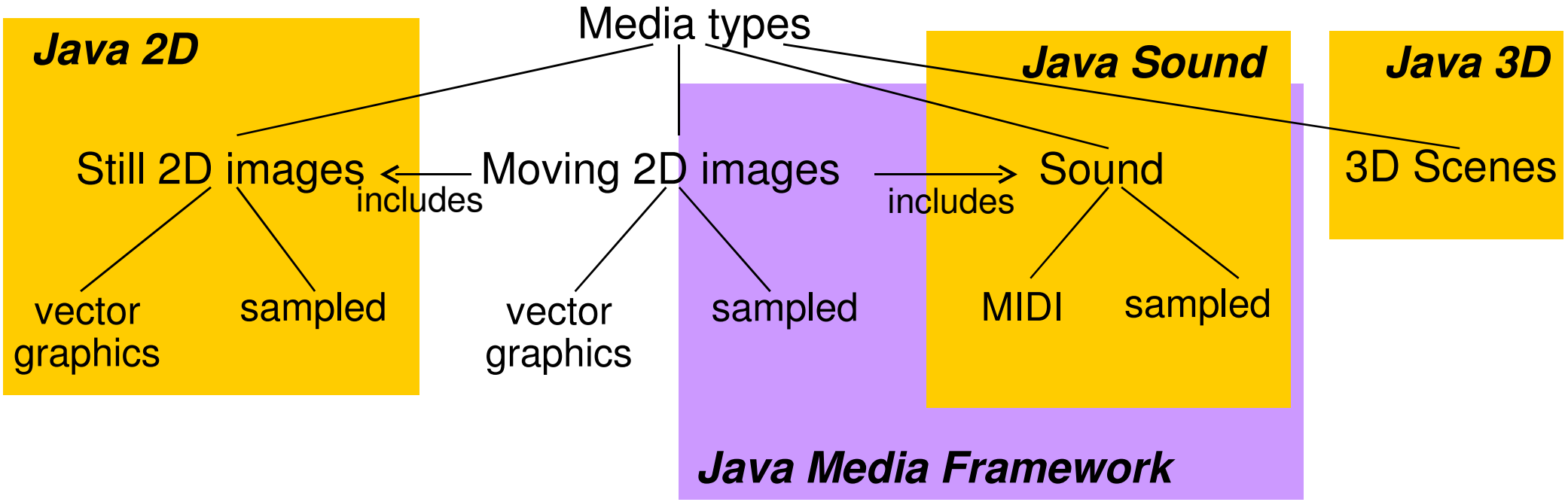
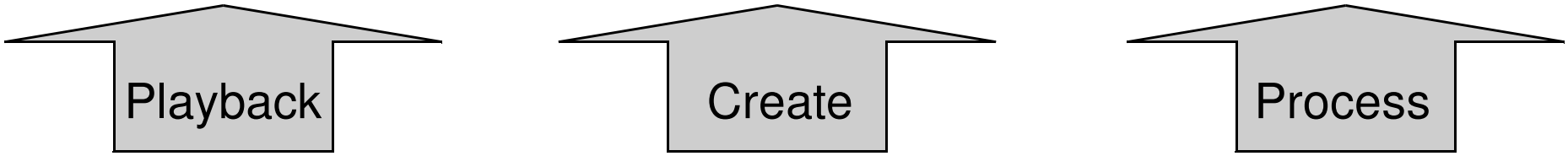
4 Overview on Approaches to Multimedia Programming

Java Media APIs

- Java was from its beginnings intended as a multimedia programming language:
  - “Oak”, Java’s predecessor:
    designed to control Set Top Boxes for Interactive TV
- Java Media APIs
  - Loose collection of APIs defined and maintained by Sun
  - Main APIs: Advanced Imaging (JAI), Java Media Framework (JMF), Java 3D
  - APIs which have become part of standard distribution: Java 2D, Java Sound
- Style rather heterogeneous
- Not all multimedia programming tasks covered
  - E.g. animation
  - “Unofficial” APIs and implementations try to fill the gap

Java Media APIs





Summary on Java Media APIs

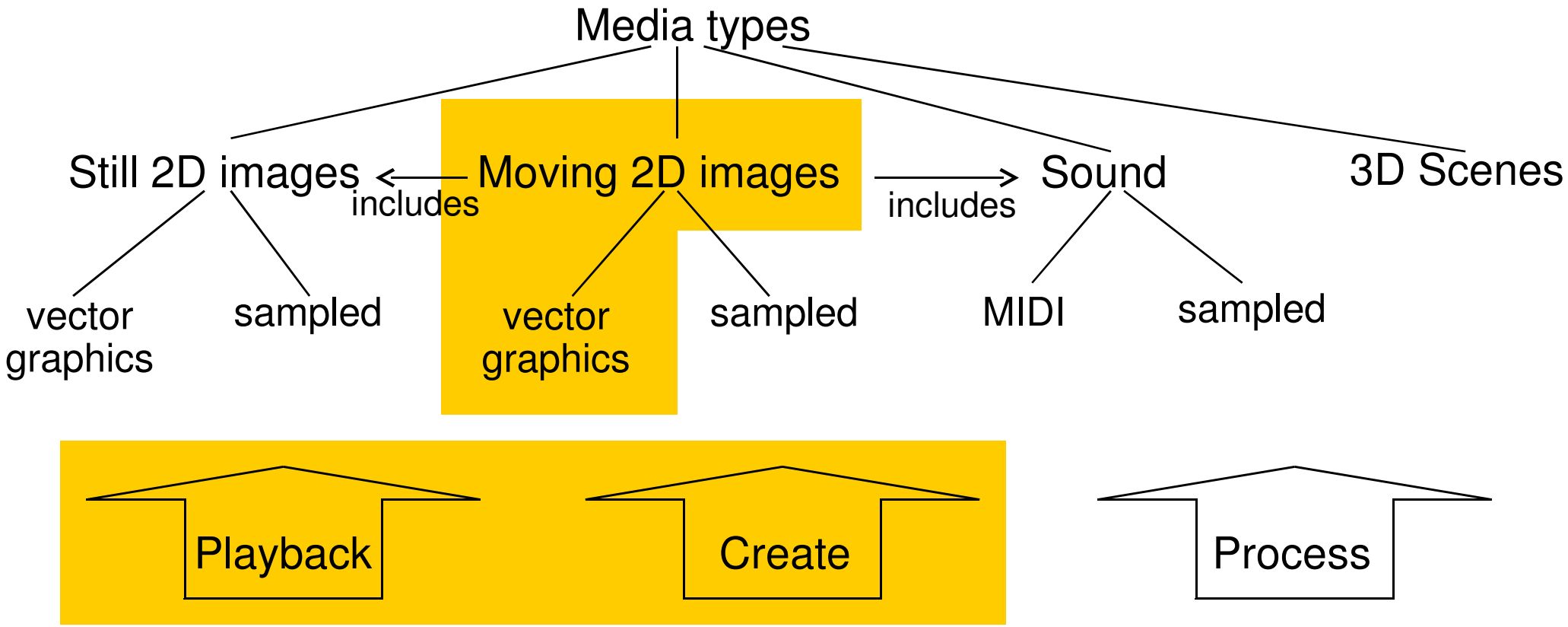
- Main application areas:
  - Creation of media creation and editing software
  - Not targeted for individual creation of multimedia applications
- Architectural principles:
  - Processing chains
  - Prefabricated components for dealing with complex media types (e.g. video)
  - Realized by various software design patterns
    - » Strategy objects encapsulating e.g. a single filter function
    - » Pipeline architectures
    - » Event handling for synchronisation
- Programming style:
  - Low-level, rather tedious, many technical details
- Expressive power:
  - Very high power when using very low level description (e.g. sound synthesis)
  - Limited power when using pre-fabricated media-processing components

4 Overview on Approaches to Multimedia Programming

Literature:

B. Bederson, J. Grosjean, J. Meyer: Toolkit Design for Interactive Structured Graphics, *IEEE Trans. Software Engineering*, Vol. 30, No. 8, August 2004

Vector Animation Framework



Examples **(Non-official, not widespread**!):

JGoodies Animation (www.jgoodies.com)

SceneBeans (www-dse.doc.ic.ac.uk/Software/SceneBeans)

Piccolo & Jazz (www.cs.umd.edu/hcil/piccolo/)

How to Design an Interaction/Animation Framework for Vector Graphics?

- Key concepts needed:
  - Time-dependency: clocks, timers
  - New variants of graphics objects
    - » Dynamic, behaviour
- Basic design idea:
  - Graph of objects rendered in a time-dependent way
- How to integrate time- and interaction-dependent behaviour?
  - (Swing) layout + global structured timeline (similar to SMIL)
    - » “Time containers”, composed at compile time by method calls

    –> e.g. in JGoodies Animation
  - Scene graphs with local time-dependent interpolators (similar to VRML)

    –> e.g. in SceneBeans
- Please note the analogy to timeline-based vs. script-based animation in Flash!

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JGoodies: General Facts

- This is NOT an official Java standard!
  - Private initiative (Karsten Lentzsch)
  - https://animation.dev.java.net/
  - Here only used as example
- “The framework uses concepts and notions as described by the W3C specification for the Synchronized Multimedia Integration Language (SMIL). Unlike SMIL we use Java to describe the animations - not XML.”
- Similar approach:
  - Chet Haase: https://timingframework.dev.java.net/

JGoodies Example (1)

```
private Animation createAnimation() {
  Animation welcome =
    BasicTextAnimation.defaultFade(
      label1,
      2500,
      "Welcome To",
      Color.darkGray);

  Animation theJGoodiesAnimation =
    BasicTextAnimation.defaultFade(
      label1,
      3000,
      "The JGoodies Animation",
      Color.darkGray);

  Animation description =
    BasicTextAnimations.defaultFade(
      label1,
      label2,
      2000,
      -100,
      "An open source framework|" +
      "for time-based|real-time animations|in Java.",
      Color.darkGray); ... } ... }
```

JGoodies Example (2)

```
Animation all =
   Animations.sequential(new Animation[] {
     Animations.pause(1000),
     welcome,
     Animations.pause(1000),
     theJGoodiesAnimation,
     Animations.pause(1000),
     description,
     Animations.pause(1000),
     features,
     Animations.pause(1000),
     featureList,
     Animations.pause(1500),
   });
```

JGoodies Example (3)

In main program:

```
JFrame frame = new JFrame();
Intropage ip = new IntroPage();
frame.setContentPane(ip.build());
frame.setSize(350, 150);
...
frame.setVisible(true);
Animator animator =
  new Animator(introPage.animation(), fps);
animator.start();
```

Method `build()` of class `IntroPage`

```
label1 = new BasicTextLabel(" ");
label1.setFont(font);
label1.setBounds(0, 0, 350, 100);
label1.setOpaque(false);
label2 = ...
animation = createAnimation();
```

Methods of JGoodies “Animations” Class

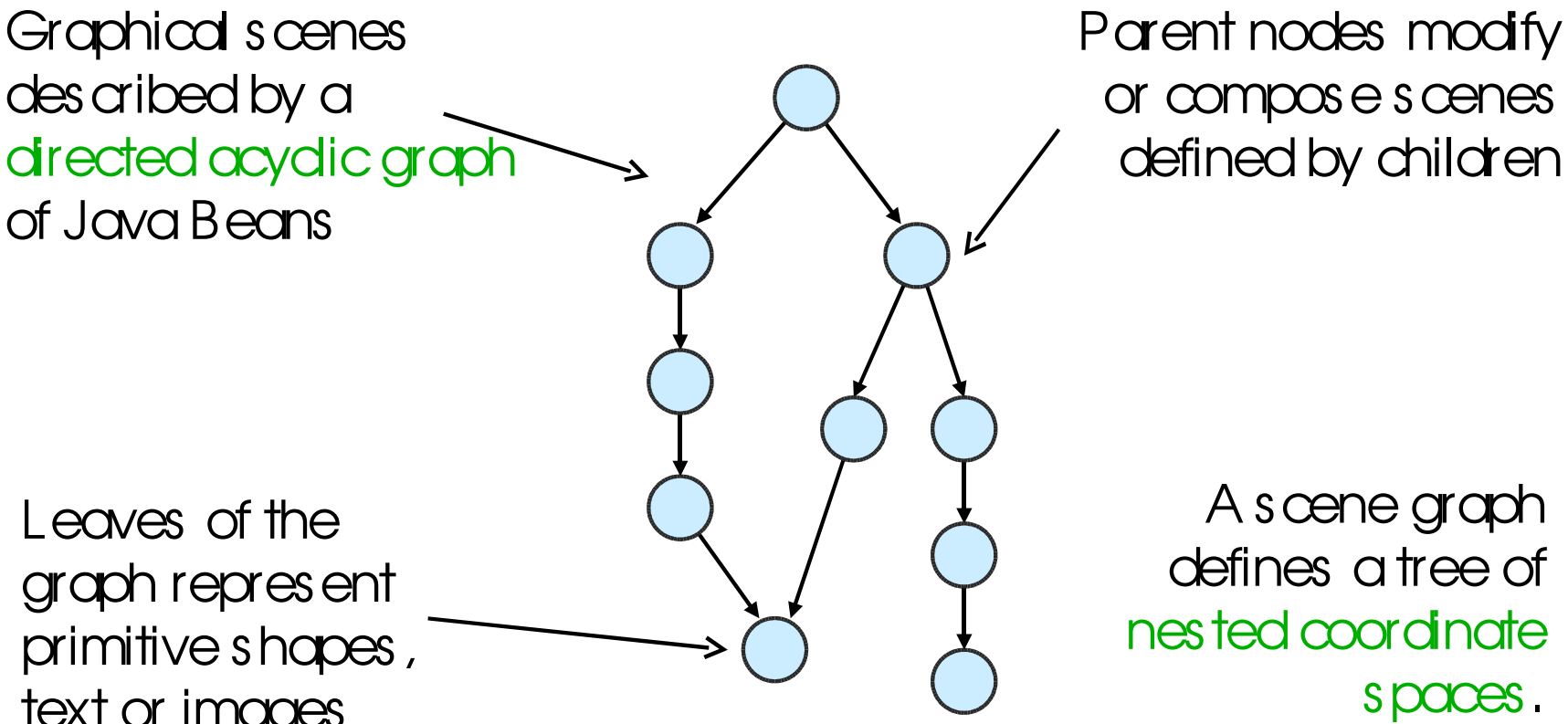
- Offset
  - beginTime
- Parallel
- Pause
  - duration
- Repeat
- Reverse
- Sequential

SceneBeans: General Facts

- This is NOT an official Java standard!
  - Research product from Imperial College, UK
  - http://www-dse.doc.ic.ac.uk/Software/SceneBeans/
- Jeff Magee, Nat Pryce, Dimitra Giannakopoulou, Jeff Kramer: Graphical Animation of Behavior Models**,** International Conference on Software Engineering 2000
  - Animation of formal models of concurrent processes
- Nat Pryce and Jeff Magee: SceneBeans: A Component-Based Animation Framework for Java (at above Web address)
- Software “Animator” interpreting an XML file

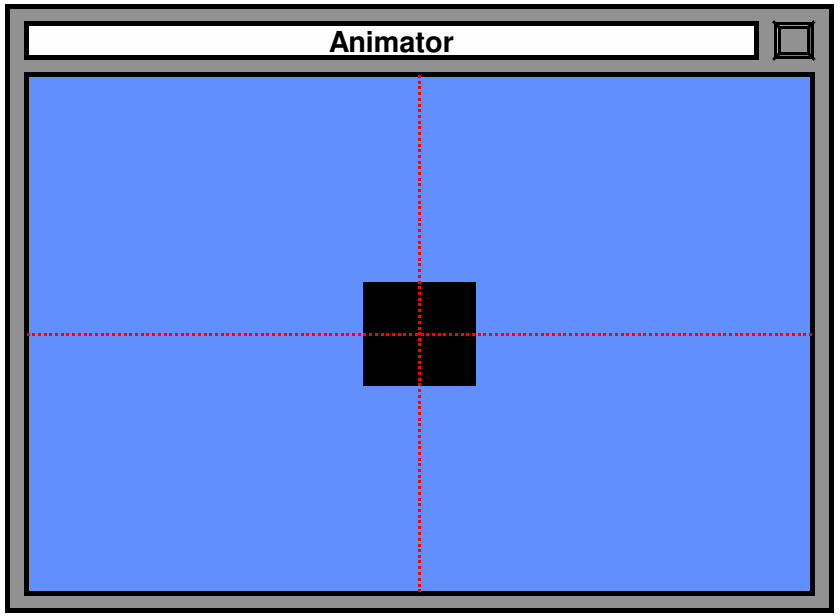
Scene Beans

- SceneBeans defines a graphical display using a "*scene graph*".
  - A Java Bean is a simple software component in Java following naming conventions to enable manipulation in authoring systems.



Material on SceneBeans adapted from Nat Bryce

Example: Spinning Square



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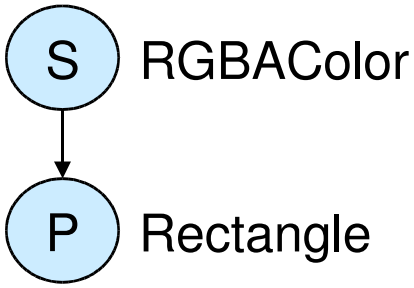

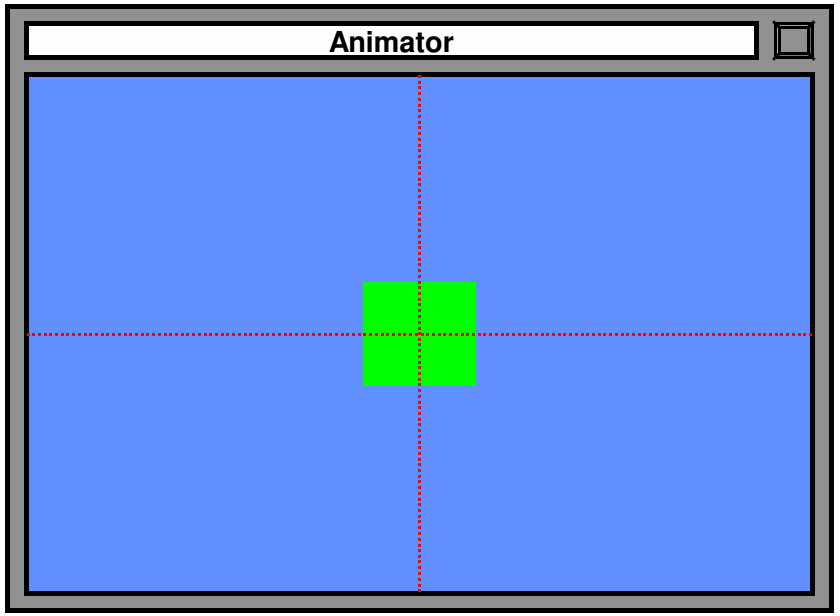

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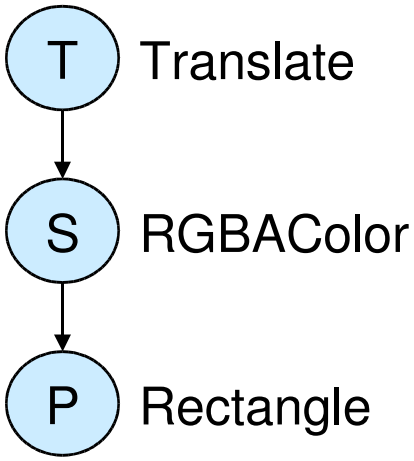

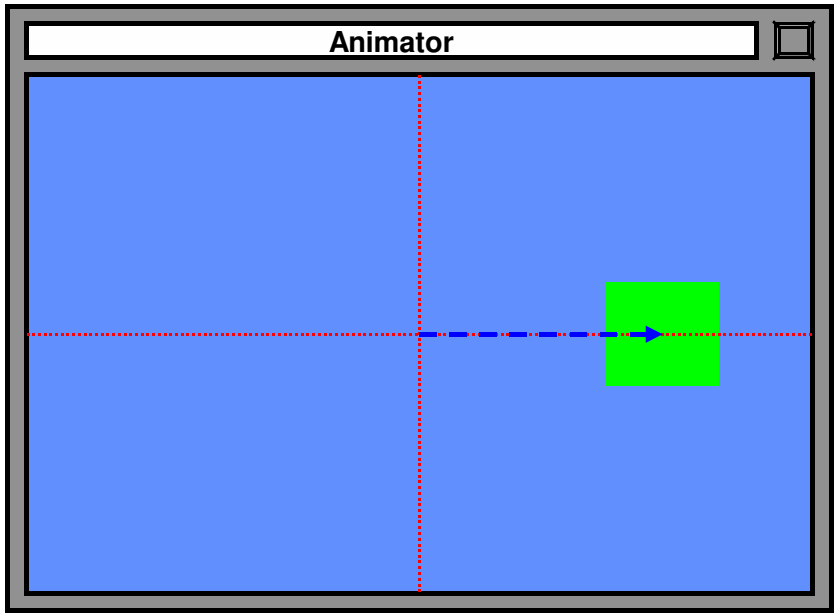

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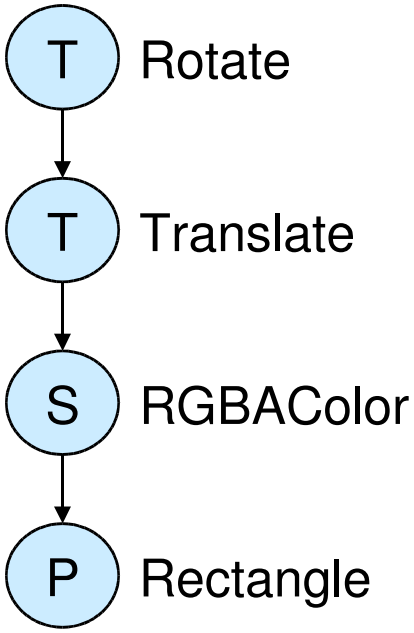
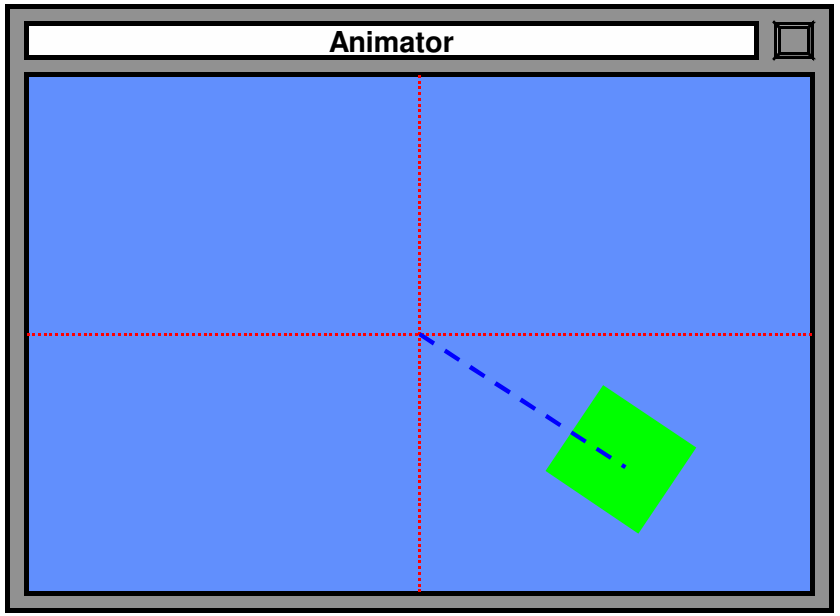
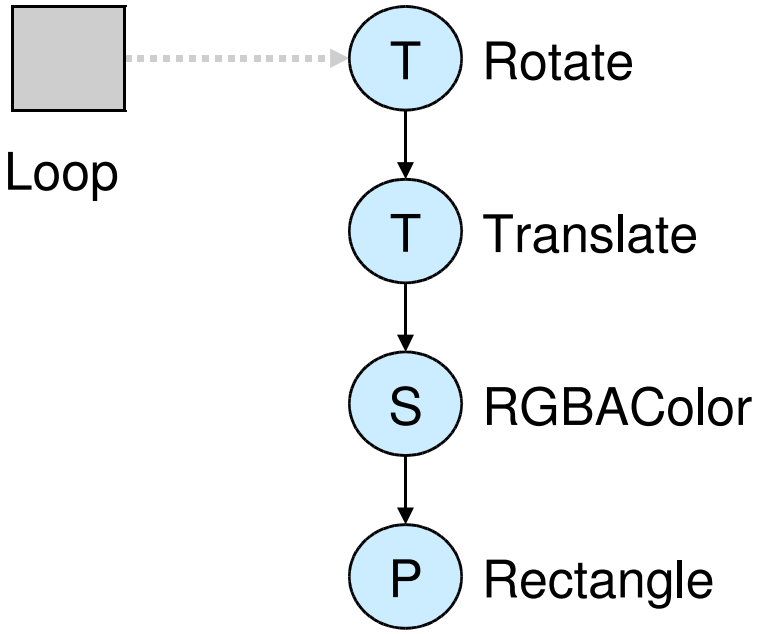
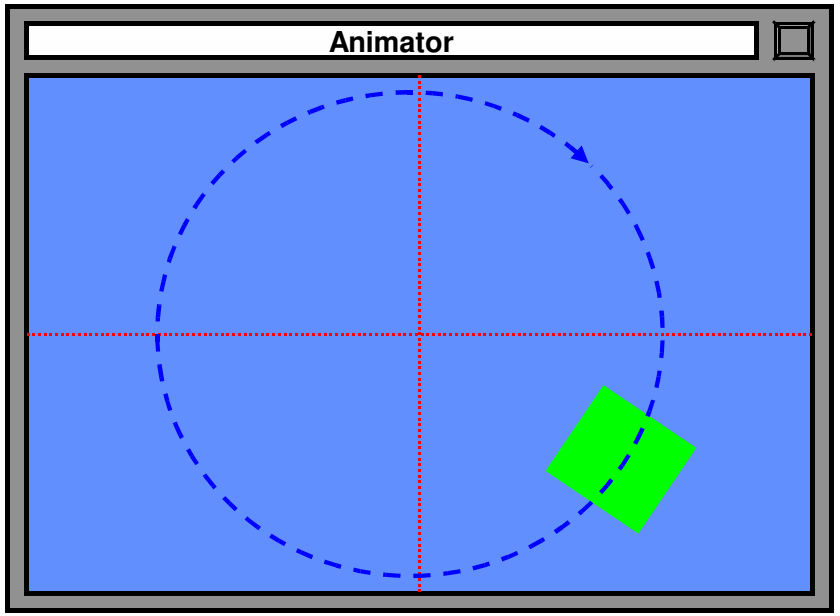


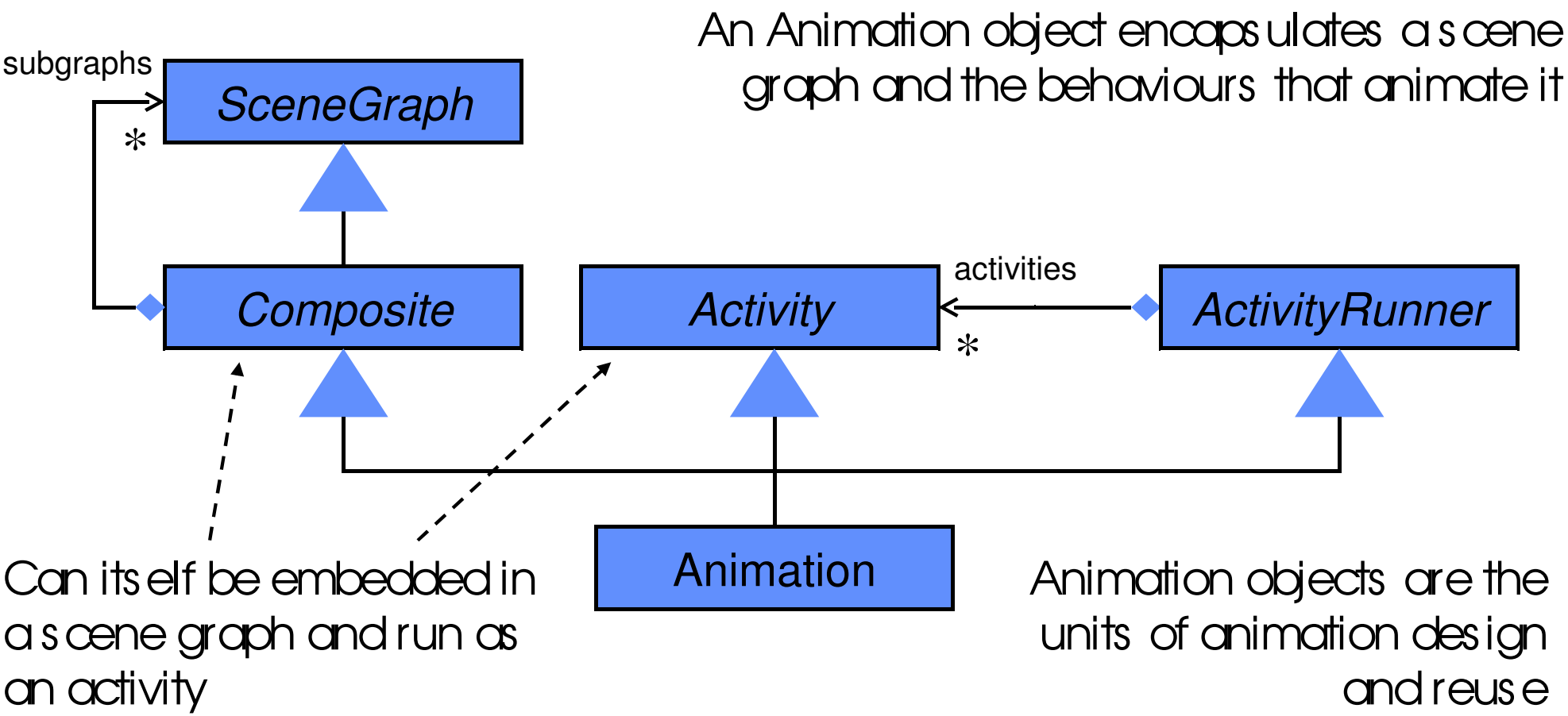


Example: Spinning Square





Composable Animations in SceneBeans



Scene Graph Example (in XML) (1)

```
<?xml version="1.0"?>

<animation width="256" height="256">
  <behaviour id="rotor-spin" algorithm="Loop"
  state="${rotor_state=stopped}">
    <param name="from" value="0.0" />
    <param name="to" value="2*pi" />
    <param name="duration" value="1.0" />
  </behaviour>

  <command name="start">
    <start behaviour="rotor-spin" />
  </command>

  <command name="stop">
    <stop behaviour="rotor-spin" />
  </command>
...
```

Scene Graph Example (in XML) (2)

```
...
  <define id="rotor">
    <primitive type="polygon">
      <param name="pointCount" value="4" />
      <param name="points" index="0" value="(0,0)" />
      <param name="points" index="1" value="(-16,96)" />
      <param name="points" index="2" value="(0,100)" />
      <param name="points" index="3" value="(16,96)" />
    </primitive>
  </define>

  <define id="rotors">
    <style type="RGBAColor">
      <param name="color" value="000000"/>
      <primitive type="circle">
        <param name="radius" value="12" />
      </primitive>
    </style>

    ...
```

Scene Graph Example (in XML) (3)

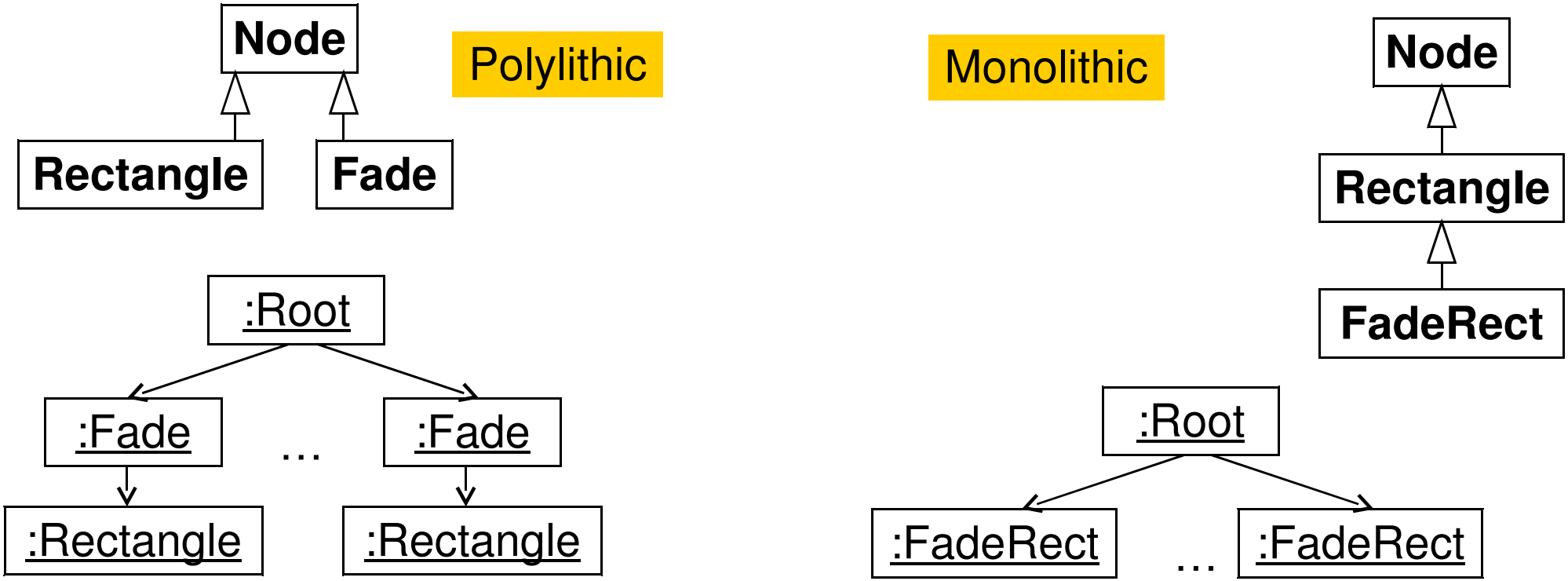
```
...
    <transform type="rotate">
      <param name="angle" value="1.0" />
      <animate param="angle" behaviour="rotor-spin" />
        ...
        <transform type="rotate">
          <param name="angle" value="2*pi/3" />
          <paste object="rotor" />
        </transform>

        <transform type="rotate">
          <param name="angle" value="4*pi/3" />
          <paste object="rotor" />
        </transform>
      </style>
    </transform>
  </define>

  <draw>
    <paste object="rotors" /> ……
```

University of Maryland “Piccolo” Framework

- “A revolutionary way to create robust, full-featured *graphical applications* in Java and C#, with striking visual effects such as *zooming, animation* and *multiple representations*.”
  - Piccolo is a layer built on top of a lower level graphics API.
  - Piccolo.Java is written in 100% java, and is based on the Java2D API.
  - Piccolo uses a "scenegraph" model, this means that Piccolo keeps a hierarchical structure of objects and cameras.
- “History”:
  - Ken Perlin, New York University: “Pad” zoomable interface
  - Ben Bederson, Jim Hollan, Bellcore: “Pad++”
  - Ben Bederson et al, UMD: Jazz
    - » Many objects
  - Ben Bederson, Jesse Grosjean, UMD: Piccolo
- Also NOT an official Java standard but in widespread use

Monolithic and Polylithic Class Hierarchies

- *Monolithic:* Primarily uses compile-time *inheritance* to structure and extend functionality
- *Polylithic:* Primarily uses run-time *composition* to structure and extend functionality
  - More flexible, but creation of MANY objects



Piccolo Terminology

- ***PNode:*** Any object that wants to paint itself on the screen should inherit from the node class. In addition to painting on the screen all nodes may have other "child" nodes added to them.
- ***PCamera:*** Cameras are nodes that have an additional view transform and a collection of layers.
- ***PLayer:*** Layer nodes are nodes that can be viewed by one or more cameras. They maintain a list of the cameras that are viewing them, and notify these cameras when they are repainted.
- ***PRoot:*** The ***PRoot*** serves as the topmost node in the Piccolo runtime structure.
- ***PCanvas:*** The ***PCanvas*** views the scene graph through a ***PCamera***. It forwards input events to that camera, and uses that camera to draw itself.

Activities in Piccolo

- Activities control some time-dependent aspect of the Piccolo system, usually some part of a node.
- This behavior may be of fixed duration or may continue until some termination condition is met (or perhaps forever).
- Activities are scheduled by the ***PRoot*** until they have completed.
- Each activity has a start time and a duration, that together determine when an activity starts stepping and how long it continues to step.
  - **PActivity public PActivity (long aDuration, long aStepRate,long aStartTime)**
  - ***aDuration:*** –1 for infinite
  - ***aStepRate:*** the maximum rate that this activity should receive step events
  - ***aStartTime***: the time (relative to System.currentTimeMillis()) that this activity should start
- **protected void activityStep(long elapsedTime)**
  - Execution of activity

Example: Animation in Piccolo (1)

```
package edu.umd.cs.piccolo.tutorial;

import java.awt.Color;

import edu.umd.cs.piccolo.*;
import edu.umd.cs.piccolo.activities.*;
import edu.umd.cs.piccolo.nodes.*;
import edu.umd.cs.piccolox.*;

public class EffectsFrame extends PFrame {
  public void initialize() {
      // Create the Target for our Activities.

      // Create a new node that we will apply different
      // activities to, place that node at location 200, 200.
      final PNode aNode =
            PPath.createRectangle(0, 0, 100, 80);
      PLayer layer = getCanvas().getLayer();
      layer.addChild(aNode);
      aNode.setOffset(200, 200);
...
```

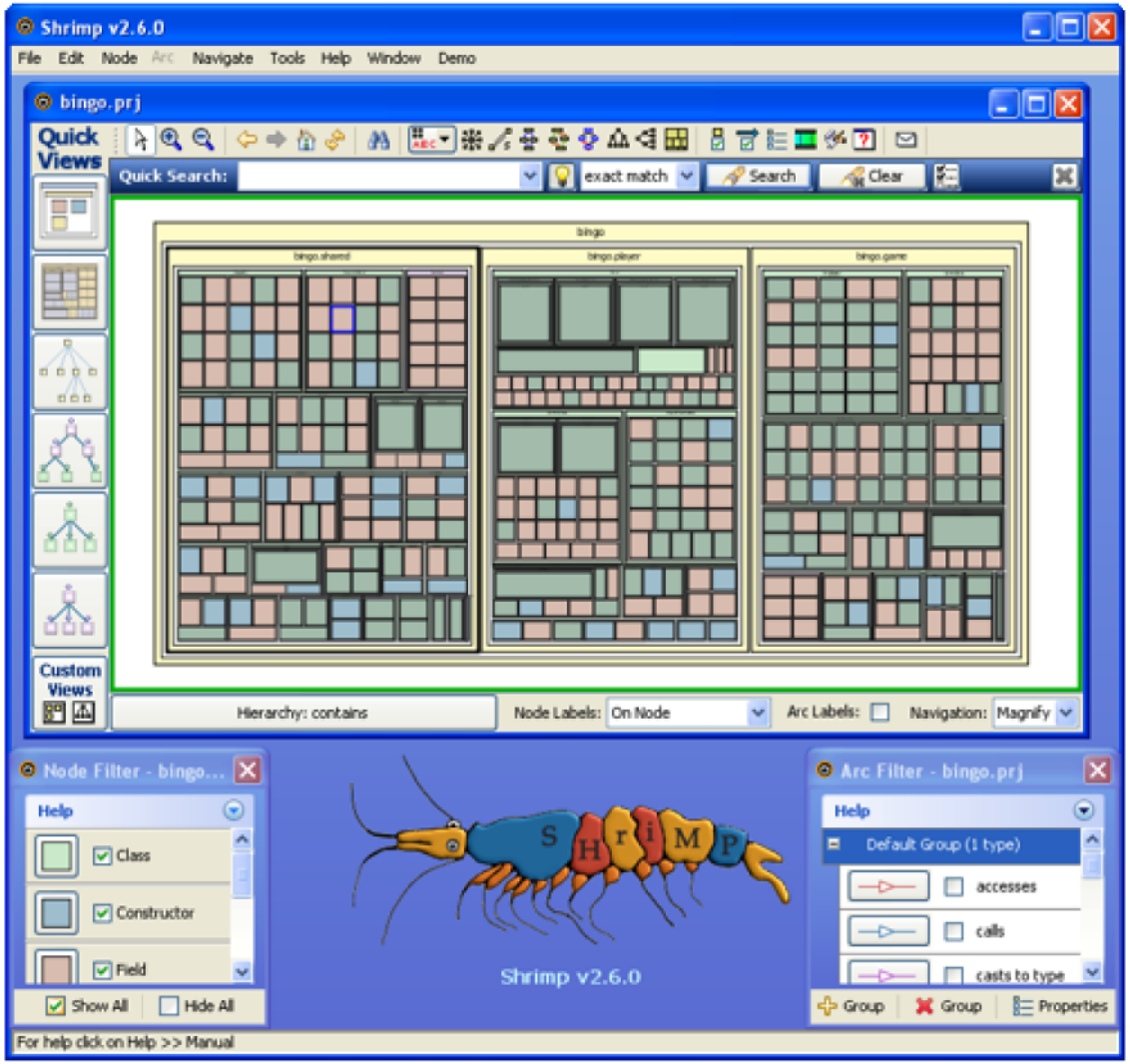
Example: Animation in Piccolo (2)

```
…     // Extend PActivity.
      // Store the current time in milliseconds for use below.
      long currentTime = System.currentTimeMillis();

      // Create a new custom "flash" activity.
      PActivity flash =
                  new PActivity(-1, 500, currentTime + 5000) {
            boolean fRed = true;

            protected void activityStep(long elapsedTime) {
                  super.activityStep(elapsedTime);
                  if (fRed) {
                        aNode.setPaint(Color.red);
                  } else {
                        aNode.setPaint(Color.green);
                  }

                  fRed = !fRed;
            }
      };
 …
```

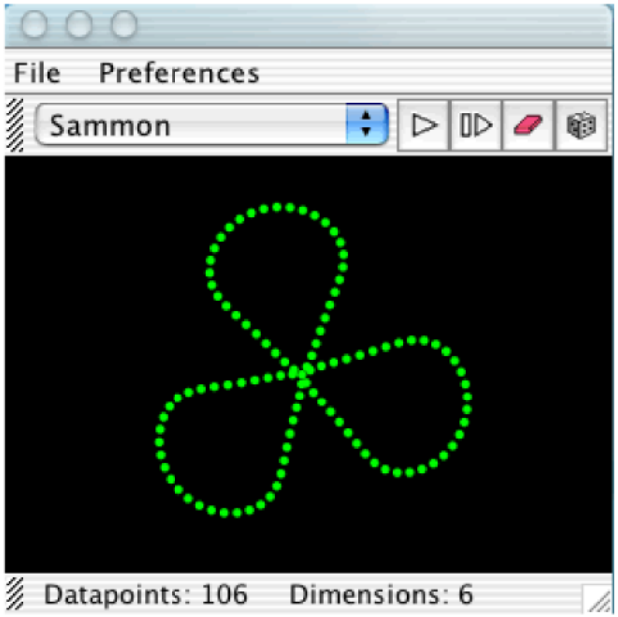
Example: Animation in Piccolo (3)

```
        getCanvas().getRoot().addActivity(flash);
                                              // Schedule it

        PActivity a1 =
          aNode.animateToPositionScaleRotation
              (0, 0, 0.5, 0, 5000);
        PActivity a2 =
          aNode.animateToPositionScaleRotation
              (100, 0, 1.5, Math.toRadians(110), 5000);
        PActivity a3 =
          aNode.animateToPositionScaleRotation
    `         (200, 100, 1, 0, 5000);

        a1.setStartTime(currentTime);          // Schedule it
        a2.startAfter(a1);                     // Schedule it
        a3.startAfter(a2);                     // Schedule it

    public static void main(String[] args) {
        new EffectsFrame();
    }
}
```

Example Applications Realized with Piccolo (1)

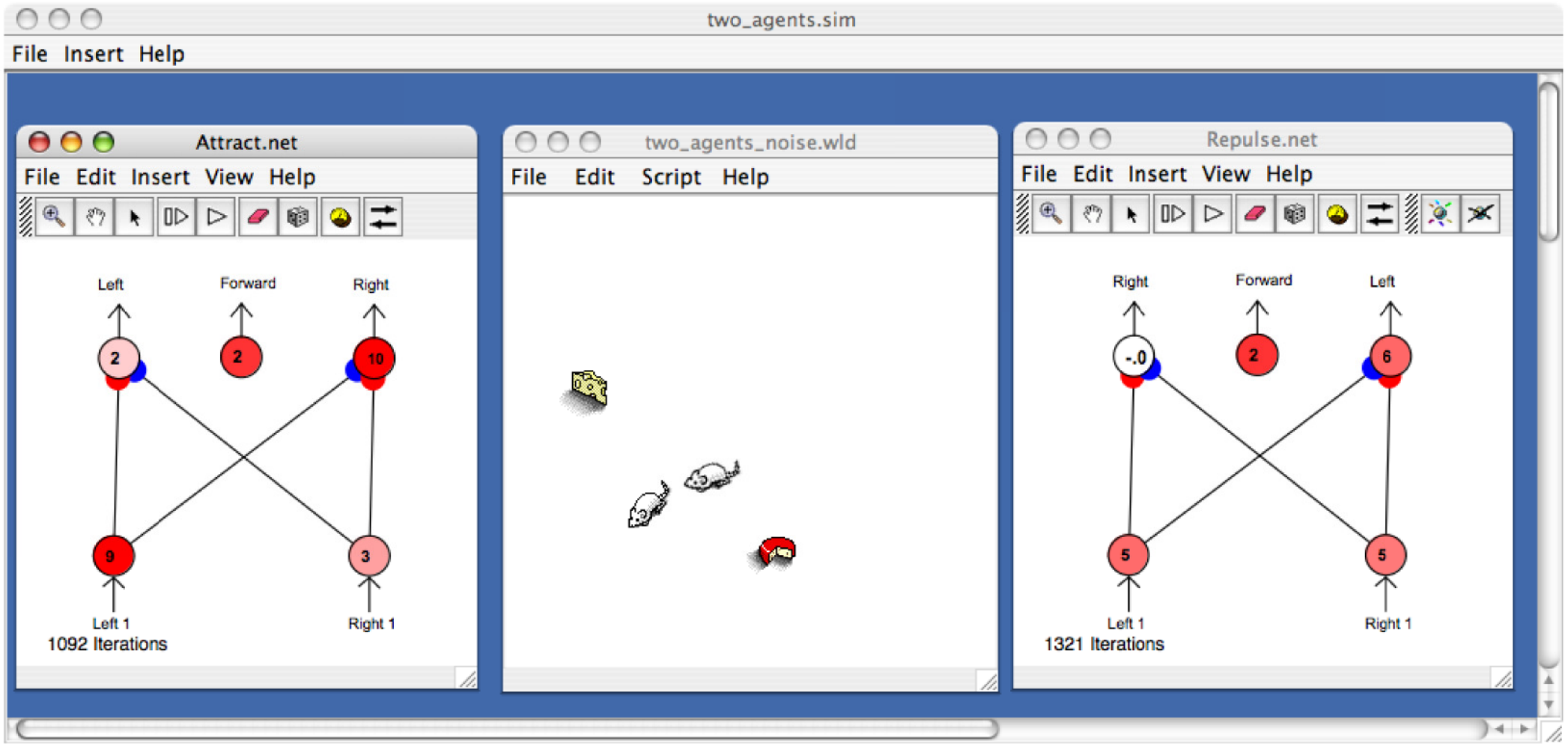


Shrimp: Multiperspective Visualization



HiSee: Visualization
of multi-dimensional data

Example Applications Realized with Piccolo (2)



SimBrain: Neural network simulation (using also HiSee)