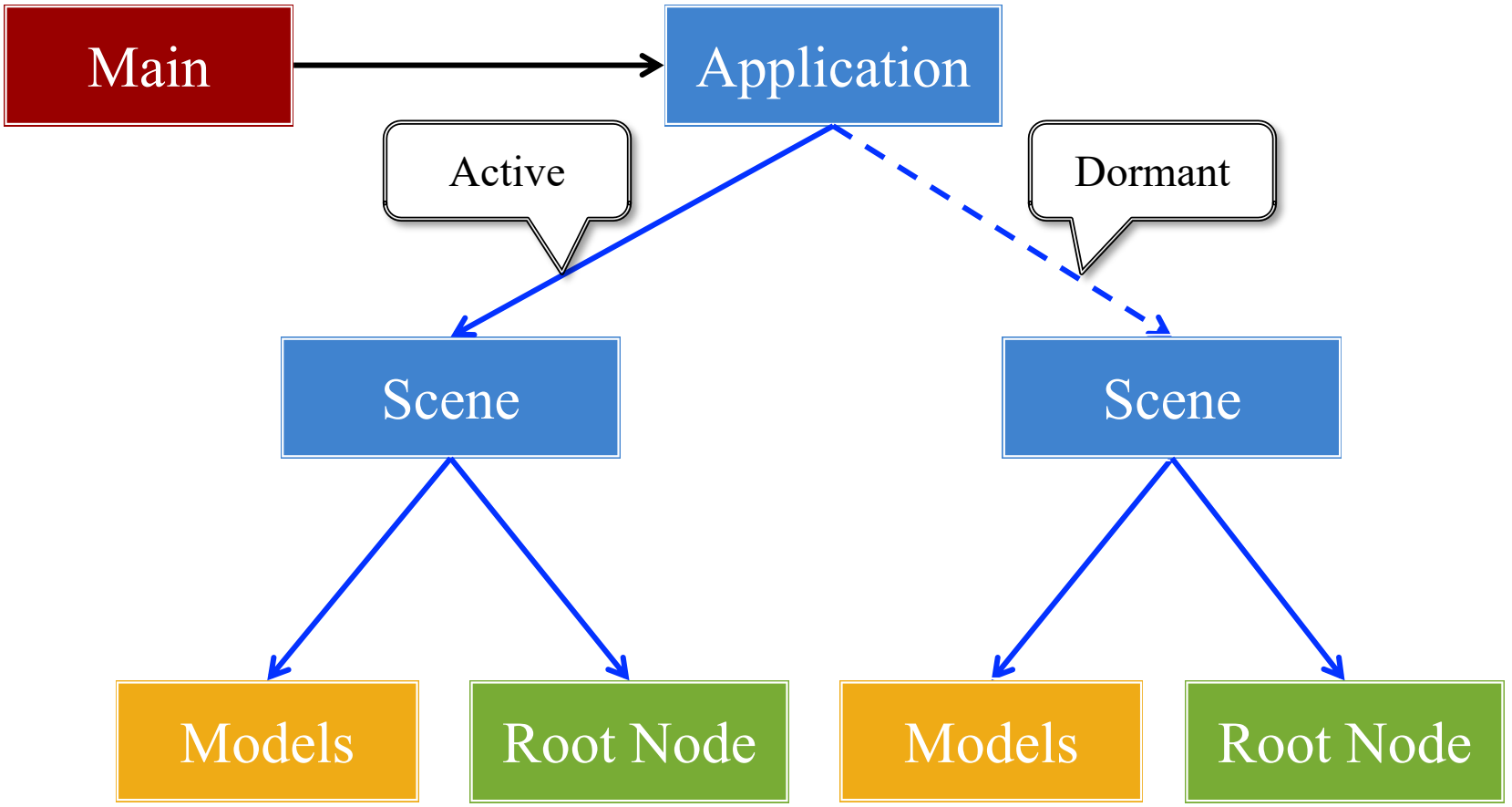
the gamedesigninitiative at cornell university

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 `GDXRoot` 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
- S… …tons
  - …els
- C… …ny 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 in… …ons
  - … …or
  - … …olves other interactions
- Updates the scene graph
  - Transforms nodes
  - Enables/disables nodes

Does not draw! Handled separately

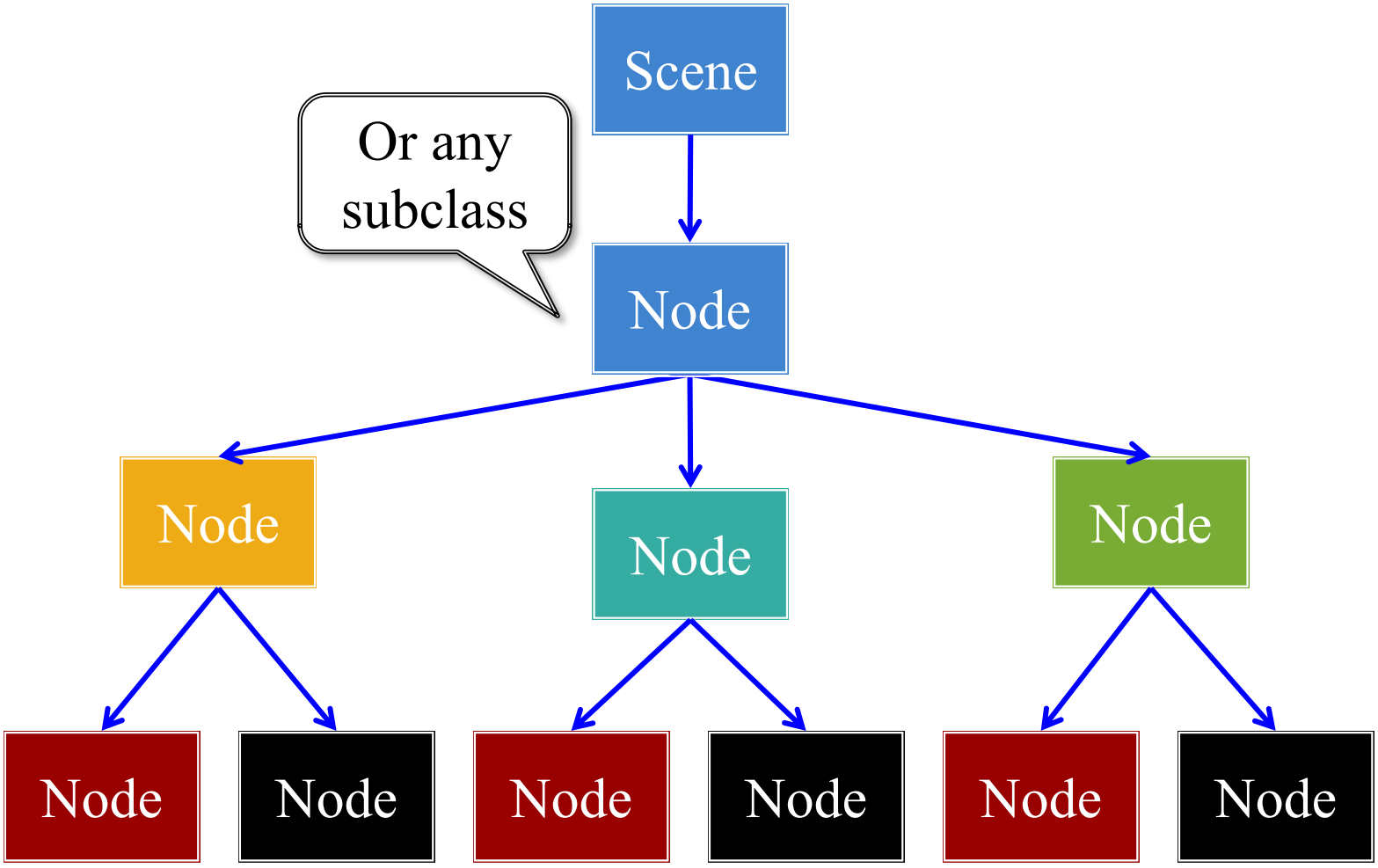
Drawing in CUGL

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

```
void draw() {
    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 draw() {
    batch->begin();
    batch->draw(image1,Vec2(10,10));
    batch->draw(image2,Vec2(50,20));
    batch->end();
}
```

The Scene Graph



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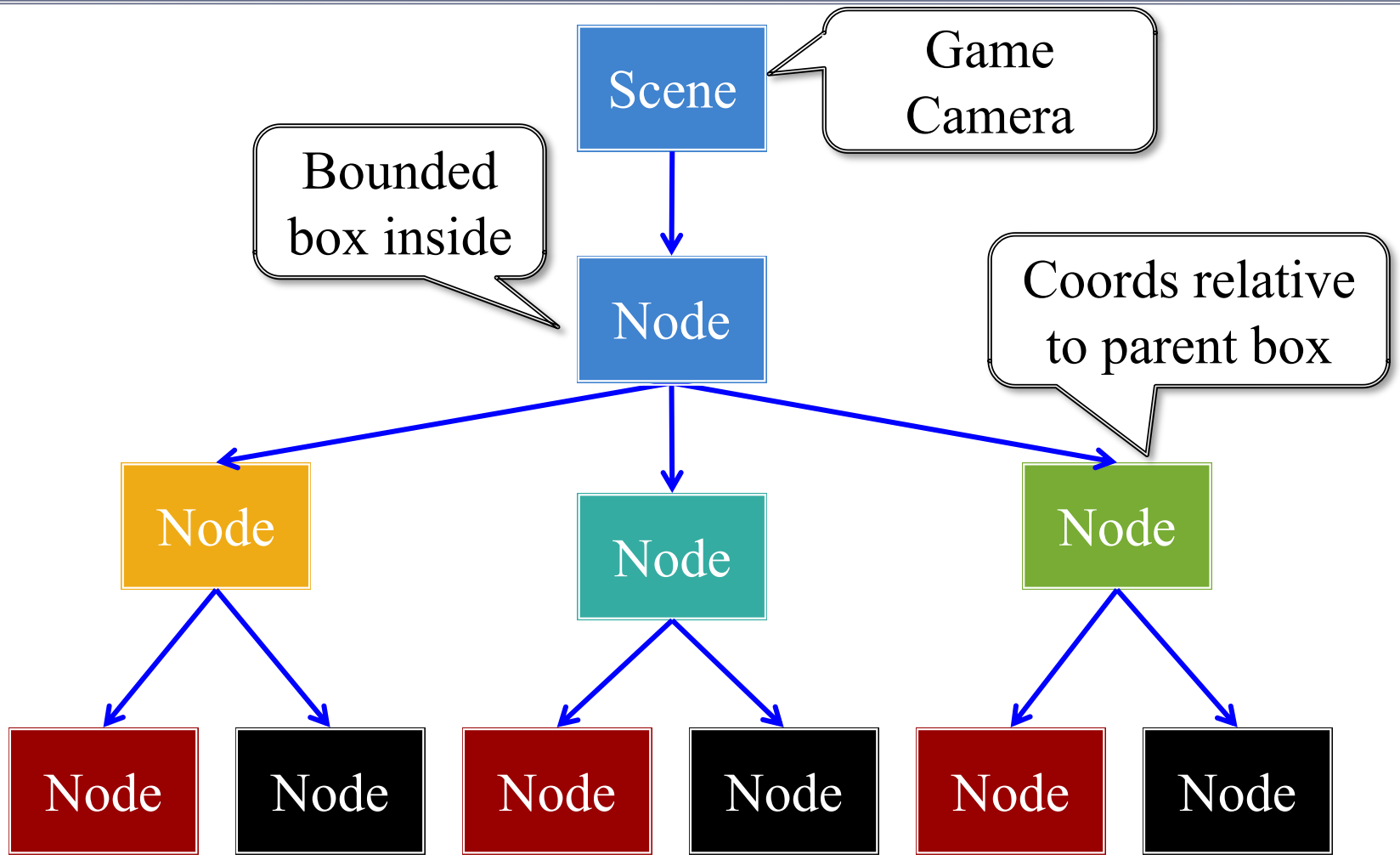
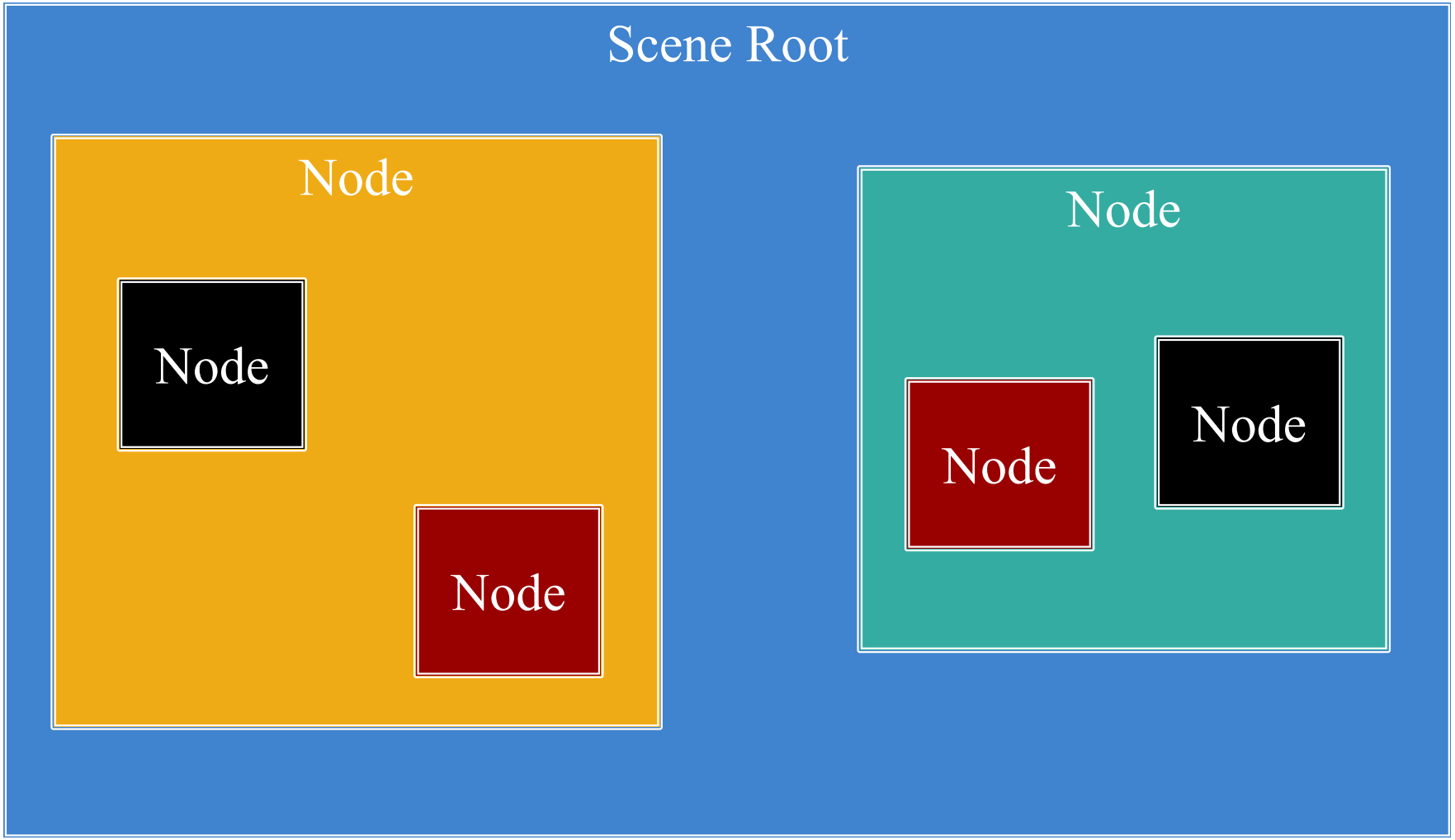


Each Node is a Coordinate System



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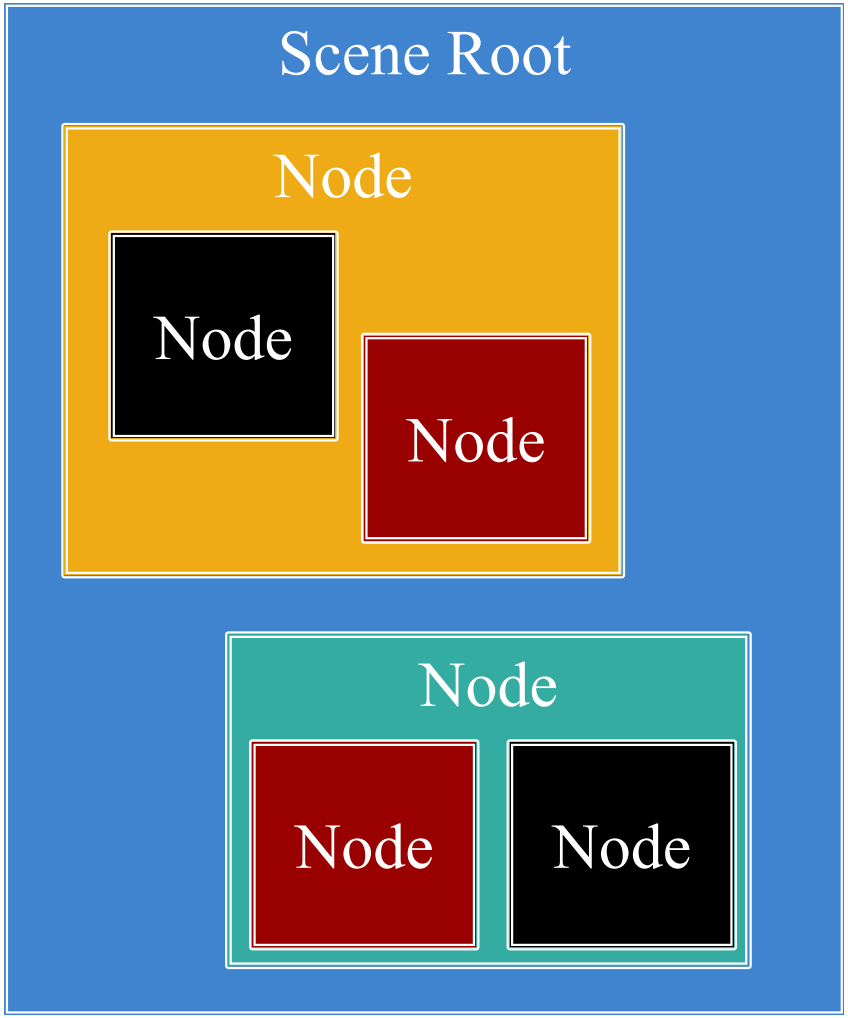

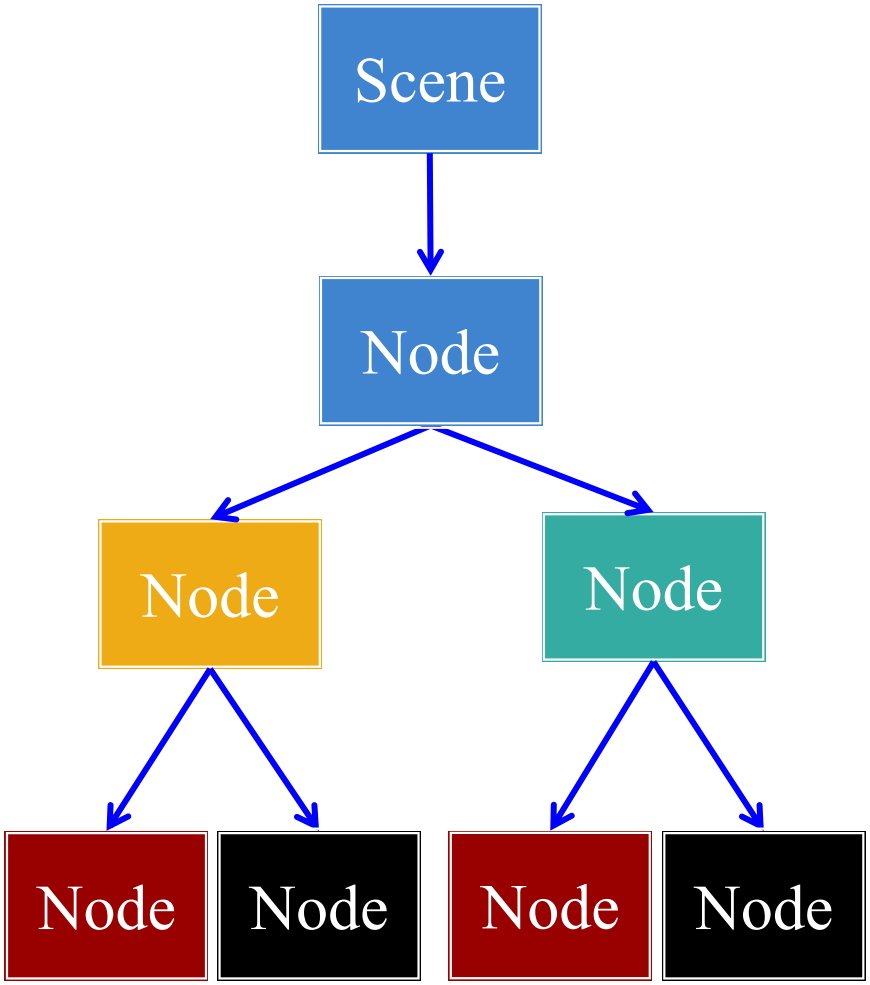

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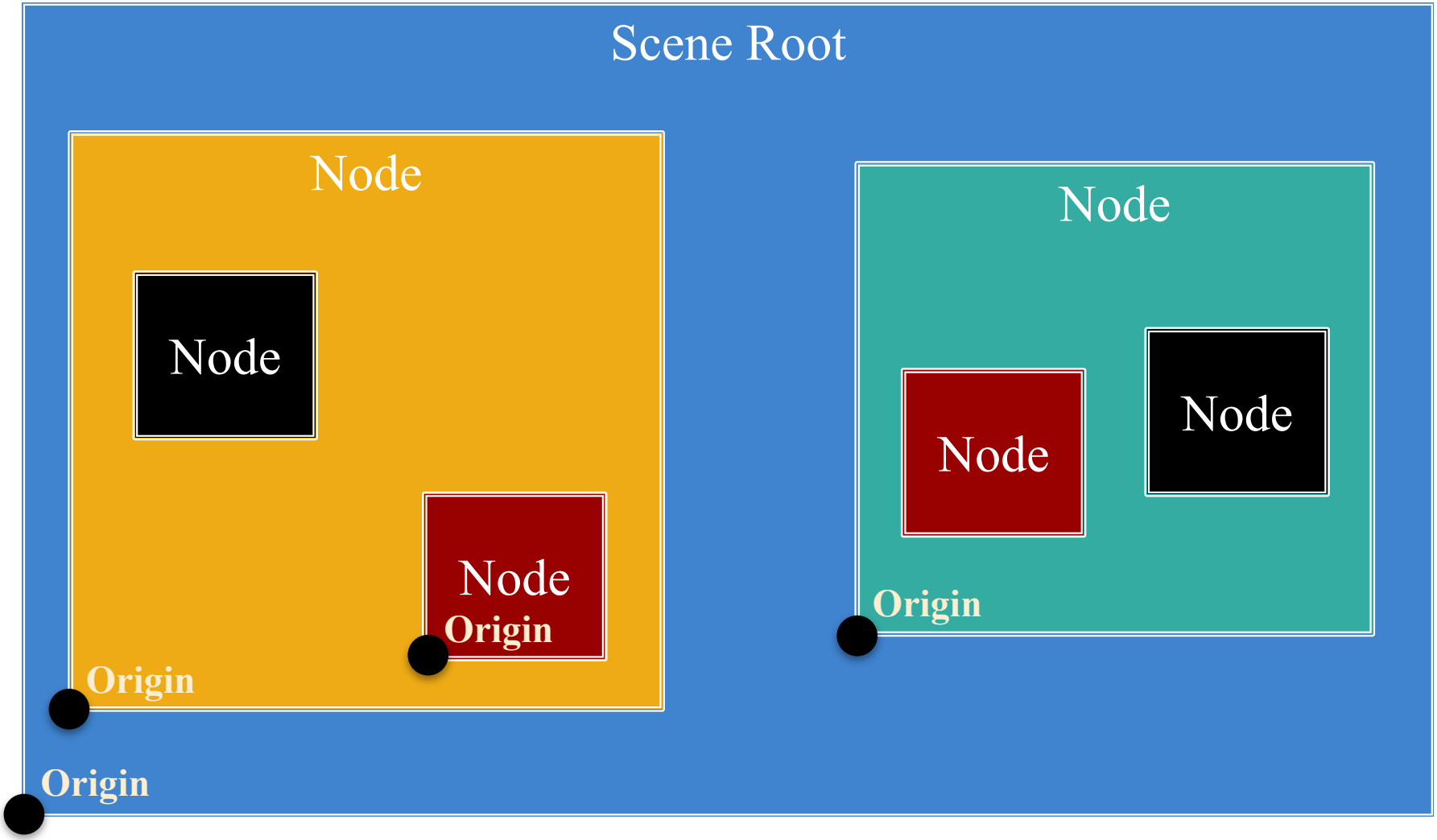
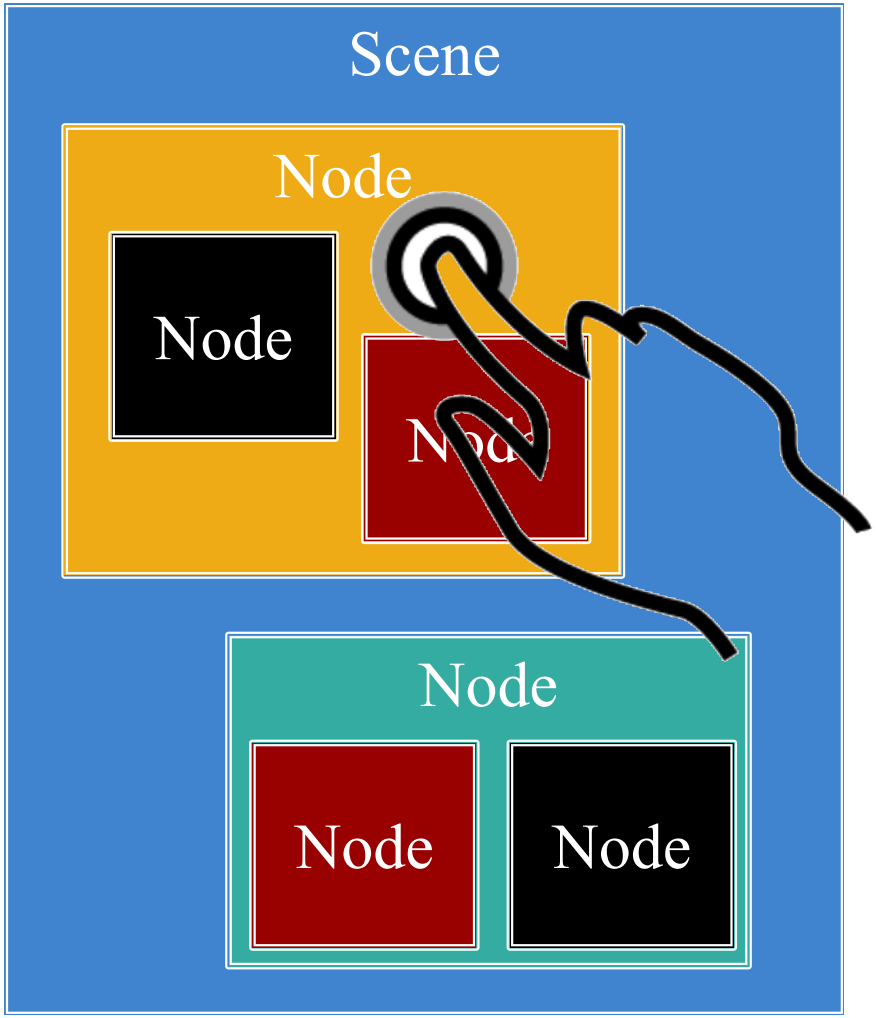
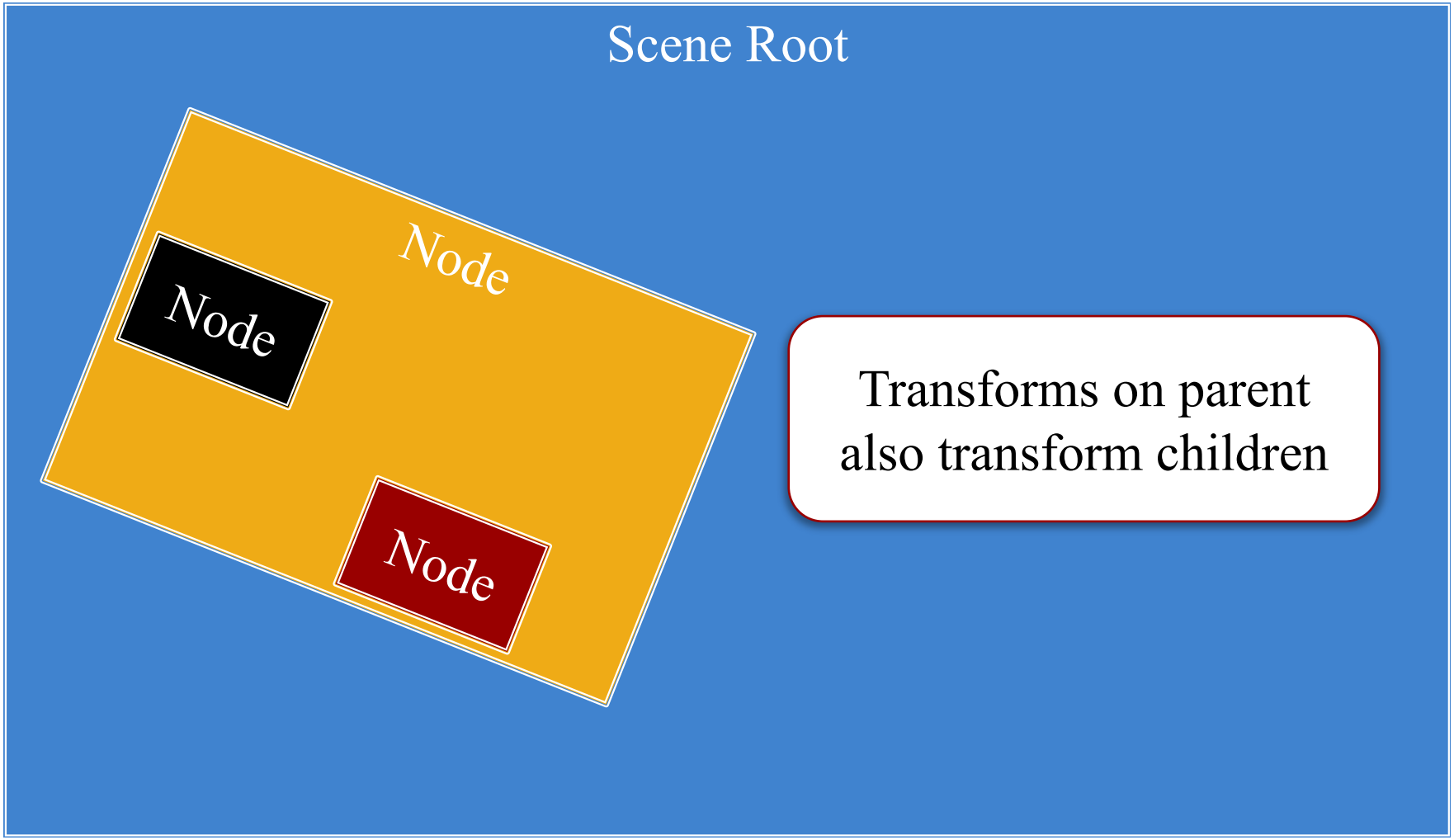


Motivation: Touch Interfaces

- 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



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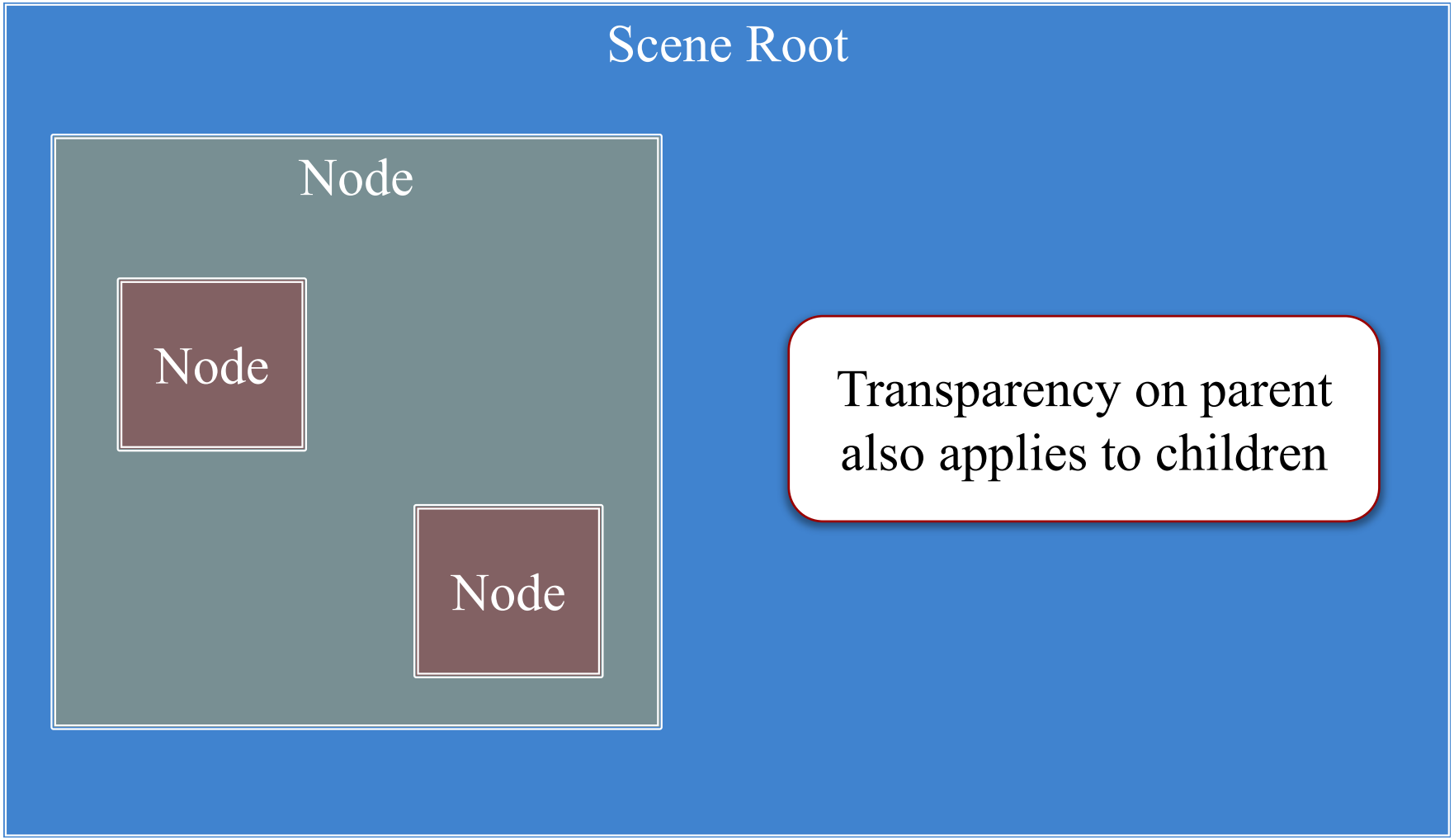

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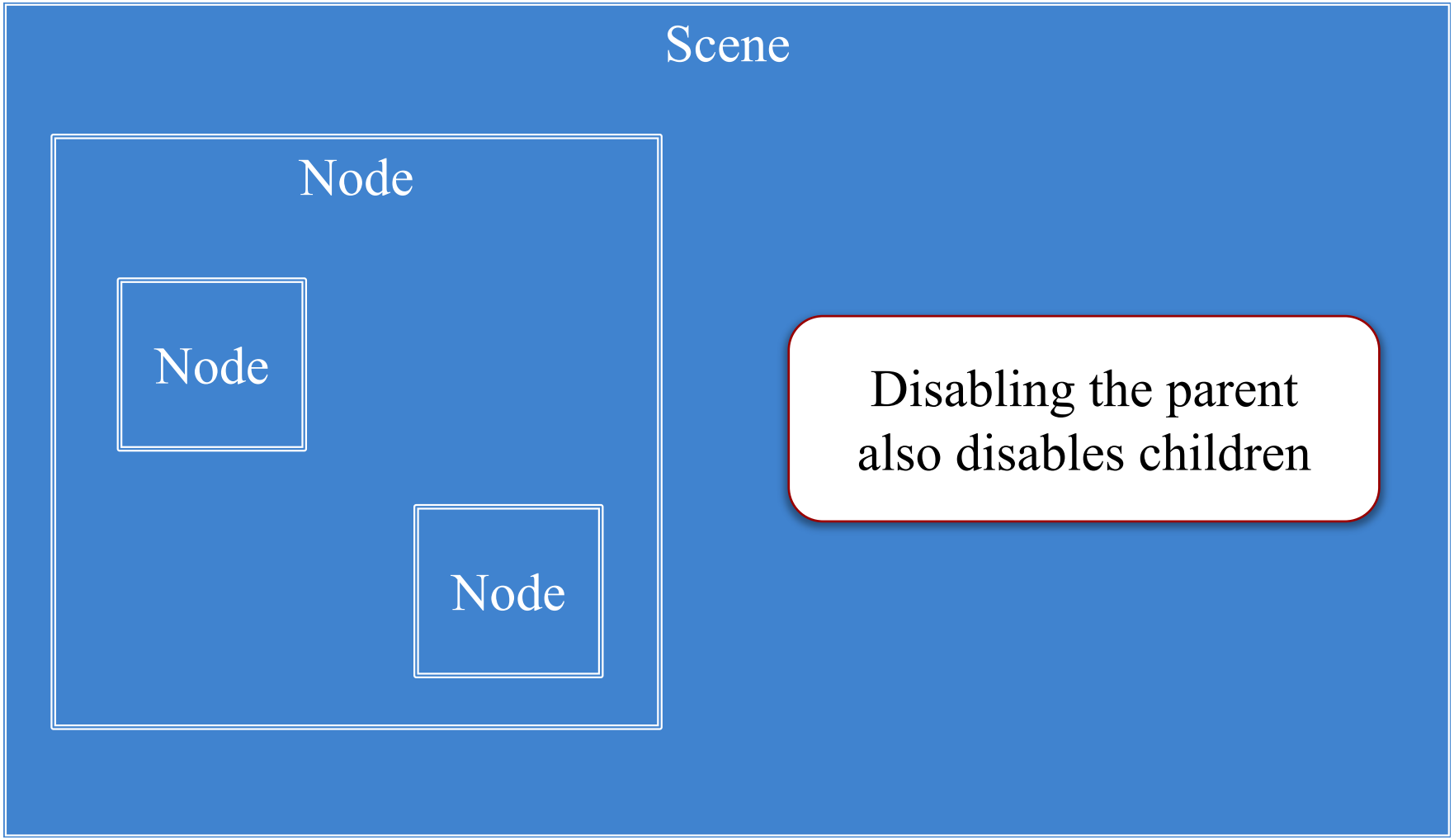
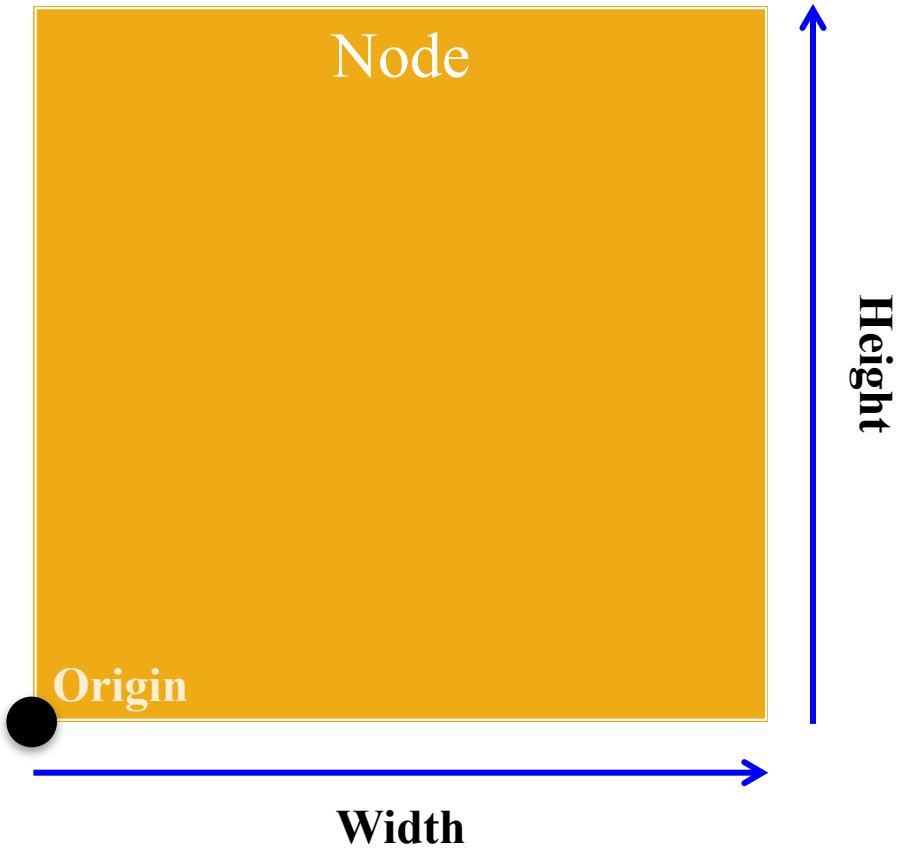


Anchors and Content

- 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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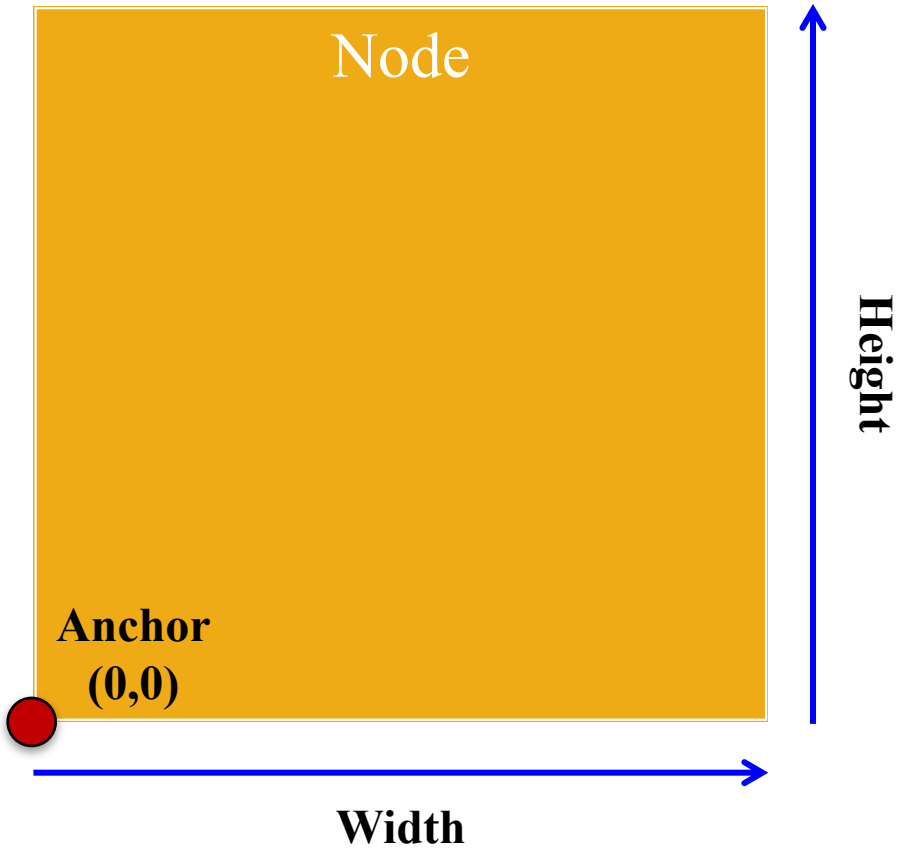

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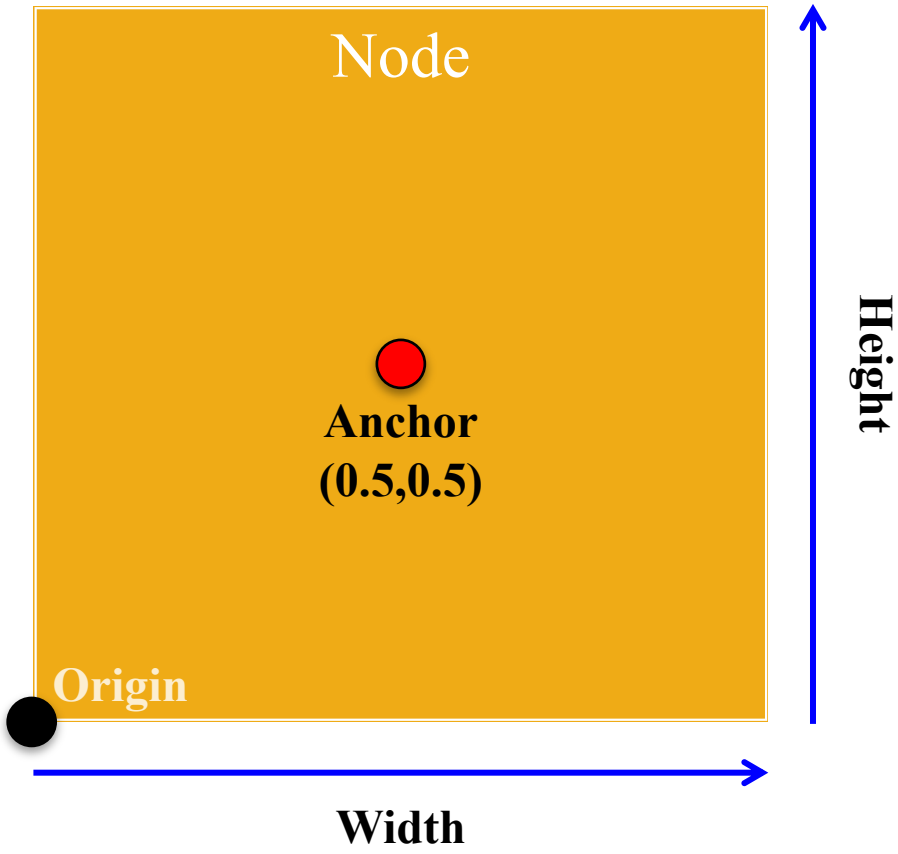

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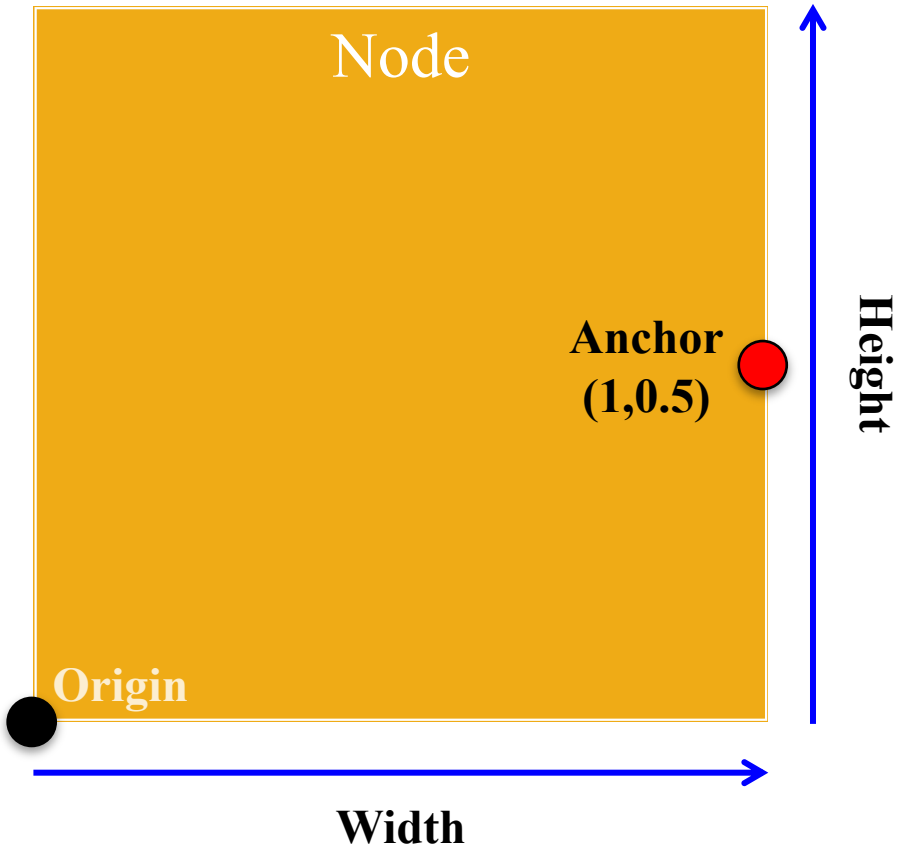

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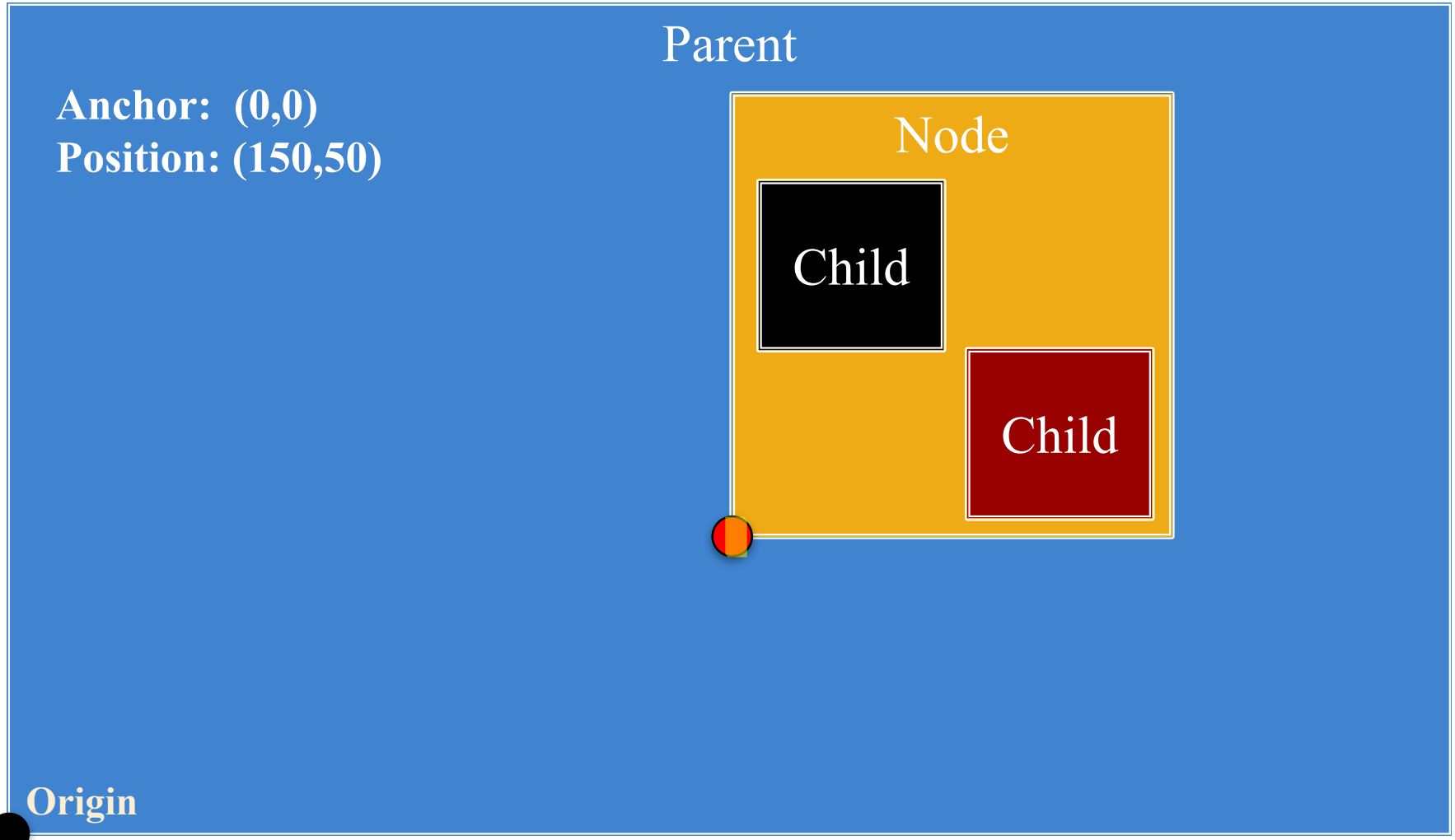

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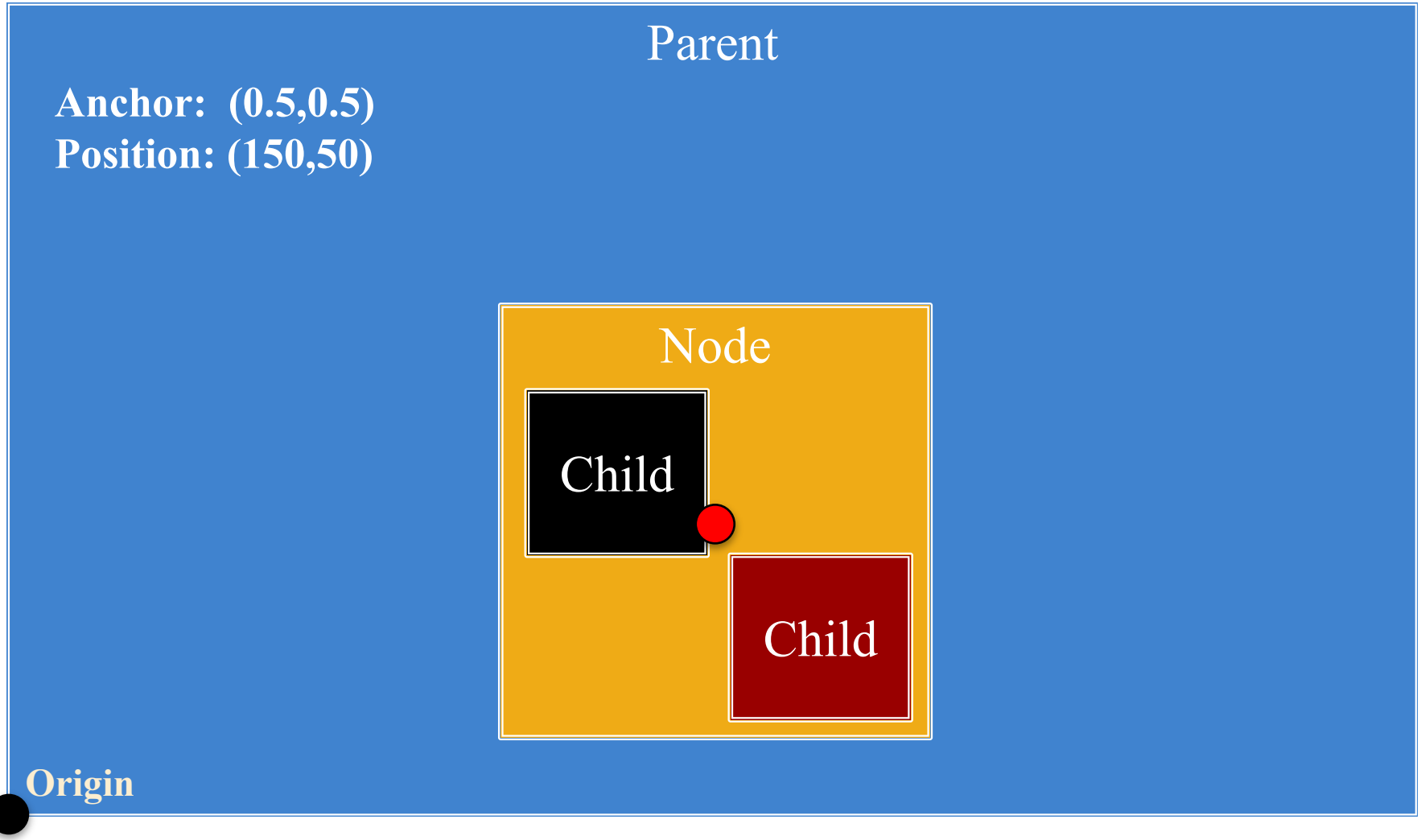
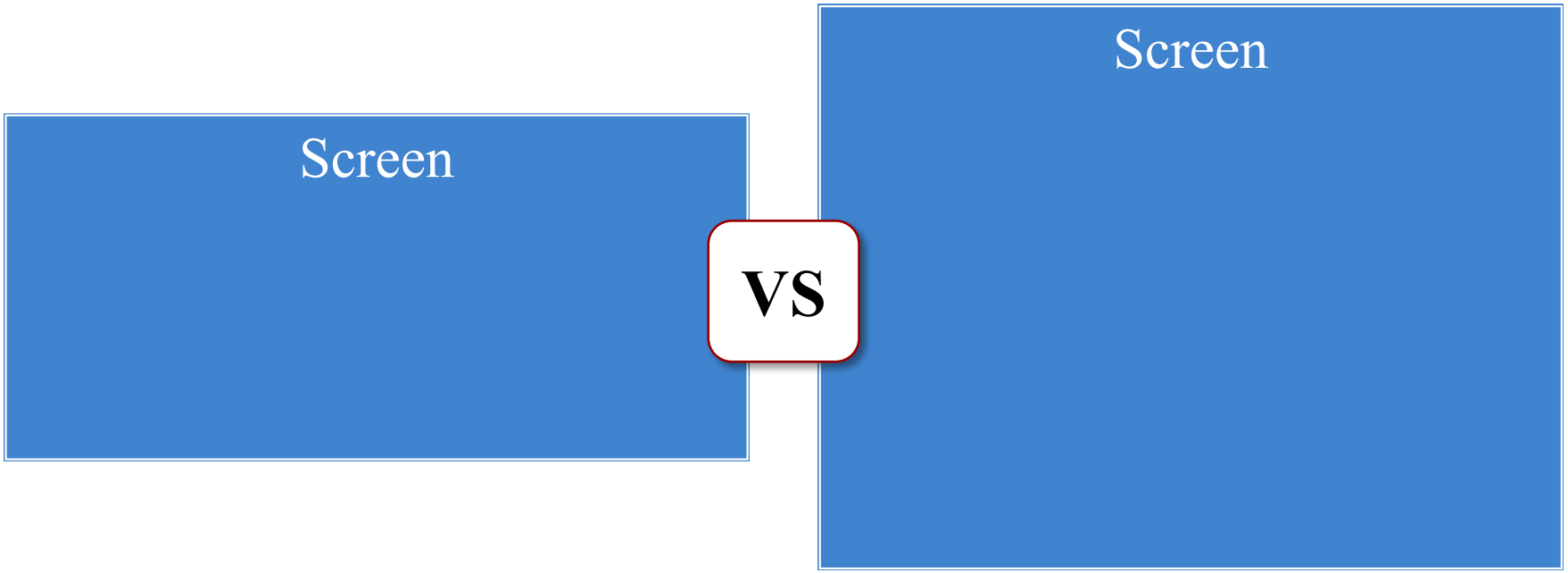


Layout Managers

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



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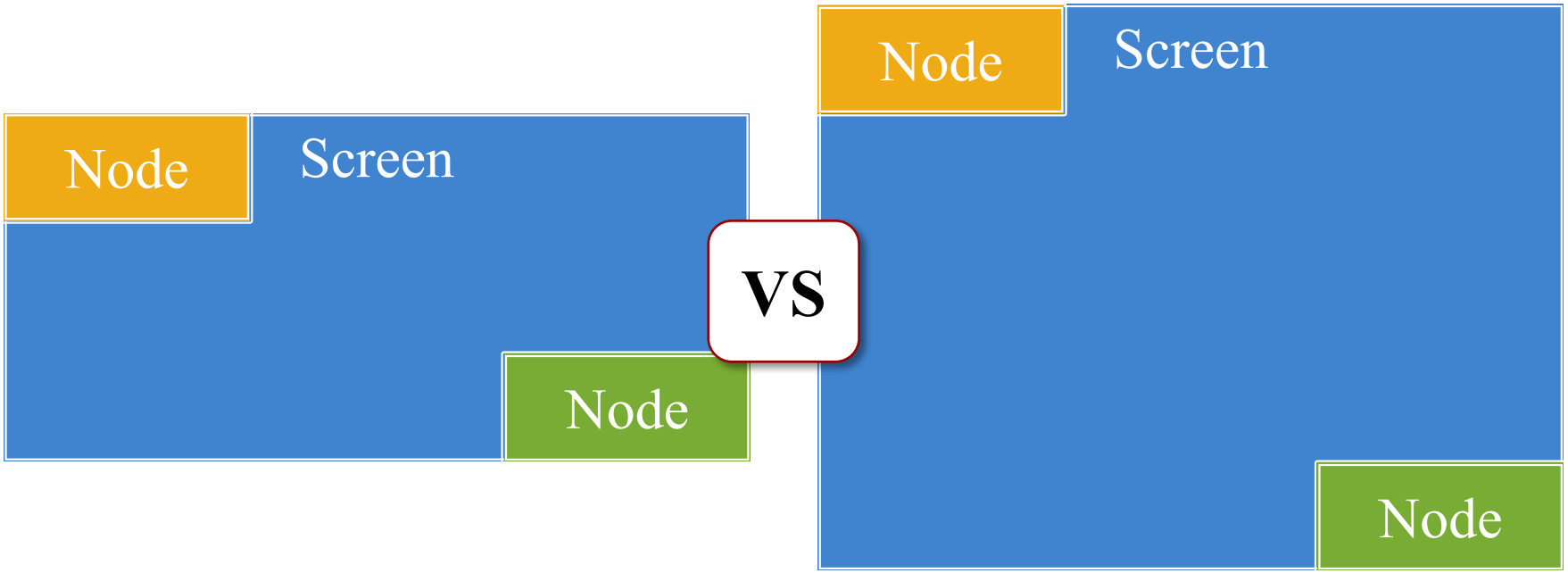

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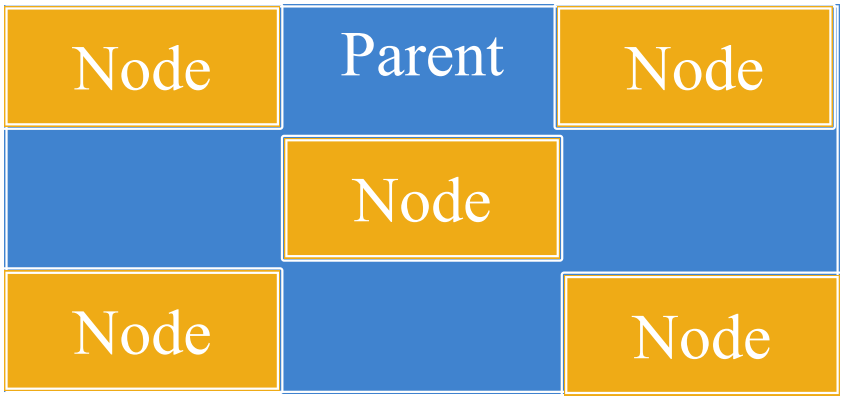
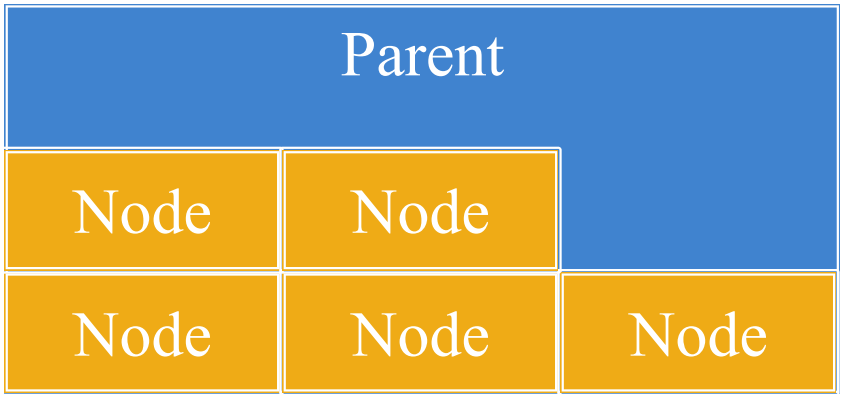
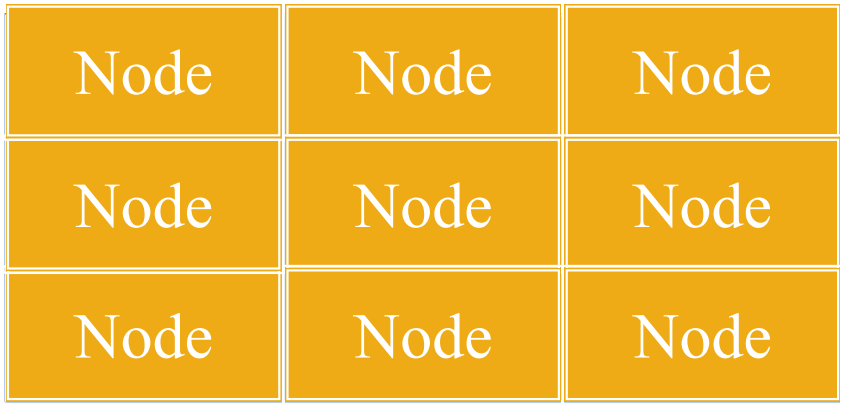


AnchorLayout

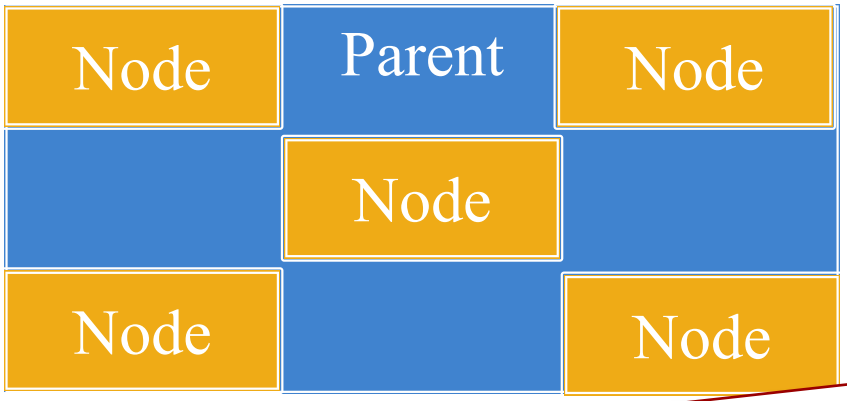


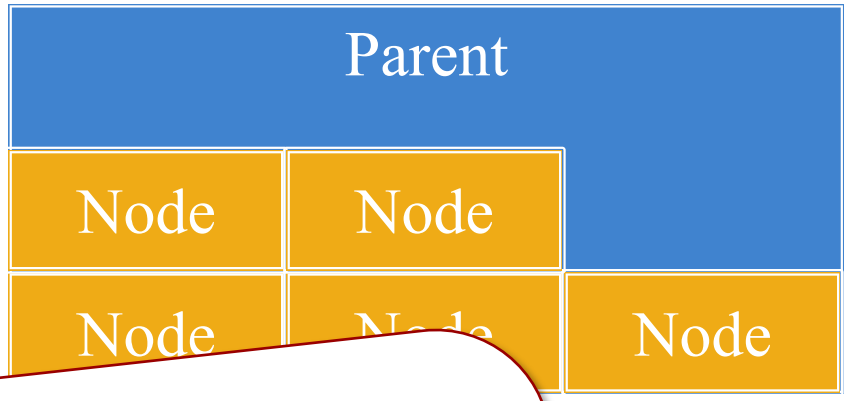
FlowLayout



GridLayout

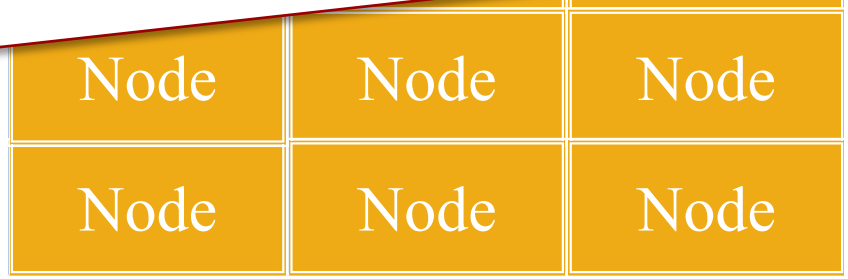
Layout Managers





Anch ut

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

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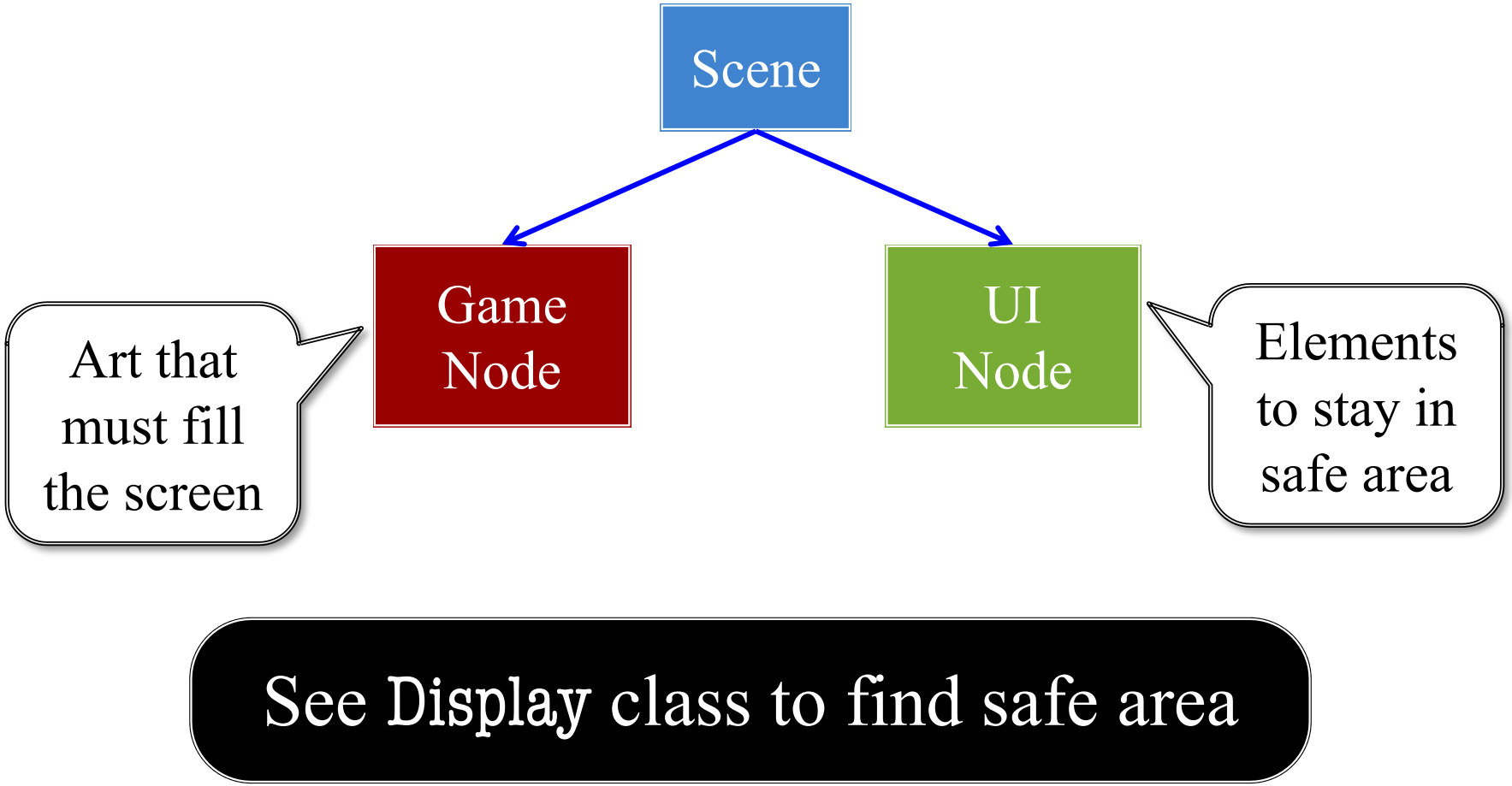
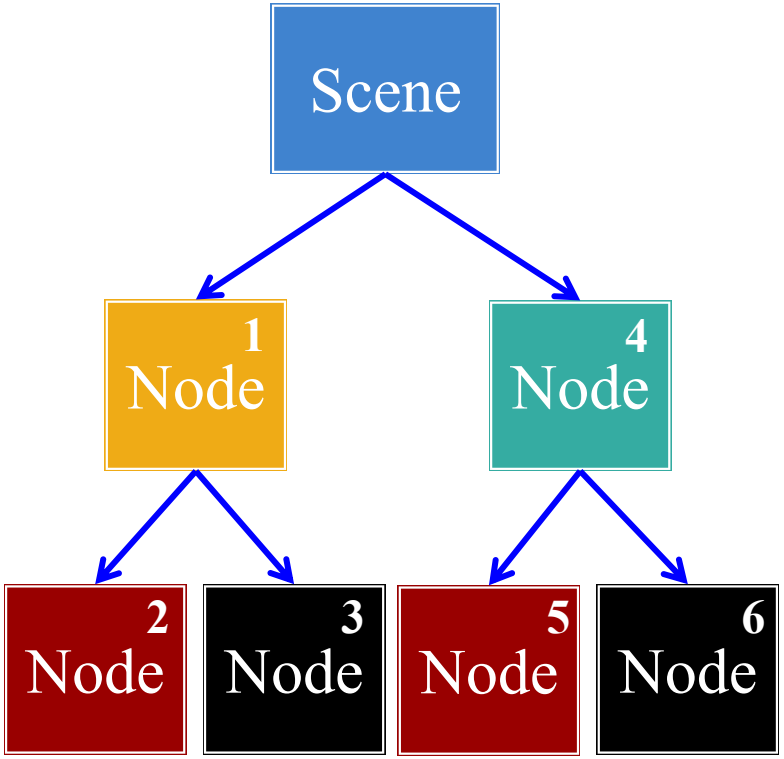
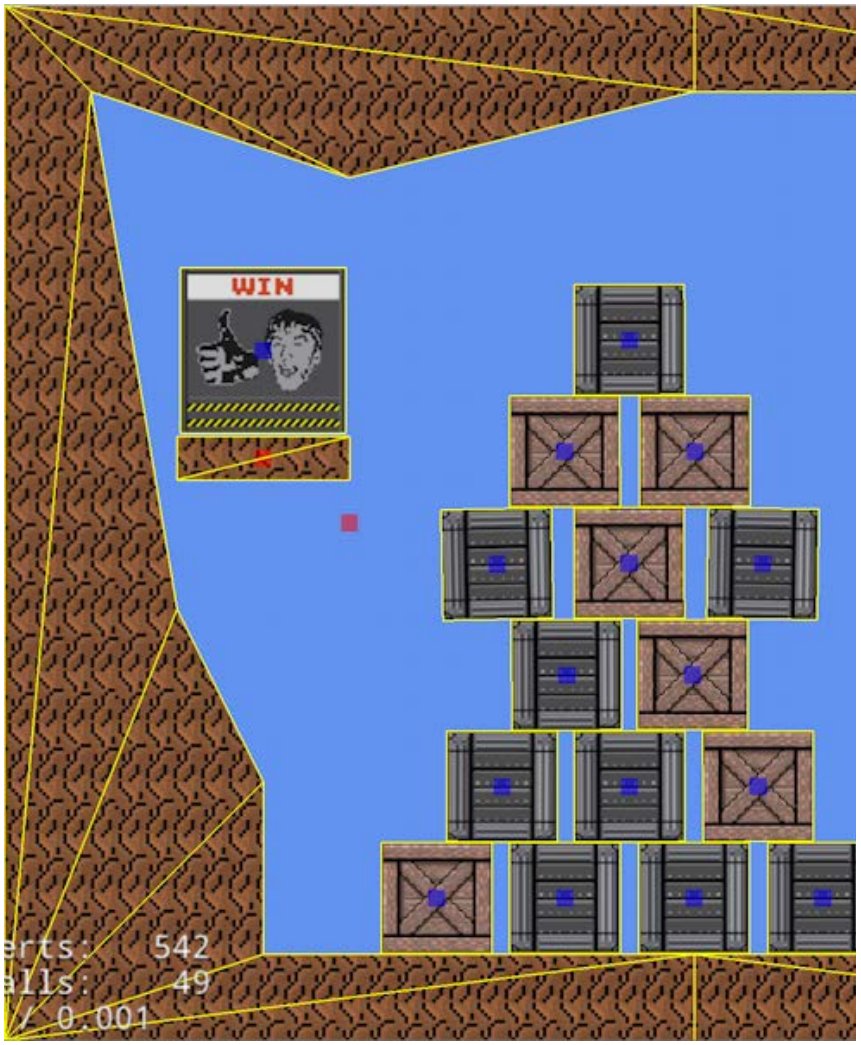


Rendering a Scene is Easy

- **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



How Does a SpriteBatch Work?



- Sprites = textured **triangles**
  - Gather all sprite vertices
  - Make one list of triangles
  - Send them to GPU at once
- But stall on texture change
  - Reorder data on texture
  - Draw texture all at once
  - Limits texture switches
  - Safe if there is **no overlap**
- Hence the name!

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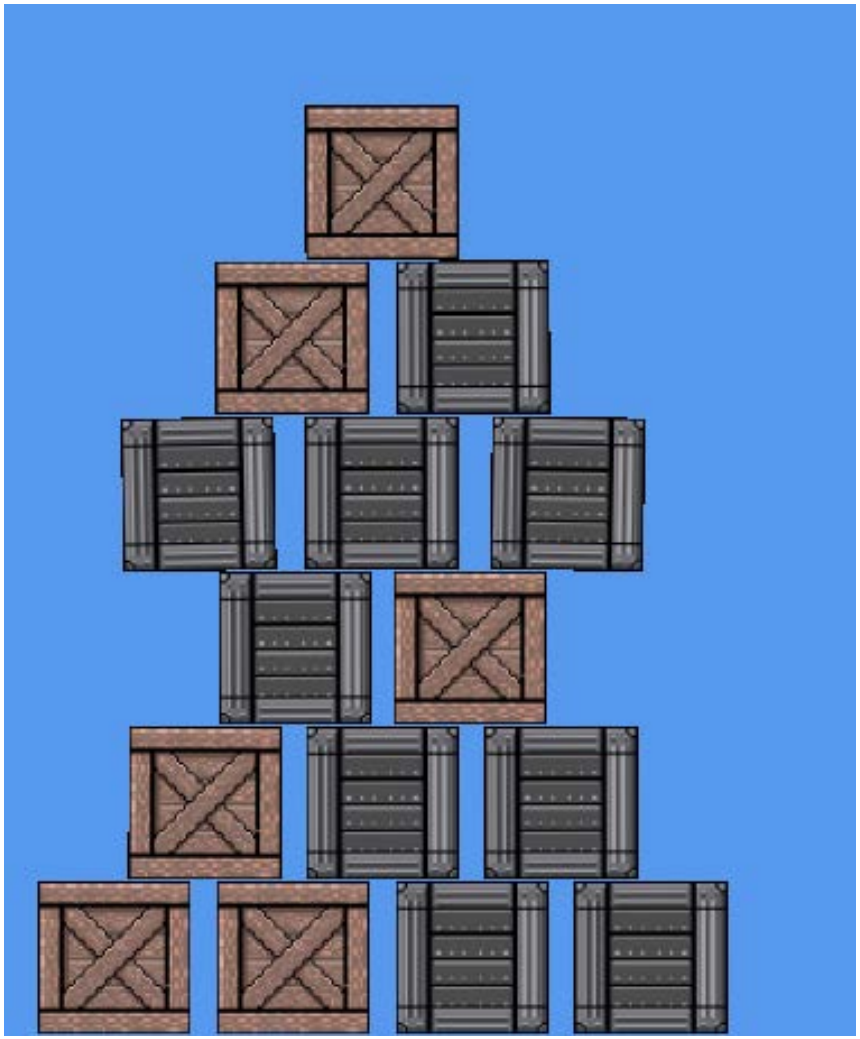

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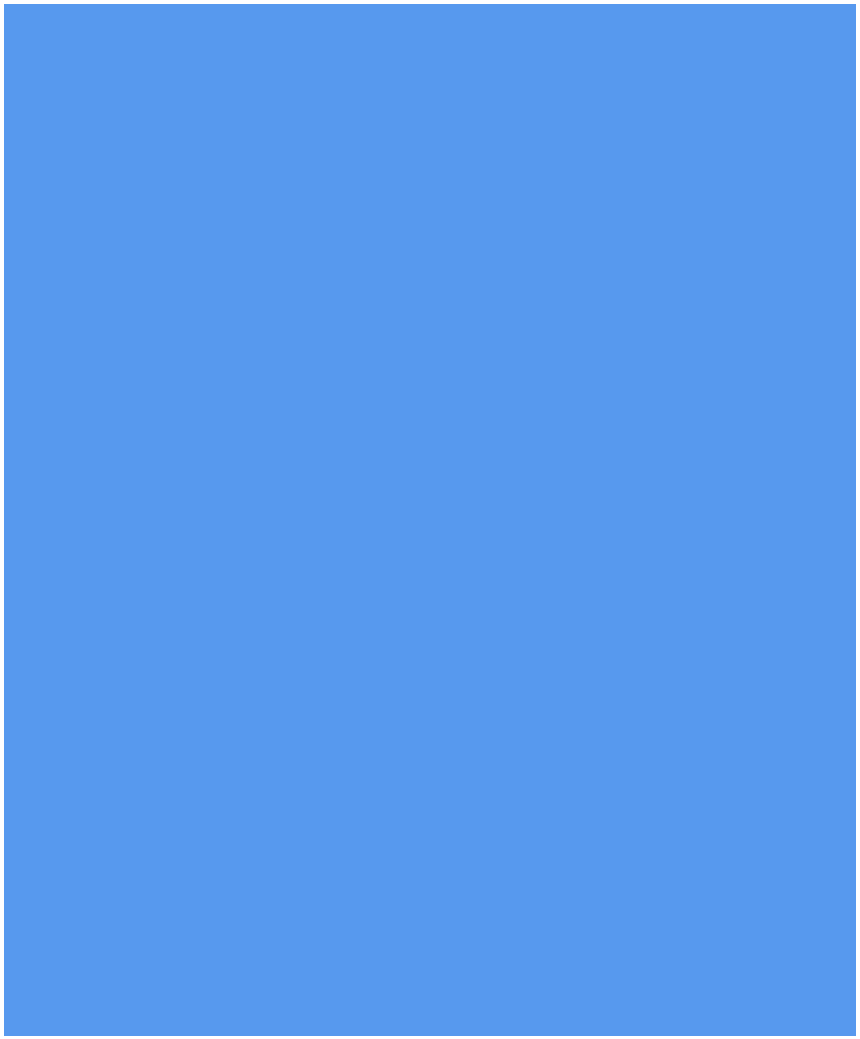

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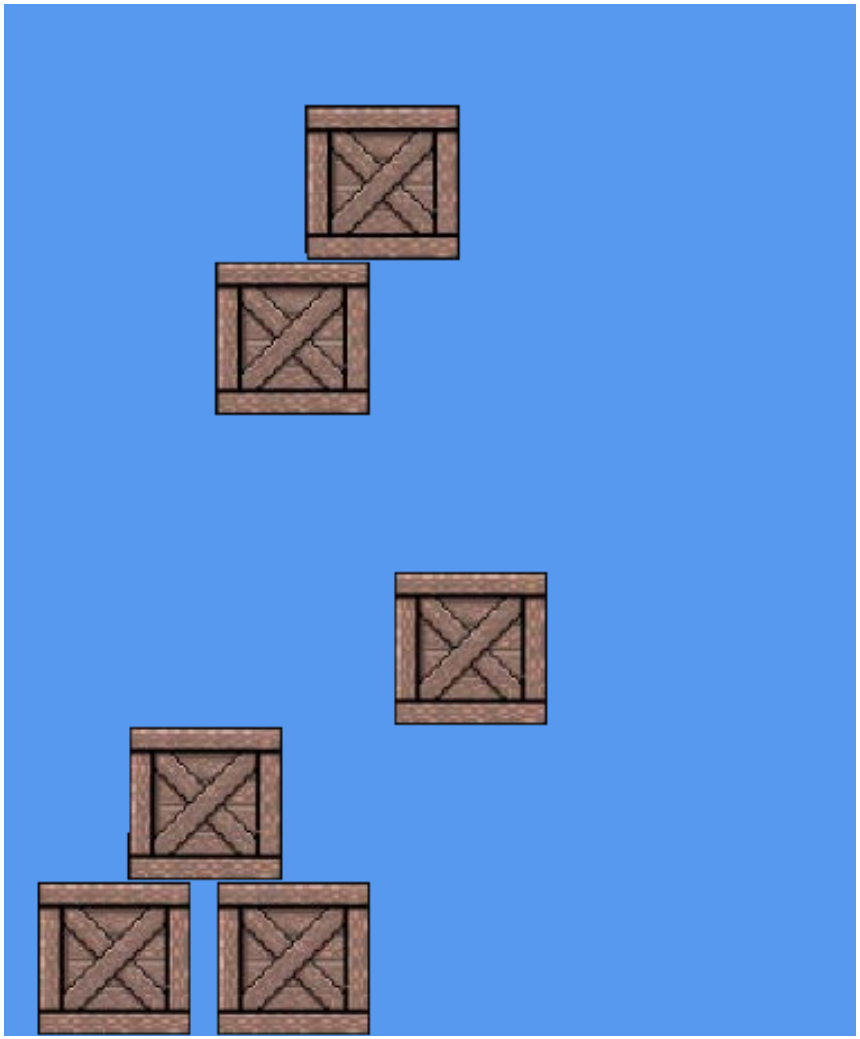

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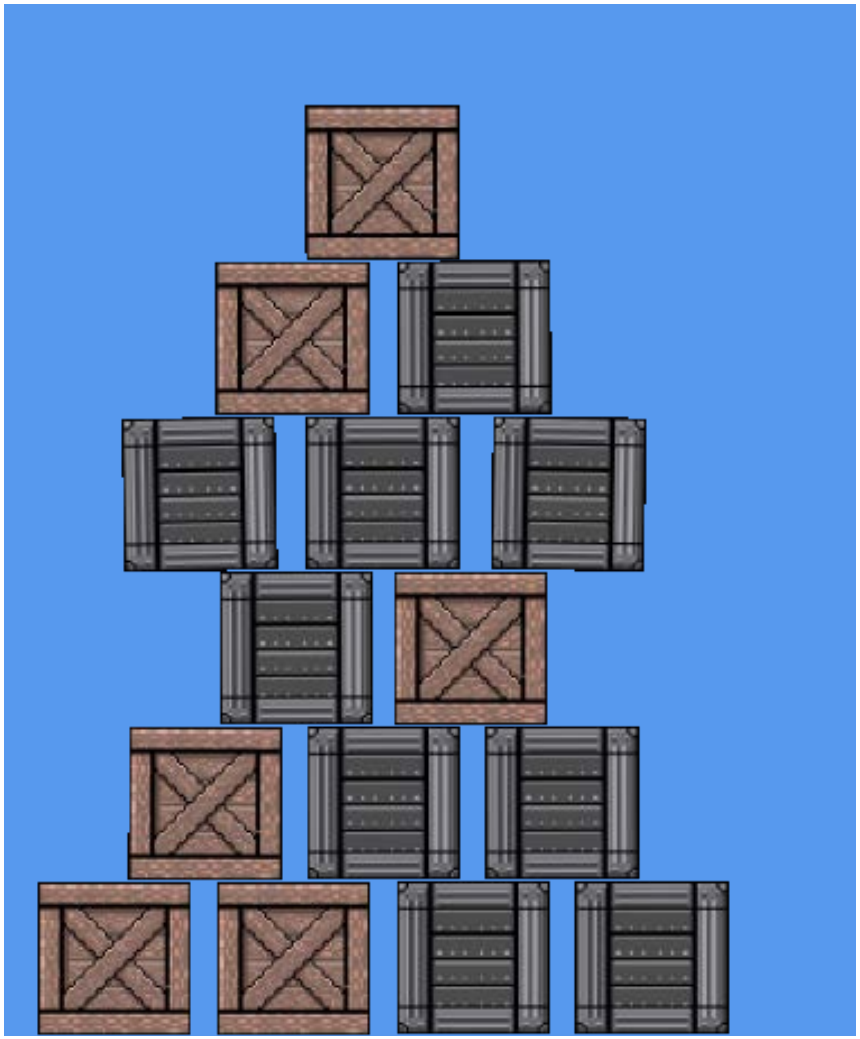

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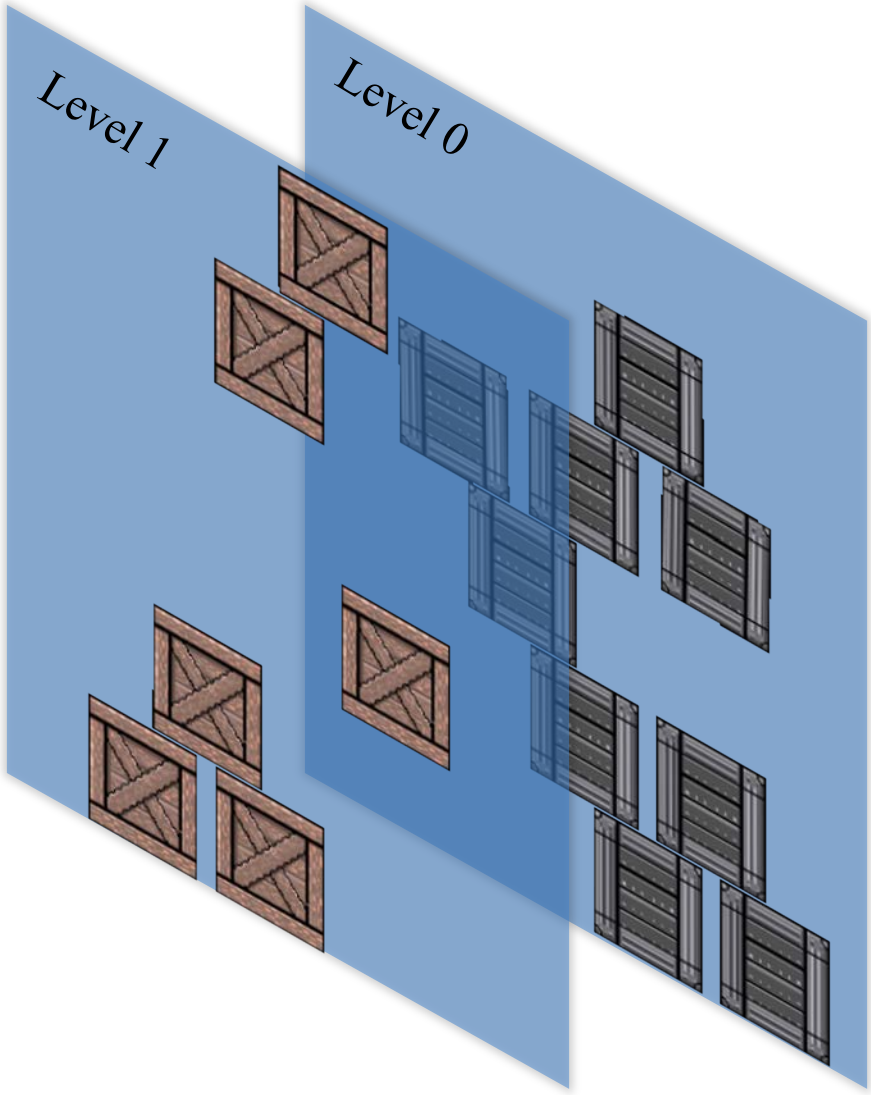
Optimizing Performance: **zOrder**

- `SpriteBatch` defers to `Scene`
  - Scene determines order
  - Nec. because of recursion
- Give ***hints*** to the `Scene`
  - Give each child a *z*-value
  - Ties are permitted
  - `sortZOrder()` sorts tree
  - Can make this automatic
- Controls **texture switching**
  - One texture = one *z*-value
  - Reduces it to one draw call



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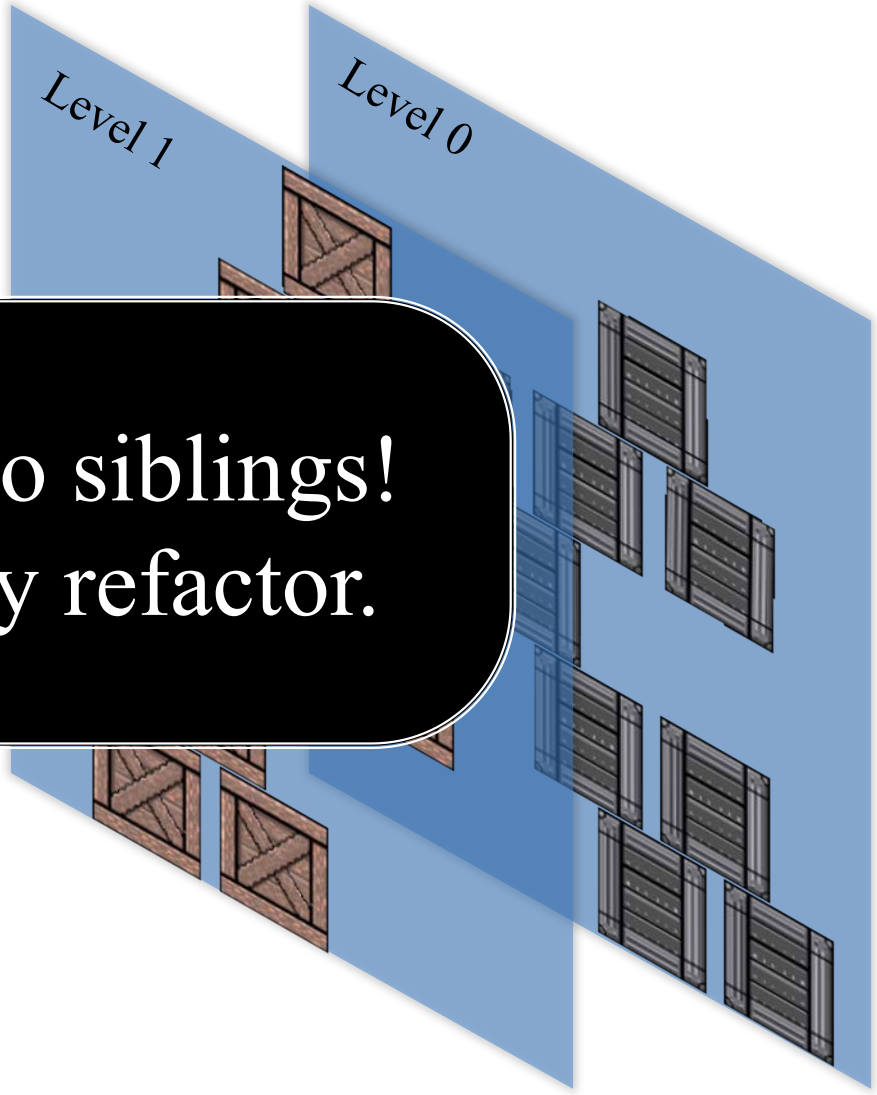
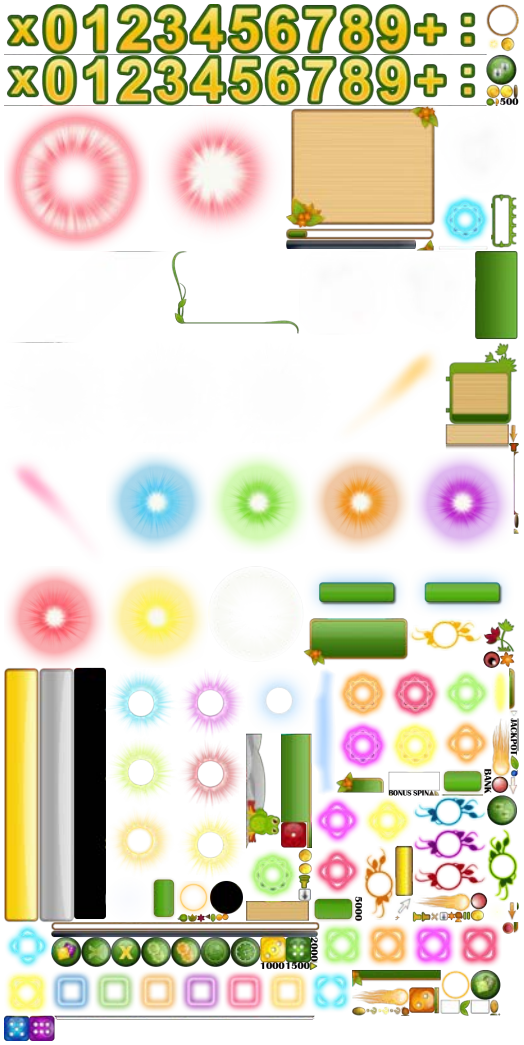


But limited to siblings!
High priority refactor.

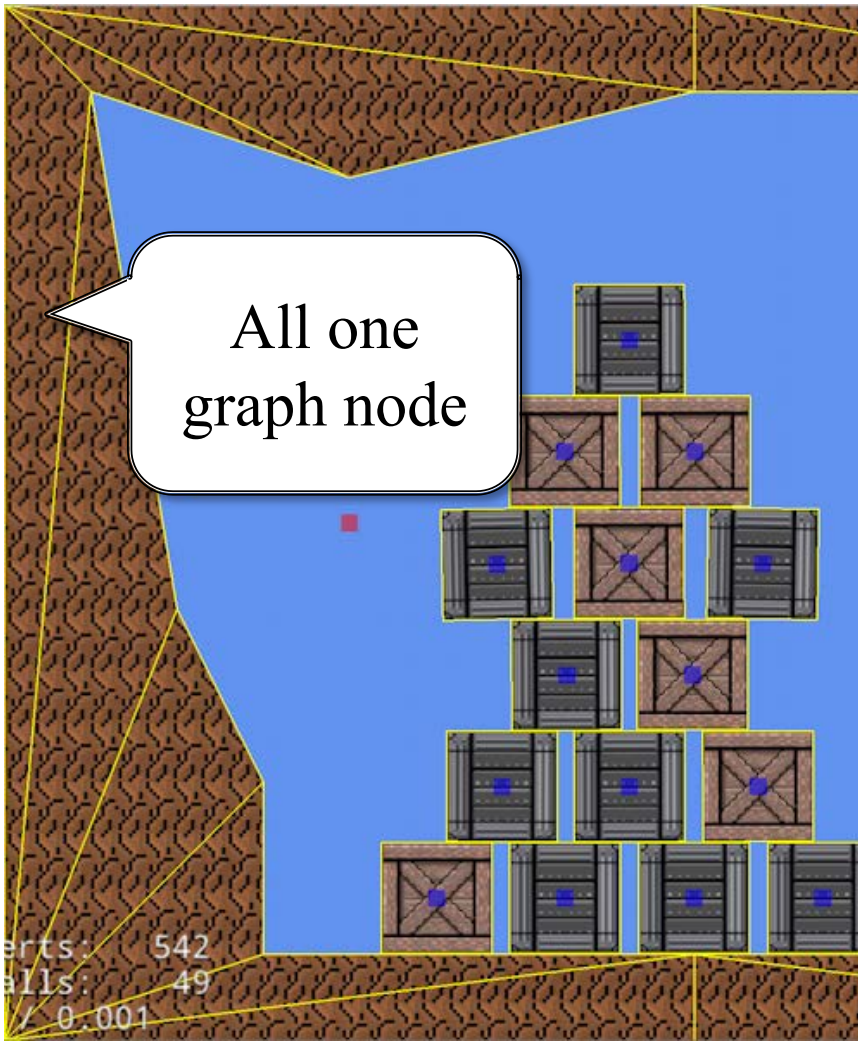
Optimizing Performance: **Atlases**

- **Idea**: Never switch textures
  - Film strip is many images
  - We can draw part of texture
  - One texture for everything?
  - Called a **texture atlas**
- Disadvantages?
  - Cannot tile textures
  - Can be tricky to pack
- Ideal for **interface design**
  - Images for UX widgets
  - Often small and compact

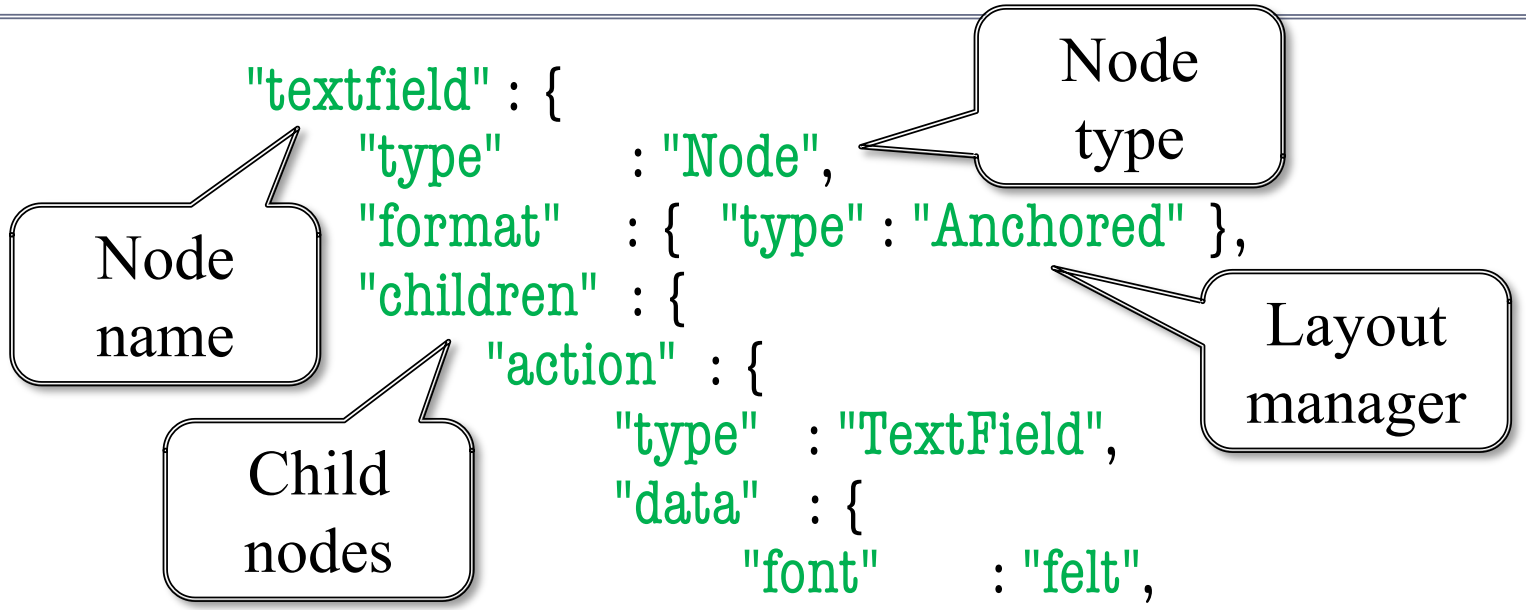


Specialized Nodes

- CUGL has many node types
  - `AnimationNode` (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




```
"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"
            }
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Layout manager

Node data

Info for parent layout

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                  }
```

Each node has

- Type
- Format
- Data
- Children
- Layout

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"}
   }}}
```

JSON

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

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"   : "Bu
   "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

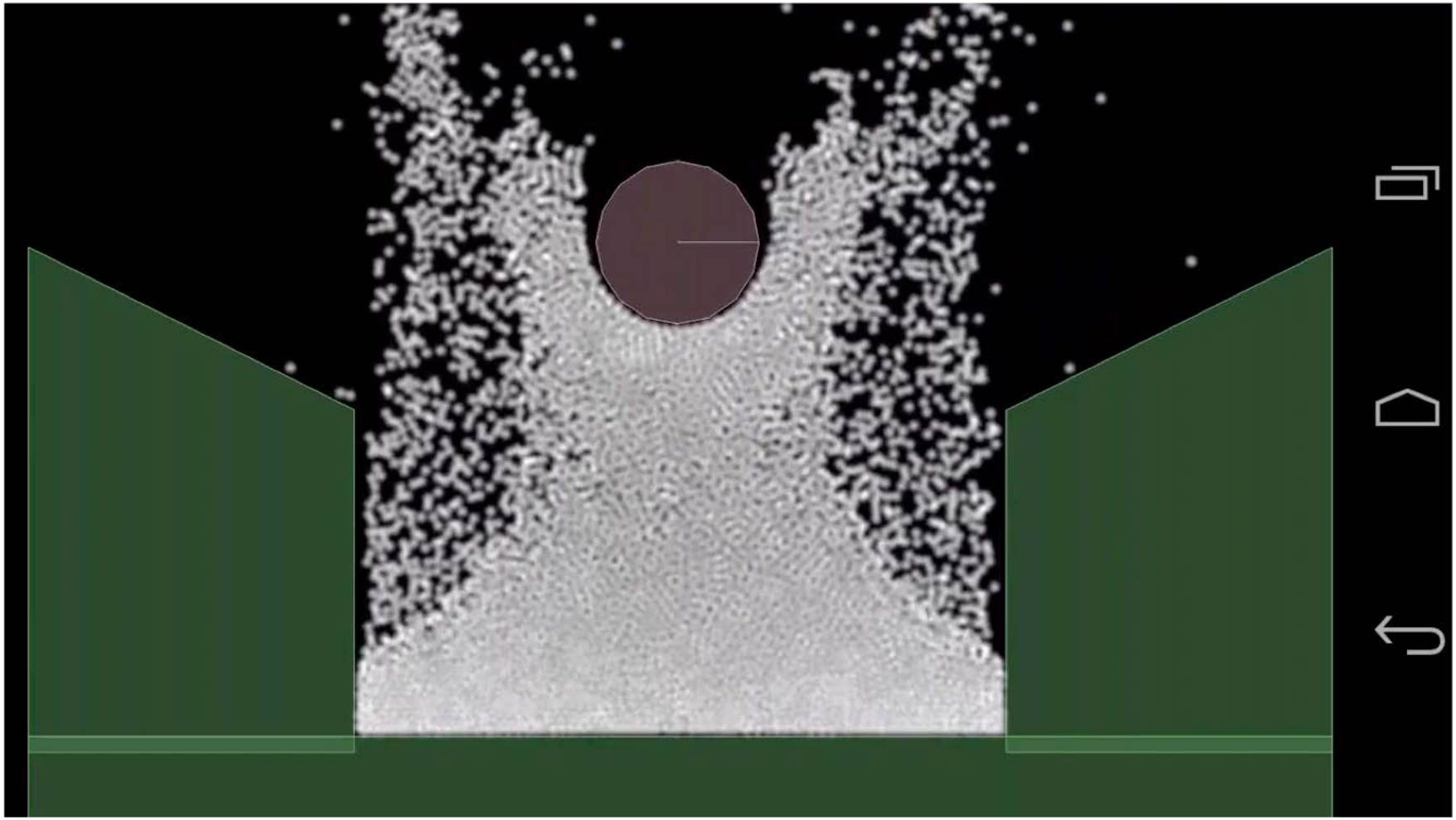
Provide the layout

JSON

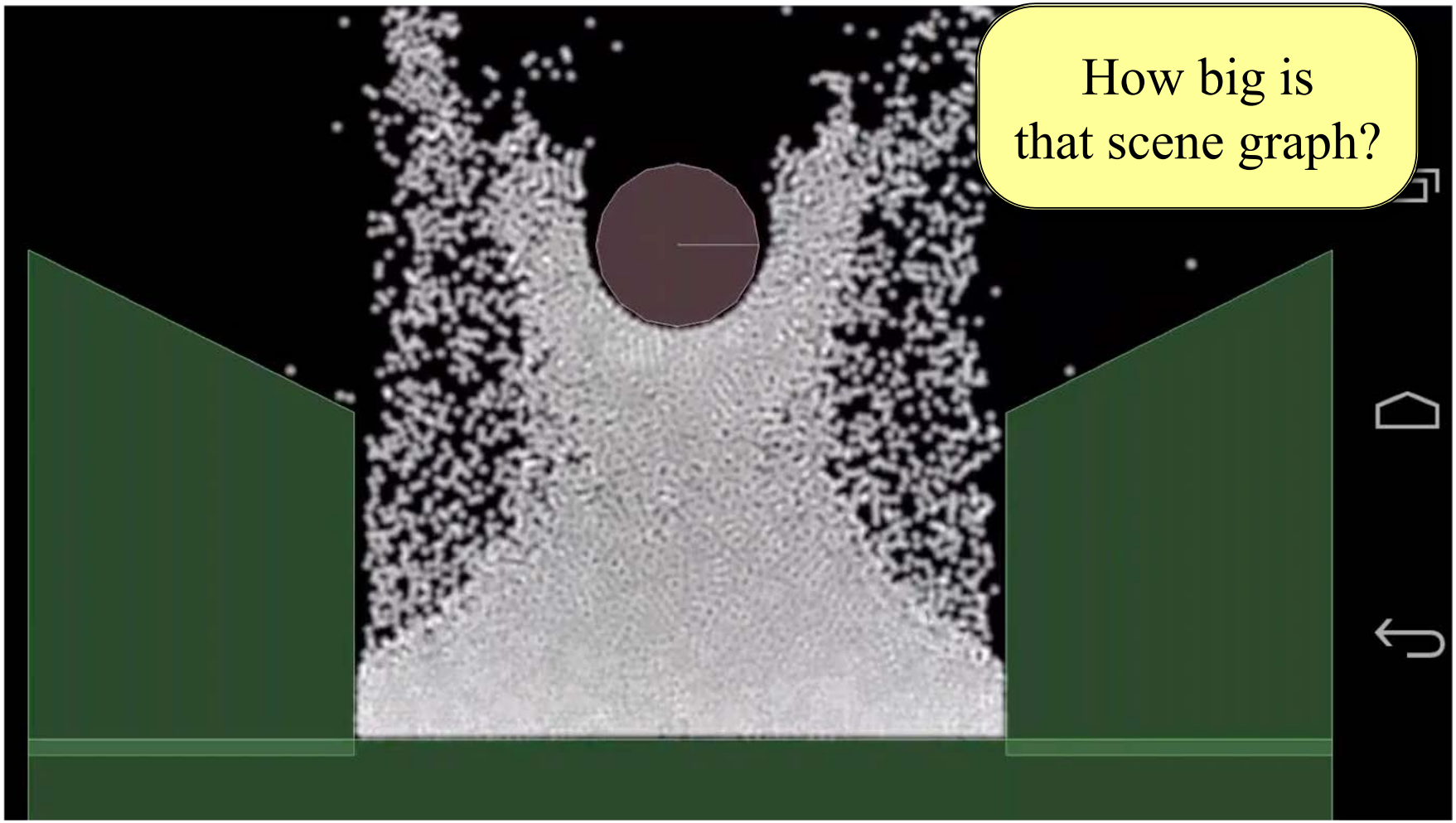
```
"widgets": {
   "mybutton" : "widgets/mybutton.json",
},
"scene2s": {
   "thescene" : {
   "type"     : "Node",
   "format" : { "type" : "Anchored" },
   "children"  : {
      "button"  : {
         "type"   : "V
         "data"   : {
            "key" : "mybutton",
            "variables" : { "image":"altplay"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

Change the variable

The Problem: **Physics**



The 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 Mat4& transform, Color4 tint) {

    if (!_rendered) {
        generateRenderData();
    }

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

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

The **draw()** Method

```
void CustomNode::draw(const std::shared_ptr<SpriteBatch>& batch,
                      const Mat4& transform, Color4 tint) {

    if (!_rendered) {
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    batch->setBlendFunc(_srcFactor, _dstFactor);

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

Computed from parent (+camera)

Computed from parent (+scene)

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)
- New JSON language makes design easier