Object Oriented Programming - Lecture 13

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Content

- Design patterns
  - Composite
  - Observer
  - Factory method
  - Iterator

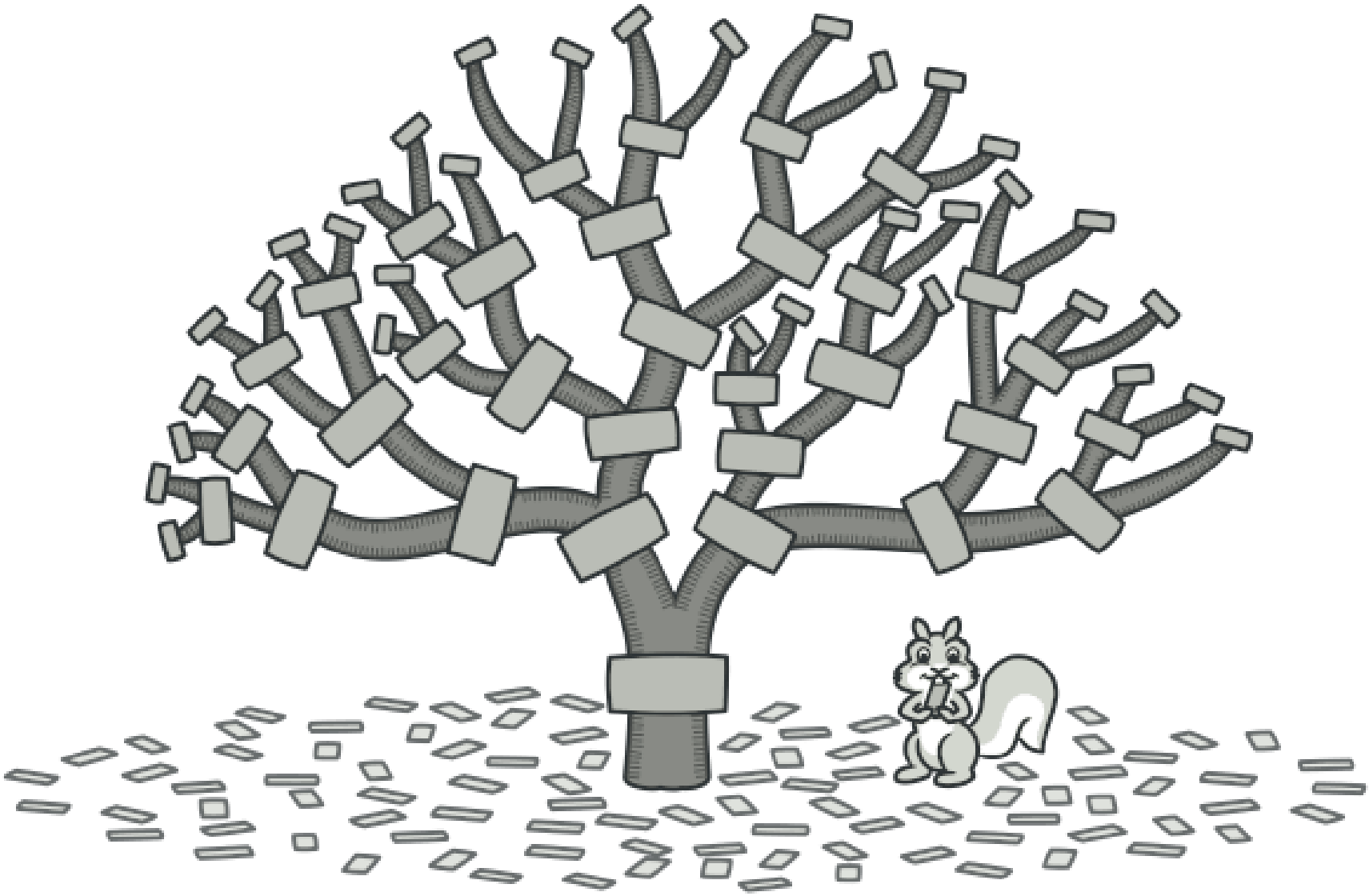
Structural design patterns

Structural patterns *are concerned with how classes and objects are* **composed** *to form* **larger structures**. *Structural class patterns use* **inheritance** *to compose interfaces or implementations.*

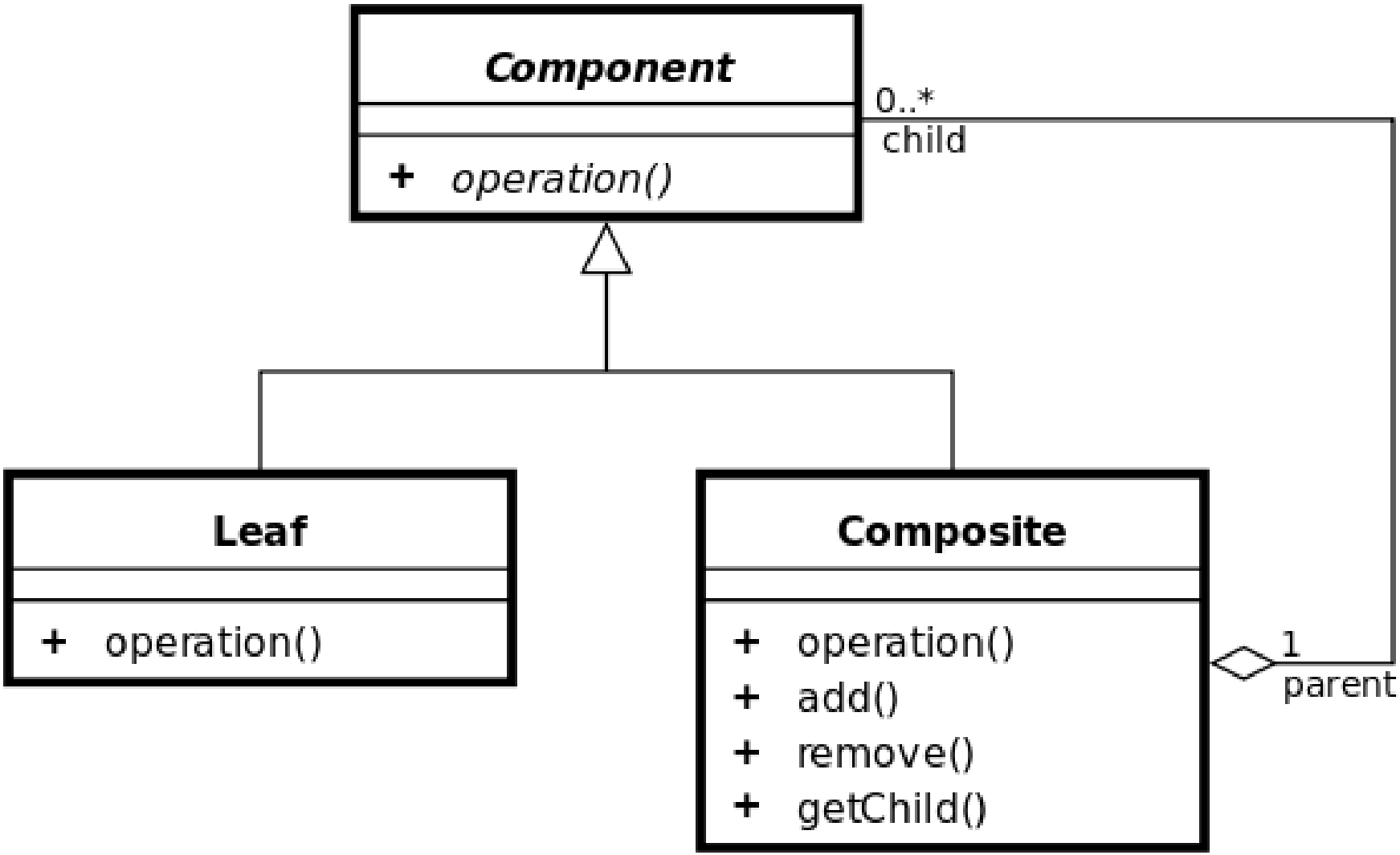
Composite

- **Intent**
  - Compose objects into tree structures to represent p**art-whole hierarchies**. Composite lets clients treat individual objects and compositions of objects uniformly.
- **Applicability**
  - you want to represent part-whole hierarchies of objects.
  - you want clients to be able to ignore the difference between compositions of objects and individual objects.

Composite



Composite - structure



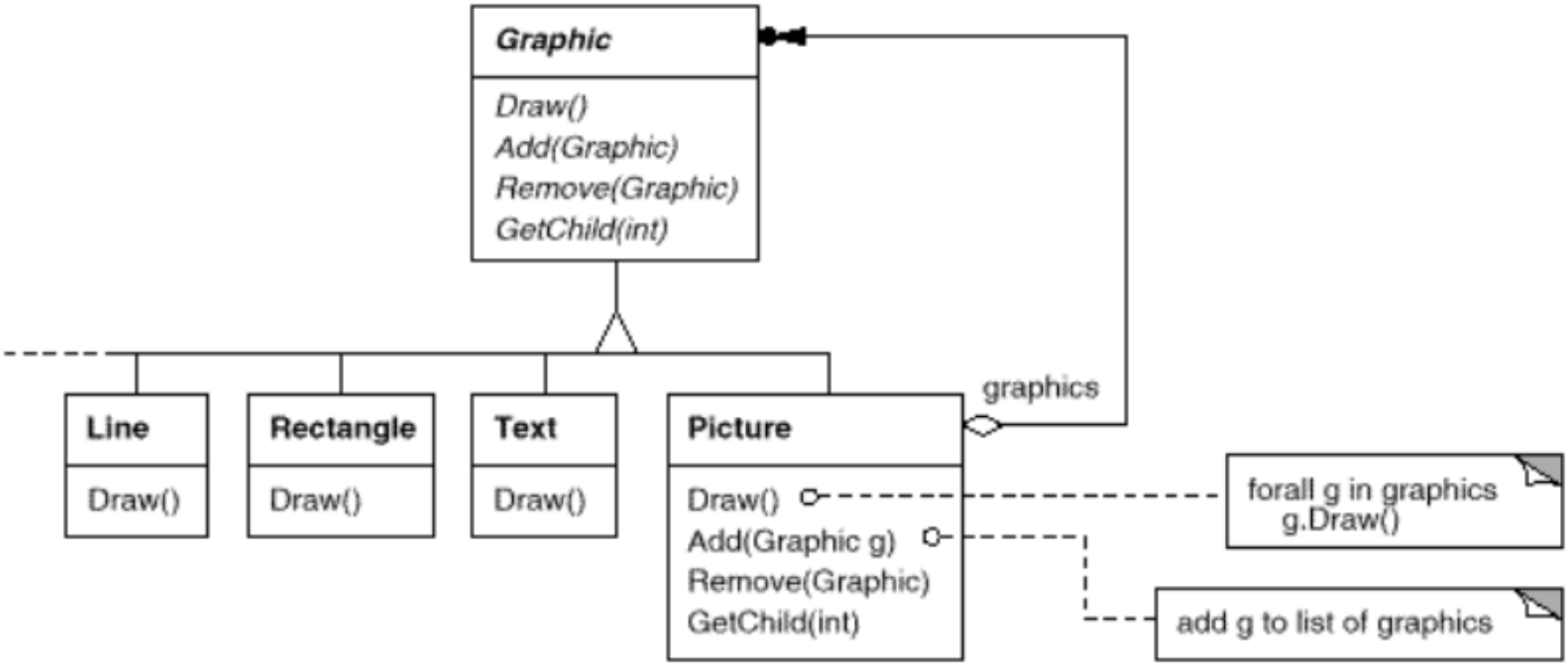
Composite - participants I

- **Client**
  - Manipulates objects in the composition through the Component interface.
- **Component**
  - declares the interface for objects in the composition.
  - implements default behavior for the interface common to all classes, as appropriate.
  - declares an interface for accessing and managing its child components.
  - (*optional*) defines an interface for accessing a component's parent in the recursive structure, and implements it if that's appropriate.

Composite - participants II

- **Leaf**
  - represents leaf objects in the composition. A leaf has no children.
  - defines behavior for primitive objects in the composition.
- **Composite**
  - defines behavior for components having children.
  - stores child components.
  - implements child-related operations in the Component interface.

Composite - demo



Demo

Composite design pattern

Composite - consequences

- **Advantages**
  - Makes the client simple. Clients can treat composite structures and individual objects uniformly. Clients normally don't know (and shouldn't care) whether they're dealing with a leaf or a composite component.
  - You can work with complex tree structures more conveniently: use polymorphism and recursion to your advantage.
  - Open/Closed Principle. You can introduce new element types into the app without breaking the existing code, which now works with the object tree.
- **Disadvantages**
  - It might be difficult to provide a common interface for classes whose functionality differs too much.
  - In certain scenarios, you'd need to overgeneralize the component interface, making it harder to comprehend.

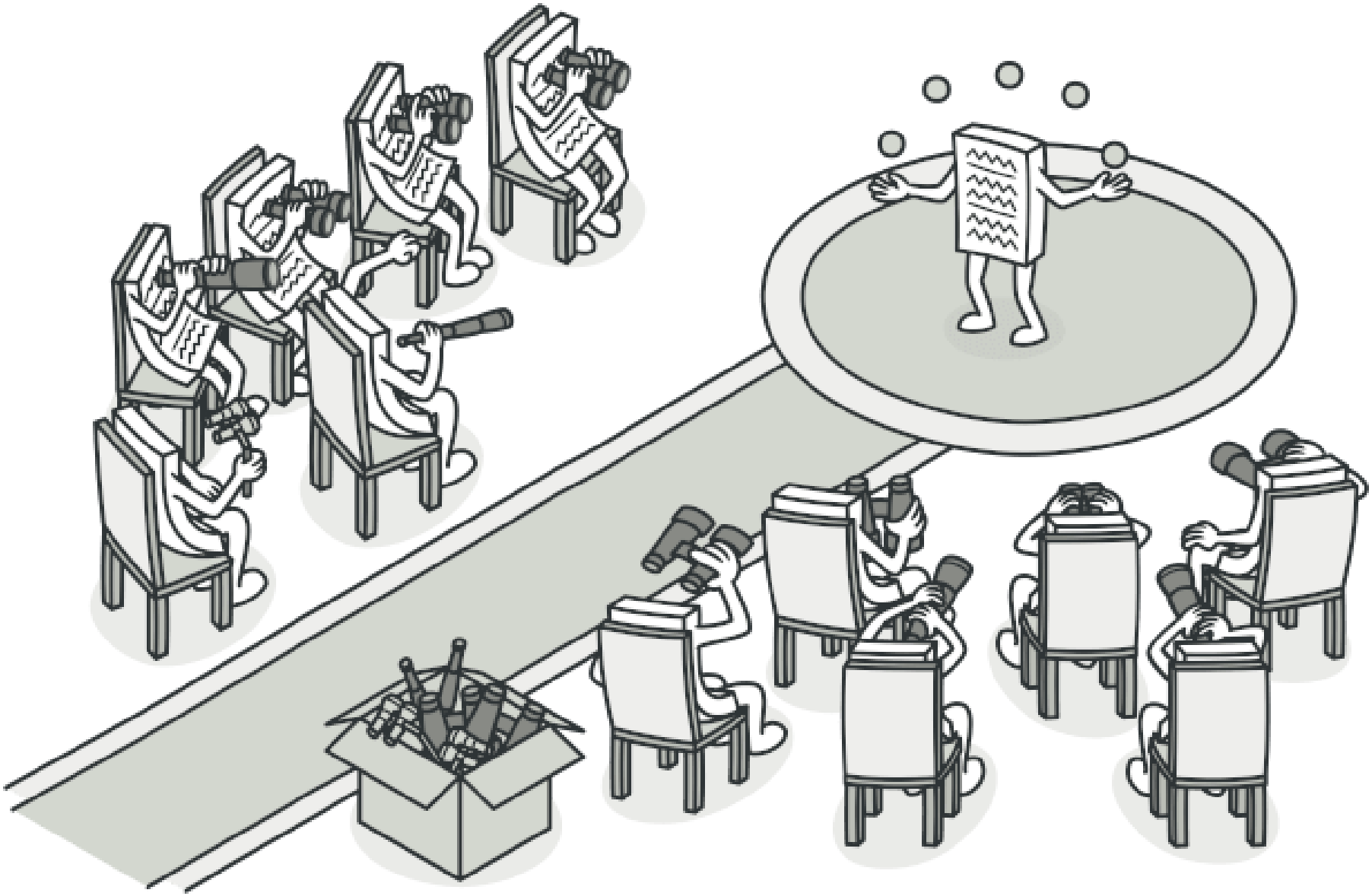
Behavioural patterns

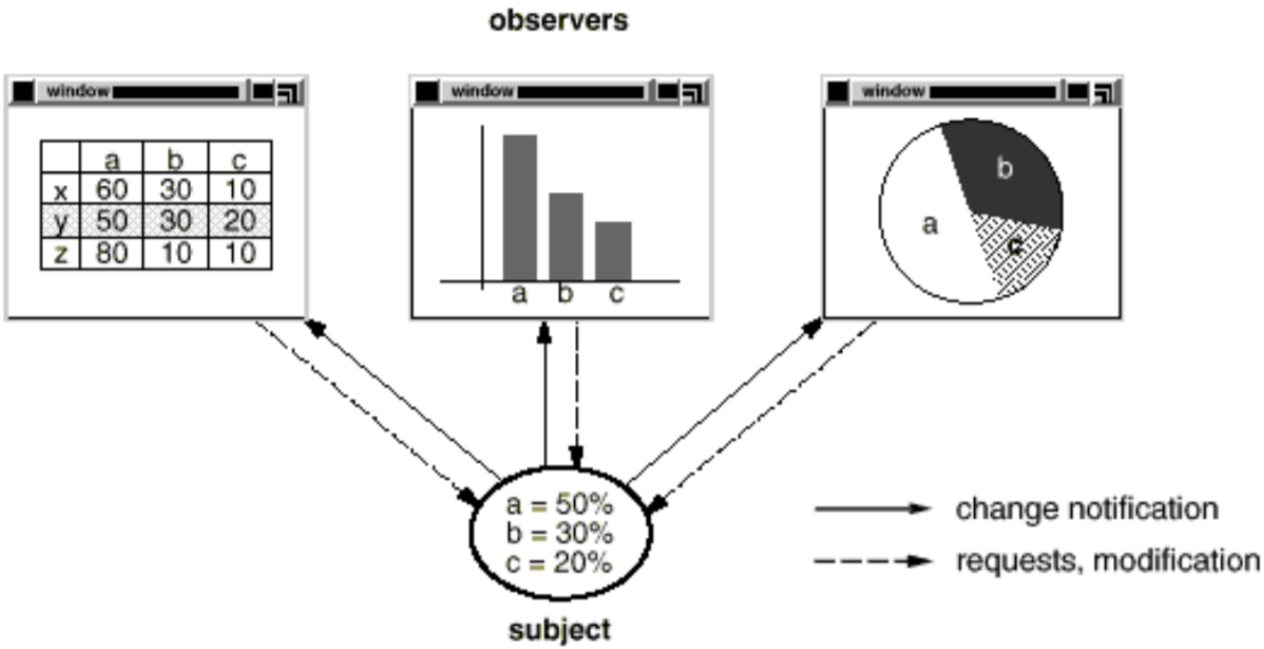
Behavioral patterns are concerned with algorithms and the assignment of **responsibilities** *between objects. Behavioral patterns describe not just patterns of objects or classes but also the patterns of communication between them.*

Observer

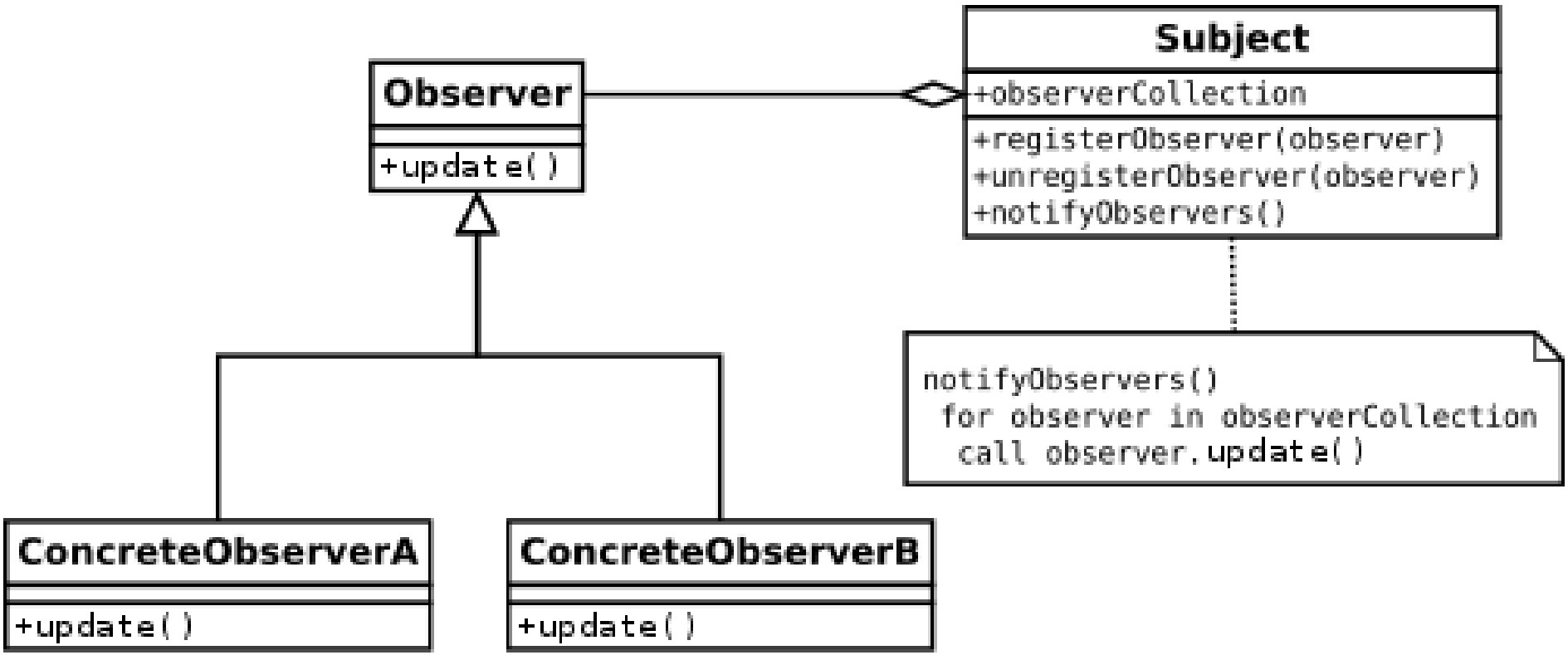
- **Intent**
  - Define a one-to-many dependency between objects so that when one object changes state, all its dependents are notified and updated automatically.
- **Applicability**
  - When an abstraction has two aspects, one dependent on the other.Encapsulating these aspects in separate objects lets you vary and reuse them independently.
  - When a change to one object requires changing others, and you don't know how many objects need to be changed.
  - When an object should be able to notify other objects without making assumptions about who these objects are (low coupling between objects)
- **Also known as**
  - Publish-Subscribe

Observer




observers
window
window
window
a b c
x 60 30 10
y 50 30 20
z 80 10 10
a b c
b
a
c
a = 50%
b = 30%
c = 20%
subject
change notification
requests, modification

Observer - structure



Observer - participants I

- **Subject**
  - knows its observers. Any number of Observer objects may observe a subject.
  - provides an interface for attaching and detaching Observer objects.
- **ConcreteSubject**
  - stores state of interest to ConcreteObserver objects.
  - sends a notification to its observers when its state changes.

Observer - participants II

- **Observer**
  - defines an updating interface for objects that should be notified of changes in a subject.
- **ConcreteObserver**
  - maintains a reference to a ConcreteSubject object.
  - stores state that should stay consistent with the subject's.
  - implements the Observer updating interface to keep its state consistent with the subject's.

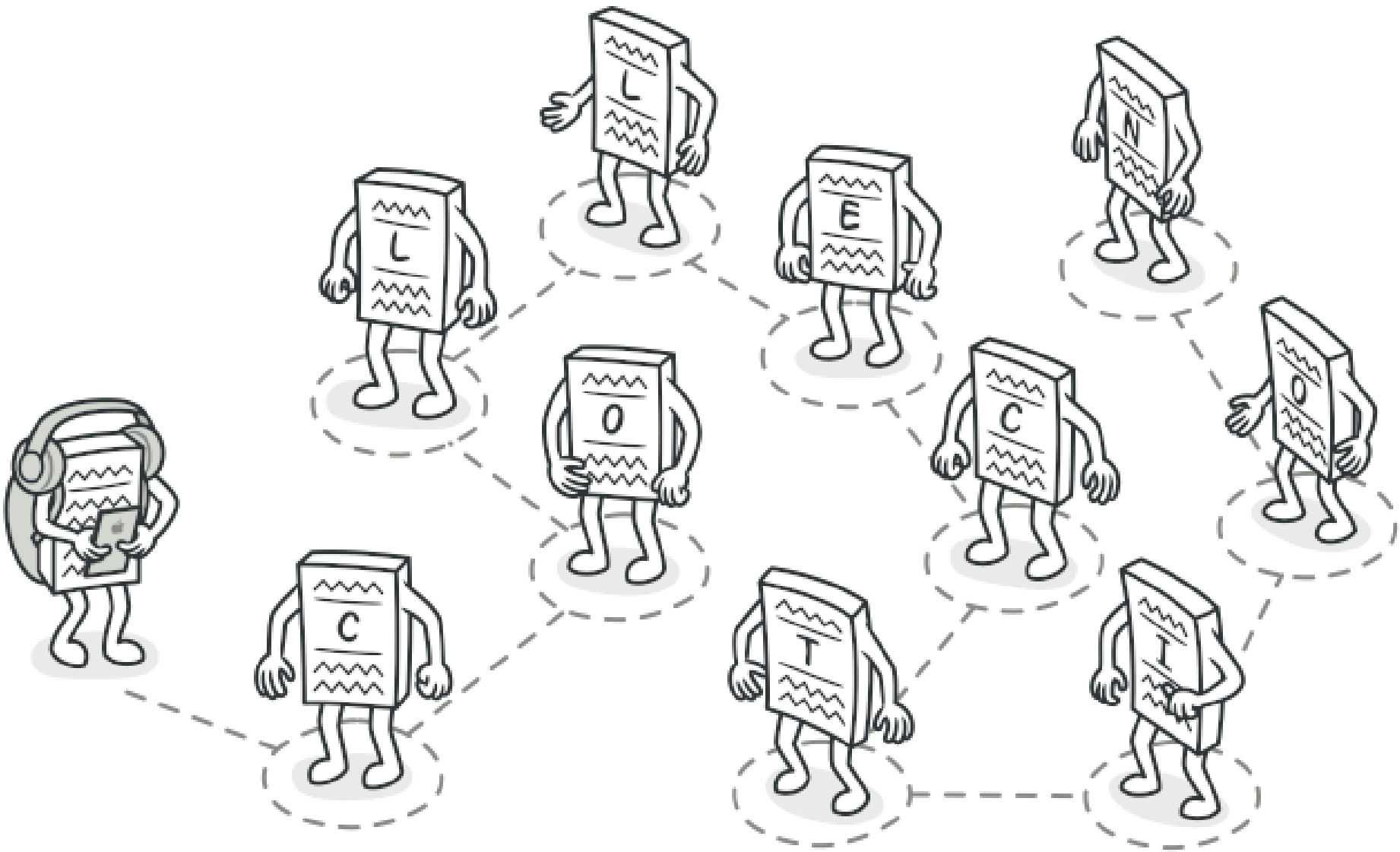
Observer - consequences

- **Advantages**
  - Lets you vary subjects and observers independently. You can reuse subjects without reusing their observers, and vice versa.
  - It lets you add observers without modifying the subject or other observers.
  - Abstract coupling between Subject and Observer: all a subject knows is that it has a list of observers, each conforming to the simple interface of the abstract Observer class (not the concrete class).
  - Support for broadcast communication.
- **Disadvantages**
  - Unexpected updates: observers have no knowledge of each other's presence, they can be blind to the ultimate cost of changing the subject.
  - The simple update protocol provides no details on what changed in the subject. (observers maybe forced to work hard to deduce the changes.)

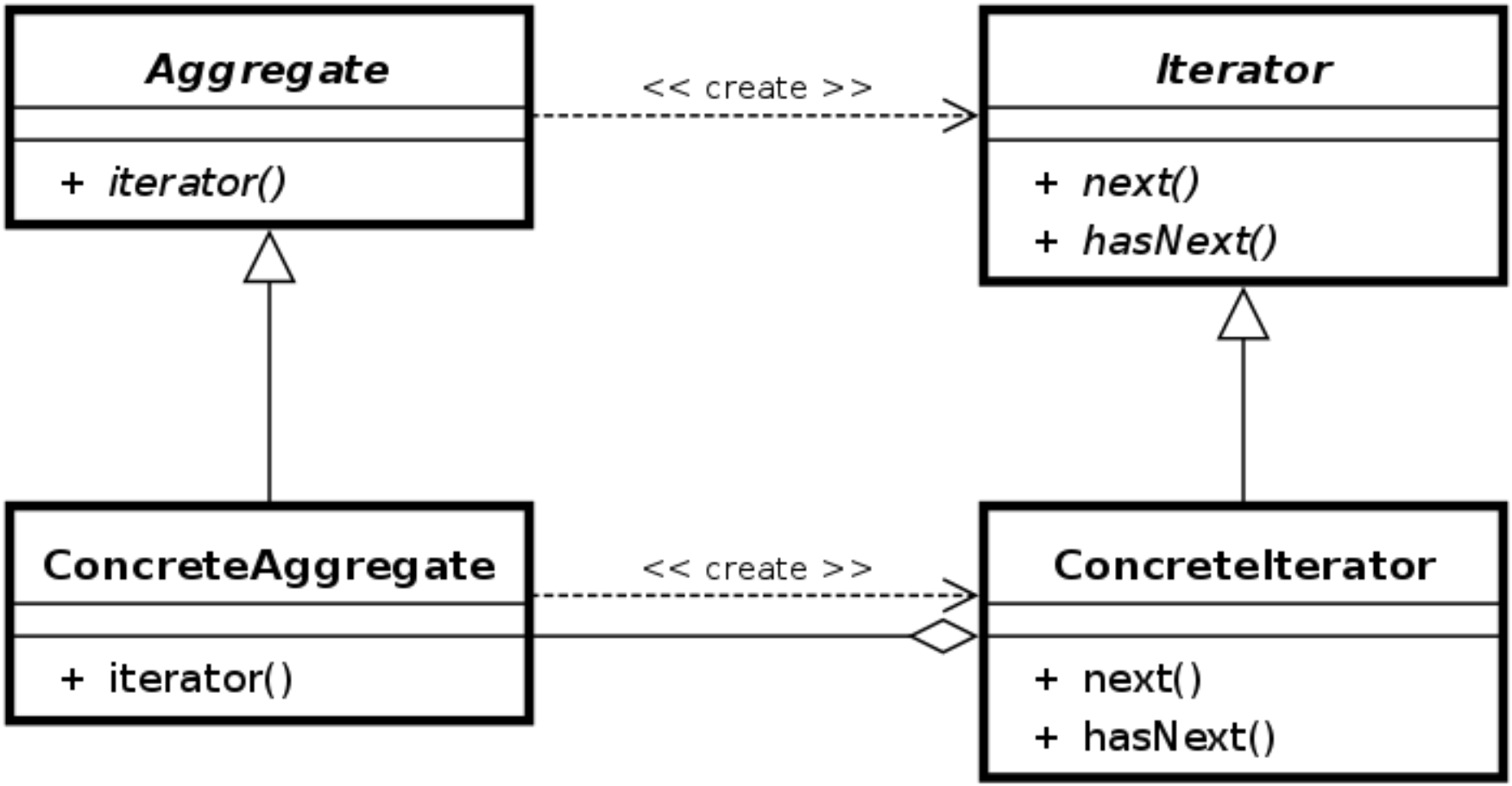
Iterator

- **Intent**
  - Provides a way to access the elements of an aggregate object sequentially without exposing its underlying representation.
- **Applicability**
  - to access an aggregate object's contents without exposing its internalrepresentation.
  - to support multiple traversals of aggregate objects.
  - to provide a uniform interface for traversing different aggregate structures (that is, to support polymorphic iteration).

Iterator



Iterator - structure



Iterator - participants

- **Iterator**
  - defines an interface for accessing and traversing elements.
- **ConcreteIterator**
  - implements the Iterator interface.
  - keeps track of the current position in the traversal of the aggregate.
- **Aggregate**
  - defines an interface for creating an Iterator object.
- **ConcreteAggregate**
  - implements the Iterator creation interface to return an instance of the proper ConcreteIterator.

Iterator - implementation

Demo

Iterator design pattern

Iterator - consequences

- **Advantages**
  - It supports variations in the traversal of an aggregate. Complex aggregates may be traversed in many ways.
  - Iterators simplify the Aggregate interface.Iterator's traversal interface obviates the need for a similar interface in Aggregate, thereby simplifying the aggregate's interface.
  - More than one traversal can be pending on an aggregate.An iterator keeps track of its own traversal state. Therefore you can have more than one traversal in progress at once.
- **Disadvantages**
  - Applying the pattern can be an overkill if your app only works with simple collections.
  - Using an iterator may be less efficient than going through elements of some specialized collections directly.

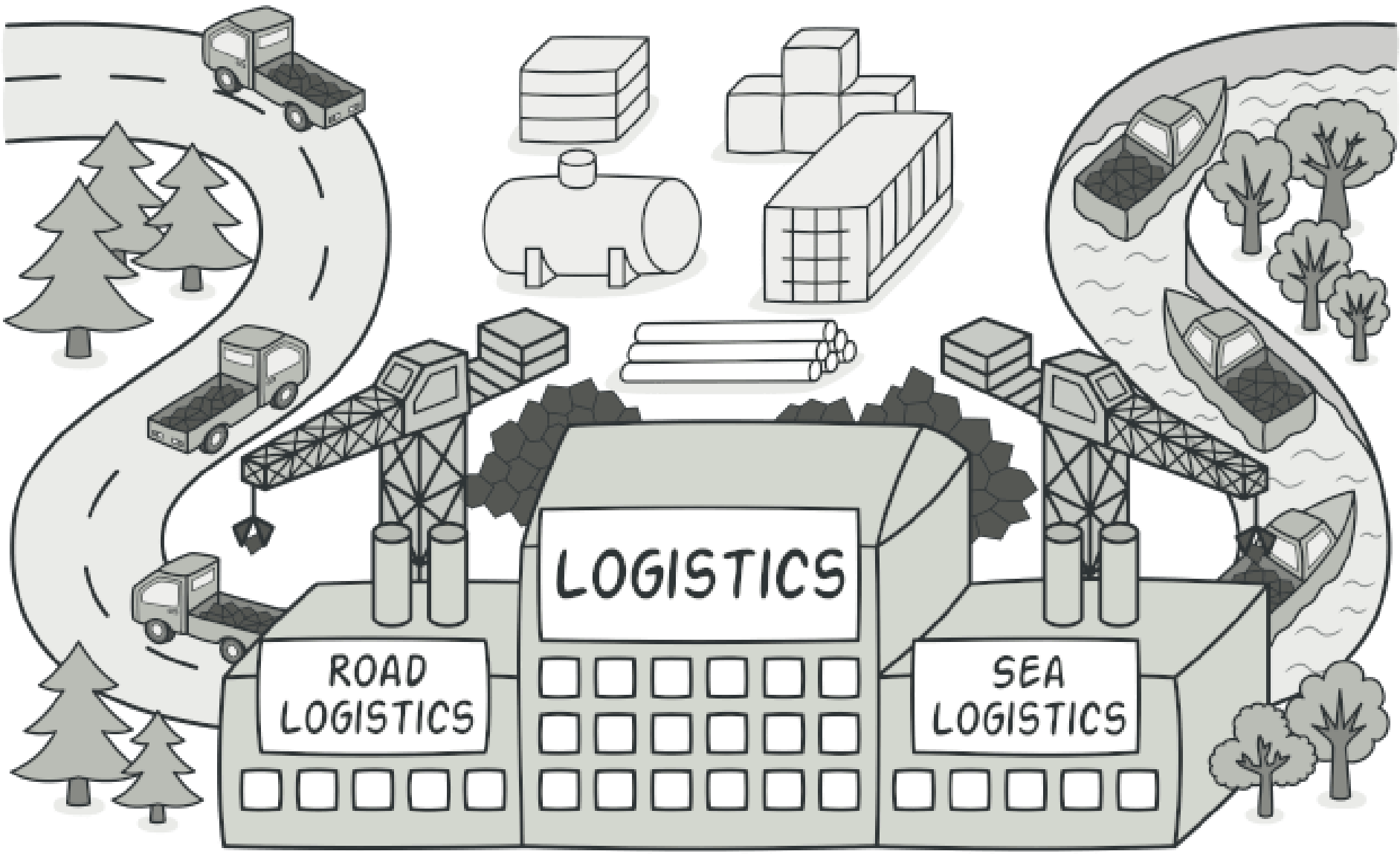
Creational design patterns

Creational design patterns abstract the **instantiation process**.*They help make a system independent of how its objects are created, composed, and represented.*

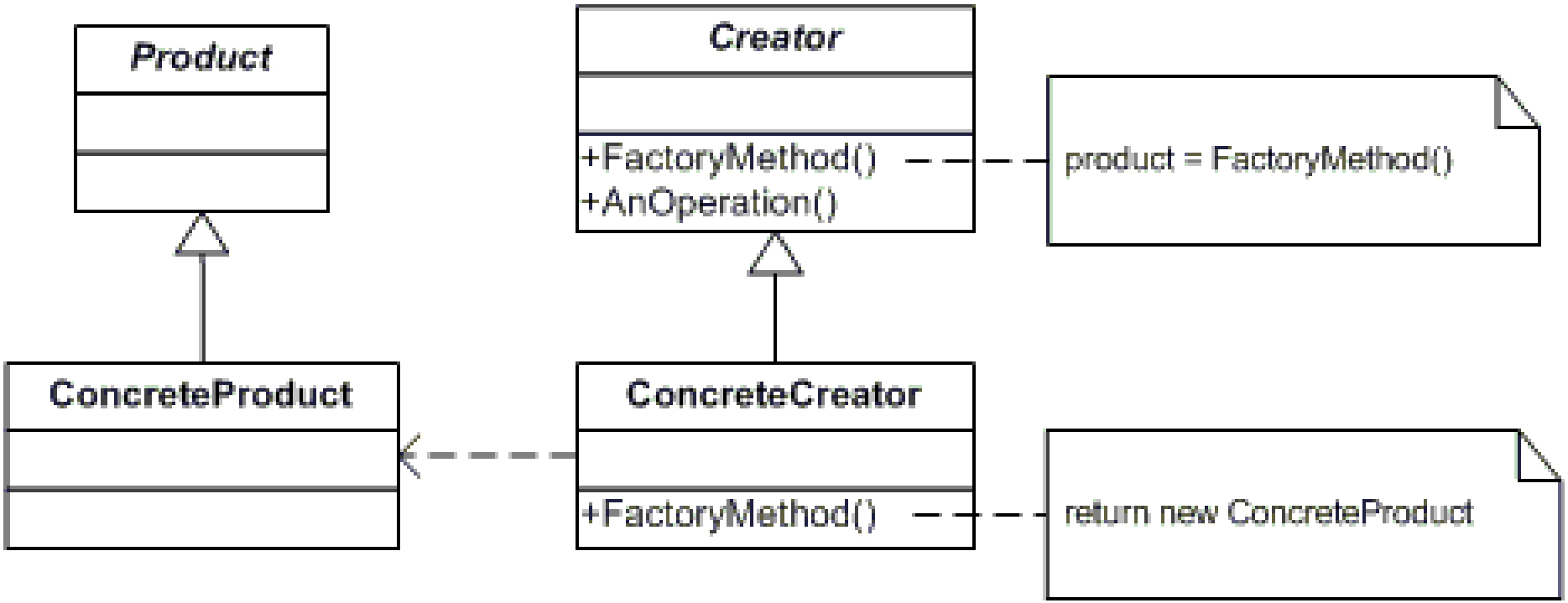
Factory method

- **Intent**: Define an interface for creating an object, but let subclasses decide which class to instantiate.
- **Also known as**: Virtual Constructor
- **Applicability**
  - a class can't anticipate the class of objects it must create.
  - a class wants its subclasses to specify the objects it creates.
  - classes delegate responsibility to one of several helper subclasses, and you want to localize the knowledge of which helper subclass is the delegate.

Factory method



Factory method - structure



Factory method - participants

- **Product**
  - defines the interface of objects the factory method creates.
- **ConcreteProduct**
  - implements the Product interface.
- **Creator**
  - declares the factory method, which returns an object of type Product.
  - may also define a default implementation of the factory method that returns a default ConcreteProduct object.
  - may call the factory method to create a Product object.
- **ConcreteCreator**
  - overrides the factory method to return an instance of a ConcreteProduct.

Factory method - implementation

Demo

Factory method

Factory method - consequences

- **Advantages**
  - Eliminates the need to bind application-specific classes into your code. The code only deals with the Product interface; therefore it can work with any user-defined ConcreteProduct classes.
  - *Single Responsibility Principle*. You can move the product creation code into one place in the program, making the code easier to support.
  - *Open/Closed Principle*. You can introduce new types of products into the program without breaking existing client code.
- **Disadvantages**
  - The code may become more complicated since you need to introduce a lot of new subclasses to implement the pattern.
  - Clients might have to subclass the Creator class just to create a particular ConcreteProduct object.

Bibliography design patterns

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http://www.uml.org.cn/c++/pdf/DesignPatterns.pdf