CS354R

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# GAME ENGINE ARCHITECTURE

Assembly-CSharp - Assets\ScriptGame\scriptPlayer.cs -

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Globals.cs × GameControl.cs × Gamepl

scriptPlayer ▸ downPress ()

```
1  using UnityEngine;
2  using System.Collections;
3
4  public class scriptPlayer : M
5      bool going, spotReached,
6      public short direction, s
7      movePlayer moveP; GameObj
8      Color colorStart; Color c
9
10     void Start() {// Use this
11       going = false; north =
12       speed = Globals.pSpeed;
13       moveP = GetComponent<mo
14       gameSFX = GameObject.Fi
15       gameBGM = GameObject.Fi
16       colorStart = renderer.m
17     }
18
19     void Update() { if(!Globa
20       //check if still moving
21       if(going){ //moving to
22         if(spotReached){
23          if(north){ direction = 1; transform.eulerAngles = new Vector3(0, 0, 0); }
24          if(east){ direction = 2; transform.eulerAngles = new Vector3(0, 0, 270); }
25          if(south){ direction = 3; transform.eulerAngles = new Vector3(0, 0, 180); }
26          if(west){ direction = 4; transform.eulerAngles = new Vector3(0, 0, 90); }
27         }
28         spotReached = false; if(steps == 3) sfxScript.sndMove();
29         //move in direction
30             //count steps until in next space
31         if(Globals.readyP) moveP.Move(direction); steps++; if(steps >= (20/speed)){ steps = 0; spotReached = true; }
32       }
33       else{ //let go of button
34         if(!spotReached){ //let go of button, but still moving
35           if(Globals.readyP) moveP.Move(direction); steps++; if(steps >= (20/speed)){ steps = 0; spotReached = true; }
36         }
```

Ready 57 : 59 INS Feedback Task List

BLUEPRINT

# WHAT IS A GAME ENGINE?

- Run-time system
  - Low-level architecture
    - 3D system
    - Physics system
    - GUI system
    - Sound system
    - Networking system
  - High-level architecture
    - Game objects
    - Game mechanics
- Toolsets
  - Level editor
  - Character and animation editor
  - Material creator
- Subsystems
  - Run-time object model
  - Real-time object model updating
  - Messaging and event handling
  - Scripting
  - Level management and streaming

# WHAT ARE GAME OBJECTS?

- Anything that has a representation in the game world
  - Characters, props, vehicles, projectiles, cameras, trigger volumes, lights, etc.
- Created/modified by world editor tools
  - Object model presented to designers
- Managed at runtime in the runtime engine
  - Object model efficiently implemented for players
- What is an architecture model that can accomplish all this?

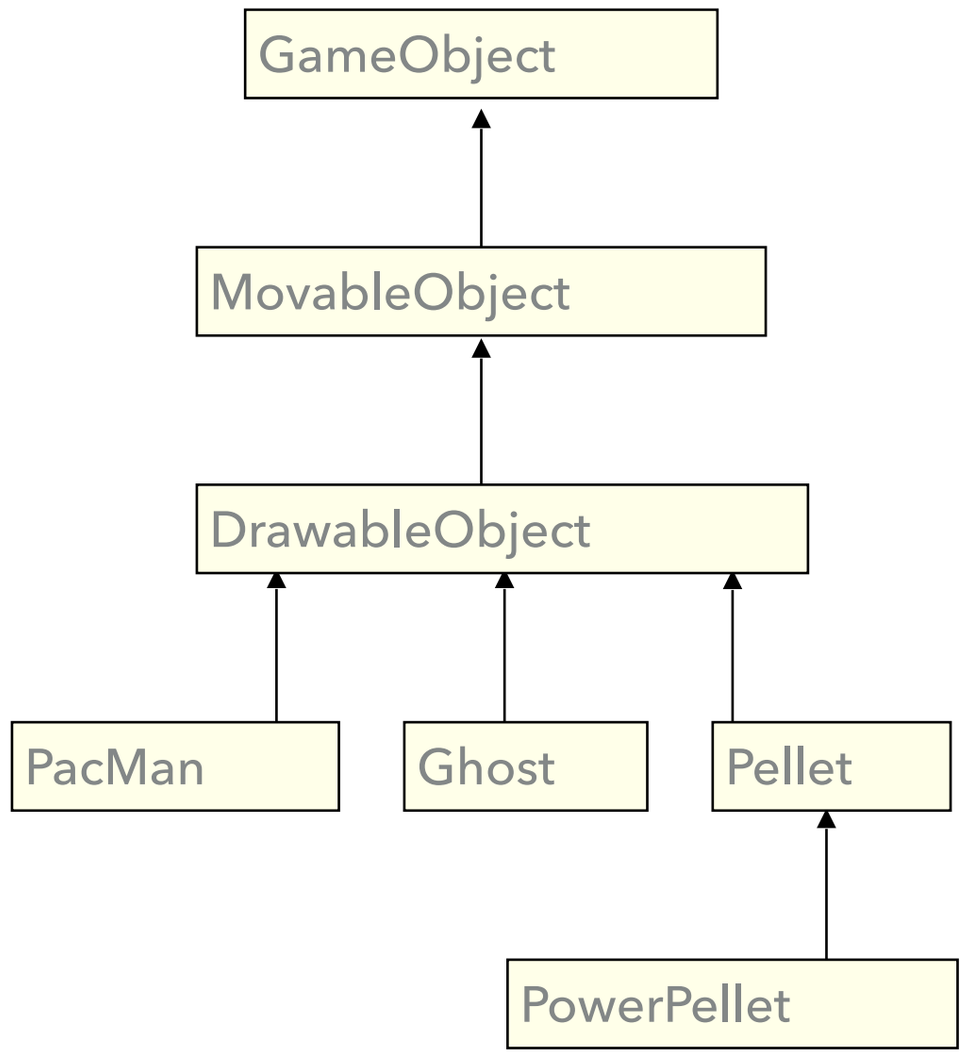
# RUN-TIME OBJECT MODEL ARCHITECTURES

- Object-centric
  - Objects implemented as class instances
  - Object's attributes and behaviors encapsulated within the class(es)

- Property-centric
  - Object attributes are implemented as data tables, one per attribute
  - Game objects are just IDs of some kind
  - Properties of an object are distributed across tables associated with engine systems (keyed by the object's id)

# OBJECT-CENTRIC ARCHITECTURES

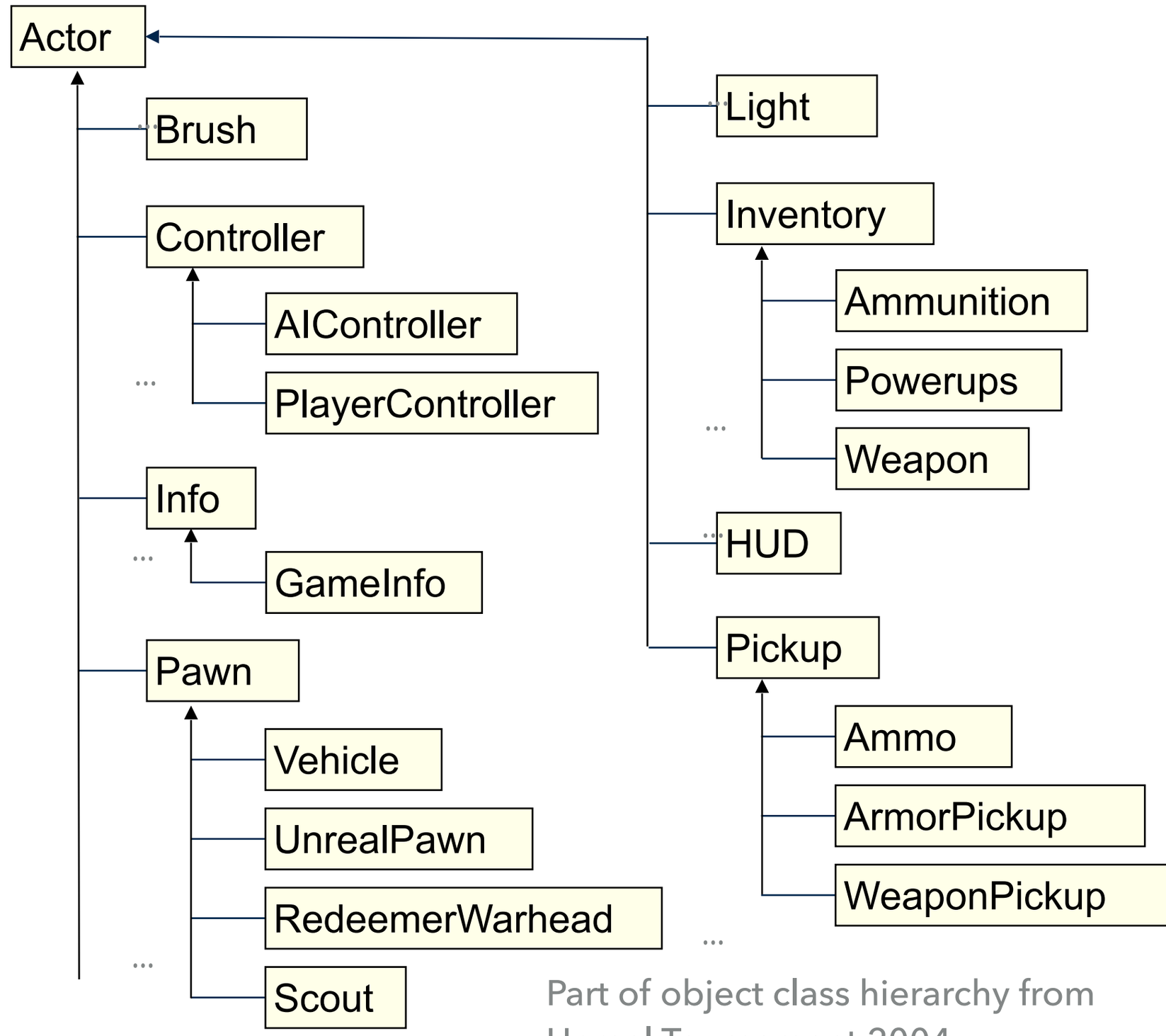
- Natural taxonomy of game object types
- Common, generic functionality at root
- Specific game object types at the leaves




Hypothetical PacMan Class Hierarchy

# MONOLITHIC CLASS HIERARCHIES

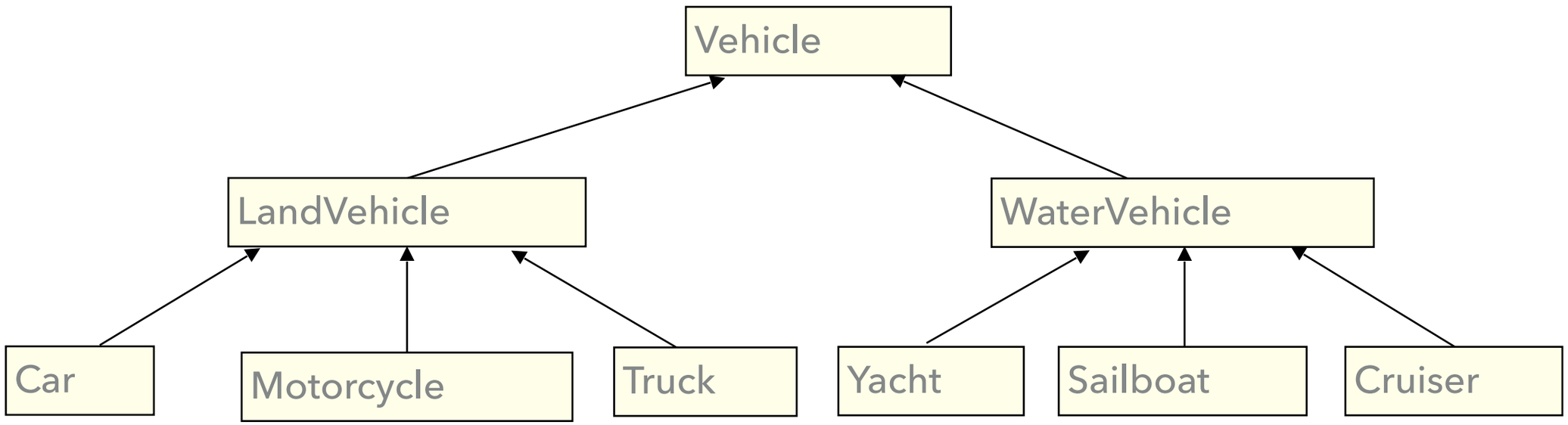
- Very intuitive for small simple cases
- Tend to grow ever wider and deeper
- Virtually all classes in the game inherit from a common base class




Part of object class hierarchy from Unreal Tournament 2004

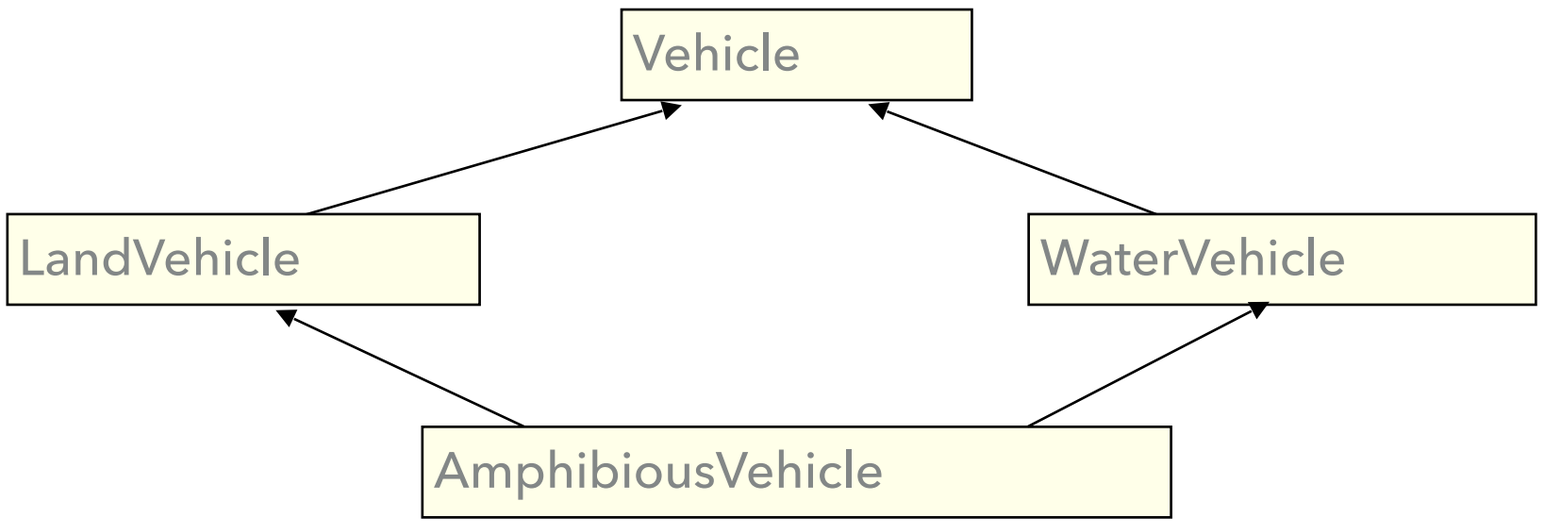
# PROBLEMS WITH MONOLITHIC HIERARCHIES?

- Hard to understand, maintain, and modify classes
  - Need to understand a lot of parent classes
- Hard to describe multidimensional taxonomies
  - How to classify objects along more than one axis?
  - e.g. how would you include an amphibious vehicle?



# USE MULTIPLE INHERITANCE?

- NOOOO!!!!!
  - There's a reason languages like Java don't support it
- Derived classes often end up with multiple copies of base class members
- Compiler cannot resolve ambiguities

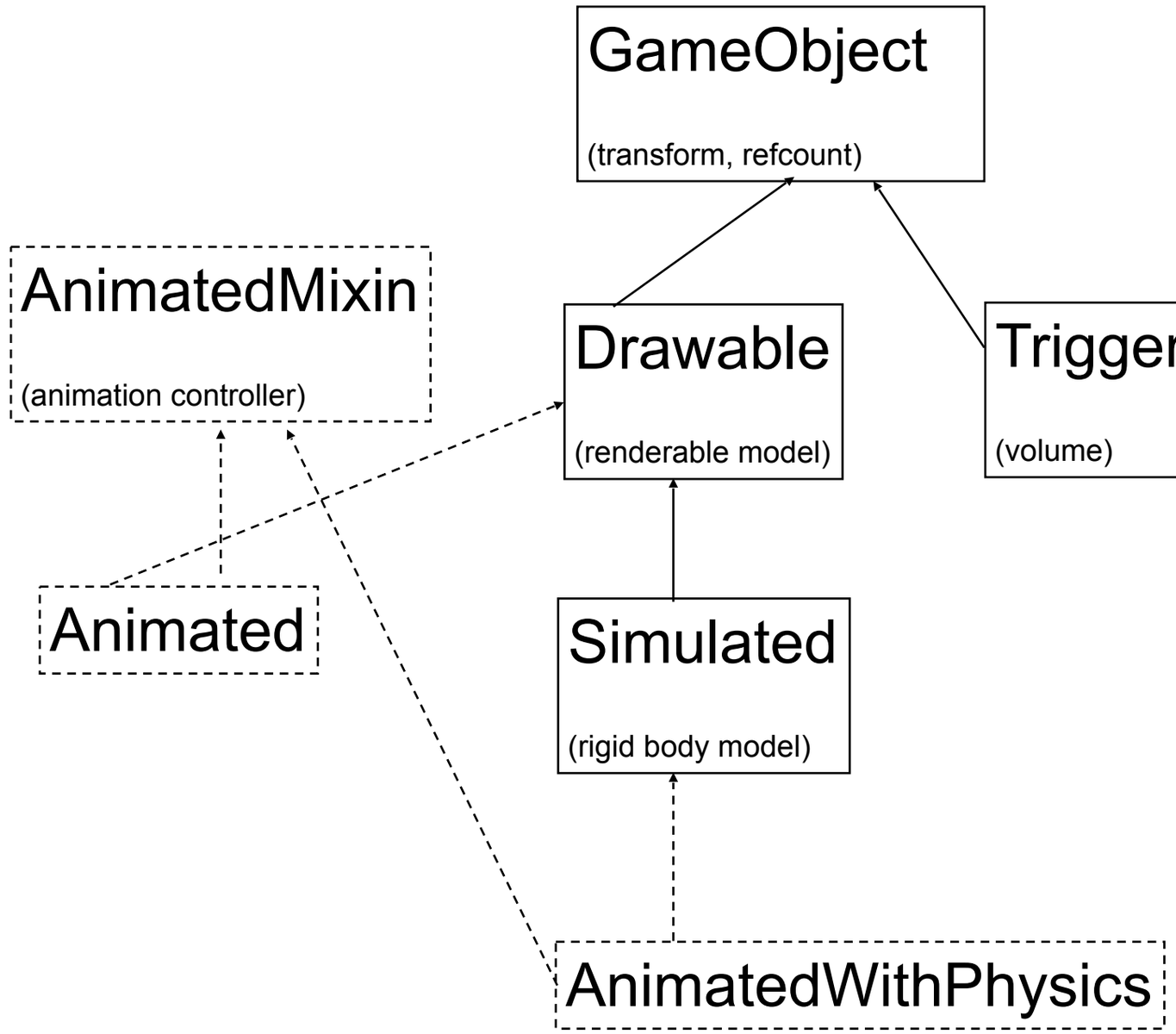


# MIX-IN CLASSES

- Mix-in classes (stand alone classes with no base class) can solve deadly diamond problem
- Similar to an interface with implemented methods (traits) except mix-ins have state (e.g. can store properties)
- Supported natively in many languages
- Can be implemented in C++ using templates

# MIX-IN EXAMPLE

- AnimatedMixin is a standalone class that Drawable and Simulated can use in different, need-specific ways
- Another approach is to use composition or aggregation in addition to inheritance

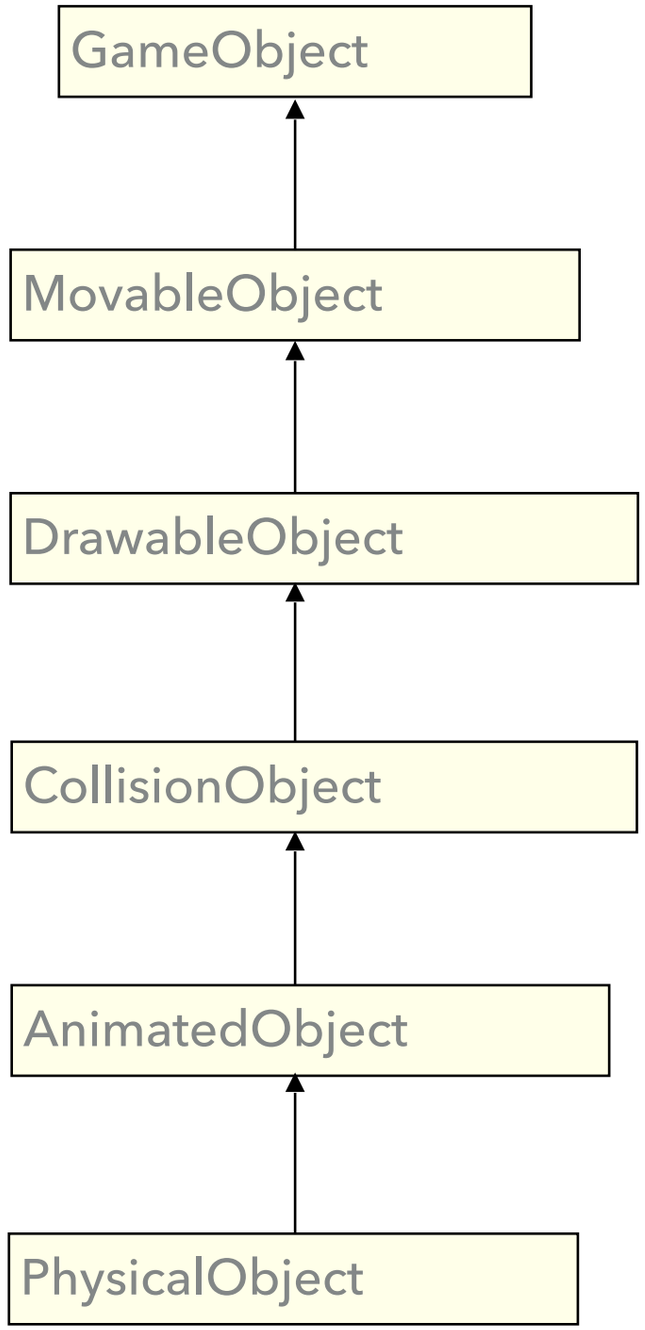


# OBSERVATIONS ABOUT INHERITANCE

- Not every set of relationships can be described in a directed acyclic graph
- Class hierarchies are hard to change
- Functionality drifts upwards
- Specializations pay the memory cost of the functionality in siblings and cousins

# OTHER ISSUES WITH INHERITANCE

- Consider a simple generic GameObject specialized to add properties for full blown physical simulation
- What if you want to use physical simulation on objects that don't use skeletal animation?

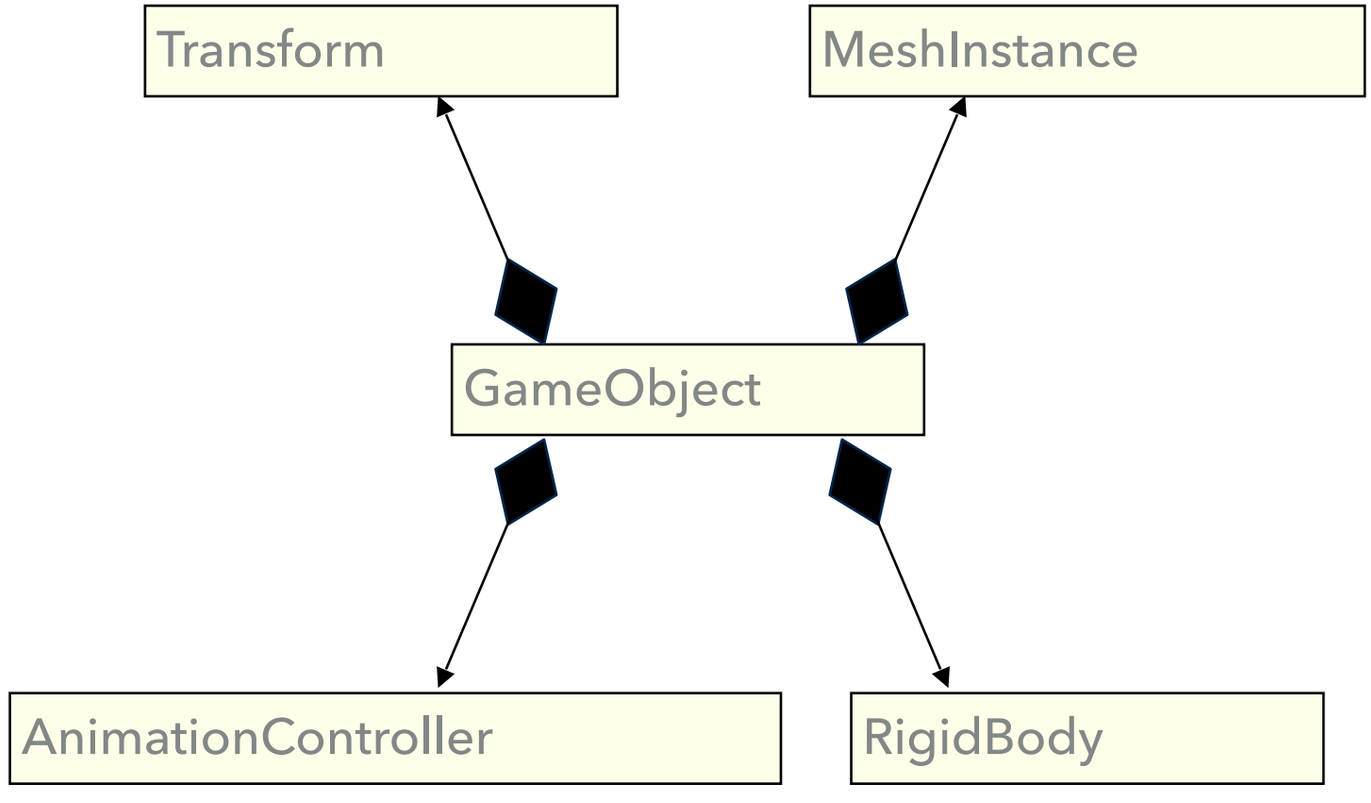


# SHOULD YOU EVER USE INHERITANCE?

- Very hotly debated topic – particularly in game engine development
- Yes, it is possible to throw it out entirely, but you trade one set of issues for another, so not always the right answer
- Inheritance works well for logical reasoning about game objects and taxonomies
- Shallow inheritance with composition can be both performant and easier to maintain

# COMPONENTS

- One “hub” object contains pointers to instances of various service class instances as needed (e.g. composition).



# COMPONENT-BASED EXAMPLE (1/2)

```
class GameObject {

protected:

    //  My transform (position, rotation, scale)
    Transform m_transform;

    // Standard components

    MeshInstance* m_pMeshInst;

    AnimationController* m_pAnimController;

    RigidBody* m_pRigidBody

public:

    GameObject() {

        ...
```

# COMPONENT-BASED EXAMPLE (2/2)

```
GameObject() {

    // Assume no components. Derived classes will override

    m_pMeshInst = nullptr;

    m_pAnimController = nullptr;

    m_pRigidBody = nullptr;

}

~GameObject() {
    // Automatically delete any components

    delete m_pMeshInst;

    delete m_pAnimController;

    delete m_pRigidBody;

};
```

# COMPONENT-BASED EXAMPLE WITH INHERITANCE (1/2)

```
class Vehicle : public GameObject {

protected:

    // Add some more components specific to vehicles

    Chassis* m_pChassis;

    Engine*  m_pEngine;

    // ...

public:

    Vehicle();

   ~Vehicle();
```

# COMPONENT-BASED EXAMPLE WITH INHERITANCE (2/2)

```
Vehicle::Vehicle() {

        // Construct standard GameObject components

        m_pMeshInst = new MeshInstance();

        m_pRigidBody = new RigidBody();

        m_pAnimController = new AnimationController(*m_pMeshInst);

        // Construct vehicle-specific components

        m_pChassis = new Chassis(*this, *m_pAnimController);

        m_pEngine = new Engine(*this);

    }

Vehicle::~Vehicle() {

        // Only need to destroy vehicle-specific components

        delete m_pChassis;

        delete m_pEngine;

    }

};
```

# USING COMPOSITION

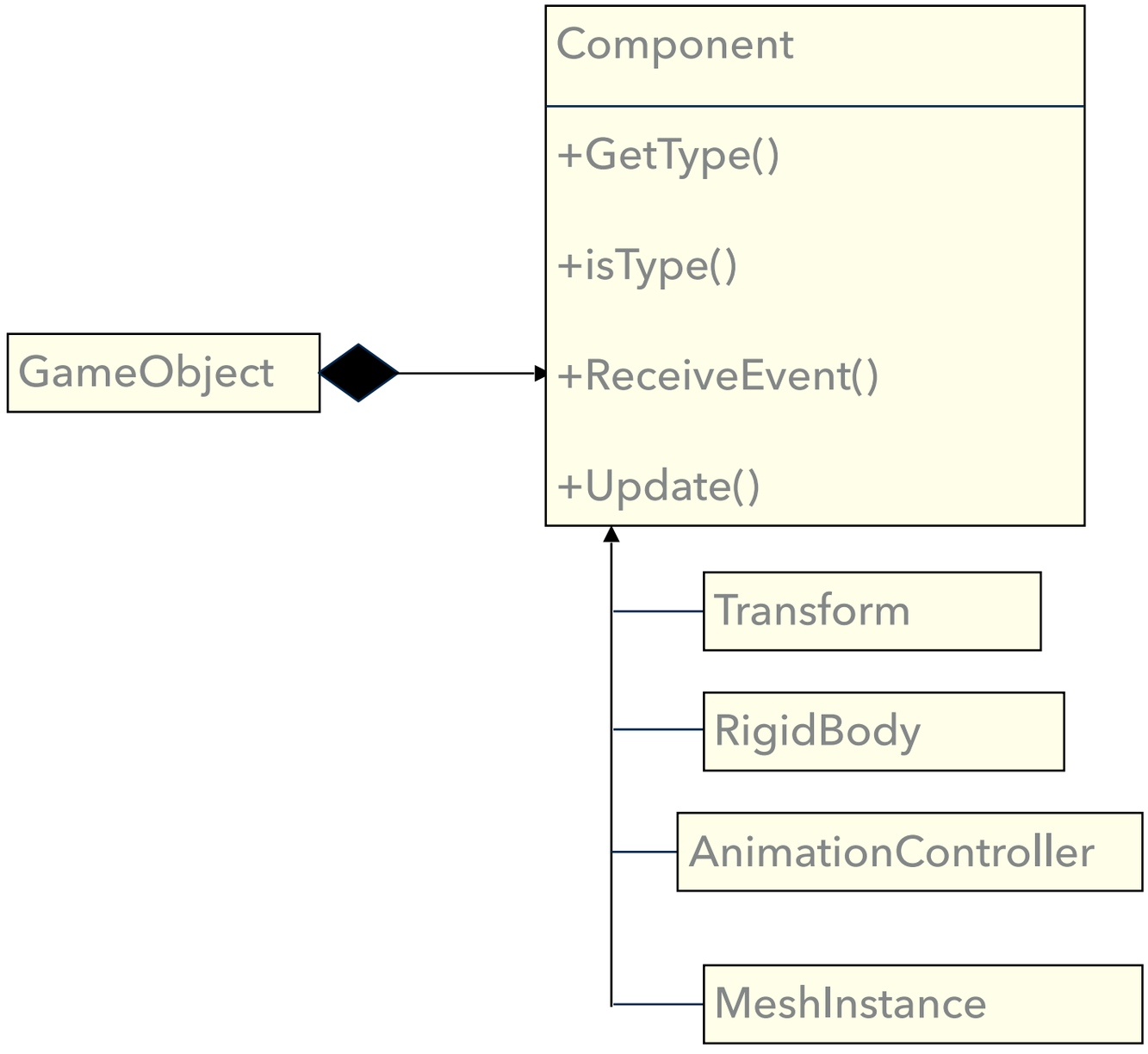
- "Hub" class owns its components and manages their lifetimes (i.e. creates and destroys them)
- Naive component creation:
  - The GameObject class has pointers to all possible components, initialized to nullptr
  - Only creates needed components for a given derived class
  - Destructor cleans up all possible components for convenience
  - All optional add-on features for derived classes are in component classes

# MORE FLEXIBLE (AND COMPLEX) ALTERNATIVE

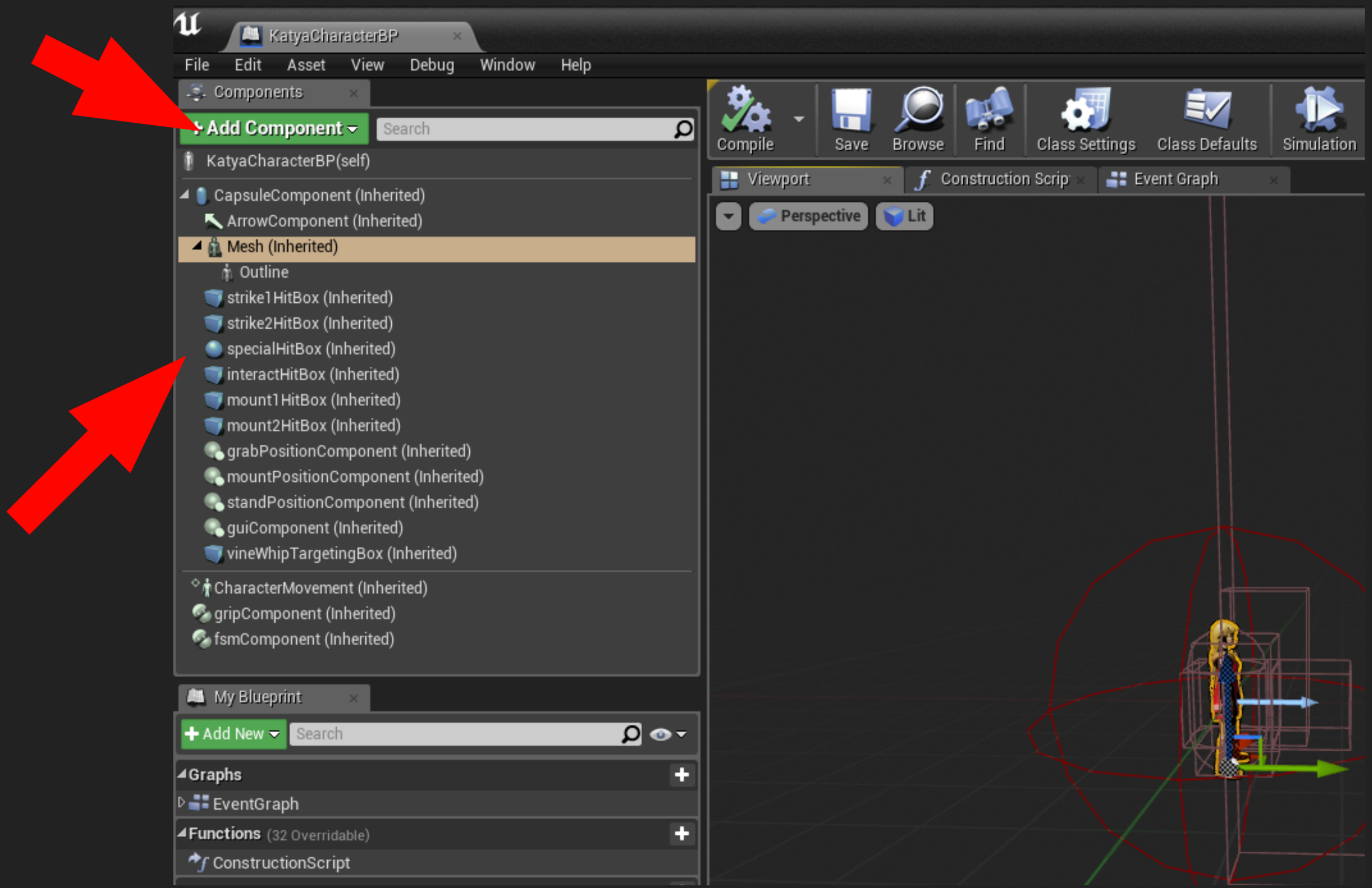
- Root GameObject contains a list of generic components

- Derive specific components from the component base class

- Allows arbitrary number of instances and types of components



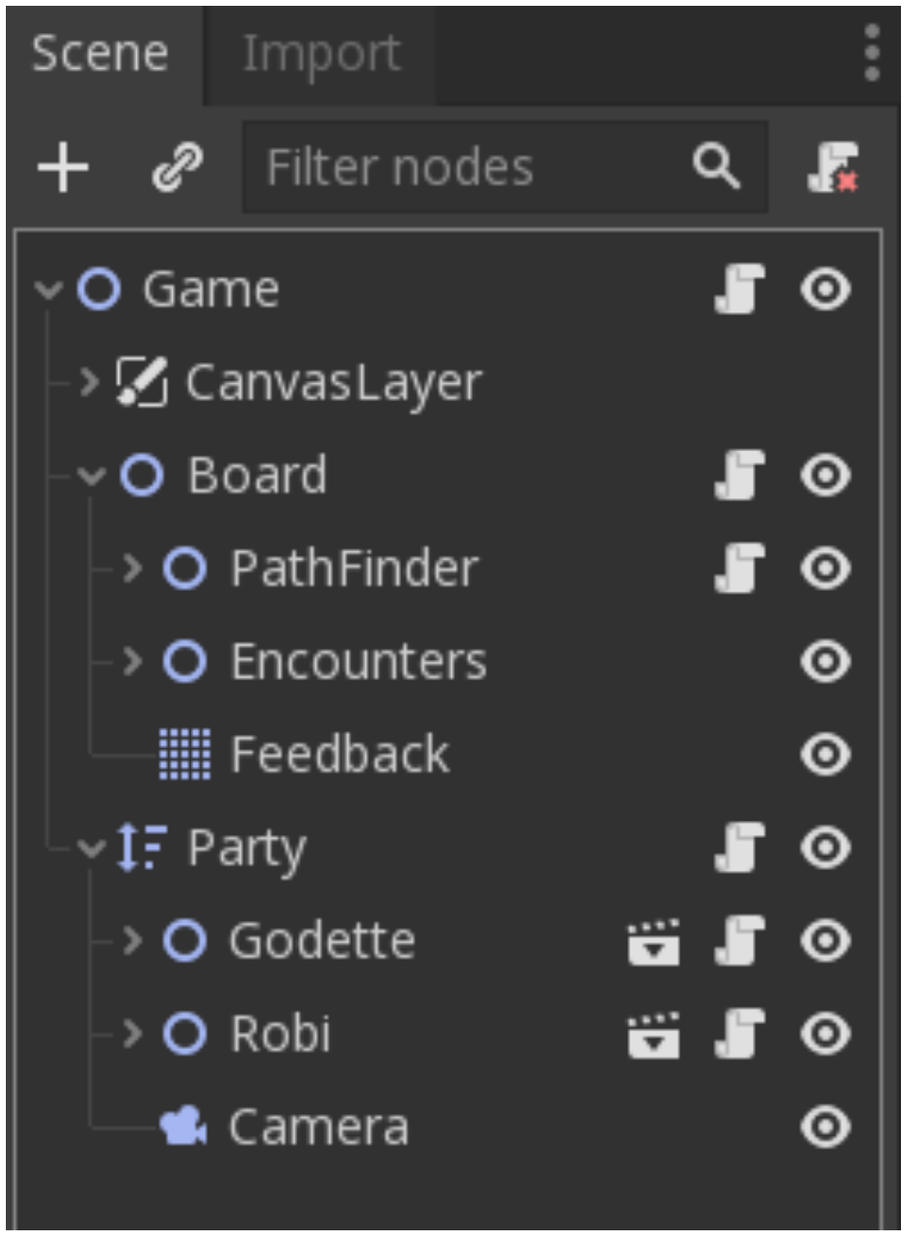
# EXAMPLE: UE4 AND UACTORCOMPONENTS



# AGGREGATION VERSUS COMPOSITION

- In composition, child life cycle is managed by parent object
  - Child cannot exist outside of parent object
- In aggregation, child life cycle exists outside of parent object
  - Child exists outside of parent object but can be associated with parent object

# EXAMPLE: GODOT AND SCENES




https://github.com/razcore-art/godot-open-rpg

# DO WE NEED A GAME OBJECT?

- We can reduce GameObject to an id and a list of its components
  - Id is unique to each game object (entity)
  - Components of a game object describe properties of that game object
  - Systems run on all their associated components to update game object
- Basis of Entity-Component-System style architecture

# PROPERTY-CENTRIC ARCHITECTURES

- Think in terms of properties (attributes) of objects rather than in terms of objects
- For each property, build a table containing that property's values keyed by object ID
- Now you get something like a relational database
  - Each property is like a column in a database table whose primary key is the object ID
- Object's behavior defined by its property types and scripts
  - Scripts have a script ID in object's properties and can be the target of messages