7 Software Engineering Techniques for Multimedia Software

7.1 Design Patterns: The Idea

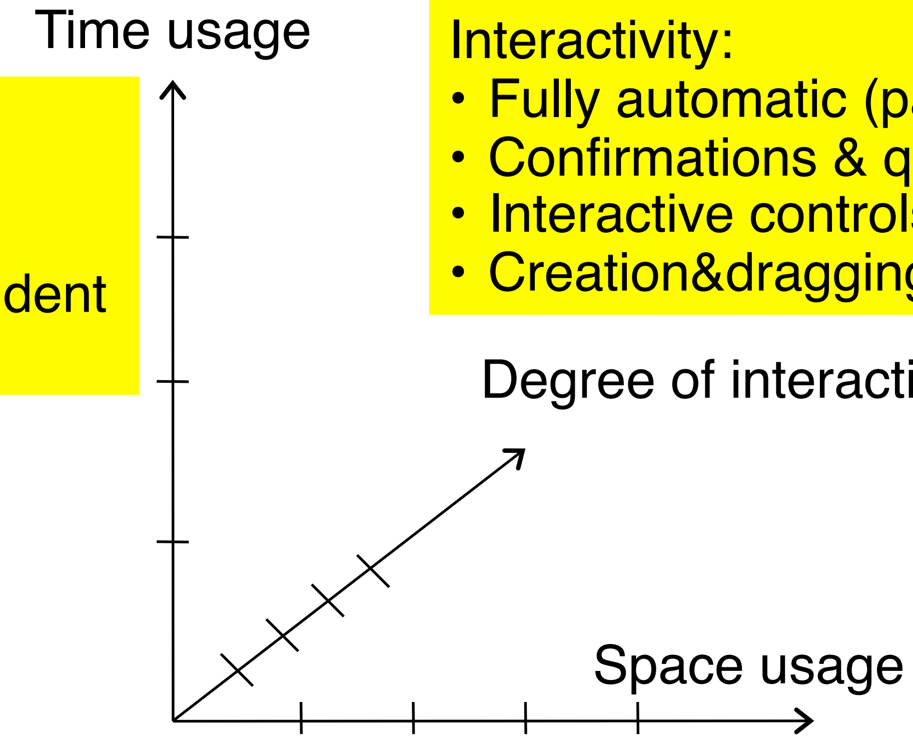
7.2 Patterns for Multimedia Software
(contd.)

7.3 Gang-of-Four Patterns Applied to Multimedia

7.4 Modeling of Multimedia Applications

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

Multimedia Development 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,synchronisation 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

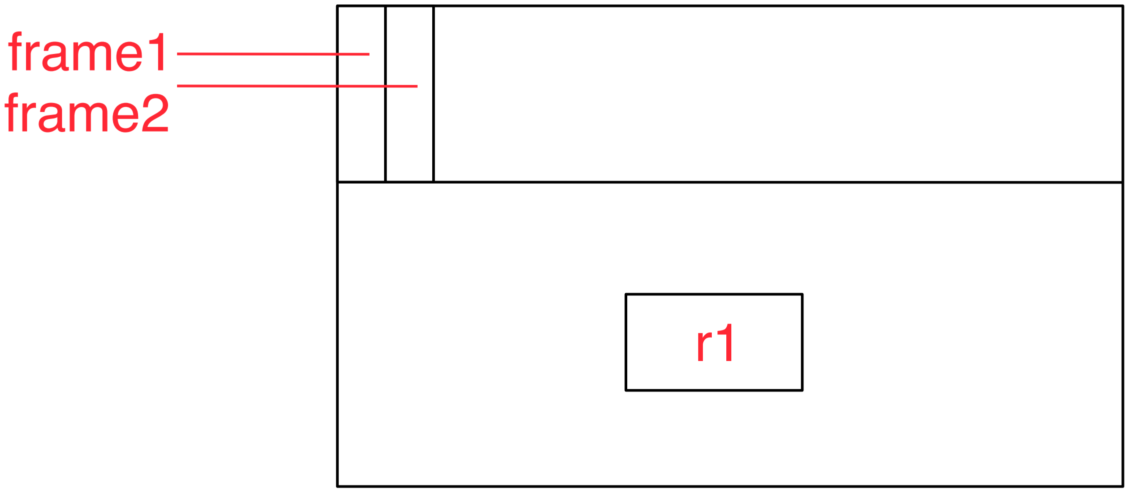
Various Representations of a Single Concept

```
<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)

Flash Pattern: Start Frame Code

- **Problem**: A Flash movie needs to carry out some ActionScript code which cannot be easily defined in a local, object-oriented style
  - Creation of objects on an application-global scale
  - Invocation of methods defined in external “.as” files
  - Assignment of methods to visible objects instantiated from the standard library (e.g. TextField)
- **Solution:**
  - Keep the “global code” in the main timeline.
  - Add a separate layer (e.g. “code” or “actions”) to the main timeline.
  - Add all “global” code to frame 1 of the newly created layer of the main timeline.
  - Advantage: There is just one place where all global code can be found.
- **Examples**:
  - Plenty found in literature

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7.3 Gang-of-Four Patterns Applied to Multimedia

- Factory Method
- State

7.4 Modeling of Multimedia Applications

Literature:

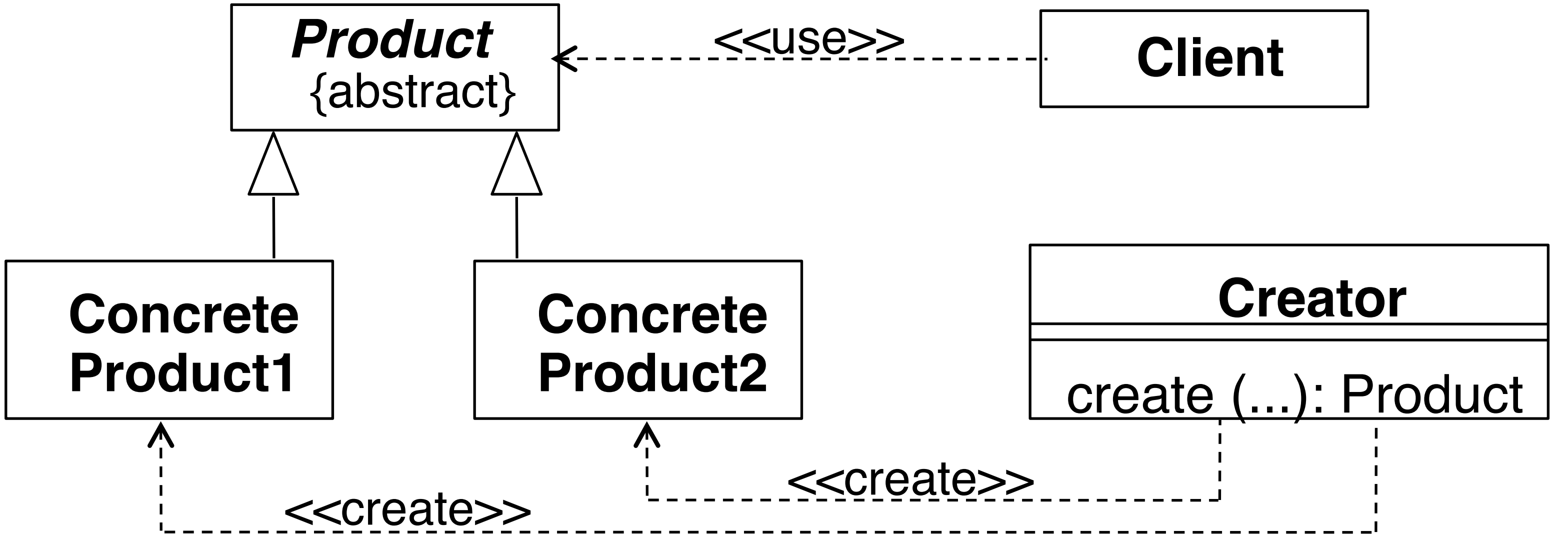
W. Sanders, C. Cumaranatunge: ActionScript 3.0 Design Patterns, O'Reilly 2007

Creation Pattern Example: Factory Method

- Situation:
  - Families of products which behave similarly
    - Same interface
  - Example: Different kinds of players, weapons etc. in a game
- Motivation:
  - Keep code easy to change
    - Typical change: Adding a new member of the family
  - Decouple *using* the products from *creating* the products
  - Code creating a product shall not know about the range of possible products
    - Shall not have access to the product subclasses
- Idea:
  - Provide method with the only purpose of creating products (factory method)

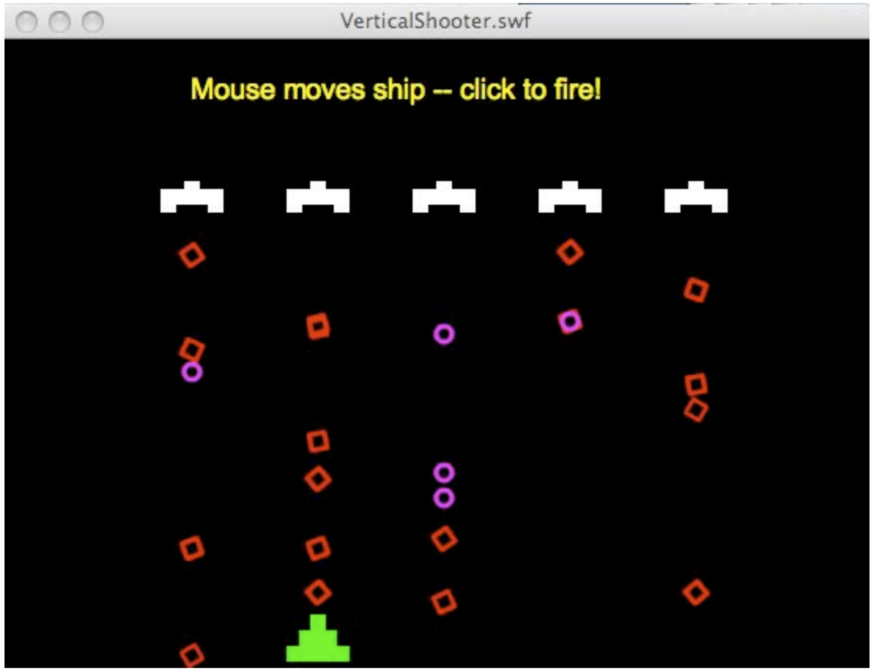
GoF Creation Pattern: Factory Method

- Name: **Factory Method**
  (dt.: Fabrikmethode, auch: Virtueller Konstruktor)
- Problem:
  - Choose at creation time between variants of a product
- Solution:



Example for Factory Method (1)

- Variants of products:
  - Ships:
    - Hero ship
    - Alien ship
  - Weapons:
    - Hero weapon
      - Cannon
    - Alien weapon
      - Cannon
      - Mine

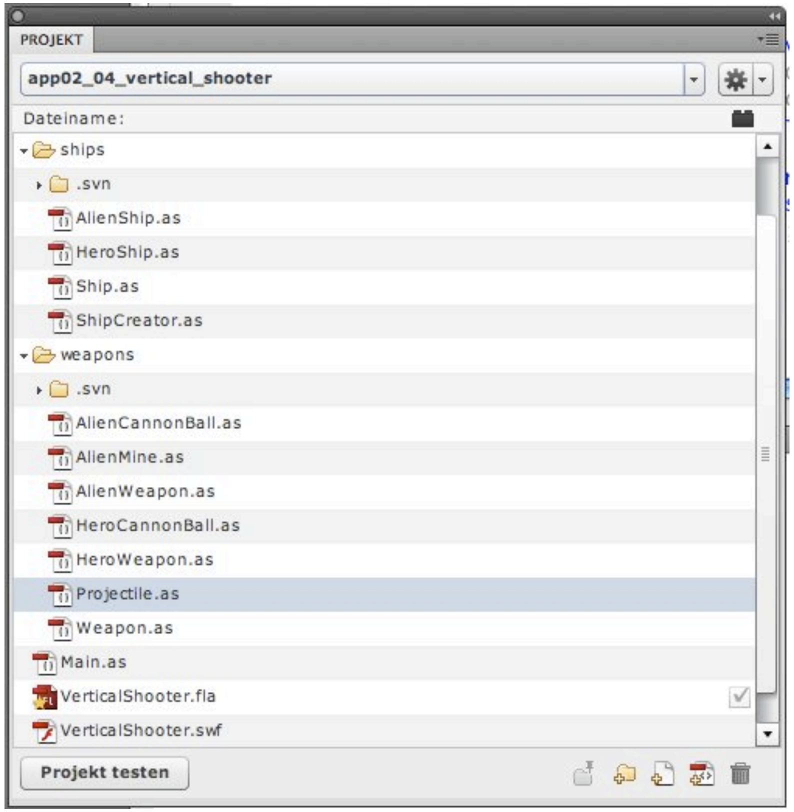


- We want to keep the code extensible for new ship and weapon types

"***Open-closed principle***":
Open for extensions, closed for code modification

Example: Sanders/Cumaranatunge

Example for Factory Method (2)

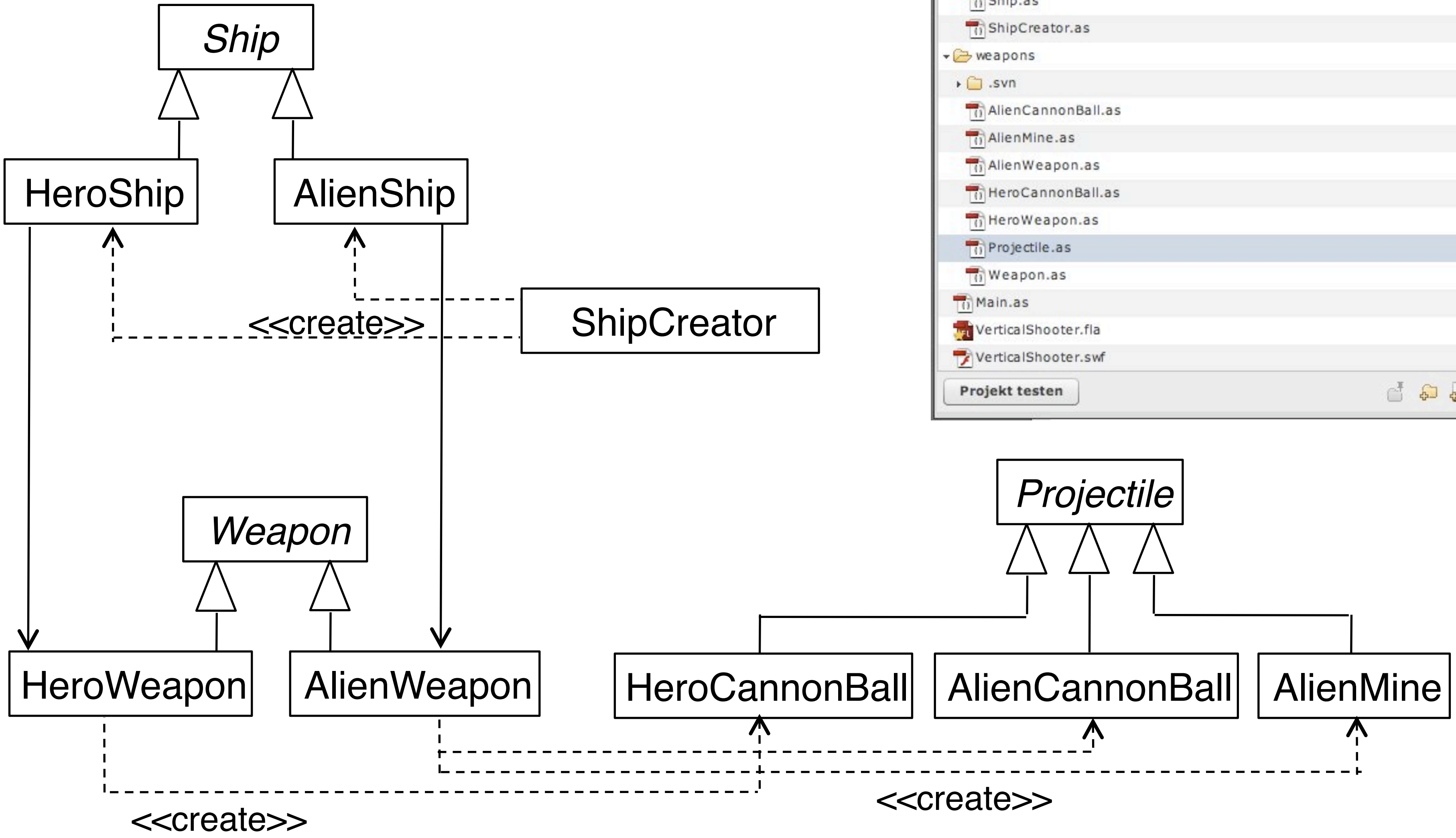


PROJEKT

app02_04_vertical_shooter

Dateiname:

- ships
  - .svn
  - AlienShip.as
  - HeroShip.as
  - Ship.as
  - ShipCreator.as
- weapons
  - .svn
  - AlienCannonBall.as
  - AlienMine.as
  - AlienWeapon.as
  - HeroCannonBall.as
  - HeroWeapon.as
  - Projectile.as
  - Weapon.as
- Main.as
- VerticalShooter.fla
- VerticalShooter.swf



Example for Factory Method (3)

```
package ships {

   import flash.display.Sprite;
   import flash.events.*;

   // ABSTRACT Class (should not be instantiated)
   internal class Ship extends Sprite {

      internal function setLoc(xLoc:int, yLoc:int):void {
            this.x = xLoc;
            this.y = yLoc;
      }

      // ABSTRACT Method (must be overridden in a subclass)
      internal function drawShip():void {
      }

      // ABSTRACT Method (must be overridden in a subclass)
      internal function initShip():void {
      }
   }
}
```

Example for Factory Method (4a)

```
package ships {

   import flash.display.*;
   import weapons.HeroWeapon;
   import flash.events.*;

   internal class HeroShip extends Ship {

      private var weapon:HeroWeapon;

      override internal function drawShip():void {
           graphics.beginFill(0x00FF00); // green color
           graphics.drawRect(-5, -15, 10, 10);
           graphics.drawRect(-12, -5, 24, 10);
           graphics.drawRect(-20, 5, 40, 10);
           graphics.endFill();
      }

   ...
```

Example for Factory Method (4b)

```
   ...

      override internal function initShip():void {
         weapon = new HeroWeapon();
         this.stage.addEventListener(MouseEvent.MOUSE_MOVE,
            this.doMoveShip);
         this.stage.addEventListener(MouseEvent.MOUSE_DOWN,
            this.doFire);
      }

      protected function doMoveShip(event:MouseEvent):void {
         this.x = event.stageX;
         event.updateAfterEvent(); // process this event first
      }

      protected function doFire(event:MouseEvent):void {
         weapon.fire(HeroWeapon.CANNON,
            this.stage, this.x, this.y - 25);
         event.updateAfterEvent(); // process this event first
      }
   }
}
```

Example for Factory Method (5)

```
package {

  import flash.display.*;
  import flash.text.*;
  import ships.*;

  public class Main extends MovieClip {

     public function Main() {
           // show instructions
           ...
           var shipFactory:ShipCreator = new ShipCreator();
           shipFactory.addShip
             (ShipCreator.HERO, stage,
                stage.stageWidth/2, stage.stageHeight-20);
           for (var i:Number = 0; i < 5; i++) {
              shipFactory.addShip(ShipCreator.ALIEN,
                stage, 120 + 80 * i, 100);
           }
     }
  }
}
```

Example for Factory Method (6a)

```
package ships {

  import flash.display.Stage;

  public class ShipCreator {

     public static const HERO          :uint =  0;
     public static const ALIEN         :uint =  1;

     public function addShip(cShipType:uint,
           target:Stage, xLoc:int, yLoc:int):void {

        var ship:Ship = this.createShip(cShipType);
        ship.drawShip();
        ship.setLoc(xLoc, yLoc);
        target.addChild(ship);
        ship.initShip();
     }

...
```

Example for Factory Method (6b)

```
...

     // concrete factory method
     private function createShip(cShipType:uint):Ship {
        if (cShipType == HERO) {
           trace("Creating new hero ship");
           return new HeroShip();
        }
        else if (cShipType == ALIEN) {
           trace("Creating new alien ship");
           return new AlienShip();
        }
        else {
           throw new Error("Invalid kind of ship specified");
           return null;
        }
     }
  }
}
```

Test for Encapsulation

```
public function Main() {
     ...
     var testShip = new HeroShip();
     ...
}
```

Compiler-Fehler:

1180: Aufruf einer möglicherweise undefinierten Methode HeroShip.

Test for Extensibility (1)

- How to add a new weapon?
- HeroShip.as:

```
override internal function initShip():void {
   weapon = new HeroWeapon();
   this.stage.addEventListener
      (MouseEvent.MOUSE_MOVE, this.doMoveShip);
   this.stage.addEventListener(MouseEvent.MOUSE_DOWN, this.doFire);
   var newweapon = new NewWeapon();
   newweapon.fire(NewWeapon.NEW, this.stage, this.x, this.y - 50);
}
```

- New classes added *(without modification of existing code!)*
  - NewWeapon.as
    - » The new kind of weapon
    - » Concrete creator for bullets, derived from abstract creator *Weapon*
  - NewBullet.as
    - » The bullet fired by the new kind of weapon
    - » Concrete product, derived from abstract product *Projectile*

Test for Extensibility (2)

```
package weapons {

  public class NewWeapon extends Weapon {

     public static const NEW           :uint =  3;

     override protected function
          createProjectile(cWeapon:uint):Projectile {
        if (cWeapon == NEW) {
           trace("Creating new bullet");
           return new NewBullet();
        } else {
           throw new Error("Invalid kind of projectile");
           return null;
        }
     }
  }
}
```

NewWeapon.as

Test for Extensibility (3)

```
package weapons {

  internal class NewBullet extends Projectile {

     override internal function drawProjectile():void
     {
          graphics.beginFill(0xFF0000);
          graphics.drawCircle(0, 0, 15);
          graphics.endFill();
     }

     override internal function arm():void {
          nSpeed = -15; // set the speed
     }
  }
}
```

NewBullet.as

- Methods **`drawProjectile()`** and **`arm()`** are called in method **`fire()`** of abstract class Weapon
  - Idea of *Template Method* pattern

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Factory Method

State

7.4 Modeling of Multimedia Applications

Literature:

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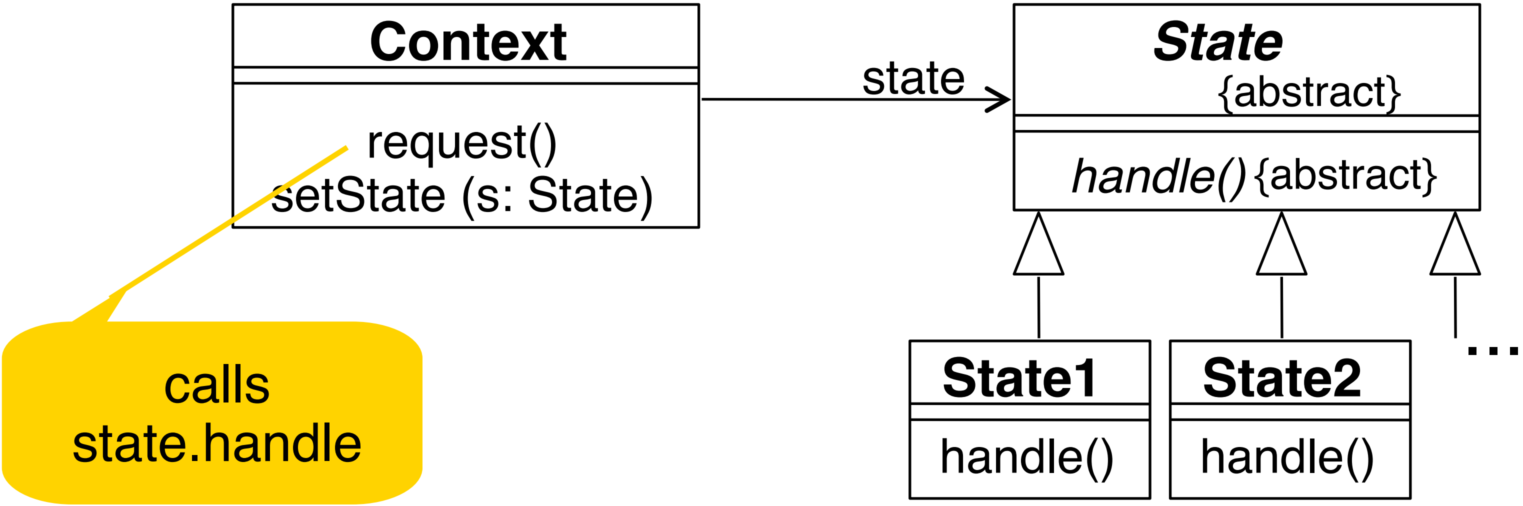
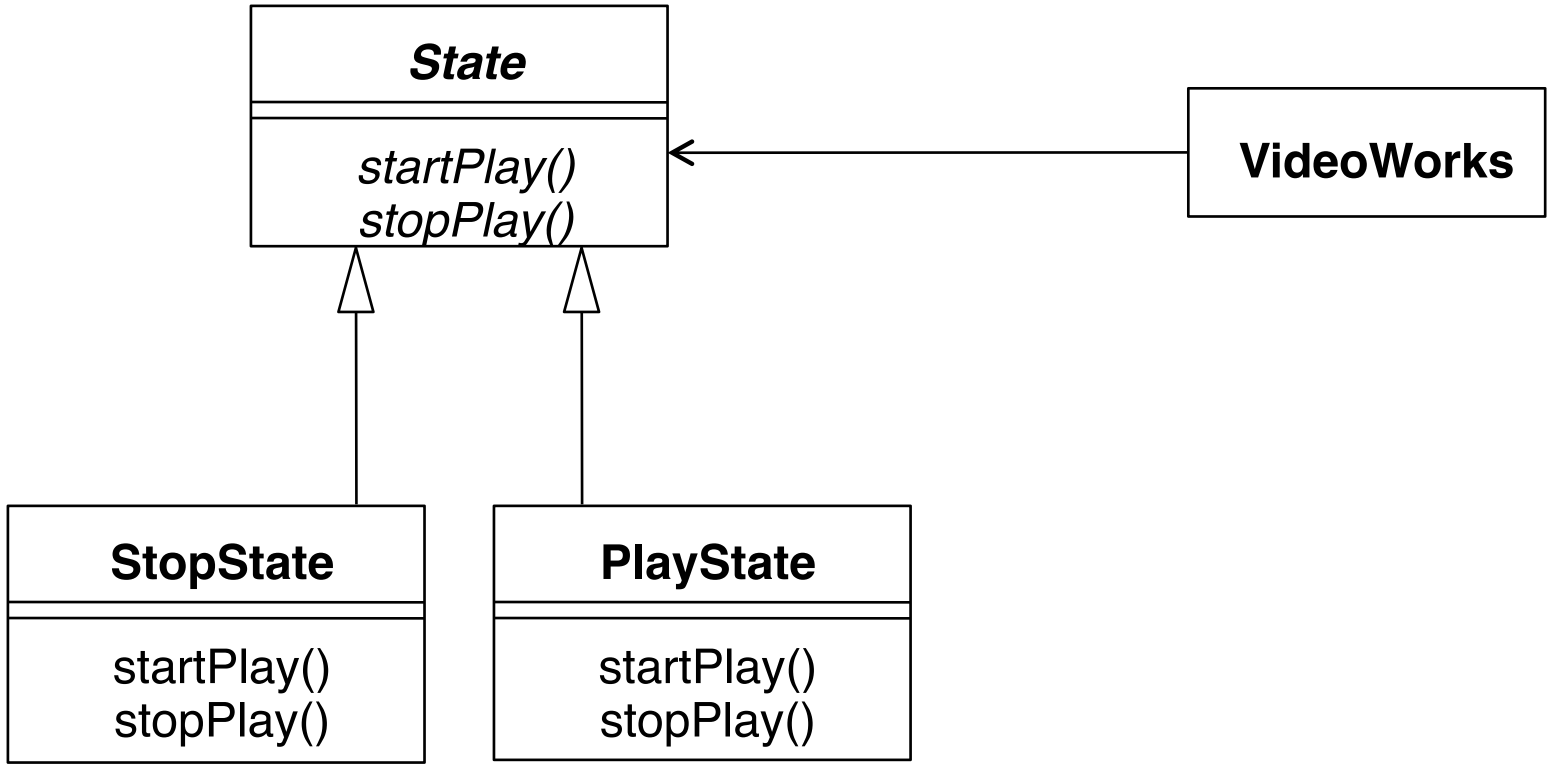
GoF Structural Pattern: State

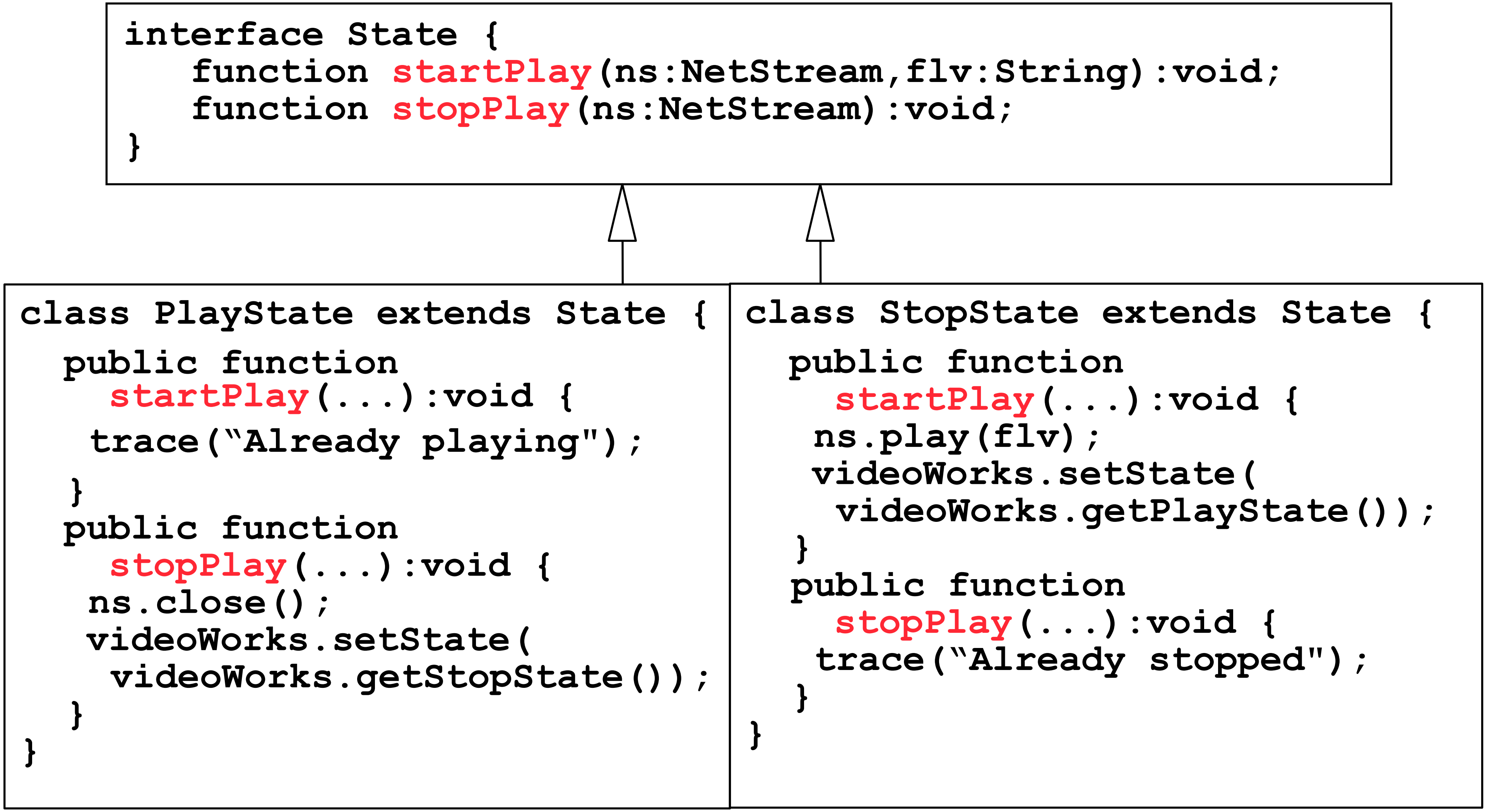
- Name: **State**
- Problem:
  - Flexible and extensible technique to change the behavior of an object when its state changes.
- Solution :



Example for State (1)



Example for State (2)



```
interface State {
   function startPlay(ns:NetStream,flv:String):void;
   function stopPlay(ns:NetStream):void;
}
```

```
class PlayState extends State {
  public function
    startPlay(...):void {
   trace(“Already playing");
  }
  public function
    stopPlay(...):void {
   ns.close();
   videoWorks.setState(
    videoWorks.getStopState());
  }
}
```

```
class StopState extends State {
  public function
    startPlay(...):void {
   ns.play(flv);
   videoWorks.setState(
    videoWorks.getPlayState());
  }
  public function
    stopPlay(...):void {
   trace(“Already stopped");
  }
}
```

Test for Extensibility

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

  ```
  function doPause(ns:NetStream):void;
  ```

  - Compiler checks completeness of transitions
- (1044: Schnittstellenmethode *doPause* in Namespace *State* nicht durch Klasse *PlayState* implementiert.

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Literature:

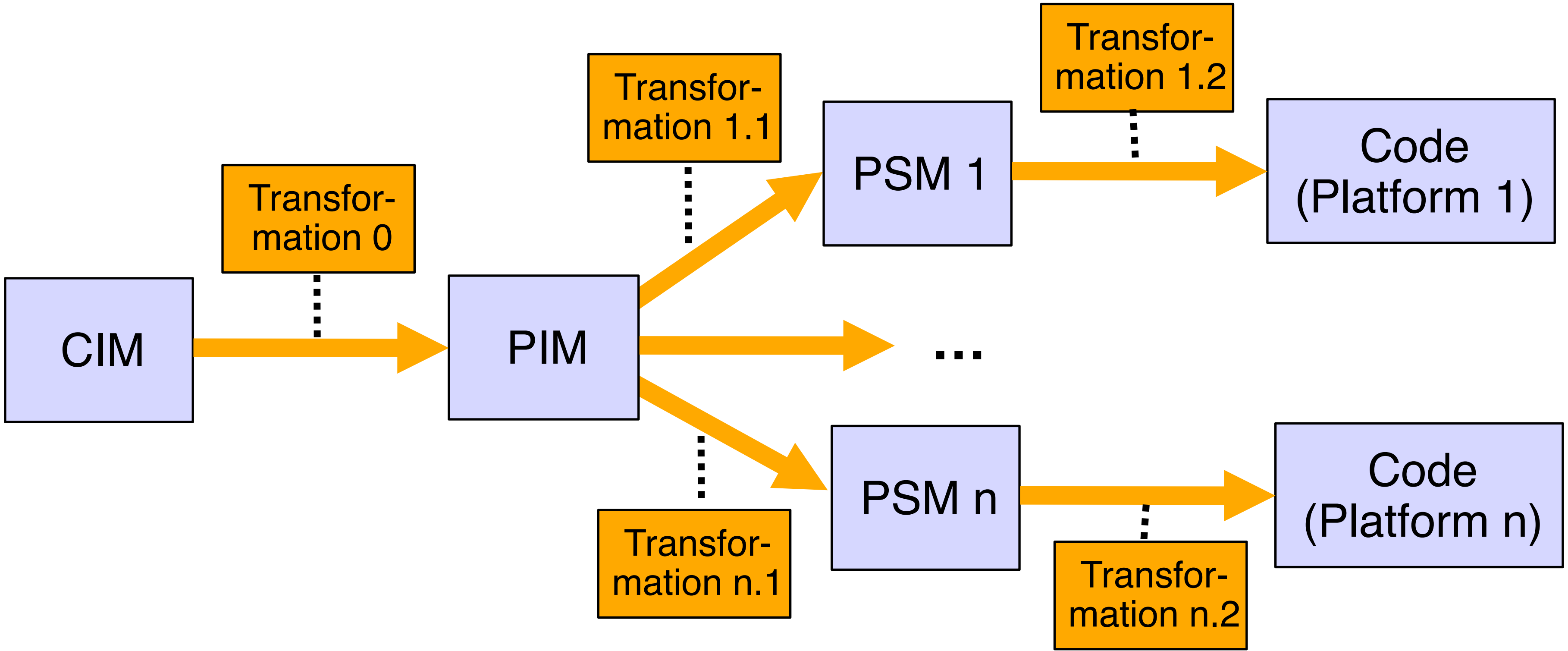
A. Pleuß: MML - A Language for Modeling Interactive Multimedia Applications.
Seventh IEEE International Symposium on Multimedia (ISM 2005), pp. 465 - 473, IEEE Society Press, 2005

Model-Driven Development

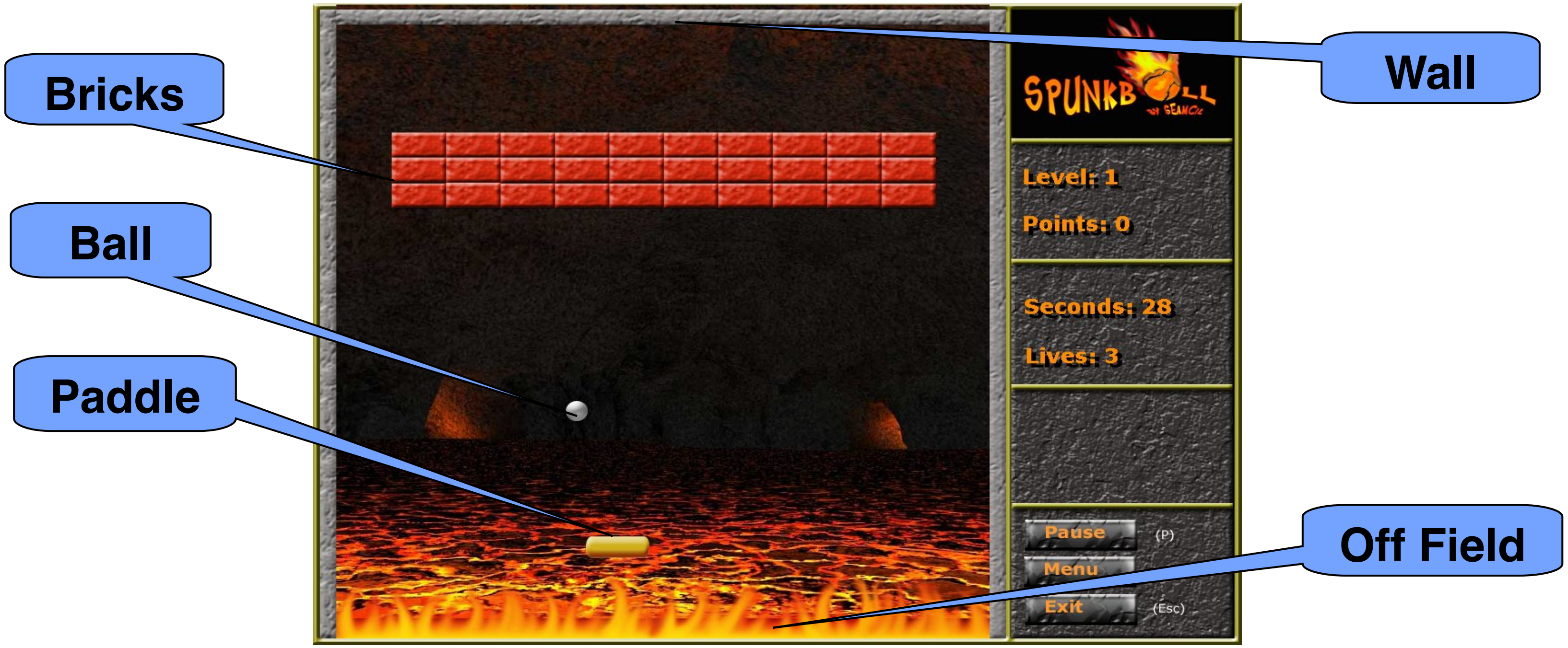
- Development process with models as core assets
  - "Model" = 'a simplified image of a system'
- Idea:
  - ‘Programming’ on abstract conceptual level
  - Implementation code is generated automatically from models
  - Expert knowledge about implementation details is put into the code generator
- Requirements:
  - Various models available to cover development process:
    - » Different levels of abstraction during development
    - » Different views on the system to cover all aspects of the system
  - Transformations (mappings) between the models
    - » Forward, to derive more concrete models from earlier models
    - » Backwards, to allow iterations
- Transformations specified explicitly and treated as assets of their own
  - Customizable

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

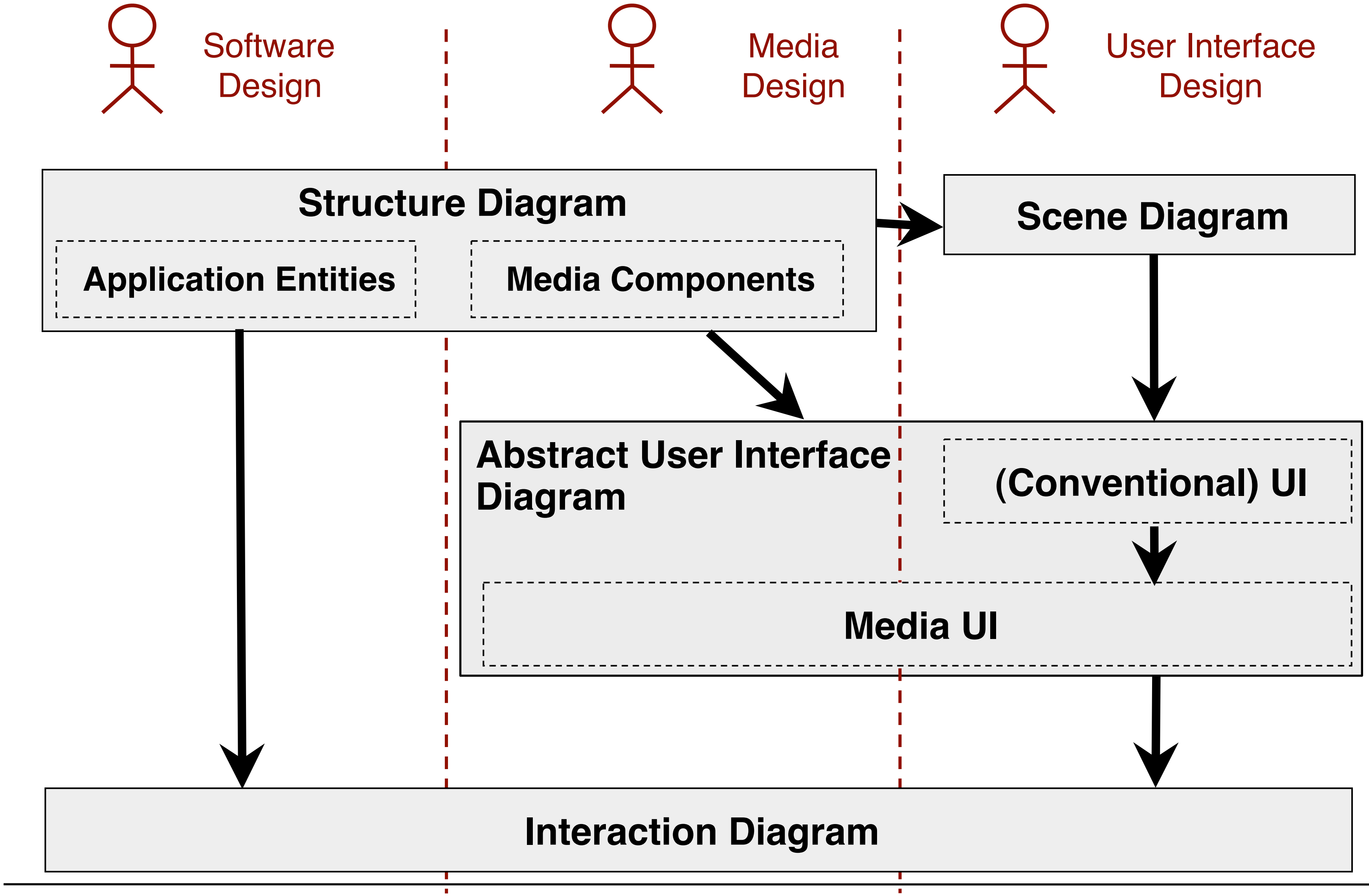


Example Application: Break Out Game

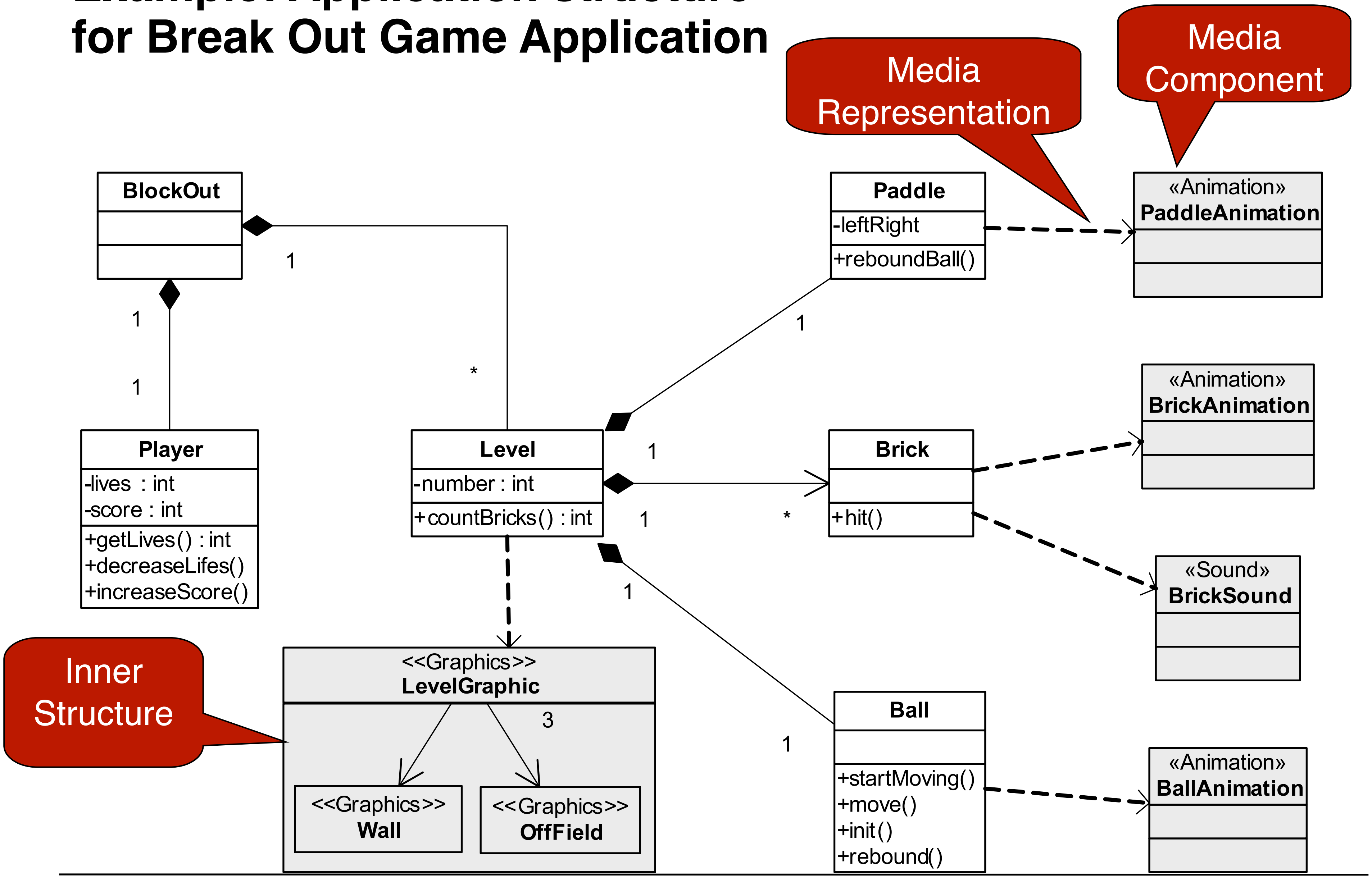


- (Small) games are good examples for interactive multimedia applications
  - Make intensive use of media objects, interaction and complex user interfaces
  - Functionality can be understood easily without specific domain knowledge

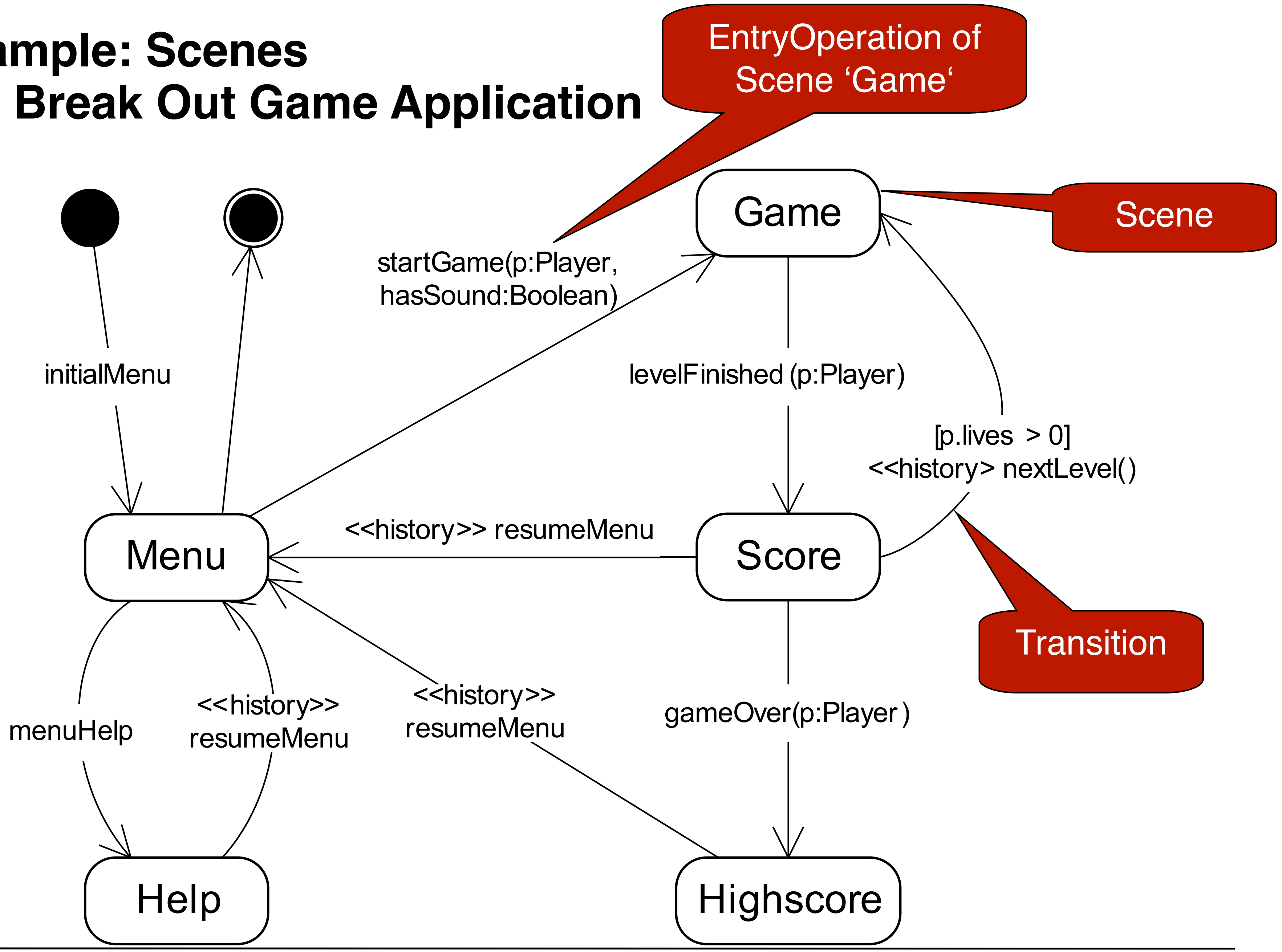
Diagrams in MML



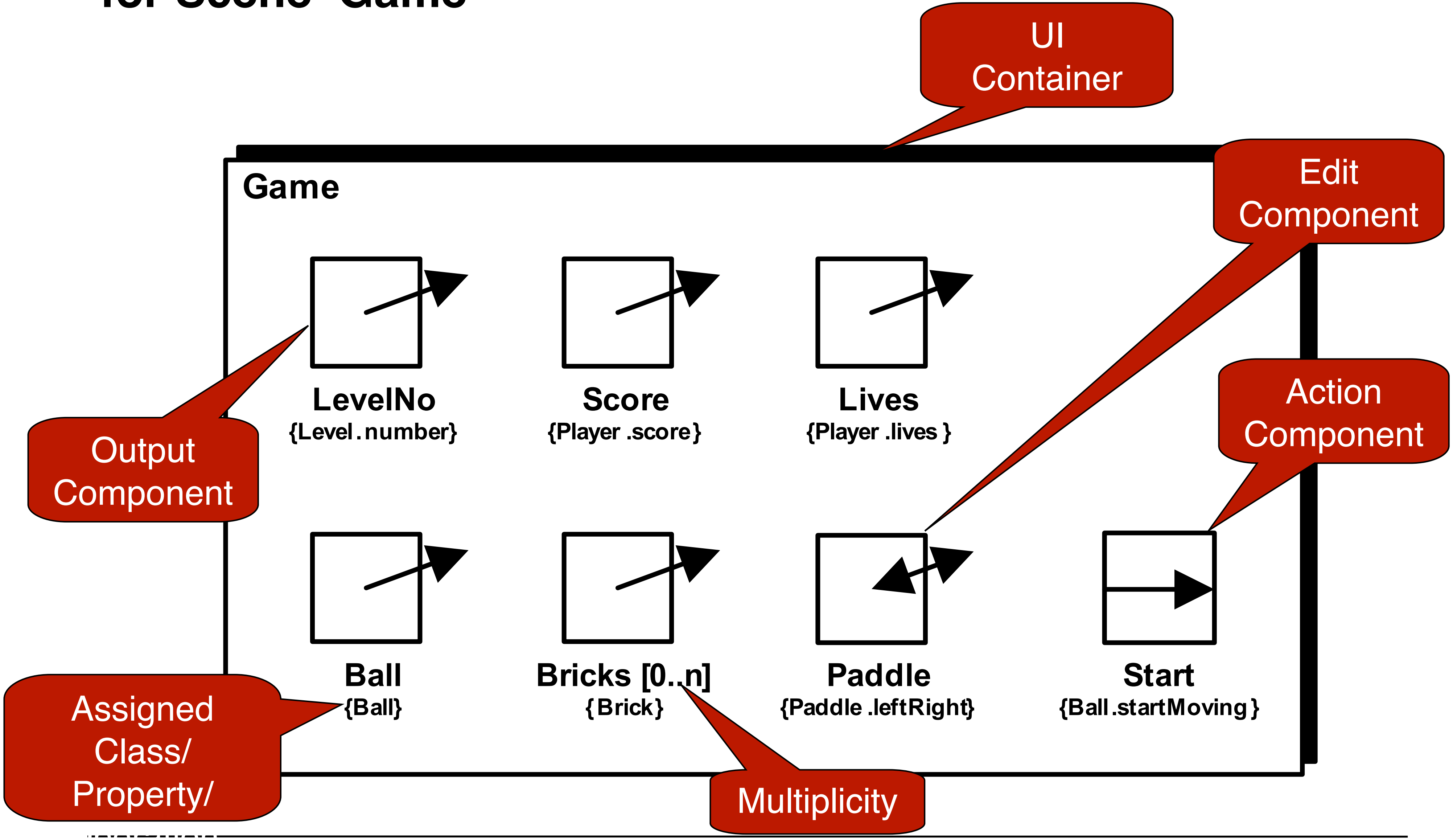
Example: Application structure for Break Out Game Application



Example: Scenes
for Break Out Game Application



Example: Abstract User Interface for Scene ‘Game’



UI Container

Game

Edit Component

LevelNo
{Level.number}

Score
{Player.score}

Lives
{Player.lives}

Output Component

Action Component

Ball
{Ball}

Bricks [0..n]
{Brick}

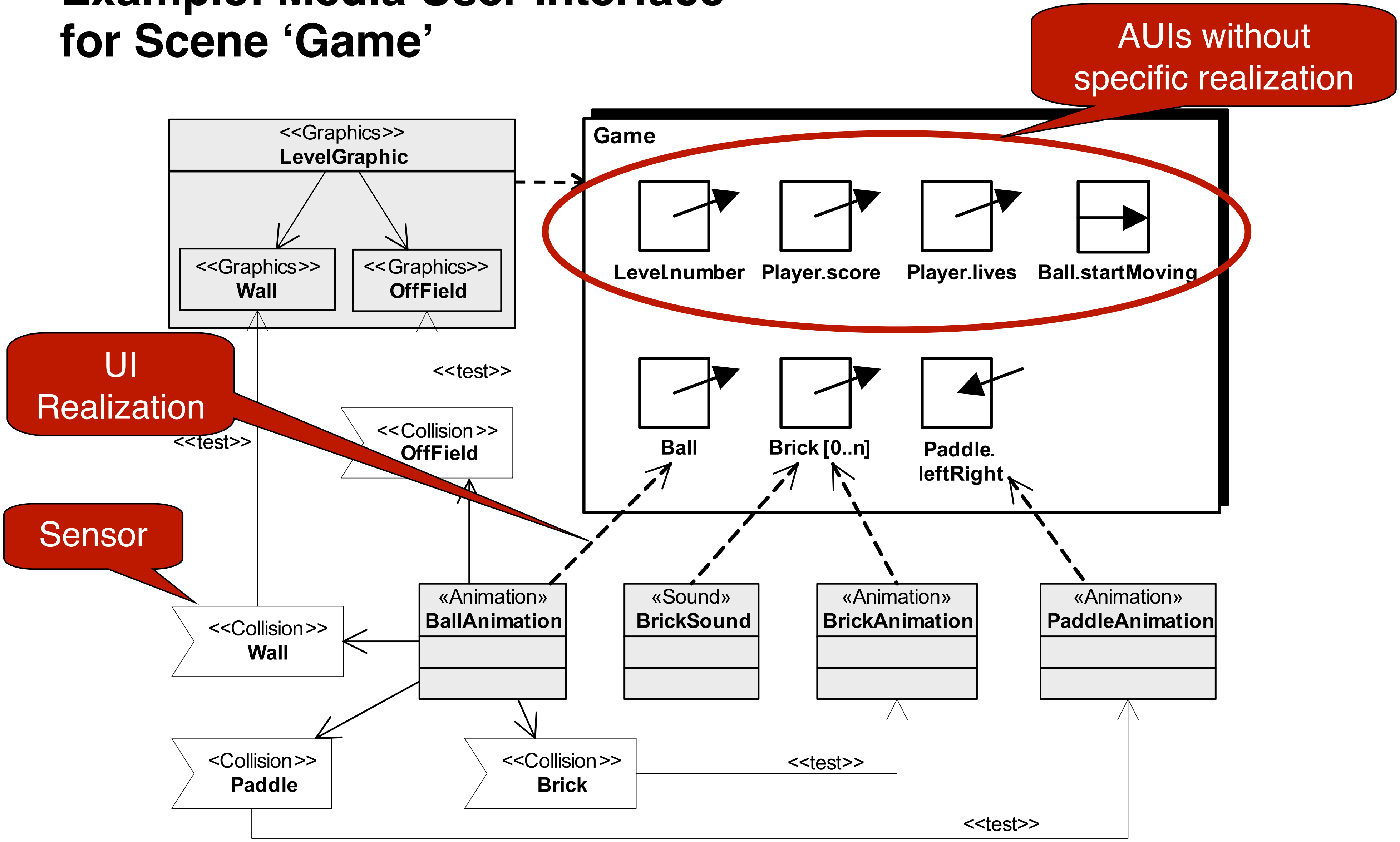
Paddle
{Paddle.leftRight}

Start
{Ball.startMoving}

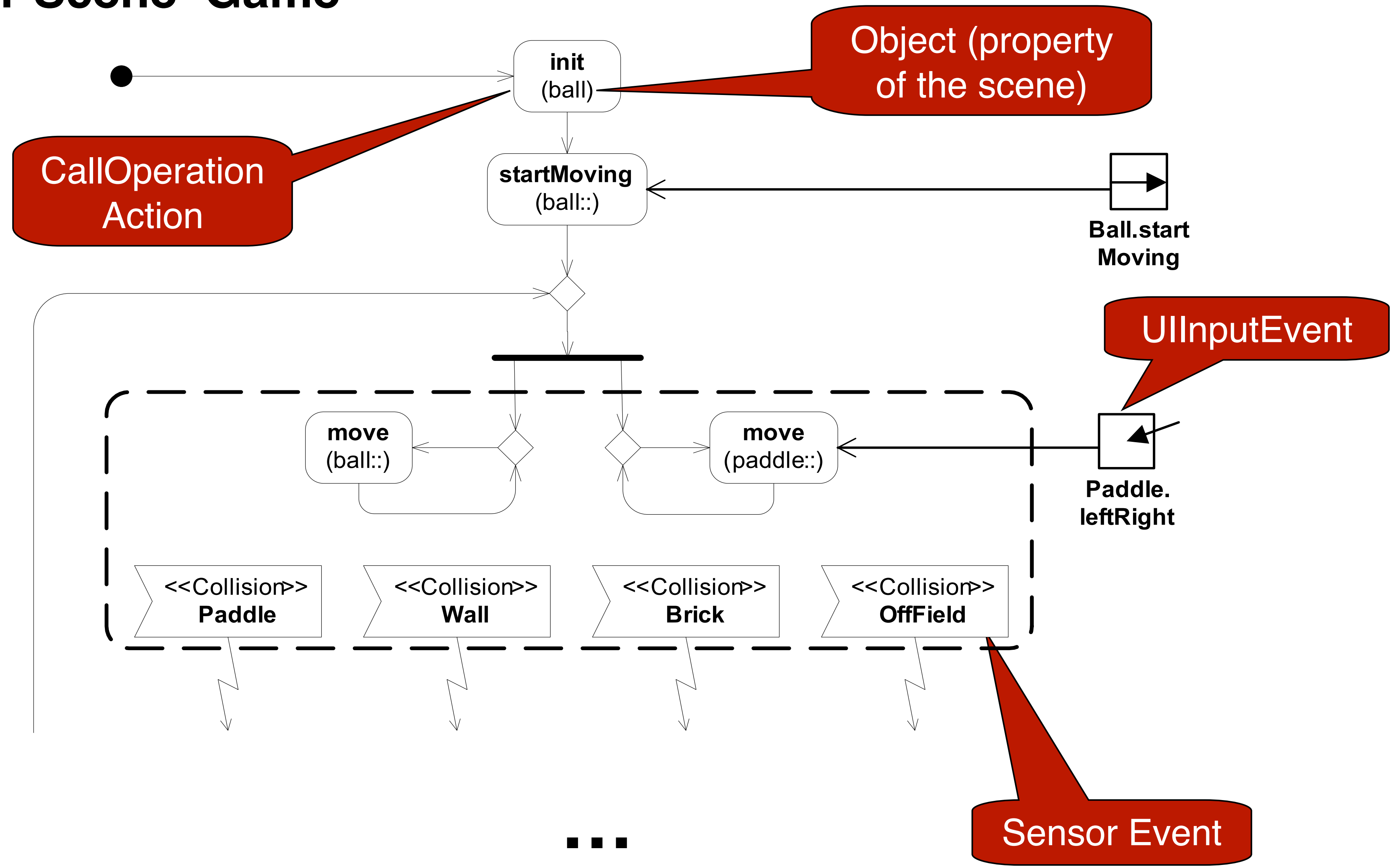
Assigned Class/ Property/

Multiplicity

Example: Media User Interface for Scene 'Game'

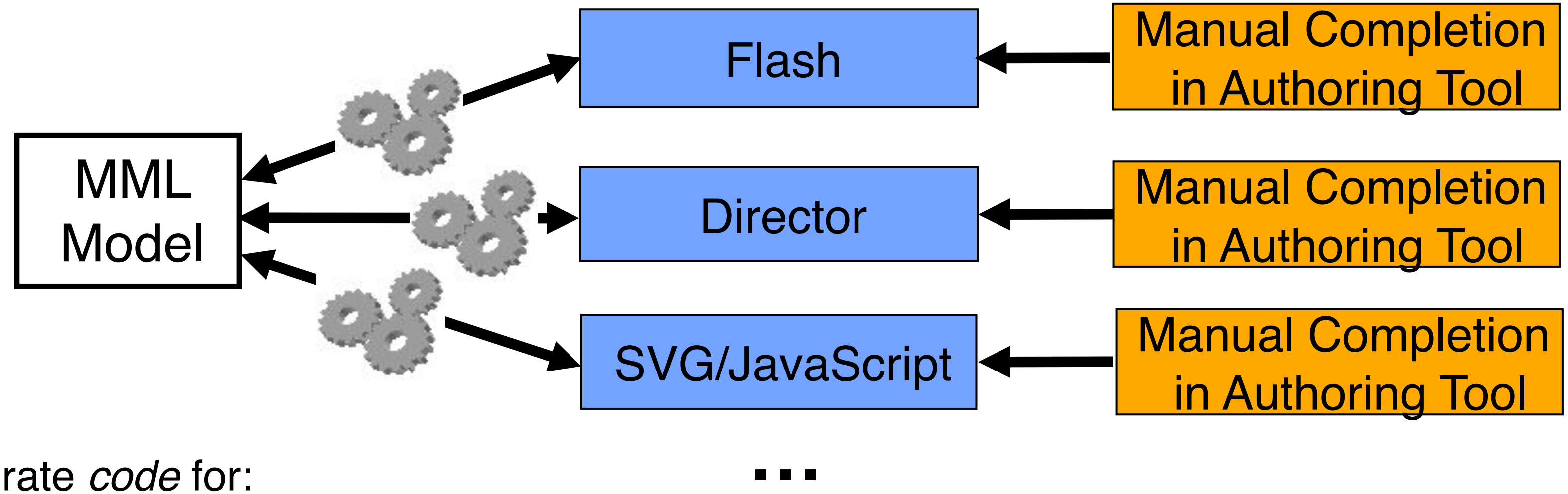


Example: Interaction diagram for Scene ‘Game’



Code Generation: Integration of authoring tools

- How to integrate – for the creative design tasks - the powerful multimedia authoring tools into the model-driven development process?


MML Model
Flash
Director
SVG/JavaScript
Manual Completion in Authoring Tool
Manual Completion in Authoring Tool
Manual Completion in Authoring Tool
...

Generate *code* for:

- Classes and class attributes
- Overall behavior
- Integration of media objects and the user interface

Generate *placeholders* for:

- Class operations
- Media objects
- User interface objects and layout

Structure and integration managed in model

Creative design performed in authoring tools

Pros and Cons of Model-Driven Development for Multimedia Application

- Advantages:
  - Switch in platform (ideally) requires only change of code generation transformations
    - » E.g. from ActionScript 2 to ActionScript 3, from Flash to Silverlight
  - 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 not (yet) possible, platform-specific completions prohibit easy switching between platforms
  - 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?