Winter Semester 16/17

Software Engineering Design & Construction

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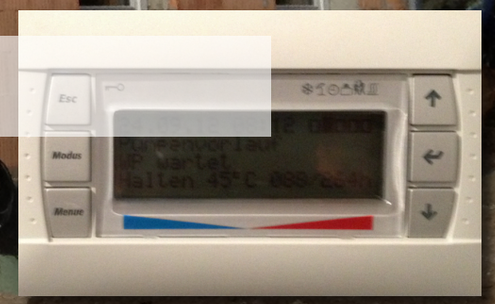
Smart Home Example



A First Sketch (I/II)

```
abstract class Location {
  private List<Shutter> shutters; // FEATURE: DARKENING
  private List<Light> lights; // FEATURE: LIGHTING

  public Location(List<Shutter> shutters, List<Light> lights) {
     this.shutters = shutters;
     this.lights = lights;
  }

  public List<Shutter> shutters() { return shutters; }
  public List<Light> lights() { return lights; }
}

abstract class CompositeLocation<L extends Location> extends Location {
  private List<L> locations;

  public CompositeLocation(List<L> locations) {
     super(shutters(locations), lights(locations));
     this.locations = locations;
  }
  private static List<Light> lights(List<? extends Location> locs) {…}
  private static List<Shutter> shutters(List<? extends Location> locs) {…}

  public List<L> locations() { return locations; }
}
```

A First Sketch (II/II)

```
class Room extends Location {
  public Room(List<Shutter> shutters, List<Light> lights) {
     super(shutters, lights);
  }
}

class Floor extends CompositeLocation<Room> {
  public Floor(List<Room> locations) { super(locations); }
}
```

```
class House extends CompositeLocation<Floor> {
  public House(List<Floor> locations) { super(locations); }
}

class Main {
  public static void main(String[] args) {
     House house = new House(null);
     List<Floor> floors = house.locations();
  }
}
```

A Second Sketch (I/II)

We try to achieve feature decomposition.

```
public interface Location { }

interface CompositeLocation<L extends Location> extends Location {
   abstract List<L> locations();
}

class Room implements Location { }
```

```
class Floor implements CompositeLocation<Room> {
   private List<Room> rooms;

   public List<Room> locations() { return rooms; }
}

class House implements CompositeLocation<Floor> {
   private List<Floor> floors;

   public List<Floor> locations() { return floors; }
}
```

A Second Sketch (II/II)

We try to achieve feature decomposition.

```
interface LocationWithLights extends Location {
  List<Light> lights();
}

class RoomWithLights extends Room implements LocationWithLights {
  private List<Light> lights;
  public List<Light> lights() { return lights; }
}

abstract class CompositeLocationWithLights<LL extends LocationWithLights>
  implements CompositeLocation<LL> {

  public List<Light> lights() {
     List<Light> lights = new ArrayList<Light>();
     for (LocationWithLights child : locations()) {
        lights.addAll(child.lights());
     }
     return lights;
  }
}
```

Traits in Scala

```
trait Table[A, B] {
   def defaultValue: B
   def get(key: A): Option[B]
   def set(key: A, value: B)
   def apply(key: A) : B = get(key) match {
      case Some(value) ⇒ value; case None ⇒ defaultValue
   }
}

class ListTable[A, B](val defaultValue: B) extends Table[A, B] {
   private var elems: List[(A, B)] = Nil
   def get(key: A) : Option[B] = elems collectFirst { case (`key`,value) => value }
   def set(key: A, value: B) = elems = (key, value) :: elems
}

trait SynchronizedTable[A, B] extends Table[A, B] {
   abstract override def get(key: A): Option[B] =
      synchronized { super.get(key) }
   abstract override def set(key: A, value: B) =
      synchronized { super.set(key, value) }
}
object MyTable extends ListTable[String, Int](0) with SynchronizedTable[String, Int]
```

mixin composition

Traits in Scala (Continued)

```
trait LoggingTable[A, B] extends Table[A, B] {
    abstract override def get(key: A): B = {
        println("Get Called"); super.get(key)
    }
    abstract override def set(key: A, value: B) = {
        println("Set Called"); super.set(key, value)
    }
}

object MyTable
    extends ListTable[String, Int](0)
    with LoggingTable
    with SynchronizedTable
```

mixin composition (Order matters!)

Mixin Composition in Scala

- In Scala, if you mixin multiple traits into a class the inheritance relationship on base classes forms a directed acyclic graph.

- A linearization of that graph is performed.
  The Linearization (Lin) of a class C (`class C extends C1 with ... with Cn`) is defined as:
  Lin(C) = C, Lin(Cn) ≫ ... ≫ Lin(C1)
  where ≫ concatenates the elements of the left operand with the right operand, but elements of the right operand replace those of the left operand.
  $\{a,A\} \gg B \quad = a,(A \gg B)$ if $a \notin B$
  $= (A \gg B)$ if $a \in B$

Mixin Composition in Scala

```
abstract class AbsIterator extends AnyRef { ... }
trait RichIterator extends AbsIterator { ... }
class StringIterator extends AbsIterator { ... }
class Iter extends StringIterator with RichIterator { ... }
```

- The linearization of class `Iter` is:
  - { Iter, Lin(RichIterator) ≫ Lin(StringIterator) }
  - { Iter, Lin(RichIterator) ≫ { StringIterator ≫ Lin(AbsIterator) } }
  - { Iter, Lin(RichIterator) ≫ { StringIterator, AbsIterator, AnyRef } }
  - { Iter, { RichIterator, AbsIterator, AnyRef } ≫ { StringIterator, AbsIterator, AnyRef } }
  - { Iter, RichIterator, StringIterator, AbsIterator, AnyRef, Any }

2nd Rule

Abstract Types in Scala

```
1.  class Food

3.  class Grass extends Food

5.  abstract class Animal {
6.      type SuitableFood <: Food
7.      def eat(food: SuitableFood)
8.  }

10. class Cow extends Animal {
11.     type SuitableFood = Grass
12.     override def eat(food: Grass) {}
13. }
```

Abstract Type

Path-dependent types in Scala

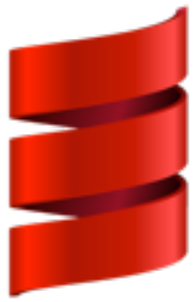
```
class DogFood extends Food

class Dog extends Animal {
  type SuitableFood = DogFood
  override def eat(food: DogFood) {}
}

scala> val bessy = new Cow
   bessy: Cow = Cow@10cd6d
scala> val lassie = new Dog
   lassie: Dog = Dog@d11fa6
scala> lassie eat (new bessy.SuitableFood)
   <console>:13: error: type mismatch;
    found   : Grass
    required: DogFood
          lassie eat (new bessy.SuitableFood)
```

A Third Sketch

```
trait Shutter
trait Light

abstract class Location {
   def shutters: List[Shutter]
   def lights: List[Light]
}

abstract class CompositeLocation[L <: Location] extends Location {
   def lights: List[Light] = locations.flatMap(_.lights)
   def shutters: List[Shutter] = locations.flatMap(_.shutters)
   def locations: List[L]
}
class Room(
   val lights: List[Light],
   val shutters: List[Shutter]) extends Location
class Floor(val locations: List[Room]) extends CompositeLocation[Room]
class House(val locations: List[Floor]) extends CompositeLocation[Floor]

object Main extends App {
   val house = new House(new Floor(new Room(Nil, Nil) :: Nil) :: Nil)
   val floors: List[Floor] = new House(Nil).locations
}
```


Java Inspired

A Third Sketch (Base)



```
trait Building {

   trait TLocation {}
   type Location <: TLocation

   trait TRoom extends TLocation
   type Room <: TRoom with Location
   def createRoom(): Room

   trait CompositeLocation[L <: Location] extends TLocation {
      def locations: List[L]
   }

   trait TFloor extends CompositeLocation[Room]
   type Floor <: TFloor with Location
   def createFloor(locations: List[Room]): Floor

   trait THouse extends CompositeLocation[Floor]
   type House <: THouse with Location
   def createHouse(locations: List[Floor]): House

   def buildHouse(specification: String): House = {
      // imagine to parse the specification...
      createHouse(List(createFloor(List(createRoom()))))
   }
}
```

Enable the refinement of TLocation!

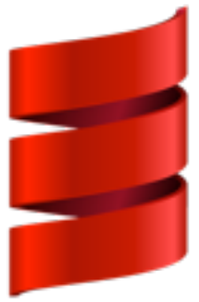
We need a Factory method to create (yet unknown) rooms.

A Third Sketch (Adding Lights)

```
trait Lights extends Building {

   trait TLocation extends super.TLocation {
      def lights(): List[Light]
      def turnLightsOn = lights.foreach(_.turnOn())
      def turnLightsOff = lights.foreach(_.turnOff())
   }
   type Location <: TLocation

   trait TRoom extends super.TRoom with TLocation
   type Room <: TRoom with Location

   trait CompositeLocation[L <: Location]
      extends super.CompositeLocation[L] with TLocation {
      def lights: List[Light] = locations.flatMap(_.lights())
   }

   trait TFloor extends super.TFloor with CompositeLocation[Room]
   type Floor <: TFloor with Location

   trait THouse extends super.THouse with CompositeLocation[Floor]
   type House <: THouse with Location
}
```

Shutters is comparable!

A Third Sketch (Lights And Shutters)



```
trait LightsAndShutters extends Lights with Shutters {

   trait TLocation
      extends super[Lights].TLocation
      with super[Shutters].TLocation
   type Location <: TLocation

   trait TRoom extends super[Lights].TRoom with super[Shutters].TRoom with TLocation
   type Room <: TRoom with Location

   trait CompositeLocation[L <: Location]
      extends super[Lights].CompositeLocation[L]
      with super[Shutters].CompositeLocation[L]
      with TLocation

   trait TFloor extends super[Lights].TFloor with super[Shutters].TFloor
      with CompositeLocation[Room]
   type Floor <: TFloor with Location

   trait THouse extends super[Lights].THouse with super[Shutters].THouse
      with CompositeLocation[Floor]
   type House <: THouse with Location
}
```

A Third Sketch (Usage)

```
object BuildingsWithLightsAndShutters extends LightsAndShutters with App {

    type Location = TLocation
    type Room = TRoom
    type Floor = TFloor
    type House = THouse

    def createRoom(): Room = new Room {
       var lights = List.empty[Light];
       var shutters = List.empty[Shutter]
    }
    def createFloor(rooms: List[Room]): Floor =
       new Floor { val locations = rooms }
    def createHouse(floors: List[Floor]): House =
       new House { val locations = floors }

    val h = buildHouse("three floors with 6 rooms each")
    h.lights
    h.shutters
    h.locations
    h.turnLightsOn
}
```