

## Lecture 12

# Data-Driven Design

# Take-Away for Today

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- What is “data-driven” design?
  - How do the programmers use it?
  - How to the designers/artists/musicians use it?
- What are the benefits of data-driven design?
  - To both the developer and the player
- What is a level editor and how does it work?
  - What can you do graphically?
  - How does scripting work in a level editor?

# Recall: Game Components

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- **Game Engine**

- Software, created primarily by programmers

- **Rules and Mechanics**

- Created by the designers, with programmer input

- **User Interface**

- Coordinated with programmer/artist/HCI specialist

- **Content and Challenges**

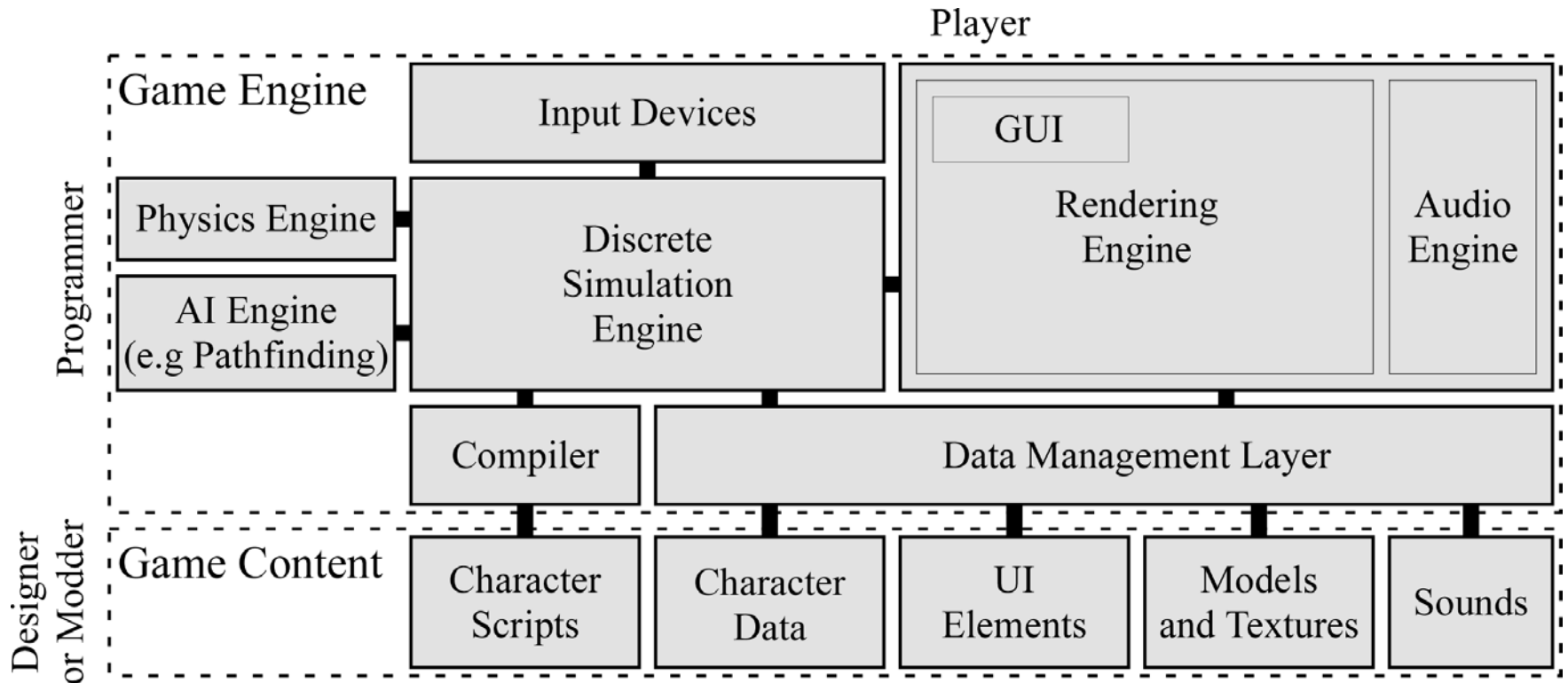
- Created primarily by designers

# Data Driven Design

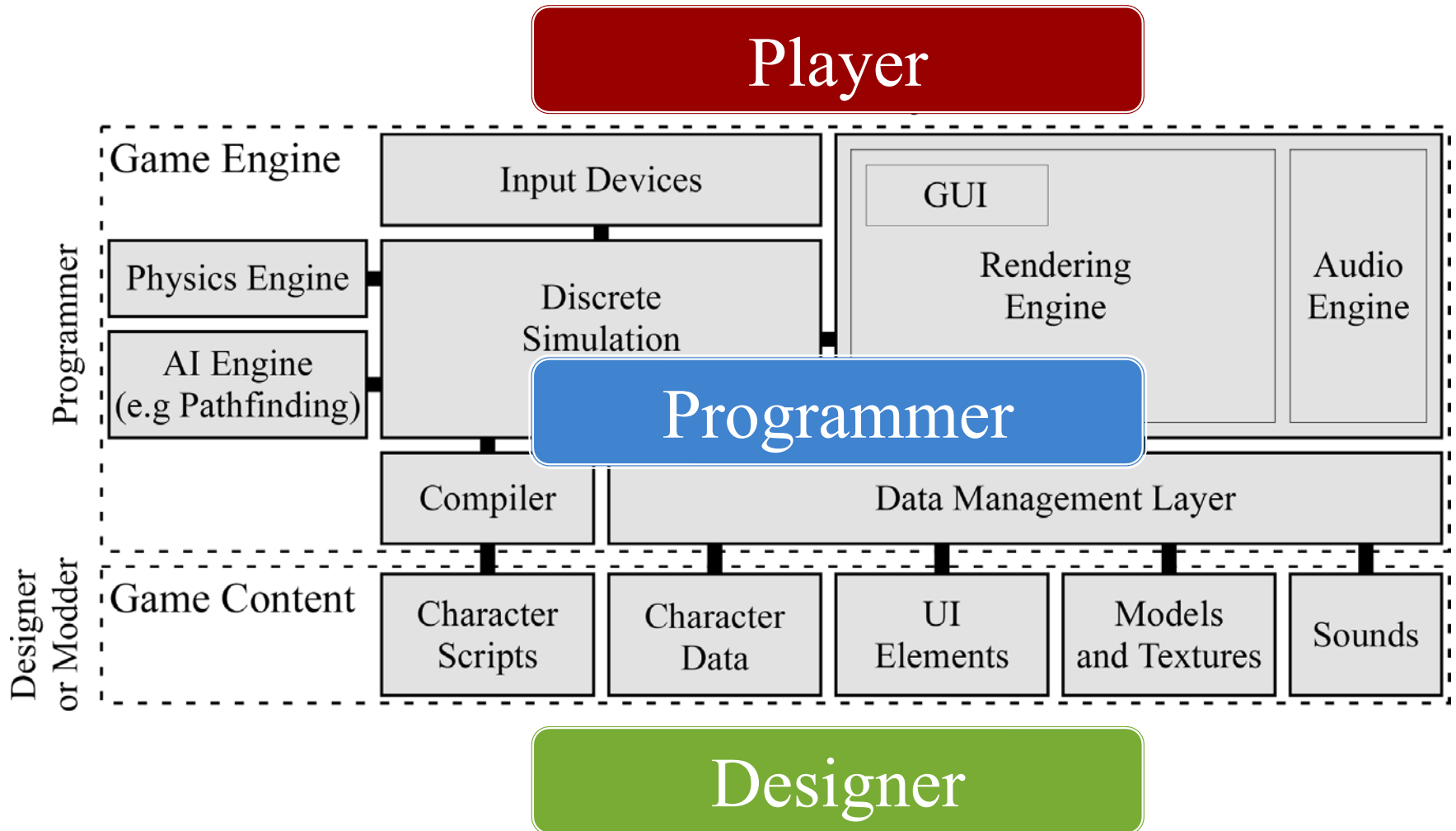
---

- **No code outside engine**
  - Engine determines space of possibilities
  - Actual possibilities are data/scripts
- **Examples:**
  - Art and music in industry-standard file formats
  - Object data in JSON or other data file formats
  - User interface in JSON or other data files
  - Character behavior specified through scripts

# Architecture: The Big Picture



# Architecture: The Big Picture



# Common Development Cycle

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- Start with small number of programmers
- Programmers create a **content pipeline**
  - Productivity tools for artists and designers
  - Data can be imported, viewed and playtested
- Hire to increase number of artists, designers
  - **Focus**: creating content for the game
- Ship title and repeat (e.g. cut back on artists)

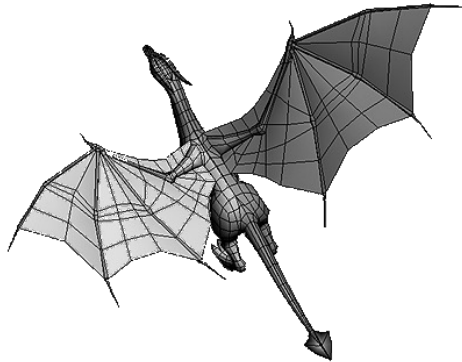
# Content Pipeline

Art Tools

Initial File  
Format

Final File  
Format

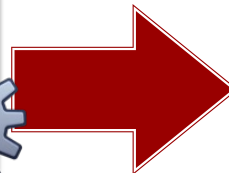
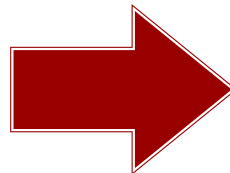
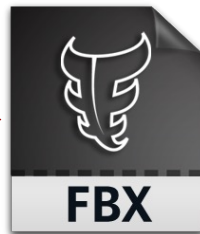
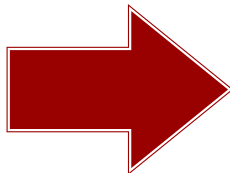
Software



AUTODESK  
**FBX**

**G3DJ**

**lib**  
**GDX**





# Content Creation Tools

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- **Level Editor**

- Create challenges and obstacles
- Layout the user interface
- Tune parameters (physics, difficulty, etc.)

- **Scripting Tools**

- Layout the user interface
- Define character behavior
- Script triggers and events

# Level Editor Features

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- **Create Terrain**

- Defines game geometry as 2D or 3D space
- Terrain can be **free-form** or as **grid tiles**

- **Place Objects**

- Includes NPCs, hazards, power-ups, etc.
- Again can be free-form or aligned to a grid

- **Annotate Objects/Terrain**

- Attach scripts to interactive objects
- Define boundaries for event triggers

# Example: *Blades of Avernum*

*Bahssikava*  
by Tom Watts

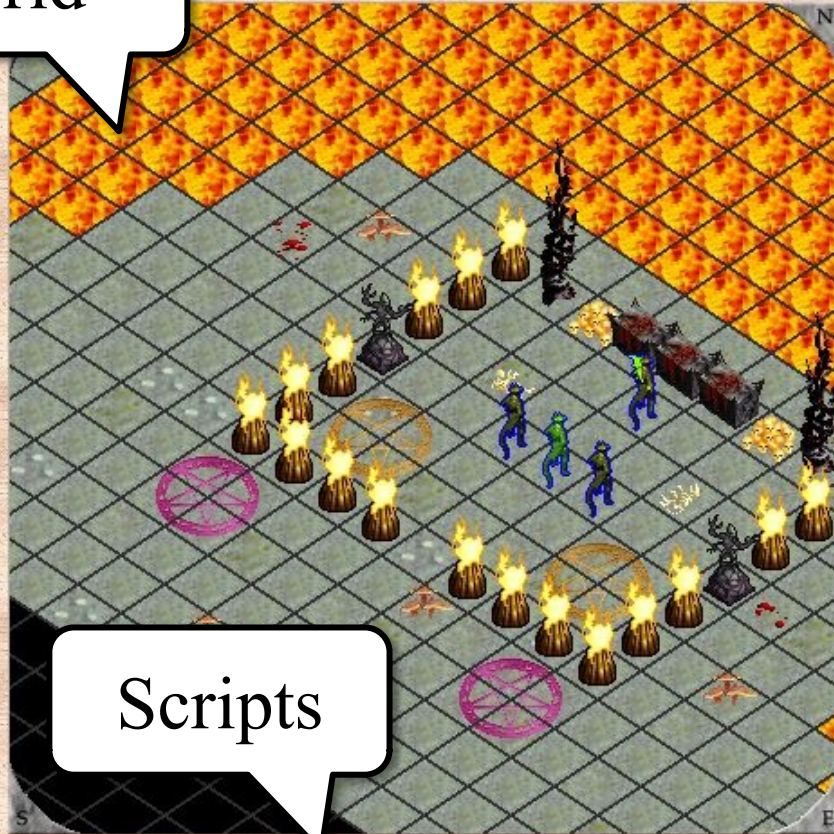
Creation and editing statistics for a creature:

Creature 68: Slith priest	Hidden Class: 0
Edit This Creature (Type 36, L12)	Drop Item 1: None
Script: Default	Drop Item 2: None
Attitude: Friendly	Personality: 0
Character ID: 462	Facing: North

Drawing mode: FLOORS  
Center: x = 32, y = 32  
Select/edit placed object  
Select object to edit

# Example: *Blades of Avernum*

Grid



Scripts

Creature 68: Slith priest  
Edit This Creature (Type 36, L12)  
Script: Default  
Attitude: Friendly  
Character ID: 462

Hidden Class: 0  
Drop Item 1: None  
Drop Item 2: None  
Personality: 0  
Facing: North

Terrain



Tools



# Level Editor: Code Sharing

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- **Option:** level editor in **same project**
  - Single IntelliJ project for both
  - **Pro:** Easy to integrate into the game itself
  - **Con:** Harder to separate modules/subsystems
- **Option:** develop **core technology**
  - Identify source code used by each
  - JAR for both level editor and game
  - **Pro:** Cleaner separation of subsystems
  - **Con:** Harder to iterate the design

# Level Editor: **Serialization**

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Stores:  
Game Model



# Level Editor: **Serialization**

- Do not **duplicate** data
  - Art and music are separate files
  - Just reference by the file name
- Must **version** your file
  - As game changes, format may change
  - Version identifies the current file format
  - Want a **conversion utility** between versions
  - Version should be part of **file header**



# Standard Serialization Formats

---

## XML

---

```
<NPC>
  <type>Orc</type>
  <health>200</health>
  <position>
    <x>50</x>
    <y>25</y>
  </position>
</NPC>
```

## JSON

---

```
{
  "NPC" : {
    "type" : "Orc",
    "health" : 200,
    "position" : {
      "x" : 50,
      "y" : 25
    }
  }
}
```



# Standard Serialization Formats

## XML

```
<NPC>
  <type>Orc</type>
  <health>200</health>
  <position>
    <x>50</x>
    <y>25</y>
  </position>
</NPC>
```

XmlReader

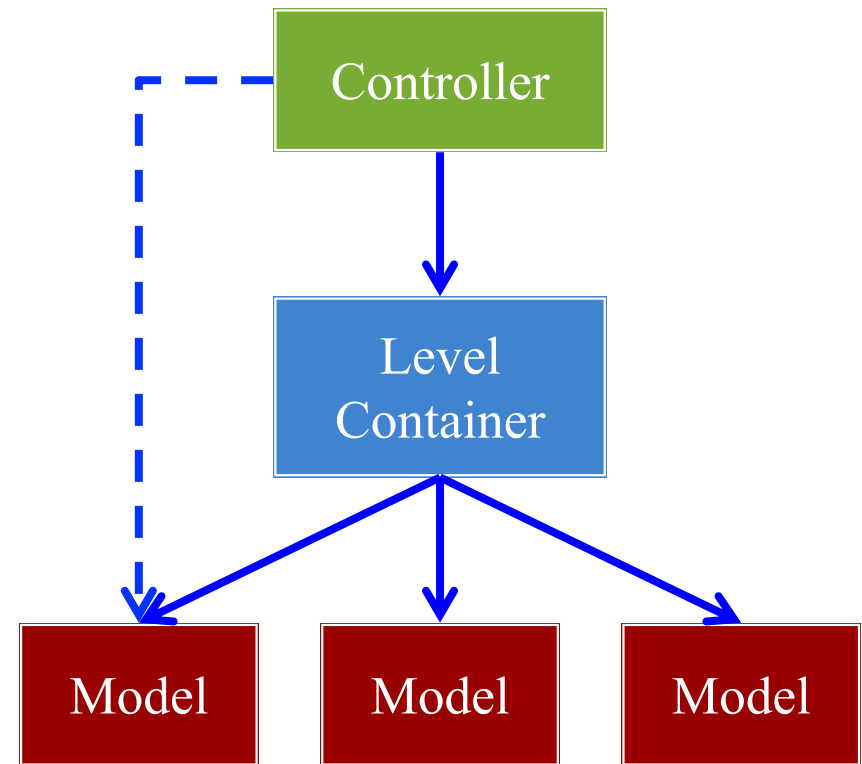
## JSON

```
{
  "NPC" : {
    "type" : "Orc",
    "position" : {
      "x" : 50,
      "y" : 25
    }
  }
}
```

JsonReader

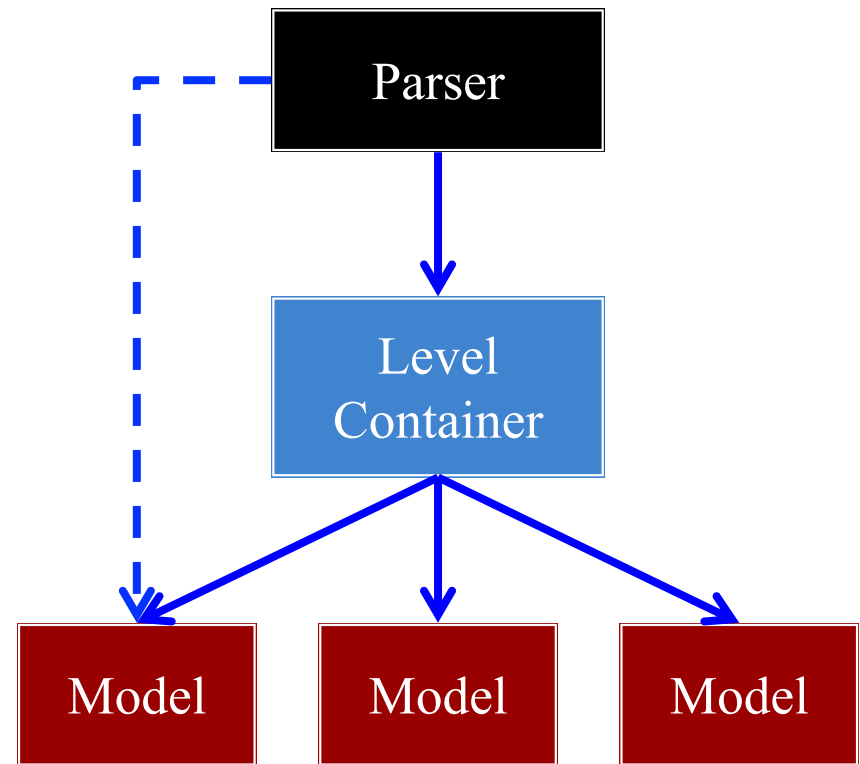
# Levels and Game Architecture

- Level container (**model**)
  - Collection of model objects
  - Interface to the controllers
  - Similar to a collection type
  - May have other methods
- Level parser (**controller**)
  - Performs (de)serialization
  - Collabs with *all* models
  - Typically a factory pattern
  - Can embed *some* in model



# Levels and Game Architecture

- Level container (**model**)
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  - Collabs with *all* models
  - Typically a factory pattern
  - Can embed *some* in model



# In-Model Deserialization

---

## Unacceptable

---

```
class Model {  
  
    ...  
  
    void loadFile(String name) {...}  
  
    ...  
  
    void loadFile(File file) {...}  
  
    ...  
  
}
```

## Acceptable

---

```
class Model {  
  
    ...  
  
    void loadData(JSON data) {...}  
  
    ...  
  
    void loadData(XML data) {...}  
  
    ...  
  
}
```

# In-Model Deserialization

## Unacceptable

```
class Model {  
  ...  
  void loadFile(String name) {...}  
  ...  
  void loadFile(File file) {...}  
  ...  
}
```

I/O handled  
in model

## Acceptable

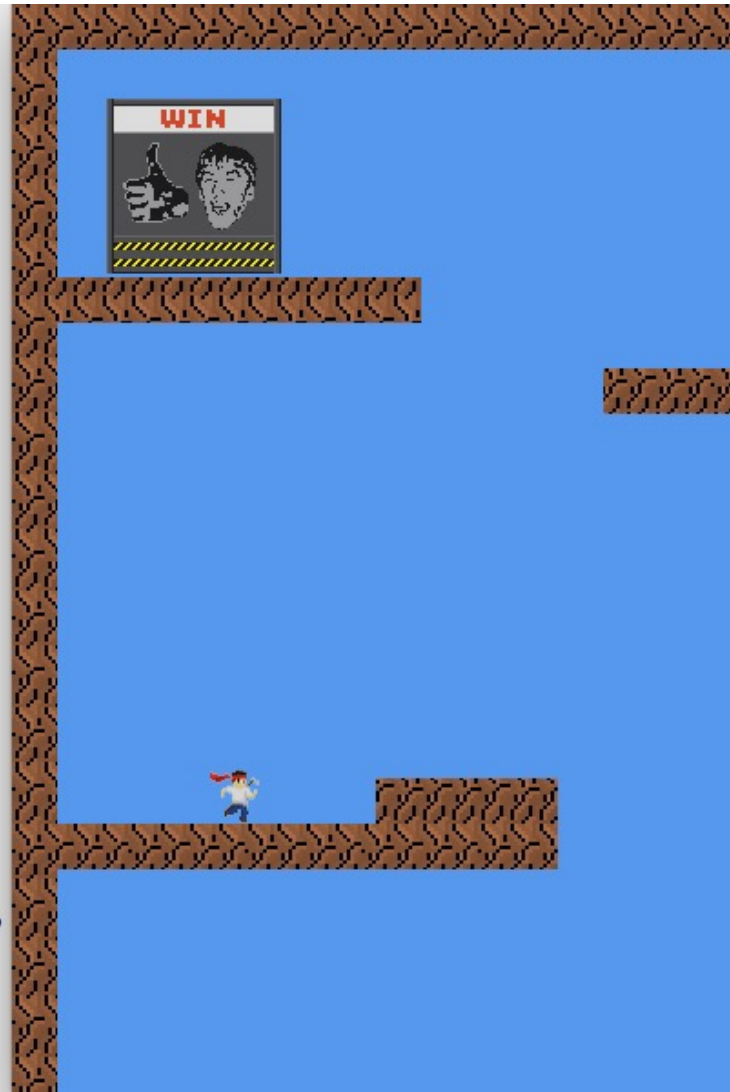
```
class Model {  
  ...  
  void loadData(JSON data) {...}  
  ...  
  void loadData(XML data) {...}
```

I/O handled  
previously

**I/O Code is brittle and platform-specific**

# Example: JSON Demo

```
"physicsSize": [16.0,12.0],
"graphicSize": [ 800, 600],
"gravity": -9.8,
"avatar": {
  "pos": [ 2.5, 5.0],
  "size": [ 0.45, 0.61],
  "bodytype": "dynamic",
  "density": 1.0,
  "friction": 0.0,
  "restitution": 0.0,
  "force": 10.0,
  "damping": 10.0,
  "maxspeed": 5.0,
  "jumppulse": 2.25,
  "jumplimit": 30,
  "jumpsound": "jump",
  "texture": "dude",
  "debugcolor": "white",
  "debugopacity": 192,
  "sensorsize": [ 0.183, 0.05 ],
  "sensorname": "dudeGroundSensor",
  "sensorcolor": "red",
  "sensoropacity": 192,
},
"exit": {
```



# I/O is Brittle and Platform Specific

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- Not all platforms **specify files** in the same way
  - Windows uses \ for directories, not /
  - Only Windows maps drives to letters
  - macOS is not *case sensitive* but .jar files are
- Not all platforms allow you to **read/write files**
  - macOS restricts access to Desktop/Documents
  - Application must get *permission* first
- Some platforms have **no file system** at all!
  - iOS and Android only have *application data*
  - But no concept of folders or directories

# LibGDX Has Three File Types

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- **Internal:** Read-Only
  - Location where the assets are stored
  - Could be inside of a .jar file!
- **Local:** Read-Write (**Preferences**)
  - Special save directory dedicated to your game
  - Maybe hard to find (Library folder on macOS)
  - But it is always guaranteed to exist
- **External:** Read-Write
  - The folder the application/.jar is located
  - You rarely have permission to write here



# LibGDX Has Three File Types

- **Internal:** Read-Only

- Assets are stored
- **Assets** jar file!

See LibGDX File class for more

- **Local:** Read-Write

- Special save directory dedicated to your game
- **Saved Games** library folder on macOS)
- But it is always guaranteed to exist

- **External:** Read-Write

- **Do Not Use** ation/.jar is located
- **Do Not Use** permission to write here

# Levels and Error Detection

---

- Game data is **not compiled** into software
  - Files go into a well-define folder
  - Game loads everything in folder at start-up
  - Adding new files to folder adds levels
- But this requires **robustness**
  - What if the levels are **missing**?
  - What if the levels are **corrupted**?
  - What if you are using **wrong file version**?



# Levels and Error Detection

---

- **Corruption** a major problem in this design
  - Player might trash a level file (or directory)
  - Modder might alter level improperly
  - Content patch might have failed
- Process all errors **gracefully**
  - Check **everything** at load time
  - If level corrupt, allow play in others
  - Give helpful error messages



# Content Creation Tools

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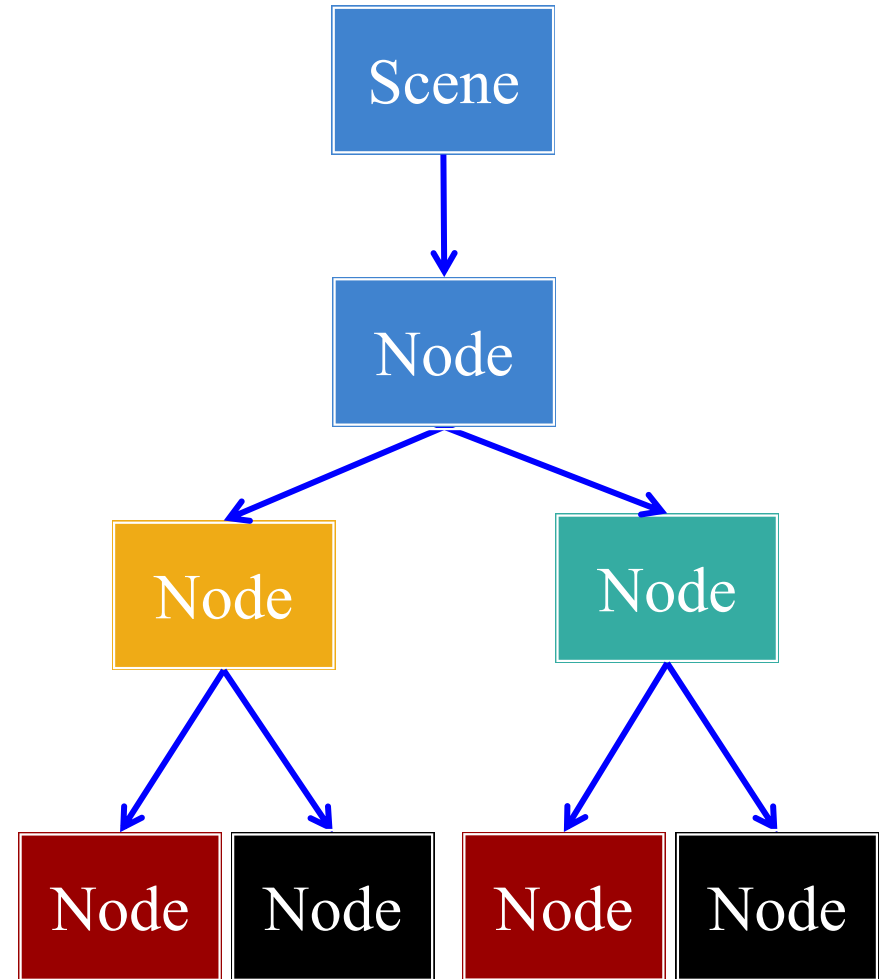
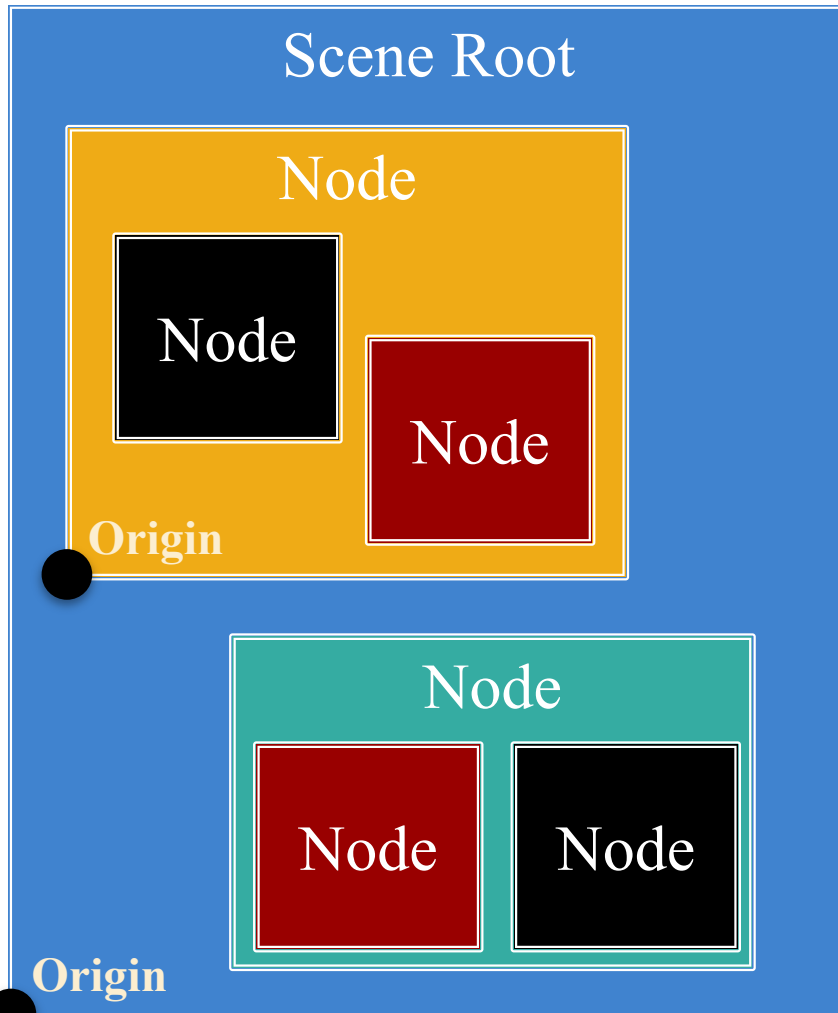
- **Level Editor**

- Create challenges and obstacles
- Layout the user interface
- Tune parameters (physics, difficulty, etc.)

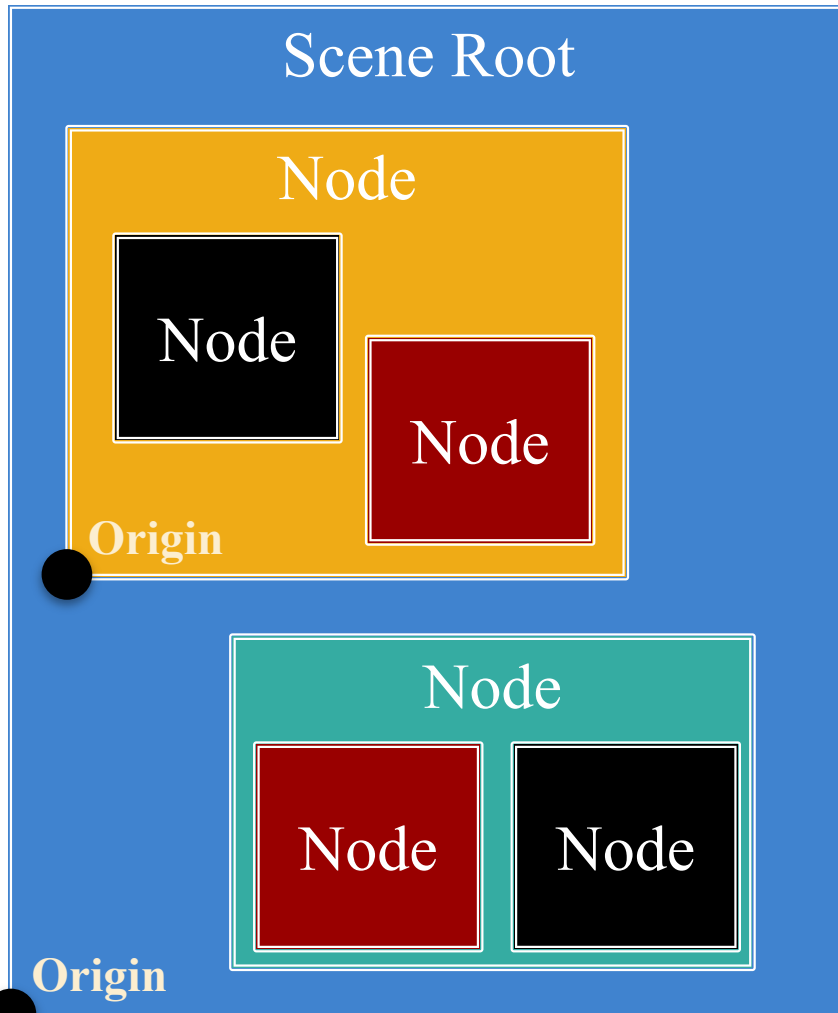
- **Scripting Tools**

- Layout the user interface
- Define character behavior
- Script triggers and events

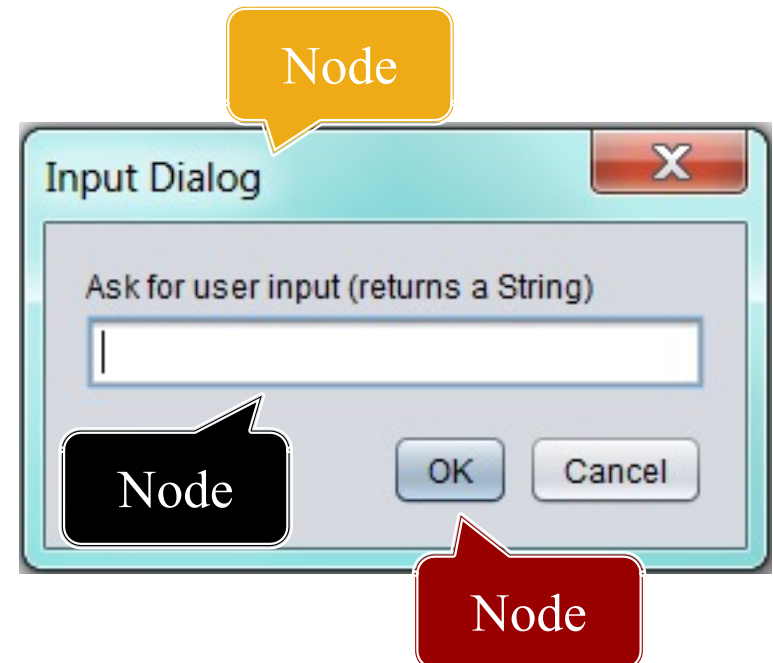
# UI Design: Scene Graphs



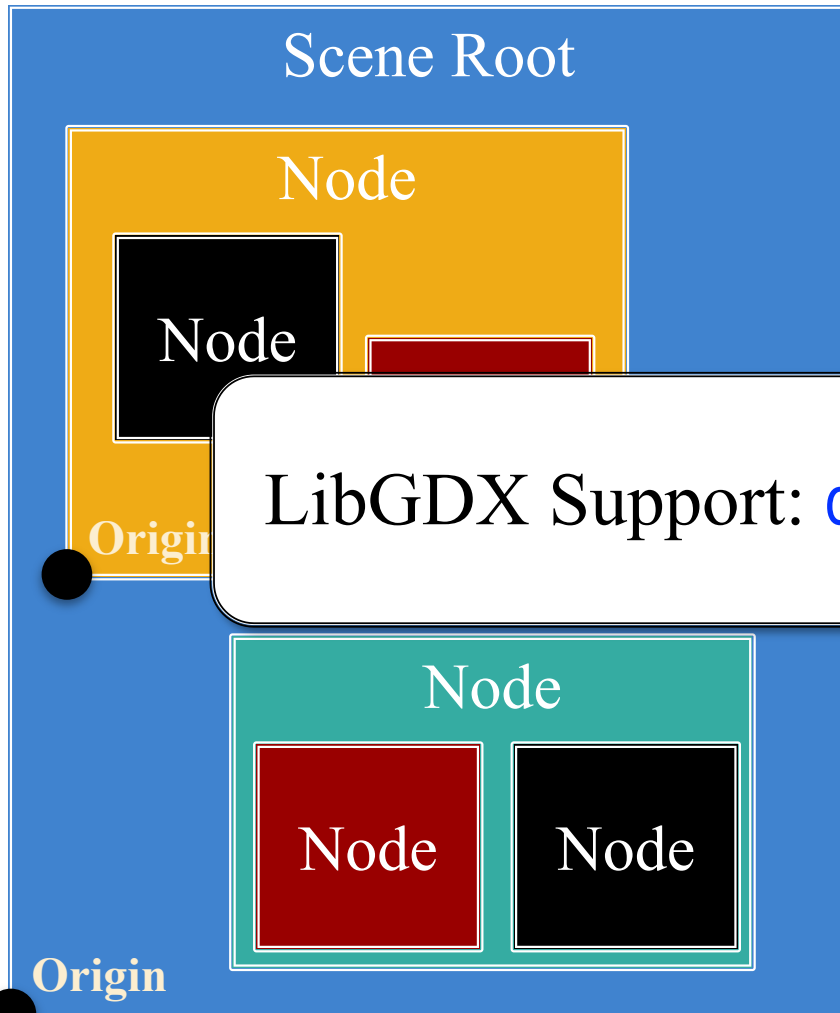
# UI Design: Scene Graphs



- Node is a coordinate system
  - Logically a “window”
  - Children move with parent
- Hierarchically build widgets

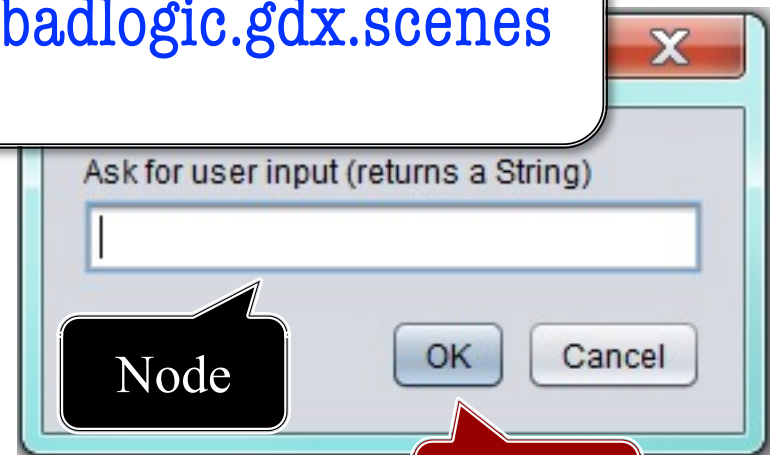


# UI Design: Scene Graphs

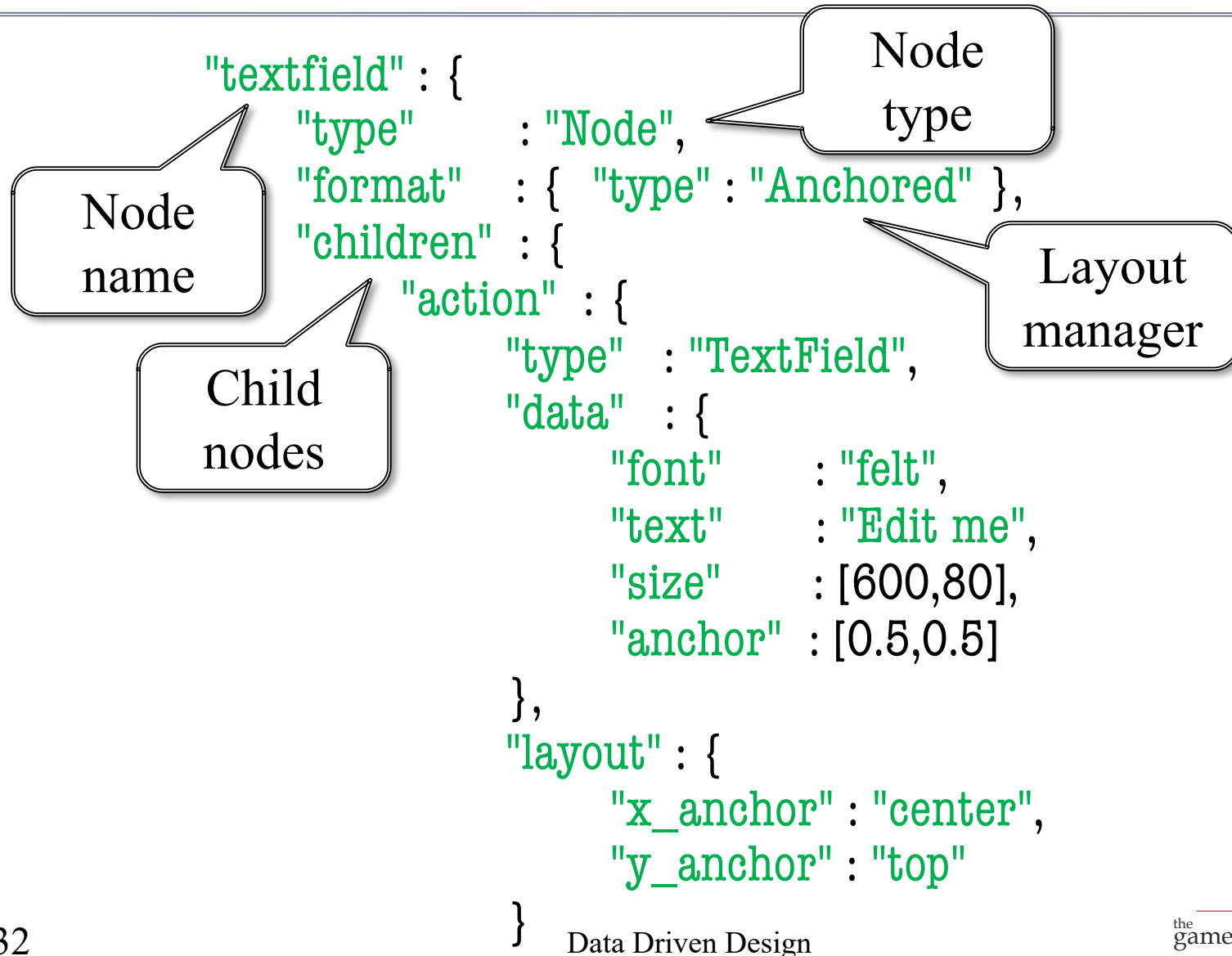


- Node is a coordinate system
  - Logically a “window”
  - Children move with parent
- Hierarchically build widgets

LibGDX Support: [com.badlogic.gdx.scenes](http://com.badlogic.gdx.scenes)



# CUGL: JSON for Scene Graphs





# CUGL: JSON for Scene Graphs

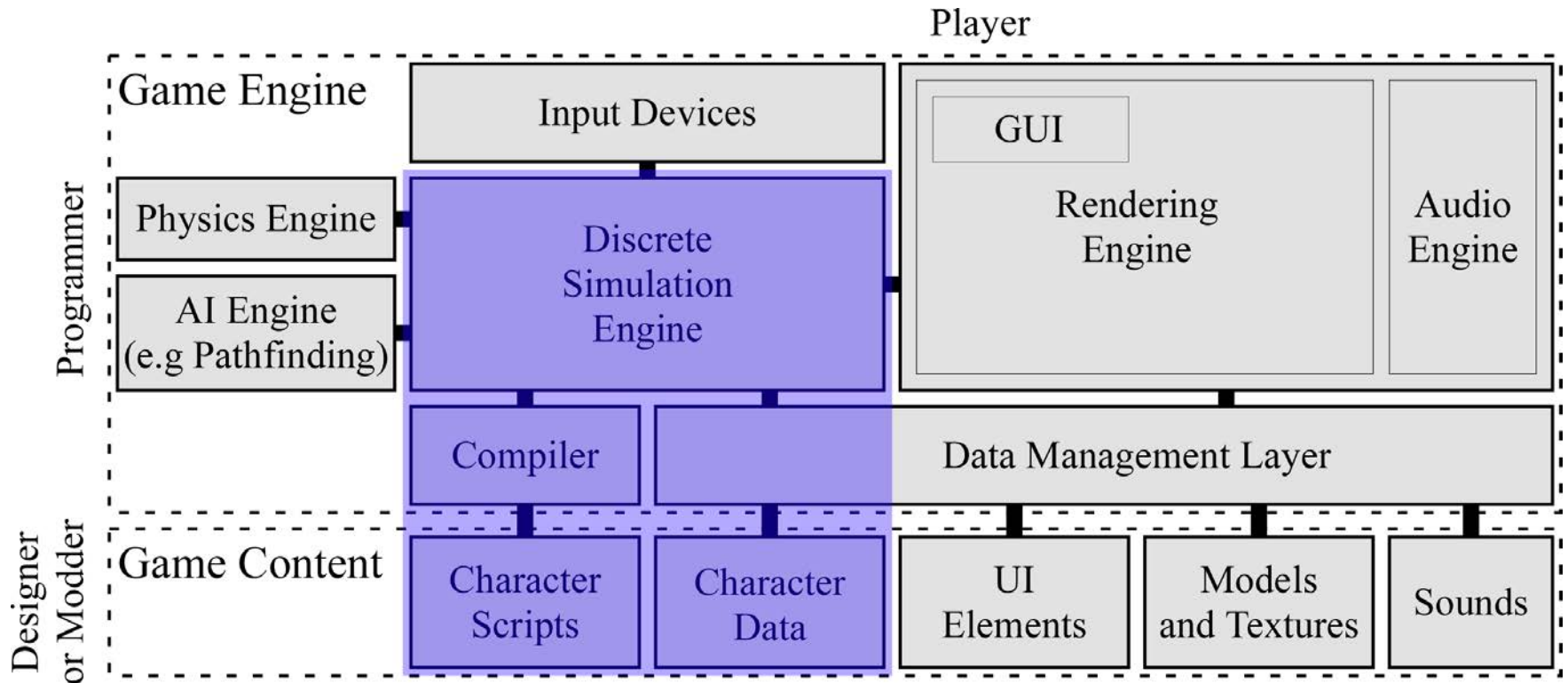
```
"textfield" : {  
  "type"      : "Node",  
  "format"    : { "type" : "Anchored" },  
  "children"  : {  
    "action" : {  
      "type" : "TextField",  
      "data" : {  
        "font"   : "felt",  
        "text"   : "Edit me",  
        "size"   : [600,80],  
        "anchor" : [0.5,0.5] 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

Layout manager

Node data

Info for parent layout

# Scripting Languages



# Why Scripting?

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- **Character AI**

- Software only aware of high level actions
- Specific version of each action is in a script

- **Triggers**

- Actions happen in response to certain events
- Think of as an `if-then` statement
  - **if**: check if trigger should fire
  - **then**: what to do if trigger fires

# Triggers and Spatial Boundaries



# Ways of Scripting

---

- Static **functions/constants** exposed in editor
  - Script is just the name of function to call
  - Used in the sample level editor
  - Typically good enough for this course
- Use standard **scripting language**
  - **Examples:** Lua, stackless python
  - A lot of overhead for this class
  - Only if writing high performance in C/C++

# Scripting in *Dawn of War 2*

```
infantry-plan.squadai * Sc1
File Edit Search View Tools Options Language Buffers Help
1 assault-building-plan.lua 2 sniper-plan.squadai 3 infantry-plan.squadai *
16 -----
17 -- plan
18
19 plan =
20 -{
21
22 -----
23 -- phase0: Before First Bound
24 {
25     type = DATA_PHASE,
26     name = "START PLAN: all move NO COVER NO BACKWARDS",
27     --
28     {
29         apply_to = {ET_Core, ET_RFlank, ET_LFlank},
30         actions =
31         {
32             ACTION_MOVE_POSTURE_EXT( DT_MAX_SQUAD_RANGE, .95, 4.0, 30.0, "squad_formation/squad_ai.lua"
33         },
34     },
35 }
36
37 {
38     type = DATA_PHASE,
39     name = "1st SQUAD BOUND -- LOOK FOR COVER",
40     --
41     {
42         apply_to = {ET_Core, ET_RFlank, ET_LFlank},
43         actions =
44         {
45             ACTION_MOVE_POSTURE( DT_MAX_SQUAD_RANGE, 0.85, 10.0, 60.0, "squad_formation/squad_ai.lua",
46         },
47     },
48 }
49 -----
50 -- phase2 -- BOUND 1 CORE (core runs in an drops to prone)
51 {
52     type = DATA_PHASE,
53     name = "Core 1st Bound"
```

Data Driven Design

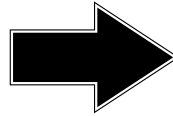
# Simpler: XML Specification

The screenshot shows the 'Attribute Editor' window for 'squad\_plan'. The left pane shows a tree view of assets, with 'eld\_teleport\_range' selected. The right pane shows a list view of the selected attribute's properties.

Attribute Name	Value
types\plan_phase	types\plan_phase
types\plan_phase	types\plan_phase
types\plan_phase	types\plan_phase
types\plan_phase	types\plan_phase
debug_phase_name	----- Core bound 1st BOUND -----
phase_finished_mode	ranged_combat
types\plan_action_entry	types\plan_action_entry
types\plan_actions\maleable_move	types\plan_actions\maleable_move
types\pathfinding\move_info	types\pathfinding\move_info
allow_backwards_move	True
allow_leave_los	False
always_move	False
always_move_if_not_in_cover	True
always_move_if_not_in_max_range	True
chance_to_jump	1
cover_search_angle	360
cover_search_radius	8
face_target_after_move	True
formation	formation\eldarline
max_order_delay_secs	2
min_dist_from_target	10
min_order_delay_secs	1
move_distance_percentage	0.75
move_distance_type	min_squad_range
speed_multiplier_max	1.5
speed_multiplier_min	1.5

# JSON/XML as a “Scripting Language”

```
"myevent" : {  
  "id" : 4,  
  "sparkle" : {  
    "color" : "blue",  
    "size" : 2,  
    "duration" : 3,  
  },  
  "buff" : {  
    "attrib" : "health",  
    "value" : 4,  
  },  
  "sound" : "magic4"  
}
```



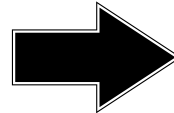
```
codefrag = "  
switch (triggerId) {  
  ...  
  case 4:  
    sparkleCharacter(BLUE,2,3);  
    buffCharacter(HEALTH,4);  
    playSound(MAGIC4);  
    break;  
  ...  
}"
```

This is text, not  
compiled code



# JSON/XML as a “Scripting Language”

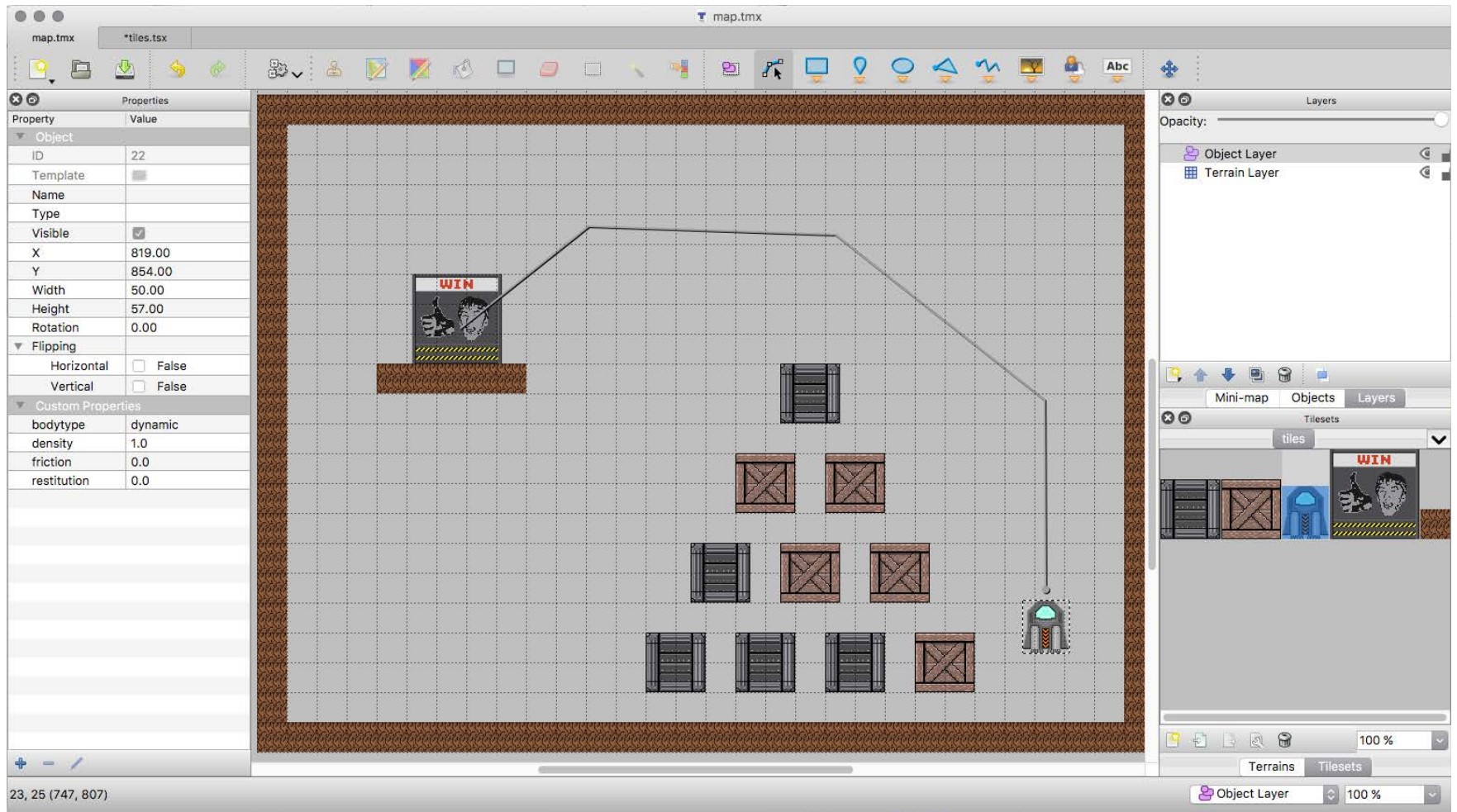
```
codefrag = "  
switch (triggerId) {  
...  
case 4:  
    sparkleCharacter(BLUE,2,3);  
    buffCharacter(HEALTH,4);  
    playSound(MAGIC4);  
    break;  
...  
}"
```



```
class MyEvent implements Event {  
    void process(int triggerId) {  
        switch (triggerId) {  
            ...  
            case 4:  
                sparkleCharacter(BLUE,2,3);  
                buffCharacter(HEALTH,4);  
                playSound(MAGIC4);  
                break;  
        }  
    }  
}
```

**Java Support:** `javax.tools.JavaCompiler`

# Final Words: The Tiled Level Editor



# Using Tiled for 3152

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## Advantages

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- Supports **almost any game**
  - Only places terrain/objects
  - You interpret placement
  - Allows custom properties
- Supports **custom collisions**
  - Each object has a “hit box”
  - Not just rectangular shapes
- Supports **XML and JSON**

## Disadvantages

---

- No **polygonal terrain**
  - Terrain must fit to the grid
  - NOT how Lab 4 works
- No (real) **AI scripting**
  - At best have “JSON scripts”
  - Also can define patrol paths
- No **built-in parser**
  - To convert JSON to classes

# No Built-in Parser?

libgdx API

OVERVIEW PACKAGE CLASS USE TREE DEPRECATED INDEX HELP

PREV CLASS NEXT CLASS FRAMES NO FRAMES

SUMMARY: NESTED | FIELD | CONSTR | METHOD   DETAIL: FIELD | CONSTR | METHOD

com.badlogic.gdx.maps.tiled

**Interface TiledMapRenderer**

All Superinterfaces:  
[MapRenderer](#)

All Known Implementing Classes:  
[BatchTiledMapRenderer](#), [HexagonalTiledMapRenderer](#), [IsometricStaggeredTiledMapRenderer](#), [IsometricTiledMapRenderer](#), [OrthoCachedTiledMapRenderer](#), [OrthogonalTiledMapRenderer](#)

class in com.badlogic.gdx.maps.tiled.renderers

```
public interface TiledMapRenderer
extends MapRenderer
```

**Method Summary**

All Methods	Instance Methods	Abstract Methods
	<b>Modifier and Type</b>	<b>Method and Description</b>
	void	<a href="#">renderImageLayer(TiledMapImageLayer layer)</a>
	void	<a href="#">renderObject(MapObject object)</a>
	void	<a href="#">renderObjects(MapLayer layer)</a>
	void	<a href="#">renderTileLayer(TiledMapTileLayer layer)</a>

Methods inherited from interface com.badlogic.gdx.maps.MapRenderer

[render](#), [render](#), [setView](#), [setView](#)

Open "https://libgdx.badlogicgames.com/nightlies/docs/api/com/badlogic/gdx/maps/tiled/renderers/OrthoCachedTiledMapRenderer.html" in a new tab

# No Built-in Parser?

The image shows a screenshot of a web browser displaying the libgdx API documentation for the `TiledMapRenderer` class. The browser's address bar shows the URL `libgdx.badlogicgames.com/nightlies/docs/api`. The page title is `TiledMapRenderer (libgdx API)`. The navigation menu includes `OVERVIEW`, `PACKAGE`, `CLASS` (highlighted), `USE TREE`, `DEPRECATED`, `INDEX`, and `HELP`. The left sidebar shows a tree of classes, with `com.badlogic.gdx.maps.tiled` selected. The main content area shows the `Interface TiledMapRenderer` with its methods: `renderImageLayer(TiledMapImageLayer layer)`, `renderObject(MapObject object)`, `renderObjects(MapLayer layer)`, and `renderTileLayer(TiledMapTileLayer layer)`. A large red banner with the text **Forbidden!** is overlaid on the page. The status bar at the bottom indicates the page was opened in a new tab.

# The Problem with External Editors

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- Editors often come with **runtimes**
  - Premade classes for the editor objects
  - Parser converts JSON/XML into these classes
- This shackles your architecture design
  - You must design your classes around these
  - They often violate MVC in hideous ways
- Reject tools that screw up your architecture!
  - Good tools should be *decoupled* (e.g. Box2d)

# Summary

---

- Data-driven design has several advantages
  - Faster content production; code reuse is easier
  - Embrace of modder community can add value
- Two major focuses in data-driven design
  - **Level editors** place content and challenges
  - **Scripts** specify code-like behavior outside of code
- Be careful with 3<sup>rd</sup> party editors
  - Can streamline your development process
  - But it can also screw up your architecture