the gamedesigninitiative at cornell university

Lecture 14

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?

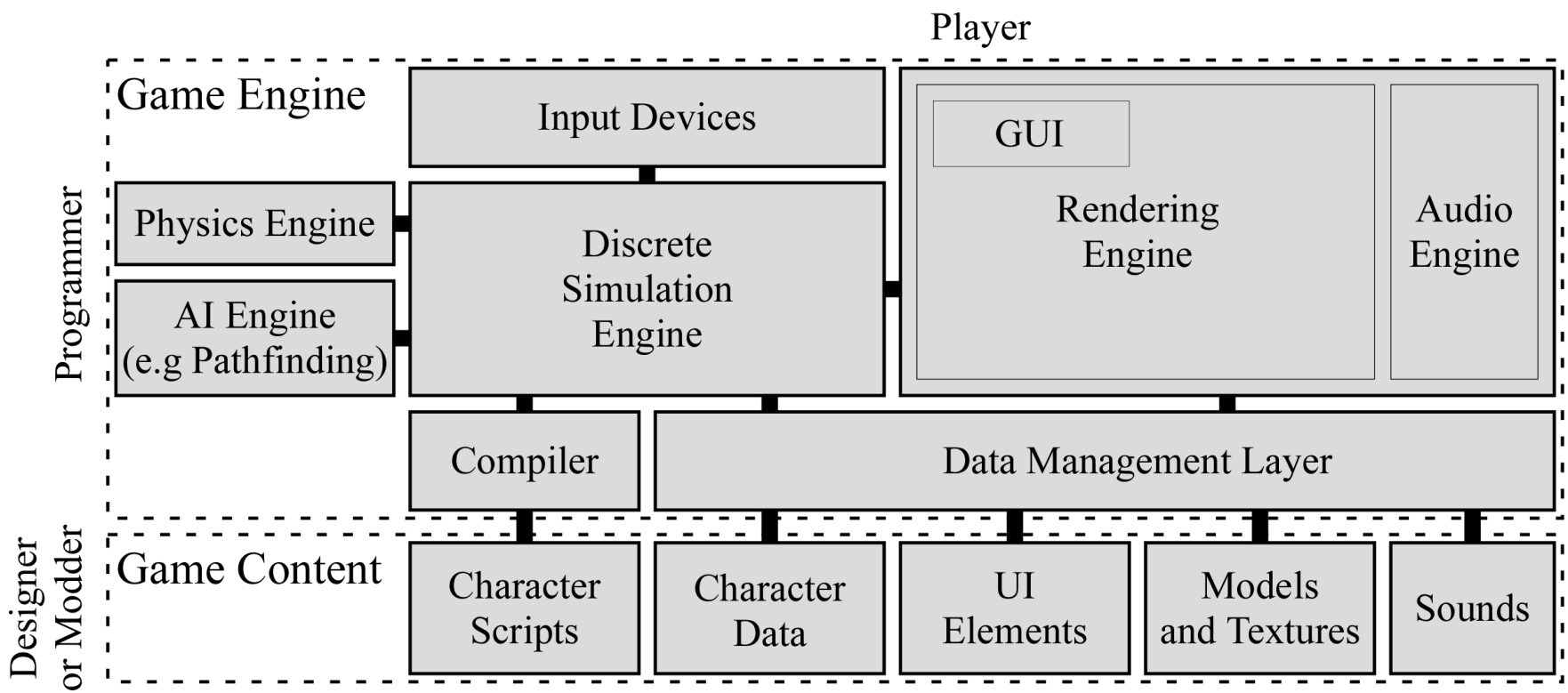
Recall: Game Components

- **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 XML or other data file formats
  - User interface in XML or other data files
  - Character behavior specified through scripts

Architecture: The Big Picture



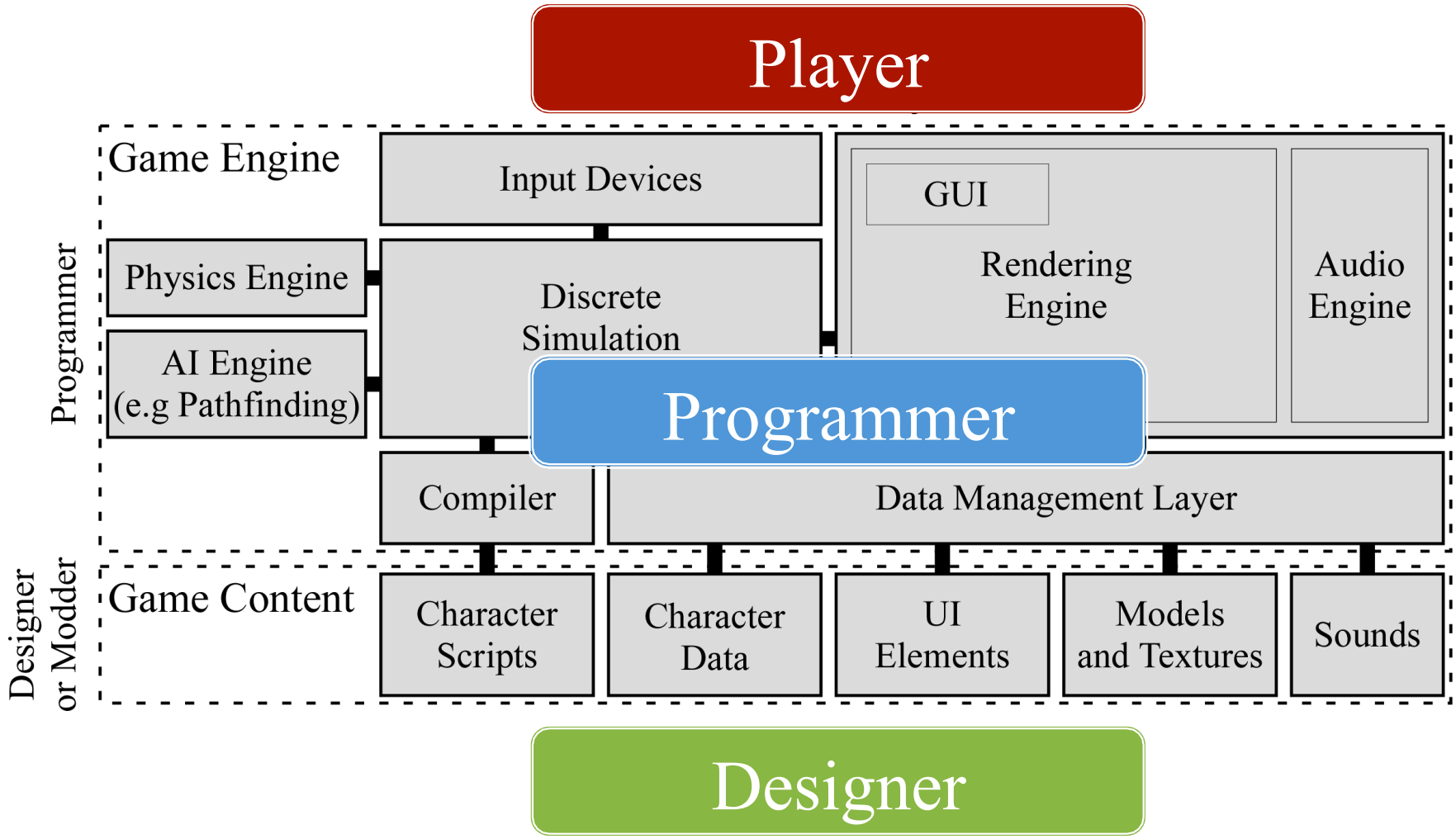
Why Data Driven Design?

- Games involve many actors:
  - Programmers: Create the game engine
    - Focus on technological development
  - Designers: Create the game content
    - Typically artistic/behavioral content

.....

  - Players: Interact with the game
  - Modders: Modify the game content
    - Post-market "designers"
- Optimize the **production pipeline**

Architecture: The Big Picture



The Benefits of Modding

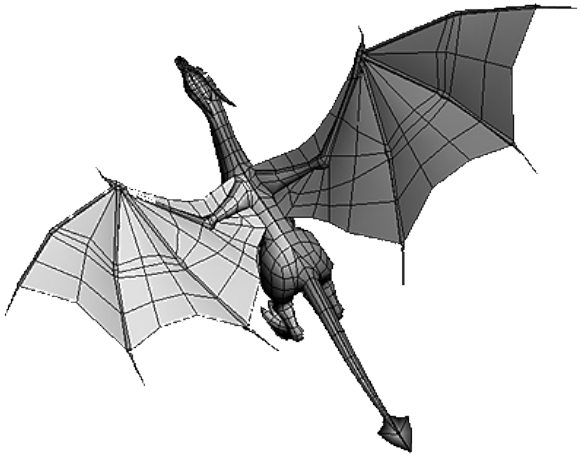
- Can extend the life span of the game
  - Keep the game content fresh over many years
  - If gamers are playing, will buy DLC!
- Community can add new game play
  - *Counter Strike* was a community mod
  - New quests and items for *Skyrim*
- Open up game to new markets
  - *Starcraft* in training and education

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

Artist | Data Format | Software



COLLADA

xna

MAX

XML

<xml />

Game Engine

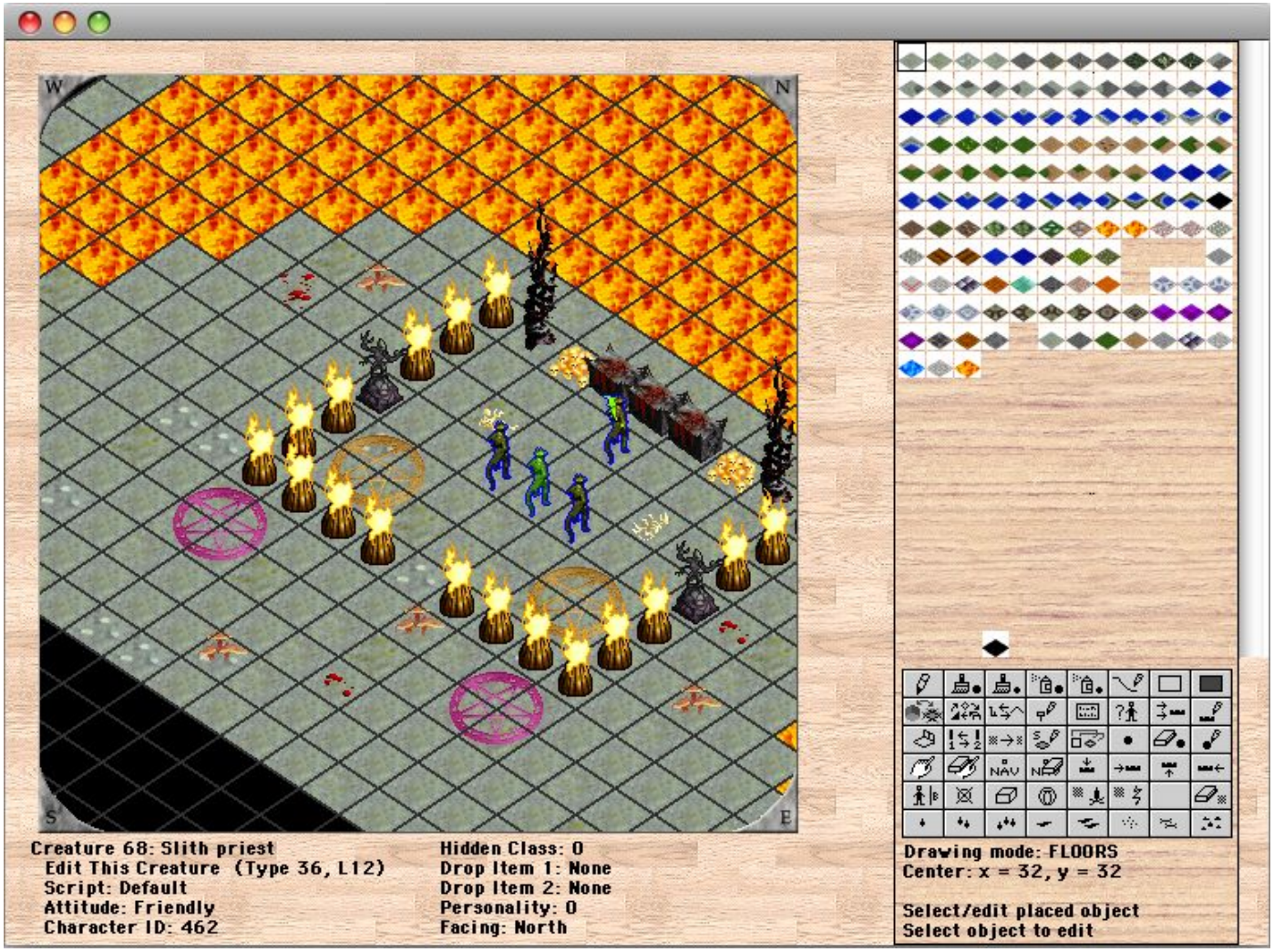
Content Creation Tools

- **Level editor**
  - Create challenges and obstacles
  - Place objects in the world
  - Tune parameters (physics, difficulty, etc.)
- **Scripting Languages**
  - Define character behavior
  - Script triggers and events
  - Layout the user interface

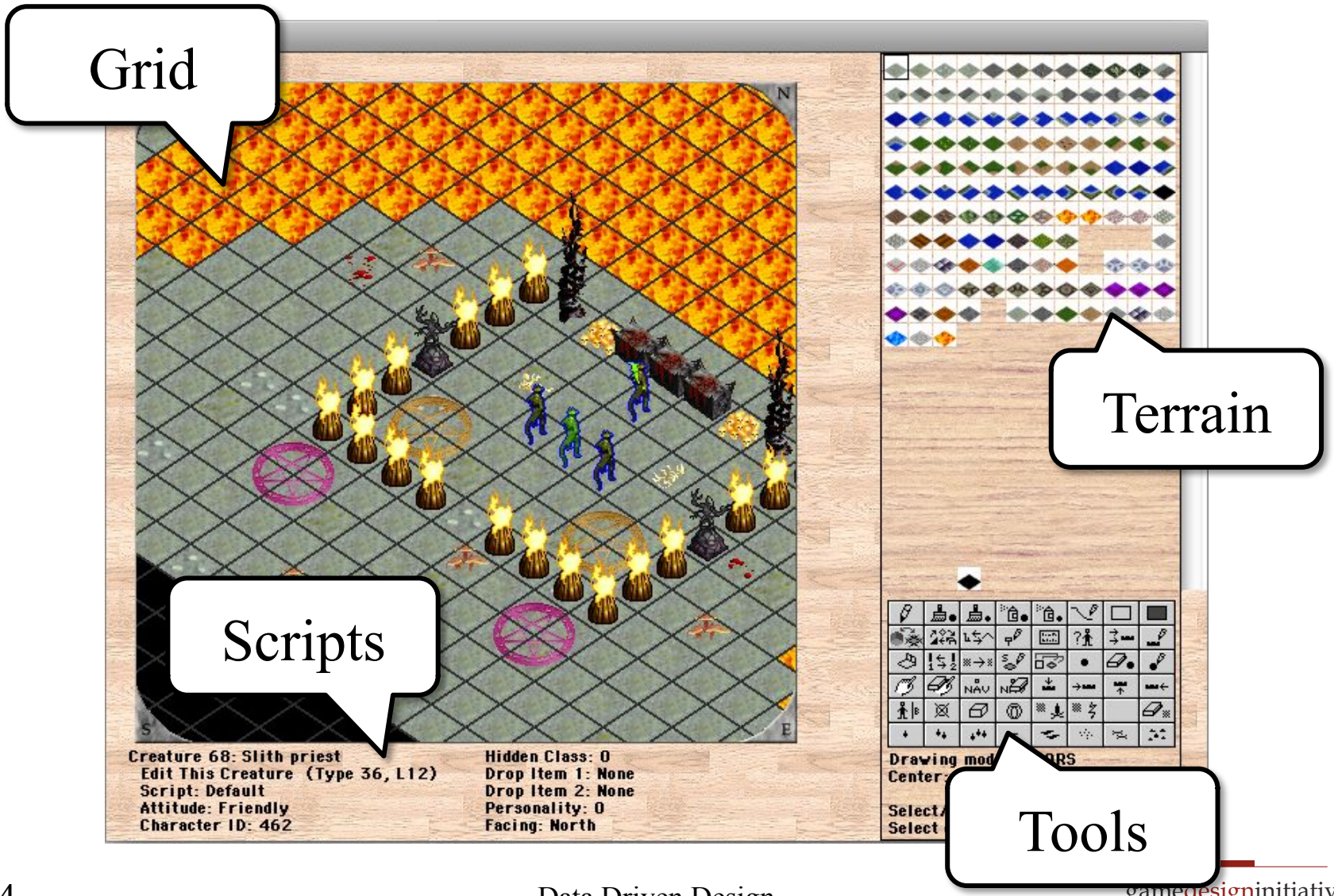
Level Editor Features

- **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*



Example: *Blades of Avernum*



Level Editor: **Code Sharing**

- **Option**: level editor in **same project**
  - Single Visual Studio 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
  - DLL for both level editor and game
  - **Pro**: Cleaner separation of subsystems
  - Con: Harder to iterate the design

Level Editor: **Serialization**

Stores:
Game Model

Level
File

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**

Levels and Game Architecture

- 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

Serialization and XML

Advantages

- **Human readable**
  - Easy for modders
- **Extendible**
  - Easy to add new tags
  - Easy to track versions
- **Portable**
  - Readers on all OSs

Disadvantages

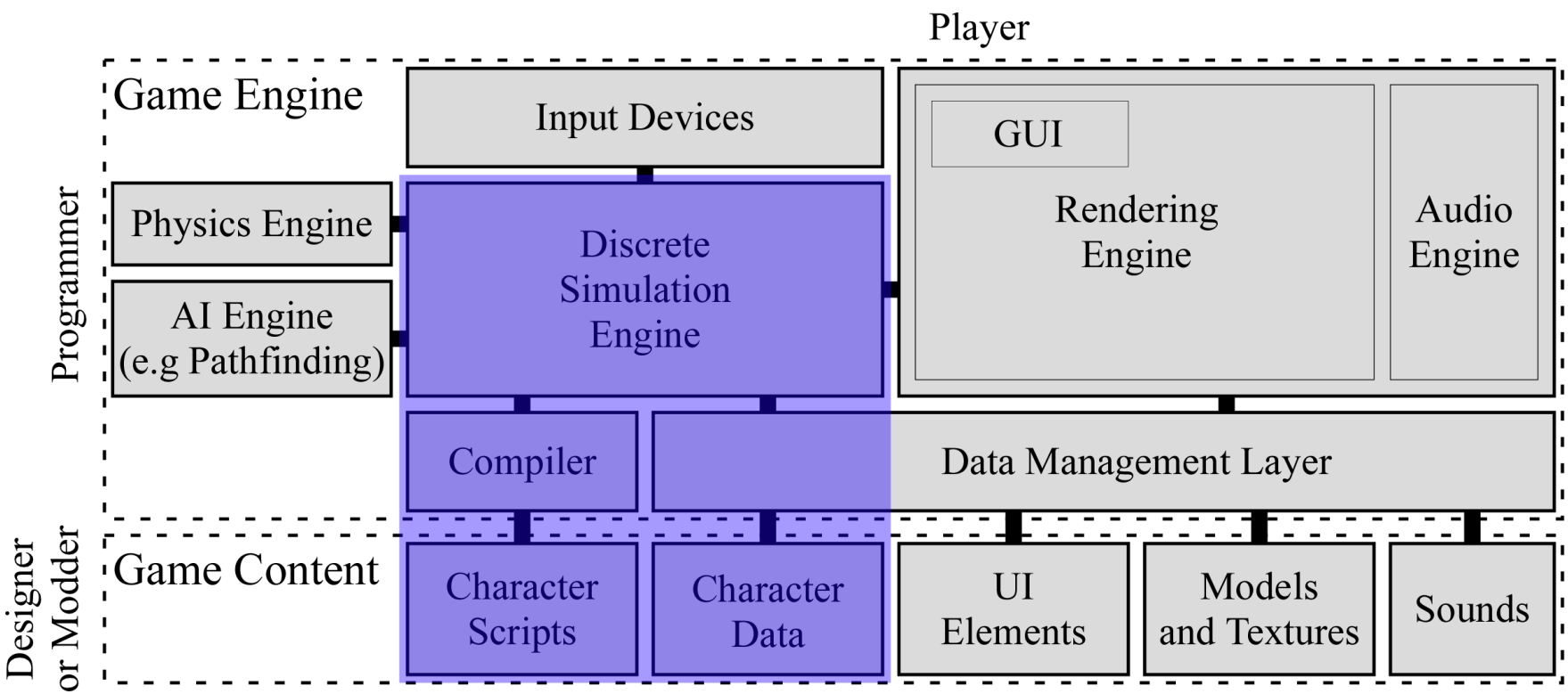
- **Overhead**
  - Parsers not efficient
- **Verbose**
  - Everything is text
  - Tags take up space
- **No Free-Lunch**
  - Only portable if code is

Content Creation Tools

- **Level editor**
  - Create challenges and obstacles
  - Place objects in the world
  - Tune parameters (physics, difficulty, etc.)
- **Scripting Languages**
  - Define character behavior
  - Script triggers and events
  - Layout the user interface

Won't cover

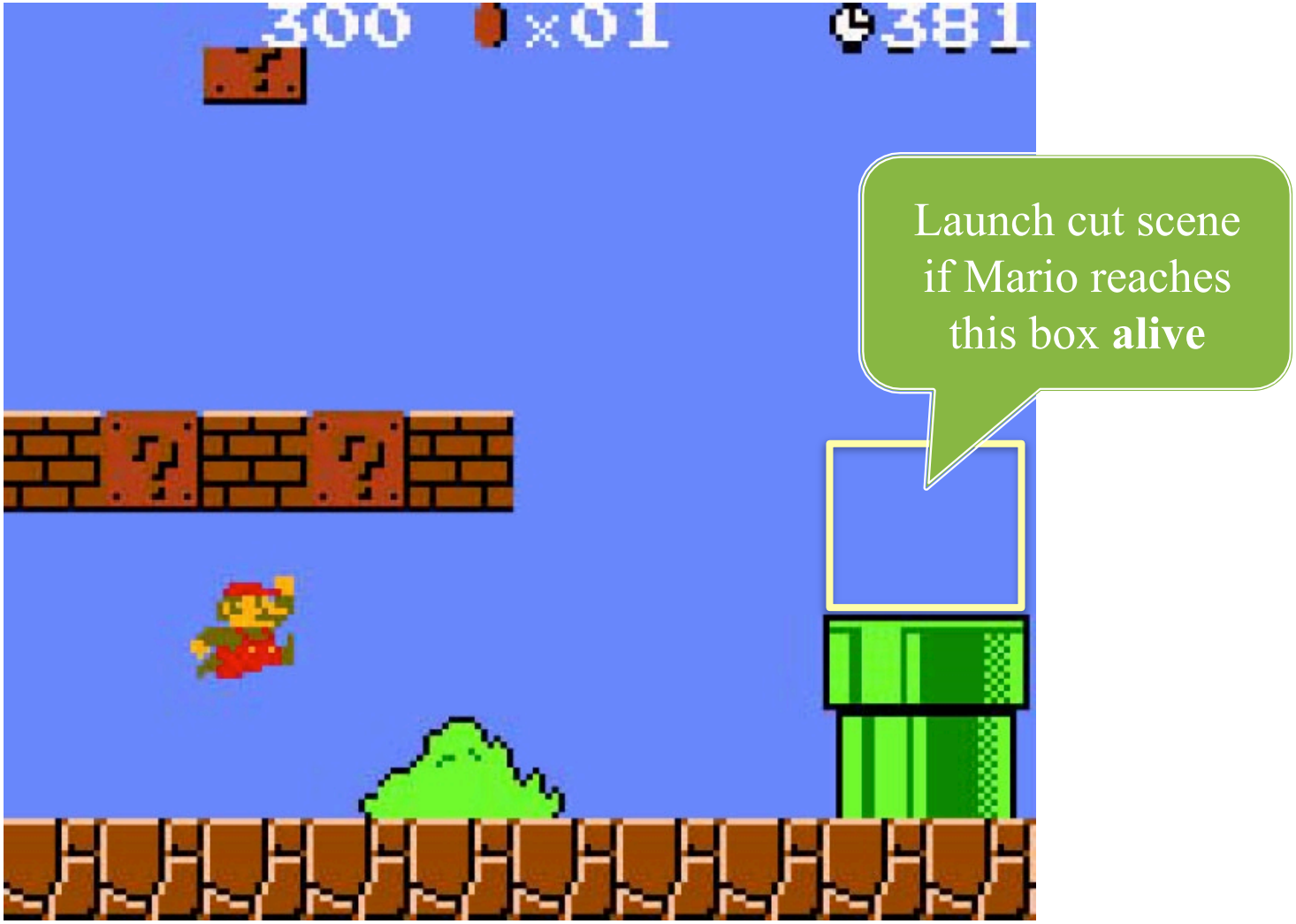
Scripting


Player
Game Engine
Input Devices
GUI
Rendering Engine
Audio Engine
Programmer
Physics Engine
AI Engine (e.g Pathfinding)
Discrete Simulation Engine
Compiler
Data Management Layer
Designer or Modder
Game Content
Character Scripts
Character Data
UI Elements
Models and Textures
Sounds

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



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      -- phase0: Before First Bound
23      {
24          type = DATA_PHASE,
25          name = "START PLAN: all move NO COVER NO BACKWARDS",
26          --
27          {
28              apply_to = {ET_Core, ET_RFlank, ET_LFlank},
29              actions =
30              {
31                  ACTION_MOVE_POSTURE_EXT( DT_MAX_SQUAD_RANGE, .95, 4.0, 30.0, "squad_formations/squad_ai.lua"
32              }
33          },
34      },
35      {
36          type = DATA_PHASE,
37          name = "1st SQUAD BOUND -- LOOK FOR COVER",
38          --
39          {
40              apply_to = {ET_Core, ET_RFlank, ET_LFlank},
41              actions =
42              {
43                  ACTION_MOVE_POSTURE( DT_MAX_SQUAD_RANGE, 0.85, 10.0, 60.0, "squad_formations/squad_ai.lua",
44              }
45          },
46      },
47
48      ------------------------------------------------------------------------
49      -- phase2 -- BOUND 1 CORE (core runs in an drops to prone)
50      {
51          type = DATA_PHASE,
52          name = "Core 1st Bound"
```

Simpler: XML Specification

Attribute Editor (localhost:1676 JurneyRemoteDesktop chris.jurney) - [squad_plan]

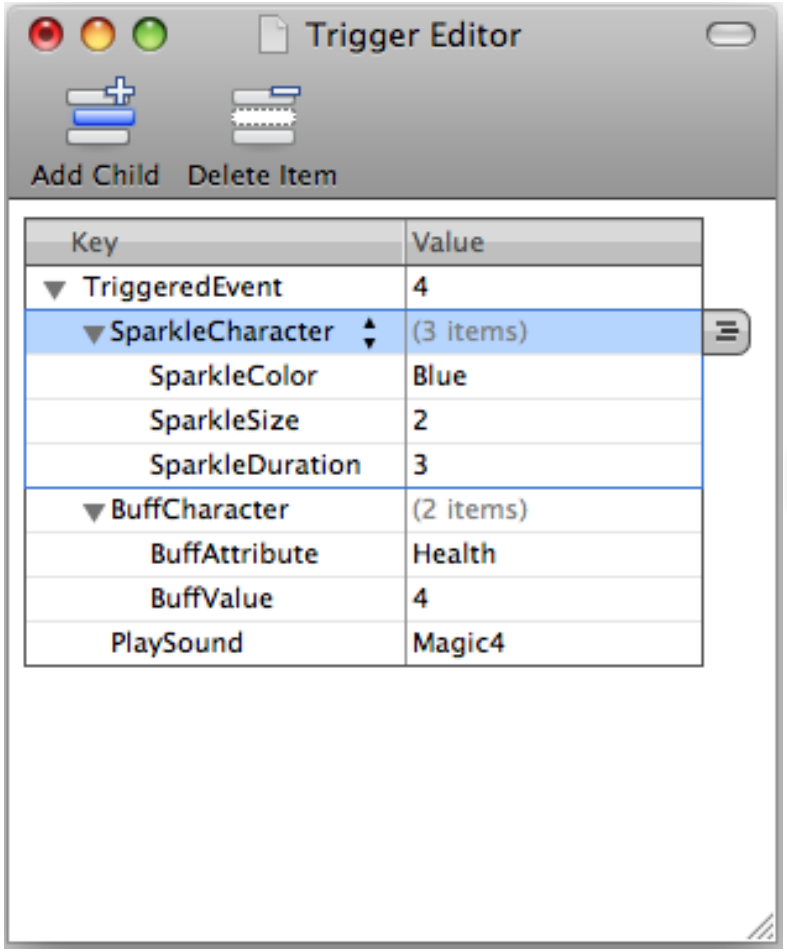
File View Categories Reports Window

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

XML as “Scripting Language”




```
<TriggeredEvent id="4">
  <SparkleCharacter>
    <SparkleColor>Blue</SparkleColor>
    <SparkleSize>2</SparkleSize>
    <SparkleDuration>3
     </SparkleDuration>
  </SparkleCharacter>
  <BuffCharacter>
    <BuffAttribute>Health
     </BuffAttribute>
    <BuffValue>4</BuffValue>
    <PlaySound>Magic4</PlaySound>
  </BuffCharacter>
</TriggeredEvent>
```

XML as “Scripting Language”

```
<TriggeredEvent id="4">
  <SparkleCharacter>
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    <SparkleDuration>3
      </SparkleDuration>
  </SparkleCharacter>
  <BuffCharacter>
    <BuffAttribute>Health
      </BuffAttribute>
    <BuffValue>4</BuffValue>
    <PlaySound>Magic4</PlaySound>
  </BuffCharacter>
</TriggeredEvent>
```

```
switch (triggerIdentifier) {
  …
  case 4:
    sparkleCharacter(BLUE,2,3);
    buffCharacter(HEALTH,4);
    playSound(MAGIC4);
    break;
  …
}
```

This is text, not compiled code

Dynamic Code Compilation

- **Reflection** is a form of data-driven design
  - Allows languages to treat code as data
  - In most modern languages (Java, C#, etc.)
- **Dynamic code compilation** aids reflection
  - Read source code from text file as string
  - Generates new object implementing code
- **Primary class**: `ICodeCompiler`

Automatic Code Generation

- **Goal**: Generate simple code
- **Problem**: Need C# code
  - Reflection creates an object
  - May need subclassing
  - May need memory allocation
- **Solution**: Code Generation
  - Scripter writes minimal code
  - Game engine pads string
  - Compiles result to an object

```
WriteLine("Hello!");
```


```
using System;

public class HelloClass {
   public static void Main() {
      Console.WriteLine("Hello!");
   }
}
```

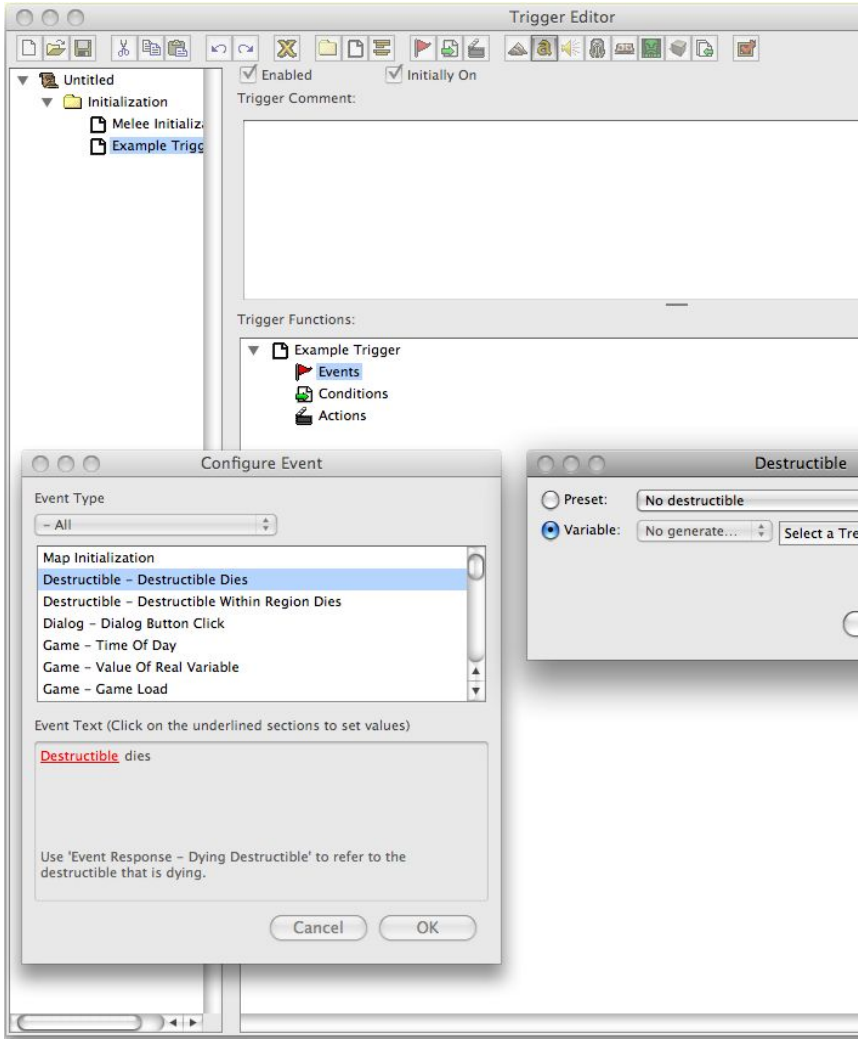
Script Design

- Main if-then statements
- Loops used **sparingly**
  - Recursion = bad!
  - Only **foreach** loops
- Heavy use of function calls
  - Functions in engine
  - Define the **game system**
- No memory allocation

```
// if target in range attack it
if (target_ok() &&
  dist_to_char(get_target()) > 16) {
  set_foe_target(ME,-1);
}

if (get_foe_target(ME,8,0)) {
  do_attack();
}

if (who_shot_me() >= 0) {
  set_foe_target(ME,who_shot_me());
  do_attack();
}

if ((get_attitude(ME) >= 10) &&
    (dist_to_pc() <= hunt_range)) {
  set_foe_target(ME,pc_num());
}

if (am_i_doing_action() == FALSE) {
  end_combat_turn();
}
```

If REALLY not Programmers

- Need a scripting GUI
  - Everything from menu
  - Other visualization
    - FSM Graphs
    - iTunes-style rules
- Great for modders
  - Highly restricted scripts
  - Will not crash program



Modders and Scripting

- Giving modders lots of power is **dangerous**
  - Can create malicious plug-ins
    - Show one functionality, but cause another
    - Or may be simply buggy
  - Can create bots or cheats
- Supporting modders is a **serious decision**
  - Can be a tech support nightmare
  - Do or do not; there is no try

Summary

- Data-driven design has several advantages
  - Faster content production; code reuse is easier
  - Embrace of modder community can add value
- But it comes with some pitfalls
  - Must expect data to become lost/corrupted
  - Modders can introduce malicious data
- Two major focuses in data-driven design
  - **Level editors** place content and challenges
  - **Scripts** specify code-like behavior outside of code