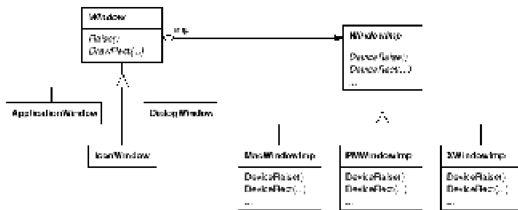
Bridge Pattern

- Problem
  - The client interface and implementation of an abstraction should be able to vary independently.
  - This is not possible with a single class hierarchy.
- Solution:
  - Create two class hierarchies, one for the logical abstraction, and the other for the implementation.
  - Create a “bridge” to bring them together, implementing classes in the abstraction hierarchy using ones in the implementation hierarchy.

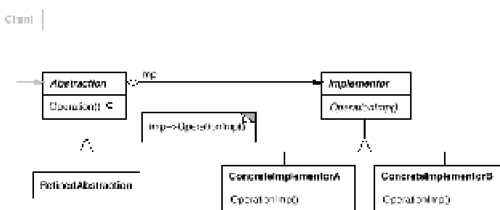
Example: Multiple Window Systems

- Goal: separate windowing system structure from how it’s implemented
  - Applications depend on the window hierarchy and the operations it defines, but are shielded from separate (low-level) issues of implementation.
- Sketch of Solution:
  - Abstraction hierarchy rooted by class **Window**, defining window functionality.
  - Bridge to implementation hierarchy rooted by class **WindowImp** to handle a vendor’s implementation

Example: Multiple Window Systems



Structure of Bridge Pattern



Consequences

- Decouple abstraction from implementation and representation
  - Clients depend on the logical abstraction; shielded from implementation details which could change.
- Change implementation at run time
  - Simply switch abstraction classes to point to a different implementation classes at runtime.

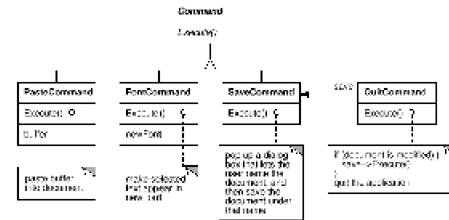
Command Pattern

- Problem
  - An application often performs similar actions that could be effected in different ways
- Solution
  - Parameterize objects by the commands they perform: encapsulate a command as an object
  - All commands inherit from same interface, but implement it differently
  - Permits reusing commands in different contexts, and allows commands to be aware of their receiver

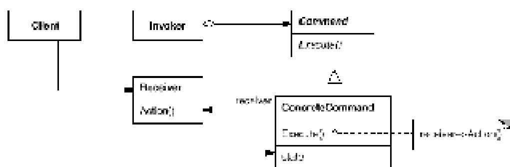
Example: Lexi Commands

- Initiate a command from a button, or a menu item
- Allow some commands to be undone or redone
  - Cutting and pasting vs. printing
  - Requires command objects store history
- Each command might have a different context
  - Cut command does the same thing, but might be operating on different documents, and different text within those documents
- A sequence of commands can form a macro

Command Objects



Structure of Command Pattern



Consequences

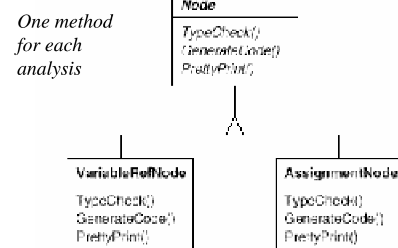
- Decouple receiver and executor of requests
  - Lexi example: Different icons can be associated with the same command
  - Commands can change without affecting callers
- Easy to support undo and redo
  - command has method to check whether it's reversible
  - must add state information
- Can create composite commands
  - Editor macros

Visitor: Implementing Analyses

- Problem: want to implement multiple analyses on the same kind of object data
  - Spellchecking and Hyphenating Glyphs
  - Generating code for and analyzing an Abstract Syntax Tree (AST) in a compiler
- Flawed solution: implement each analysis as a method in each object
  - Follows idea "objects are responsible for themselves"
  - But many analyses will occlude the object's main code
  - Result is classes hard to maintain

Naïve approach (not a visitor)

One method for each analysis

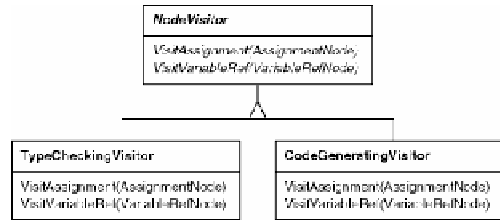


Visitor Pattern

- We define each analysis as a separate **Visitor** class
  - Defines operations for each element of a structure
- A separate algorithm traverses the structure, applying a given visitor
  - But, like iterators, objects must reveal their implementation to the visitor object
- Separates structure traversal code from operations on the structure
  - Observation: object structure rarely changes, but often want to design new algorithms for processing

129

Sample Visitor class



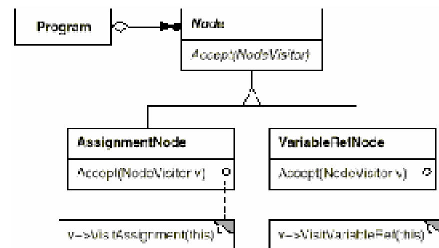
130

Traversing a structure

- Add **accept**(Visitor) method to each structure class, that will invoke the given visitor on **this**.
  - Builds on Java's dynamic dispatch.
- Use an iteration algorithm to call **accept()** as each object is reached.

131

Sample visited objects



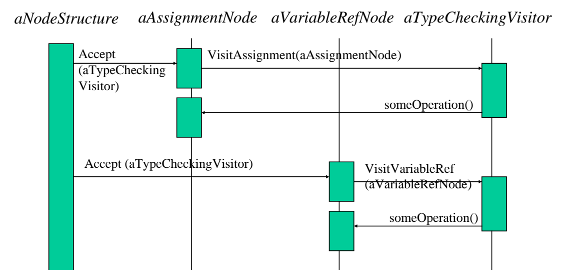
132

Double-dispatch

- Accept code is a way of doing *double-dispatch*
- Traversal routine takes two arguments, the visitor **aVisitor** and the object **o** to traverse
  - **o.accept(aVisitor)** will dispatch on the actual identity of **o** (the object being considered)
  - and **accept()** will internally dispatch on the identity of **aVisitor** (the object visiting it).

133

Vistor Interaction

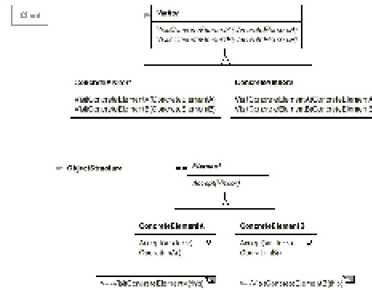


134

Structure

- One class hierarchy for object structure
  - AST in compiler, Glyphs in Lexi
- One class hierarchy for each operation family, called visitors
  - One for typechecking, code generation, pretty printing in compiler
  - One for spellchecking or hyphenation in Lexi

Structure of Visitor Pattern



Using overloading in a visitor

- You can name all of the visitCLASS(CLASS x) methods just visit(CLASS x)
  - E.g., change visitAssignmentNode(AssignmentNode n) and visitVariableRefNode(VariableRefNode n) to be visit(AssignmentNode n) and visit(VariableRefNode n)
- Calls distinguished by compile time overload resolution
  - Distinguishes visit (AssignmentNode n) from visit(VariableRefNode n)

Visitor Pattern Consequences

- Gathers related operations into one class
- Adding new analyses is easy
  - New visitor for each one
  - Easier than modifying the object structure
- Adding new concrete elements is difficult
  - must add a new method to each concrete Visitor subclass
- Allows visiting across class hierachies
  - Iterator needs a common superclass (i.e. composite pattern)

State in a visitor pattern

- A visitor can contain state
  - E.g., the results of typechecking the program so far

```
class TypeCheckingVisitor extends Visitor {
  private TypeMap map;
  void visit(VariableRefNode n) { …
    map.add(n,t)
  … }
}
```


Visitor Traversal Choices

- Traversal in object structure (typical, see Liskov)
  - Define operation that performs traversal while applying visitor object to each component
- Traversal implemented in visitor itself
  - E.g., perform processing at this node, then pass visitor to children nodes.
  - Traversal code replicated in each concrete visitor
- External Iterator

Traversal in Object Structure

- **Accept**() method responsible for traversing children
  - Requires all visitors to have same traversal pattern
    - E.g., visit all nodes in pre-order traversal
  - Could provide Visitor **previsit** and **postvisit** methods to allow for more complicated traversal patterns
    - Still visit every node
    - Can't do out of order traversal
    - In-order traversal requires **inVisit** method

Traversal in Object Structure Example

```
interface Node { void accept(Visitor); … }
class BinaryOperatorNode implements Node {
  Node lhs, rhs;
  void accept(Visitor v) {
     v.visit(this);
     lhs.accept(v);
     rhs.accept(v);
  }
…
}
```


Preorder visitor

```
abstract class PreorderVisitor {
  abstract void
    process(BinaryOperatorNode n);
  …
  void visit(BinaryOperatorNode n) {
    process(n);
    n.lhs.accept(this);
    n.rhs.accept(this);
  }
…}
```


Inorder visitor

```
abstract class InorderVisitor {
  abstract void
    process(BinaryOperatorNode n);
  …
  void visit(BinaryOperatorNode n) {
    n.lhs.accept(this);
    process(n);
    n.rhs.accept(this);
  }
…}
```


Parameterized Visitor Traversals

- Have only one **visit()** method
- Parameterize a "traversal visitor" by an "operational visitor"
  - Traversal visitor invokes **visit()** methods of operational visitor
- Replaces inheritance, as above, with composition

Parameterized Preorder visitor

```
class PreorderVisitor {
  Visitor operationalVisitor;
  void visit(BinaryOperatorNode n) {
    payload.visit(n);
    n.lhs.accept(this);
    n.rhs.accept(this);
  }
  …
}
```

Traversal using Iterator

- Make it so that traversal independent of the implementation
  - Actual visit methods still need to see the underlying nodes, however
- Uses an iterator, rather than specifying sub nodes directly.
- Can specify a different traversal using different iterators.

Traversal in Using Iterator Example

```
abstract class Node {
  // generic visit routine
  void visit(Visitor v) {
    n.accept(v); // preorder
    Iterator i = iterator();
    while (i.hasNext()) {
      Node n = (Node)i.next();
      n.visit(v);
    }}
  abstract Iterator iterator();
}
```


Traversal in Using Iterator Example

```
class BinaryOperatorNode extends Node {
  Node lhs, rhs; // visit still sees these
  void accept(Visitor v) {
     v.visit(this);
  }
  Iterator iterator() { … }
…
}
```


Designing with Patterns

- How do you know which patterns to use?
- What if you choose the wrong pattern?
  - I.e. your code doesn't evolve the way you thought it would.
- What if all your work to make things extensible via patterns never pays off?
  - I.e. your code doesn't change in the way you thought it would.
- Choosing the right pattern implies prognostication

Designing with Patterns

- Some design patterns are immediately useful
  - Observer, Decorator in our EventProcessor stuff
- Some are not immediately useful, but you think they might be
  - You anticipate changing things later—prognostication
- Recently popular philosophy: XP
  - Design for your immediate needs
  - When those needs change, redesign your code to match
  - Use extensive testing to validate frequent changes
- Next time: refactoring

This document was created with Win2PDF available at http://www.daneprairie.com.
The unregistered version of Win2PDF is for evaluation or non-commercial use only.