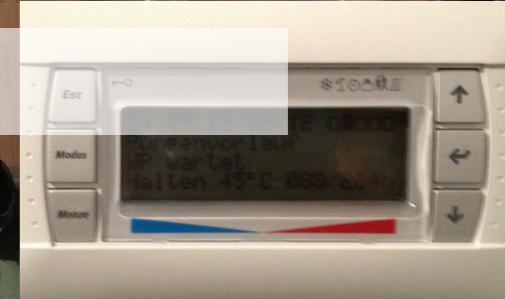


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Software Engineering Design & Construction

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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.



```
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.

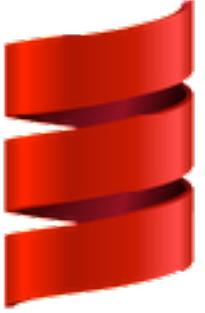
```
interface LocationWithLights extends Location {  
    List<Light> lights();  
}
```

```
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;  
    }
```





A Third Sketch

(Let's start with the translation of the Java Code)

```
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]  
}
```

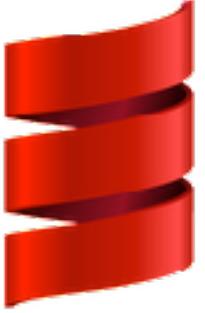
```
class Room(  
    val lights: List[Light],  
    val shutters: List[Shutter]) extends Location
```

```
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))  
    val floors: List[Floor] = new House(Nil).locations  
}
```

A naive translation doesn't solve the problem!



A Third Sketch (Base)

```
trait Building {
```

```
  trait TLocation {}  
  type Location <: TLocation
```

Enable the refinement of TLocation!

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

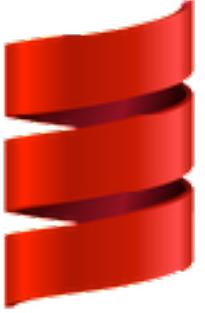
We need a Factory method to create
(yet unknown) rooms.

```
  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
```

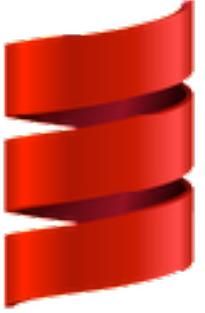
```
  trait THouse extends CompositeLocation[Floor]  
  type House <: THouse with Location  
  def createHouse(locations: List[Floor]): House
```

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



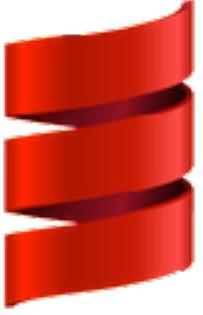
A Third Sketch (Adding Lights)

```
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  
}
```



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  
}
```