the gamedesigninitiative at cornell university

Lecture 12

Data-Driven Design

Take-Away for Today

- 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?

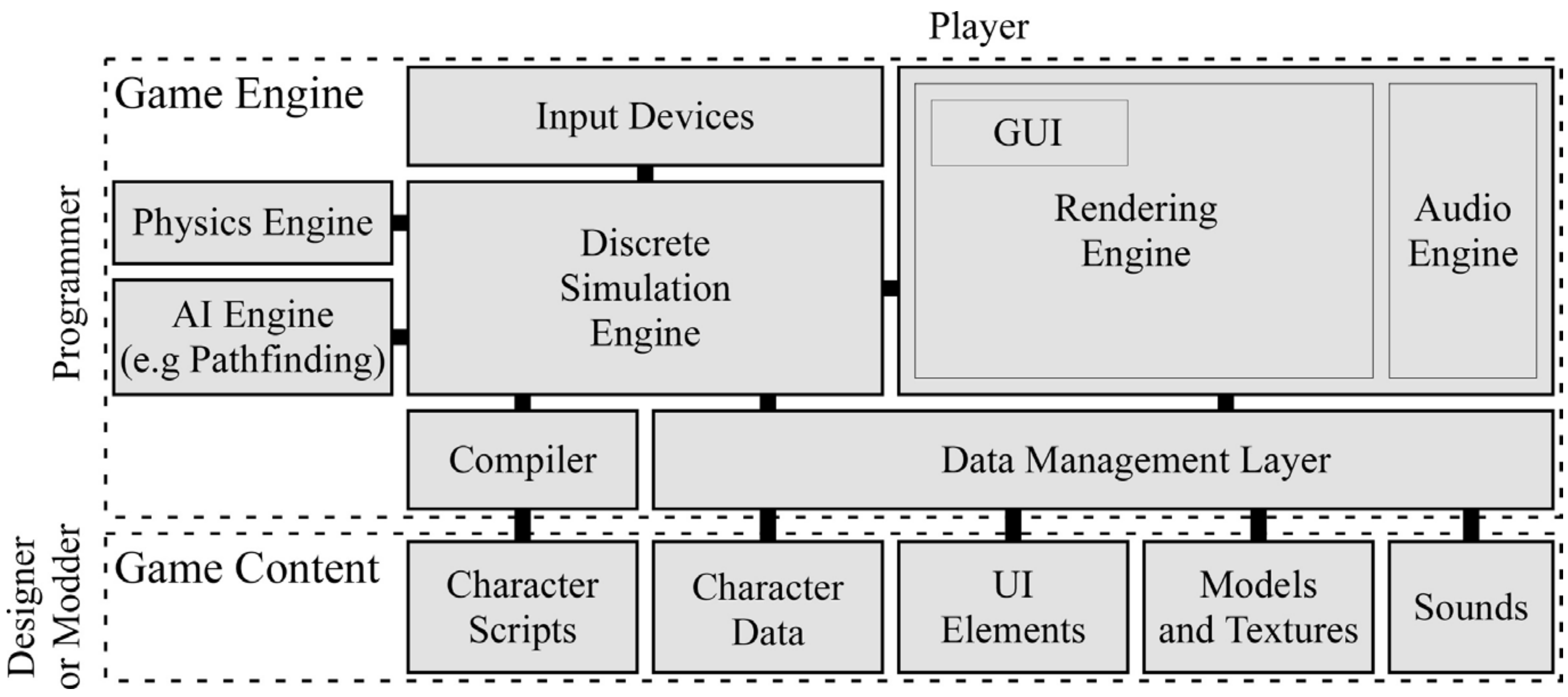
Recall: Game Components

- **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

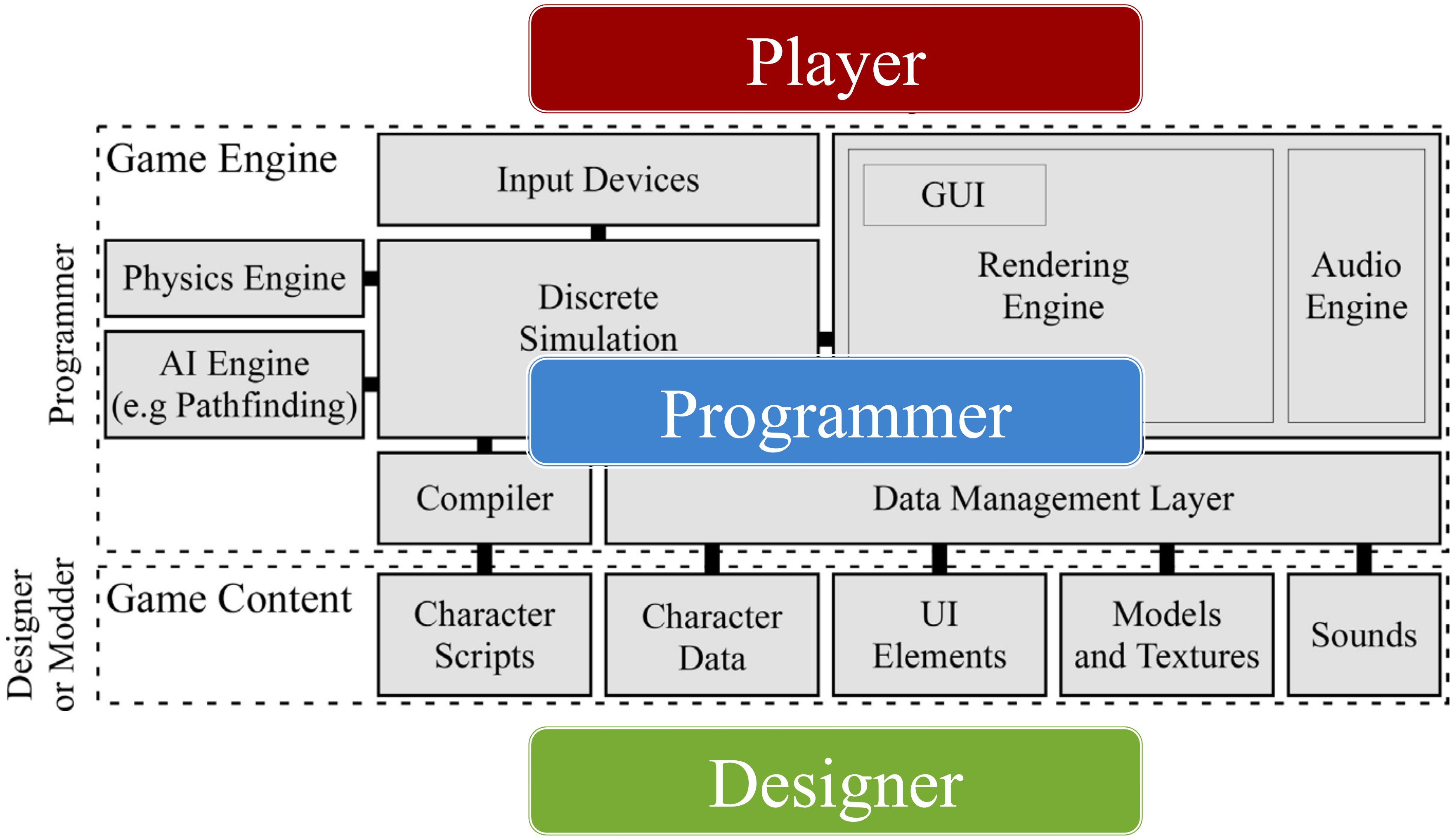
Data Driven Design

- **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

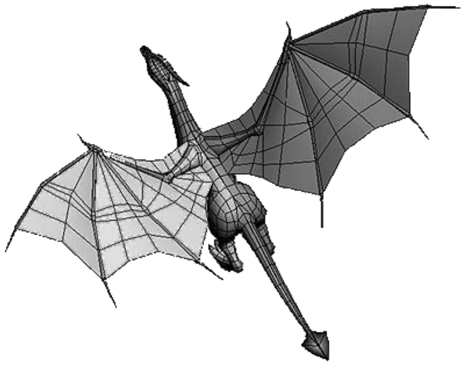


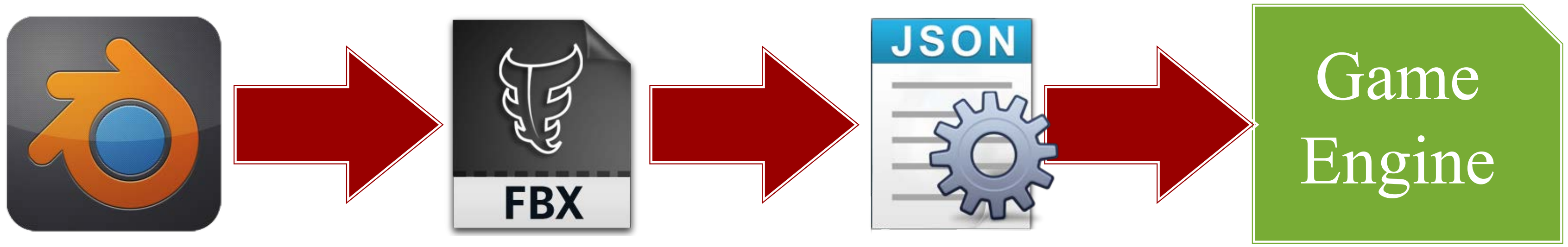
Common Development Cycle

- 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

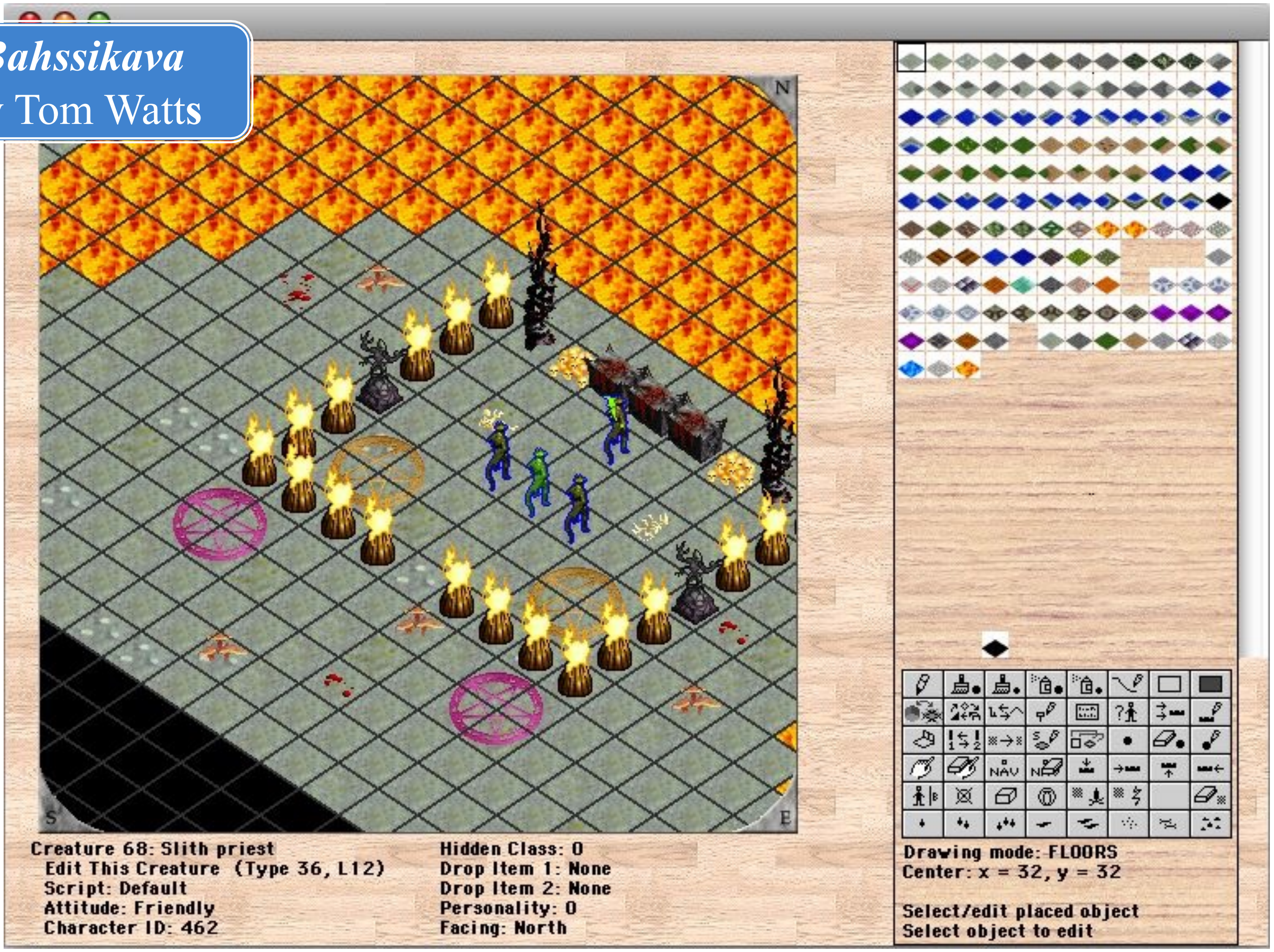
- **Level Editor**
  - Create challenges and obstacles
  - Layout the user interface
  - Tune parameters (physics, difficulty, etc.)
- **Scripting Tools**
  - Layout the user interface
  - Define character behavior
  - Script triggers and events

Level Editor Features

- **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

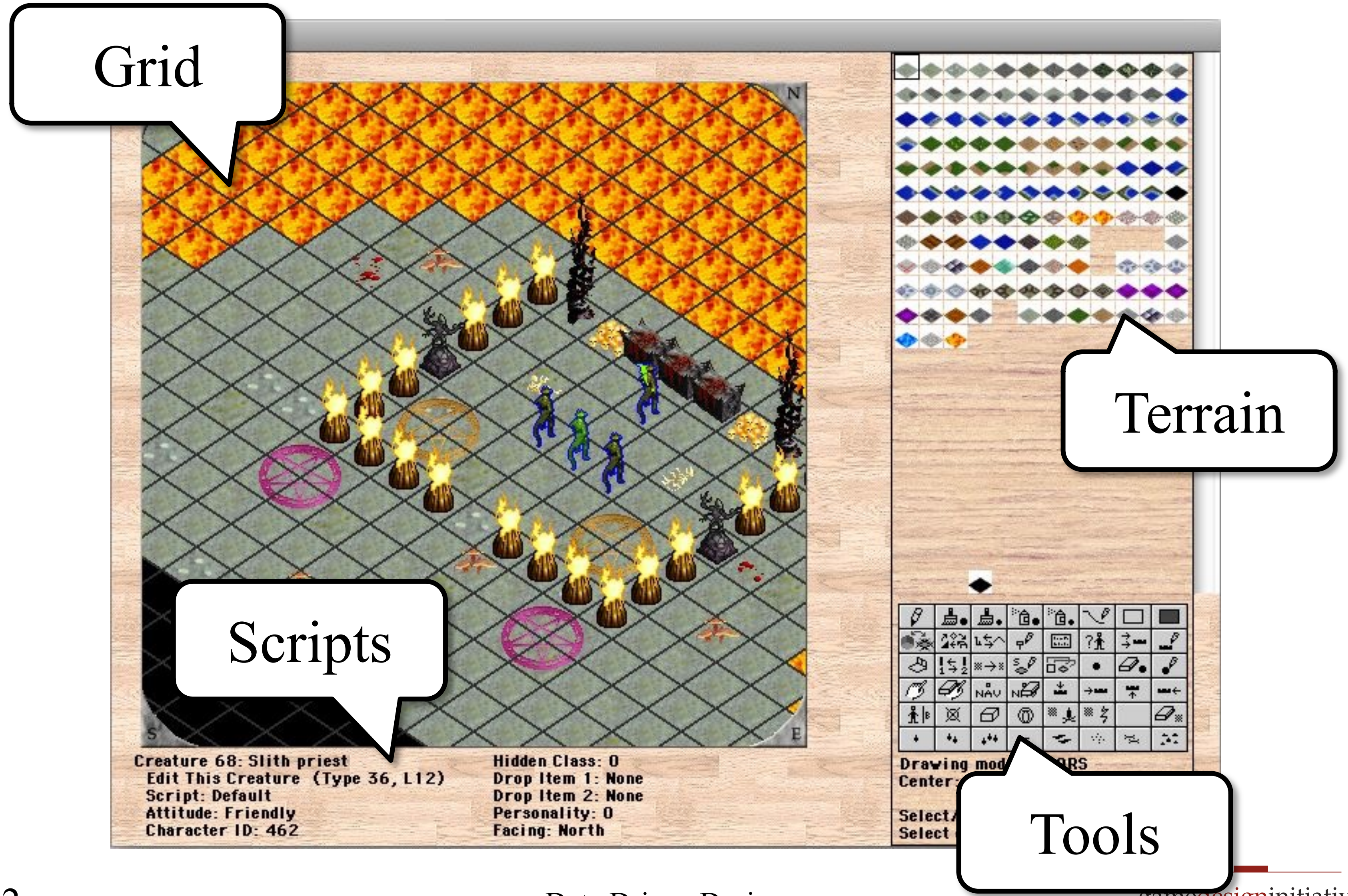
Example: *Blades of Avernum*

Bahssikava
by Tom Watts



```
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
```

Example: *Blades of Avernum*



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  Script: Default                      Drop Item 2: None
  Attitude: Friendly                   Personality: 0
  Character ID: 462                    Facing: North
```

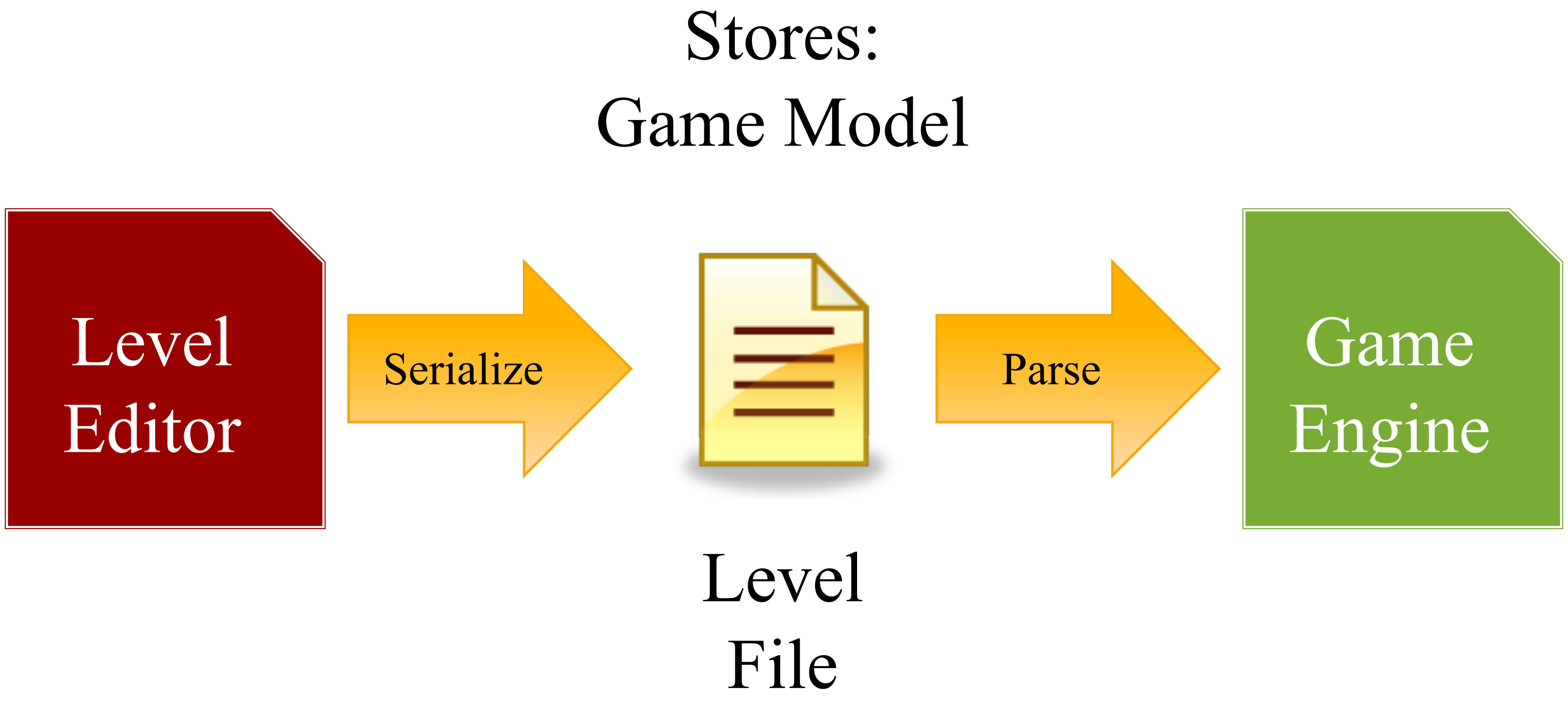
```
Drawing mod     ORS
Center:

Select
Select
```

Level Editor: Code Sharing

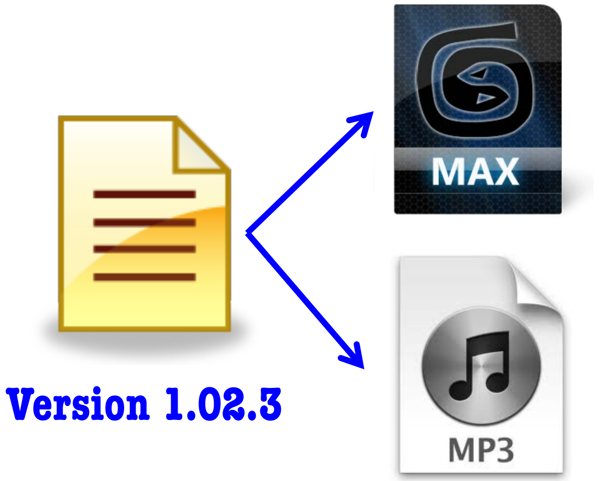
- **Option**: level editor in **same project**
  - Single IntelliJ project for both
  - **Pro**: Easy to integrate into the game itself
  - **Con**: Harder to separate modules/subsystems
- **Option**: develop **core technology**
  - Identify source code used by each
  - JAR for both level editor and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

Level Editor: **Serialization**



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>
  <po
    <x      </x>
    <y>25</y>
  </position>
</NPC>
```

XmlReader

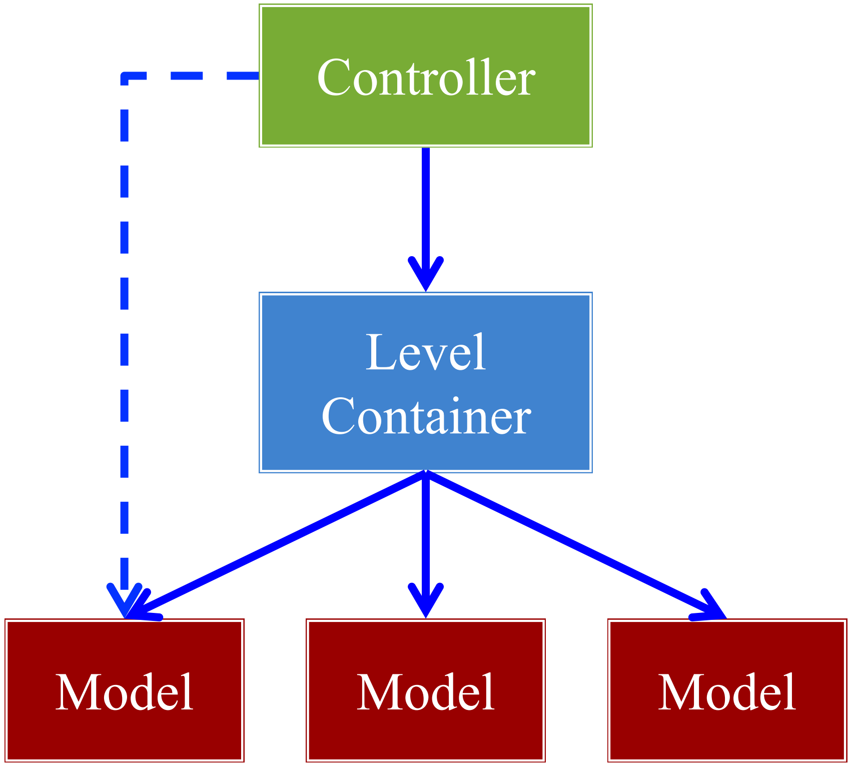
JSON

```
{
  "NPC" : {
    "type" : "Orc",
    "
    "p      ion" : {
      "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

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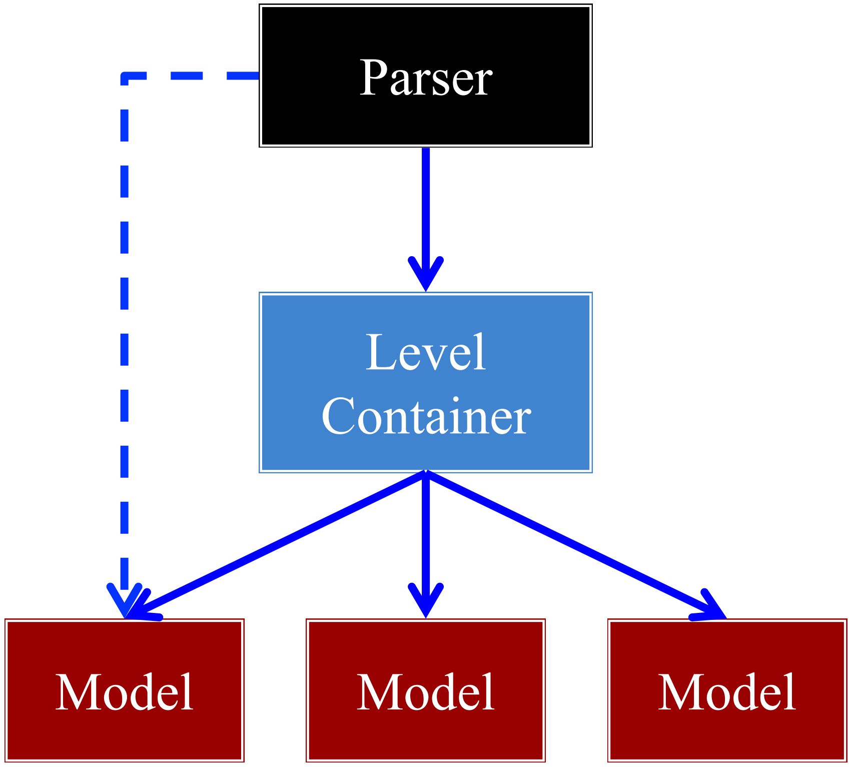


In-Model Deserialization

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

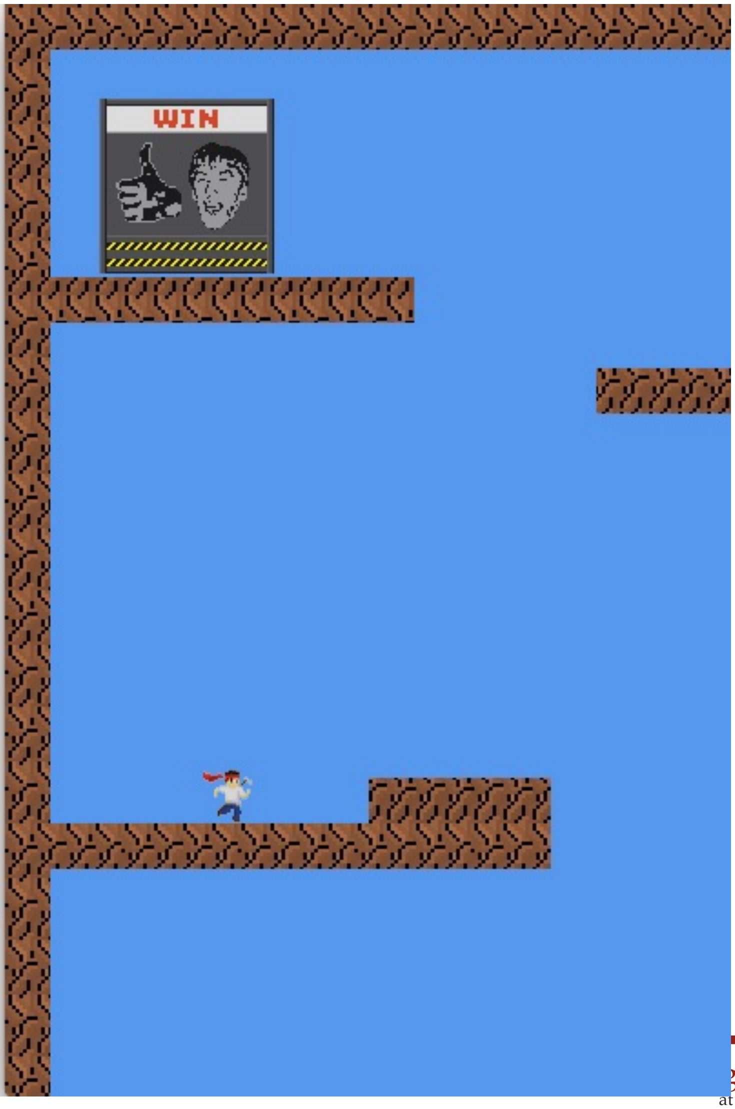
```
class Model {
  …
  void loadData(JSON data) {…}
  …
  void loadData(XML data) {…}
```

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

- 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

- **Internal**: Read-Only
  - Location where the assets are stored
  - Could be inside of a `.jar` file!
- **Local**: Read-Write
  - 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 ssets are stored
  - jar file!
- **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
  - ission to write here

See LibGDX File class for more

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

- **Level Editor**
  - Create challenges and obstacles
  - Layout the user interface
  - Tune parameters (physics, difficulty, etc.)
- **Scripting Tools**
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  - Define character behavior
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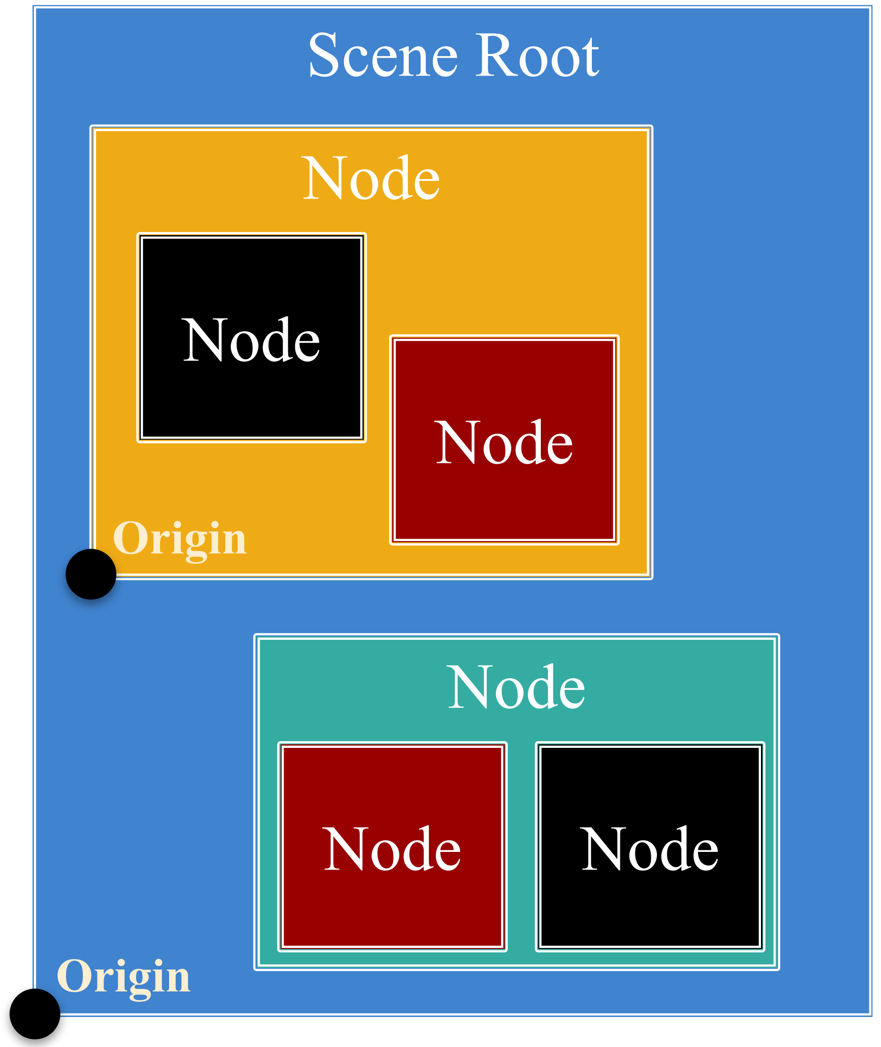
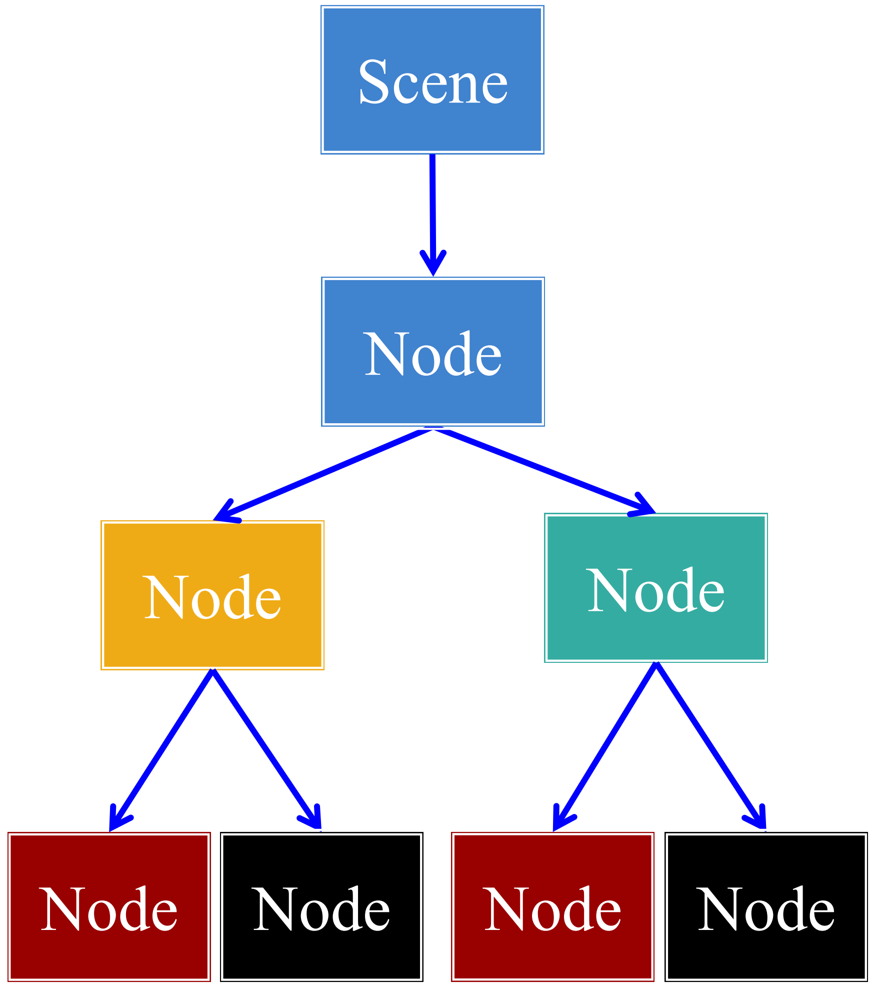
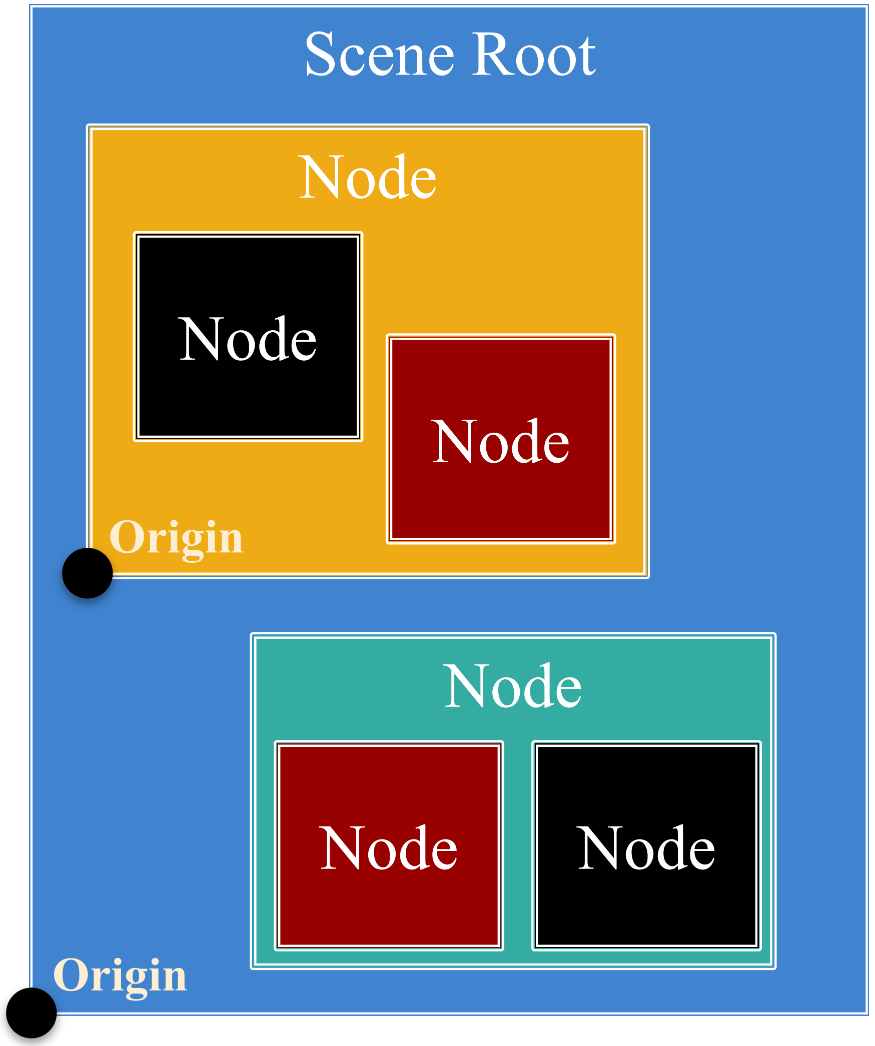
UI Design: Scene Graphs

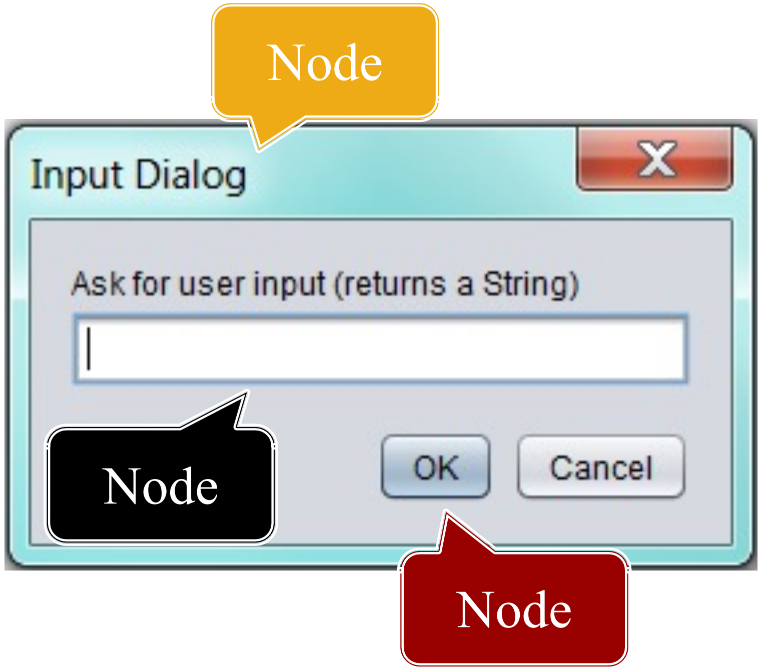




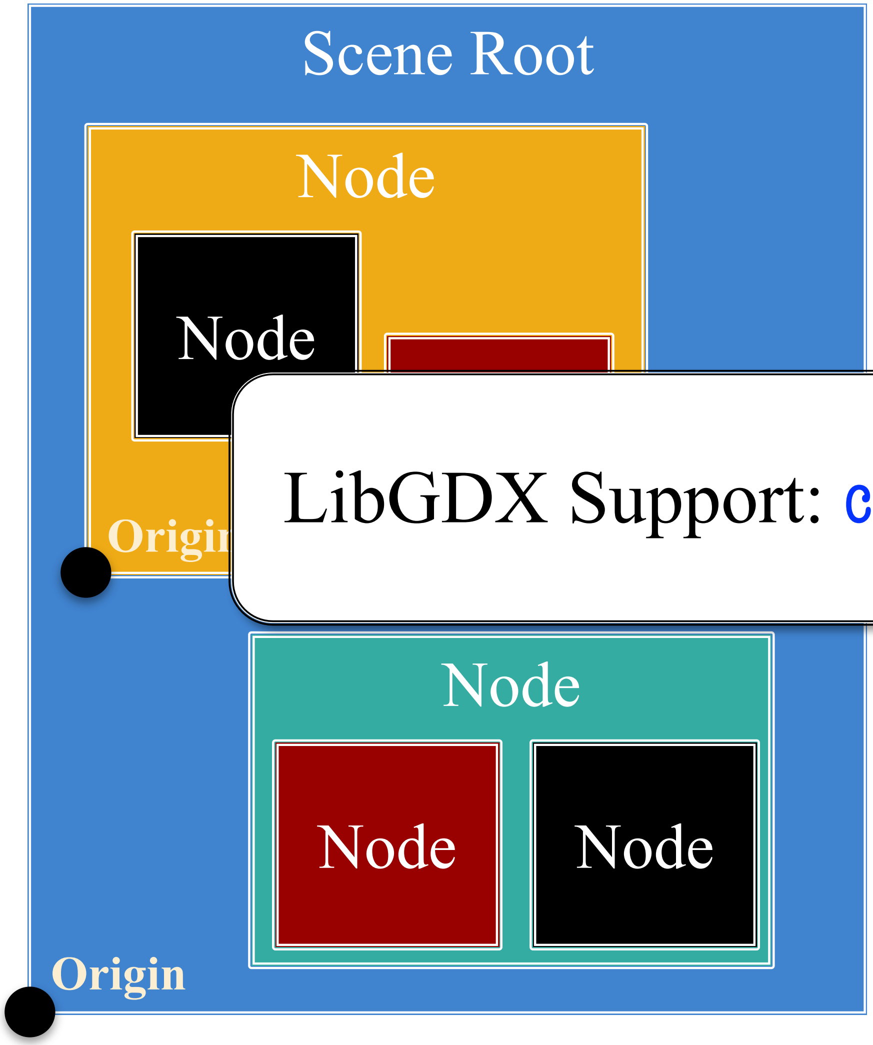
UI Design: Scene Graphs



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

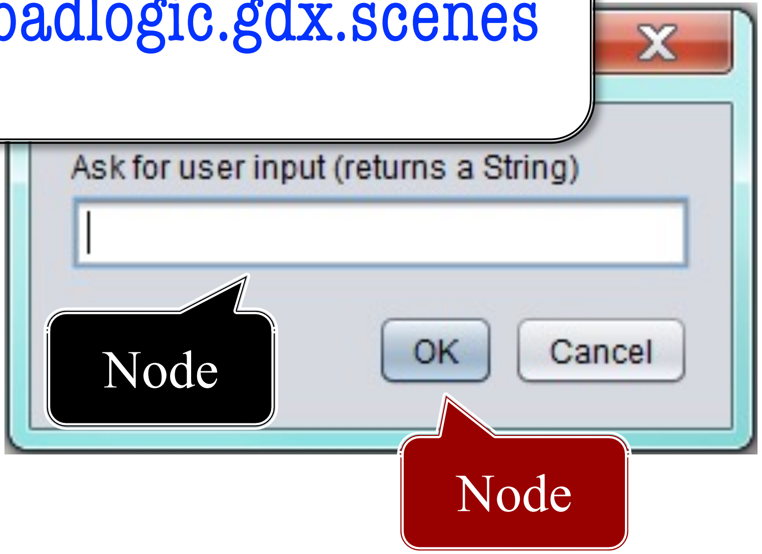


UI Design: Scene Graphs



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

LibGDX Support: com.badlogic.gdx.scenes



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"
            }
```

Node type

Node name

Layout manager

Child nodes

CUGL: JSON for Scene Graphs

```
"textfield" : {
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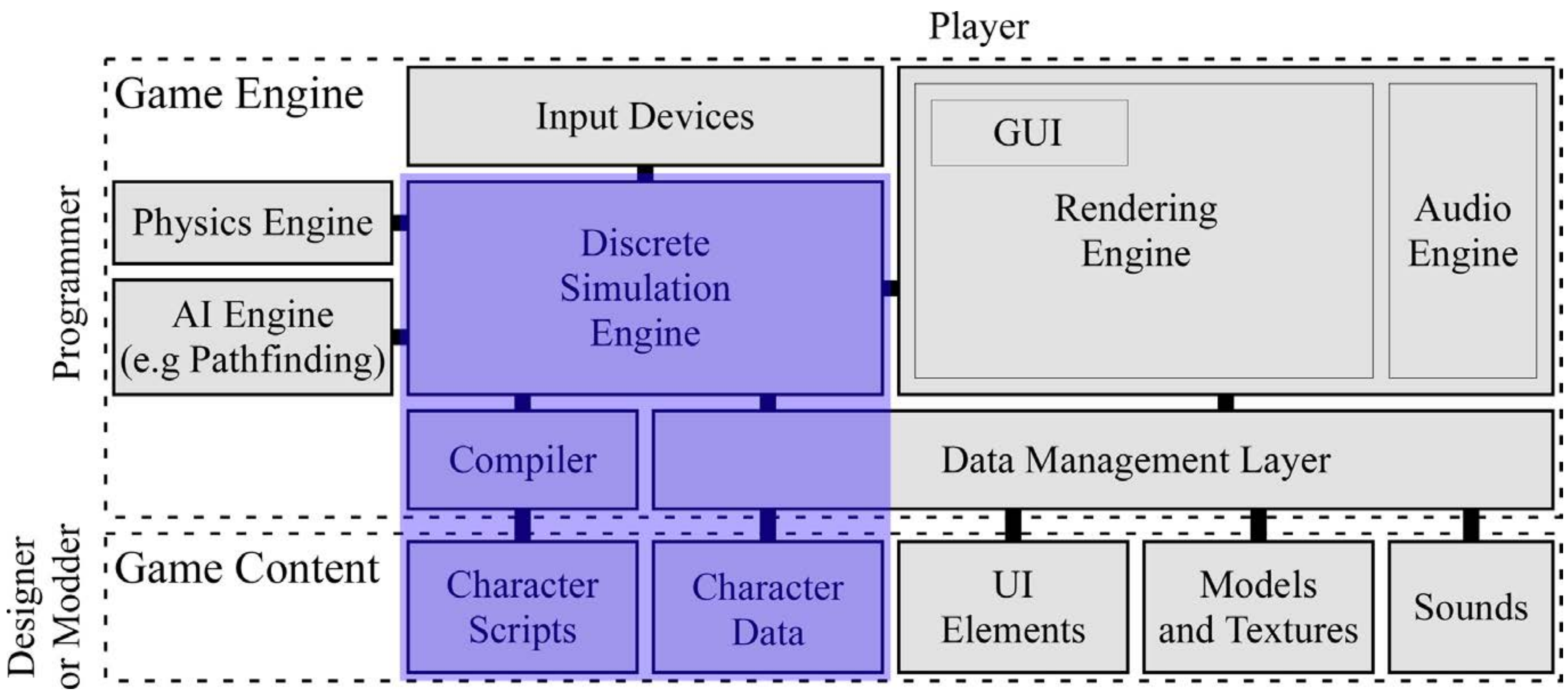
            },
            "layout" : {
                "x_anchor" : "center",
                "y_anchor" : "top"
}
```

Layout manager

Node data

Info for parent layout

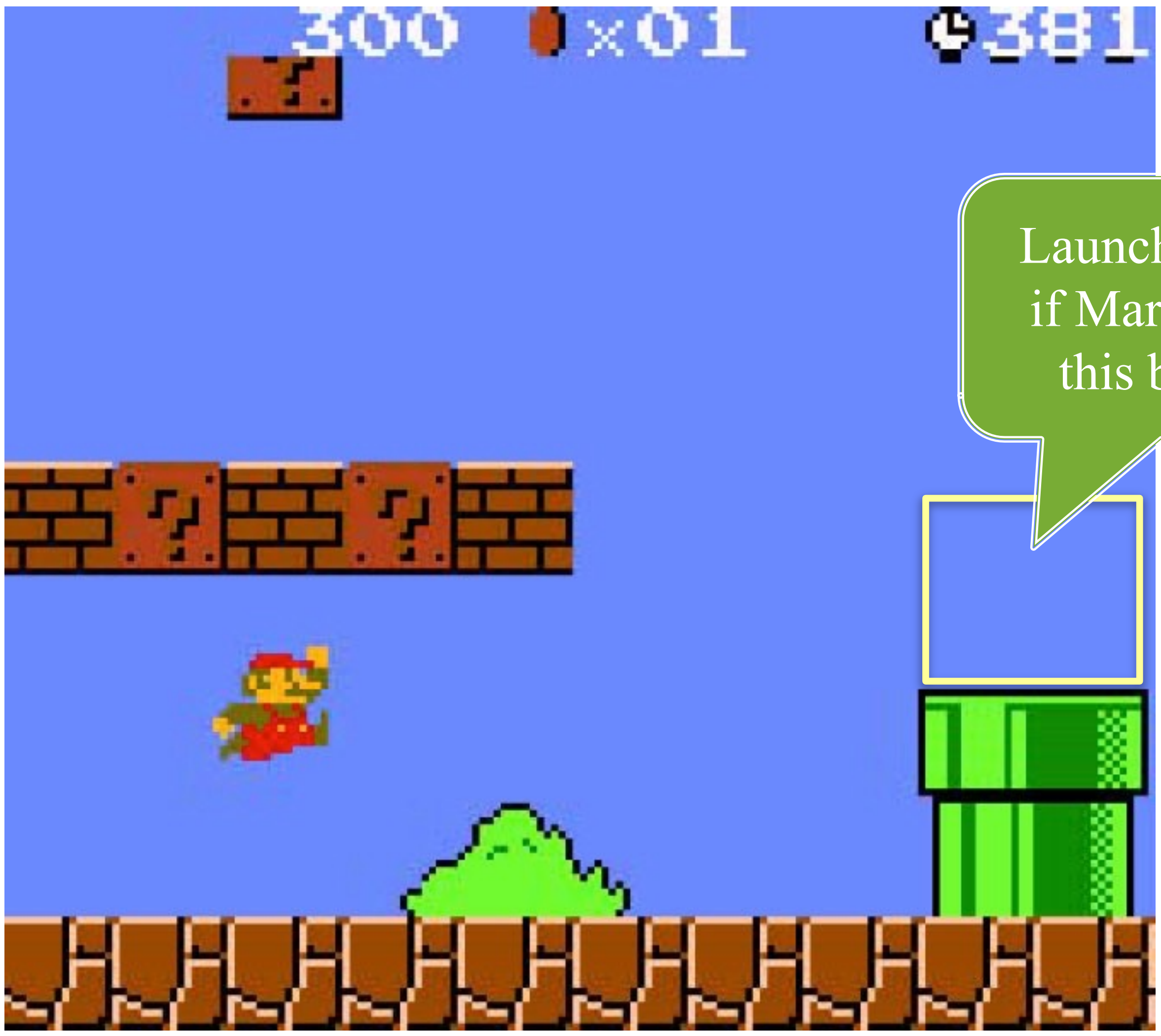
Scripting Languages



Why Scripting?

- **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

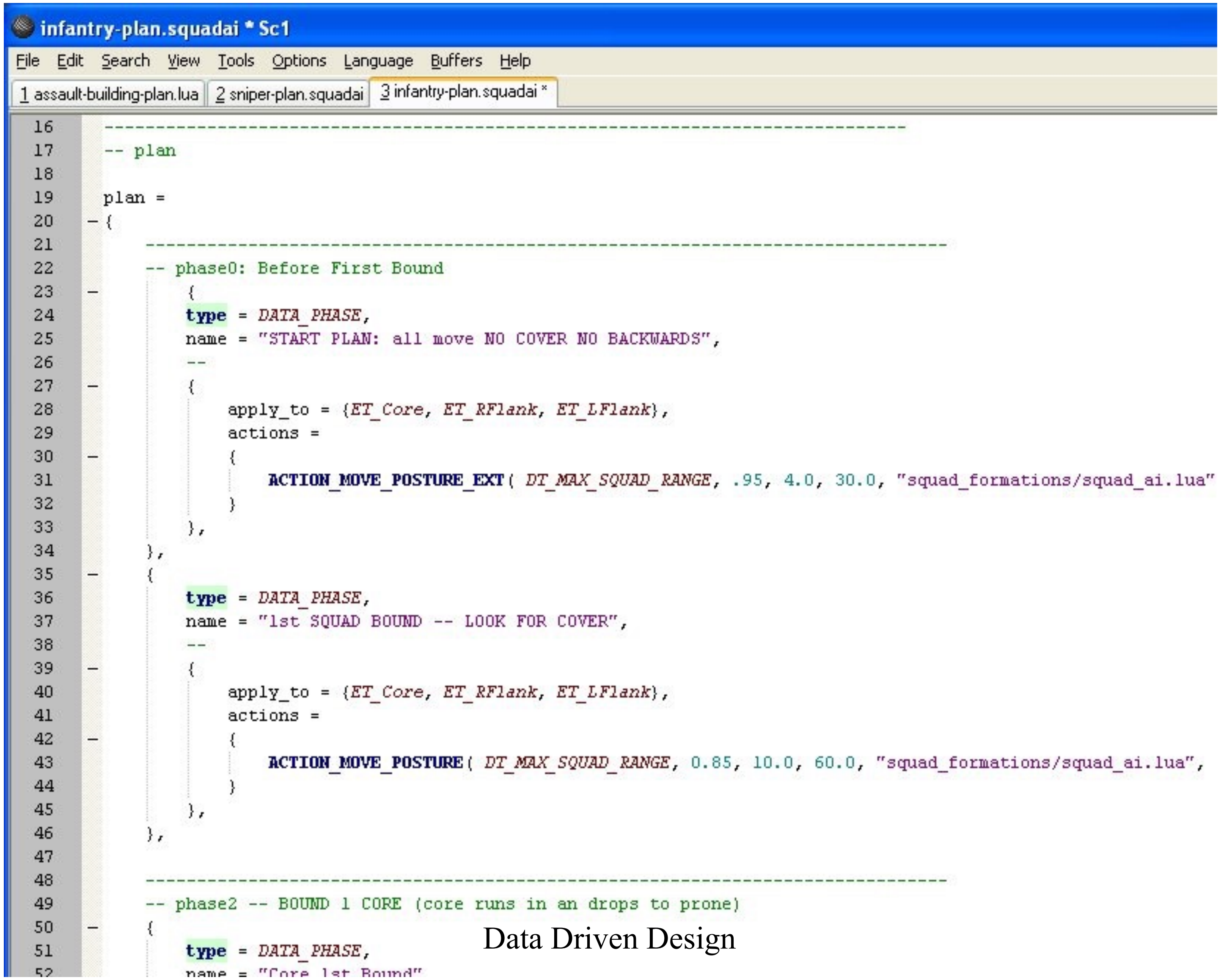


Launch cut scene if Mario reaches this box **alive**

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*

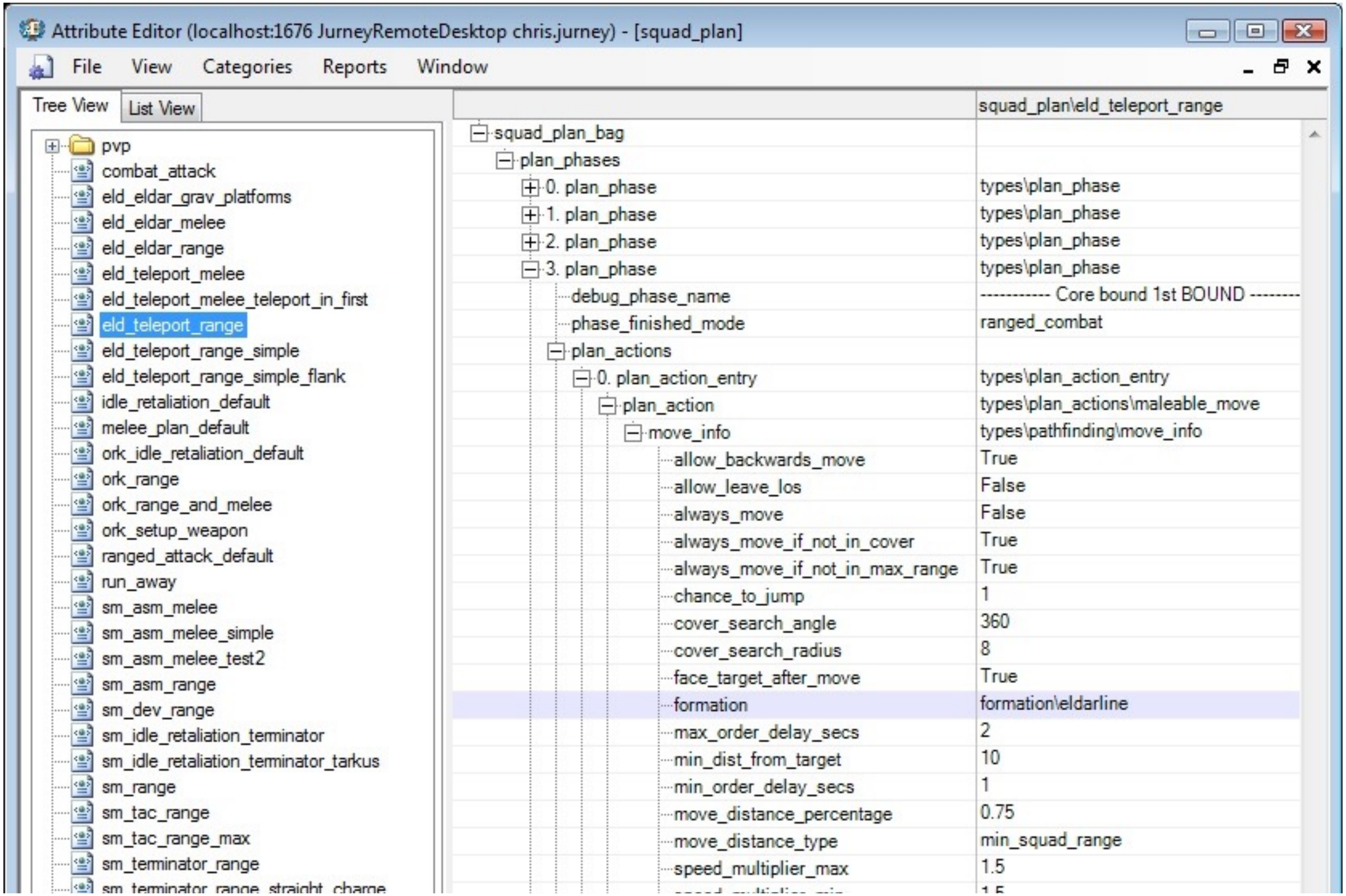

infantry-plan.squadai * Sc1
File Edit Search View Tools Options Language Buffers Help
1 assault-building-plan.lua
2 sniper-plan.squadai
3 infantry-plan.squadai *

```
--------------------------------------------------------------------------------
-- plan

plan =
{
    --------------------------------------------------------------------------------
    -- phase0: Before First Bound
        {
        type = DATA_PHASE,
        name = "START PLAN: all move NO COVER NO BACKWARDS",
        --
        {
            apply_to = {ET_Core, ET_RFlank, ET_LFlank},
            actions =
            {
                ACTION_MOVE_POSTURE_EXT( DT_MAX_SQUAD_RANGE, .95, 4.0, 30.0, "squad_formations/squad_ai.lua"
            }
        },
    },
    {
        type = DATA_PHASE,
        name = "1st SQUAD BOUND -- LOOK FOR COVER",
        --
        {
            apply_to = {ET_Core, ET_RFlank, ET_LFlank},
            actions =
            {
                ACTION_MOVE_POSTURE( DT_MAX_SQUAD_RANGE, 0.85, 10.0, 60.0, "squad_formations/squad_ai.lua",
            }
        },
    },

    --------------------------------------------------------------------------------
    -- phase2 -- BOUND 1 CORE (core runs in an drops to prone)
    {
        type = DATA_PHASE,
        name = "Core 1st Bound"
```

Simpler: XML Specification


Attribute Editor (localhost:1676 JurneyRemoteDesktop chris.jurney) - [squad_plan]
File
View
Categories
Reports
Window
Tree View
List View

- pvp
- combat_attack
- eld_eldar_grav_platforms
- eld_eldar_melee
- eld_eldar_range
- eld_teleport_melee
- eld_teleport_melee_teleport_in_first
- eld_teleport_range
- eld_teleport_range_simple
- eld_teleport_range_simple_flank
- idle_retaliation_default
- melee_plan_default
- ork_idle_retaliation_default
- ork_range
- ork_range_and_melee
- ork_setup_weapon
- ranged_attack_default
- run_away
- sm_asm_melee
- sm_asm_melee_simple
- sm_asm_melee_test2
- sm_asm_range
- sm_dev_range
- sm_idle_retaliation_terminator
- sm_idle_retaliation_terminator_tarkus
- sm_range
- sm_tac_range
- sm_tac_range_max
- sm_terminator_range
- sm_terminator_range_straight_charge

	squad_plan\eld_teleport_range
squad_plan_bag	
plan_phases	
0. plan_phase	types\plan_phase
1. plan_phase	types\plan_phase
2. plan_phase	types\plan_phase
3. plan_phase	types\plan_phase
debug_phase_name	----------- Core bound 1st BOUND --------
phase_finished_mode	ranged_combat
plan_actions	
0. plan_action_entry	types\plan_action_entry
plan_action	types\plan_actions\maleable_move
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

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;
  …
}"
```

→

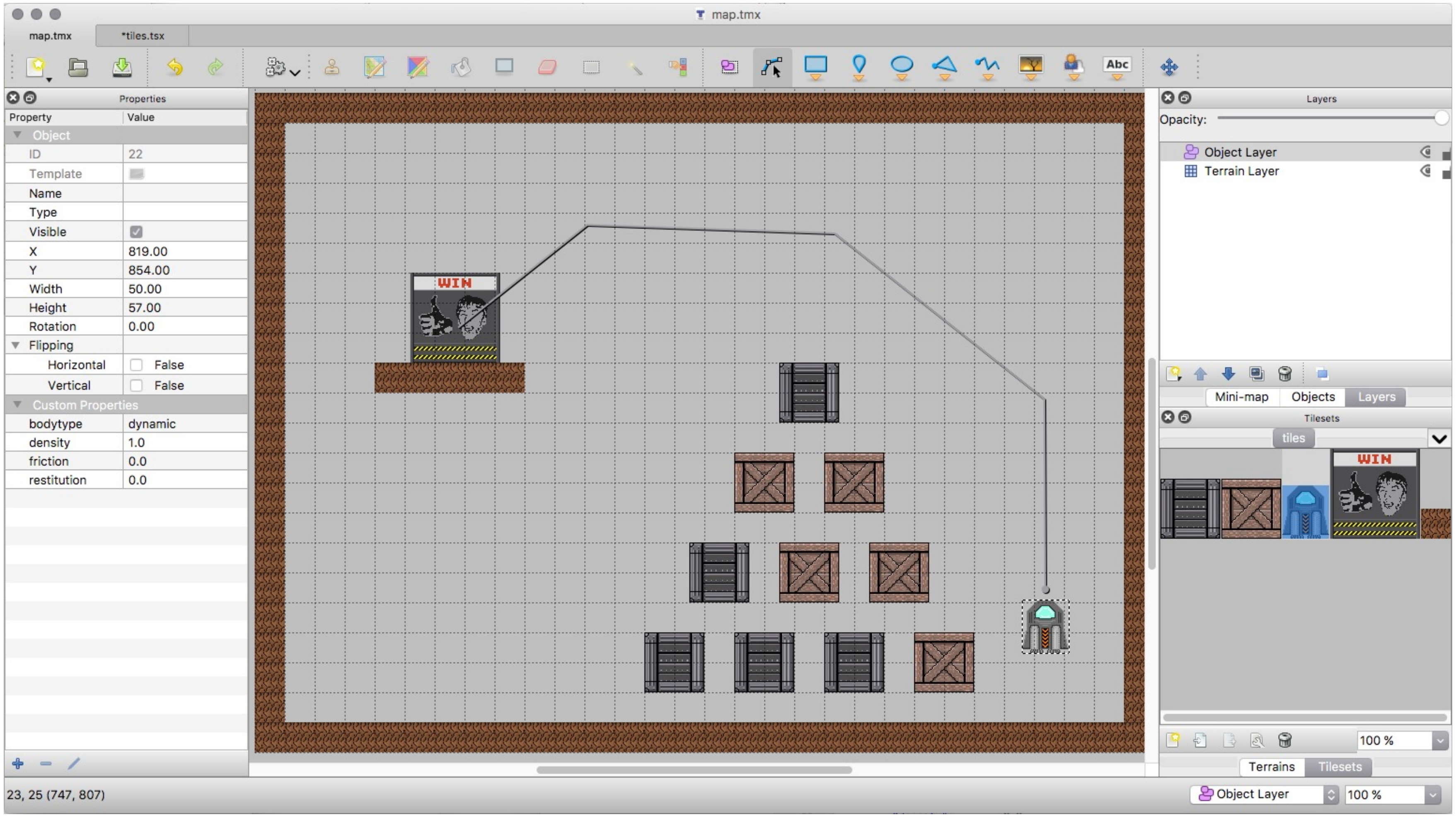
```
class MyEvent implements Event {

   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



Property	Value
Object	
ID	22
Template	
Name	
Type	
Visible	✓
X	819.00
Y	854.00
Width	50.00
Height	57.00
Rotation	0.00
Flipping	
Horizontal	False
Vertical	False
Custom Properties	
bodytype	dynamic
density	1.0
friction	0.0
restitution	0.0

Using **Tiled** for 3152

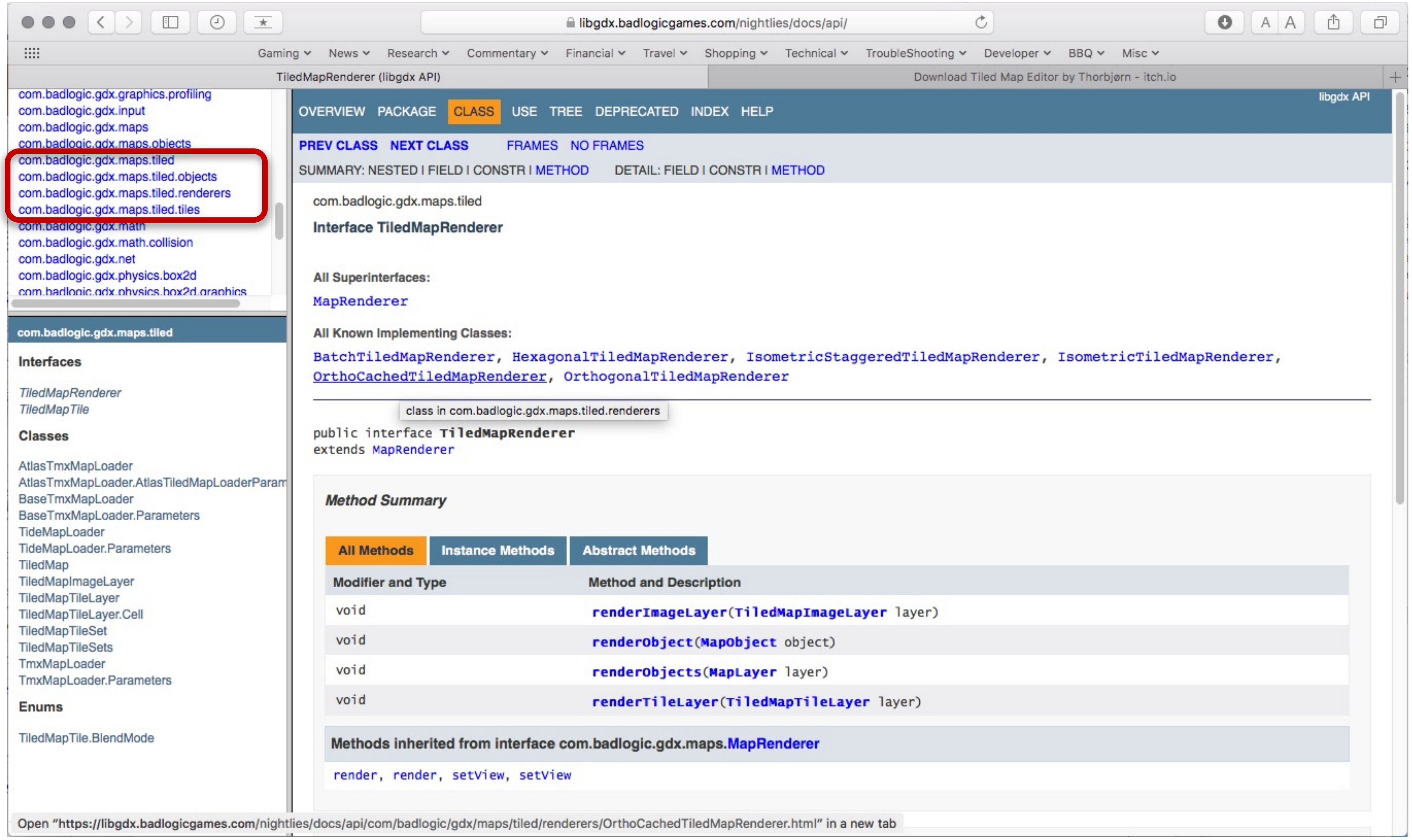
Advantanges

- Supports **almost any game**
  - Only places terrain/objects
  - Your 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.badlogicgames.com/nightlies/docs/api/

Gaming News Research Commentary Financial Travel Shopping Technical TroubleShooting Developer BBQ Misc
TiledMapRenderer (libgdx API)
Download Tiled Map Editor by Thorbjørn - itch.io

com.badlogic.gdx.graphics.profiling
com.badlogic.gdx.input
com.badlogic.gdx.maps
com.badlogic.gdx.maps.objects
com.badlogic.gdx.maps.tiled
com.badlogic.gdx.maps.tiled.objects
com.badlogic.gdx.maps.tiled.renderers
com.badlogic.gdx.maps.tiled.tiles
com.badlogic.gdx.math
com.badlogic.gdx.math.collision
com.badlogic.gdx.net
com.badlogic.gdx.physics.box2d
com.badlogic.gdx.physics.box2d.graphics

com.badlogic.gdx.maps.tiled

Interfaces

TiledMapRenderer
TiledMapTile

Classes

AtlasTmxMapLoader
AtlasTmxMapLoader.AtlasTiledMapLoaderParam
BaseTmxMapLoader
BaseTmxMapLoader.Parameters
TideMapLoader
TideMapLoader.Parameters
TiledMap
TiledMapImageLayer
TiledMapTileLayer
TiledMapTileLayer.Cell
TiledMapTileSet
TiledMapTileSets
TmxMapLoader
TmxMapLoader.Parameters

Enums

TiledMapTile.BlendMode

OVERVIEW PACKAGE CLASS USE TREE DEPRECATED INDEX HELP
libgdx API
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

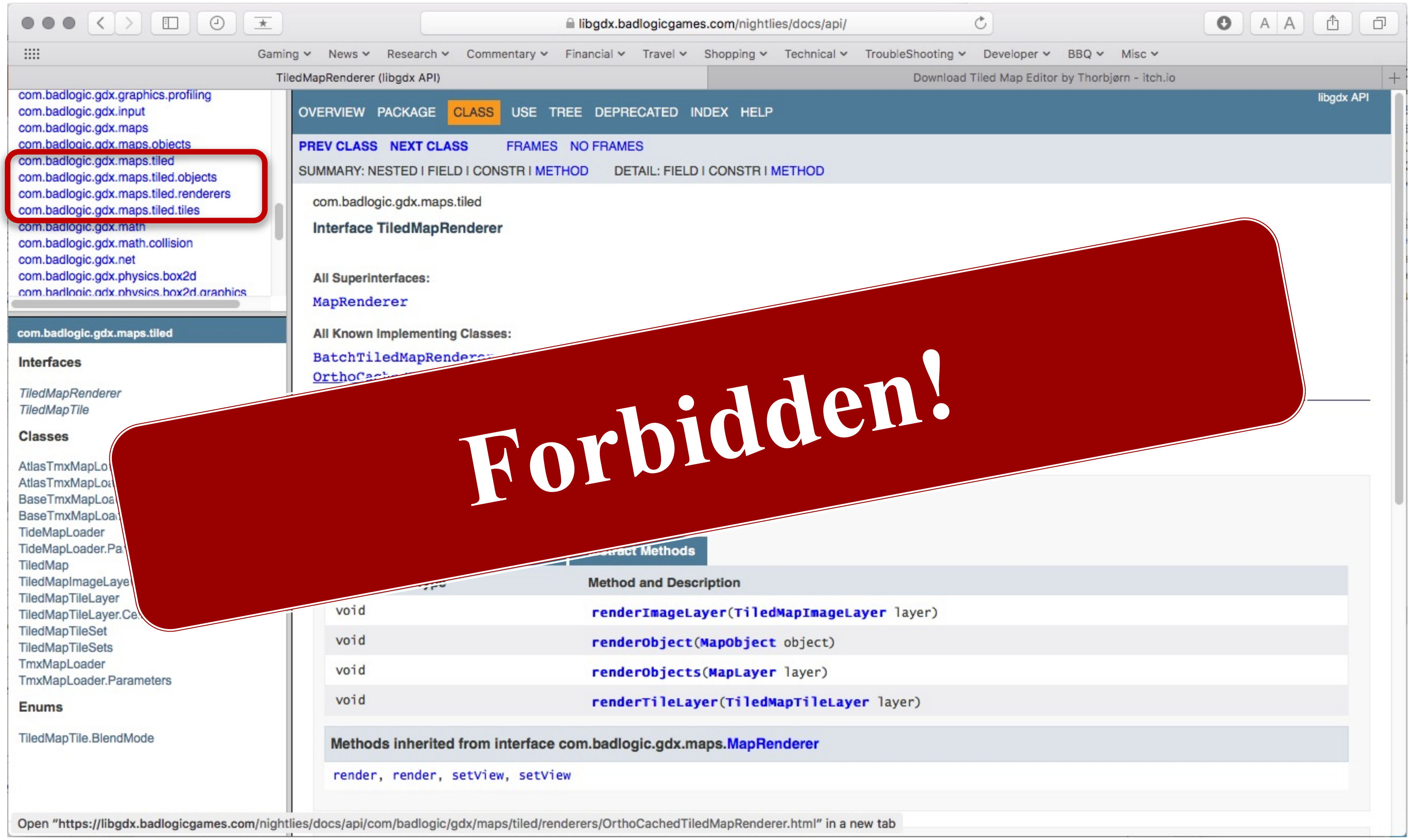
Modifier and Type	Method and Description
void	renderImageLayer(TiledMapImageLayer layer)
void	renderObject(MapObject object)
void	renderObjects(MapLayer layer)
void	renderTileLayer(TiledMapTileLayer layer)

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?



libgdx.badlogicgames.com/nightlies/docs/api/

TiledMapRenderer (libgdx API)

Download Tiled Map Editor by Thorbjørn - itch.io

com.badlogic.gdx.graphics.profiling
com.badlogic.gdx.input
com.badlogic.gdx.maps
com.badlogic.gdx.maps.objects
com.badlogic.gdx.maps.tiled
com.badlogic.gdx.maps.tiled.objects
com.badlogic.gdx.maps.tiled.renderers
com.badlogic.gdx.maps.tiled.tiles
com.badlogic.gdx.math
com.badlogic.gdx.math.collision
com.badlogic.gdx.net
com.badlogic.gdx.physics.box2d
com.badlogic.gdx.physics.box2d.graphics

com.badlogic.gdx.maps.tiled

Interfaces

TiledMapRenderer
TiledMapTile

Classes

AtlasTmxMapLo
AtlasTmxMapLo
BaseTmxMapLoa
BaseTmxMapLoa
TideMapLoader
TideMapLoader.Pa
TiledMap
TiledMapImageLaye
TiledMapTileLayer
TiledMapTileLayer.Ce
TiledMapTileSet
TiledMapTileSets
TmxMapLoader
TmxMapLoader.Parameters

Enums

TiledMapTile.BlendMode

com.badlogic.gdx.maps.tiled

Interface TiledMapRenderer

All Superinterfaces:

MapRenderer

All Known Implementing Classes:

BatchTiledMapRenderer
OrthoCach

	Method and Description
void	renderImageLayer(TiledMapImageLayer layer)
void	renderObject(MapObject object)
void	renderObjects(MapLayer layer)
void	renderTileLayer(TiledMapTileLayer layer)

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

OVERVIEW PACKAGE CLASS USE TREE DEPRECATED INDEX HELP
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Gaming News Research Commentary Financial Travel Shopping Technical TroubleShooting Developer BBQ Misc
Forbidden!

The Problem with External Editors

- 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 3rd party editors
  - Can streamline your development process
  - But it can also screw up your architecture