features can be found in the API

```
<dependency>
<groupId>javax.enterprise</groupId>
<artifactId>cdi-api</artifactId>
<version>2.0-EDR1</version>
</dependency>
```

- In the case you would need to resolve an instance by code
- For example, the class / interface is **determined runtime**

Resolving Instances Runtime

- In the case you would need to resolve an instance by code
- For example, the class / interface is determined runtime

```
public static <T> T resolveByClass(Class<?> clazz)
{
  return (T) CDI.current().select(clazz).get();
}
```

Questions?

- ...
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