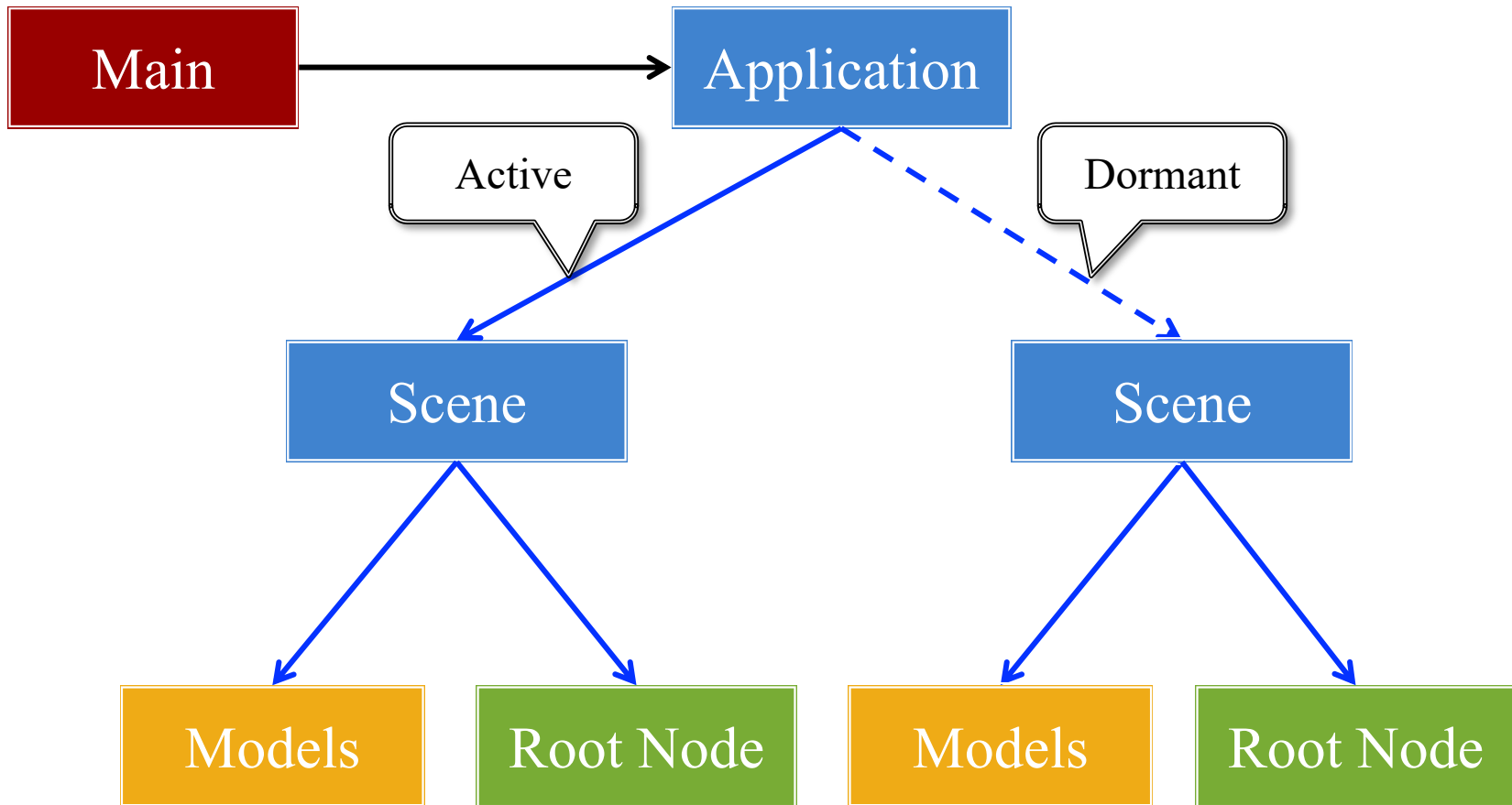


Lecture 6

Scene Graphs

Recall: Structure of a CUGL Application



Recall: The Application Class

onStartup()

- Handles the game assets
 - Attaches the asset loaders
 - Loads immediate assets
- Starts any global singletons
 - **Example:** AudioChannels
- Creates any player modes
 - But does not launch *yet*
 - Waits for assets to load
 - Like [GDXRroot](#) in 3152

update()

- Called each animation frame
- Manages gameplay
 - Converts input to actions
 - Processes NPC behavior
 - Resolves physics
 - Resolves other interactions
- Updates the scene graph
 - Transforms nodes
 - Enables/disables nodes

Recall: The Application Class

onStartup()

- Handles the game assets
 - Attaches the asset loaders
 - Loads immediate assets
- Sets up the scene graph
 - Sets up the scene graph
- Cleans up
 - Cleans up
- Checks for any player modes
 - But does not launch *yet*
 - Waits for assets to load
 - Like `GDXRoot` in 3152

onShutdown()
cleans this up

update()

- Called each animation frame
- Manages gameplay
 - Converts input to actions
 - Responds to user input
 - Responds to other interactions
- Updates the scene graph
 - Transforms nodes
 - Enables/disables nodes

Does not draw!
Handled separately

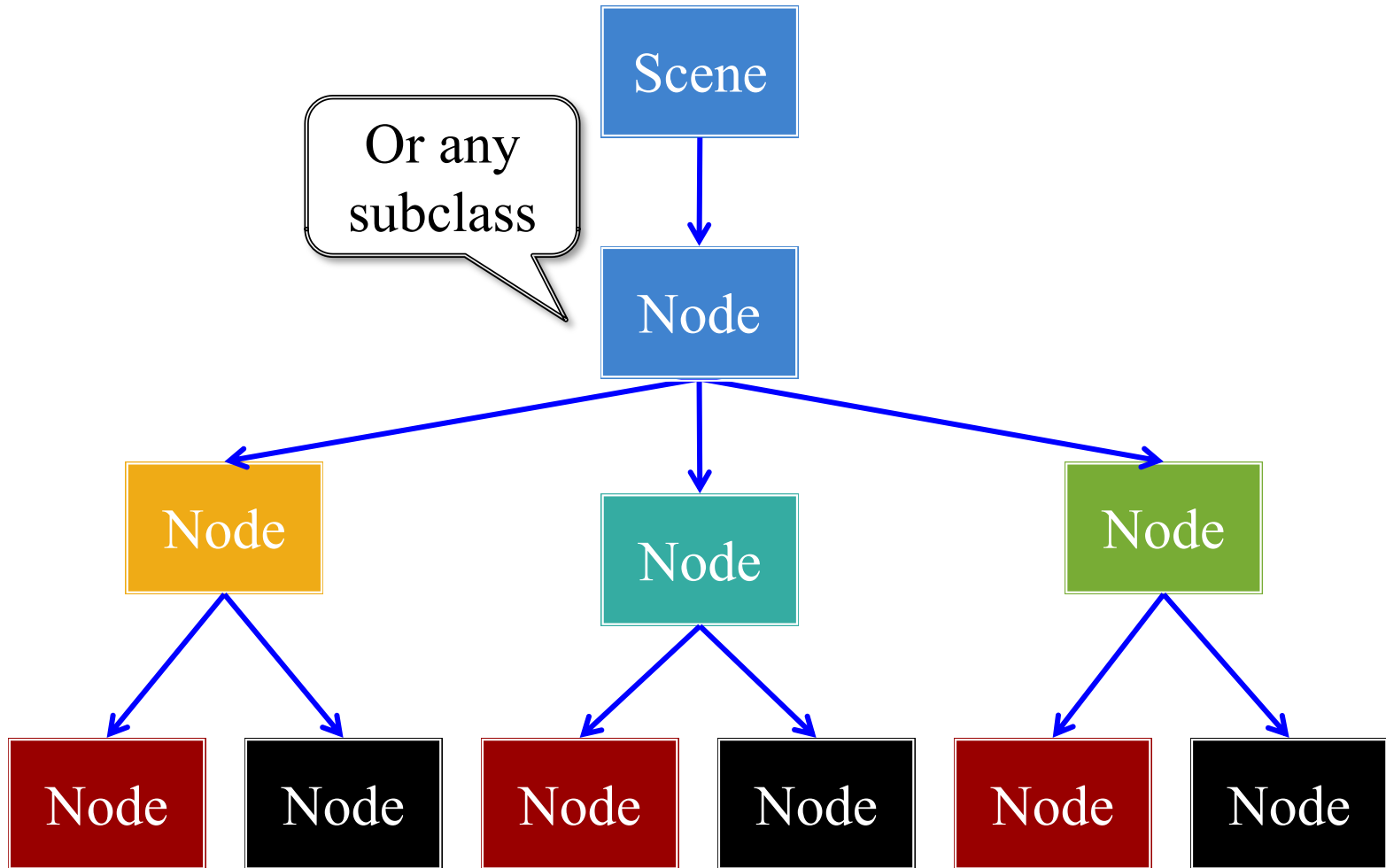
Drawing in CUGL

- Use `render()` method
 - Called after `update()`
 - Clears screen first
 - Uses clear color field
- Can use any OpenGL
 - Included in `CUBase.h`
 - Best to use OpenGL ES (subset of OpenGL)
- Or use a `SpriteBatch`
 - *Mostly* like in 3152

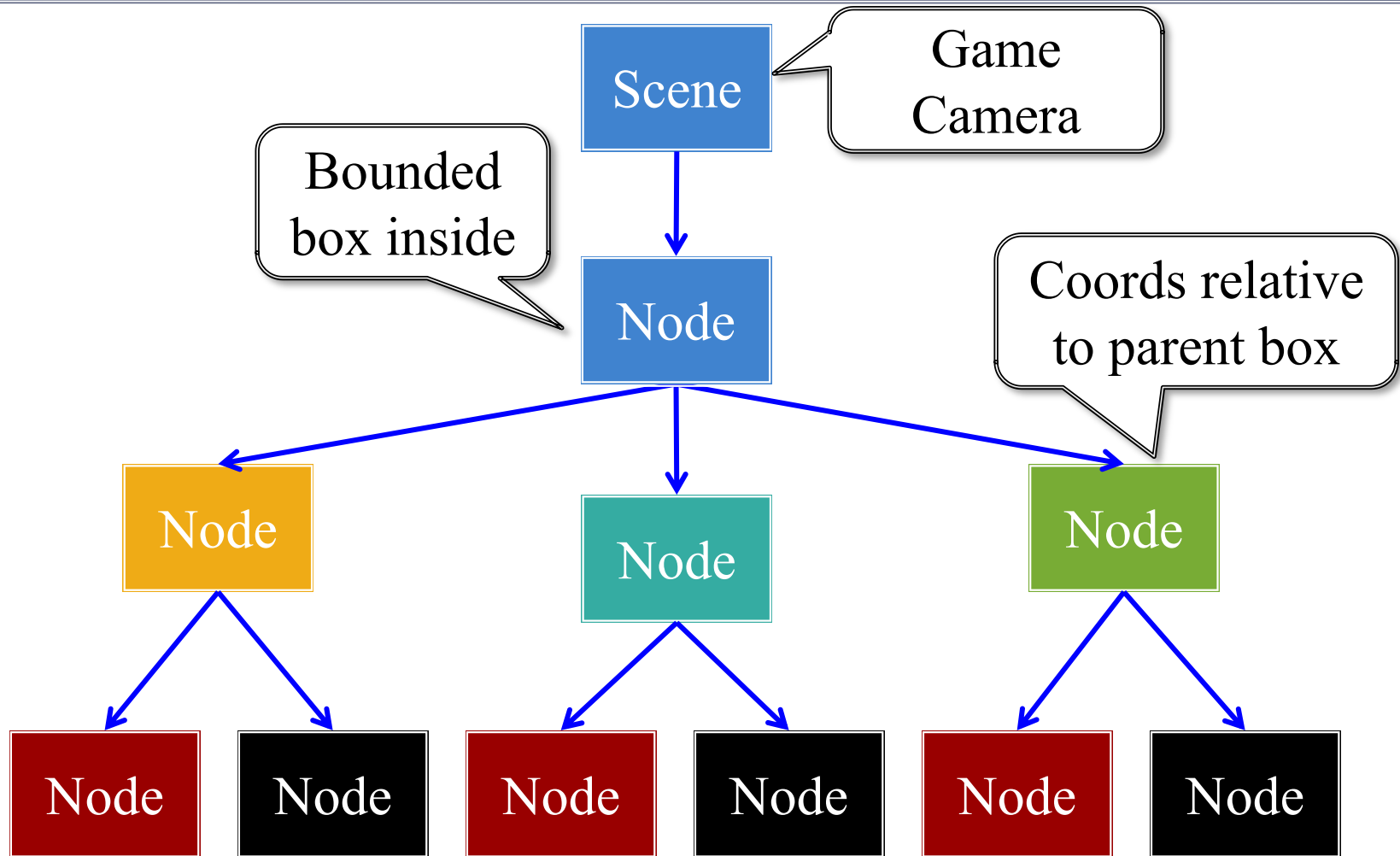
```
void render(const sh_ptr<SpriteBatch>& batch)
{
    glEnableVertexAttribArray(0);
    glBindBuffer(GL_ARRAY_BUFFER,
                 vertexbuffer);
    glVertexAttribPointer(0, 3, GL_FLOAT,
                          GL_FALSE, 0, (void*)0 );
    glDrawArrays(GL_TRIANGLES, 0, 3);
    glDisableVertexAttribArray(0);
}
```

```
void render(const sh_ptr<SpriteBatch>& batch)
{
    batch->begin();
    batch->draw(image1, Vec2(10,10));
    batch->draw(image2, Vec2(50,20));
    batch->end();
}
```

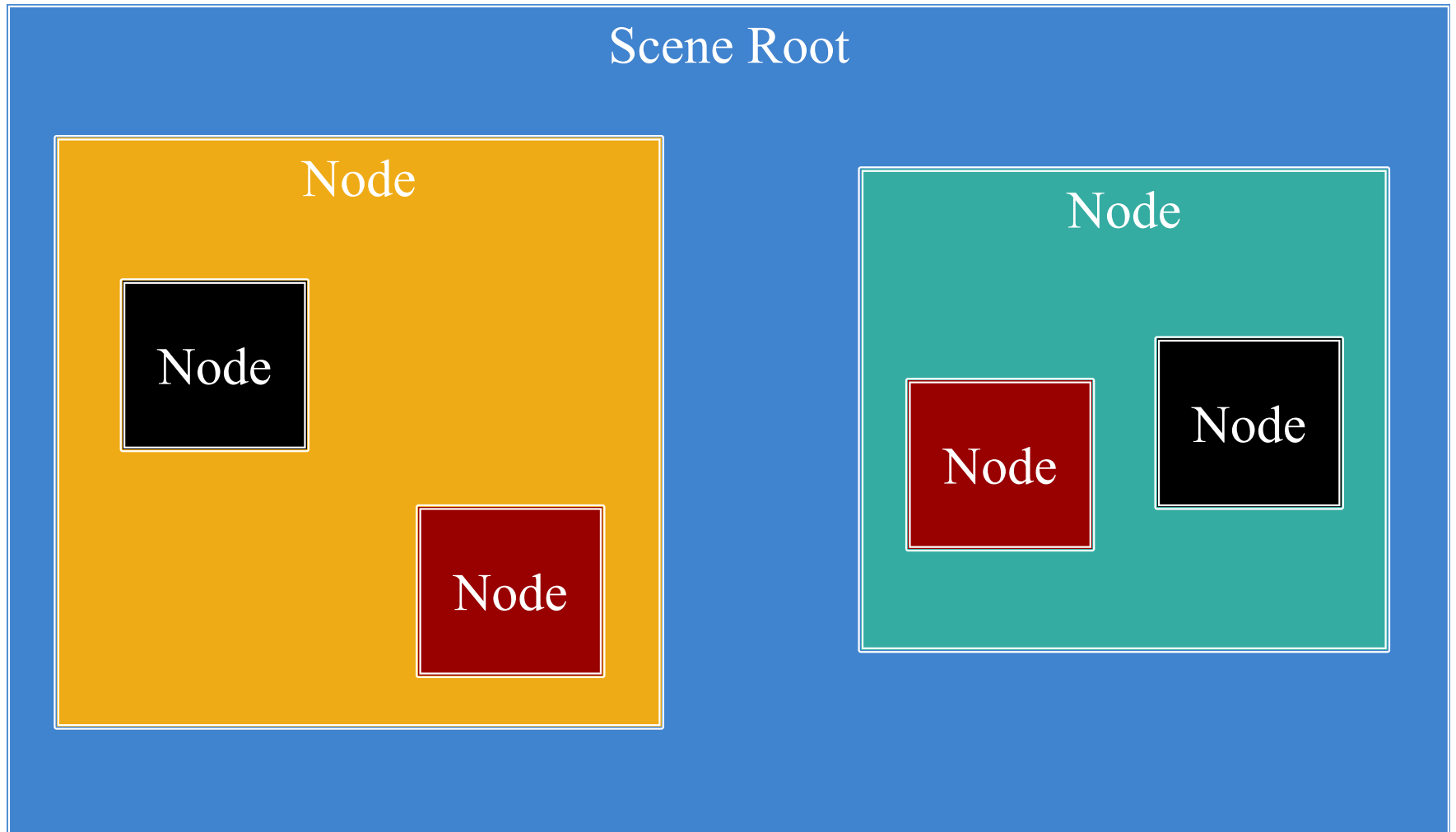
The Scene Graph



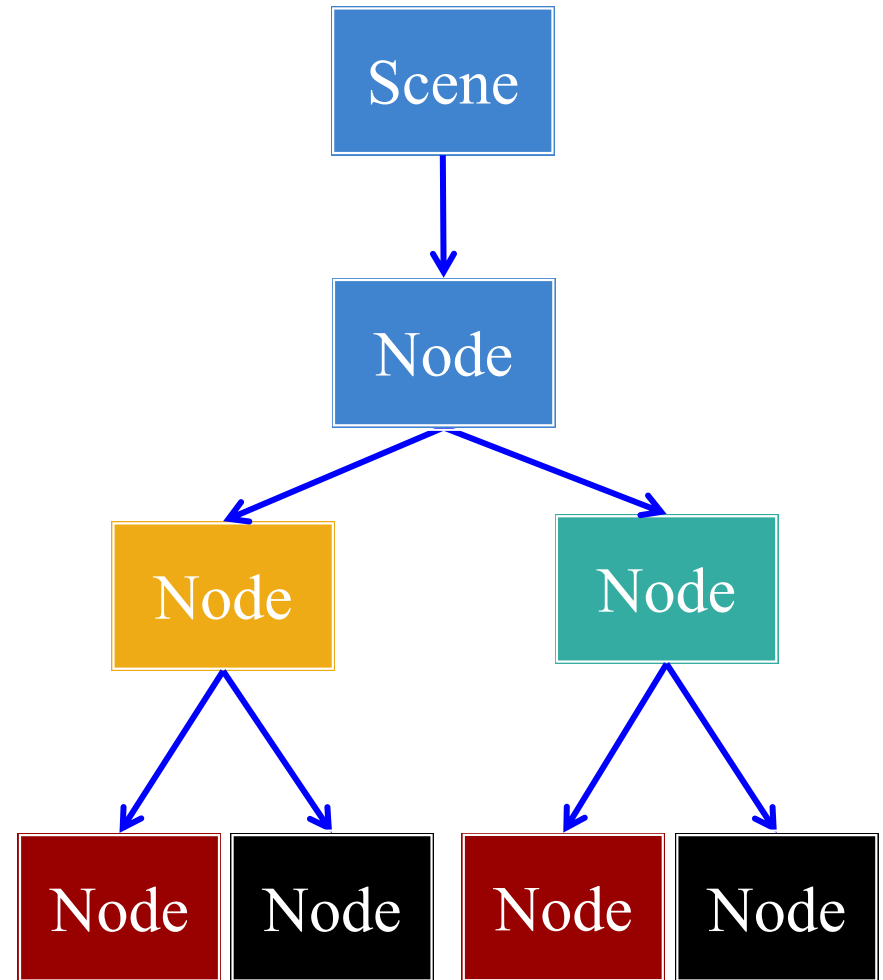
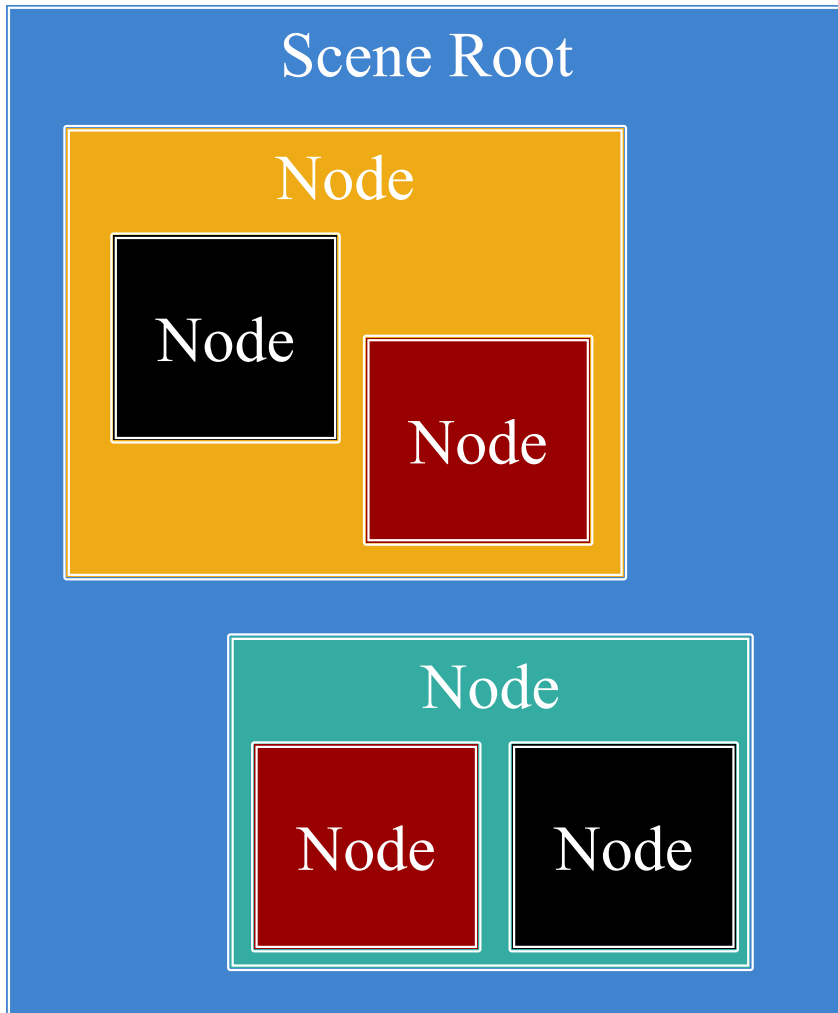
The Scene Graph



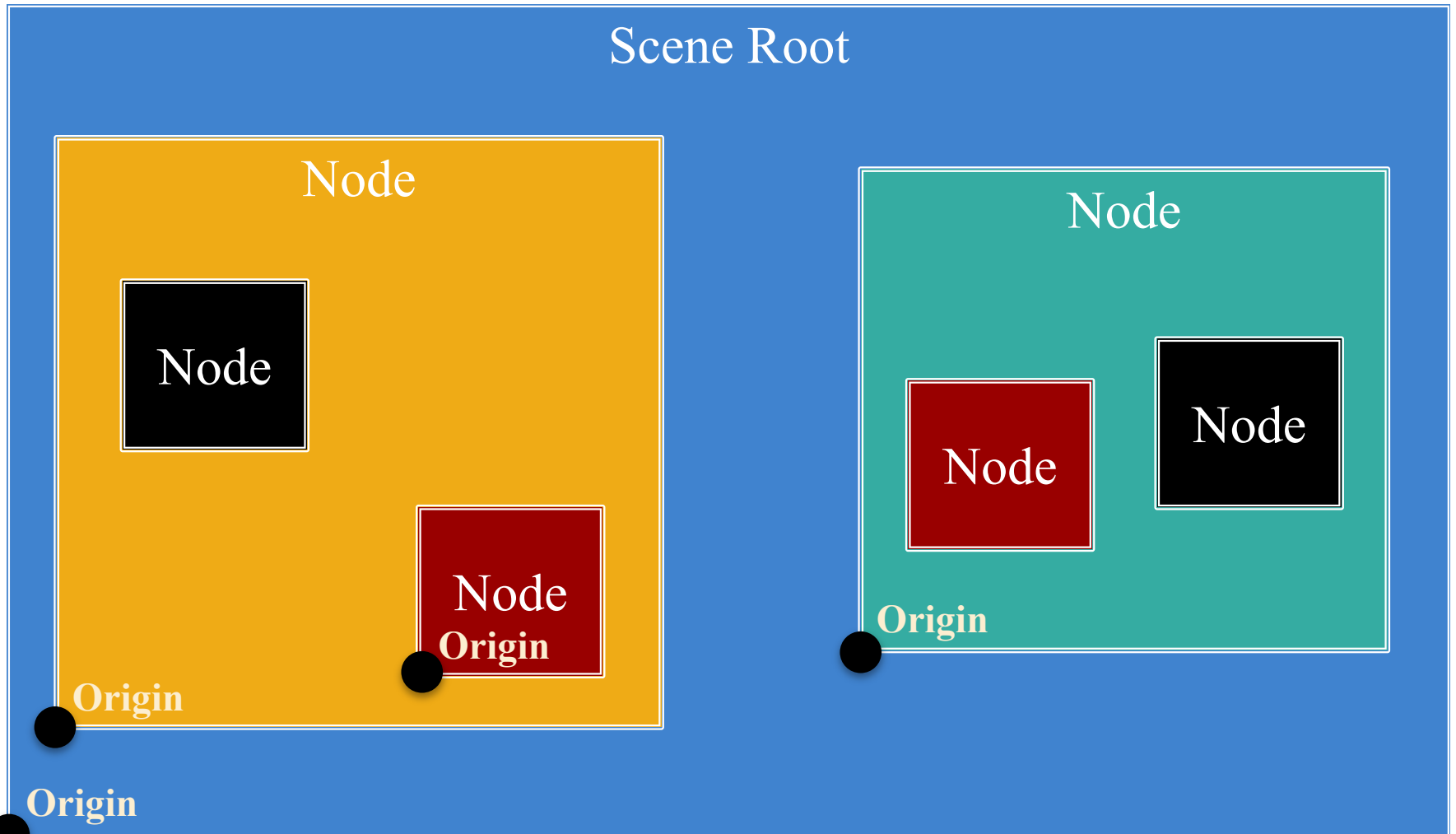
Each Node is a Coordinate System



Each Node is a Coordinate System

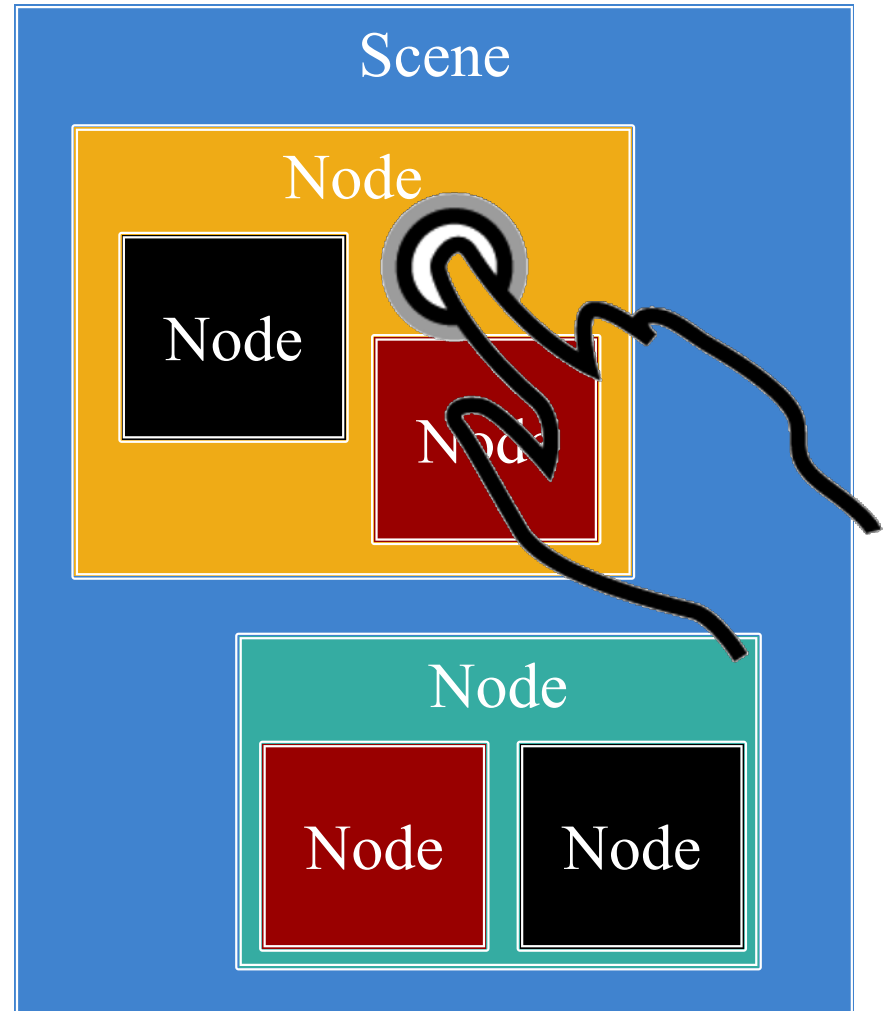


Each Node is a Coordinate System



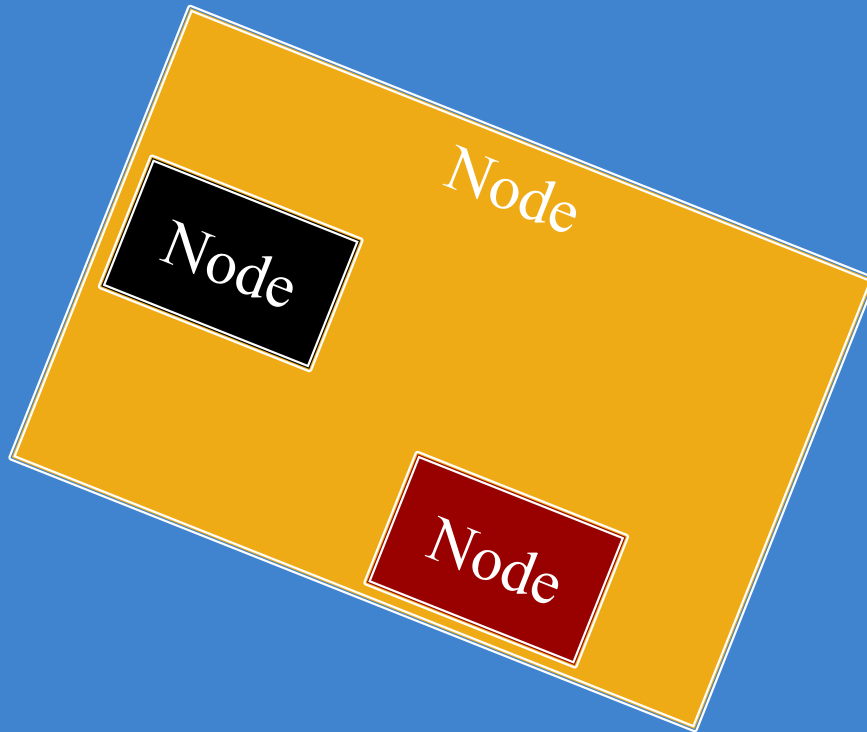
Motivation: Touch Interfaces

- Touch handler requires
 - Which object touched
 - Location inside object
- Scene graph is a *search tree*
 - Check if touch is in parent
 - ... then check each child
 - Faster than linear search
- But limit this to a **search**
 - No input control in node
 - Use polling over callbacks



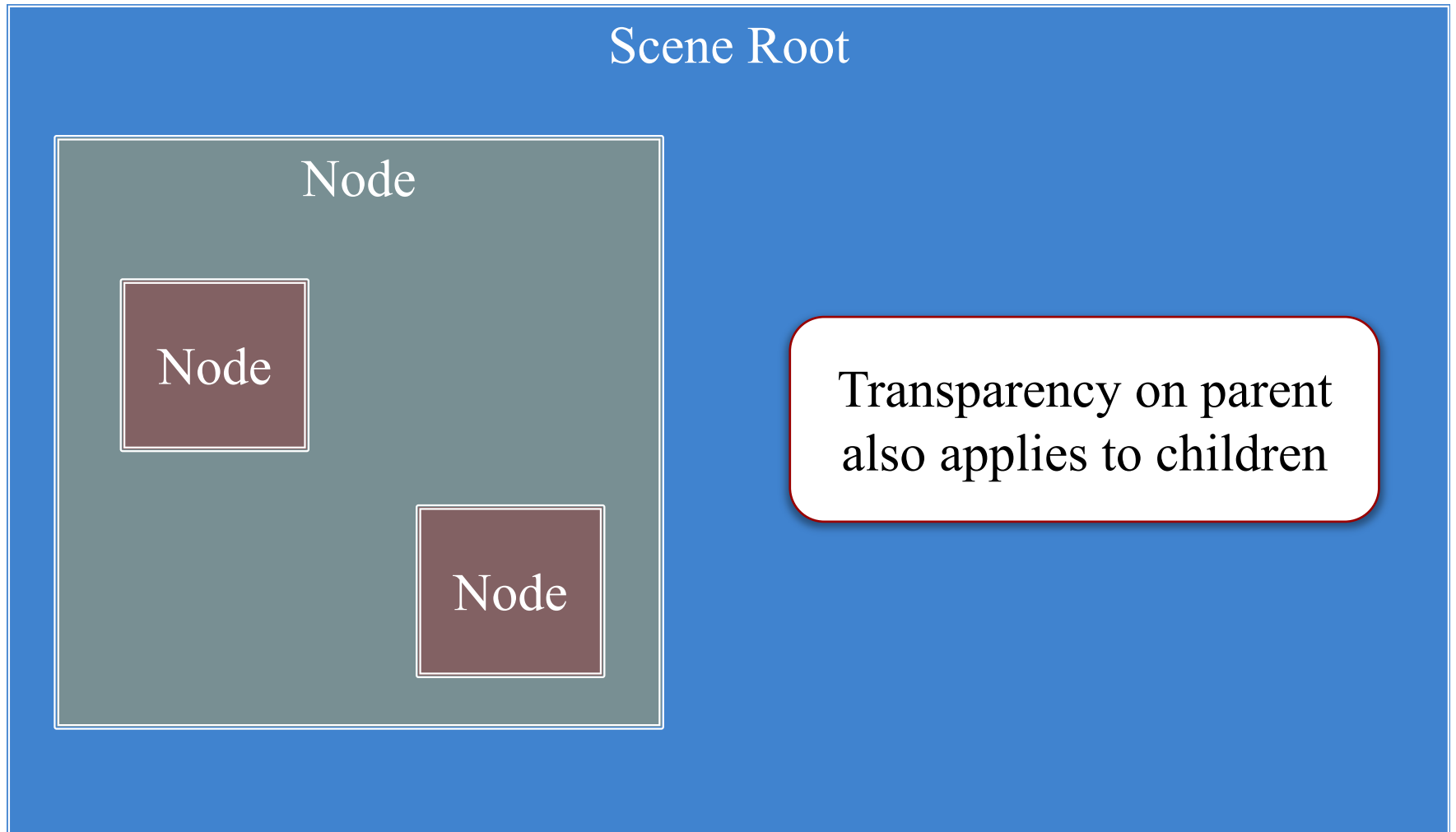
Settings Pass Down the Graph

Scene Root

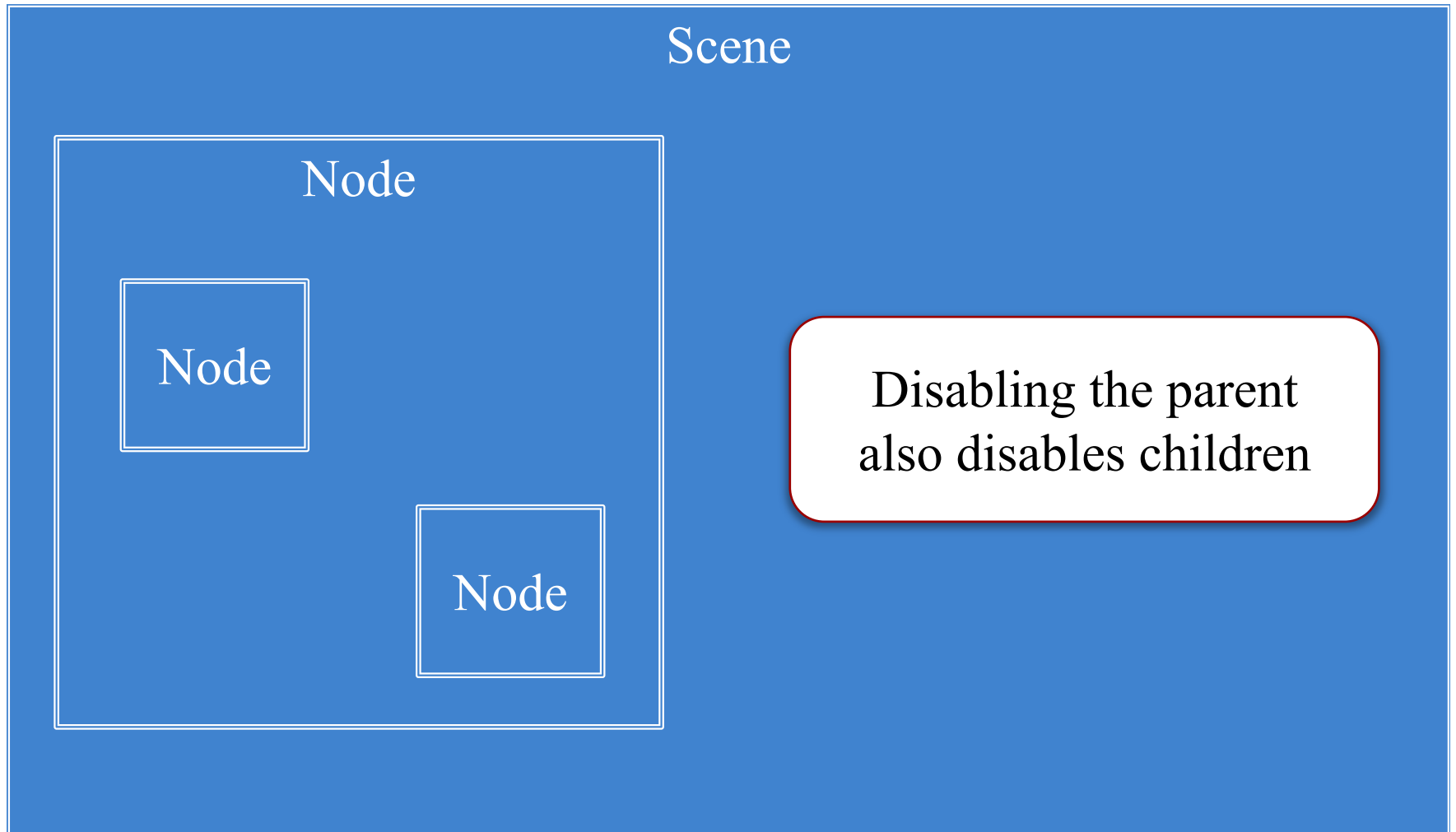


Transforms on parent
also transform children

Settings Pass Down the Graph

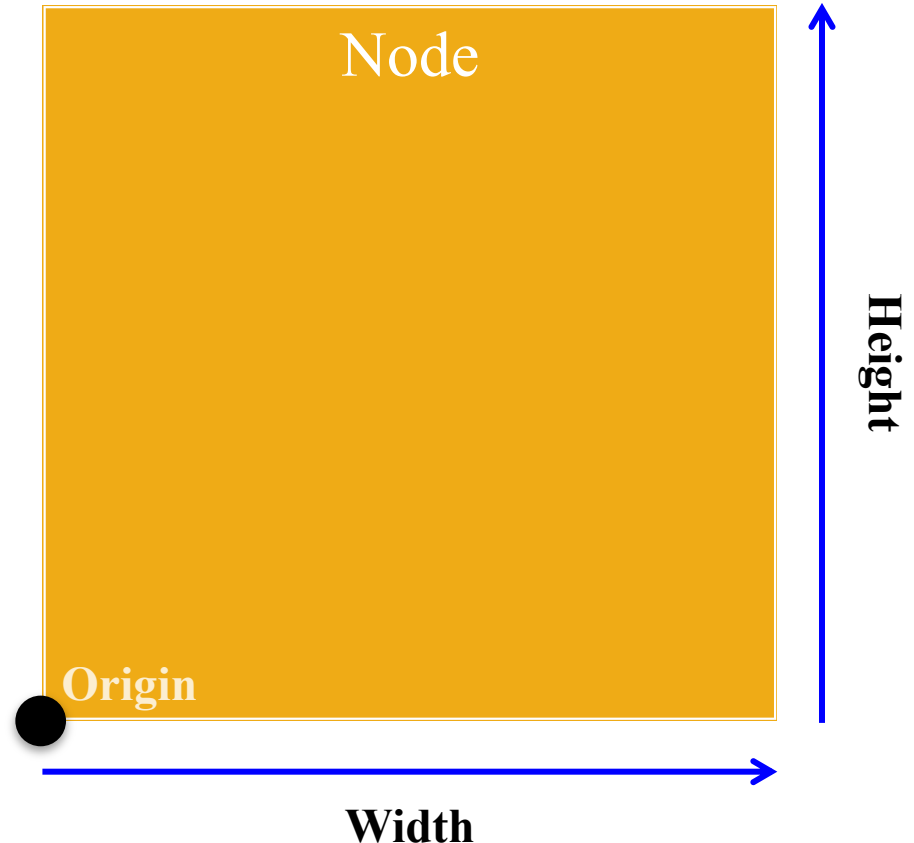


Settings Pass Down the Graph



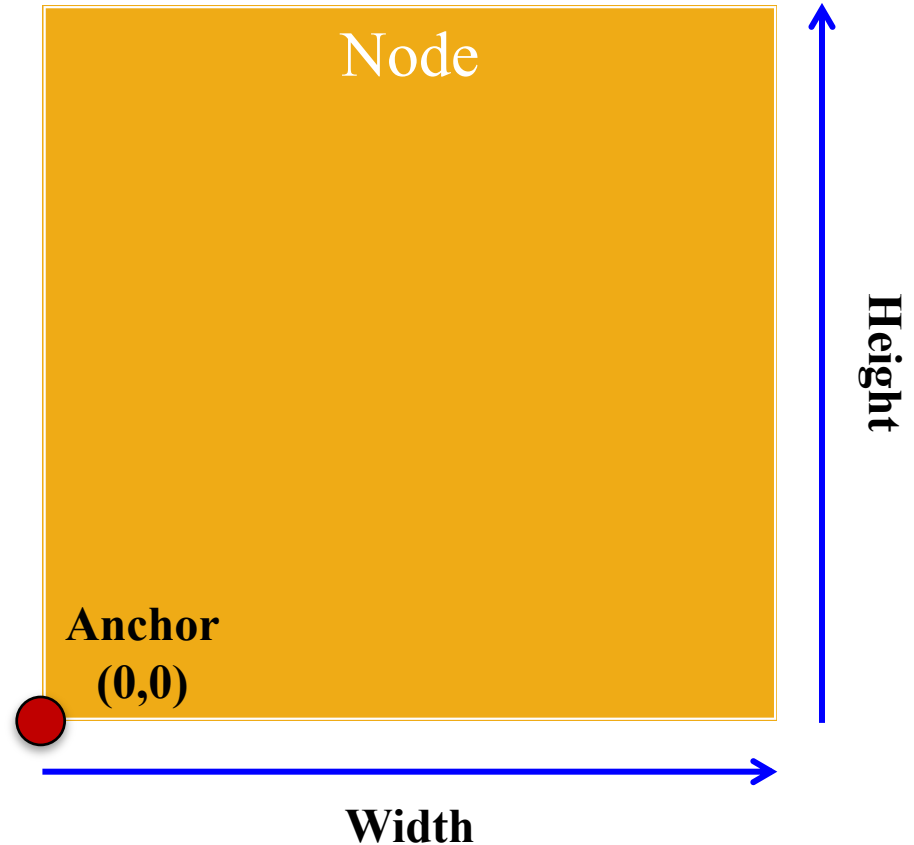
Anchors and Content

- Nodes have **content size**
 - Width/height of contents
 - Measured in node space
 - But only a guideline: content can be outside
- Nodes have an **anchor**
 - Location in node space
 - *Percentage* of width/height
 - Does not affect the origin
- Both may affect **position**



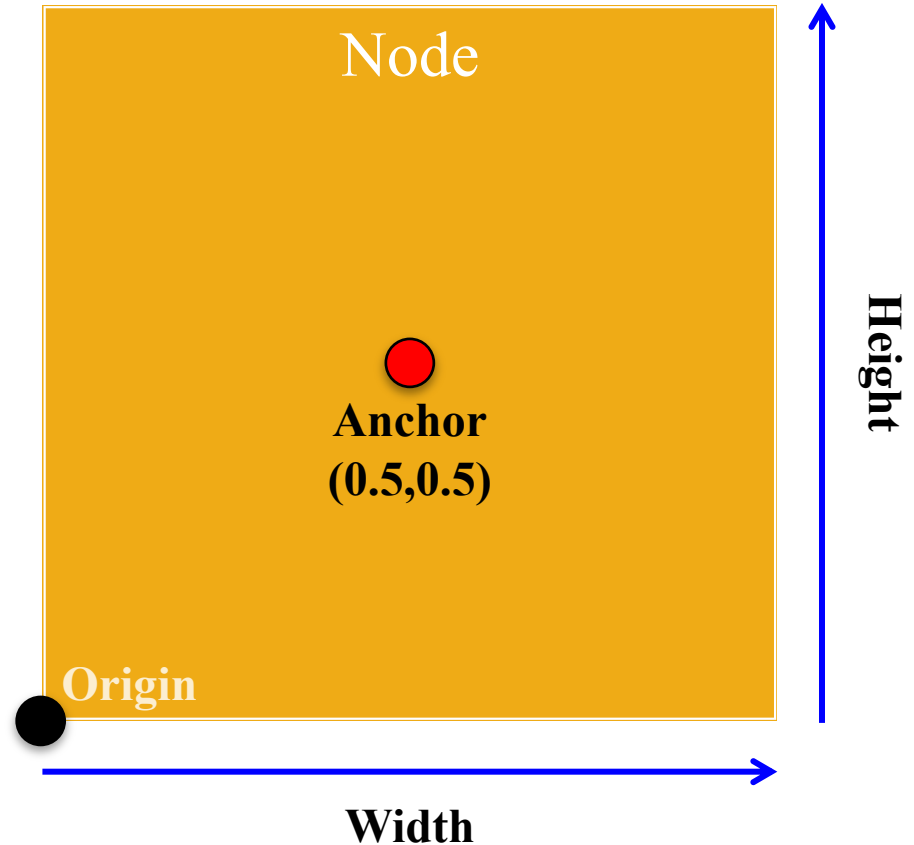
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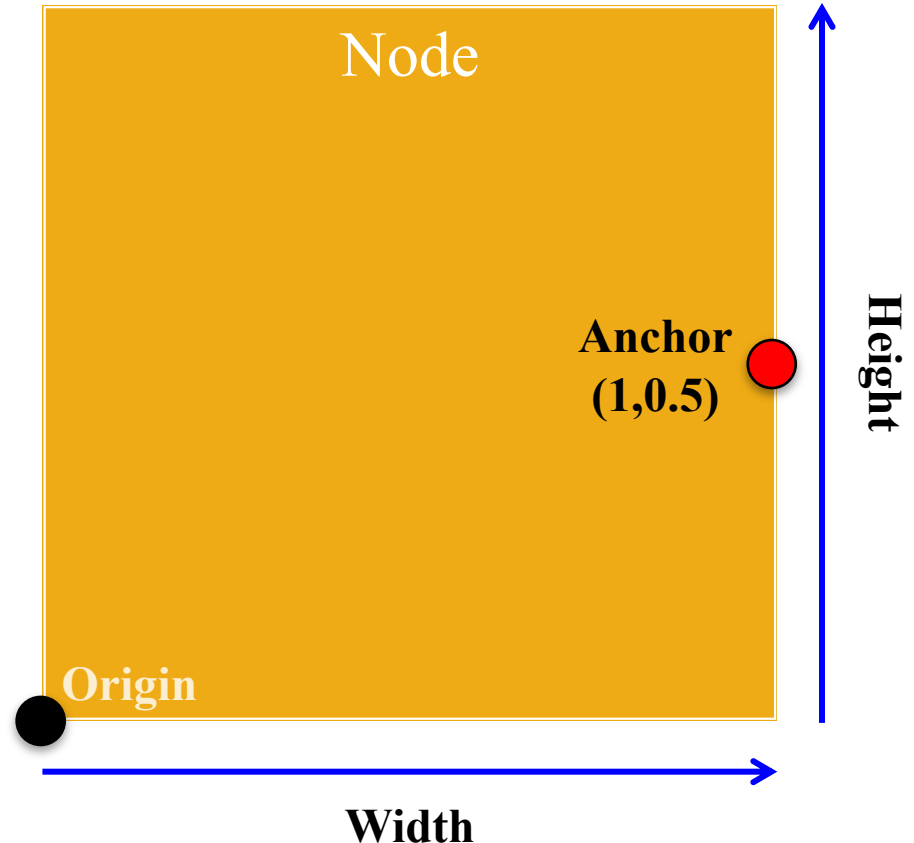
Anchors and Content

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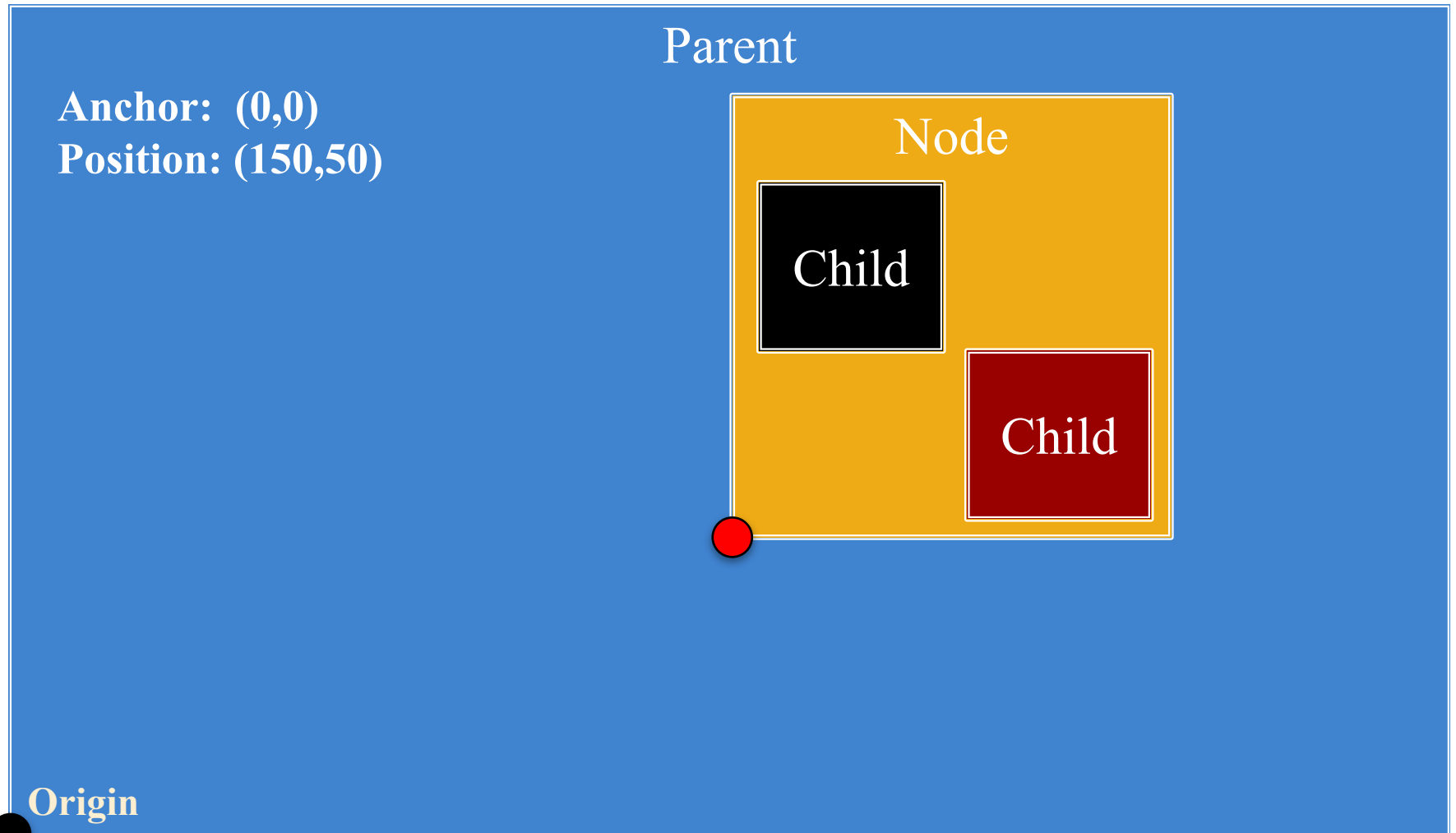


Anchors and Content

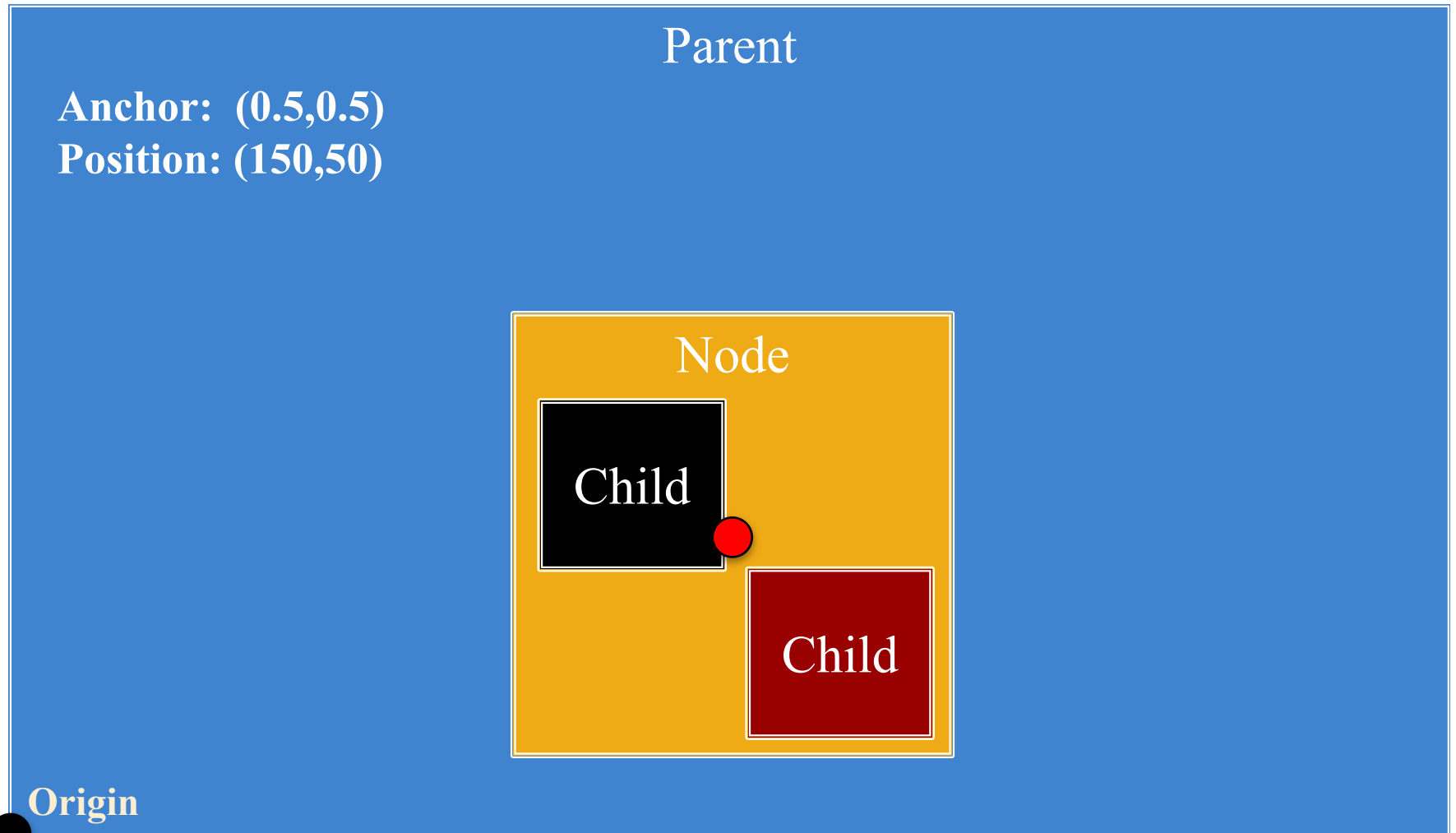
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 - Width/height of contents
 - Measured in node space
 - But only a guideline: content can be outside
- Nodes have an **anchor**
 - Location in node space
 - *Percentage* of width/height
 - Does not affect the origin
- Both may affect **position**



Anchor and Position

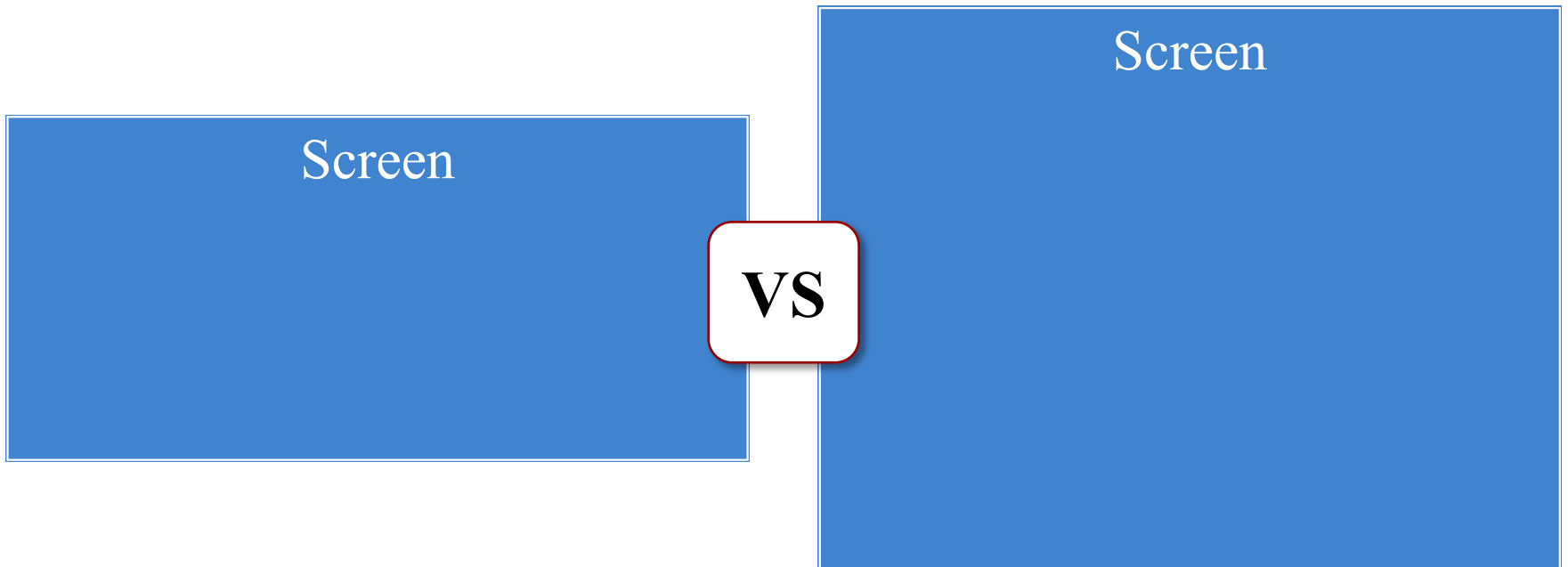


Anchor and Position



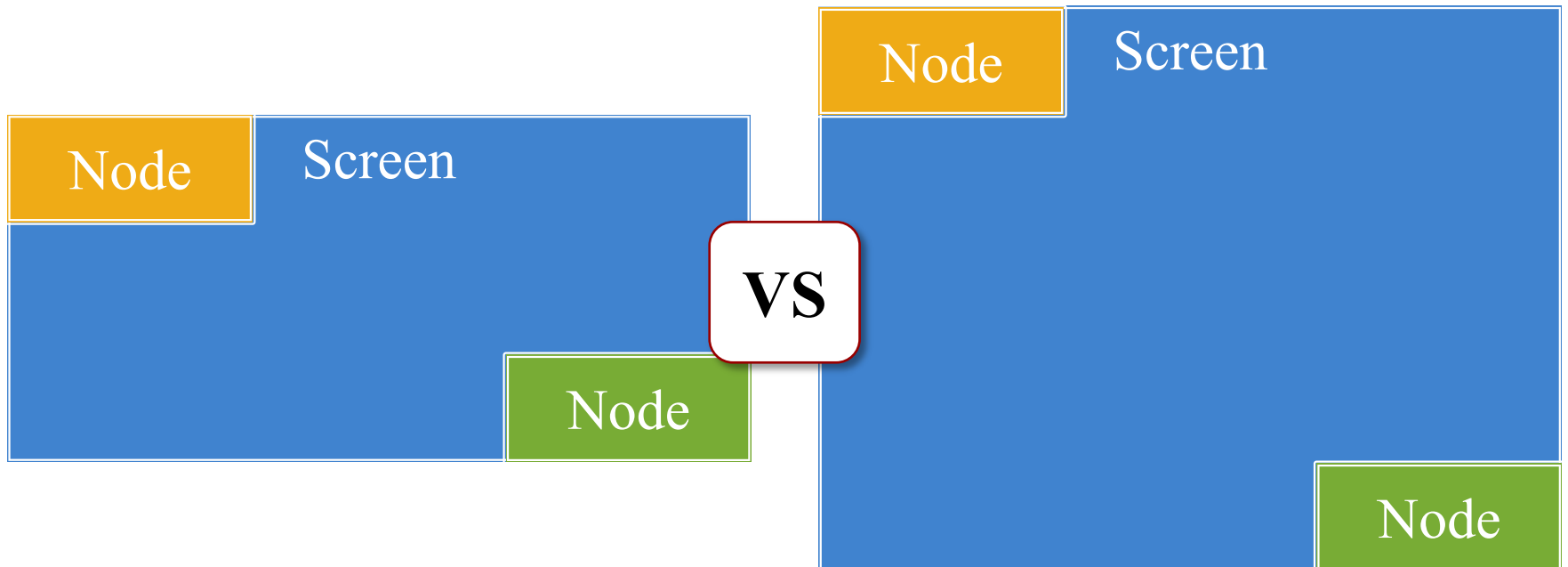
Layout Managers

- Not all devices have the same aspect ratio
- Sometimes, want placement to adjust to fit

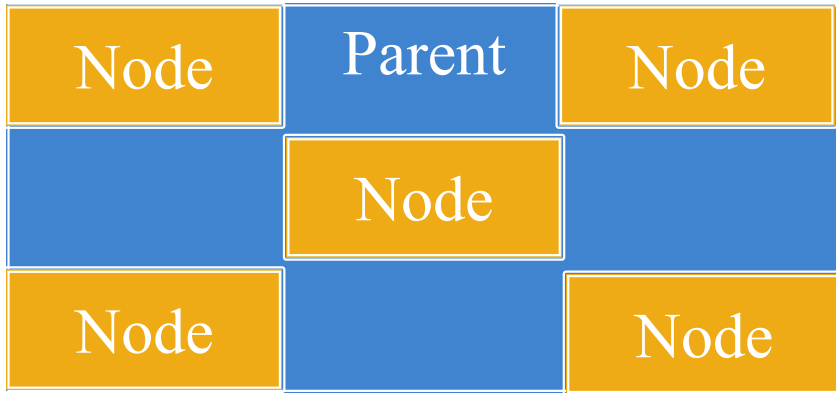


Layout Managers

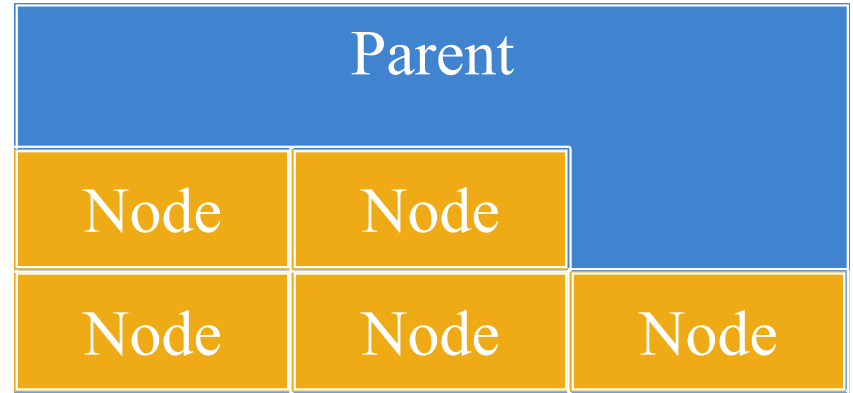
- Not all devices have the same aspect ratio
- Sometimes, want placement to adjust to fit



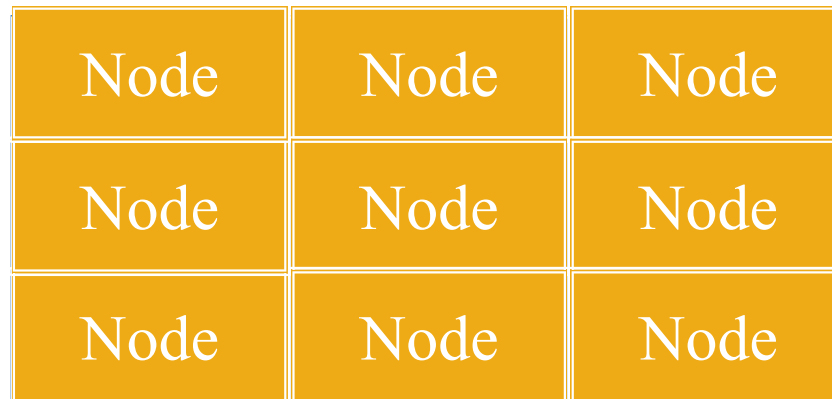
Layout Managers



AnchorLayout

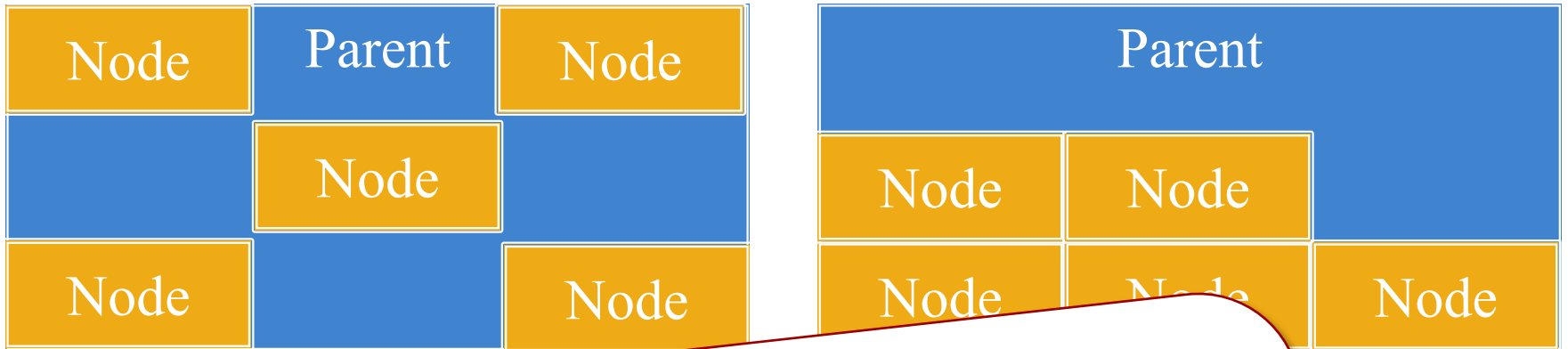


FlowLayout



GridLayout

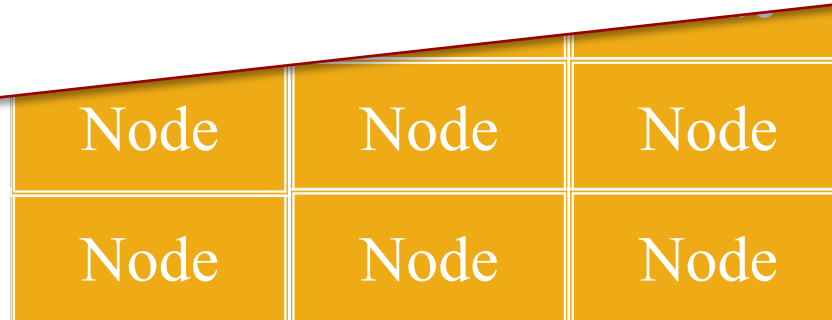
Layout Managers



AnchorLayout

BorderLayout

See Documentation for Details



GridLayout

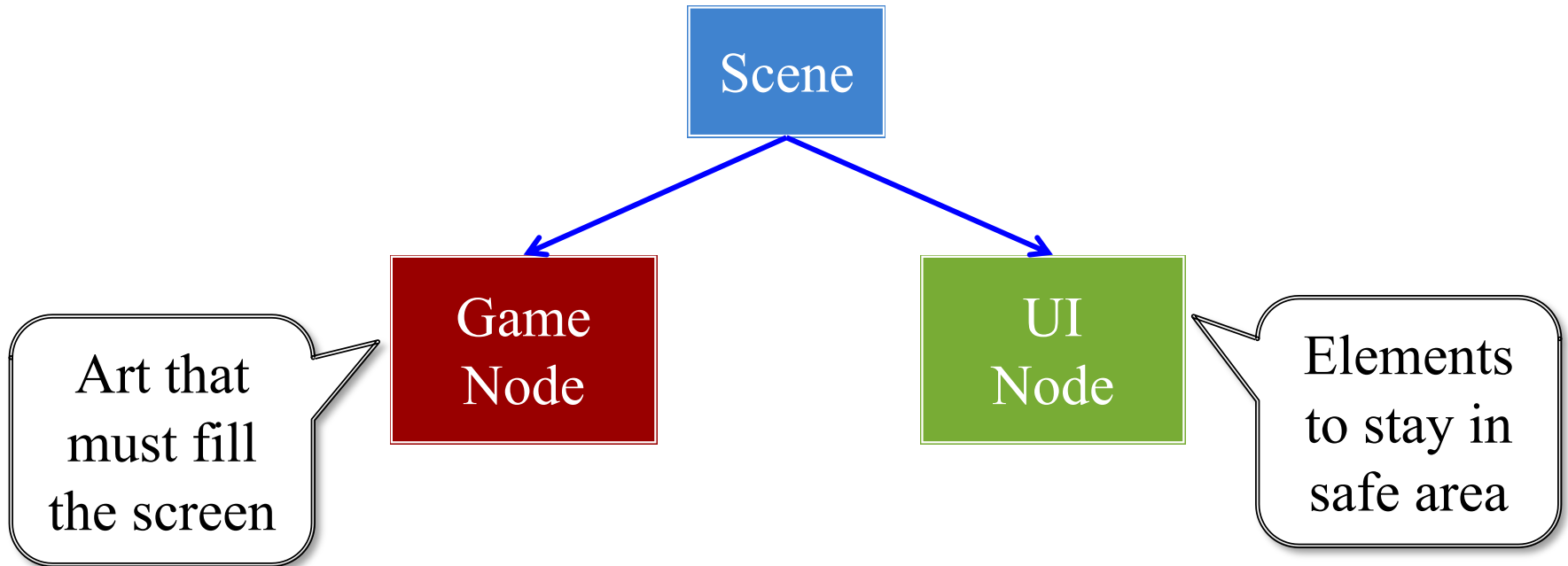
How to Use a Layout Manager

1. Create a layout manager
2. Assign a relative position to each child
 - **Example:** middle left in an anchor layout
 - Layout manager maps strings to layout
 - Use the “name” string of the child node
3. Attach manager to the parent node
4. Call **doLayout()** on the parent

Safe Area: Modern Phones



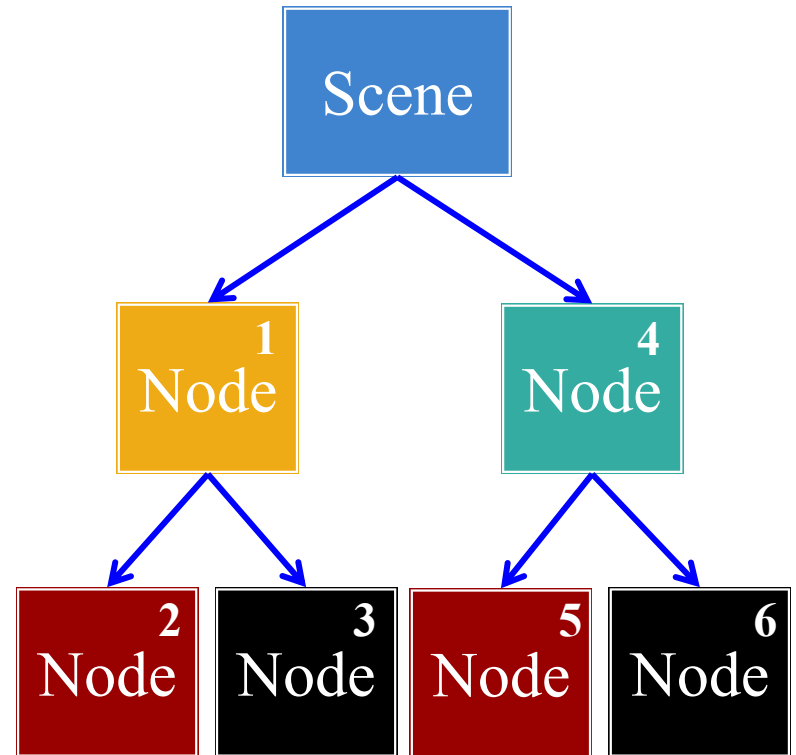
Safe Area: Modern Phones



See Display class to find safe area

Rendering a Scene is Easy

- **scene->render(batch)**
 - Uses SpriteBatch to draw
 - Calls begin()/end() for you
 - Sets the SpriteBatch camera
 - Limits *in-between* drawing
- Uses a **preorder traversal**
 - Draws a parent node first
 - Draws children in order
 - Parent acts as background



Is Preorder Traversal Always Good?

Good for UI Elements



Bad For Animation



Is Preorder Traversal Always Good?

Good for UI Elements

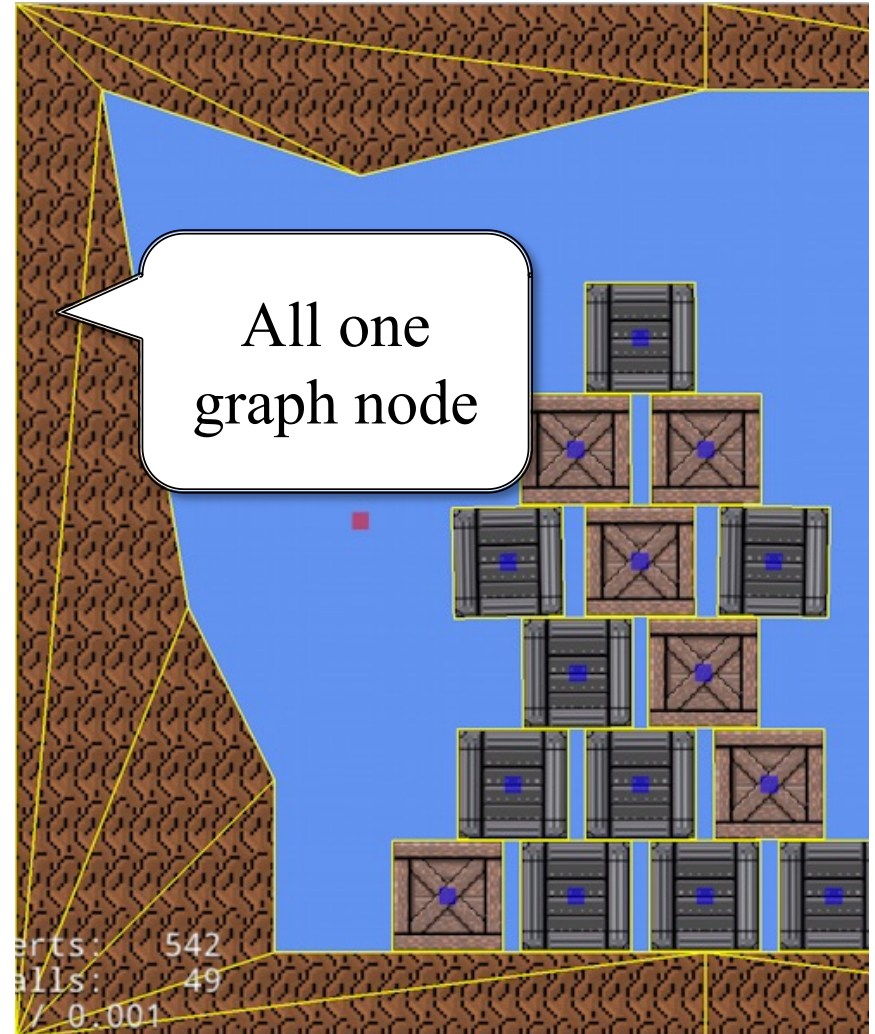
Bad For Animation



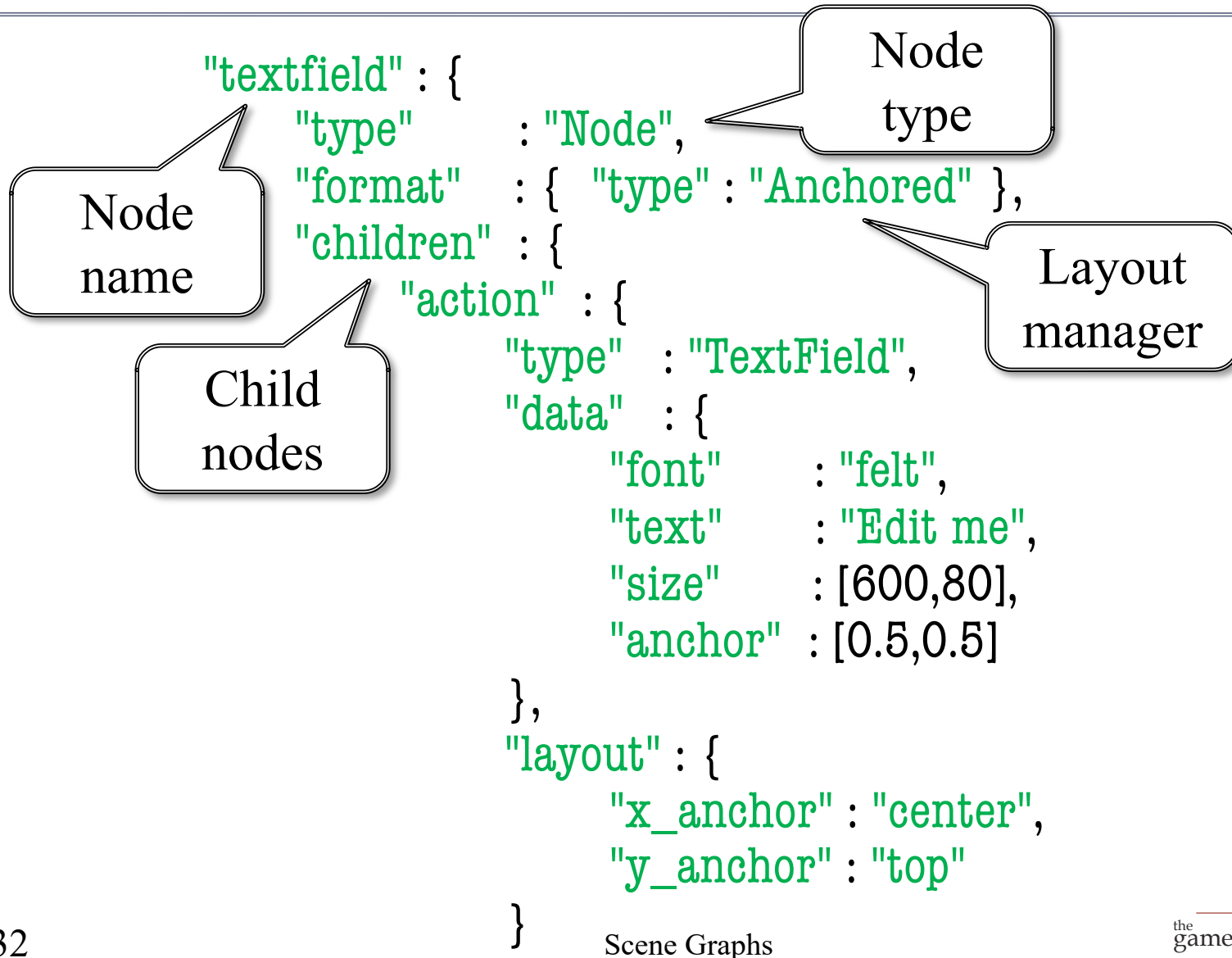
More on this later

Specialized Nodes

- CUGL has many node types
 - `SpriteNode` (animation)
 - `WireNode` (wireframes)
 - `PolygonNode` (tiled shapes)
 - `PathNode` (lines with width)
 - `NinePatch` (UI elements)
 - `Label` (text)
- Learn them outside of class
 - Read the documentation
 - Play with the demos



JSON Language for Scene Graphs



JSON Language for Scene Graphs

```
"textfield" : {  
  "type"      : "Node",  
  "format"    : { "type" : "Anchored" },  
  "children"  : {  
    "action" : {  
      "type" : "TextField",  
      "data" : {  
        "font"   : "felt",  
        "text"   : "Edit me",  
        "size"   : [600,80],  
        "anchor" : [0.5,0.5]  
      },  
      "layout" : {  
        "x_anchor" : "center",  
        "y_anchor" : "top"  
      }  
    }  
  }  
}
```

Layout manager

Node data

Info for parent layout

JSON Language for Scene Graphs

```
"textfield" : {
  "type"      : "Node",
  "format"    : { "type" : "Anchored" },
  "children"  : {
    "action"  : {
      "type"   : "TextField",
      "data"   : {
        "font"   : "felt",
        "text"   : "Edit me",
        "size"   : [600,80],
        "anchor" : [0.5,0.5]
      }
    },
    "layout"  : {
      "x_anchor" : "center",
      "y_anchor" : "top"
    }
  }
}
```

Each node has

- Type
- Format
- Data
- Children
- Layout

Using JSON Scene Graphs

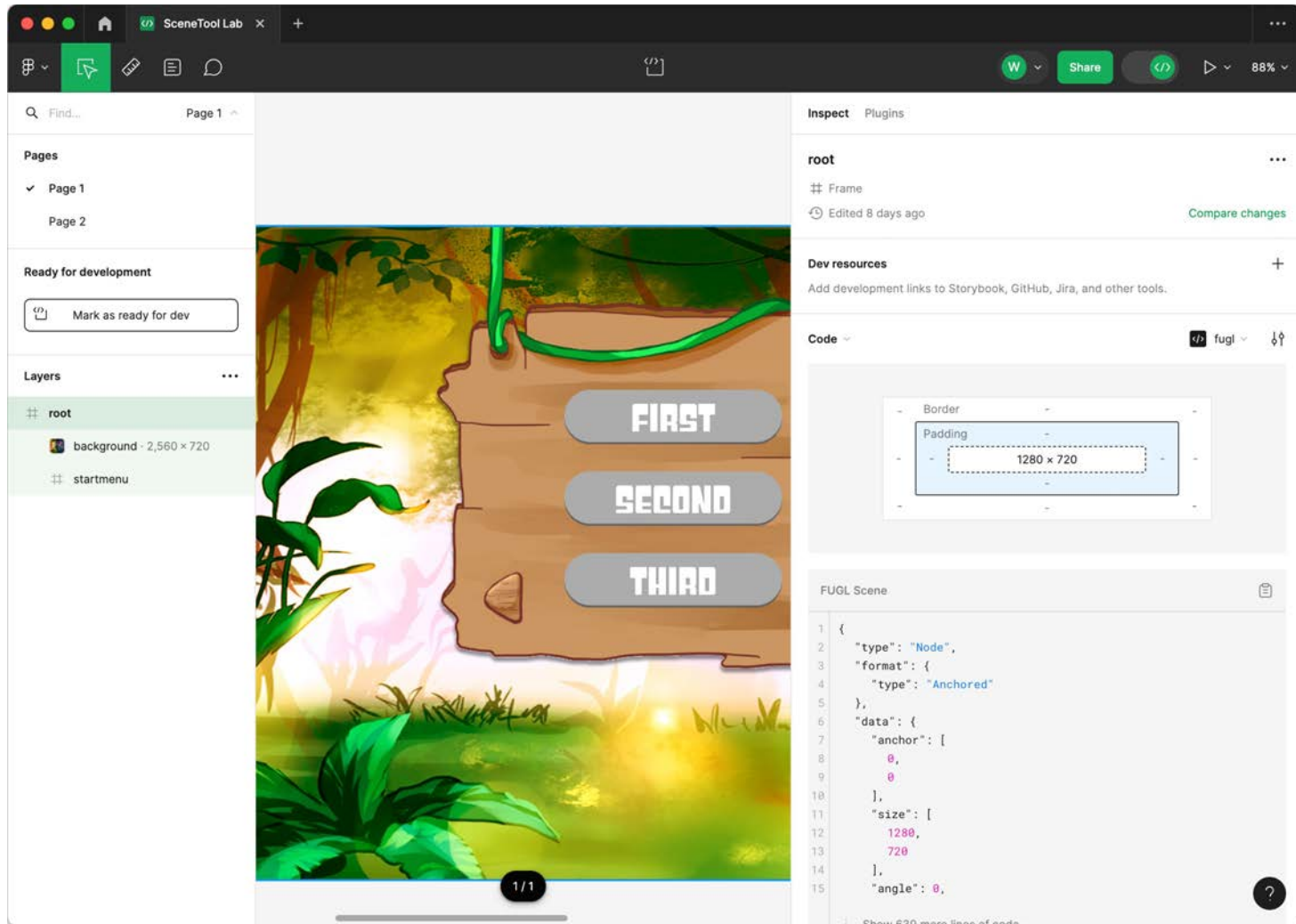
Advantages

- Designers **do not need C++**
 - Using special tool in lab
 - Tool good for entire semester
- Format is **ideal for mobile**
 - Integrated layout managers
 - Aspect ratio support is easy
- **Integration is simple**
 - Load JSON with asset loader
 - Refer to scene root by name

Disadvantages

- UI still needs **custom code**
 - Buttons etc. do nothing
 - Essentially need listeners
 - Programmers do manually
- Files can be very **confusing**
 - Format is a tree structure
 - Each tree node is verbose
- **Not a level editor format!**
 - Levels need more info

Solution: The Figma Plugin




Plugin Manages Anchors **and** Layouts


AnchorLayout

Design Prototype

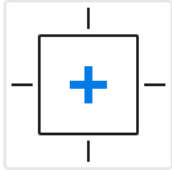
|= ≠ =| T̄ † | | ≡ ∨

X 0 Y 0

W 43.2 H 57.6 

└ 0° ∟ 0 

Constraints


 H Center ∨

I Center ∨

FloatLayout

Design Prototype


|= ≠ =| T̄ † | | ≡ ∨

Frame ∨ 

X 102 Y 160



W 320 H 280

H Fixed ∨ I Fixed ∨



└ 0° ∟ 0 

Clip content

Auto layout —

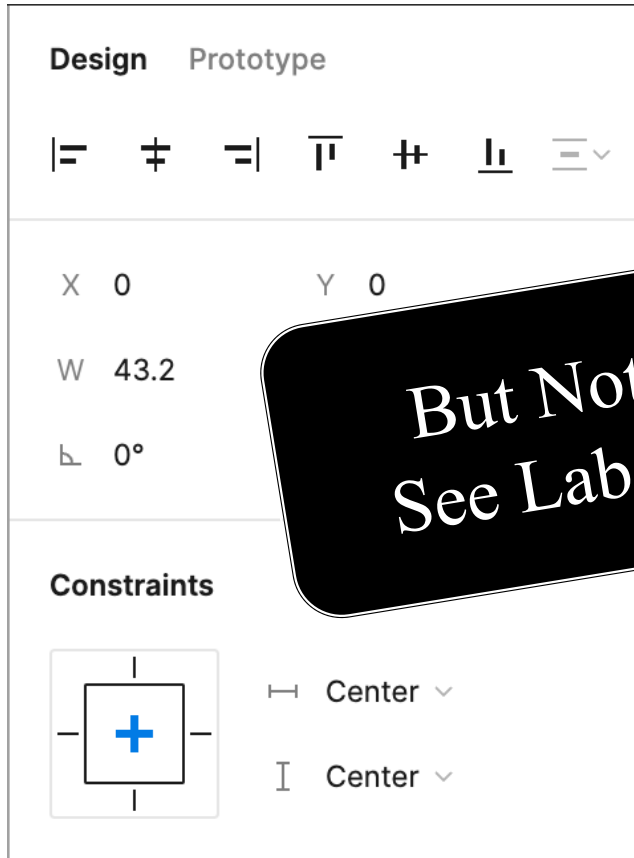
  ...

≡ 30

| | 0  0 

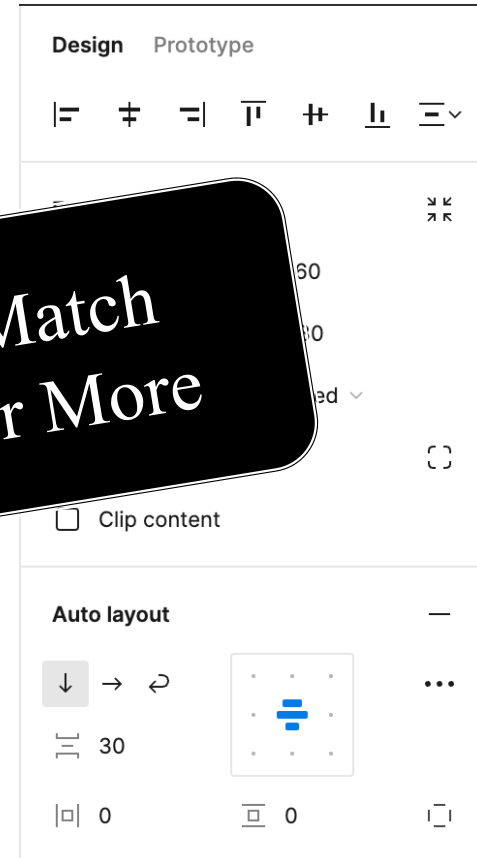
Plugin Manages Anchors **and** Layouts

AnchorLayout



**But Not an Exact Match
See Lab Activity for More**

FloatLayout



Widgets: JSON Templates

Widget

```
"variables" : {  
  "image" : ["children", "up", "data", "texture"]  
},  
"contents" : {  
  "type" : "Button",  
  "data" : {  
    "upnode" : "up", "visible" : false,  
    "anchor" : [0.5,0.5], "scale" : 0.8  
  },  
  "children" : {  
    "up" : {  
      "type" : "Image",  
      "data" : { "texture" : "play" }  
    }  
  }  
}}
```

Widget is
a subtree

JSON

```
"widgets": {  
  "mybutton" : "widgets/mybutton.json",  
},  
"scene2s": {  
  "thescene" : {  
    "type" : "Node",  
    "format" : { "type" : "An"},  
    "children" : {  
      "button" : {  
        "type" : "Widget",  
        "data" : {  
          "key" : "mybutton",  
          "variables" : { "image":"altplay" }  
        },  
        "layout" : { "x_anchor" : "center" }  
      }  
    }  
  }  
}}
```

Replace
w/ subtree

Widgets: JSON Templates

Widget

```
"variables" : {  
  "image" : ["children", "up", "data", "texture"]  
},  
"contents" : {  
  "type" : "Button",  
  "data" : {  
    "upnode" : "up", "visible" : false,  
    "anchor" : [0.5,0.5], "scale" : 0.8  
  },  
  "children" : {  
    "up" : {  
      "type" : "Image",  
      "data" : { "texture" : "play" }  
    }  
  }  
}
```

Full path to
value to change

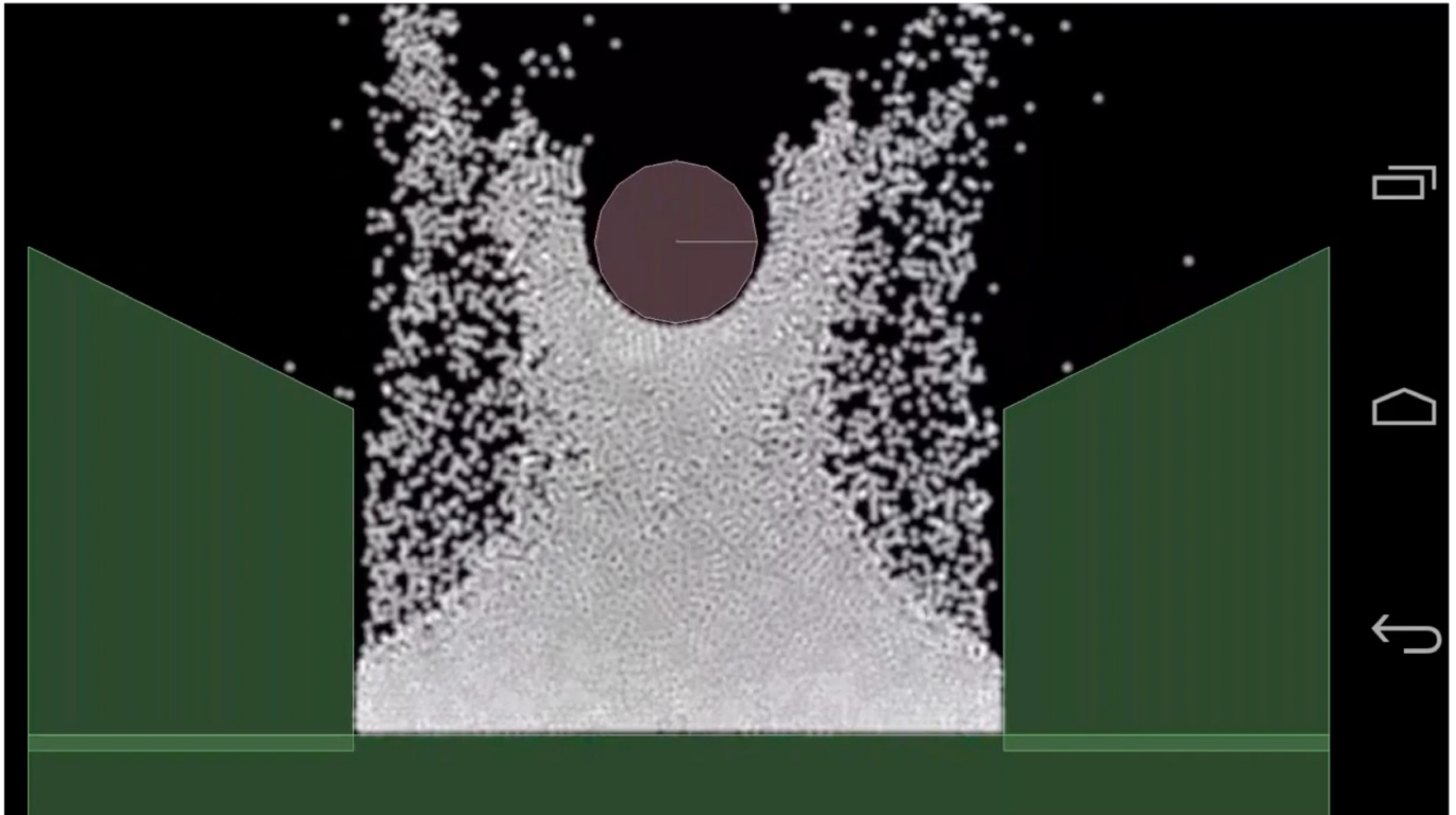
Provide the
layout

JSON

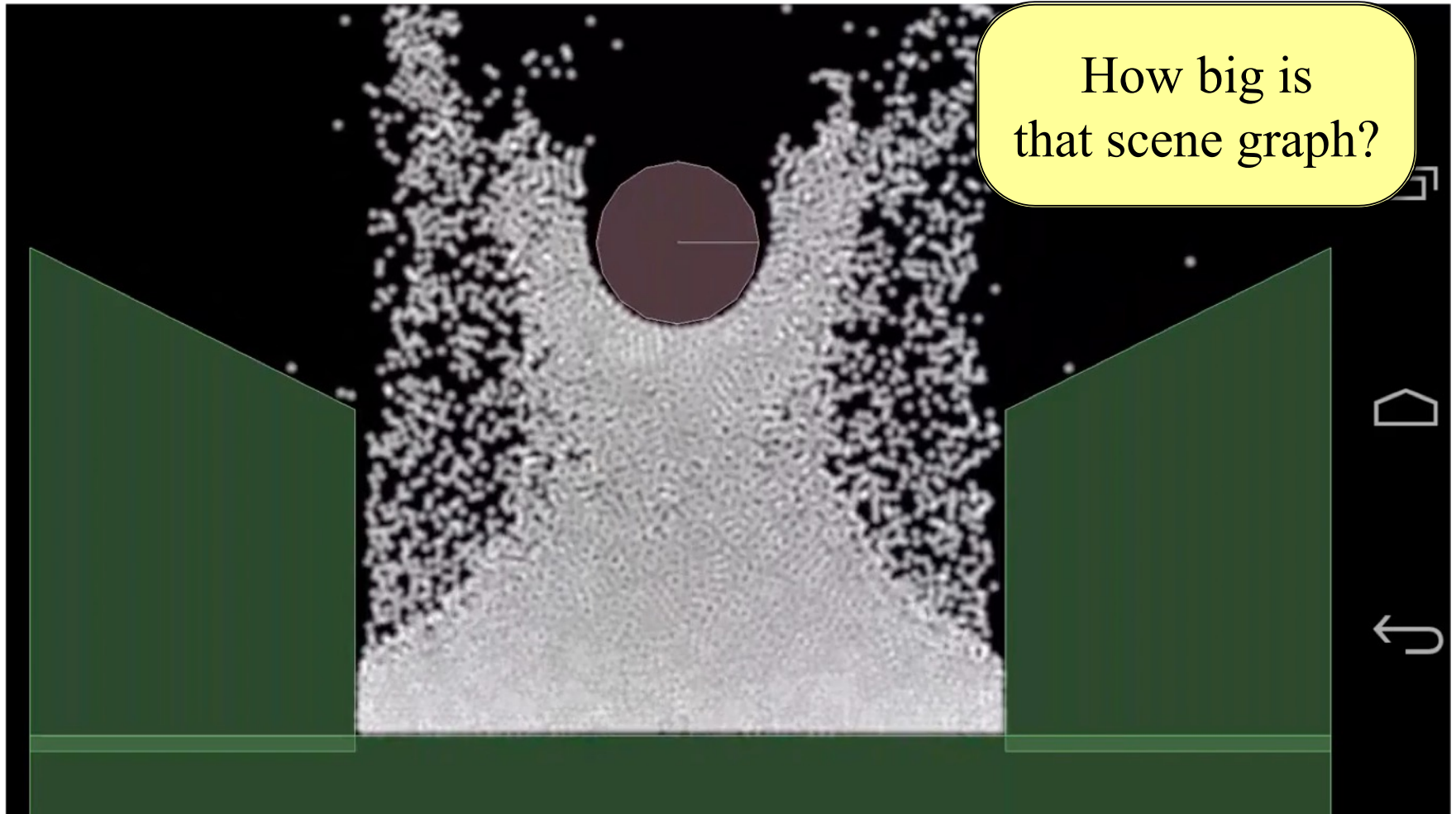
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"scene2s": {  
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    "children" : {  
      "button" : {  
        "type" : "Widget",  
        "data" : {  
          "key" : "mybutton",  
          "variables" : { "image":"altplay" }  
        }  
      },  
      "layout" : { "x_anchor" : "center" }  
    }  
  }  
}
```

Change the
variable

One Last Problem: **Physics**



One Last Problem: **Physics**



Defining Custom Nodes

draw()

- Overridden to render node
 - Only node, not children
 - The `render` method (do not touch) handles children
- Drawing data is **cached**
 - The vertex positions
 - The vertex colors
 - The texture coordinates
- Cache passed to `SpriteBatch`

generateRenderData()

- Overridden to update cache
 - Change vertex positions
 - Change vertex colors
 - Change texture coordinates
- Only needed for **reshaping**
 - Transforms for movement
 - Called infrequently
- Optimizes the render pass

The `draw()` Method

```
void CustomNode::draw(const std::shared_ptr<SpriteBatch>& batch,
                    const Affine2& transform, Color4 tint) {

    if (!_rendered) {
        generateRenderData();
    }

    batch->setColor(tint);
    batch->setTexture(_texture);
    batch->setBlendEquation(_blendEquation);
    batch->setBlendFunc(_srcFactor, _dstFactor);

    batch->fill(_vertices, _vertsized, 0,
              _indices, _indxsize, 0,
              transform);
}
```

The draw() Method

```
void CustomNode::draw(const std::shared_ptr<SpriteBatch>& batch,  
                     const Affine2& transform, Color4 tint) {
```

```
    if (!_rendered) {  
        generateRenderData();  
    }
```

Computed from
parent (+camera)

Computed from
parent (+scene)

```
    batch->setColor(tint);  
    batch->setTexture(_texture);  
    batch->setBlendEquation(_blendEquation);  
    batch->setBlendFunc(_srcFactor, _dstFactor);
```

```
    batch->fill(_vertices, _vertsized, 0,  
              _indices, _indxsize, 0,  
              transform);
```

The Render Data

```
}
```

Summary

- CUGL tries to leverage ideas from 3152
 - Top level class works like the classic GDXRoot
 - Design architecture to switch between modes
 - Use SpriteBatch class to draw textures in 2D.
- New idea is using **scene graphs** to draw
 - Tree of nodes with relative coordinate systems
 - Makes touch input easier to process
 - Also helps with animation (later)
- JSON language makes design easier