Coupling, Cohesion, & GRASP

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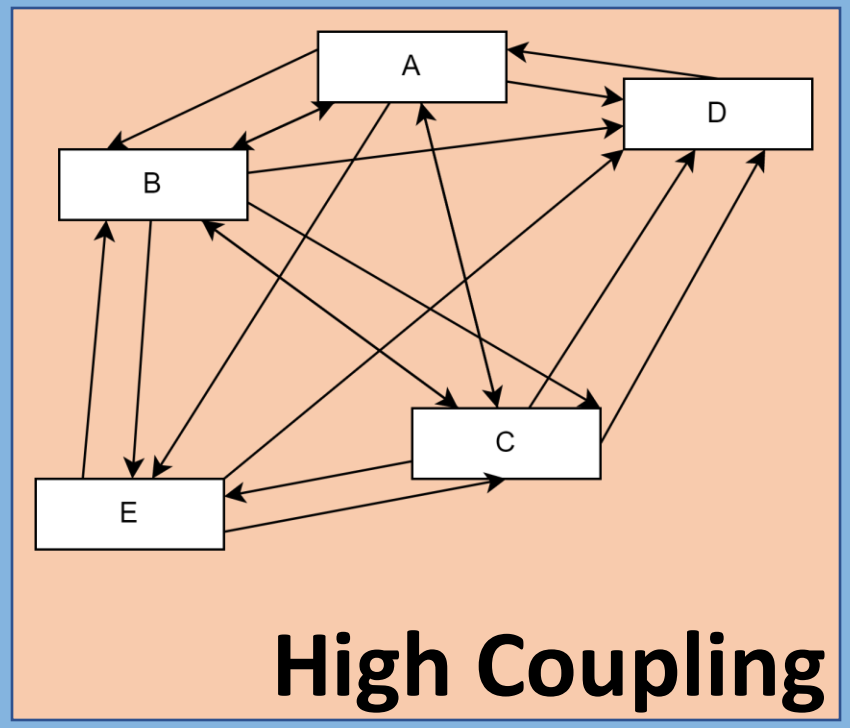
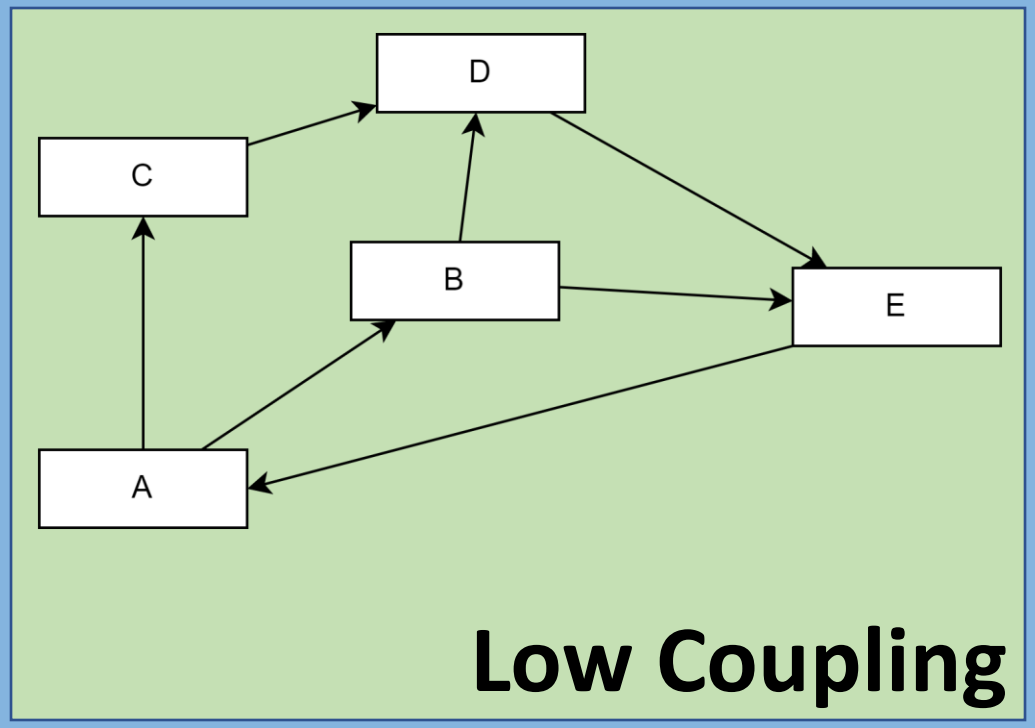
General Outline

- Introductions
- Coupling -- Hunter
- Cohesion -- Al
- Visibility – Jenna pura0273@vandals.
- GRASP
- Critique Gantt charts
- Overview of how our Master Gantt charts work (if there's time)

Coupling

- Describes how connected software modules are to each other



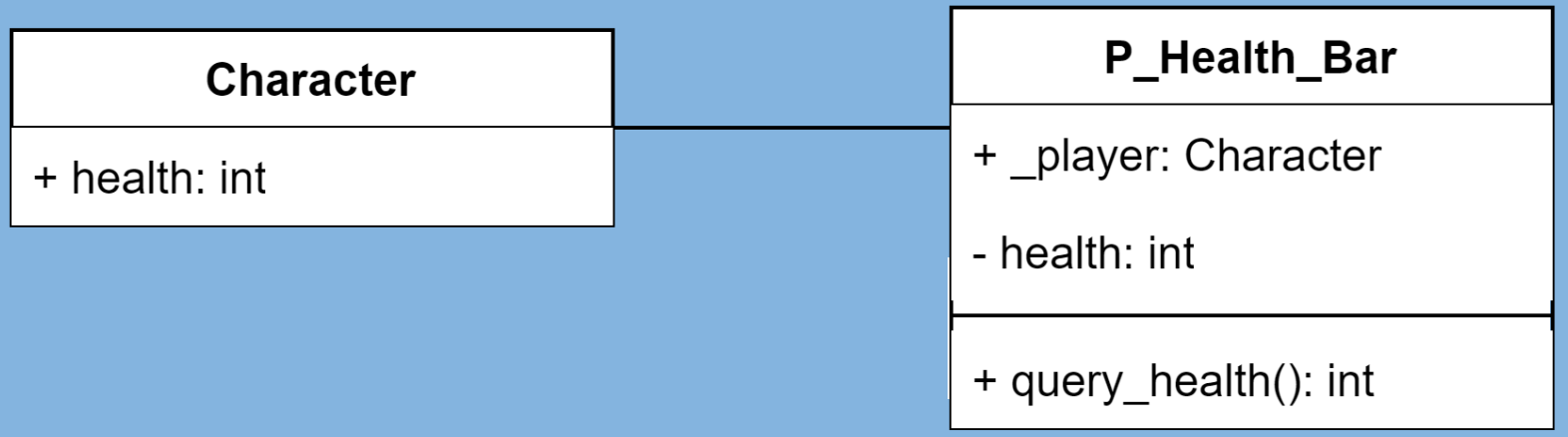


Levels of Coupling

- W Content
- Common
- Control
- Stamp
- B Data

Content Coupling

- Worst level of coupling
- Occurs when one module directly references or changes another module’s contents
- This forces modules to be highly dependent on each other

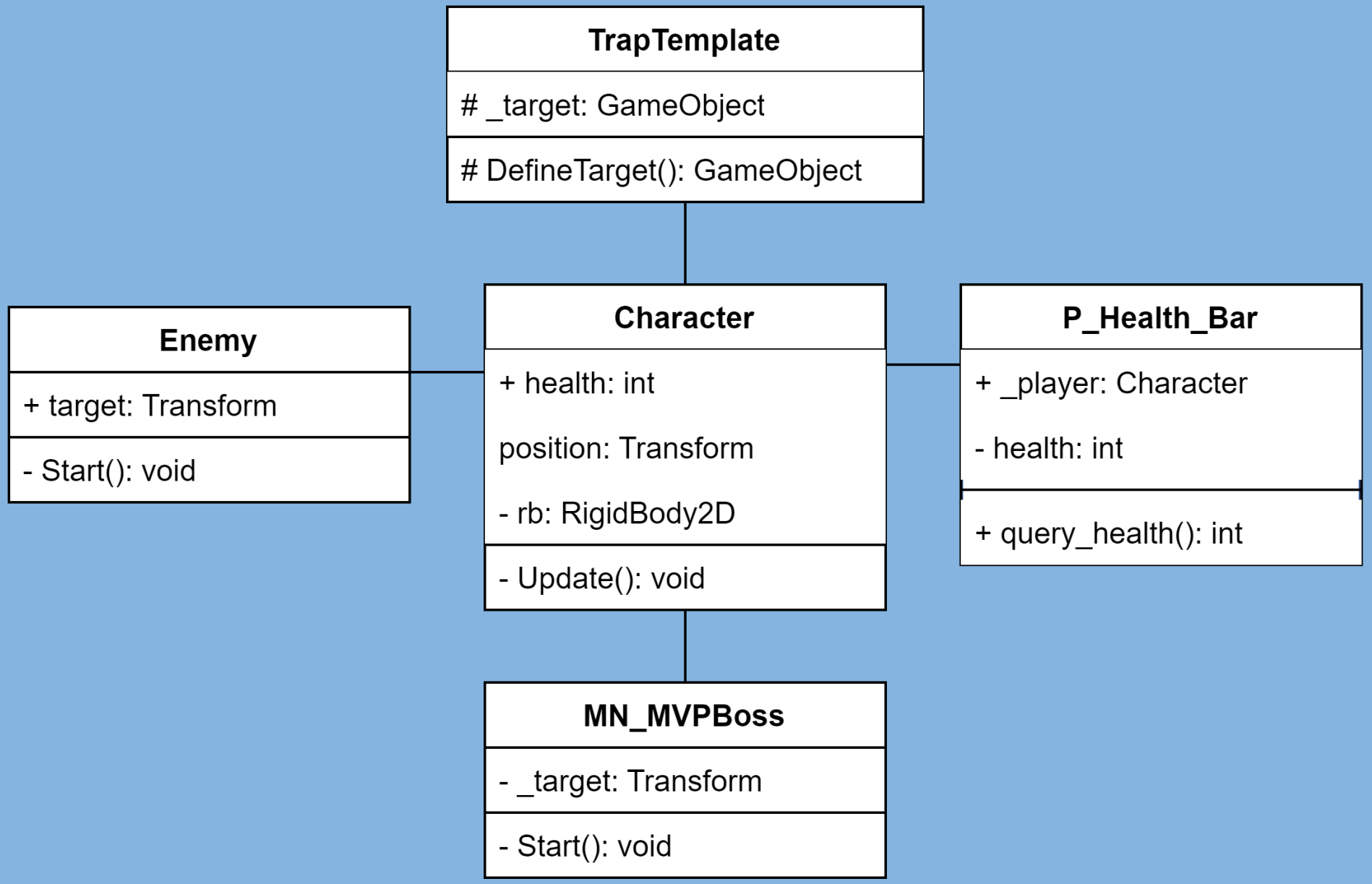



```
public class Character : MonoBehaviour
{
    ...

    public int health;

    ...
}
```

```
public class P_Health_Bar : MonoBehaviour
{
    ...
    public Character _player;
    private int health;
    ...
    public int query_health()
    {
        health = _player.health;
        return health;
    }
    ...
}
```

Common Coupling

- Occurs when multiple modules can read and/or write to the same global resource
- This can cause unintended consequences when changes are made to the global resource

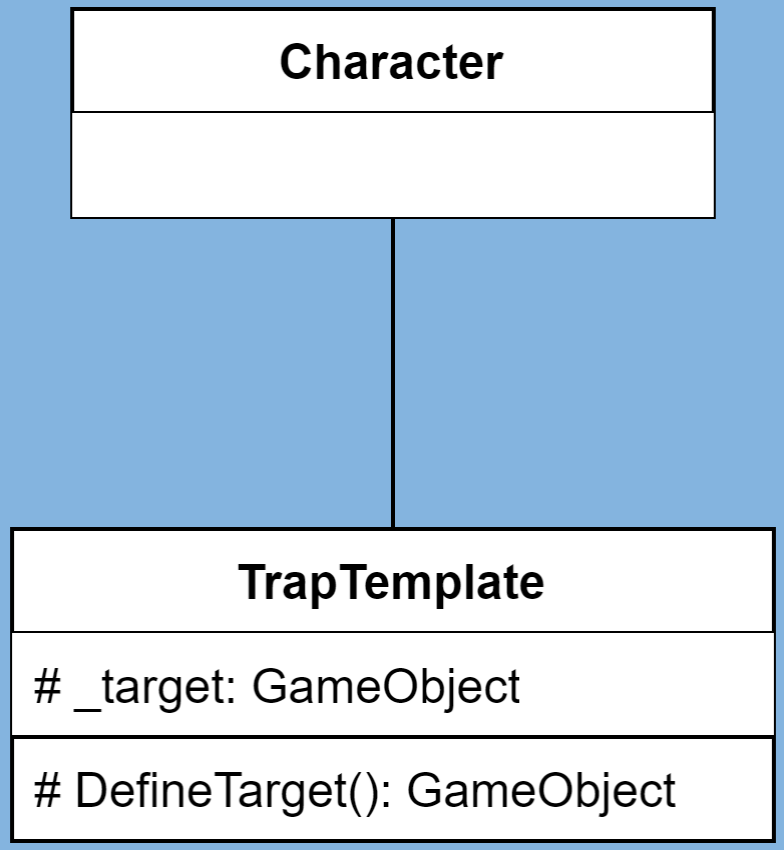

TrapTemplate
_target: GameObject
DefineTarget(): GameObject
Enemy
+ target: Transform
- Start(): void
Character
+ health: int
position: Transform
- rb: RigidBody2D
- Update(): void
P_Health_Bar
+ _player: Character
- health: int
+ query_health(): int
MN_MVPBoss
- _target: Transform
- Start(): void

Control Coupling

- Occurs when one module of code passes control to another module
- Requires one module to tell another module what to do, rather than letting that second module make decisions based on its own state.

Stamp Coupling

- Occurs when one module passes an entire data structure to another module, when the second module only needs select fields from the first module.
- This passes more data between modules than necessary

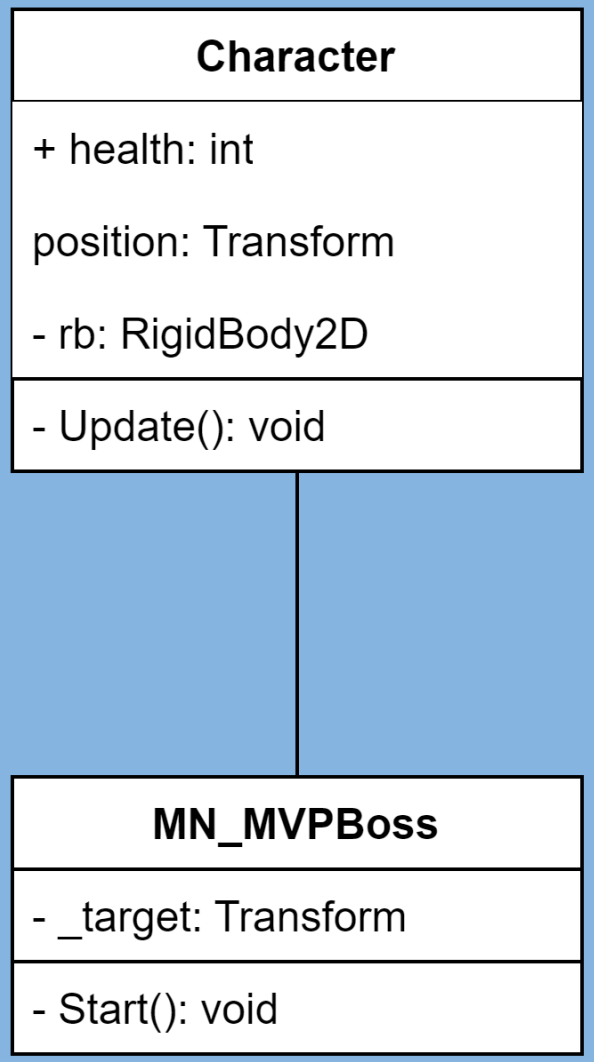



```
public class Character : MonoBehaviour
{
    ...
}
```

```
public abstract class TrapTemplate : MonoBehaviour
{
    ...
    protected GameObject _target;
    ...
    protected GameObject DefineTarget()
    {
        GameObject target = GameObject.FindGameObjectWithTag("Player");
        _target = target;
        return target;
    }
    ...
}
```

Data Coupling

- The best level of coupling
- Occurs when relationships between modules are simple operations, and there are no unused fields in shared data structures
- This lowers the dependencies between modules




```
public class Character : MonoBehaviour
{
    ...
    Rigidbody2D rb;
    ...
    void Update()
    {
        //Moves the player based upon WASD input
        float horizontal = Input.GetAxis("Horizontal");
        float vertical = Input.GetAxis("Vertical");
        Vector3 temp = new Vector3(horizontal, vertical, 0);
        temp = temp.normalized * speed * Time.deltaTime;
        rb.MovePosition(rb.transform.position + temp);
    }
}
```

```
public class MN_MVPBoss : MonoBehaviour
{
    ...
    private Transform _target;

    void Start()
    {
        ...
        _target = GameObject.FindGameObjectWithTag("Player").transform;
    }
    ...
}
```

Subclasses and Coupling

- When 2 modules are in a subclass and superclass relationship, there is inherently a strong coupling between them

```
public abstract class TrapTemplate : MonoBehaviour
{
    protected int p_trapDamage;
    protected float p_trapSpeed;
    protected Vector3 p_projectileSpeed;
    protected GameObject p_trapObject;
    protected GameObject _target;
    public GameObject trapProjectile;
    protected Rigidbody2D p_trapBody;
    protected bool _isLoaded = true;
    ...
}
```

```
public class CrossbowTrap : TrapTemplate
{
    void Start()
    {
        p_trapBody = GetComponent<Rigidbody2D>();
        p_trapObject = gameObject;
        p_trapSpeed = 1f;
        p_projectileSpeed = transform.up * 10;
        DefineTarget();

    }
    ...
}
```

Cohesion

- The measure at which elements within a module interact to increase use/performance

- The Goal
  1. Increased clarity
  2. Ease of maintenance
  3. Reusability

Levels of Cohesion

Worst

Coincidental

Logical

Temporal

Procedural

Communicational

Best

Functional or Informational

Coincidental Cohesion (worst)

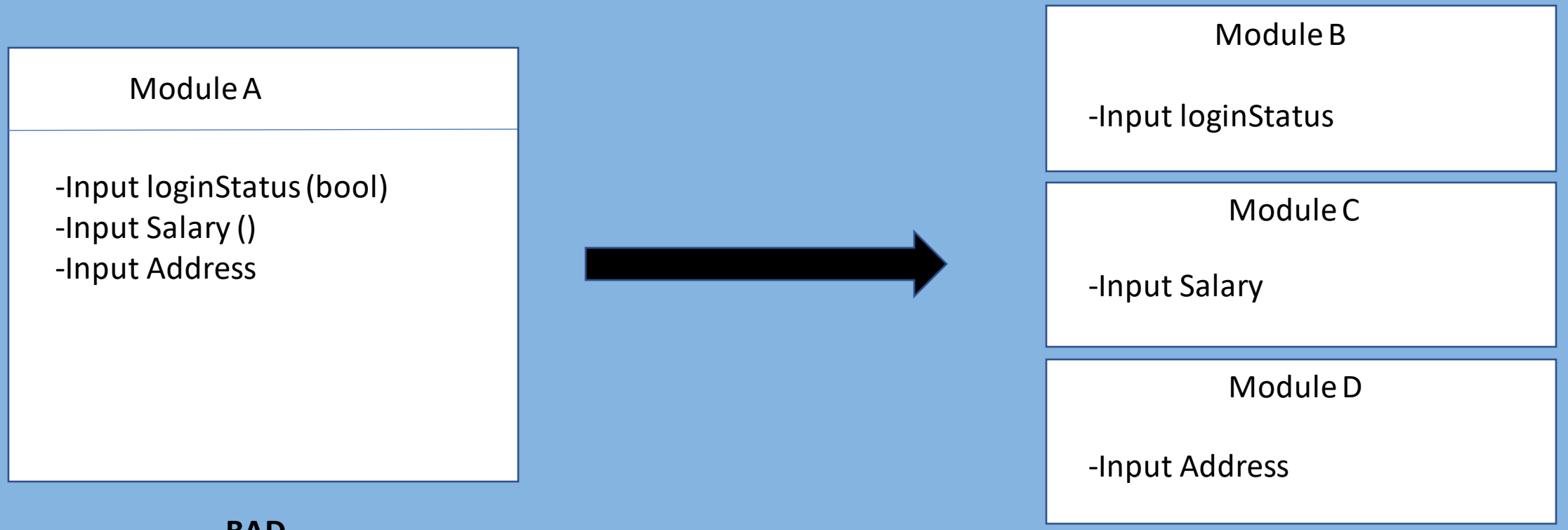
- When elements of a module are loosely related or unrelated entirely

```
public class HealthManager : MonoBehaviour
{
    2 references
    private GameObject player;

    2 references
    private Rigidbody2D rb;

    1 reference
    public float force;

    1 reference
    public static bool isOver = false;

    1 reference
    public Image healthBar;

    [SerializeField]
    5 references
    public float healthAmt = 100f;

    [SerializeField]
    1 reference
    public float damage = 34f;

    //Snowball - shoot in the direction of the palyer
    0 references
    void Start() ···
    //snowball boundary collision
    0 references
    private void OnCollisionEnter2D(Collision2D collision) ···

    // Update is called once per frame
    0 references
    void Update() { }
    //player collision upon boss give damage
    0 references
    private void OnCollisionEnter2D(Collision2D collision) ···

    1 reference
    public void takeDamage(float damage) ···
}
```

Logical Cohesion

- Module containing elements of similar actions typical I/O

- Ex.

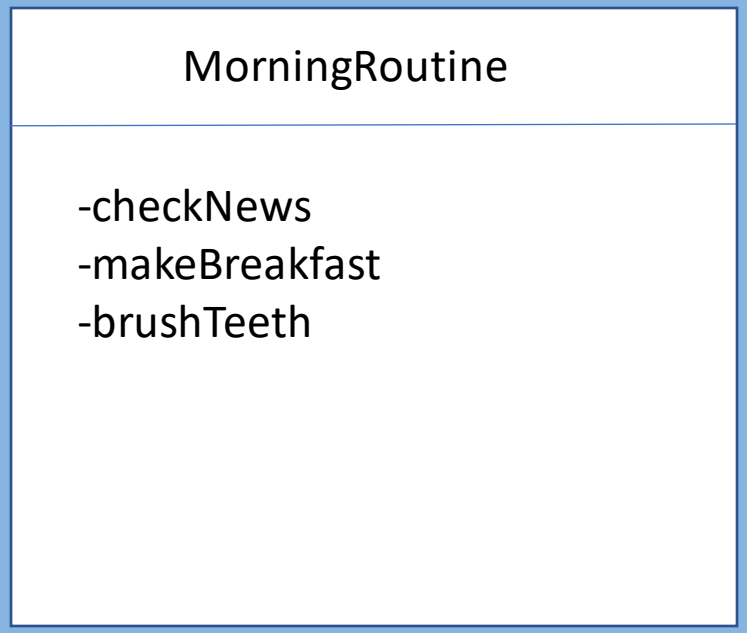


BAD

Temporal Cohesion

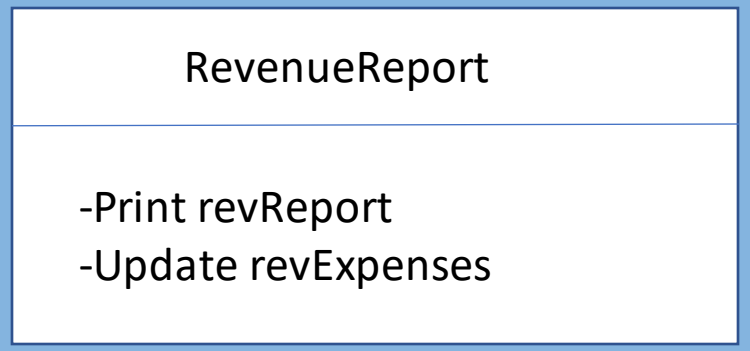
- Elements within a module are related by time

- Ex.



Procedural Cohesion

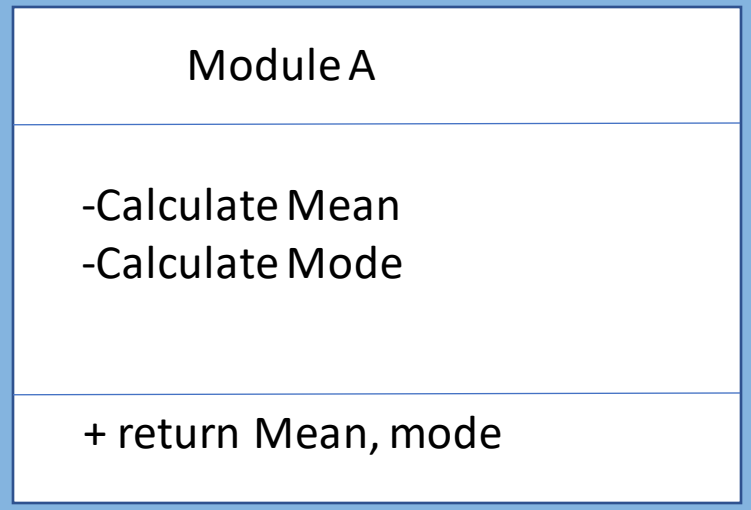
- Elements within a module are related by the sequence followed by product
- Modules of this type : Combine decision making and task execution
- Ex.



Communicational Cohesion

- Elements within a module are related by the data they all operate upon and contributing to the same output

- Ex.



Functional Cohesion (Best)

- Elements within a module performs an action in a 1-to-1 case

- Ex.

```
public static class PlayerSingleton {
    4 references
    static Player m_Player;

    //Public getter
    1 reference
    public static Player Player {
        get {
            if (m_Player != null) {
                return m_Player;
            } else {
                try {
                    m_Player = GameObject.FindWithTag("Player").GetComponent<Player>();

                } catch (Exception e) {
                    throw new Exception("Got an exception while finding the player: " + e.Message);
                }
                return m_Player;
            }
        }
    }
}
```

Informational Cohesion (Best)

- Elements within a module each have their own entry point, exit, and independent code

- Ex.

```
public float horizontal {
    get {
        return m_horizontal;
    }
}

1 reference
public bool vertical {
    get {
        return m_vertical;
    }
}
```

```
public class PlayerComputer : PlayerController {

    0 references
    public new float horizontal {
        get {
            return m_horizontal;
        }
        set {
            m_horizontal = value;
        }
    }
```

Visibility

- How accessible is a variable in a program?
- Ability for one object to see and refer to another object
- For object A to send a message to object B, B must be visible to A

Types of Visibility

- Attribute
- Parameter
- Local
- Global

Attribute Visibility

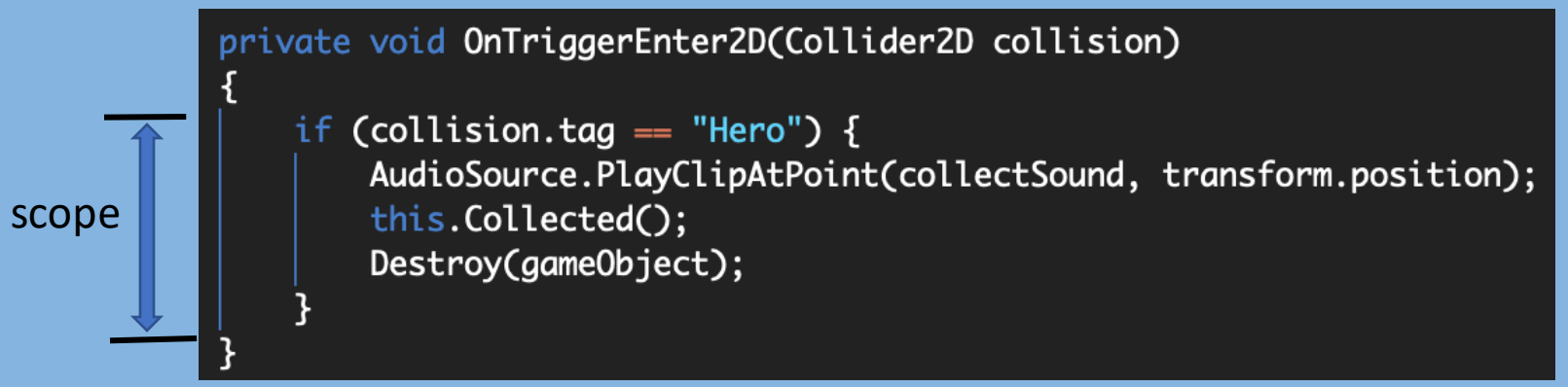
- B is an attribute of A
- A: *class Hero*
- B: *public float jumpForce*
- Permanent visibility
  - Remains if A and B exists

```
public class Hero : MonoBehaviour
{
    public float jumpForce;
    public float movementSpeed;

    private Rigidbody2D rb;
    //private Animator anim;
    private SpriteRenderer sprite;
```

Nathan, Hero.cs

Parameter Visibility

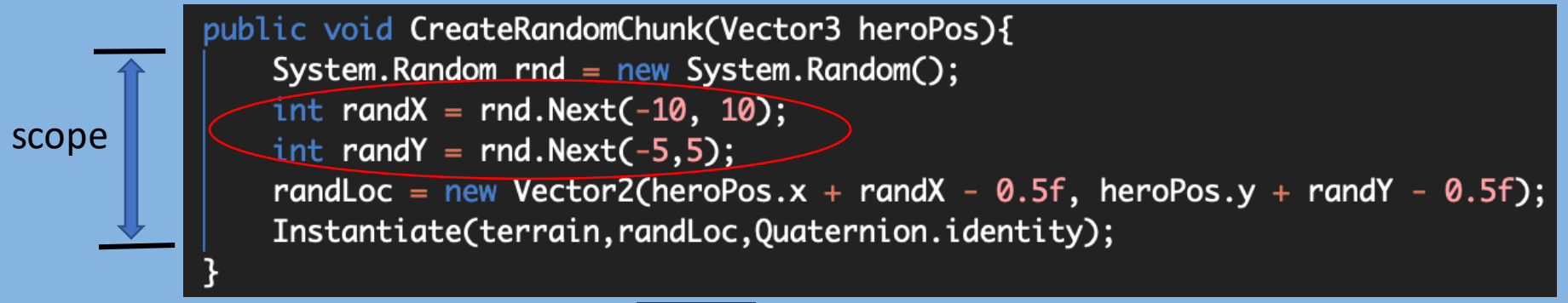
- B is passed as a parameter to a method of A
- Method of A: *void OnTriggerEvent2D*, B: *Collider2D collision*
- Temporary visibility
  - Remains only within the scope of the method



Logan, Item.cs

Local Visibility

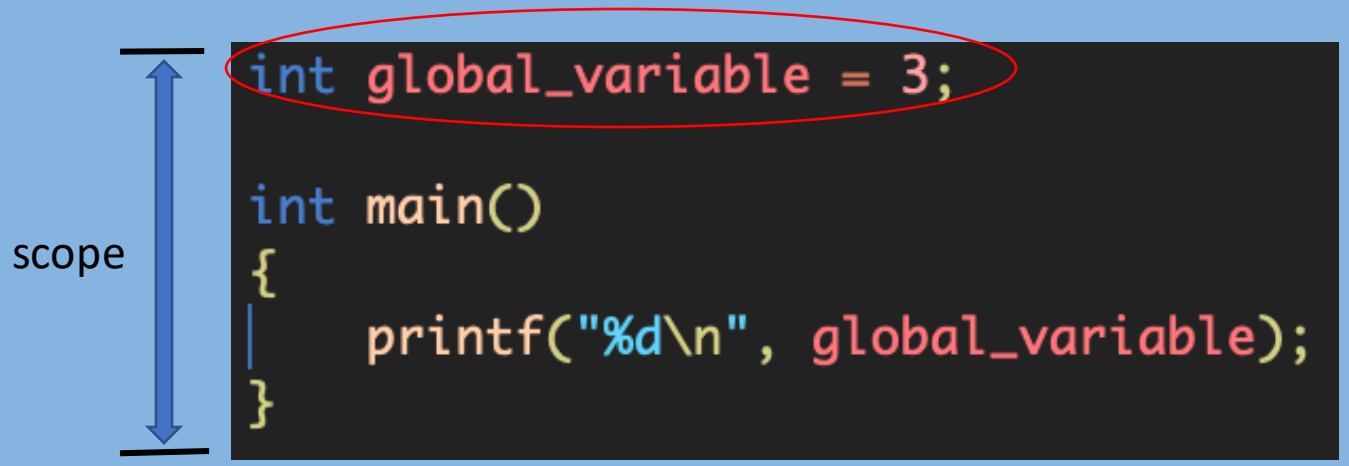
- B is declared as a local object in a method of A
- Method of A: *void CreateRandomChunck*, B: *int randX*
- Temporary visibility
  - Remains only within the scope of the method

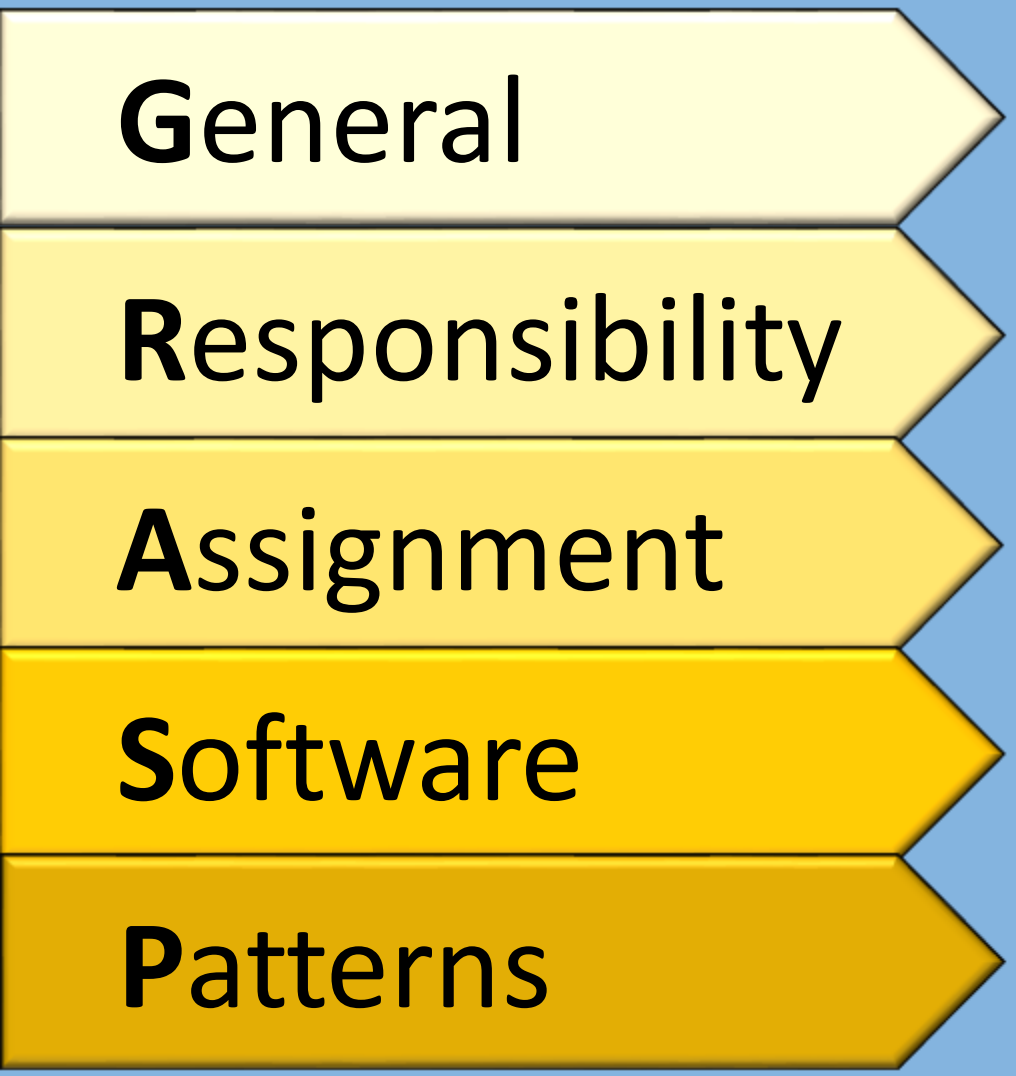


Ian, LoadLevel.cs

Global Visibility

- B is global to A
- A: *int main*, B: *global_variable*
- Permanent visibility
  - Remains if A and B exists





- *Grasp* these principles to successfully design object-oriented software
- *Grasp* these principles to succeed on the POSTMORTEM!
- Different "patterns" from previously mentioned patterns

9 GRASP Patterns

Creator

Information Expert

Low Coupling

Controller

High Cohesion

Polymorphism

Pure Fabrication

Indirection

Protected Variations

Creator

Problem

- Suppose you have an object of class A that needs to have several instances created. Who should be responsible for creating those new instances of class A?

Creator (cont.)

Solution:

Select a class B that bears the responsibility of creating objects of class A if one or more of the following is true:

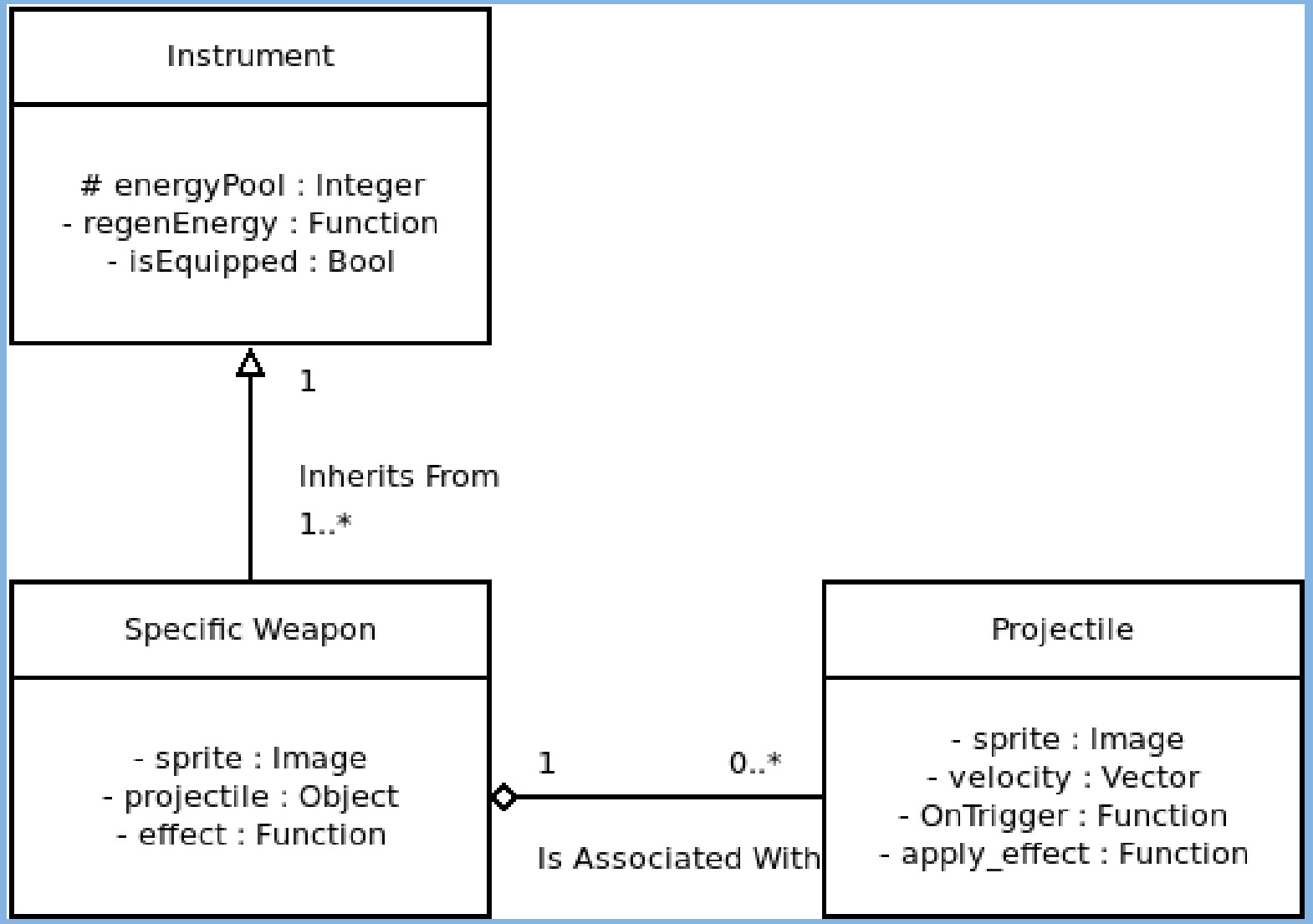
- B contains A
- B records A
- B closely uses A
- B holds the data that will be passed to A (i.e. B is an ‘Expert’ of A)

These conditions also imply that class A is visible to class B

Selecting a Creator

- Determine an object's creator based on how many of these criteria are met
- The more criteria met, the higher the coupling between the creator and the created object
  - Picking an already strongly coupled class to be the creator prevents further coupling

Creator Example



Information Expert

Problem

- What is a general principle of assigning responsibilities to objects?

Solution

- Assign responsibilities to an ‘Expert Class’, which is a class with the information to complete the task.

Information Expert (cont.)

Benefits

- Encapsulates data well
- Class behavior is spread across smaller, lightweight classes

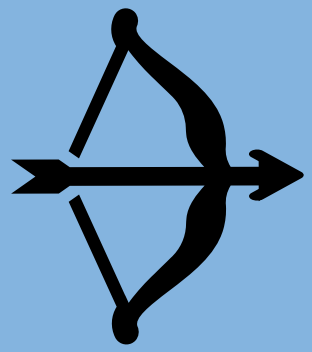
Detriments

- Tends to lower cohesion by adding responsibility to a class
- Can raise coupling if the added responsibility requires communication with a separate module

Information Expert Example

CrossbowBolt
- _bolt: RigidBody2D
+ boltSpeed: Vector3

Character
+ health: int



Who should measure that the collision occurred to maximize cohesion, minimize coupling, and best utilize visibility?

Low Coupling – How to implement it?

- Use private variables and methods
- Limit data sharing between modules
- When designing modules, classes, and objects make sure they are designed to lower coupling and not raise it

Controller

Problem

When a request comes from the UI layer, what is the first object that should receive the message to controls/coordinates within the domain layer to accomplish the request?

Solutions

1. Assign it to a class the represents the overall system

   -Façade Controller

2. Assign it to a class that represents a use case handling a specific system operation

   -Use Case controller

+ which may imply High Cohesion, Low coupling, and better visibility

Controllers (cont.)

Pros

1. Increases potential of reuse and pluggable interfaces
2. Opportunity to reason about the state of the use case

Cons

1. Over-assignment of responsibility (bloated controller

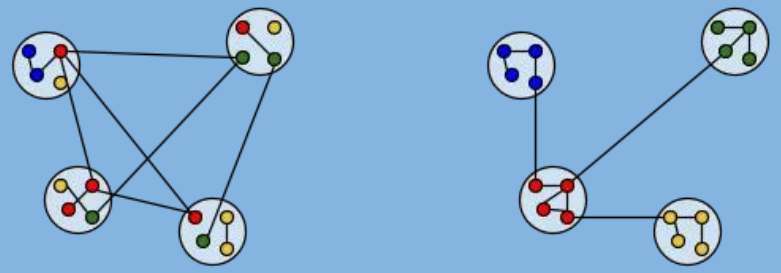
High Cohesion

Problem

Ability to keep objects Focused, Understandable, and Maintainable

Solution

Assign a responsibility so that cohesion remains high



low cohesion
high coupling

high cohesion
low coupling

Polymorphism

Problem

How to handle alternatives based on type, and to create pluggable software components

Solution

When related alternatives or behaviors vary by type(class), assign responsibility for the behaviors using polymorphic operations to types for which the behaviors differ

Pure Fabrication

Problem

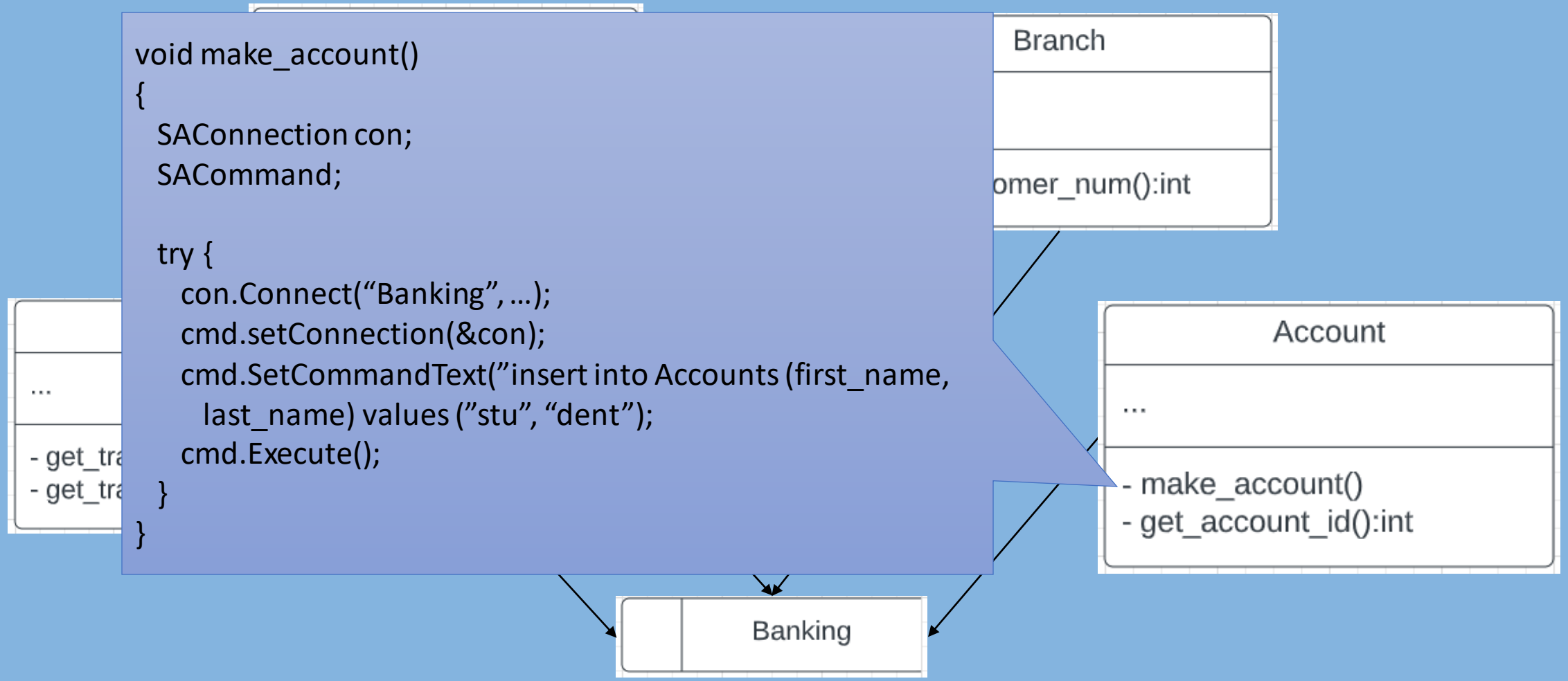
Which object should be assigned responsibility when you run the risk of violating high cohesion and low coupling?

Solution

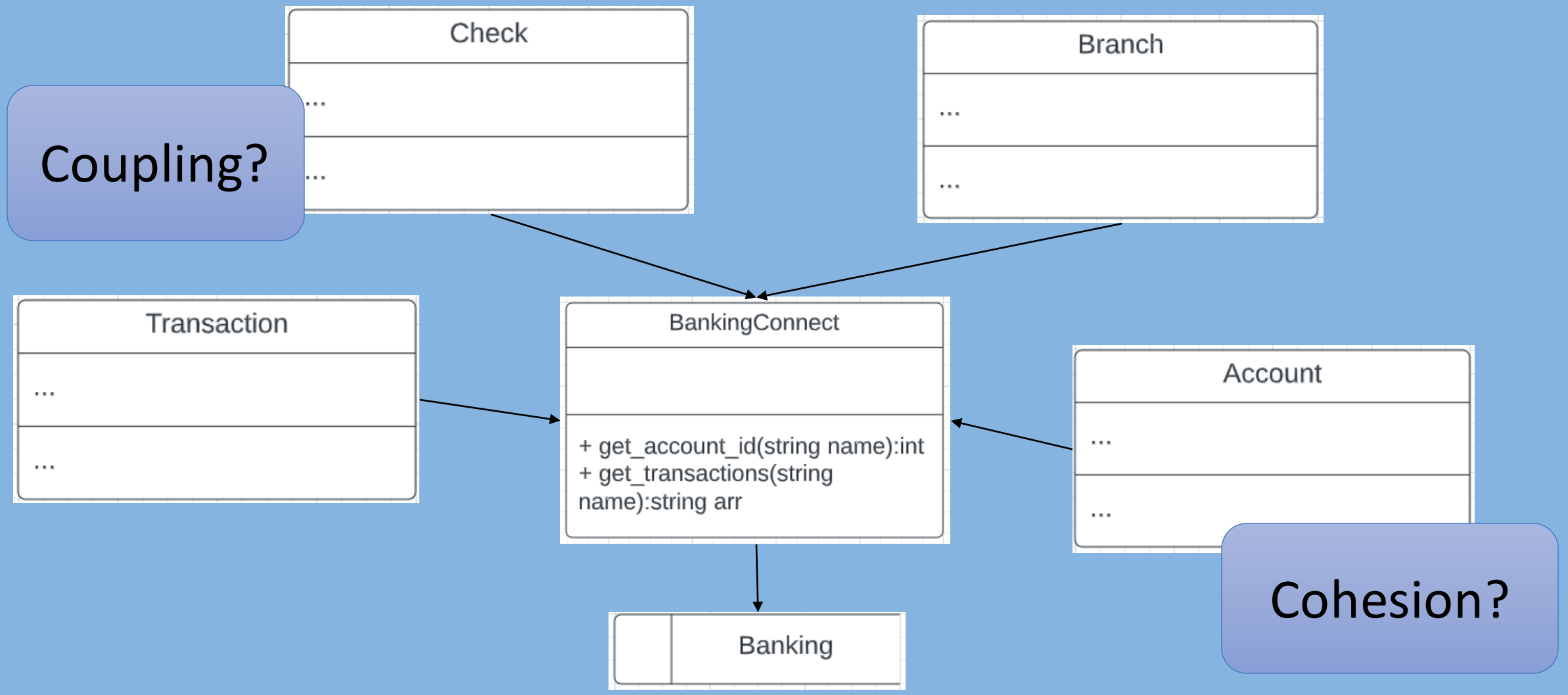
Assign a highly cohesive set of responsibilities to a new class

Pure Fabrication Example

```
void make_account()
{
  SAConnection con;
  SACommand;

  try {
    con.Connect("Banking", ...);
    cmd.setConnection(&con);
    cmd.SetCommandText("insert into Accounts (first_name,
      last_name) values ("stu", "dent");
    cmd.Execute();
  }
}
```



Pure Fabrication Example (cont.)



Pure Fabrication Example (cont.)

Low coupling

- Classes and databases are now more independent
- Changes to the database will not affect interface to database

High cohesion

- Many different classes w/ private database methods → single database class w/ public database methods

Reusability

- One database methods can be generalized using parameters

Indirection

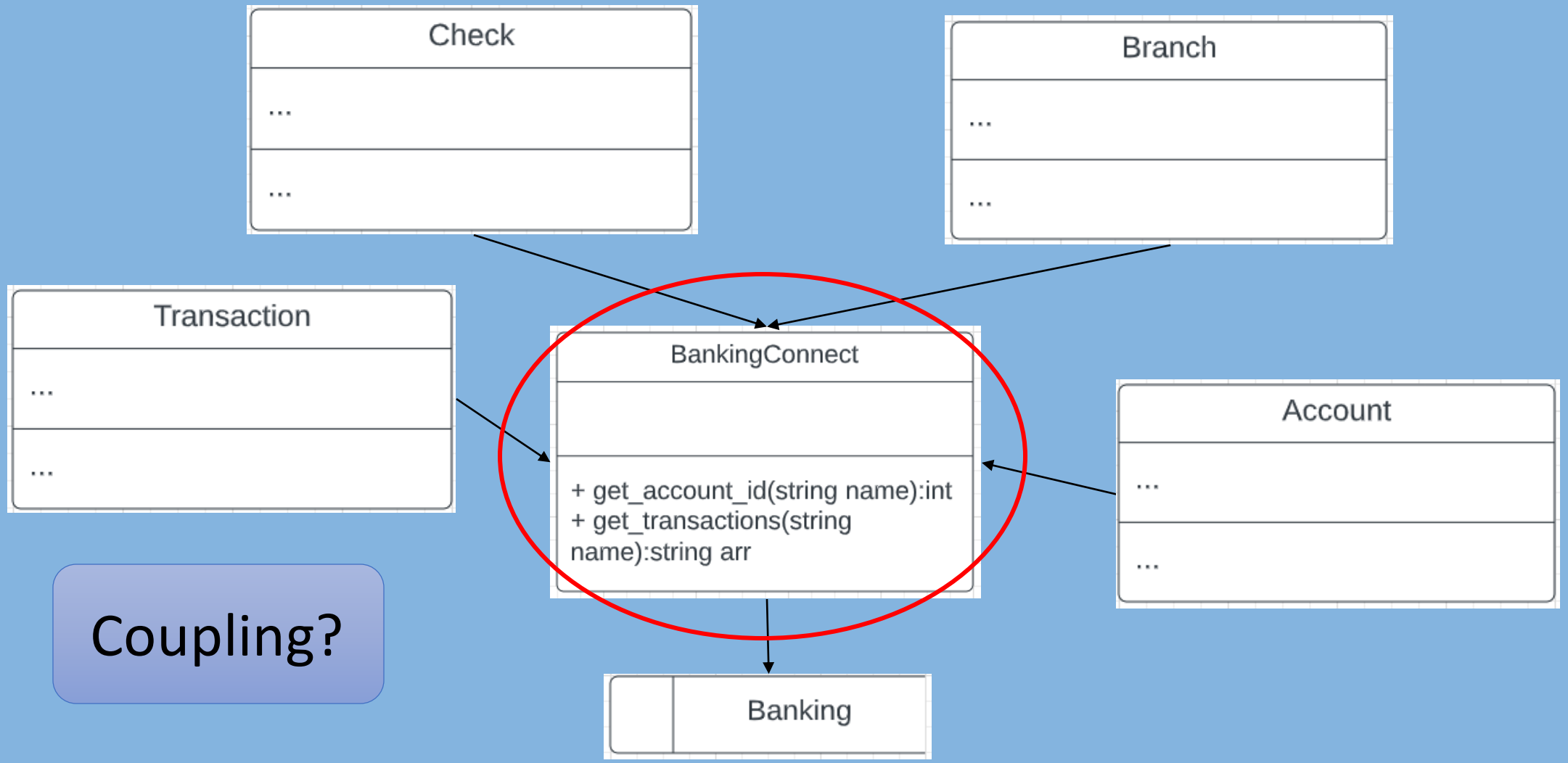
Problem

Where do we assign responsibility when we want to avoid direct coupling between two or more objects?

Solution

Assign responsibility to an intermediate object to mediate the between the other objects.

Indirection Example



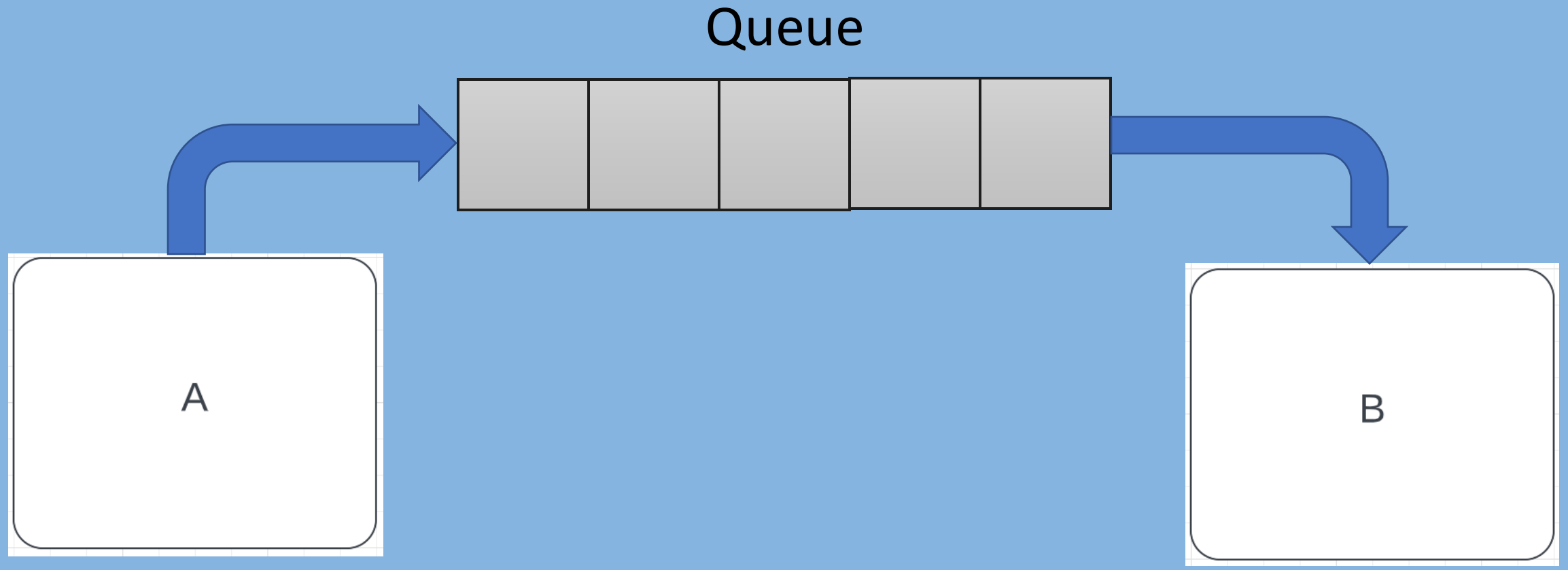
Indirection Example (cont.)

Low coupling

- Avoids direct coupling between database and other classes
- Changes to database does not affect other classes

Indirection Example (cont.)

Queues!



Protected Variations

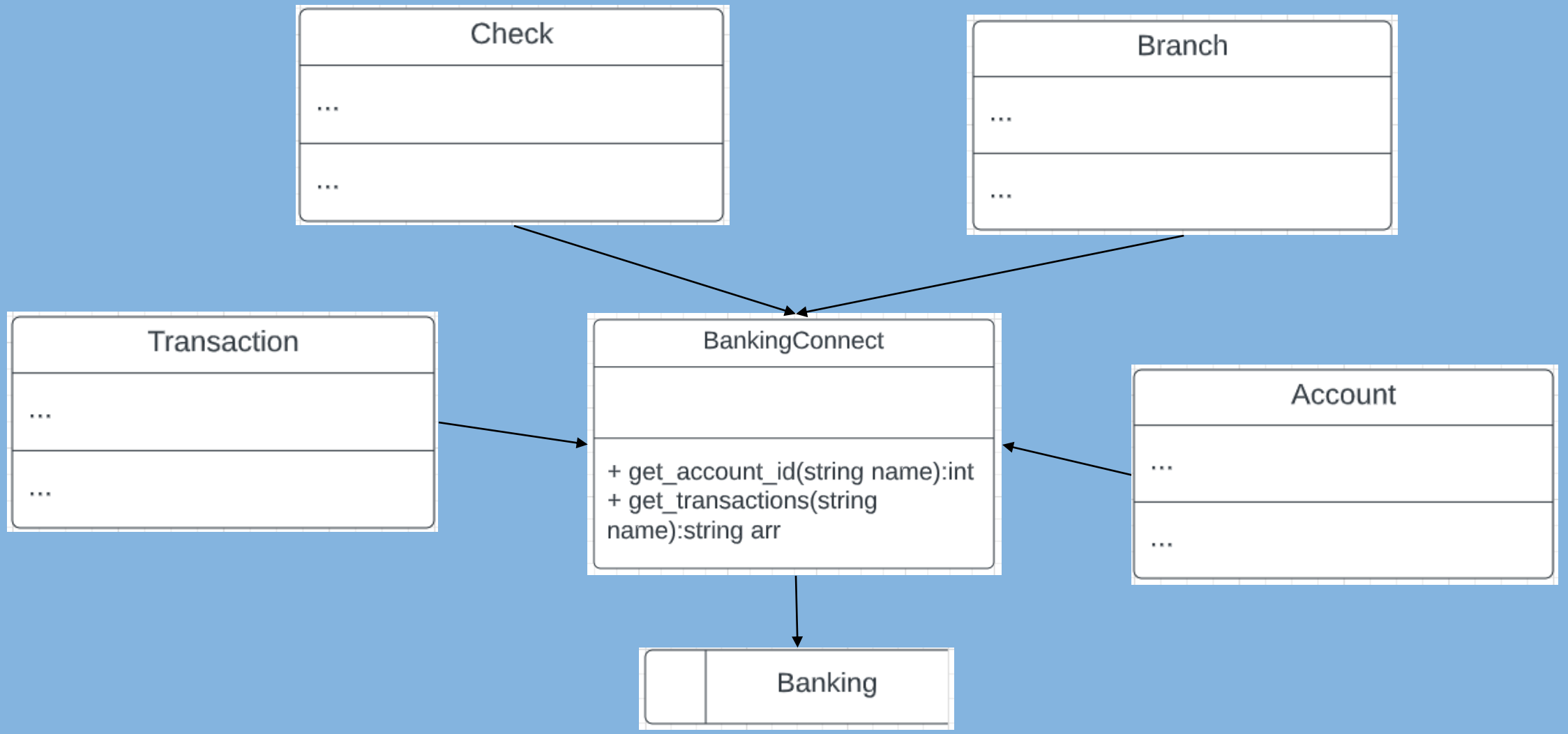
Problem

How can I design a system where variations in some elements does not inadvertently affect the functionality of other objects?

Solution

Create an interface for these varying objects to make they appear invariable.

Protected Variations Example



Protected Variations Example (cont.)

Low coupling

- Prevent changes in the database from affecting banking system classes
- Classes are *protected* from the *variations* of the database
- Especially important for frequently changing code

GANTT Chart Critiques!

Gruntworx

Clear Lake Studios

Clover Games

TTC

Exodus

EXODUS
Studios