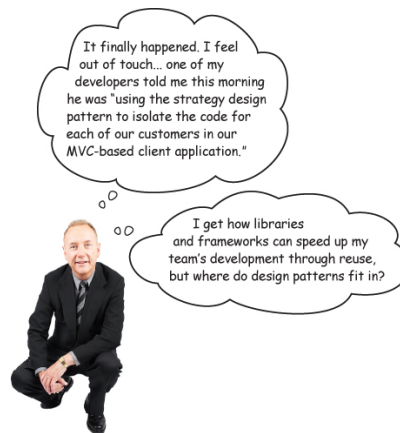




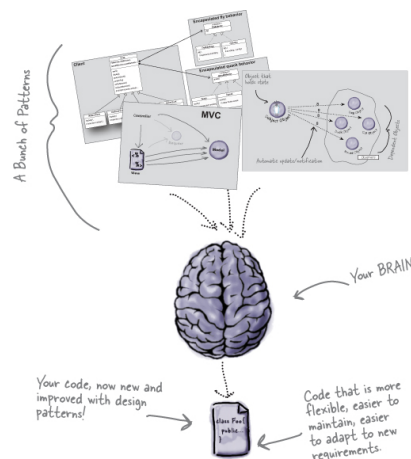
An Engineering Manager's Guide to Design Patterns



Design Patterns aren't libraries or frameworks.

We've all used off-the-shelf libraries and frameworks. We take them, write some code using their APIs, compile them into our programs, and benefit from a lot of code someone else has written. Think about the Java APIs and all the functionality they give you: network, GUI, IO, etc. Libraries and frameworks go a long way towards a development model where we can just pick and choose components and plug them right in. **But they don't help us structure our own applications in ways that are easier to understand, more maintainable and flexible.** That's where Design Patterns fit in.

You see, design patterns don't go directly into your code, they first go into your BRAIN. Once you've loaded your brain with a good working knowledge of patterns, you can then start to apply them to your new designs, and rework your old code when you fear it's degrading into an inflexible mess of spaghetti code.



OKAY, BUT WHAT ARE DESIGN PATTERNS, REALLY?

Design Patterns are all about reusing *experience*. Chances are, someone out there has had a problem similar to the one you're having, solved the problem, and captured the solution in a design pattern. **A design pattern you can use.**

But a design pattern isn't an algorithm, and it's definitely not code. Instead, a design pattern is an approach to thinking about software design that incorporates the experience of developers who've had similar problems, as well as fundamental design principles that guide how we structure software designs.



A design pattern is usually expressed by a definition and a class diagram. In patterns catalogs you'll also find example scenarios when a pattern might be applicable, the consequences of using a pattern, and even some sample code. But, as you'll see, patterns are pretty abstract, it's up to you to determine if the pattern is right for your situation and your specific problem, and once you've figured that out, how best to implement it.

We'll see an example pattern in just a bit...

there are no Dumb Questions

Q: If design patterns are so great, why can't someone build a library of them so I don't have to?

A: Design patterns are higher level than libraries. Design patterns tell us how to structure classes and objects to solve certain problems and it is our job to adapt those designs to fit our particular application.

Q: Aren't libraries and frameworks also design patterns?

A: Frameworks and libraries are not design patterns; they provide specific implementations that we link into our code. Sometimes, however, libraries and frameworks make use of design patterns in their implementations. That's great, because once you understand design patterns, you'll more quickly understand APIs that are structured around design patterns.

Q: So, there are no libraries of design patterns?

A: No, but there are patterns catalogs with lists of patterns that you can apply to your applications. You'll also find you can quickly get on top of the most common design patterns so that you can easily build them into your own designs, understand how they are used in libraries & frameworks, and turbo-charge communication with your team.



That's a common misconception...

...but good object-oriented design is more subtle than that. Just because you're using object-oriented concepts doesn't mean you're building flexible, reusable, and maintainable systems. Sometimes these concepts can even get in your way. Surprised? Many are.

By following well-thought-out and time-tested patterns, and by understanding the design principles that underlie those patterns, you'll be able to create flexible designs that are maintainable and can cope with change.



Friendly Patterns Guru

Developer: I already know about abstraction, inheritance, and polymorphism; do I really need to think about Design Patterns? Isn't it pretty straightforward? Isn't this why I took all those object-oriented programming courses? I think Design Patterns are useful for people who don't know good OO design.

Guru: Ah, this is one of the true misunderstandings of object-oriented development: that by knowing the OO basics we are automatically going to be good at building flexible, reusable, and maintainable systems.

Developer: No?

Guru: No. As it turns out, constructing OO systems that have these properties is not always obvious and has been discovered only through hard work.

Developer: So, in other words, there are time-tested, non-obvious ways of constructing object-oriented systems have been collected...

Guru: ...yes, into a set of patterns called Design Patterns.

Developer: So, by knowing patterns, I can skip the hard work and jump straight to designs that always work?

Guru: Yes, to an extent, but remember, design is an art. There will always be tradeoffs. But, if you follow well thought-out and time-tested design patterns, you'll be way ahead.



Developer: What do I do if I can't find a pattern?

Guru: There are some object-oriented principles that underlie the patterns, and knowing these will help you to cope when you can't find a pattern that matches your problem.

Developer: Principles? You mean beyond abstraction, encapsulation, and...

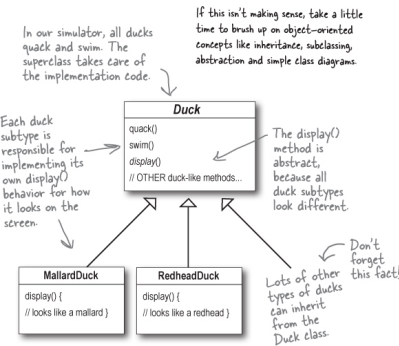
Guru: Right, there are principles beyond these that will help you design systems with flexibility, maintainability, and other good qualities.

HOW ABOUT AN EXAMPLE DESIGN PATTERN?



Enough talk about what a pattern is and isn't; let's see how one is used in practice on a super-serious business application. Say you're part of the team that built a company's award-winning Duck Simulation App.

Here's the current high-level design:



While you and your team have done stellar work, the company has been under increasing pressure from competitors. After a week long off-site brainstorming session over golf, the company executives think it's time for a big innovation. They need something *really* impressive to show at the upcoming shareholders meeting in Maui *next week*.

The executives decided that flying ducks is just what the simulator needs to blow away the other duck sim competitors. And of course your manager told them it'll be no problem for your teammate Joe to just whip something up in a week.

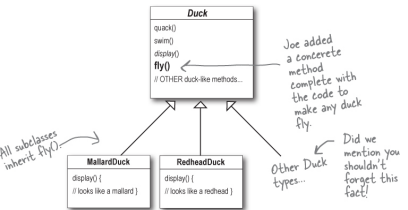
"After all," he said, "Joe's an object-oriented programmer... *how hard can it be?*"



ADDING THE FLY BEHAVIOR

Joe uses what everyone is taught when they learn object-oriented programming: if you want to add behavior to the ducks, you need only add a concrete method to the superclass, and magically all ducks will inherit that behavior and get flying superpowers.

More specifically, here's what Joe did:



So, did Joe get a nice fat pay raise by showing his object-oriented prowess?

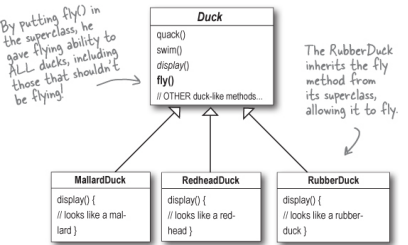


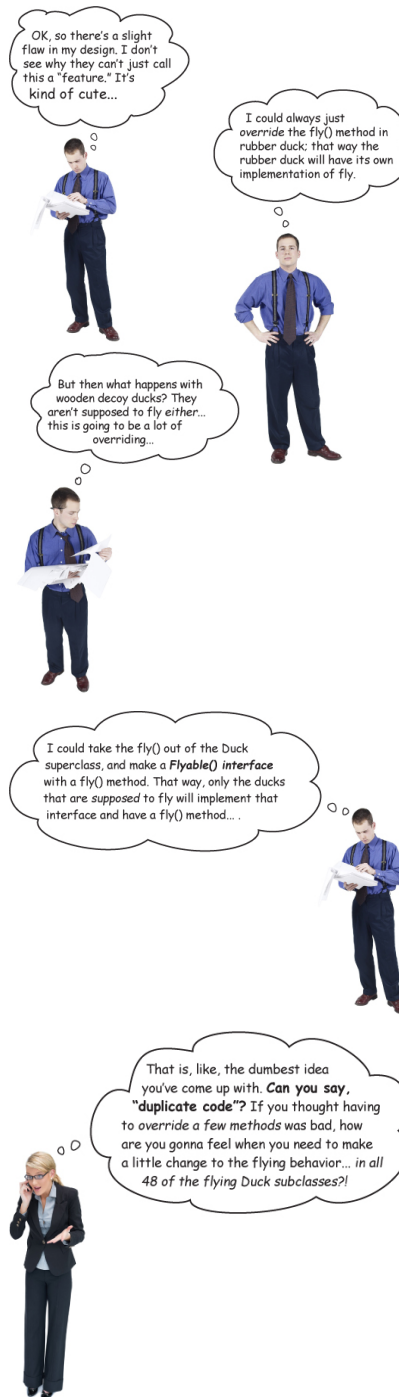
What happened?

Did we mention there were other kinds of ducks? In fact, at the shareholder's meeting they wanted to show off the entire range of possible ducks, including RubberDucks and DecoyDucks.

But Joe failed to notice that not *all* subclasses of Duck should *fly*. When Joe added new behavior to the Duck superclass, he was also adding behavior that was *not* appropriate for some Duck subclasses. He now has flying inanimate objects in the SimUDuck program.

This is an example of a localized update to the code caused a non-local side effect (flying rubber ducks)!



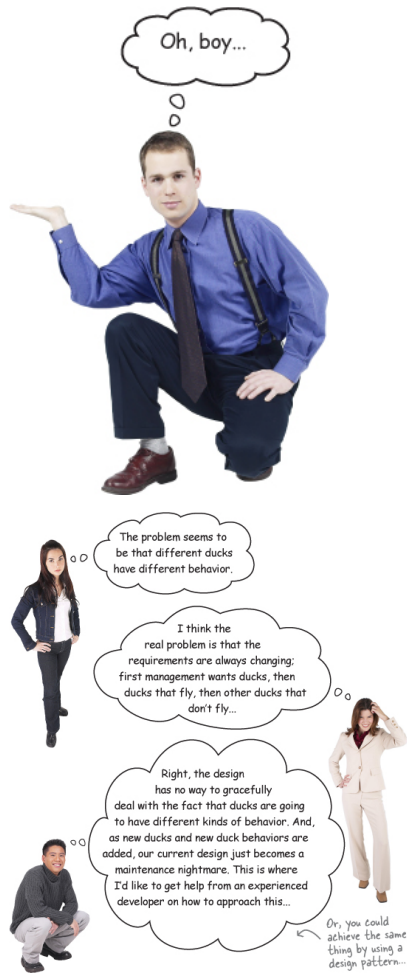


WHAT WOULD YOU DO IF YOU WERE JOE?

He's thought through a couple solutions: one that overrides the duck's inherited behavior, and the other which makes each duck implement its own specific flying behavior. Both solutions are problematic and destroy maintainability and reuse in different ways.

So what can Joe do? How about a few opinions?





BRAIN POWER



You've seen the problem: you need a flexible way to assign duck flying behavior to a duck, depending on the type of the duck—some ducks fly, others don't, and in the future maybe some game-based space ducks will fly with rocket power.

So, can you think of a design that allows this flexibility without introducing duplicate code or maintenance nightmares?




...and it's not appropriate for *all* subclasses to have those behaviors. The Flyable interface sounded promising at first—only ducks that really do fly will be Flyable—except interfaces have no implementation code, so no code reuse. And that means that whenever you need to modify a behavior, you're forced to track down and change the code in all the different subclasses where that behavior is defined, probably introducing *new* bugs along the way!

So, we need another design, but before we get to that, one thing you should know about design patterns is they are often rooted in *design principles*. Think of design principles (not to be confused with design patterns), as guiding principles that you apply to all object-oriented design. Knowing these principles not only helps you understand design patterns, it also improves every aspect of your object-oriented work. So, let's look at one such principle to motivate the design pattern we'll use to solve Joe's problems.

A DESIGN PRINCIPLE FOR CHANGE



Let's say you've got some aspect of your code that is changing, say, every time you have a new requirement. If that happens, one thing you can do is take that code and separate it from all the stuff that doesn't change. This approach to isolating code that frequently changes is indispensable in well-designed object-oriented systems—so much so, it's a core design principle:



Design Principle

Identify the aspects of your application that vary and separate them from what stays the same.

One of many design principles, but we've got to start somewhere, and this one is fundamental.

Here's another way to think about this principle: **take the parts that vary and encapsulate them, so that later you can alter or extend the parts that vary without affecting those that don't.** As simple as this concept is, it forms the basis for almost every design pattern. Many patterns provide a way to let *some part of a system vary independently of all other parts.*

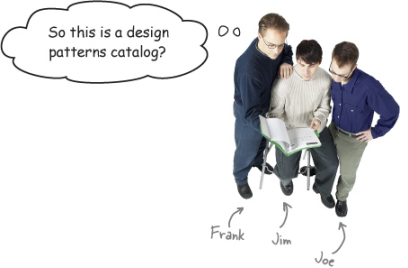
This principle gives us a clue to how we might start thinking about fixing the Duck Simulator, but how do we actually apply it? How do we translate this abstract design principle into actual object-oriented design? This is where you want to rely on that time-tested pattern that has been worked out on the backs of other developers; in other words, *we need a design pattern.*

But which one? Experience and knowledge of design patterns can help you determine that, and you can get some of that experience through patterns catalogs—that is, catalogs of patterns that include where and when a pattern is appropriate, the general problem it solves, how it's designed, code examples, and a lot more.

there are no Dumb Questions

Q: I thought we were learning design PATTERNS? Why are you teaching me design principles? I've had a class in object-oriented design already.

A: Design principles are the foundation of most patterns, so learning design principles is key to understanding how design patterns work. And, believe it or not, object-oriented classes don't always do a good job of really teaching these principles. The principle above is just one of many design principles, and it's key in many design patterns. If you want to learn more about design principles, check out the resources at the end of this report.



Frank: Fill us in, Jim. I've just been learning patterns by reading a few articles here and there.

Jim: Sure, each patterns catalog takes a set of patterns and describes each pattern in detail along with its relationship to the other patterns.

Joe: Are you saying there is more than one patterns catalog?

Jim: Of course; there are catalogs for fundamental design patterns and there are also catalogs on domain-specific patterns, like enterprise architecture patterns.

Frank: Which catalog are you looking at?

Jim: This is the classic GoF catalog; it contains 23 fundamental design patterns.

Frank: GoF?

Jim: Right, that stands for the Gang of Four. The Gang of Four are the guys that put together the first patterns catalog.

Joe: What's in the catalog?

Jim: There is a set of related patterns. For each pattern there is a description that follows a template and spells out a lot of details of the pattern. For instance, each pattern has a *name*.

Frank: Wow, that's earth-shattering—a name! Imagine that.

Jim: Hold on, Frank; actually, the name is really important. When we have a name for a pattern, it gives us a way to talk about the pattern.

Frank: Okay, okay. I was just kidding. Go on, what else is there?

Jim: Well, like I was saying, every pattern follows a template. For each pattern we have a name and a few sections that tell us more about the pattern. For instance, there is an Intent section that describes what the pattern is, kind of like a definition. Then there are Motivation and Applicability sections that describe when and where the pattern might be used.

Joe: What about the design itself?



Jim: There are several sections that describe the class design along with all the classes that make it up and what their roles are. There is also a section that describes how to implement the pattern and often sample code to show you how.

Frank: It sounds like they've thought of everything.

Jim: There's more. There are also examples of where the pattern has been used in real systems, as well as what I think is one of the most useful sections: how the pattern relates to other patterns.

Frank: Oh, you mean they tell you things like how patterns differ?

Jim: Exactly!

Joe: So Jim, how are you actually using the catalog? When you have a problem, do you go fishing in the catalog for a solution?

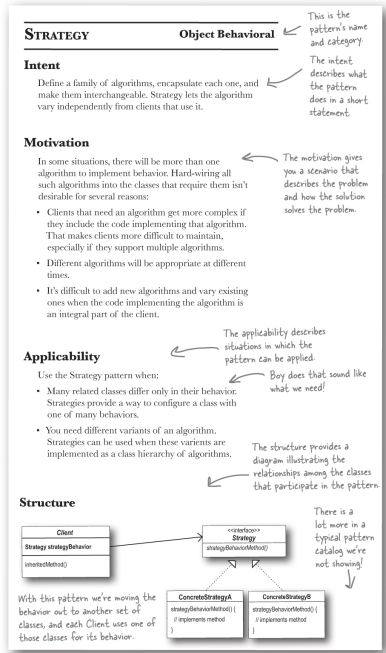
Jim: I try to get familiar with all the patterns and their relationships first. Then, when I need a pattern, I have some idea of what it is. I go back and look at the Motivation and Applicability sections to make sure I've got it right. There is also another really important section: Consequences. I review that to make sure there won't be some unintended effect on my design.

Frank: That makes sense. So once you know the pattern is right, how do you approach working it into your design and implementing it?

Jim: That's where the class diagram comes in. I first read over the Structure section to review the diagram to make sure I understand each class's role. From there, I work it into my design, making any alterations I need to make it fit. Then I review the Implementation and Sample Code sections to make sure I know about any good implementation techniques or gotchas I might encounter.

Joe: I can see how a catalog is really going to accelerate my use of patterns!

Jim: Let me show you a particular pattern you might be interested in given your, um, recent problem with the ducks—it's called the Strategy Pattern.



Frank: Can you step us through how, Joe?

Joe: Well, see here in the Motivation section, it says that the Strategy Pattern is appropriate if you've got more than one algorithm implementing behaviors for the client. In our case the client is the Duck...

Jim: ...and the algorithms are the flying behaviors?

Joe: Exactly.

Frank: And look here, it says that Strategy applicable when you have many similar classes that differ only in their behavior. Our ducks are like that, right?



Joe: Right. The pattern represents each behavior as another class, which implements that behavior.

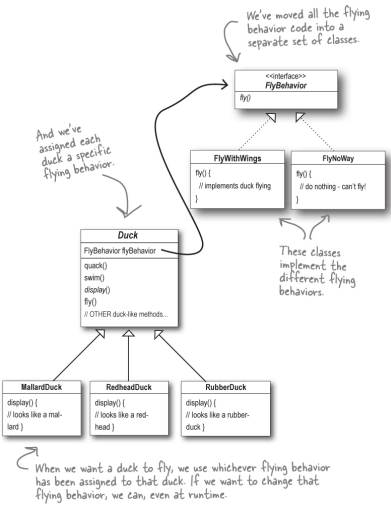
Frank: So in other words, if a duck wants to fly in the air, it uses a FlyInTheAir class instead of a CantFly class.

Jim: That's a nice design because you can have any number of fly behaviors, and each duck can use the most appropriate one. Heck I bet you could even change the behavior at runtime.


Joe: Guys, you realize what this means? By reworking my code slightly, I may just get that raise after all!

THE NEW AND IMPROVED DUCK SIMULATOR

Let's take a quick look at the Duck Simulator now that Joe's redesigned it using the Strategy Pattern. Don't worry too much about the details; just notice that the structure of the Duck Simulator now implements the Strategy Pattern. And by that we mean that all the code to implement flying behaviors now resides in another set of classes, which are used by the ducks as needed. Overall, Joe now has a design that is a lot more flexible, extensible and easier to maintain. He also won't have to go through the embarrassment of flying rubber ducks again.




Sharpen your pencil



What improved when Joe implemented the strategy pattern (check all that apply)?

- All duck behaviors are implemented in one place (no code duplication).
- Each duck can easily be assigned any of the available behaviors (mallards can use the FlyWithWings behavior and rubber ducks can use the FlyNoWay behavior).
- It's easy to add new behaviors. Simply create a new class that implements Flyable (like a FlyWithRockets behavior).
- Joe's paycheck.

Answer: All of the above.



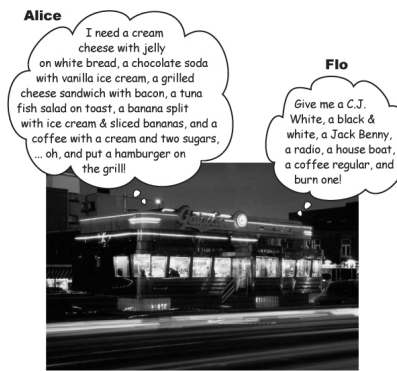
So, let me just see if I fully understand what we just did. We identified the aspects of the duck that were likely to change—namely, the flying behavior—and we pulled it right out of the class so that we could change it independently of the ducks?

That's right.

In this short report we've skipped a lot of steps showing how we get from the problem to the pattern and solution, but you're getting the idea.

This is just an simple example showing how a non-obvious design problem can be approached by making use of a design pattern and applying it in your code.



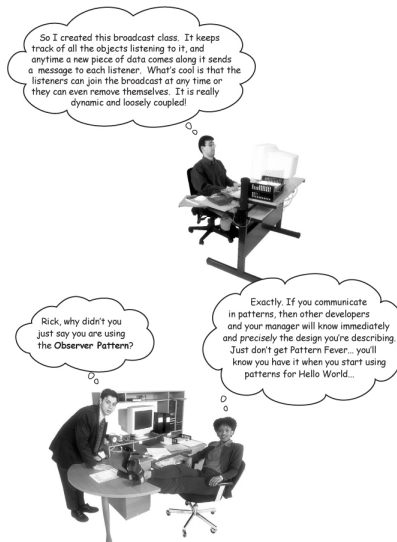


What's the difference between these two orders? Not a thing! They're both the same order, except Alice is using twice the number of words and trying the patience of a grumpy short-order cook.

What's Flo got that Alice doesn't? **A shared vocabulary** with the short-order cook. Not only does that make it easier to communicate with the cook, but it gives the cook less to remember because he's got all the diner patterns in his head.

Design Patterns give you a shared vocabulary with the developers on your team. Once you've got the vocabulary you can more easily communicate about software design and inspire those who don't know patterns to start learning them. It also elevates your thinking about architectures by letting you **think at the pattern level**, not the nitty-gritty *object* level.

OVERHEARD IN THE NEXT CUBICLE...



SHARED VOCABULARIES ARE POWERFUL

When you communicate with your team using patterns, you are communicating not just a pattern name but a whole set of qualities, characteristics, and constraints that the pattern represents.

Patterns allow you to say more with less.

When you use a pattern in a description, other developers quickly know precisely the design you have in mind.

Talking at the pattern level allows you to stay "in the design" longer.

Talking about software systems using patterns allows you to keep the discussion at the design level, without having to dive down to the nitty-gritty details of implementing objects and classes.

How many design meetings have you been in that quickly degrade into implementation details?

Shared vocabularies can turbo-charge your development team.

A team well versed in design patterns can move more quickly with less room for misunderstanding.

As your team begins to share design ideas and experience in terms of patterns, you will build a community of patterns users.

Shared vocabularies encourage more junior developers to get up to speed.

Junior developers look up to experienced developers. When senior developers make use of design patterns, junior developers also become motivated to learn them. Build a community of pattern users at your organization.

BRAIN POWER



Can you think of other shared vocabularies that are used beyond OO design and diner talk? (Hint: how about auto mechanics, carpenters, gourmet chefs, air traffic control.) What qualities are communicated along with the lingo?

Can you think of aspects of object-oriented design that get communicated along with pattern names, e.g. "Strategy Pattern"?



I'm sold. We're going to be able to write code that is more flexible, extensible, maintainable, and the team's communication is going to improve. So, how can we quickly get up to speed on all the patterns?

Well, learning all the patterns is probably not the right approach.

There are hundreds of patterns at this point (the field has been developing since 1994), so it doesn't make sense for you to try to understand every pattern that exists. In addition, you'll find there are fundamental patterns that apply to most software design, and there are domain-specific patterns that apply to specific fields, like, say, enterprise software development. So depending on the type of work you and your team do, you're going to want to focus on a subset of patterns to wrap your head around.

Start with a few of the original GoF patterns; you'll find these patterns show up regularly in all kinds of software development, and also make frequent appearances in libraries and frameworks. Studying these patterns will also help you learn to "think in patterns" so you can better recognize situations where a pattern could potentially help solve a problem.

From there, it may be appropriate to learn more about the patterns that are specific to your domain (for instance enterprise patterns, JavaScript patterns, etc.).

PATTERNS CHEAT SHEET



You've seen one of the fundamental design patterns, the Strategy Pattern; how about a few more examples just to wet your appetite? We're going to give you just a little exposure here to some common patterns; it's up to you to take it further and actually learn them. For now, at least, you'll be able to hold your own in the next developer's happy hour.

Decorator: Need to dynamically add functionality to objects? With Decorator, you can do this without affecting the behavior of other objects from the same class. Great for keeping classes simple and adding on new combinations of behavior at runtime.

Observer: Need your objects to be notified when events happen? With the Observer pattern you can get notified in a way that keeps everything in your design flexible and loosely coupled.

Adapter: Need to isolate your code from two or more APIs? Adapters are commonly used.

Dependency Injection: Does your software depend on services from libraries to get things done, but you don't want to be too dependent on any one implementation of a service? Dependency Injection keeps your code loosely coupled from modules so you can change your mind later and use a different service without having to rewrite a bunch of code.

Model-View-Controller (MVC): This is the go-to pattern for building systems with user interfaces (views). The MVC pattern allows you to keep your UI, business logic, and model code all nice and separate.

Module: This pattern helps keep all your library code separate from your own code with a handy public interface to all the functionality you need.

Singleton: The Singleton pattern is used when you need to have one, and only one, of an object. Use it to represent critical resources that can only exist once in your app.

Iterator: Need to be able to iterate through a collection of things without knowing the specifics of the things? Use the Iterator pattern.

Command: Want to delegate work to other objects, without specifying exactly who should do it, and without telling them how to do their job? Use the Command pattern.

WARNING: Overuse of design patterns can lead to code that is downright over-engineered. Always go with the simplest solution that does the job and introduce patterns where and when the need emerges.

Once you begin learning about Design Patterns, you start seeing patterns everywhere. This is good: it gets you lots of experience with and practice thinking about how patterns can influence and improve your designs. But also realize that not every situation needs a pattern. Patterns can help make more



flexible designs, but they can also introduce complexity, which we want to reduce unless necessary. Just remember: complexity and patterns should be used only where they are needed for practical extensibility.

Here's a short and handy guide to keep in mind as you think about patterns:

Keep It Simple (KISS): Your goal should always be simplicity, so don't feel like you always need to use a pattern to solve a problem.

Design patterns aren't a magic bullet: They are time-tested techniques for solving problems, but you can't just plug a pattern into a problem and take an early lunch. Think through how using a pattern will affect the rest of your design.

When to use a pattern? That's the \$10,000 question. Introduce a pattern when you're sure it addresses a problem in your design, and only if a simpler solution won't work.

Refactoring time is patterns time: A great time to introduce patterns is when you need to refactor a design. You're improving the organization and structure of your code anyway, so see if a pattern can help.

If you don't need it now, don't do it now: Design Patterns are powerful, but resist the temptation to introduce them unless you have a practical need to support change in your design today.

YOUR JOURNEY HAS JUST BEGUN...

You've barely scratched the surface of Design Patterns in this report, but now you have an idea of what they are and how they can benefit you and your team, you're ready to dig deeper. Where to begin? We've got resources to get you started and set you on your way to Design Patterns mastery.

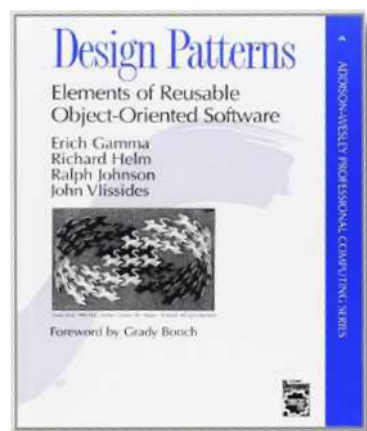
Where to start...

This little report is based on, and borrows heavily from *Head First Design Patterns*. Over the past decade this book has become the go-to guide for learning about design patterns because it takes you through every aspect of what they are, the core design principles they are based on and through fourteen of the fundamental patterns, all in one place and in a brain-friendly way.



Where to reference...

Design Patterns: Elements of Reusable Software, known as the “Gang of Four” book, in reference to the four authors, kicked off the entire field of Design Patterns when it was released in 1995. This is the definitive book on the core design patterns, and so, it belongs on any professional’s bookshelf.



Video

If video learning is your cup of tea, check out *Foundations of Programming: Design Patterns* to get you up to speed on patterns including a half dozen of the core GoF patterns.





Online

The Portland Pattern Repository is a great resource as you enter the Design Patterns world. It is a wiki, so anyone can participate. You'll find it at <http://e2.com/ppr/> (<http://e2.com/ppr/>).



[Support / Sign Out](#)

[PREV](#)
[Title Page](#)

