

SWE 4743:
Object-Oriented Design

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'OO Foundations Review



Why Review OO Concepts?

- Students arrive with uneven OO backgrounds
- We need shared terminology
- Design discussions assume these concepts
- The *following* lecture demonstrates how to diagram OO relationships using Mermaid.js

Agenda

- Polymorphism, encapsulation, inheritance, interfaces
- Access modifiers and visibility boundaries
- Classes, fields, methods, properties
- Primitive, abstract, and concrete types
- Namespaces, modules, and basic organizational structure



Demo Code

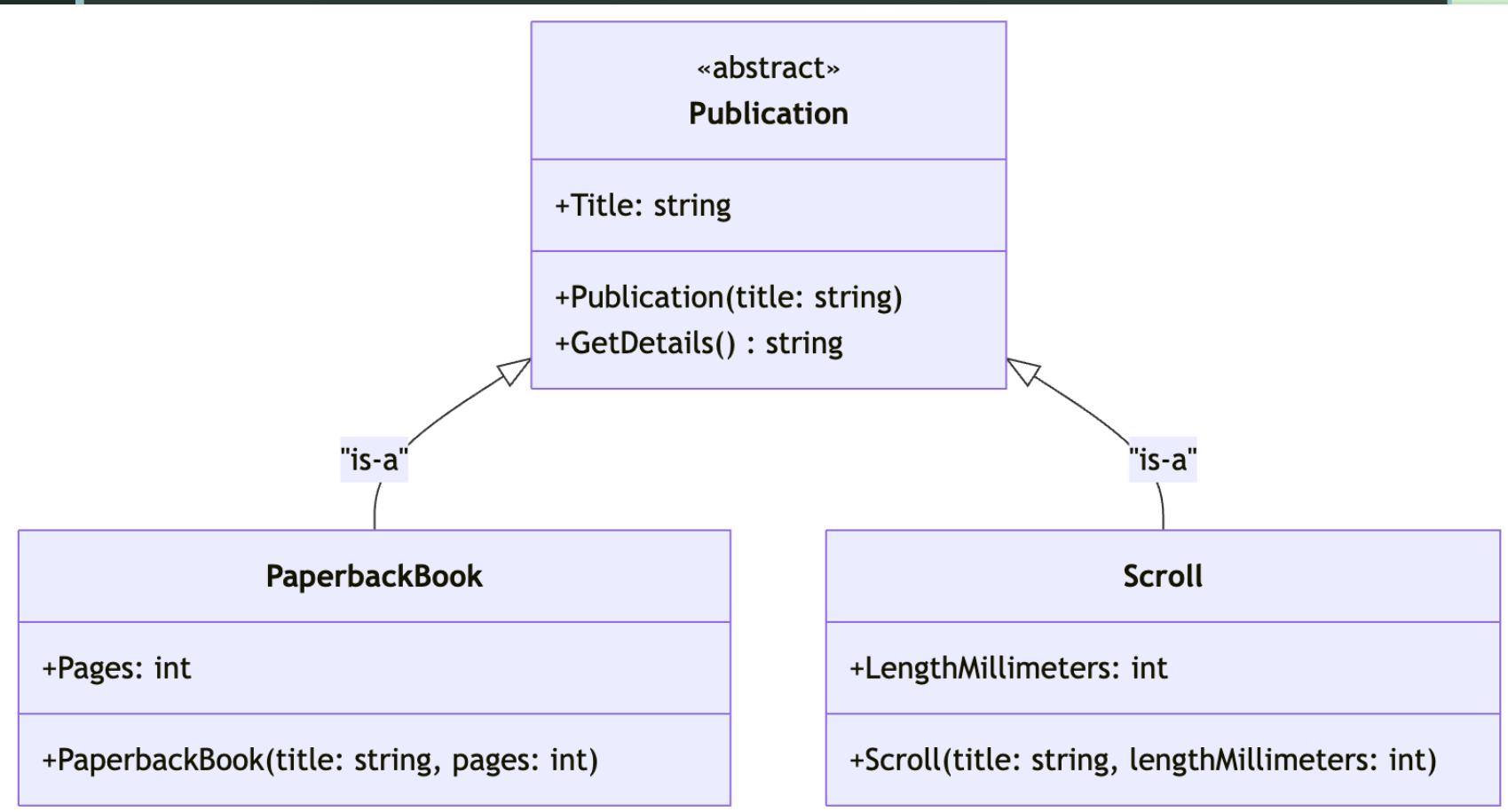
- Demo code is located in the course repository under **demos/02-foundations-review**
- Most demo code is in C#.
- There is one version of Program-01.cs in Java to demonstrate the difference in how Java handles namespaces (must be in separate folders and files).

Inheritance

- Allows one class to reuse another class's behavior
- Represents an "is-a" relationship
- Creates a relationship between types

Inheritance

Program-01.cs



```
● → 01-inheritance git:(main) ✘ dotnet run Program-01.cs
My Publication Collection [C#]:
* A Philosophy of Software Design
* War Scroll / Dead Sea Collection
```

Inheritance Program-01.cs

Architecture

- Defines an **abstract base class (Publication)** that represents a general domain concept.
- Concrete subclasses (PaperbackBook, Scroll) **inherit shared state** from the base class.
- The base class provides **non-abstract shared behavior** (GetDetails) that subclasses may override.
- Client code operates on a **collection of the base type**.

OO Concepts Illustrated

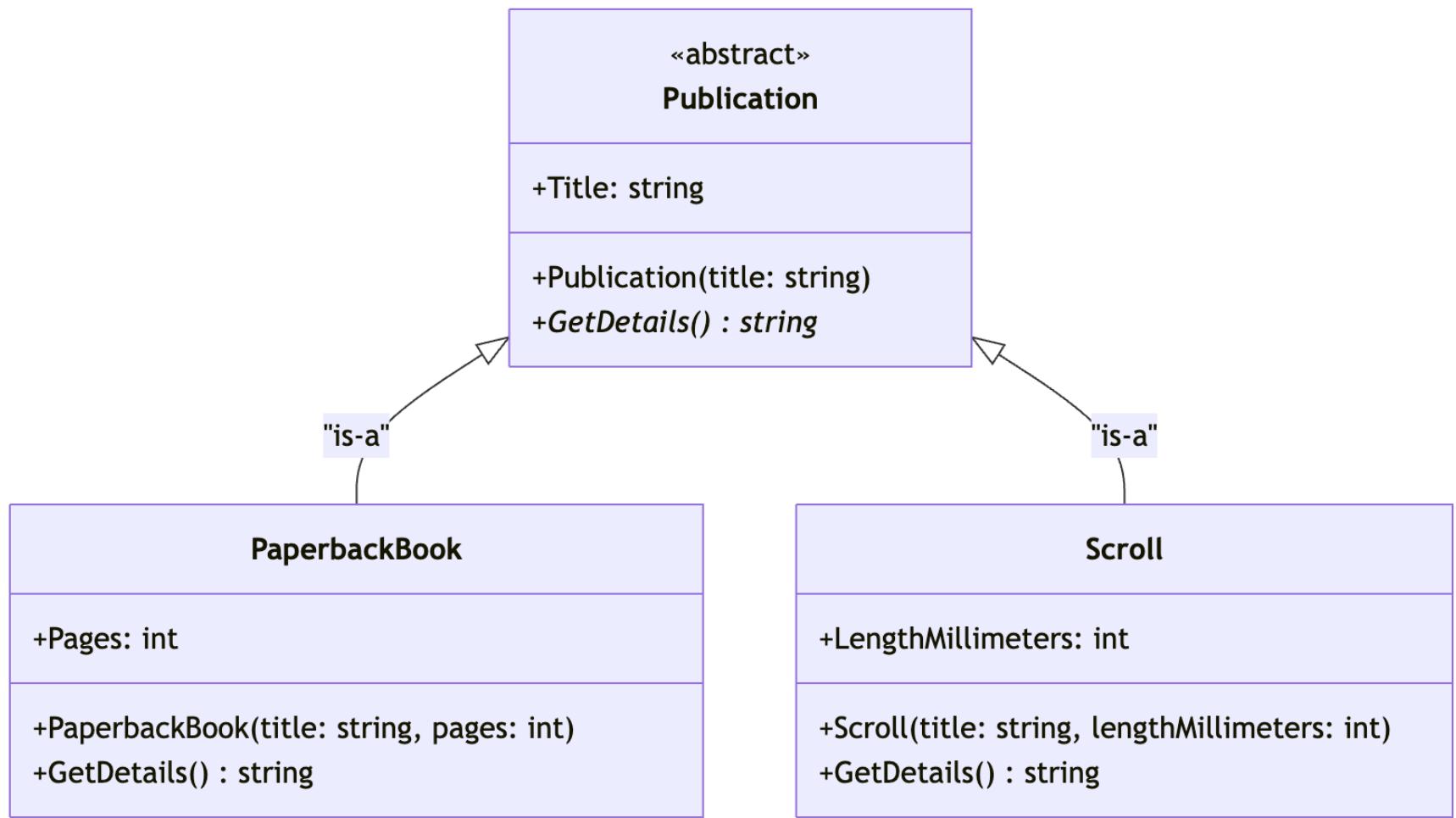
- Abstract classes
- Inheritance
- Code reuse through shared base implementation

Polymorphism

- Code works with many related types
- Uses a base type reference
- Enables flexible behavior
- There are various polymorphic techniques
 - Abstract classes
 - Interfaces
 - Abstract methods (children must implement)
 - Virtual methods (descendants *can* override parent implementation)

Polymorphism 1

Program-02.cs



```
● → 02-polymorphism-1 git:(main) ✘ dotnet run Program-02.cs
My Publication Collection [C#]:
* A Philosophy of Software Design | Paperback Book | 183 pages
* War Scroll / Dead Sea Collection | Scroll | 8148 mm
```

Polymorphism 1

Program-02.cs

Architecture

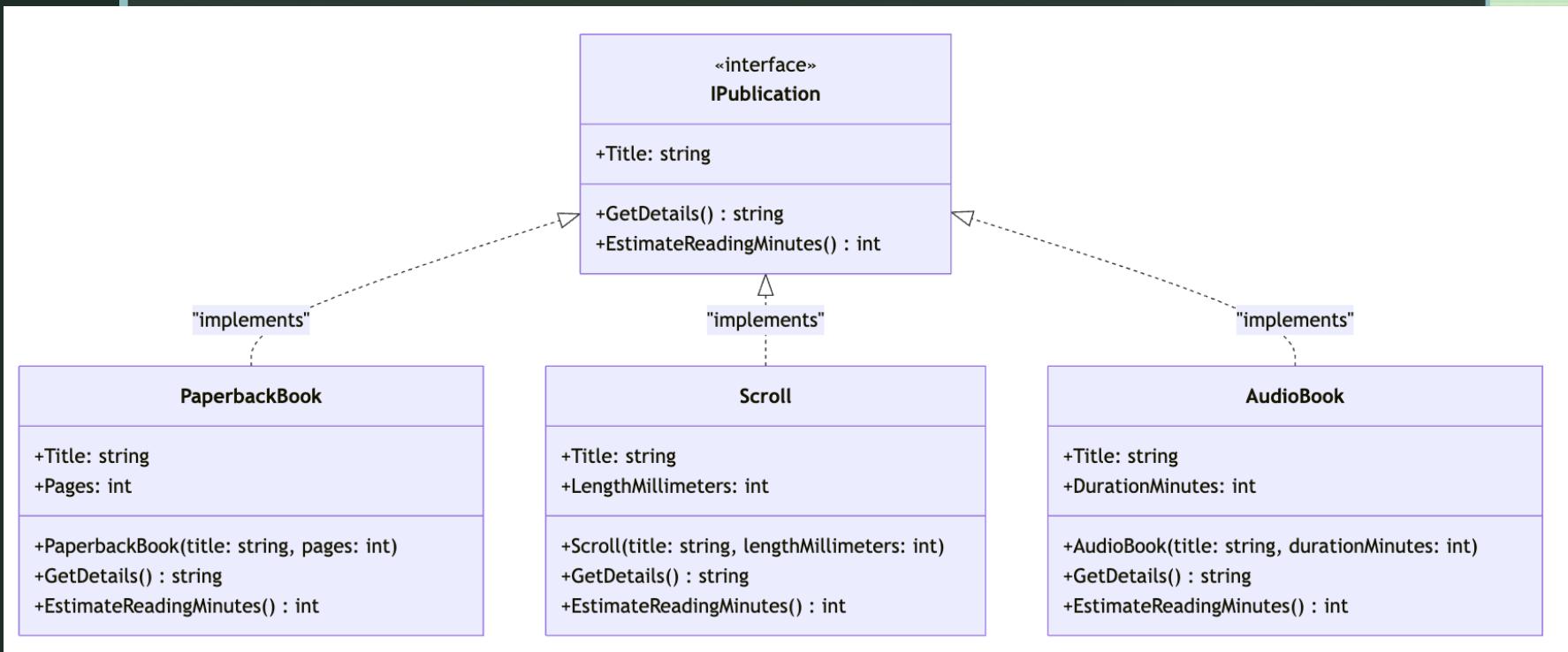
- Evolves the base class by introducing an **abstract method**.
- Subclasses are now **required to implement behavior** specific to their type.
- Polymorphism is exercised by calling the abstract method through a **base-class reference**.
- Shared data remains in the base class; behavior diverges in subclasses.

OO Concepts Illustrated

- Polymorphism
- Abstract methods
- Method overriding
- Dynamic dispatch

Polymorphism 2

Program-03.cs



```
● → 03-polymorphism-2 git:(main) ✘ dotnet run Program-03.cs
My Publication Collection [C#]:
* A Philosophy of Software Design | Paperback Book | 183 pages | ~220 min
* War Scroll / Dead Sea Collection | Scroll | 8148 mm | ~326 min
* The Pragmatic Programmer | Audiobook | 540 minutes | ~540 min

Reading plan (polymorphism demo):
- Total estimated time: 1086 minutes
- Shortest: A Philosophy of Software Design (220 min)
- Longest: The Pragmatic Programmer (540 min)

Short reads (<= 240 minutes):
* A Philosophy of Software Design (220 min)
```

Polymorphism 2

Program-03.cs

Architecture

- Introduces an **interface (IPublication)** to define behavioral contracts.
- Abstract base class is no longer responsible for polymorphic behavior.
- Concrete classes implement the interface directly.
- Base class (if present) is now focused on **shared state only**.

OO Concepts Illustrated

- Interfaces
- Interface-based polymorphism
- Separation of concerns

Interfaces

- Define what a class can do
- Do not contain implementation details
- Allow multiple implementations



Kinds of Types

- Primitive types: built-in values
 - Concrete types: instantiable classes
 - Abstract types: interfaces and abstract classes
- 
- 



Type Examples

```
int count; // primitive
```

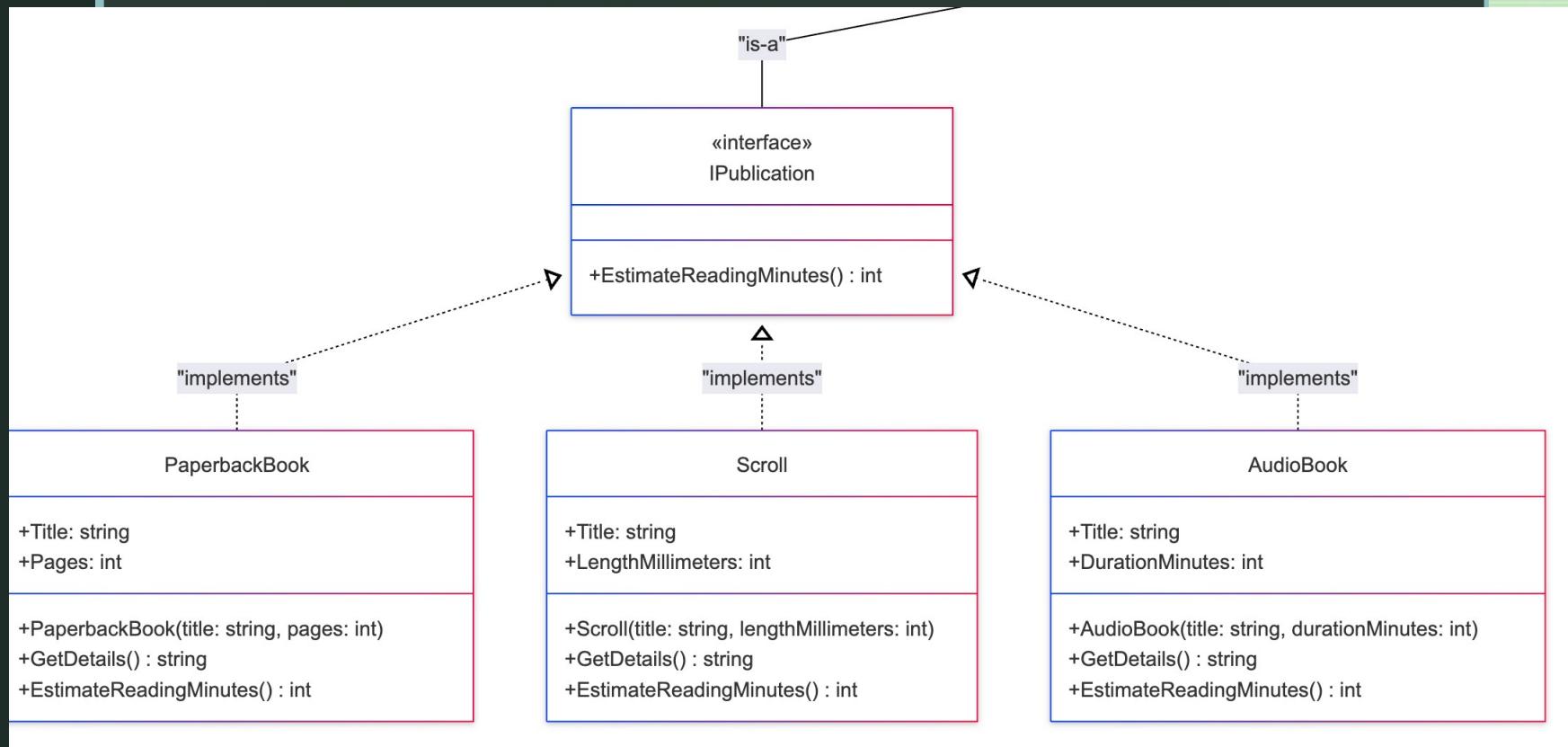
```
class User { } // concrete
```

```
interface IRepository { } // abstract
```

```
abstract class UserBase { } // abstract with  
implementation
```

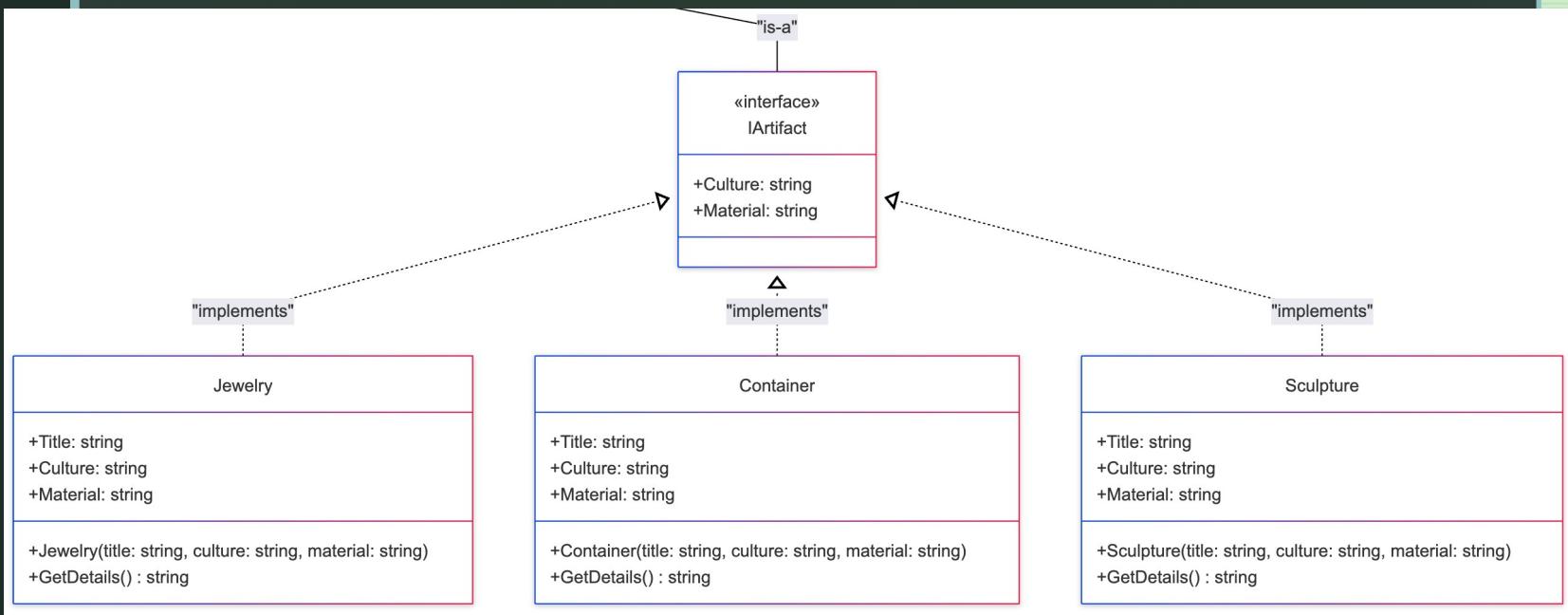
Polymorphism 3

Program-04.cs



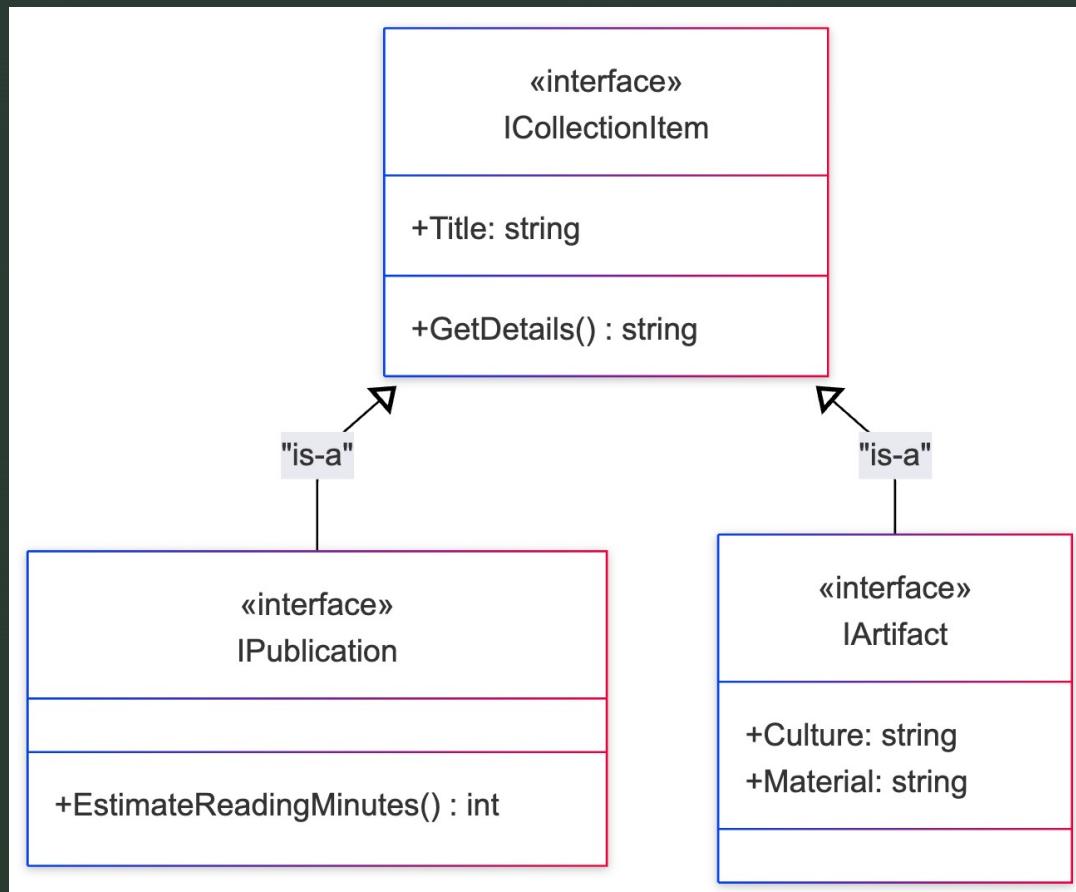
Polymorphism 3

Program-04.cs



Polymorphism 3

Program-04.cs



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- * War Scroll / Dead Sea Collection | Scroll | 8148 mm | ~326 min
- * The Pragmatic Programmer | Audiobook | 540 minutes | ~540 min
- * Labubu | Artifact | Hong Kong | Gold
- * Canopic Jar (Imsety) | Artifact | Egypt | Limestone
- * Ushabti Figurine | Artifact | Egypt | Granite

Reading plan (polymorphism demo):

- Total estimated time: 1086 minutes
- Shortest: A Philosophy of Software Design (220 min)
- Longest: The Pragmatic Programmer (540 min)

Short reads (<= 60 minutes):

My Artifacts (by Culture, Material, Name):

- * Egypt
 - + Granite
 - Ushabti Figurine
 - + Limestone
 - Canopic Jar (Imsety)
- * Hong Kong
 - + Gold
 - Labubu

Polymorphism 3

Program-04.cs

Architecture

- Introduces a **top-level interface** (ICollectionItem) representing a broad capability.
- Specialized interfaces (IPublication) **extend the top-level interface**.
- Concrete classes implement the **most specific interface** appropriate to them.
- Client code works against **multiple abstraction levels**.

OO Concepts Illustrated

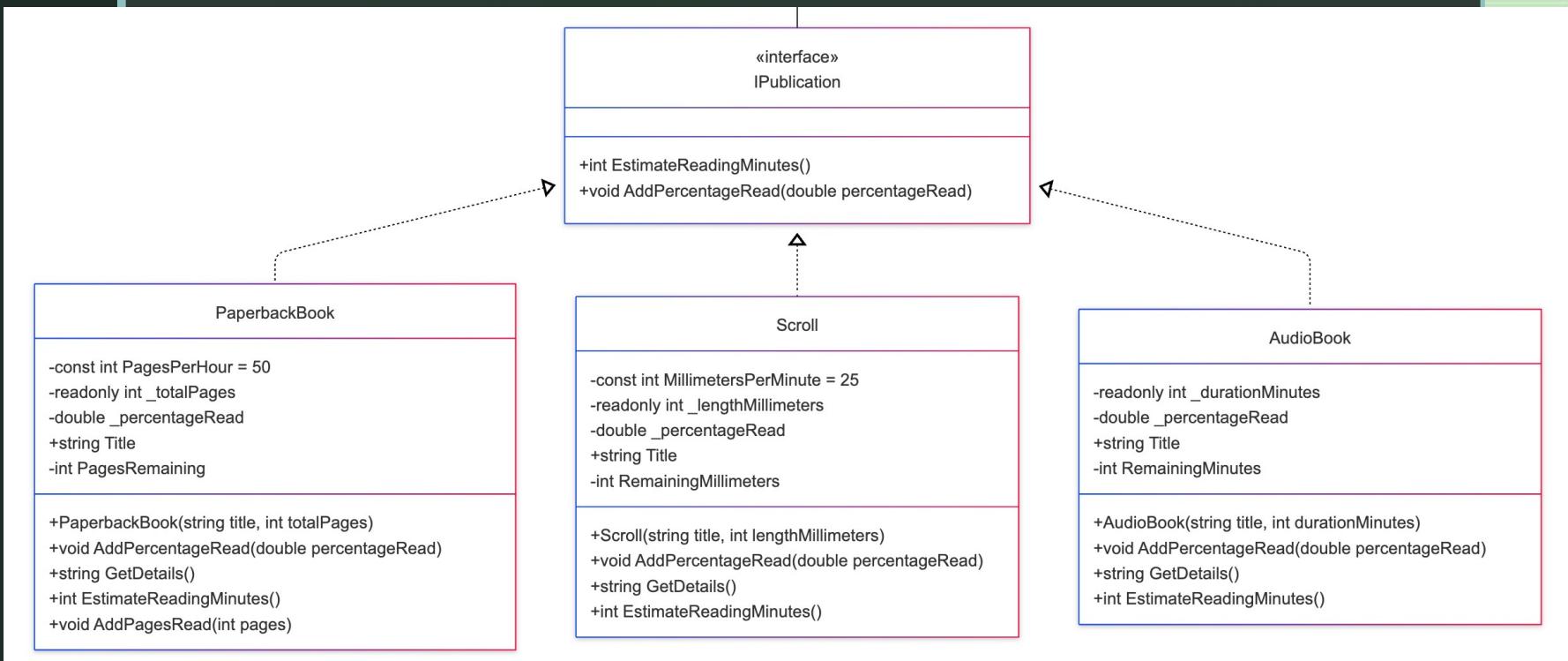
- Interface inheritance
- Liskov Substitution Principle (LSP)
- Deep polymorphism

Encapsulation

- A class controls its own data
- State is accessed through methods
- Protects internal consistency

Encapsulation 1

Program-05.cs



```
My Collection [C#]:  
* A Philosophy of Software Design | Paperback Book | 183 total pages | 16% read | 153 pages remaining | ~184 min remaining  
* War Scroll / Dead Sea Collection | Scroll | 8148 mm total | 10% read | 7334 mm remaining | ~294 min remaining  
* The Pragmatic Programmer | Audiobook | 540 min total | 25% listened | ~405 min remaining  
* Labubu | Artifact | Hong Kong | Gold  
* Canopic Jar (Imsety) | Artifact | Egypt | Limestone  
* Ushabti Figurine | Artifact | Egypt | Granite
```

```
Reading plan (polymorphism demo):
```

```
- Total estimated time remaining: 883 minutes  
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- Longest remaining: The Pragmatic Programmer (405 min)
```

```
Short reads (<= 240 minutes remaining):
```

```
* A Philosophy of Software Design (184 min remaining)
```

```
My Artifacts (by Culture, Material, Name):
```

```
* Egypt  
  + Granite  
    - Ushabti Figurine  
  + Limestone  
    - Canopic Jar (Imsety)  
* Hong Kong  
  + Gold  
    - Labubu
```

Encapsulation 1

Program-05.cs

Architecture

- Introduces **private fields** to encapsulate internal state.
- State changes are controlled via **methods and properties**.
- Demonstrates **casting between interfaces and concrete types** where appropriate.
- Maintains polymorphism while protecting object invariants.

OO Concepts Illustrated

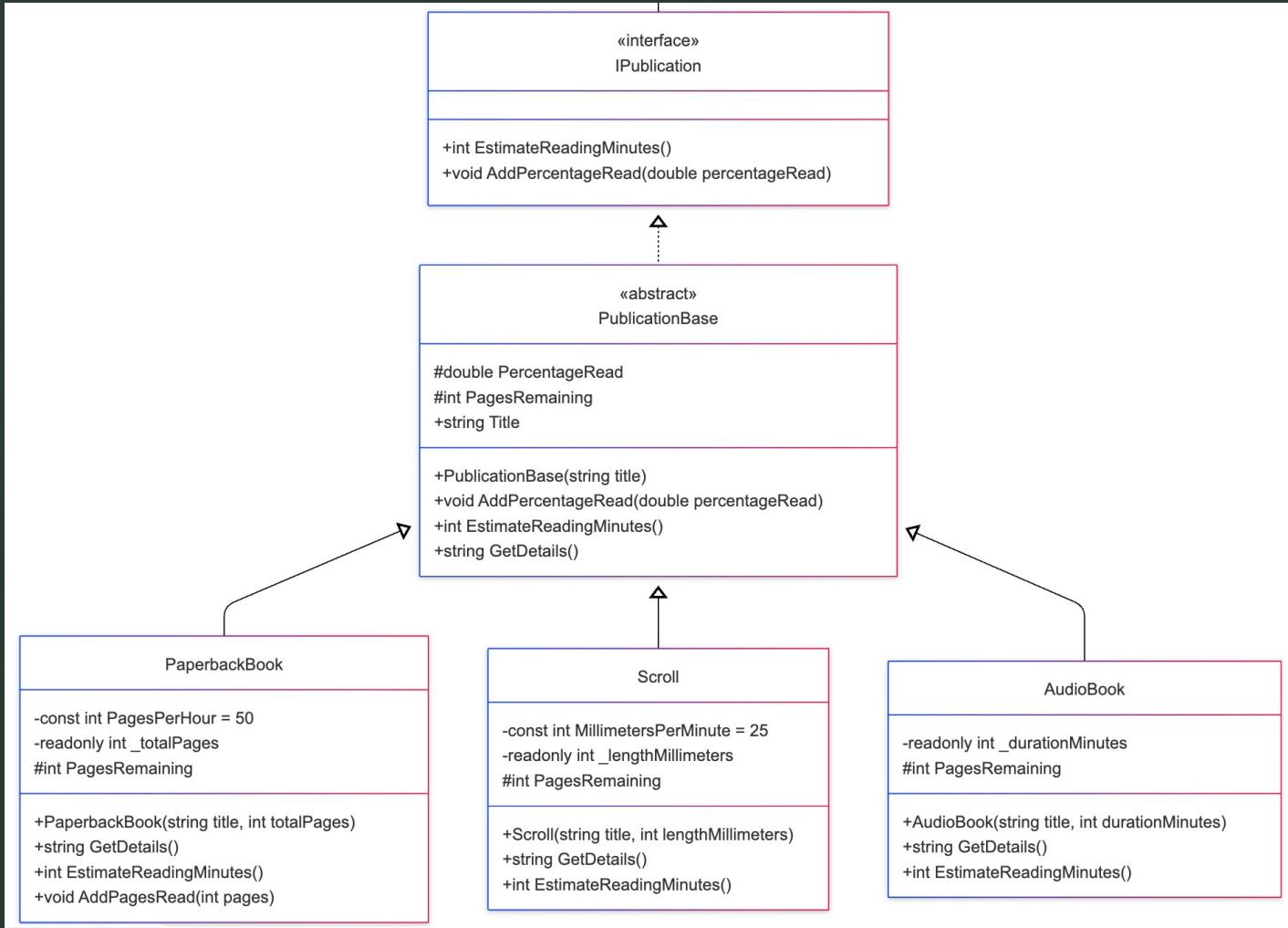
- Encapsulation
- Information hiding
- Controlled access to state
- Safe downcasting

Access Modifiers

- private: accessible only inside the class
- public: accessible everywhere
- protected: accessible to subclasses

Encapsulation 2

Program-06.cs



```
My Collection [C#]:  
* A Philosophy of Software Design | Paperback Book | 183 total pages | 16% read | 153 pages remaining | ~184 min remaining  
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- * Hong Kong
 - + Gold
 - Labubu

Architecture

- Keeps the **interface-first design**:
 - ICollectionItem remains the base interface for anything in the collection.
 - IPublication : ICollectionItem still defines “publication” capabilities (e.g., estimated time remaining + progress updates).
 - IArtifact : ICollectionItem continues to represent non-reading/listening collection items.
- Introduces a new **abstract class beneath the interface**:
 - PublicationBase : IPublication acts as a shared implementation layer.
 - Holds common state for publication progress using **protected fields** (teaching-focused encapsulation).
- Centralizes shared progress behavior:
 - A single implementation of progress mutation logic (e.g., “add % read/listened”) now lives in the abstract base.
 - Concrete publication types override only what varies (e.g., how “remaining” is computed and how details are presented).

Encapsulation 2

Program-06.cs

Encapsulation 2

Program-06.cs

OO Concepts Illustrated

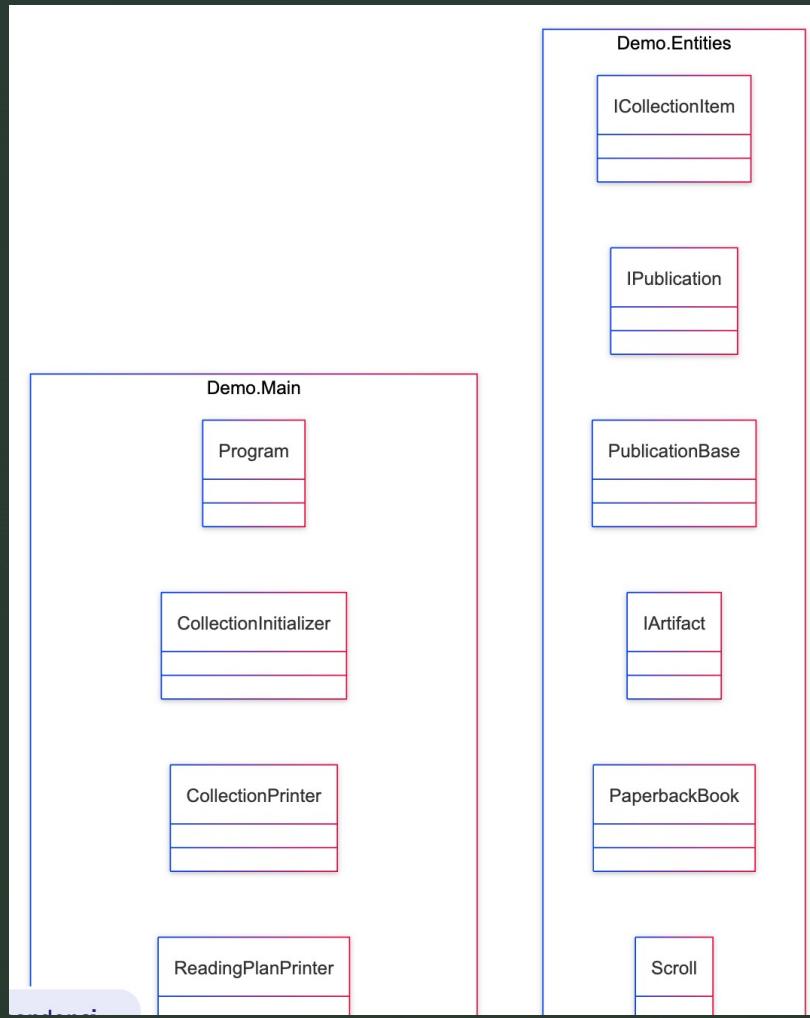
- Encapsulation via protected (and what it exposes vs private)
- Interfaces + abstract classes together (“contract + partial implementation”)
- Reuse without duplicating state/logic
- Template-style variation: base handles common mechanics, subclasses specialize specifics



Namespaces and Organization

- Group related classes
- Prevent naming conflicts
- Improve readability

Namespaces Program-07.cs



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```
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Short reads (<= 240 minutes remaining):

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* A Philosophy of Software Design (184 min remaining)
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```
* Egypt
  + Granite
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  + Limestone
    - Canopic Jar (Imsety)
* Hong Kong
  + Gold
  - Labubu
```

Architecture

- Refactors the “main program” responsibilities into **focused helper classes**:
 - CollectionInitializer (builds the collection)
 - CollectionPrinter (prints all items)
 - ReadingPlanPrinter (prints reading plan view)
 - ShortReadsPrinter (filters and prints short reads)
 - ArtifactsByCultureMaterialNamePrinter (grouping/reporting)
- Program.Main() becomes a small coordinator:
 - Instantiates helpers
 - Orchestrates the workflow
 - No longer contains all the logic itself

Namespaces Program-07.cs



Namespaces Program-07.cs

OO Concepts Illustrated

- Avoiding a **God class**
- Single Responsibility Principle (SRP)
- Basic “composition of services” (Main composes small collaborators)
- “Namespace/storytelling” benefits:
 - Code layout communicates intent (main entry + helpers + entities)



What You Should Take Away

- OO concepts give us shared language
- Each concept solves a specific problem
- The following lecture goes into diagramming with Mermaid.
- Following the diagramming lecture, we go on to how to make good OO design decisions.

Assigned Readings

A Philosophy of Software Design - Ousterhout

- Preface
- Chapter 1: Introduction
- Chapter 2: The Nature of Complexity

