BOOMING TECH GAMES104

LECTURE 1

OVERVIEW OF GAME ENGINE

Modern Game Engine –Theory and Practice

WANG XI

GAMES 104

2022

NOW 2011 2006 2004 2001 1997

BOOMING TECH

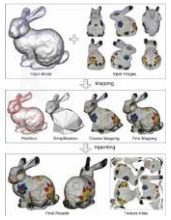
BUNGiE

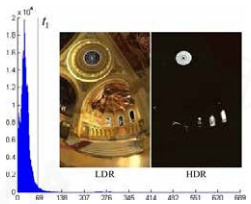
Microsoft

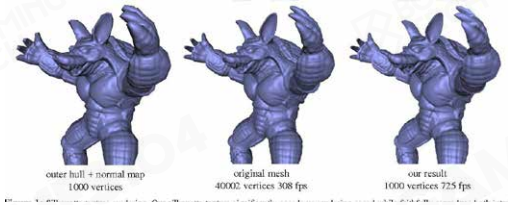
TSINGHUA UNIVERSITY 1911

ZHEJIANG UNIVERSITY 1897

CHAOS





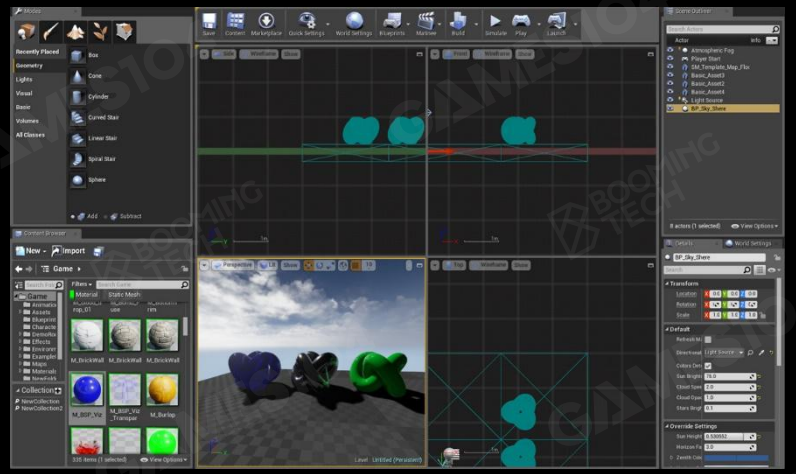


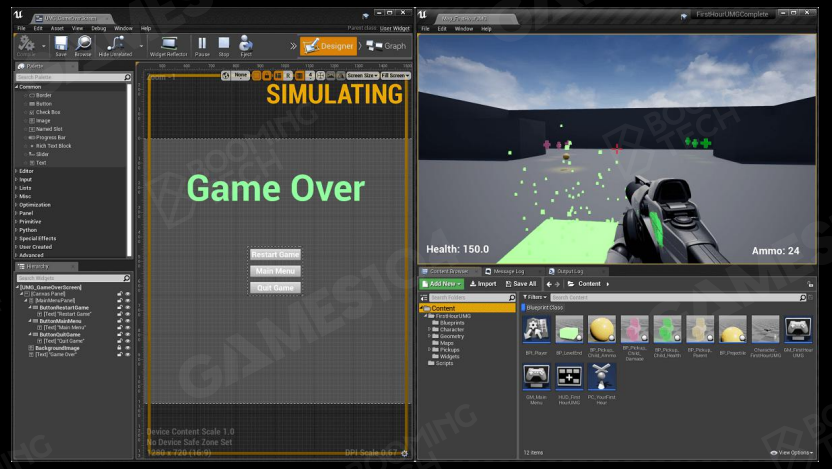
Fun facts: video games, swimming, trouble maker, etc.

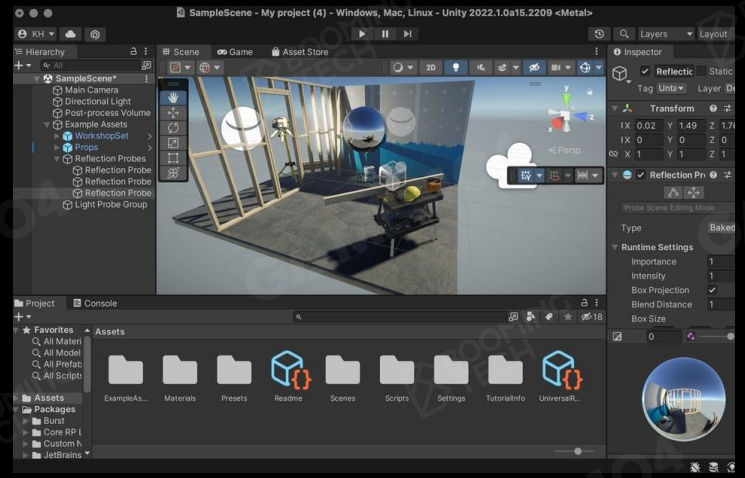

HALO 3

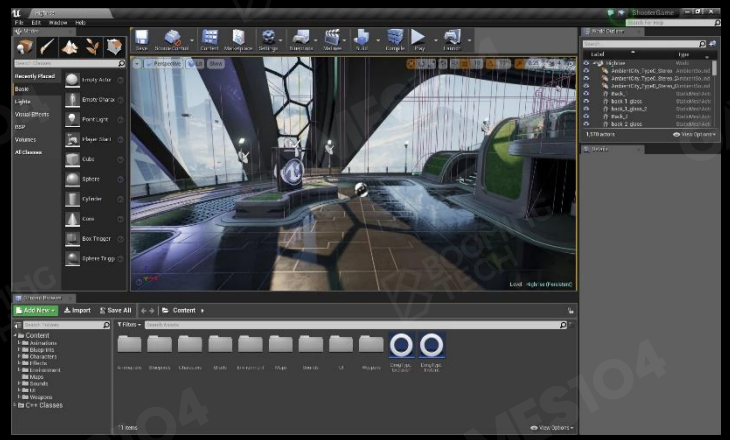

DESTINY 2

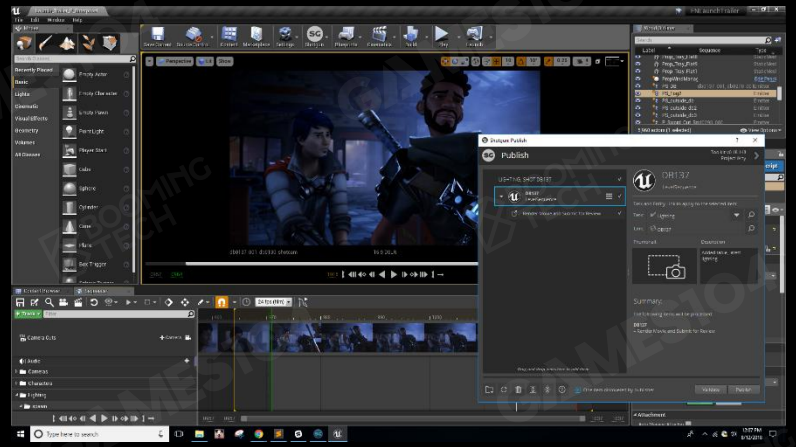
Game：Miracle of Modern Computer Technology

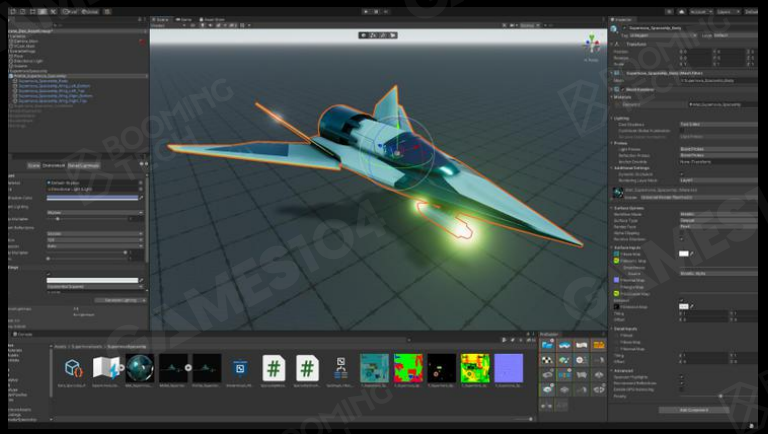










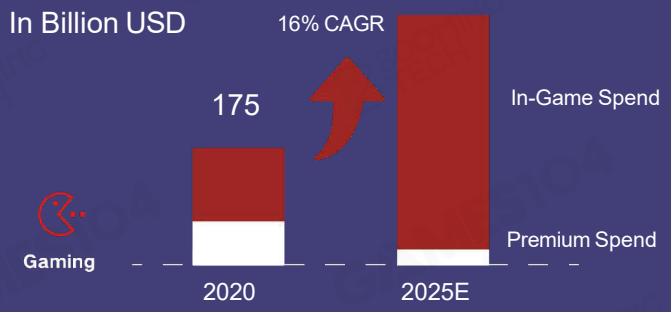


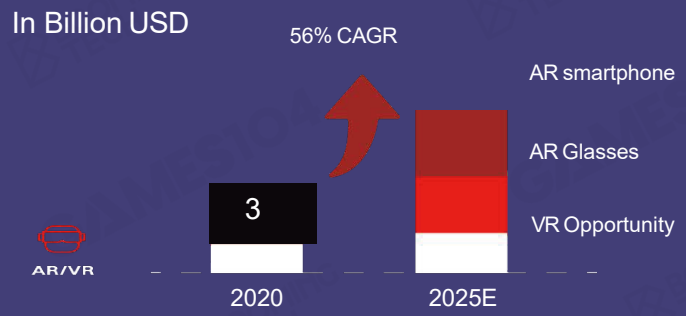
Game Engine : The Diamond on the Crown

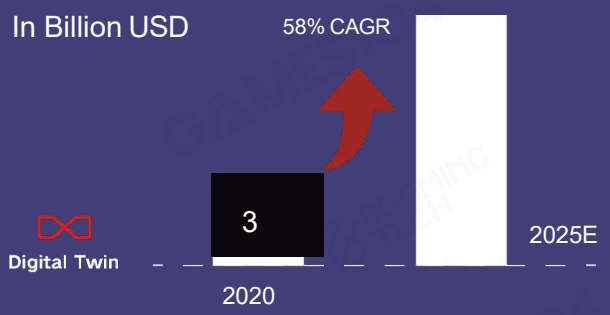
Topic 1

WHY WE NEED TO LEARN

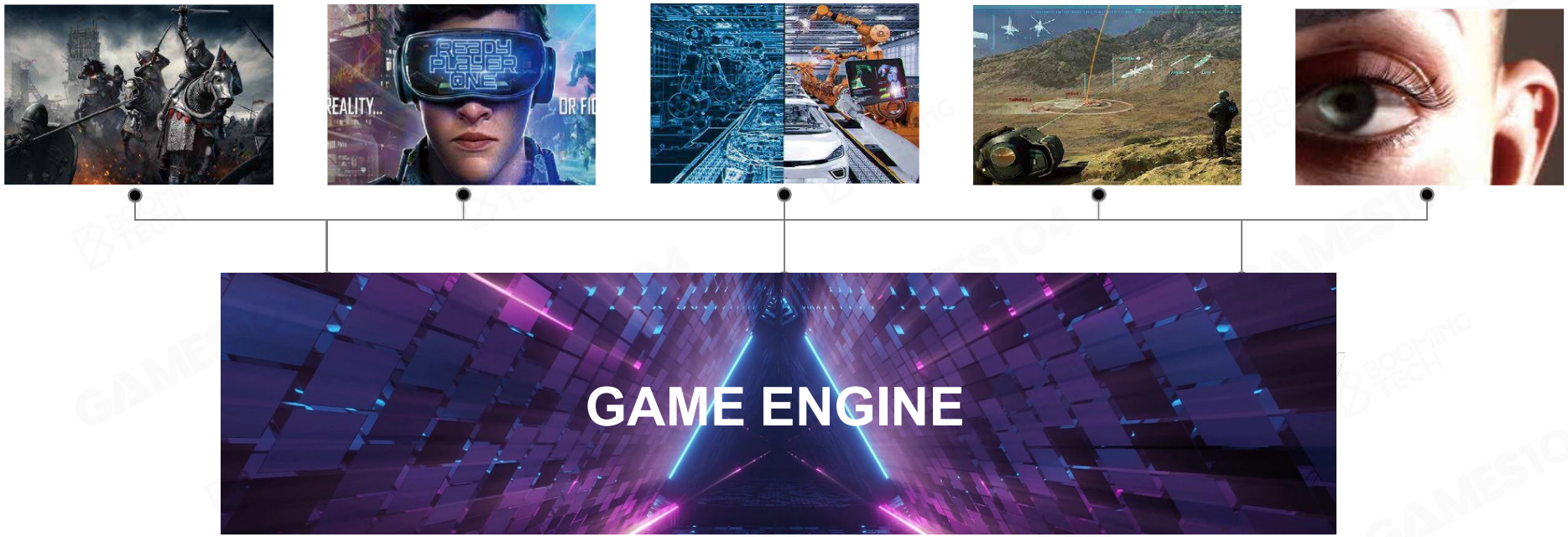
Game Engine is the Foundation of Virtual World

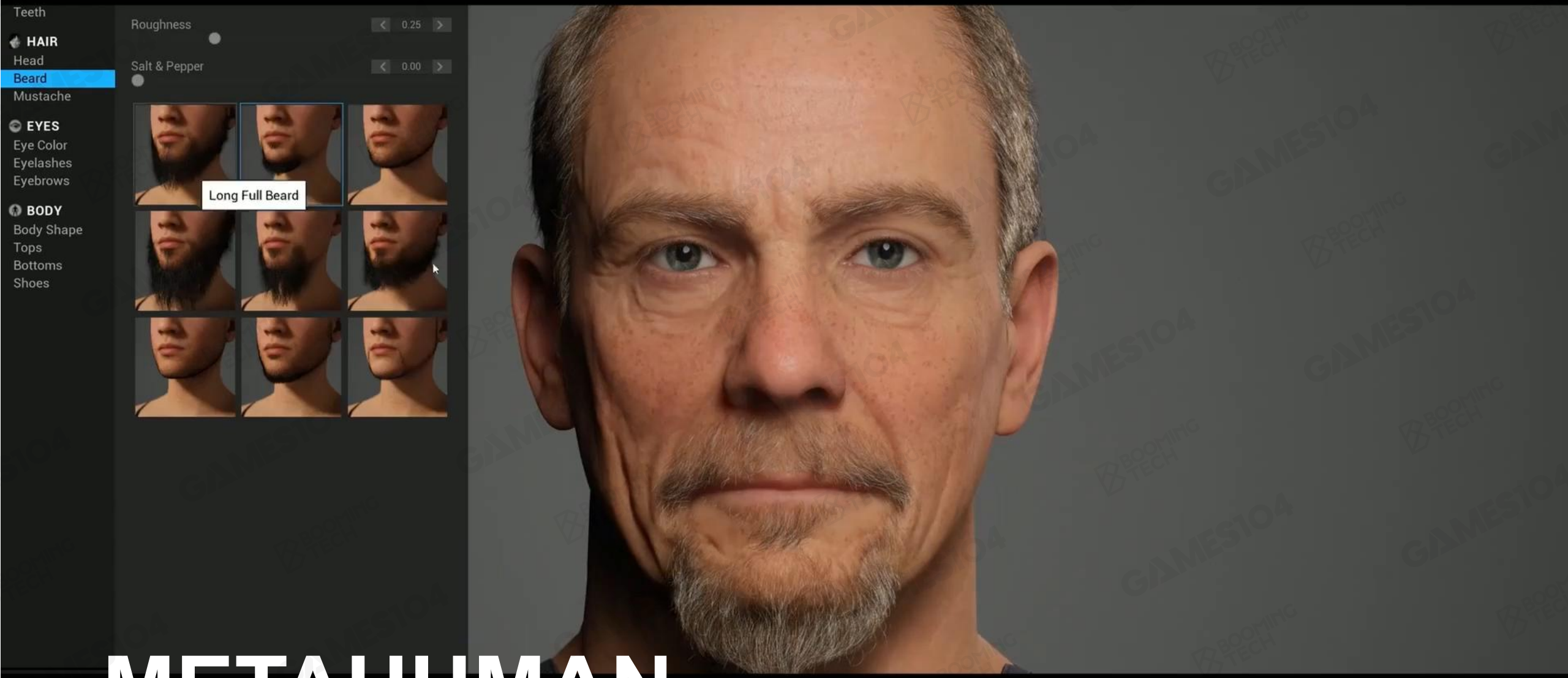






Data source: Newzoo, Markets&Markets, Microsoft; AR/VR market size includes AR/VR hardware devices and AR/VR games




Teeth
HAIR
Head
Beard
Mustache
EYES
Eye Color
Eyelashes
Eyebrows
BODY
Body Shape
Tops
Bottoms
Shoes
Roughness
0.25
Salt & Pepper
0.00
Long Full Beard

METAHUMAN

CINEMATIC & ANIMATION

SIMULATION

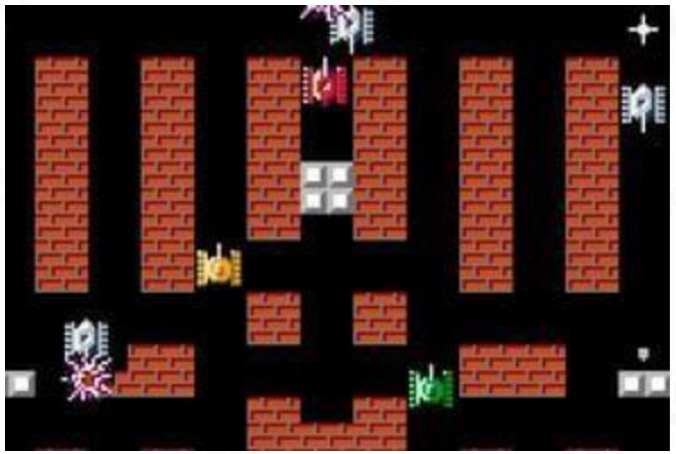
DIGITAL TWIN

Topic 2

HISTORY OF GAME ENGINE

Early Age of Video Games

Famicom（FC）



Father of Game Engine

- **John Carmack**

  John conceived and executed a new way of organizing the components of computer games by separating execution of core functionality by the game engine from the creative assets that filled the play space and content of a specific game title.

John Carmack

- **Wolfenstein 3D （1992）**

  “Father of 3D shooters“ and first demonstration of game engine application

Wolfenstein 3D

Father of Game Engine

· Doom

Along with its predecessor Wolfenstein 3D, Doom defined the FPS genre and inspired numerous similar games, often called the Doom clones. It was the first online distribution game, and it pioneered technologies including 3D graphics, networked multiplayer gaming, and support for custom modifications via packaged WAD files.

Doom

· Engine License

1994, ID Software license Doom engine to Raven, which built a successful game ShadowCaster based on it.

ShadowCaster

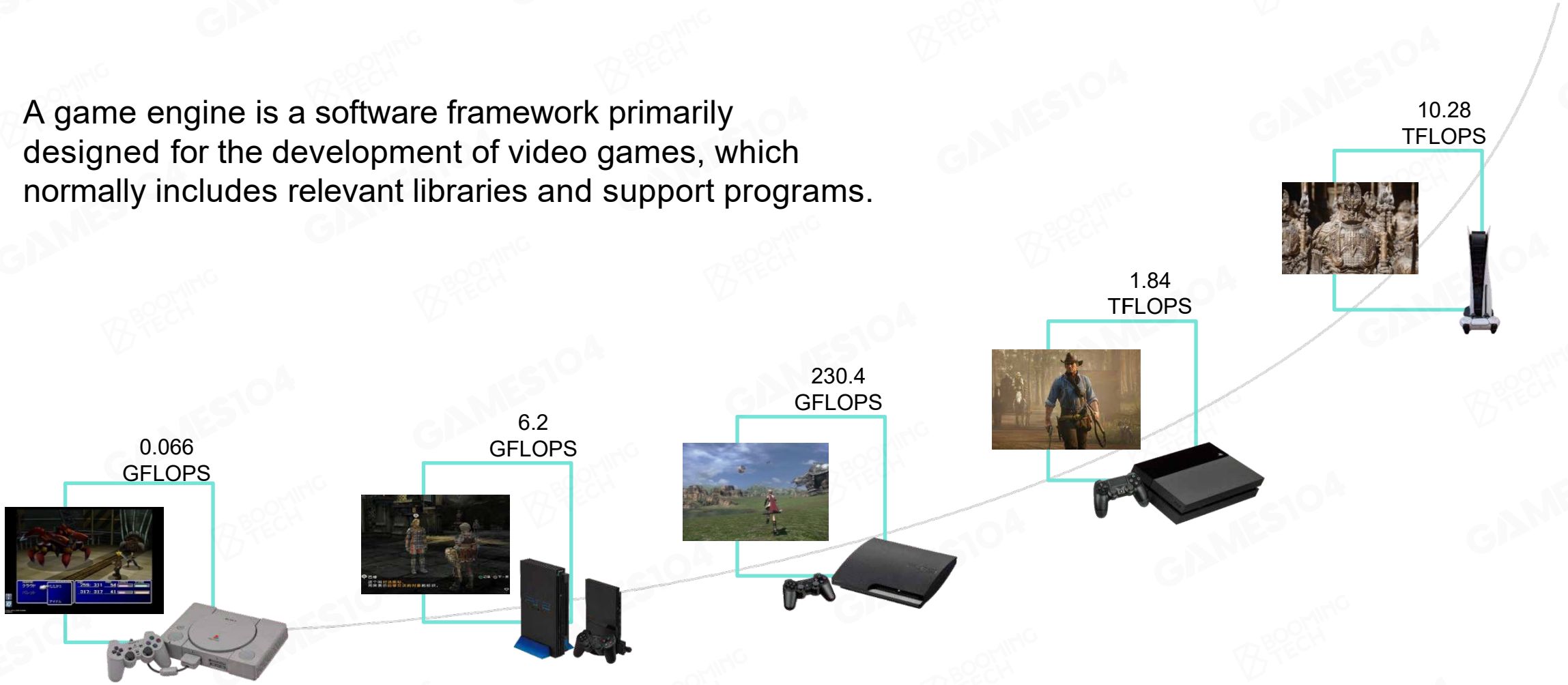
Early Age of Modern Game Engine

- Quake
  - Unlike the Doom Engine, the Quake engine offered full real-time 3D rendering and supported early 3D acceleration through OpenGL.

Quake

Diamond Multimedia的Monster 3D（3dfx Voodoo1 4MB PCI）

A game engine is a software framework primarily designed for the development of video games, which normally includes relevant libraries and support programs.



Family of Game Engines

UNREAL ENGINE
FROSTBITE3
STRIDE
source
unity
RAGE
TORQUE GAME ENGINE
infinity ward
GODOT Game engine
CRYENGINE
Anvil next
O3DE

Commercial Engine | In-house Engine | Free Engine

Middleware of Game Engine

Physics&Animation

Audio

Rendering

Other

Q&A

Topic 3

WHAT IS GAME ENGINE

What's Game Engine?

- A game engine **is a software framework primarily designed for the development of video games, and generally includes relevant libraries and support programs**.[1] The "engine" terminology is similar to the term "software engine" used in the software industry.

- Game engine can also refer to **the development software utilizing this framework**, typically offering a suite of tools and features for developing games.[2][3]

- Developers can use game engines **to construct games for video game consoles and other types of computers.** The core functionality typically provided by a game engine may include a rendering engine ("renderer") for 2D or 3D graphics,a physics engine or collision detection (and collision response), sound,scripting,animation, artificial intelligence, networking,streaming,memory management,threading,localization support,scene graph, and video support for cinematics. Game engine implementers often economize on the process of game development by reusing/adapting, in large part,the same game engine to produce different games[4] or to aid in porting games to multiple platforms.

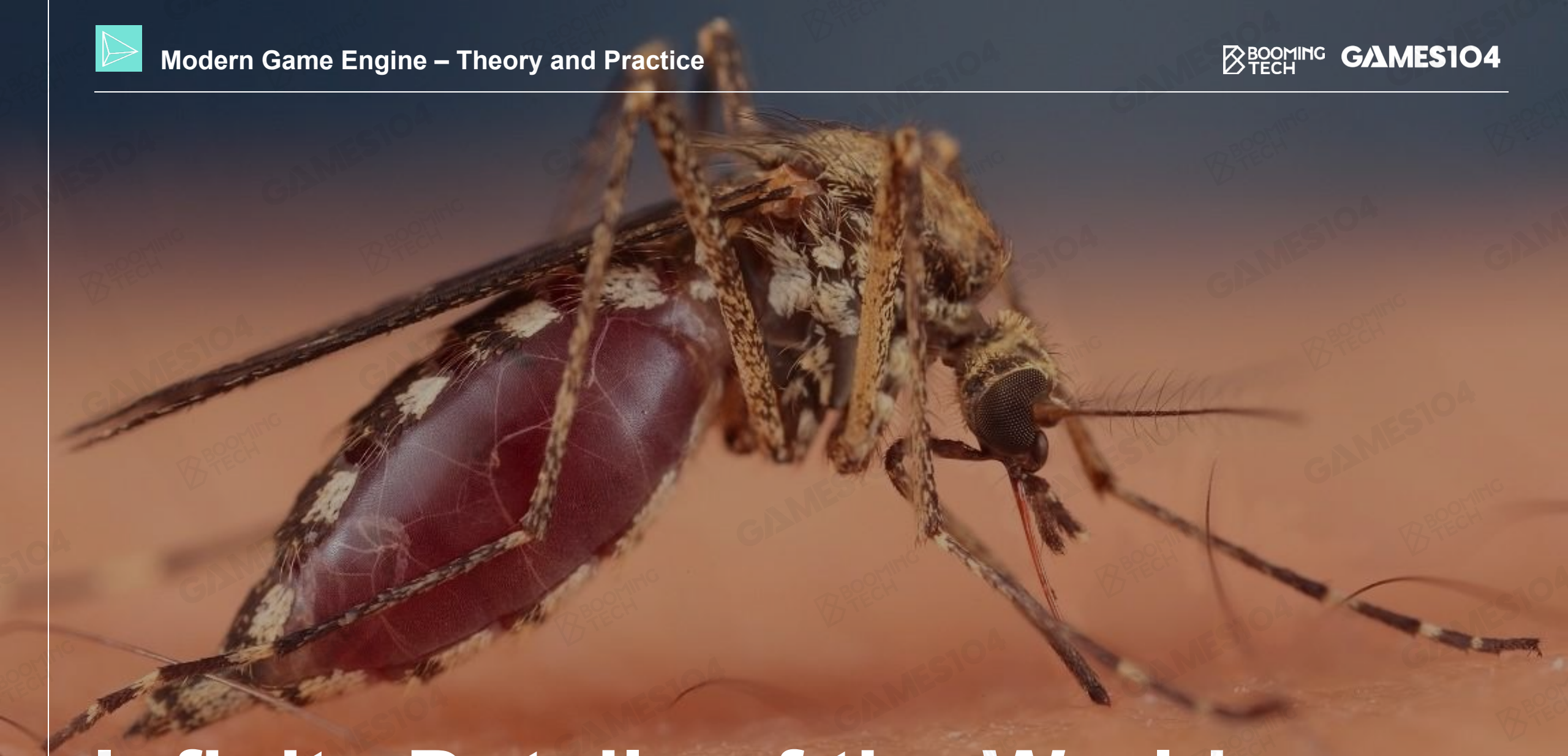
* Cited from Wikipedia

Our Definition : What's Game Engine?

· Technology foundation of the Matrix

· Productivity tools of creation

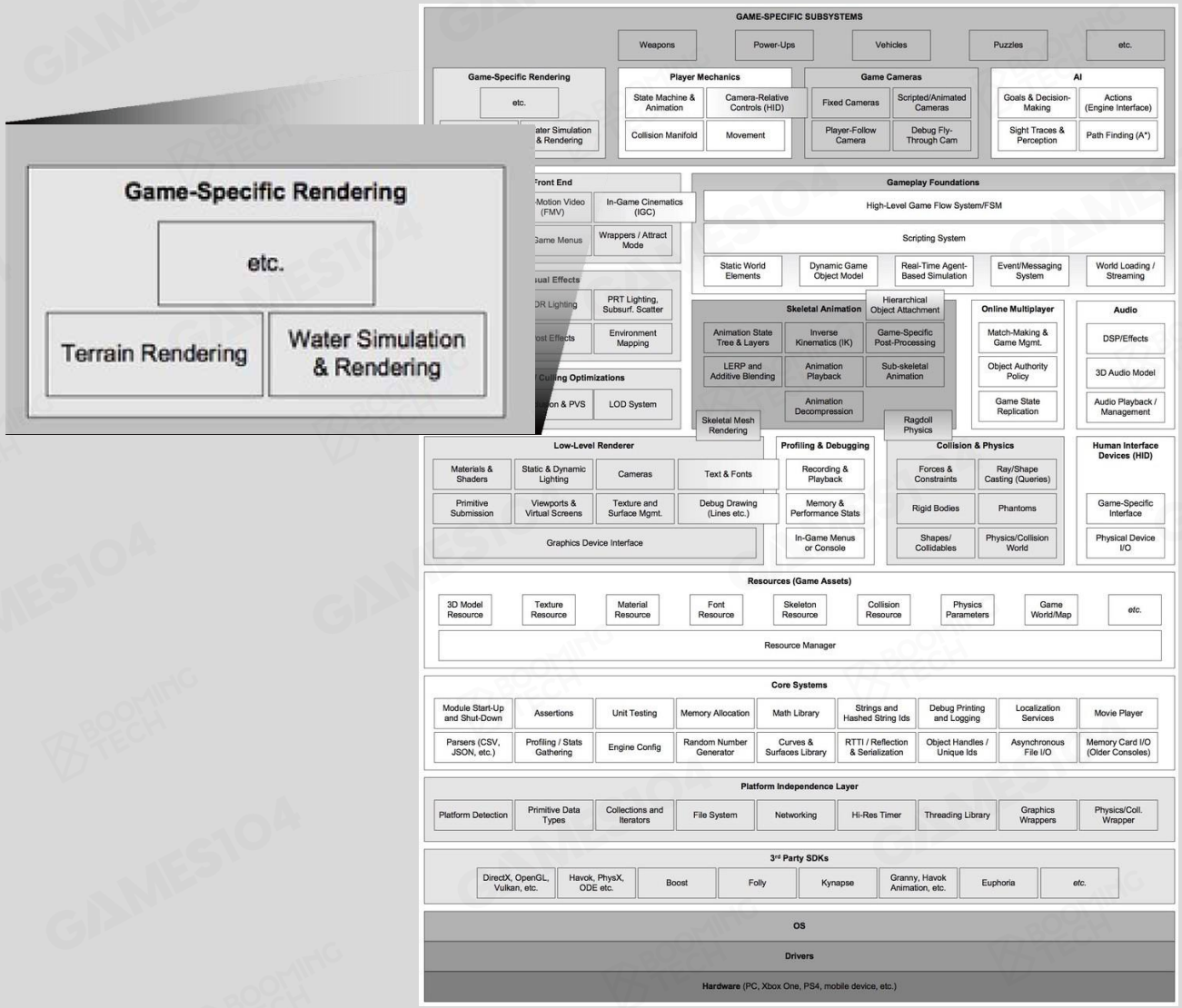
· The Art of complexity



Infinite Details of the World

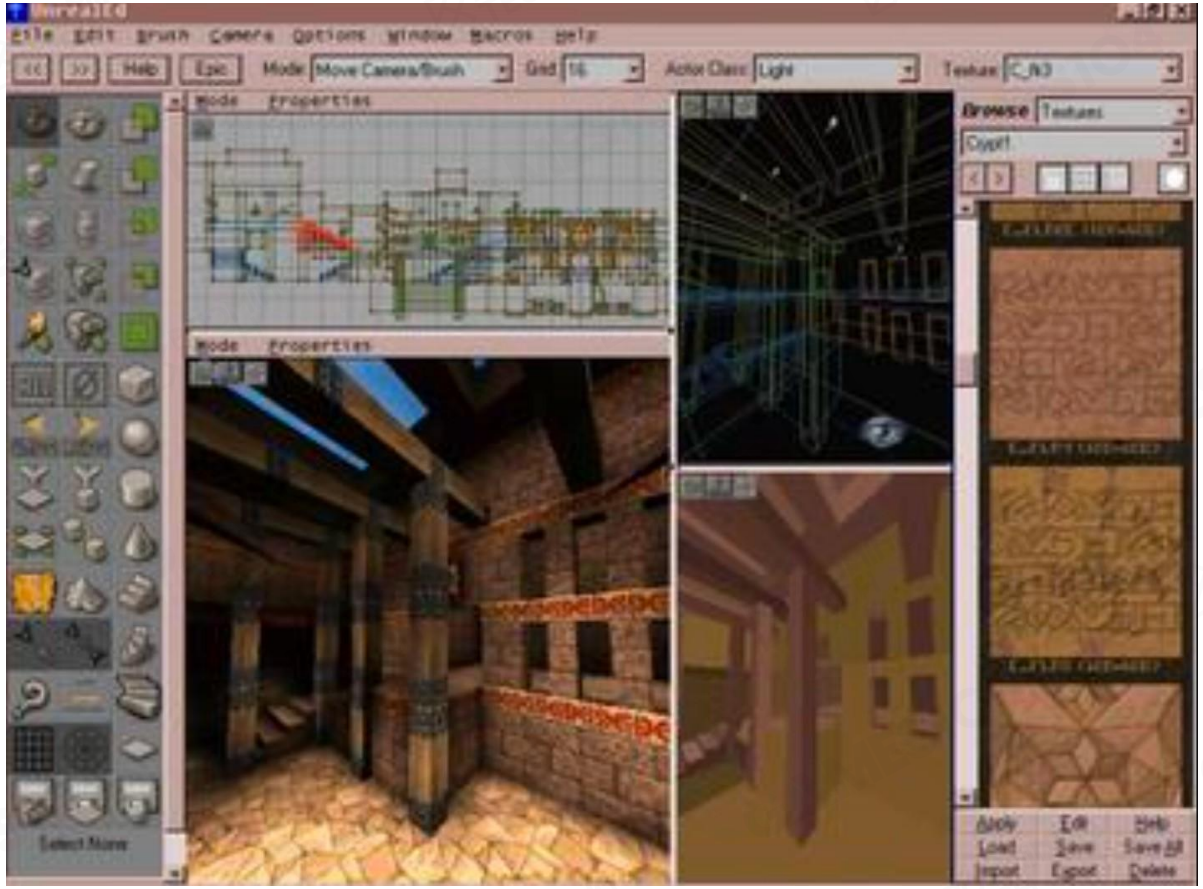
Complexity of Simulation by 0/1

Game Engine is Far Beyond Rendering

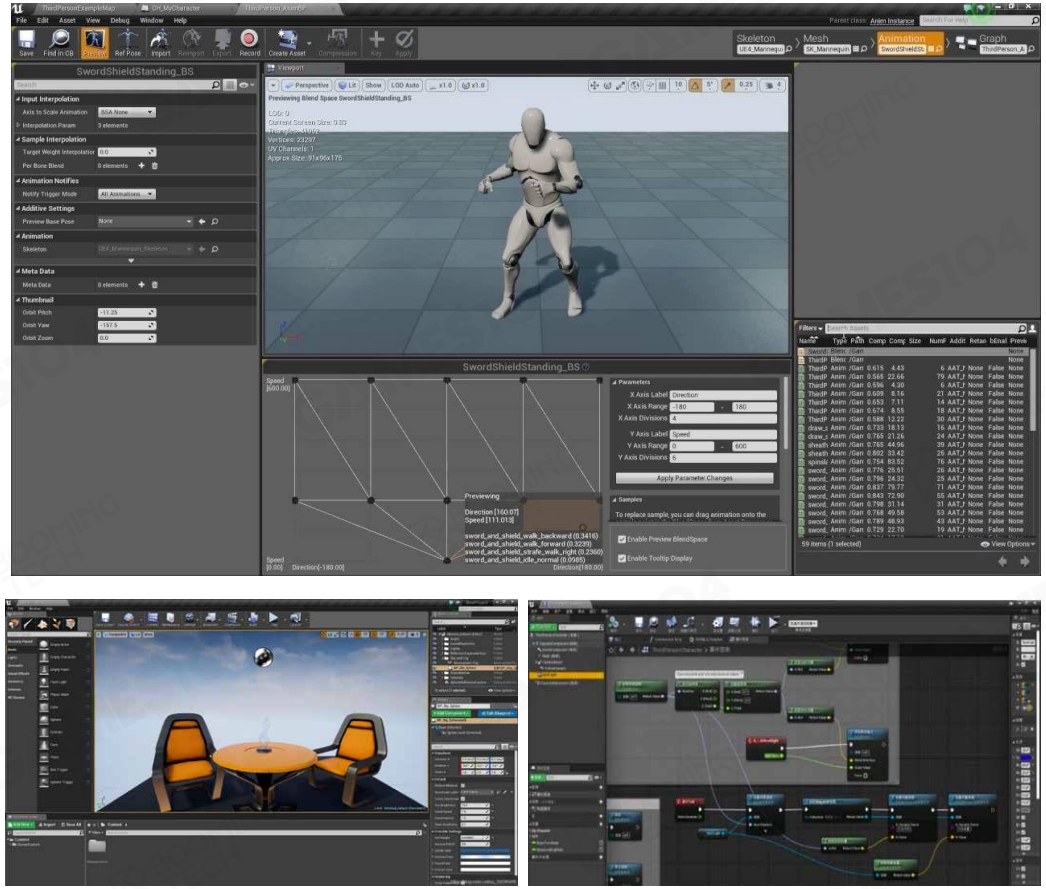

Game-Specific Rendering
etc.
Terrain Rendering
Water Simulation & Rendering
GAME-SPECIFIC SUBSYSTEMS
Weapons
Power-Ups
Vehicles
Puzzles
etc.
Game-Specific Rendering
Player Mechanics
State Machine & Animation
Camera-Relative Controls (HID)
Collision Manifold
Movement
Game Cameras
Fixed Cameras
Scripted/Animated Cameras
Player-Follow Camera
Debug Fly-Through Cam
AI
Goals & Decision-Making
Actions (Engine Interface)
Sight Traces & Perception
Path Finding (A*)
Front End
In-Game Cinematics (IGC)
Wrappers / Attract Mode
Gameplay Foundations
High-Level Game Flow System/FSM
Scripting System
Static World Elements
Dynamic Game Object Model
Real-Time Agent-Based Simulation
Event/Messaging System
World Loading / Streaming
PRT Lighting, Subsurf. Scatter
Environment Mapping
LOD System
Skeletal Animation
Hierarchical Object Attachment
Animation State Tree & Layers
Inverse Kinematics (IK)
Game-Specific Post-Processing
LERP and Additive Blending
Animation Playback
Sub-skeletal Animation
Animation Decompression
Skeletal Mesh Rendering
Ragdoll Physics
Online Multiplayer
Match-Making & Game Mgmt.
Object Authority Policy
Game State Replication
Audio
DSP/Effects
3D Audio Model
Audio Playback / Management
Low-Level Renderer
Materials & Shaders
Static & Dynamic Lighting
Cameras
Text & Fonts
Primitive Submission
Viewports & Virtual Screens
Texture and Surface Mgmt.
Debug Drawing (Lines etc.)
Graphics Device Interface
Profiling & Debugging
Recording & Playback
Memory & Performance Stats
In-Game Menus or Console
Collision & Physics
Forces & Constraints
Ray/Shape Casting (Queries)
Rigid Bodies
Phantoms
Shapes/ Collidables
Physics/Collision World
Human Interface Devices (HID)
Game-Specific Interface
Physical Device I/O
Resources (Game Assets)
3D Model Resource
Texture Resource
Material Resource
Font Resource
Skeleton Resource
Collision Resource
Physics Parameters
Game World/Map
etc.
Resource Manager
Core Systems
Module Start-Up and Shut-Down
Assertions
Unit Testing
Memory Allocation
Math Library
Strings and Hashed String Ids
Debug Printing and Logging
Localization Services
Movie Player
Parsers (CSV, JSON, etc.)
Profiling / Stats Gathering
Engine Config
Random Number Generator
Curves & Surfaces Library
RTTI / Reflection & Serialization
Object Handles / Unique Ids
Asynchronous File I/O
Memory Card I/O (Older Consoles)
Platform Independence Layer
Platform Detection
Primitive Data Types
Collections and Iterators
File System
Networking
Hi-Res Timer
Threading Library
Graphics Wrappers
Physics/Coll. Wrapper
3rd Party SDKs
DirectX, OpenGL, Vulkan, etc.
Havok, PhysX, ODE etc.
Boost
Folly
Kynapse
Granny, Havok Animation, etc.
Euphoria
etc.
OS
Drivers
Hardware (PC, Xbox One, PS4, mobile device, etc.)

God with Limited Power in Realtime

Toolchain for Creators



Engine in 1990s



Engine Nowadays

Developer Platform

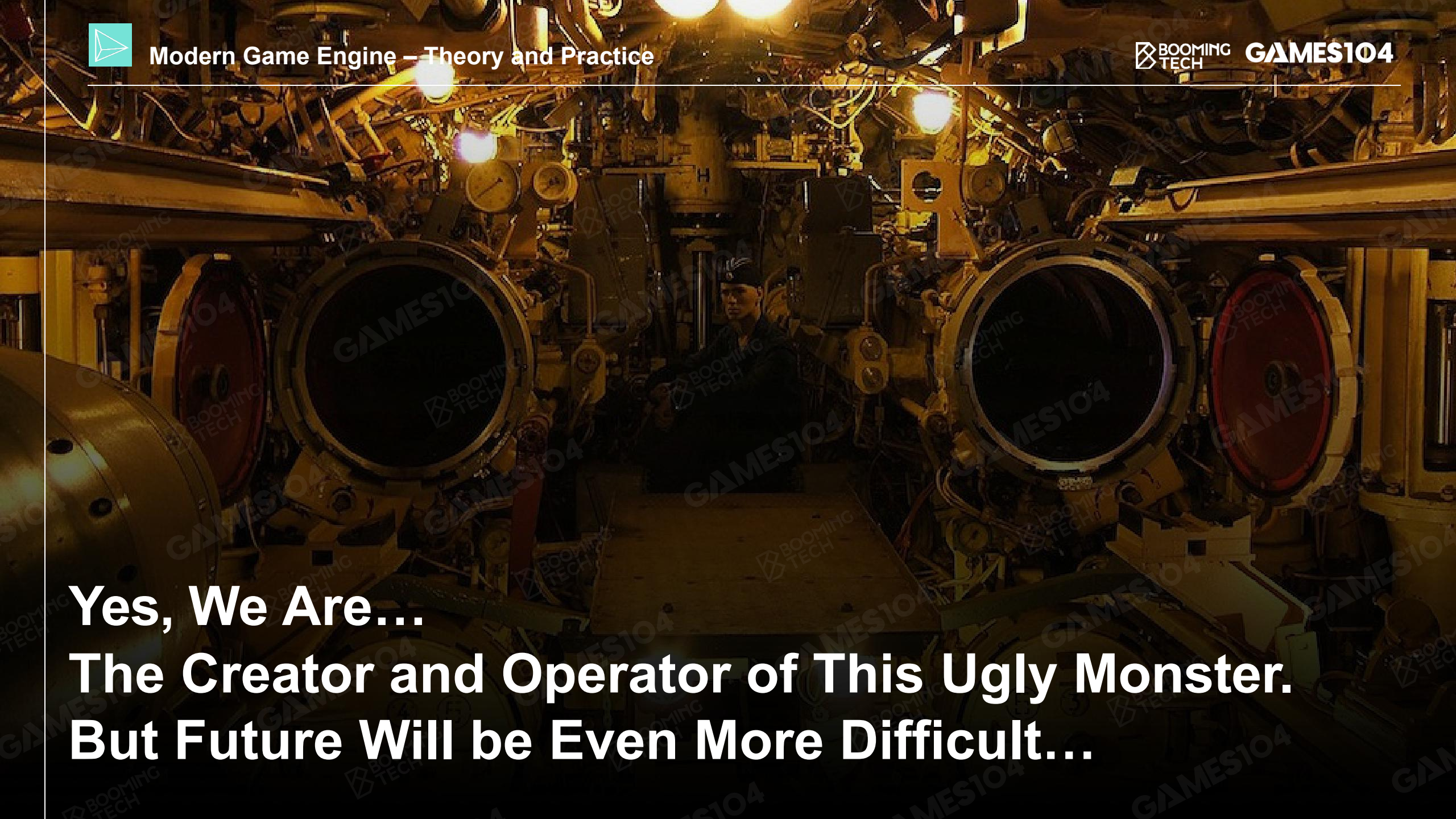
· For Programmer

- Expandable API interfaces allow programmers to define various of gameplay without changing the core.

· For Studio

- Collaborate hundreds of developers with different work streams smoothly together.

Update the Engine in the Air

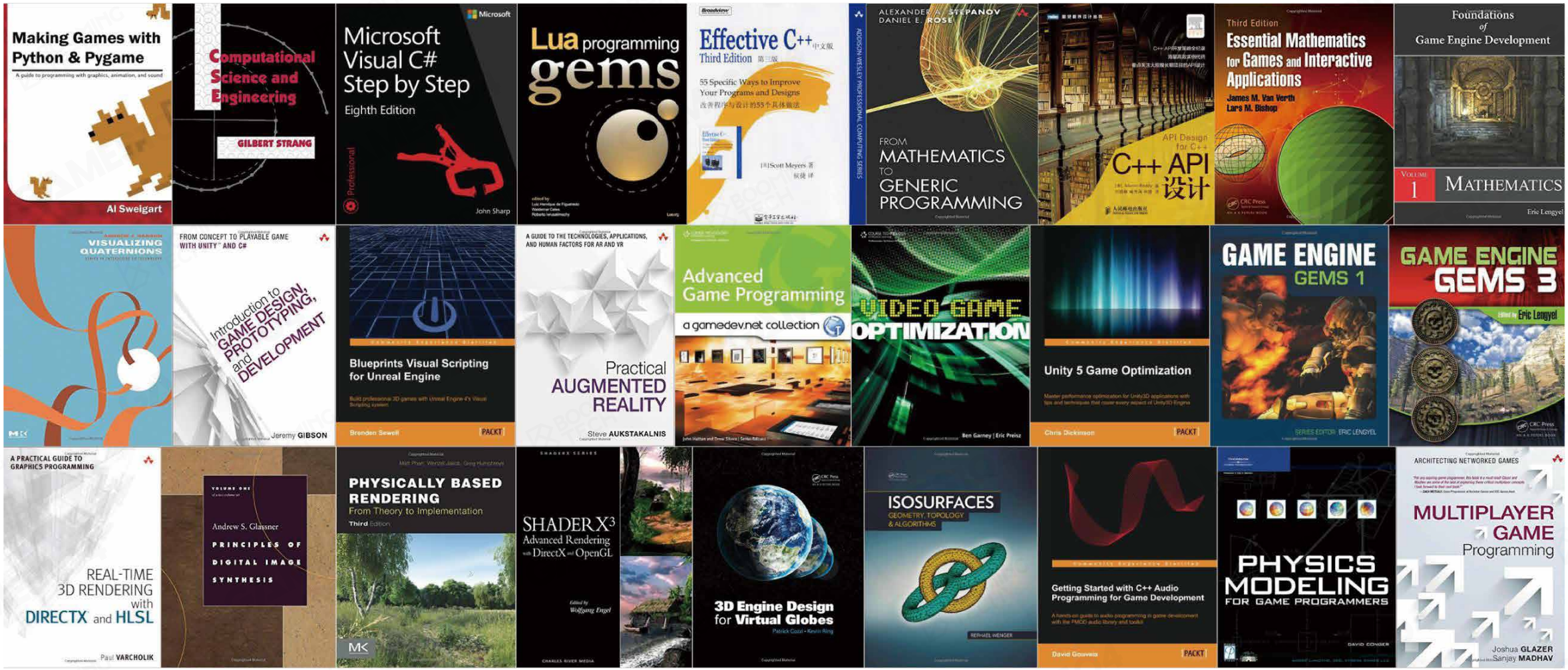


Yes, We Are…
The Creator and Operator of This Ugly Monster.
But Future Will be Even More Difficult…

Topic 4

HOW TO STUDY

Game Engine Technology Covers All Major Area of Computer Science



Focus on the Main Road by Building the Framework

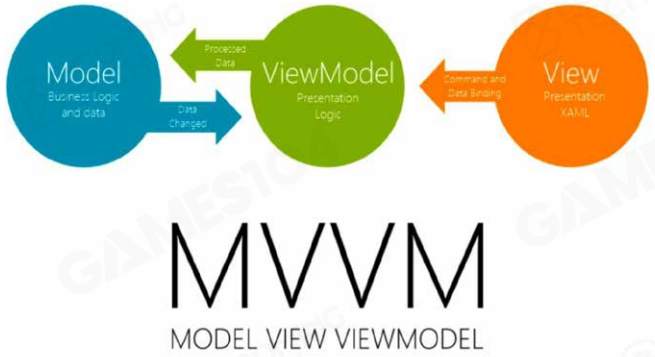
Topic 5

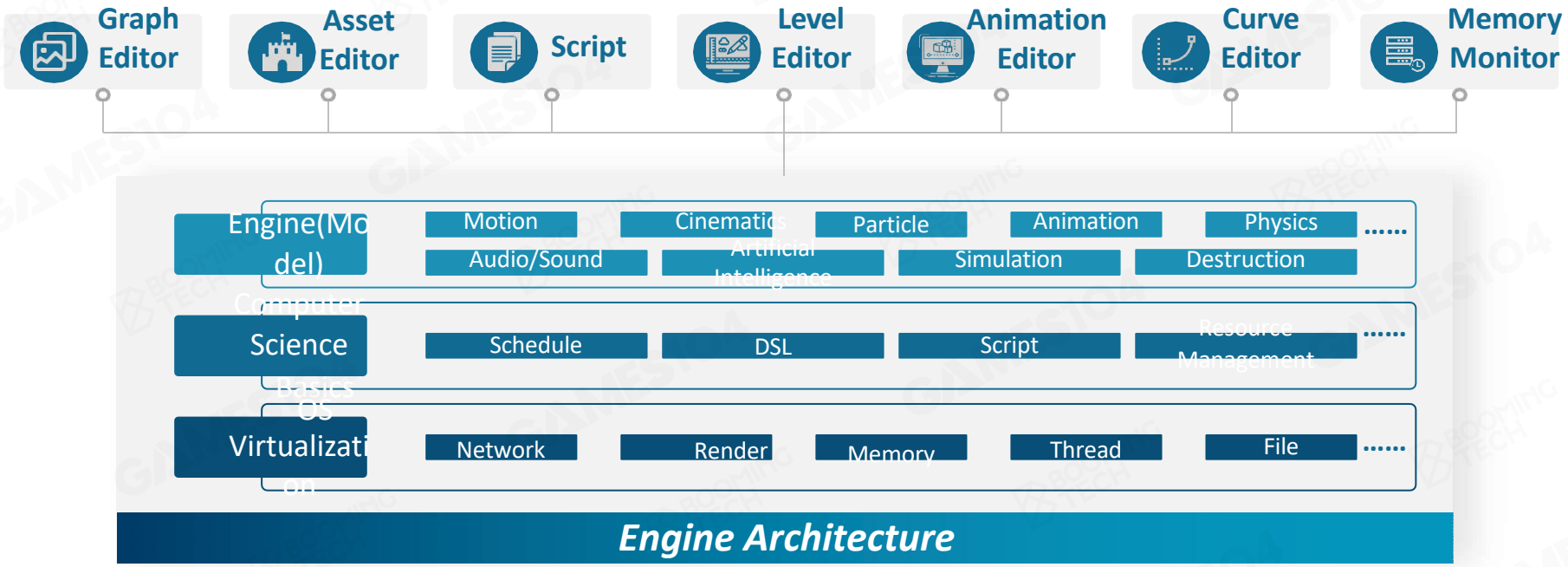
COURSE CONTENT

Basic Elements

· Engine structure and layers

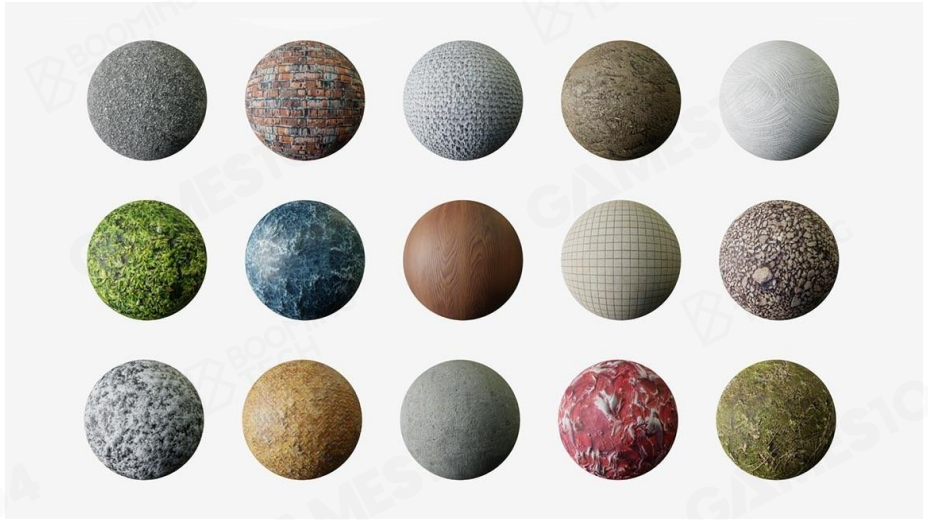
· Data organization and management

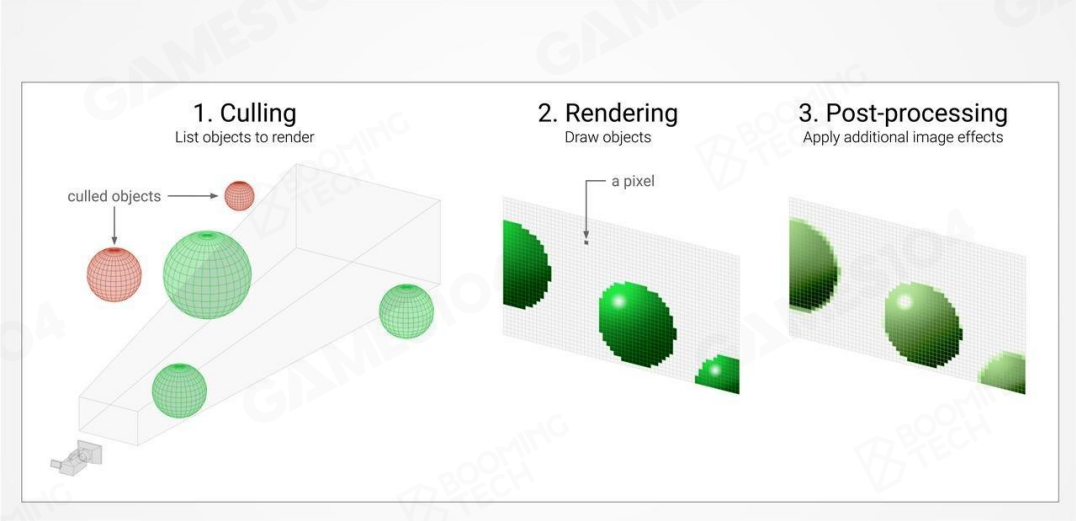




Rendering

- Model, material, shader, texture
- Light and shadow
- Render pipeline
- Sky, terrain, etc

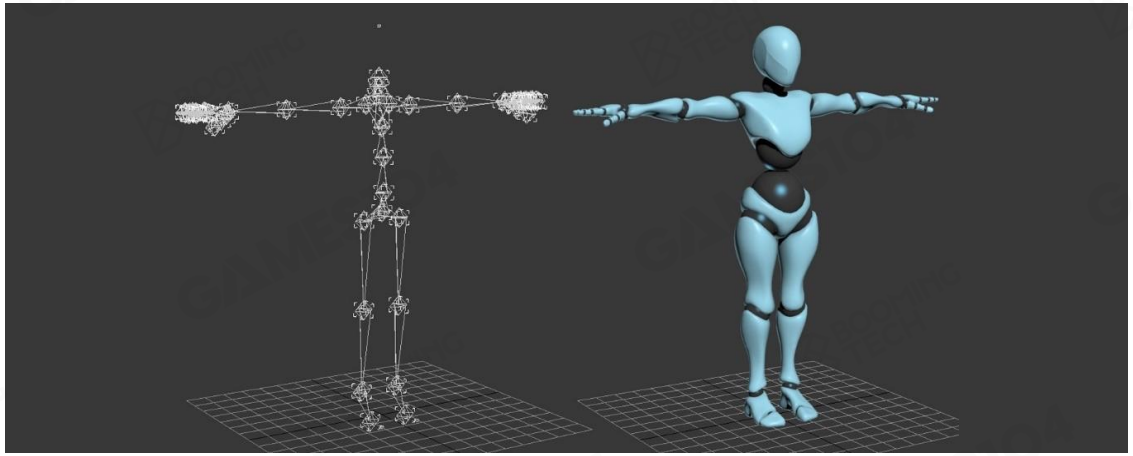


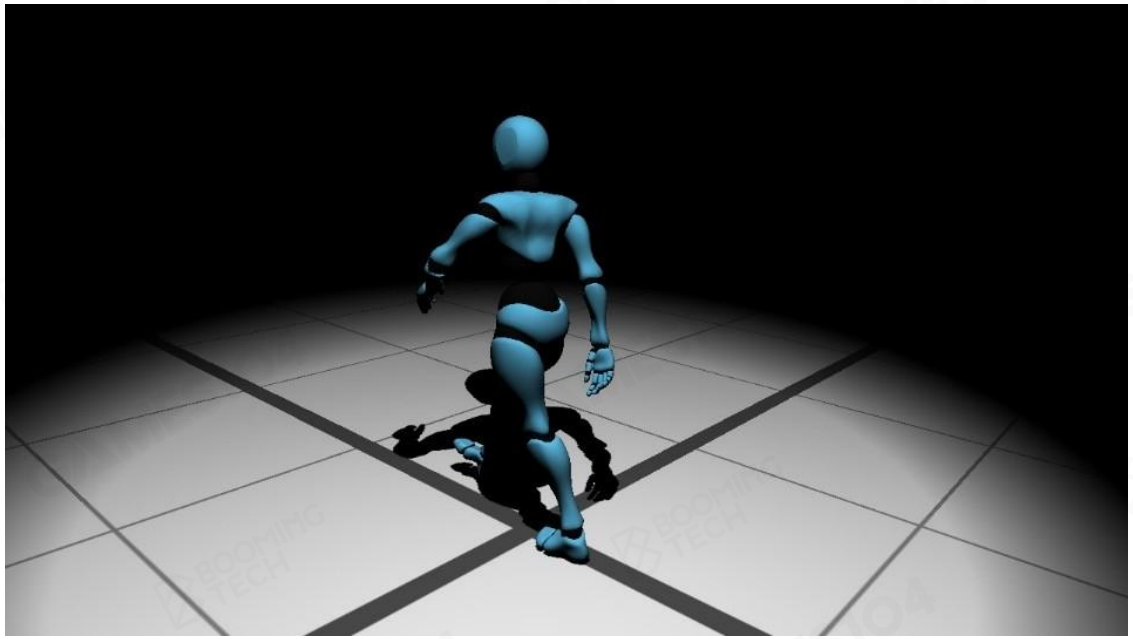


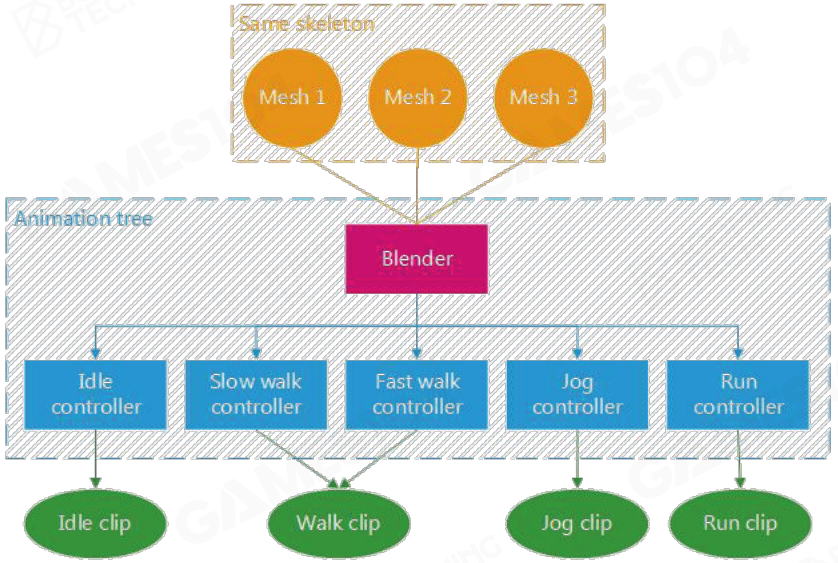
Animation

· Basic concepts of animation

· Animation structure and pipeline





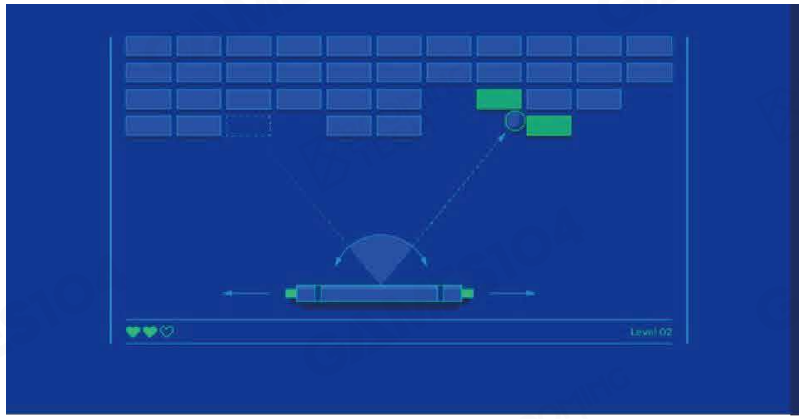


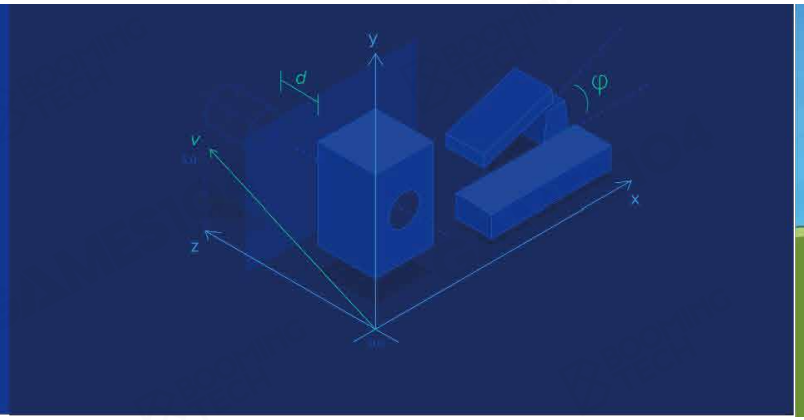
Physics

· Basic concepts of Physics System

· Gameplay applications

· Performance optimization



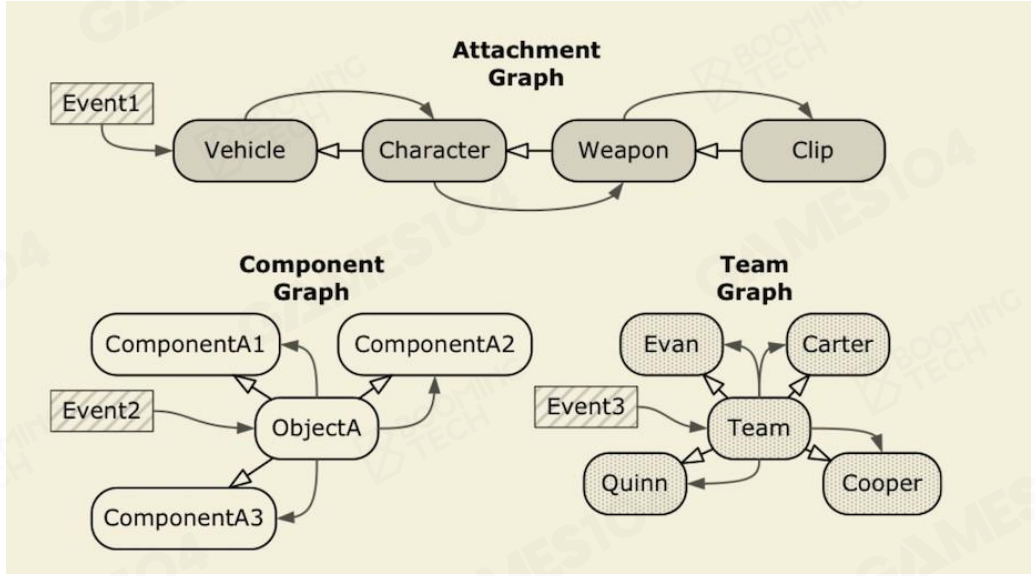


Gameplay

· Event System

· Scripts System

· Graph Driven



```
----------------------------------------------------------------------
----LUA Sample Script Version 1.0.0.0----------------------------------
----------------------------------------------------------------------
----Author: ViperGTS96-------------------------------------------------
----------------------------------------------------------------------
-------------------"The simplest design is always the best design." -------
----------------------------------------------------------------------

myLUAScript = {};

myLUAScript.myLUAScript = g_currentModDirectory;  -- Gets the Mod's base directory which can only be obtained at registration. Here it is transfered to this main script.
--myLUAScript.myLUAScript = now equals the base Directory of the mod for importing files.

function myLUAScript.prerequisitesPresent(specializations)
    return true;
end;

function myLUAScript:load(savegame)

    self.renderHelp = false;--Boolean used for toggling the Help Menu controls.

end;

function myLUAScript:delete()
end;

function myLUAScript:mouseEvent(posX, posY, isDown, isUp, button)
end;

function myLUAScript:keyEvent(unicode, sym, modifier, isDown)
end;

function myLUAScript:updateTick(dt)
end;

function myLUAScript:update(dt)

    if g_currentMission.controlledVehicle == self then --Is in a vehicle

        if not self.isBroken then -- Vehicle is not broken

            if InputBinding.hasEvent(InputBinding.yourInputNameKey1) then

                -- Code for Inputbinding 1

            end;

            if InputBinding.hasEvent(InputBinding.yourInputNameKey2) then

                -- Code for Inputbinding 2

            end;

            if InputBinding.hasEvent(InputBinding.yourInputNameKey3) then
```

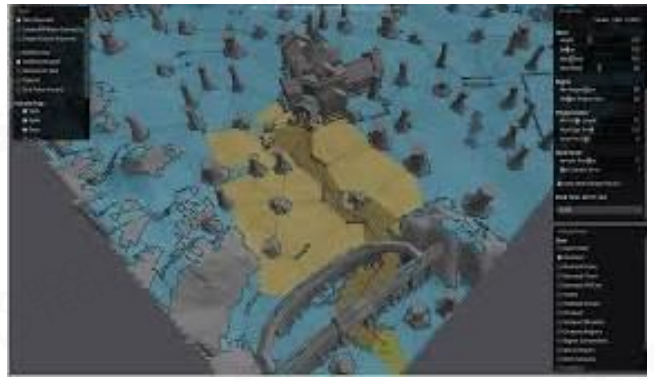
Misc. Systems

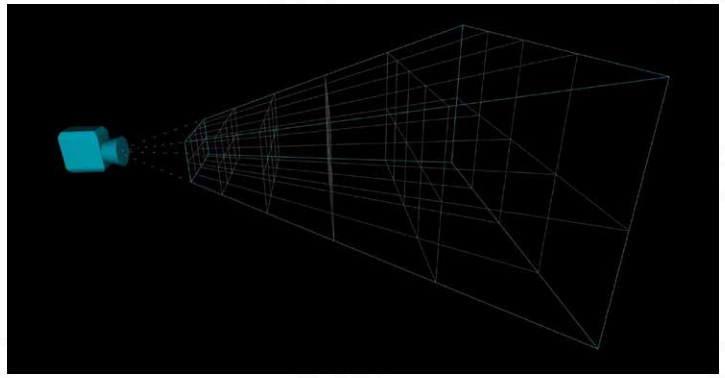
· Effects

· Navigation

· Camera

· …

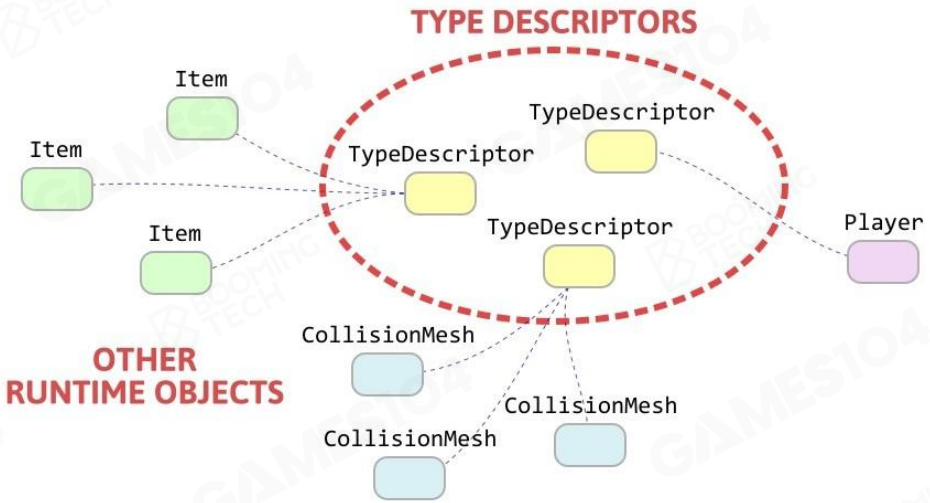




Toolchain

· C++ Reflection

Expose variables and functions used in the editor. That is, the game creation tool will use a form of reflection (or similar) on the code provided by the developers, which then allows it to expose parts of it in editors for designers.



· Data Schema

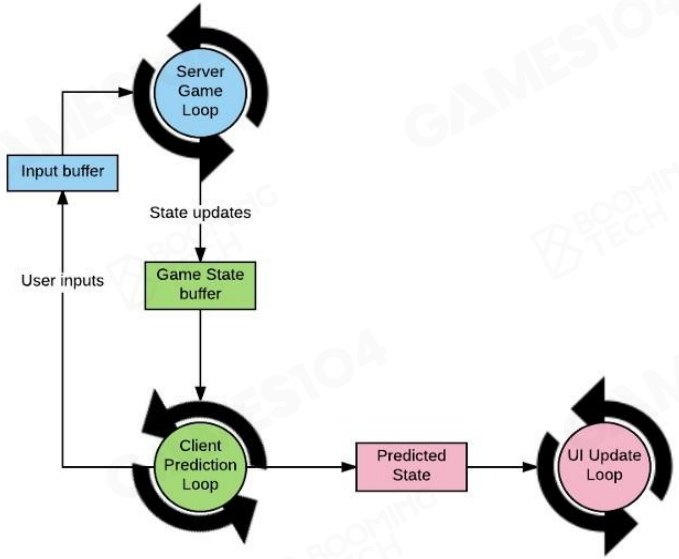
A data schema is the formal description of the structures which a system is working with.

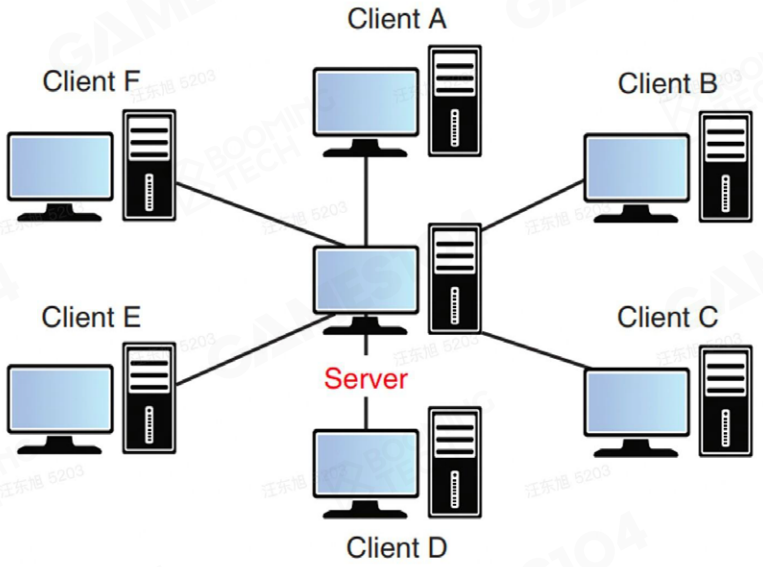
Online Gaming

· Lockstep synchronization

· State synchronization

· Consistency





Advanced Technology

· Motion Matching

Motion Matching is a simple yet powerful way of animating characters in games. Compared to other methods, it doesn't require very much manual work once you have a basic set-up: there is no need to structure clips in graphs, to carefully cut or synchronize them, or to explicitly create new transitions between status.

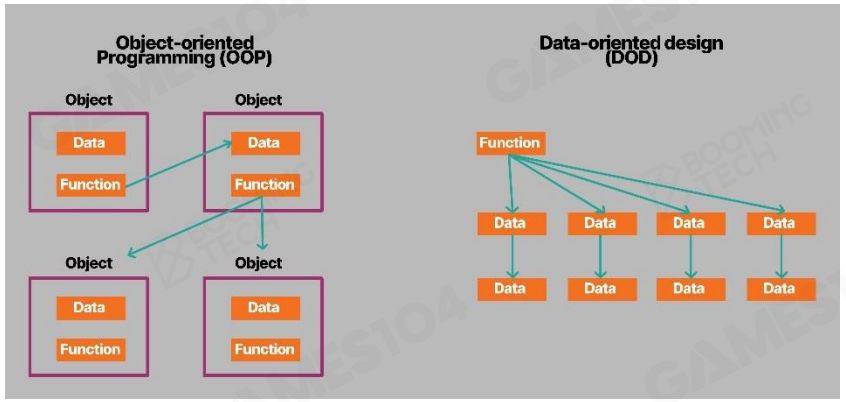
· Procedural Content Generation (PCG)

PCG is a method of creating data algorithmically as opposed to manually, typically through a combination of human-generated assets and algorithms coupled with computer-generated randomness and processing power.

Advanced Technology

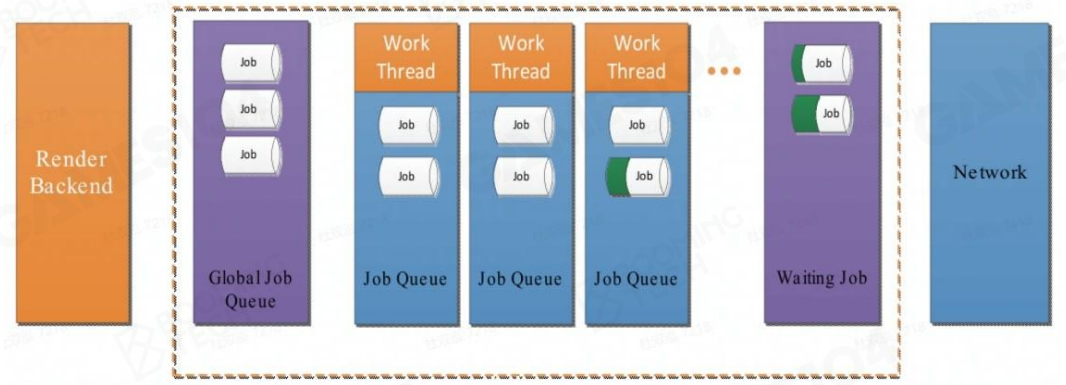
· Data-Oriented Programming (DOP)

DOP is an exciting new paradigm that eliminates the usual complexity caused by combining data and code into objects and classes. In DOP, you maintain application data in persistent generic data structures separated from the program's code. You use general-purpose functions to manipulate the data without mutating it. This approach rids your applications of state-related bugs and makes your code much easier to understand and maintain.



· Job System

A job system manages multithreaded code by creating jobs instead of threads.



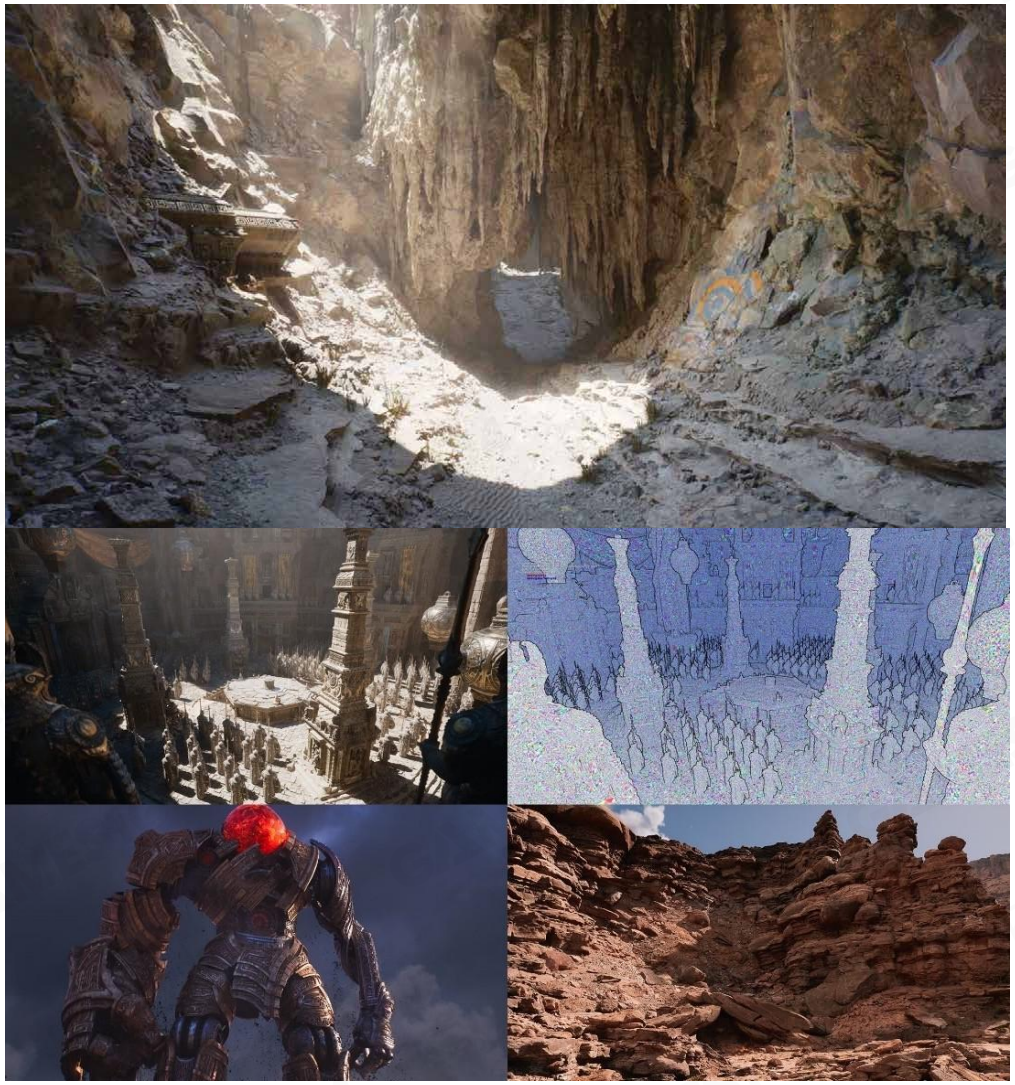
Advanced Technology

· Lumen

Unreal Engine 5's new fully dynamic global illumination and reflections system that is designed for next-generation consoles. It renders diffuse interreflection with infinite bounces and indirect specular reflections in large, detailed environments at scales ranging from millimeters to kilometers.

· Nanite

Unreal Engine 5's new virtualized geometry system which uses a new internal mesh format and rendering technology to render pixel scale detail and high object counts.



Topic 6

COURSE LOGISTICS

General Information

· Course Website

- https://games104.boomingtech.com
- course slides

· Q & A

- Sign up on our BBS for discussion
  games-cn.org/forums/forum/games104-forum

· Course Wechat

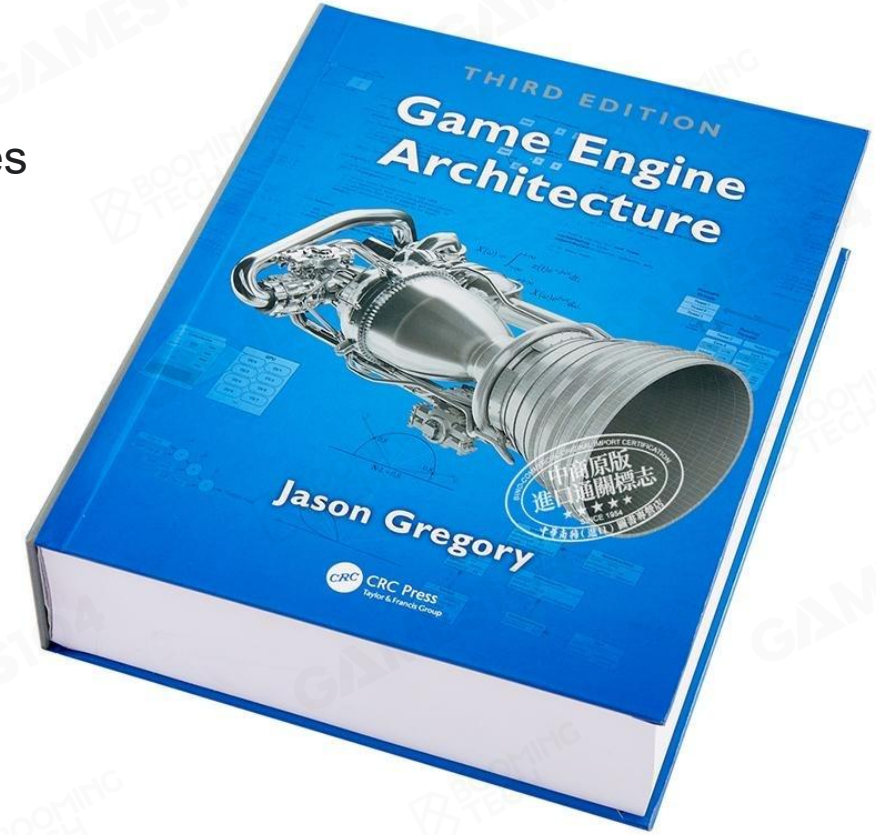
References

· No Textbooks Required

- Reading materials (if any) will available online before lectures
- Lecture slides will be available after each class

· Most Recommended Reference

- Jason Gregroy, “Game Engine Architecture”, 3rd or later editions

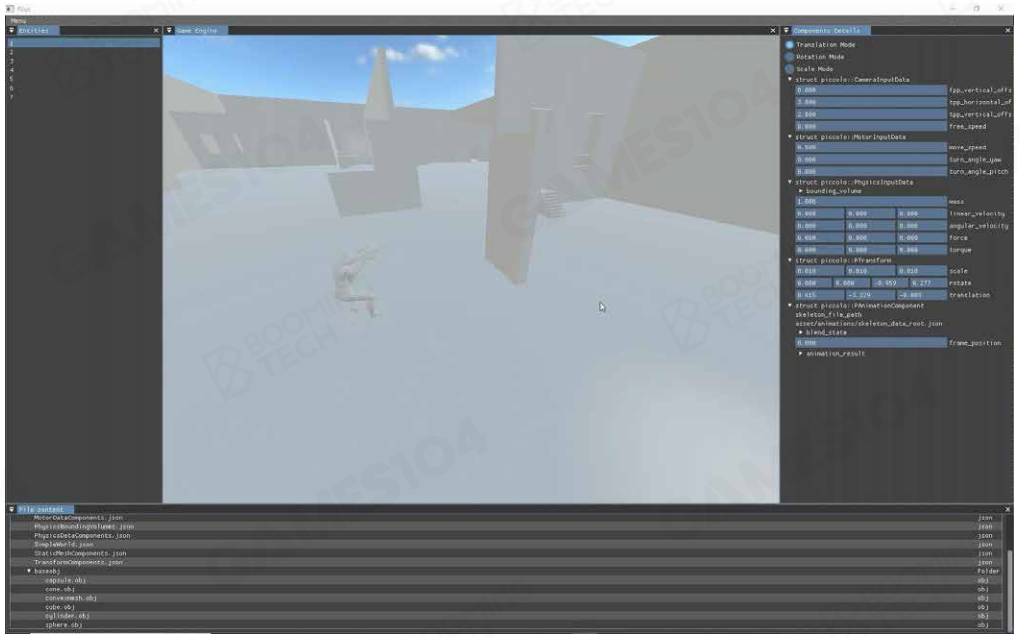


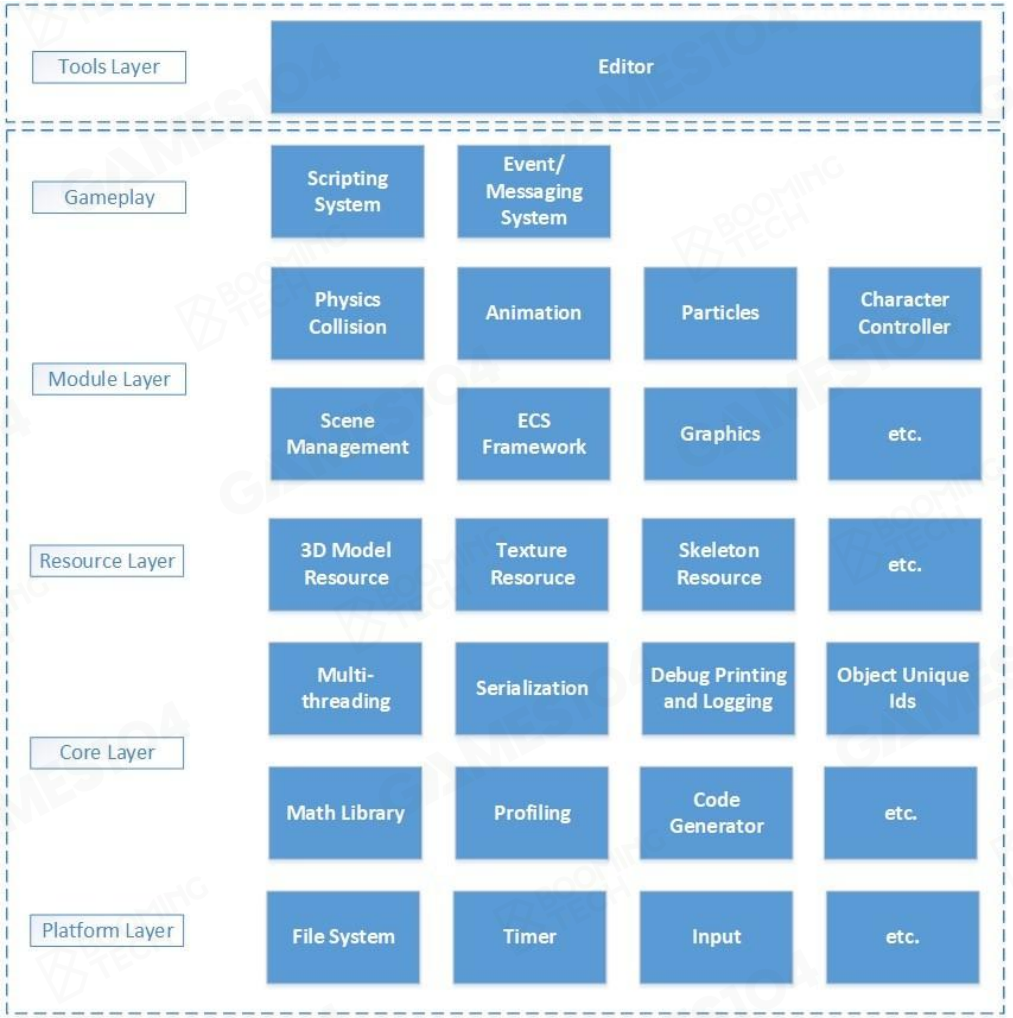
Mini Engine

· Mini runtime framework

· Mini editor

· Building basic knowledge system of game engine





Assignments

· Assignments

- Mostly programming tasks with code skeletons and virtual machine image provided
- Monthly (usually no more than 200 lines of code per week)
- Language C++

· Submission

- Every four weeks for homework
- Feedback will be given in a week

Assignments

- **Assignment Submission Website**

  www.smartchair.org/GAMES104

- **No Exams**

- **Course Project / Final Project**
  - Midway of this course
  - References will be provided, but you decide the topic
  - Best work will be posted online or demonstrated in other ways

Course Contributor

- Claire （清华大学 ）
- Bear （游戏引擎开发者）
- 彭渊 （《实时渲染 4th》译者）
- 常楠 Alfred （英雄游戏 ）
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- 施祺（Gameplay研发&游戏设计师）
- 毛彦凯（上海交大）
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- 鲁瀚洋 （东南大学）
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Course Team

- 大喷
- 爵爷
- 德辉
- 靓靓
- 之栋
- 胖丁
- 东旭
- 砚书
- SHINE
- JUDY
- BOOK
- MANDY
- 吴俗
- 邓导
- QIUU
- 金大壮
- LEON
- 梨叔
- KAI
- C佬
- 阿乐

More will be recruited soon after this lecture(based on need).

Enjoy ;)
Coding

Thankyou for attending this course
Please scan here to let me know, how you think of our course

Please note that all videos and images and other media are cited from the Internet for demonstration only.