Overview of Patterns: Part 1

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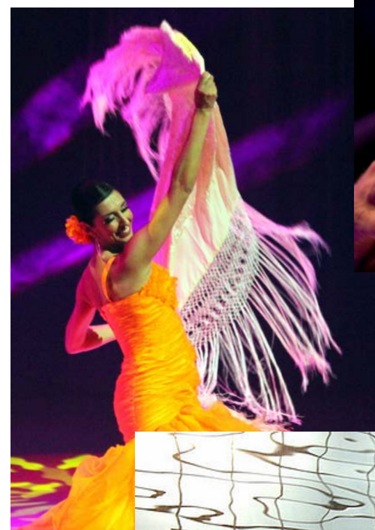
Topics Covered in this Part of the Module

- Motivate the importance of design experience & leveraging recurring design structure in becoming a master software developer

Becoming a Master

- Experts perform differently than beginners
  - Unlike novices, professional athletes, musicians & dancers move fluidly & effortlessly, without focusing on each individual movement



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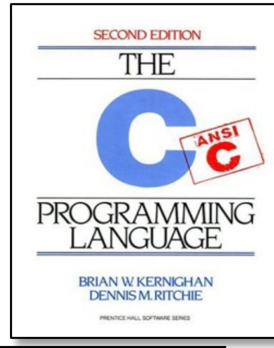
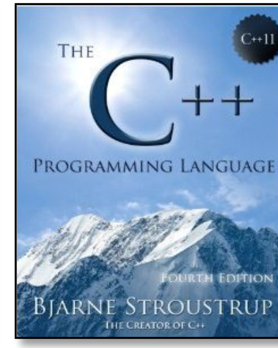
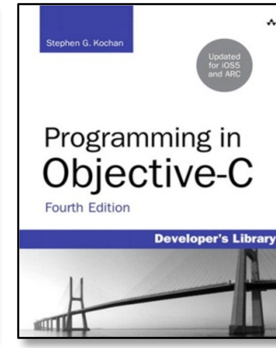
- Continuous repetition & practice are crucial to success
- Mentoring from other experts is also essential to becoming a master

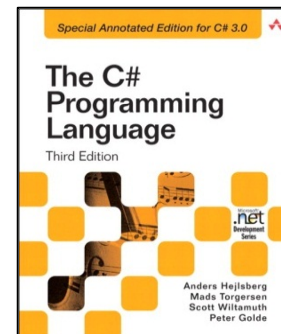
Becoming a Master Software Developer

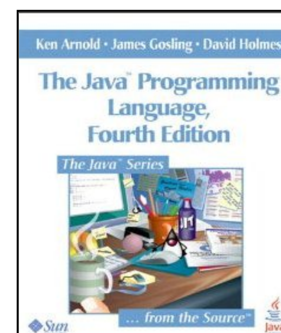
- Knowledge of programming languages is necessary, but not sufficient
  - Can fall prey to "featuritis" or worse
    - e.g., GPERF perfect hash function generator, circa 1990

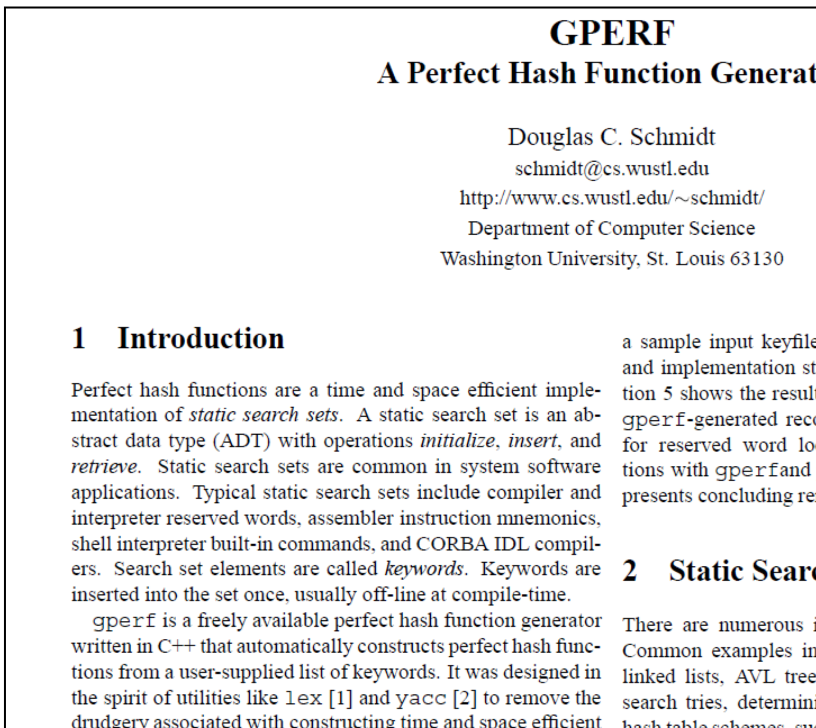












GPERF

A Perfect Hash Function Generator

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1 Introduction

Perfect hash functions are a time and space efficient implementation of *static search sets*. A static search set is an abstract data type (ADT) with operations *initialize*, *insert*, and *retrieve*. Static search sets are common in system software applications. Typical static search sets include compiler and interpreter reserved words, assembler instruction mnemonics, shell interpreter built-in commands, and CORBA IDL compilers. Search set elements are called *keywords*. Keywords are inserted into the set once, usually off-line at compile-time.

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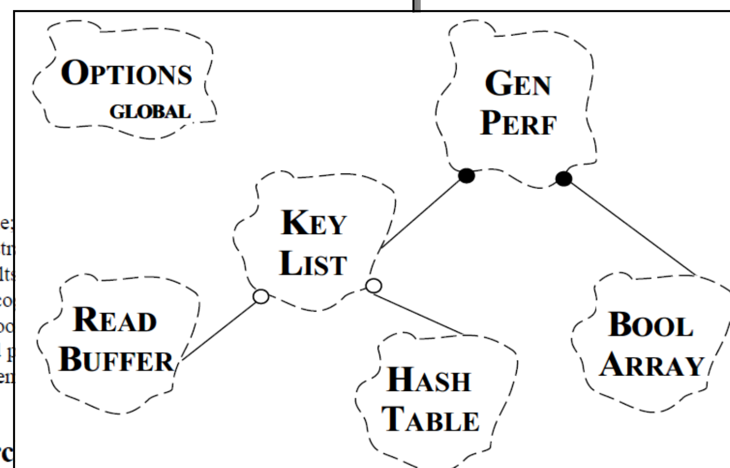

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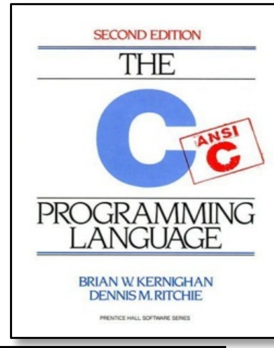

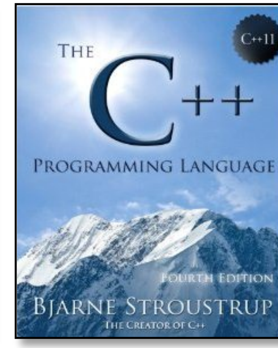

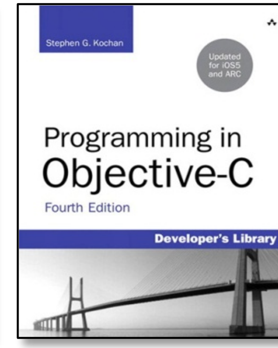

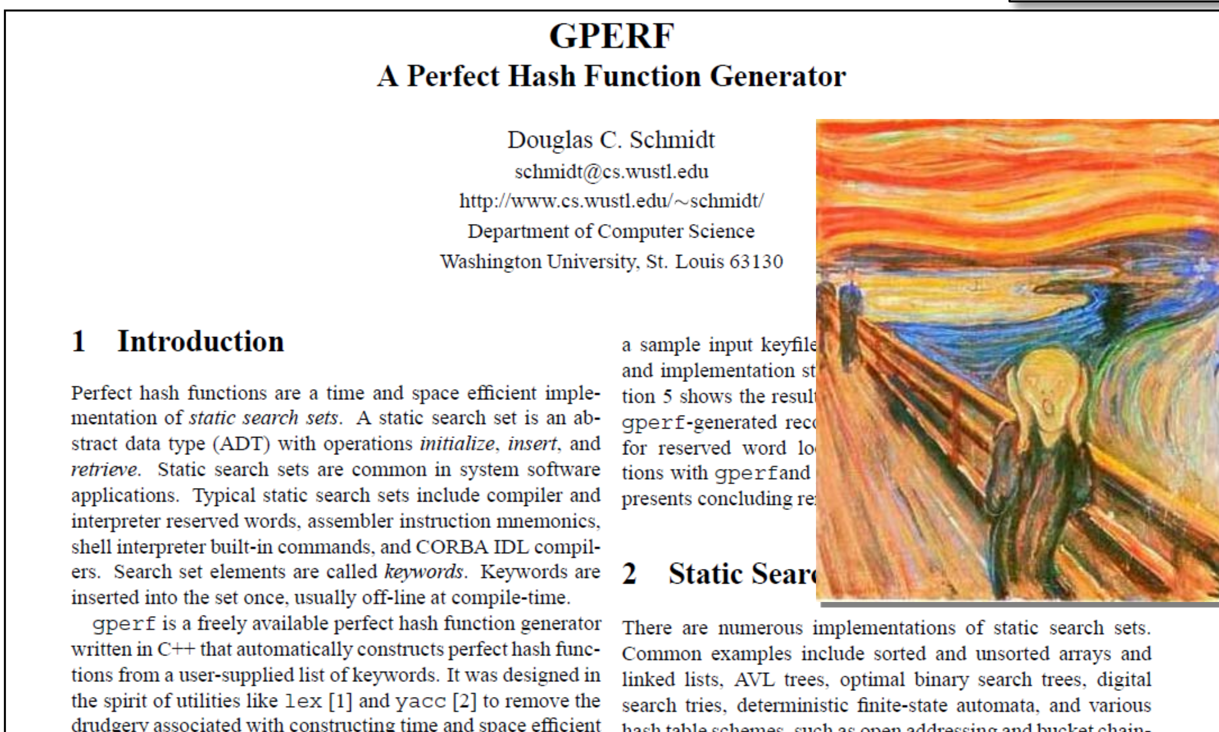

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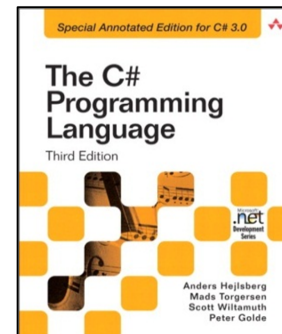
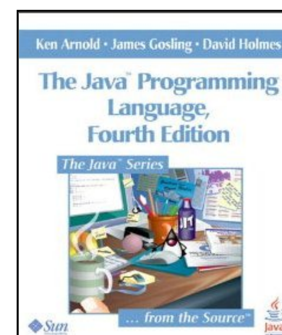
Problems
- Hard-coded algorithms
- Hard-coded data structures
- Hard-coded generators
- etc.





See www.dre.vanderbilt.edu/~schmidt/PDF/gperf.pdf for a paper on GPERF

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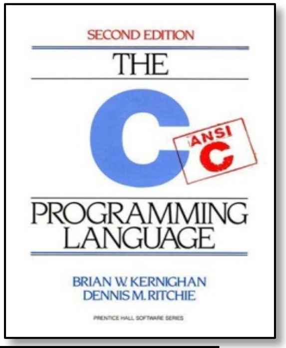

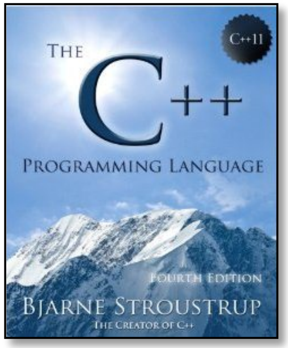

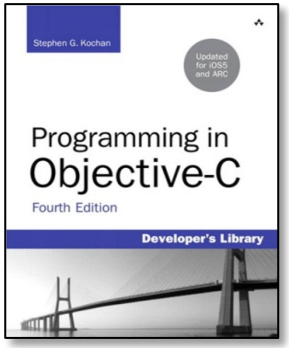

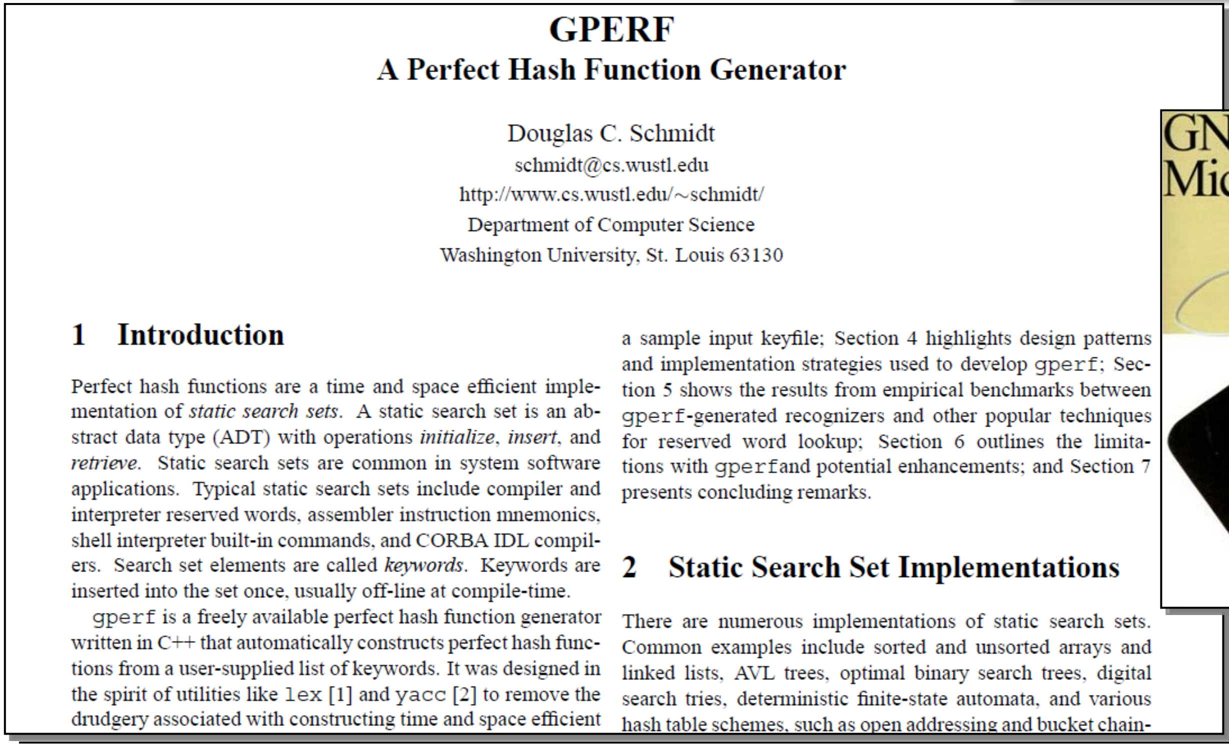

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a sample input keyfile; Section 4 highlights design patterns and implementation strategies used to develop `gperf`; Section 5 shows the results from empirical benchmarks between `gperf`-generated recognizers and other popular techniques for reserved word lookup; Section 6 outlines the limitations with `gperf`and potential enhancements; and Section 7 presents concluding remarks.

2 Static Search Set Implementations

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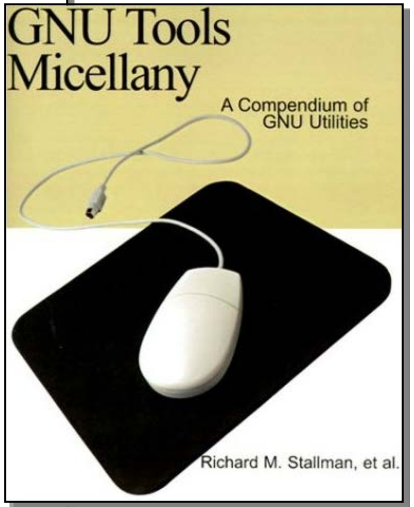

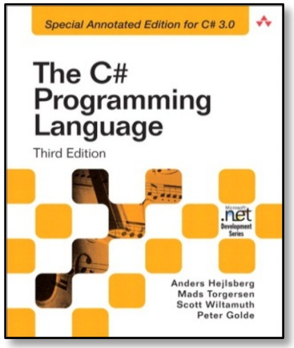

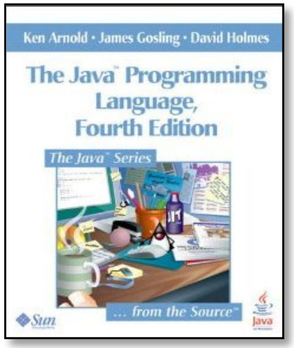

GPERF is part of the GNU software release at www.gnu.org/software/gperf

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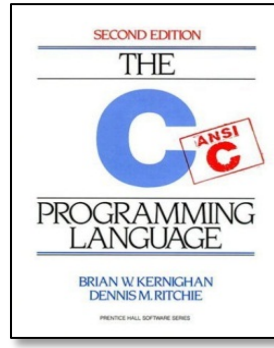
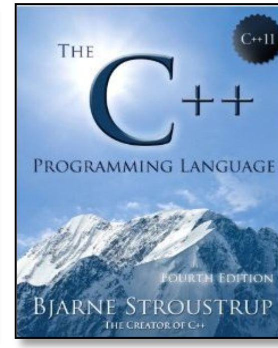
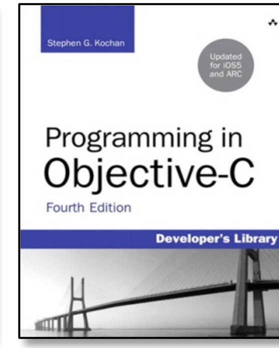
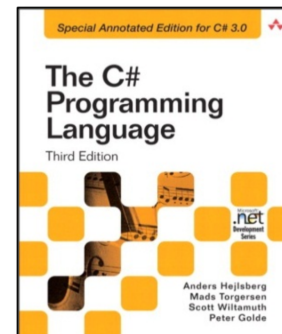
  - Can fall prey to “featuritis” or worse!
    - e.g., “Best one-liner” from 2006 “Obfuscated C Code” contest





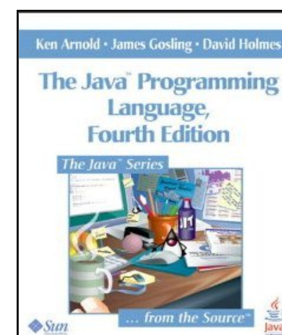



```
main(_){_^448&&main(-~_);putchar(--_%64?32|-~7[
__TIME__-_/8%8][">'txiZ^(~z?"-48]>>";;;====~$::199"
[_*2&8|_/64]/(_&2?1:8)%8&1:10);}
```



- This program prints out the time when it was compiled!

```
!!!!!!  !!!!!!              !!      !!              !!  !!!!!!
    !!      !!              !!      !!          !!  !!      !!
    !!      !!              !!      !!          !!  !!      !!
  !!!!    !!!!    !!        !!      !!    !!    !!!!!!      !!
!!      !!                  !!      !!              !!      !!
!!      !!                  !!      !!              !!      !!
!!!!    !!!!                !!      !!              !!      !!
```



See www.ioccc.org for many examples of obfuscated C

Becoming a Master Software Developer

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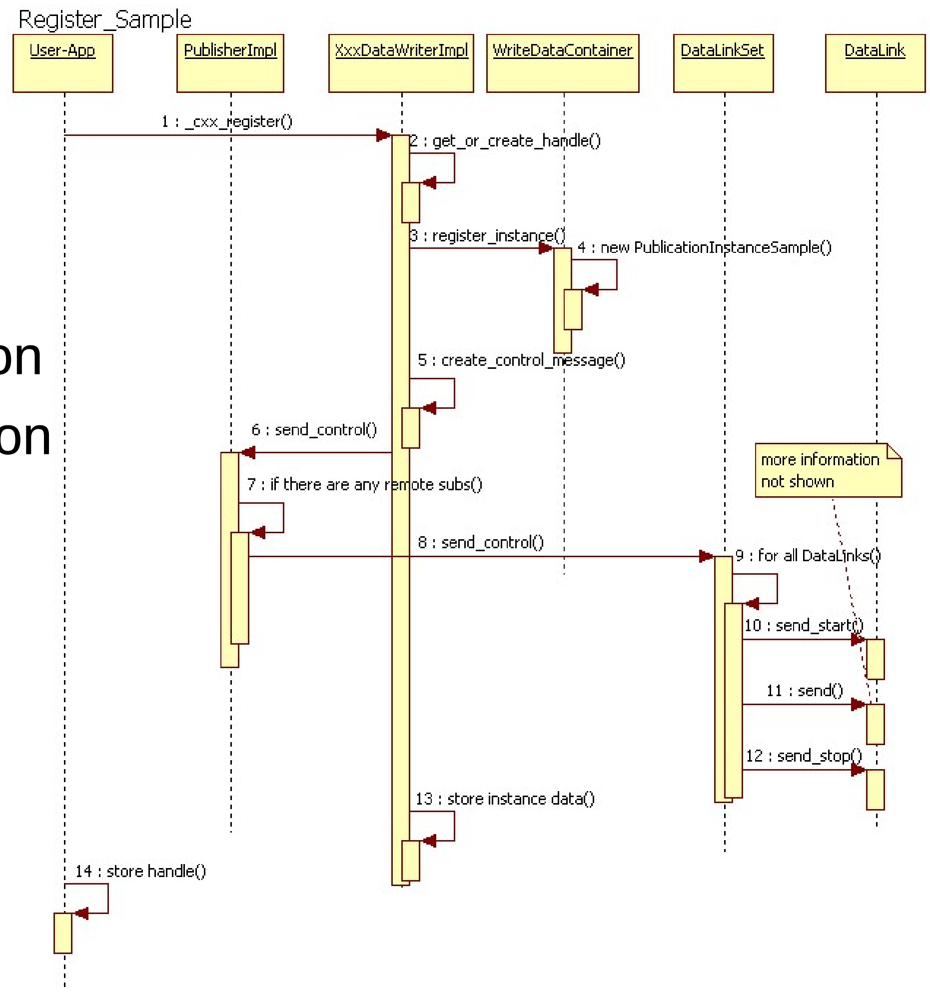
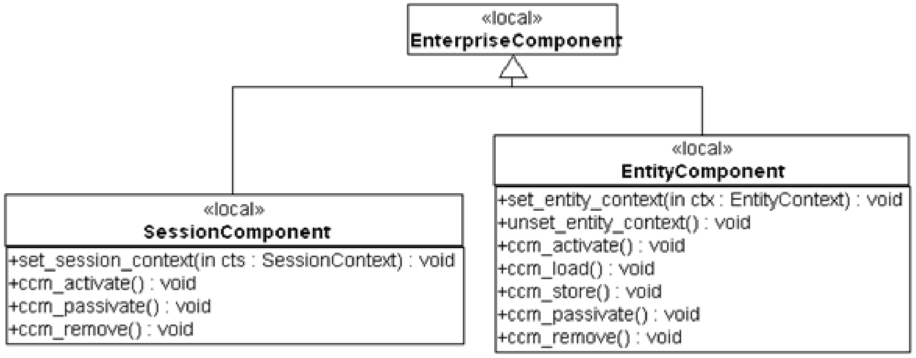
- Software methods emphasize design notations, such as UML
  - Fine for specification & documentation
    - e.g., omits mundane implementation details & focuses on relationships between key design entities





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  - Good draftsmen/artists are not necessarily good architects!

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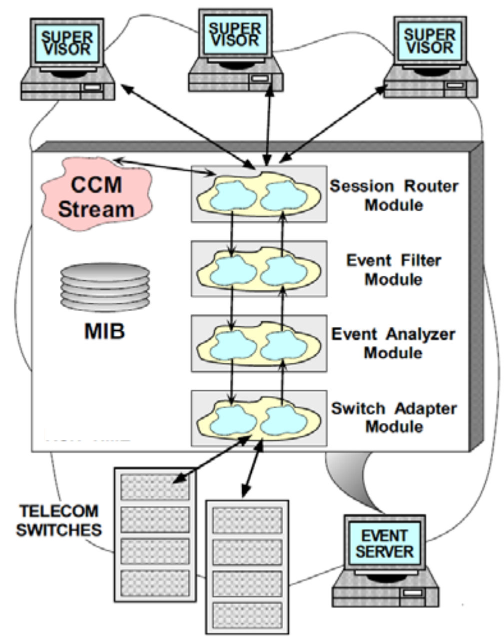
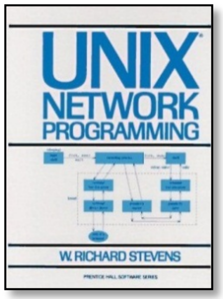
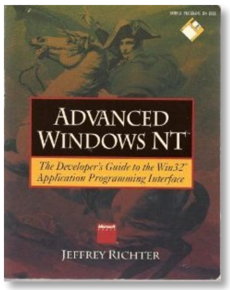
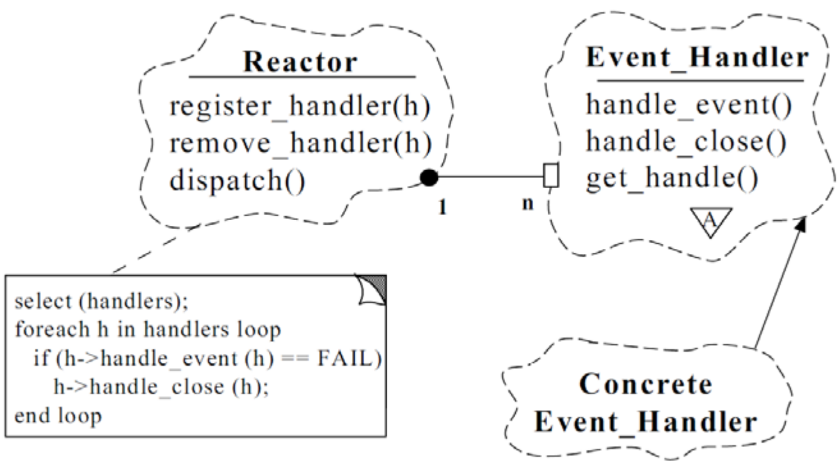
- But good software design is more than drawing diagrams
  - Good draftsmen/artists are not necessarily good architects!
- **Bottom-line**: Master software developers rely on *design experience*
  - At least as important as knowledge of programming languages & environments







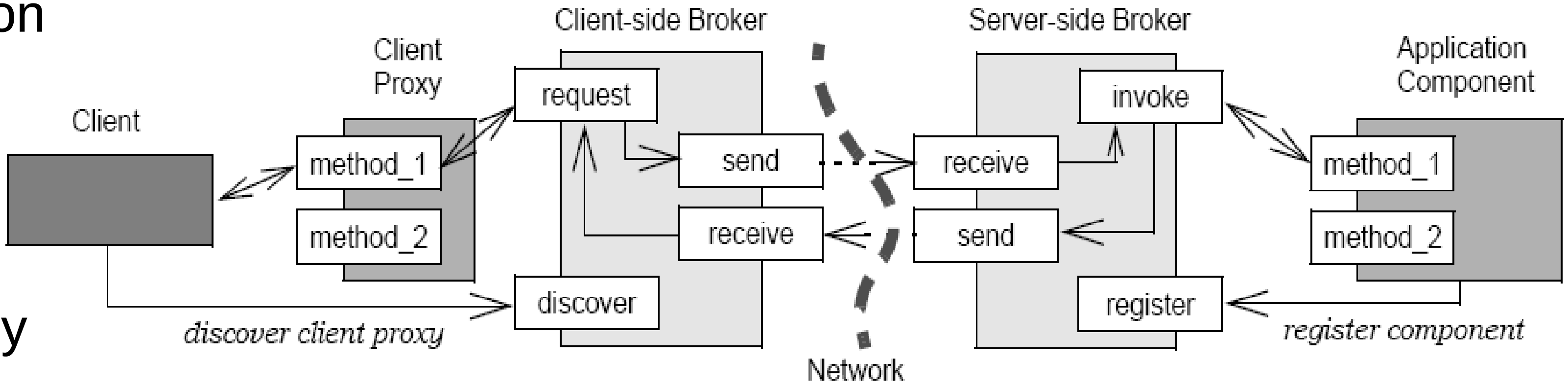


See www.dre.vanderbilt.edu/~schmidt/PDF/ECOOP-95.pdf for more info

Where Should Design Experience Reside?

Well-designed software exhibits recurring structures & behaviors that promote

- Abstraction
- Flexibility
- Reuse
- Quality
- Modularity



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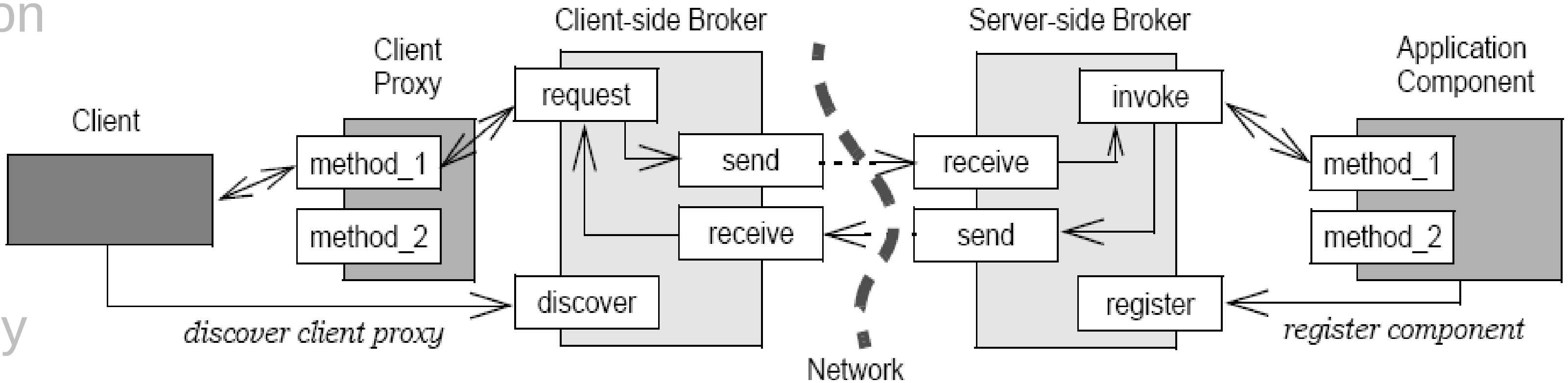

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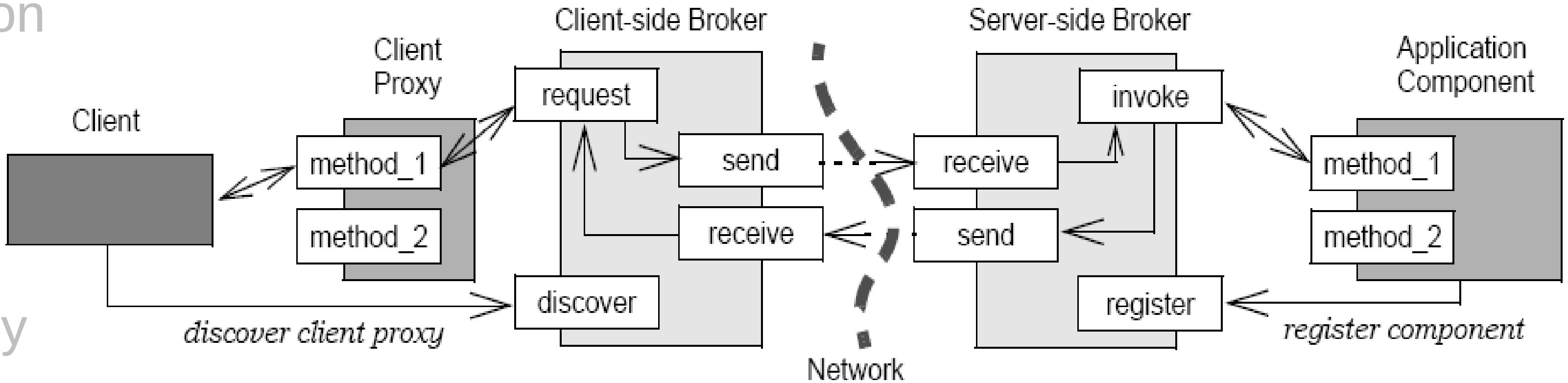

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Unfortunately, this design knowledge is typically located in:

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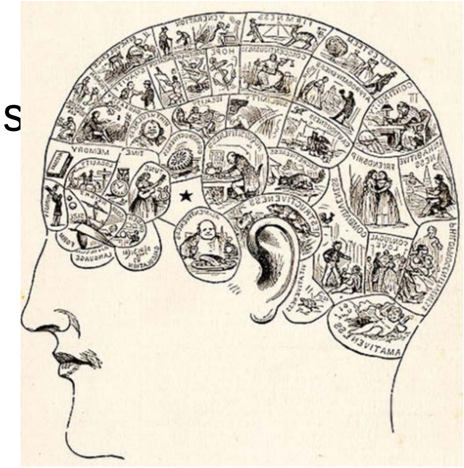

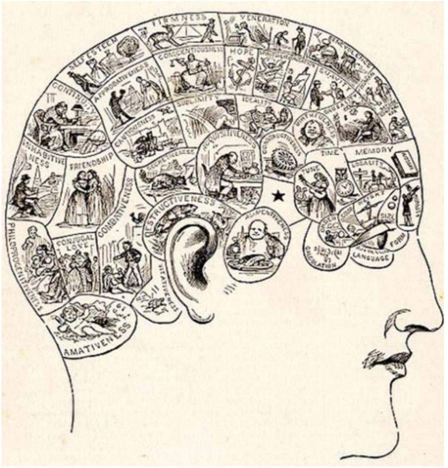

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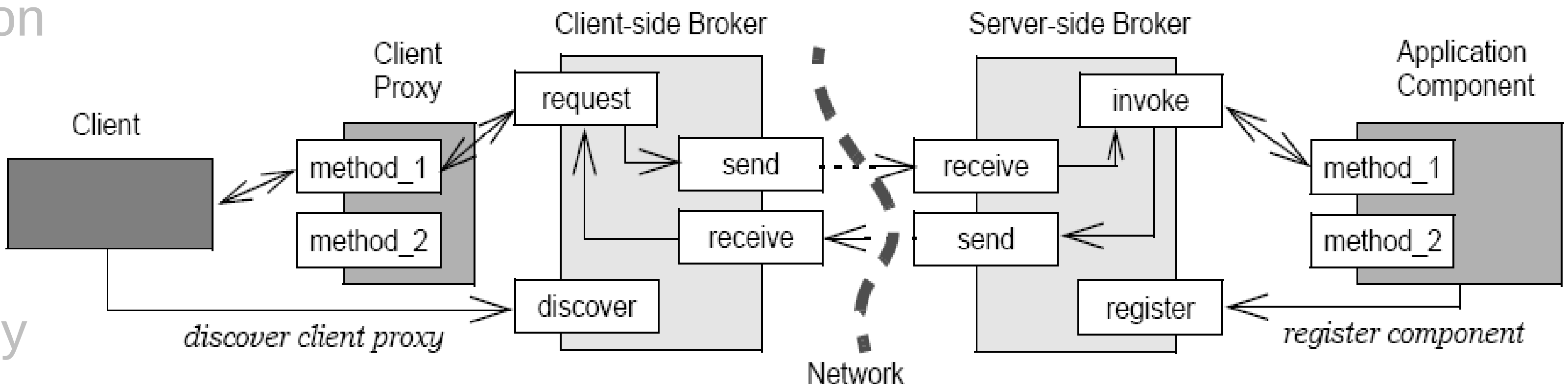

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2. the bowels of the source code

```
public class KeyGeneratorImpl extends Service {
    private Set<UUID> keys = new HashSet<UUID>();
    private final KeyGenerator.Stub binder = new KeyGenerator.Stub() {
        public void setCallback (final KeyGeneratorCallback callback) {
            UUID id;
            synchronized (keys) {
                do { id = UUID.randomUUID(); } while (keys.contains(id));
                keys.add(id);
            }
            final String key = id.toString();
            try {
                Log.d(getClass().getName(), "sending key" + key);
                callback.sendKey(key);
            } catch (RemoteException e) { e.printStackTrace(); }
        }
    };
    public IBinder onBind(Intent intent) { return this.binder; }
}
```

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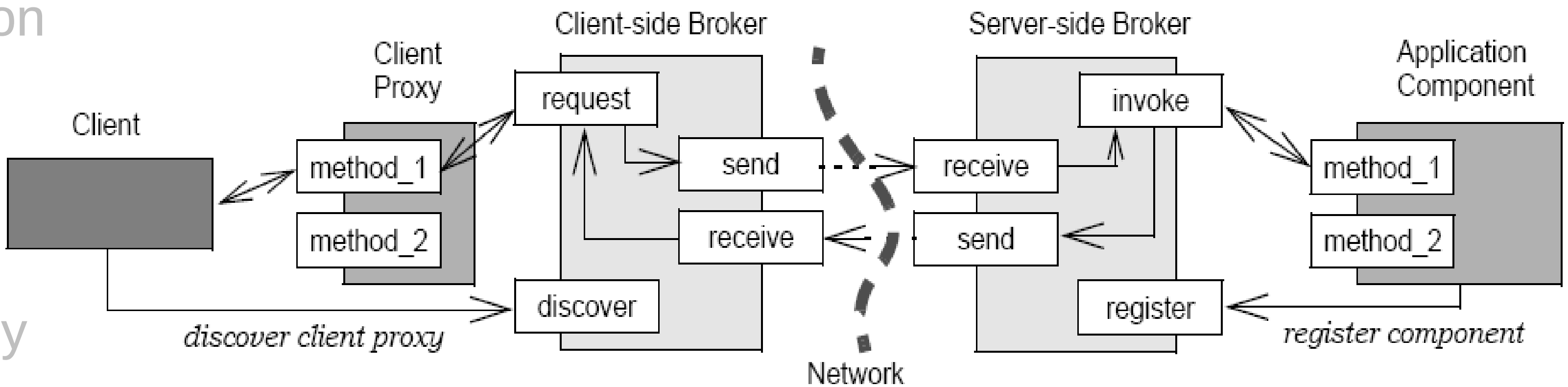

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Both locations are fraught with danger!

Summary

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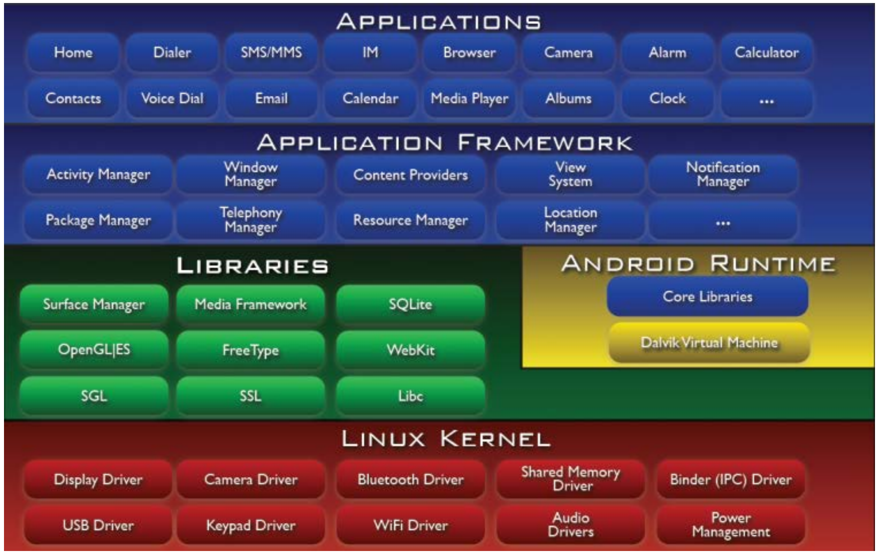
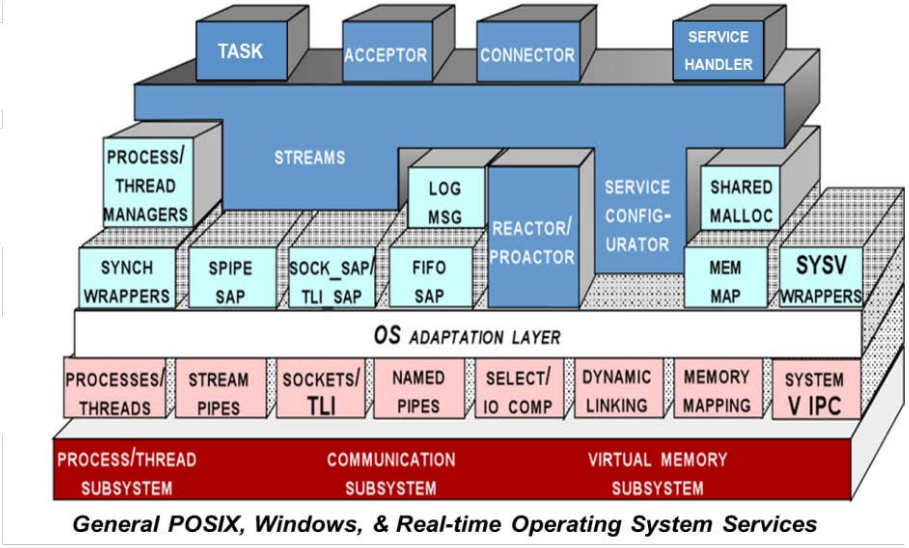
  - Open-source & open courses are vital resources





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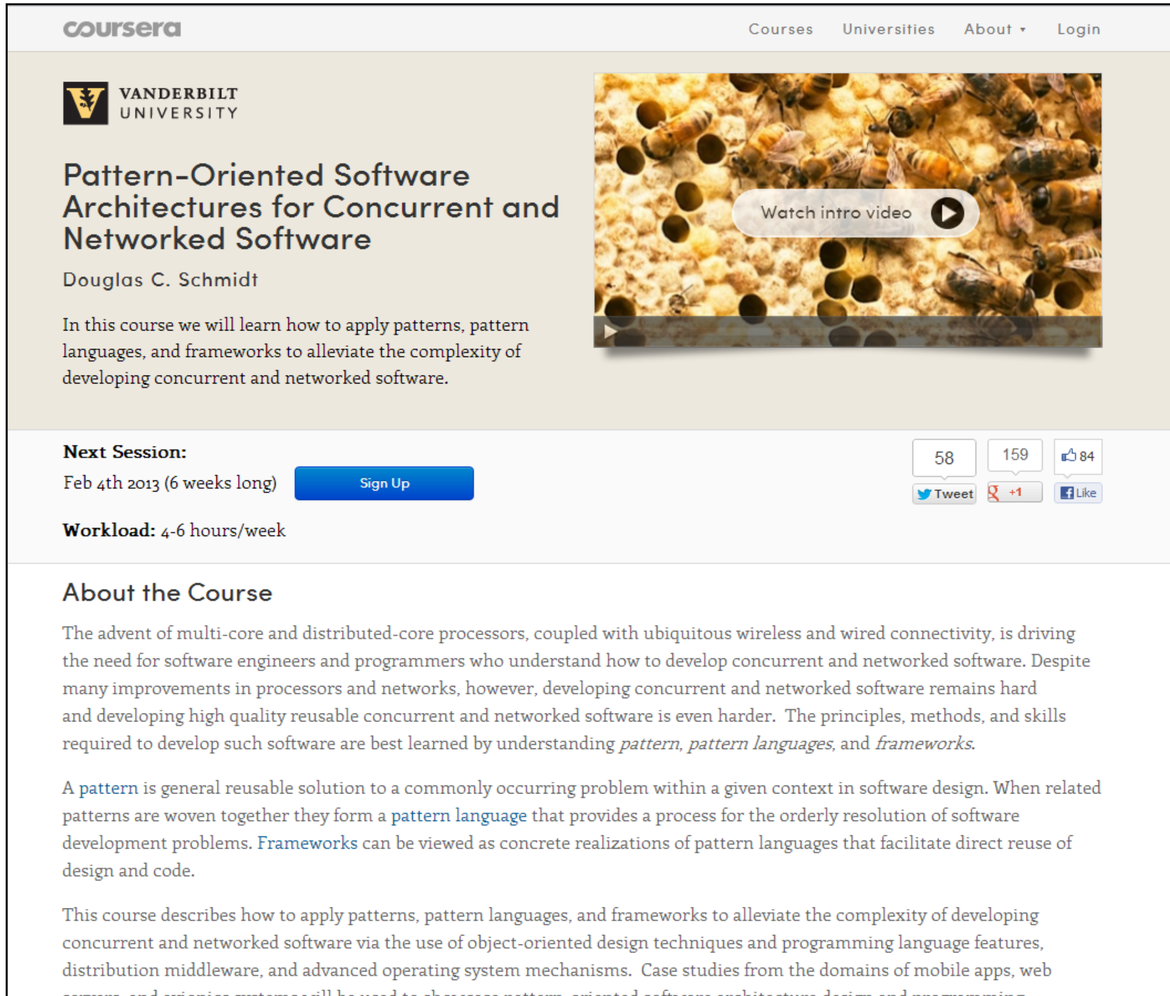

Information & registration available at www.coursera.org/course/posa

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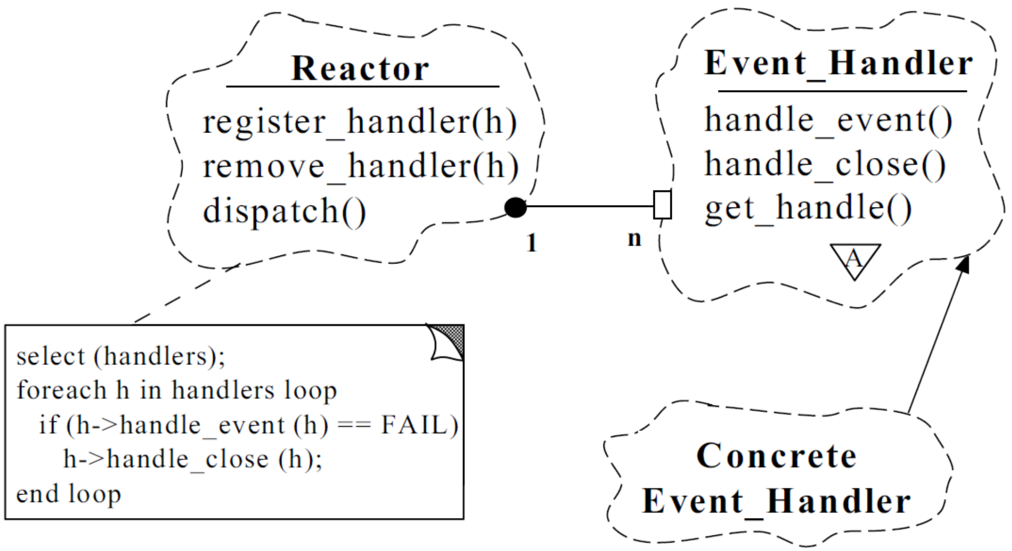

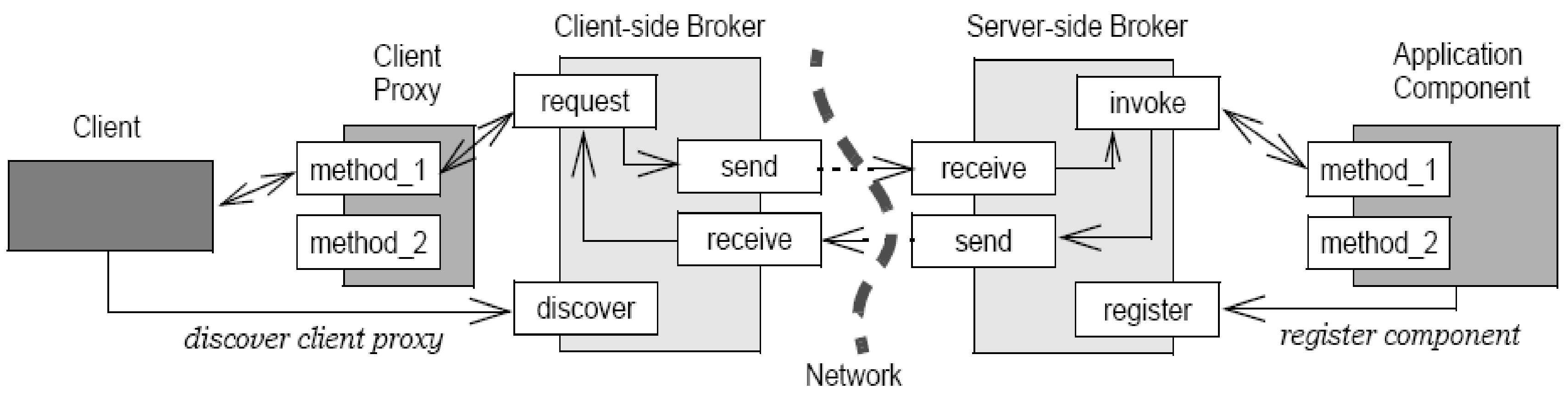

Summary

- Achieving mastery of software development requires continuous repetition, practice, & mentoring from experts
- Good software developers rely on experience gleaned from successful designs
- What we need is a means of extracting, documenting, conveying, applying, & preserving this design knowledge without undue time, effort, & risk!

Overview of Patterns: Part 2

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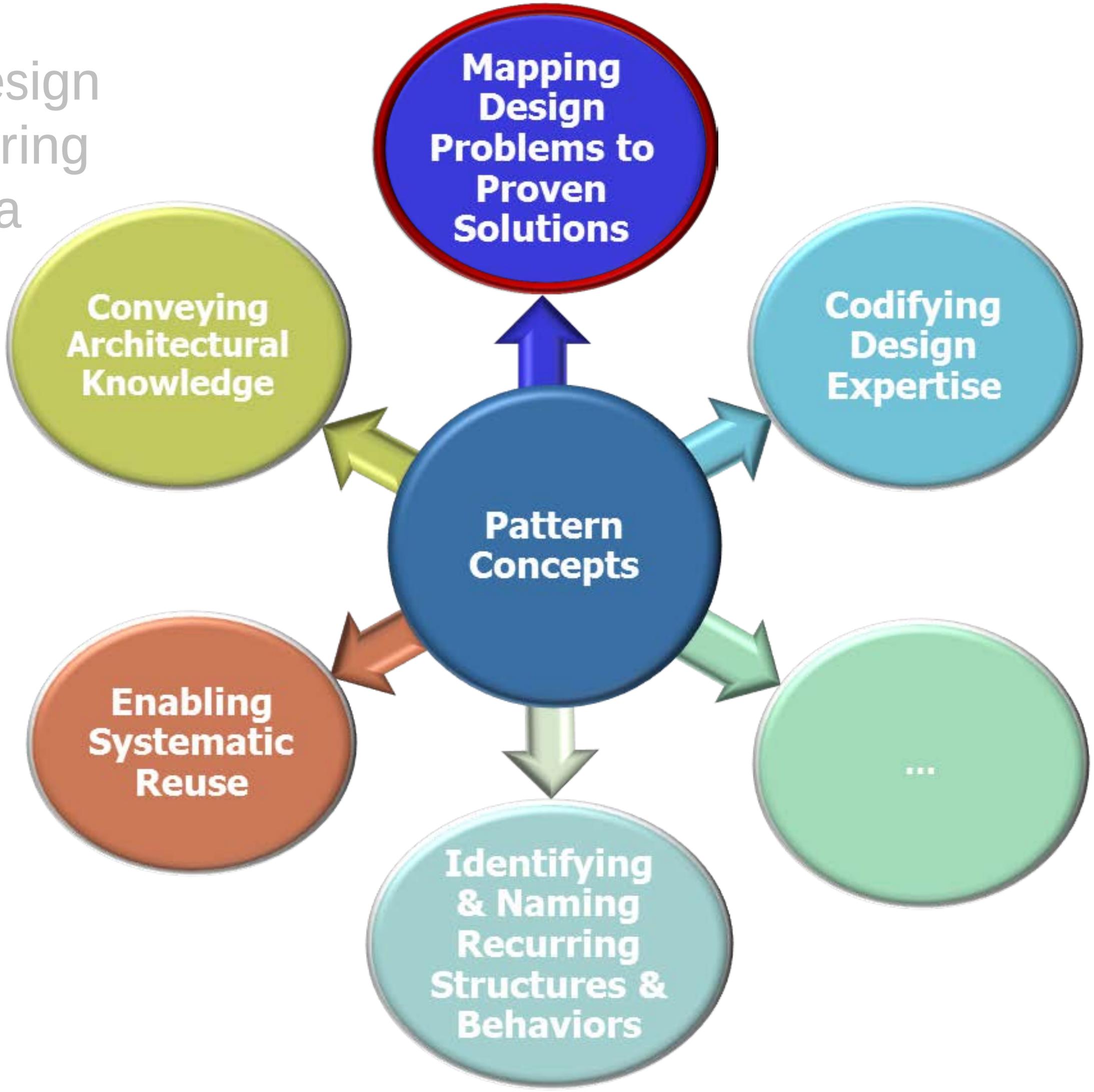
- Introduce patterns as a means of improving software quality & developer productivity by...



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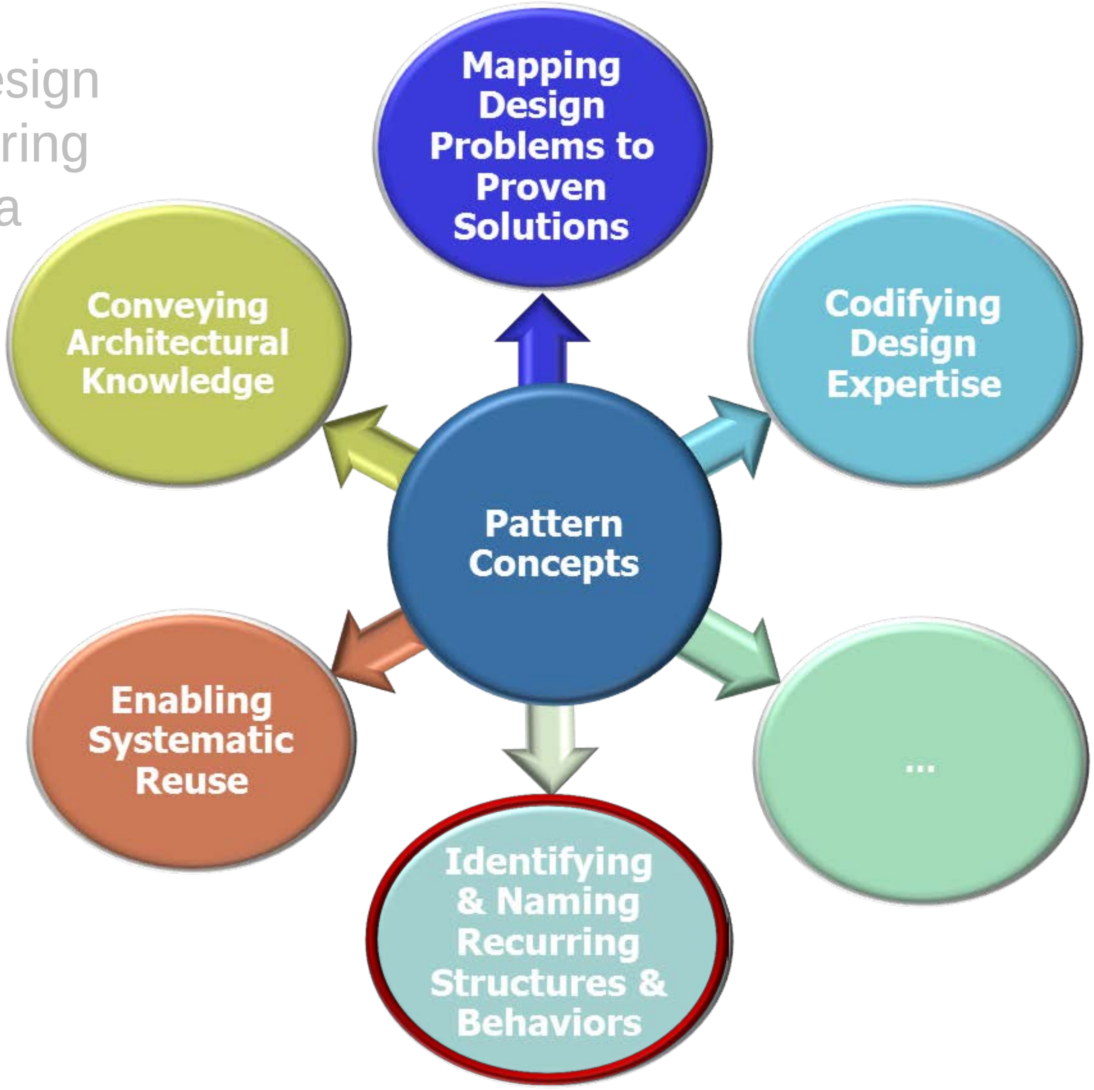

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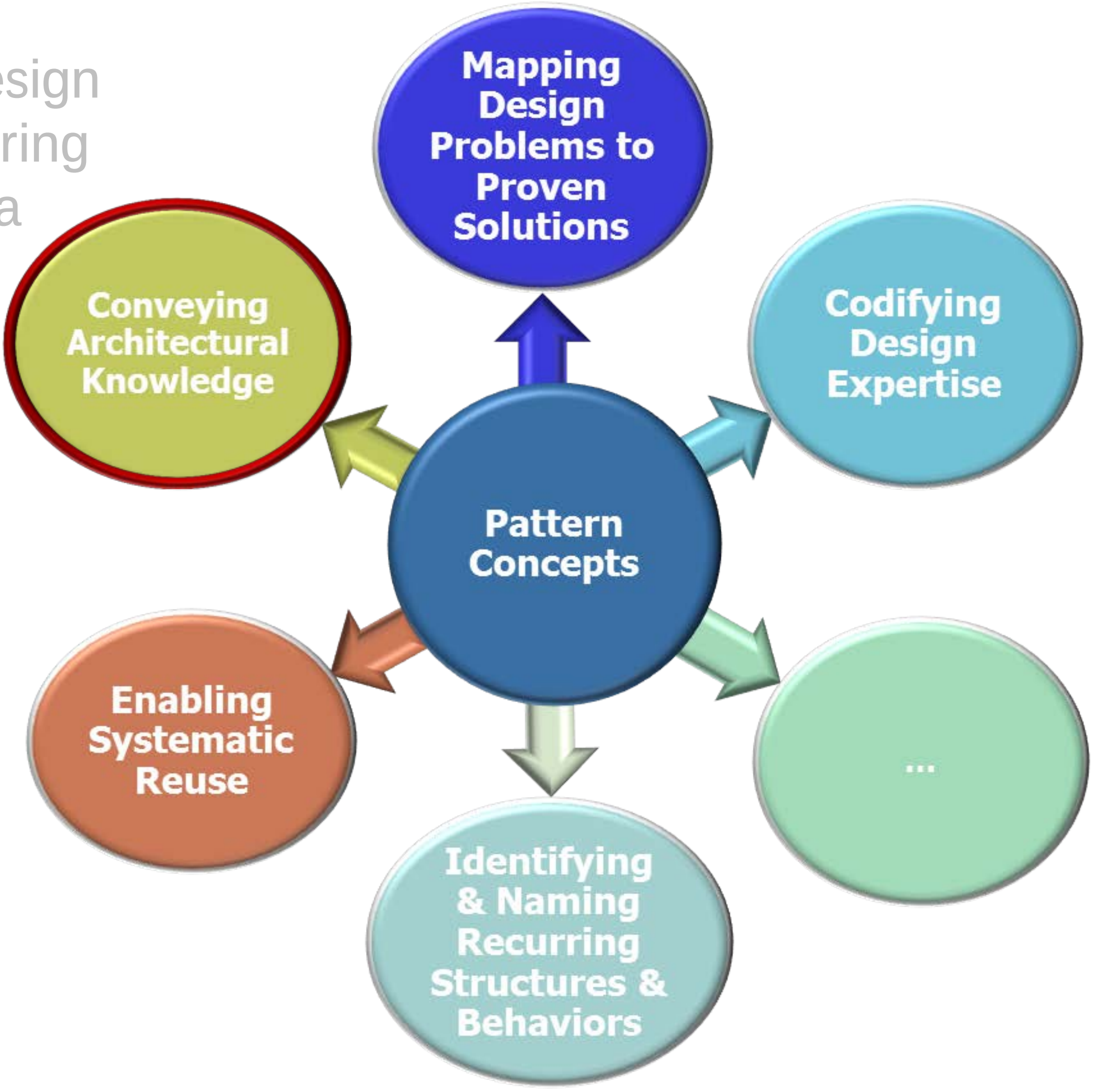

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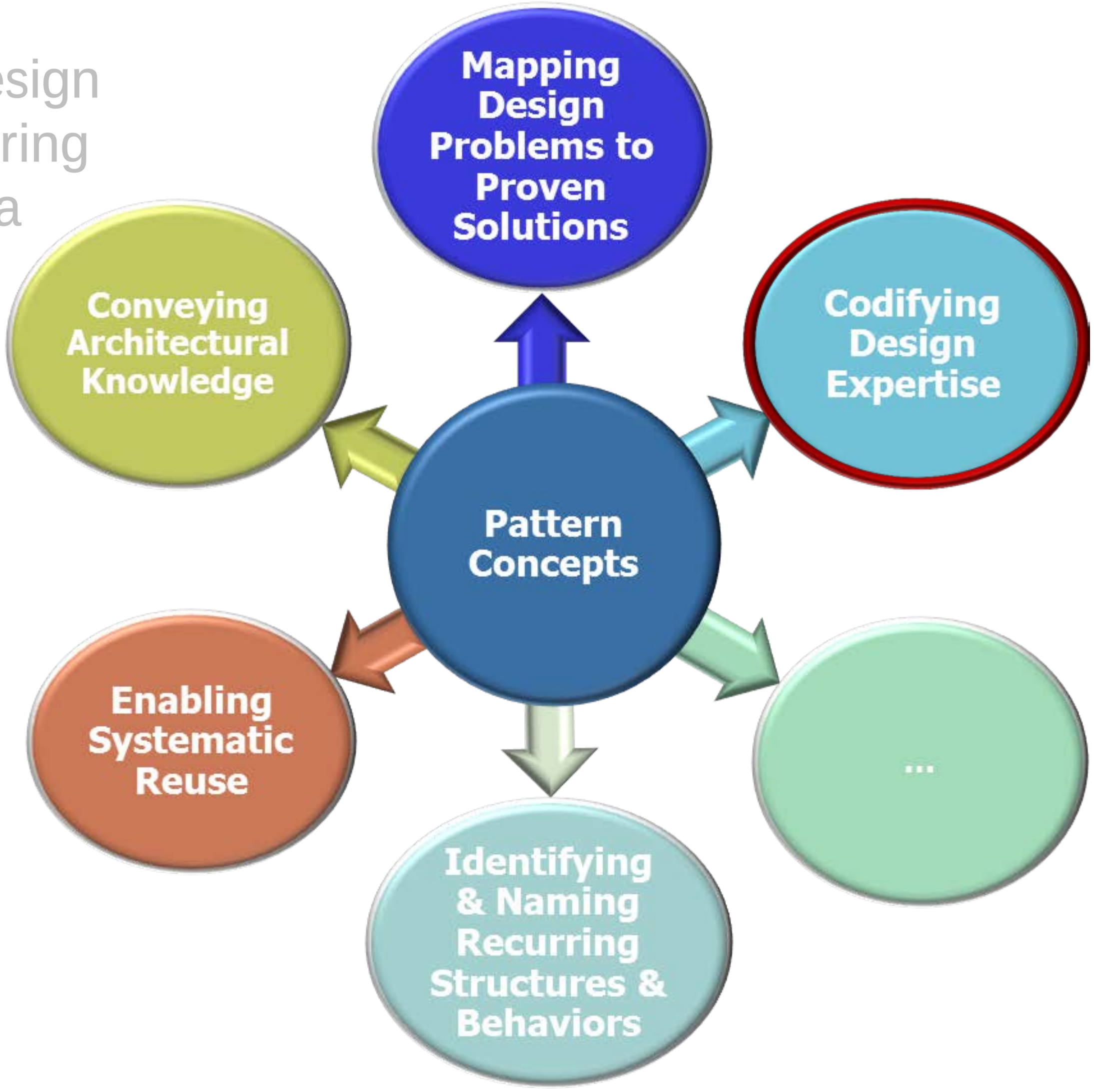

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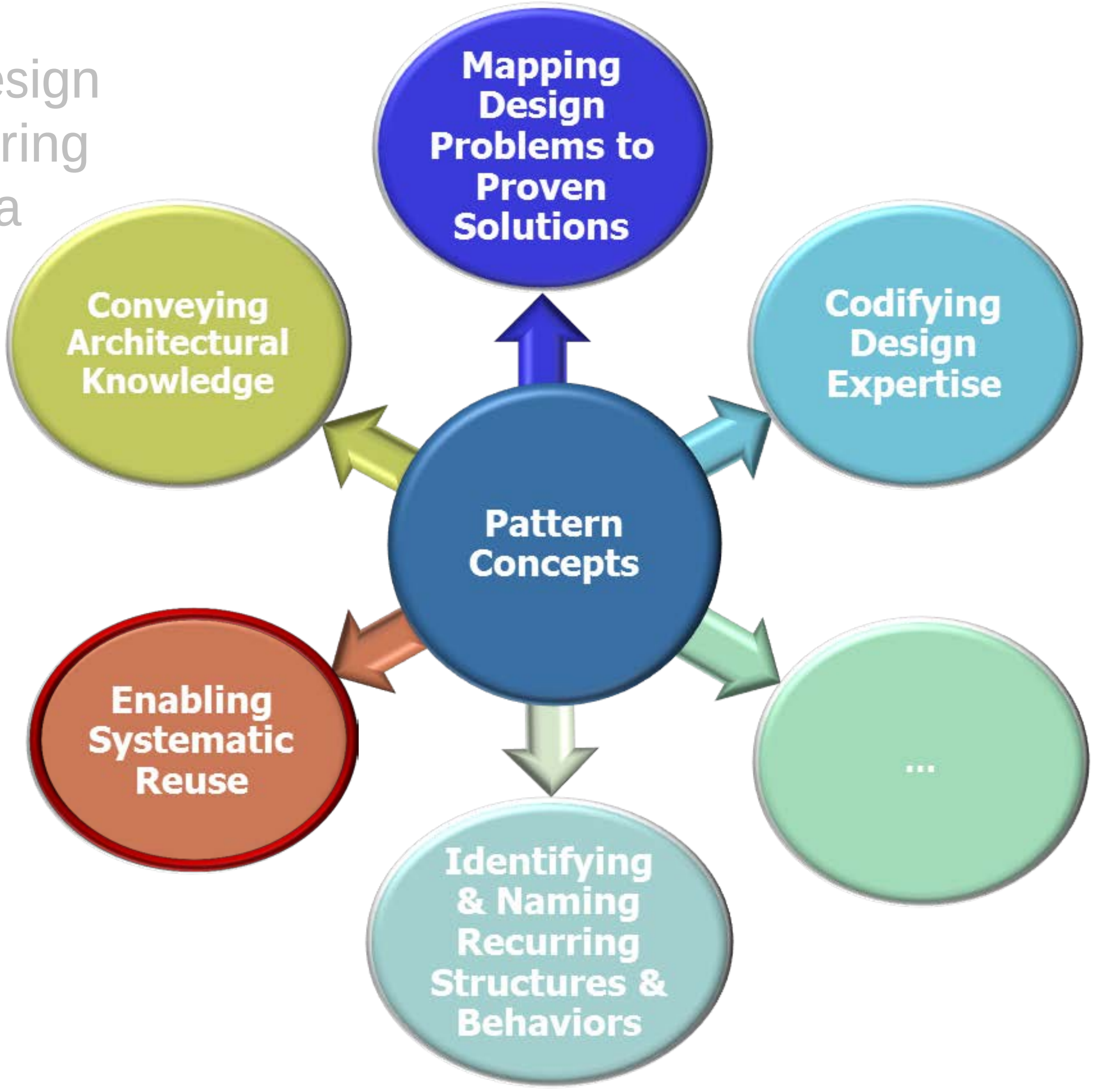
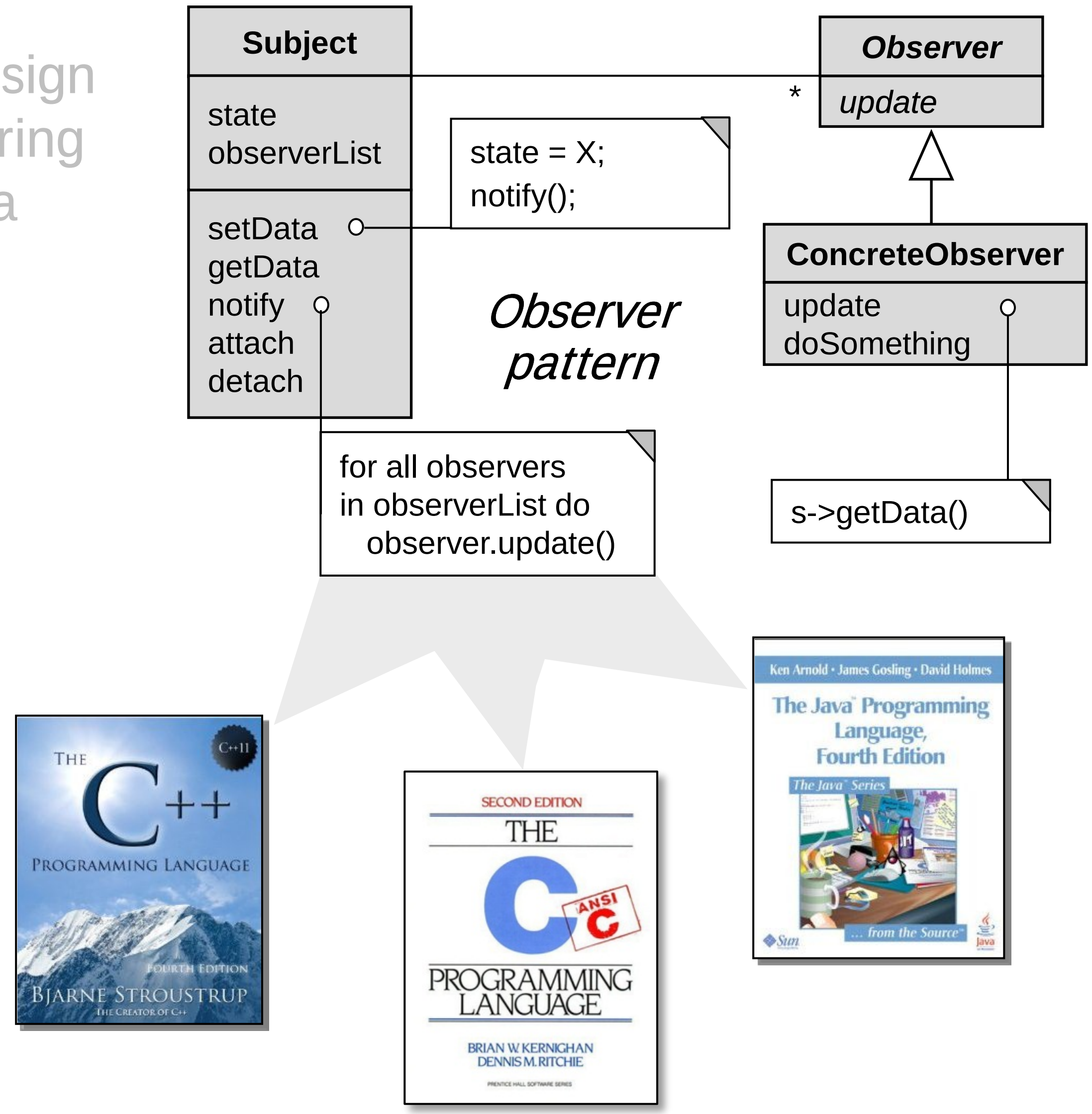


Topics Covered in this Part of the Module

- Motivate the importance of design experience & leveraging recurring design structure in becoming a master software developer
- Introduce patterns as a means of improving software quality & developer productivity
- Summarize common characteristics of patterns

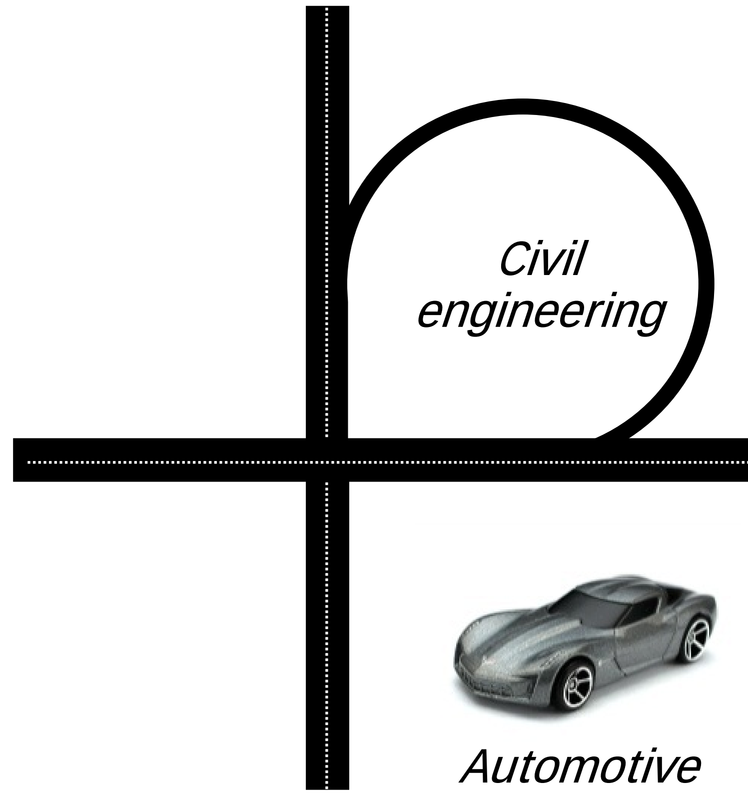


Key to Mastery: *Knowledge of Software Patterns*

- Describes a **solution** to a common **problem** arising within a **context**

Aerospace

Mobile devices

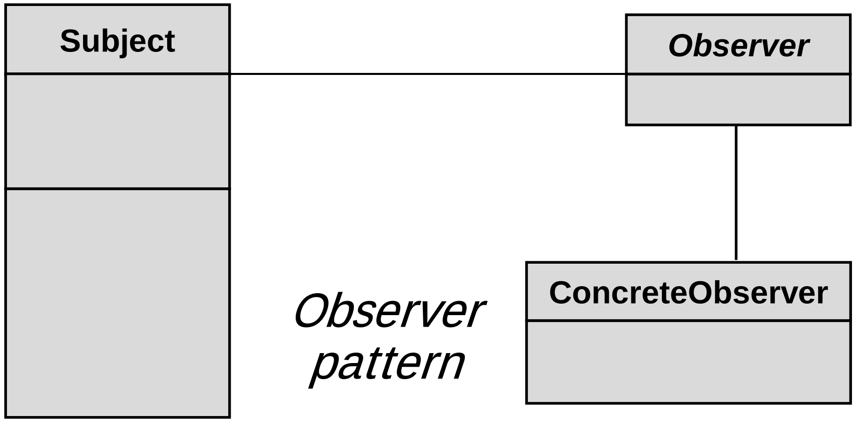


Automotive

Electronic Trading

Key to Mastery: *Knowledge of Software Patterns*

- Describes a **solution** to a common **problem** arising within a **context** by
  - **Naming** a recurring design structure

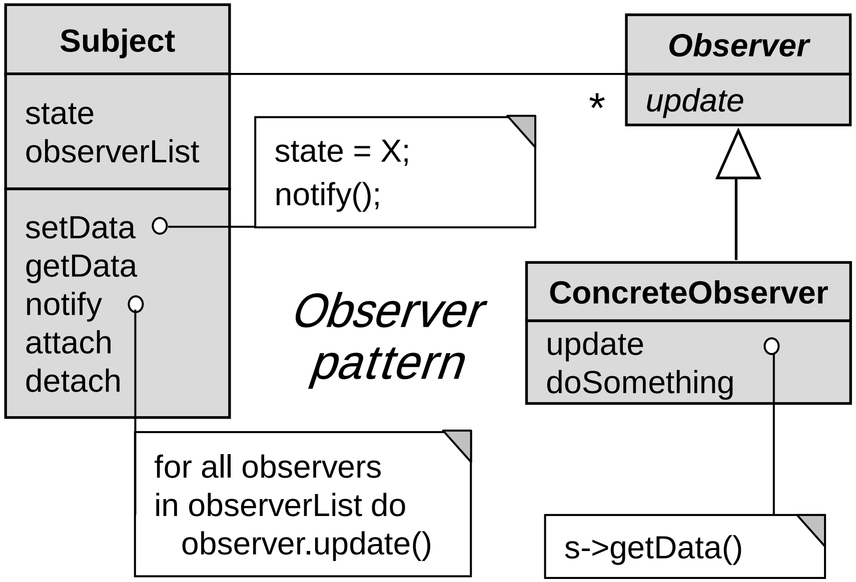


Observer pattern

Intent: "Define a one-to-many dependency between objects so that when one object changes state, all dependents are notified & updated"

Key to Mastery: *Knowledge of Software Patterns*

- Describes a **solution** to a common **problem** arising within a **context** by
  - **Naming** a recurring design structure
  - **Specifying** design structure explicitly by identifying key class/object *
    - Roles & relationships
    - Dependencies
    - Interactions
    - Conventions



*Interpret "class" & "object" loosely: patterns are for more than OO languages!

Key to Mastery: *Knowledge of Software Patterns*

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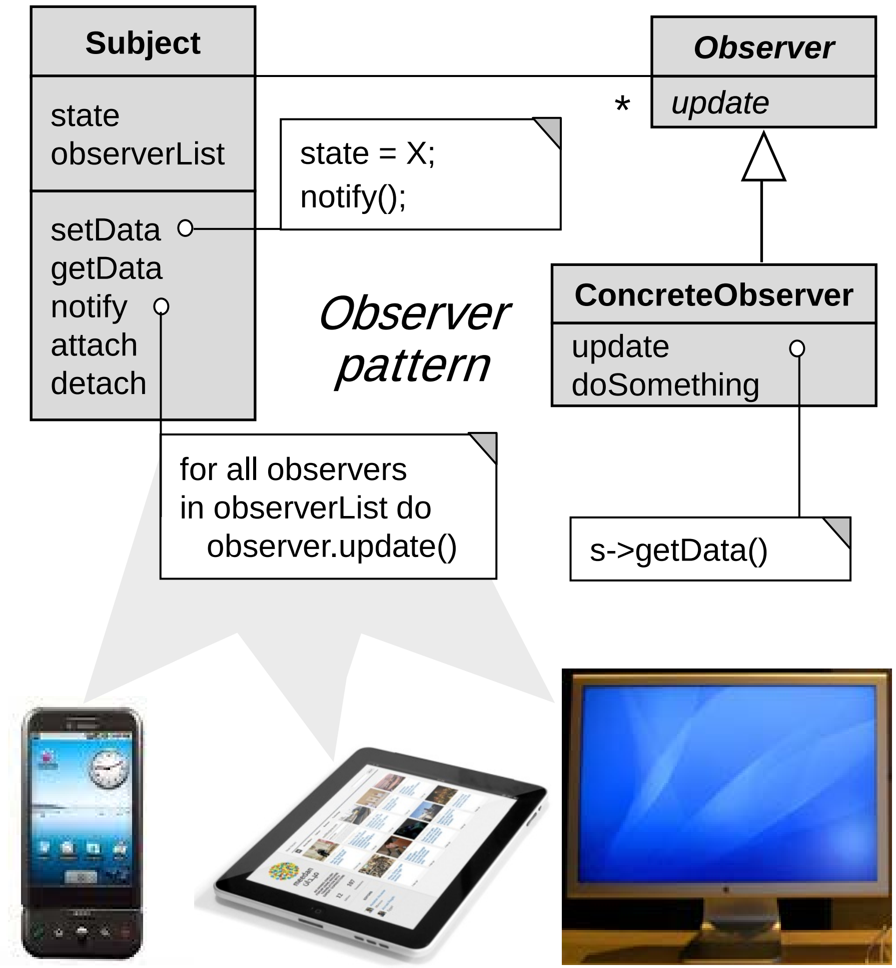
    - Dependencies
    - Interactions
    - Conventions
  - **Abstracting** from concrete design elements
    - e.g., problem domain, form factor, vendor, etc.



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    - Interactions
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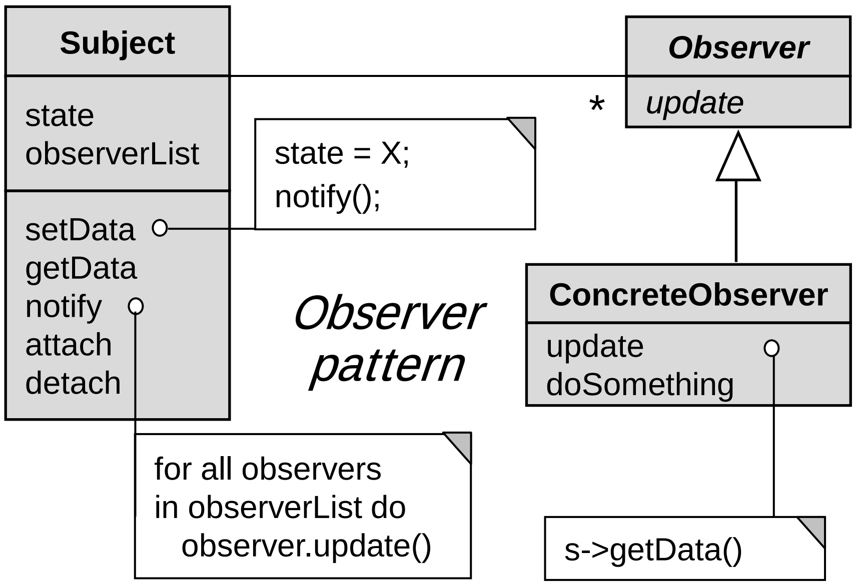
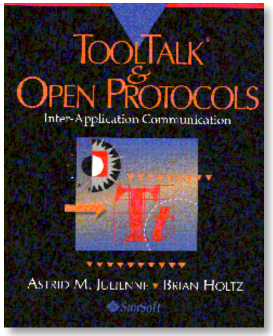
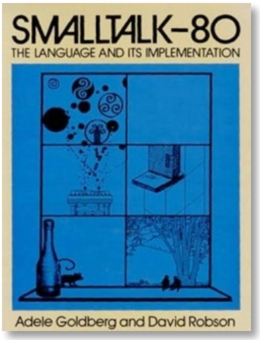
  - **Abstracting** from concrete design elements
  - **Distilling & codifying knowledge** gleaned by experts from their successful design experiences







Common Characteristics of Patterns

- They describe both a *thing* & a *process*:
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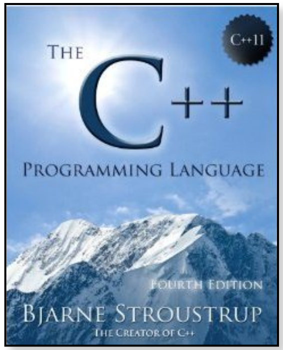
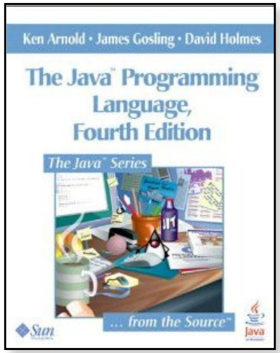
- They describe both a *thing* & a *process*:
  - The “thing” (the “what”) typically means a particular high-level design outline or description of code detail
  - The “process” (the “how”) typically describes the steps to perform to create the “thing”

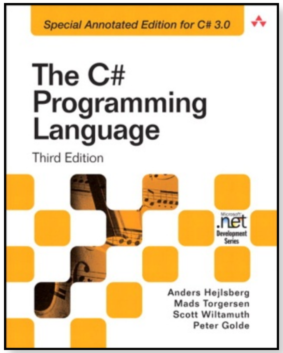
csis.pace.edu/~bergin/dcs/SoftwarePatterns_Coplien.pdf has more info

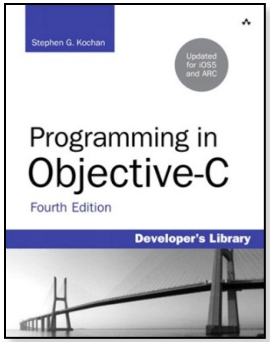
Common Characteristics of Patterns

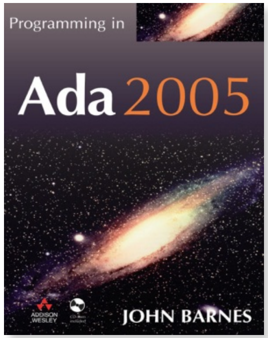
- They describe both a *thing & a process*
- They can be independent of programming languages & implementation techniques

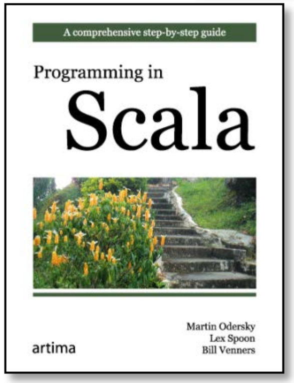


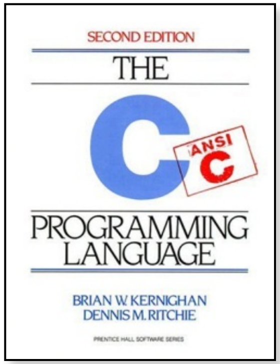


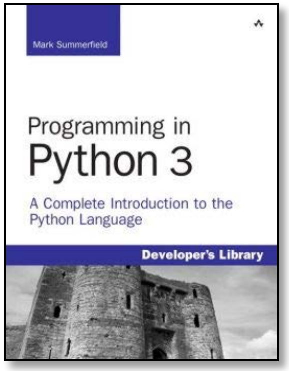








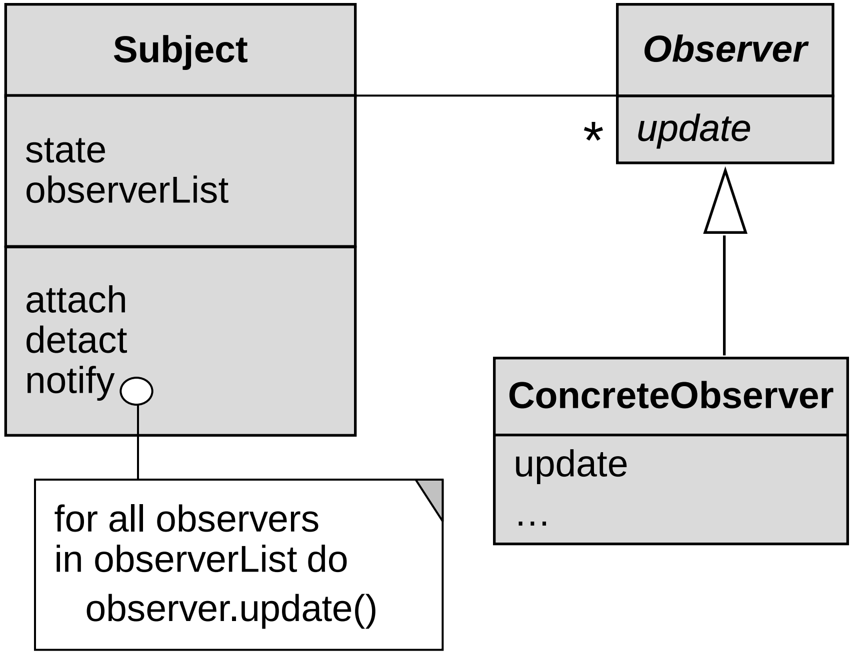




Naturally, different patterns apply to different programming languages

Common Characteristics of Patterns

- They describe both a *thing &* a *process*
- They can be independent of programming languages & implementation techniques
- They define "micro-architectures"
  - In other words, recurring design structure



Observer pattern

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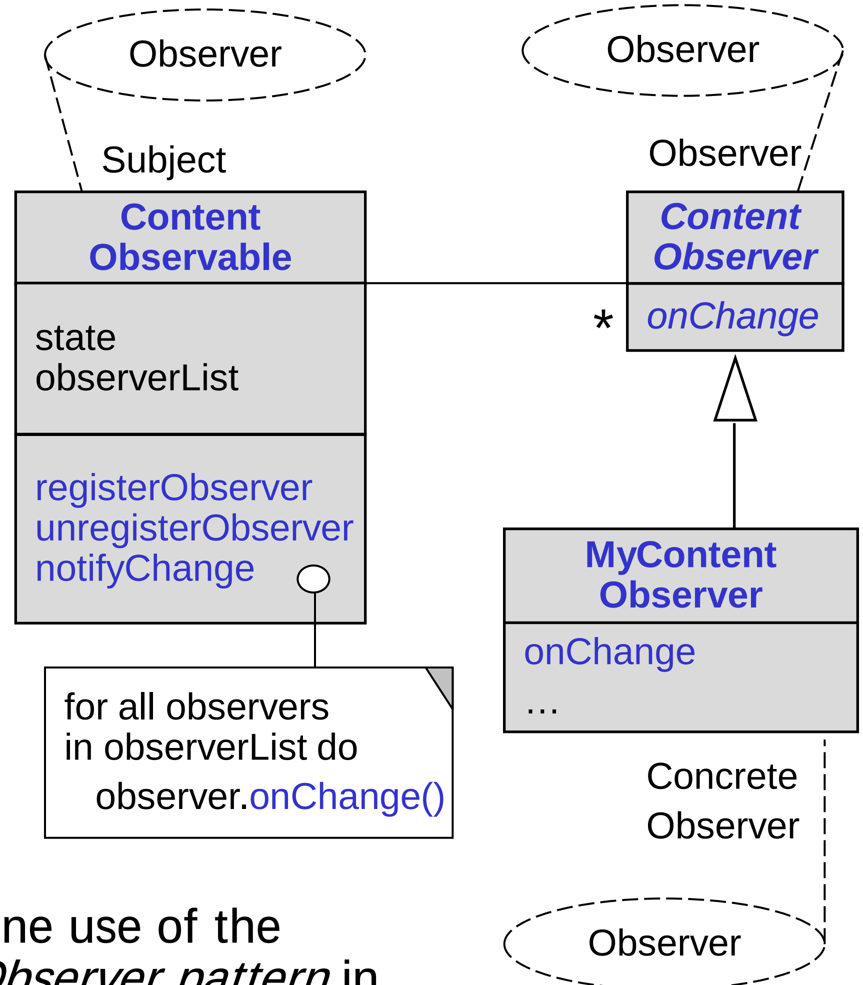
  - Certain properties may be modified for particular contexts



One use of the *Observer pattern* in Android

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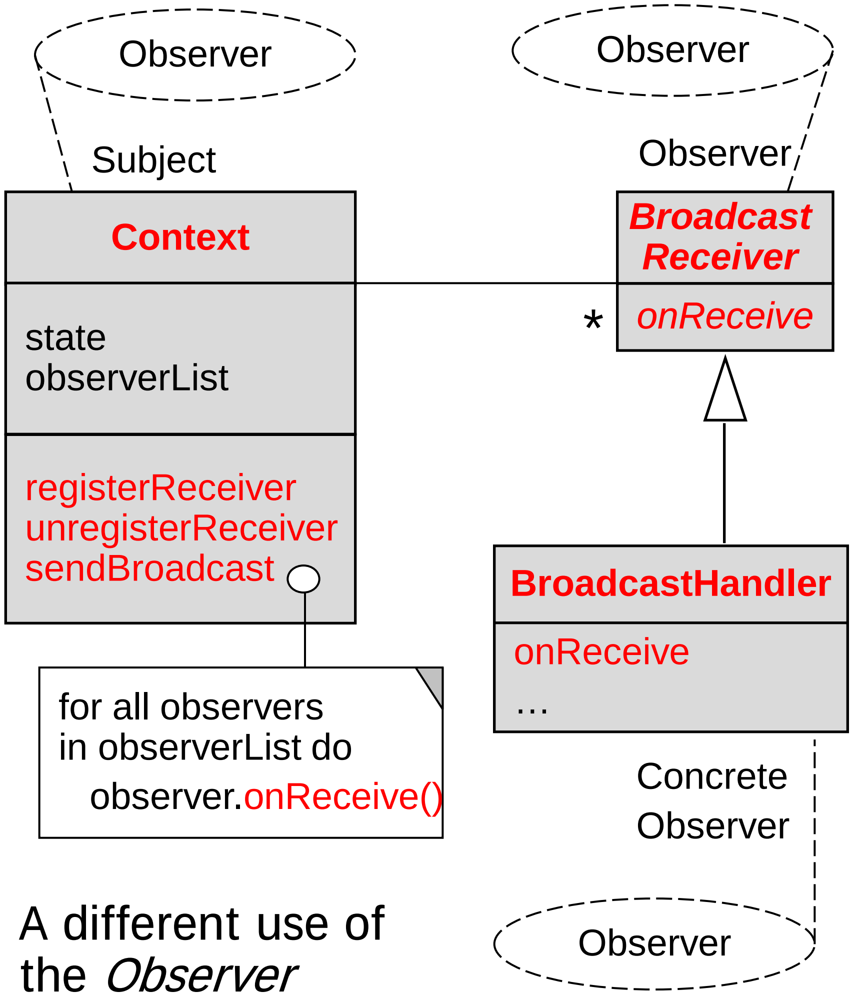

A different use of the *Observer pattern* in Android

Common Characteristics of Patterns

- They describe both a *thing &* a *process*
- They can be independent of programming languages & implementation techniques
- They define "micro-architectures"
- They aren't code or (concrete) designs, so they must be reified and applied in particular languages

```
public class EventHandler
    extends Observer {
  public void update(Observable o,
                     Object arg)
  { /*…*/ }
    …

public class EventSource
    extends Observable,
    implements Runnable {
  public void run()
  { /*…*/ notifyObservers(/*…*/); }
    …

EventSource eventSource =
       new EventSource();
EventHandler eventHandler =
       new EventHandler();
eventSource.addObserver(eventHandler);
Thread thread
           = new Thread(eventSource);
thread.start();
…
```

Observer pattern in Java

Common Characteristics of Patterns

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- They can be independent of programming languages & implementation techniques
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```
class Event_Handler
    : public Observer {
public:
  virtual void update(Observable o,
                      Object arg)
  { /* … */ }
    …
class Event_Source
    : public Observable,
      public ACE_Task_Base {
public:
  virtual void svc()
  { /*…*/ notify_observers(/*…*/); }
    …

Event_Source event_source;
Event_Handler event_handler;
event_source->add_observer
                      (event_handler);
Event_Task task (event_source);
task->activate();
…
```

Observer pattern in C++/ACE

(uses the GoF Bridge pattern with reference counting to simplify memory management & ensure exception-safe semantics)

Common Characteristics of Patterns

- They describe both a *thing &* a *process*
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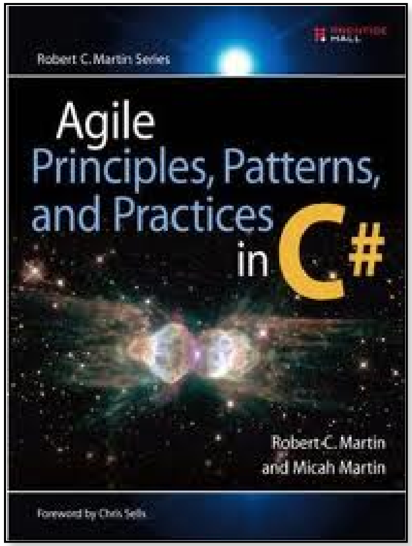
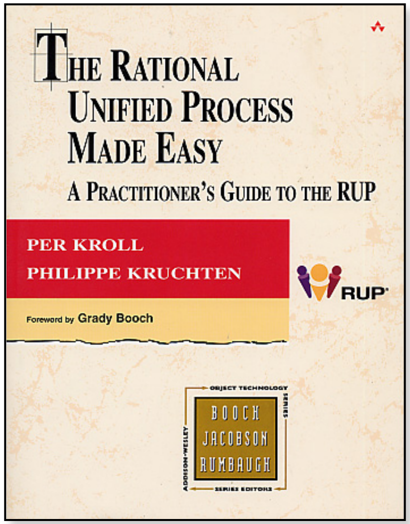
- They define "micro-architectures"
- They aren't code or (concrete) designs, so they must be reified and applied in particular languages
- They are not methods but can be used as an adjunct to methods, e.g.:
  - Rational Unified Process
  - Agile
  - Others





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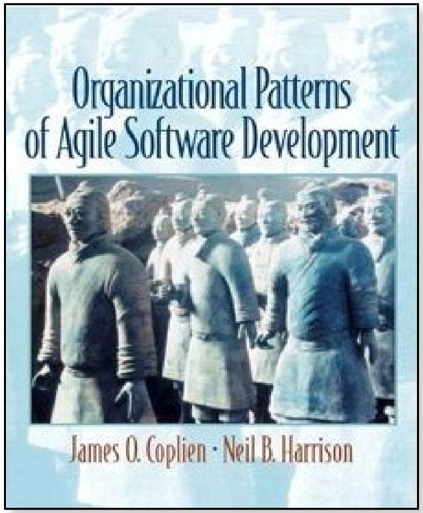
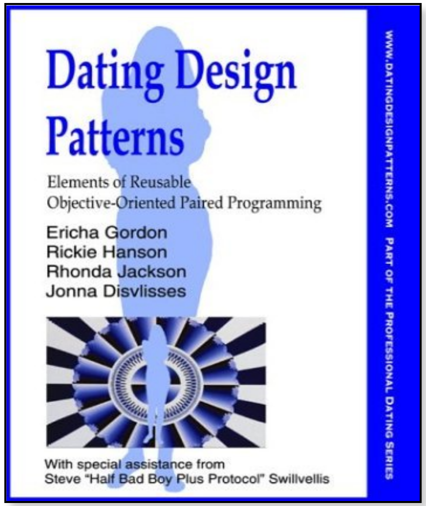
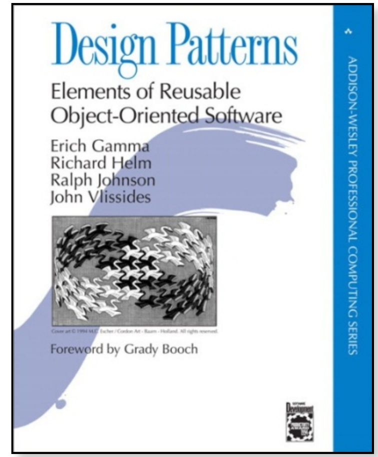
- They define "micro-architectures"
- They aren't code or (concrete) designs, so they must be reified and applied in particular languages
- They are not methods but can be used as an adjunct to methods
- There are also patterns for organizing effective software development teams and navigating other complex settings

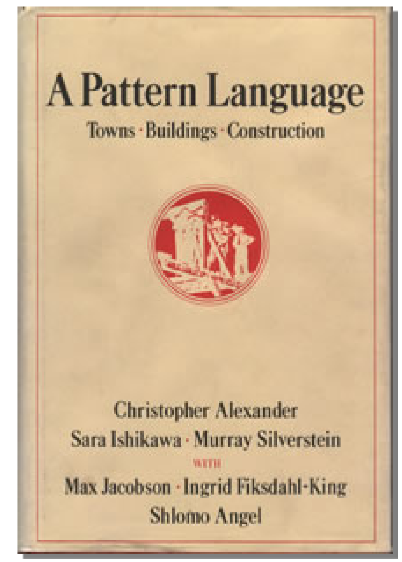


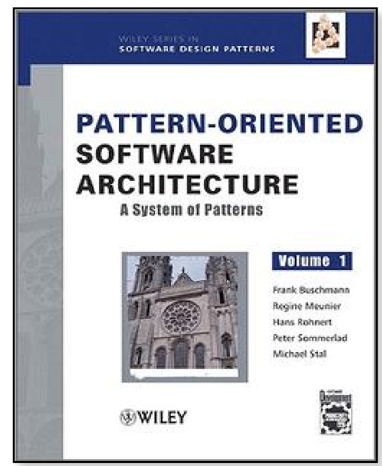


Common Parts of a Pattern Description

- **Name**
  - Should be pithy & memorable
- **Intent**
  - Goal behind the pattern & the reason(s) for using it
- **Problem** addressed by pattern
  - Motivate the "forces" & situations in which pattern is applicable
- **Solution**
  - Visual & textual descriptions of pattern static structure, participants, and collaboration dynamics

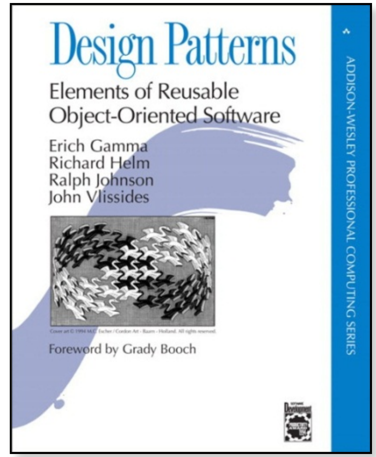


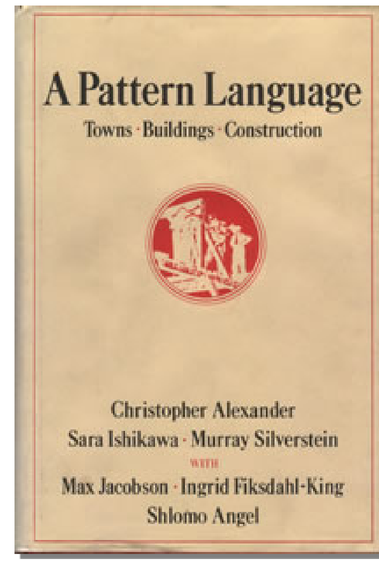


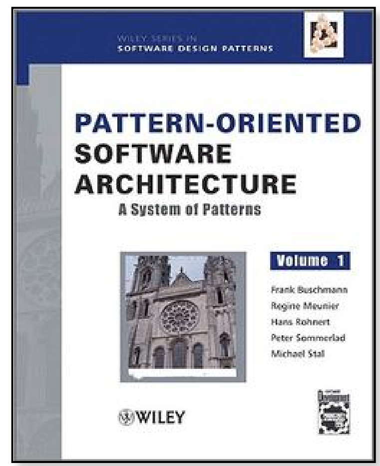


Common Parts of a Pattern Description

- **Examples & Implementation guidance**
  - May include source code snippets in one or more programming languages
- **Consequences**
  - Pros & cons of applying the pattern
- **Known uses**
  - Examples of real uses of the pattern
  - Should follow the "rule of three"
- **Related patterns**
  - Summarize relationships & tradeoffs between alternative patterns for similar problems



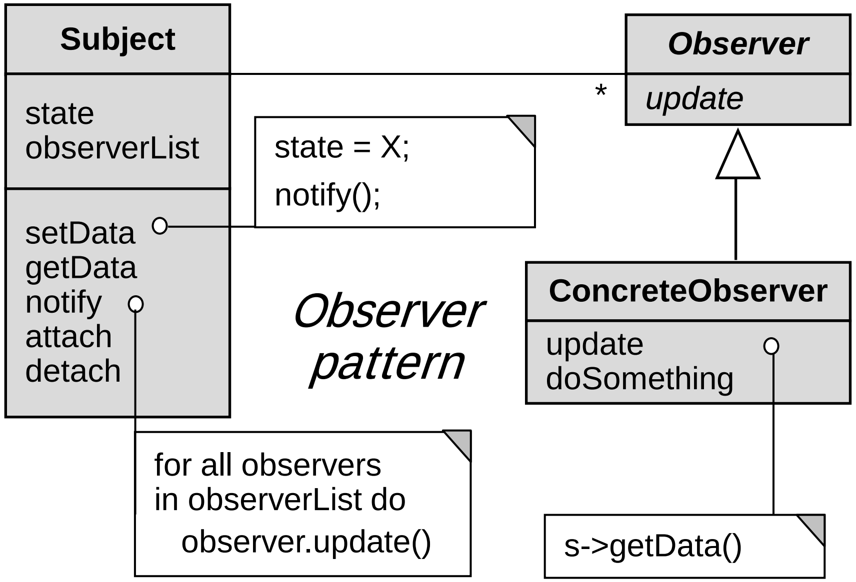




See c2.com/cgi/wiki?PatternForms for more info on pattern forms

Summary

- Patterns codify software expertise & support design at a more abstract level than code
  - Emphasize design *qua* design, not (obscure) language features
    - e.g., the *Observer* pattern can be implemented in many programming languages

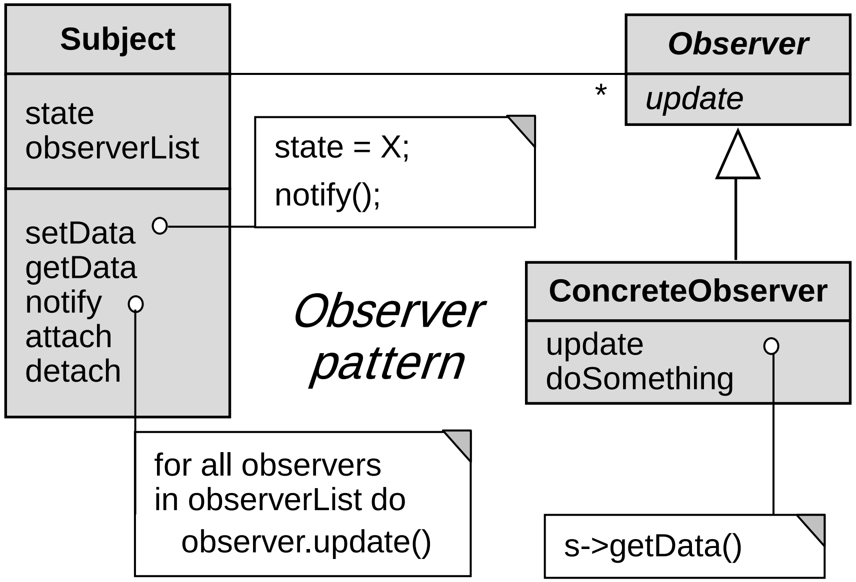


Observer pattern

Patterns often equated with OO languages, but can apply to non-OO languages

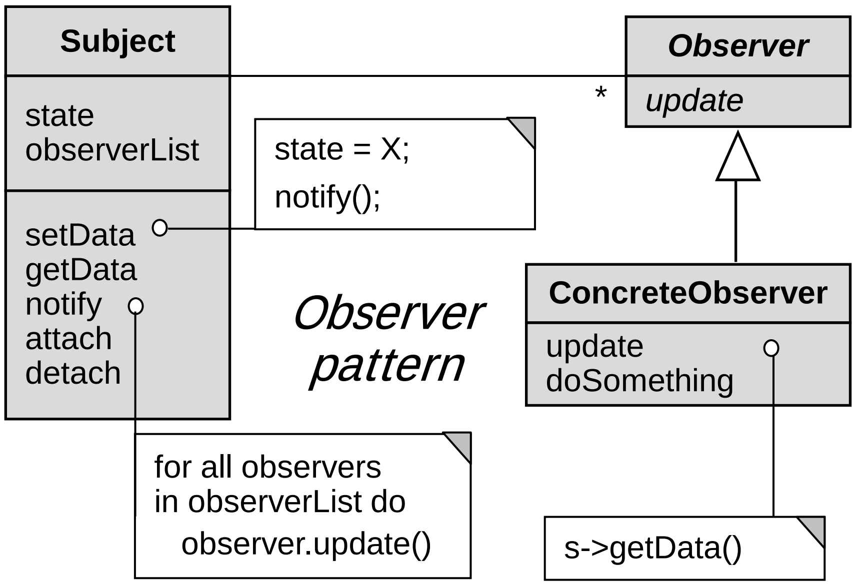
Summary

- Patterns codify software expertise & support design at a more abstract level than code
  - Emphasize design *qua* design, not (obscure) language features
  - Treat class/object interactions as a cohesive conceptual unit
    - e.g., form the building blocks for more powerful pattern relationships



Summary

- Patterns codify software expertise & support design at a more abstract level than code
  - Emphasize design *qua* design, not (obscure) language features
  - Treat class/object interactions as a cohesive conceptual unit
  - Provide ideal targets for design and implementation refactoring
    - e.g., adapters & (wrapper) facades



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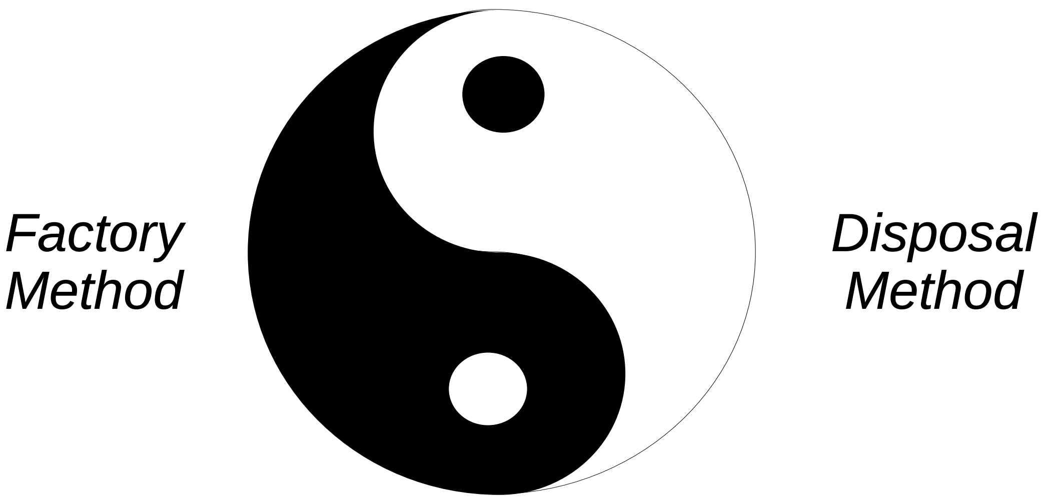
  - Pattern complements



Summary

- Stand-alone "pattern islands" are unusual in practice
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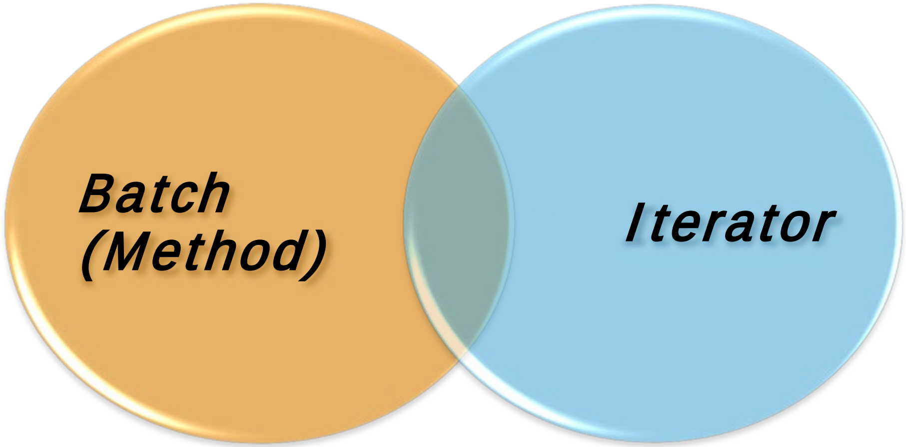
  - Pattern complements
  - Pattern compounds



Summary

- Stand-alone "pattern islands" are unusual in practice
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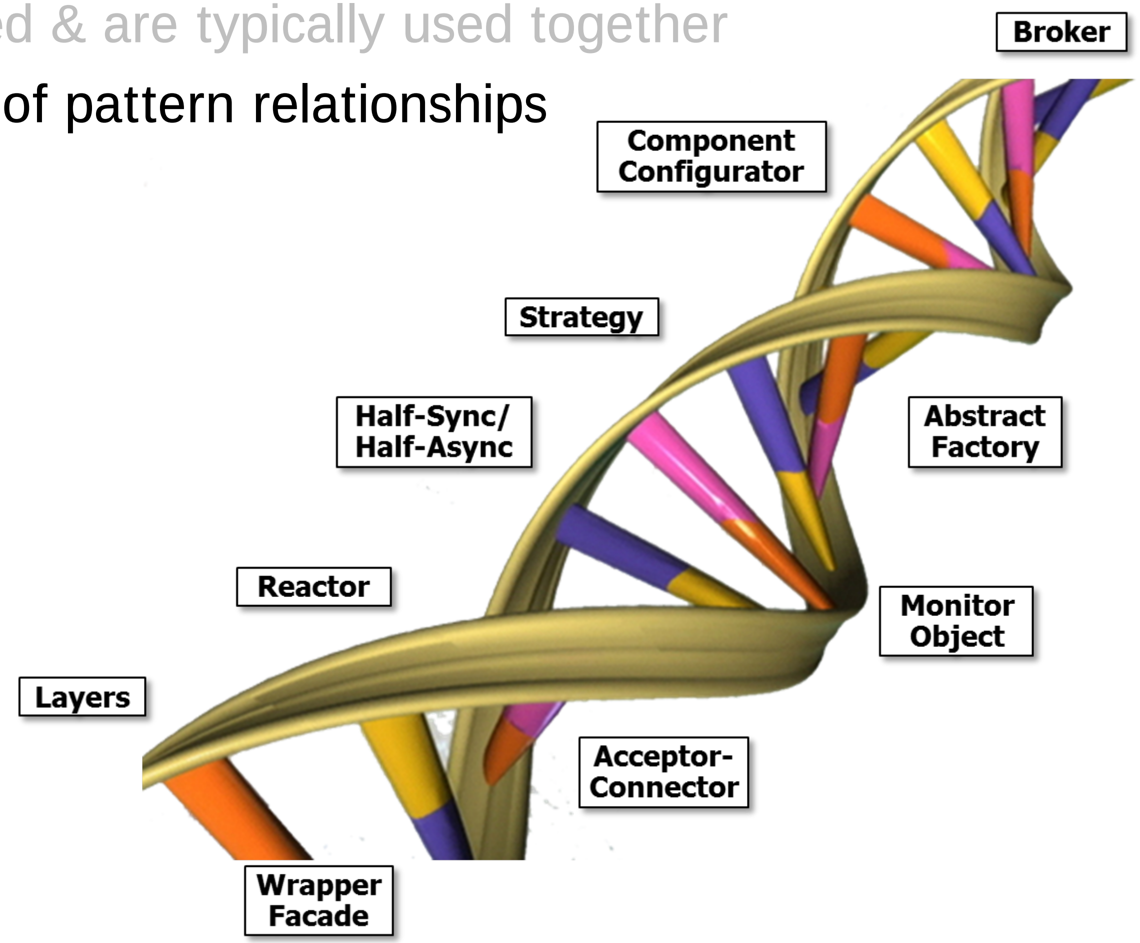
  - Pattern sequences



Summary

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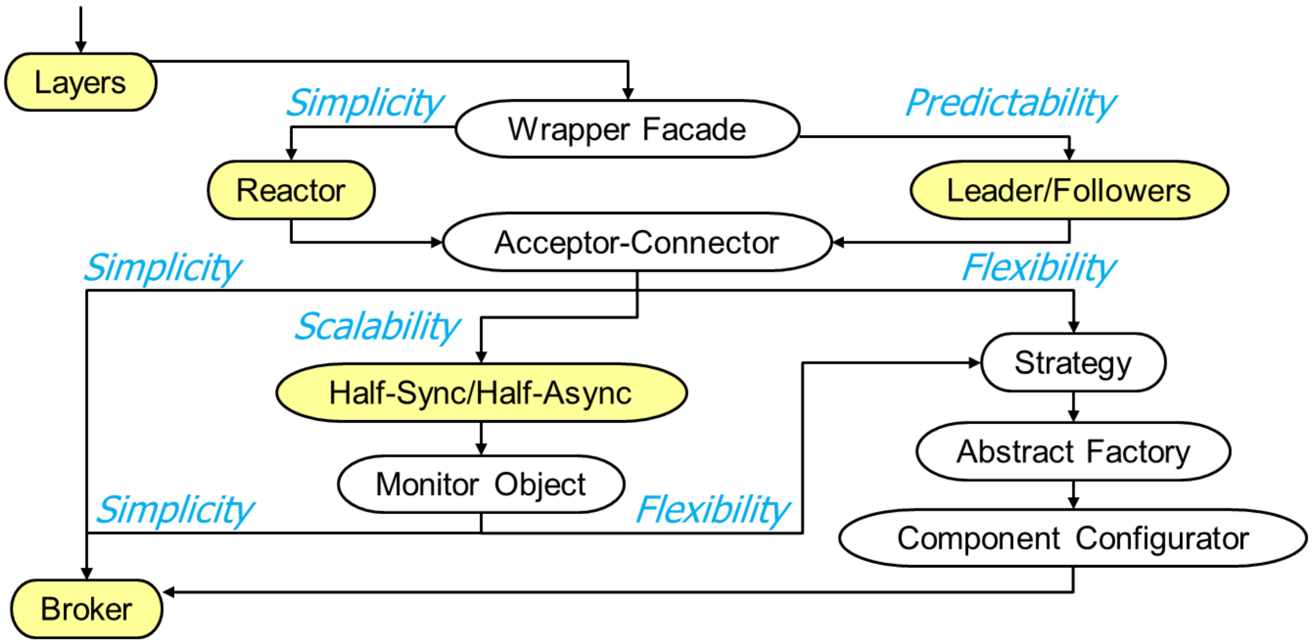
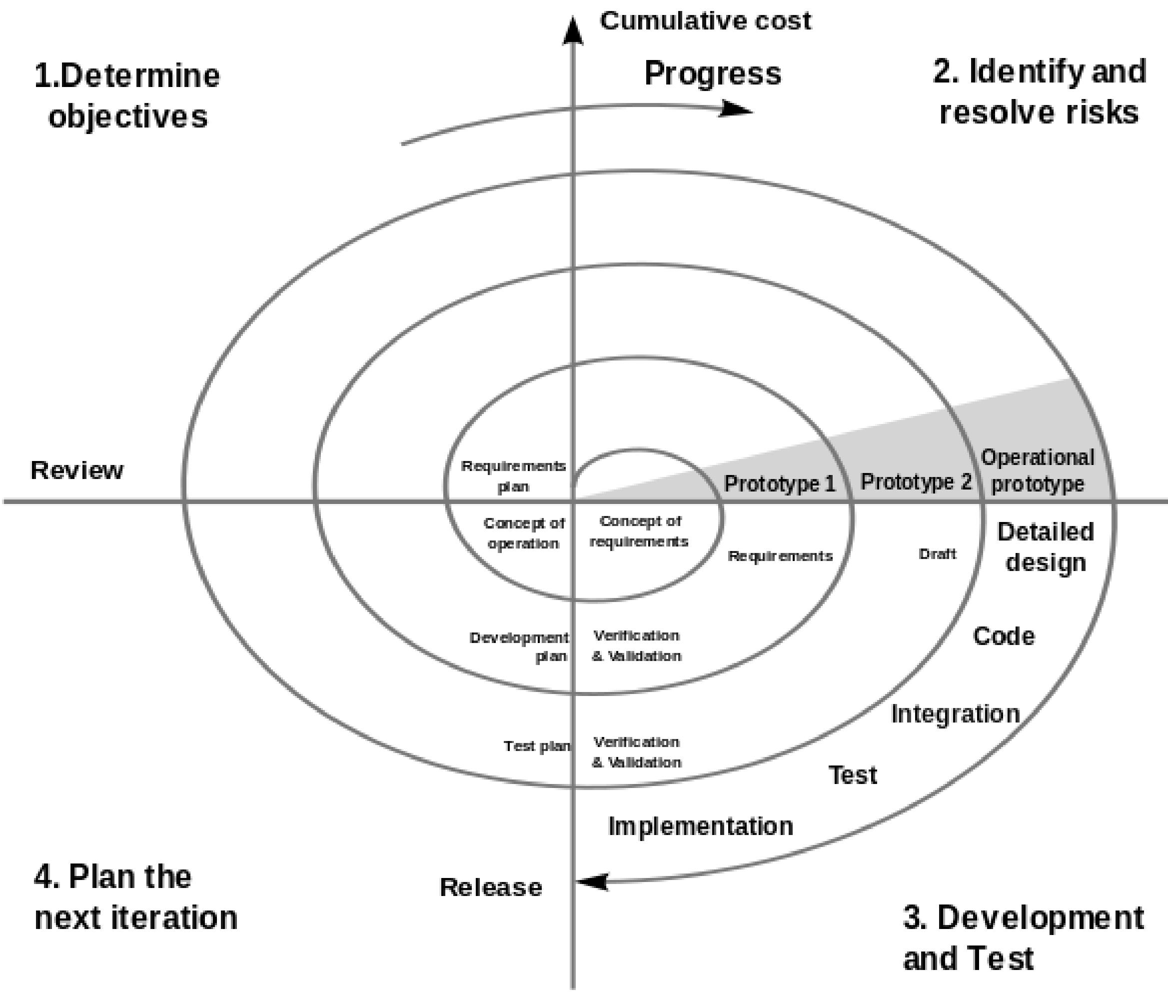


en.wikipedia.org/wiki/Pattern_language has discussions of pattern languages

Summary

- Patterns can be applied in all software lifecycle phases
  - Analysis, design, & reviews
  - Implementation & optimization
  - Testing & documentation
  - Reuse & refactoring



Overview of Patterns: Part 3

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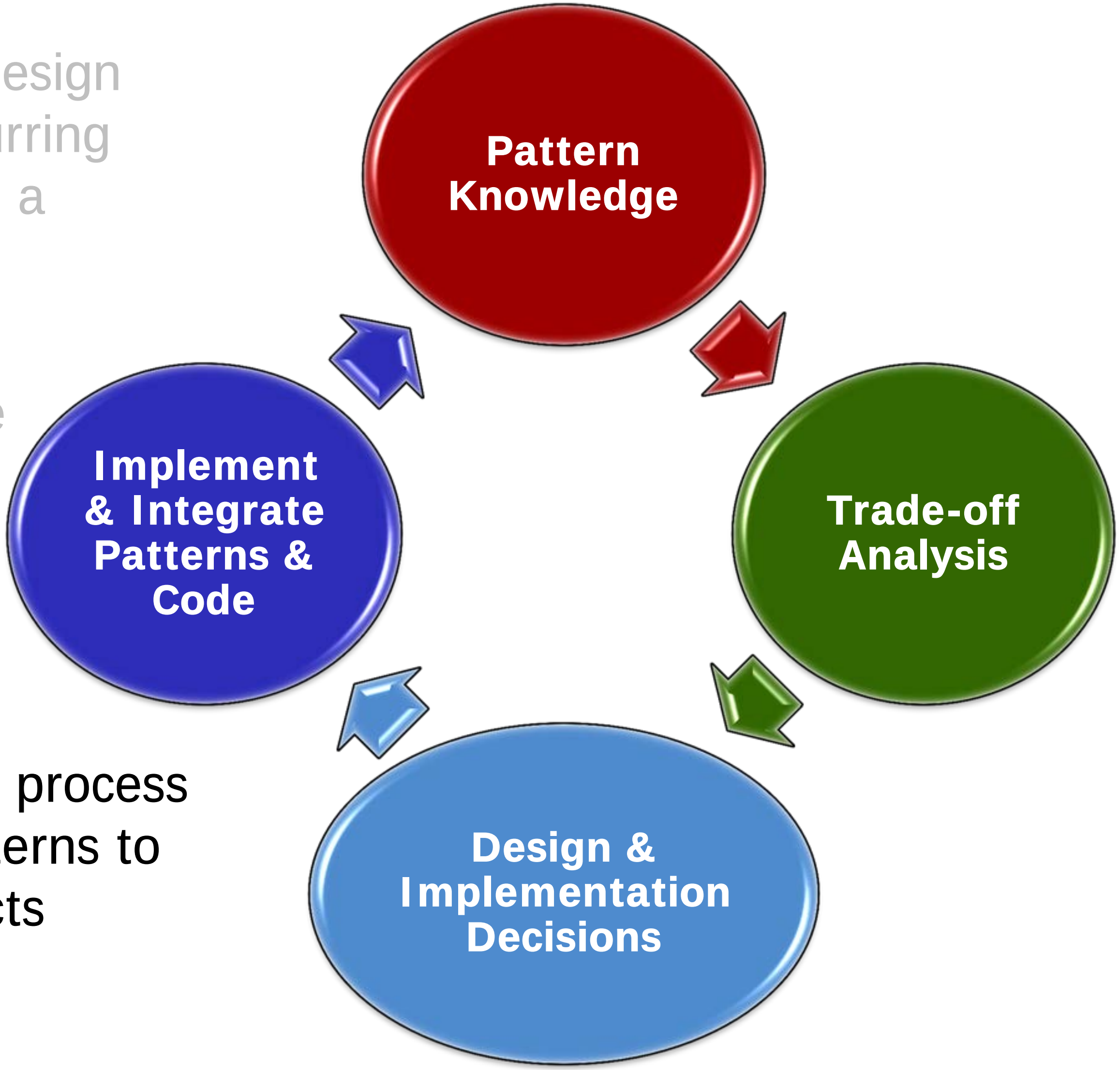
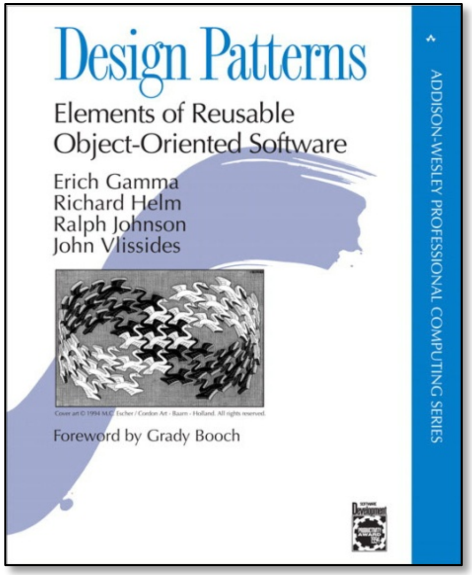
Topics Covered in this Part of the Module

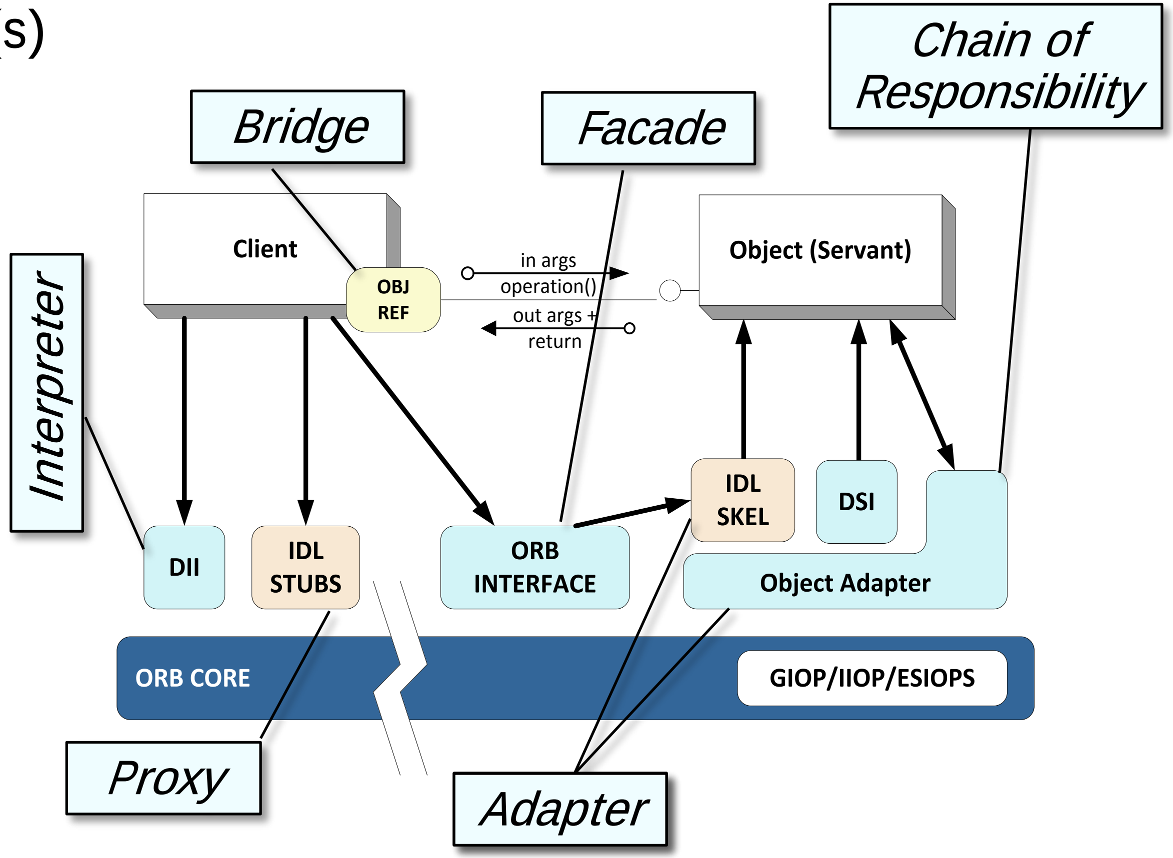
- Motivate the importance of design experience & leveraging recurring design structure in becoming a master software developer
- Introduce patterns as a means of improving software quality & developer productivity
- Summarize common characteristics of patterns
- Describe a variation-oriented process for successfully applying patterns to software development projects



Variation-oriented Process for Applying Patterns

- To apply patterns successfully, software developers need to:
  - Have broad knowledge of patterns relevant to their domain(s)





See www.dre.vanderbilt.edu/~schmidt/PDF/ORB-patterns.pdf for more info

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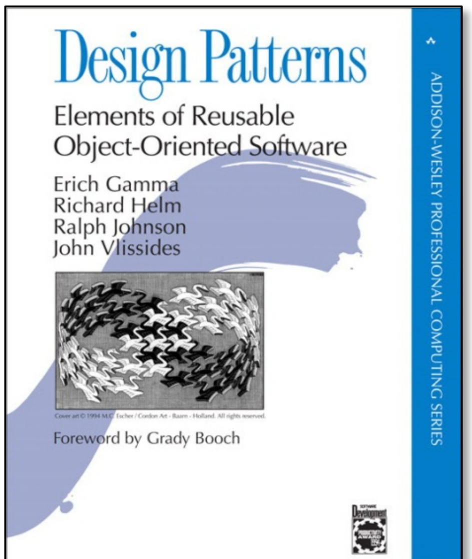

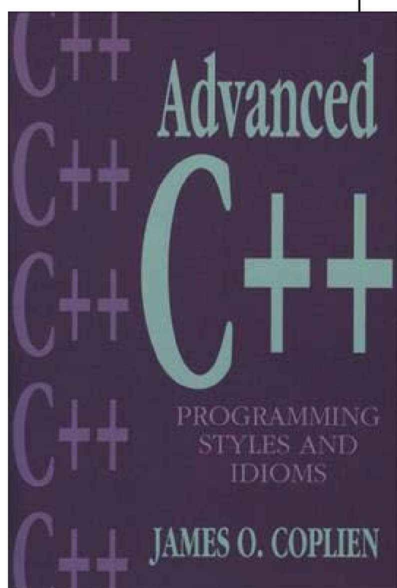

Design Patterns: Abstraction and Reuse of Object-Oriented Design

Erich Gamma[1*], Richard Helm[2], Ralph Johnson[3], John Vlissides[2]

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Abstract. We propose **design patterns** as a new mechanism for expressing object-oriented design experience. Design patterns identify, name, and abstract common themes in object-oriented design. They capture the intent behind a design by identifying objects, their collaborations, and the distribution of responsibilities. Design patterns play many roles in the object-oriented development process: they provide a common vocabulary for design, they reduce system complexity by naming and defining abstractions, they constitute a base of experience for building reusable software, and they act as building blocks from which more complex designs can be built. Design patterns can be considered reusable micro-architectures that contribute to an overall system architecture. We describe how to express and organise design patterns and introduce a catalog of design patterns. We also describe our experience in applying design patterns to the design of object-oriented systems.

1 Introduction

Design methods are supposed to promote good design, to teach new design
how to design well, and to standardize the way designs are developed. Typica
a design method comprises a set of syntactic notations (usually graphical) an
set of rules that govern how and when to use each notation. It will also descr
problems that occur in a design, how to fix them, and how to evaluate a desi
Studies of expert programmers for conventional languages, however, have sho
that knowledge is not organized simply around syntax, but in larger concept
structures such as algorithms, data structures and idioms [1, 7, 9, 27], and pl
that indicate steps necessary to fulfill a particular goal [26]. It is likely that
signers do not think about the notation they are using for recording the desi
Rather, they look for patterns to match against plans, algorithms, data str
tures, and idioms they have learned in the past. Good designers, it appears,

* Work performed while at UBILAB, Union Bank of Switzerland, Zurich, Switzerla

O.M. Nierstrasz (Ed.): ECOOP '93, LNCS 707, pp. 406-431, 1993.
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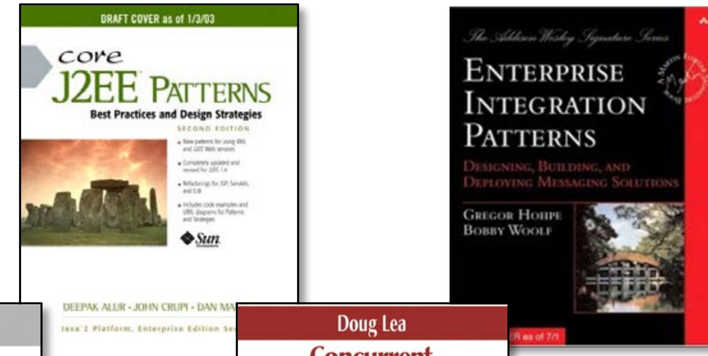
See c2.com/cgi/wiki?HistoryOfPatterns for a history of patterns

Variation-oriented Process for Applying Patterns

- To apply patterns successfully, software developers need to:
  - Have broad knowledge of patterns relevant to their domain(s)



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Mentoring from pattern experts is invaluable, especially when you first start

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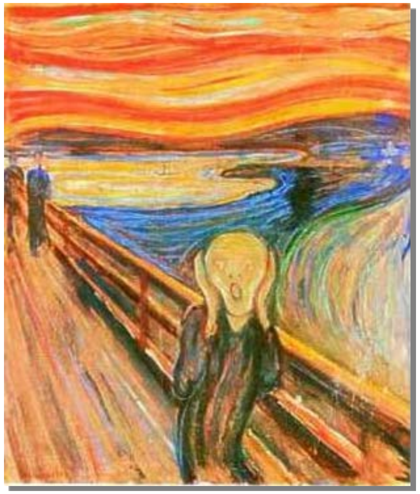
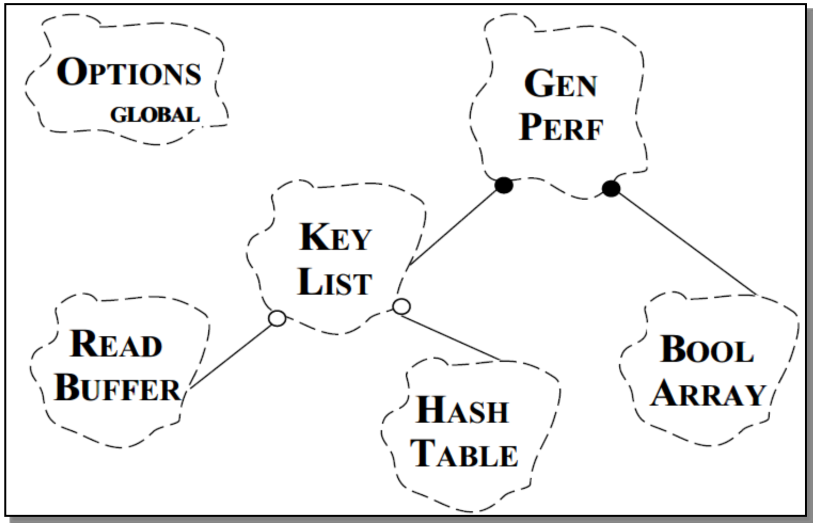


Problems

- Hard-coded algorithms
- Hard-coded data structures
- Hard-coded generators
- etc.



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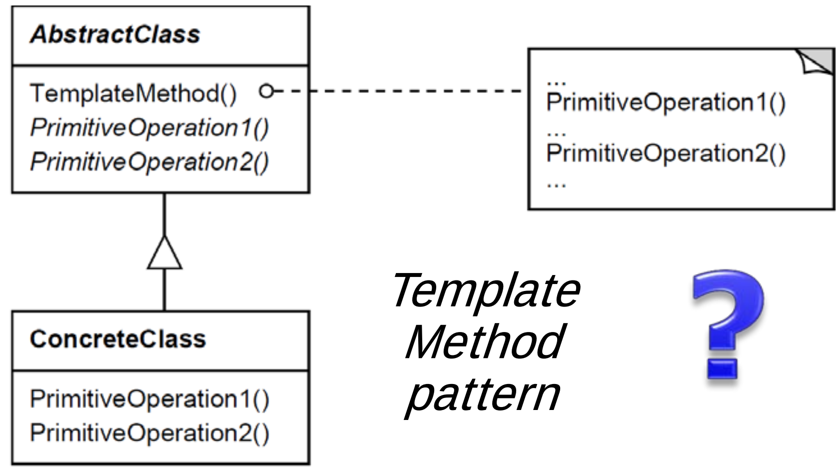
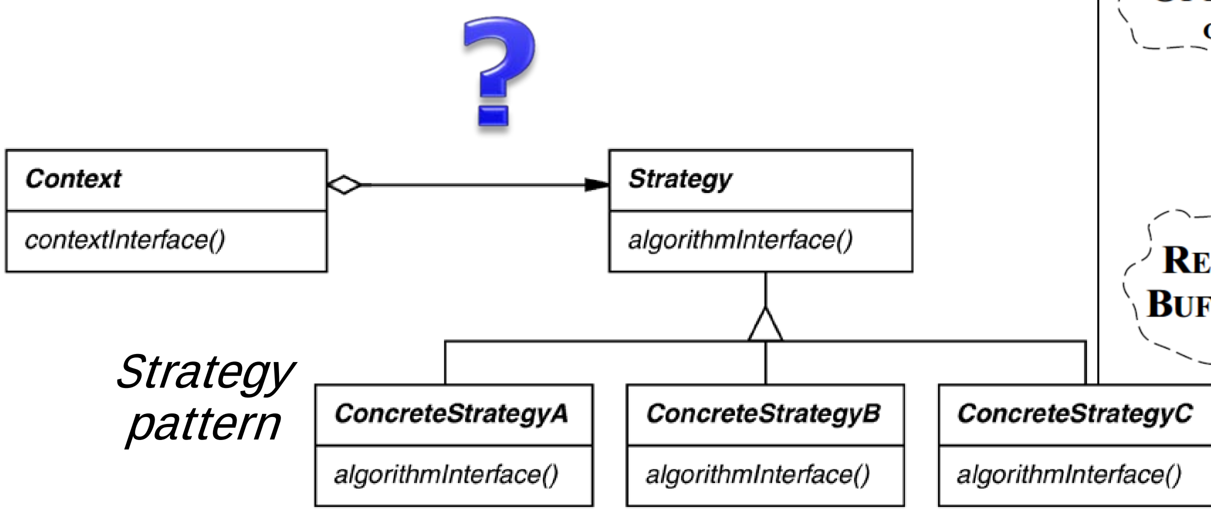
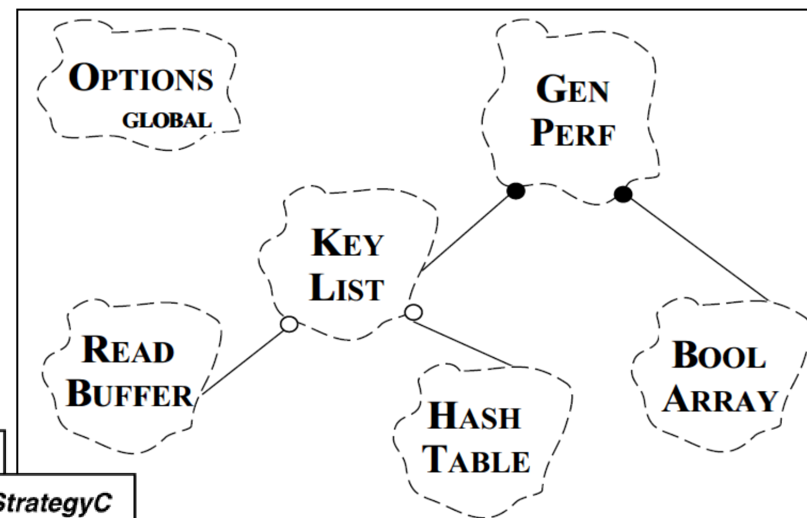


Template Method pattern



Strategy pattern



Pattern languages help developers navigate thru trade-offs

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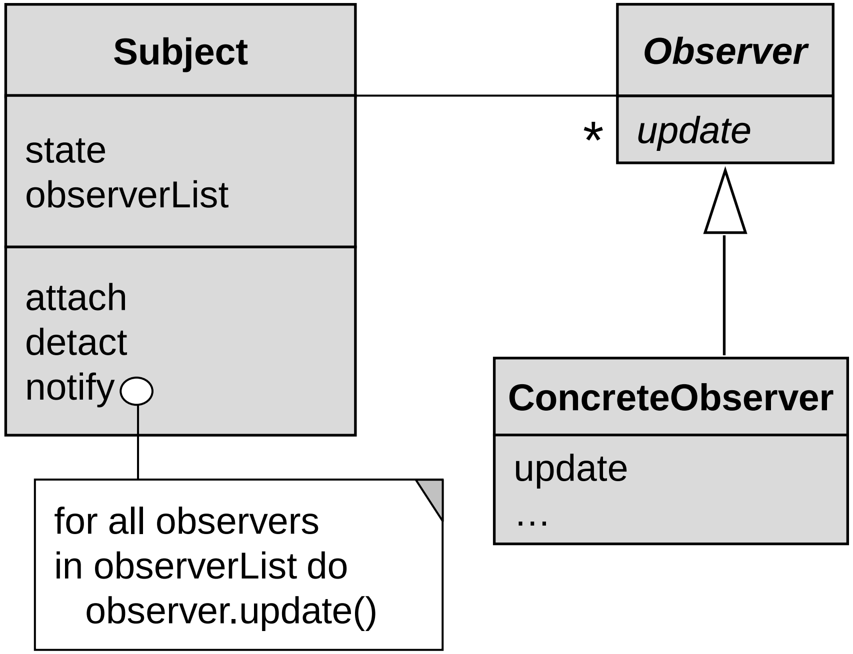

The Observer Pattern

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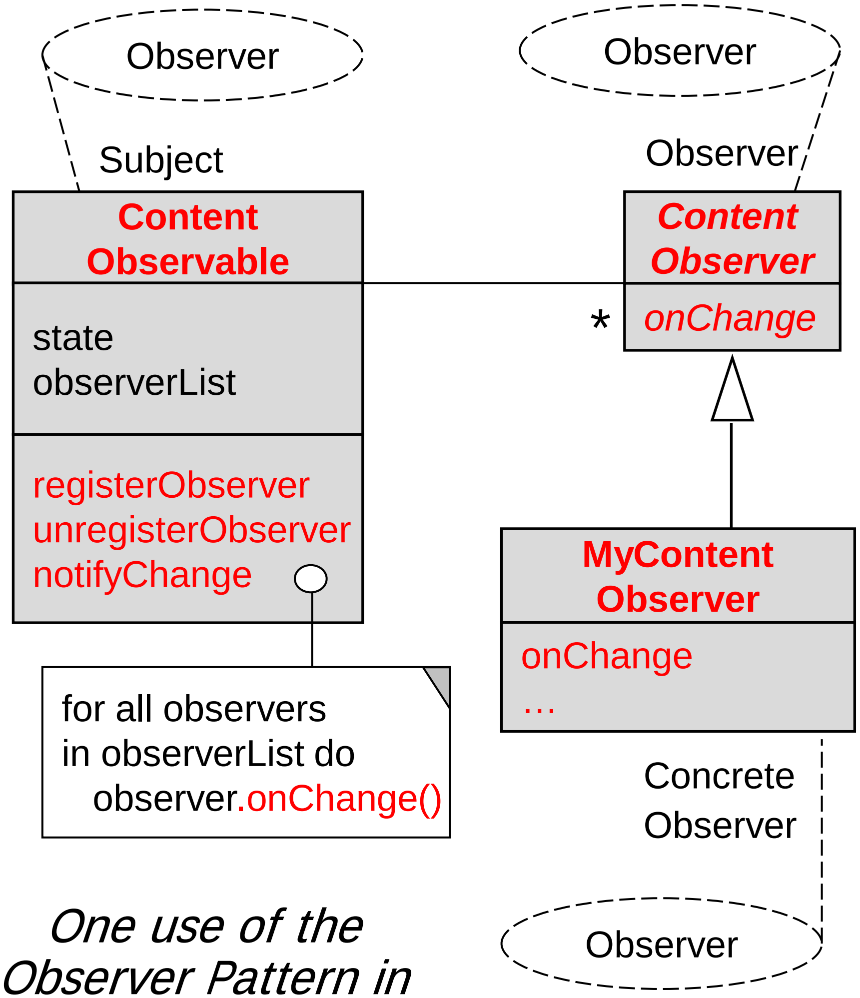

One use of the Observer Pattern in Android

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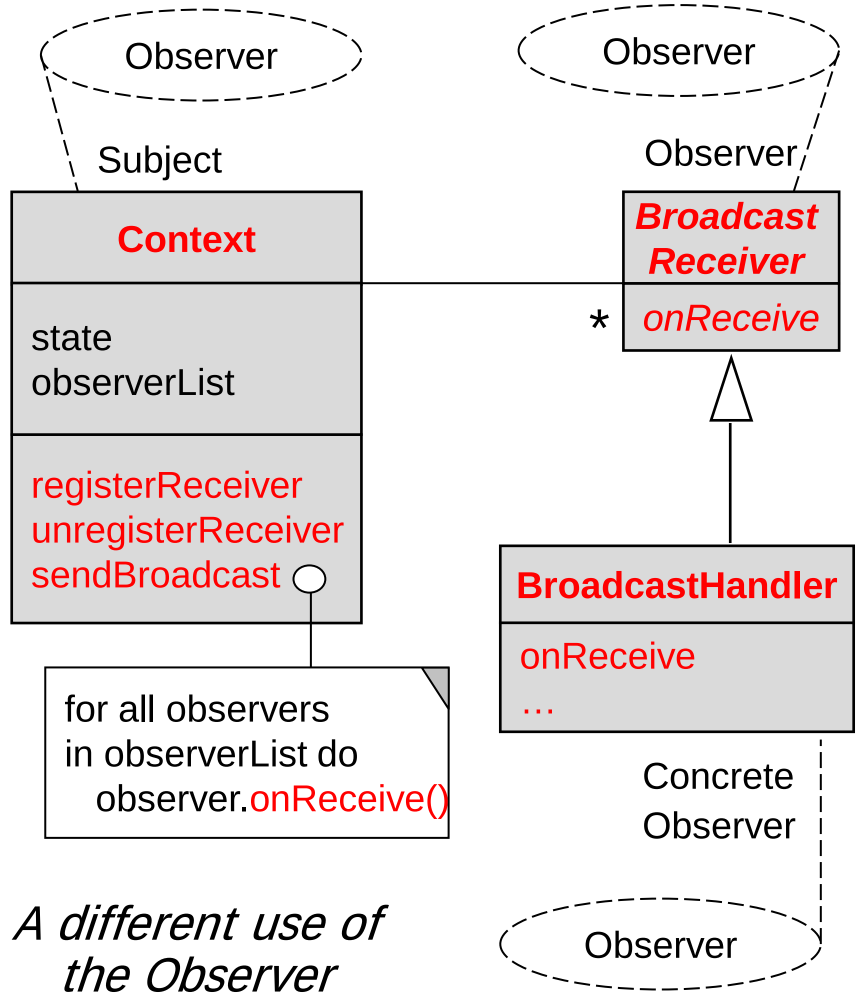

A different use of the Observer Pattern in Android

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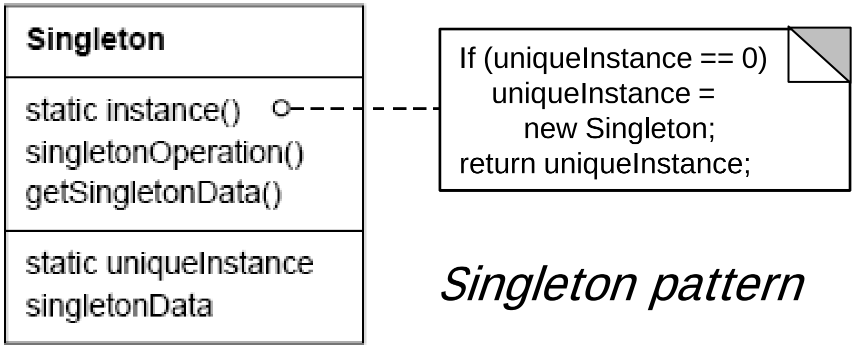

Singleton pattern

John Vlissides, "To Kill a Singleton"
sourcemaking.com/design_patterns/to_kill_a_singleton

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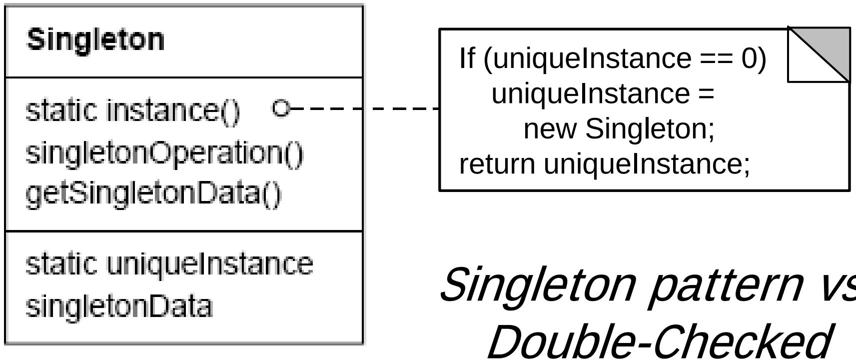

Singleton pattern vs. Double-Checked Locking Pattern

```
class Singleton {
  private static Singleton inst = null;
  public static Singleton instance() {
    Singleton result = inst;
    if (result == null) {
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    }
    return result;
  }
  ...
```

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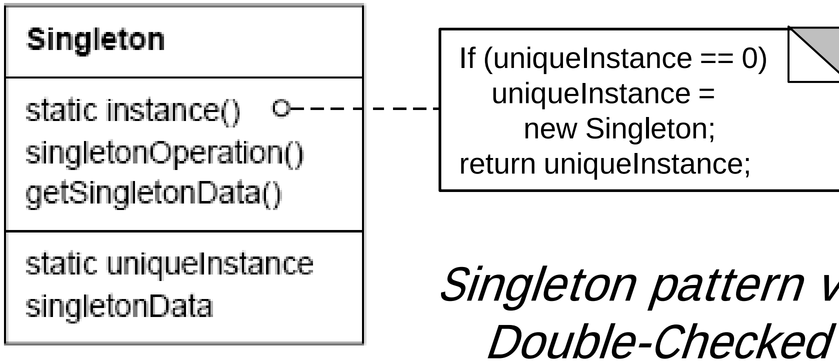

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Too little synchronization

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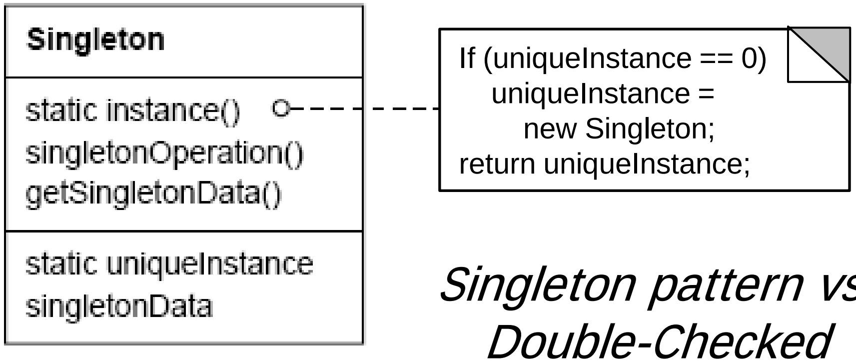

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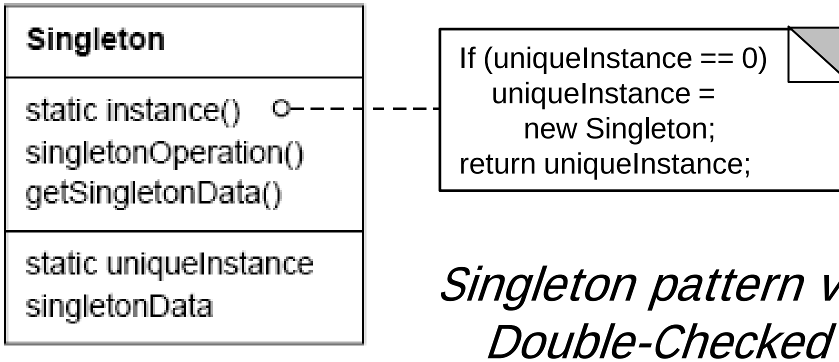

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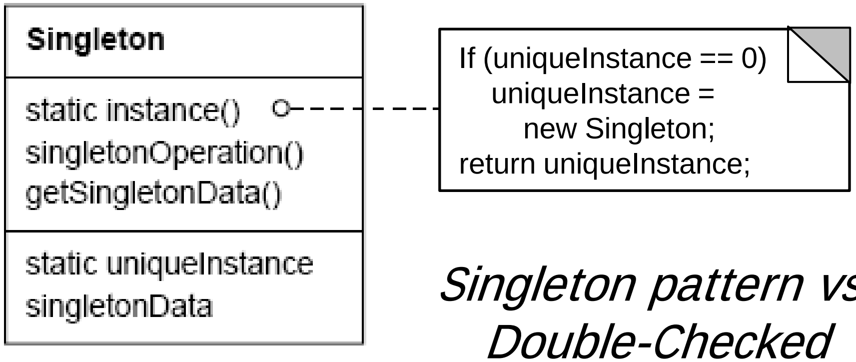

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      synchronized(Singleton.class) {
        result = inst;
        if (result == null)
        { inst = result = new Singleton(); }
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    return result;
  ...
```

Just right amount of synchronization

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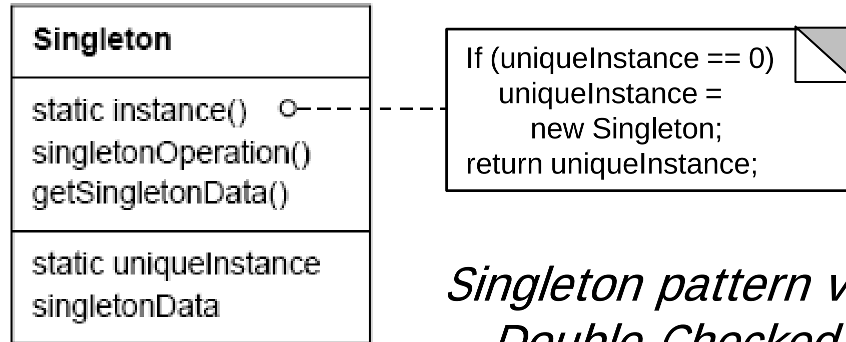

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  ...
```

Only synchronizes when inst is null

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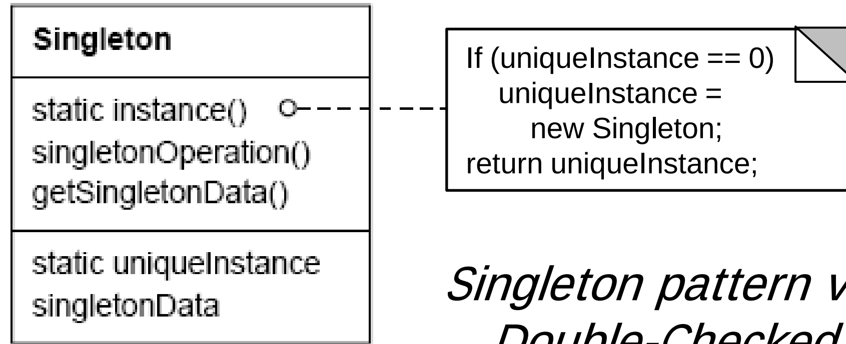

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```

No synchronization after inst is created

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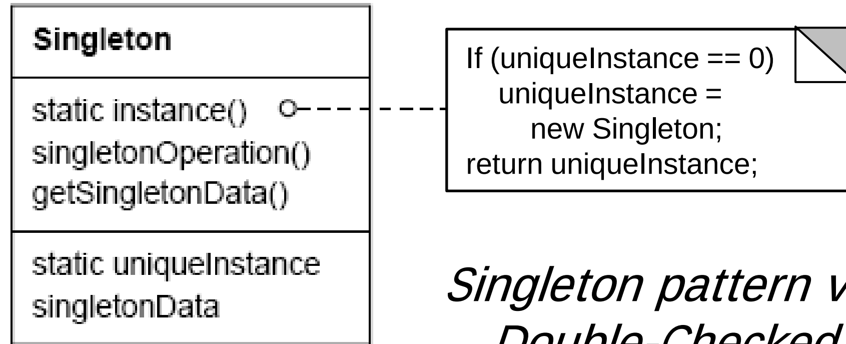

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Solution only works in JDK5 & above

See en.wikipedia.org/wiki/Double-checked_locking for more info

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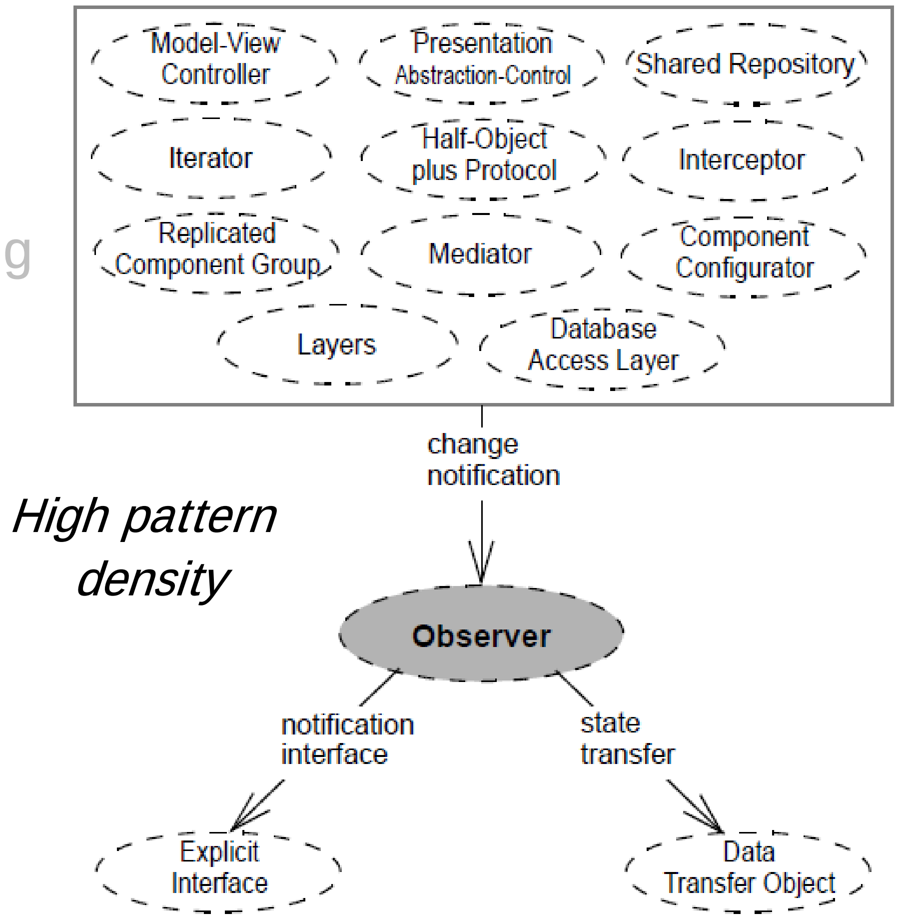
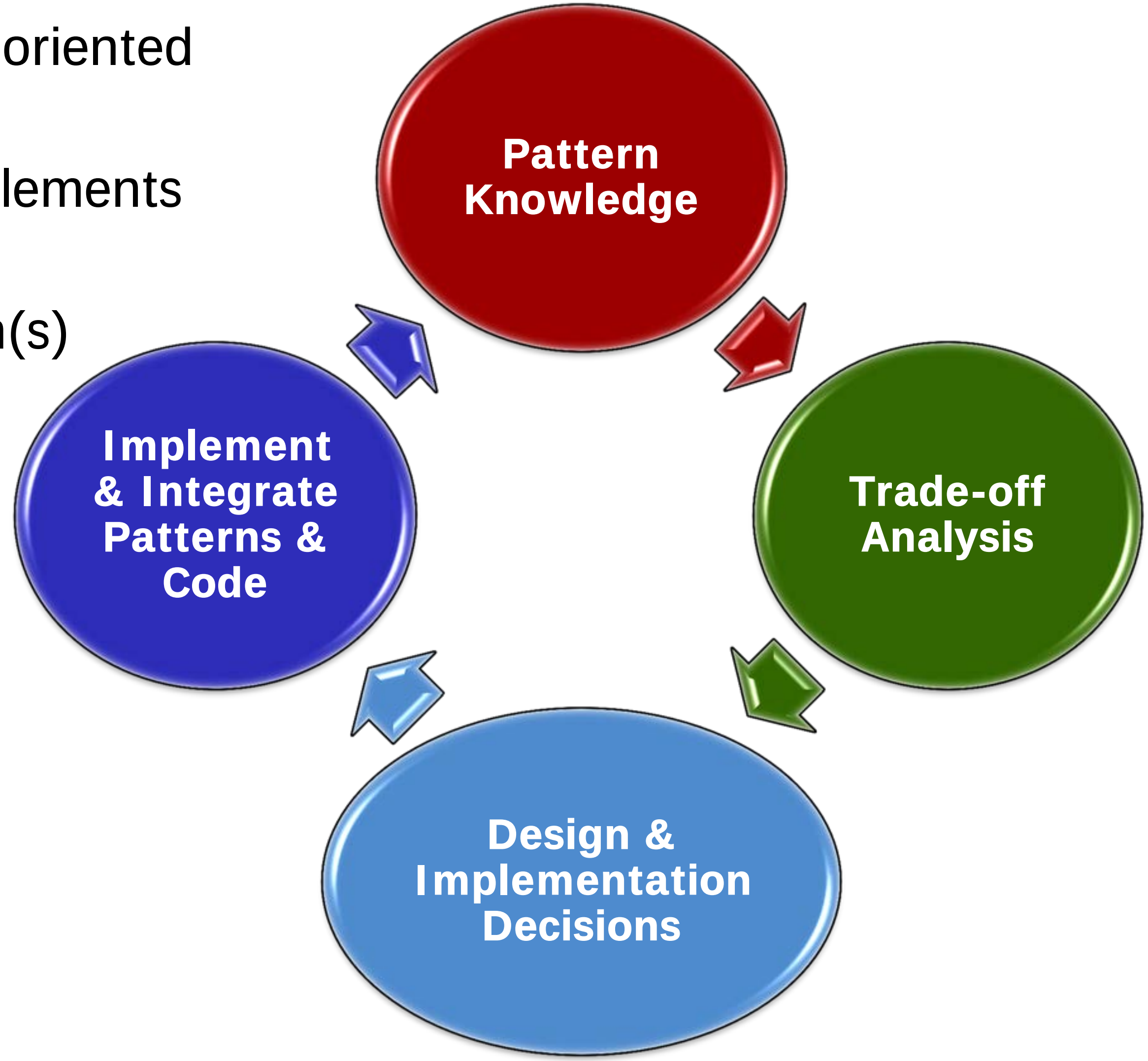


Summary

- Patterns support a variation-oriented design process
  1. Determine which design elements can vary
  2. Identify applicable pattern(s)
  3. Vary patterns & evaluate trade-offs
  4. Repeat…



Summary

- Seek generality, but don't brand everything as a pattern

Summary

- Seek generality, but don't brand everything as a pattern
- Articulate specific benefits and demonstrate general applicability
  - e.g., find three different existing examples from code other than yours!