Pattern Connections

Putting Together the Pieces of the Design Jigsaw

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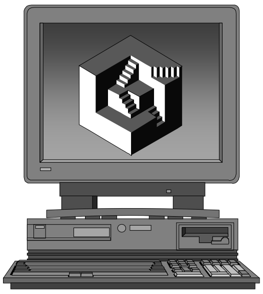
Agenda

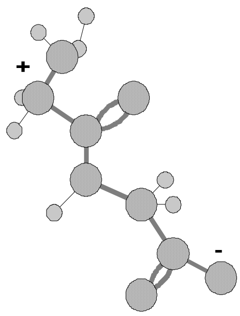
- Intent
  - Present a number of pattern concepts, going from lone patterns to a more connected view of patterns
- Content
  - Overview of Pattern Concepts
  - Some Examples
  - From a Pattern to a Language



Shameless Plug

Overview of Pattern Concepts

- Intent
  - Present core pattern terminology and ideas
- Content
  - Patterns and pattern quality
  - Patterns of misunderstanding
  - Pattern communities
  - Pattern stories and sequences
  - Pattern compounds
  - Pattern languages



Patterns

- A pattern documents a recurring problem–solution pairing within a given context
  - A pattern is more than either the problem or the solution structure
  - A pattern contributes to design vocabulary
- A problem is considered with respect to forces and a solution that gives rise to consequences
  - The full form in which a pattern is presented should emphasise forces and consequences, also stating the essential problem and solution clearly

Kinds of Patterns

- There are many kinds of patterns, not just OO-focused design patterns
  - Patterns for designing user interfaces
  - Patterns for programmer testing
  - Patterns for organisational structure and development process
- However, the focus of this talk is on patterns that relate to the design of code
  - These focus on artefacts visible to the programmer

Pattern Quality

- Contrary to popular belief, a pattern is not by definition "good"
  - There are also poor patterns — dysfunctional designs recur, through either habit or fashion
  - And there are also poor applications of good patterns
- A poor pattern or pattern application can be characterised as being out of balance
  - Its consequences and forces do not adequately match up

Patterns of Misunderstanding

- There are other misconceptions concerning the pattern concept that are worth clearing up...
  - *Design Patterns* is a limited subset of design patterns and the pattern concept
  - Patterns are not frameworks, components, blueprints or parameter-based collaborations
  - Patterns are more than just a sample class diagram of the solution
  - Only language-independent patterns are language independent: patterns may be language specific

Pattern Communities

- Patterns can be used in isolation with some degree of success
  - Represent foci for discussion or point solutions
  - Offer localised design ideas
- However, patterns are, in truth, gregarious
  - They're rather fond of the company of patterns
  - To make practical sense as a design idea, patterns inevitably enlist other patterns for expression and variation, where they compete and cooperate

Pattern Stories and Sequences

- A pattern story brings out the sequence of patterns applied in a given design example
  - They capture the conceptual narrative behind a given piece of design, real or illustrative
  - Forces and consequences are played out in order
- More generally, pattern sequences describe specific ordered applications of patterns
  - A pattern story is to a pattern sequence as a pattern example is to an individual pattern

Pattern Compounds

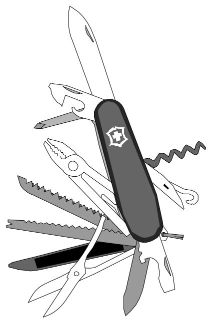
- Pattern compounds capture commonly recurring subcommunities of patterns
  - In truth, most patterns are compound, at one level or another or from one point of view or other
  - Also known as *compound patterns* or — originally and confusingly — *composite patterns*
- We can see many pattern compounds as named pattern subsequences
  - They are commonly recurring design fragments that can be further decomposed, if desired

Pattern Languages

- A pattern language connects many patterns together to capture a broader range of paths
  - The intent of a language is to generate a particular kind of system or subsystem
  - A pattern language can describe vernacular design style, with general patterns incorporated into a language that is presented more specifically
- There may be many possible and practical sequences through a pattern language
  - In the limit, a sequence is a narrow language

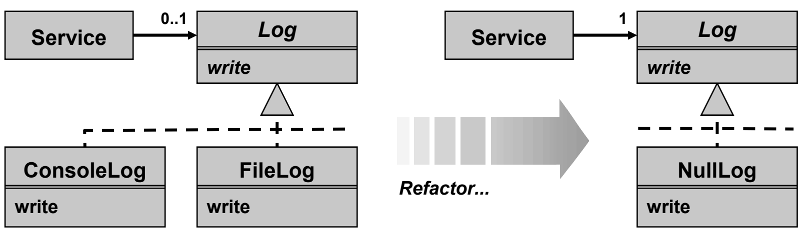
Some Examples

- Intent
  - Illustrate some of the concepts discussed with specific examples
- Content
  - Lone patterns
  - Complementary patterns
  - Pattern compounds and sequences
  - Pattern languages



Something for Nothing

- Where a non-null reference is interpreted as an option and a null as its absence...
  - Code may be littered with guard *if* statements
- Polymorphism can replace the explicit decision



Null Object

- The *Null Object* pattern is a tactical design based on substitution of pluggable parts
  - It generalises beyond object orientation, although it is often described in those terms

if
- An object reference may optionally be null **and**
- This reference must be checked before every use **and**
- The result of a null check is to do nothing or use a default value

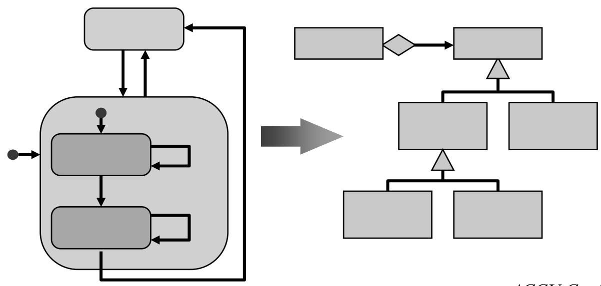
then
- Provide a class subclasses from object reference's type **and**
- Implement all of its methods to do nothing or provide default results **and**
- Use an instance of this class when the object reference would have been null

Modal Object Lifecycles

- Many objects can be characterised as having groups of states (modes)
  - Each mode defines a set of behaviour that is significant and different to that of other modes
  - Objects transition from mode to mode in response to certain events
- There are many patterns that deal with the expression of the modes and the transitions
  - There is more to state than *State*

Objects for States

- Reflect a hierarchical view of the state model in a class hierarchy
  - A context object delegates to a behavioural object whose class represents a mode of behaviour



Implementing *Objects for States*

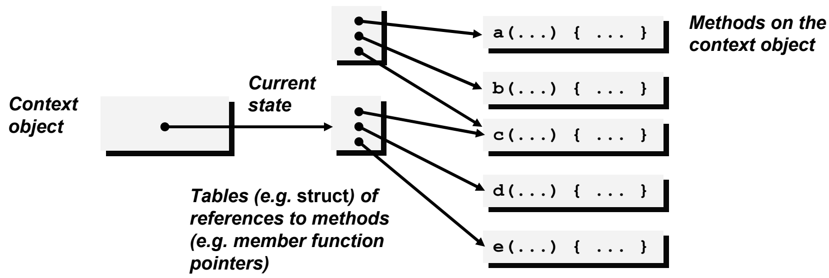
- There are many considerations, some of which are language specific
  - In Java, inner classes can be used to simplify access of the context object's fields
  - In C++, the whole state-behaviour hierarchy can be fully encapsulated using a Cheshire Cat

```
class context
{
public:
    ... // public functions
private:
    struct representation;
    representation *body;
};
```

```
struct context::representation
{
    class mode;
      class first_mode;
      ... // other mode types
    mode *current;
    ... // other context state
};
```

Methods for States

- Methods for States represents each state as a table or record of method references
  - Methods referenced are on the target object



Implementing *Methods for States*

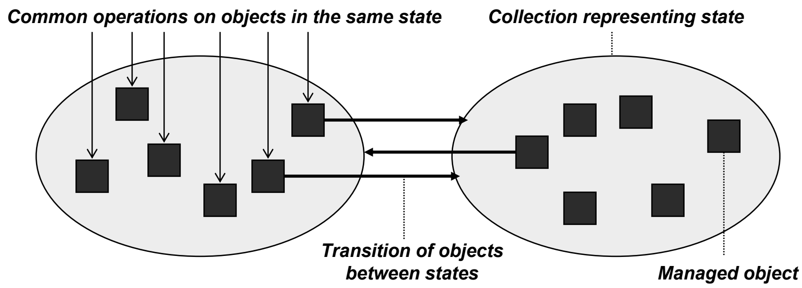
- This pattern is only suitable for languages that support simple manipulation of methods
  - E.g. member function pointers in C++, delegates in C# and use of *send* for *Pluggable Selector* in Ruby

```
class context
{
public:
    void function();
    ... // other public functions
private:
    ... // private functions
    struct mode;
    const mode *behaviour;
    ... // other private data
};
```

```
struct context::mode
{
    void (context::*function)();
    ... // other 'public' functions
    static const mode first_mode;
    ... // other modes
};
```

Collections for States

- For objects managed collectively, objects can be collected together according to state
  - State is extrinsically represented by membership



Implementing *Collections for States*

- There are different ways of organising the collections, depending on the situation
  - For *N* modal states, at least *N* collections are needed, e.g. a collection for each mode
  - But more than *N* can sometimes be useful, e.g. a collection for all objects plus a collection for each mode

```
class manager
{
public:
    ... // public functions
private:
    std::list<managed> all;
    std::set<managed *> first_mode;
    ... // containers for other modes
};
```

Encapsulated Iteration

- Traversal over object collection contents should preserve the encapsulation of the collection
  - But it should also reflect the environment of use of the collection — design is sensitive to context
- There are a number of solutions that range from distinct to constructively complementary
  - E.g. *Iterator*, *Enumeration Method*, *Batch Method*, *Collecting Parameter*, *Combined Iterator*, *Batch Iterator*
  - The detail of realisation varies with environment

Iterator and *Batch Method*

- *Iterator* presents the common and conventional design of iteration over an encapsulated target
  - Separate the responsibility for iteration from that of collection into separate
- *Batch Method* is an alternative that addresses the needs of remote or otherwise costly access
  - The repetition is provided in data structure rather than in control flow
  - The granularity of access is coarser, which reduces one aspect of access overhead

Batch Iterator as a Pattern Compound

- *Batch Iterator* is a compound resulting from combining both *Iterator* and *Batch Method*
  - Offers a compromise in granularity and control, allowing a caller to step through a collection in strides greater than one step but less than the whole

```
typedef sequence<any> many;
interface BatchIterator
{
    boolean next_n(in unsigned long how_many, out many result);
    boolean skip_n(in unsigned long how_many);
};
```

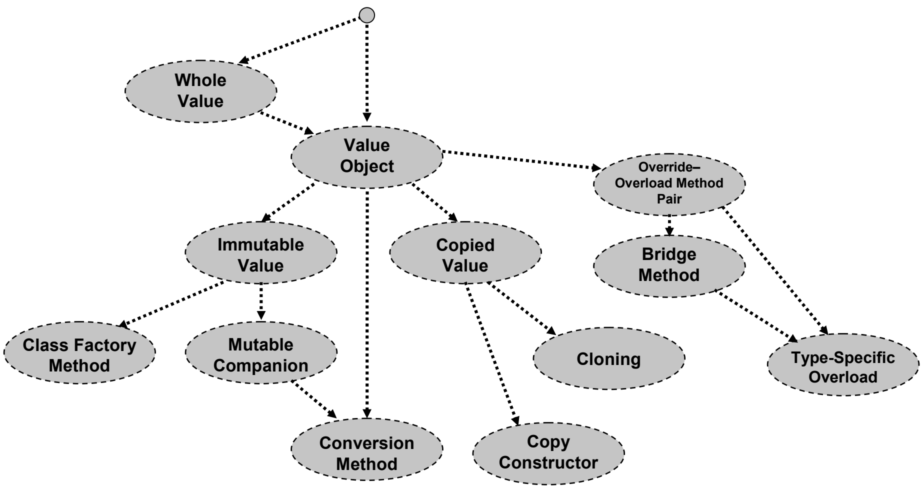

Batch Iterator as a Pattern Sequence

- Another take on *Batch Iterator* is that it is the result of...
  - First, introducing an *Iterator*
  - Second, expressing its interface with a *Batch Method*
- In other words, a (very) short pattern sequence
  - This can be named as a proper noun, e.g. *Batch Iterator* or *Chunky Iterator*
  - Or labelled with respect to its parts and process, i.e. ⟨*Iterator*, *Batch Method*⟩

Value-Based Programming

- Values express simple informational concepts, such as quantities
  - In programming, values are expressed as objects, but their object identity is considered transparent, with state governing behaviour and use
- A number of idiomatic practices go together to support value-based programming in Java
  - The *Patterns of Value* language is a work in progress that aims to capture these

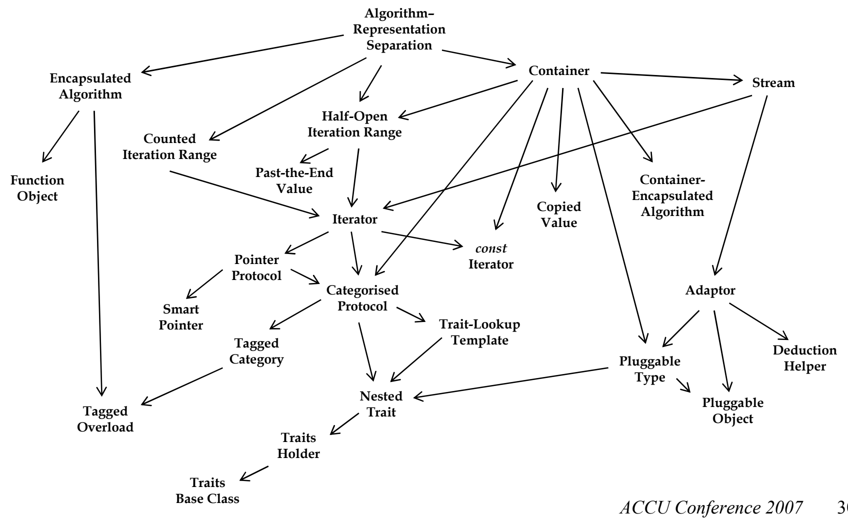
(A Part of) *Patterns of Value*



Generic Programming

- Generic programming is characterised by an open, orthogonal and expressive style
  - It is an approach to program composition that emphasises algorithmic abstraction, loose coupling and a strong separation of concerns
- The approach that underpins the STL
  - More than just coding with templates in C++ — this is a common misunderstanding: the principle of generic programming is not actually about generics
  - Originated with Alex Stepanov and others

STL Patterns



From a Pattern to a Language

- Intent
  - Present the *Context Encapsulation* pattern language, starting from its root
- Content
  - *Encapsulated Context Object*
  - *Decoupled Context Interface*
  - *Role-Partitioned Context*
  - *Role-Specific Context Object*

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- Consider the context of a loosely coupled and extensible architecture
  - The extensibility can be per runtime, per release or per product configuration
- How can objects in different parts of this system gain access to common facilities?
  - Keeping in mind the goal of loose coupling, which supports extensibility, comprehensibility, testability, etc.

Encapsulated Context Object

- Pass execution context for a component — whether a layer or a lone object — as an object
  - Avoids tedium and instability of long argument lists of individual configuration parameters
  - Avoids explicit or implicit global services, e.g. *Singleton*s, *Monostate*s and other uses of *static*
- The context may include external configuration information and services, such as logging
  - But features should not be included arbitrarily

⟨ECO⟩

```
public final class ExecutionContext
{
    public void writeLog(String message) ...
    public void writeConsole(String message) ...
    public boolean containsVariable(String name) ...
    public String valueOfVariable(String name) ...
    ...
}
```

```
public void configure(ExecutionContext context)
{
    String serverName = context.valueOfVariable("server");
    ...
}
public void start(ExecutionContext context)
{
    try ...
    catch(RuntimeException caught)
    {
        context.writeLog("Failed to start: " + caught);
        context.writeConsole("Error: " + caught);
        throw caught;
    }
}
```

Decoupled Context Interface

- Reduce the coupling of a component to the concrete type of the *Encapsulated Context Object*
  - Define its dependency in terms of an *interface* rather than the underlying implementation class
- This allows substitution of alternative implementations
  - E.g. *Null Object*s and *Mock Object*s
  - Also decouples context dependent from any changes in a single implementing class

⟨ECO, DCI⟩

```
public interface ExecutionContext
{
    void writeLog(String message);
    void writeConsole(String message);
    boolean containsVariable(String name);
    String valueOfVariable(String name);
    ...
}
```

```
public class EnvironmentalContext implements ExecutionContext
{
    public void writeLog(String message) ...
    public void writeConsole(String message) ...
    ...
}
```

```
public class MockContext implements ExecutionContext
{
    public void writeLog(String message) ...
    public void writeConsole(String message) ...
    ...
}
```

Role-Partitioned Context

- Split uncohesive *Encapsulated Context Object*s into smaller more cohesive context interfaces
  - It is all too easy to end up with a bucket of arbitrary variables that have no genuine relation to one another, either in concept or in use
- Base the partitioning on usage role, i.e. features that are used together should stay together
  - Each partitioned piece of context can be expressed with a *Decoupled Context Interface*, or through a *Role-Specific Context Object*, or both

⟨ECO, DCI, RPC⟩

```
public interface Reporting
{
    void writeLog(String message);
    void writeConsole(String message);
    ...
}
```

```
public interface Configuration
{
    boolean containsVariable(String name);
    String valueOfVariable(String name);
    ...
}
```

```
public class EnvironmentalContext implements Reporting, Configuration
{
    public void writeLog(String message) ...
    public void writeConsole(String message) ...
    public boolean containsVariable(String name) ...
    public String valueOfVariable(String name) ...
    ...
}
```

Role-Specific Context Object

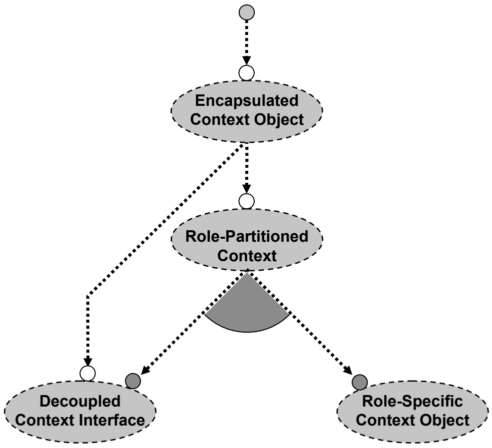
- Multiple *Role-Partitioned Context*s may be expressed at runtime as a single object per role
  - This allows independent parts of a context to be more loosely coupled and separately parameterized
- The *Role-Partitioned Context* may also be expressed with *Decoupled Context Interface*s
  - Which also allows the context to be contained in a single object, offering an additional degree of parameterization freedom

⟨ECO, DCI, RPC, RSCO⟩

```
public class NullReporting implements Reporting
{
    ...
}
public class FileBasedConfiguration implements Configuration
{
    ...
}
```

```
public void configure(Configuration config)
{
    String serverName = config.valueOfVariable("server");
    ...
}
public void start(Reporting reporter)
{
    try ...
    catch(RuntimeException caught)
    {
        reporter.writeLog("Failed to start: " + caught);
        reporter.writeConsole("Error: " + caught);
        throw caught;
    }
}
```

Context Encapsulation



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⟨ECO⟩

⟨ECO, DCI⟩

⟨ECO, DCI, RPC⟩

⟨ECO, DCI, RPC, RSCO⟩

⟨ECO, RPC, DCI⟩

⟨ECO, RPC, DCI, RSCO⟩

⟨ECO, RPC, RSCO⟩

⟨ECO, RPC, RSCO, DCI⟩

In Conclusion

- A pattern captures recurrence, structure and intention in design
  - But beware: not all that recurs is necessarily good
- Patterns inevitably combine to address more intricate problems than lone patterns can
  - A pattern compound captures common groupings
  - A pattern sequence represents a gradual process of stable transformation from one design to another
  - A pattern language describes connections between patterns that can yield many different paths