Protected Variations and Polymorphism

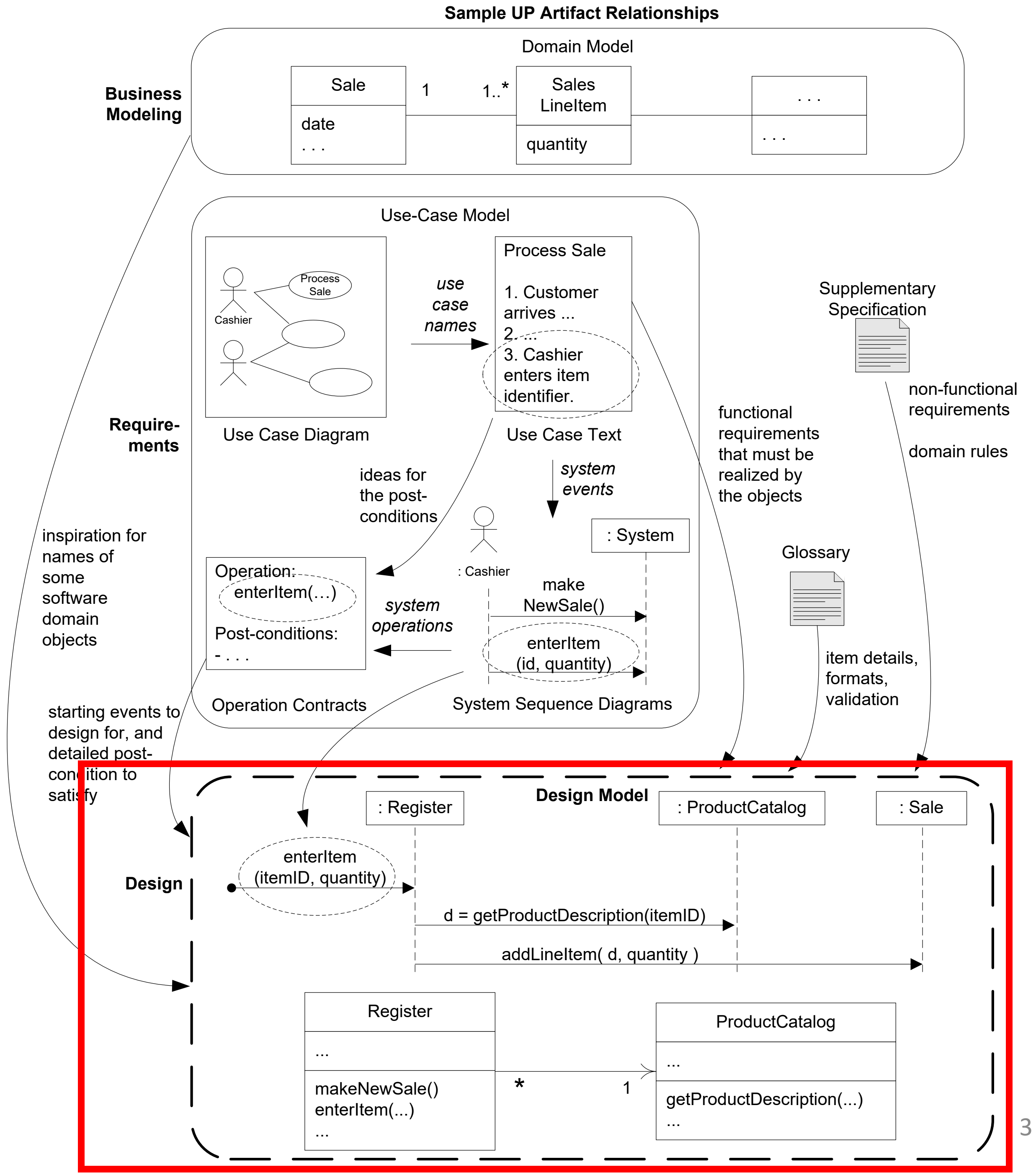
ISEP / LETI / ESOFT

Topics

- GRASP
  - Protected Variations
  - Polymorphism

- Examples
  - Password Generation Algorithms
  - Using External Services
  - Painting Objects

Artifacts Overview



GRASP - General Responsibility Assignment Software Patterns (or Principles)

Recall previous lectures

- GRASP is a methodical **approach to OO Design**
  - Based on principles/patterns for **responsibilities assignment**
  - Helps to understand the fundamentals of object design
  - Allows to apply design reasoning in a methodical, rational, and understandable way

- In UML, the design of Interaction Diagrams (e.g. class and sequence diagrams) is a means to consider and represent responsibilities
  - When designing, you decide which responsibilities to assign to each object

GRASP

- Pure Fabrication
- Controller
- Information Expert
- Creator

- High Cohesion
- Low Coupling
- Polymorphism *
- Indirection
- Protected Variation *

* Patterns addressed in this slide deck

Protected Variations

Motivation for the Problem

Motivating the Need For Protected Variations

- Consider the two example scenarios presented in the following slides
  - **Scenario 1: Password Generation Algorithms**
  - **Scenario 2: Obtaining Geographic Areas**

- Generalize both problems/scenarios to a more universal one

- Analyze the proposed solution for the generic problem and also for the example scenarios

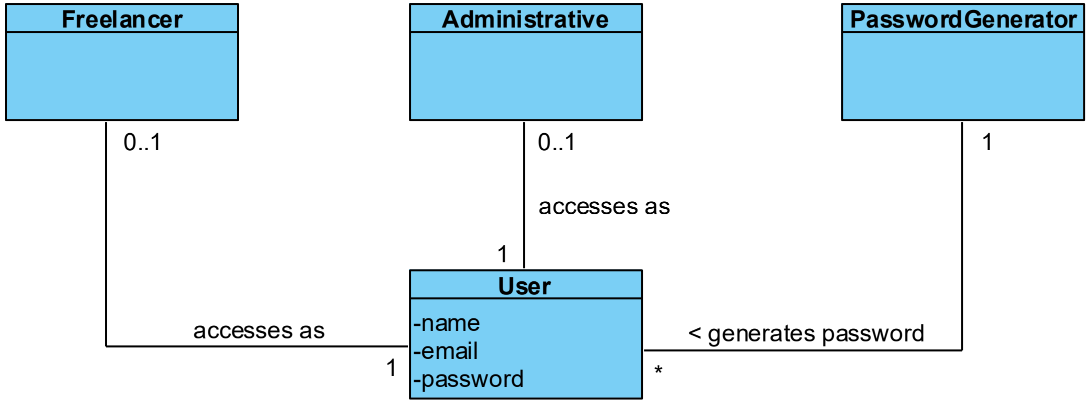
Scenario 1 – Password Generation

For a given application, the **user’s initial passwords** must:

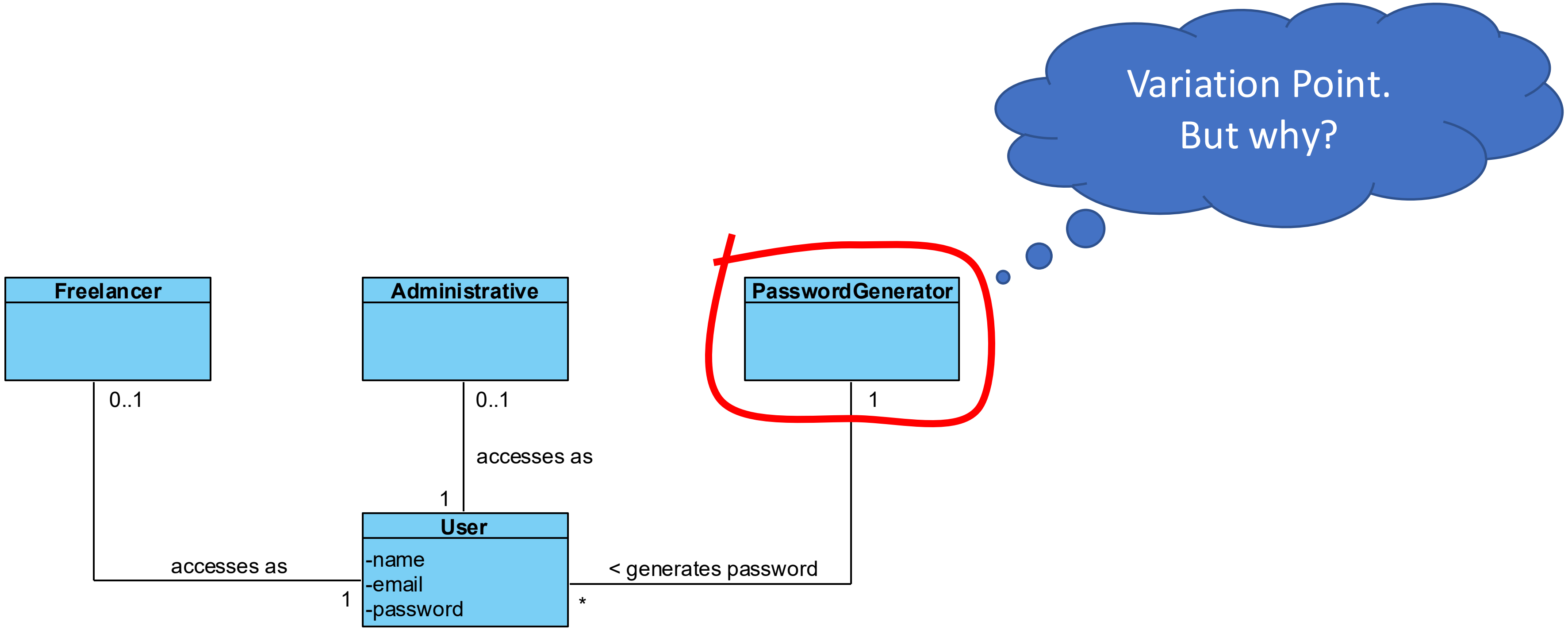
- Be **generated by the system**;
- Using an **external password generator algorithm** (i.e. designed by a third party); and
- Configured only **when deploying the system**.

HOW TO SUPPORT/DESIGN THIS?

Scenario 1 – (Partial) Domain Model (1/2)

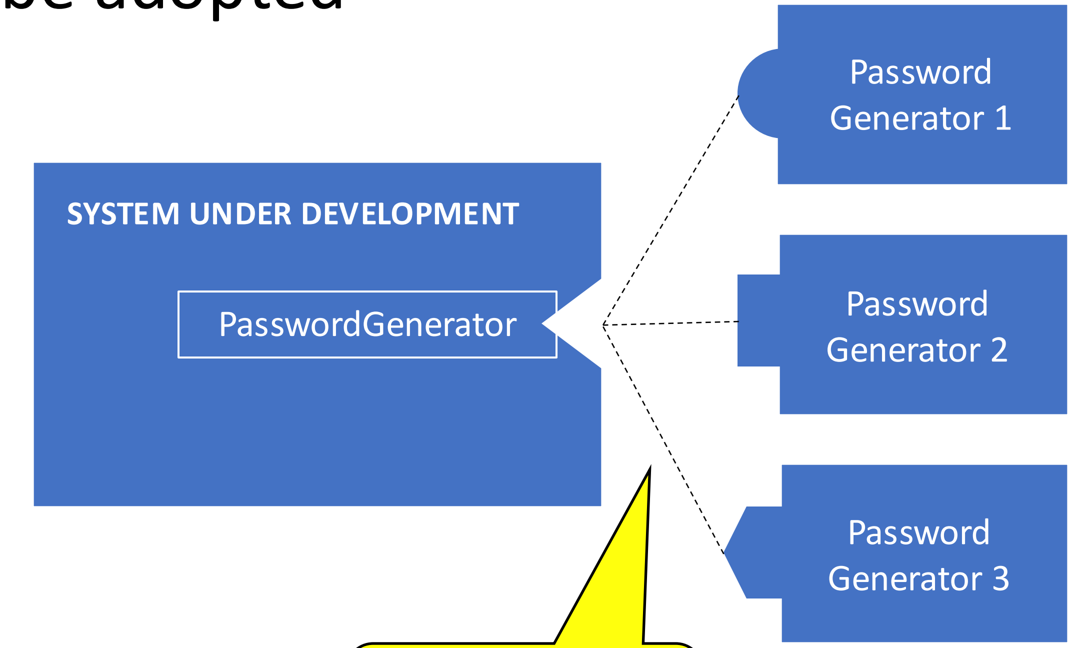


Scenario 1 – (Partial) Domain Model (2/2)



Scenario 1 – Variation Point

- A.k.a. Instability Point
- Several algorithms may exist and be adopted
- Possibly different regarding the:
  - Form of invocation
  - Input data
  - Output data
  - Process / flow
  - …



Lack of compatibility!

Scenario 1 – Coding (with current knowledge)

```
#include <iostream>
#include <string>
using namespace std;
template<typename Base, typename T>

inline bool instanceof(T* obj) {
   return ( (is_base_of<Base, T>::value) ||
            (dynamic_cast<Base*>(obj) != nullptr) );
}

string generatePassword(string name, string email) {
   String pwd;

   if (instanceof<XXX>(this->pwdGenerator)) {
      //...
   }
   else if (instanceof<YYY>(this->pwdGenerator)) {
      //...
   }
   else if (instanceof<ZZZ>(this->pwdGenerator)) {
      //...
   }

   return pwd;
}
```

Variation Point

- To which class does this code belong?
  - Controller? Why?
  - Another class (e.g. PasswordGenerator)?
- Does this code do what is needed?
- Is it “nice” or “pretty”?
- What happens if more rules are needed?

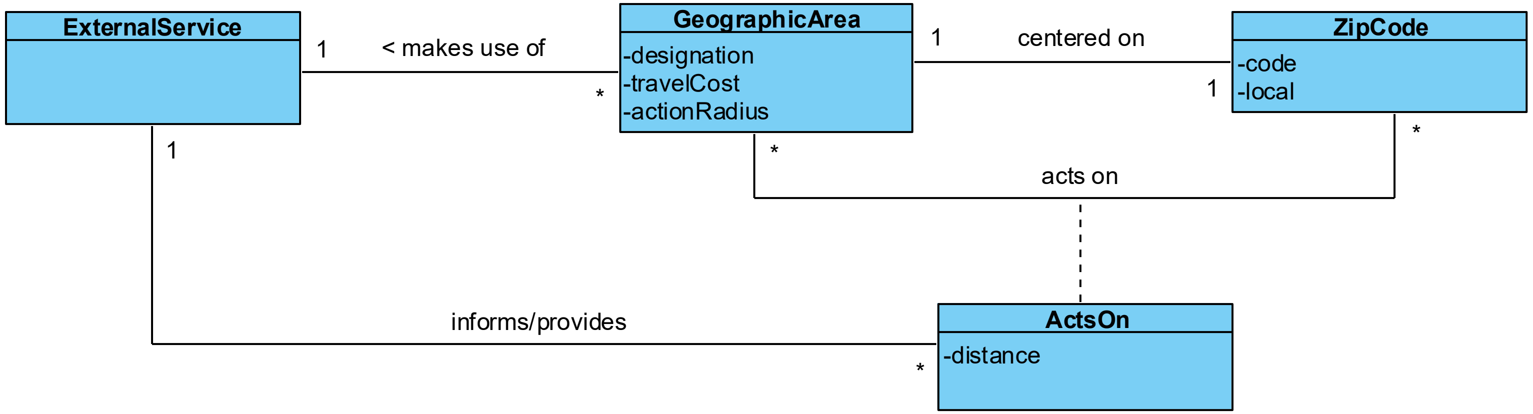
Too many engineering problems to maintain the software!

Scenario 2 – Obtaining Geographic Areas

- For an existing project, each **geographic area** is centered on a single zip code (e.g. “4249-015”) and operates on all postal addresses whose zip code is within its radius of action (e.g. 5 km).
- To obtain the zip codes within the radius of action of another zip code, **an external service is used**
- The system must **support different external services** and the one to be used is **set by configuration at the time of deployment**
- If a zip code is covered by more than one geographic area, the one with the shortest distance is chosen

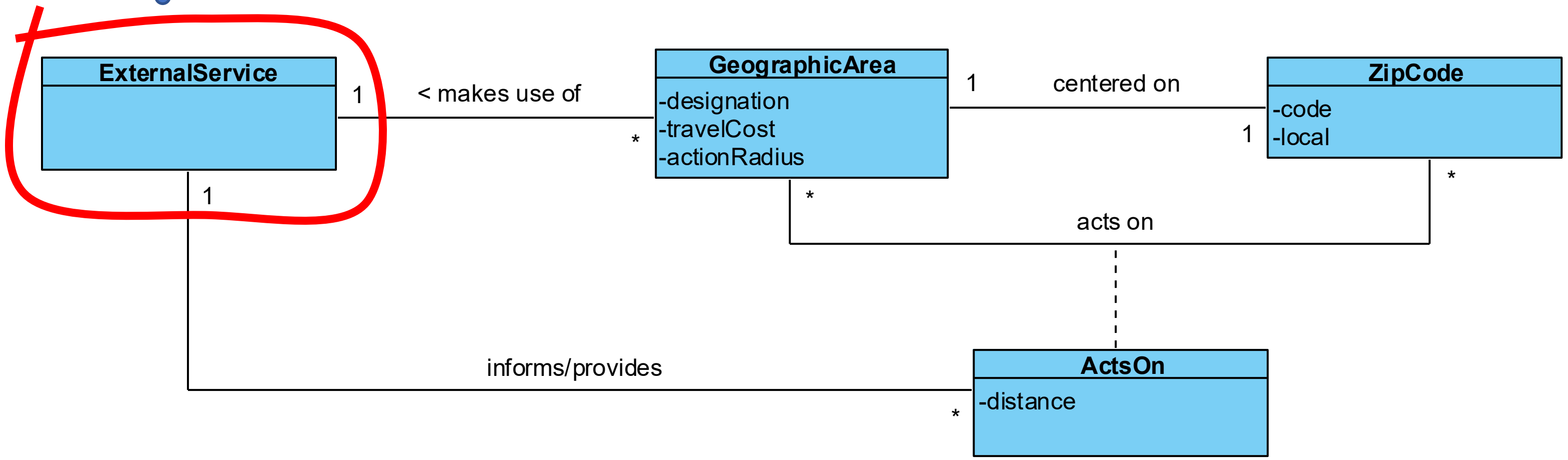
HOW TO SUPPORT/DESIGN THIS?

Scenario 2 – (Partial) Domain Model (1/2)



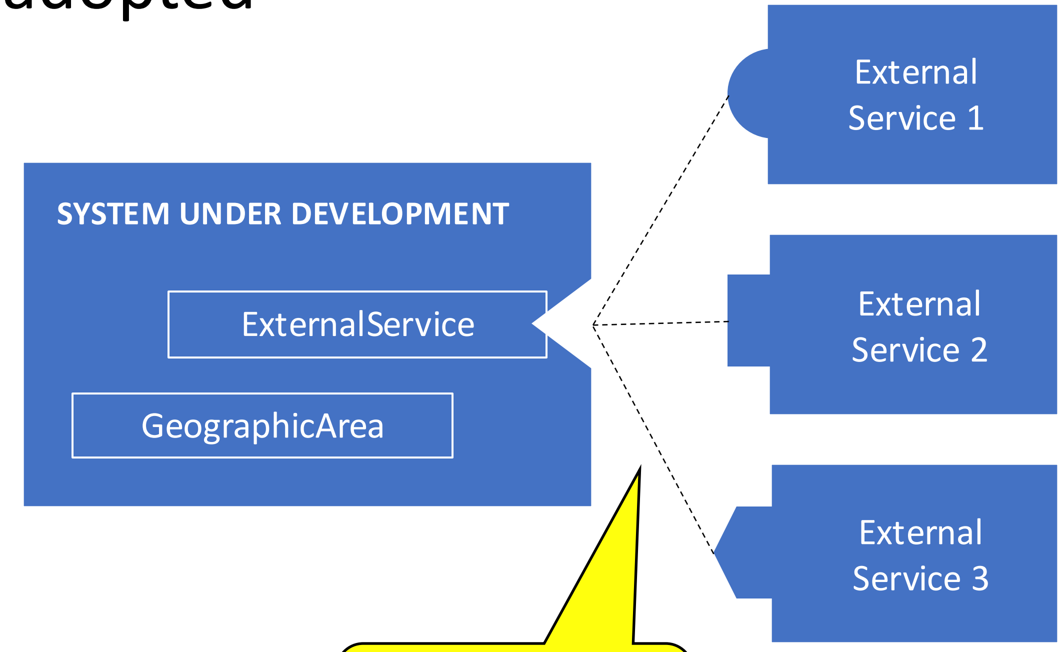
Scenario 2 – (Partial) Domain Model (2/2)

Variation Point.
But why?



Scenario 2 – Variation Point

- A.k.a. Instability Point
- Several services may exist and be adopted
- Possibly different regarding the:
  - Form of invocation
  - Input data
  - Output data
  - Process / flow
  - …



Lack of compatibility!

Scenario 2 – Coding (with current knowledge)

```
list<ActsOn> computeActsOn (ZipCode base,
                            float radius) {

   list<ActsOn> listOfActsOn;

   if (instanceof<XXX>(this->externalService)) {
      //...
   }
   else if (instanceof<YYY>(this->externalService)) {
      //...
   }
   else if (instanceof<ZZZ>(this->externalService)) {
      //...
   }

   return listOfActsOn;
}
```

Variation Point

- To which class does this code belong?
  - GeographicArea? Why?
  - Another class?
- Does this code do what is needed?
- Is it “nice” or “pretty”?
- What happens if more rules are needed?

Too many engineering problems to maintain the software!

Generalizing the Underlying Problem (1/2)

- Possibility of doing the same thing in different ways
  - Known *a priori* by the development team
  - Not yet known to the team
  - Developed by other teams (third parties)
    - in the past; or
    - in the future

Variation Point

- Variation
  - Over time
  - By deployment/installation

Generalizing the Underlying Problem (2/2)

- Possibility of doing the same thing in different ways
  - Known *a priori* by the development team
  - Not yet known to the team
  - Developed by other teams (third parties)
    - in the past; or
    - in the future

Variation Point

- Variation
  - Over time
  - By deployment/installation

HOW TO HANDLE VARIATION POINTS?

GRASP

Protected Variations

Protected Variations

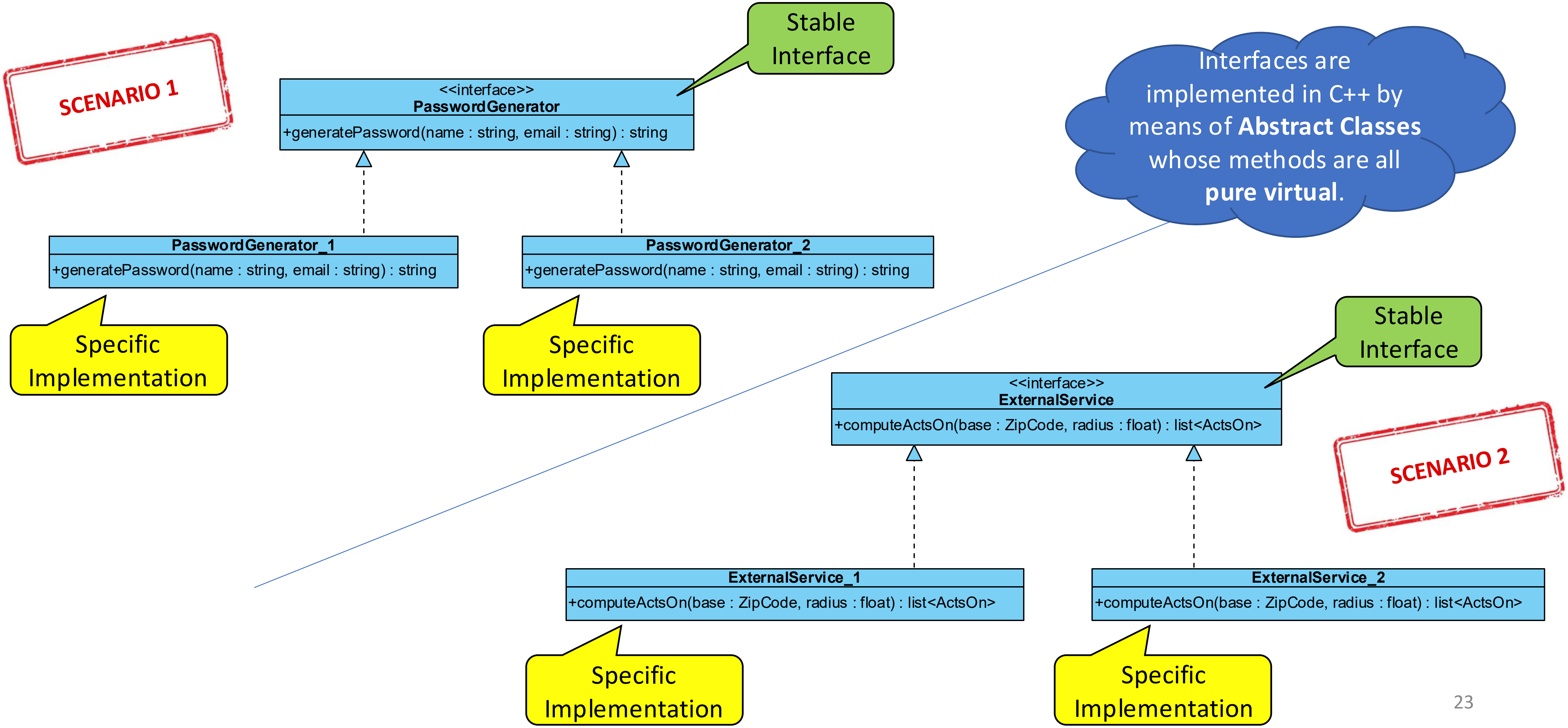
- **Problem**
  - How to design objects, components and systems so that variations in these elements do not have an undesirable impact on other elements of the system?

- **Solution**
  - Identify predictable points of variation
  - Assign responsibilities to create a **stable interface** around these points

Proposed Solution for the Example Scenarios (1/2)

- The **point of variation** (or instability) is the **existence of different interfaces (API)** for:
    - Scenario 1: Password Generator Algorithms
    - Scenario 2: Obtaining Geographic Areas
- Solution
    - Internal objects collaborate with a **stable interface**
        - Scenario 1: **`string generatePassword(string name, string email)`**
        - Scenario 2: **`list<ActsOn> computeActsOn(ZipCode base, float radius)`**
    - Specific implementations of the interface hide the variants of different algorithms/services

Proposed Solution for the Example Scenarios (2/2)



SCENARIO 1

Stable Interface

<<interface>>
PasswordGenerator
+generatePassword(name : string, email : string) : string

PasswordGenerator_1
+generatePassword(name : string, email : string) : string

PasswordGenerator_2
+generatePassword(name : string, email : string) : string

Specific Implementation

Specific Implementation

Interfaces are implemented in C++ by means of **Abstract Classes** whose methods are all **pure virtual**.

Stable Interface

<<interface>>
ExternalService
+computeActsOn(base : ZipCode, radius : float) : list<ActsOn>

SCENARIO 2

ExternalService_1
+computeActsOn(base : ZipCode, radius : float) : list<ActsOn>

ExternalService_2
+computeActsOn(base : ZipCode, radius : float) : list<ActsOn>

Specific Implementation

Specific Implementation

Protected Variations – Another Example

- **Scenario 3: Application that paints several distinct objects according to their characteristics**
    - Painting a **Car** involves painting the wheels, the bodywork, avoiding windows, etc.
    - Painting a **Table** implies painting the table legs and the tabletop.

- Point of Instability
    - Each object has its own painting particularities and consequently, a distinct way of painting
    - There are **different painting algorithms**

- How to create a stable interface?
    - Internal objects collaborate with a **stable interface** named **`Paintable`** that declares the **`paint()`** method
    - Each interface implementation hides a specific painting algorithm under the **`paint()`** method

GRASP

Polymorphism

Polymorphism (1/2)

- **Problem**
  - How to handle alternatives based on types (classes)?
  - How to create pluggable software components?

- **Solution**
  - When alternatives or related behavior vary depending on the type, responsibilities should be assigned to polymorphic operations on such types.

- **Polymorphism** argues that polymorphic operations should be used rather than decisions based on types

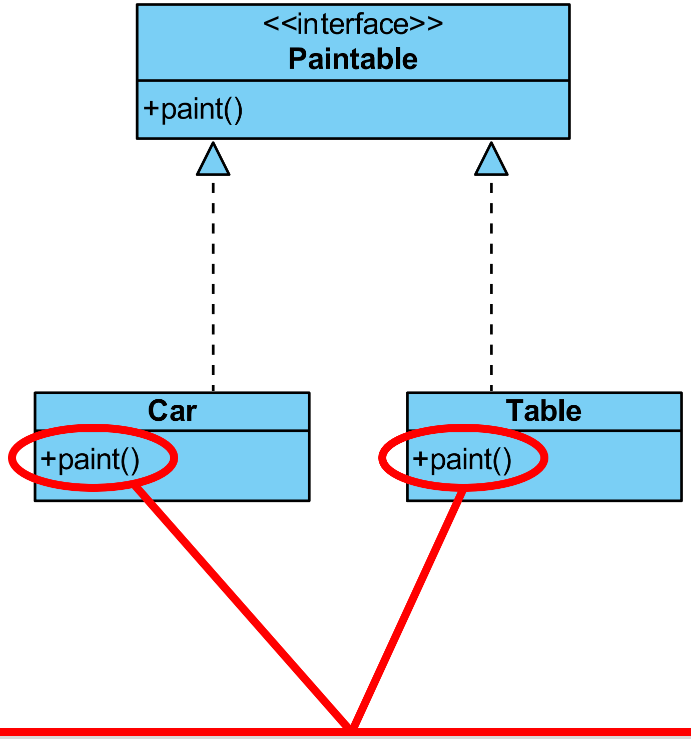
Polymorphism (2/2)

- Target (or cause)
  - Applications with logical and/or behavioral variations typically handled with multiway branch statements (e.g. if-then-else, switch-case)

- Consequences (of not using polymorphism)
  - Makes it difficult to understand and evolve the program
  - A new variation implies modifying the “logic” in several parts of the code

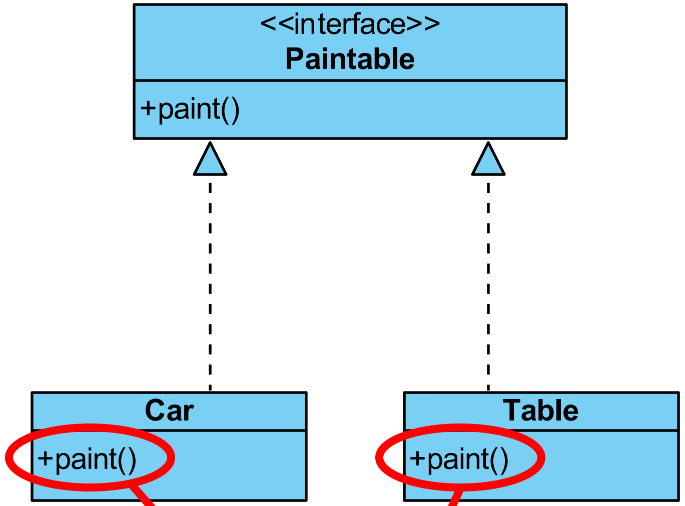
- Polymorphic methods
  - These are methods with the same name and signature/header on different objects, but with different behaviors
  - E.g.: The `paint()` method in `Car` and `Table` classes

Polymorphism Example – Design (1/2)

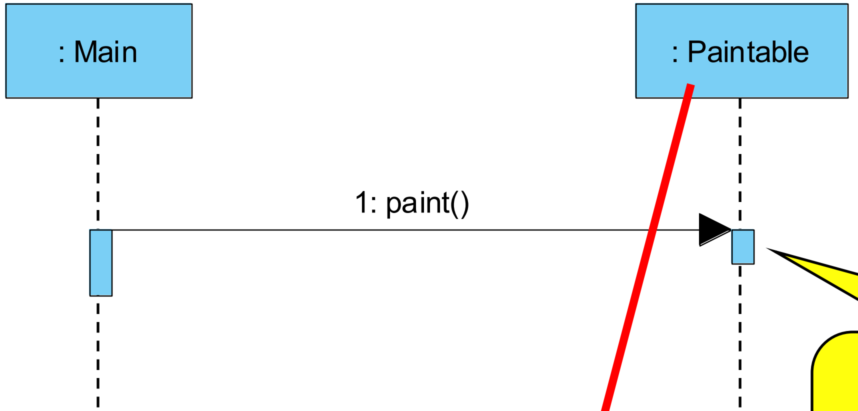


The implementation of the `paint()` method differs from one class to another.

Polymorphism Example – Design (2/2)



The implementation of the paint() method differs from one class to another.



It doesn't matter what it does or how it does it.
It depends on the Paintable implementation.

This is an instance of any class that implements the Paintable interface (e.g. Car, Table).

One cannot detail what happens in Paintable when the paint() method is invoked, as it depends on the instance type.

Polymorphism Example – Code

```
int main() {
   //...
   paintObject(object);
   //...
 }

void paintObject(Object *obj) {
   if (instanceof<Car>(o))  {
      paintCar(dynamic_cast<Car*>(o));
   } else if (instanceof<Table>(o)) {
      paintTable(dynamic_cast<Table*>(o));
   }
}

void paintCar(Car *c) {
   //... Behavior A
}

void paintTable(Table *t) {
   //... Behavior B
}
```

```
class Paintable {
   public:
      void paint()=0;
}
```

```
class Car  : public Paintable {
   public:
      void paint() {
         //... Behavior A
      }
}
```

```
class Table : public Paintable {
   public:
      void paint() {
         //... Behavior B
      }
}
```

```
int main() {
   Table *t = new Table();
   paintObject(t);

   Car *c = new Car();
   paintObject(c);
}

void paintObject(Paintable *p) {
   p->paint();
}
```

Polymorphism Application

- It is a fundamental principle when specifying how a system should be organized to handle variations on similar behaviors
  - E.g.: Adding a new class (e.g. `Computer`) that implements the `Paintable` interface, has less impact on the application design than implementing the various algorithms in methods of a single class

- Benefits
  - Required extensions for new variants are easily added
  - New implementations can be introduced without affecting clients

Summary

- We’ve discussed how to protect a system from implementation variations of different external services, making use of Polymorphism, thus achieving Protected Variations.

- On the next lectures, you’ll see how to implement this using the Adapter Pattern.

Bibliography

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