Games and Simulation

2021-202
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Introduction to Game Development

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What is a game?

"*An **interactive experience** that provides the **player** with an increasingly **challenging sequence of patterns** which he or she **learns** and eventually **masters**.*"

in Raph Koster's "A Theory of Fun for Game Design"

- For our purpose we are mainly interested in:
  - 2D or 3D virtual worlds
  - a small number of players
  - Examples: first person shooters, third person action/platform, racing, fighting, …

Game Development

- Game development teams can range from a single developer to large groups where specialisation is king:
  - **Engineers**: develop the software and the tools that make the game (runtime programmers and tool programmers). Further specialisation is possible: rendering, AI, sound, networking, gameplay, scripting, system…
  - **Artists**: produce all the visual and audio content of the game, exception made to procedurally generated content. Specialisations: concept, modellers, texture, lighting, animators, motion capture actors, sound designers, voice actors,…
  - **Game designers**: design the gameplay usually with a hierarchical approach: story arc, high-level goals and objectives, level design and game world areas, challenge design, …
  - **Producers**: human resources manager, scheduler, interact with marketing and financing areas
  - **Other Staff**: executive directors, marketing, administrative, IT department, …
  - **Publishers and Studios**: in charge of promoting and selling and distributing the game.

Games and Simulation?

- Games are mostly soft, real-time, interactive, agent-based simulations
  - subset of a real or imaginary world modelled mathematically (approximated/simplified) and simulated in a computer
  - distinct entities (agents) interact: vehicles, characters, projectiles, etc.
  - temporal simulation with dynamic content (user controlled or not)
  - respond to user input and present a story, thus interactive.
  - soft real-time: a new image every 1/30 … 1/120 of a second. No disaster if some are generated after the deadline.

What is a game engine?

- Nowadays, no one programs a game from scratch!
  - In the early years, a game was programmed in assembly language and tied to a specific hardware
    - slow development, few highly skilled developers
  - Over time, games started to fell into categories, bearing resemblances in style and gameplay with other titles
  - Eventually, development teams started to put the common features into game libraries that could be reused in different/similar games: rendering, networking, input, AI techniques, …
    - Shorter development period, more programmers could build a game
  - Libraries later gave way to entire development suits composed of realtime game engines with scripting to avoid low level programming and other development tools such as game world editors, animation editors, sound editors, etc.
    - everyone can create a game!

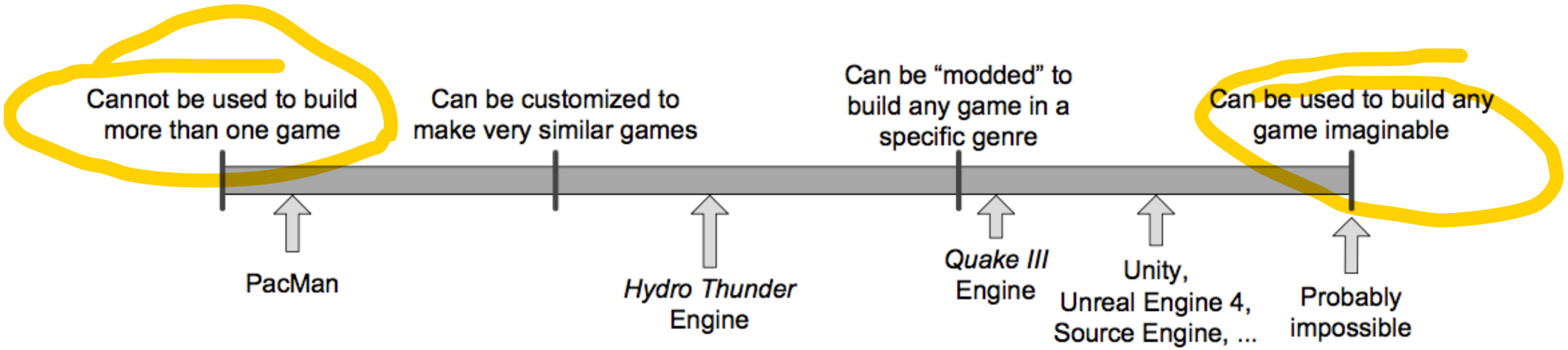
What is a game engine?

- A game engine is just a part of the overall suite of tools used in game development.
- It is the part that interests engineers the most.
- Is composed of several subsystems that deal with specific parts/needs of a game:
  - graphics/rendering
  - scene/world management
  - animation
  - sound
  - networking
  - user interaction
  - operating system interaction
  - …

John Carmack - Interview (2000)

look for game engine definition after 0:21:00

Game engine reusability



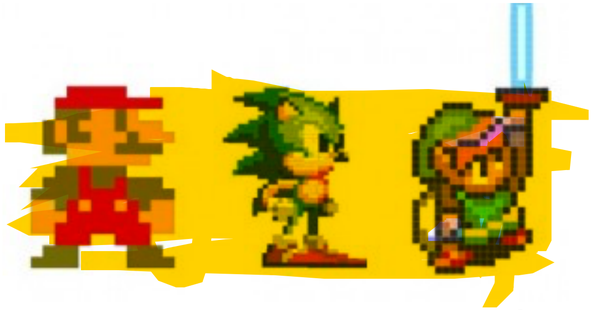
Game engine reusability gamut

Reproduced from Jason Gregory's "Game Engine Architecture", 2nd Ed.

There is no universal game engine yet…

Game Engines 2D/3D

- Some game engines are oriented to 2D sprite based games
- A sprite is a rectangular array of pixels that can be manipulated on the screen
- Old video games were sprite based



- Old hardware had sprite specific hardware (bitmap manipulations)
- Today, graphics hardware is 3D oriented. 2D worlds a special case of 3D worlds (Flat objects, an orthographic camera, and textures…)

Video Game Genres

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Action Games

- Based on **physical challenges** requiring **eye-hand coordination**
- Centred around the **player** who is **in control of the action**
- Subtypes:
  - platform games
  - shooter games
  - fighting games

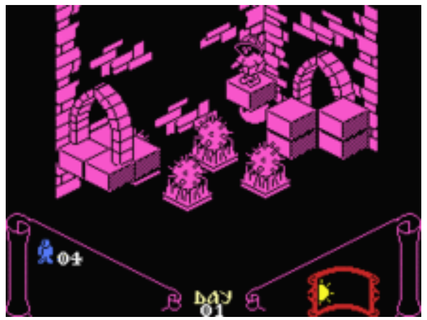
Action Games
Platform games (platformers)

Super Mario Bros

Sonic the Hedgehog

Donkey Kong

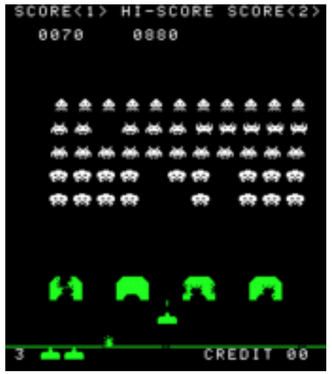
Manic Miner



Knight Lore

Little Big Planet 2

Action Games
Shooter games (Shoot ‘em up)



Space Invaders

1942

Moon Patrol

Defender

Resogun

Commando

Action Games
Fighting games

Virtua Fighter

Street Fighter 2

Tekken Tag Tournament


Fight Night


Mortal Kombat X

Adventure Games

- Some of the first computer games were text based adventure games
- A style of gameplay **without action or reflex challenges**
- Usually some **puzzles need to be solved** by interacting with characters and the environment
- Subtypes:
  - Text adventures
  - Graphic adventures
  - Visual novels and Interactive movies
  - Real-time 3D adventures

Adventure Games

Zork (Text Adventure)

Mystery House

Lords of Midnight


Shadow of memories


No Man's Sky

Role Playing Games

- The **player** is usually **casted into the role of a specific character**, with **specialised skills**
- The game progresses trough a **predetermined timeline**
- Early games were **turn based** games but modern are mostly **real-time** combat games
- Subtypes:
  - Action RPGs - incorporate elements of action or action-adventure games
  - MMORPGs - Massively multiplayer online RPGs
  - Rogue likes - randomised dungeon crawl style games
  - Tactical RPGs - the player controls a finite party and battles a similar number of enemies
  - Sandbox RPGs - large amount of non player characters (NPC) not critical to the game's storyline, large worlds to explore.

Role Playing Games

Diablo (Action RPG)

Fable (Sandbox RPG)

Eve online (MMORPG)

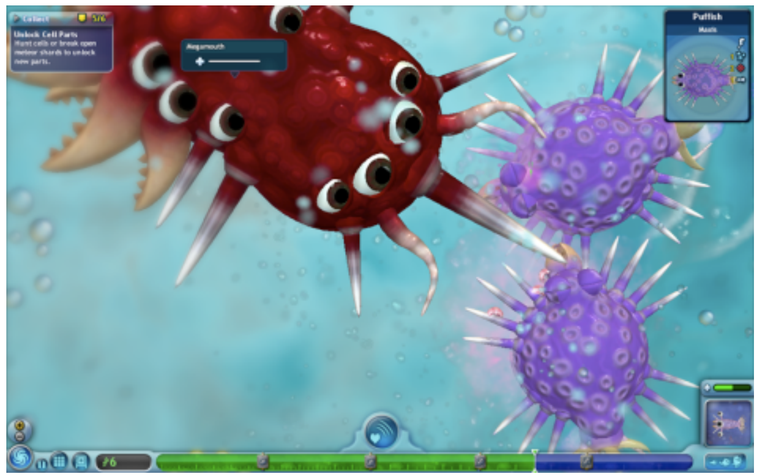
Simulation Games

- At the heart of the game is **simulation of a complex phenomenon**
- Subtypes:
  - Construction and Management
  - Life simulation
  - Vehicle simulation

Simulation Games

Sim City (Construction)

X-Plane (Vehicle)



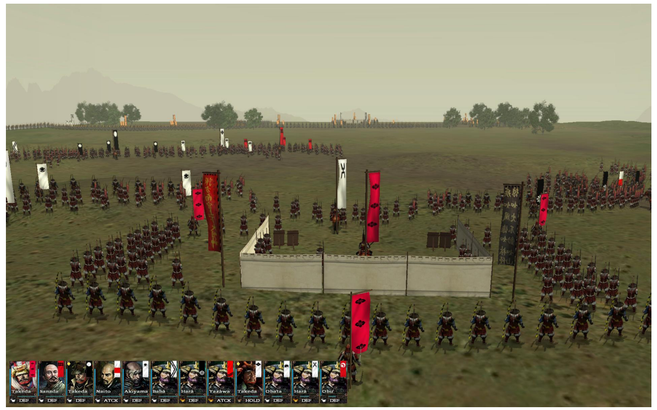
Spore (Life)

Strategy Games

- The gameplay relies on **careful** and **skilful thinking** and **planning**.
- Sometimes the player is given a god's view of the game world and controls the units under his command.
- 4 archetypes categorised according to:
  - **t**urn **b**ased vs. **r**eal **t**ime
  - military **t**actics vs. **s**trategy
- TBT, TBS, RTT, RTS

Strategy Games

The Battle of Wesnoth (TBS)



Tacked 3 (RTT)

Starcraft (RTS)

Sports Games

- A special kind of a simulation game where the **simulated object is a sport**.
- Usually **played against** other people or AI
- Common subtypes:
  - Racing
  - Individual/team Sports game

Sports Games
Racing games

Wipeout 2048

Grand Turismo 6

Sports Games

FIFA 2016

PGA Tour

Game Genres

- The previous classification was based on https://en.wikipedia.org/wiki/List_of_video_game_genres
- There are other alternative taxonomies based on:
  - purpose (educational, serious, training, entertainment)
  - type of camera used (First person, third person, god's view)
  - number of players (single, two, multiplayer, massive multiplayer)
  - …

Requirements by Genre

Common Requirements

- Process low level user input from devices like keyboard, joystick, mouse
- 3D mesh rendering
- Head-up display - HUD (overlays of text and graphics)
- Audio system
- Resources management
- …

First Person Shooter Features

- **F**irst **P**erson **S**hooters (FPS) are partially named after the fact that the camera is connected to the head of the player's avatar (as in virtual reality)
- Older games included slow on-foot roaming of a confined rooms and corridors based world.
- Newer games also support vast outdoor areas that are roamed in every imaginable way: by foot, on rails, by vehicle, by ground, water or air

Notable FPS titles
Quake

Notable FPS titles
Unreal Tournament

Notable FPS titles
Half-life

Notable FPS titles
Battlefield 4

FPS Requirements

- Technologically demanding
- Aim to provide the illusion of being immersed in a detailed and realistic world
- Many technological advances came from this type of games
- Requirements:
  - efficient rendering of 3D virtual worlds
  - responsive camera control and aiming
  - high-fidelity animations of the player's arms and weapons
  - powerful handheld weaponry
  - forgiving player character motion and collision model (floaty feel)
  - high-fidelity animations and artificial intelligence of non-player characters
  - small-scale online multiplayer capabilities

Platformers and Third-Person* Features

- Platformer is a third-person character-based action game where jumping from platform to platform is the primary gameplay mechanic
- The camera follows the character
- The game action can happen in a 2D, 2.5D or a 3D world.
- Platformers and third-person shooters/action/adventure share requirements.
- A lot of common requirements from First Person games
- More emphasis on main character's abilities and locomotion (full body animation)

Notable platformer/TP* titles
New Super Mario Bros

Notable platformer/TP* titles
Super Mario 64

Notable platformer/TP* titles
Crash Bandicoot

Notable platformer/TP* titles
Jak and Daxter

Notable platformer/TP* titles
Little Big Planet

Notable platformer/TP* titles
The Last of Us

Notable platformer/TP* titles
The Last of Us

Platformer and Third-Person* Requirements

- moving platforms, ladders, ropes, etc.
- puzzle-like environmental elements.
- third-person “follow camera” focused on the player (in 3D it can rotate)
- camera collision system to ensure that the camera is not affected by foreground objects.

Fighting Games
Features

- Typically two player games with humanoid characters
- Small game world (usually a ring, patio, etc.)
- Detailed movements
- Complex blows and attacks
- Different characters with different abilities/skills

Notable Fighting Games
Virtua Fighter 5

Notable Fighting Games
Fight Night 4

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Fighting Games Requirements

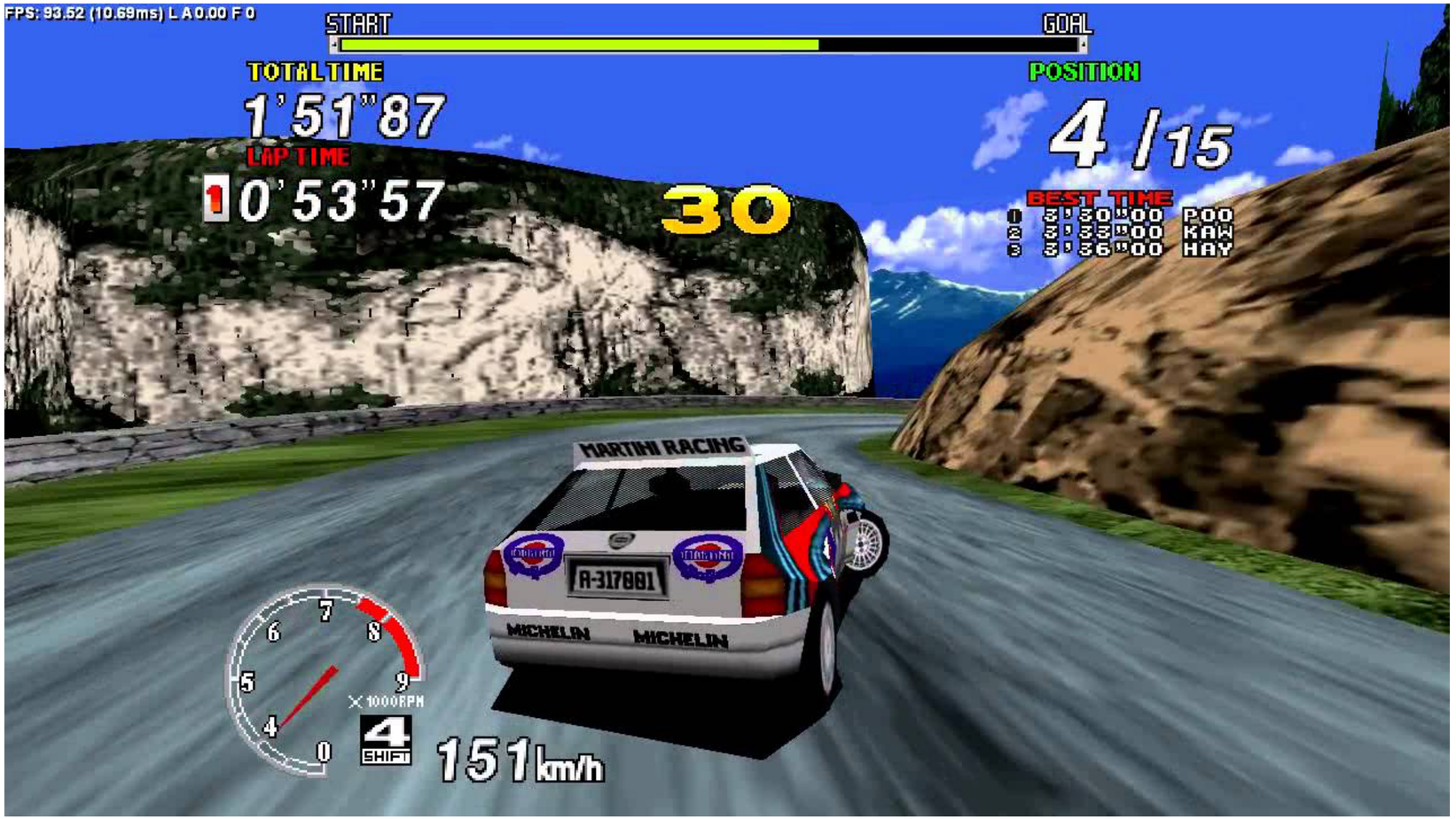
- Rich set of fighting animations
- accurate hit detection (an ellipsoid around the body won't work)
- user input system capable of detecting complex button combinations (and more important: sequences of input)
- crowds with relatively static backgrounds
- high-definition character graphics, realistic skin shaders, subsurface scattering, sweating, bruises, …
- physics based cloth and hair animation

Racing Games
Features

- Goal: Drive a car or other vehicle in some kind of track.

- Some, like Grand Turismo, focus on realism and are labeled as sims, while others (e.g. Sega Rally Championship) explore the fun and entertainment (arcade style).

Notable Racing Games
Sega Rally



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Notable Racing Games
Grand Turismo

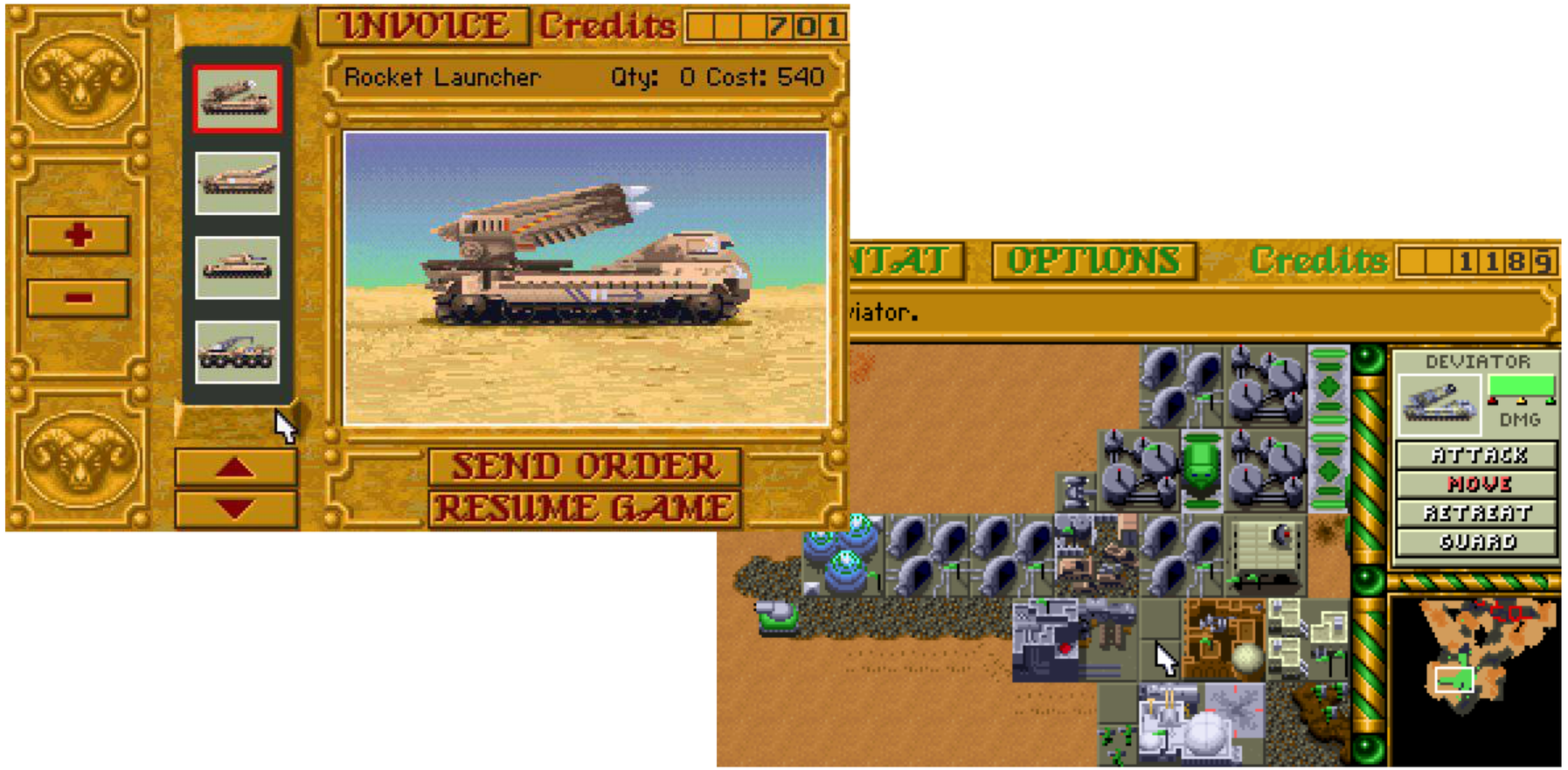
Racing Games Requirements

- tricks for rendering distant objects like trees and mountains
- track needs to be broken down into sectors to optimize rendering (visibility determination)
- camera can be outside (third person) or in the cockpit (fps) or even in the public or in an helicopter (replays)

Real-time Strategy Games
Features

- Player deploys the battle units across a large playing field
- Playing field displayed in an oblique top-down viewing angle
- No long distance viewing which leads to some optimisations
- Older games used cells in a grid layout to align elements like buildings properly
- Player's orders are translated into micro actions

Notable RTS Games
Dune II: The Building of a Dynasty



Notable RTS Games
Command & Conquer 3

Notable RTS Games
Command & Conquer 3

Notable RTS Games
Command & Conquer 3

Real-time Strategy Games Requirements

- Each unit has a relatively low resolution to support a large number of them simultaneously
- The game world is usually an height-field terrain
- Apart from deploying the units, building constructions is also usually allowed
- user interaction is single click (single selection) or area based (multiple selection) followed by menus, toolbars, shortcuts.
- The game simulates order execution by having agents performing micro level tasks: move, aim, fire, retreat, avoid, etc.

MMOG* Games Features

- Any game supporting from a thousand to hundreds of thousands of simultaneous players
- Usually all players are playing in a large persistent world (persistent across individual game sessions)
- A battery of servers at the back of the game (sign-in, sign-out, subscriptions, keep authoritative state of the world, handle micro-transactions)
- Subtypes: MMORPG, MMORTS, MMOFPS
- Similar to non MMOG* counterparts but with lower graphics fidelity to be able to handle huge world sizes and large number of players

Notable MMOG* Games
World of Warcraft

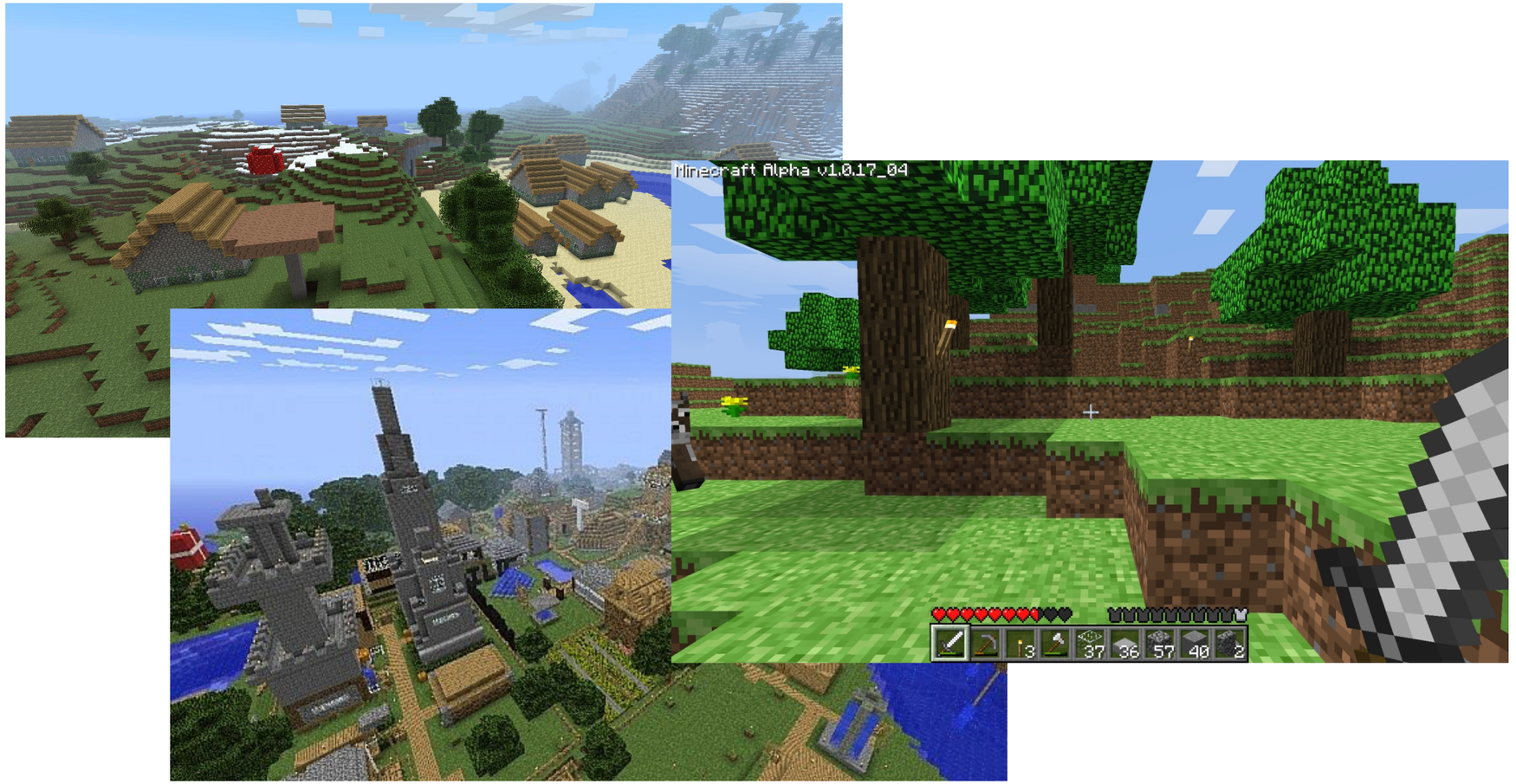
Player-Authored Content Games
Features

- Recent trend in game industry as social media take off
- Encourage players in creating, polishing and sharing game content (levels, characters, etc.)
- Reduces the need for extension packs and allow longer longevity

Notable Player-Authored Content Games
Little Big Planet/LBP2/LBP3

Notable Player-Authored Content Games

Minecraft



Game Engine Survey

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Quake Family

- A family of game engines created by idSoftware
- Castle Wolfenstein 3D (1992), Doom, Quake, Quake II, Quake III
- Technology was incorporated in other titles/engines: Sin, Medal of Honor
- Quake II source code free at https://github.com/ id-Software/Quake-2. You can compile it yourself and use the assets from your private copy of the game.

Unreal Family

- Started with Epic’s Unreal game in1998
- Unreal Engine 2 is the base for Unreal Tournament 2004 and is at the base of numerous mods and projects
- Unreal Engine 5(preview2) is the latest version with some of the best tools and richest engine features in the industry:
  - graphical interfaces for shader creation and logic programming (blueprints)
  - Nanite: virtualised geometry (polygonal mesh + LOD + compression + streaming)
- Lots of online community resources and documentation

Half-life Source Engine

- Source is the game engine behind Half-life 2 and its sequels
- High quality engine rivalling Unreal Engine in terms of graphics and tools

DICE’s Frostbite Engine

- Emerged out of Battlefield Bad Company (2006)
- Widely adopted in Electronic Arts
- Used in:
  - Mass Effect, Battlefield, Need for Speed, Dragon Age
  - Frostbite 3 used in Battlefield 4 (PC, Xbox One, Xbox 360, PS3 and PS4)
- Powerful unified asset creation and game engine.

CryENGINE

- Started as a tech demo for Nvidia
- First game: Far Cry
- Other titles: Crysis, Codename Kingdoms, Warface and Ryse: Son of Rome
- CryENGINE 5.7 is latest version with asset creation tools and sophisticated real-time graphics
- Targets all major platforms: Xbox One, Xbox 360, PlayStation 4, PlayStation 3, Wii U and PC.

Sony's PhyreEngine

- Grew from an effort (2008) to make game development for PS3 easier (Cell processor is quite unique)
- Used in many studios
- Tied to Sony's platforms: PS4, PS3, Vita and PSP
- Free of charge to any licensed Sony developer as part of the PlayStation SDK

Unity

- Powerful game development environment and runtime engine
- Targets around 20 native platforms: mobiles, consoles, desktop, in almost all flavours and Web too.
- Easy to use integrated editor environment to create and manipulate assets and entities.
- Quick preview in the editor or on target hardware.
- Supports scripting in C# (Javascript and Boo also, in older versions).

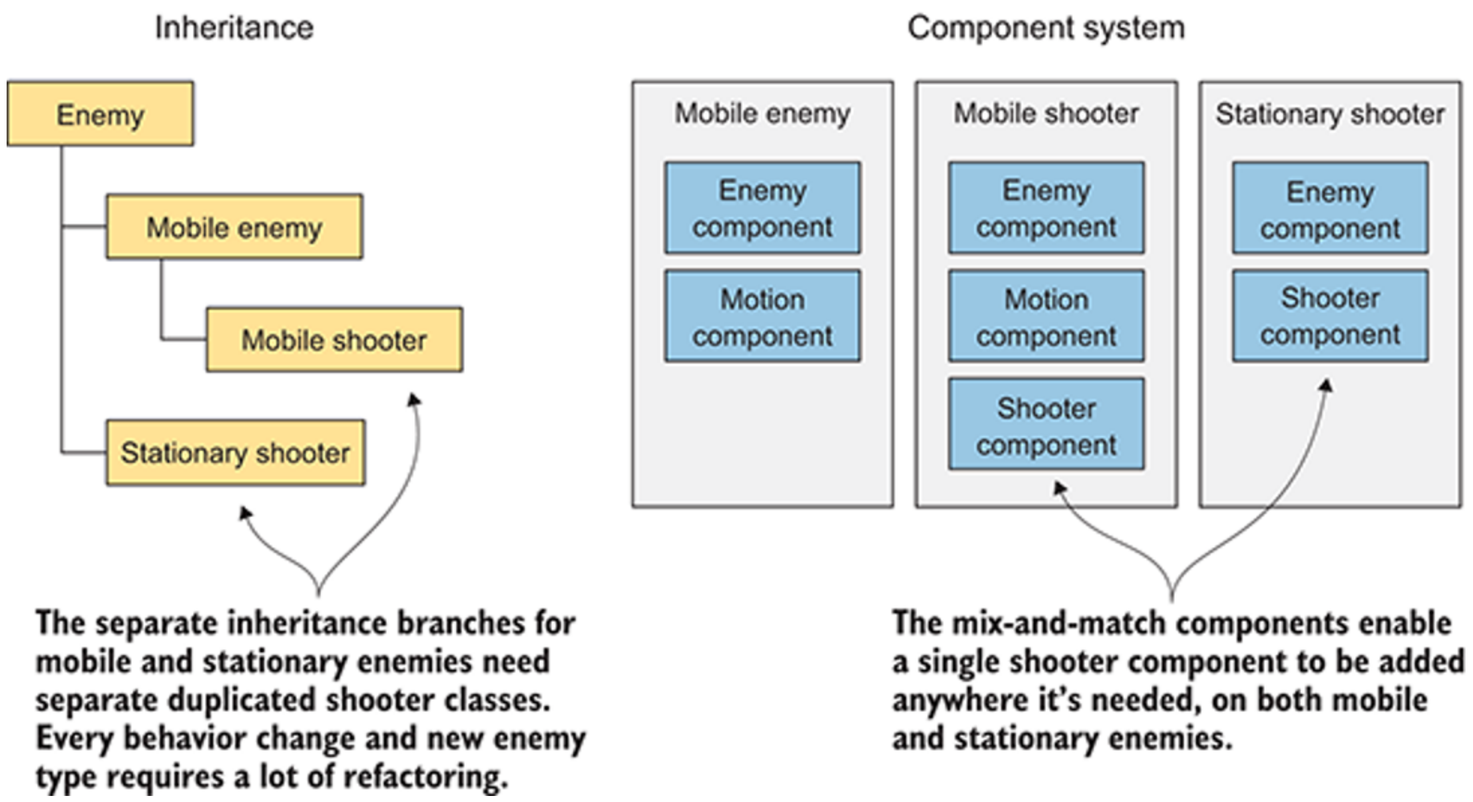

ROBOCRAFT
BUILD · DRIVE · FIGHT
POKÉMON
SWITCH
GO
SUBNAUTICA
DREAMFALL
CHAPTERS
Goh
Gohh...
DOOM
ENTER THE
GUNGEON
Sir, You Are Being
HUNTED
Fe
SUPER
BOMBER
KERBAL
SPACE PROGRAM
SLENDER
THE ARRIVAL
HOLLOW KNIGHT


ZIGGURAT


gone
home

Unity

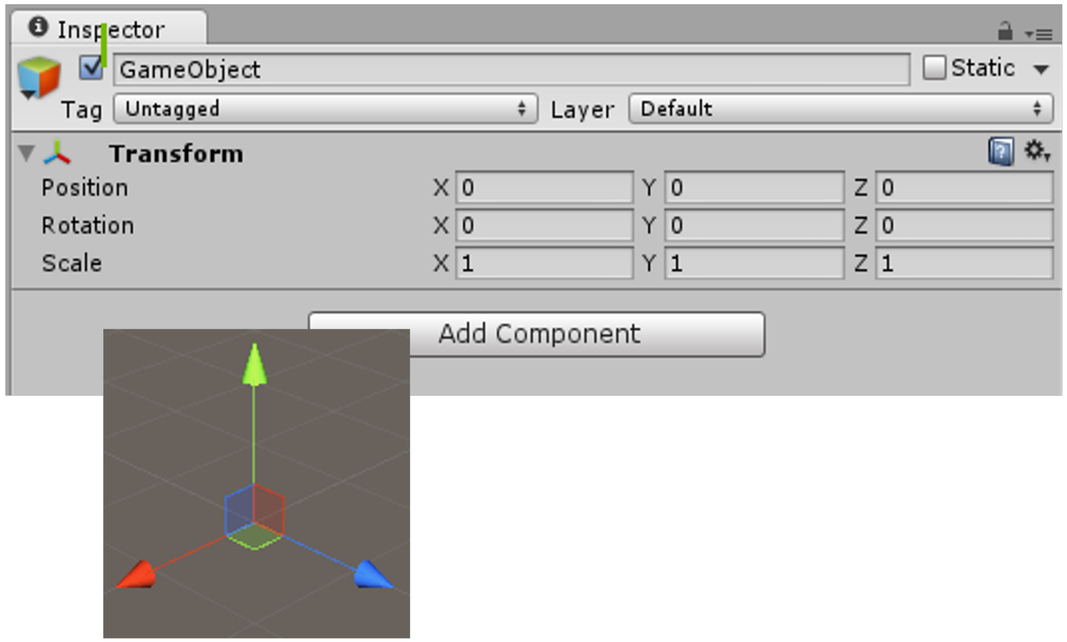
- Component based architecture
- Each game object can contain components that specialize in one task (light, phisics, collisions, positioning,…)

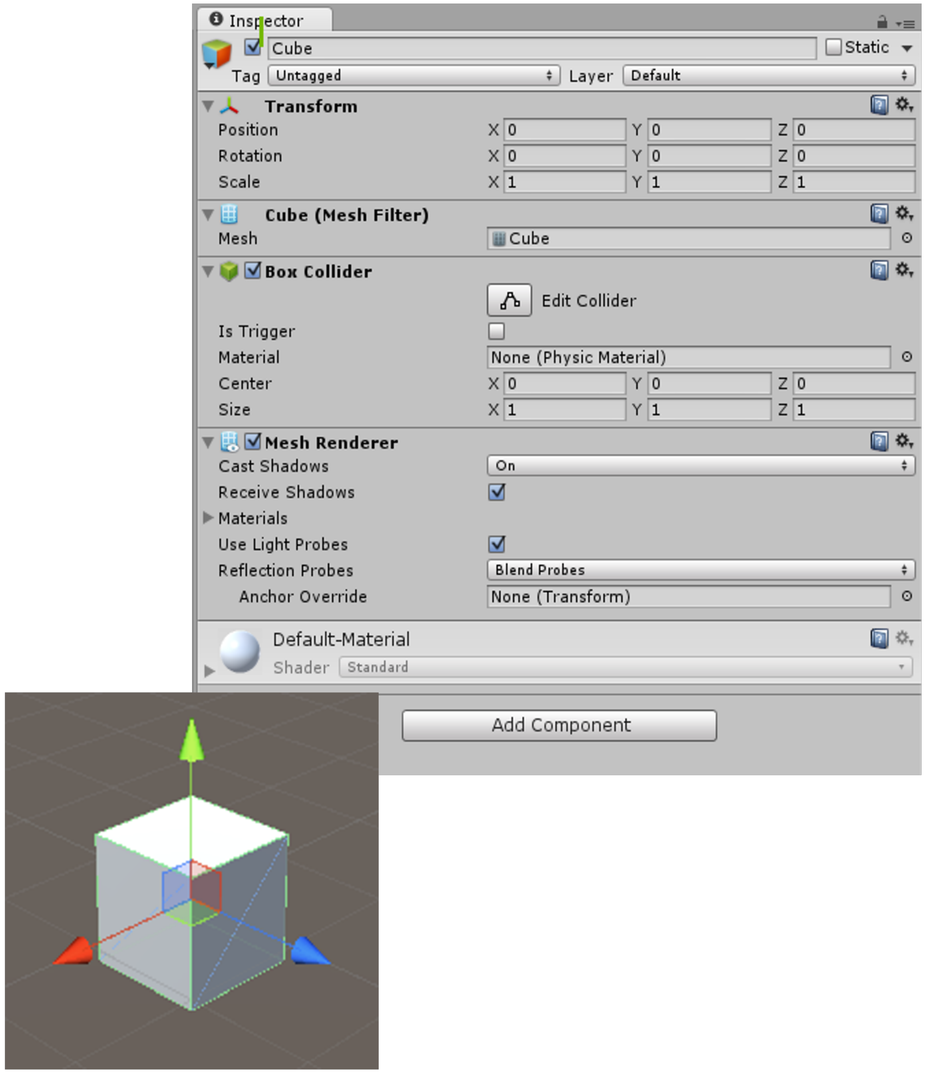


Inheritance vs. Components (from Unity in Action (Second Edition))

Unity

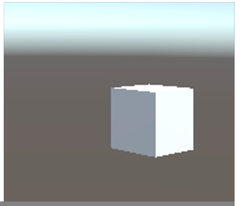
- Simple Components



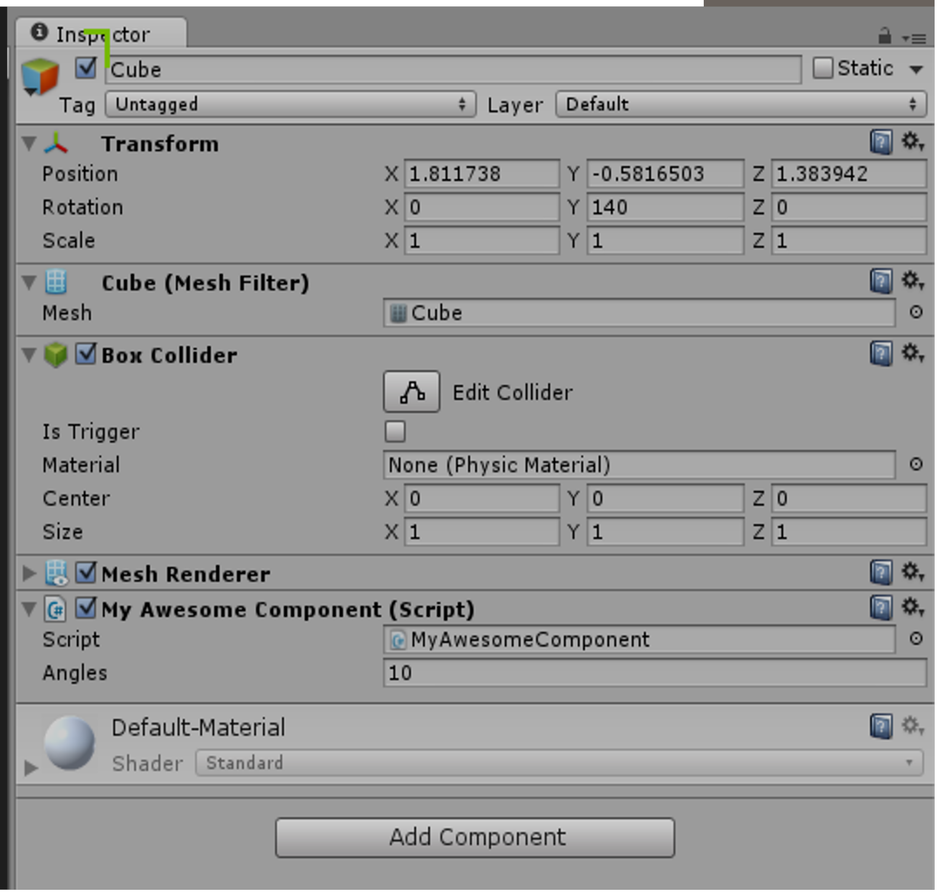


Unity

- Custom Components

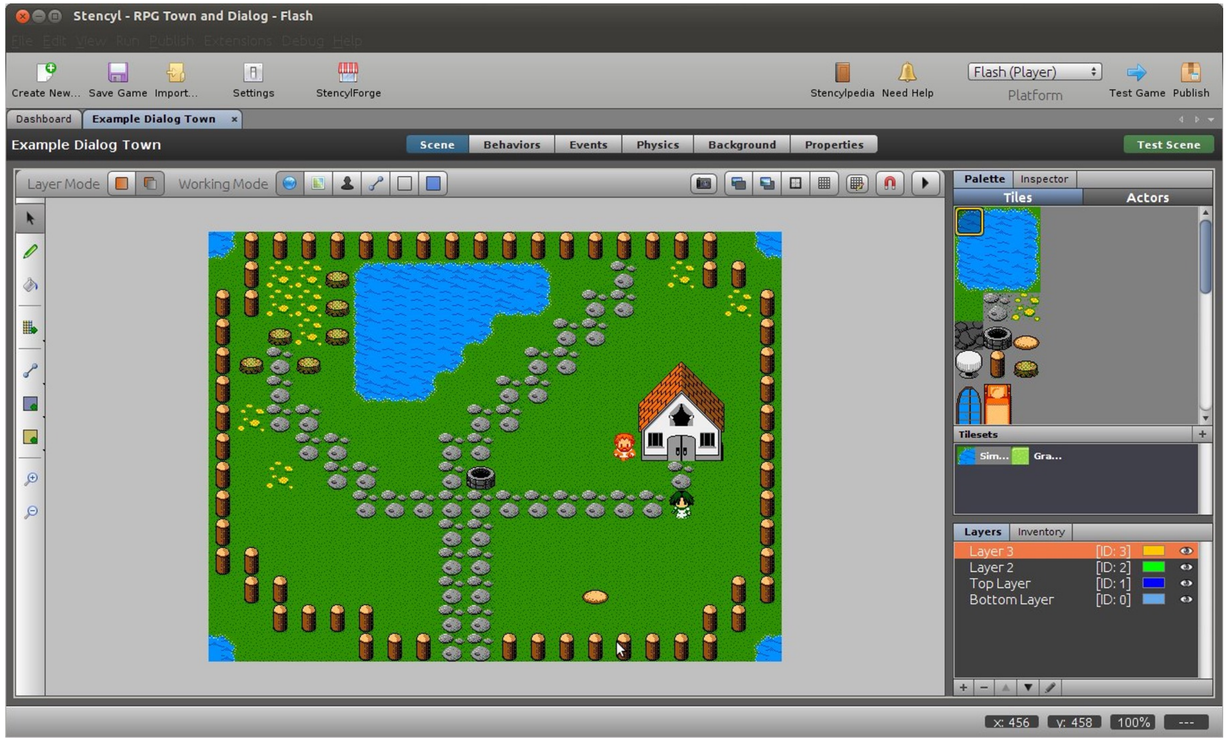


```
using UnityEngine;
using System.Collections;

public class MyAwesomeComponent : MonoBehaviour {

    public float Angles;
 // Use this for initialization
 void Start () {

 }

 // Update is called once per frame
 void Update () {
        transform.Rotate(transform.up, Angles);
 }
}
```



2D Engines

- Lots of 2D engines for non programmers out there…
  - Stencyl
  - Pygame
  - Godot
  - Processing (p5.js, processing.js)
  - Some also have 3D capabilities



OpenSource Engines

- Ogre
- jMonkeyEngine (Java)
- Panda3D (Python/C++)
- Torque
- Irrlicht

Further readings

- http://en.wikipedia.org/wiki/History_of_video_games#Defining_the_video_game
- http://en.wikipedia.org/wiki/Game_engine
- http://www.slant.co/topics/341/~2d-game-engines
- http://en.wikipedia.org/wiki/First-person_shooter
- http://en.wikipedia.org/wiki/Platformer
- http://en.wikipedia.org/wiki/Fighting_game
- http://en.wikipedia.org/wiki/Racing_game
- http://en.wikipedia.org/wiki/Real-time_strategy
- http://en.wikipedia.org/wiki/MMOG
- http://en.wikipedia.org/wiki/List_of_game_engines