



Dipartimento di Elettronica e Informazione

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Software Engineering II

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Last Name

First Name

Id number (Matricola)

Note

1. The exam is not valid if you don't fill in the above data.
2. Write your answers on these pages. Extra sheets will be ignored. You may use a pencil.
3. The use of any electronic apparatus (computer, cell phone, camera, etc.) is strictly forbidden.
4. You cannot keep a copy of the exam when you leave the room.

Question 1 Alloy (7 points)

The civil protection department wants to build a system to support management of crises due to natural events such as earthquakes, inundations and the like.

During a crisis first aid units have to be distributed in the affected territory in such a way that each area in the territory is controlled by at least one unit.

After the crisis the refunding requests by citizens need to be evaluated and fulfilled or discharged, depending on the outcome of the analysis.

We aim at writing an Alloy specification for this system. Answer to all points below:

1. What are the concepts that we should represent as signatures? Please provide a motivation for your answer.
2. Define the signature you have identified by providing an explanation for all attributes that you introduce.
3. Define all facts that are needed to maintain the consistency and the integrity of your model (if any) and explain in words what you mean by each of them.
4. Define two facts that describe the situations occurring during crisis and after crisis. In particular, the during crisis fact should ensure that each area in the territory is supported by a first aid unit. The after crisis fact should ensure that refunding requests are either under evaluation or in one of the following two states: fulfilled or discharged.

Solution

Answer to point 1. The following concepts can be represented as signatures

Crisis: it is the main concept in our model as the distribution of first aid units and the management of refunding requests depends on its occurrence. It could be specialized in earthquake and inundation but since these concepts are not anymore used in the description, we can decide to leave this specialization for the future.

First aid units: they are relevant, as we need to check that they are correctly deployed in the territory.

Territory: it is the surroundings in which the crisis has happened.

Areas: the parts in which a territory is divided

During crisis and after crisis: these are two relevant states for the system to be modeled

Refunding requests: these are important to describe the after crisis situation

Under evaluation, fulfilled, discharged: these represent the states in which the refunding requests can be.

Answers to points from 2 to 4

```
abstract sig CrisisStatus {}  
one sig After extends CrisisStatus {}  
one sig During extends CrisisStatus {}
```

```
abstract sig RefundingStatus {}  
one sig UnderEval extends RefundingStatus {}  
one sig Accepted extends RefundingStatus {}  
one sig Discharged extends RefundingStatus {}
```

```

sig Area {}

sig Territory {
  areas: set Area
} {#areas >= 1}

sig Crisis {
  status: one CrisisStatus,
  territory: Territory
}

sig FirstAidUnit {
  area: lone Area
}

sig RefundingRequest {
  crisis: Crisis,
  status: RefundingStatus
} {status = UnderEval || status = Accepted || status = Discharged}

fact noSameAreaInTwoTerritories {
  no a: Area | some disjoint t1, t2: Territory | a in t1.areas and a in t2.areas
}

fact duringCrisisFirstAid {
  all c: Crisis, t: Territory, a: Area | (c.status = During and c.territory = t and a in t.areas) implies
    (some fau: FirstAidUnit | fau.area = a )
}

fact afterCrisisRefunding {
  all rr: RefundingRequest |
    rr.crisis.status = After implies #rr.status > 0
}

pred show() {#Crisis >1 and #Area > 2}
run show

```

Question 2 Testing (4 points)

Consider the following function, written in a C-like programming language:

```
1 int foo(int a, int b) {  
2     a++;  
3     while (a < b) {  
4         if (a != b) {  
5             a++;  
6         }  
7     }  
8     return a;  
9 }
```

You are to:

- Execute `foo` symbolically limiting the execution of the loop statement to *exactly two iterations*. Show, for each non-conditional statement being executed, the *symbolic value* of all variables and the *path condition* that applies at that point in the execution.
- Define the pre-condition to the execution of `foo` such that the `while` loop is executed exactly twice.

Solution

The symbolic execution of `foo` unfolds as follows, considering A, B the starting symbols for variable a and b , respectively:

- 1) $a = A, b = B$ when `foo` starts executing;
- 2) $a = A+1, b = B$ after executing line 2;
- 3) if $[A+1 < B]$ the while loop executes;
- 4) as the execution entered in the loop, $a \neq b$ necessarily; then the execution continues on line 5 and $a = A+2, b = B$;
- 5) the **while** condition is checked again and the loop executes if $[A+2 < B]$;
- 6) again, as the execution entered the loop, $a \neq b$ necessarily; the execution continues on line 5 and $a = A + 3, b = B$;
- 7) the while condition is checked again; as the loop should not be executed again, the path-condition should be $[A+3 < B]$; in this case the execution jumps to line 7
- 8) the function ends and the value $A + 3$ is returned.

The pre-condition on the execution of `foo` that guarantees that the loop is executed exactly twice is then $b = a+3$

Questions 3 and 4 Planning (4 points) and Design (7 points)

A company offering a music and video web downloading service has to develop the information system to support the interaction of users with the downloading infrastructure. Users can subscribe for a number of downloading services, e.g., “pay for what you download”, “pay every month a fixed amount and download what you want”. Periodically, the company offers special deals on some of the downloading services, for instance, it could offer to the “pay for what you download” users a “pay half price for downloading music of the sixties” deal. The system to be developed should:

- (I) Manage data about both users and the different types of downloading services. The system will store the user data (User id, personal data, the type of subscribed downloading service, any applying special deal). Each downloading service has its own pricing model that can be different for music and video. Special deals change some of the costs only for a well-defined period of time.
- (II) Allow users to access their information, change downloading services, activate promotions, browse and download music/video.
- (III) Allow the employees of the company to manage user billing based on information retrieved from the downloading infrastructure. This is a separate system managing the streaming of audio/video. It provides to the information system data about the amount of MB downloaded by each user within each day.

A) Calculate the Function Points for the information system described above. Refer to the following table to associate weights to the function types.

Function types	Weights		
	Simple	Medium	Complex
N. Inputs	3	4	6
N. Outputs	4	5	7
N. Inquiry	3	4	6
N. Internal Files	7	10	15
N External Files	5	7	10

B) Address the following points:

1. Identify the Actors involved in the application
2. Define one or more UML Use Case diagrams describing the main functions offered by the information system.
3. Select the Use Case that you think is most important and describe it in text.
4. Define the key components of the system architecture.