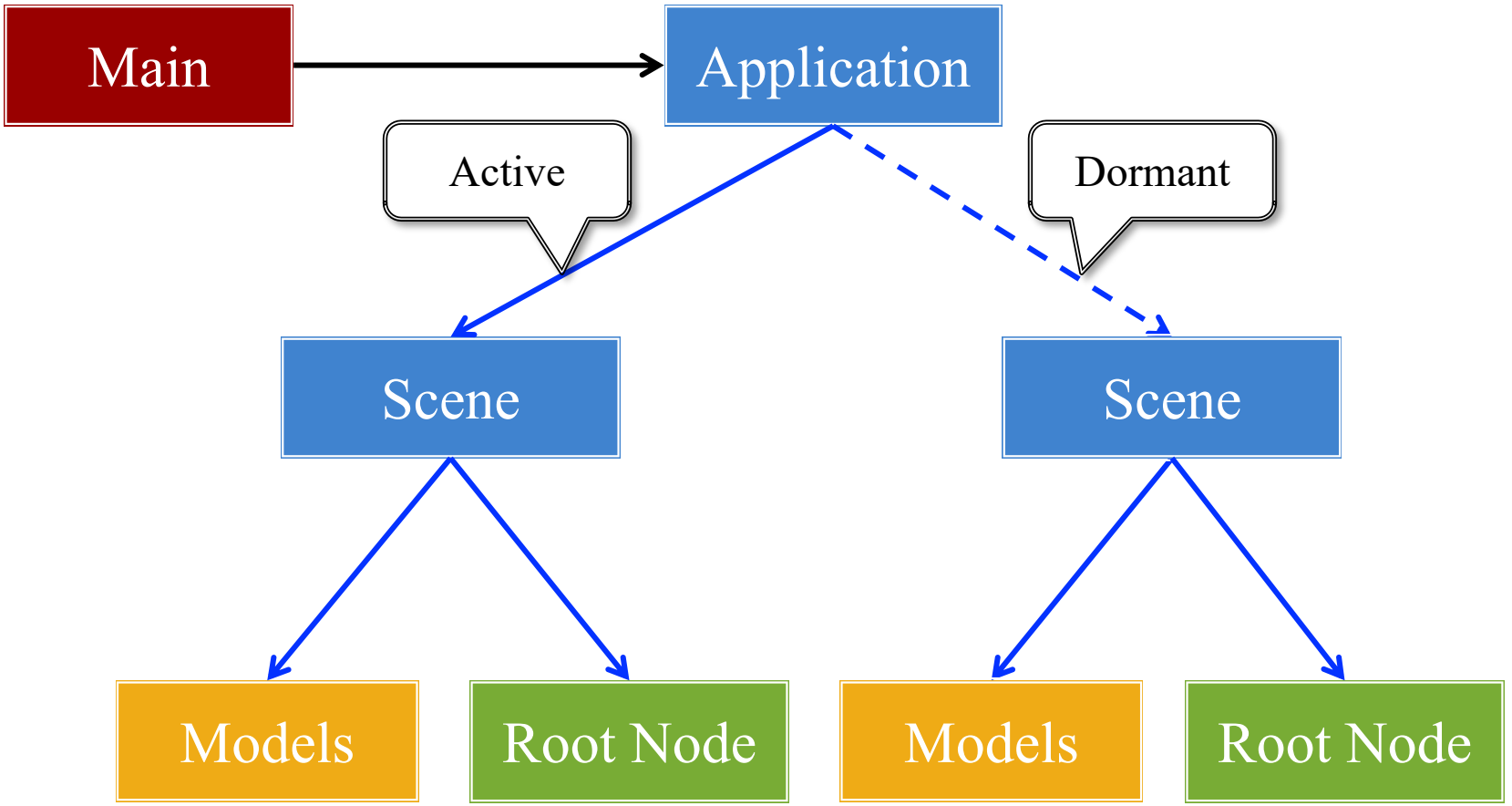
the gamedesigninitiative at cornell university

Lecture 7

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
- C… …ay 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
  - …
  - …solves other interactions
- Updates the scene graph
  - Transforms nodes
  - Enables/disables nodes

Does not draw! Handled separately

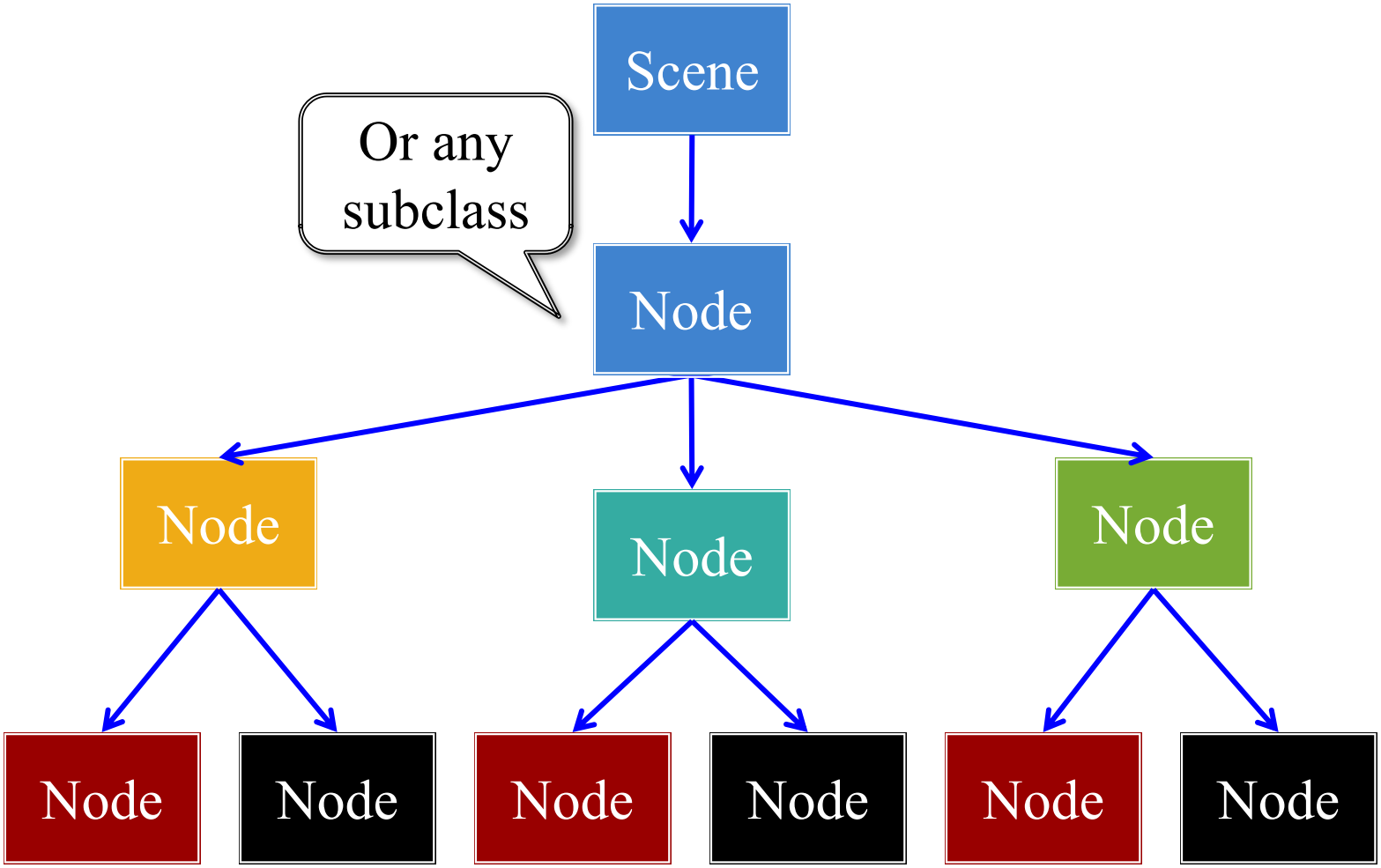
Drawing in CUGL

- Use **render()** method
  - Called after update()
  - Clears screen first
  - Uses clear color field
- Can use any OpenGL
  - Included in CUBase.h
  - Best to use OpenGLES (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



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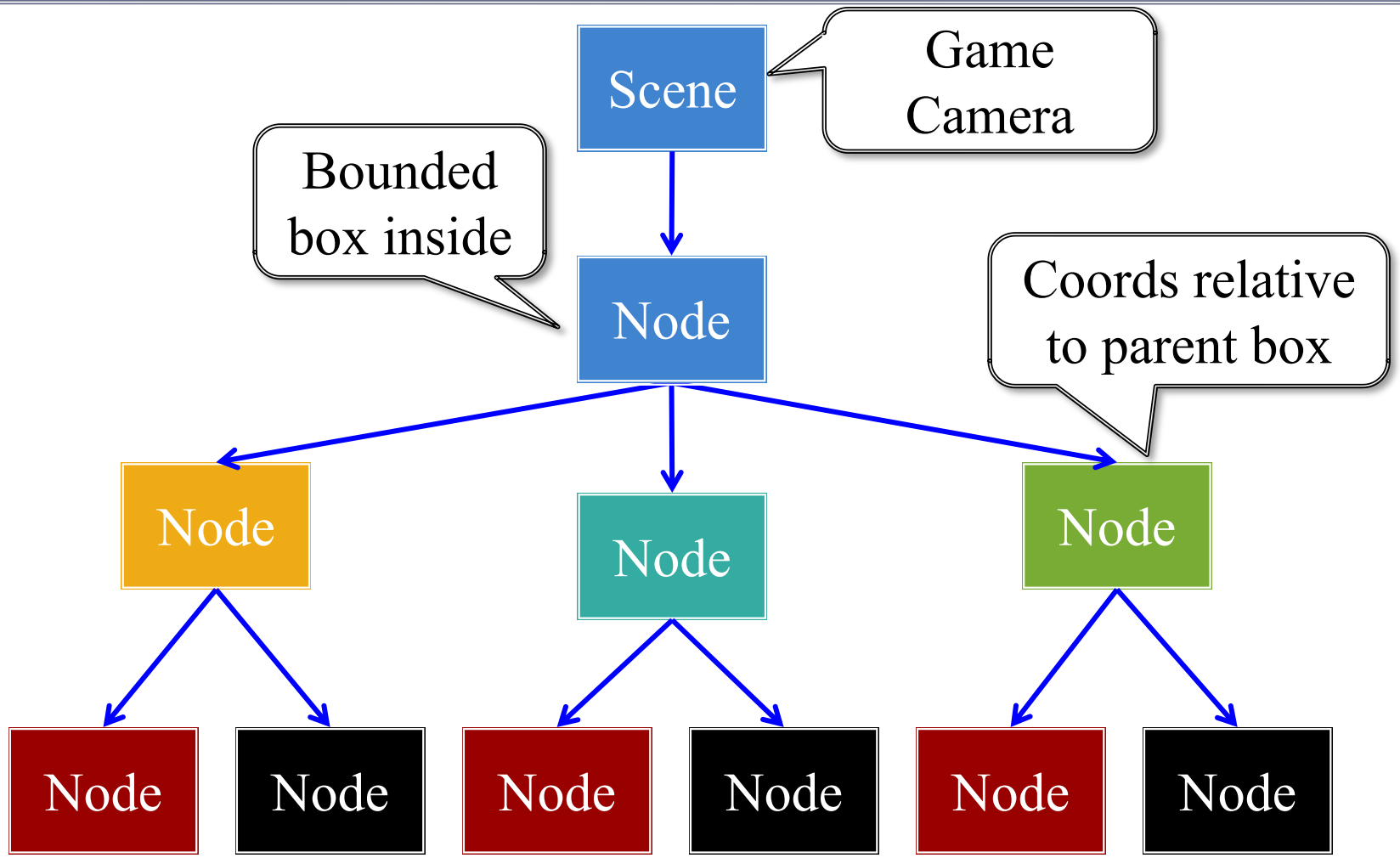
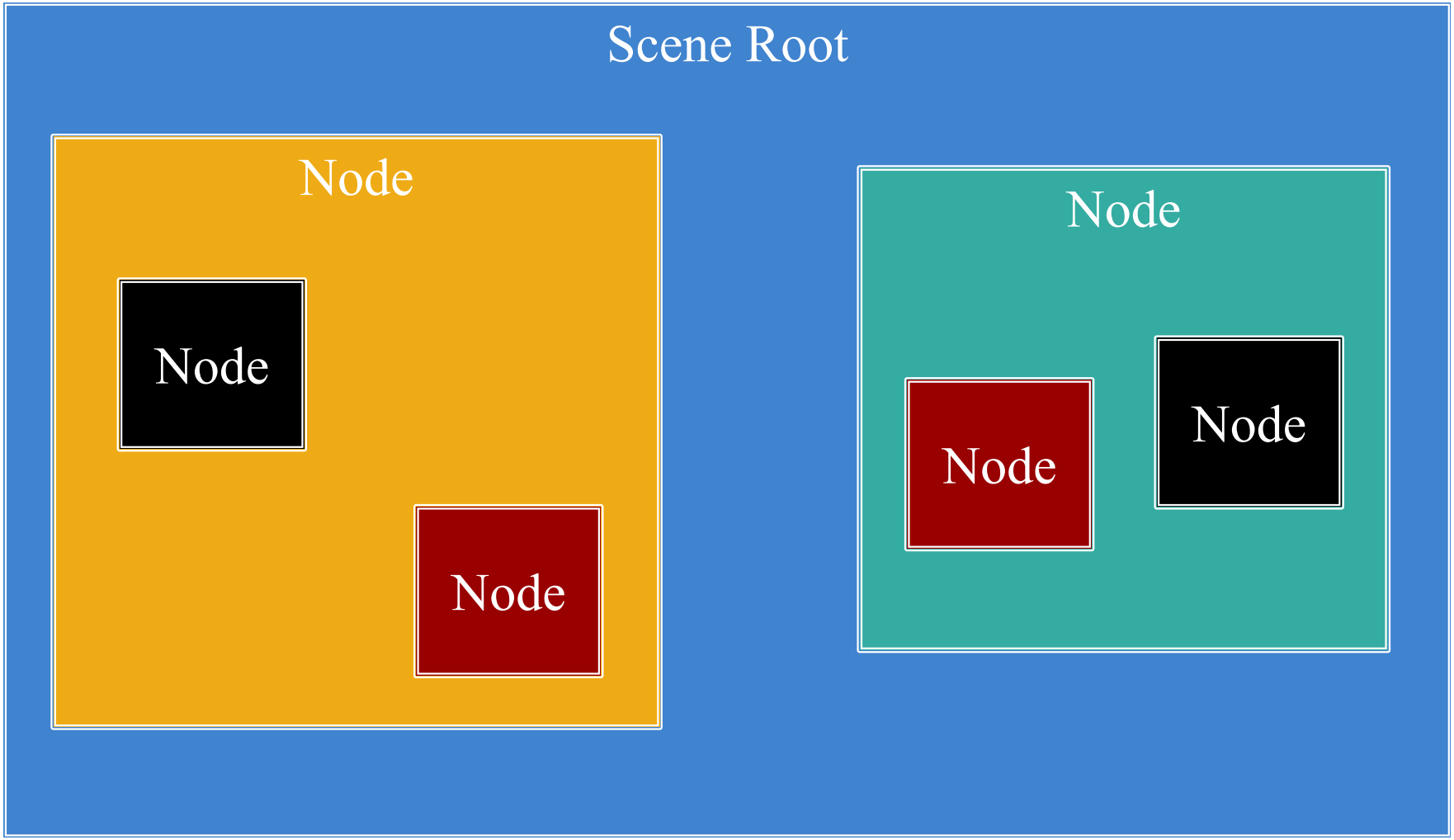


Each Node is a Coordinate System



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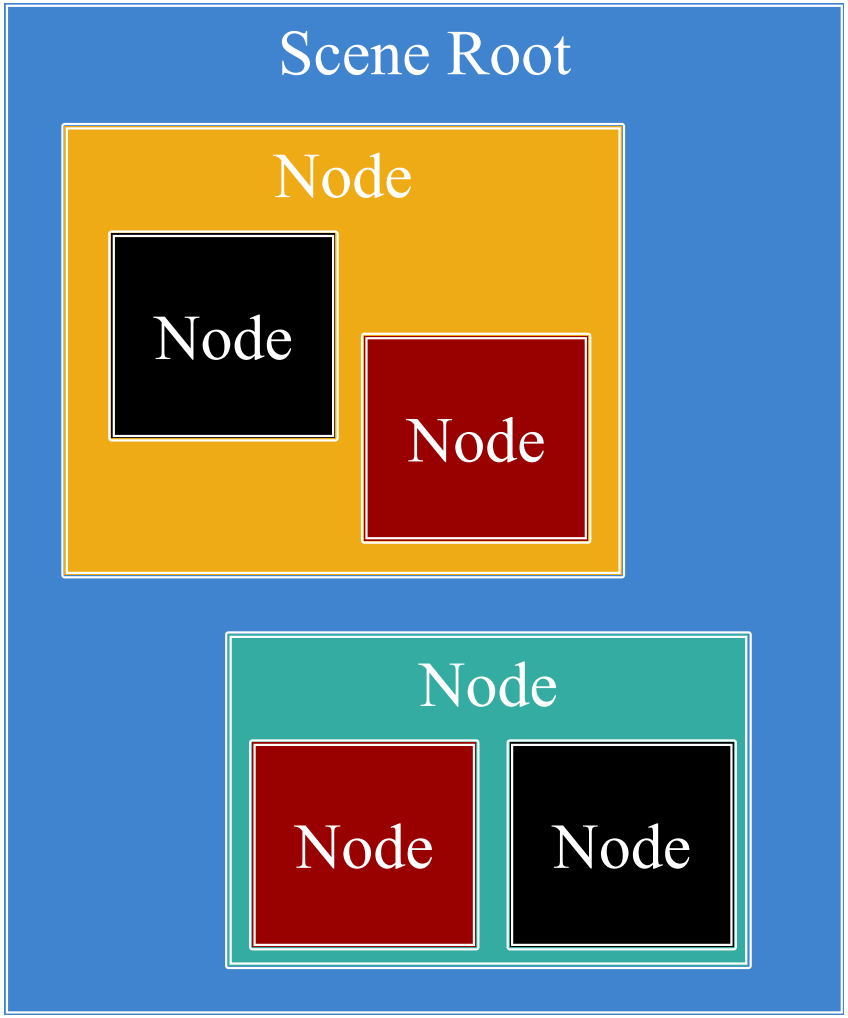

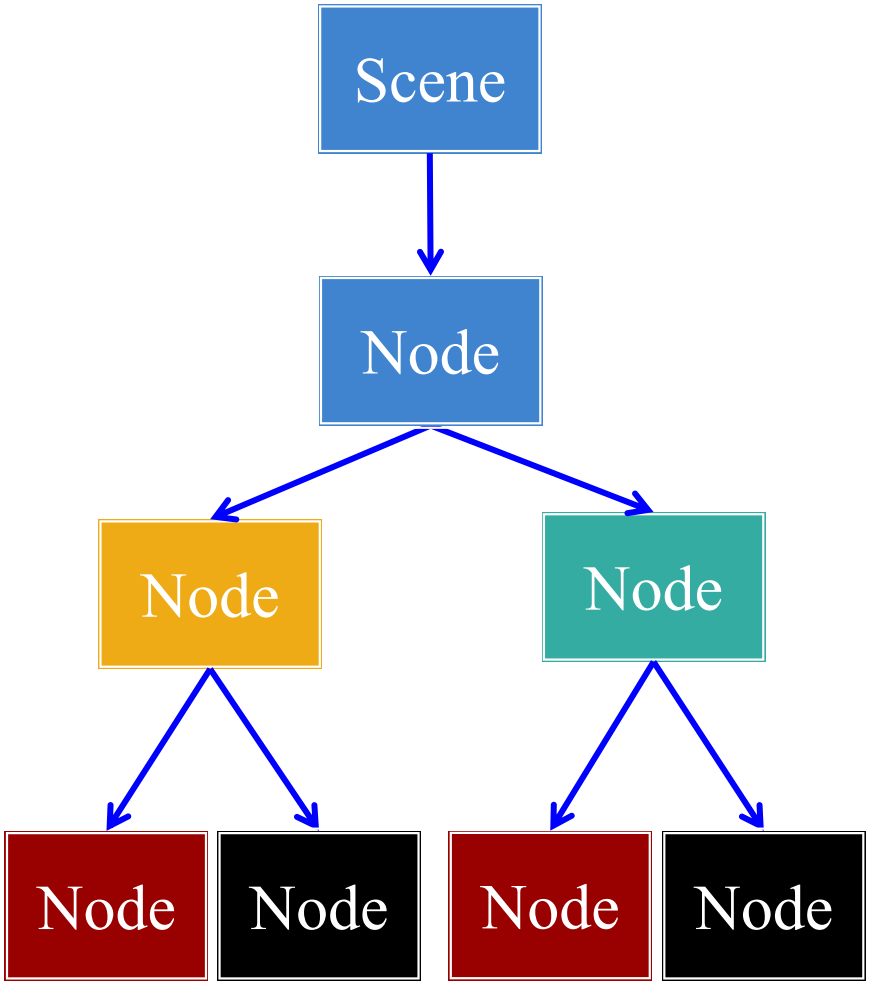

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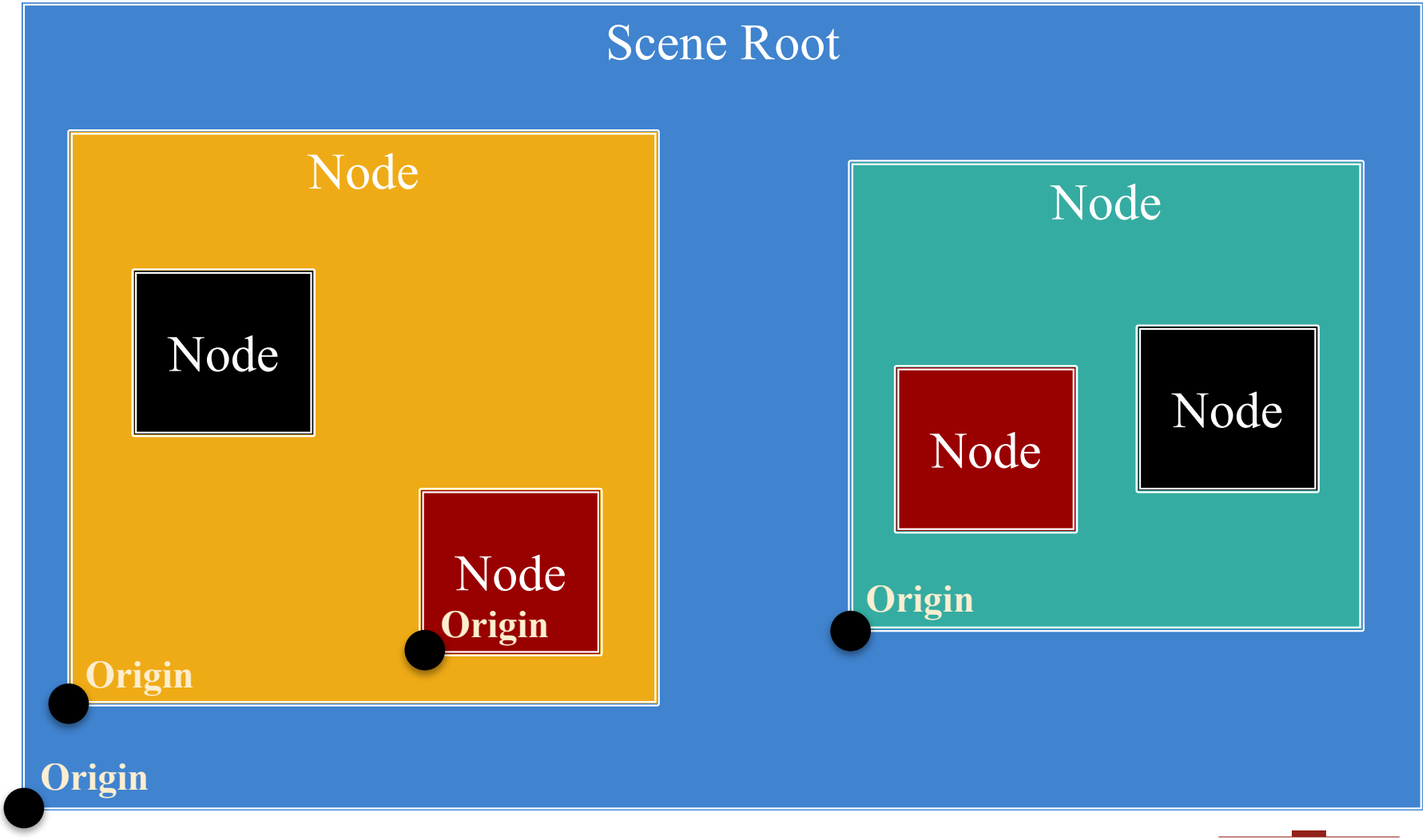
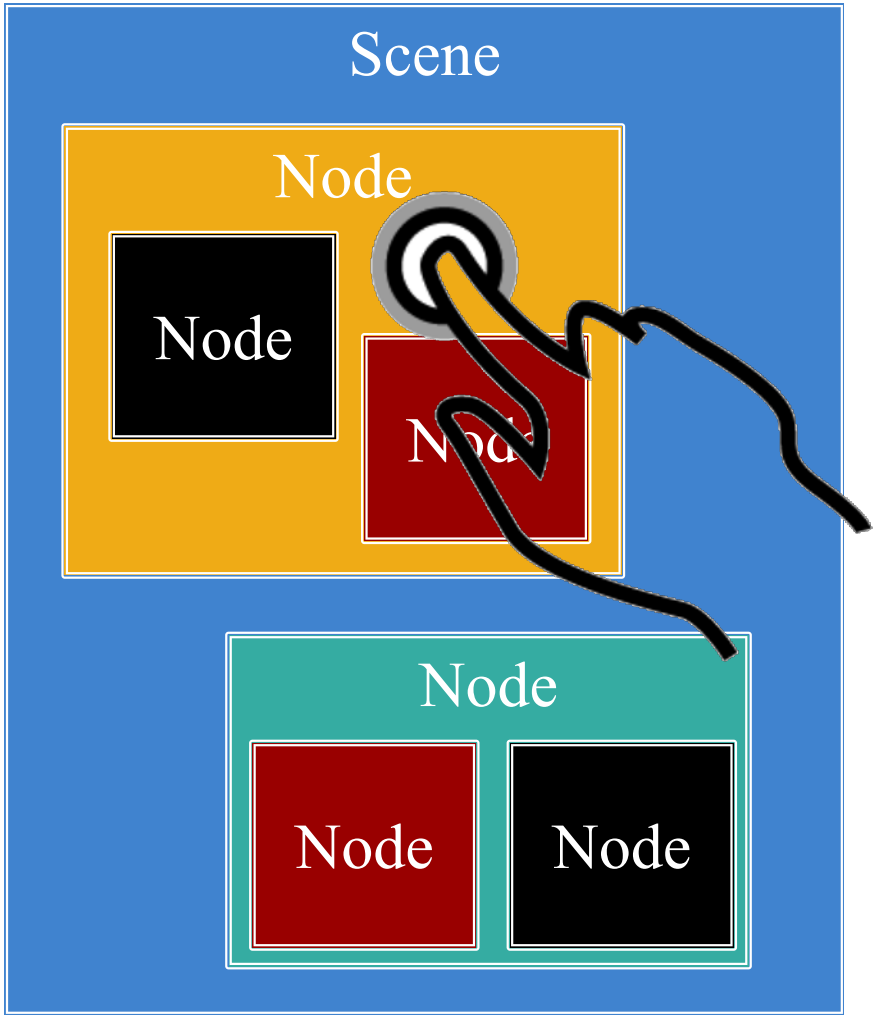
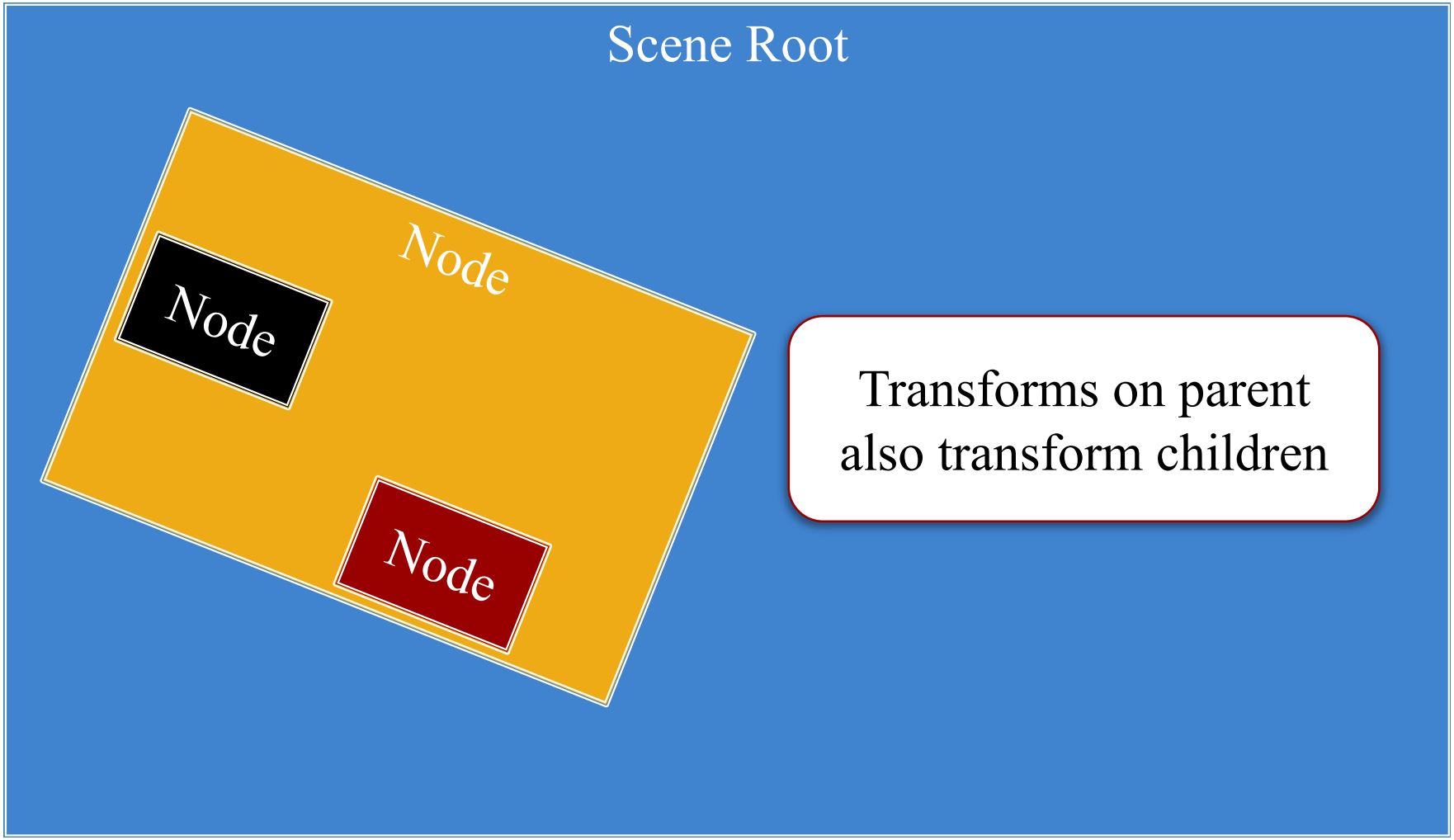


Motivation: Touch Interfaces

- 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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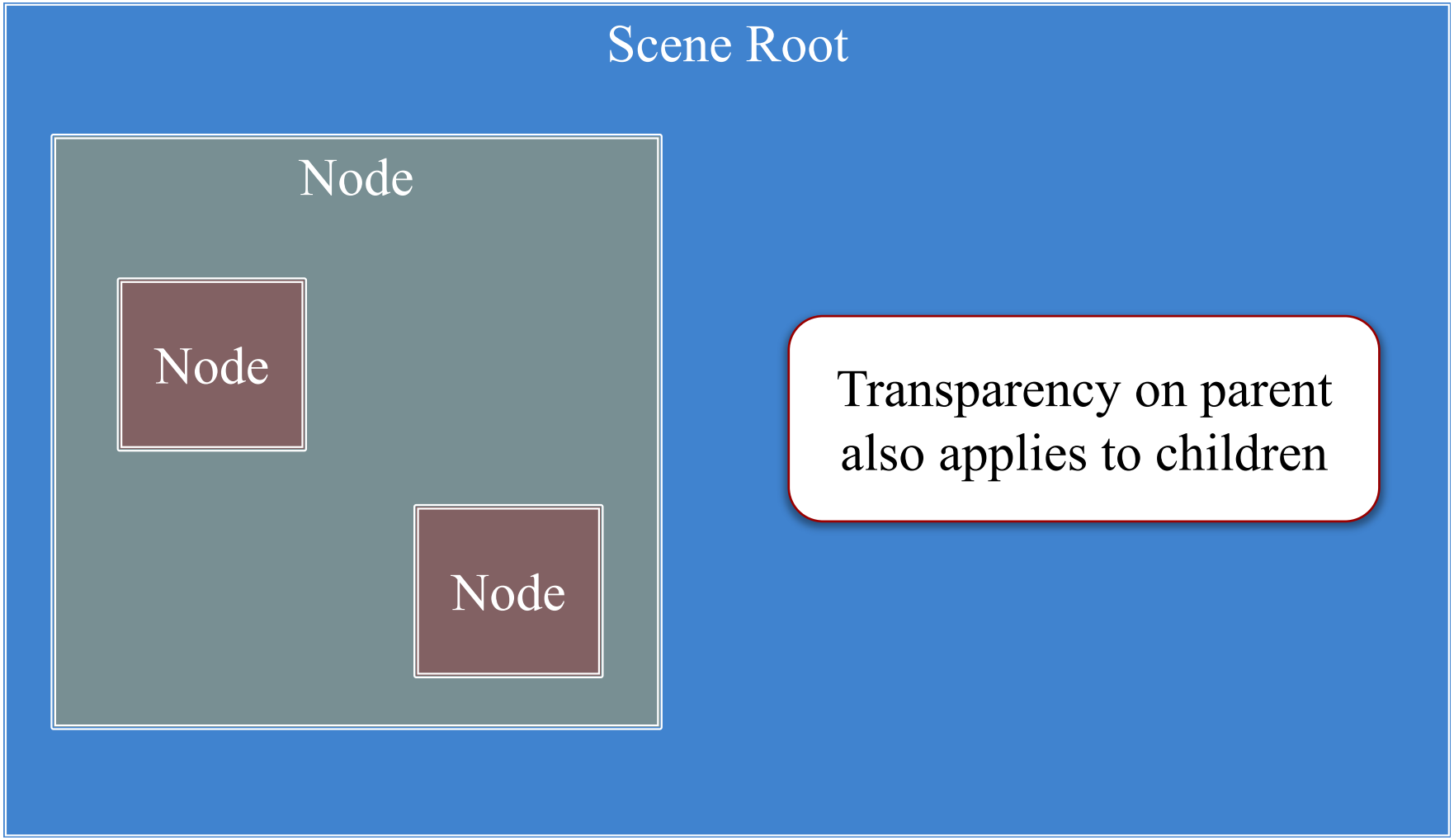

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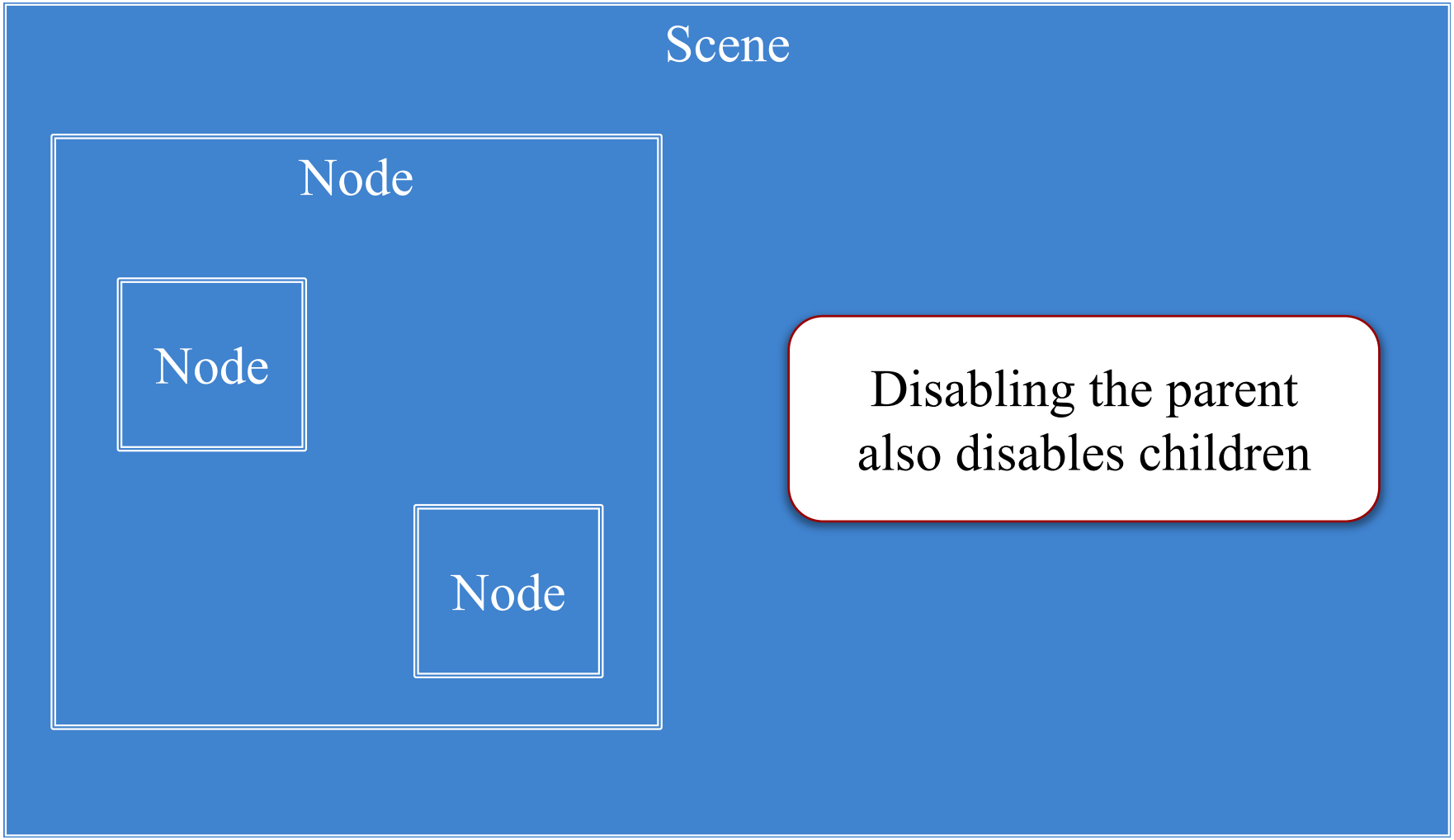
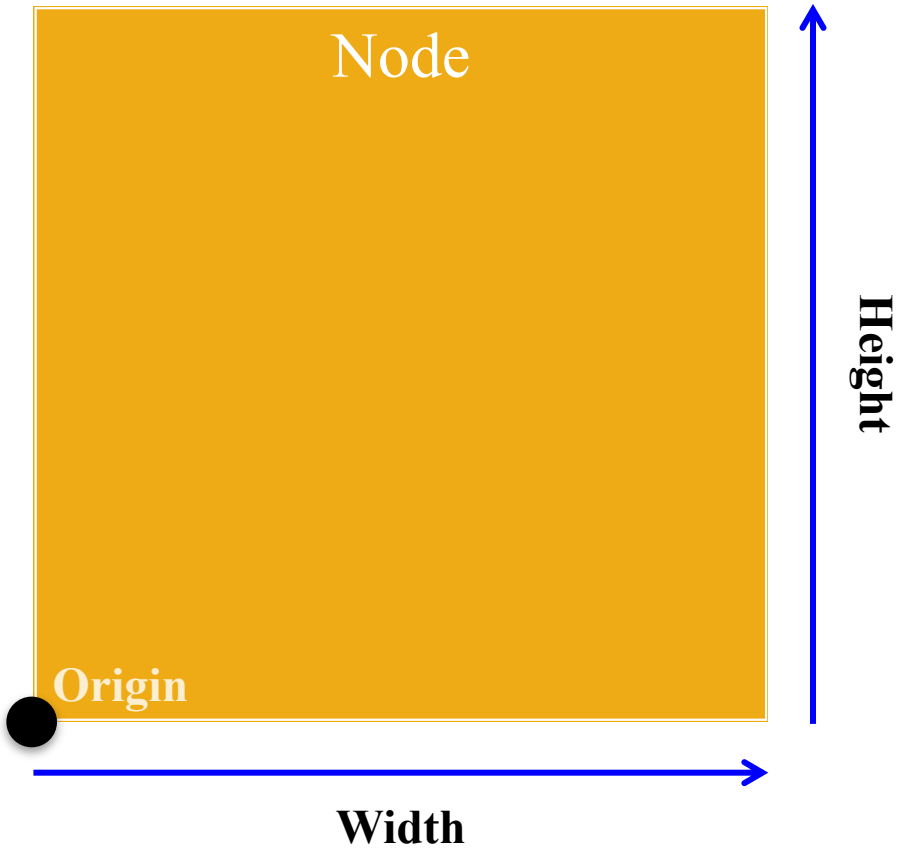


Anchors and Content

- 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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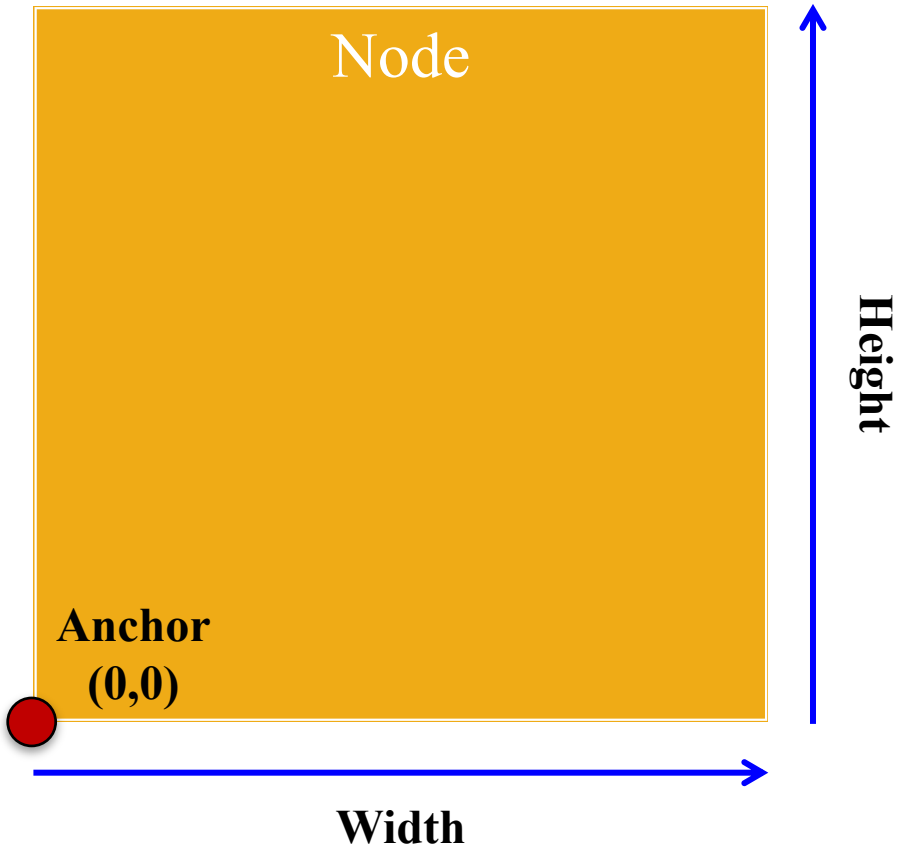

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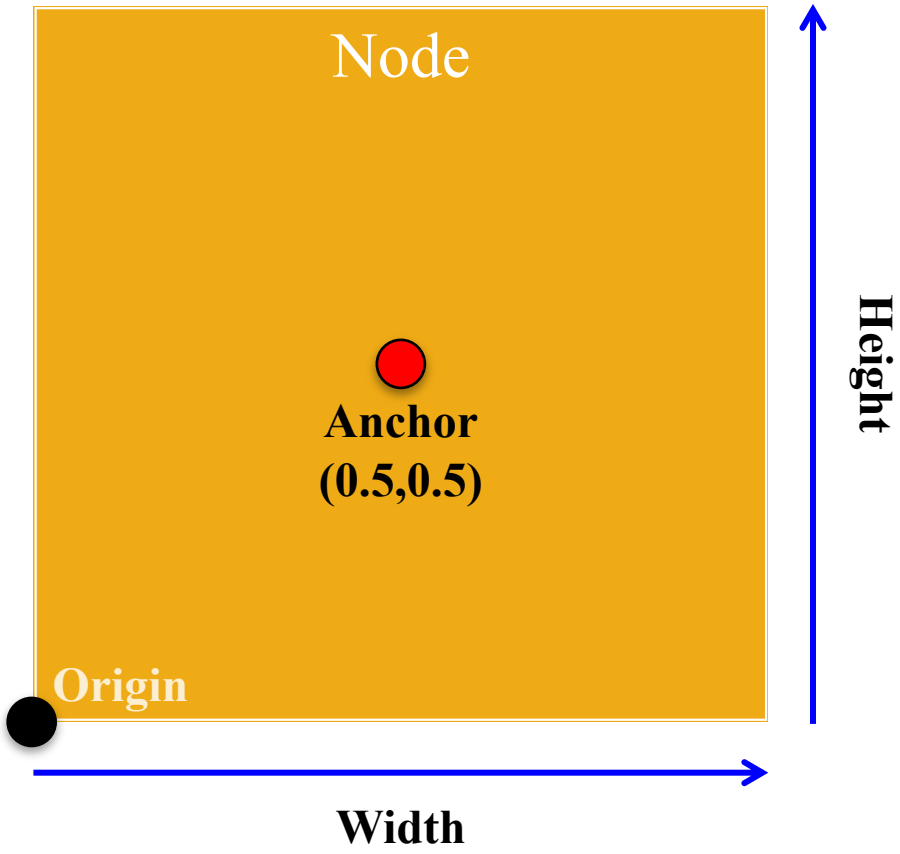

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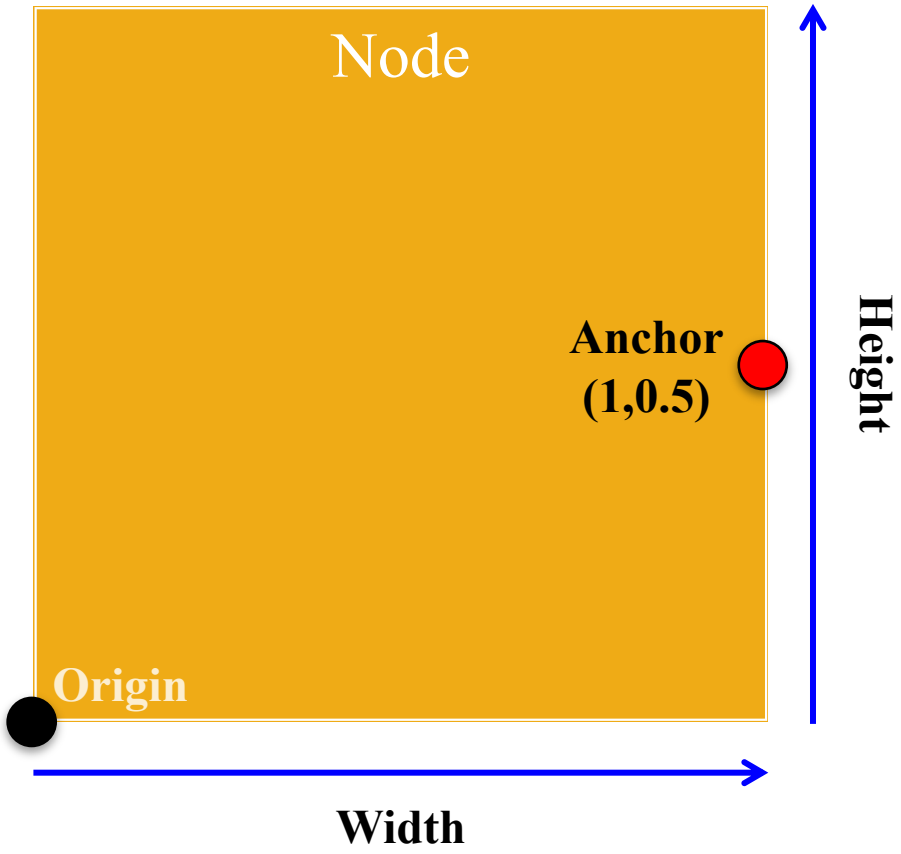
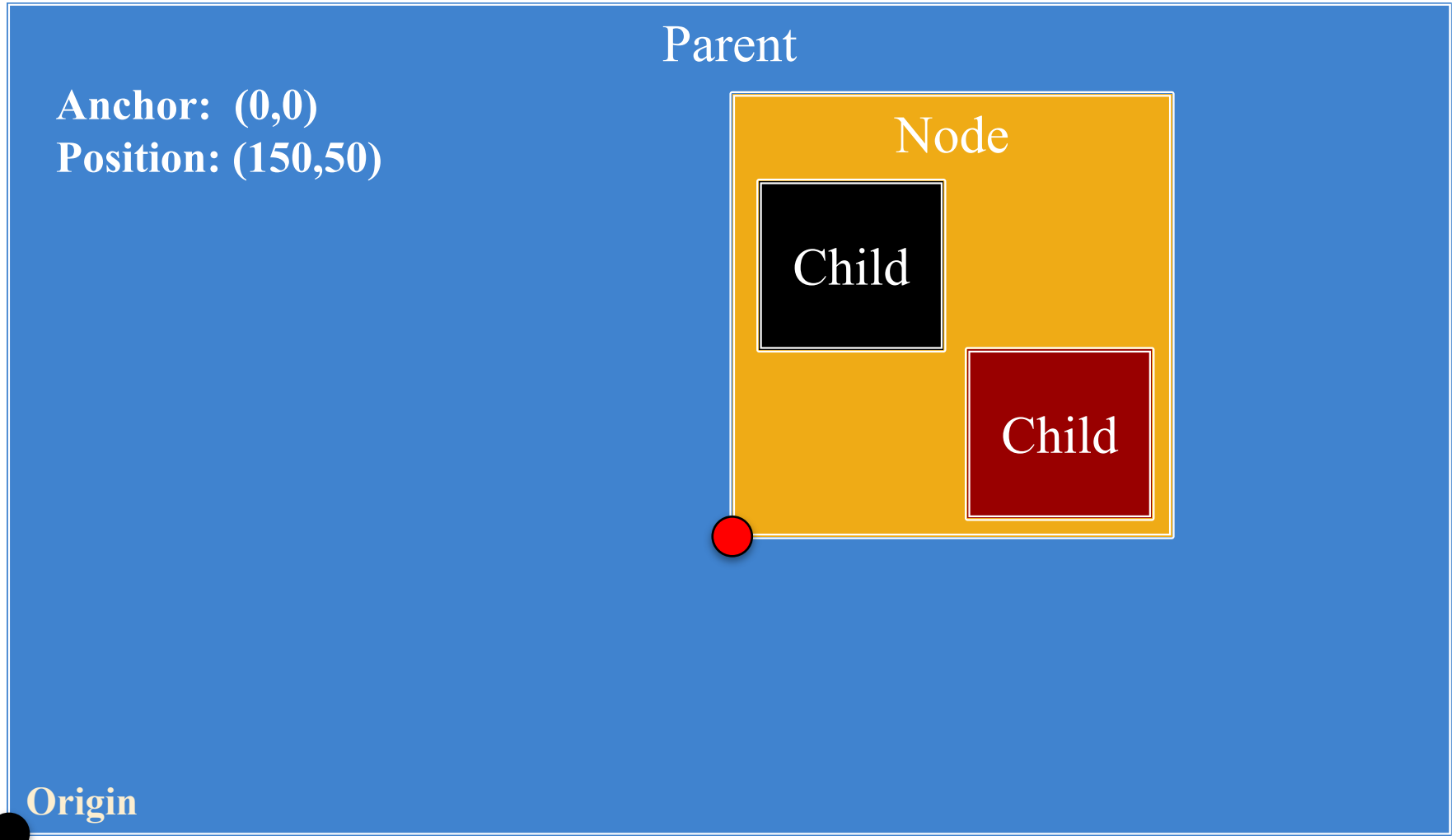
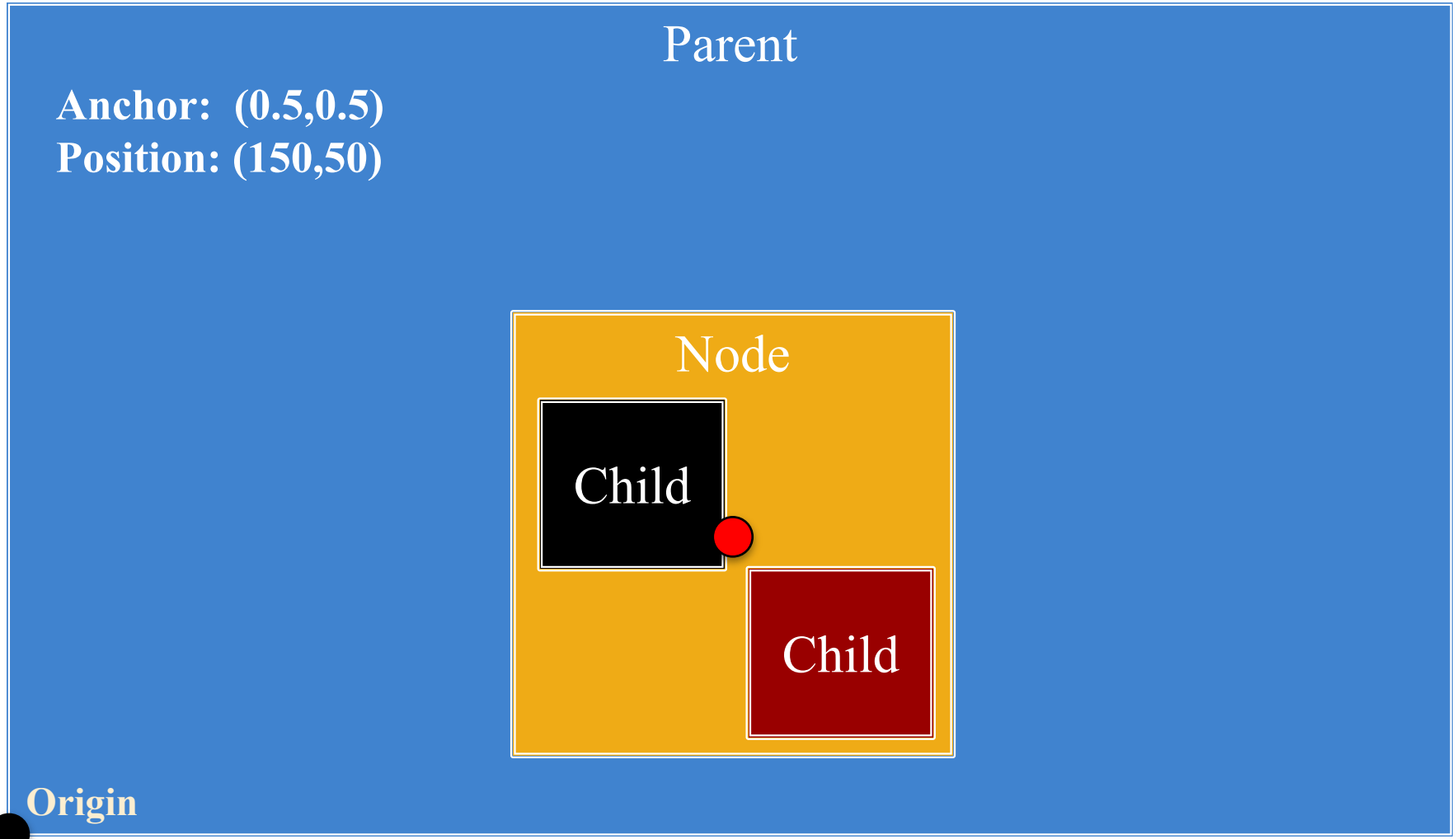


Anchor and Position

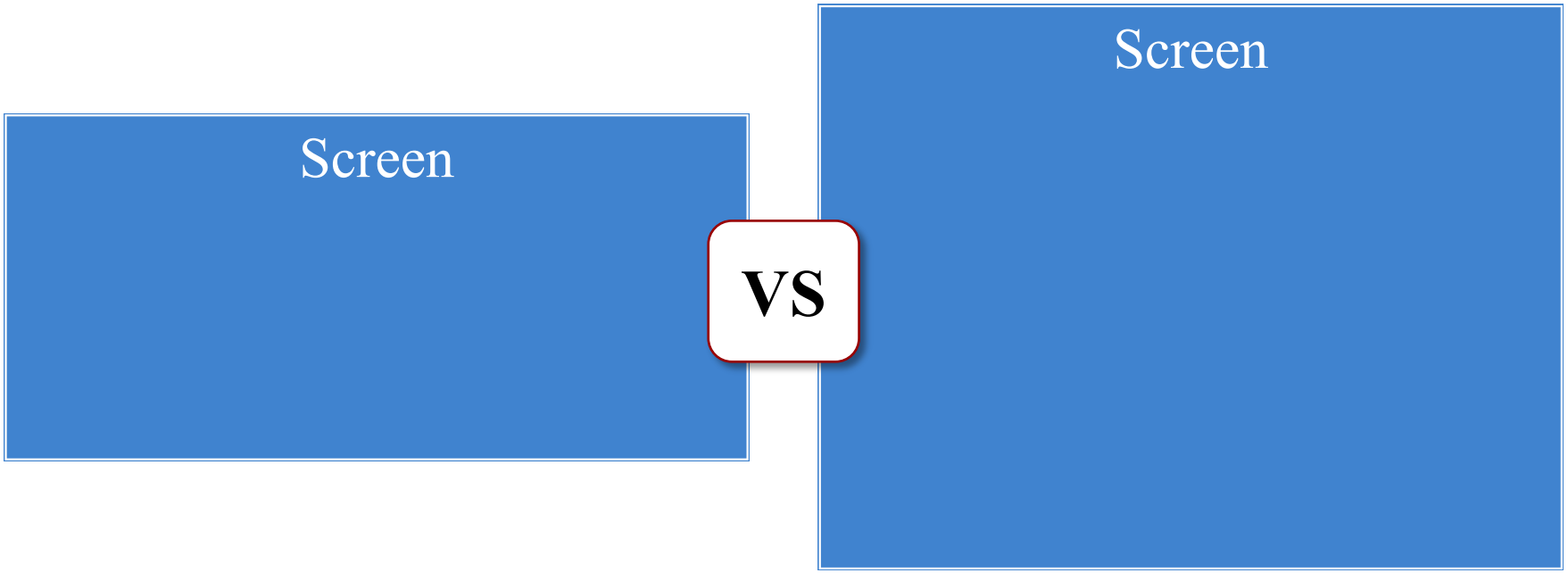


Anchor and Position



Layout Managers

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



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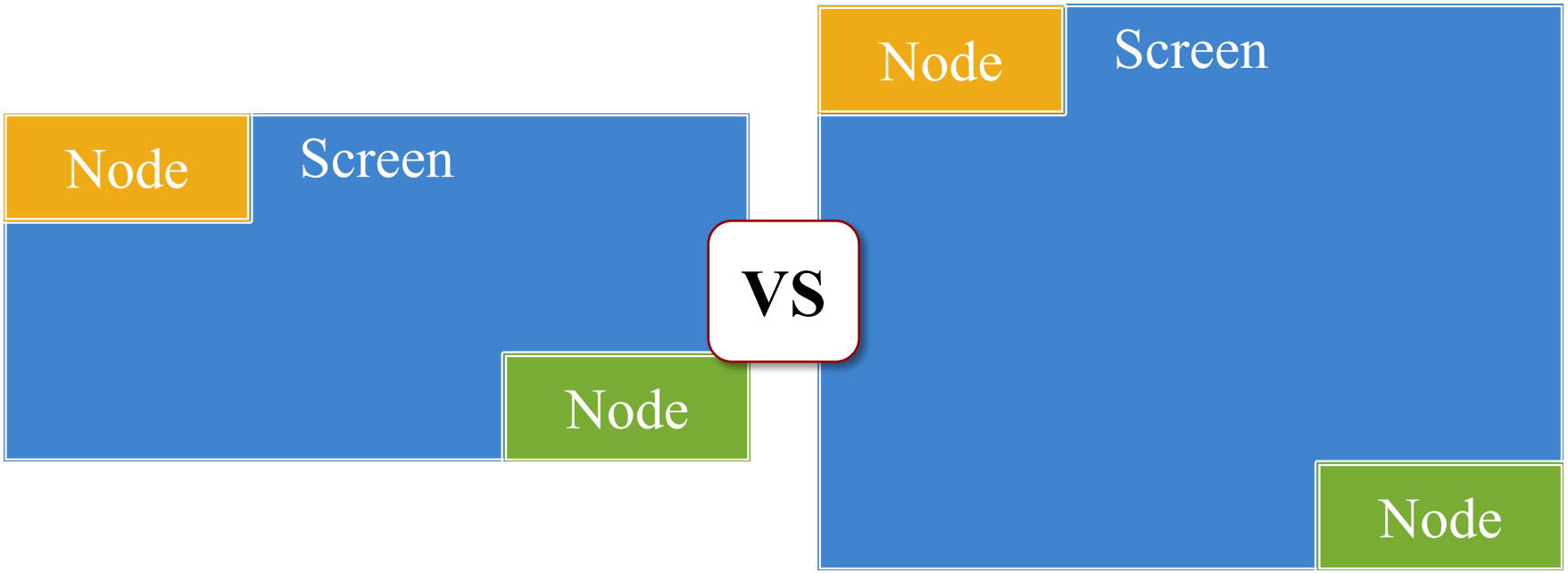
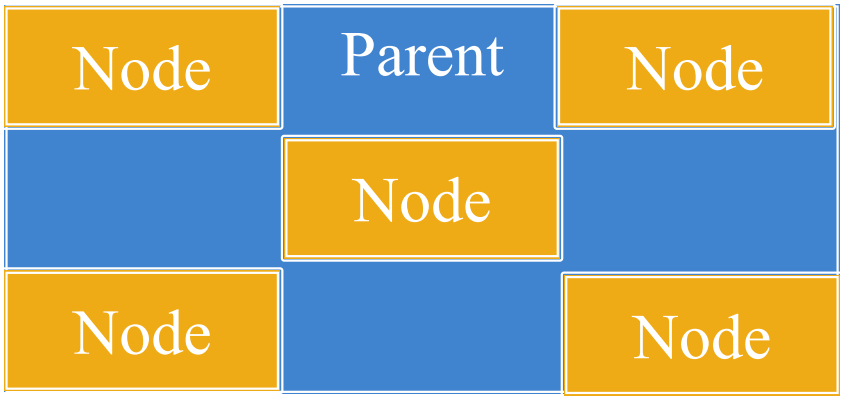
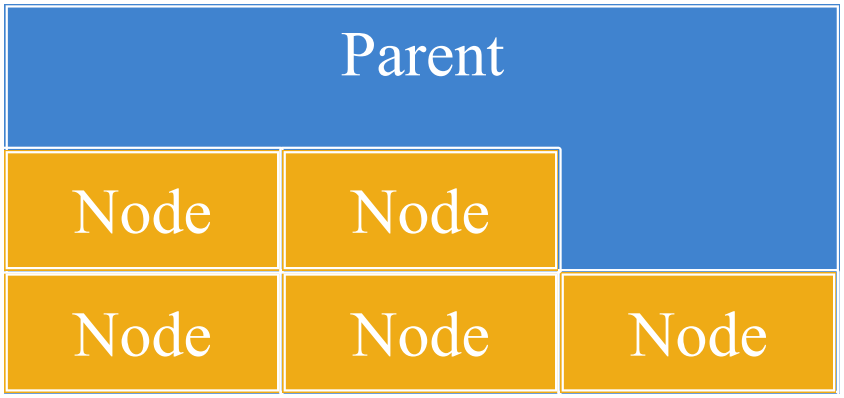


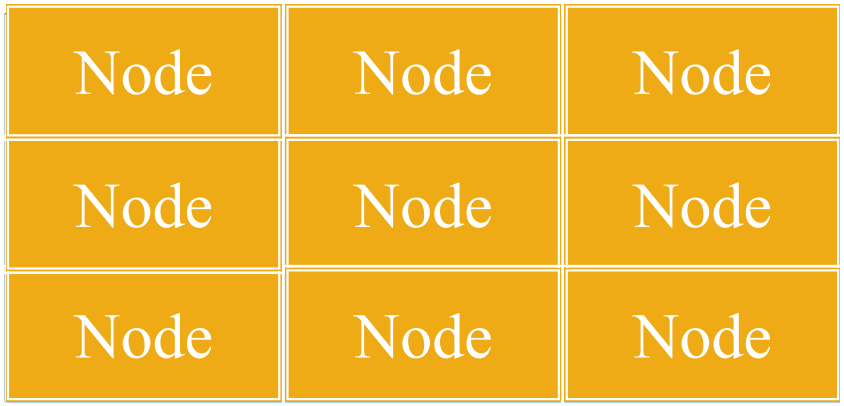
Layout Managers



AnchorLayout

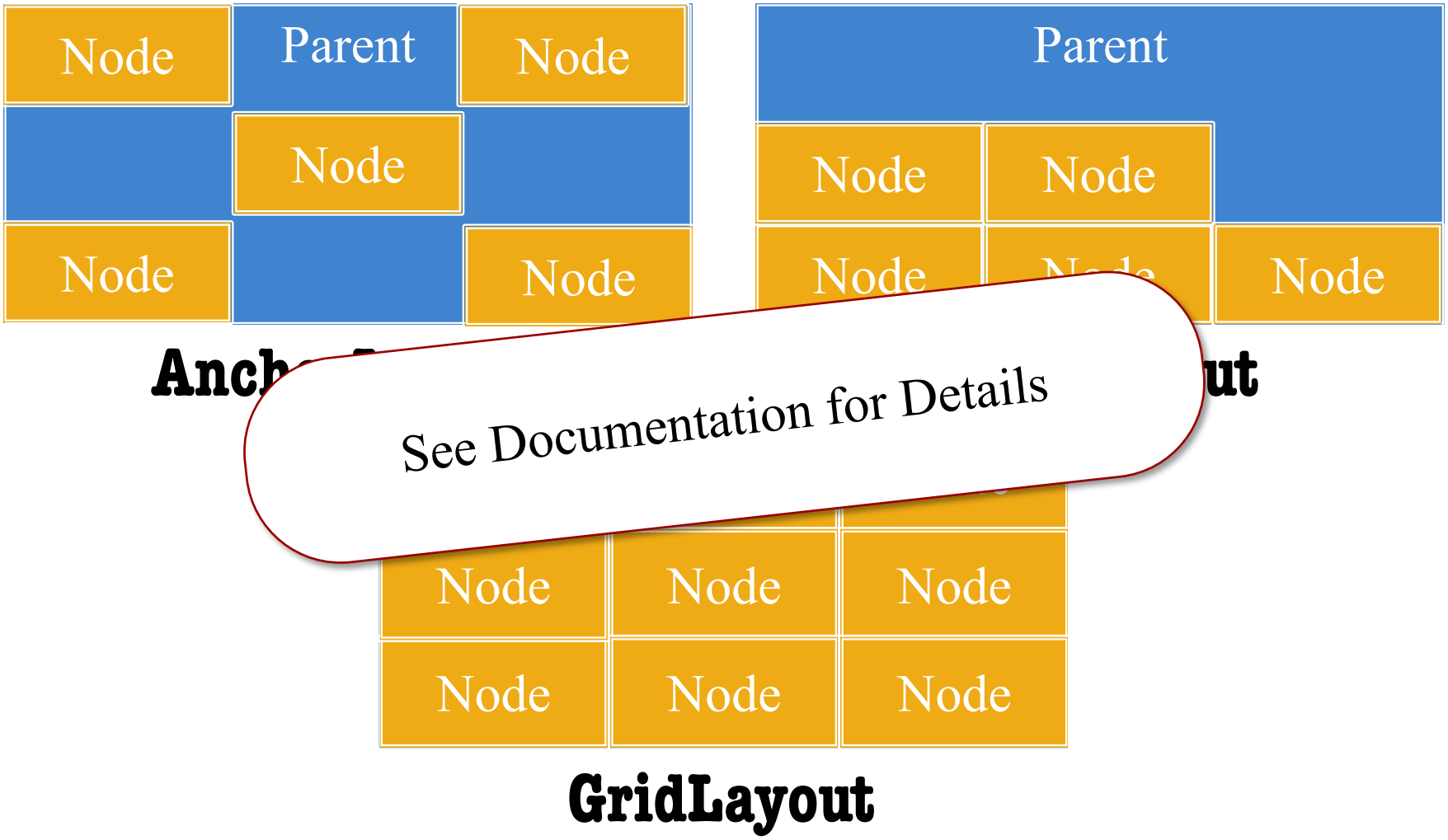


FlowLayout



GridLayout

Layout Managers

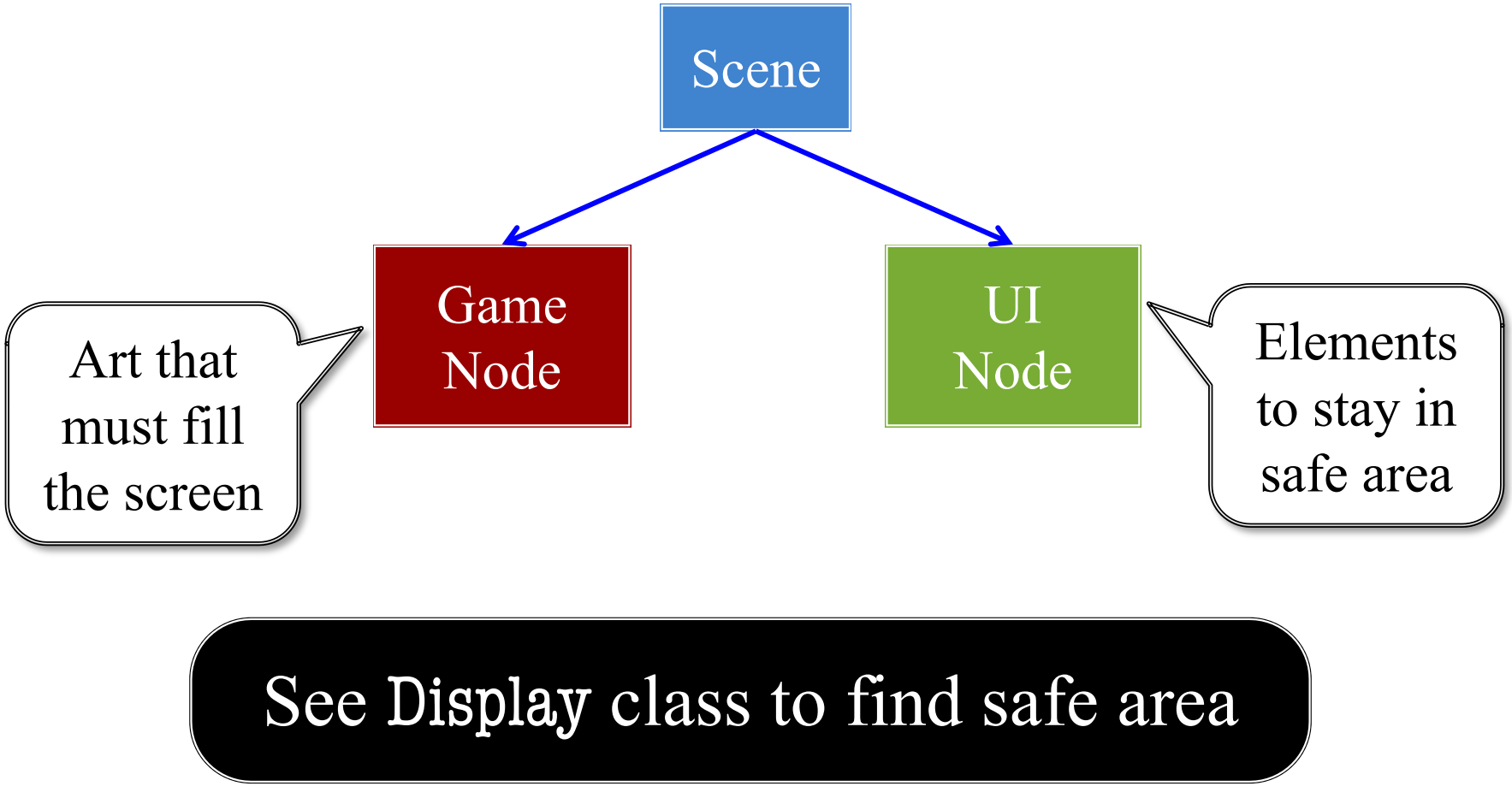


How to Use a Layout Manager

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

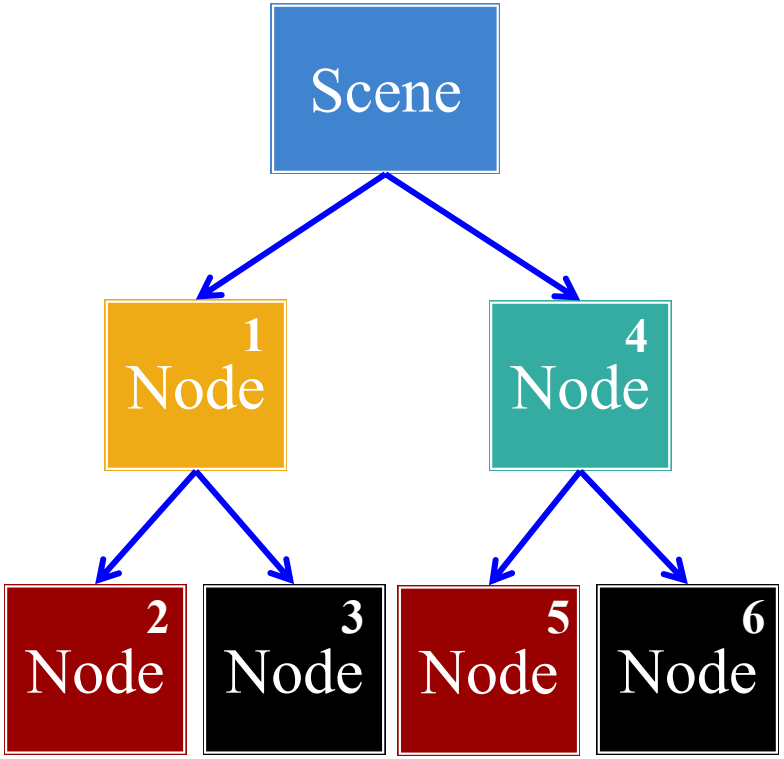
Safe Area: Modern Phones

Safe Area: Modern Phones



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?

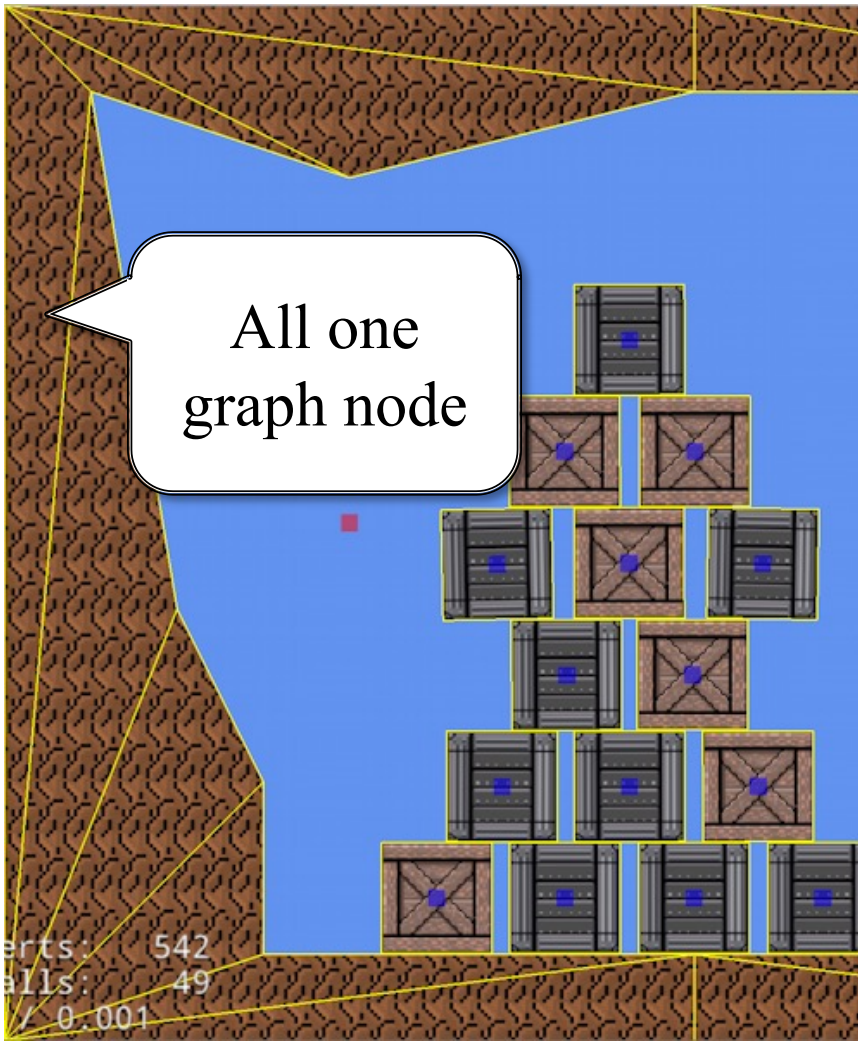
Good for UI Elements

Bad For Animation

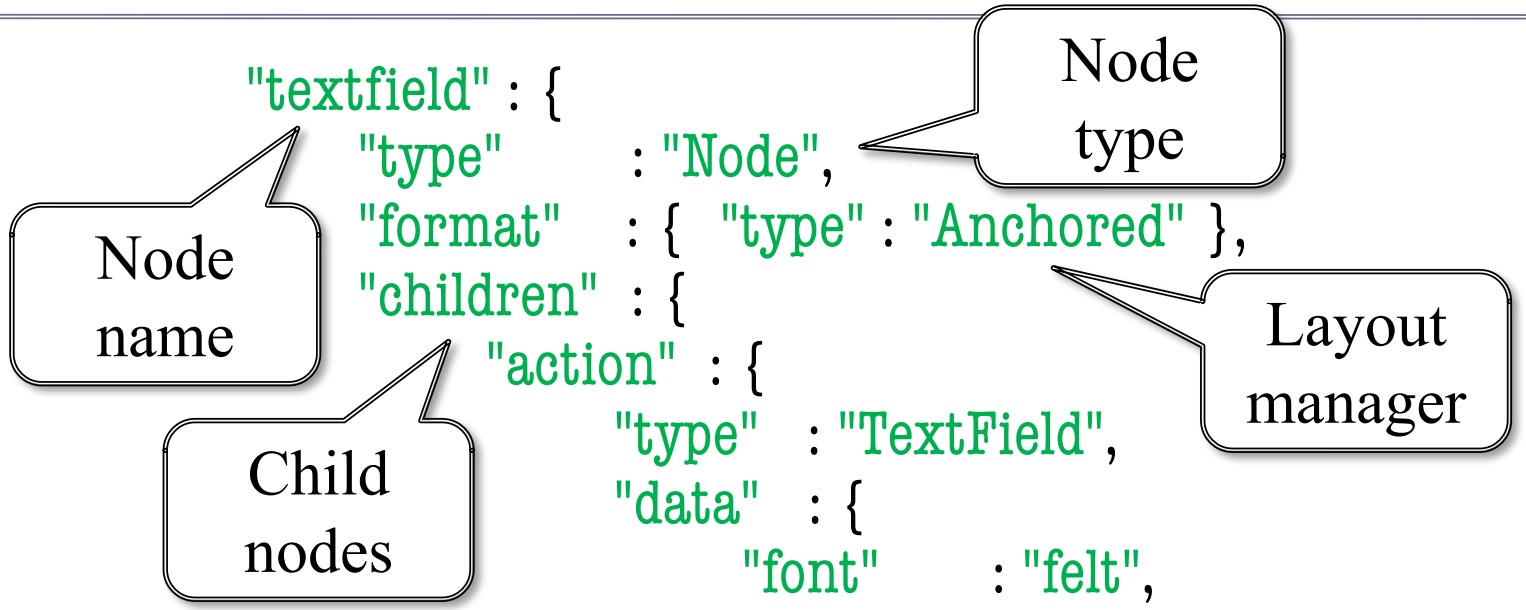
More on this next lecture

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" : {
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            },
            "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

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" : {
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},
"contents"  : {
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   "data"   : {
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      "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": {
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         },
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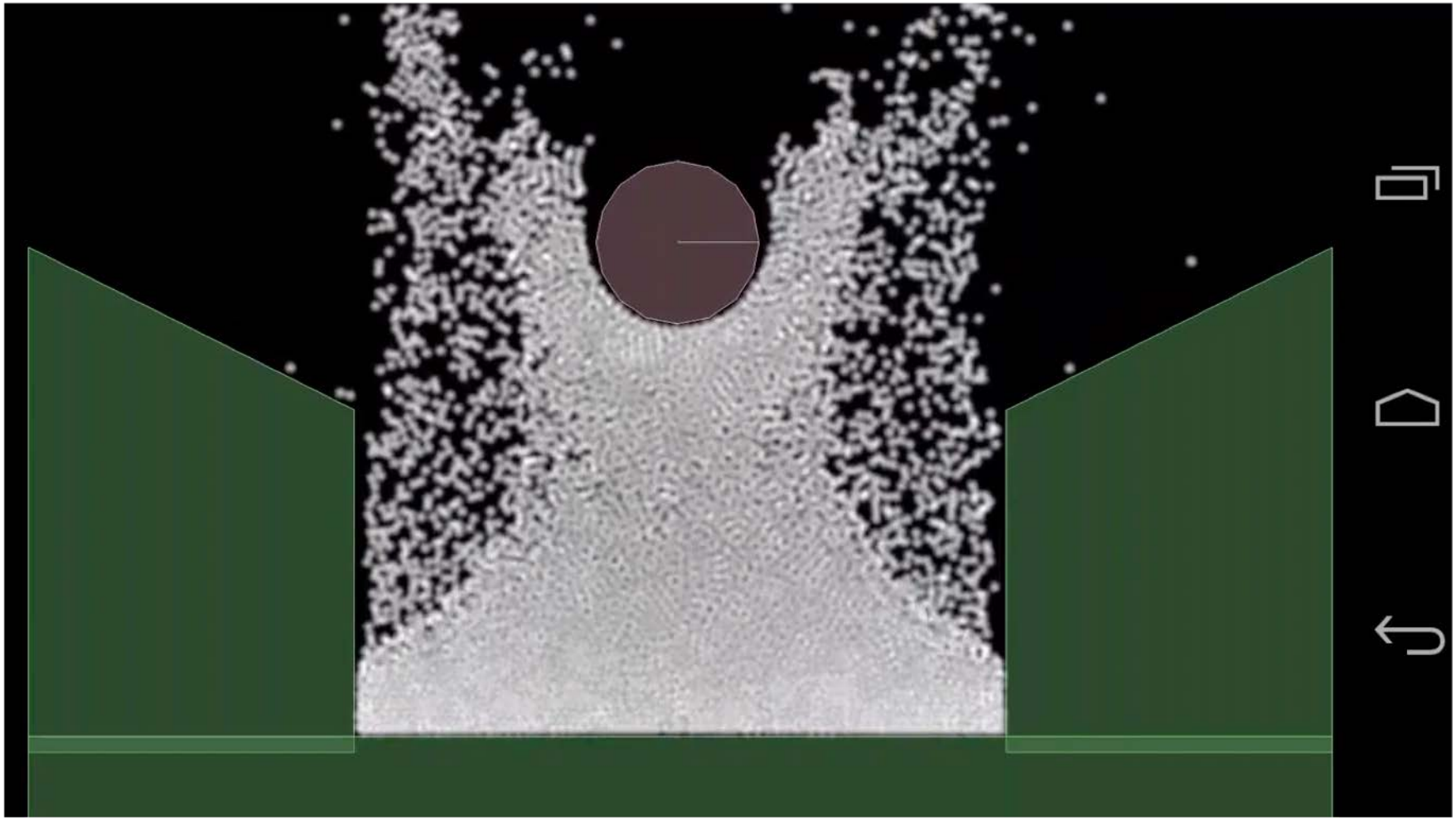
      }}}
```

Change the variable

One Last Problem: **Physics**



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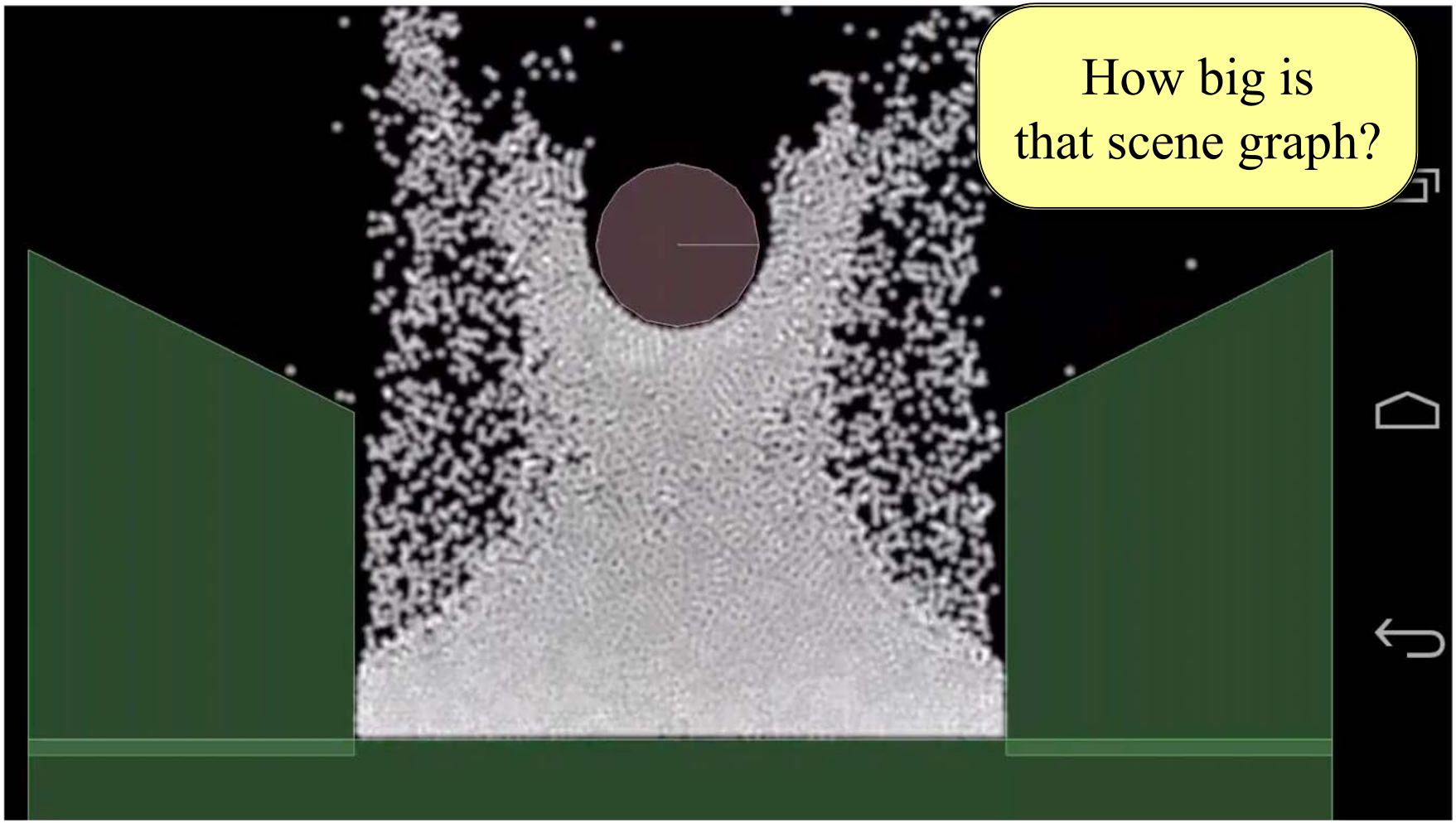

Defining Custom Nodes

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, _vertsize, 0,
                _indices,  _indxsize, 0,
                transform);
}
```

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```

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)
- JSON language makes design easier