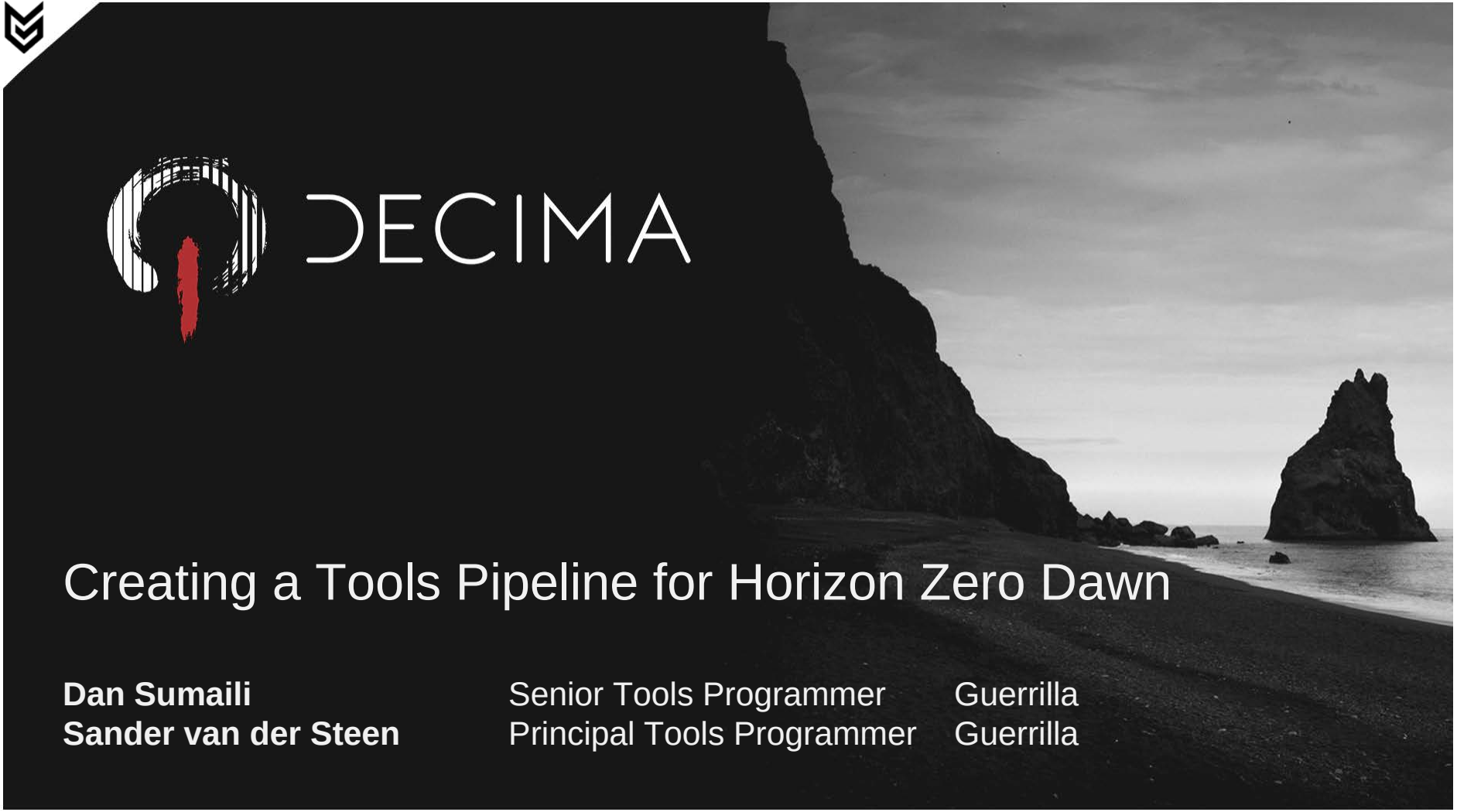
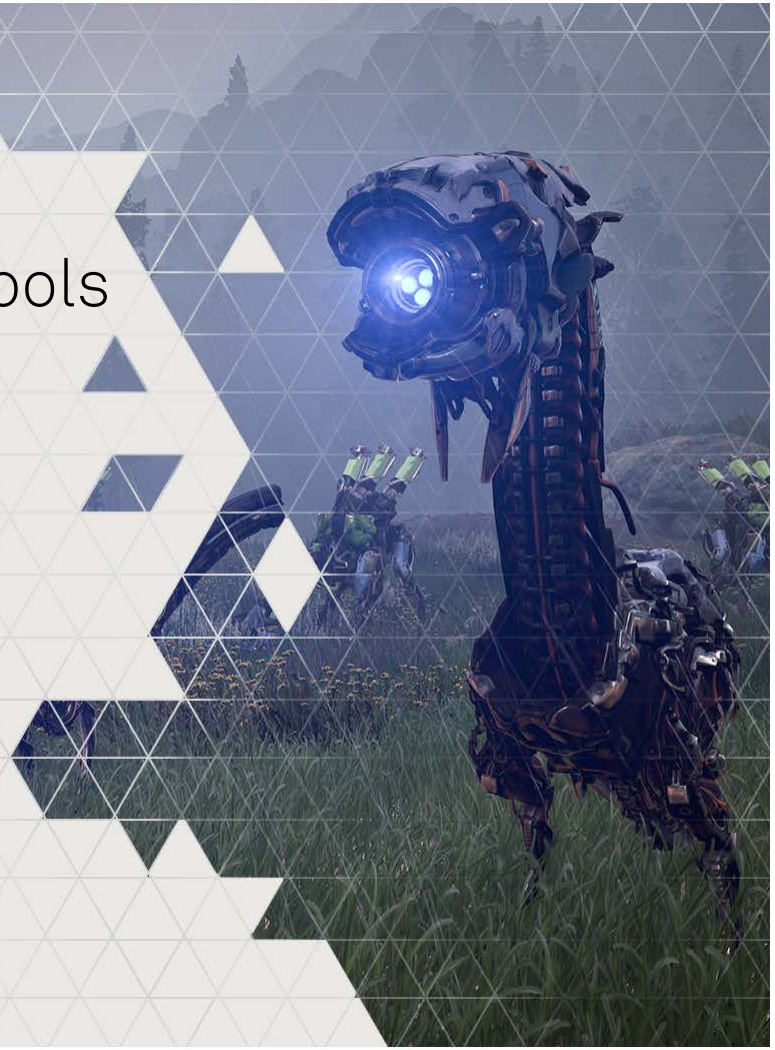


Creating a Tools Pipeline for Horizon Zero Dawn

Dan Sumaili Senior Tools Programmer Guerrilla
Sander van der Steen Principal Tools Programmer Guerrilla

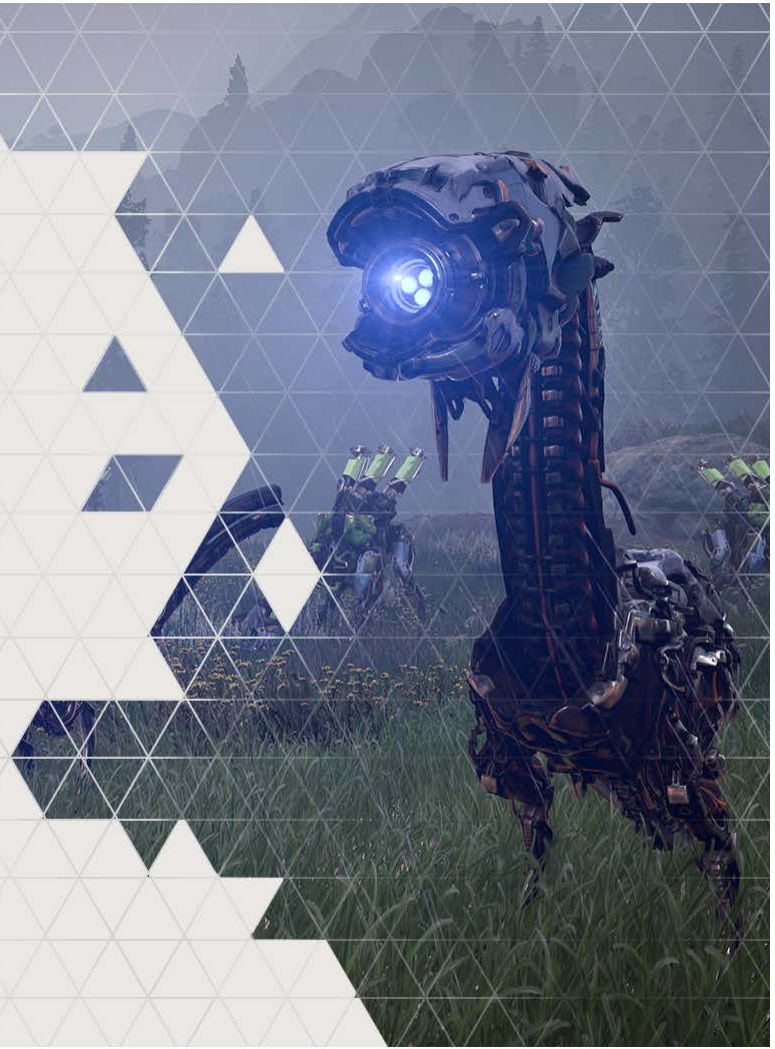
Takeaways

- Insight into why we rebuilt our tools
- How we did it during production
- How it paid off



Overview

- Our legacy tools
- Rebuilding the tools
- Building a 3D Editor
- Editing data
- Other tools
- Where we are today

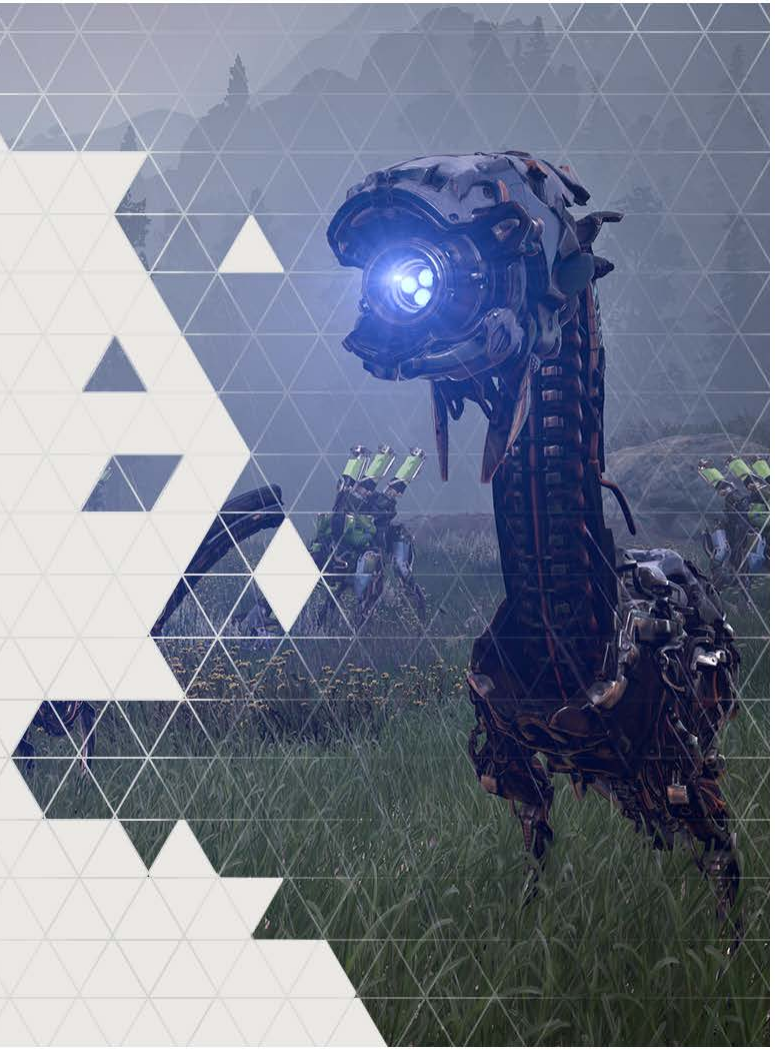


In the beginning... (Nov 2013)

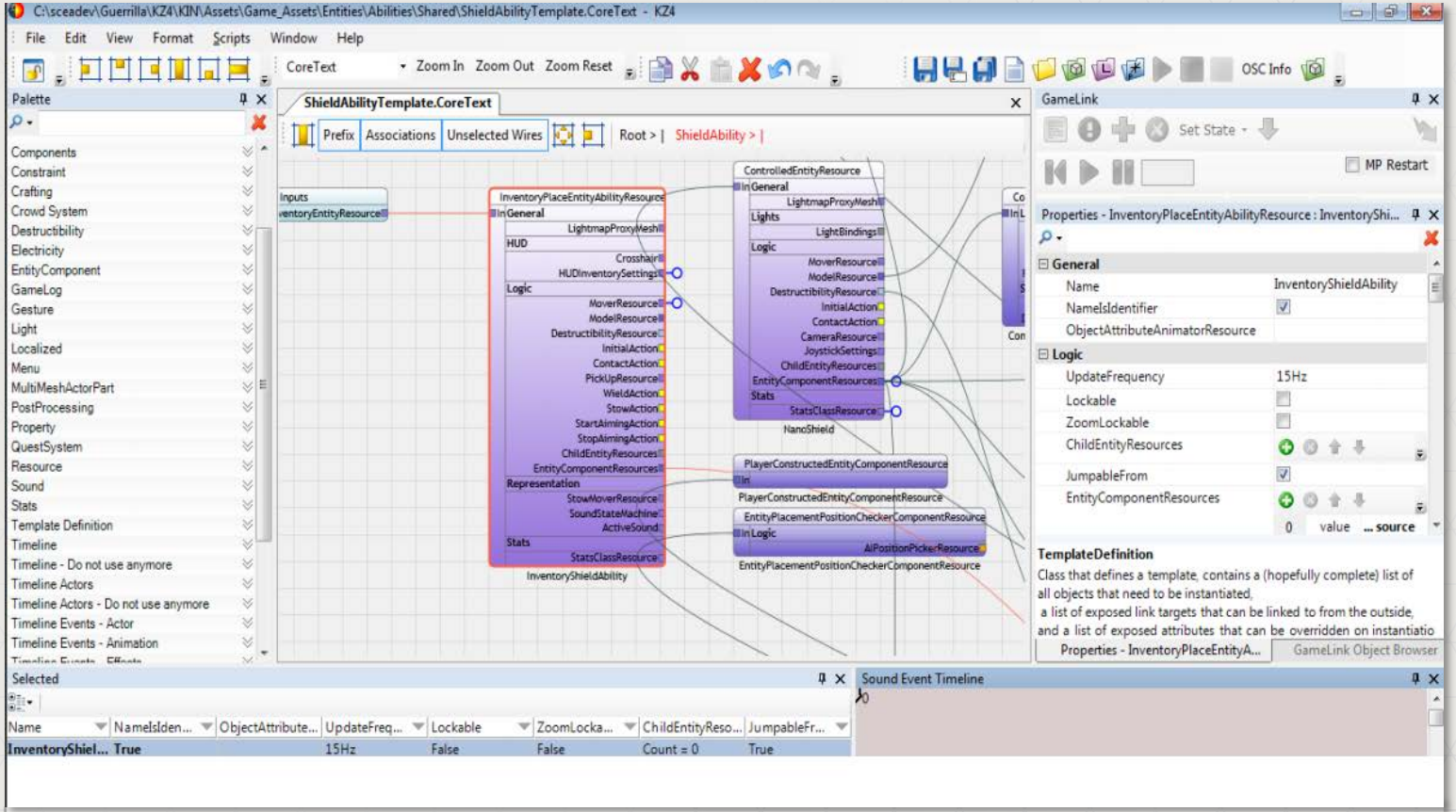
- We had fragmented tools
  - Mix of languages & frameworks
- Long iteration times (20-30 mins.)
- Dissatisfied Users
  - Far behind our competition

The CoreText Format

- Intermediate plaintext format
- Used for most data
  - Except Textures and Audio
- **Converted** to binary for game

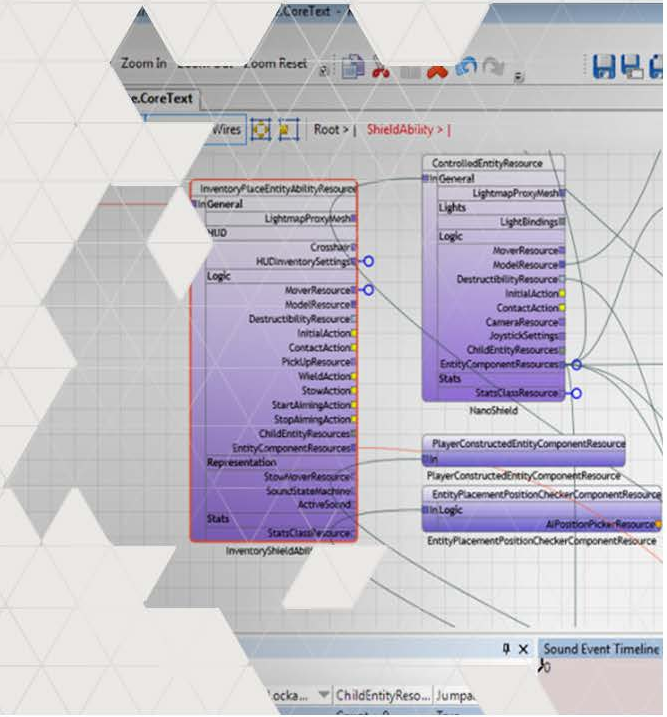


CoreText Editor

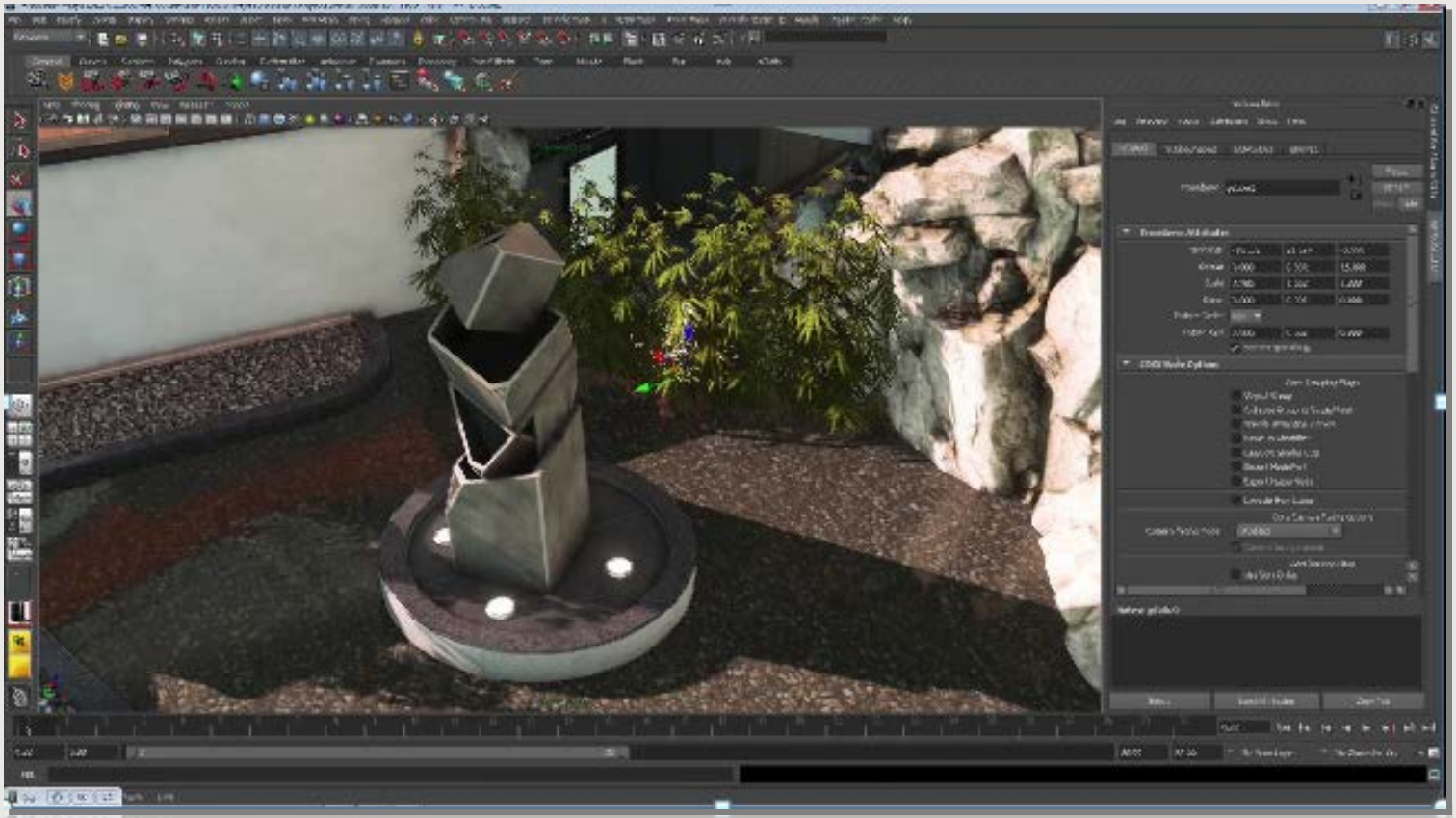


CoreText Editor

- Used to create & configure game data
- Written in C#, WinForms, ATF
- Absurdly complex code



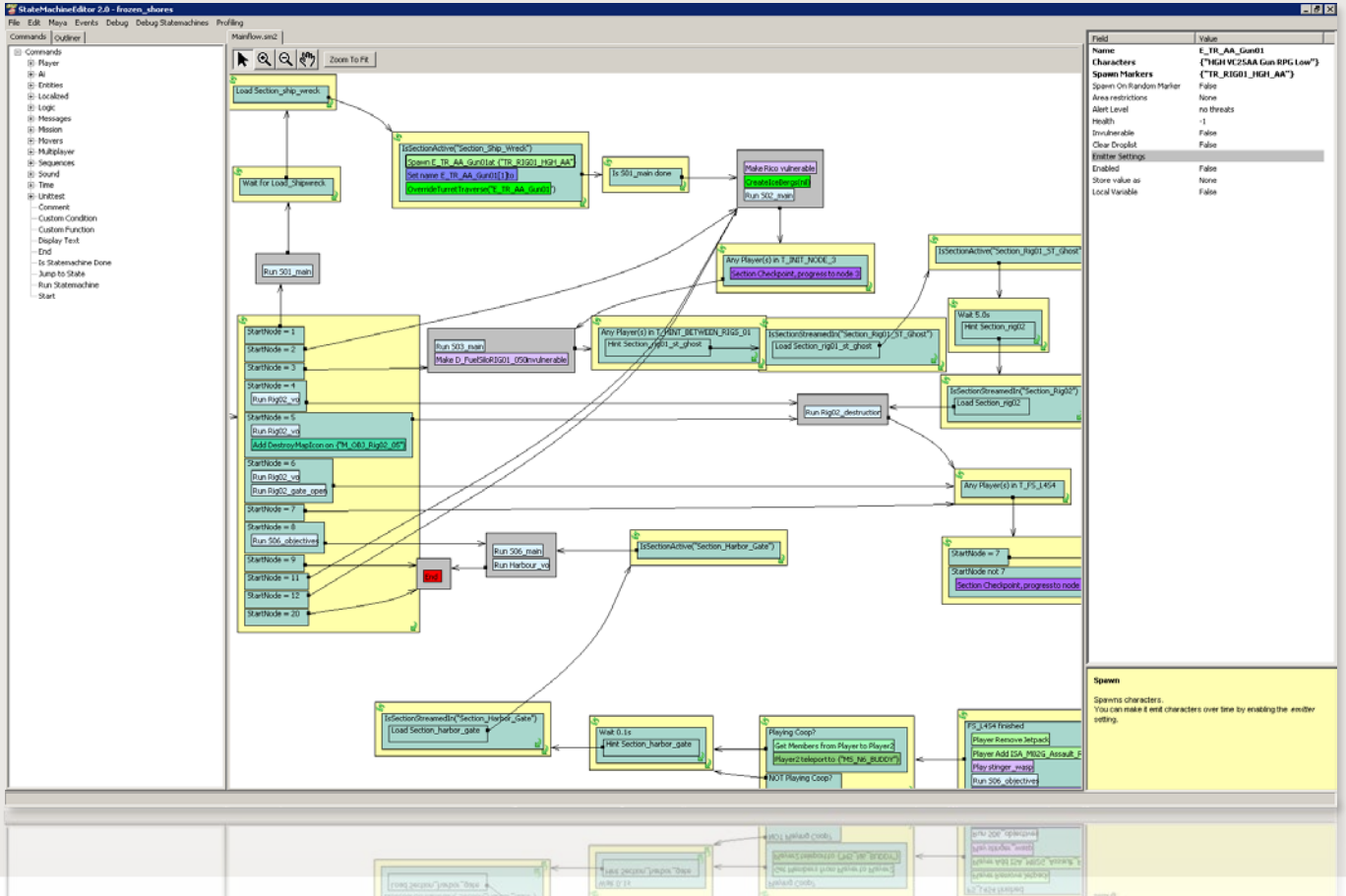
Maya Plugin



Maya Plugin

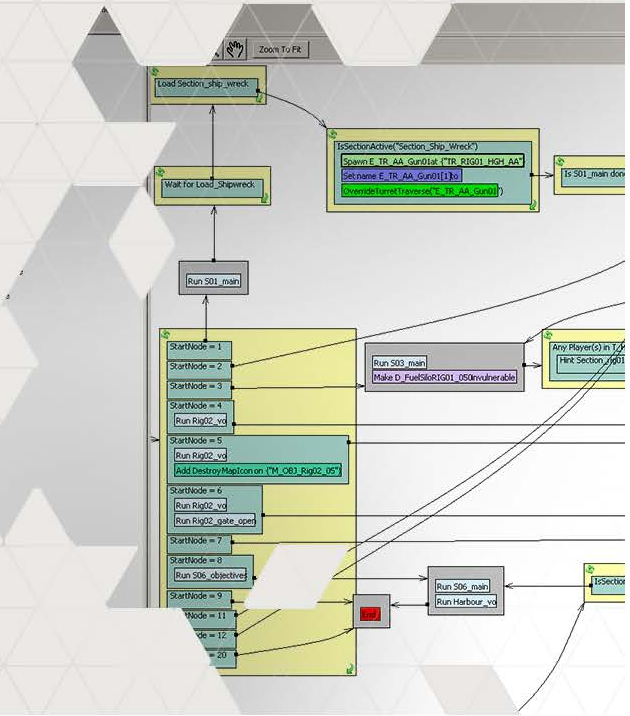
- Exports Maya data to .CoreText
- Used Decima's Renderer
- C++, Python, Maya API
- **Killzone Shadow Fall** Art Tools
  - http://www.gdcvault.com/play/1020711

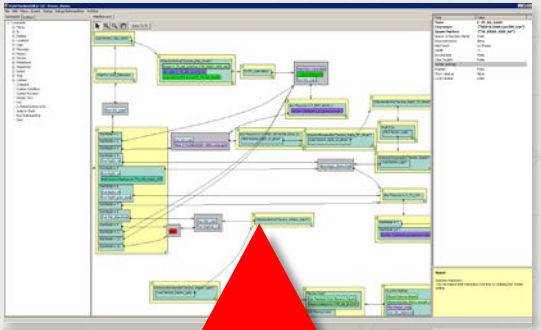
State Machine Editor – ‘SMED’

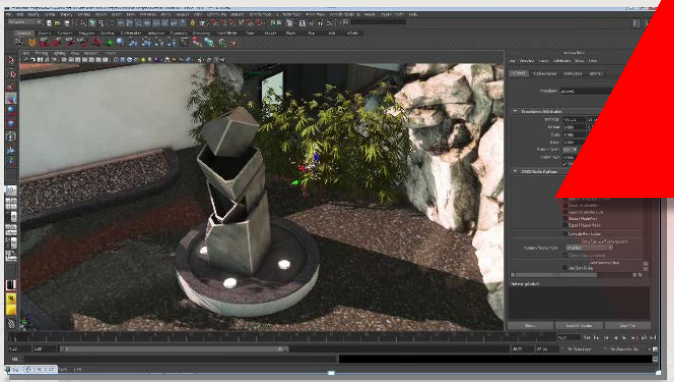


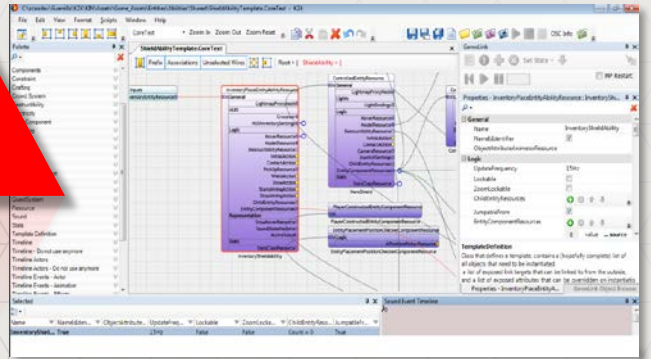
State Machine Editor – ‘SMED’

- Node-based State Machine editor
- Generates LUA script
- Maintained by a Technical Designer
- Written in Python

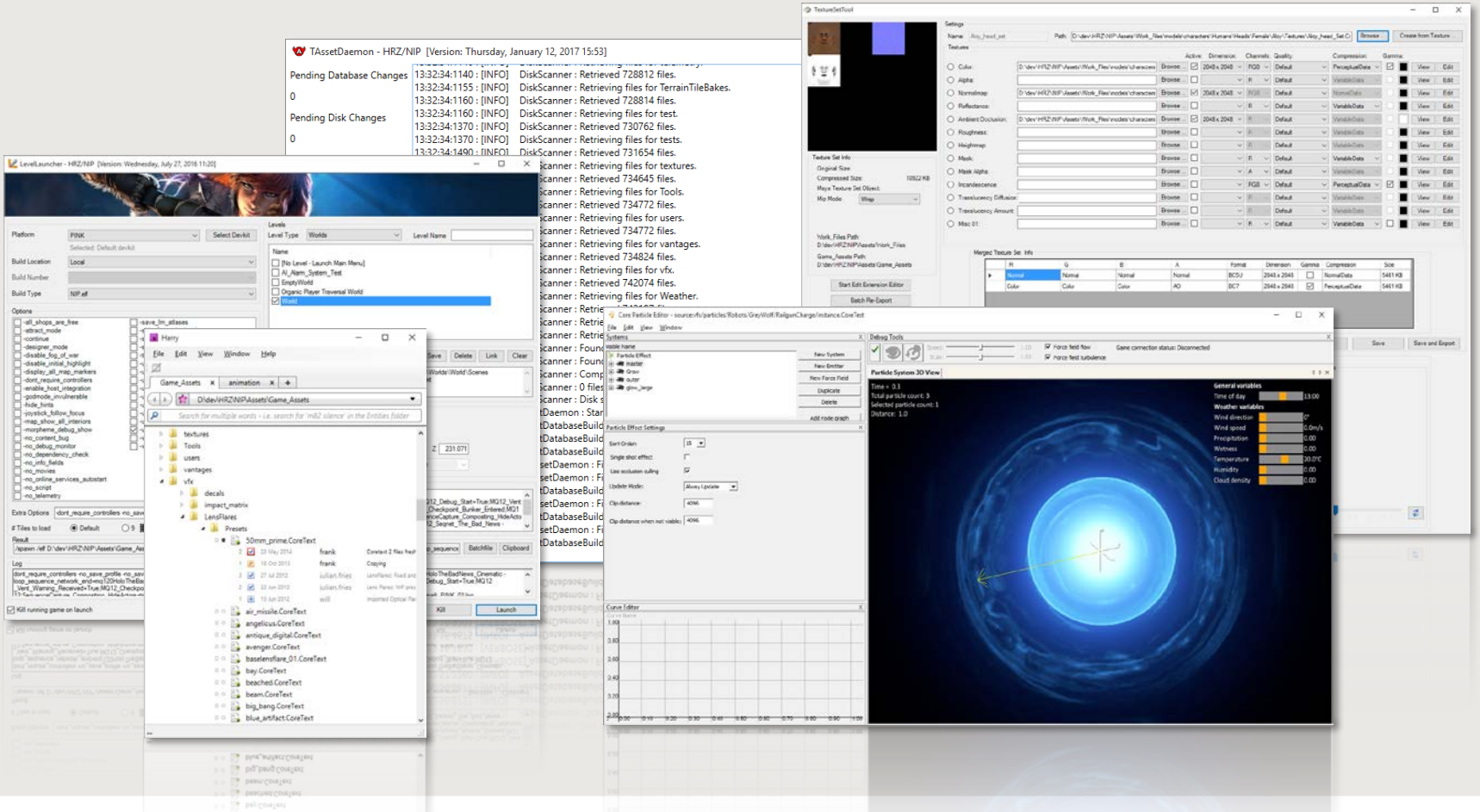








And many more...

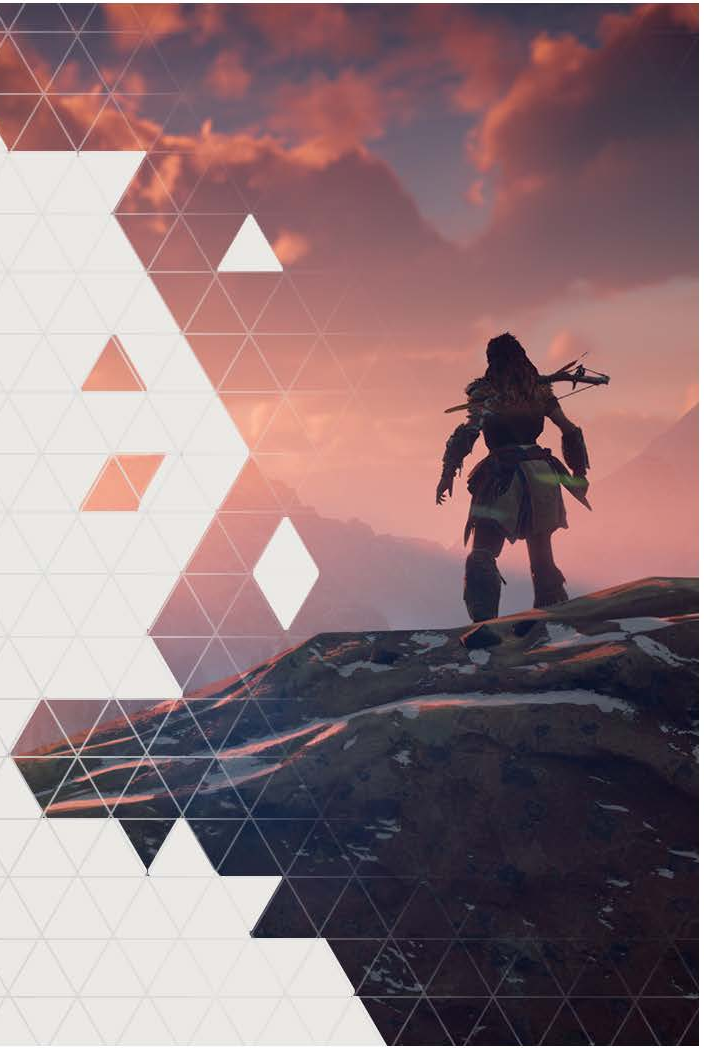


Debug UI

- In-game UI framework
  - Created during **Shadow Fall**
- Programmers found it easy to use
  - Led to many in-game debug tools

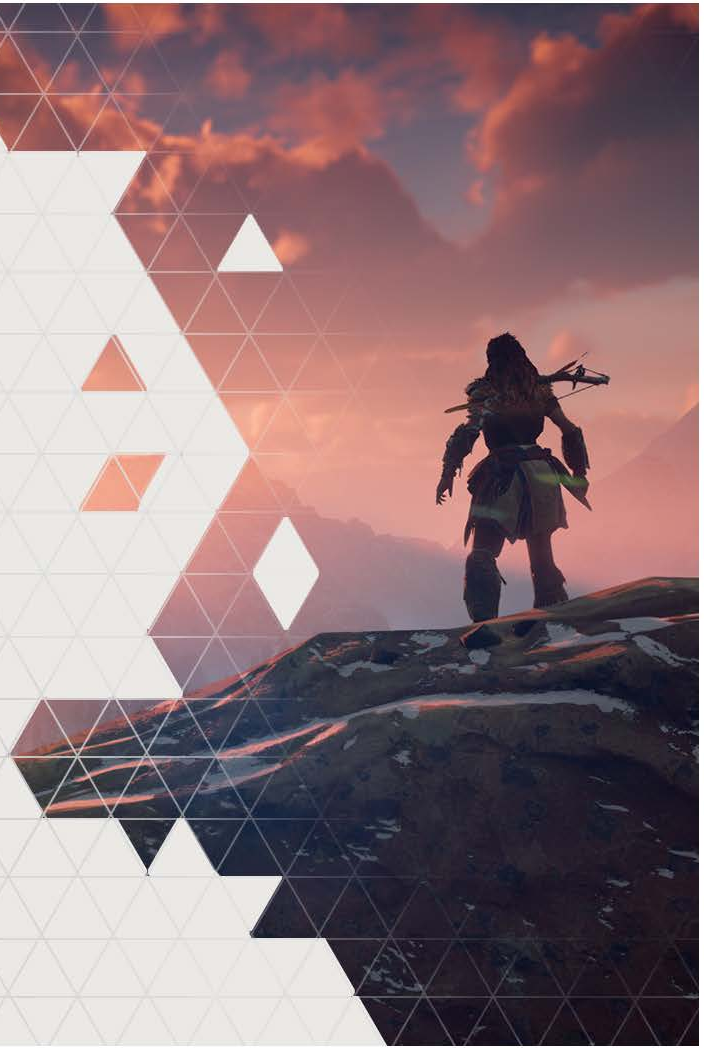
Horizon Zero Dawn

- Horizon was new for us
- New types of content
- Tools team was small
  - Had to use time and resources efficiently



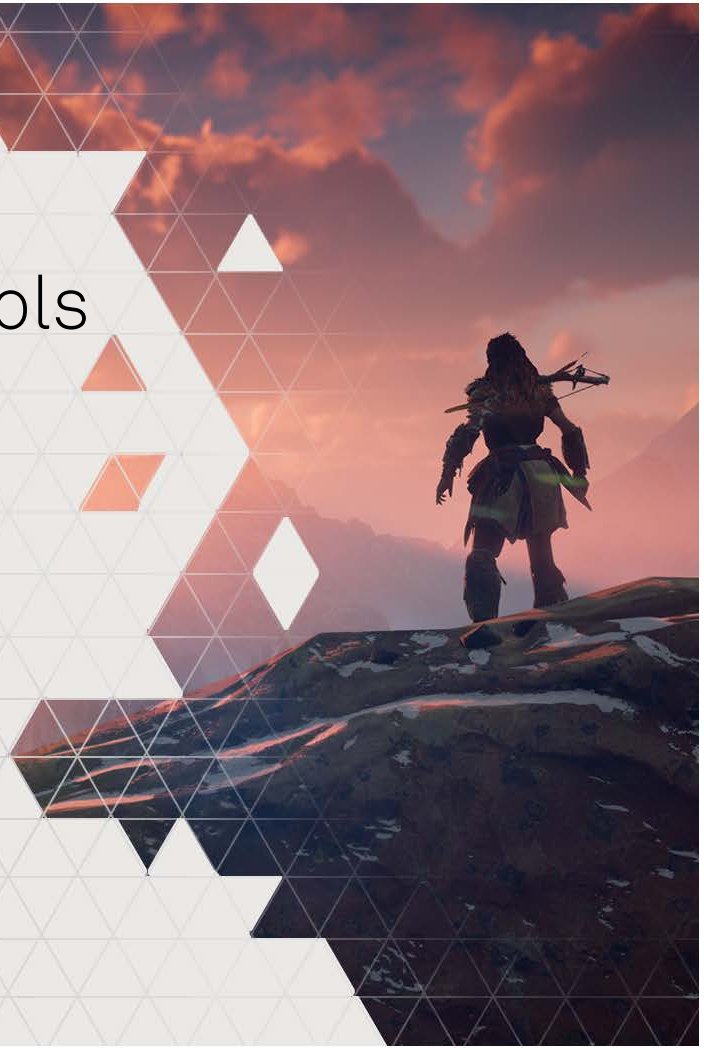
Horizon Zero Dawn

- The old ways would not scale
- We must begin again…



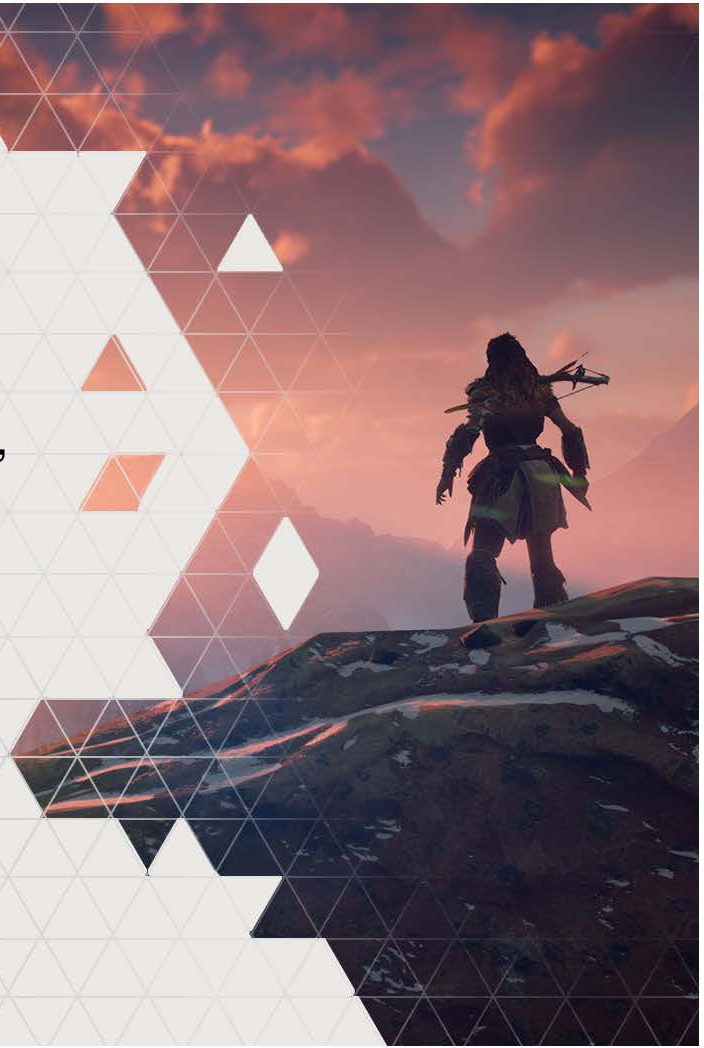
Tools Goals: Code

- Create a Framework to build Tools
- Re-use **Decima** engine libs
- Making tools should be easy



Tools Goals: Editor

- Users need tools that fit their work
  - Discipline-specific ‘Editing Contexts’
  - Built from reusable components
- User should be able to stay in **one** Program
  - Decima Editor



DECIMA

TOOLS FRAMEWORK

GAME CODE

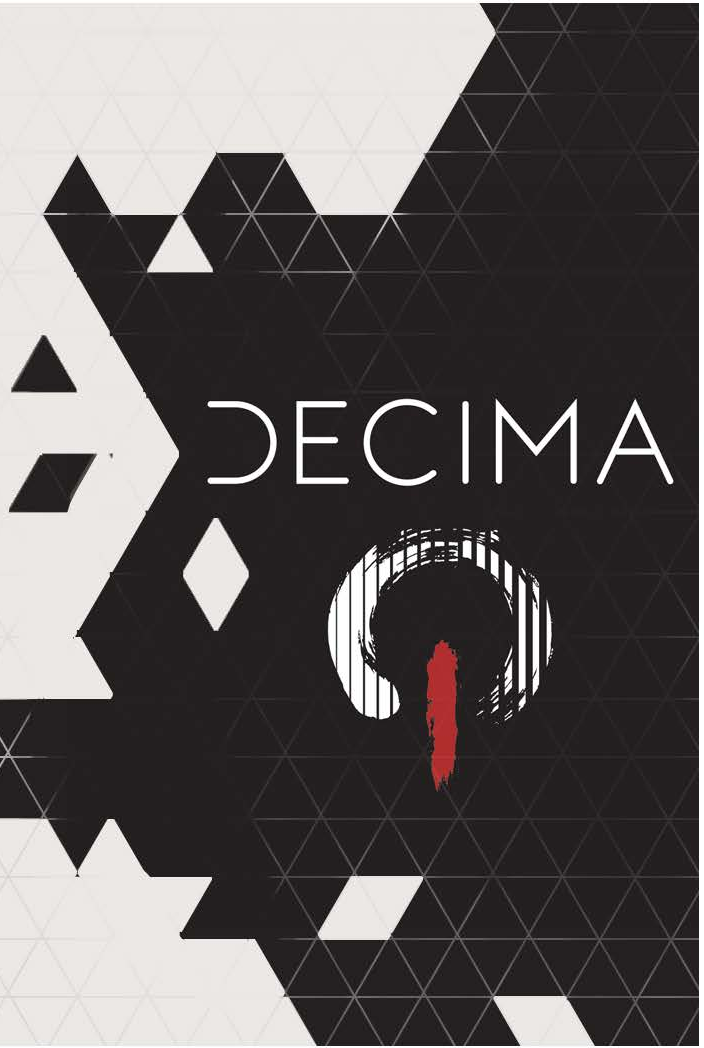
CORE

PIGS

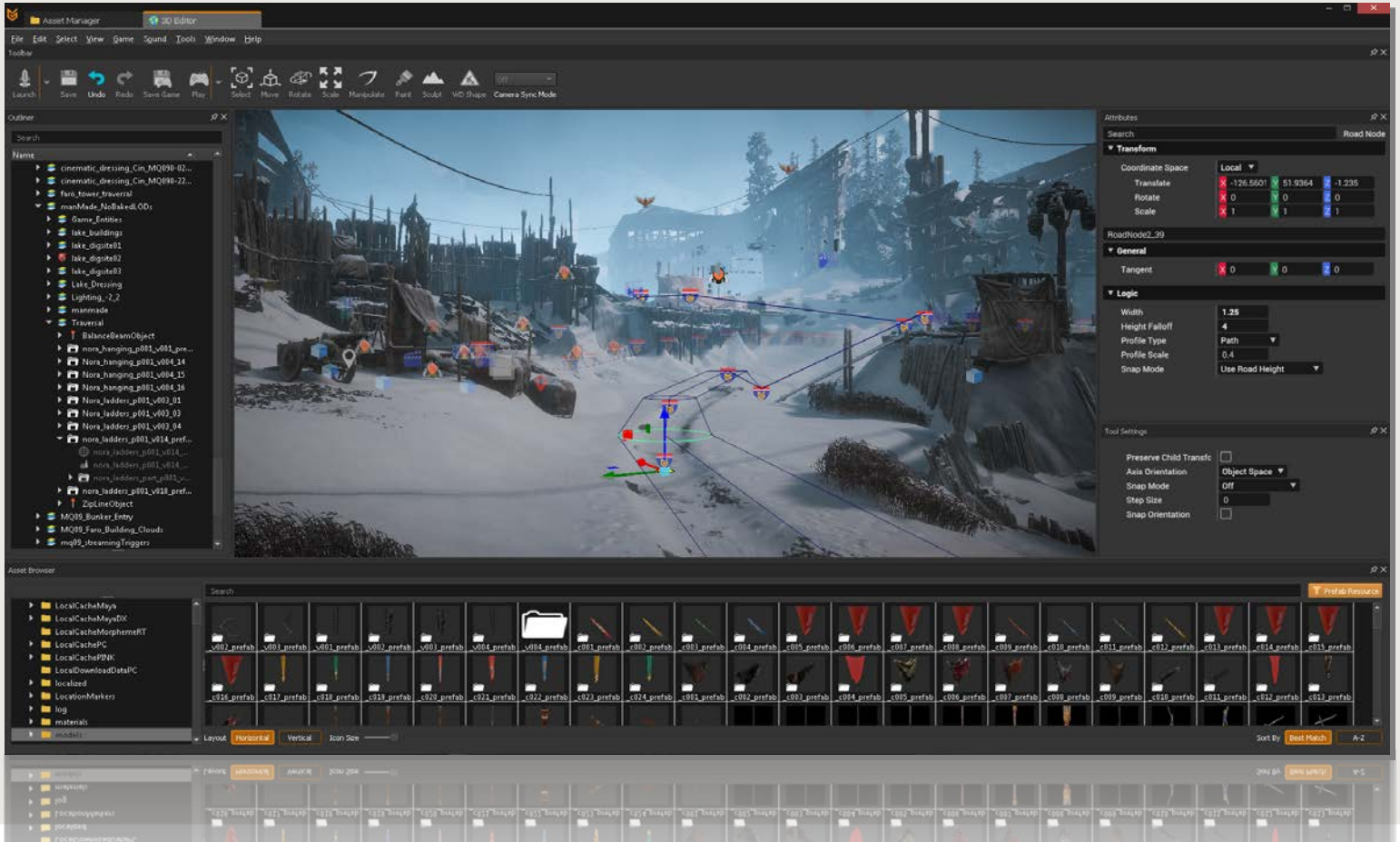
OS

Decima Engine

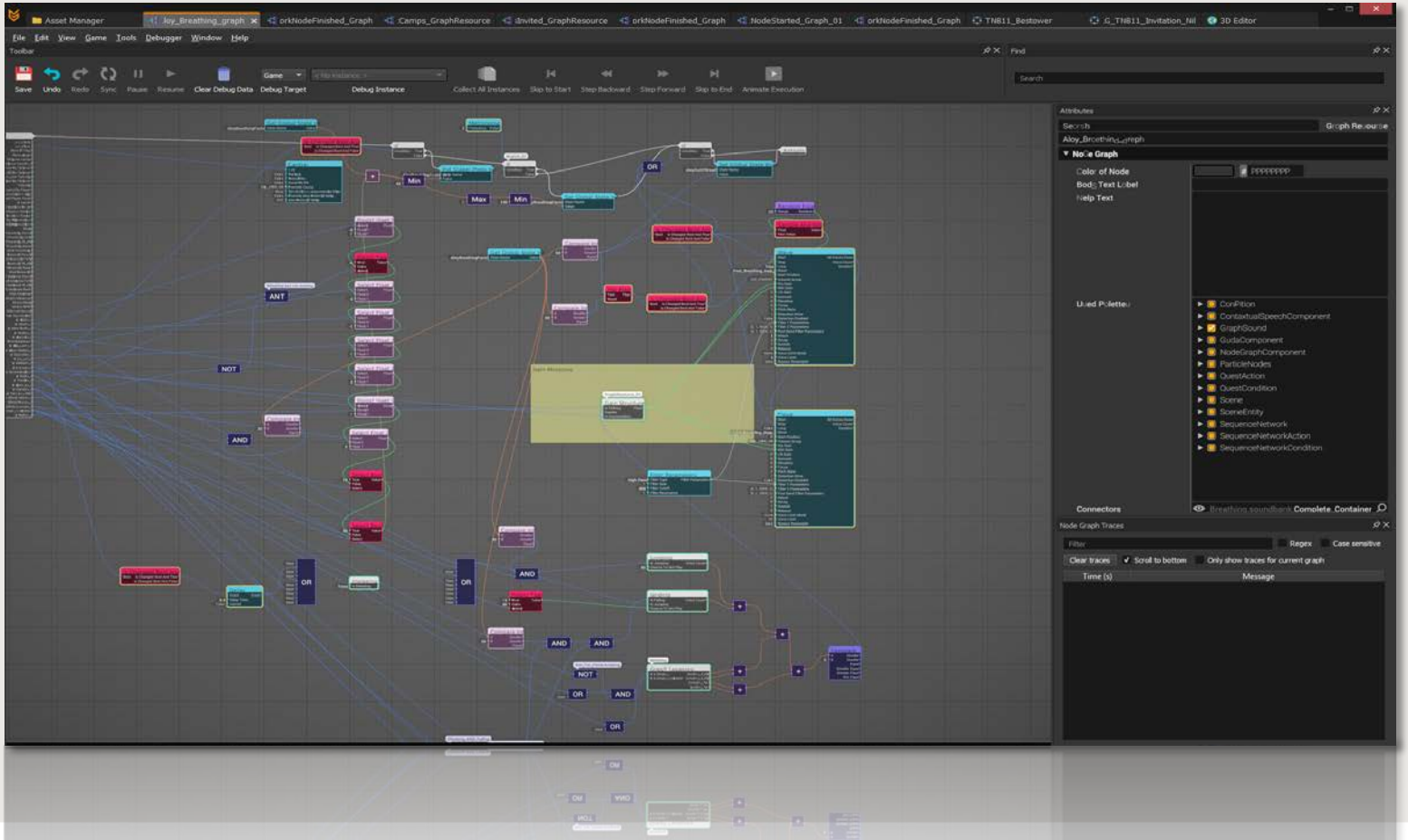
- Data Serialization & Deserialization
- Runtime Type Introspection (RTTI)
- File I/O, Networking, Threads, Jobs
- Image Readers & Writers
- Compression, Hashing, Algorithms
- Unit Testing Framework



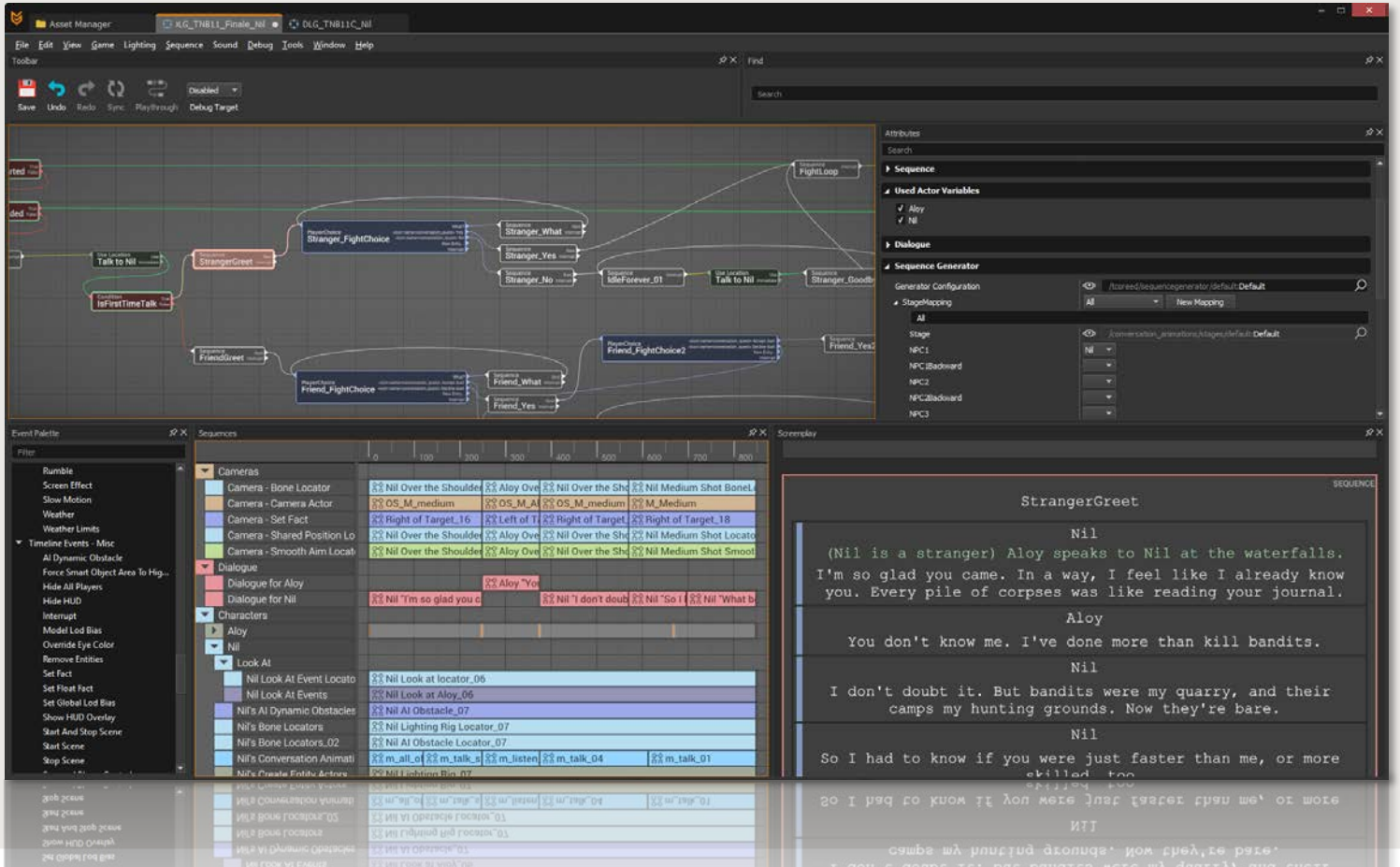
Level Editor



Visual Script Editor



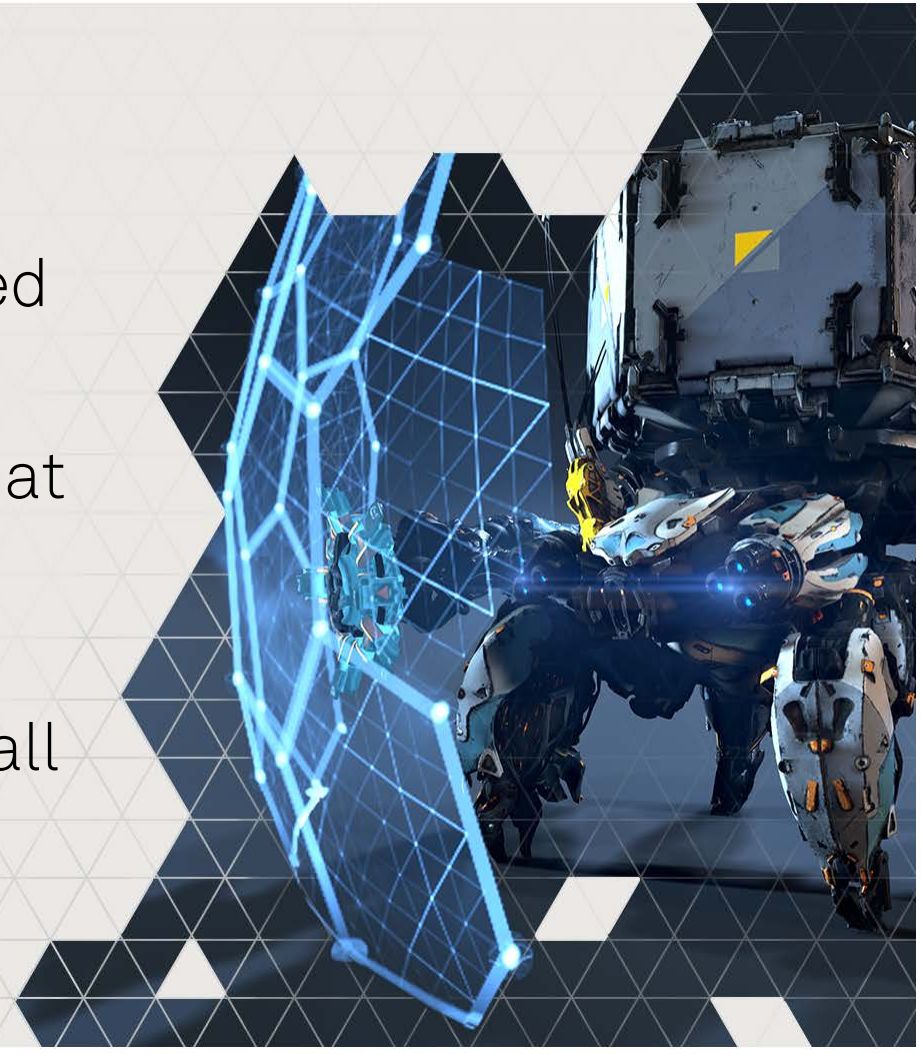
Conversation Editor



The first steps to a new editor

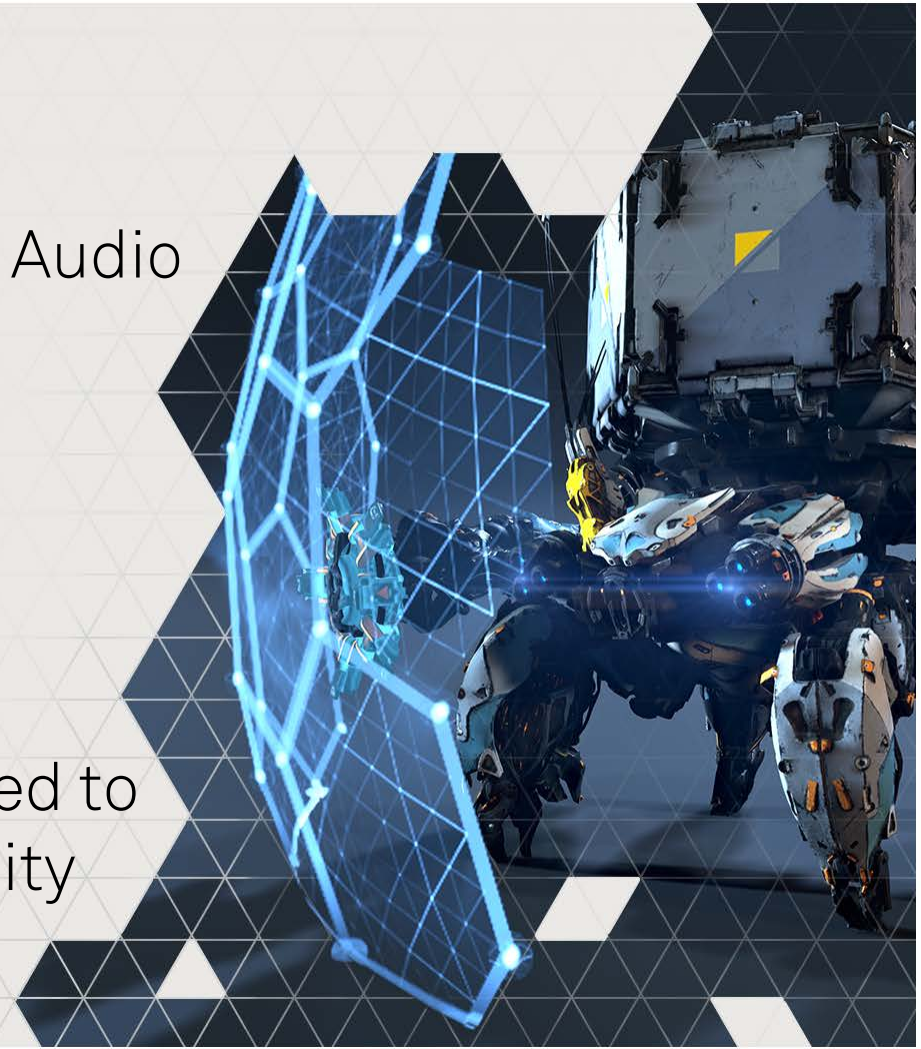
Where do we begin?

- Production is getting started
- Users already have tools that they’re familiar with
- We would need to start small and and minimize risk



Where do we begin?

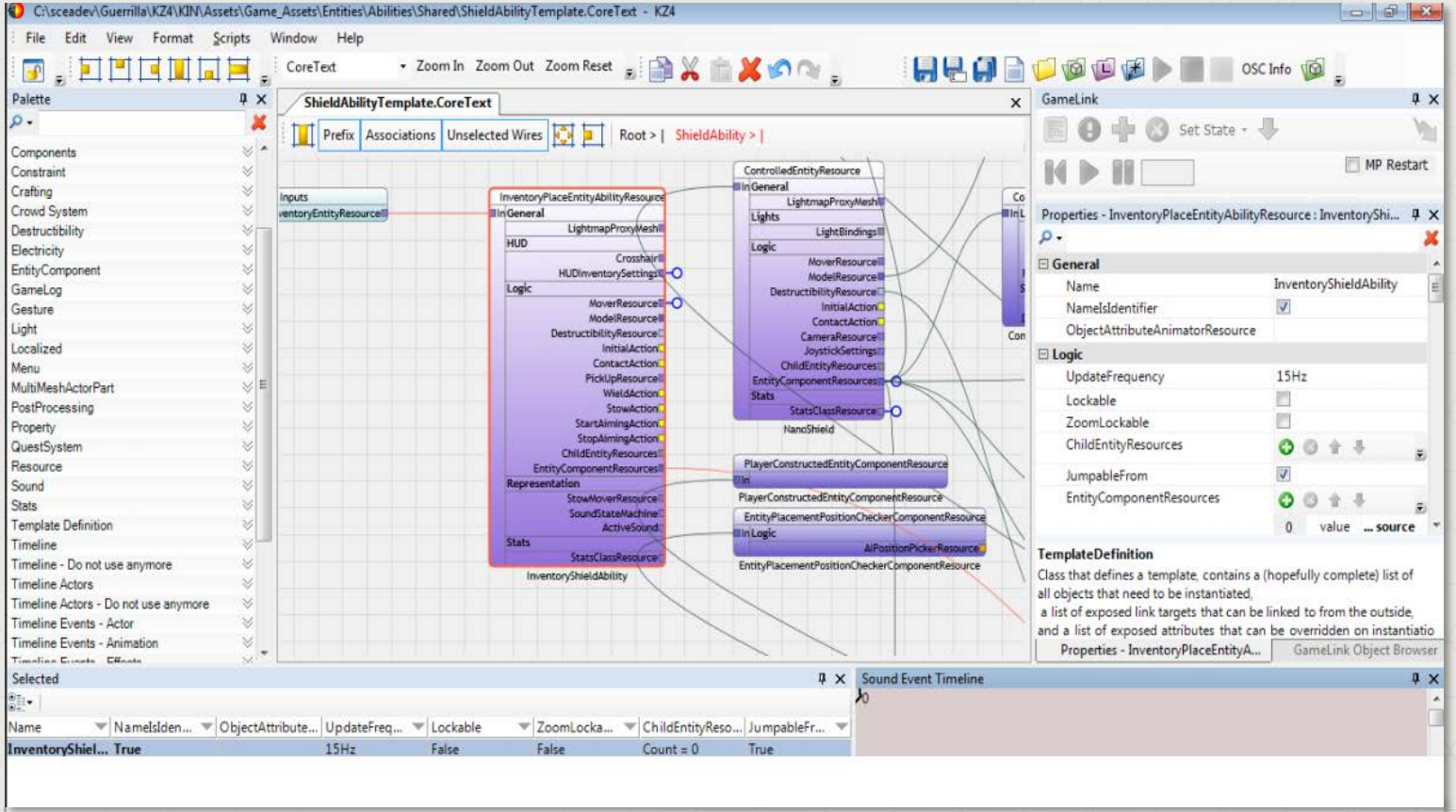
- We decided to focus on the Audio Team
- A small group of users with specific needs
- Their workflow could be used to test the Framework's viability



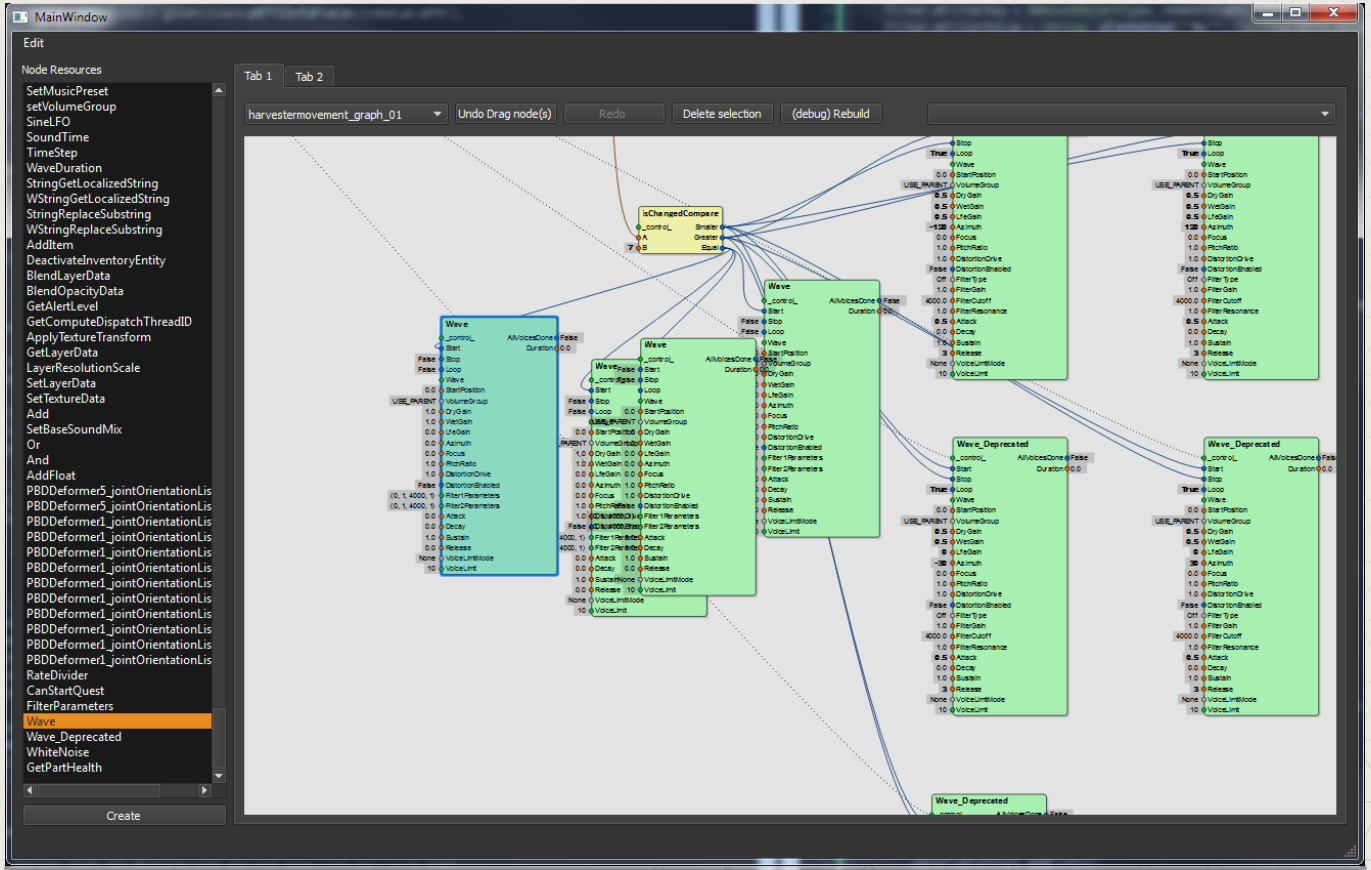
Where do we begin?

- The Audio Team primarily worked with NodeGraphs
- NodeGraph is our High Performance Visual Scripting language
  - Generates native C++ code, that runs on target
- Proven tech, used for audio in **Killzone: Shadow Fall**
  - http://www.gdcvault.com/play/1020559 [Varga, Woldhek 2014]

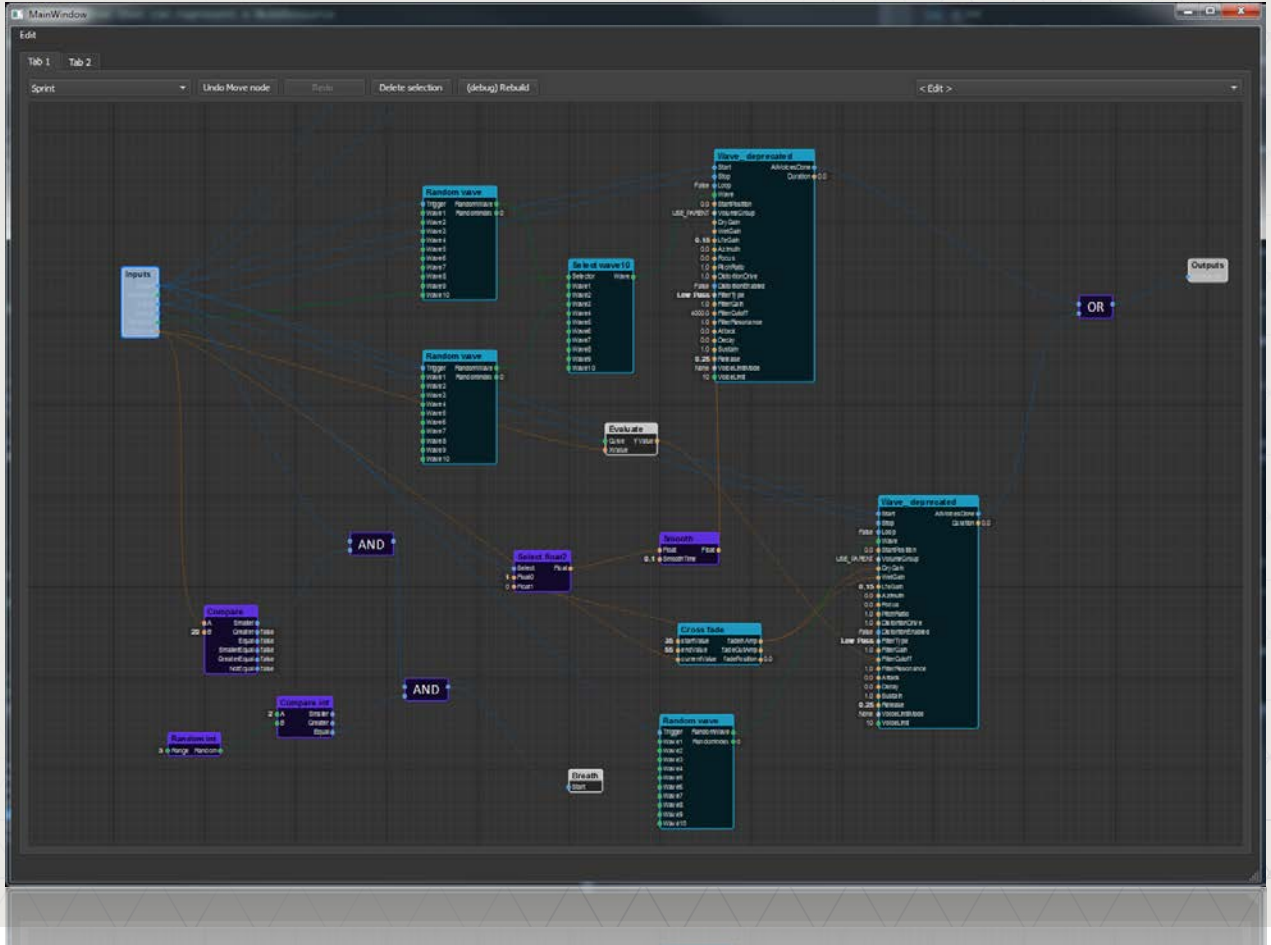
CoreText Editor



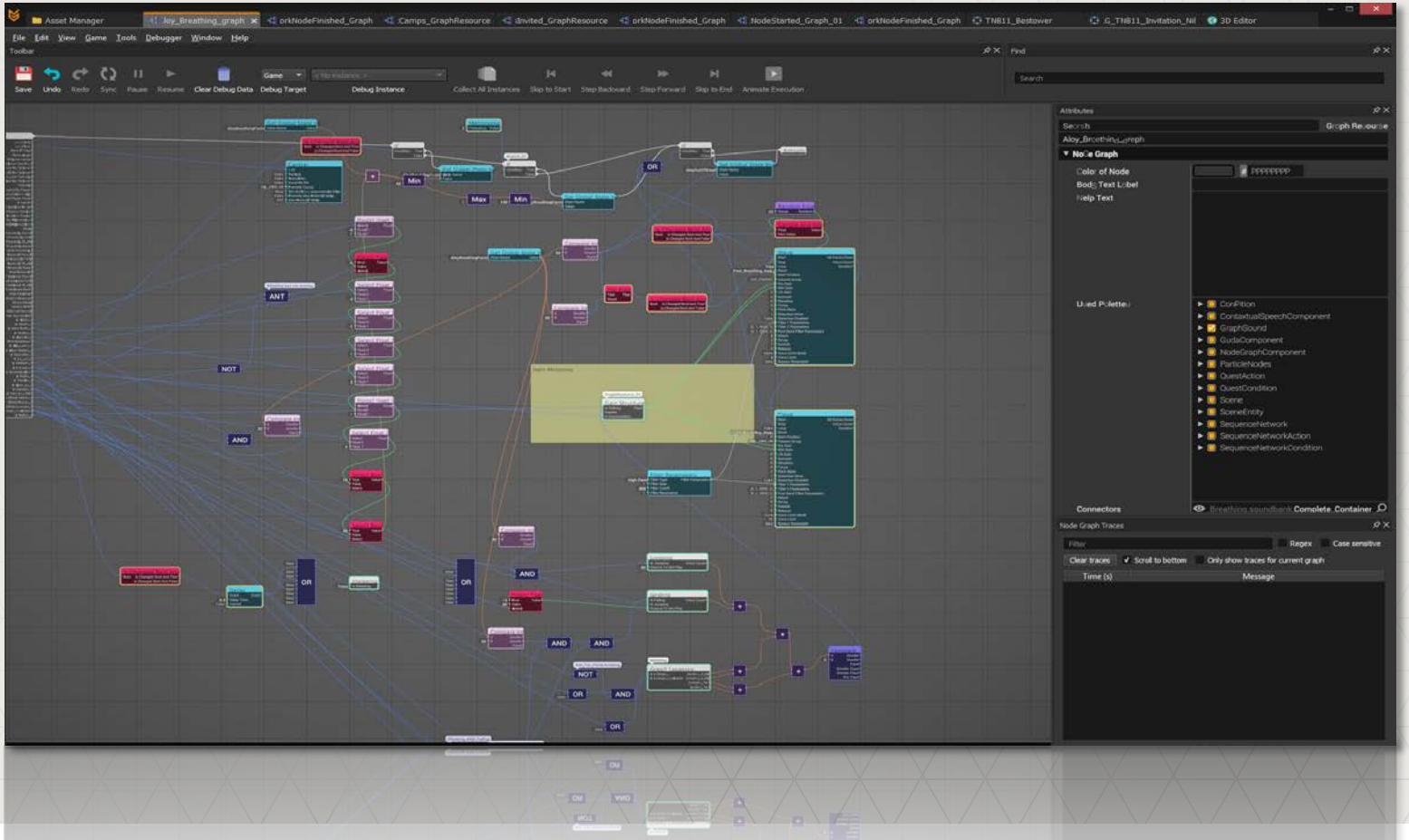
NodeGraph: Prototype #1



NodeGraph: Prototype #2

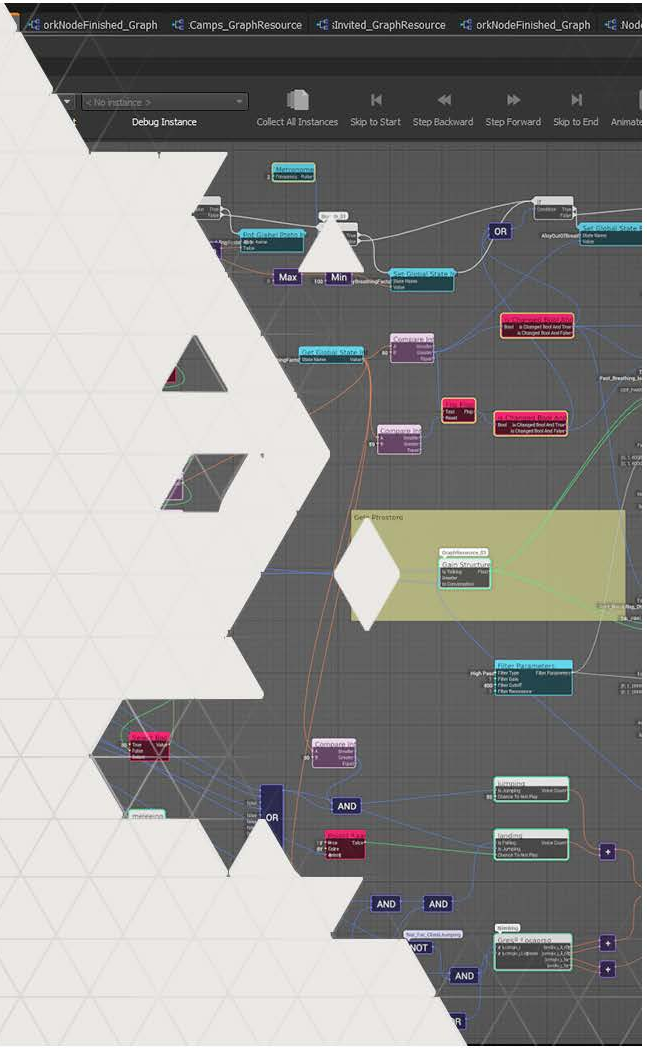


Node Graph Editor Context



Node Graph Editor

- We reached feature parity within a few months
- New features could be implemented easily
- Programmers from other teams could also contribute

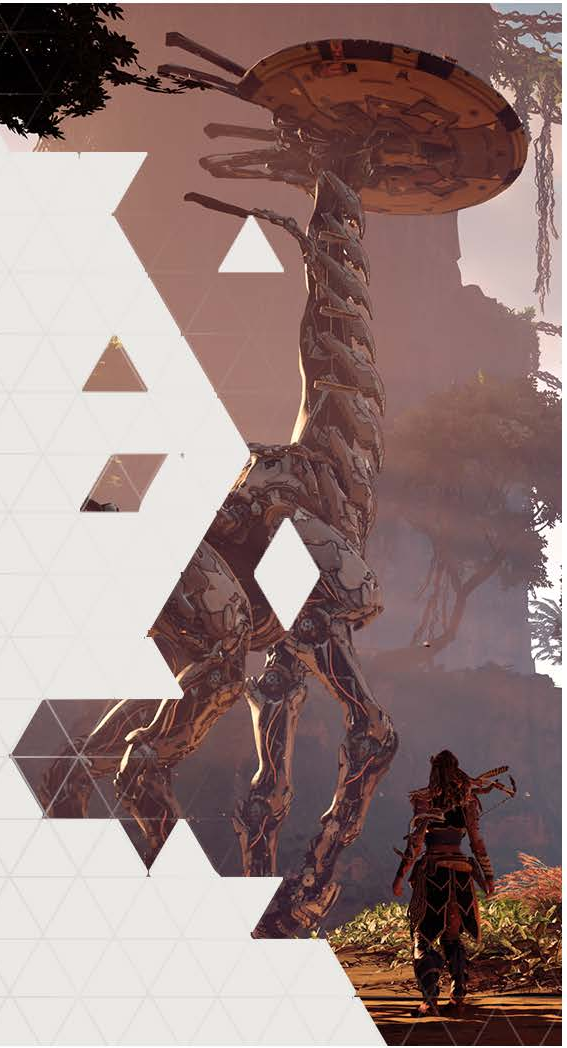


A new workflow for Game Design

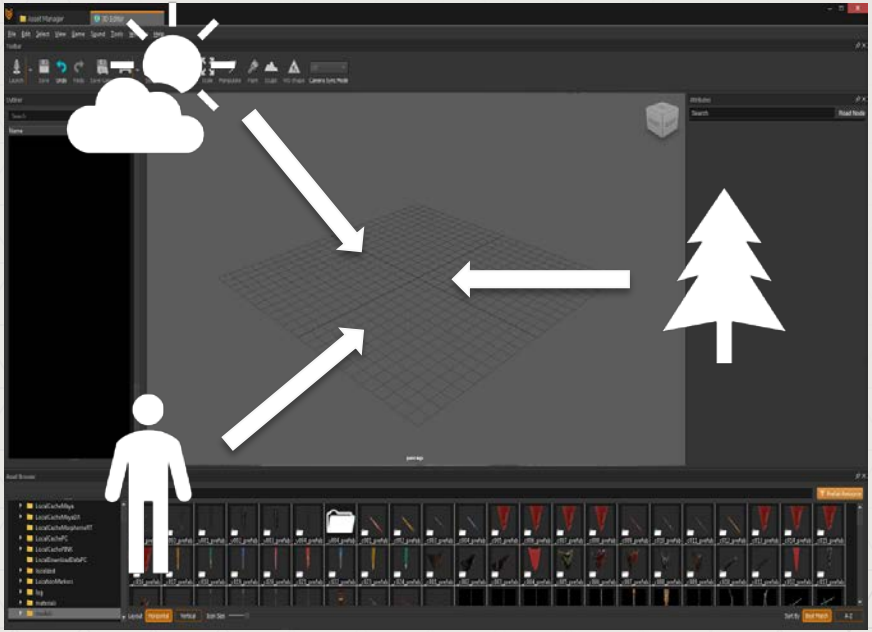
Creating a 3D Editor

Why a 3D Editor?

- *Maya* not suitable for quest content
- *3D Editor* was urgently needed
- Focus on Object placement & creation



Integrate sub-systems or full game?



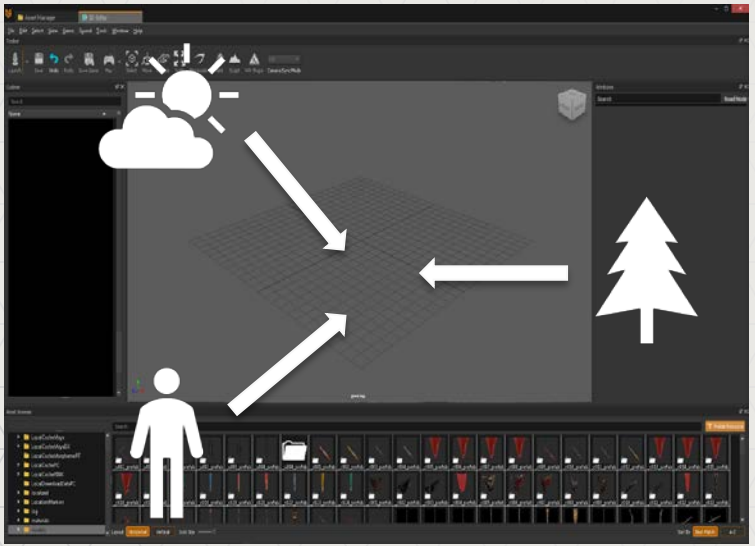
Integrate only sub-systems into Editor?

+ Purpose build, controllable
+ Fast

- New code-path

  Longer development

- Visual/behavioral disparity



Integrate full game into editor?

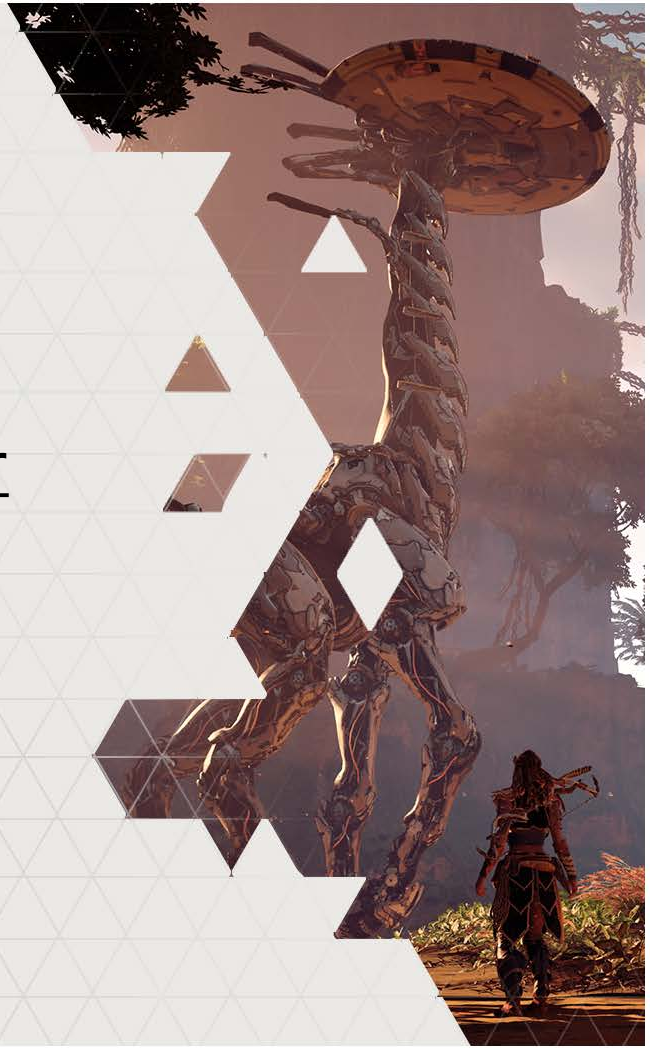
+ All game systems available
+ *DebugUI* (tools) for free
+ Single code path (play/edit)

- Overhead of running game

3D Editor – Architecture

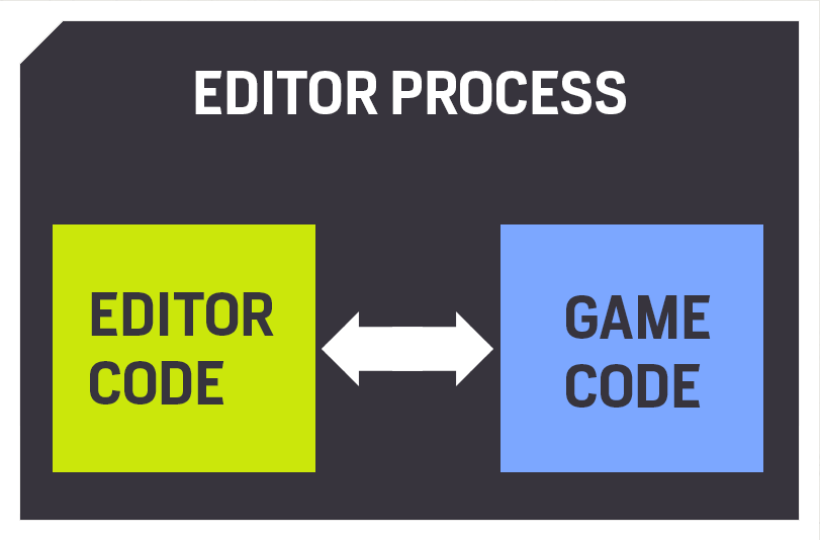
Due to time constraints:

Integrate full game into Editor

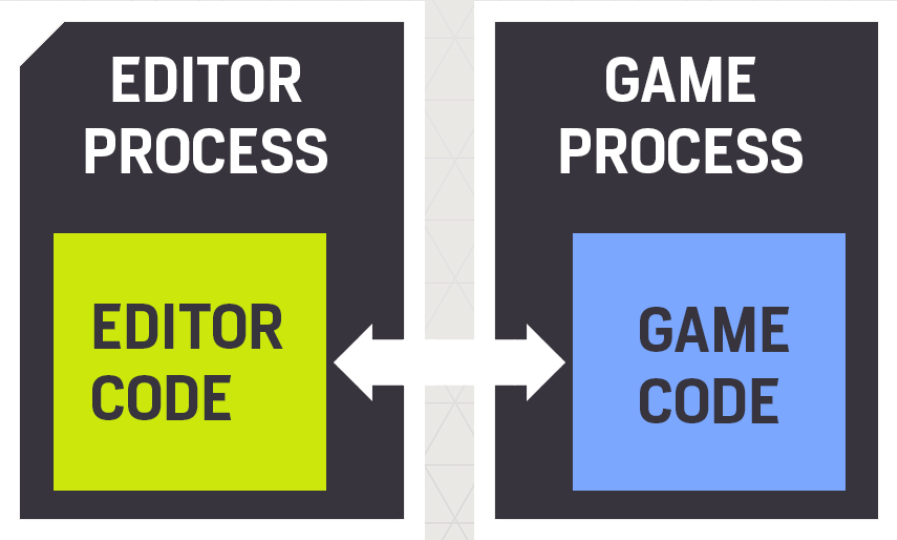


How to integrate a full game into Editor?

In process?



Out of process?

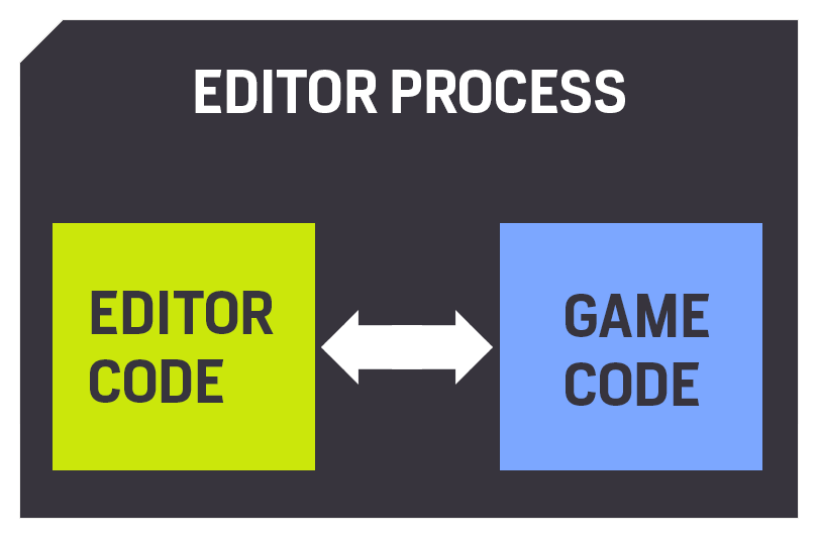


In-process integration

+ Fast to setup

+ Direct synchronous data changes

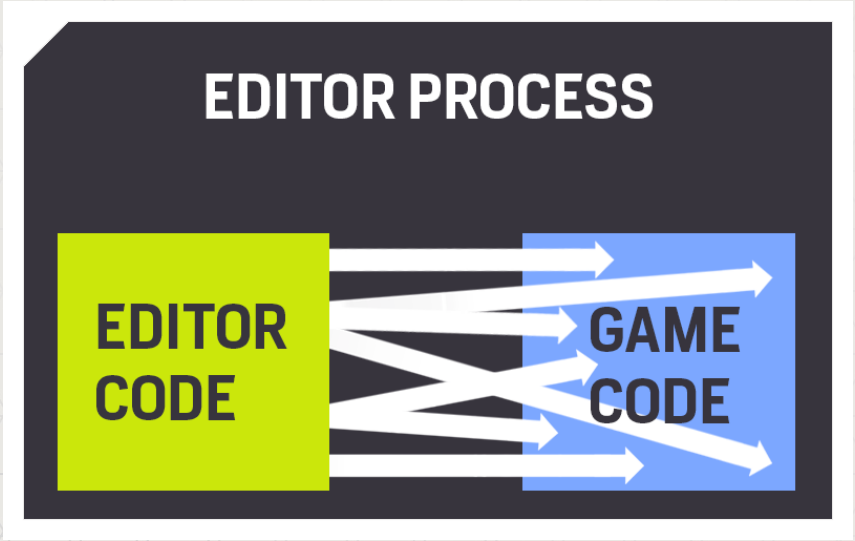
- Crash in game = crash in editor



In-process integration

+ Fast to setup
+ Direct synchronous data changes

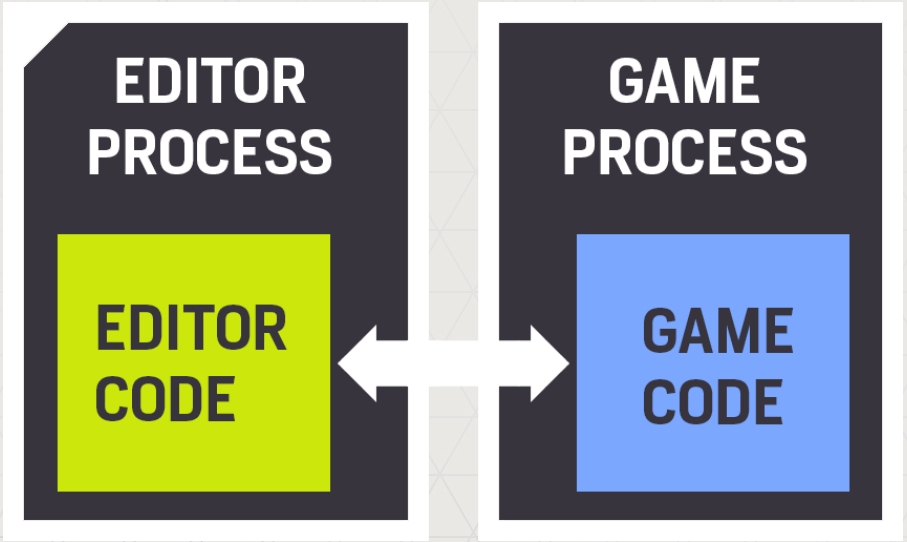
- Instability
- Enforcing code separation



Out of process integration

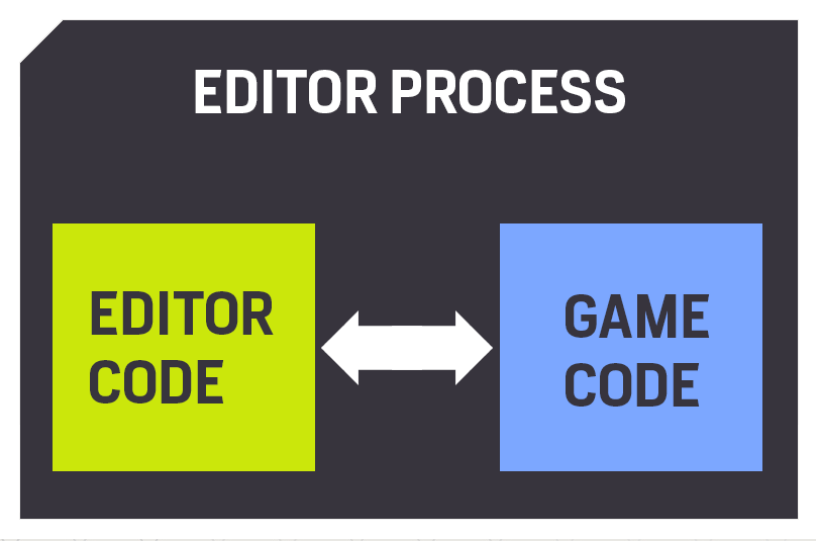
+ Stability
+ Cleaner code
+ Responsive UI

- Longer initial development
- Harder to debug 2 asynchronous processes



3D Editor: Initial design

- Develop **in-process** with a **full game**
- **Goal**: Out of process should remain possible



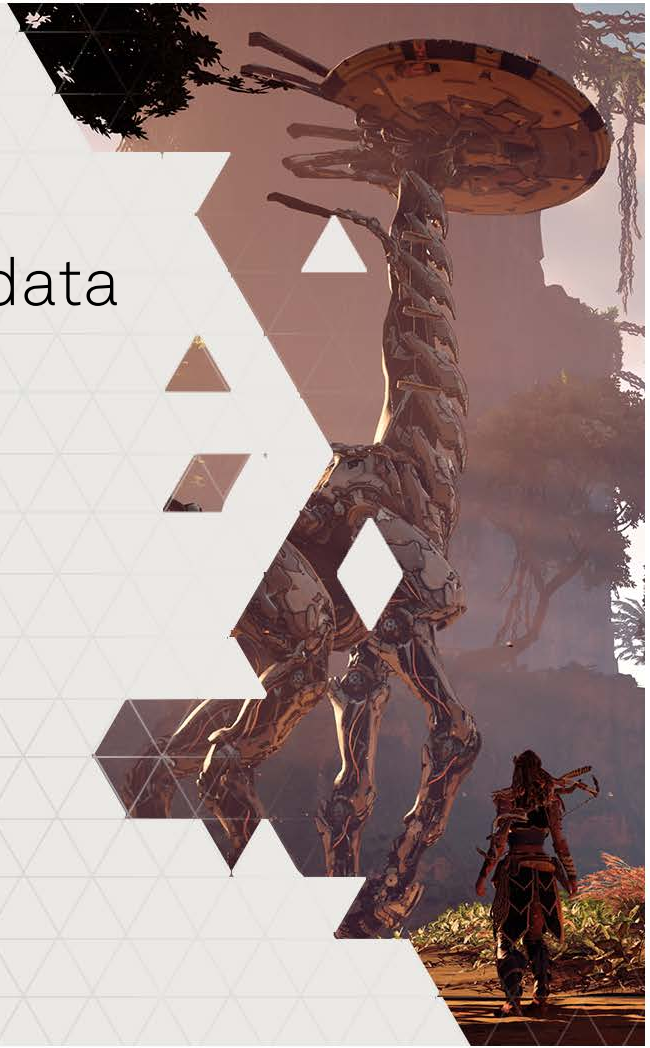
Editing content in a running game

Required sub-systems for Level Editor

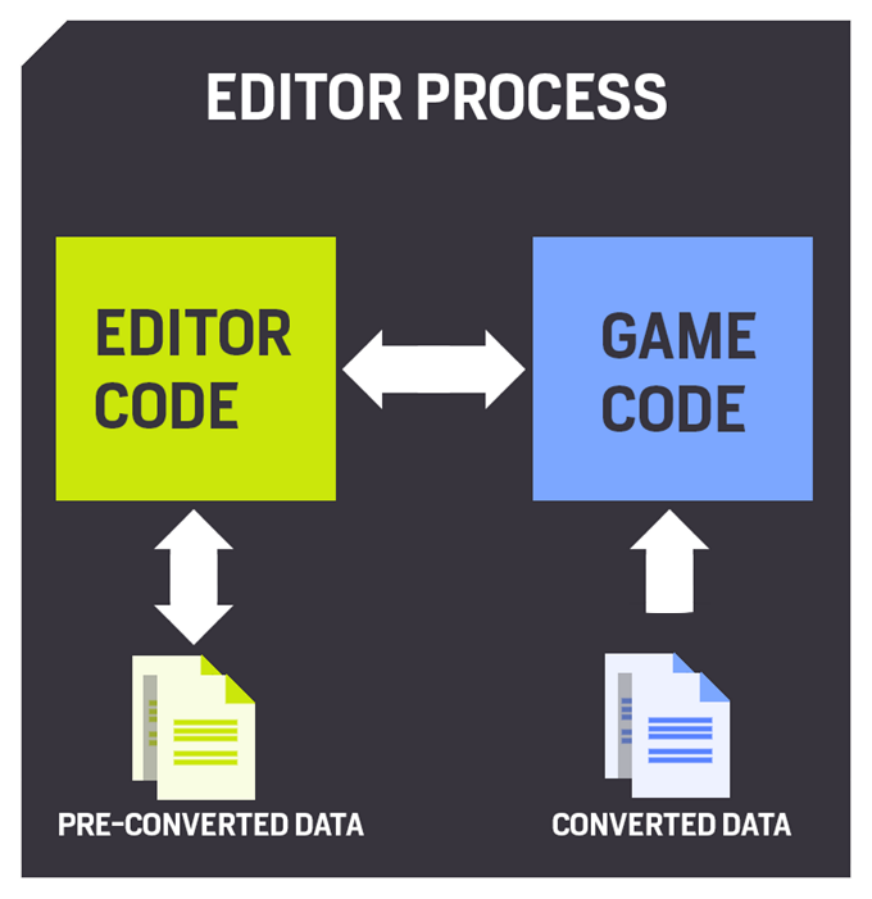
Game data

- **Problem**: Game reads binary game data

- Creation is *destructive*
  - Shader compilation
  - Meshes optimization
  - Data packing

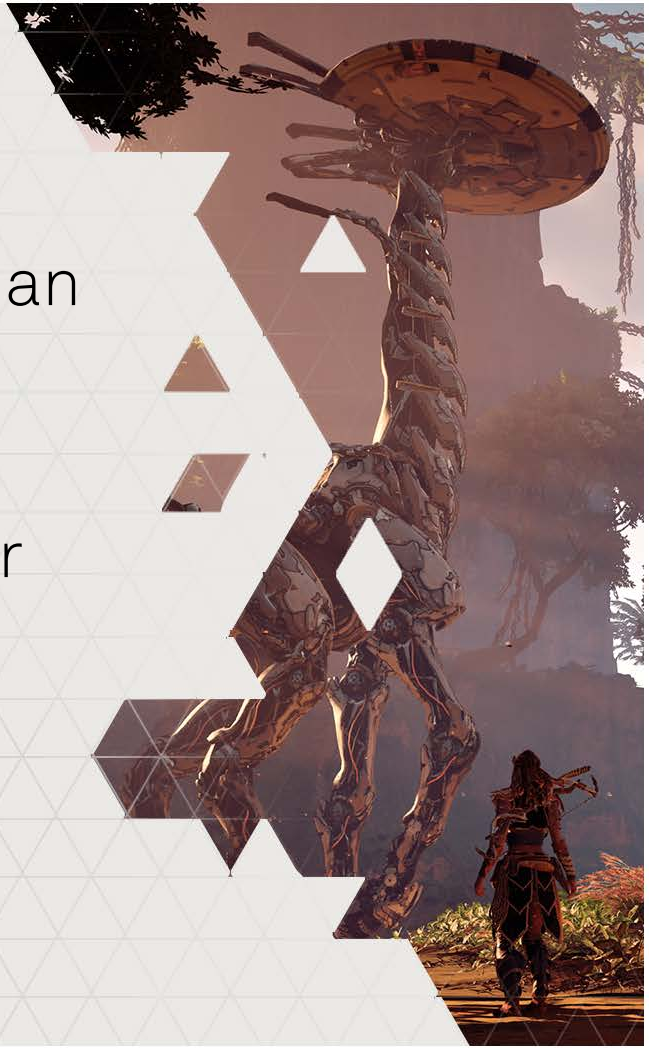


3D Editor: Initial design



EditorNode

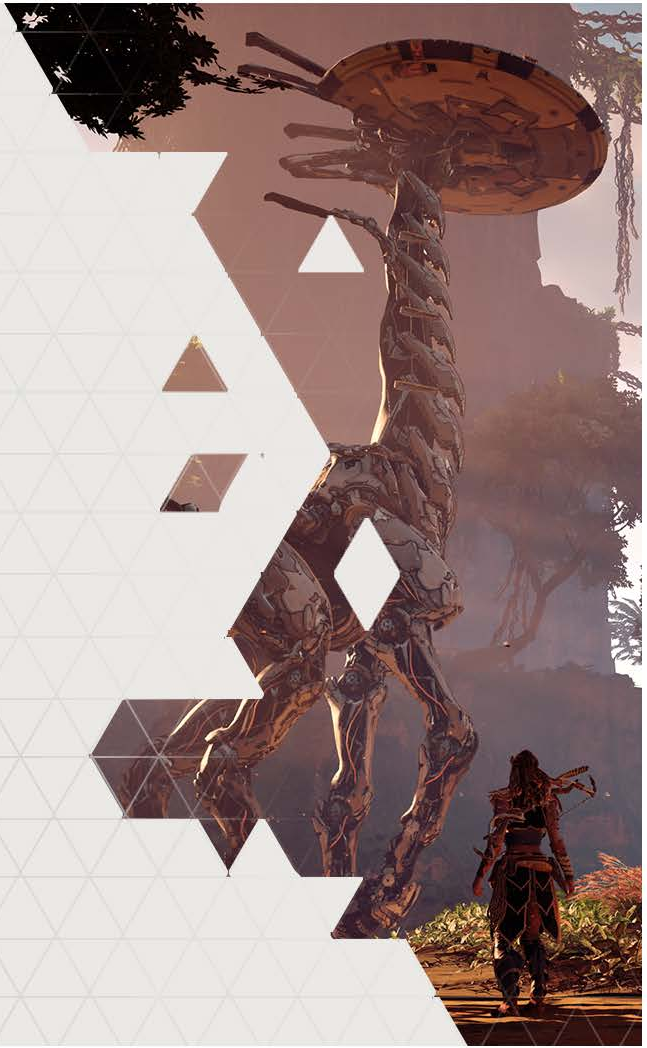
- Provides **all** editing functionality for an object in game
- Game object does **not** know of Editor Node
- Keeps code clean, no editor specific code interwoven in game code



Only WorldSpace in-game

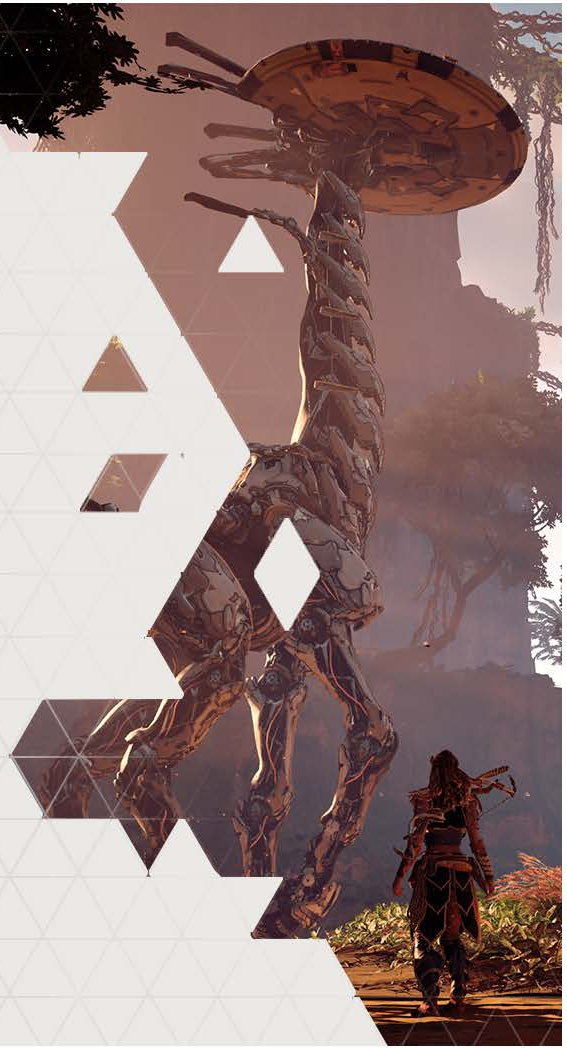
- **Problem**: Less hierarchy in game

- Flat list of objects
  - Fast and efficient
  - Transforms in World Space

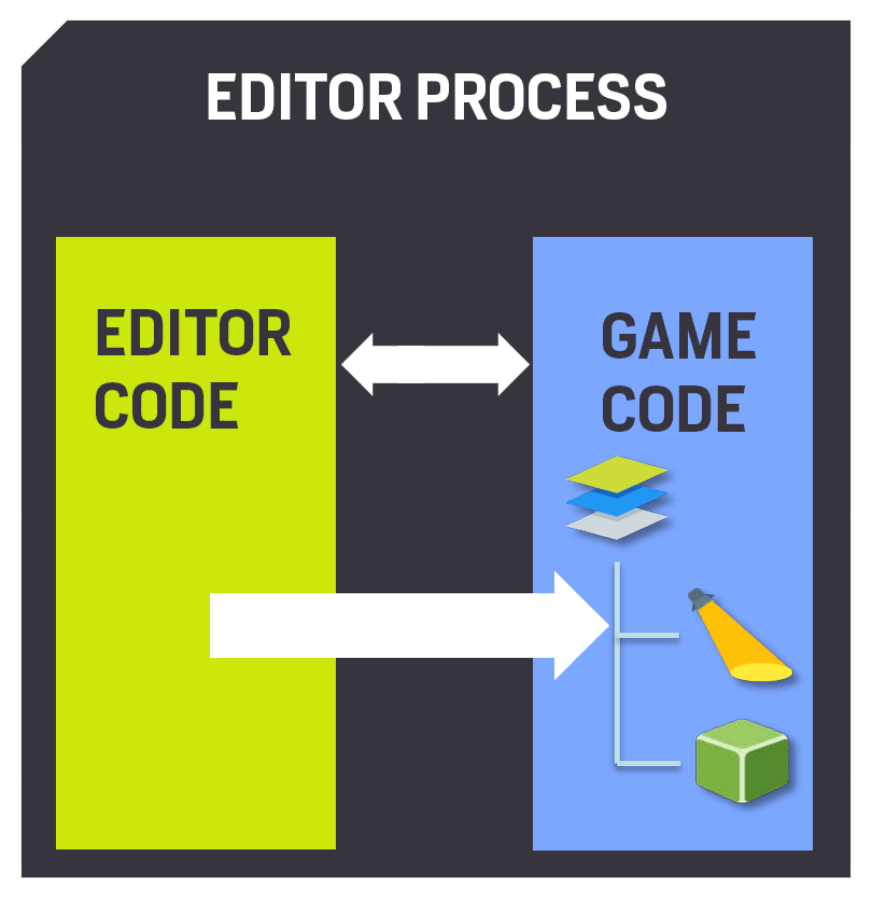


EditorNodeTree

- Hierarchical structure of in-game data
- Constructed from game data, reflects hierarchy of objects in-game.
  - When entering “*edit mode*”
  - Top down (starting at root)



Accessing the EditorNodeTree

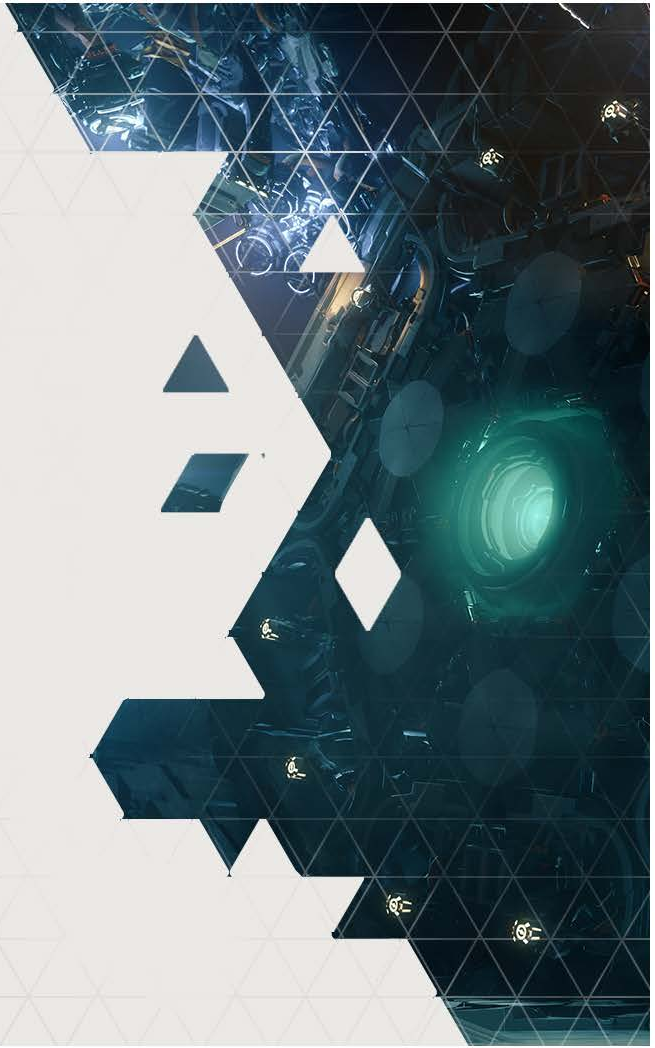


2 Editor Node Trees

Making Changes to Objects

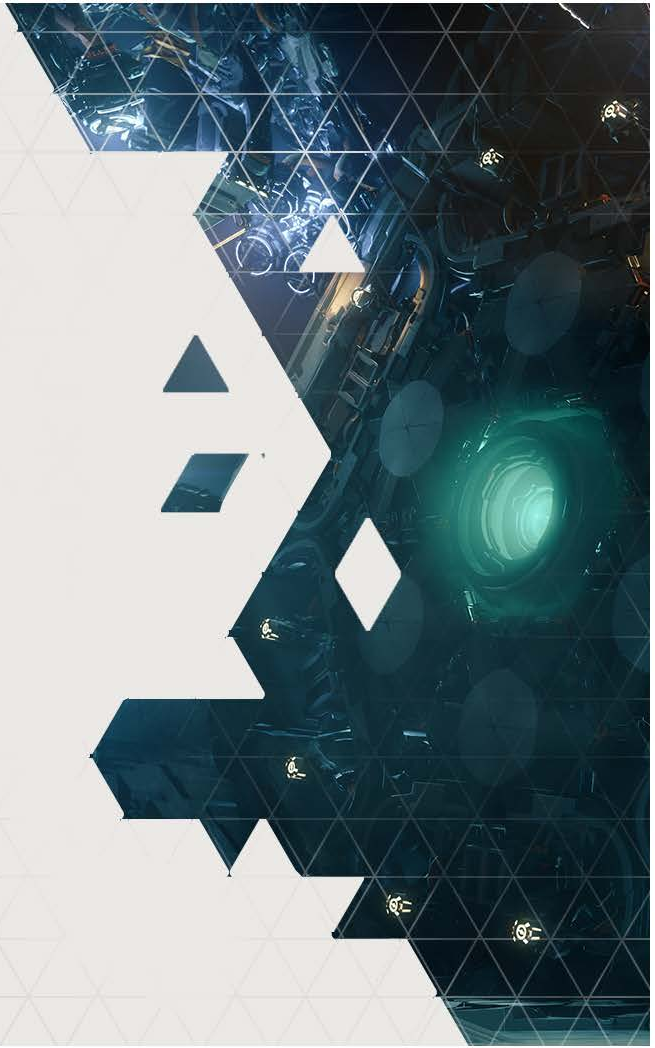
What we didn't want

- Proxy representations
- String-based accessors
- Editor-specific boilerplate
- Code generation steps in the build



What we wanted

- Work directly with concrete objects
- Directly modify object members
- Re-use existing systems and utilities to create and transform data

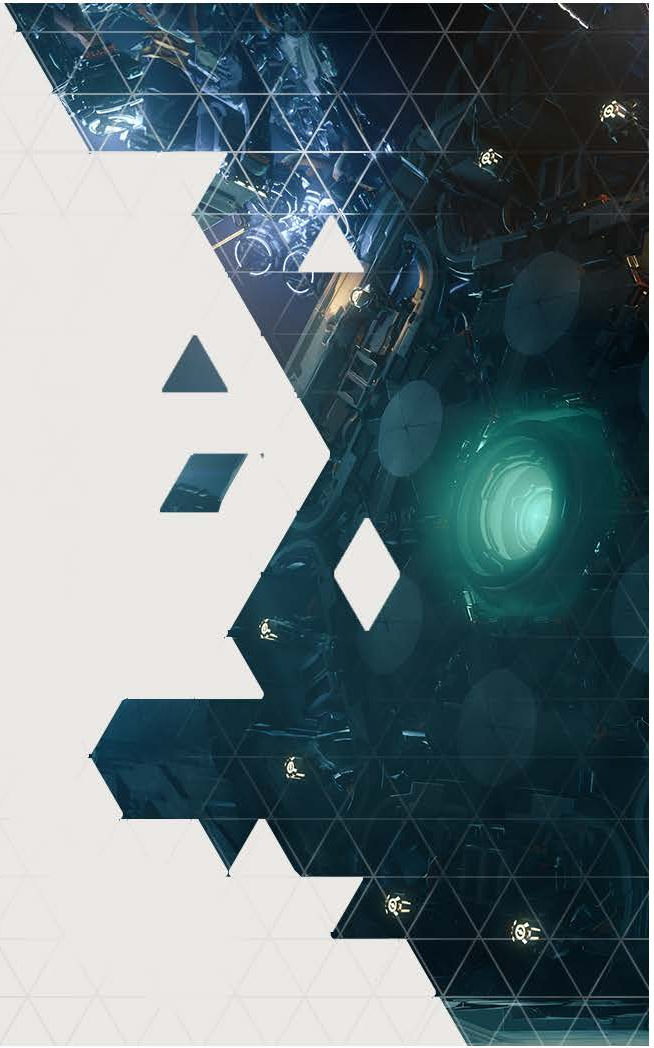


Making changes to objects

- Being able to make changes is good, but...

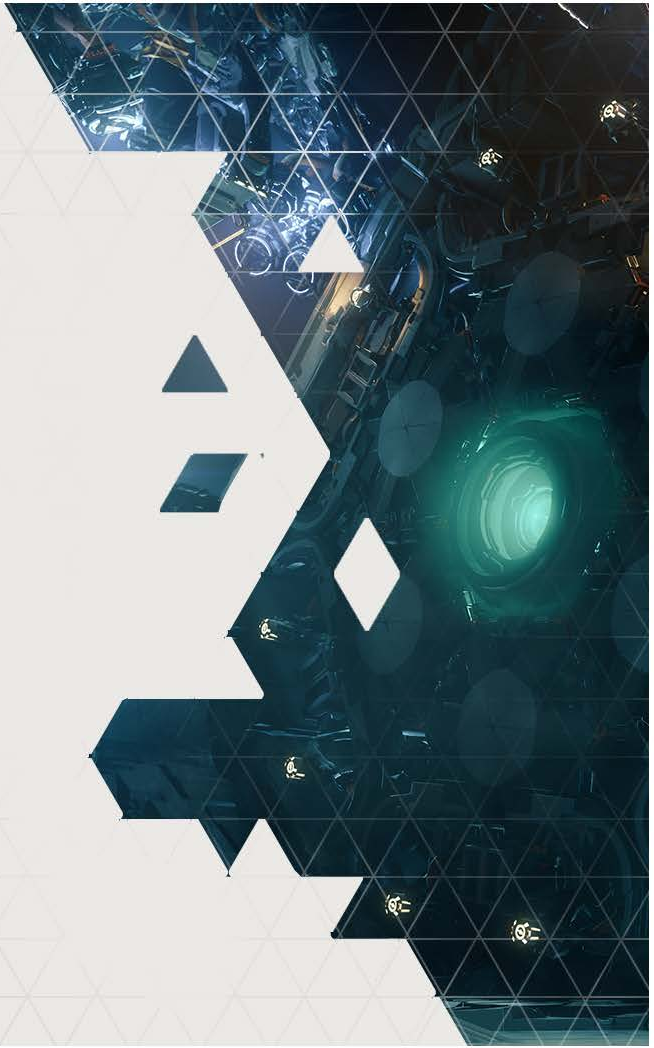
"What is best in life?"

- An **Undo** system is essential for users to remain in control and have the freedom to experiment



Undo System – Goals

- Simplicity & Reliability
- No virtual **‘Do’** and **‘Undo’** functions
- No new undo code for new features
  - Prevent transformation asymmetry



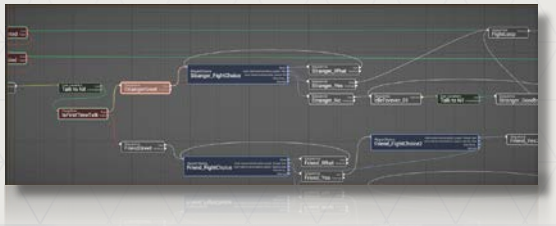
Undo System

- The ideal scenario:
  - An undo system that automatically detects object changes, and knows how to revert them
- The compromise, in our case:
  - Beforehand, code indicates which objects will be modified, and when the modifications are completed

Undo System – Transactions

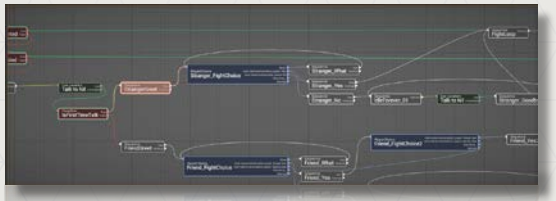
- Describes all modifications in a change
  - Commands represent individual changes
- Built on the RTTI system
- Subscribers are notified of all transactions

Transaction Notifications



ADD OBJ
ADD OBJ
SET VALUE
SET VALUE
DEL OBJ

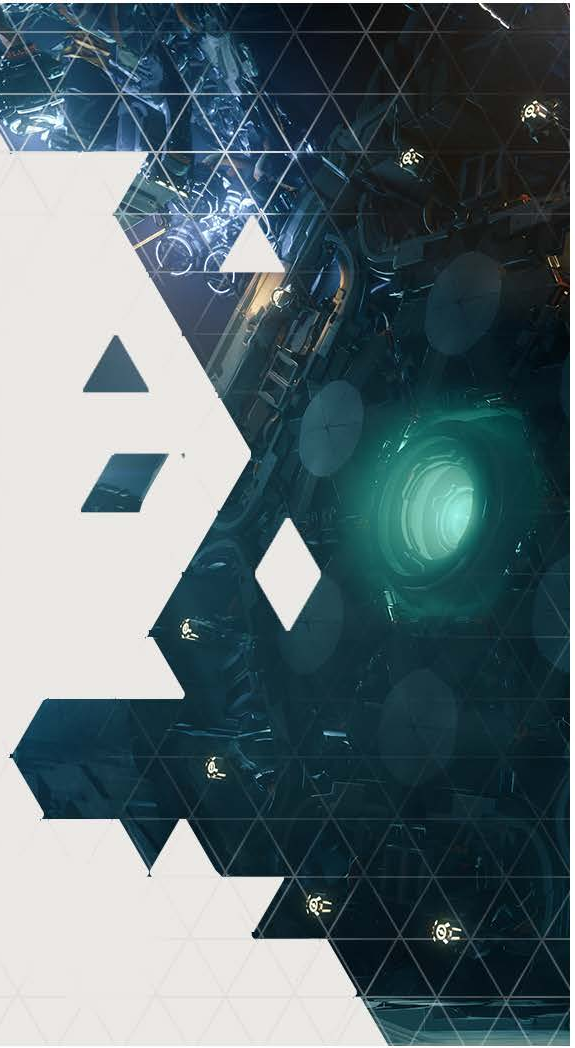
Transaction Notifications



- Code Separation
- Changes can be made from anywhere
- No knowledge of do and undo in editor code

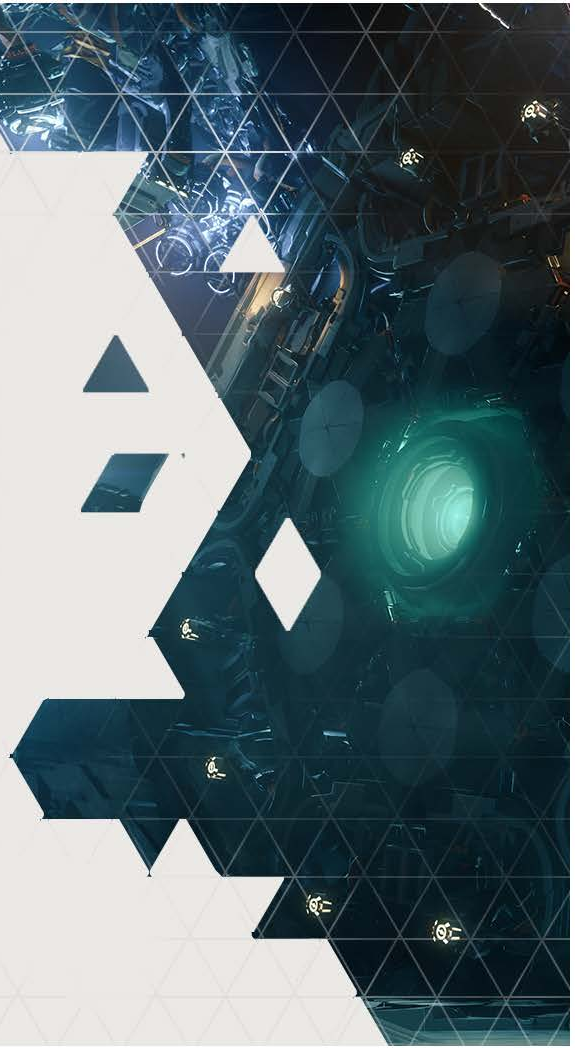
Undo System – DiffUtil

- Building transactions is hard
- **DiffUtil** builds them
  - Produces transactions by looking at changes that have already happened



Undo System – DiffUtil

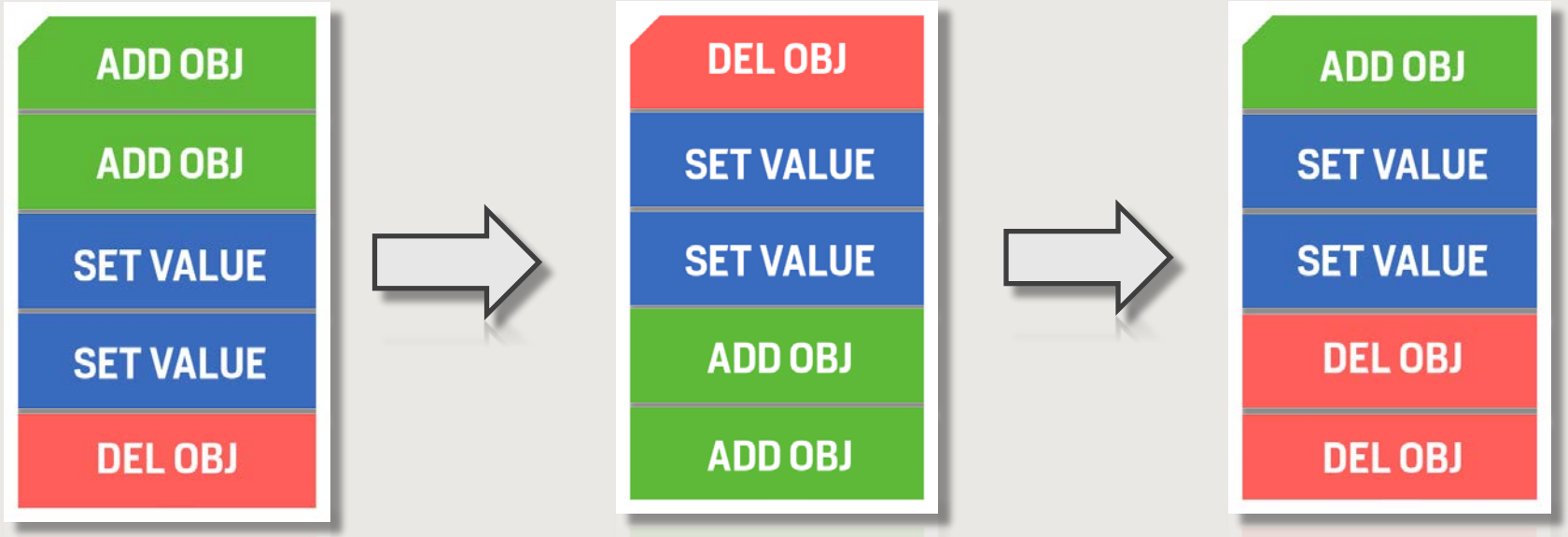
- Before changes are made:
  - DiffUtil takes **snapshot** of objects' state
- After changes:
  - Analyzes what has changed between the snapshot and the current state



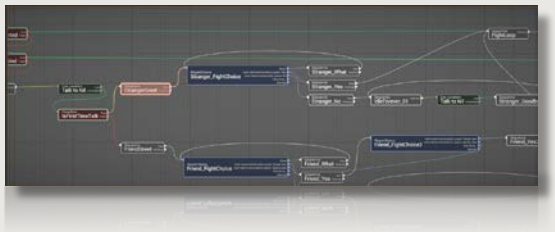
DiffUtil – Code Example

```
// Get the spotlight to edit...
pSpotLightResource spotlight = GetSpotlightToEdit();

// Take a snapshot of the spotlight's current state
DiffUtil diff;
diff.TakeSnapshot(spotlight);

// Update the cone angle
spotlight->SetConeAngle(30.0f);

// Indicate that we have finished making changes
diff.CommitChanges("Set Cone Angle to 30");
```

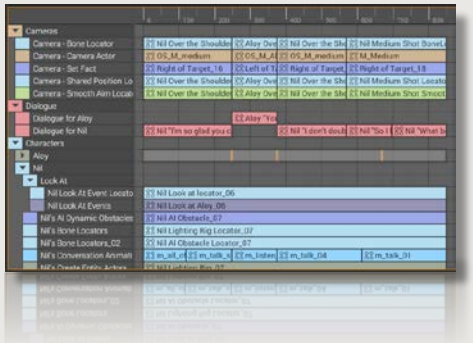
Undo System – Reverting Changes



Applying the Undo Transaction

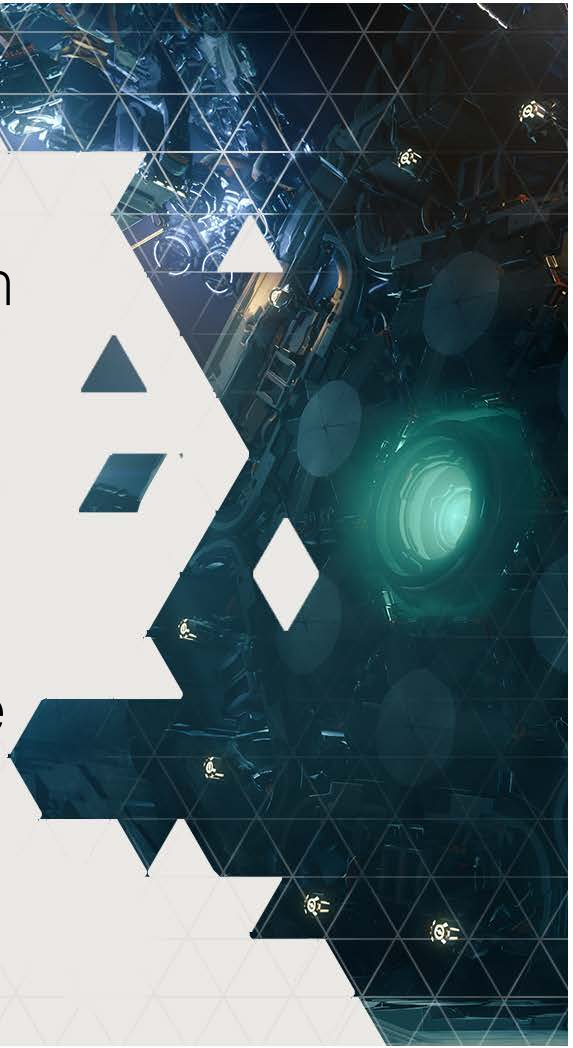


ADD OBJ
SET VALUE
SET VALUE
DEL OBJ
DEL OBJ



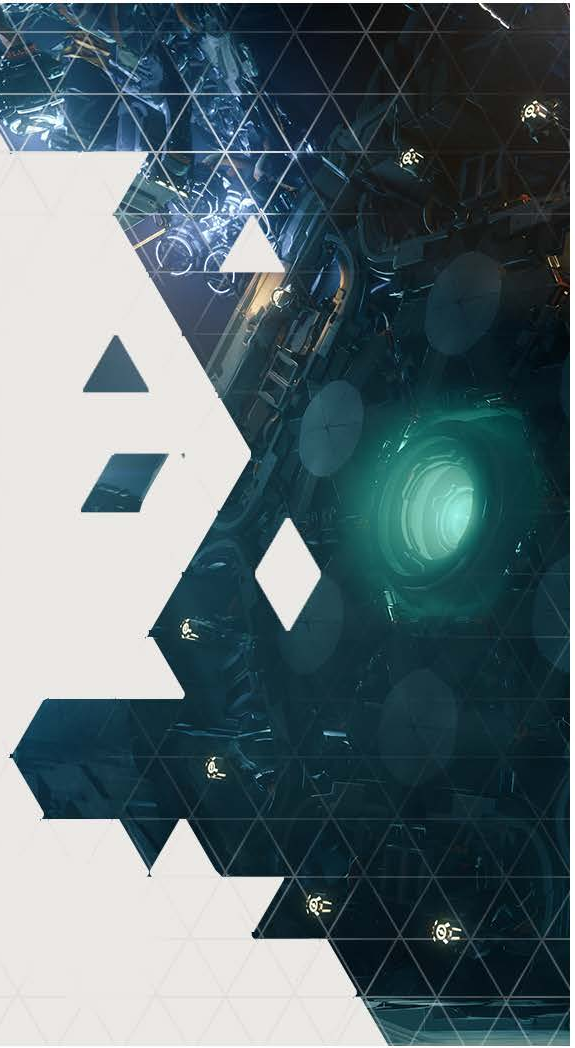
What worked?

- A reliable, transparent system that can represent arbitrarily complex changes
- No distinction between **do** and **undo**
- Stable code, that changed very little in the time since it was written



What didn’t work?

- Easy for programmers to forget to use a **DiffUtil**
- Transactions validated in Debug
  - But this doesn’t catch everything
- Doesn’t support filesystem operations



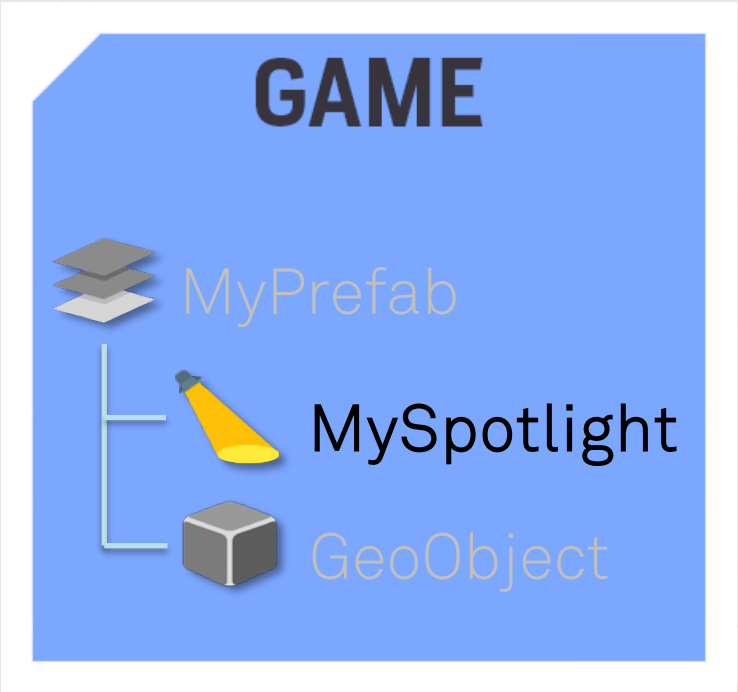
Transactions in the 3D Editor

Changes in the 3D Editor

- Transactions to the Game

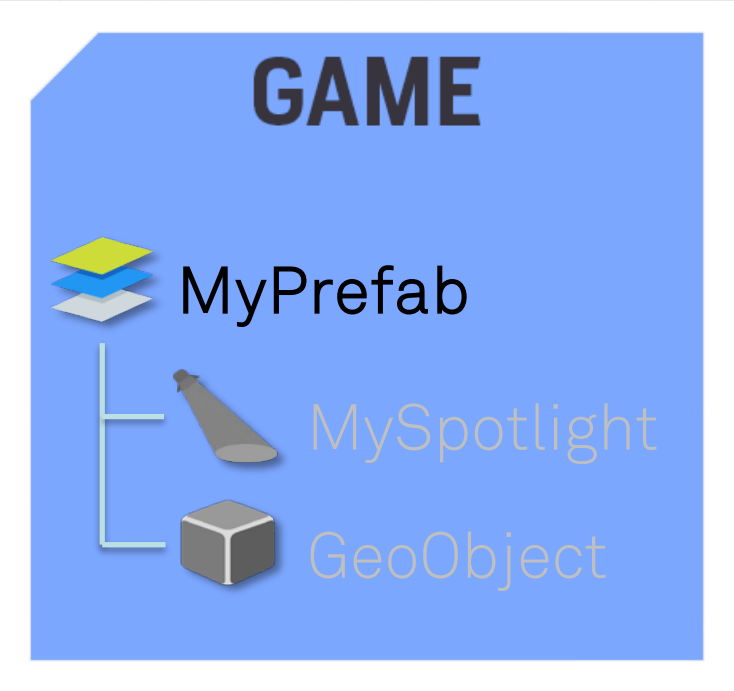
EditorNodeTree in space conversion

3D Editor – Applying a change in the tree



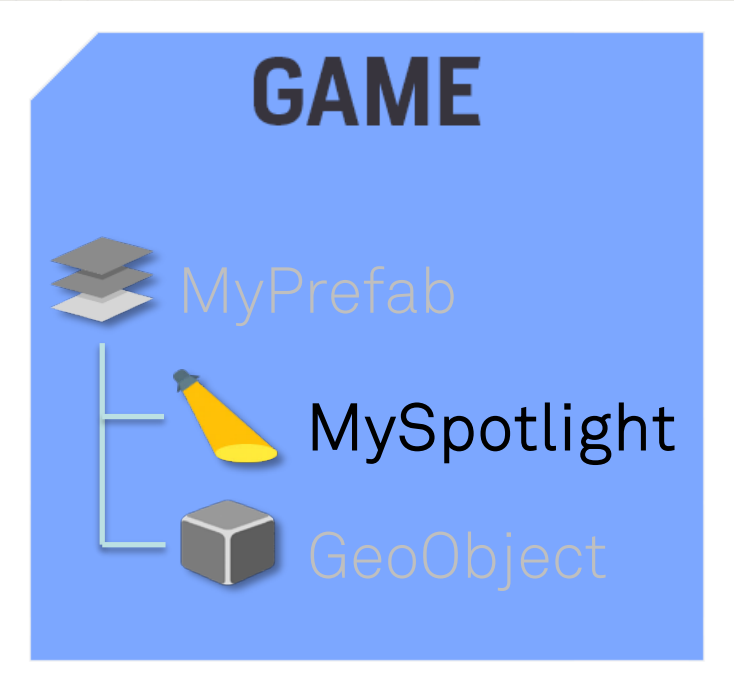
- Modify local space of *MySpotlight*

3D Editor – Applying a change in the tree



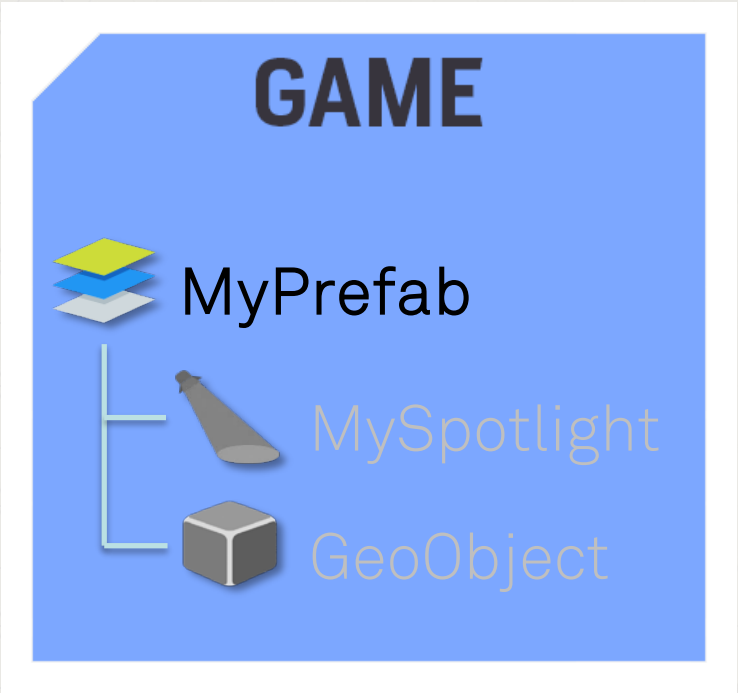
- *MyPrefab* multiplies transform change with it's local matrix
- Modified transaction passed to *MySpotLight*

3D Editor – Applying a change in the tree



- *MySpotlight* consumes the change
- The modified transaction is in WorldSpace

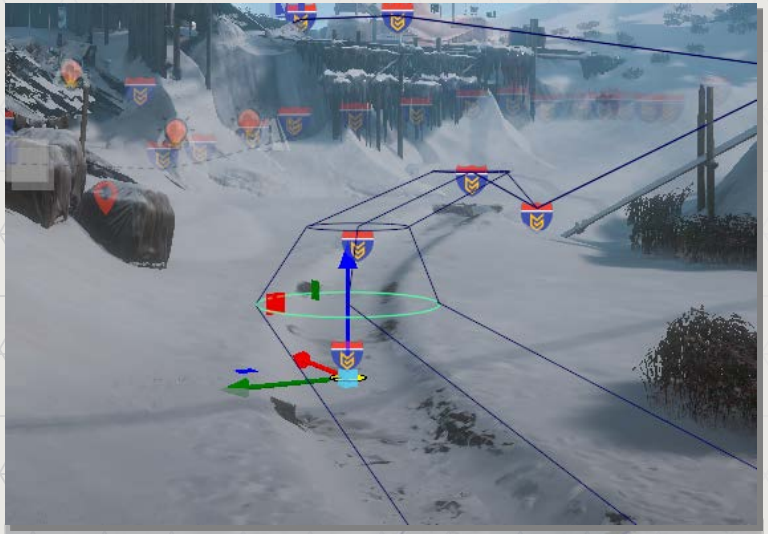
3D Editor – Applying a change in the tree



- *[Optional]: MyPrefab* invalidates cached data or updates dependencies

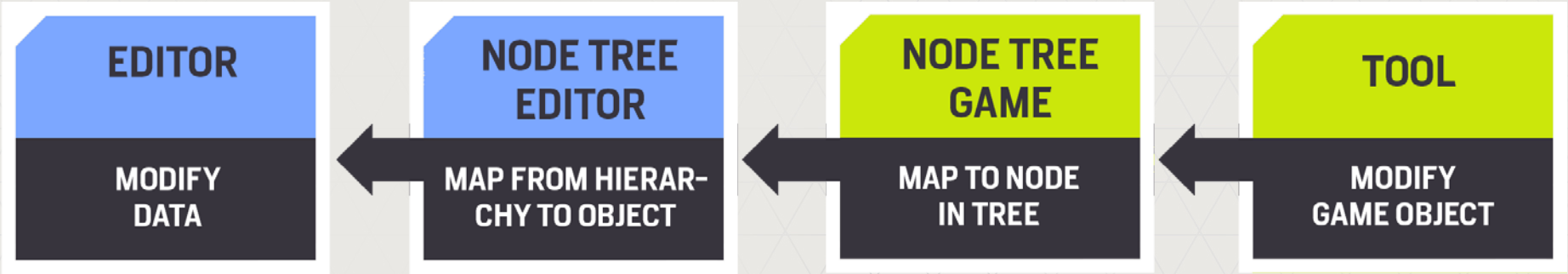
Interactive changes

- **Problem**: Interactive changes start *in-game*
  - Orientate an object in viewport
  - Painting vegetation
  - Terrain sculpting
  - Etc.



Naïve implementation of tool change

- (Tool) Transactions from the Game ?

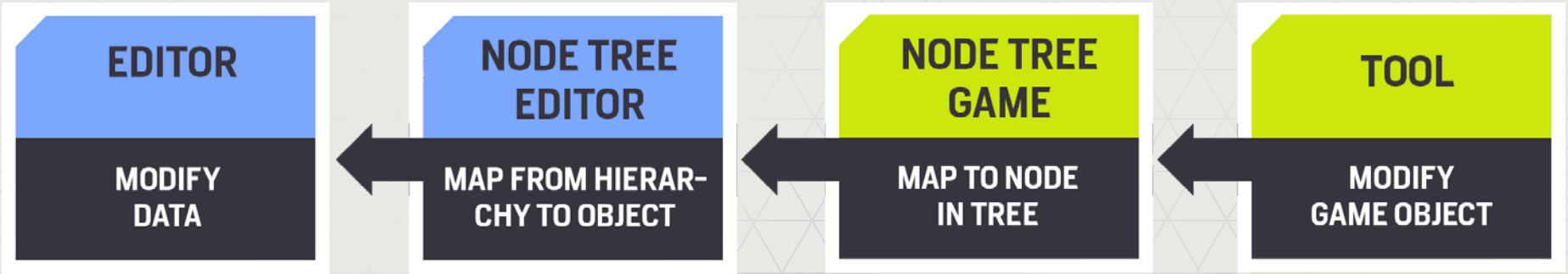


Naïve implementation of tool change

- (Tool) Transactions from the Game ?

Naïve implementation of tool change

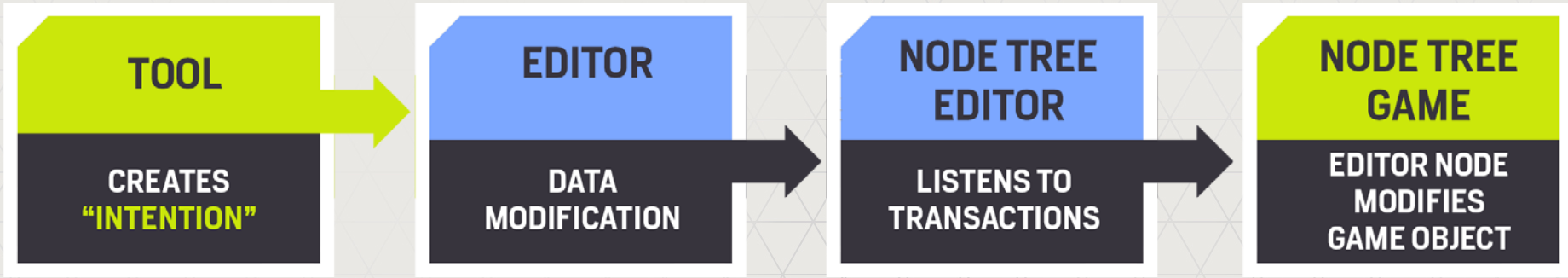
- Who has authority over data?
- Impossible due to dataloss in conversion
- Creates a cycle going back to game



Tool changes

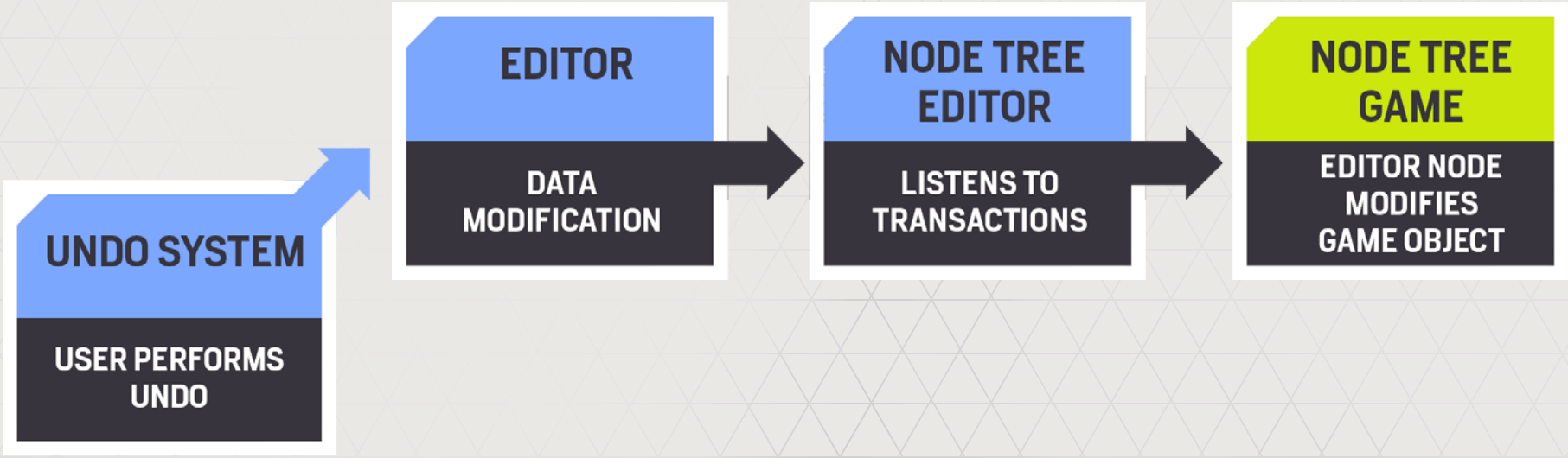
Solution:

- Tool does **not** modify data
- Editor keeps authority over data



Undoing tool changes

Undo works the same way!



GameSync

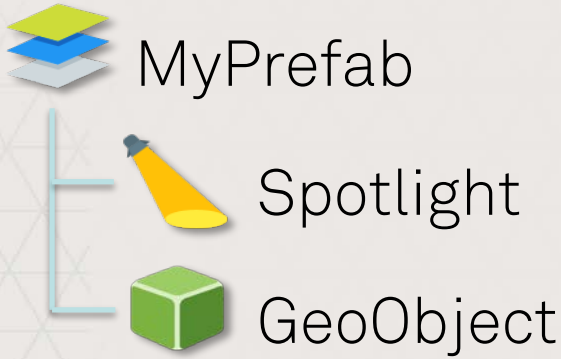
Updating structural changes in the game

GameSync

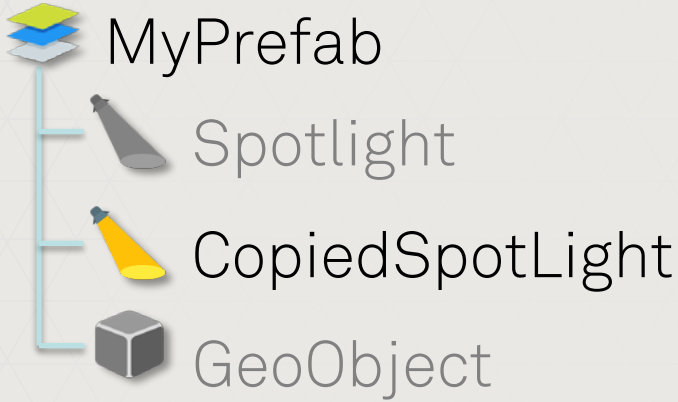
- *Gamesync* handles structural changes to the game
- Pre-dates Tools Framework
- Creates patch file to apply in game

GameSync

- Create a copy of *Spotlight*

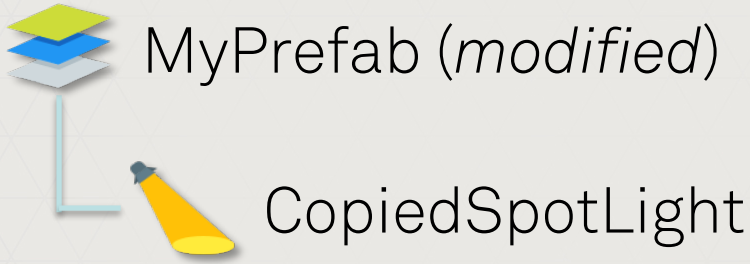


GameSync – Analyze change



GameSync – Patch file

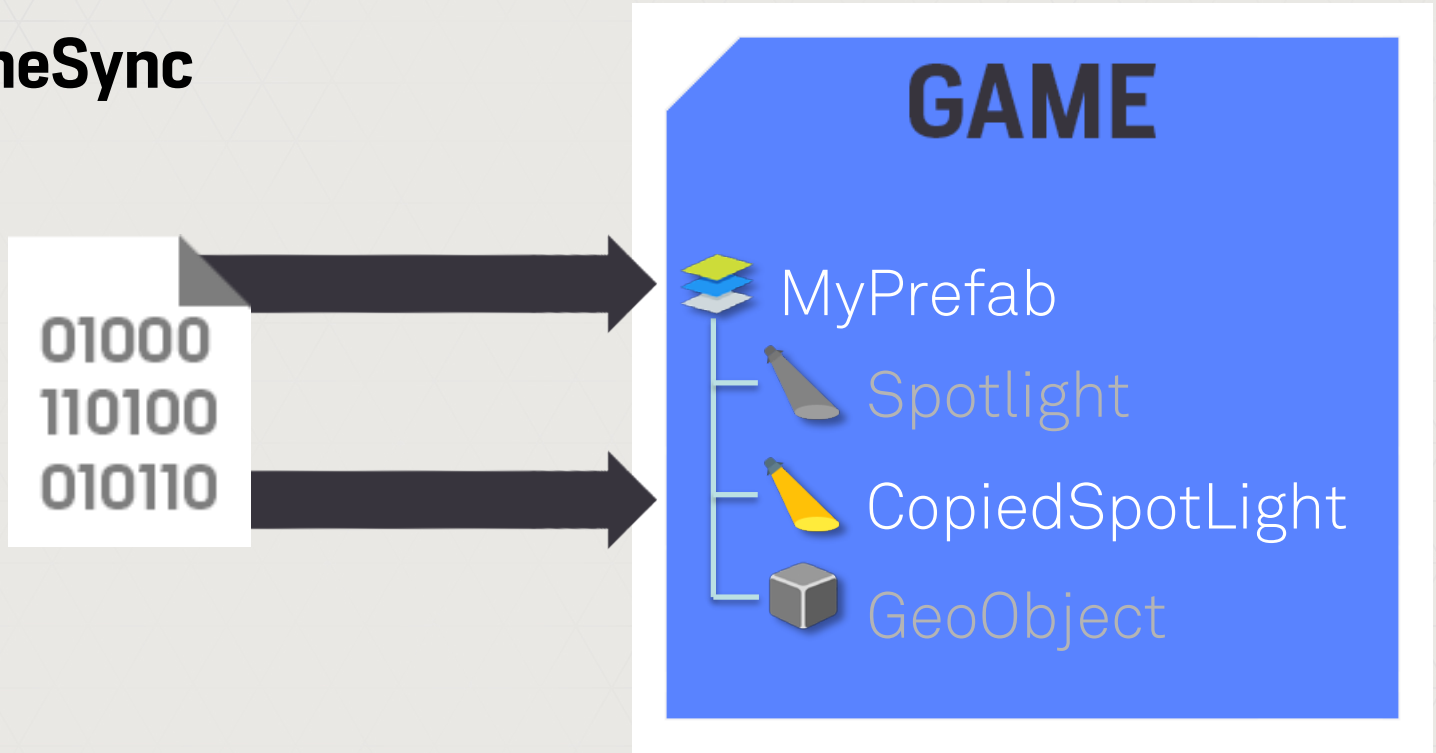
GameSync – Conversion



GameSync

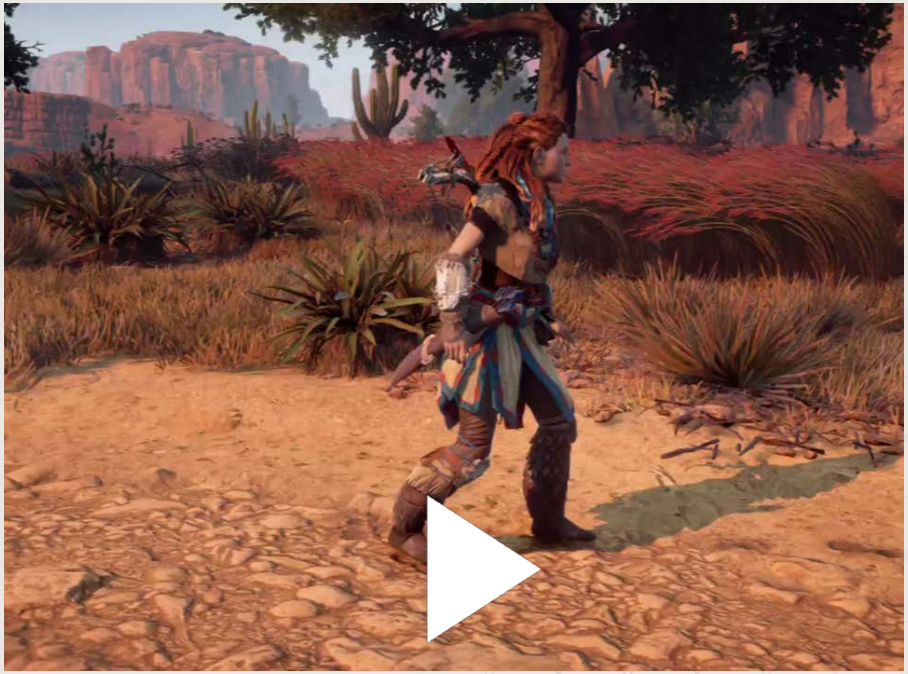
ANALYSE CHANGE → CREATE PATCH FILE → CONVERT PATCH FILE → PAUSE GAME SYSTEMS → APPLY PATCH → RESUME GAME

GameSync



ANALYSE CHANGE → CREATE PATCH FILE → CONVERT PATCH FILE → PAUSE GAME SYSTEMS → APPLY PATCH → RESUME GAME

GameSync



ANALYSE CHANGE → CREATE PATCH FILE → CONVERT PATCH FILE → PAUSE GAME SYSTEMS → APPLY PATCH → RESUME GAME

GameSync – The Good

- Works on all changes throughout Editor
- Can sync to target as well (PS4)
- No game restart required

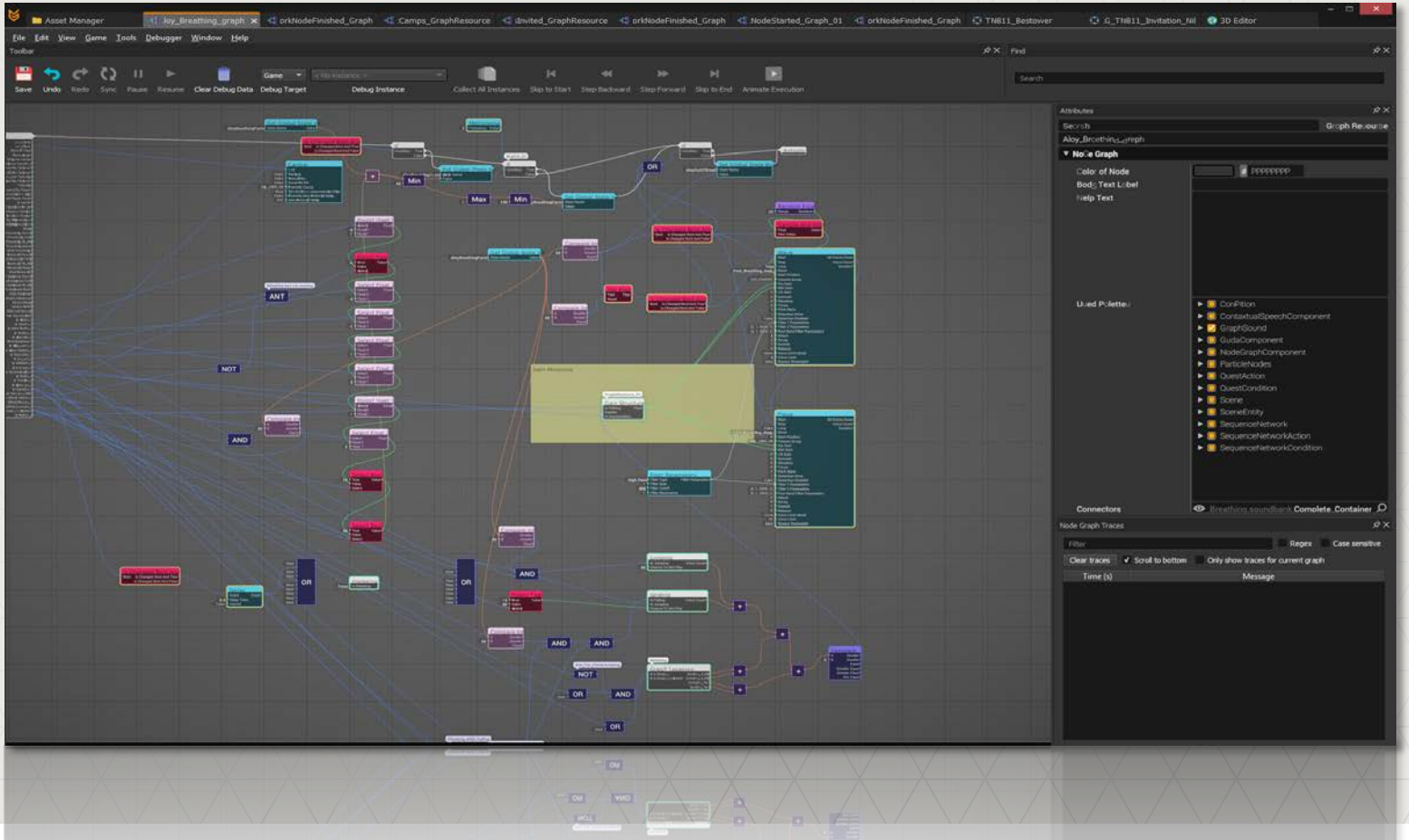
GameSync – The Bad

- Systems were not designed to work with GameSync
- The change analysis code became very complex
- Performance issues

- Inconsistent behavior
  - Crashes, incomplete updates
- Low level of confidence from users

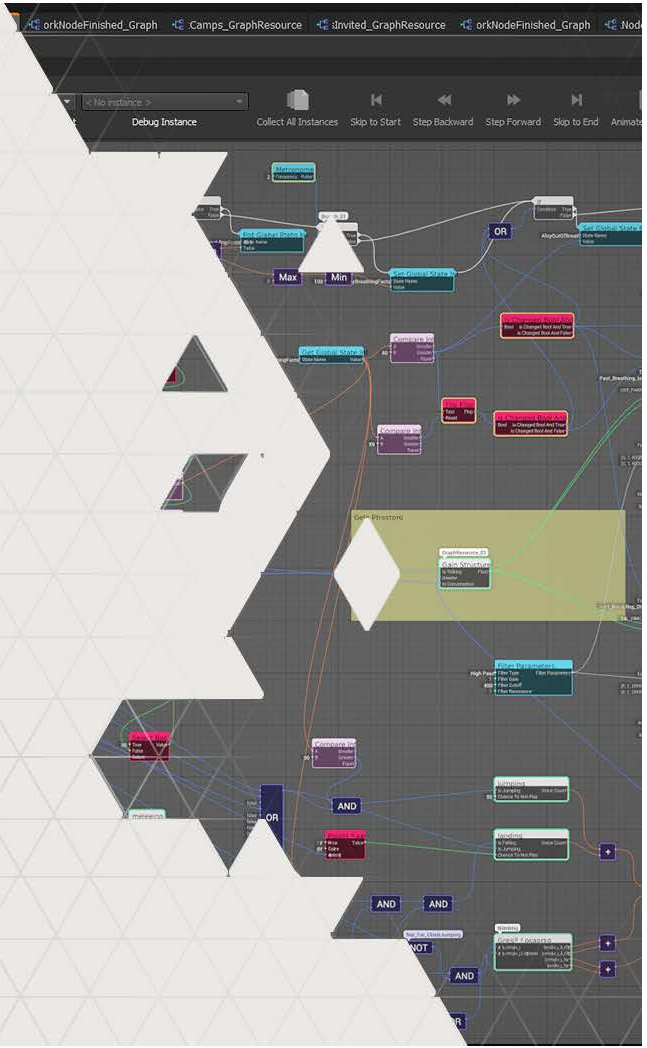
Other Tools

NodeGraph Debugger



NodeGraph Debugger

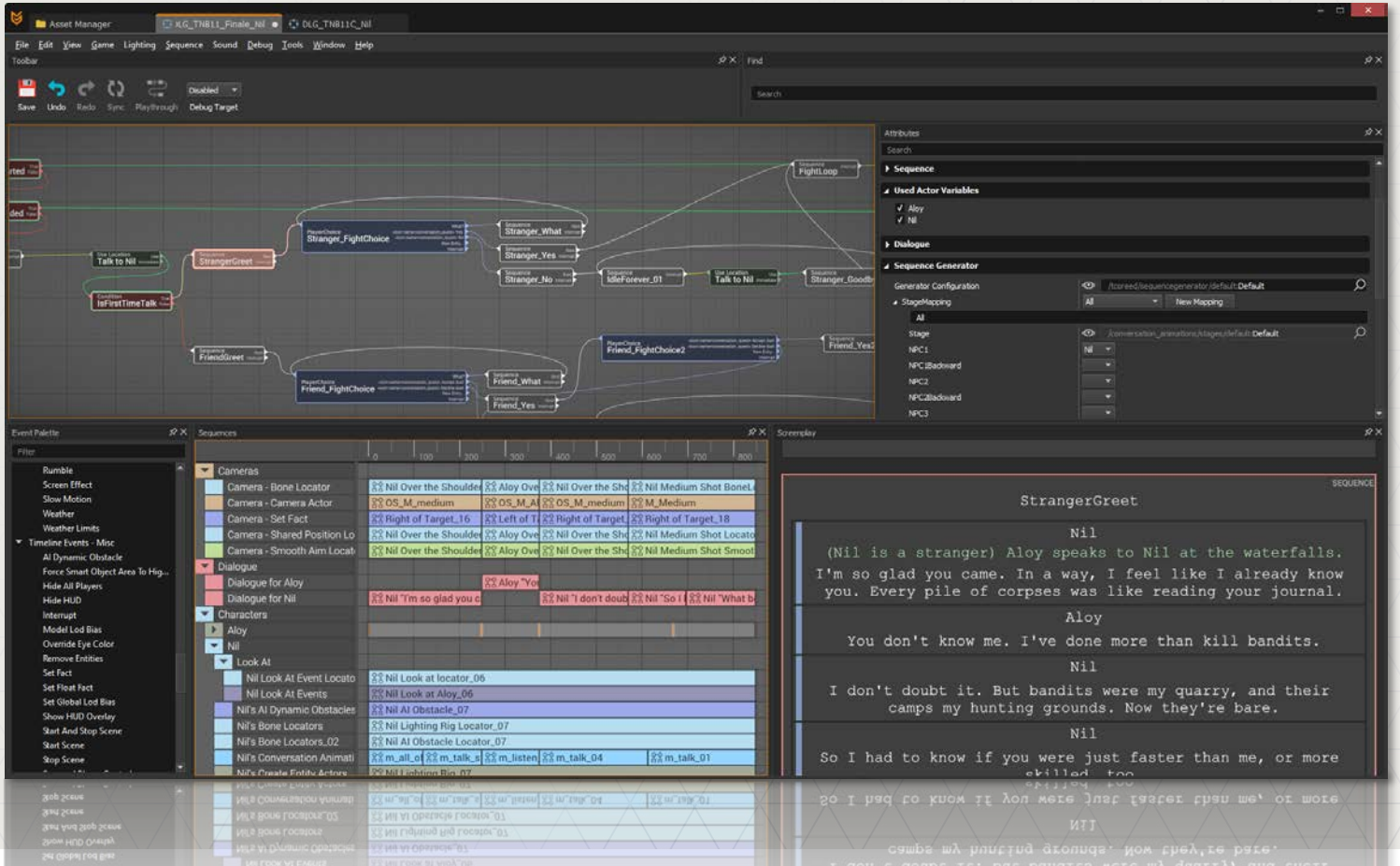
- Powerful debugging features
  - Variable inspection
  - Execution visualization
  - Historical debugging
- Minimal involvement from the tools team
  - Almost all of the work was done by game tech



Interactive Conversations

- A new feature for **Horizon**
- Free to build a workflow from scratch
- Built specifically for:
  - Writers
  - Quest designers
  - Cinematic artists

Conversation Editor Context



Conversation Generator

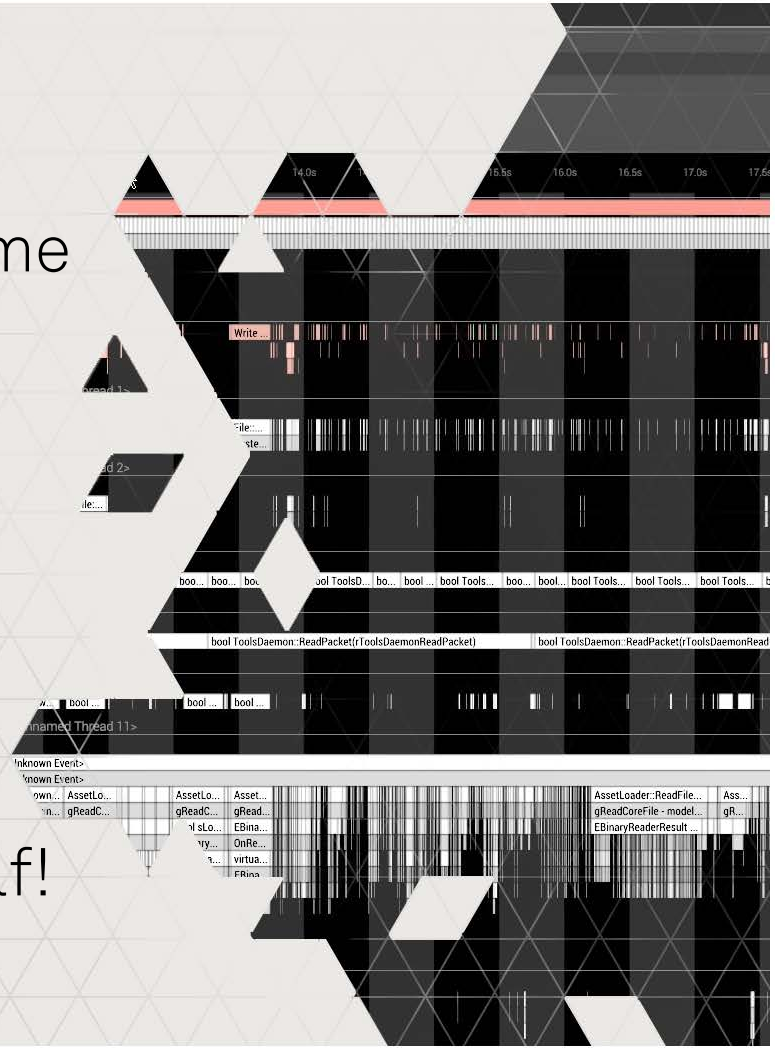
- This conversation was auto-generated
- Camera cuts, animation, gestures selected by rule-based system
- **RoboVoice** and lip-sync animations created for mock-up content

Conversation Generator

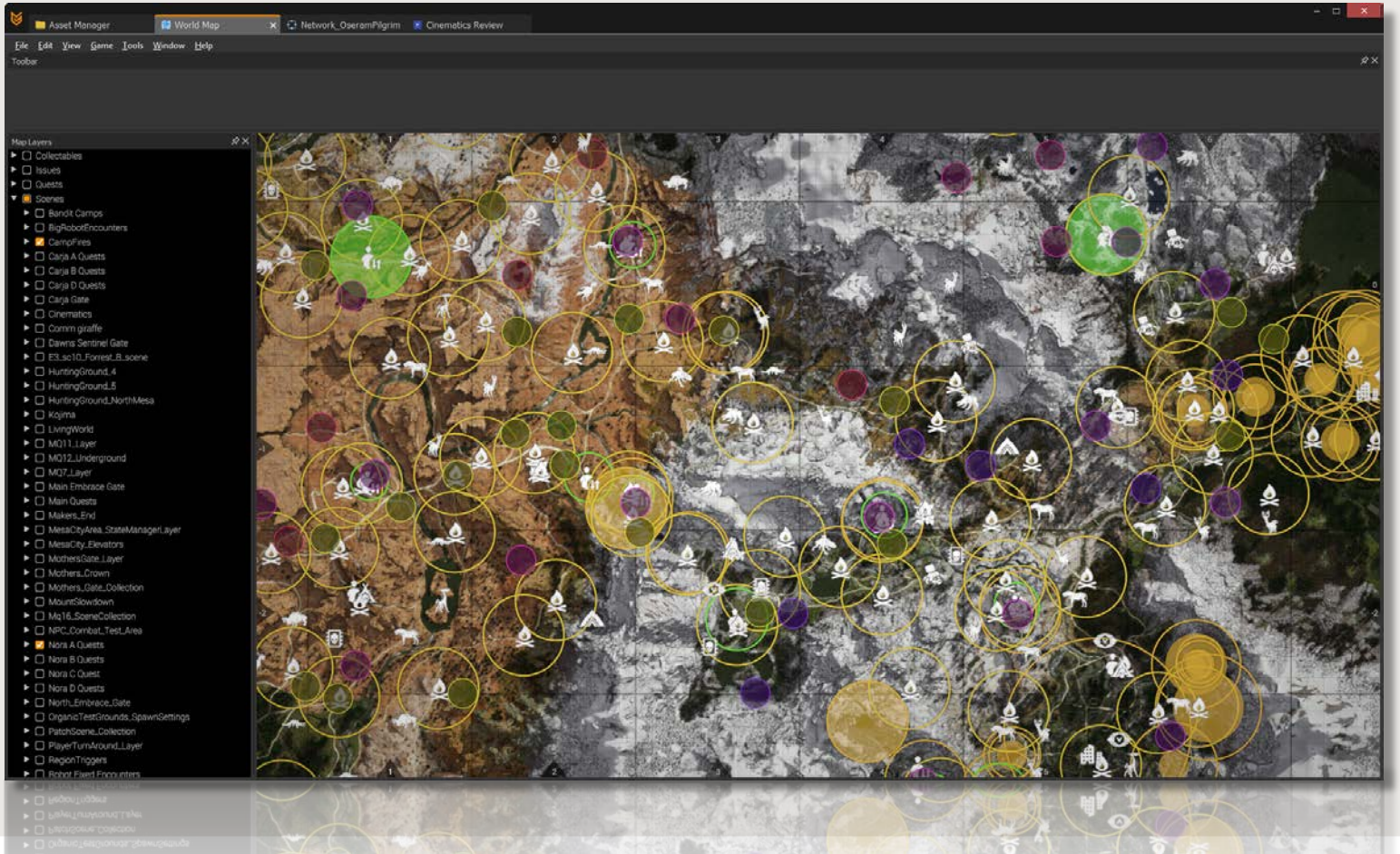
- Inspired by the work of **CD Projekt RED** and **BioWare**
- Was possible because it was easy to build in the new framework
- Behind the Scenes of Cinematic Dialogues in ‘The Witcher 3: Wild Hunt’
  - http://www.gdcvault.com/play/1023285/

Profiler

- Built on top of an existing in-game profiler framework
- Real-time data from any app running the profiler framework
- Editor runs the profiler framework, so it can profile itself!



World Map


Asset Manager
World Map
Network_OseramPilgrim
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Scenes
Bandit Camps
BigRobotEncounters
CampFires
Carja A Quests
Carja B Quests
Carja D Quests
Carja Gate
Cinematics
Comm giraffe
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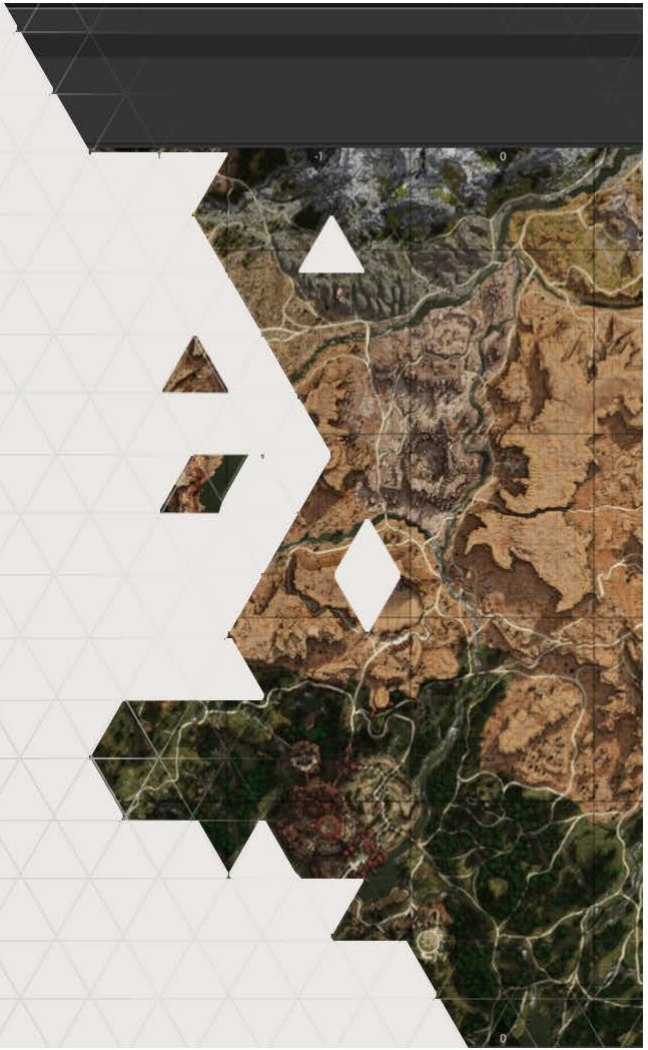
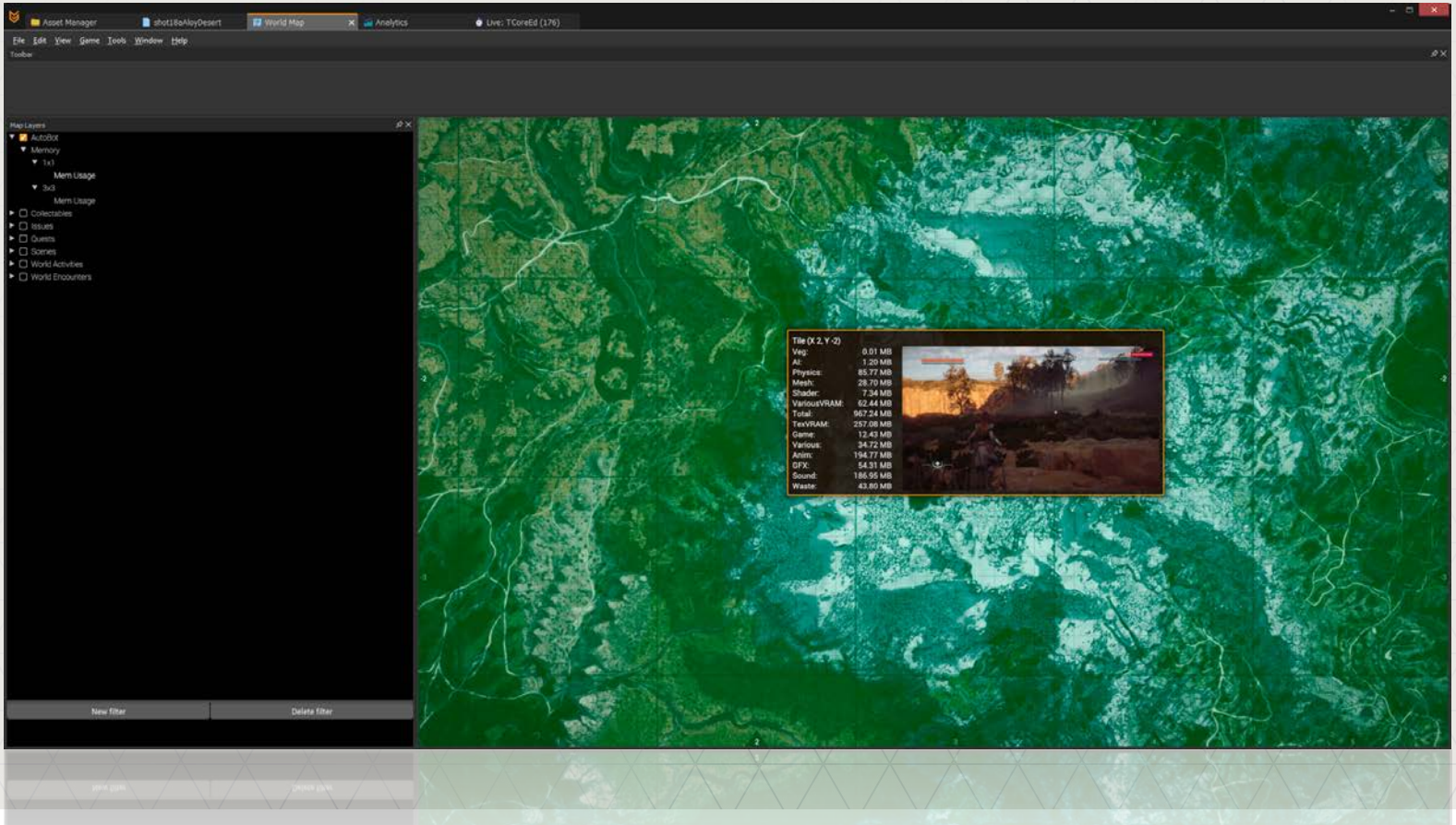
HuntingGround_4
HuntingGround_5
HuntingGround_NorthMesa
Kojima
LivingWorld
MQ11_Layer
MQ12_Underground
MQ7_Layer
Main Embrace Gate
Main Quests
Makers_End
MesaCityArea_StateManagerLayer
MesaCity_Elevators
MothersGate_Layer
Mothers_Crown
Mothers_Gate_Collection
MountSlowdown
Mq16_SceneCollection
NPC_Combat_Test_Area
Nora A Quests
Nora B Quests
Nora C Quest
Nora D Quests
North_Embrace_Gate
OrganicTestGrounds_SpawnSettings
PatchScene_Collection
PlayerTurnAround_Layer
RegionTriggers

World Map

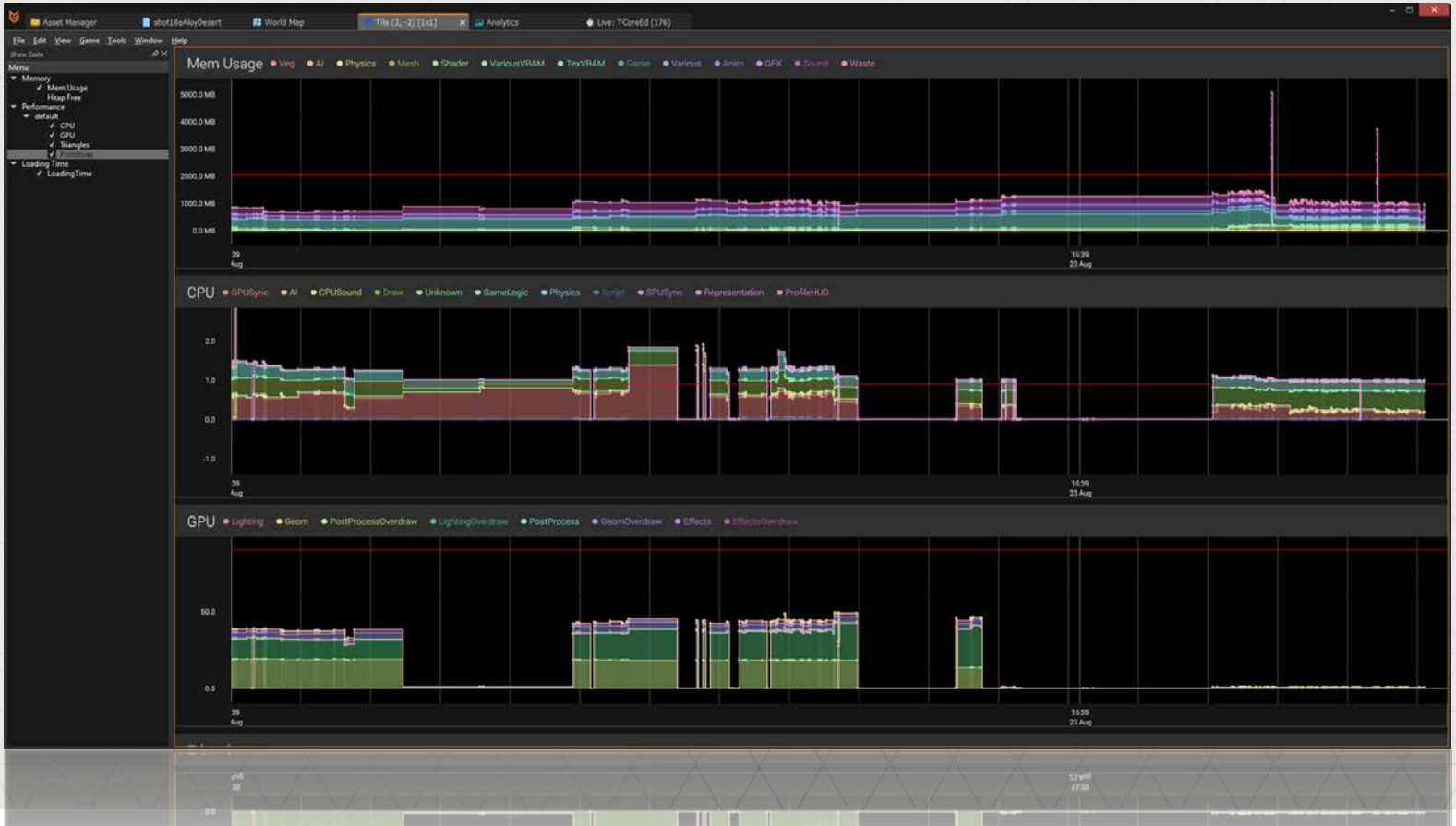
- Visualizes game features on a 2D world map
- Pluggable system for overlays
  - Quests
  - JIRA bugs
- Came online late in the project, and wasn't heavily used



World Map – Perf Report Overlay



Perf Report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Memory
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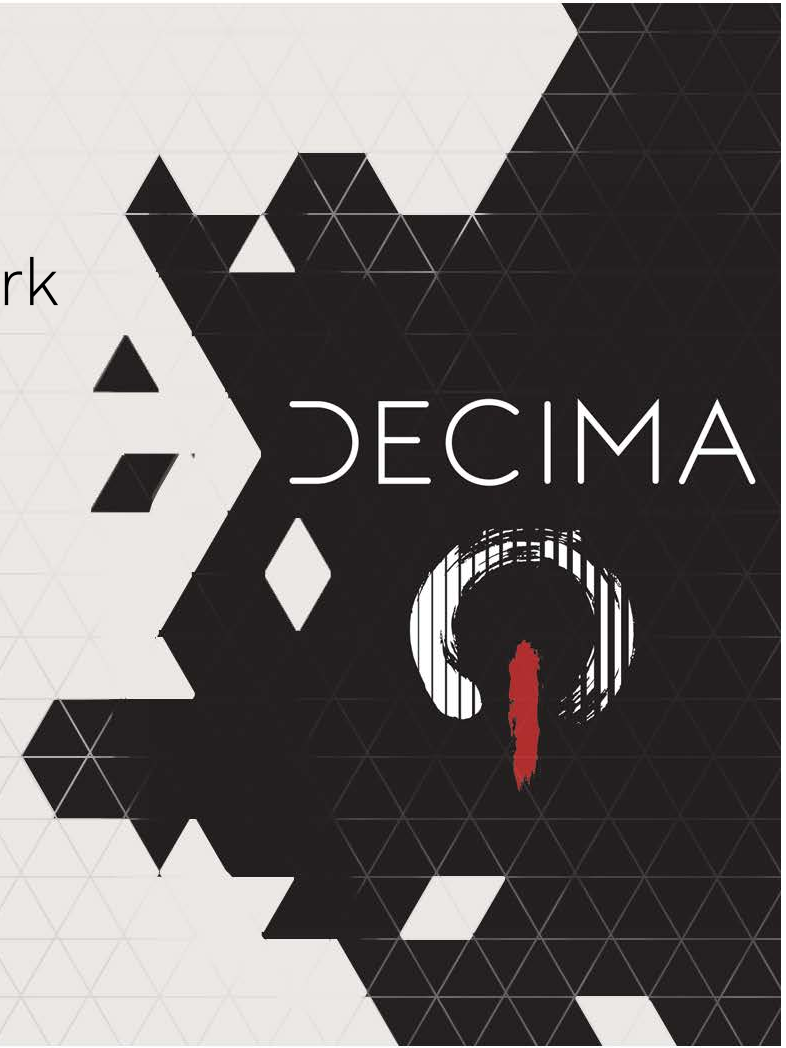
Decima API

- C-API to expose Tools Framework functionality
  - File loading/saving
  - Object manipulation
- Python wrapper
  - Artists and designers can create scripts manipulate game content

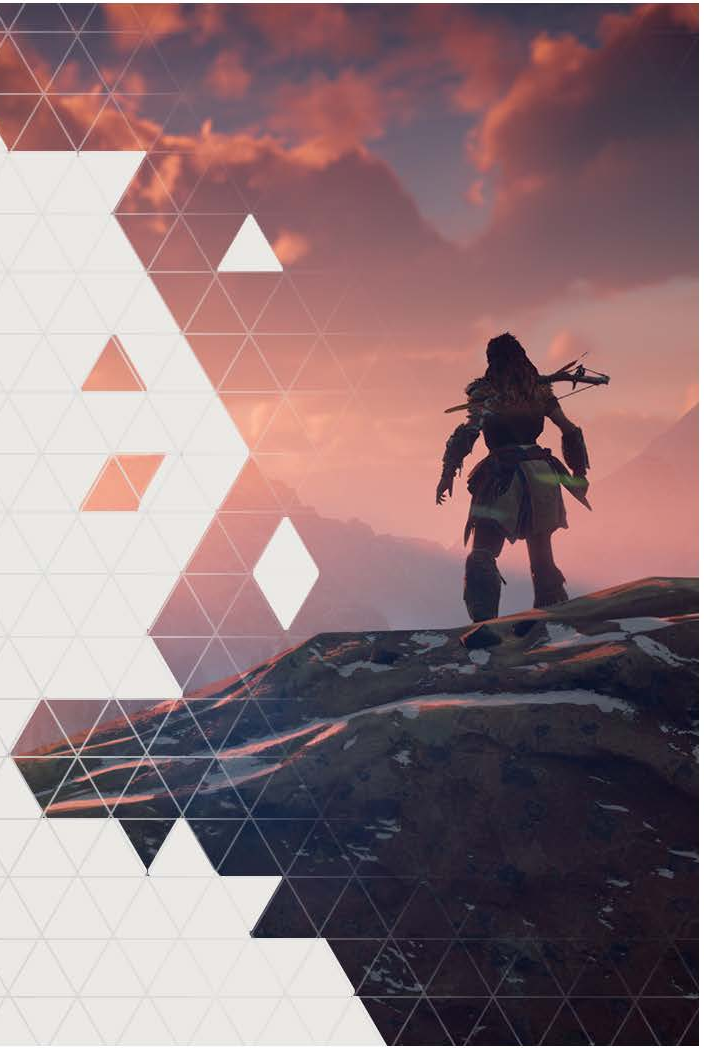


Decima API

```
# Get the spotlight to edit...
spotlight = GetSpotlightToEdit()

# Open a transaction, to start modifying objects
with DecimaAPI.Transaction() as transaction:

    # Update the cone angle
    spotlight.ConeAngle = 30.0

    # Indicate that we have finished making changes
    transaction.Commit()
```

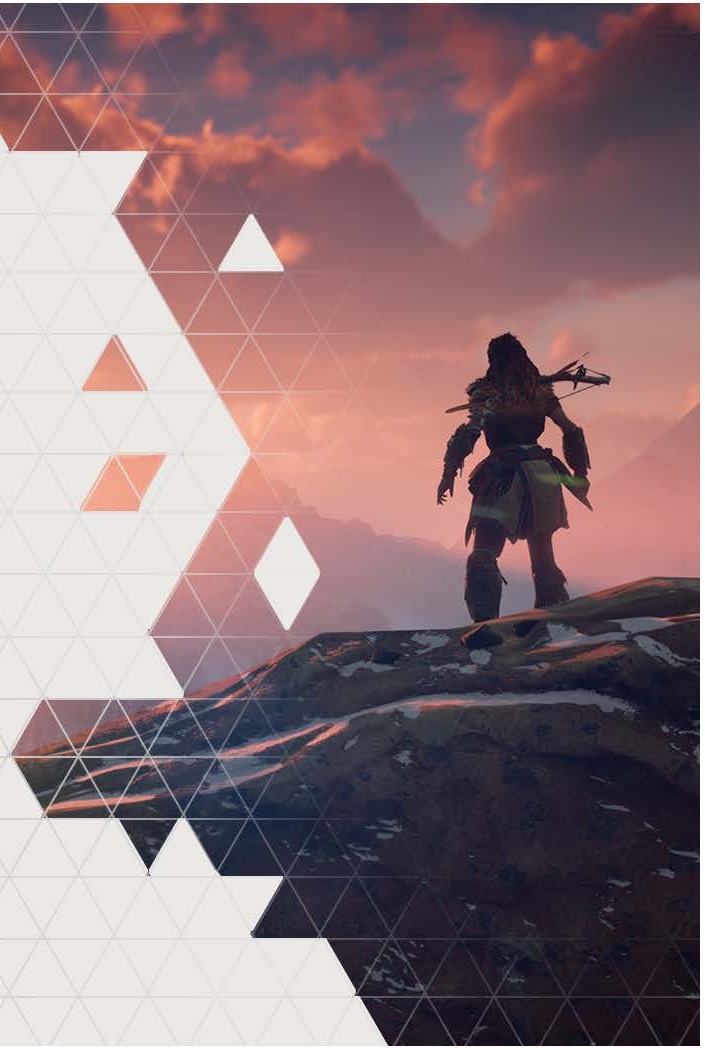
Future goals

- Move other teams into new editor
  - (VFX, Environment Art, ..)
- Build new Editor Contexts
  - Entity editor
  - Particle editor
  - Shader/Material editor



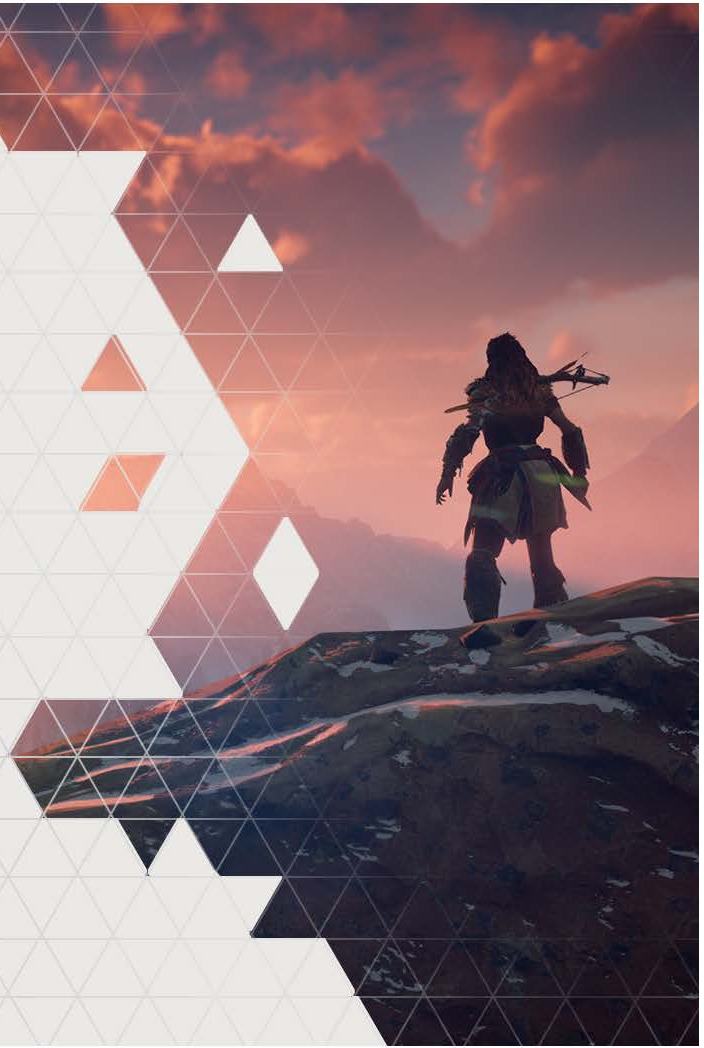
Future goals

- Rewrite GameSync system
- Take the 3D editor out of process
- Improve UI/UX of the editor



Thanks

- Everyone at Guerrilla
- Special Thanks
  - Michiel van der Leeuw
  - Jelle van der Beek
  - Ritesh Oedayrajsingh Varma
  - Guido de Haan
  - Laurens Simonis
  - Kenzo ter Elst
  - Johanna Persson
  - Olaf Jansen
  - Bryan Keiren
  - Emile van der Heide
  - Remco Straatman
  - Stefan Reek
  - Nathan Vos

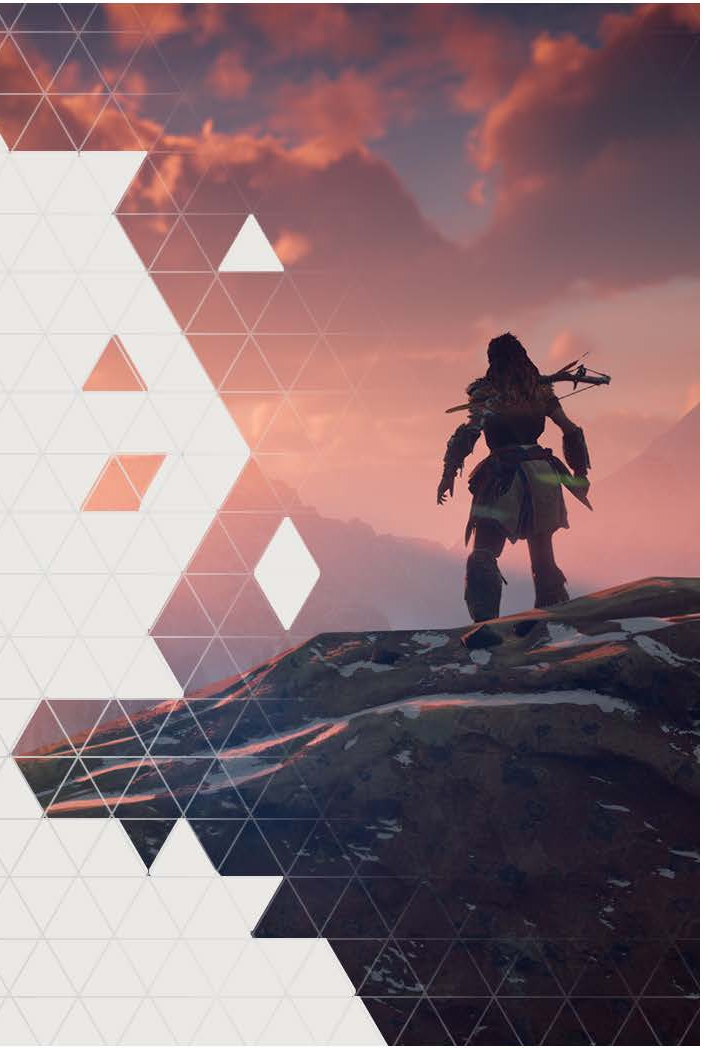


We’re Hiring!

https://www.guerrilla-games.com/join

Contact

- dan.sumaili@guerrilla-games.com
- sander.vandersteen@guerrilla-games.com



DECIMA
Questions?