Visitor Pattern

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Design Aspect of Visitor

Operations that can be applied to objects without changing their classes

Outline

Compiler and AST (Visitor)

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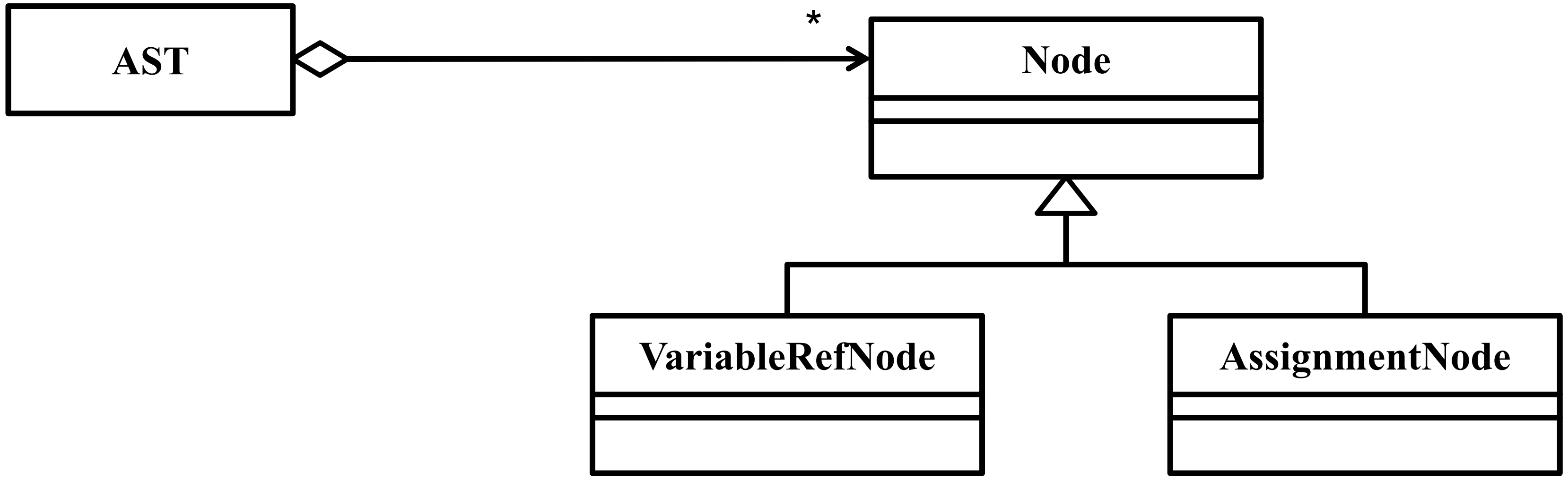
Requirements Statement

- There are several nodes in an abstract syntax tree (AST), such as VariableRefNode and AssignmentNode, which represent respective parts in source code and keep the code information.
- Each node currently provides three interfaces for the compiler to use in order to check its type, generate code and print out the content.

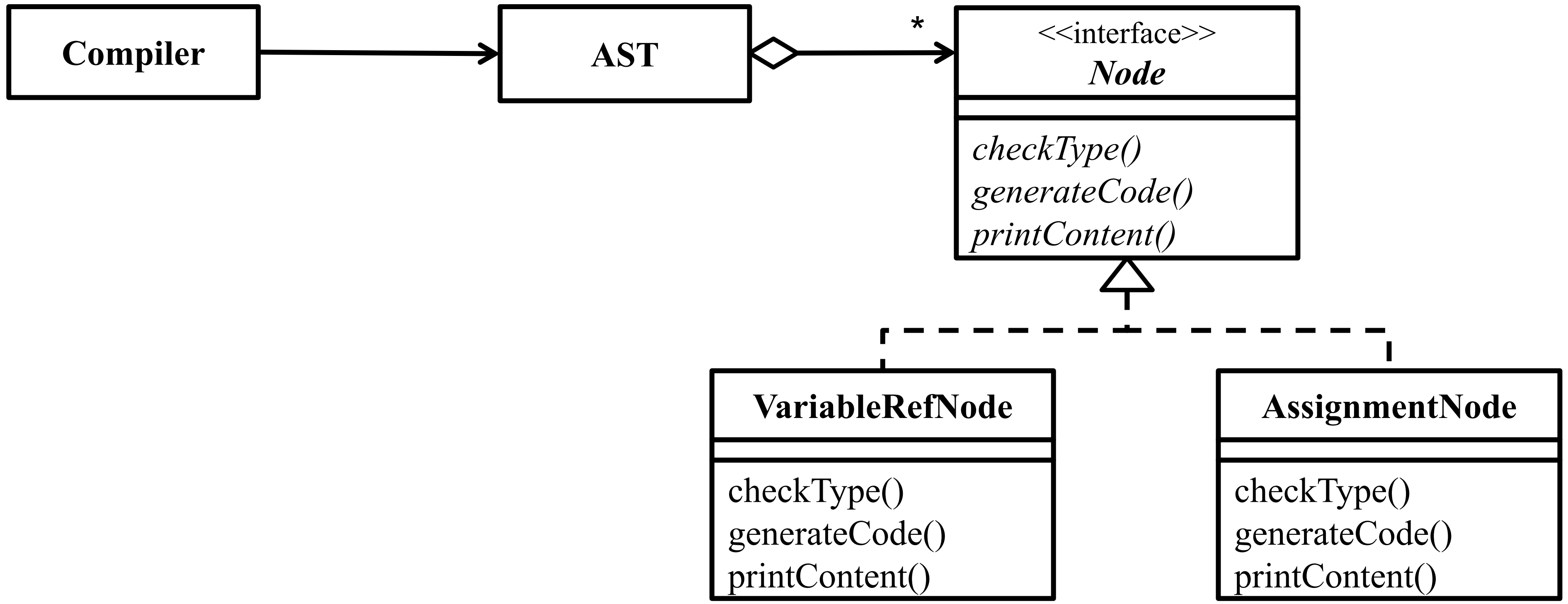
Requirements Statements$_1$

- There are several nodes in an abstract syntax tree (AST), such as VariableRefNode and AssignmentNode, which represent respective parts in source code and keep the code information.

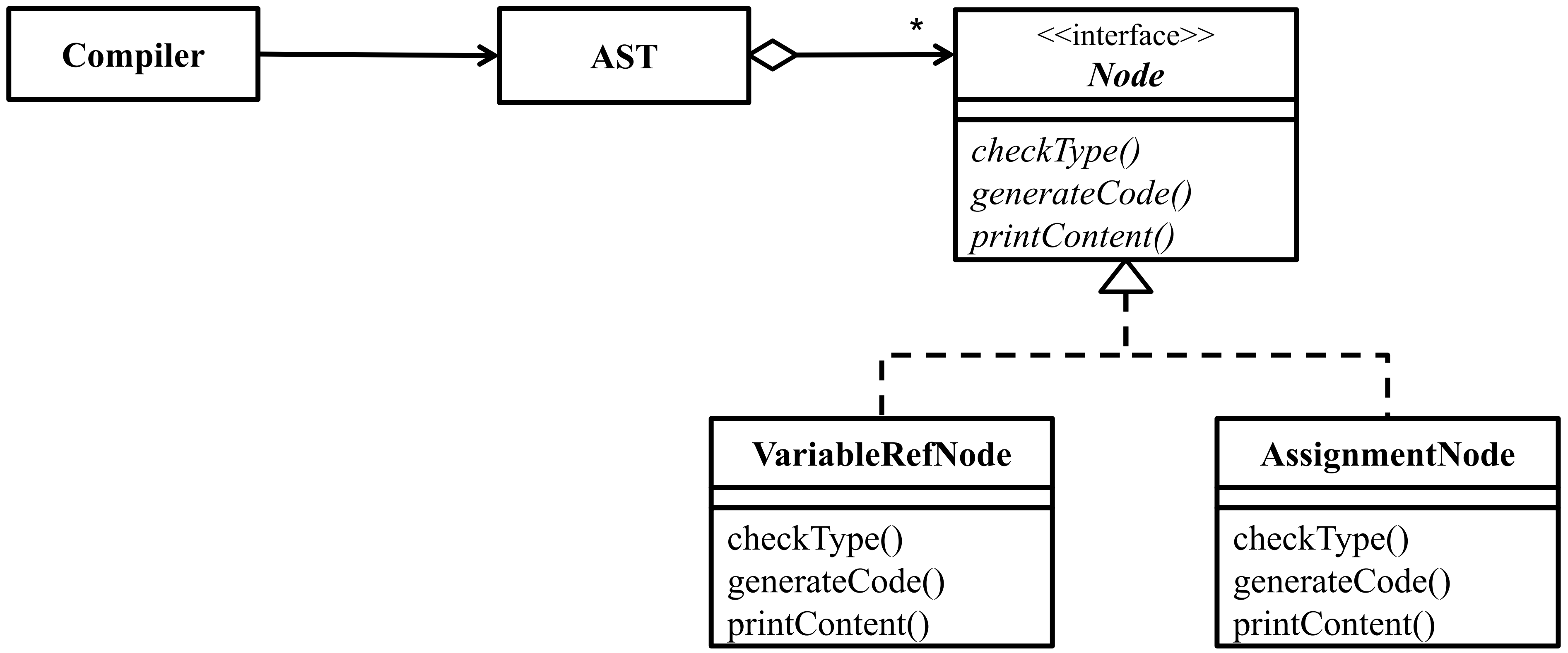


Requirements Statements$_2$

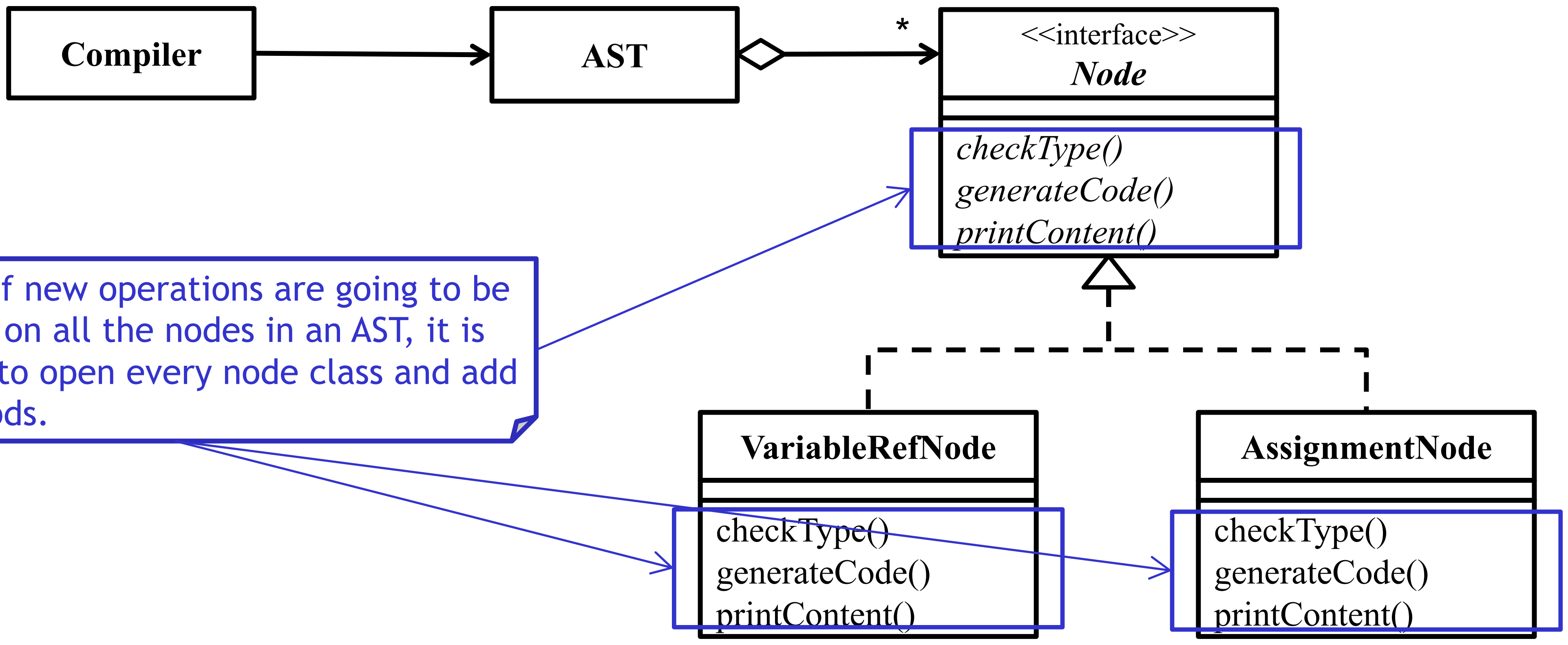
- Each node currently provides three interfaces for the compiler to use in order to check its type, generate code and print out the content.



Initial Design

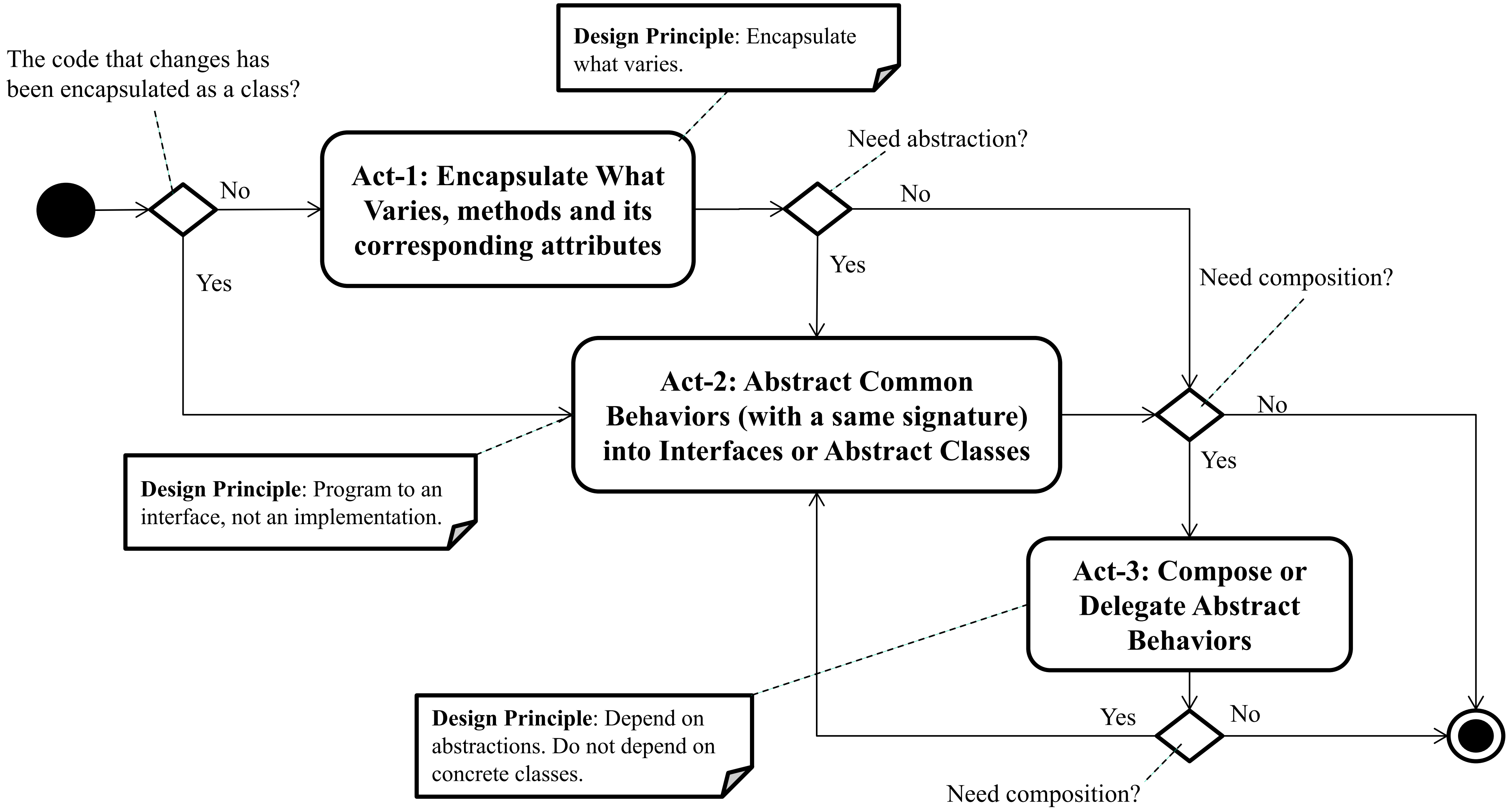


Problem with the Initial Design



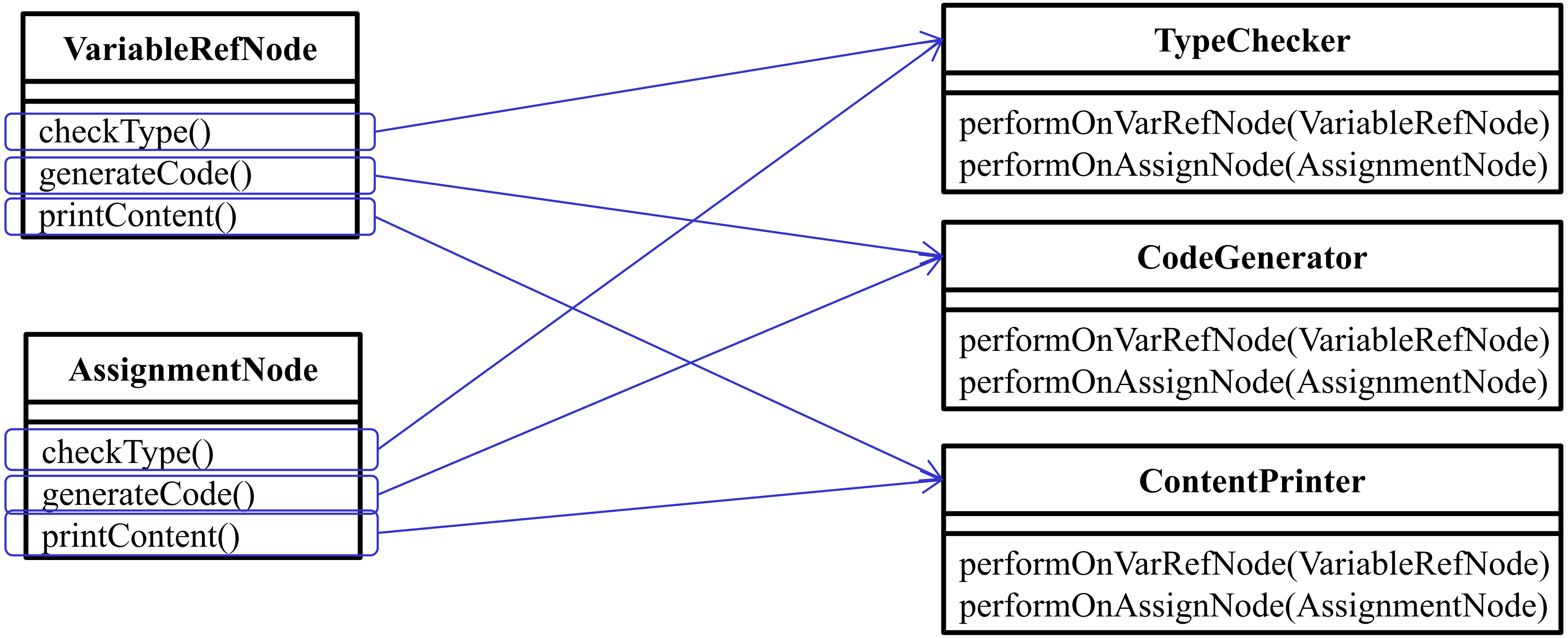
Problem : If new operations are going to be performed on all the nodes in an AST, it is inevitable to open every node class and add new methods.

Design Process for Change

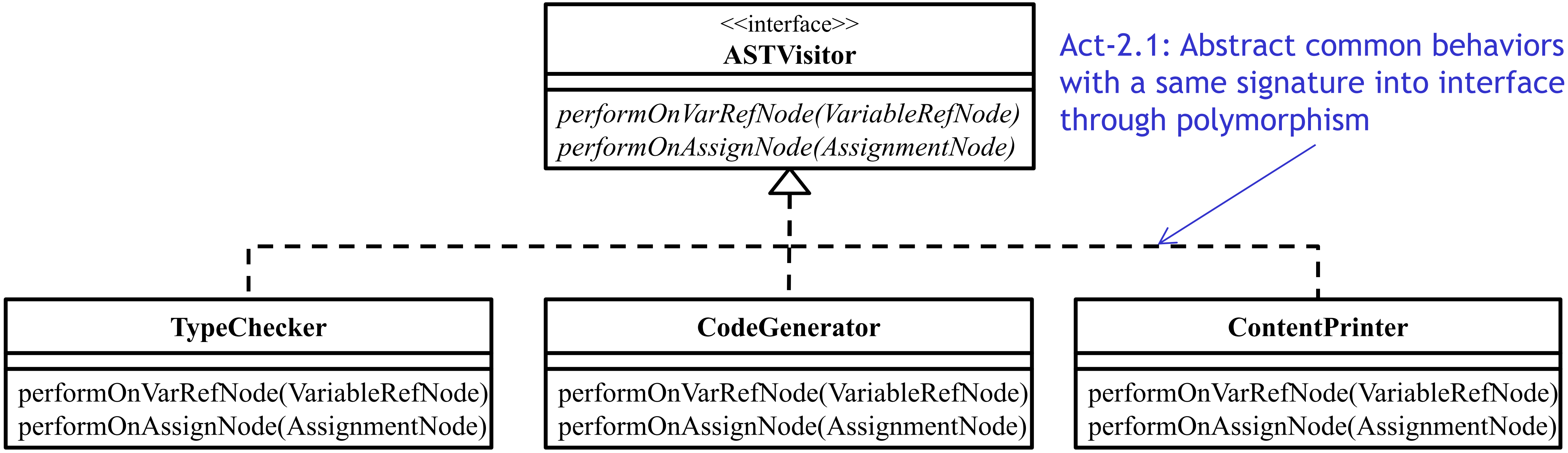

Design Principle: Encapsulate what varies.
The code that changes has been encapsulated as a class?
No
Yes
Act-1: Encapsulate What Varies, methods and its corresponding attributes
Need abstraction?
No
Yes
Need composition?
Act-2: Abstract Common Behaviors (with a same signature) into Interfaces or Abstract Classes
No
Yes
Design Principle: Program to an interface, not an implementation.
Act-3: Compose or Delegate Abstract Behaviors
Design Principle: Depend on abstractions. Do not depend on concrete classes.
Yes
No
Need composition?

Act-1: Encapsulate What Varies

Act-1.2: Encapsulate a method into a concrete class


VariableRefNode
checkType()
generateCode()
printContent()
AssignmentNode
checkType()
generateCode()
printContent()
TypeChecker
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)
CodeGenerator
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)
ContentPrinter
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)

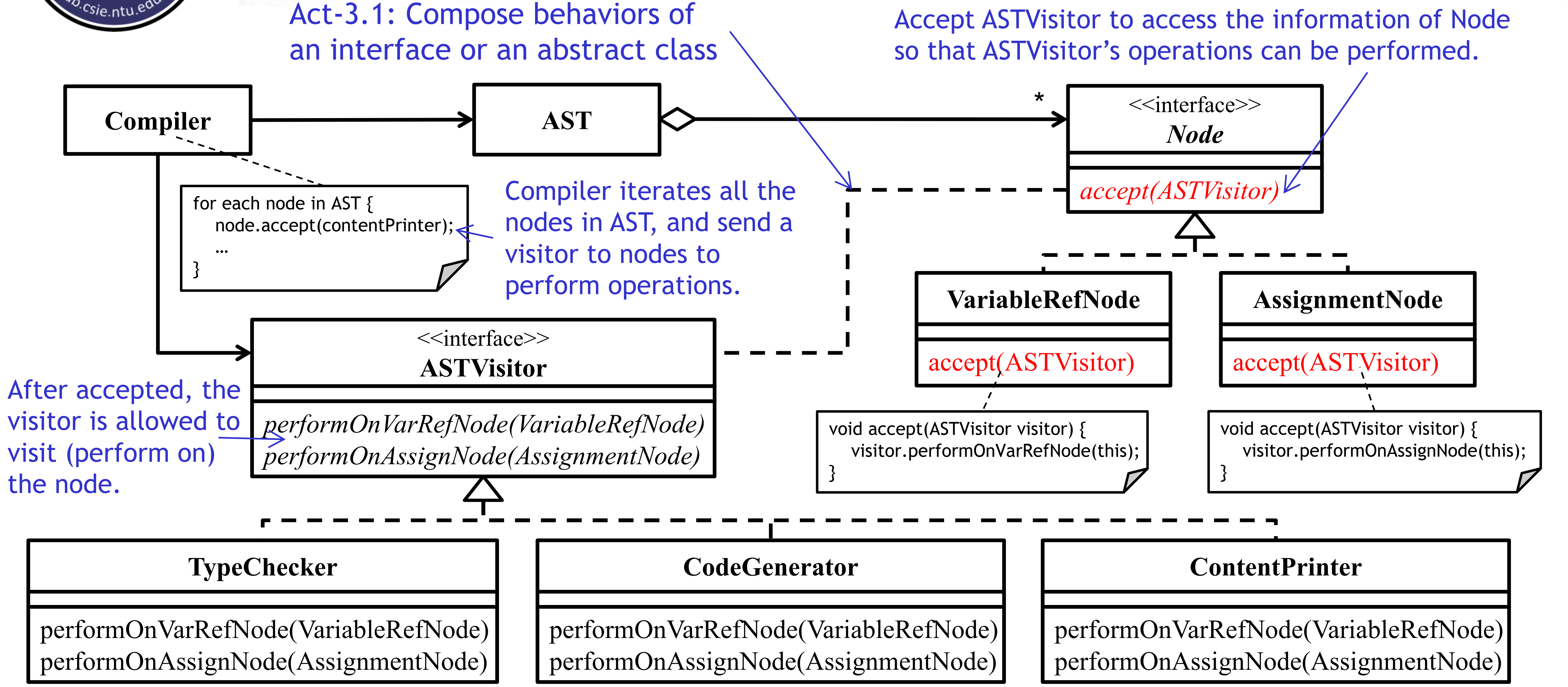
Act-2: Abstract Common Behaviors



<<interface>>
ASTVisitor
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)
TypeChecker
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)
CodeGenerator
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)
ContentPrinter
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)

Act-2.1: Abstract common behaviors with a same signature into interface through polymorphism

Act-3: Compose Abstract Behaviors



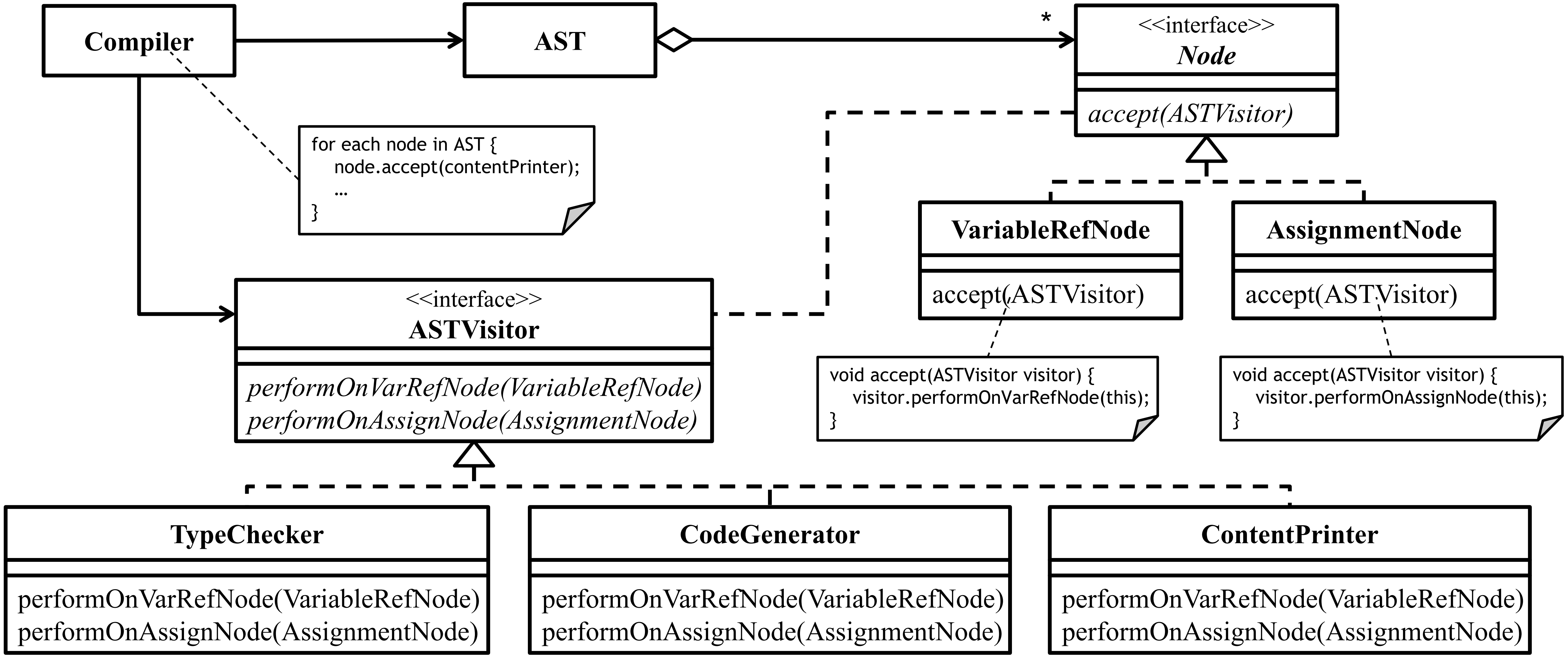
Act-3.1: Compose behaviors of an interface or an abstract class
Accept ASTVisitor to access the information of Node so that ASTVisitor's operations can be performed.
Compiler
AST
*
<<interface>>
Node
accept(ASTVisitor)
Compiler iterates all the nodes in AST, and send a visitor to nodes to perform operations.
VariableRefNode
accept(ASTVisitor)
AssignmentNode
accept(ASTVisitor)
<<interface>>
ASTVisitor
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)
After accepted, the visitor is allowed to visit (perform on) the node.
TypeChecker
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)
CodeGenerator
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)
ContentPrinter
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)

```
for each node in AST {
    node.accept(contentPrinter);
    …
}
```

```
void accept(ASTVisitor visitor) {
    visitor.performOnVarRefNode(this);
}
```

```
void accept(ASTVisitor visitor) {
    visitor.performOnAssignNode(this);
}
```

Refactored Design after Design Process



Compiler
AST
*
<<interface>>
Node
accept(ASTVisitor)
VariableRefNode
accept(ASTVisitor)
AssignmentNode
accept(ASTVisitor)
<<interface>>
ASTVisitor
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)
TypeChecker
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)
CodeGenerator
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)
ContentPrinter
performOnVarRefNode(VariableRefNode)
performOnAssignNode(AssignmentNode)

```
for each node in AST {
   node.accept(contentPrinter);
   …
}
```

```
void accept(ASTVisitor visitor) {
   visitor.performOnVarRefNode(this);
}
```

```
void accept(ASTVisitor visitor) {
   visitor.performOnAssignNode(this);
}
```

Recurrent Problem

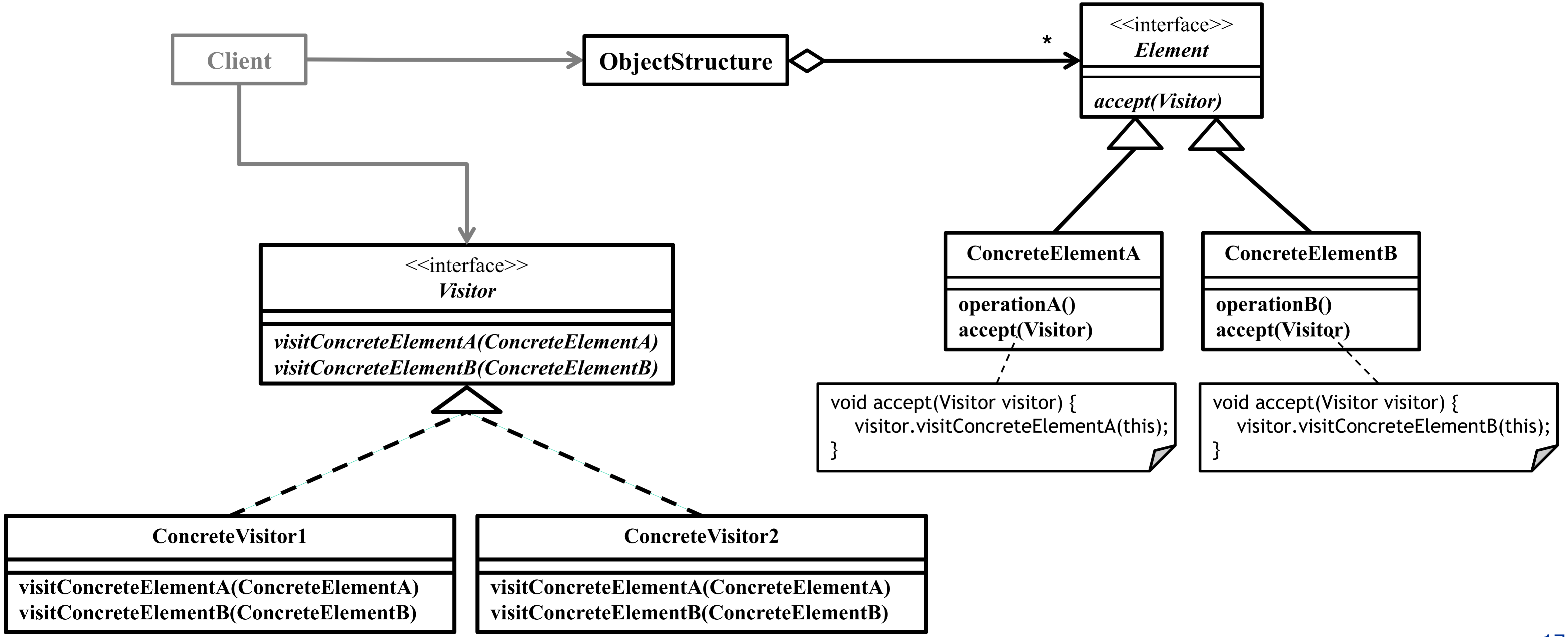
- The problem is that distributing all these operations across the various classes in an object structure leads to a system that's hard to understand, maintain, and change. Moreover, adding a new operation usually requires recompiling all of these classes.

Intent

- Represent an operation to be performed on the elements of an object structure.

- Visitor lets you **define a new operation without changing the classes of the elements on which it operates.**

Visitor Pattern Structure$_1$


Client
ObjectStructure
*
<<interface>>
Element
accept(Visitor)
ConcreteElementA
operationA()
accept(Visitor)
ConcreteElementB
operationB()
accept(Visitor)
<<interface>>
Visitor
visitConcreteElementA(ConcreteElementA)
visitConcreteElementB(ConcreteElementB)
ConcreteVisitor1
visitConcreteElementA(ConcreteElementA)
visitConcreteElementB(ConcreteElementB)
ConcreteVisitor2
visitConcreteElementA(ConcreteElementA)
visitConcreteElementB(ConcreteElementB)

```
void accept(Visitor visitor) {
   visitor.visitConcreteElementA(this);
}
```

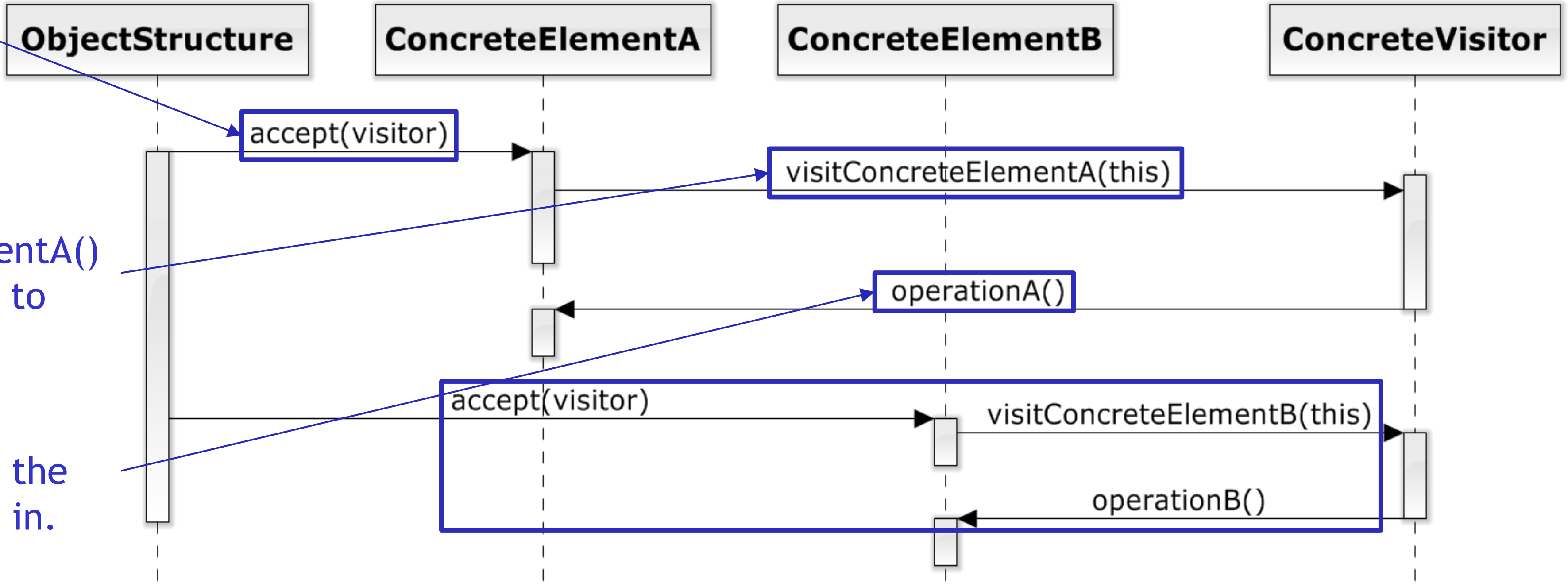
```
void accept(Visitor visitor) {
   visitor.visitConcreteElementB(this);
}
```

Visitor Pattern Structure$_2$

1. ObjectStructure invokes ConcreteEmelemtA's accept() and passes a ConcreteVisitor instance.

2. ConcreteElementA invokes ConcreteVisitor's visitConcreteElementA() and passes itself to allow the visitor to access its state.

3. ConcreteVisitor invokes ConcreteElementA's operationA() by the ConcreteElementA reference passed in.



4~6. The same process as 1~3 for ConcreteElementB.

Visitor Pattern Structure$_3$

	Instantiation	Use	Termination
Visitor	X	ConcreteElement invokes Visitor's visit method through polymorphism.	X
ConcreteVisitor	Client	Client passes ConcreteVisitor to ObjectStructure, and ObjectStructure invokes the accept() of Element with the ConcreteVisitor. In the accept() of Element, the visit method of ConcreteVisitor is invoked and Element passes itself to the visit method so that the visitor can access the state of Element.	Client
Element	X	Element provides accept() that allows ObjectStructure to pass Visitor to Element.	X
ConcreteElement	Don't Care	ConcreteElement realizes the accept() to allow Visitor accessing the state of ConcreteElement.	Don't Care
ObjectStructure	Don't Care	ObjectStructure that consists of multiple Elements invokes the accept() of Element and passes ConcreteVisitor to Element.	Don't Care

Double-Dispatch

- "Double-dispatch" simply means the operation that gets executed depends on the kind of request and the types of two receivers (Visitor and Element).
- accept() is a double-dispatch operation. Its meaning depends on two types: the Visitor's and the Element's. Double-dispatching lets visitors request different operations on each class of element.
- Instead of binding operations statically into the Element interface, you can consolidate the operations in a Visitor and use accept() to do the binding at run-time.
- Extending the Element interface amounts to defining one new Visitor subclass rather than many new Element subclasses.

Double-Dispatching

- Instead of binding operations statically into the Element interface, you can consolidate the operations in a Visitor and use accept() to do the binding at run-time.
- We can extract operations in the elements of an Object Structure into a Visitor. By doing so, we can add new elements to the object structure without affecting the existing code, and we can also add new operations to Visitor without affecting Elements.
- Single-dispatch polymorphism is where a function or method call is dynamically dispatched based on the actual derived type of the object on which the method has been called.

Nutrition Retrieval from A Restaurant Menu (Visitor)

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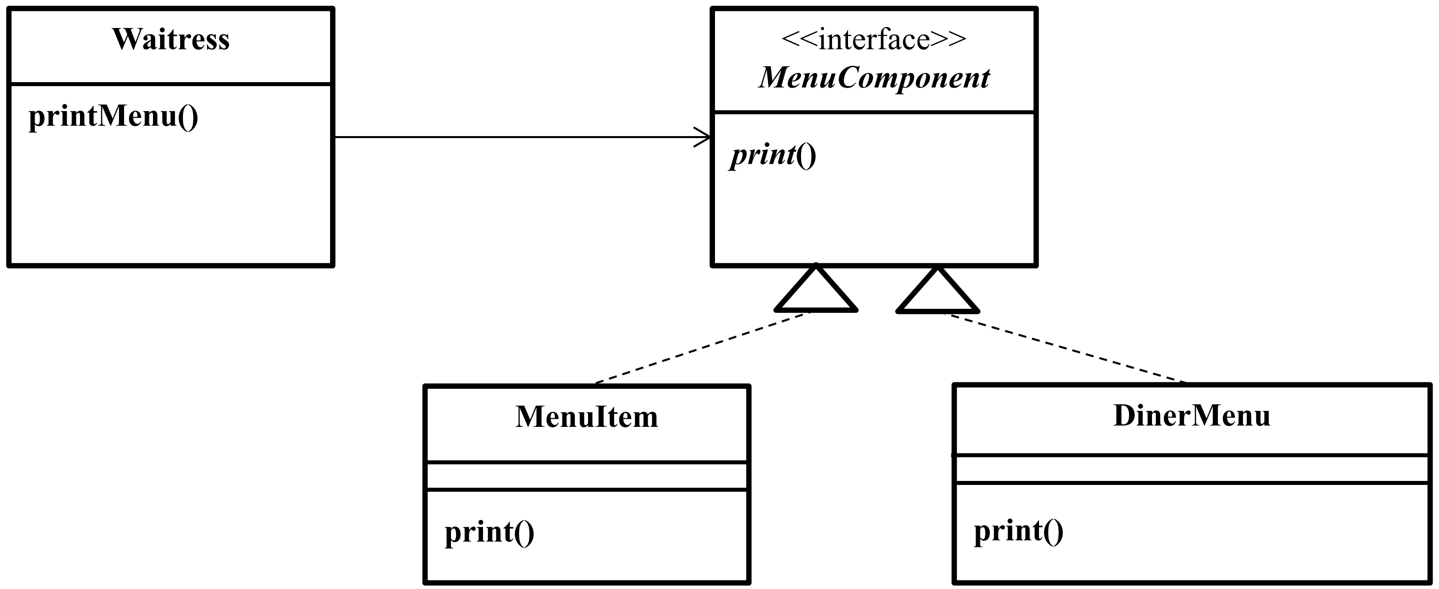
Requirements Statements

- The menu components of the Diner restaurant comprises menu items and diner menus that can be printed by a waitress.
- Each diner menu consists of several menu items.
- The Diner restaurant would like to provide calories, protein, and carbon dioxide (carbs) information for each menu item.

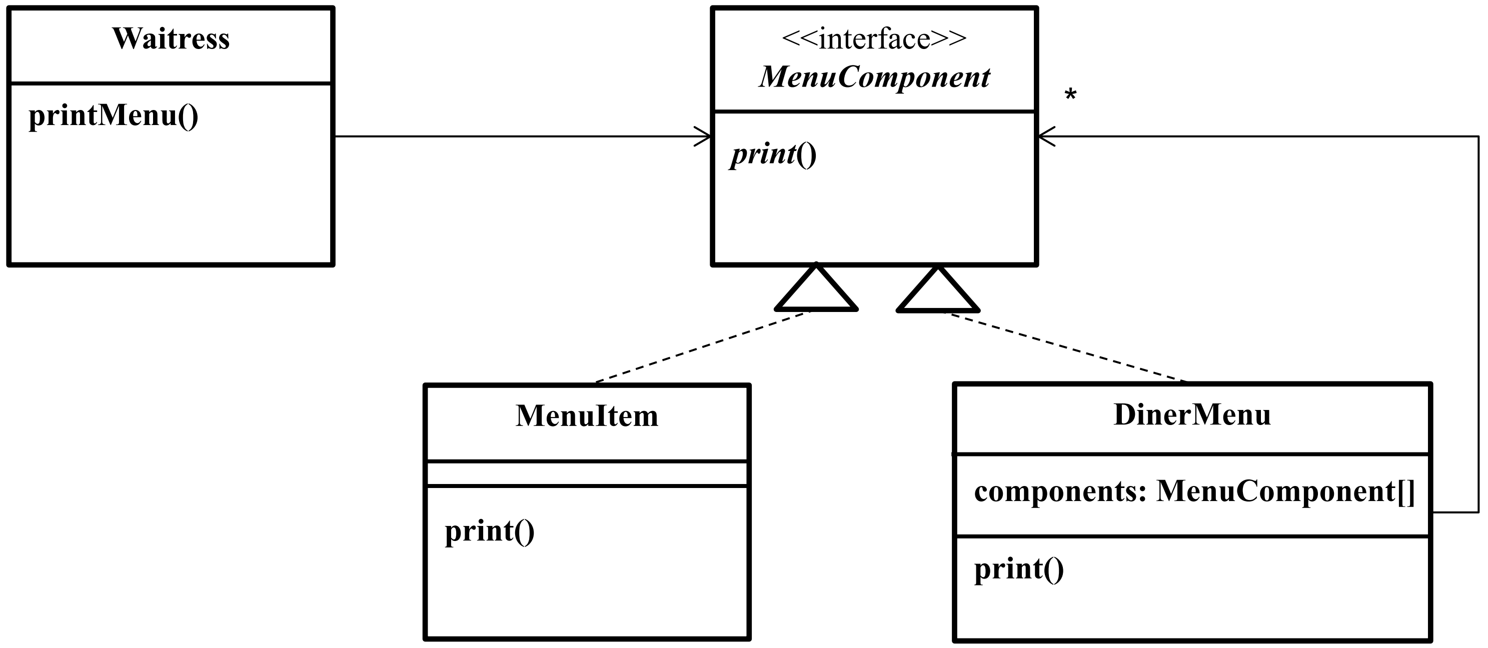
Requirements Statements$_1$

- The menu components of the Diner restaurant comprises menu items and diner menus that can be printed by a waitress.



Requirements Statements$_2$

- Each diner menu consists of several menu items.



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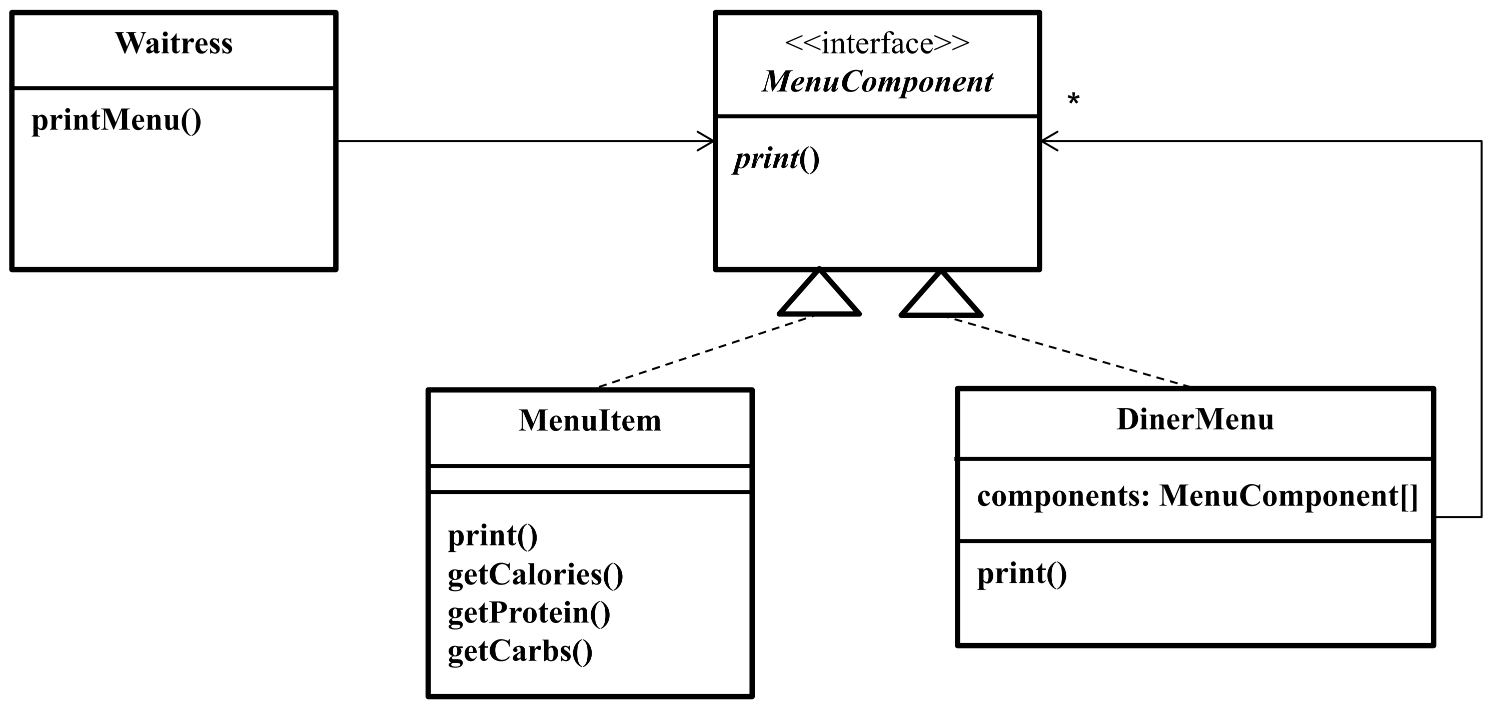
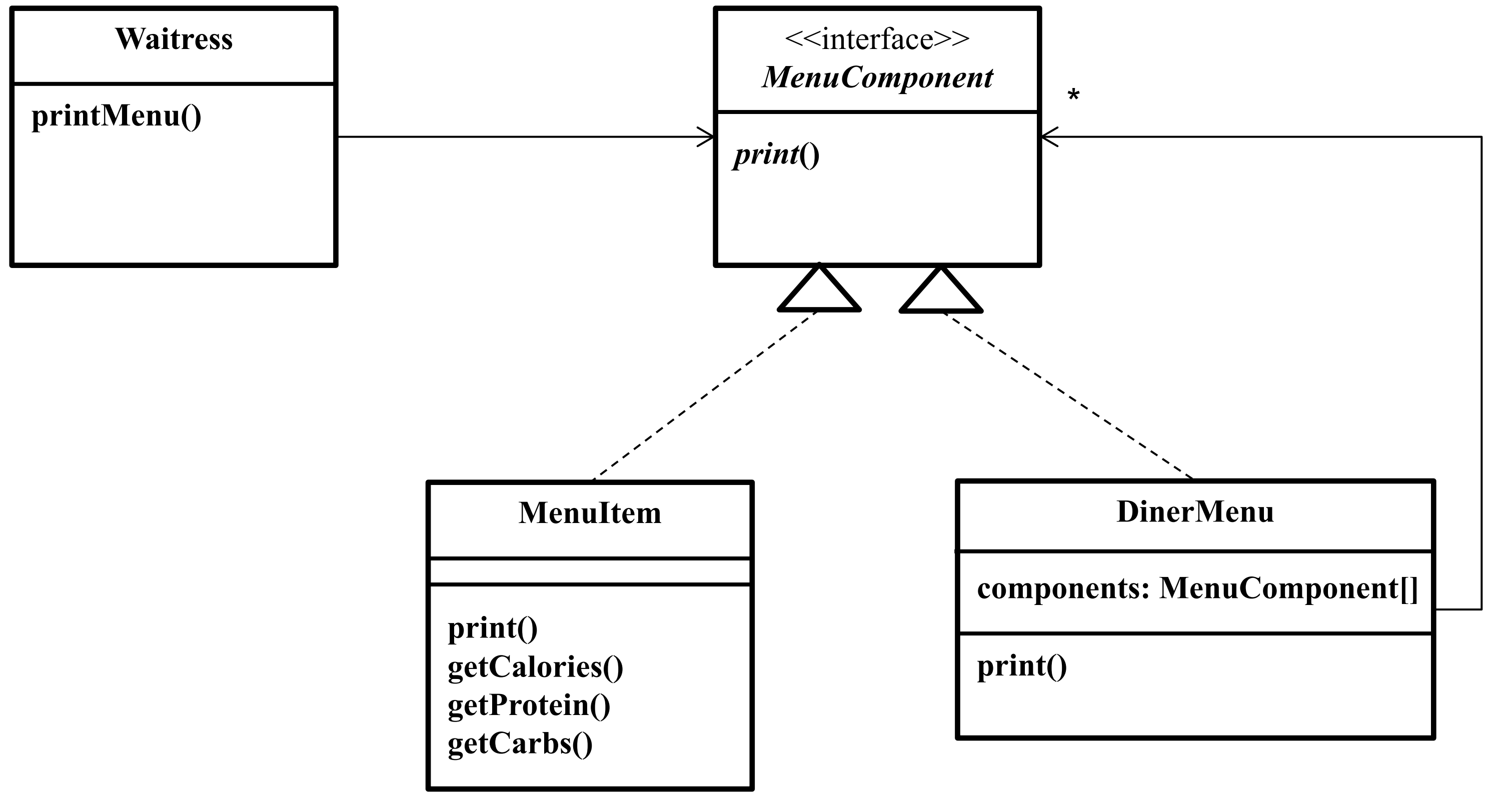
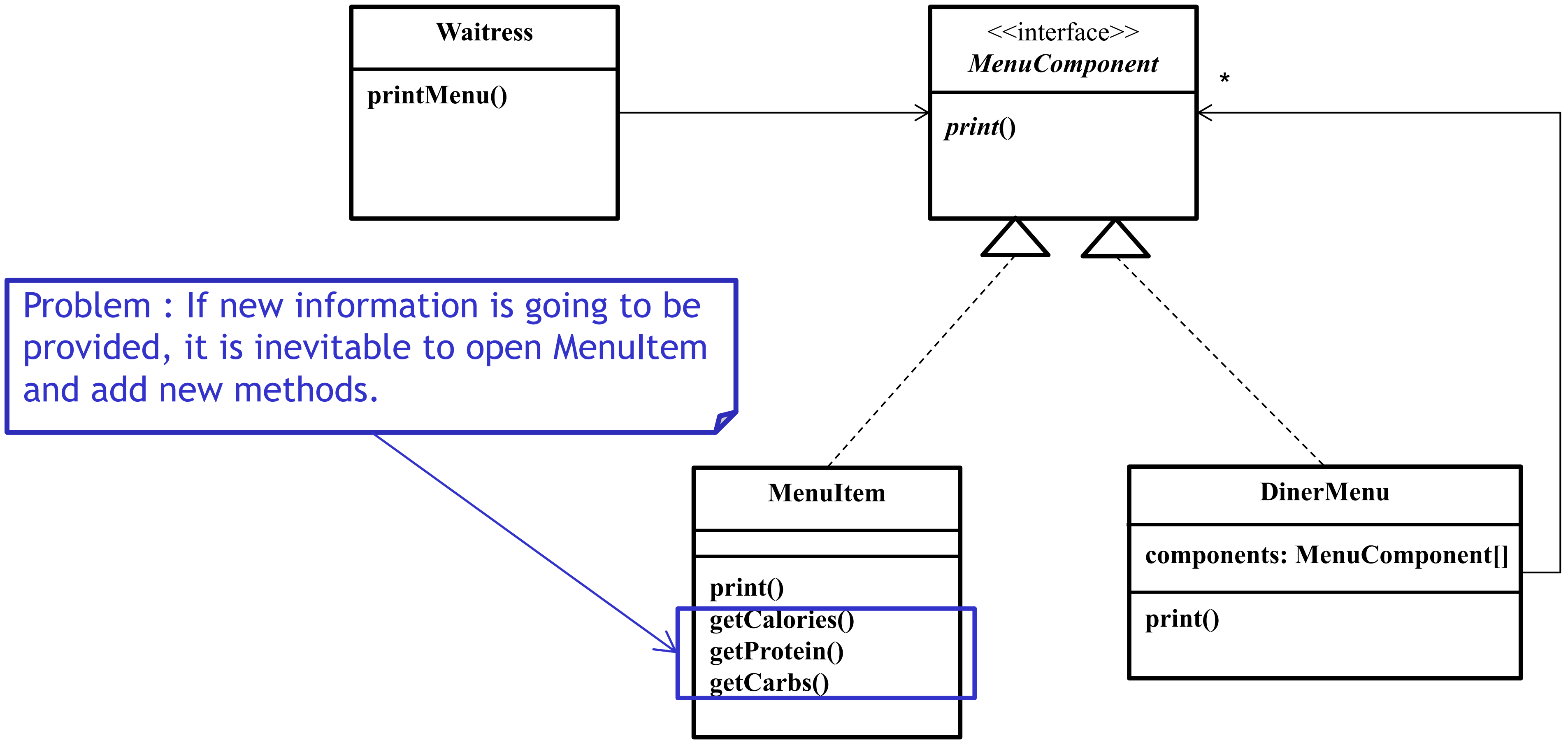
- The Diner restaurant would like to provide calories, protein and carbon dioxide (carbs) information for each menu item.



Initial Design

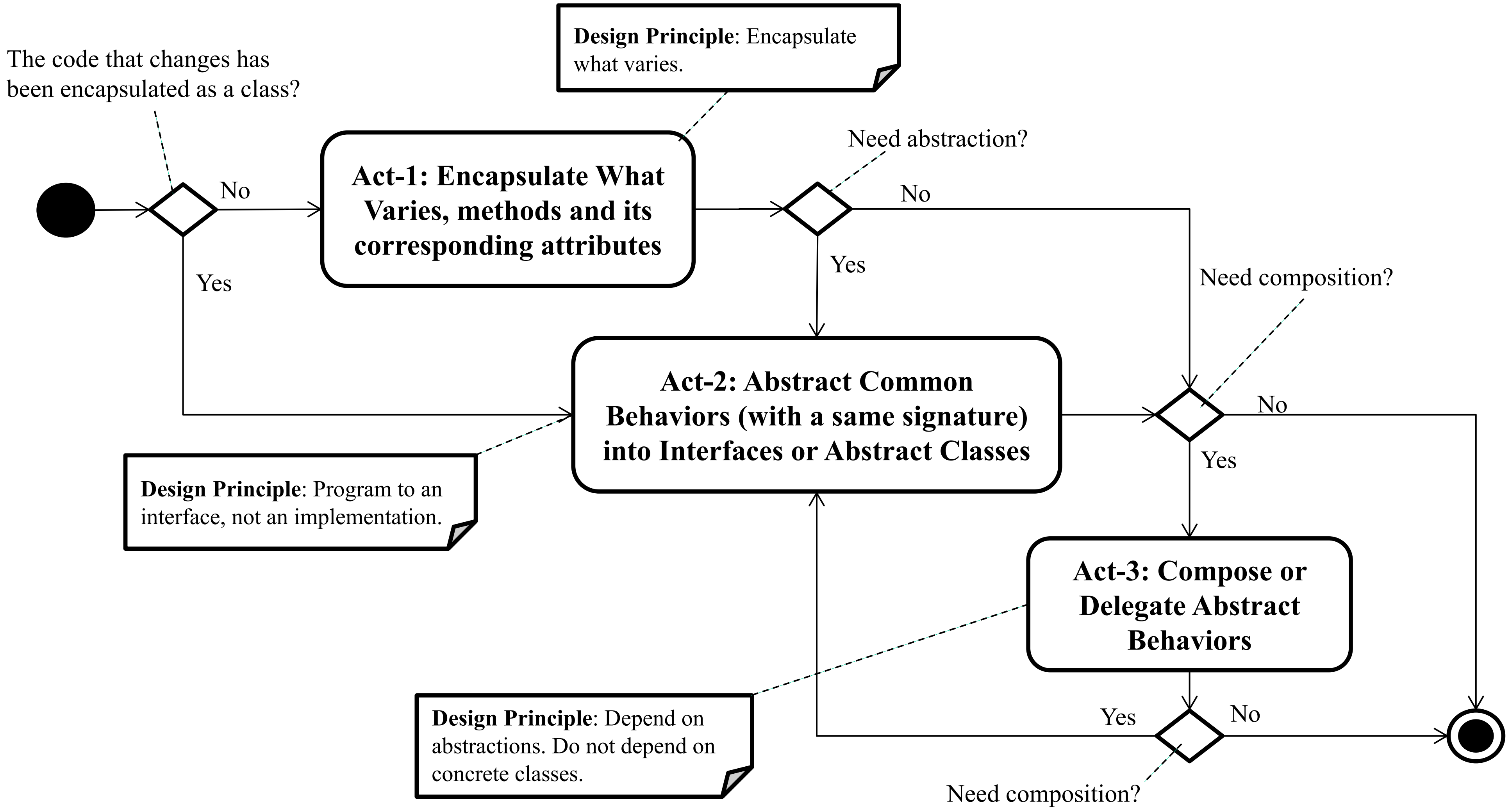


The Problem with the Initial Design



Problem : If new information is going to be provided, it is inevitable to open MenuItem and add new methods.

Design Process for Change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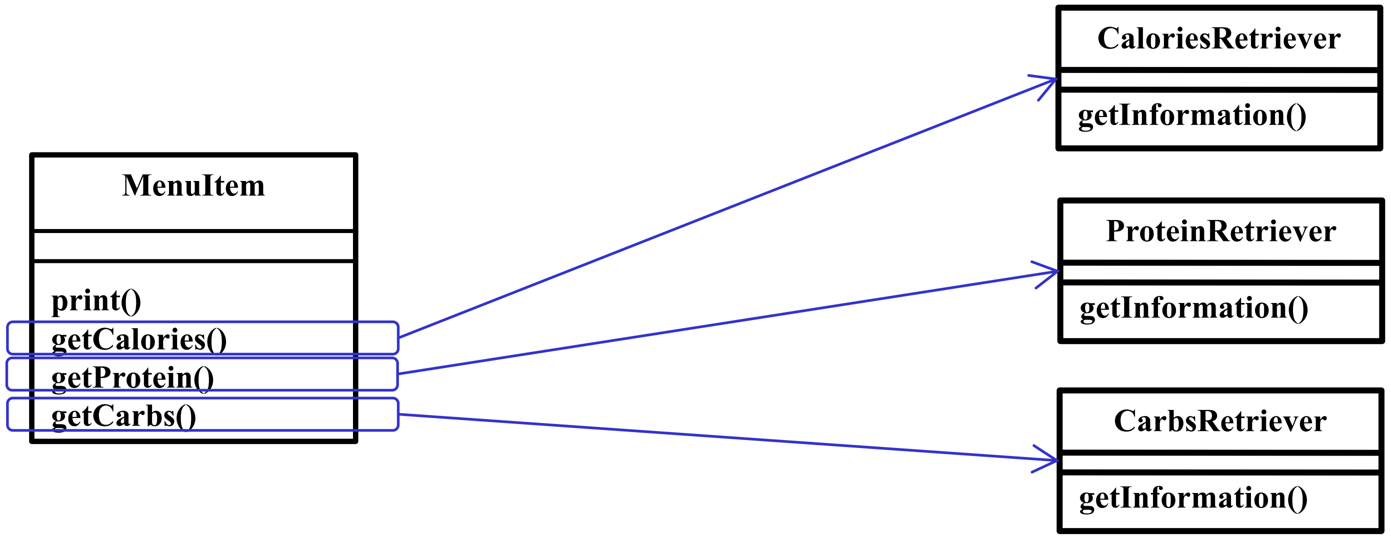
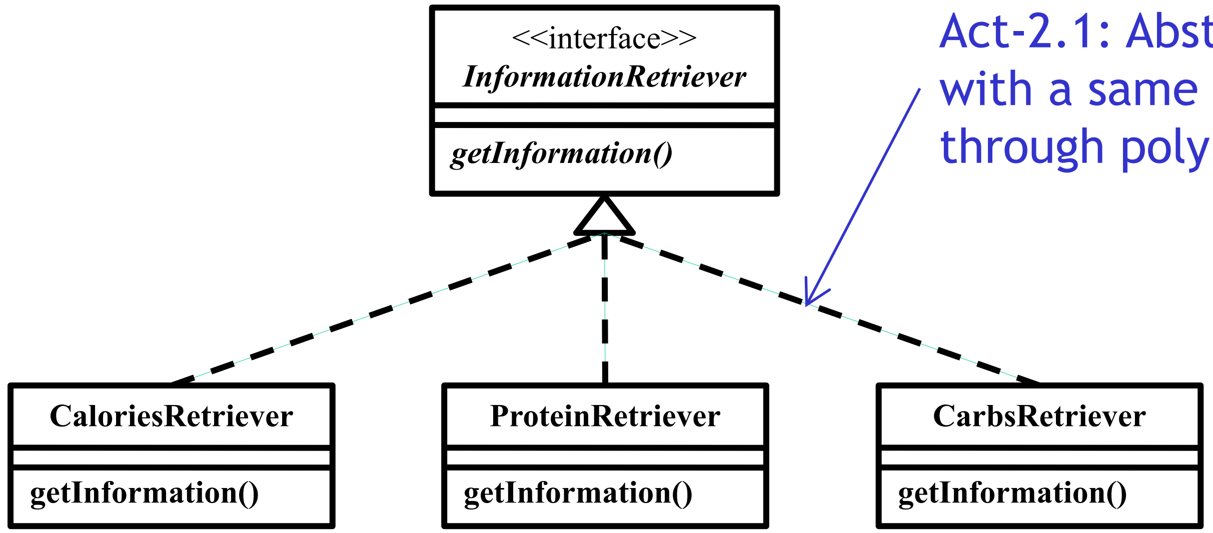
Need composition?

Act-1: Encapsulate What Varies

Act-1.2: Encapsulate a method into a concrete class

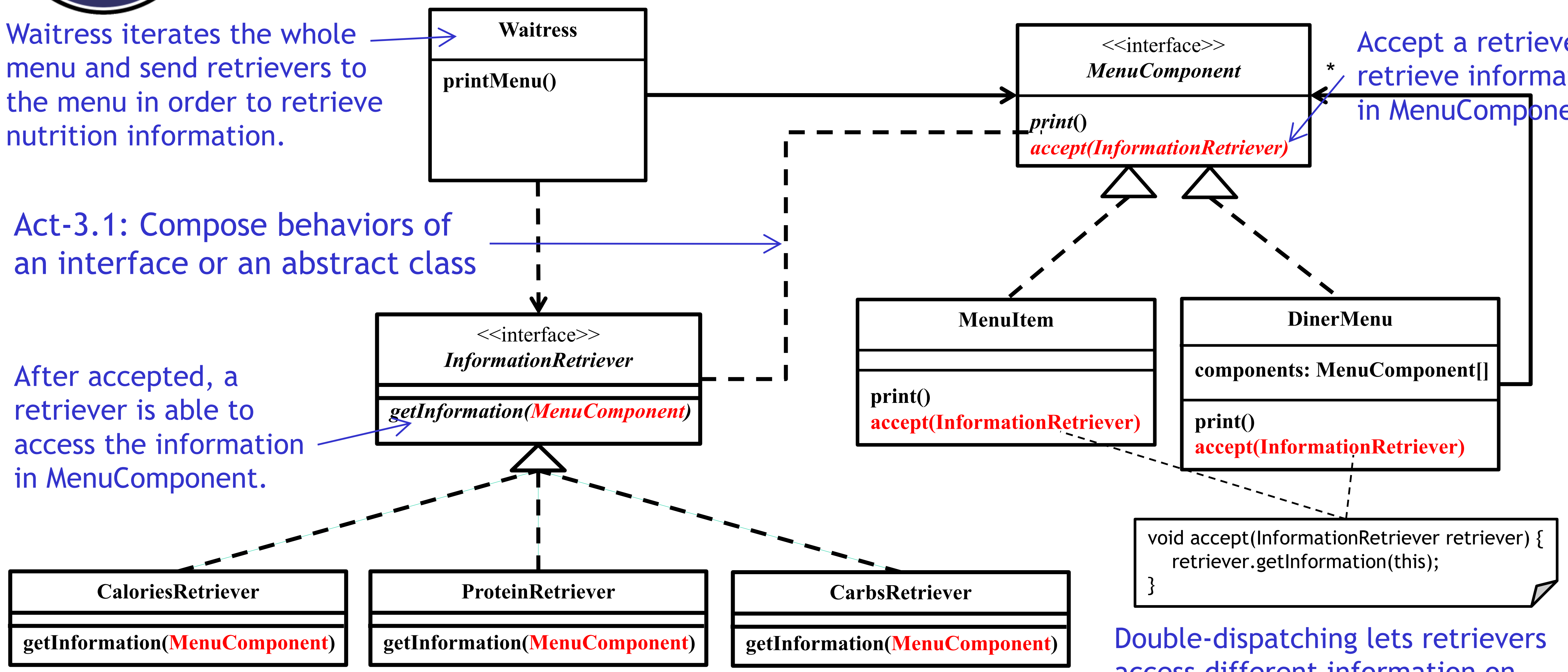


Act-2: Abstract Common Behaviors



Act-2.1: Abstract common behaviors with a same signature into interface through polymorphism

Act-3: Compose Abstract Behaviors


Waitress
printMenu()
<<interface>>
MenuComponent
print()
accept(InformationRetriever)
*
<<interface>>
InformationRetriever
getInformation(MenuComponent)
MenuItem
print()
accept(InformationRetriever)
DinerMenu
components: MenuComponent[]
print()
accept(InformationRetriever)
CaloriesRetriever
getInformation(MenuComponent)
ProteinRetriever
getInformation(MenuComponent)
CarbsRetriever
getInformation(MenuComponent)

```
void accept(InformationRetriever retriever) {
    retriever.getInformation(this);
}
```

Waitress iterates the whole menu and send retrievers to the menu in order to retrieve nutrition information.

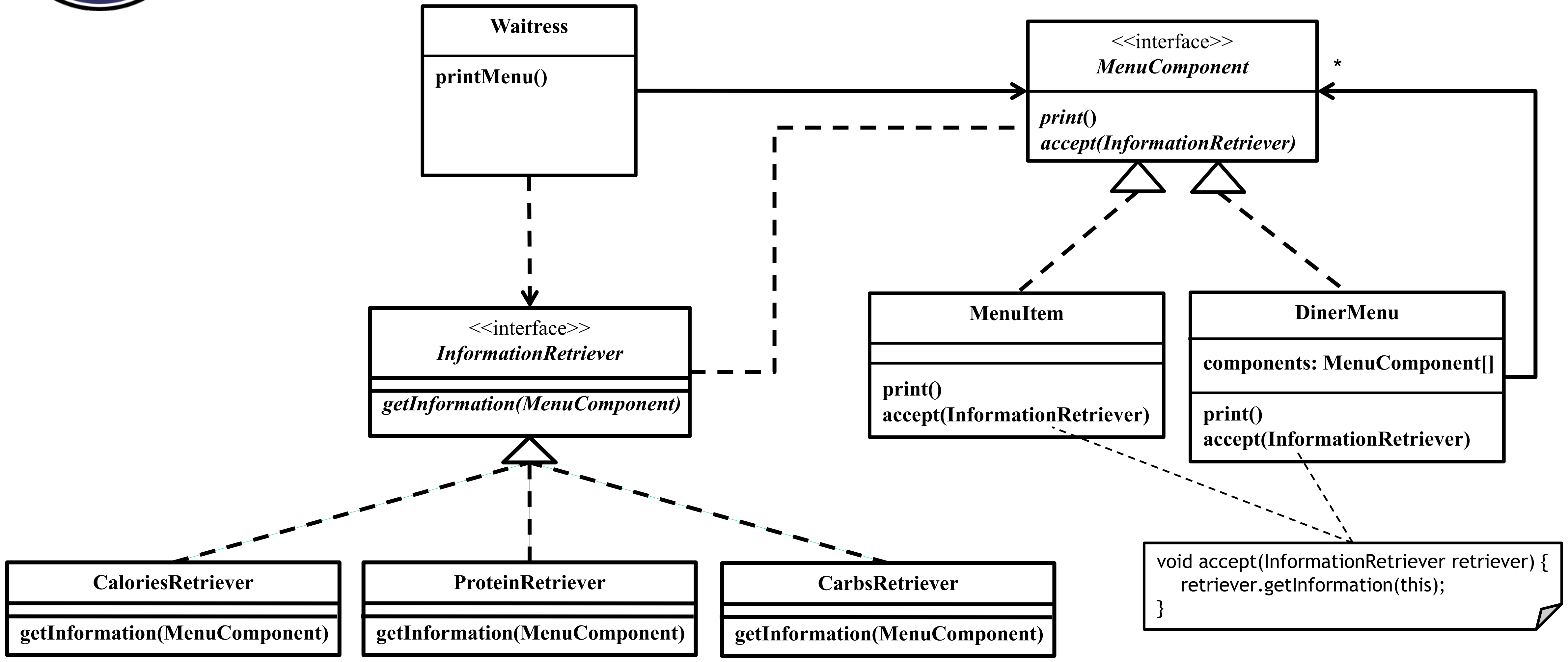
Accept a retriever to retrieve information in MenuComponent.

Act-3.1: Compose behaviors of an interface or an abstract class

After accepted, a retriever is able to access the information in MenuComponent.

Double-dispatching lets retrievers access different information on each class of MenuComponent.

Refactored Design after Design Process


Waitress
printMenu()
<<interface>>
MenuComponent
print()
accept(InformationRetriever)
*
<<interface>>
InformationRetriever
getInformation(MenuComponent)
MenuItem
print()
accept(InformationRetriever)
DinerMenu
components: MenuComponent[]
print()
accept(InformationRetriever)
CaloriesRetriever
getInformation(MenuComponent)
ProteinRetriever
getInformation(MenuComponent)
CarbsRetriever
getInformation(MenuComponent)

```
void accept(InformationRetriever retriever) {
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```