Iterator pattern

Acknowledgement: Eric Braude

Let's try this…

Data structures:

- Array
- Binary Tree
- Vector
- Linked list
- Hash table

Algorithm:

- Sort
- Find
- Merge

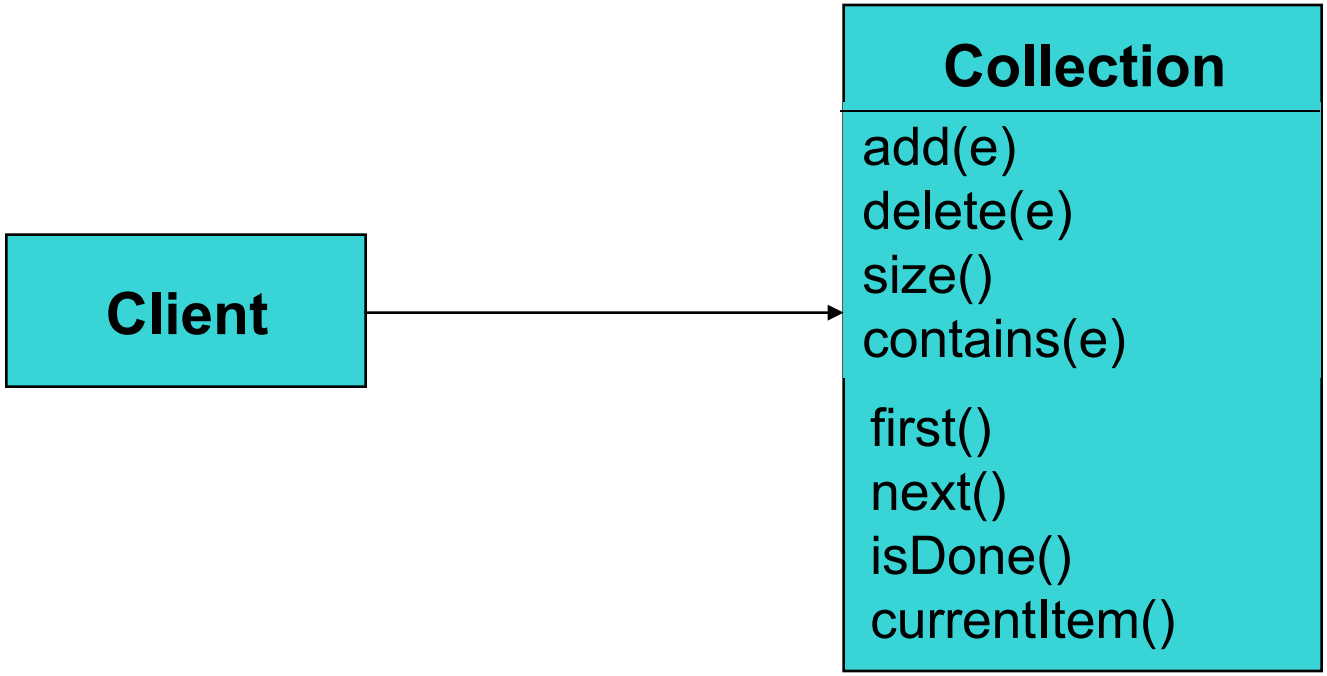
How many permutations to develop/maintain ?

Iterators – The Problem

- Given
  - An aggregate collection of objects
- Desired
  - Access all elements in the collection
  - Do not expose internal structure
  - Access is independent of the collection
  - Multiple accesses can be done independent of each other
  - Collection can be maintained independent of the access
- Solution
  - Iterator object controls access

Embedded Iterator

- Embed Iterator support in the Collection



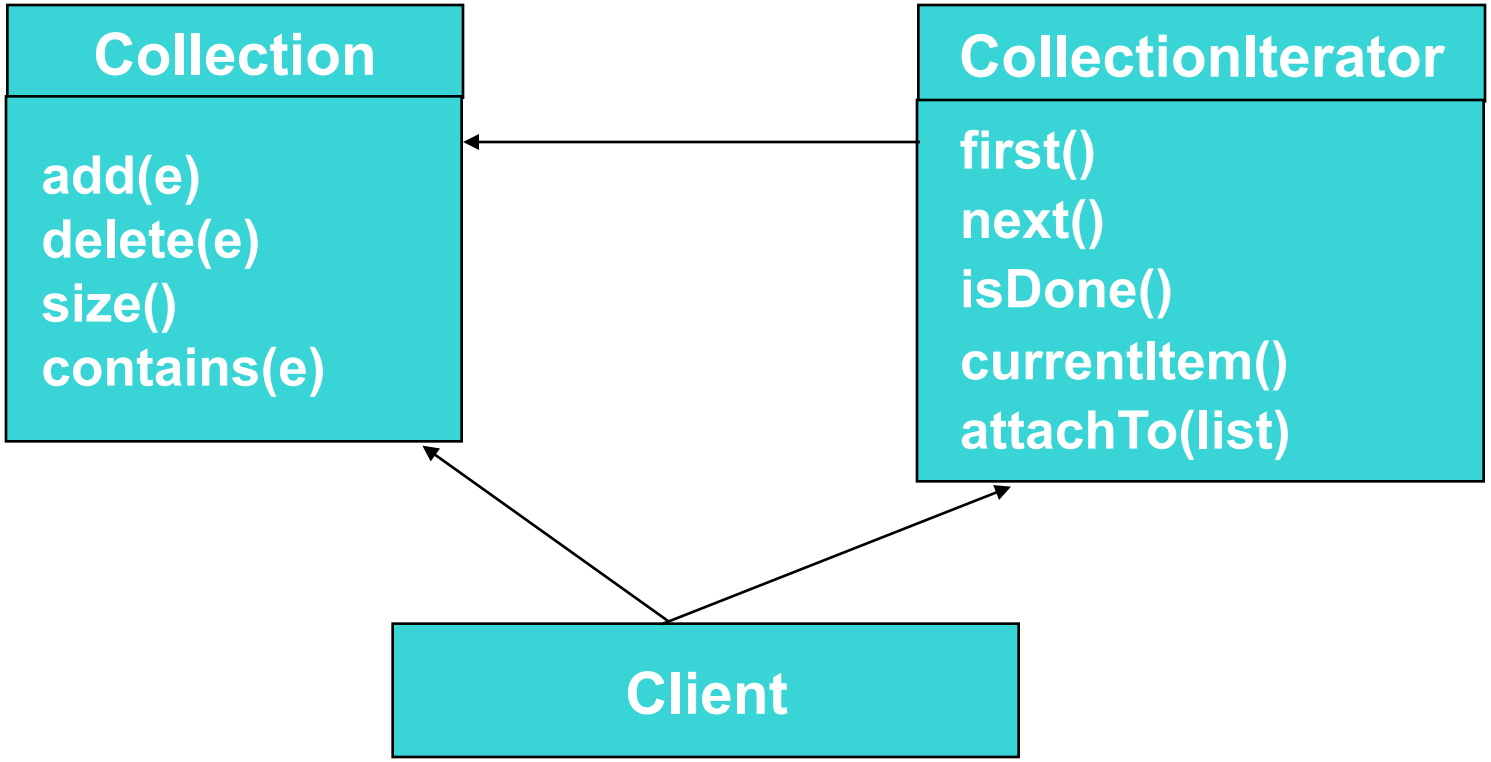
Issues with Embedded Iterators

- Mixes structure maintenance and traversal
- Only one traversal at a time
- Adds to collection interface
- Adds to collection implementation
- Clumsy when adding different traversal algorithms:
  - Lists: forward / reverse traversal
  - Trees: pre / post / inorder
  - Graphs: depth first vs. breadth first

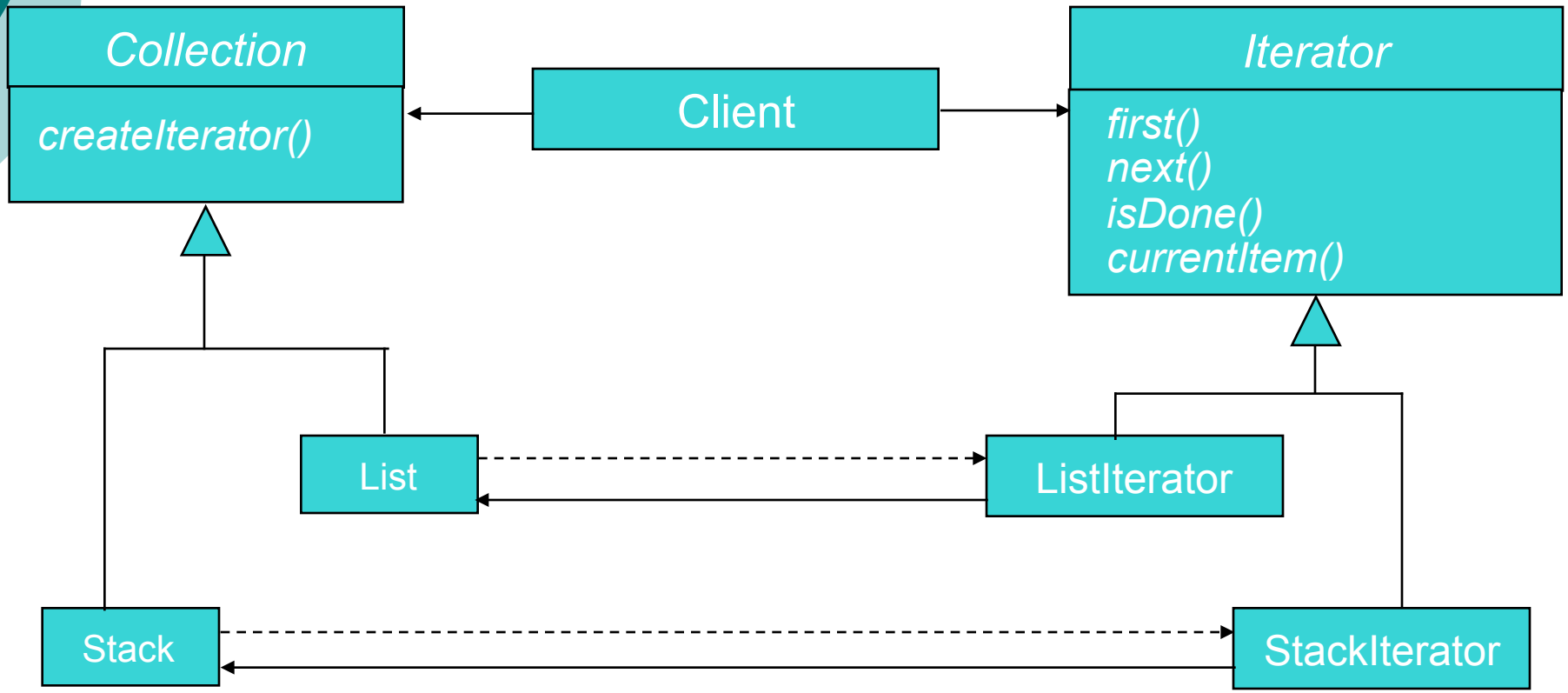
Alternative: Separate Iterator Class & Objects

- Create iterators as needed for a collection
- Attach to collection at creation time or via attach method
- Use iterator object, not collection, to access elements.

Separate Collection Iterator



Abstract Collections & Iterators



Consequences

- Supports various traversal algorithms via different iterators over same collection.
- Simplifies collection interface: At most must return different iterators
- More than one traversal can be in progress

Internal and External Iterators

- Examples so far are external iterators
  - Client object does iteration using provided methods
- Internal iterators
  - The iterator controls the traversal.
  - Client hands iterator some operation to perform on each element in aggregate.
  - Iterator traverses aggregate (Iteration done by iterator object itself)

Builder pattern

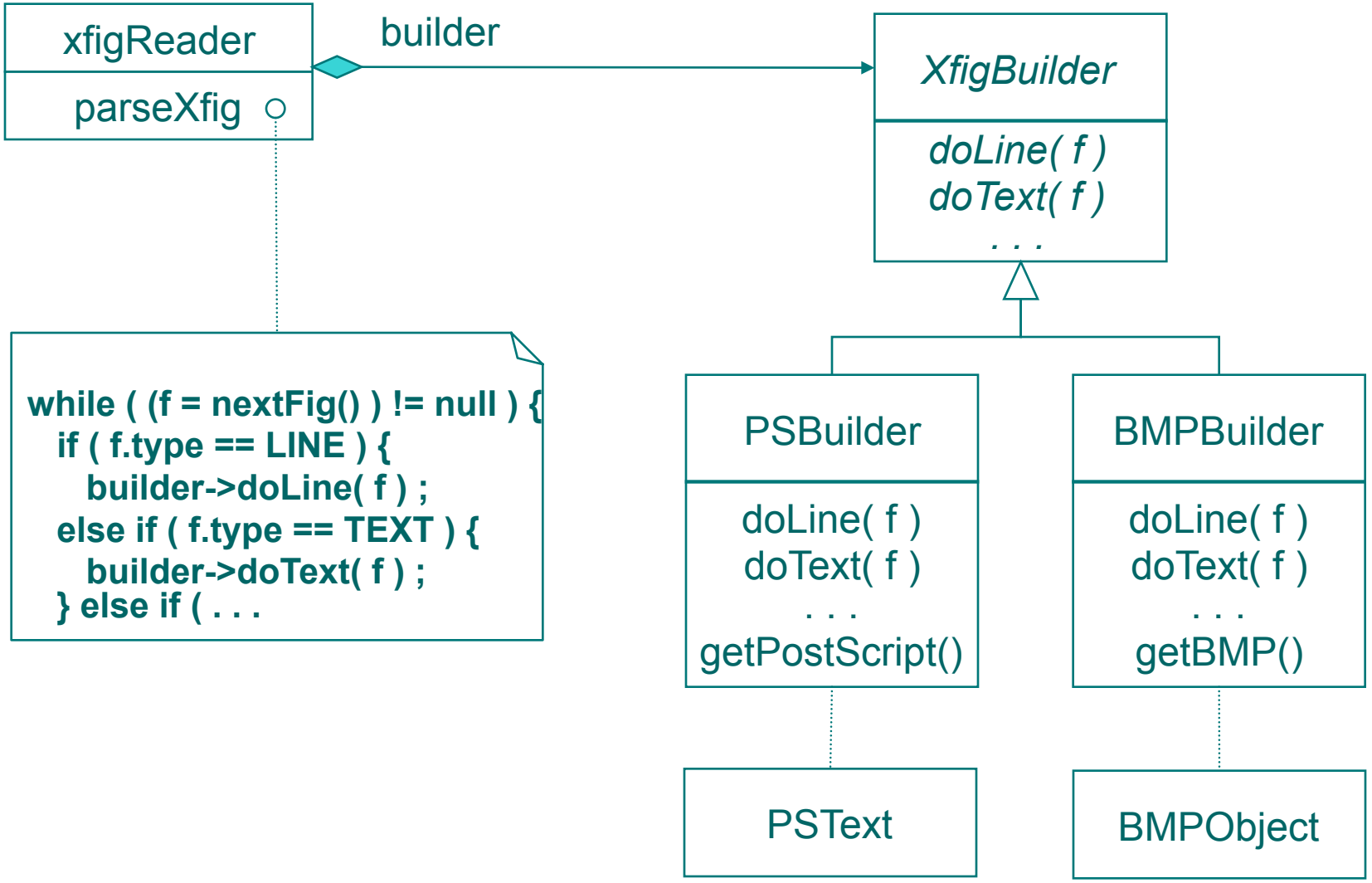
The Problem

- Need to construct complex object incrementally.
- There may be many variants of complex object
- Example: *fig2dev*
  - One input -- the *xfig* file of figure descriptions
  - Many output objects:
    - Postscript
    - BMP for Windows
    - TIFF for fax
- **fig2dev -L** *language* [*fig-file* [*out-file*]]
- How to abstract the construction process?

Possible Solution: Builder

- Builder provides abstract interface for incremental construction
- Concrete builders provide variant on this interface
- Select desired concrete builder and provide to client
- Client simply invokes interface methods for each constituent "piece"
- Parameterizes the construction of many variants.

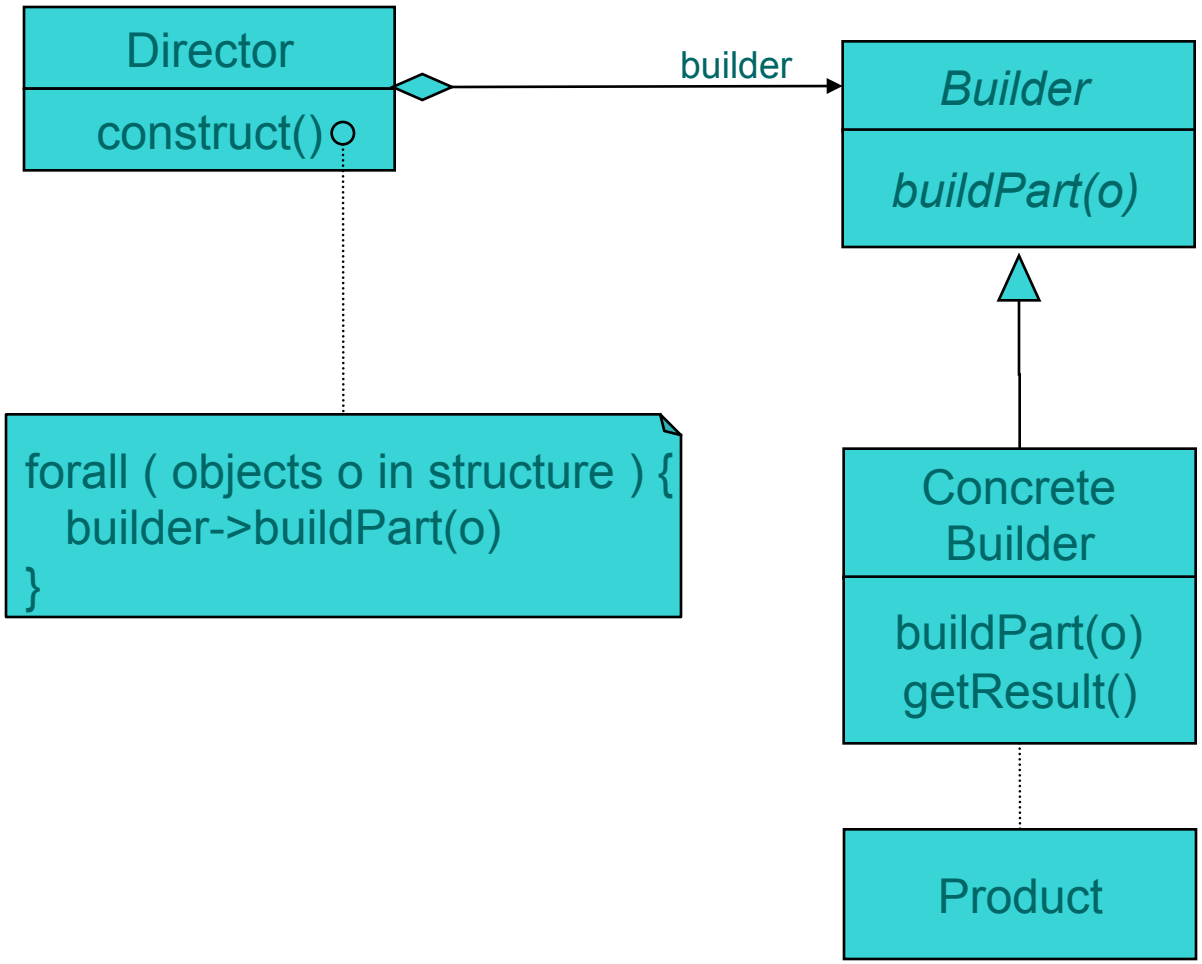
A Builder for Xfig Format



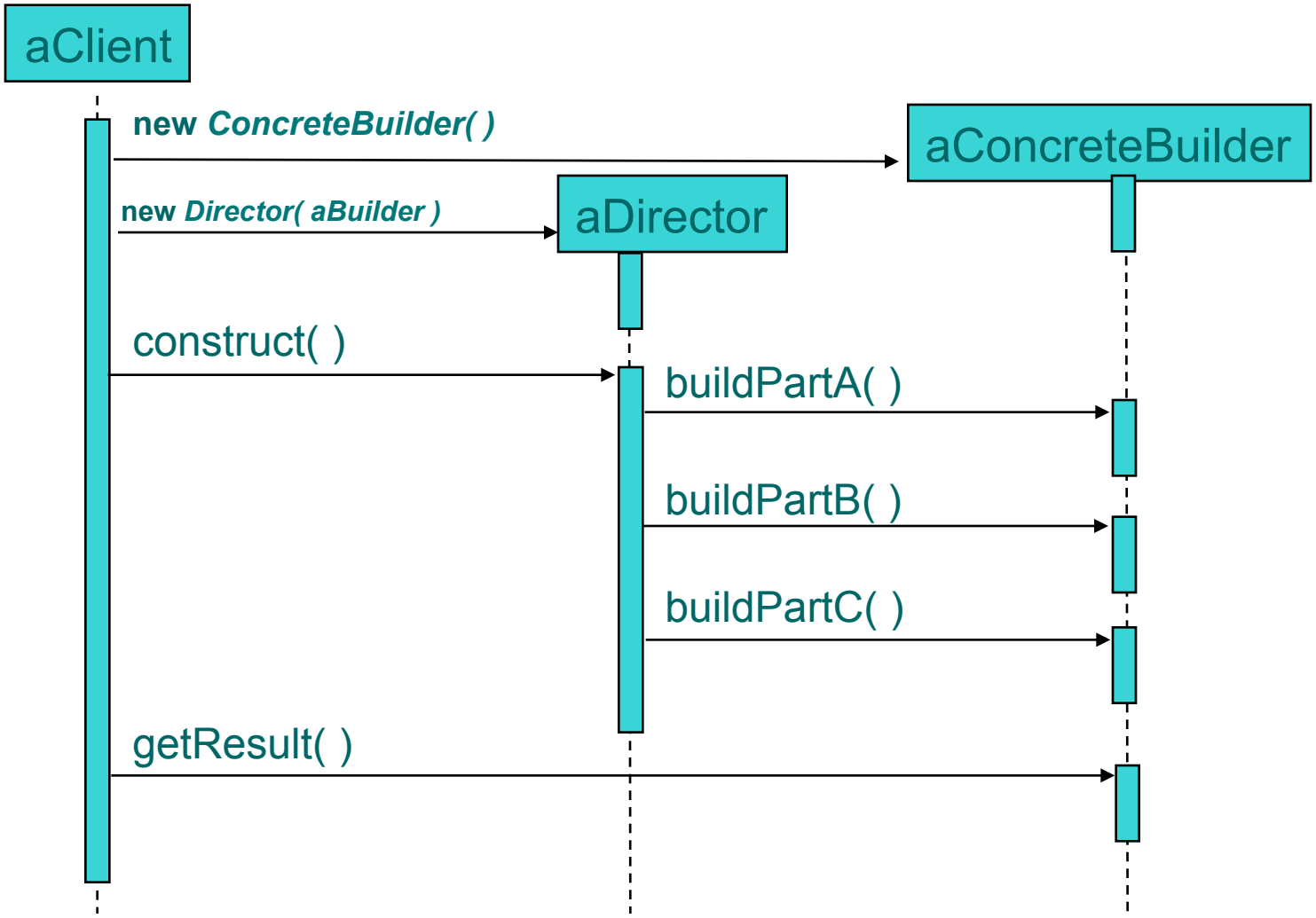
Use the Builder Pattern When

- Need algorithm / assembly independence
  - Algorithm for construction in the client
  - Specific parts of complex object hidden in builder
  - Assembly performed in builder
- Many variant representations
  - Construction fixed
  - Construction incremental
  - Many possible construction variants

General Builder Structure



Builder Interaction Diagram



Collaborations

- *Client* creates *Director* and configures it with a specific *Builder*
- *Director* notifies *Builder* when a part is to be added to the *Product*
- *Builder* adds parts requested to the *Product*
- *Builder* returns *Product* to *Client* on request

Consequence: Can Vary Product

- Can add new types of products built according to common process
- In our example, can add drivers for other forms of xfig output.
- Specifics of how assembly proceeds are hidden, as long as every legal assembly sequence can be accommodated

Consequence: Isolates Construction Algorithm From Representations

- Encapsulates *process* of construction in *Director*
  - Might construct objects from different inputs
  - Example: fig2dev driven by another drawing program format
- Encapsulates *product* of construction in *Builder*
- Can vary each independently as long as *Builder* interface is stable.
- Note: There may be semantic constraints on Builder interface sequencing:
  - E.g. each "startComposite( )" needs a matching "endComposite( )"

Consequence: Fine-Grained Construction Control

- Does not construct full product object in one-shot
- Supports step-by-step construction: Like building a house
- Only retrieve the product when Director is finished with the construction
- Changes to *Director*s
  - Must recognize new types of parts
  - Must know how to invoke construction of part inside the Builder
- Changes to *Builder*s
  - Need to add a new part construction method to interface
  - Need to update all subclasses (e.g., all concrete builders)

Command pattern

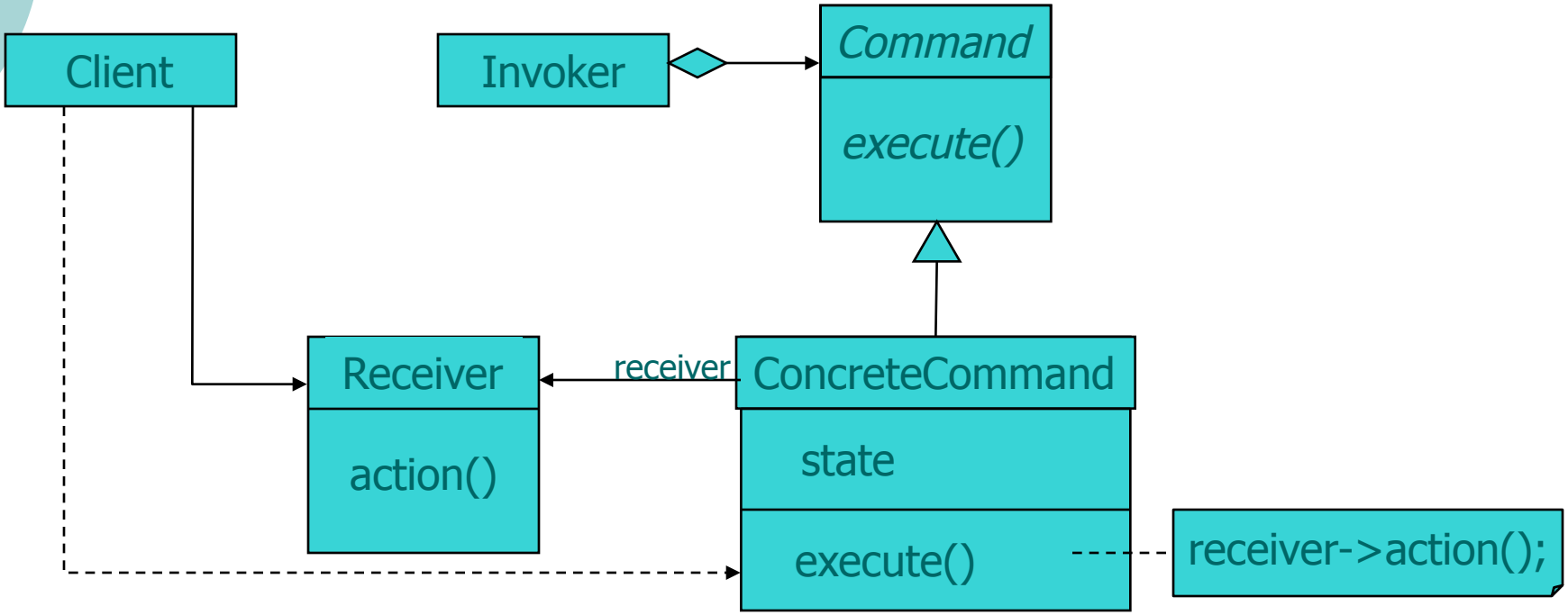
The Problem

- Problem
  - An application has multiple commands being issued via different mechanisms
- Desire: Decouple invoking of the action from
  - Knowledge of how to perform it
  - Knowledge of the receiver of request
- Solution
  - Create **Command** objects that know how to execute the operations

Example

- Image manipulation program allows commands to be issued from
  - Toolbar item
  - Menu item
  - Script language
  - Fly-over menu
- All these interface elements should not need to know how to perform the operation

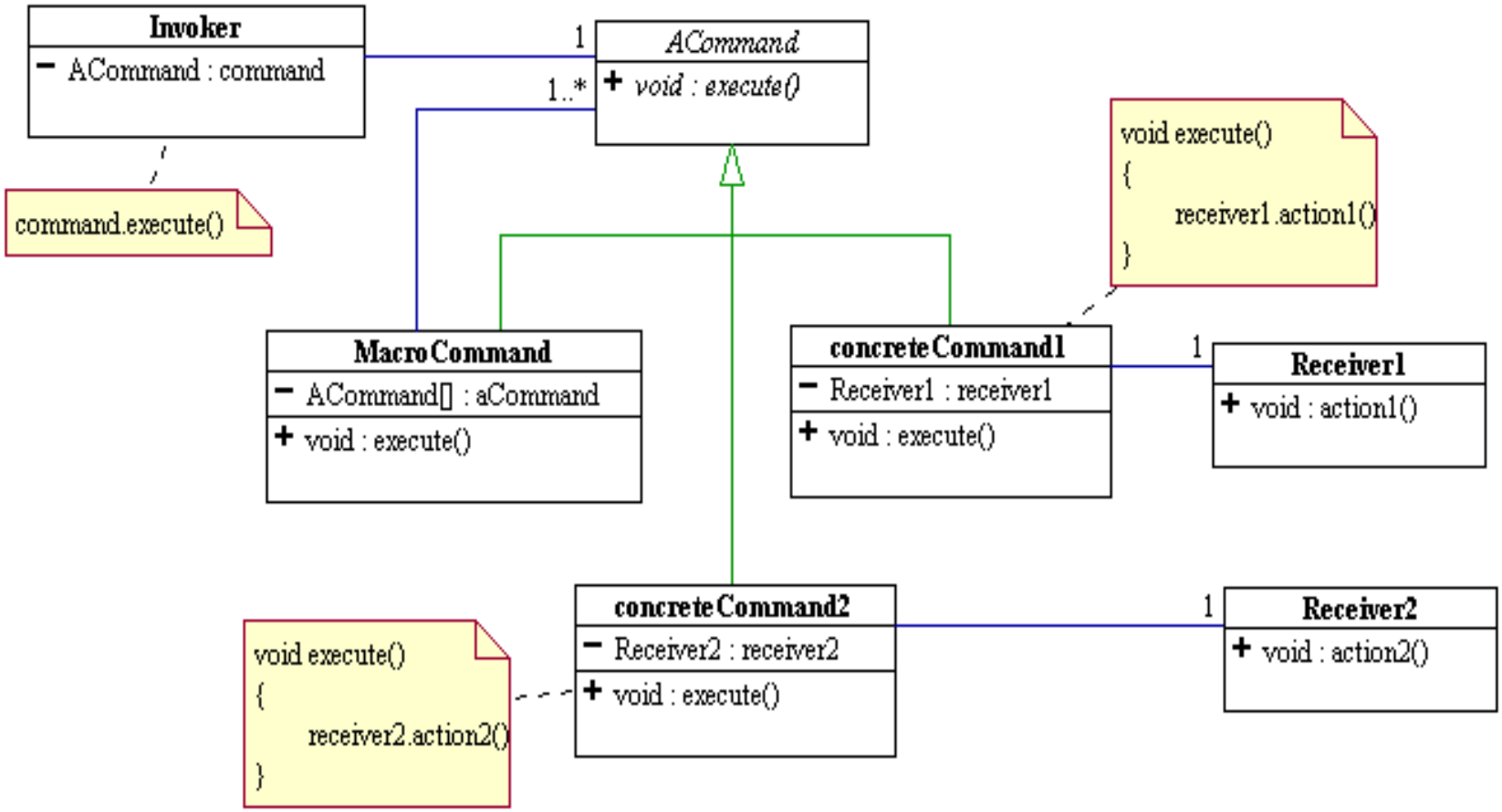
Pattern Structure



Participants

- Command
  - Interface for executing every operation
- Concrete Command
  - Implements operation
  - Binds receiver and action
- Client
  - Creates Concrete Command
  - Determines Receiver
- Invoker
  - Requests command to execute operation
- Receiver
  - Performs the operations needed

Example


Invoker
- ACommand : command
1
1..*
ACommand
+ void : execute()
command.execute()
void execute()
{
receiver1.action1()
}
MacroCommand
- ACommand[] : aCommand
+ void : execute()
concreteCommand1
- Receiver1 : receiver1
+ void : execute()
1
Receiver1
+ void : action1()
concreteCommand2
- Receiver2 : receiver2
+ void : execute()
1
Receiver2
+ void : action2()
void execute()
{
receiver2.action2()
}

Consequences

- Invocation is decoupled from execution
- Command is an object ⇒ it can be extended
- Macro commands accommodated
- Easy to add new commands to the application interface

Undo / Redo

- Unexecute operation
- How to return to original state of receiver?
  - Save state in receiver?
  - "Unaction" in receiver?
  - Save state in command? ⇒ Memento
- History list
  - Going backward
  - Going forward
  - Do you need a copy of command? ⇒ Prototype
- Reliable restoration over repeated undo/redo cycles