Lexi: Simple GUI-Based Editor

- Lexi is a WYSIWYG editor
  - supports documents with textual and graphical objects
  - scroll bars to select portions of the document
  - be easy to port to another platform
  - support multiple look-and-feel interfaces
- Highlights several OO design issues
- Case study of design patterns in the design of Lexi

Design Issues

- Representation and manipulation of document
- Formatting a document
- Adding scroll bars and borders to Lexi windows
- Support multiple look-and-feel standards
- Handle multiple windowing systems
- Support user operations
- Advanced features
  - spell-checking and hyphenation

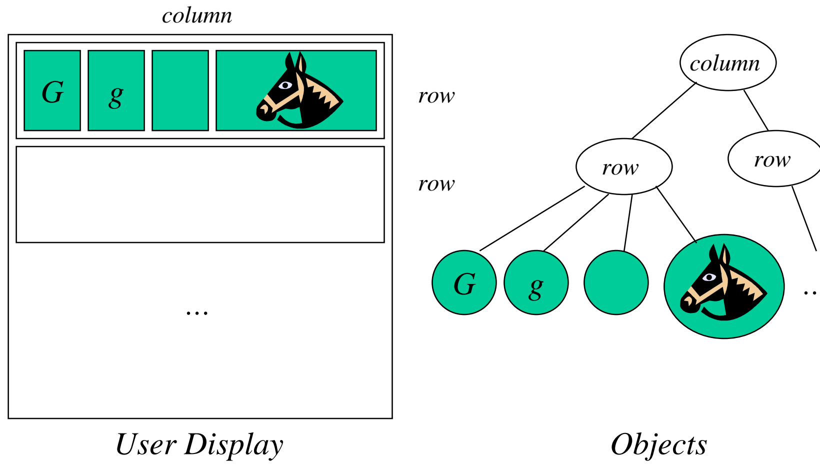
Structure of a Lexi Document

- Goals:
  - store text and graphics in document
  - generate visual display
  - maintain info about location of display elements
- Caveats:
  - treat different objects uniformly
    - e.g., text, pictures, graphics
  - treat individual objects and groups of objects uniformly
    - e.g., characters and lines of text

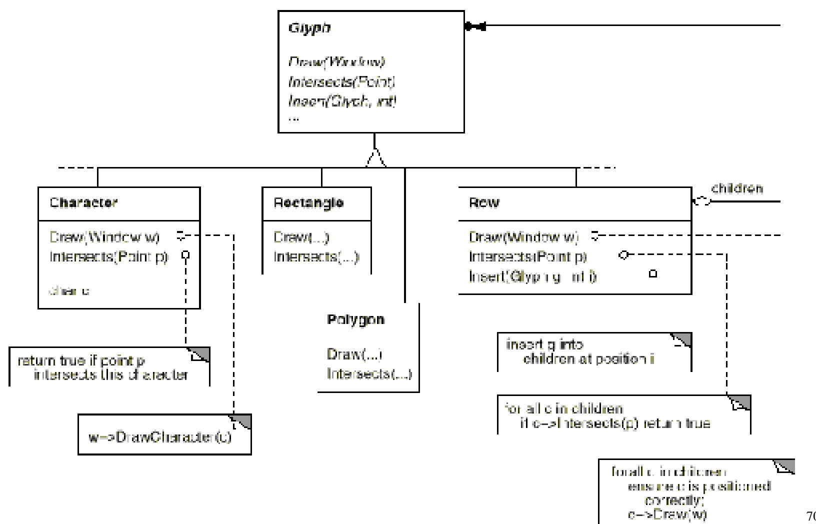
Structure of a Lexi Document

- Use **recursive composition** for defining and handling complex objects
  - Abstract class Glyph for all displayed objects
  - Glyph responsibilities:
    - know how to draw itself
    - knows what space it occupies
    - knows its children and parent
  - Glyph instances can recursively **compose** other Glyph instances

Recursive Composition



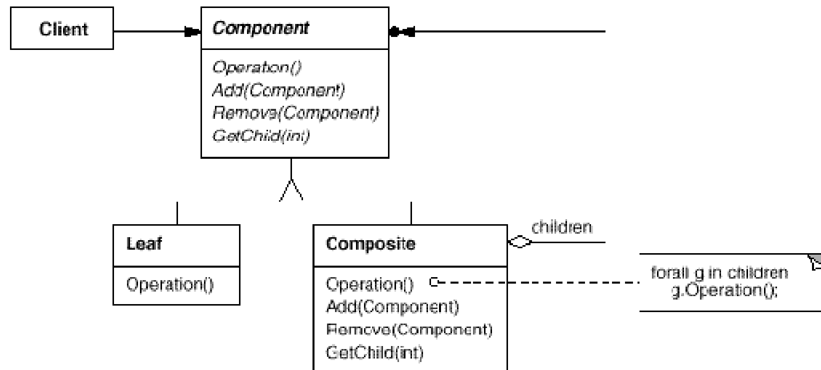
Glyph Class Diagram



The Composite Pattern

- Motivation:
  - support recursive composition in such a way that a client need not know the difference between a single and a composite object (as with Glyphs)
- Applicability:
  - when dealing with hierarchically-organized objects (e.g., columns containing rows containing words …)

Composite Pattern Structure



Composite Pattern Consequences

- Class hierarchy has both **simple** and **composite** objects
- Simplifies clients
- Aids extensibility
  - clients do not have to be modified
- Too general a pattern?
  - difficult to to restrict functionality of concrete leaf subclasses

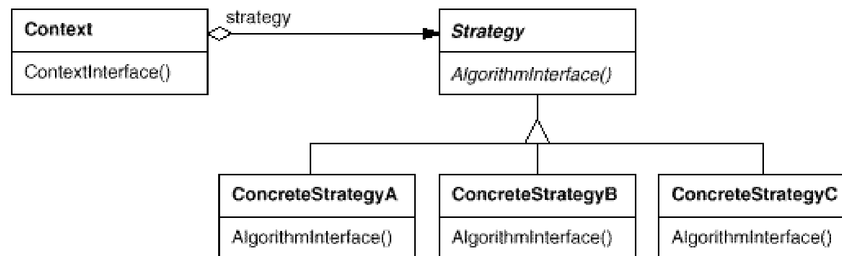
Formatting Lexi Documents: Strategy

- We know that documents are represented as Glyphs, but not how documents are constructed.
- Formatting:
  - Document structure will be determined based on rules for justification, margins, line breaking, etc.
  - Many good algorithms exist;
    - different tradeoffs between quality and speed
- Design decision: implement different algorithms, decide at run-time which algorithm to use
  - define root class that supports many algorithms
  - each algorithm implemented in a subclass

Strategy Pattern

- Name
  - Strategy (aka Policy)
- Applicability
  - many related classes differ only in their behavior
  - many different variants of an algorithm
  - need to encapsulate algorithmic information

Strategy Pattern: Structure



Strategy Pattern: Consequences

- Clear separation of algorithm definition and use
  - glyphs and formatting algorithms are independent
  - alternative (many subclasses) is unappealing
    - proliferation of classes
    - algorithms cannot be changed dynamically
- Elimination of conditional statements
  - Like State, Template, …
  - Typical in OO programming

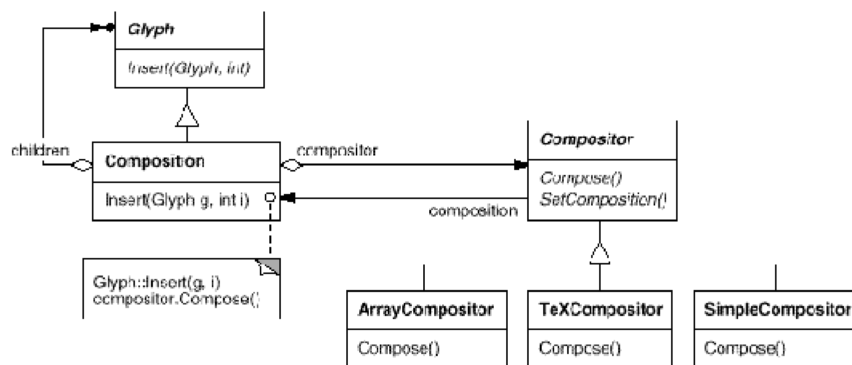
Strategy Pattern Consequences (cont'd)

- Clients must be aware of different strategies
  - when initializing objects
- Proliferation of instances at run-time
  - each Glyph has a strategy object with formatting information
  - if strategy is stateless, share strategy objects

Lexi: Using Strategy

- Compositor and Composition classes
  - Compositor: class encapsulating formatting algorithm
    - pass Composition objects to be formatted as parameters to Compositor methods
  - Composition: things being formatted
    - Glyph subclass
    - Each Composition object refers to its Compositor object
    - When a Composition needs to format itself, it sends a message to its Compositor instance

Class Diagram



Adding Scroll Bars and Borders: Decorator

- How to define classes for scrollbars and borders?
- Define as subclasses of Glyph
  - Scrollbars and borders are displayable objects
  - Will use notion of **transparent enclosure**
    - Clients don't need to know whether they are dealing with a component or with an enclosure
- Inheritance increases number of classes
  - Use composition instead ("has a")

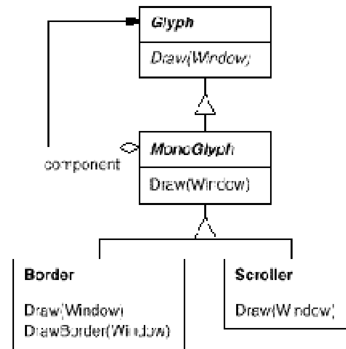
Transparent Enclosure

- Two features:
  - Single-child composition
    - Calls its child, then adds its own behavior
  - Compatible interfaces
    - Can use the enclosing object in place of the one it encloses
- Implemented by the Decorator pattern
  - Saw this earlier

Monoglyph class: a Decorator

```
Class Monoglyph { …
  void Draw (Window w)  {
      component.Draw(w);
  } …
}

Class Border extends Monoglyph { ..
  void Draw (Window w) {
     super.Draw(w);
     DrawBorder(w);
  } …
}
```



Changing look-and-feel: Abstract Factory

- Goal: easily change Lexi's look-and-feel
  - When new libraries are available (future variability)
  - At run-time by switching between them (present variability)
- Thoughtless implementation technique:
  - use distinct class for each widget and standard
  - let clients handle different instances for each standard
    - Button pb = new MotifButton(); // bad

Abstracting Creation

- Concrete Creation problems:
  - Class of object is fixed at compile-time
    - can't change standard at run-time
  - Changing the class means making changes all over the code
- Instead:
  - Use a class to create abstract classes:
    - Button pb = guiFactory.createButton();// better

Solution: Use Abstract Factory

- Define abstract class GUIFactory with creation methods for widgets
  - Concrete subclasses of GUIFactory actually define creation methods for each look-and-feel standard
    - MotifFactory, MacFactory, etc.
  - Specialize each widget into subclasses for each look-and-feel standard
- Thus, can easily change the kind of factory without changes all over the place

Class diagram for GUIFactory

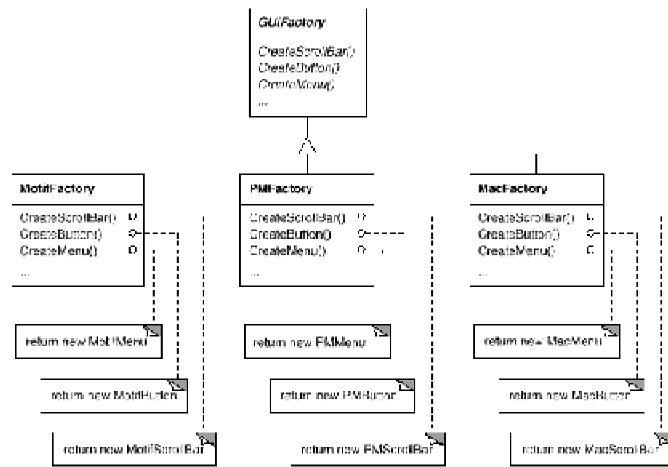


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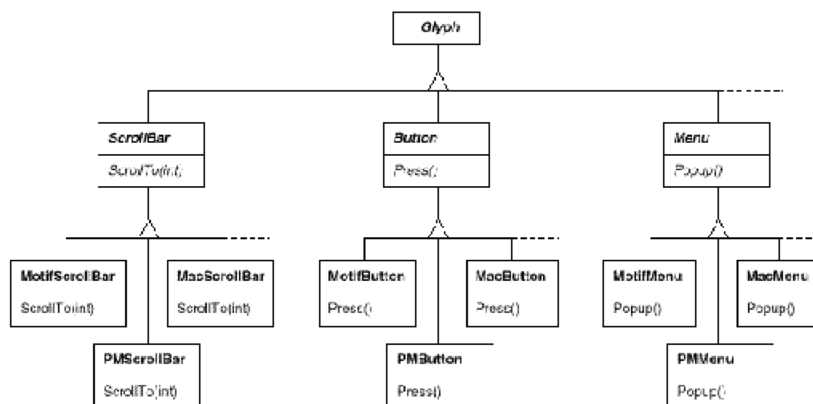
Diagram for product classes



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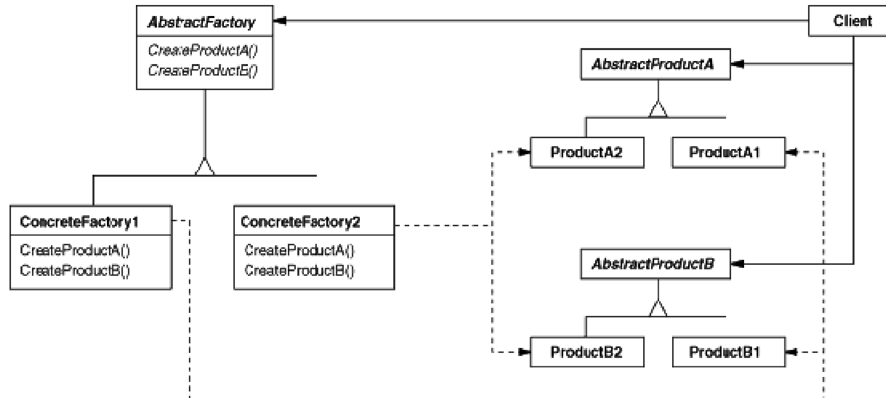
Abstract Factory pattern

- Name
  - Abstract Factory or Kit
- Applicability
  - different families of components (products)
  - must be used in mutually exclusive and consistent way
  - hide existence of multiple families from clients

Structure of Abstract Factory



Abstract Factory: Consequences

- Isolate instance creation and handling from clients
- Can easily change look-and-feel standard
  - Reassign a global variable;
  - Recompute and redisplay the interface
- Enforce consistency among products in each family
- Adding to family of products is difficult
  - Have to update factory abstract class and all concrete classes

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