4 Overview on Approaches to Multimedia Programming

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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

Java 2D
- Still 2D images
  - vector graphics
  - sampled
- Moving 2D images
  - vector graphics

Java Sound
- Sound
  - MIDI
  - sampled

Java 3D
- 3D Scenes

Java Media Framework
- Media types
  - includes

Playback
Create
Process
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
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Literature:
Vector Animation Framework

Media types
- Still 2D images
  - vector graphics
  - sampled
- Moving 2D images
  - vector graphics
  - sampled
- Sound
  - sampled
  - MIDI
- 3D Scenes

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, SceneBeans, Piccolo

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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)

```java
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:

```java
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`

```java
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/

  – 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.

![Scene Graph Diagram](image)

Material on SceneBeans adapted from Nat Bryce
Example: Spinning Square

P Rectangle
Example: Spinning Square

S

RGBAColor

P

Rectangle
Example: Spinning Square

```
T  Translate
S  RGBAColor
P  Rectangle
```
Example: Spinning Square
Example: Spinning Square

Loop

- **T** Rotate
- **T** Translate
- **S** RGBAColor
- **P** Rectangle

Diagram showing a spinning square animation.
Composable Animations in SceneBeans

An Animation object encapsulates a scene graph and the behaviours that animate it.

- **SceneGraph**: Can itself be embedded in a scene graph and run as an activity.
- **Composite**: Activities
- **Activity**: Animation objects are the units of animation design and reuse.
- **ActivityRunner**
- **Animation**

Additional note:

- **Subgraphs**: An Animation object encapsulates a scene graph and the behaviours that animate it.
Scene Graph Example (in XML) (1)

```xml
<?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>
</define>

...
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>
</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)

```java
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)

```java
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)