Architecture

Prerequisites

- C Programming
- C++ Object Oriented Programming
  - Classes
  - Inheritance
  - Virtual Functions

Architecture

- Architecture is the organizational structure of a system, including its decomposition into parts, their connectivity, interaction mechanisms, and the guiding principles and decisions that you use in the design of the system.

Architecture Principles

- Same for all languages
- Fundamental, not just a strategy for implementation
- These are the guiding principles on which all design patterns are built

Architecture Principle #1

Simplify.

Simplicity

- **Architecture is simplicity**
- “Everything should be made as simple as possible, but not simpler.” – Albert Einstein
- The job of the architect is to make all the other programmers’ job simple.
- Do not build complexity for complexity’s sake.

Simplify Code

- Removing Redundancy (Serialization, File IO, Cross Platform)
- Providing a common interaction system (Messaging)
- Removing Redundancy
- Standardizing certain solutions. (STL, containers)

Architecture Principle #2

Embrace change.

Embrace Change

- Plan for change.
- Build for change.
- Develop good enough.
- Maximize flexibility while maintaining simplicity.
- Data drive functionality.
- Do not waste time building what may not be needed.
- Bias towards ACTION.
- Iteration Wins.

Architecture Principle #3

Organize by what it does.

Organize by what it does

- Code should be divided into functional atomic pieces.
- Also applies to systems, code files, etc.
- However, simplicity and flexibility are more important.
- Organize by what it does, not by what it IS.

Organize by what it does

- If the code does not do something why does it exist?
- Think in terms of functionality.
- Code is transformations of sets of data.
- One class one responsibility. Also called the Single Responsibility Principle (SRP)

Architecture Principle #4

Encapsulate what varies.

Encapsulate variability

- Program to an abstraction not an implementation.
- Move the code and responsibility inside abstracted object.
- In C++, delegate varying behavior to the abstracted object, such as serialization, loading, updating, etc.

Bad Abstractions

- Functional abstractions not a model of the real world.

Architecture Principle #5

Minimize Dependencies.

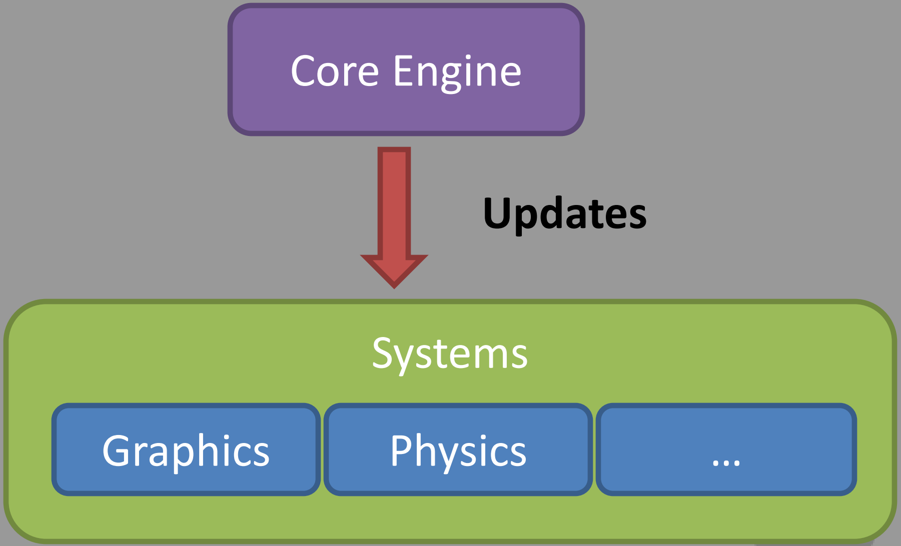
Dependencies

- Dependencies can be code, headers, people, libraries, etc.
- Minimize does not mean eliminate
- Good libraries can help by moving responsibility to specialists and leveraging broadly used code
- Strive for loose coupling between all objects.
- **Do not create artificial dependencies!**

High Level

- Game engine consists of systems.
- Each system is in charge of a single aspect of the game:
  - Graphics
  - Physics
  - Logic
  - Etc.
- Every frame each system is updated.

Simple Game Engine



How do these system communicate and share data?

Game Objects

Game Objects

- Pieces of logical interactive content.
- Have data that all systems need.
- For this example an RTS:
  - Tanks
  - Bombers
  - Infantry
  - Bases
- Also things like triggers, trees, etc.

Game Objects

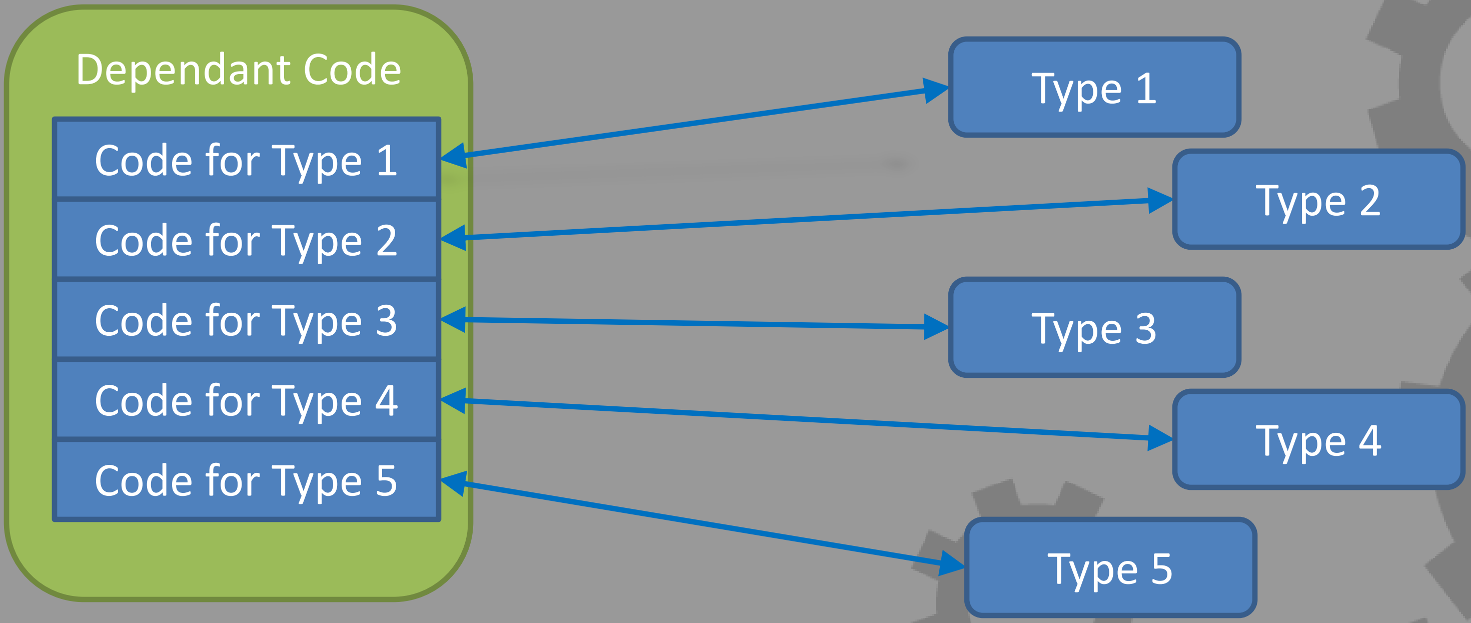
- So how do we build game objects?
- Start with basic object oriented principles
  - – Base class called GameObject
  - – Specialization derived from this class.

Abstraction

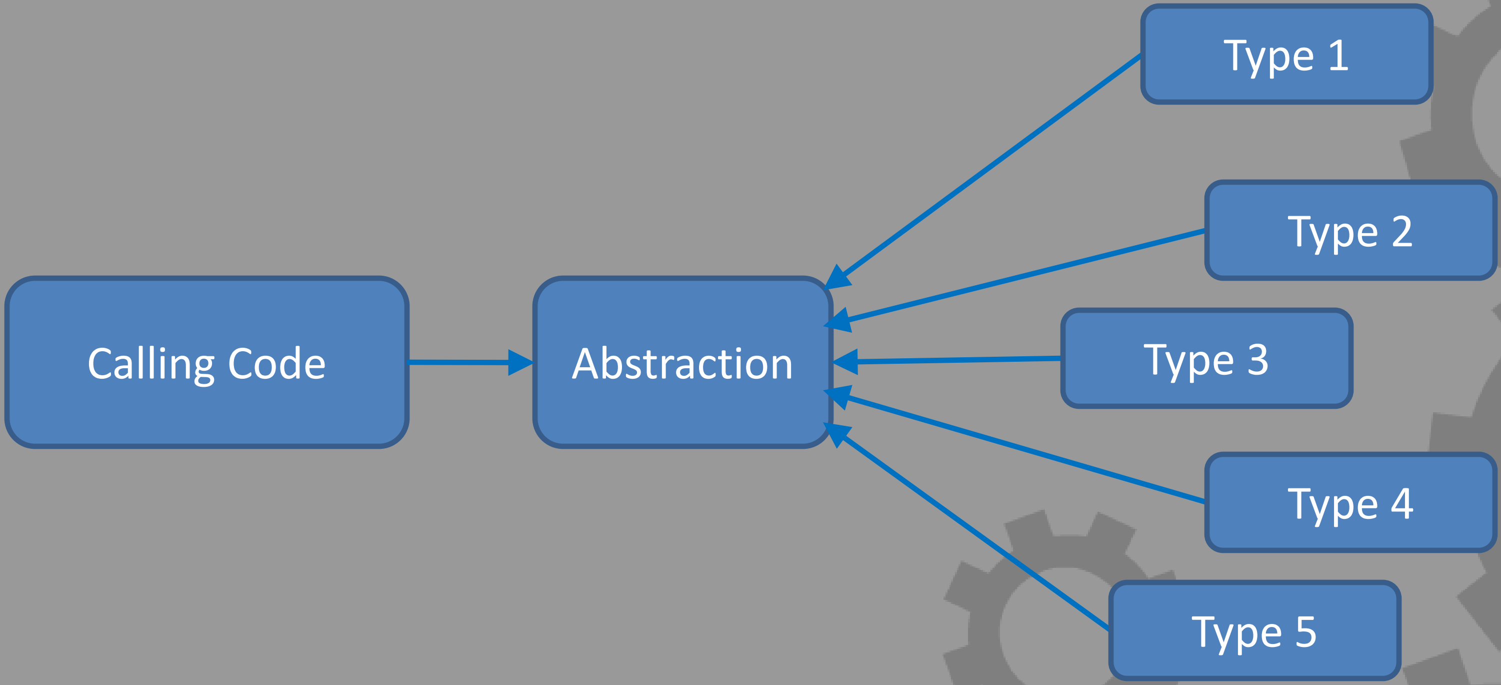
Dependant Code Example

```
void GameLogic::FireGun(GameObject* go)
{
    if( go->Type == “Sniper” )
           //Code for firing sniper rifle
    else if( go->Type == “Rifleman” )
           //Code for firing rifle
    else if( go->Type == “MachineGunner” )
           //Code for firing machine gun
}
```

Dependant Code



Abstraction

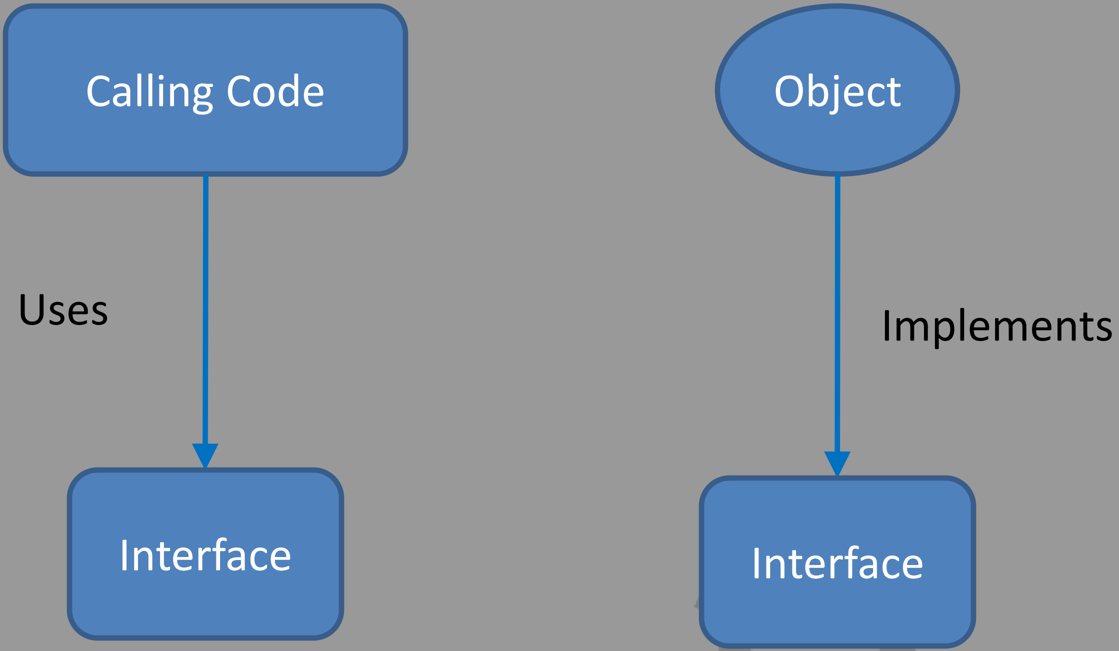


Abstraction Code Example

```
class Infantry
{
    virtual void FireGun();
};

void FireGun(GameObject* go)
{
    go->FireGun();
}

void OtherCode(GO* go)
{
    go->FireGun();
}
```

```
class Infantry
{
  virtual void FireGun();
};

class Sniper : public Infantry
{
  virtual void FireGun()
  {
      //Code for firing sniper
      rifle
  }
};
```

Abstraction



Abstraction

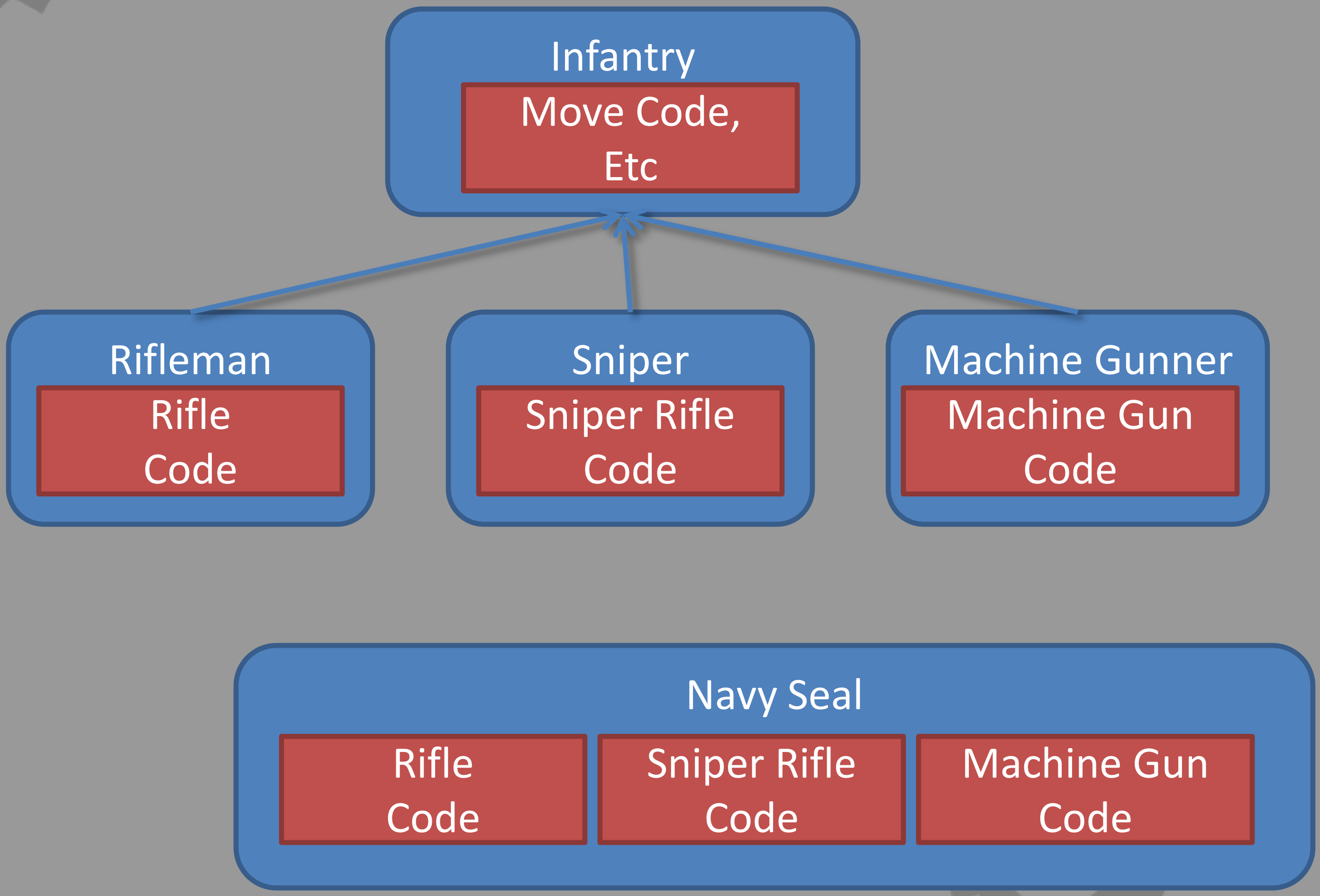
- Calling code can treat all objects with same abstraction as if they are the same.
- Calling code now relies on an abstraction and the implementation now also relies on an abstraction.
- Abstraction applies to more than just methods, it also applies to objects, algorithms, data, relationships, etc.

Interface

- **Interface** – An interface abstracts a set of operations on an object
- In C++ this is implemented with virtual functions and inheritance
- Virtual functions come with a low cost in both memory and performance
- Interfaces are a fundamental code concept and are provided by almost all object oriented languages
- This is formally called **polymorphism**

Architecture Strategy

Program to an abstraction, not an implementation.



Infantry

Move Code, Etc

Rifleman

Rifle Code

Sniper

Sniper Rifle Code

Machine Gunner

Machine Gun Code

Navy Seal

Rifle Code

Sniper Rifle Code

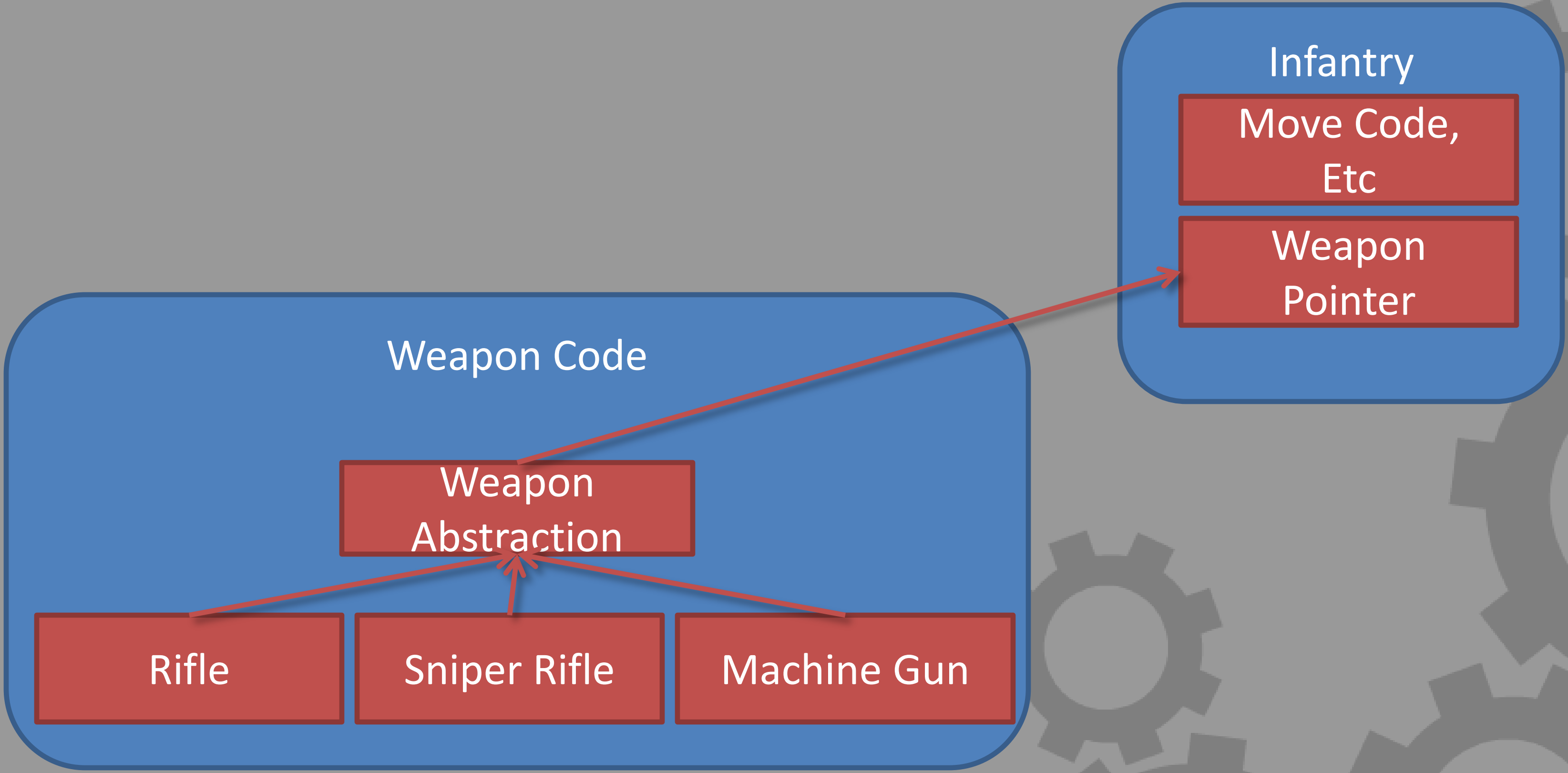
Machine Gun Code

What went wrong?

IS-A vs HAS-A

- We did not organize our code well.
- Prefer “has a” to “is a” relationships.
- Many relationships are better modeled with aggregation instead of inheritance.
- Has a relationships are more flexible.

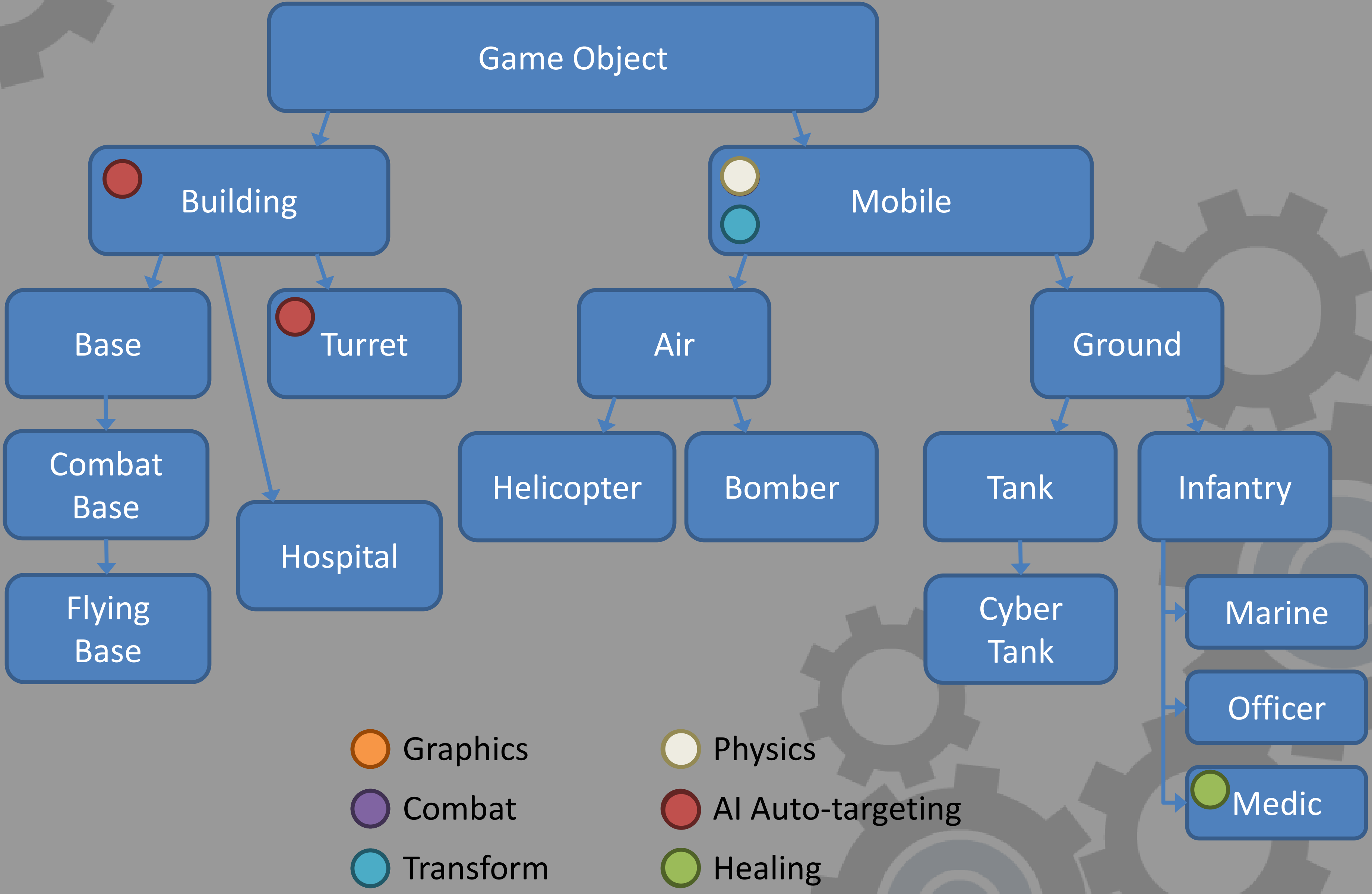
Infantry has a weapon



Architecture Strategy

Identify aspects of the code that vary and separate them from those that stay the same.

Game Object System



Game Object

🔴 Building

⚪ 🔵 Mobile

Base

🔴 Turret

Air

Ground

Combat Base

Hospital

Helicopter

Bomber

Tank

Infantry

Flying Base

Cyber Tank

Marine

Officer

🟢 Medic

🟠 Graphics

🟣 Combat

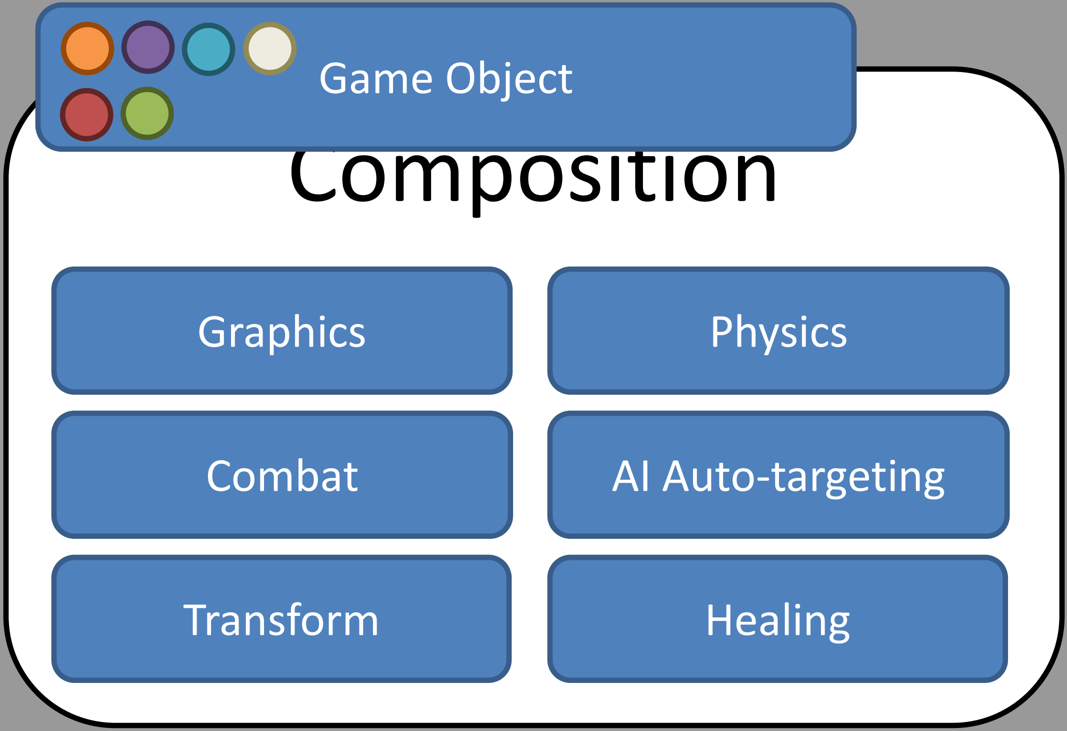
🔵 Transform

⚪ Physics

🔴 AI Auto-targeting

🟢 Healing

Composition



Game Object

Graphics

Physics

Combat

AI Auto-targeting

Transform

Healing

Aggregation vs Composition

- Aggregation
  - Object references different objects.
  - Not necessarily lifetime bound.
  - Multiple objects may reference the same aggregated object.
- Composition
  - Object owns different objects called components.
  - Components do not exist outside of composition.
  - When composition is destroyed so are components.
  - Each component has only one owner.

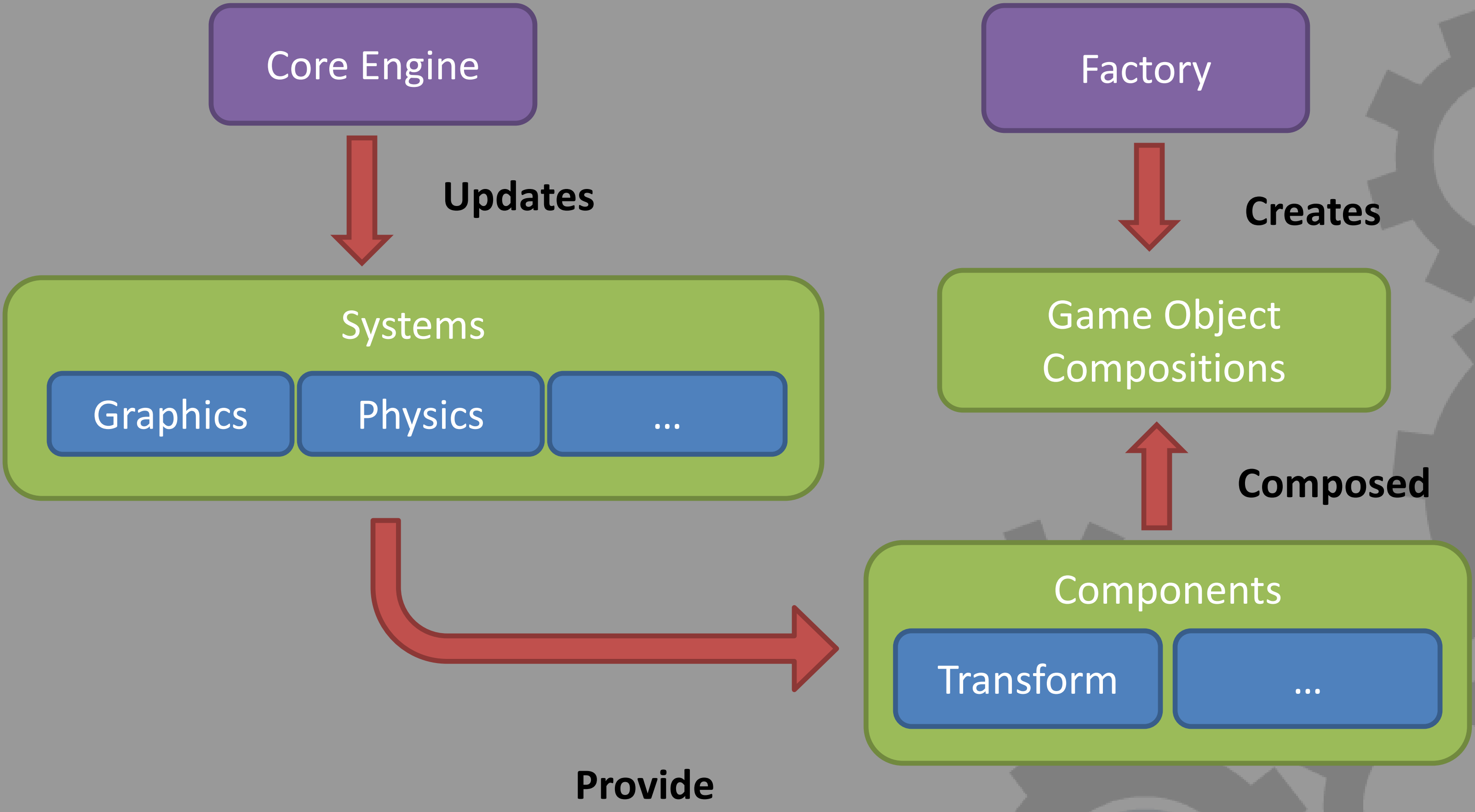
Architecture Strategy

Always prefer aggregation and composition to inheritance.

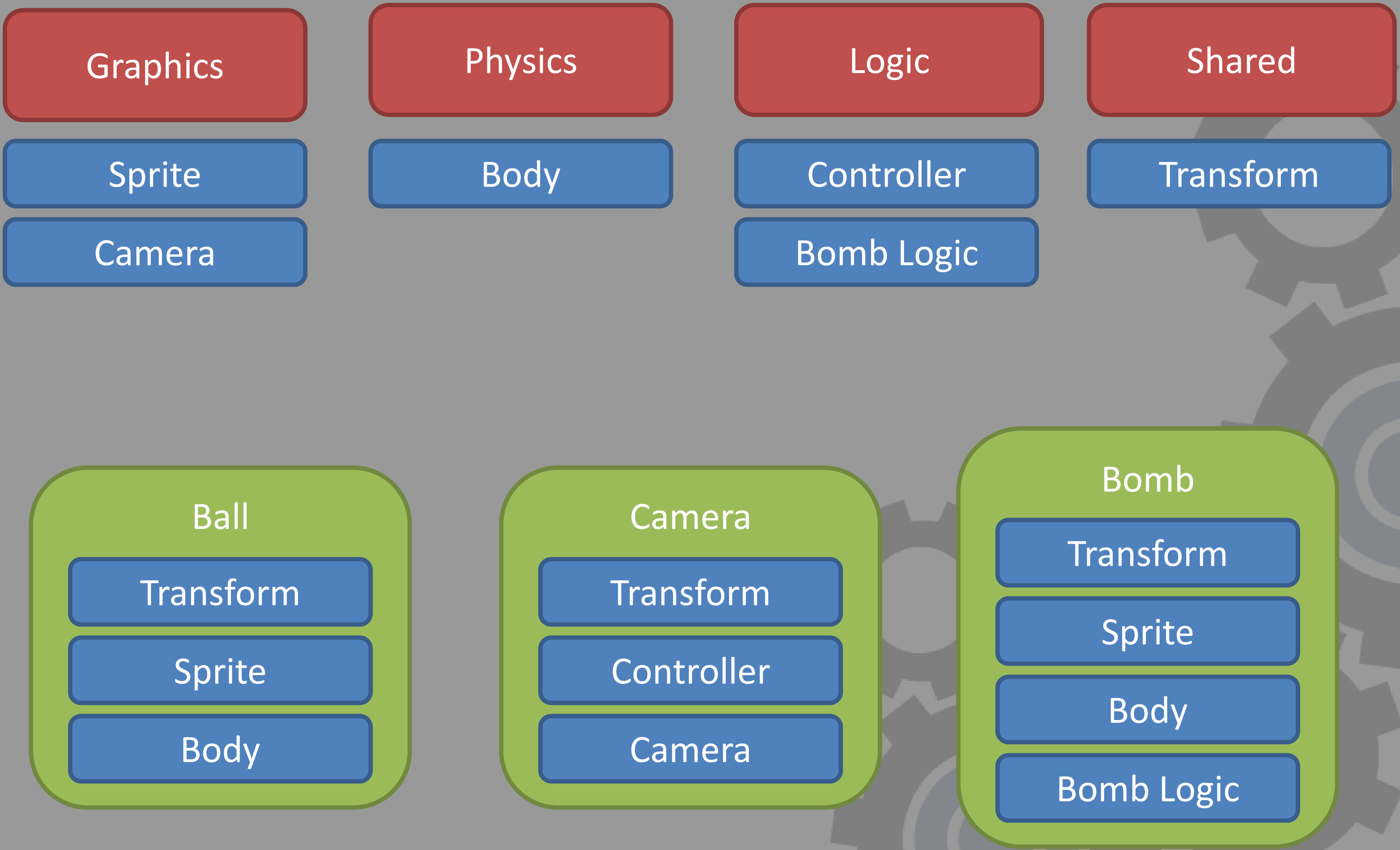
Component Based Engine

- The base class is a collection of components provided by the different systems.
- The components represent orthogonal views of a single entity.
- Every component class inherits from a base component class and has pointer to its owning composition.
- A component can be data, behavior, and/or a link to a system.
- When the game object composition is destroyed it destroys all of its components.

Component Based Engine



Simple Components



Graphics

Sprite

Camera

Physics

Body

Logic

Controller

Bomb Logic

Shared

Transform

Ball

Transform

Sprite

Body

Camera

Transform

Controller

Camera

Bomb

Transform

Sprite

Body

Bomb Logic

Dependencies between components

- Components still have dependencies between each other.
- Need a flexible simple way for components to handle dependencies.
- To allow for inspections of a composition we need to provide a query function.
- This is done to having a std::map of strings to component pointers.

Dynamic Linking

```
void Sprite::Initialize(GameObject* parent)
{
    // Looks up component named “Transform” in map
    // Using the ‘has’ operation
    this->Transform = GetOwner()->has(Transform);
    //
    // Add any additional dependencies here
    //
}
```

Architecture Strategy

Strive for loose coupling between objects.

Dynamic Interaction

```cpp
void Game::MoveObjectLeft(GameObject* ObjectToBeMoved)
{
  if(Transform* transform =
           ObjectToBeMoved->has(Transform) )
    {
        transform->position.x -= 10;
    }
}
```

Static Linking and Composition

- Could also just have a pointer to each component type.
- Pointer is NULL if component is not present.
- Not as elegant but fast.

Questions?