10 Software Engineering Techniques for Multimedia Software

10.1 Specific Design Patterns for Multimedia Software

10.2 Classical Design Patterns Applied to Multimedia

10.3 Modeling of Multimedia Applications

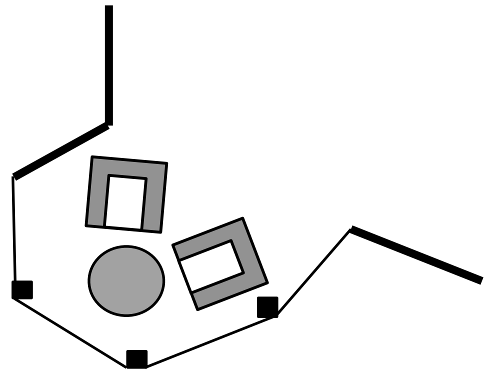
Design Patterns

- A *design pattern* is a generic solution for a class of recurring programming problems
  - Helpful idea for programming
  - No need to adopt literally when applied
- Origin:
  - Famous book by Gamma/Helm/Johnson/Vlissides (“Gang of Four”)
    - » List of standard design patterns for object-oriented programming
    - » Mainly oriented towards graphical user interface frameworks
    - » Examples: Observer, Composite, Abstract Factory
- Frequently used in all areas of software design
- Basic guidelines:
  - Patterns are not invented but recovered from existing code
  - Pattern description follows standard outline
    - » E.g.: Name, problem, solution, examples

Window Place: Architectural Pattern

Christopher Alexander et al., A Pattern Language, 1977
(quoted in Buschmann et al. 1996)

- **Problem:** In a room with a window and a sitting opportunity users have to decide whether to have a look or to sit.
- **Solution:**
  At least one window of the room shall provide a sitting place.
- **Structure:**



Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice.

Christopher Alexander et al., A Pattern Language

Description of a Design Pattern

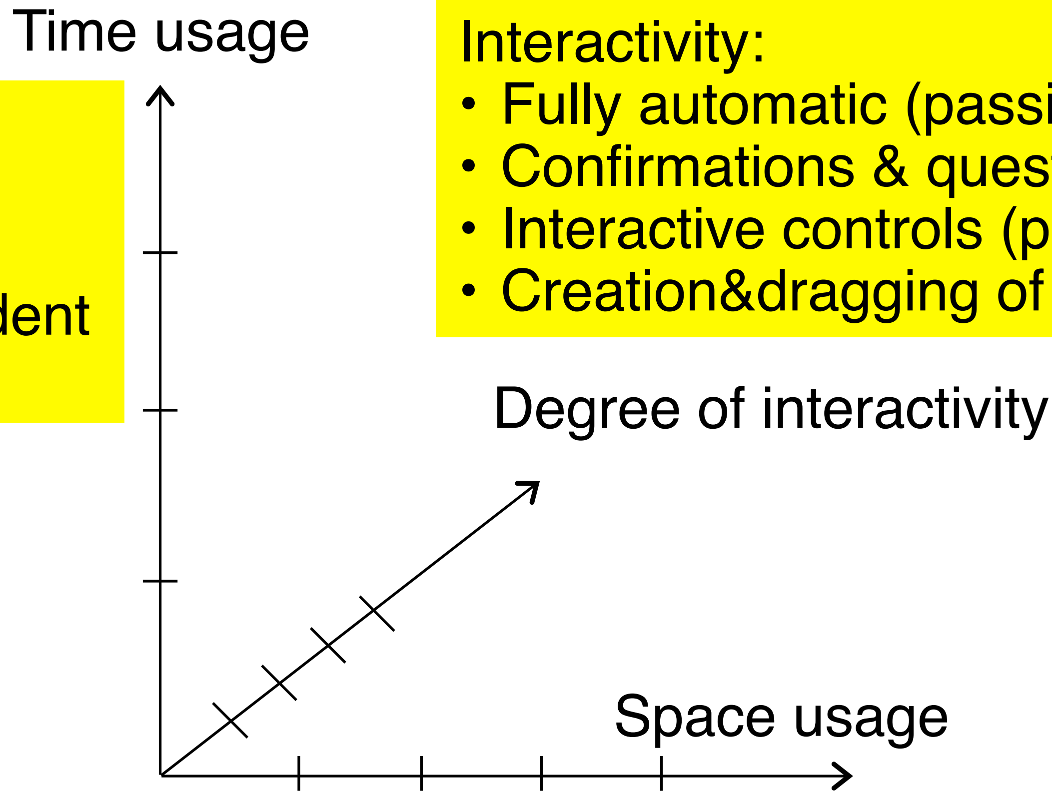
- Name
- Problem
  - Motivation
  - Application area
- Solution
  - Structure (class diagram)
  - Participants (usually class, association und operation names):
    - » Role name, i.e. place holders for parts of implementation
    - » Fixed parts of implementaton
  - Collaboration (sequence of events, possibly diagrams)
- Discussion
  - Pros and cons
  - Dependencies, restrictions
  - Special cases
- Known uses

Patterns for Multimedia Software

- The following examples of patterns are not taken from literature, but derived from the material in this lecture
  - Based on various platforms, also older ones
- Types of patterns:
  - Cross-platform patterns
  - Patterns specific for a certain platform

Classification Space

Time usage:
- Still picture
- Linear progress
- Interaction dependent progress



Interactivity:
- Fully automatic (passive)
- Confirmations & questions (reactive)
- Interactive controls (proactive)
- Creation&dragging of objects (directive)

Space usage:
- Static layout
- Scenes
- Scenes & objects
- Fully dynamic

Aleem, T. A. (1998). A Taxonomy of Multimedia Interactivity.(Doctoral Dissertation, The Union Institute, 1998).

Cross-Platform Multimedia Pattern: Clockwork

- The current properties of presentation elements are derived from the current value of a “clock” ticking at regular time intervals
- Time usage: Linear progress
- Limited interactivity: Automatic or confirmations&questions
- Usually combined with static layout or scenes and objects
- Examples:
  - Timeline in Flash, Director, JavaFX
  - EnterFrame-Events in Flash ActionScript
  - Ticking scripts in Squeak
  - Clock class in PyGame
  - CreateJS “Ticker”

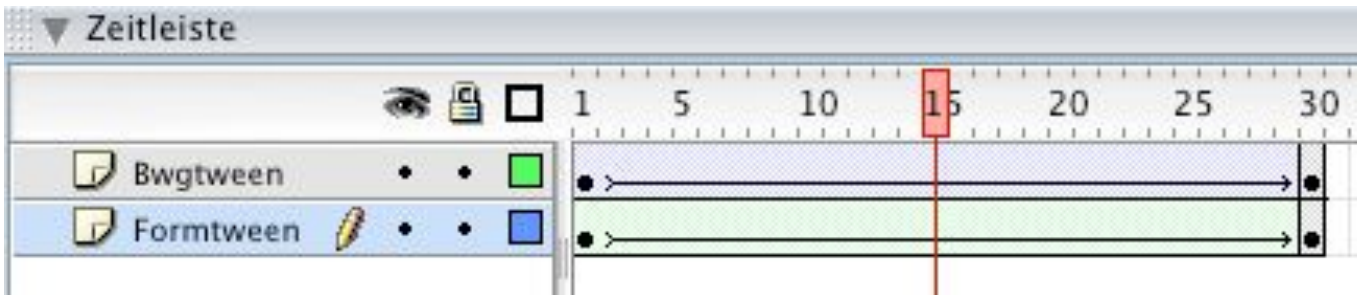
University of Maryland
“Piccolo” framework
(see cs.umd.edu/hcil/piccolo)

```
PActivity flash =
       new PActivity(-1, 500, currentTime + 5000) {

       protected void activityStep(long elapsedTime) {
       … }
```

Cross-Platform Multimedia Pattern: Interpolation

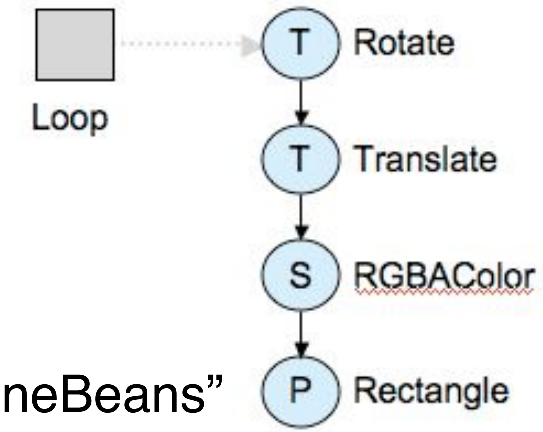
- A parameter (usually regarding a graphical property) is assumed to change its value continuously dependent of another parameter (e.g. time). The dependency can follow a linear or other rules of computation.
  - Fixed values for the dependent parameter are given for certain values of the base parameter.
  - Intermediate values of the dependent parameter are computed by interpolation.
- Space usage: scenes&objects mainly
- Time usage: Linear progress only
- Usually combined with low interactivity (on this level)
- Examples:
  - Tweening in Flash
  - Animation methods in Piccolo
  - JavaFX transitions



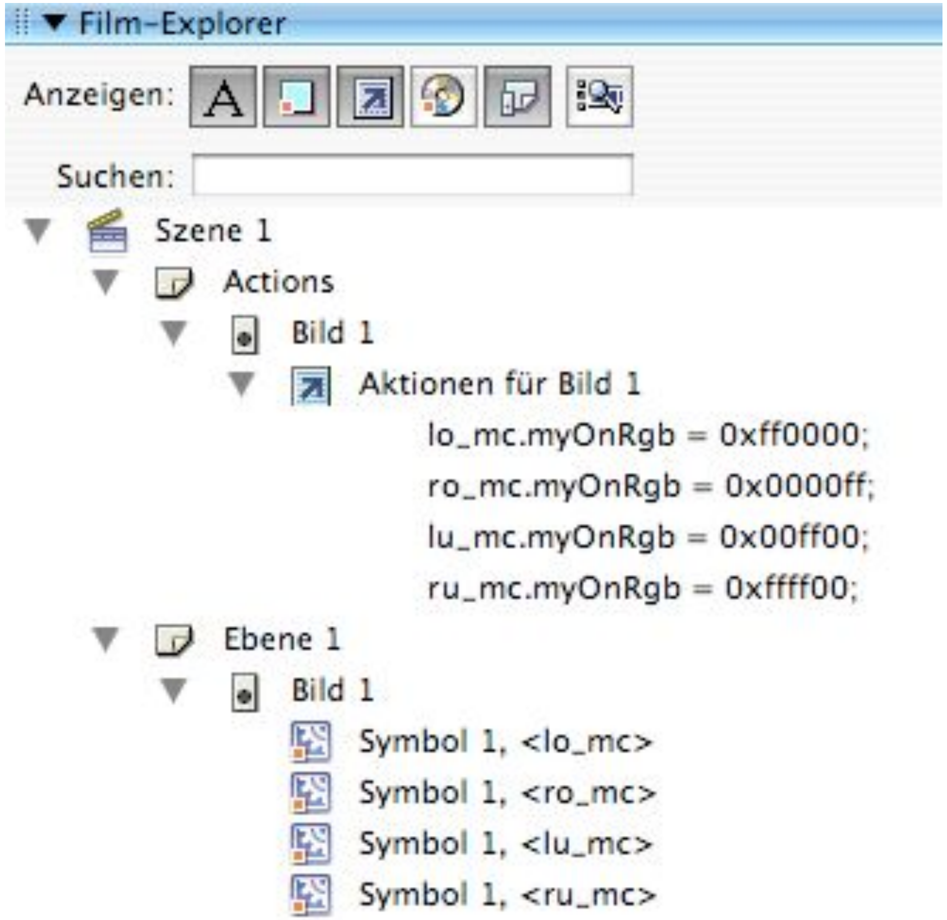

```
PActivity a1 =
     aNode.animateToPositionScaleRotation(0, 0, 0.5, 0, 5000);
```

Cross-Platform Multimedia Pattern: Scene Graph

- Graph structure for all represented objects
- Space usage: Scenes&objects or fully dynamic
- Time usage: Linear progress or interaction dependent
- Examples:
  - Scene graph of JavaFX
  - Scene graph of Piccolo
  - Implicit: Film Explorer view in Flash



"SceneBeans"



Cross-Platform Pattern: Time Container Algebra

- Presentation is built from atomic parts (processes) each of which is executed in a *time container*.
- Time containers are composed by algebraic operations: sequential composition, parallel composition, repetition, mutual exclusion, synchronization options
- Time usage: Linear progress
- Space usage: Scenes or scenes&objects
- Low interactivity
- Examples:
  - SMIL body: seq, par, excl
  - Animations class of “JGoodies” animation framework for Java
  - Sequence of frames and parallelism of layers in Flash

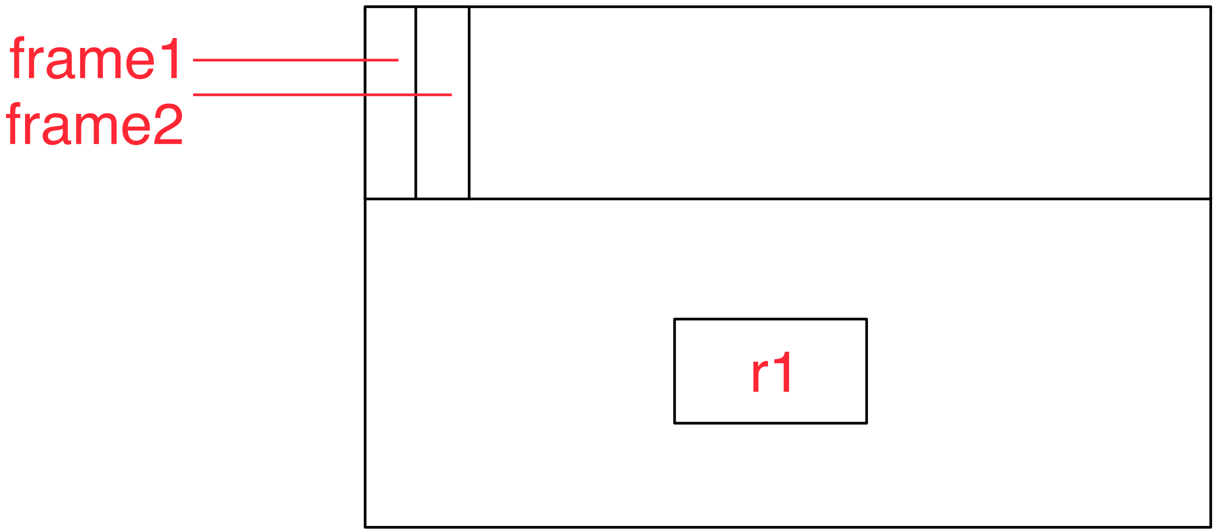
Various Syntactical Representations for a Single Concept

```
<layout>
  <region id="r1" ...>
</layout>
<body>
  <seq>
      ...frame1
      ...frame2
  </seq>
</body>
```

XML

```
Component r1 = ...;
Animation frame1 = ...;
Animation frame2 = ...;
Animation all =
  Animations.sequential(
    new Animation[]{
      frame1, frame2});
```

Java



Authoring Tool (Flash-like)

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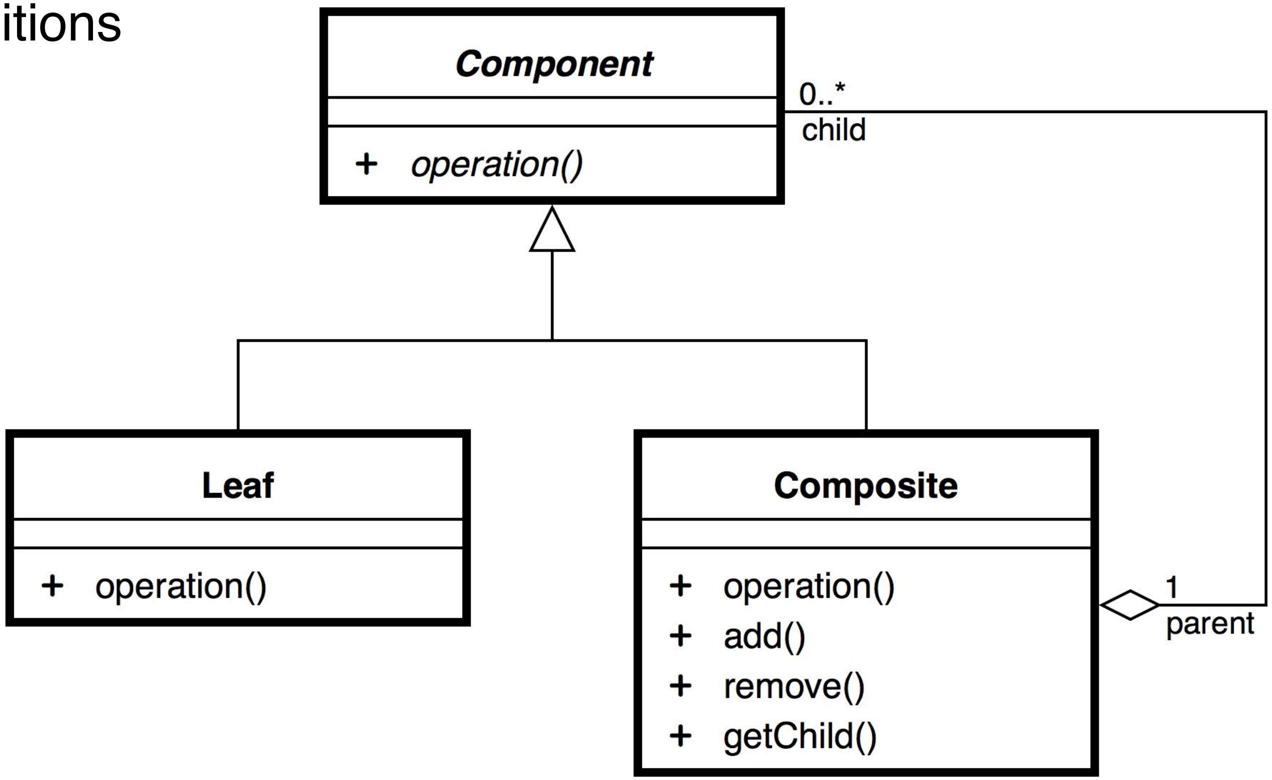
Literature:

Gamma/Helm/Johnson/Vlissides: Design Patterns, Addison-Wesley 1994
(= „Gang of Four“, „GoF“)

GoF Structural Pattern: Composite

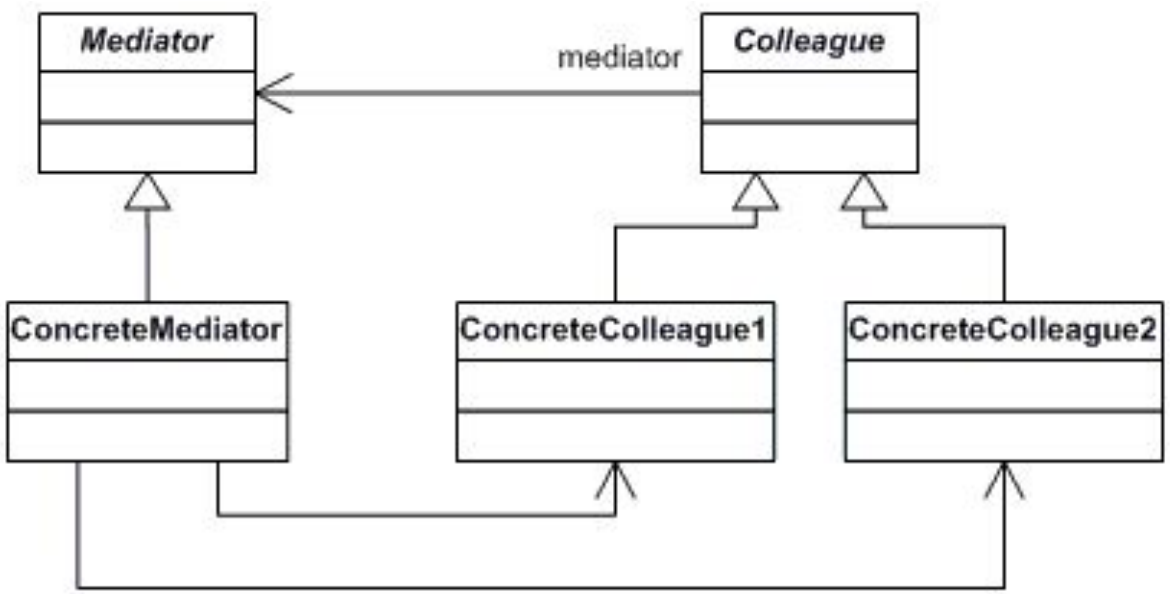
- Situation:
  - Complex tree-structured objects
- Motivation:
  - Use homogeneous interface for objects and compositions thereof



Exercise (JavaFX):
Compare with classes
- Node
- Parent
- Group
- Rectangle
- MediaView

GoF Behavioral Pattern: Mediator

- Situation:
  - Many objects interact in a complex way
  - Individual objects are not able to co-ordinate their communication
- Motivation:
  - Create single point of co-ordination



Mediator Example: Sprite Manager

```
public class SpriteManager {

   private List<Sprite> sprite_list;

    public SpriteManager(double scW, double scH) {
       sprite_list = new ArrayList<Sprite>();
    }

    public void addSprite(Sprite s) {
        sprite_list.add(s);
   }

    public void updateSprites() {
        for (Sprite s: sprite_list) {
            s.update();
        }
        for (Sprite s1: sprite_list) {
            for (Sprite s2: sprite_list) {
                if (s1 != s2) {
                    s1.handleCollision(s2);
                }
            }
        }

    }
}
```

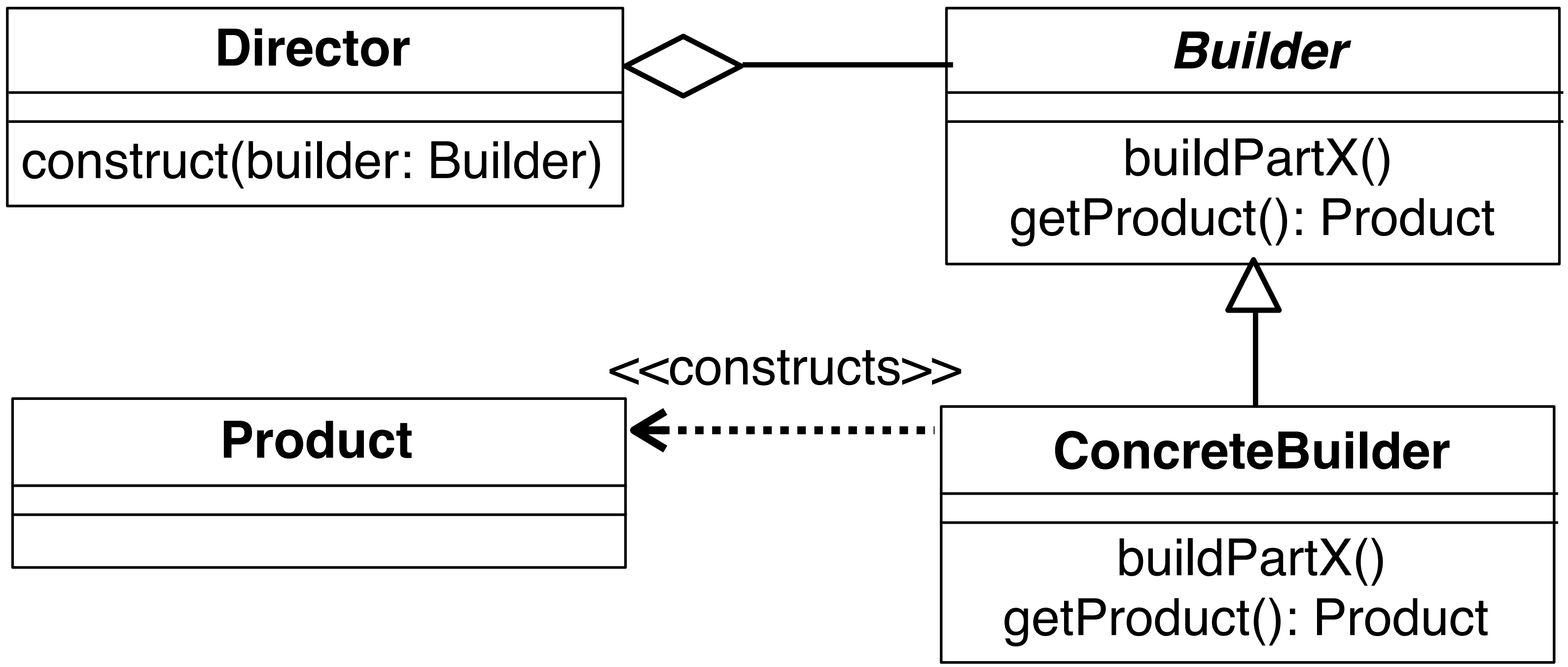
JavaFXBallMotion Project

Creation Pattern Example: Builder

- Situation:
  - Many parameters of a constructor have to be set
  - Leading to an explosion of constructor variants (*telescoping constructor anti-pattern*)
- Motivation:
  - Make code simpler
  - Separate between concrete (low-level) representation and creation process
  - Move default settings to appropriate location
  - Avoid typical copy-paste errors
- Idea:
  - Provide static class which first collects information on object to be built and finally constructs it

GoF Creation Pattern: Builder

- Name: **Builder** (dt.: Erbauer)
- Problem:
  - Step-by-step creation of complex objects
- Solution:



Example: Series of Similar Buttons

- Do not repeat all detailed settings (e.g. styles) for all buttons
  - Avoid copy-paste problems
- Define standard combinations for settings to be applied easily in construction process
- Remove low-level information (like styles) from high-level program logic

Button Series without Builder

```
Button btn1 = new Button();
btn1("-fx-background-color: lightgrey;
   -fx-padding: 9; -fx-font: 20pt 'sans-serif';");
btn1((ActionEvent event) -> {
   System.out.println("Btn1 clicked");
});
Button btn2 = new Button();
btn2("-fx-background-color: lightgrey;
   -fx-padding: 9; -fx-font: 20pt 'sans-serif';
   -fx-border-color: black;-fx-border-width: 2px;");
btn2.setOnAction((ActionEvent event) -> {
   System.out.println("Btn2 clicked");
});
Button btn3 = new Button();
btn3.setStyle("-fx-background-color: lightgrey;
   -fx-padding: 9; -fx-font: 20pt 'sans-serif';");
btn3.setOnAction((ActionEvent event) -> {
   System.out.println("Btn3 clicked");
});
```

Please Note: Lambda Expressions in Java 8

```
btn1((ActionEvent event) -> {
    System.out.println("Btn1 clicked");
});
```

Example: Builder (1)

```
public class MyButton extends Button {

    private MyButton (Builder builder) {
        super(builder.label);
        if (builder.hilited) {
            this.setStyle("-fx-background-color: lightgrey;
              -fx-padding: 9; -fx-font: 20pt 'sans-serif';
              -fx-border-color: black;-fx-border-width: 2px;");
        }
        else {
            this.setStyle("-fx-background-color: lightgrey;
              -fx-padding: 9; -fx-font: 20pt 'sans-serif';");
        }
        this.setOnAction((ActionEvent event) -> {
            System.out.println(this.getText()+" clicked");
        });
        builder.reset();
    }
...
```

Example: Builder (2)

```
public static class Builder {
    private String label;
    private Boolean hilited;

    public Builder() {
        reset();
    }

    private void reset() {
        label = "";
        hilited = false;
    }

    public Builder label(String label) {
        this.label = label;
        return this;
    }

    public Builder hilited() {
        this.hilited = true;
        return this;
    }
...
```

Additional pattern:
Method chaining
Builder method returns builder object

Example: Builder (3)

```
        public MyButton build() {
            return new MyButton(this);
        }

    }

}
```

Inner Class!

```
class MyButton {

   private MyButton(Builder builder) {
     …
   }

   public static class Builder {
     // collection of properties
     // construction methods
   }
}
```

Example: Builder (4)

```
MyButton.Builder builder = new MyButton.Builder();
Button btn1 = builder.label("Btn 1").build();
Button btn2 = builder.label("Btn 2").hilited().build();
Button btn3 = builder.label("Btn 3").build();
```

QUIZ:
What are advantages and disadvantages of using this pattern?

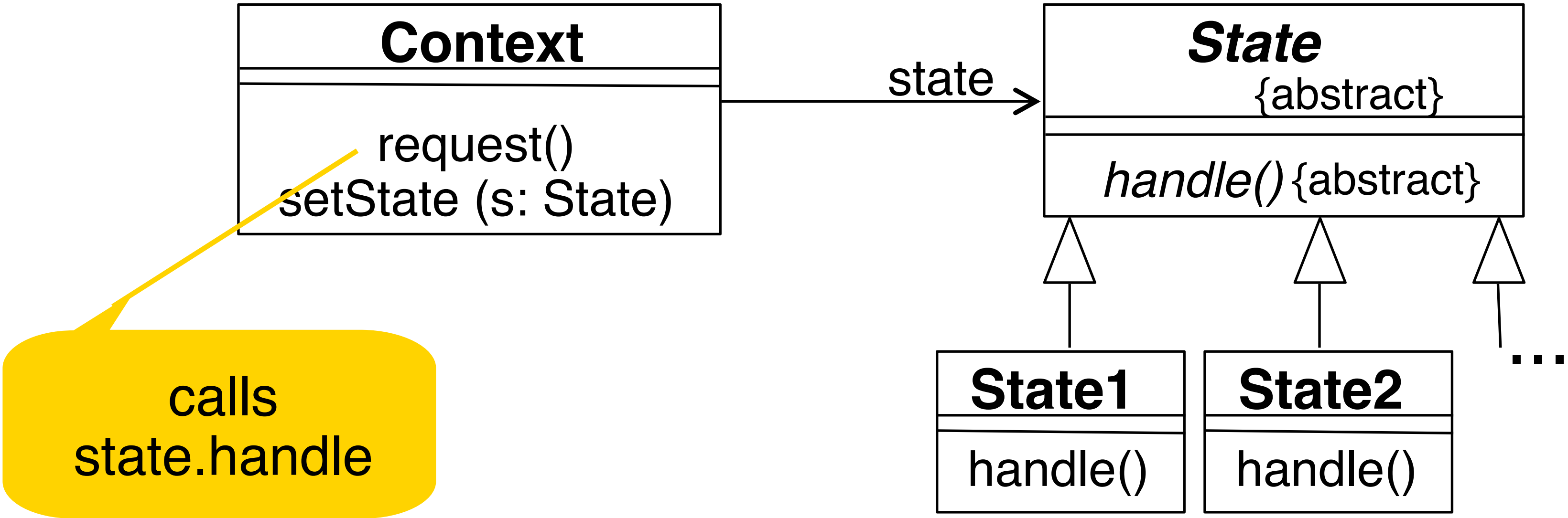
Builder in JavaFX

Richard Bair richard.bair at oracle.com
Mon Mar 25 10:35:51 PDT 2013

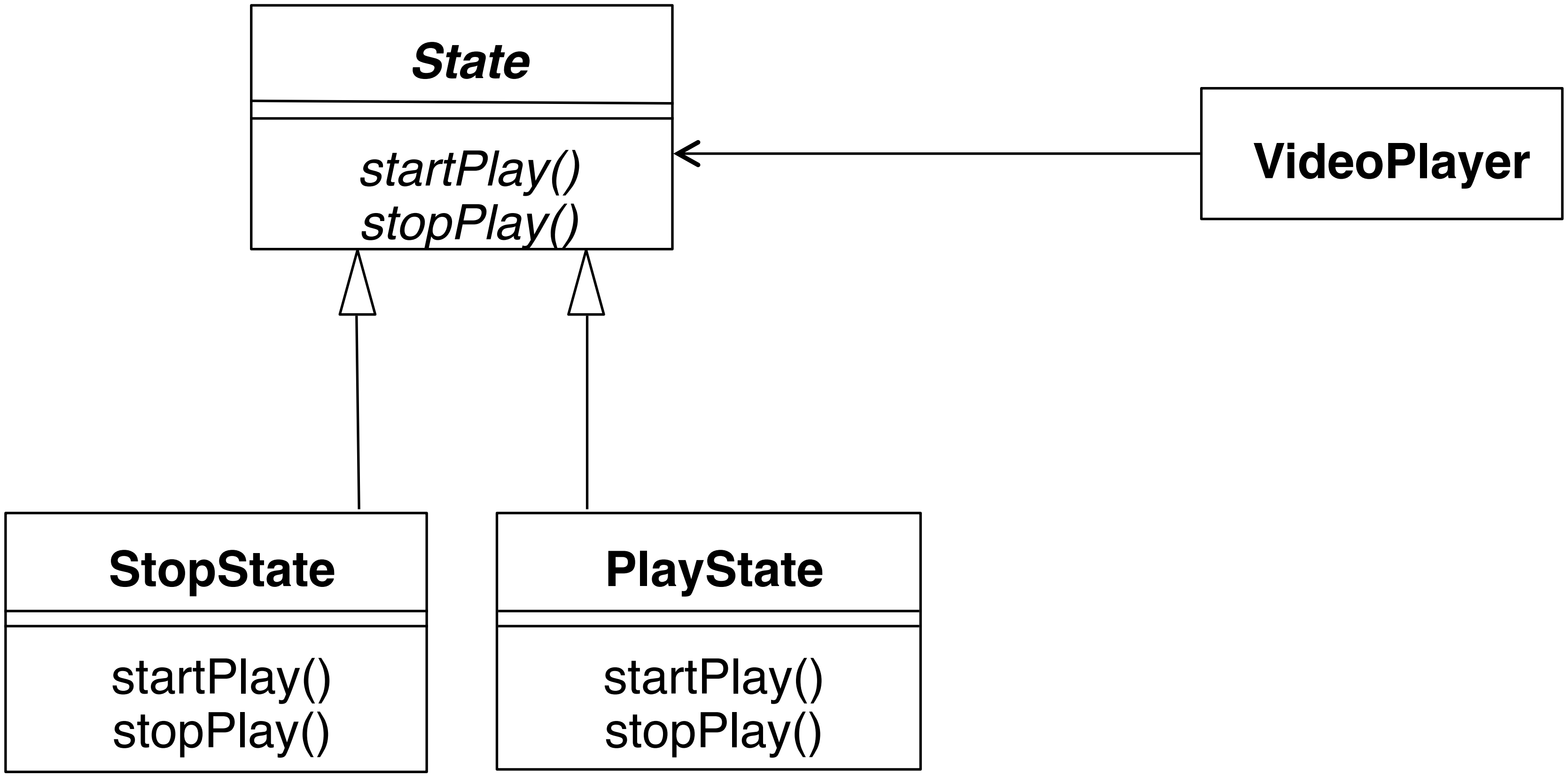
```
We made a mistake. When we released JavaFX 2.0 we included a (large)
set of *Builder classes to provide a builder-pattern approach to
building JavaFX UIs. The builder-pattern approach provides several
very nice features:
    - Ability to setup generic configuration once and "stamp out"
multiple copies
    - Structured code style that closely approximates the "container
hierarchy" of the UI
    - Strongly-typed "declarative" style programming

The Builders did come at a cost. […]

My proposal after having weighed the options is to phase out the
Builders by deprecating them in 8 and removing them from the class
path in 9.
```

GoF Structural Pattern: State

- Name: **State**
- Problem:
  – Flexible and extensible technique to change the behavior of an object when its state changes.
- Solution :



Example for State (1)



Example for State (2)

```
abstract class State {
    abstract void startPlay();
    abstract void stopPlay();
}
```

```
class PlayState extends State {
  @Override
  void startPlay() {
    System.out.println(
      "Already playing...");
  }

  @Override
  void stopPlay() {
    context.setState(
      context.getStopState());
  }

}
```

```
class StopState extends State {
  @Override
  void startPlay() {
    context.setState(
      context.getPlayState());
  }

  @Override
  void stopPlay() {
    System.out.println(
      "Already stopped...");
  }

}
```

Administrative Overhead for State

```
interface Context {
    abstract public void setState (State s);
    abstract public State getStopState();
    abstract public State getPlayState();
}
```

```
public class JavaFXStatePattern
  extends Application implements Context {

  private State state;
  final private State stopState = new StopState();
  final private State playState = new PlayState();

  @Override
  public void setState (State s) {
    state = s;
  }

  @Override
  public State getStopState() {
    return stopState;
  } …
```

Test for Extensibility

- Adding a “pause” state
- First step: Change the *State* interface

```
abstract void pausePlay();
```

—> Compiler checks completeness of transitions

- All additional code is concentrated in one class = one file

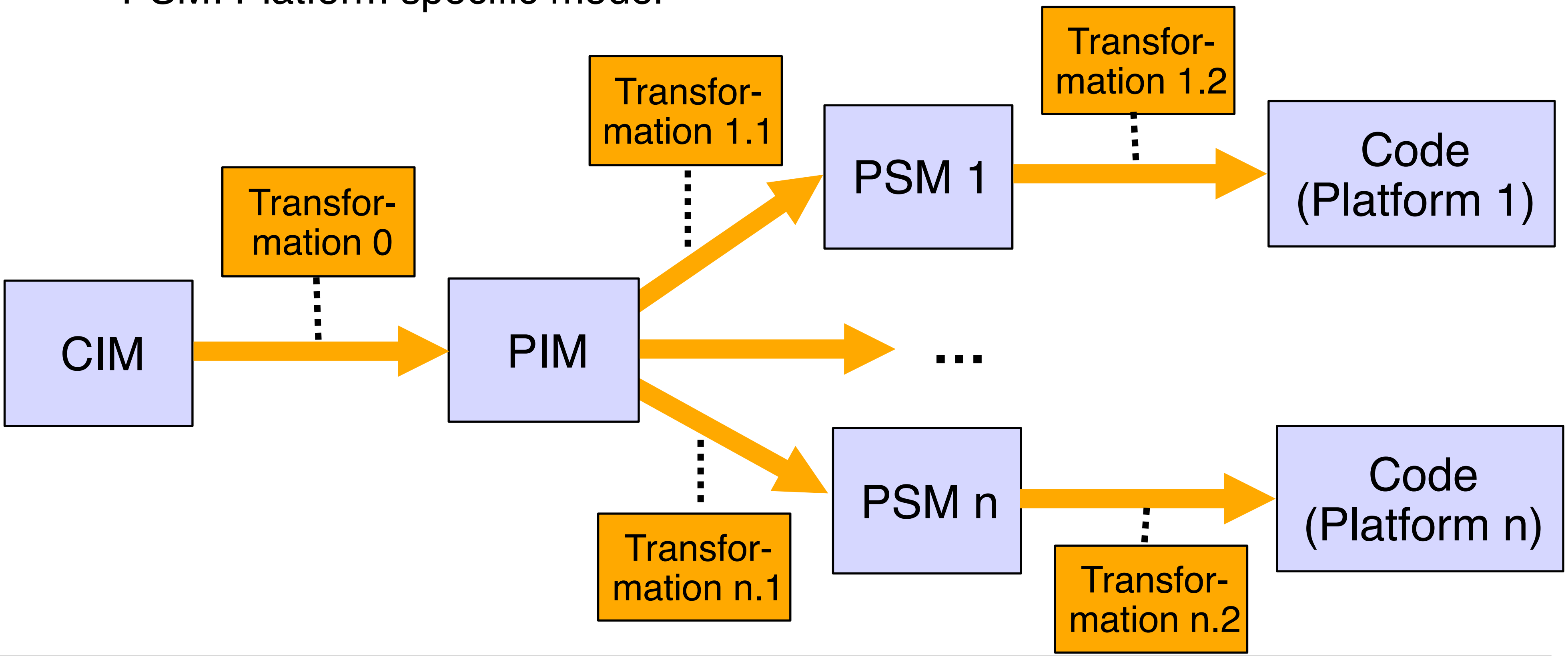
10 Software Engineering Techniques for Multimedia Software

Literature:

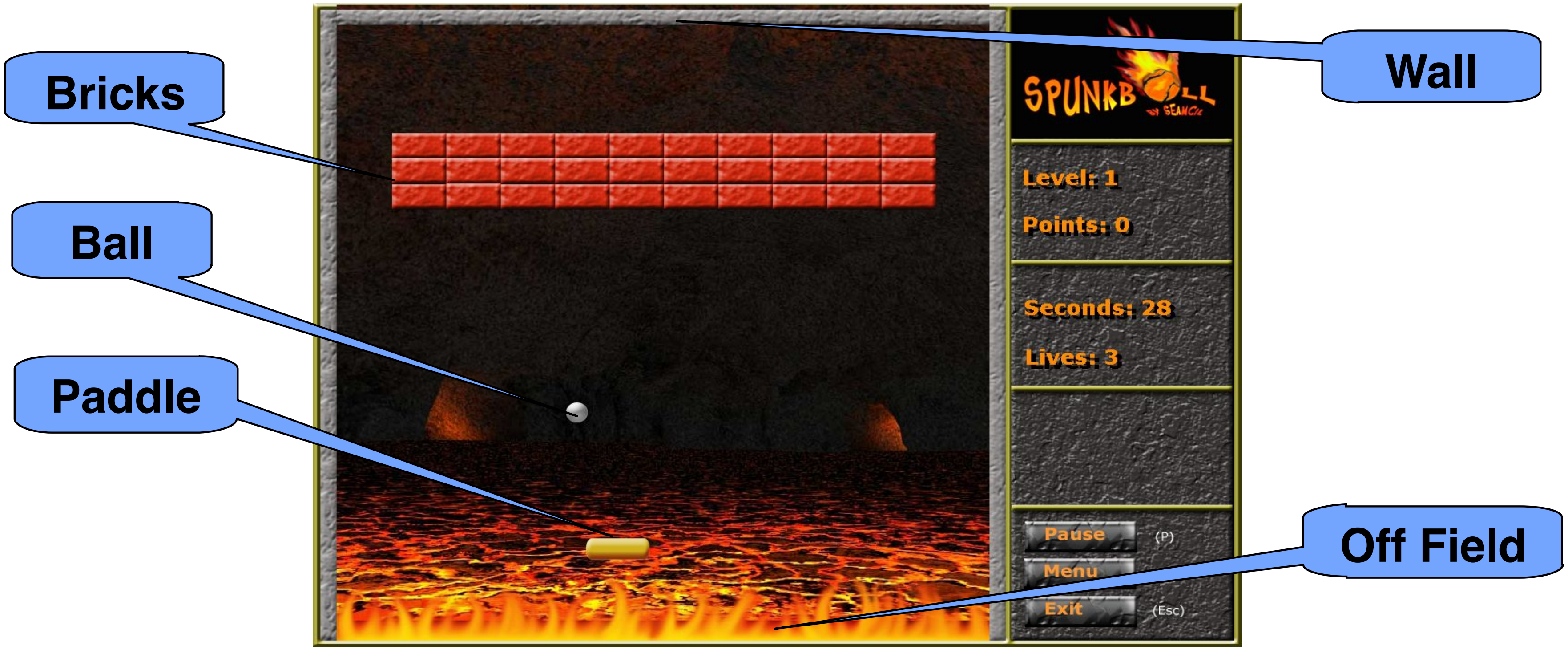
A. Pleuß: MML - A Language for Modeling Interactive Multimedia Applications.
Seventh IEEE International Symposium on Multimedia (ISM 2005), pp. 465 - 473, IEEE Society Press, 2005

Model-Driven Architecture

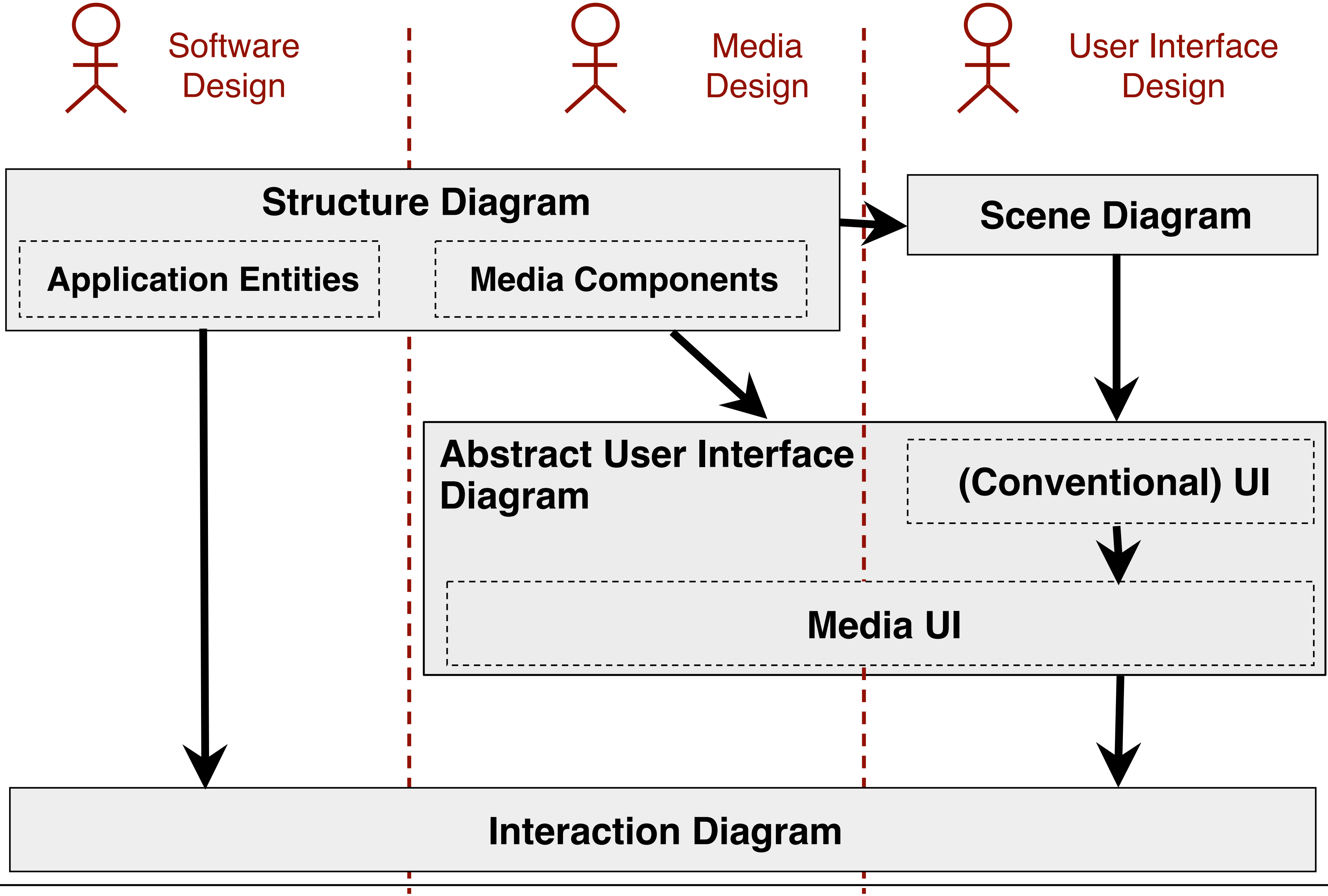
- *Model-Driven Architecture* (MDA): A concrete framework defined by the *Object Management Group* (OMG) for model-driven development
  - CIM: Computation independent model
  - PIM: Platform independent model
  - PSM: Platform specific model



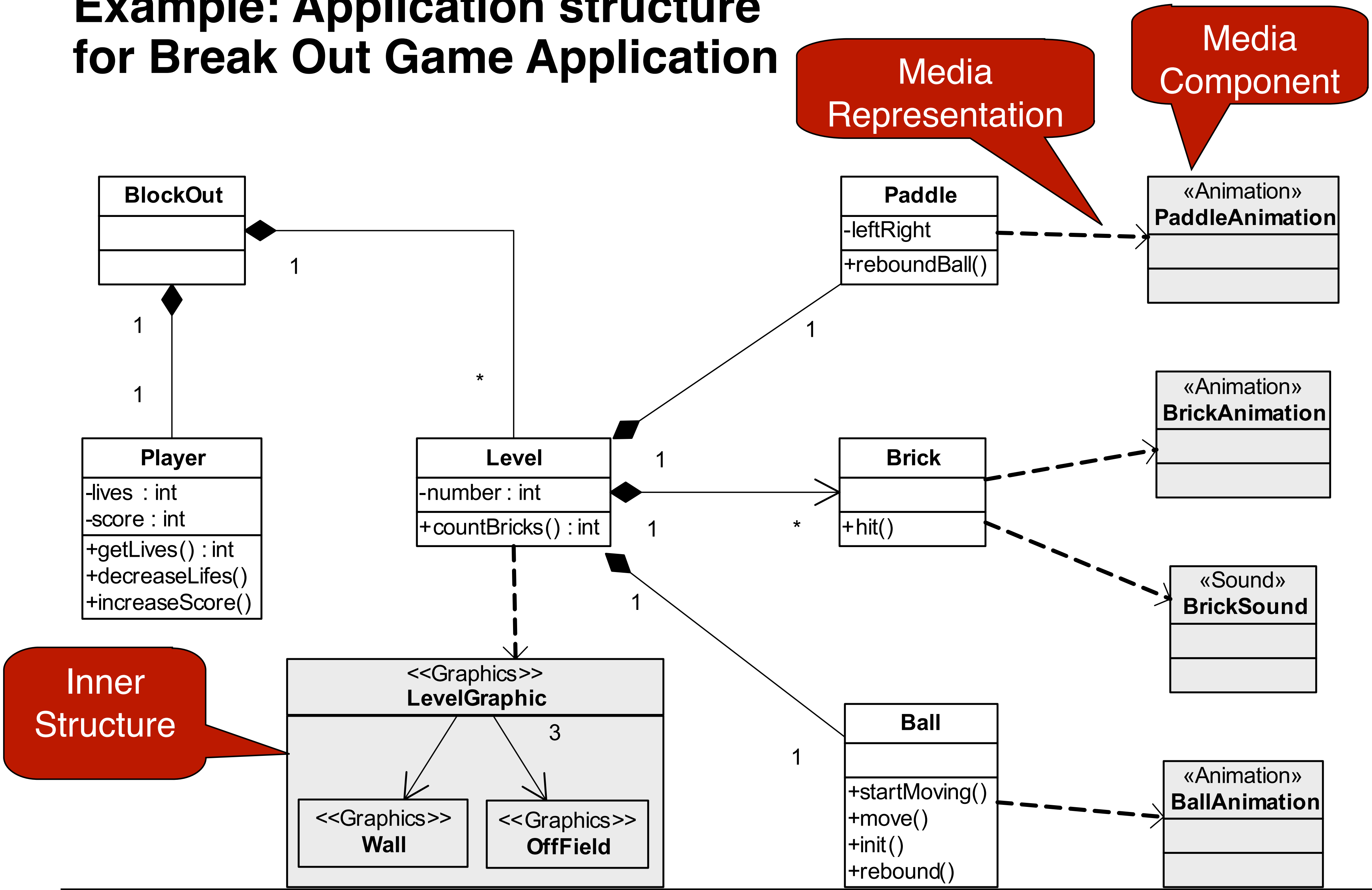
Example Application: Break Out Game



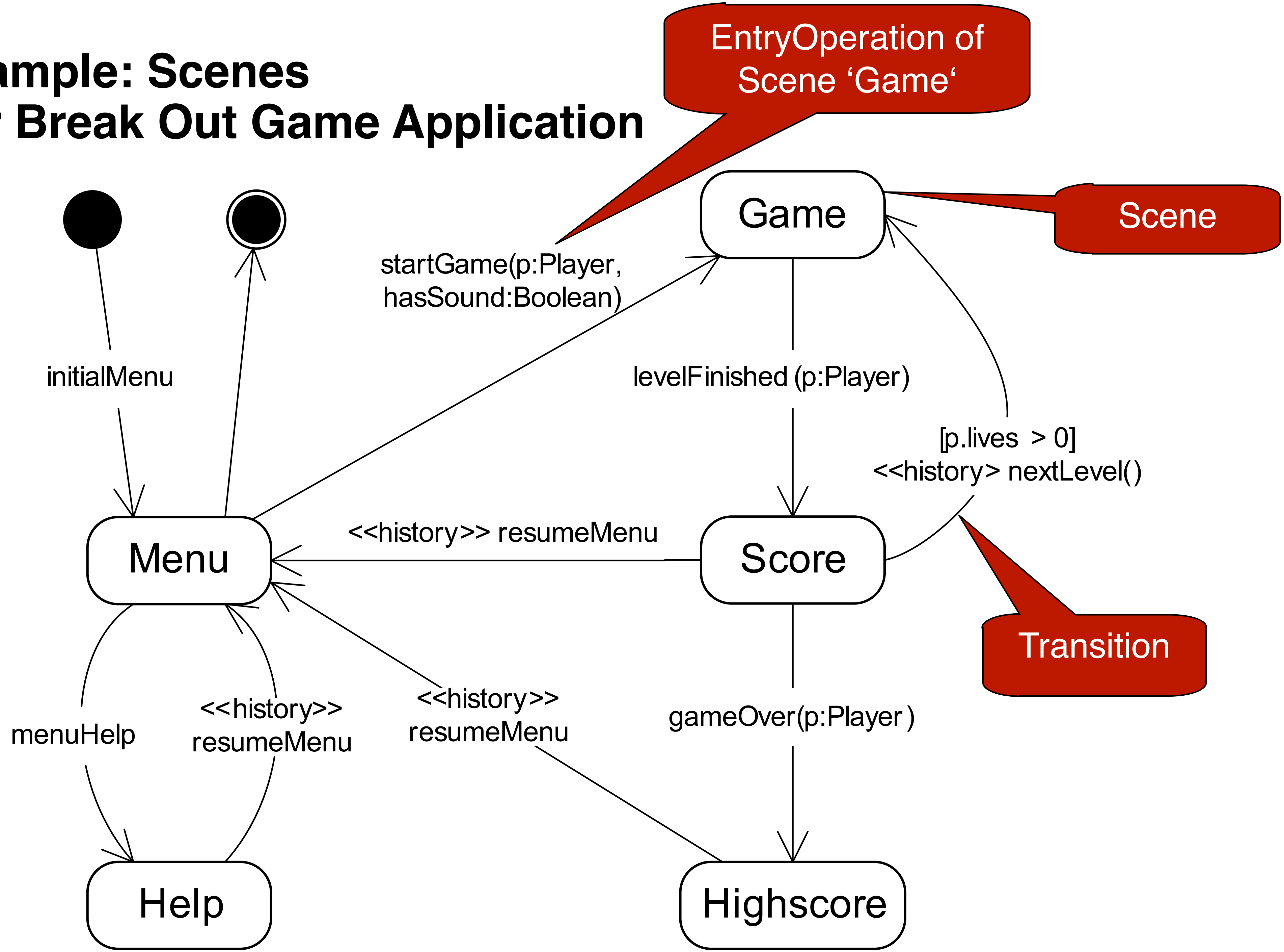
Diagrams in MML



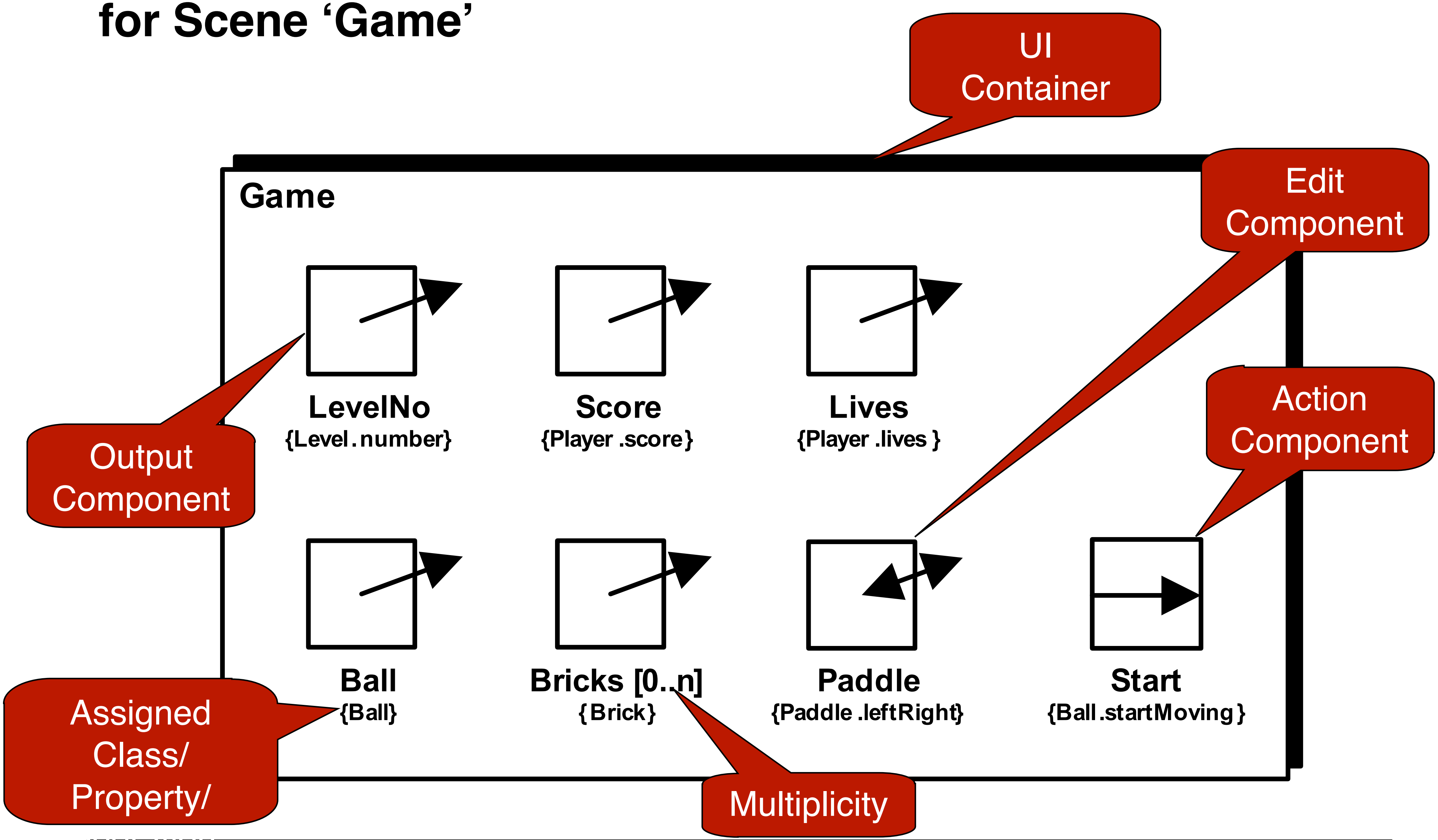
Example: Application structure for Break Out Game Application



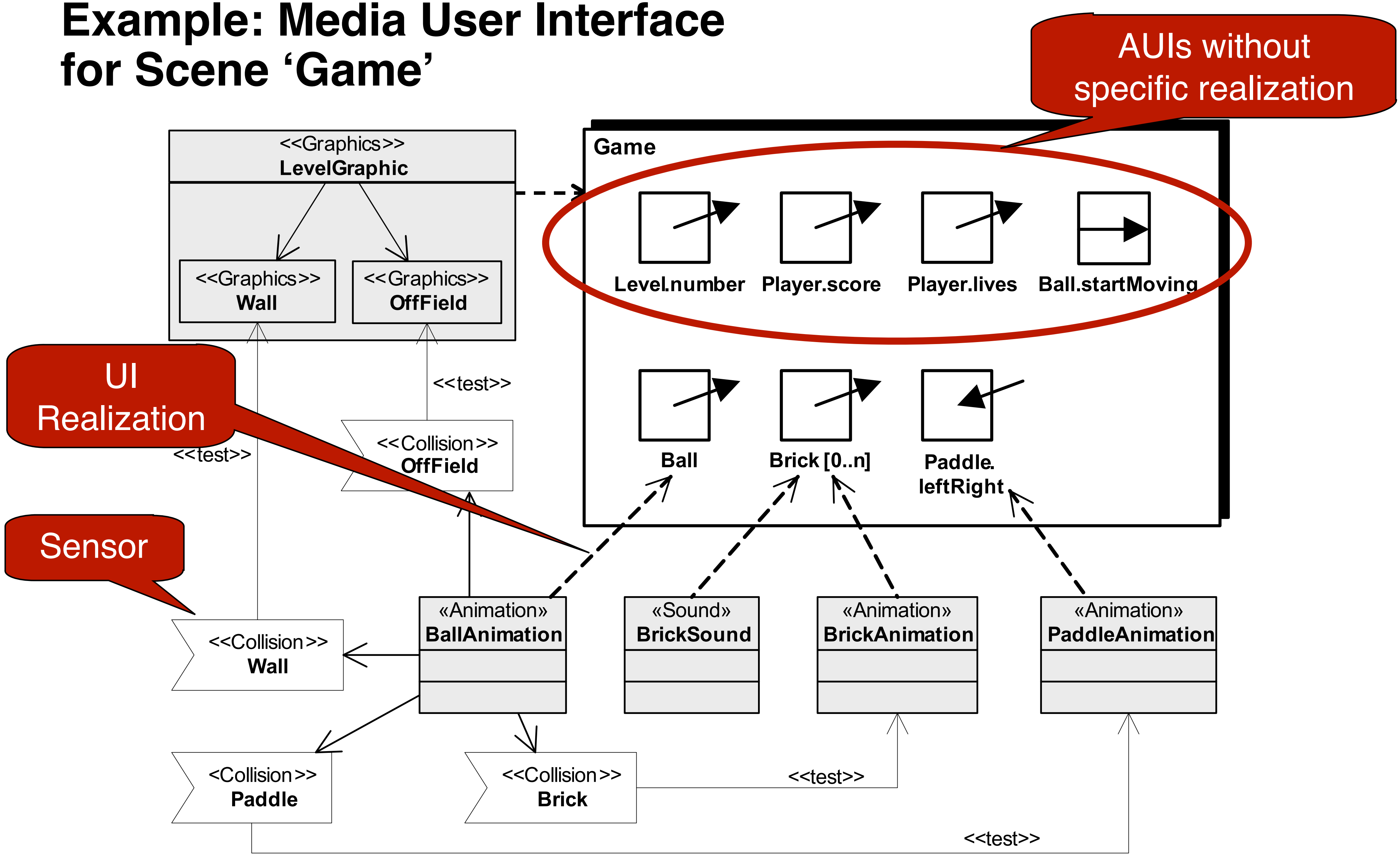
Example: Scenes for Break Out Game Application



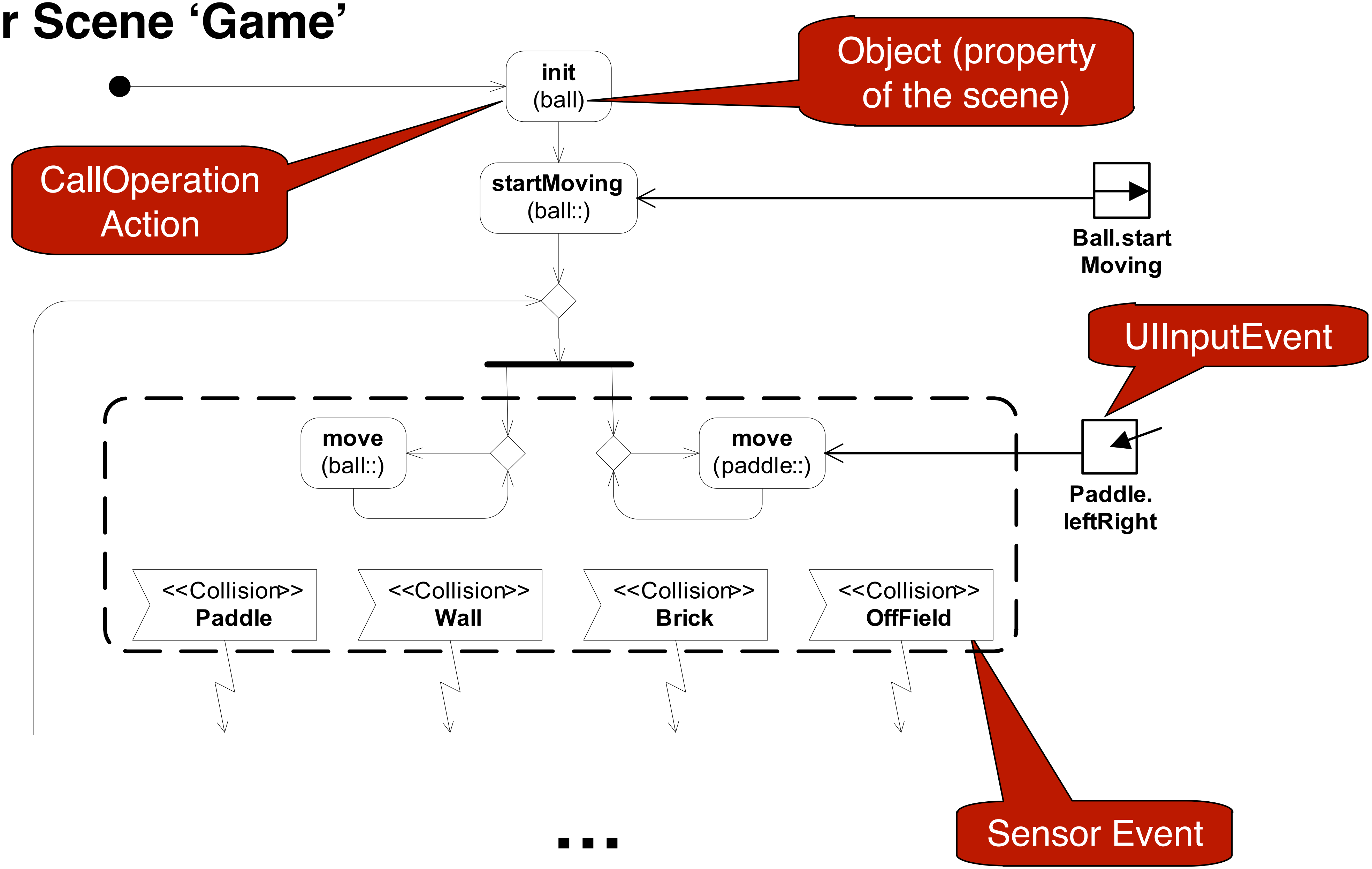
Example: Abstract User Interface for Scene 'Game'



Example: Media User Interface for Scene ‘Game’



Example: Interaction diagram for Scene 'Game'



Pros and Cons of Model-Driven Development for Multimedia Applications

- Advantages:
  - Code generation achieves independence form multimedia platform
  - Higher level of abstraction leads to deeper analysis
  - Code generators can help to create well-structured code (e.g. modular Flash applications)
- Disadvantages:
  - Full code generation problematic, platform-specific additions needed
  - Round-trip engineering still needs to be developed
  - Writing abstract specifications is not attractive for multimedia developers
- Open issue:
  - What is the right language level for integrating the various design views/ activities?