CLEAN RUBY

by Jim Gay

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Introduction

Our simple ideas are often far more difficult to implement than we first expect. Over time we develop new ideas, change our understanding, discover unexpected consequences, and more. We grow programs with new features in a way that makes us curse our "monolith." Often we are the victims of our own devices.

It's easy to blame the bigness of our application and formulate plans to make things better. "If I only had time to refactor this," you might be thinking as you browse your massively large classes. But how do we get there? How is it that we start with something simple and the best of intentions, but we end up with code bloated with unnecessary indirection and complicated responsibilities?

Despite studying and following common design patterns in your program you continue to lose the ability to maintain a clear mental model of your growing codebase. Jumping in at any point in the code requires digging around in your classes before you're reminded of exactly how every piece fits together. Does this sound familiar?

You can change this. You can make your program more intentional and your intentions more obvious. *Clean Ruby* is an introduction to a way of thinking about object orientation that's a bit unlike your current understanding. This book focuses on teaching you ways to remove distractions and unnecessary hierarchy from your business logic.

I have four goals with this book; that you will:

1. Learn to understand the difference between your program's *form* and *function*;
2. Describe your application's *use cases* in code;

3. Write code that feels familiar, even to new developers; and
4. Dramatically simplify and speed up your automated tests.

Clean Ruby comes from my own experience in working with teams to simplify our code and apply a new way of thinking about object-oriented programs with DCI (Data, Context and Interaction). DCI is the brainchild of Trygve Reenskaug[1] and while you may or may not know the Reenskaug name, you know and likely practice an approach to object-oriented programming that he created: MVC.

The MVC paradigm (Model, View, Controller) is a way to ensure that programmers, like you and me, write code that supports the end user's actual understanding of a program and its functions. This approach became popular because it allows us to very clearly separate concerns and encapsulate required logic into individual objects, and distinctly map the ways of the world in our programs.

What you, I, and many others—including Reenskaug—have found is that we still tend to write code that's not quite as revealing about its purpose as it should be. After spending years considering problems that we find in our object-oriented code, Reenskaug has formulated an approach that puts the business use case in the driver's seat of your programs. DCI is a complement to your MVC structure and is an approach that isn't just an example of writing tests in a BDD (Behavior Driven Development[2]) style; it's all about writing **code** that describes the behavior.

James "Cope" Coplien[3] has been a major partner in developing DCI along with Reenskaug, and pushing the ideas into the OOP community. Cope is a leader in Agile and Lean software development communities. Among many things, Cope is the co-author of *Organizational Patterns of Agile Software Development,* and he and Gertrud Bjørnvig[4] lay out a clear picture of DCI in *Lean Architecture*[5], an excellent book on the hows and whys of the thinking that begat DCI.

Many programmers begin serious programming with object orientation. There are now so many "best practices" and patterns for OOP that it's hard to avoid writing a

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[1] http://heim.ifi.uio.no/~trygver/

[2] [2] http://en.wikipedia.org/wiki/Behavior_Driven_Development

[3] http://en.wikipedia.org/wiki/Jim_Coplien

[4] http://scrumfoundation.com/about/gertrud-bjornvig

[5] http://leanarchitecture.com

program without them. Many of us still don't spend time considering the purpose of OO and how it can be used to benefit our applications, so it's well worth our time to consider object modeling perspectives from early languages like Simula.

What This Is

Clean Ruby is a guide for understanding and applying thinking that will allow you to build systems. It's focused on discussing ideas to communicate the semantics of working software.

There's plenty of thinking and understanding that needs to occur before you have any chance of writing a coherent, maintainable program. *Clean Ruby* first will lay a foundation exploring why we approach programming from an object-oriented perspective and what we can learn from user interface design.

User interface design can teach us a lot about programming. When we create applications, we interact with the files, classes, method names, and more in the same way we interact with a graphical user interface. In this book we'll explore aspects of interface design that can help us have a better intuition about our application architecture.

This assumes that you'll know Ruby and be familiar with Ruby on Rails. Rails is used as a frame of reference for application code but the ideas and approaches covered will apply elsewhere.

What This Is Not

To get the most out of *Clean Ruby* you should have experience writing Ruby. This isn't a tutorial that will get you up to speed on the language. This isn't a tutorial on how to use any of the popular frameworks like Ruby on Rails either. So be prepared.

Lost In Translation

Modeling a Business

"We only need a simple registration form," your client says. You pause, knowing well enough that use of the words "only" and "simple" implies that they'd like your work to be fast and cheap. It also means they likely haven't thought things through.

It's moments like this that often lead us to either love or hate our jobs.

Mental models are an important feature both in object-oriented programming and the ideas in this book. While the phrase *mental model* seems easy enough to grasp by itself as a representation of something in our minds, it's helpful to consider deeper aspects of it.

In *Mental Models*[6], one of the first books to introduce the idea, a few of its main points are discussed by Donald Norman (Gentner 7-14). Norman points out that through observation of test subjects he discovered that mental models are:

- incomplete
- difficult to mentally "run"
- unstable
- unscientific
- ungenerous (favoring manual labor over cognitive load)

[6] Gentner, D., and Albert L. Stevens eds. Mental Models, Lawrence Erlbaum Associates, Inc., 1983. Print.

These characteristics of our mental models show us that it's no surprise that business owners (or any person in charge of determining a business process) will often approach developers with an incomplete idea. A "simple registration form" may represent an understanding of a process but that understanding may not be complete. It may reflect someone's incorrect assumptions about both the needs of the software and the needs of the business process itself.

> "Do you want immediate membership or will we need to confirm, for example, by clicking on a link in an email generated after the visitor submits the form?"
>
> *"Why would we do that?"*
>
> "One reason would be to prevent accounts from being registered and used to immediately to add spam messages to your system."
>
> *"Oh. I hadn't thought of that. Do we need that?"*

Our mental models of relevant business processes can be (and often are) incomplete. There may be reasons why one aspect or another goes unnoticed until later in the development of your software, but that's not always because someone is inexperienced or incompetent.

Norman points out that if we represent any system as *t*, then an end user's mental model of the system is *M(t)*. That is, it's a function of the mental model; there's a separation between the actual system and the understanding of it. Worse yet, we can formulate our own understanding of the end user's mental model as *C(M(t))*. We need to cut through layers of indirection in an attempt to understand an understanding of a system.

Our First Bugs

One of the greatest challenges in writing software is communication. What does each variable, method, and class do? Even in answering that question, how can we describe how it all fits together to form the whole?

We can learn from research like Norman's that mental models are both difficult to communicate and often misunderstood. This is where our first bugs enter the program. These bugs aren't of the kind that come from typos or `nil` return values leading to unexpected results. Our first bugs often come from our expected results being incorrect or our mental models being incomplete.

Over time, these incorrect expectations and incomplete mental models lead us to anticipate something: *change*. Change is why so many have found value in the Agile and Lean approaches to software development. Change seems to come more often than anything else in software development, and to deliver working software the creators of the Agile Manifesto[7] specifically highlight "responding to change" as more valuable than following a plan. Responding to change is more valuable than following a plan because we base our plans on mental models of a system and if our mental models are incomplete, then so too will be our plans.

Going forward with this knowledge about the limitations of our mental models we can confidently say: we will be wrong. Our first attempts at understanding will be wrong and we'll go back to the business owner for more details, more discussion and more thinking. But this response is a good thing; it means we take the time to get it right. Unfortunately, more often than not, these "final" discussions aren't, and we eventually become frustrated or disappointed when it ends up that "final" isn't really final.

To avoid frustration and to prevent these bugs from complicating our code, making it even harder to change, we can separate our business processes from our domain models. We should prepare our application's architecture to respond well to the changes in our processes and the changes in our understanding of the models we're building. We should keep in mind some words of wisdom from Reenskaug and Coplien:

> A key, longstanding hallmark of a good program is that it separates what is stable from what changes in the interest of good maintenance.[8]

Change is expected, so plan for it; build for it.

[7] http://agilemanifesto.org

[8] http://www.artima.com/articles/dci_vision.html

Object Orientation

Where We Are

Every Ruby programmer knows about object orientation. In Ruby, almost everything is an object that can be given properties and actions. The ruby-lang.org website highlights this feature in particular under "Seeing Everything as an Object"[9] teaching newcomers that numbers are even treated as objects.

Object-oriented Programming (OOP) has been a dominant style of programming in recent decades. Although this style is pervasive, the definition of "object-oriented" seems to have a number of interpretations. Smalltalk gave us a definition of objects:

> An Object is an entity that has identity and that encapsulates state and behavior.[10]

Alan Kay, who coined the term "object-oriented programming" later said:

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[9] http://www.ruby-lang.org/en/about/

[10] http://heim.ifi.uio.no/~trygver/2011/DCI-Glossary.pdf

> I thought of objects being like biological cells and/or individual computers on a network, only able to communicate with messages[.]
>
> OOP to me means only messaging, local retention and protection and hiding of state-process, and extreme late-binding of all things.[11]

The SOLID[12] principles give us a guide for building Object-oriented (OO) systems in a way that helps us balance control of responsibilities and flexibility. In particular, as Jim Coplien has pointed out to me in discussions about object orientation, the Liskov Substitution Principle (LSP) "is a quite broadly accepted definition in the OO world."

LSP is a principle that, when followed, ensures that an operation expecting an instance of one class should accept a substitute instance of one of it's subclasses and continue to function without the need to change the program. The "Treaty of Orlando"[13] solidified requirements of OO systems that they implement sharing mechanisms for object behavior via either delegation or inheritance.

It would be helpful to have a simple definition which combines these ideas and to which we can anchor our discussion. Let's pick one.

> Object-oriented programs execute algorithms by sending messages among objects, where the objects are an encapsulation of data and functions that perform operations.

Perhaps you might choose to word this differently, but it's of little consequence. We're saying that we represent things in a program with objects and those objects know how to perform actions. And, these objects talk to each other by sending messages.

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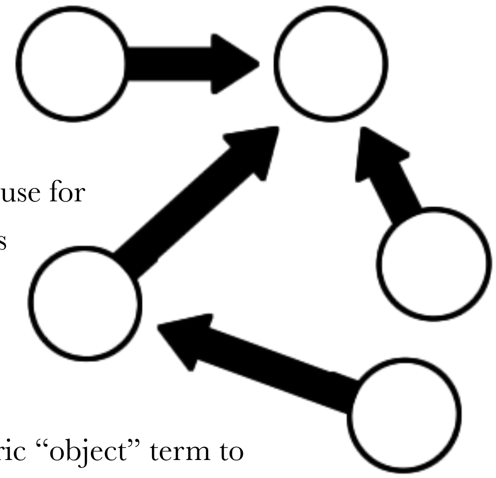
[11] http://www.purl.org/stefan_ram/pub/doc_kay_oop_en

[12] http://en.wikipedia.org/wiki/SOLID_(object-oriented_design)

[13] [Stein et al., 1989] Stein, L. A., H. Lieberman, and D. Ungar. "A Shared View of Sharing: The Treaty of Orlando." Object-Oriented Concepts, Databases and Applications. Ed. W. Kim and F. H. Lochovsky. Reading (MA), USA: ACM Press/Addison-Wesley, 1989. 31–48.

We can extrapolate this simple idea into a graphic view of the objects of our system communicating by sending messages: objects (circles) sending messages to each other (arrows between them).



What are objects?

The objects that we use may be called "account," "article," "user," or any other word we use for these things. This is important because using words like this **reveals** to us the **intentions** of what these objects represent. We tend to focus on nouns with OO design.

In our world of programming we use the generic "object" term to refer to so many things, but when we get into the details of our applications we have objects with more specific and meaningful names. Most often our program's objects are given certain behavior as well: behavior that often reflects the typical functions of real world objects. We model what we know so we can better reason about how it functions and better communicate with each other through our software.

In a typical Ruby application we initialize objects through a relevant class.

```
class Account
   def initialize(cents)
      @cents = cents
   end
end
account = Account.new(500000)
=> #<Account:0x101a776f8 @cents=500000>
```

Here, we've set up an `Account` class to store an amount of cents when creating the new object. This is just basic Ruby code and it allows us to initialize an object that represents an account containing an amount of money.

Doing more

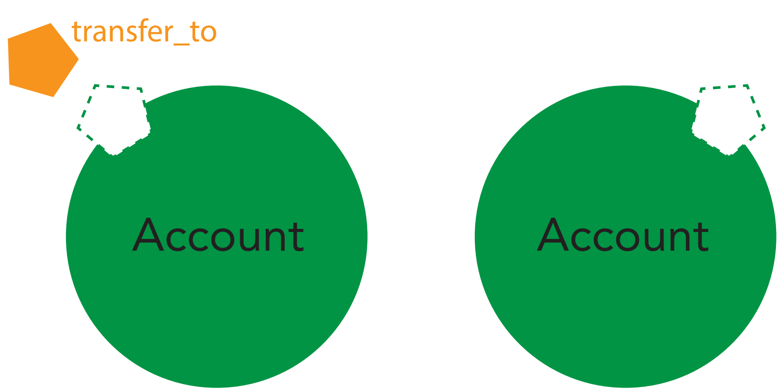
Along come requirements from the business that says the account holder needs to add money to an account and we dutifully add that ability to the class:

```
class Account
  def add_money(cents)
    @cents += cents
  end
end
```

Now, of course, with objects that manage money you're likely to need to transfer from one to the other and the business owners are quick to remind you of that need. This class is simple enough, so we can just add a method to do that:

```
class Account
  def transfer_to(account, amount)
    @cents -= amount
    account.add_money(amount)
  end
end
```

When we have two `Account` objects and the system sends a message to one, our mental model is simple to diagram:



In the above diagram we see one account as a green circle receiving a message in an orange pentagon. Each account has a receptor shaped like that of the message so each can receive the same message.

We just added the `transfer_to` method to the `Account` class and we are able to move money between accounts. But there's more to what we've done than just that: we've added behavior.

This is where we begin to complicate our code, but it isn't obvious. You're probably wondering how in the world I could take a two method class and tell you that this is the start of something undesirable. This is exactly what we need when designing programs around the way the real world works, isn't it? It *feels* fine, allowing us to initialize objects that encapsulate data and functions, which is, after all, how we defined object orientation.

Restricted OO

Here's the distinction: Our `Account` is no longer just a representation of something that contains money. It now has the innate ability to add and transfer money as well.

At the outset this may seem completely normal, perfectly OK, and just plain trivial. After all, our definition of OO says that our objects encapsulate data and functions; this is exactly what we've created; this is OO.

We've gone from a class that represents a thing, to a class that represents a thing as well as defining its actions. Notice here that I referred to the code example being about the "class" and not the "object." In traditional OO Ruby programs, we initialize objects through classes and as our applications grow, we add any necessary behavior for those objects to its class. We've just implemented this feature and have complected the two requirements of the system with what we can call **Restricted OO**.

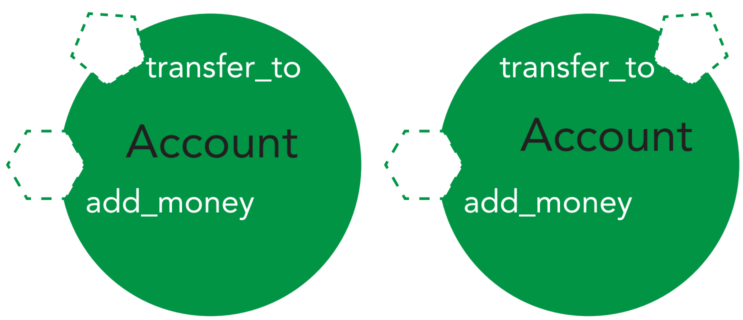
We'll better define Restricted OO in a minute, but first we need to agree that we've combined behavior and state with our `Account` class, which still fits our working definition. We built a class to represent objects that store information (how much money) as well as perform actions (transfer money). We've built our class with responsibilities in mind.

Why call this *Restricted* OO? Well, let's step back and first just call this OO, since that's what most people would call it now. With OO, the perspective the programmer takes is from within the object itself.

This traditional approach allows you to see the state of the object as defined by its class, the public methods that may be called on the objects (or the messages that may be sent to it), the private and protected methods that will be called to implement some aspect of the called public methods, and the attributes that will be changed by these methods.

The problem with a perspective like this is that we need to understand so much more about the class of an object while knowing so little about the actual execution of the program. With this paradigm, we know at some point these methods may be called and the object's state may change, but there's nothing deterministic about this. We're still left guessing about the program's actual behavior and are often forced to go spend time reading documentation files, wikis, or user acceptance test scripts that pull us further away from where we want to be: in the program code. Our understanding of each object carries with it all the baggage of the entire set of potentially unrelated behaviors regardless of the necessity of the features they provide. Going back to our example, this means that our source and destination accounts can transfer money to another even though we only intend for one to do so.

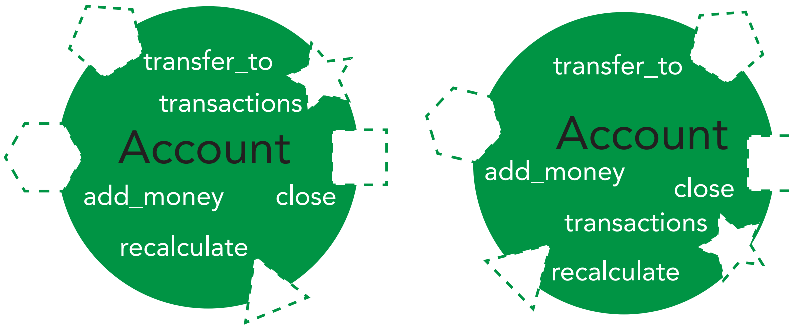
By making a diagram of these objects and what actions they can perform, their roles are less clear than what our mental model of OOP tends to be:



In this diagram we see the two objects and their available functions.

With few responsibilities in our classes this perspective appears to be reasonable. If we increase the number of methods per object (which is extremely likely as our program grows) and if we multiply the number of objects in this interaction then our simple diagram of interconnected objects becomes much more difficult to decipher.

Let's think about a visual example of this `Account` class as it grows. Currently we have `add_money` and `transfer_to` methods. As an example, we'll add more methods that you might find on a class like this. By merely adding a few more methods, our graphical depiction has grown significantly:



While visual references are often great tools, they can exaggerate problems very easily, so let's shift to some running code examples for a more concrete approach that you'll experience with your own projects. Here's an example of running code in IRB:

```
> account = Account.new(100)
 => #<Account:0x0000010085ac90 @cents=100>
```

We've initialized an account with a `@cents` value. Now that we have our account, let's see what we can do:

```
> account.public_methods(false)
 => [:add_money, :transfer_to]
```

Ruby allows us to pass `false` into the `public_methods` call to return only methods that are defined on the objects immediate ancestor and not any inherited methods. This makes understanding our object much easier. Were we to print all public methods (omitting the flag we set here) we'd see a large list of methods that are mostly unimportant to our current needs.

Unfortunately and as we've seen in our diagram, as we add methods to our class, our list of options for every object from that class grows.

```
> account.public_methods(false)
 => [:add_money, :transfer_to, :recalculate, :hold_funds,
 :subtract, :transactions, :split, :close]
```

If we only care about transfers, these extra features are noise, serving only to increase the cognitive effort require to understand our code. It's more mental strain to understand this account object. Although this list of methods is small, I'm willing to bet that you've had a class that didn't stop at seven methods.

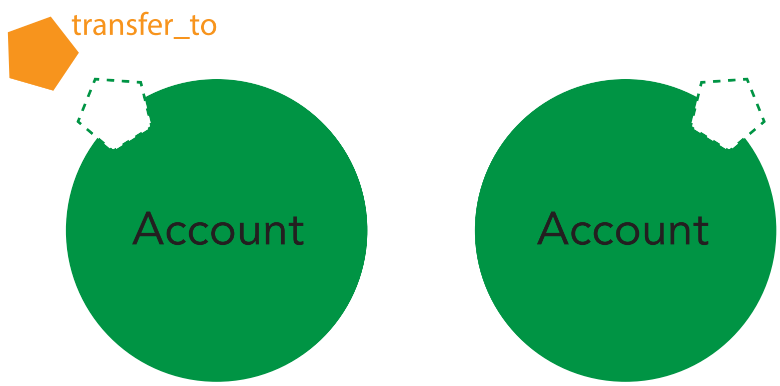
We can call this "Restricted OO" because our goal of readable code is supported only by the restrictions that we place on our architecture. Because our perspective is from within an individual class, we restrict our architecture to that view having no broad concrete understanding of how and when our domain models interact. With this, and to quote Coplien, “a programmer can understand the program behavior only in general terms.”[14]

We can only understand the code in general terms because there is no clear indication of what objects are present and of what methods they require at any given point. This is because our individual classes grow with our requirements. As a result, we are forced to understand increasingly more about our system in its entirety to make sense of specific scenarios.

How can we fix this? Can we drop the baggage of the class and move back to the perspective that we really prefer to have?

Full OO

If we were to be fully aware of the behavior of our objects during the execution of the program (that is at runtime, not at compile time as defined in our classes), we could see the world our program creates and see the world the way we think of OO.



With Full OO we observe our objects from a perspective of being among them, not within them; we don’t merely understand objects through their classes. We can see exactly what object sends what message to what other object and we can clearly see and specify where those abilities are assigned.

[14] https://groups.google.com/forum/#!msg/object-composition/umY_w1rXBEw/hyAF-jPgFn4J

> A very important goal for DCI is to give the user an illusion of working directly with his or her mental model when working with the computer. Object orientation is the key to the DCI way of achieving this goal.[15]

This mental model we seek is the network of interacting objects. It is the representation of how objects interact with what other objects and when. DCI elevates our perceived network of objects to a readable, executable algorithm. Virtually every definition of "object oriented programming" considers such a network of objects to be its goal.

Shortly we'll be looking at the way DCI makes this happen, but first let's check to make sure we're on the right track by asking: What did the first OO languages intend?

Where We've Been

Simula 67[16] was designed to represent real world objects in computer code and was the beginning of OOP as we know it. Simula 67 is the first language to introduce the concepts of objects, classes, subclasses, coroutines and more.

The first thing to remember about the first programming language to introduce the world to OOP is that it was designed to *simulate* real world objects. In "The Development of the Simula Languages," Nygaard and Dahl point out that in their experience:

> [I]t became evident that no useful and consistent set of concepts existed in terms of which the structure and interaction in these complex systems could be understood and described.[17]

What were the complex systems they needed to understand? Resonance absorption calculations related to the construction of Norway's first nuclear reactor. This isn't something that you can easily model in miniature and not worry about any nuclear radiation from your experiment. At the time, nothing existed for them to better understand their problem and potential solutions, so they simulated it by making a computer world that represented the real world.

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[15] http://folk.uio.no/trygver/2011/DCI-Glossary.pdf

[16] http://en.wikipedia.org/wiki/Simula

[17] Nygaard, K., Ole-Jahn, D. 1981The development of the Simula languages. History of Programming Languages. Association for Computing Machinery, Inc.

Next, let's look to an important description from *An Introduction to Programming in Simula* by Rob Pooley:

> A computer program is a series of instructions which contains all the information necessary for a computer to perform some task.

This quote isn't particular to Simula, but it's an attempt to describe what a *program* is. What's valuable about this is that it describes a program as a "series of instructions." This series implies a step-by-step approach to getting work done.

By following steps, we can stop and evaluate where we are. At any point, we can see how much we have done and how much is left to do. We can understand each step as a unit of work. But how often can you read your code like a series of instructions?

It's pedantic to evaluate your code this way, isn't it? After all, you've followed common patterns and have neatly encapsulated the various responsibilities of your system. Nobody ever sits down to read code as if it's a series of instructions anyway.

Where We're Going

Nobody reads code as if it's a series of instructions, but couldn't they? Shouldn't they?

We can, and we should.

Step-by-step instructions are often how we think about our business process. Step-by-step is how we evaluate what happens in our business when things work, when things fail, and when things just work differently.

There's no better argument for that than the ever-growing popularity of the Behavior Driven Development (BDD) [18] approach to programming.

In BDD you drive your application design by defining the behavior that you expect. The goal of this approach is not in writing tests, but in writing better code and, more specifically, writing an executable specification.

DCI encourages a focus on representing the real world scenarios that our applications support. This turns out to be incredibly similar to what BDD encourages. The benefit to using an approach like this in executable code is that you're not removed from your program like you are with testing. With DCI you're describing the interactions between

[18] http://dannorth.net/introducing-bdd/

objects with the actual objects that interact. In contrast, when you write tests to describe the same thing you're in a completely separate layer: the tests.

This isn't an argument to say that BDD is not valuable, but I want to point out that DCI can help us achieve the same goals that we set to achieve with these other approaches to application design. Starting with tests helps to drive us toward creating object classes that we can understand individually, but DCI pushes us to write software that we better understand in terms of object collaboration and runtime execution.

Later, in **Objects In Context**, we'll explore how to better reveal your intent and describe the program's behavior from within the program itself, but first let's take a closer look at what our objects *are* versus what they *do*.

Being and Doing

As I write this I'm watching my two oldest boys squirm and climb around a playground with two mountainous structures made of interconnected rope. To them, this is so many things: a boat, a spaceship, a mountain, and who knows what else. They carry out their play as actors of great adventure. I, on the other hand, have the misfortune of seeing through the magic to just the poles, rope, and grommets that hold it all together.

For better or worse, I see these things for what they are: raw materials. This is what the playground *is*.

Your software is a network of objects sending messages to each other for the purpose of fulfilling the requirements of your use cases. The objects in your system tend to represent things in the real world or working mental concepts.

Traditionally we create classes of things and define what their behavior is as we discussed earlier. When we discover that an `Account` needs to be able to transfer money, for example, we find the file that defines the `Account` class and add our new behavior to the class. As we've seen, one problem with this traditional approach is that we tend to grow our classes like weeds adding distraction as our requirements grow.

What we need to do is merely define what things *are,* then focus our efforts on programming what they *do*.

Let's make an example class to facilitate this discussion. Before we do, however, it's important to note that discussing example code in a way that makes it relevant is a difficult task. We could build a large class with many methods and fill up the next few pages, but by spending time on code we don't want, solely for the illustration of a large and complicated class we'd be getting further away from our goal of understanding use cases. So as we discuss these examples, if you need to, just close your eyes and imagine scrolling through hundreds of lines of methods to get to the one you want.

Let's get started.

In our application we will have end users that need to be activated before being granted access. Here's some code to support that model:

```
class User
  attr_accessor :activation_code, :activation_expires_at,
                :activated_at
  def activate
    self.activation_code = nil
    self.activation_expires_at = nil
    self.activated_at = Time.now
    save
  end
end
```

This class will initialize objects that can be activated by clearing an activation code and expiration date, setting an activation date, then saving the changes. A method such as `activate` is common and illustrates well the problem of unnecessarily complicated classes.

The ability for a user to be activated is only important when that activation needs to occur and at no other time. Over time, we will find ourselves adding more features like this to a class that represents many aspects of the behavior of the system. We complicate our class and make understanding more difficult with every method added. So why do we burden ourselves with this overhead in the `User` class?

The actual activation is something that a user will do, not what it is. Our `User` class is a representation of data and combining what the user is with what it does complicates our mental model. While simple models may support combining data and behavior in one class, doing so can lead to difficulty in responding to change later. The classes that we begin to define should represent data or model the behavior of the data object, **but not both**. This code better represents what the user is:

```
class User
 attr_accessor :activation_code, :activation_expires_at,
                  :activated_at
end
```

And our activation code can be put into a module to be used at the appropriate time:

```
module Activator
  def activate
    activation_code = nil
    activation_expires_at = nil
    activated_at = Time.now
    save
  end
end
```

These two things, the *being* and *doing*, need to come together at some point, but: why are we doing this?

A common approach to refactoring complex classes is to follow this same paradigm of identifying related methods and breaking them out from the main class using modules. Although this may clean up the number lines of code in a given class definition, often developers are just moving code around in their filesystem and their classes end up just as bloated as ever by including these modules in the class at load time. This copy-paste refactoring is well intentioned, but ultimately accomplishes little.

For example the following implementation still has all of the problems we discussed in Chapter 2 with initialized objects having unnecessary abilities:

```
class User
  include Activator
end
```

What we will see with this approach is that our objects still carry with them the ability to activate, regardless of our need for it:

```
> user = User.new
 => #<User:0x1003b1478>
> user.public_methods(false)
 => ["activate"]
```

Keep in mind that we've omitted method definitions we don't care about in this example. If our class included methods and modules for activation, email, registration, making friends, eating dinner, and more, we would have a lot to sort through. The more we add to this class, the more difficult it becomes to understand its capabilities and limitations and when its capabilities are necessary.

To avoid this, our class should stand alone:

```
class User
end
```

This example class is extremely simple, but it's only an example. Don't stop here and think that we're forming an argument for empty classes like this `User` class. We'll explore other design considerations later, but first let's look at how an instance of this class gets activated.

Managing Change

Let's expand our example class to include code you might find in a typical Rails application.

```
class User < ActiveRecord::Base
  validates :name, :presence => true
  validates :email, :presence => true
  validates :password, :confirmation => true
end
```

This class is unlikely to change. It represents users of our program for whom we store a name, email address, and password. Users are users and in general it's not what they are that drives our software development, it's what they do. So this class and our representation of users is unlikely to change significantly.

In fact, if we properly follow the Single Responsibility Principle[19] (SRP), this `User` class should only ever change when our representation of our user changes. New methods and new responsibilities that we create or discover as we develop our system probably do not belong here.

Our mode of activation, however, may change over time. Perhaps at first we merely activate new users automatically. Then, over time, we decide we need to email an activation link. Next we decide we'd prefer to collect payment first. And on and on.

[19] http://en.wikipedia.org/wiki/Single_responsibility_principle

By making these changes outside of the `User` class we have a clearer separation of concerns, we can better target a unit test to only a specific piece of functionality, and we immediately gain the ability to reuse this module elsewhere. But, most importantly, we can focus on changing only the code that is directly related to the change in requirements. Of course, we can still change that code if it all lived within the main `User` class, but then we would be mixing the *being* with the *doing*, where changing one inherently changes the other, and we'd be throwing away the values from SRP.

Since the activation of a `User` is a separate responsibility we could create an `Activator` module or class to handle it. We'll initialize another object to handle the responsibility of activation so for now, let's do this as a class:

```
class Activator
  def initialize(user)
    @user = user
  end

  def activate
    @user.activation_code = nil
    @user.activation_expires_at = nil
    @user.activated_at = Time.now
    @user.save
  end
end

activator = Activator.new(user)
activator.activate
```

This class lives on it's own and clearly represents the activation of a user. Over time, as the needs of our application grow we'll know to look to the `Activator` class to make changes.

On the other hand, if we elevate every procedural action to a class like this we'll be adding a lot of new language into our code in the form of classes. Looking at our files we'll have little indication that `activator.rb` has any significant relationship to `user.rb`. Perhaps that's a good thing, or maybe we want things a little clearer and decide to name this class `UserActivator` in `user_activator.rb`. Only the needs of your project and its domain can determine that, but let's take a step back for a moment.

Implicitness, Explicitness, and Encapsulation

The OO purists might stop right here and claim that we've broken encapsulation. This example shows that we have an `activator` reaching into the `user` object to alter its state.

This `Activator` code assumes that the `user` instance will provide methods that allow the alteration of its attributes. The methods `activation_code=`, `activation_expires_at=`, `activated_at=`, and `save` are all required to exist on all `User` instances by the `Activator`. By doing this, we've made an implicit contract.

Implicit structure is often good. Class methods such as `attr_accessor` allow you to imply the existence of getter and setter methods for the given attribute name. But explicit structure is obvious. Explicit code reveals your intentions far better than implicit code because it shows you exactly what it means. Often the balance between these styles has to do with the preferences of developers writing the code, the complexity of the task, and the common idioms of the language.

What's missing here is a reliable notion of what contract we need to enforce. While any object could implement the required methods, a unit test can help enforce the requirements of the `Activator` class. We'll leave that only as a point of discussion for now, but we'll get back to discussing contracts and tests later in the book.

Simplifying the Code

We've been thinking about this separation of data and interaction but this feels heavy handed. Imagine every procedure required that we create a new class to handle it. All of these bits and pieces seem like even more to worry about, not less. What problems are we trying to solve here? And why exactly would we go about all this setup just to keep our data objects separate from the interactions?

What we care about is that our code is written well enough that it is easily understood and easily tested. So let's think about our typical path through managing our code with Rails.

If you follow the general approach to building web applications in Rails, then you've likely been down the road of seeing controller methods handling a lot of responsibilities. Often we have them find records, call methods on them, send emails, log details, notify external systems, all within a single action. For example, the following code might be similar to something you've either seen, written, or refactored. Let's take a simple signup form. Visitors come to your site, they enter their credentials, and receive a welcome email while the administrators also receive an email about their new member:

```
class UsersController < ApplicationController
  def create
    @user = User.create!(params[:user])
    Notifier.send_welcome(@user.id)
    Notifier.notify_admin_of_new_member(@user.id)
  rescue ActiveRecord::RecordInvalid
    render :new
  end
end
```

In this code we see a `User` being created and two emails sent out for notification related to that event. If there's an exception during the process of creating the `User`, then we render the `new` page with a simple display of the errors.

As you develop your application you come to realize that you need this exact same functionality elsewhere in your system. Because you've chosen to put this business logic in your controller you're now faced with the possibility of duplicating your code in another controller and causing you more maintenance headaches down the road.

The answer, as you well know, is to solve this problem with skinny controllers and fat models. All of this code related to sending notifications for this event can be pushed into our `User` model, making our controller skinny (with fewer responsibilities) and our model fat (with more responsibilities). You might decide that callbacks from `ActiveRecord::Callbacks` are the simplest way to go to get what you need. In a matter of minutes you've got code similar to this:

```
class User < ActiveRecord::Base
  after_create :send_welcome, :notify_admin_of_new_member

  private

  def send_welcome
    Notifier.send_welcome(self.id)
  end

  def notify_admin_of_new_member
    Notifier.notify_admin_of_new_member(self.id)
  end
end
```

You can safely go back to your controller and clean things up:

```
class UsersController < ApplicationController
  def create
    @user = User.create!(params[:user])
  rescue ActiveRecord::RecordInvalid
    render 'new'
  end
end
```

Pat yourself on the back, great developer, you have made a skinny controller and a fat model. Your code is DRY! Tell all the world of your refactoring prowess!

You wrote tests for all of this, of course, but I'm leaving them out here for the demonstration.

Wrong turn

Later in your development you realize that the administrators prefer to create users themselves. This leads you down the obvious road of creating another controller for almost the same purpose:

```
class Admin::UsersController < ApplicationController
  def create
    @user = User.create!(params[:user])
  rescue ActiveRecord::RecordInvalid
    render 'new'
  end
end
```

This is easy stuff! You've now got another endpoint where only your authorized administrators can go, likely at `/admin/users` I imagine, and you have a nice little interface for them too. During development you realize, of course, that you don't really need to notify administrators that a new user has been created when the administrator did the creating in the first place.

This problem should be simple enough to solve since it all lives in your well tested model. Where was that functionality again? Oh, right; this should go in `notify_admin_of_new_member` which happens after the object is created.

But now we're working with an alternate scenario. Since the method `notify_admin_of_new_member` is called in an `after_create` callback we're stuck with some unpleasant ideas about how to adjust for this new scenario.

How about just setting a flag on the new user like this:

```
class User < ActiveRecord::Base
  attr_accessor :dont_send_to_admin?
  def notify_admin_of_new_member
    Notifier.notify_admin_of_new_member(self.id) unless
dont_send_to_admin?
  end
end
```

This option is awful. In order to understand the behavior of this program you'd not only need to know about the callback, but you'd need to know how to alter it by setting `dont_send_to_admin?` to `true`. It's ugly English too. Perhaps instead we can say `Notifier.notify_admin_of_new_member(self.id) unless ignore_admin?`, but even then it's not beautiful prose and is difficult to quickly understand. No, this setting of flags to skip parts of the procedure is just too prone to cause confusion.

We could create an alternate class method where we delineate the behavior and luckily enough `ActiveSupport::Callbacks` gives us the `skip_callback` method. What about just skipping the callback in a new method:

```
class User < ActiveRecord::Base
  def self.create_without_admin_notification!(params)
    self.skip_callback :create, :after, :notify_admin_of_new_member
    self.create!(params)
    # Turn the callback back on
    self.set_callback :create, :after, :notify_admin_of_new_member
  end
end
```

I feel terrible even suggesting that this is a reasonable solution.

Not only would you need to control the setting of a callback in two places (its original declaration and now in this method) but you'd also be adding another method to load into your head whenever you needed to understand the behavior of this class in the future. When should you use `create_without_admin_notification!` and when shouldn't you? There's an answer that only spending time diving deeper into the code will reveal. Callbacks are often a developers first foray into spaghetti code. Sadly a common first thought of many developers is not to refactor, but to just skip those callbacks they don't currently need.

This need to understand increasingly more things is a problem. When we concentrate on our programming, we should consider how much we need to keep in our heads to understand the task at hand. Often the limited use cases are easy to understand when we write them, or when they are explained to us, but when those use cases are executed in a world where there's much more to understand we easily lose focus. Sometimes our code can feel like Times Square with many new and old things vying for our attention. How many times have you started out writing code to implement a new feature only to be distracted by a misunderstanding, lack of knowledge, or lines of ugly code screaming out at you in mercy to be refactored?

The examples in this chapter are just some of the ways that we solve our problems by making more down the road. Setting flags and adding more methods to a global namespace are just two ways that we increase the cognitive load on ourselves just to understand something that, especially in our example, should be extremely simple. If this example is difficult to keep simple, what will it mean for our application as its list of features grows?

Despite knowing our needs for business logic will change and have exceptional cases, we still tend to interweave *being* and *doing*. The more we combine these two things into one, the more knowledge is required to understand the one thing. Our knowledge deficit always grows as our features grow, but with this class-oriented approach our deficit grows at a greater rate. This creates a gap in our ability to quickly and effectively continue development.

By loading our data classes with behavior for all aspects of their use we increase the demand on our brains to understand and we create gaps in our understanding. The more we need to understand, the harder it is to understand. What we really want to have is a much more even and high level of understanding of when, where, and how the methods in our program are used.

Objects in Context

The answer to our woes of requiring so much knowledge to understand simple things is to merely *control our perspective*. DCI is an approach that removes the distraction of unrelated code. Our runtime objects don't have those extra and distracting abilities, likewise our written classes aren't cluttered with extra features, and our brains aren't burdened with understanding them outside of the context in which they are needed.

We've looked at some tangled ways we write code for our needs and how that will drastically increase our cognitive load. By lumping our responsibilities in to a single class and attempting to skip the parts we don't want for a particular part of our program, we split our focus for related parts of code, and combined responsibilities for unrelated parts. This is the opposite of what we want for easy to understand code.

We've seen how we can separate *being* and *doing*, but that alone isn't enough to make a useful tool. We need to fully understand when, where, and how to bring these parts together. We need to worry about codifying our business logic in a way the reflects the working whole, rather than a way that defines the individual parts.

Typically we organize what happens in our Rails applications in controllers. A web request hits the application server, the Rails router determines which controller is responsible, and the controller does its thing.

Let's look at our earlier example of transferring money between accounts to see how we can apply the idea of a DCI context.

We'll set our router to map a POST to our `TransfersController`:

```ruby
AccountManager::Application.routes.draw do
  resources :accounts do
    resources :transfers, :only => [:index, :create]
  end
end
```

This sets us up with paths to manage accounts and their transfers. What we're currently concerned with is the request to initialize a transfer. We can setup our `TransfersController` to handle this request:

```ruby
class TransfersController < ApplicationController
  def create
    account = Account.find(params[:account_id])
    account.transfer_to(params[:destination_id], params[:amount])
    redirect_to account_transfers_path(account)
  end
end
```

This first example is a typical Rails controller action. It's written assuming that the initialized `account` can call the `transfer_to` method. We've discussed some reasons why we'd not want `account` to have that ability inherently, so let's alter this example to add it only now that we need it.

```ruby
class TransfersController < ApplicationController
  def create
    source = Account.find(params[:account_id])
    destination = Account.find(params[:destination_id])
    source.extend(Transferrer)
    source.transfer_to(destination, params[:amount])
    redirect_to account_transfers_path(source)
  end
end
```

This example assumes that you've got a `Transferrer` module that defines `transfer_to`, but we can leave the implementation up to our imagination for now.

Your typical test for this controller in Rails might look something like this:

```ruby
class TransfersControllerTest < ActionController::TestCase
  test "POST#create" do
    source = Account.new(:balance => 900)
    destination = Account.new(:balance => 900

    Account.expects(:find).with('1').returns(source)
    Account.expects(:find).with('2').returns(destination)

    post :create, :account_id => '1',
                  :destination_id => '2',
                  :amount => '500'
    assert_equal 400, source.balance
    assert_equal 1300, destination.balance

    assert_redirected_to account_transfers_path(source)
  end
end
```

This example code uses the "mocha" gem[20] to provide for some simple mocking.

This controller test checks that a post to the `create` action will find the accounts with the given `account_id` and `destination_id`, transfer the `amount` between them and then redirect to the list of transfers.

You might argue that we're doing this backwards. I should have shown you the test first to drive the design and then show the code. We'll get to that, but I want to start with something that I've found to be typical. Many developers write code and tests this way so it's likely that you've done so as well, but our focus is on setting up what's typical, not discussing how we got here.

We've already discussed a problem with leaving logic like this in a controller: if we need the same behavior again, we might find ourselves duplicating code. The example we discussed previously with our `User` moved our repeatable code into the model by using ActiveRecord's callbacks. We can't use that same idea here because we're not performing any action on the account that would trigger a callback in a way that wouldn't be messy. This example is simplistic and there's always the YAGNI argument: You Ain't Gonna

[20] https://rubygems.org/gems/mocha

Need It[21]. But will our application architecture help us or hurt us when we finally do need to reuse this code?

In any application where we can transfer money between accounts, we could also provide the option to pay bills; this can be just like our transfer example. What do we do when we want to do a transfer of money to multiple accounts at once? Can we reuse the code in this controller the way it is? Perhaps we could if we automated sending requests to it, but even the thought of that should immediately cause you to wince at the unnecessary complexity. Imagine explaining that solution to your colleagues.

Clearer Perspective

This is where the ideas in DCI can help improve our architecture. In our example we have two accounts where one acts as the source and the other acts as the destination for the transfer of funds. As we saw in the chapter **Being and Doing**, we can separate the responsibilities of representing what the system is from what it does. Our `User` objects control our data, and our `Activator` was responsible for maintaining the behavior.

The **context** is the object responsible for organizing the data and roles for carrying out your use cases. It's a powerful model for encapsulating your business logic because it gives you a clear way to organize the interactions of objects in your system.

We'll review an example of a DCI context, but first consider common approaches to organizing logic. Just in the examples we've discussed so far we've seen application logic in controllers, models, and even split into modules or classes to be added to or used with data models later.

Where is the business logic? In some cases it's in our controllers, in others it's in our models, and still in other cases it's in modules and classes too.

While we might build a working and well-tested system like this, we'll find that as our program grows, we'll have more difficulty understanding how the pieces fit together. The more pieces we add in the absence of a clear structure guiding us about how they fit together, the harder it will be to understand exactly how the system functions.

Often as a program grows the team of developers grows with it. Some new developers are added, some leave and are replaced by others. How can you, as the owner of your code, hand over a program and make it easy to understand? Does a successful hand-off

[21] If English isn't your primary language this might look strange to you. Both "ain't" and "gonna" are slang terms. A proper expansion would be "You Aren't Going to Need It."

require a long explanation? Do you rely on a "read the tests" approach or are you sending new programmers to go "read the documentation?"

Wait a minute! Are you arguing against documentation or even tests!?

No, I'm not, but these additional artifacts require more of our limited attention spans. Going from tests to code or documentation to code changes your locus of attention. Your locus of attention is the single point on which you are able to concentrate your mind. You're human and you can only focus on one thing at a time.

As you change your focus from code to documentation, you might need to remember what line of code you were reviewing, or what it meant. You might also need to recall other parts of a method or class, and perhaps need to recall what some other part of the documentation said or what was happening in the tests before and after that line is run.

By pointing to tests and documentation to understand a system we are adding more complexity. What we want is less. The goal is to have less for us to know in order to better understand the system. It should make sense without a deep dive because that would be faster. Our locus of attention should change as little as possible. We should be able to rely on our intuition and immediate needs to get going.

Will DCI make this magical codebase with no tests and no documentation happen?

No. You should still write tests, you should still write documentation where you need it, but if your goal is to understand your program, your program code should be your best source of that understanding. Make it so.

In my experience, the power of the DCI context object will get you closer to this intention-revealing code far better than any other approach, so let's take a look.

Describing the System

Let's start off with a description of DCI by Coplien:

> The "D" is for data modeling: what we know as traditional objects, though bereft of knowledge about scenarios. It captures the static structure of objects[...]
>
> The "C" is for context: the mapping of roles onto objects on a per-use-case basis[...]
>
> The "I" is for interaction: an algorithm of a stateless role, written in terms only of other roles, that defines in readable terms what the system does, and how it does it.[22]

Let's start by focusing on context's "mapping of roles onto objects." Previously we've explored the separation of data objects and their responsibilities but we pulled them together in our controller. This is a logical place for that to occur in a Rails application, but as we saw it doesn't lend itself to reuse, and if you begin to add this feature to your controllers you'll find they become bloated with responsibility. We can limit the controllers to handling requests and responses, and put our business logic into contexts.

```
class MoneyTransfer
  def execute(amount)
    @source.transfer_to(@destination, amount)
  end
end
```

This sample code shows us the behavior that we want; a source is transferring some amount to a destination. What's left out of this is the setup about how source and destination are pulled into the algorithm and given their responsibilities:

```
class MoneyTransfer
  def initialize(source, destination)
    @source, @destination = source, destination
  end
end
```

In this context we now have the concept of **Roles**. Although we will pass accounts to this context when it's initialized, we want to refer to them in terms relevant to our context. Often these are called **Methodless Roles**.

[22] James Coplien - https://sites.google.com/a/gertrudandcope.com/www/thedciarchitecture

Our concern with DCI is with the interactions between and among roles. Objects in your program play different roles at different times during its execution. It doesn't really matter to the use case if the `@source` is a `SavingsAccount` object or a `CheckingAccount` object or something else altogether. A Role is an identifier of an object in the execution of an algorithm. It is a marker signifying an actor performing a part in a play.

In our transfer we have two accounts. These two objects aren't called `account1` and `account2` for a very specific reason: those names have no meaning relevant to our business logic. Our actual use for these objects is that one will be the source of money, the other will be the recipient of a transfer, so a good selection of Roles are `source` and `destination`.

Choosing these names is important in the communication about what this code is doing. Were we to use placeholder names with no relevance, we'd be forcing the future readers of the code to slow down merely to understand what each item is. Good names grease the wheels of understanding.

In an excellent and well named book called "Clean Code," Robert C. Martin succinctly explains:

> Choosing descriptive names will clarify the design of the module in your mind and help you to improve it. It is not at all uncommon that hunting for a good name results in a favorable restructuring of the code.[23]

Naming has everything to do with communication. The Roles communicate the purpose of each object with a descriptive name and the purpose of your code is not only to create working software, but, most importantly, to communicate to you and other people about its purpose.

Programs can easily be written for computers to understand, and the litmus test is that it works properly. If, however, a person is ever to read, write, or edit the code, then human communication becomes significantly more important rather than merely working properly.

Back in our context, we're still missing something. We're missing the ability to do anything. If our accounts are merely representations of funds with no inherent ability to transfer money, this context will do nothing but raise an error when we get to the `transfer_to` method call. Let's alter the context a bit to be sure we've gotten this right:

---

[23] Martin, Robert C. *Clean code: a handbook of agile software craftmanship*. Upper Saddle River, NJ: Prentice Hall, Copyright 2009. informit.com/ph

```ruby
class MoneyTransfer
  def initialize(source, destination)
    @source = source
    @destination = destination
    assign_transferrer(@source)
  end

  def execute(amount)
    @source.transfer_to(@destination, amount)
  end

  private

  def assign_transferrer(account)
    account.extend(Transferrer)
  end

  module Transferrer
    def transfer_to(destination, amount)
      self.balance -= amount
      destination.balance += amount
    end
  end
end
```

A complete example would include transactions for the transfer procedure as well as other needs like logging but we're keeping it simple and only manipulating a value in this case.

We have just added what we call a **RoleMethod**. While we had our objects playing roles in this context as `source` and `destination`, these roles had no special functions other than to clarify the purpose of your logic. The `Transferrer` is a module which contains a RoleMethod which becomes available to the object playing the `source` role.

Implementing Your System

We want to be sure that we know how to use this new context and we want to test the before and after states of the accounts to be sure that this transfer is handled properly:

```ruby
class MoneyTransferTest < ActiveSupport::TestCase

  test "initializes with a source and destination" do
    assert MoneyTransfer.new(Account.new, Account.new)
  end

  test "initialization errors without 2 objects" do
    assert_raises(ArgumentError) {
      MoneyTransfer.new(Account.new)
    }
  end

  test "#execute subtracts the given amount from the source and
       adds it to the destination" do
    source = Account.new
    source.balance = 2000
    destination = Account.new
    destination.balance = 0
    transfer = MoneyTransfer.new(source, destination)

    transfer.execute(99)

    assert_equal 1901, source.balance
    assert_equal 99, destination.balance
  end

end
```

Now we have something useful and reusable, but what does our controller look like?

```
class TransfersController < ApplicationController
  respond_to :html
  def create
    source = Account.find(params[:account_id])
    destination = Account.find(params[:destination_id])
    transfer = MoneyTransfer.new(source, destination)
    transfer.execute(params[:amount])
    respond_with source do |format|
      format.html{ redirect_to account_transfers_path(source) }
    end
  end
end
```

Although we've put our business logic in a central and reusable container, this controller action is still quite complicated. We can simplify its responsibilities. I'd much prefer that it be as easy to write as this:

```
class TransfersController < ApplicationController
  respond_to :html
  def create
    transfer = MoneyTransfer.new(params[:account_id],
                                 params[:destination_id])
    account = transfer.execute(params[:amount])
    respond_with account do |format|
      format.html { redirect_to account_transfers_path(account) }
    end
  end
end
```

Let's alter our test of the transfer context to reflect this:

```ruby
class MoneyTransferTest < ActiveSupport::TestCase

  def setup
    @source = Account.new
    @destination = Account.new

    @source.balance = 2000
    @destination.balance = 0

    Account.expects(:find).with(1).returns(@source)
    Account.expects(:find).with(2).returns(@destination)

    @transfer = MoneyTransfer.new(1, 2)
  end

  test "#execute subtracts the given amount from the source and
       adds it to the destination" do
    @transfer.execute(99)

    assert_equal 1901, @source.balance
    assert_equal 99, @destination.balance
  end

  test "execute returns the source account" do
    assert_equal @source, @transfer.execute(99)
  end

end
```

Our tests will fail without altering our context with the ability to find the appropriate objects, so we'll add that ability now:

```
class MoneyTransfer
   def initialize(source_id, destination_id)
     @source = find_account(source_id)
     @destination = find_account(destination_id)
     assign_transferrer(@source)
   end

   def execute(amount)
      @source.transfer_to(@destination, amount)
   end

   private

   def find_account(id)
     Account.find(id)
  end
end
```

Here we've changed the behavior as we intended. Our controller will pass along the appropriate argument and the context takes care of finding the relevant objects and assigning them their roles. Finally, the controller tells our context to `execute` and returns the response.

All Set Up

We've managed to put our business logic in a place that's reusable and can easily be tested, and we've implemented a system that doesn't rely on inherent behavior from our classes. The value here is that we have a clear definition of the behavior and we won't need to go diving into class definitions to figure it out.

When explaining our implementation to our business owners or to new developers on our team, we can point here and say, "this is how it works." Instead of answering "what can Accounts do?" we can answer "what does the system do?"

With our focus on the program's duties we can more quickly react to changes. Our reaction to changes in business logic is faster because we've put the business logic in plain view in an object that describes our interacting data objects. The `MoneyTransfer` context in this example centralizes our understanding of the system.

Will we do this for every procedure that our application needs to perform? Not quite. We're not implementing our entire system with procedures, but we do have a better way to organize our procedural flow. Beyond this small example we have a powerful tool to organize the *doing* part of our program outside of its *being*.

There's a lot more to implementing business logic than this. To better manage our flow we need a way to organize related scenarios, and we'll explore that in the next chapter.

Gazelles And Gazebos

> "A user story is to a use case as a gazelle is to a gazebo"
> –Alistair Cockburn[24]

Many projects are begun by gathering user stories[25] to describe the end user behavior when completing tasks. User stories, which describe an end user's behavior, are often helpful in describing tasks which a developer may translate into code, but use cases are a fundamentally different thing.

A use case helps us to describe multiple scenarios for a business requirement. When writing a use case you'll say that you have specific preconditions, specific actors, and of course specific goals.

A short summary to help you remember comes from a comment on Cockburn's website by Ted Husted:

> Another answer is that you can fit a gazelle inside a gazebo just as you can fit a user story inside of a use case. And in both cases, the inverse would be cruel.

A use case will describe at least two exit points for a business process: the success and the failure. Often there are many variations and multiple exit points in related scenarios.

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[24] http://alistair.cockburn.us/A+user+story+is+to+a+use+case+as+a+gazelle+is+to+a+gazebo

[25] http://en.wikipedia.org/wiki/User_story

We can look to Cockburn[26] again for the full understanding of use cases. Here are the main points about what a use case should do and some points about how we can apply this to our executable code. In Cockburn's words (with my comments afterward) use cases DO:

- **Hold Functional Requirements in an easy to read, easy to track text format.** We can do this in code. Ruby is widely known for being easy to read and the community values beautiful code. As far as holding functional requirements, that should be very simple for executable code to do.
- **Represents the goal of an interaction between an actor and the system.** The goal represents a meaningful and measurable objective for the actor. This is both an important aspect of your business, and an important aspect of DCI. When we're attempting to achieve our business goals, we should write software that is uniquely designed to do that. The context is an object that encapsulates this concept.
- **Records a set of paths (scenarios) that traverse an actor from a trigger event (start of the use case) to the goal (success scenarios).** In simple code this is easy enough to do with if/else blocks or case statements, for example.
- **Records a set of scenarios that traverse an actor from a trigger event toward a goal but fall short of the goal (failure scenarios).** An example here might be the above if/else blocks or perhaps a rescue from an exception. A use case describes a complete interaction between the user and your system and it is the responsibility of your context to implement this.
- **Are multi-level: one use case can use/extend the functionality of another.** This is reflected in DCI in the fact that we want to achieve the vision of Alan Kay, to create a network of interacting objects much like biological cells or computer networks. A context can trigger other contexts within.

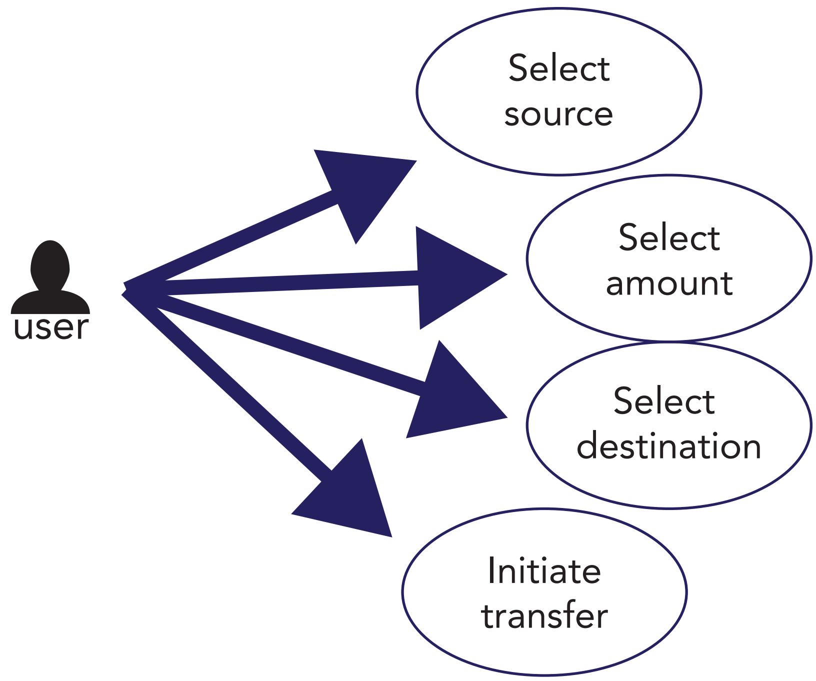
What you're attempting to do with DCI is not battle junk drawer objects with other junk drawer objects, but to implement business logic in an organized set. Take a specific need and describe it, including variations, using a single context to coordinate the data and interactions. The context has real meaning and real value to your business, it's not just a place to call `extend` on your objects.

[26] http://alistair.cockburn.us/Use+case+fundamentals

Our money transfer use case is simple. The actor performs a few tasks:

1. User selects a source account.
2. User selects amount to transfer.
3. User selects the destination account.
4. User initiates the transfer.
5. System displays the source and destination original and final balances.

These steps illustrate a functional mental model of our system. You may find that illustrating the requirements can give you a different perspective on the problem.

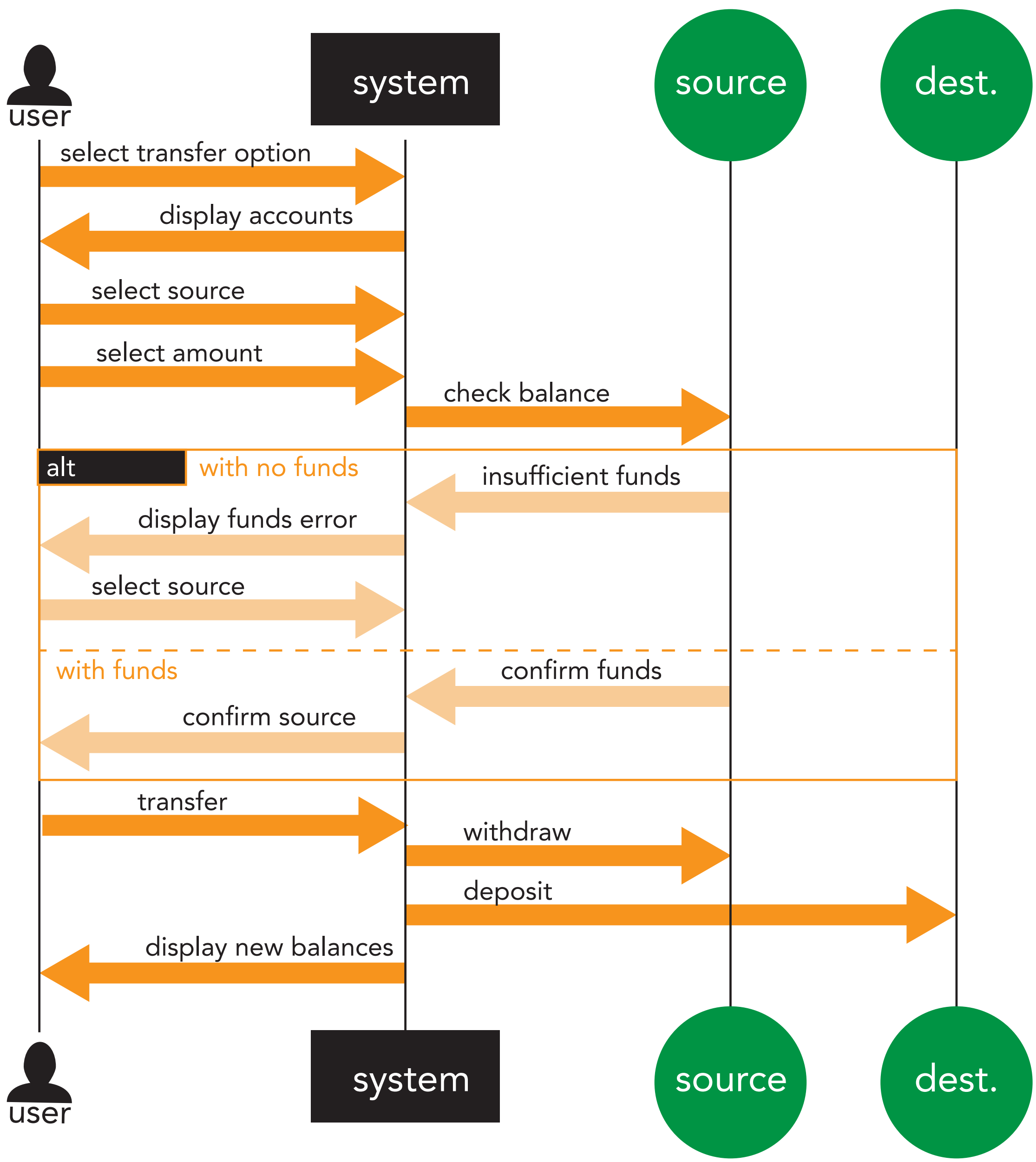


These steps might also describe a simple user story as well, but there's more to it. We can create a more forgiving interface if the system warned us that the amount selected was too great for the source account to successfully transfer. What would happen if there were insufficient funds for the transfer? In one scenario the funds may be present, but in another they may not; so we need be sure we cover those outcomes.

1. User selects a source account.
2. User selects amount to transfer.
    a) System finds source balance insufficient
    b) System requests user to select a new source

3. User selects the destination account.
4. User initiates the transfer.
5. System displays the source and destination original and final balances.

A user visits a screen where she may select a source account, amount to transfer, and a destination account. When she presses, clicks, or taps, this triggers the system to initialize a transaction where the amount is withdrawn from the source and deposited to the destination. The result of the transfer is then displayed to the user.



We can better see the requirements for our use in an interaction diagram like this. After working through these scenarios we can take this to another developer or a business owner to review.

What about account holders who don't have additional accounts? If the source doesn't have funds, that may be the end for them.

That's certainly something we need to cover. It would be frustrating to be told to select another source when there are no others.

1. User selects a source account.
2. User selects amount to transfer.
    a) System finds source balance insufficient
    b) System requests user to select a new source
        1. System displays error that no other sources are available
3. User selects the destination account.
4. User initiates the transfer.
5. System displays the source and destination original and final balances.

Now we have a better understanding of the use case for transferring money. And these steps would need multiple user stories to cover everything. While there may still be alternative outcomes beyond these, we're able to see them altogether in a single use case and are more likely to find additional scenarios.

In Rails or a similar framework, your controllers should handle the user actions that trigger these use cases. You might have multiple ways to trigger a use case. For example, in a typical view your user can interact with objects in your system, but in an admin view another user can do the same with perhaps an alternate scenario allowing him to override certain aspects of the scenario. Perhaps our program allows admins to push source accounts to negative balances to allow a transfer to go through.

It makes business sense to look at this use case and scenarios together, so why not put that code into one place? Why not create context that explains all of this in executable code? We can trigger them from wherever our interfaces require. Use cases reveal the needs of the program and show the value of the DCI context in centralizing your business needs with the roles required and interactions among them.

Crossing the Use Chasm

My former business partner always used to remind me that, “software is never finished, you just stop working on it.” There’s always a new perspective, a new way to simplify code, a new feature to add, and there’s always change. Good application architecture will allow you to respond to change.

We can write use cases to clarify the requirements of our program. Creating a context helps us to implement those requirements in executable code. With this approach we can leave the decisions about incidental support, such as data persistence, to a later time, focusing on the semantics of what our system will *do* during its operation.

We’ve seen code that reflects ideas for user activation and money transfers between accounts but it is useful to work with a more complex scenario to experience how this approach can clarify your program. Let’s begin by defining a use case and then look to Ruby to help us make it reality.

Framing The Problem

When working with my own finances, my worries are put at ease by asking an expert for advice. I review my account statements and just pick up the phone or fire off an email to get the answer I need.

We’ll be building an application so let’s create a scenario for this use case: *a user submits a question and receives an answer from an expert.*

Get yourself prepared in your command line and `cd` into wherever you manage your source code.

```
rails new ask_the_experts
```

With that command we've got a standard Rails application framework ready to go.

What we're not going to do is jump into defining our models. We're not going to begin defining a user or an expert. We're working on a program to allow people to help each other so let's spend our time modeling that interaction.

```
touch app/models/expert_questioning.rb
```

Now we've got our first file with a name signaling it's purpose. This is the context for describing our use case. Here is where we'll begin to define our system.

A Note On Naming And Code Use

You might be tempted to give yourself some other signal about what this is. Perhaps `expert_questioning_context.rb` seems attractive as a filename. It's a context, after all, and Rails requires that we name our controllers with a similar pattern. So why not take a note from the book of Rails?

File appendages, in the case of Rails controllers such as `users_controller.rb`, are a great way to simplify the setup of an application. The `_controller` convention allows our code to lean on the framework for support in what would be mundane and repetitive work.

The convention for the `_controller` appendage in Rails simplifies the setup of routing requests to the appropriate class to handle them. A `UsersController` will be automatically initialized when a request matches the `:users` route. Almost no thinking needs to be done by us to decide how to handle the web requests. Follow the naming convention and the magic takes care of it. Without a naming convention, the Rails router would likely require more manual configuration to get the appropriate class hooked up to handle the request.

Additionally, as third-party framework, Rails takes control of names that we likely wouldn't choose for our own code. By favoring the `Controller` appendage for controller classes, Rails will take the name `AccountController` for its needs, allowing us to make use of the `Account` name for our domain objects. To paraphrase a Bible verse[27]: *render unto Rails things which are Rails', and render unto your domain the things that are your domain's.*

Choosing to add `Context` to our context classes and `_context` to their filenames does nothing to simplify our code nor make magic happen. It's unlikely that you'll find a need for this and we certainly don't have any need for it now.

Perhaps you've already jumped ahead and chosen to use a namespace within a module. A namespace allows you to organize your ideas, and you might feel it makes sense to put a file in `app/models/contexts`. That sets you up to refer to your class as `Context::ExpertQuestioning`.

A namespace does exactly what the word suggests: provides space for the name to exist. But it does this, primarily, to avoid clashes in names. These two classes, for example, are entirely separate:

```
module Context
  class ExpertQuestioning; end
end

class ExpertQuestioning; end
```

We're at the beginning of our development and we have neither of these classes yet defined. We have no reason to choose the more verbose `Context::ExpertQuestioning` name. By choosing to nest our class inside a namespace we would be signaling to others that we don't want this class to clash with the other class named `ExpertQuestioning`. The other class, however, would never exist.

Lastly, regarding our class name, a *gerund* is often an intention revealing choice for a context. A gerund, a word that functions like a noun but is derived from a verb, helps us to describe what the system is doing in simple terms. Our domain models are **objects** represented by nouns, and our object interactions are **methods** represented by verbs. Our context is something **happening** represented by a gerund.

We're likely to find alternates to these ideas and only the needs of a program and the terms we use to describe it will best determine good names, but this will guide us toward code that helps both us and others understand.

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[27] http://en.wikipedia.org/wiki/Render_unto_Caesar

Keep your entire team involved in the language you use to describe your business process. Too often developers choose names that make sense to a developer but which need to be translated in discussion with a non-programmer business analyst. Think about how you will describe your process in spoken language before you put it into terms of a programming language.

Expanding Our Use Case

Now that we've got our context created, let's open it up and begin.

First, we'll have our use case triggered by a regular user of the system. This is our **Primary Actor**.

```
# Primary Actor: a regular user
```

Next, we want to specify that our **Goal** is for the user to gain information related to her question.

```
# Goal: user gains information about a specific finance question
```

We should list any **Supporting Actors** so that we have a better understanding of who is involved. These may be additional users, other parts of your system, or other systems entirely.

```
# Supporting Actors: a financial expert
```

And we'll specify that we expect our user to be allowed to trigger the use case in our **Preconditions**. We don't currently have any need to be concerned with any aspect of either of authentication and authorization so we'll begin by just expecting that they are already solved.

```
# Preconditions: user is authenticated and authorized
```

We begin writing our code like this because it quickly answers questions that we'll have. Who is doing this? What is the goal? Who else is involved? And what else do I need for this to work?

Without creating any working code, we've begun with a clear understanding of what this program is going to do. With these initial comments we use BLUF (Bottom Line Up Front[28]) to get to the important information faster. This allows us to focus on the concerns of our current problem by limiting the things which we need to understand. We'll also ignore other parts of our larger system we don't need to understand.

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[28] http://en.wikipedia.org/wiki/BLUF_(communication)

Preparing The Context

Because our context is an object in our program, let's begin be defining what we need to bring it to life. To get started, we know we'll need someone to ask a question, and we'll need her question. We'll begin with the specification so let's make the files.

```
mkdir -p spec/models
touch spec/models/expert_questioning_spec.rb
```

Next we specify the requirements of the initialization method where we define what arguments we'll need.

```
describe ExpertQuestioning do
  it 'initializes with a questioner and a question' do
    questioner = Object.new
    question = "what?"
    expect {
      described_class.new(questioner, question)
    }.to_not raise_error
  end
  it 'errors without a questioner and question' do
    expect { described_class.new }.to
       raise_error(ArgumentError, %r{0 for 2})
  end
end
```

The `described_class` method in RSpec will return the class used in the current `describe` block. This helps to keep our focus on the behavior of the object under test. Additionally, if we decide to change the name of our class, we only need to change the class and the describe block.

We could run this file with `rspec spec` but we know we'll run into the `uninitialized constant ExpertQuestioning (NameError)` because we haven't required our model file yet. Let's do that by taking a tip from Avdi Grimm's book Objects On Rails[29] by making a simpler helper file giving us only what we need.

```
touch spec/spec_helper_lite.rb
```

Typically we'd load the `spec/spec_helper.rb` file generated by RSpec but it will boot up our Rails application and we don't need that here. Later, and in other tests, we may want to load the entire application so rather than alter the default helper file, we'll create our own.

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[29] http://objectsonrails.com/

To that we'll add references to RSpec's libraries (or another testing library if you prefer).

```
require 'rspec/autorun'
```

And lastly we'll add references to our necessary files in our `spec/models/expert_questioning_spec.rb`. We've done some back and forth, so here's what our entire test looks like now:

```
require 'spec_helper_lite'
require_relative '../../app/models/expert_questioning'

describe ExpertQuestioning do
 it 'initializes with a questioner and a question' do
    questioner = Object.new
    question = "what?"
    expect {
      described_class.new(questioner, question)
    }.to_not raise_error
  end
  it 'errors without a questioner and question' do
    expect{ described_class.new }.to
       raise_error(ArgumentError)
  end
end
```

We can run this spec file with `rspec spec` and we'll see that it fails because the class is not yet defined. Then, if we define the class and run it again we'll see that we need to define the initialize method because we'd have an `ArgumentError`. Let's cut through all that and just make the class definition. Here's what our model looks like now:

```
# Primary Actor: a regular user
# Goal: user gains information about a specific finance question
# Supporting Actors: a financial expert
# Preconditions: user is authenticated and authorized

class ExpertQuestioning
   def initialize(questioner, question_text)
   end
end
```

Now we can see our first success.

```
rspec spec/
..

Finished in 0.0005 seconds
2 examples, 0 failures
```

Decoupling the File System

The `require_relative` method is useful for pulling in relevant files for our tests, but the path argument stinks of coupling to the file system. We've specified that our model file will be two levels up and then two levels down in another part of the directory structure with `'../../app/models/expert_questioning'`. This may seem unimportant, but being able to move things around in an application without having to rewrite irrelevant details like the path to a file allows us a bit more freedom if we decide we need some reorganization.

Instead, we can specify what our test needs and use simple `require` statements. Here's a helper method to use in `spec_helper_lite.rb`.

```
def needs(path_fragment)
  full_path = File.expand_path(Dir.pwd + '/app/' + path_fragment)
  unless $LOAD_PATH.include?(full_path)
    $LOAD_PATH.unshift full_path
  end
end
```

In our test we can replace our `require_relative` statement with:

```
needs 'models'
require 'expert_questioning'
```

While one could argue that we still have a reference to our file system here, but we're also free to change that. Although we might have our classes in `app/models` we could alternatively use `lib/ask_the_experts/models` or somewhere else that makes sense. All we'd need to do is change this one method in our helper file to accommodate that.

Why do this at all? Well, we could automatically add `app/models` to our load path whenever we run these tests without ever creating the `needs` method. With all paths loaded we could simply rely on `require` to do its job, but we may want more control over the load path later. The more we add to our load path for every file that we need, the more overhead we'll have in just booting up to run our tests.

It's better to keep things simple at this point by keeping our load path small.

Defining Success

Now that we have our tests running, we can implement the behavior for the success path of our program. So let's begin discussing success.

Our goal is for a user to get an answer to a finance question. What's the scenario for making that happen? There are a few things we'll need to do.

Our experts probably won't be sitting around waiting for questions to come in so we'll need to notify them when a question needs their attention. Likewise, we'll need to notify the user when the question has been answered. Let's take a look at this scenario.

The **Trigger** for this use case is the submitting of a question by the **Primary Actor**.

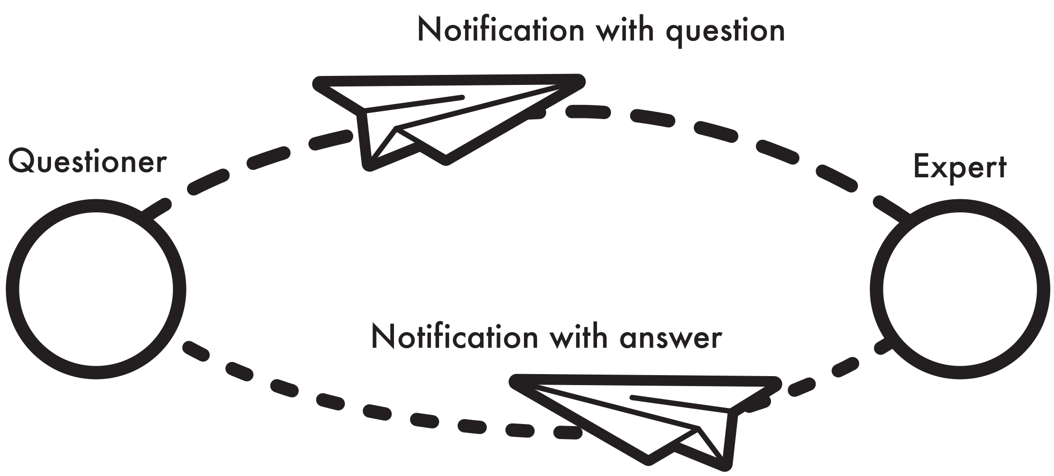
1. User submits Question to System.
2. System sends notification to User that Question will be answered.
3. System assigns Question to available Expert.
4. System notifies Expert of Question.
5. Expert submits Answer to the System.
6. System notifies User of Answer.

There are two main parts to this success scenario. In one part we see the actions triggered by the Primary Actor (steps 1, 2, 3, and 4) and in the second, the actions triggered by a Supporting Actor (steps 5 and 6).

This describes a value to the business. We're not discussing what makes an expert nor are we defining a notification system. The sole purpose with this procedure is to define exactly what needs to happen for us to be successful. Our success comes when these steps are completed and our Primary Actor gets her answer.

An important point to remember in defining our use case is that it describes what the actions are and not what the actors are. While it does mention the actors, there's no opinion about what makes an actor. There's no mention of implementation: no parameters, no database, no extra details at all.

This procedure gets to the heart of the matter. When we want to know what to do with our money, we ask the system and we're notified of an answer from an expert. Our implementation can be as simple as throwing paper airplanes around for a notification delivery system.



It's fun to fold up some paper and toss a plane across the room but the larger point to remember here is about the human aspect of our software. Our goal is not to push bits around in a computer system, our goal is to help people get what they need. By driving our design with a use case, we remove the distractions of technical thinking.

Because the success of this procedure is our goal, we make the procedure a first-class citizen in our code. That's not to say that every procedure will become it's own class, and we don't want to live in the Kingdom of Nouns[30], but when we have interaction between

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[30] http://steve-yegge.blogspot.com/2006/03/execution-in-kingdom-of-nouns.html

and among objects, a use case driven approach with DCI can narrow our focus to what really matters.

There's more, however, to a well-defined use case than a single procedure. The five steps we've created represent just one scenario. There are also **Extensions** to this use case that we'll see where we have alternate outcomes and failures.

Brainstorming

When we form a mental model, for any task, we typically do just enough to understand and operate effectively. That is to say that we form functional, but incomplete models.

When *programming* a system model, however, we need to spend more time and effort exploring the possibilities. As our program is used, we're more likely to run into edge cases and alternate outcomes that our simple mental model didn't cover.

What do we do when we fail at any point in the system? What alternatives are there to our main success scenario? Are there other actors we haven't considered?

Here are some Extensions for our procedure:

3a. No expert is available

3a.1. The user is notified that no expert is available for her question

5a. The expert determines that the question is answered already.

5a.1. The expert assigns the question to an existing answer

There's so much that we could do, too much to explore fully in this book, but this is an exercise for every team member. We can learn from the Lean[31] approach that software development should include this upfront thinking about the domain with as many stakeholders of the system as possible.

The approach to determining the aspects of this use case should be exhaustive. For now, we'll stop here because we have enough of an understanding to move on.

Even in this short bit of brain-storming, we've found a problem. Our success scenario first notifies a user that her question will be answered soon. Then if no expert is available we notify the user that no expert is available to provide the answer. That would be quite confusing to receive two contradictory emails.

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[31] http://en.wikipedia.org/wiki/Lean_software_development

This thinking up front, *before* writing our code, is at the heart of BDD and helps us find problems like this. We won't always save ourselves from mistakes this early in the process, but hopefully we can establish an approach that will make it more likely.

Now we can see that we should swap our second and third steps from our main success scenario.

1. User submits Question to System.
2. *System assigns Question to available Expert.*
3. *System sends notification to User that Question will be answered.*
4. System notifies Expert of Question.
5. Expert submits Answer to the System.
6. System notifies User of Answer.

Setting Boundaries

With our code and tests hooked up and our needs described we can begin digging into the dirt to grow this use case into something functional. We'll start by thinking about the language we'll use to describe this use case.

Our `ExpertQuestioning` will begin when a user submits a question. This is more, however, than just a single trigger. We're building a web application that requires two users to act, so we'll need a break in the procedure where we wait for the expert to answer a question.

The terms we use should be simple to understand. In previous chapters we've built code to execute a money transfer. Later, we'll find that as we build our applications we need to think more about the terms we use to describe how we interact with them.

We're venturing into mental models that are more complex, so it's important to spend time considering the names we use and how they affect our communication. What triggers the context? Will an `execute` method always reflect our understanding? Perhaps, perhaps not.

There's a definite benefit to following naming conventions. Doing so limits the required information for understanding a system. But there is a downside too. Our use case is a description of system behavior and we should focus on communicating the business process in our code not fitting our process to our code. The conventions we follow should be derived from implementing our business processes, not the other way around.

Discussing, with another developer, the way we will use our code will help us choose terms that will reveal our intentions. A good way to begin this discussion is to ask: *how would you expect to use this?*

Would you "execute" this use case?

No. I don't think about it that way. We have a person asking a question, I don't "execute" my questioning.

We have multiple triggers for this too, since we're splitting the use case when we wait for the expert. Why not just choose "ask" and "answer"?

Well, we could, but our primary actor is asking and our expert is answering. This isn't what the context is doing. And our role players might do other things too.

Let's go with "start" and "finish" since we could say that we'd start with asking and finish by answering.

```
class ExpertQuestioning
  # 1. User submits a Question to System
  def start
    # 2. An available expert is assigned to the question.
    #   2a.   No expert is available.
    #   2a.1  The user is notified that no expert is available.
    # 3. A notification is sent to the user that her question
         will be answered soon.
    # 4. The expert is notified of the unanswered question.
  end
  # 5. The expert submits an answer to the question.
  def finish
    #   5a.  The expert determines that the question has already
             been answered.
    #   5a.1 The expert assigns the question to an existing answer.
    # 6. The user is notified of the answer to her question.
  end
end
```

We chose our method names in an imaginary discussion because this is a book, after all. But even a solo programmer should go through an exercise imagining how he or she will understand the code later. The next developer to read the code might not be someone else, it might be you or me with six months of time since the last time we read it.

The discussion of the code, its use, and how it's related to our business process is an important aspect of designing our system. When you are pair programming, doing Test Driven Development, or both, you drive the design of your application like this. These approaches help us to consider what we should do, how we should do it, and what it will communicate to the next person to read it.

Now we've got a basic shell for our context after a short discussion, but we'd better move to our tests to ensure that we don't build what we don't need and give ourselves a safety net if we decide to start making changes.

```
describe ExpertQuestoning do
  context ‘when starting the questioning’ do
    it 'assigns an available expert to the question'
    it 'notifies the questioner that the answer is queued'
    it 'notifies the assigned expert of the question'
  end
  context ‘when finishing the questioning’ do
    it 'stores the expert answer'
    it 'notifies the questioner of the answer'
  end
end
```

We're looking at a variety different actions for this use case. Every one of them can be implemented in a different way and our initial mental model of creating an ask-the-experts application begins, here, to show just how complex it is. This example still only includes the main success scenario.

All of these tests are pending for now, and each one can be a point of discussion for the implementation. Indeed, each item could be another use case altogether. We'll go with what's simple in the beginning, but how you or any other programmer might approach this will vary.

We've discussed structuring our code, but more importantly we've looked at ways to pull details from our mental model. Thinking about what we need our program to do often seems less important than building the parts. It's much easier to jump into creating a database and all the models required for the application before writing the methods they'll use.

Next, we'll dive into ways this context can be implemented and how even our implementation might contain sub-contexts to apply more fine-grained requirements.

Screenplay In Action

Building your context takes work. Evaluating the possible extensions for your use case and determining the actors helps you plan the path. But eventually the time comes to dive into implementation.

We've got our `ExpertQuestioning` context prepared. Now we need to begin deciding how we'll implement the parts.

Finding the Expert

The first aspect of the scenario is the assignment of an expert. Because this is a requirement for the context to get going, it makes sense to set this up in the initialization:

```
def initialize(questioner, question_text)
  @expert = #???
end
```

So how, exactly, should we find that expert? The simplest approach is to just take the first expert that we find

```
@expert = Expert.first
```

The obvious problem is that we'll just get back an expert having nothing to do with availability. Determining availability may become a complicated matter. Is an expert on leave for some time or no longer working? Is any given expert capable of answering the question? We can avoid making decisions about that merely by kicking the problem down the line. For now, we could just use the code we want to have:

```
@expert = Expert.first_available
```

But even beyond this desired code could be yet another use case.

How is someone an expert? Does an expert volunteer themselves? Is expert status determined by calculating votes of other users? Perhaps there are legal regulations governing the qualifications of our experts.

We could sit and think of dozens of ways to determine how someone is an expert. But right now we don't care about exactly how we'll determine that. What we can do here is decide that another object will play the role of getting us our expert.

The expert selection isn't a part of what we're doing yet, so we set our code to depend on an object we deem responsible for this task. It's often a mistake to solve too many problems at once. This Context that we build keeps our focus on the interaction between a user, an expert, and the question.

For this use case, where we are modeling the interaction among the user, expert, and question, our selection of the expert is a distraction. This is a point where further thought and decisions must be made that are not immediately relevant to the task at hand. It is appropriate, therefore, to write our code in a way that will give us flexibility to easily make changes later.

Recognizing decision points in our code can help us to realize a need for separation. If we were to represent the knowledge for selecting an expert in this `ExpertQuestioning` class we would not only be violating SRP but the name of our class would no longer reflect its responsibilities. Our main concern is the asking and answering of a question, so focusing on expert selection will be abstracted away to deal with the decision later.

Let's leave a note for ourselves and others that this is a point for further consideration.

```
def initialize(questioner, question_text)
  @expert = available_expert
end
def available_expert
  # TODO: Expert selection requires consideration
  Expert.first_available
end
```

This approach is often a first step in leaving junk comments in a project. Developers leave notes for themselves or others never to return to them. The best way to avoid this junk is to never leave it in the first place. We will be coming back to this shortly but Rails and many text editors and IDEs provide a simple way to list comments like this.

```
rake notes
app/models/expert_questioning.rb:
  * [ 41] [TODO] Expert selection requires consideration
```

Leave comments if you must, but stay on top of them with something that will report these trouble spots.

Next we can look to creating the question object that we'll need.

We might want to handle a question merely as data. A string is good enough to represent the actual question, after all. But there's important metadata about our question that we'll need for our use case to give us any value. For example, who asked the question? And later we might want to know if there's an expert already handling this particular question.

```
def initialize_question(text)
  Question.new(:text => text)
end
```

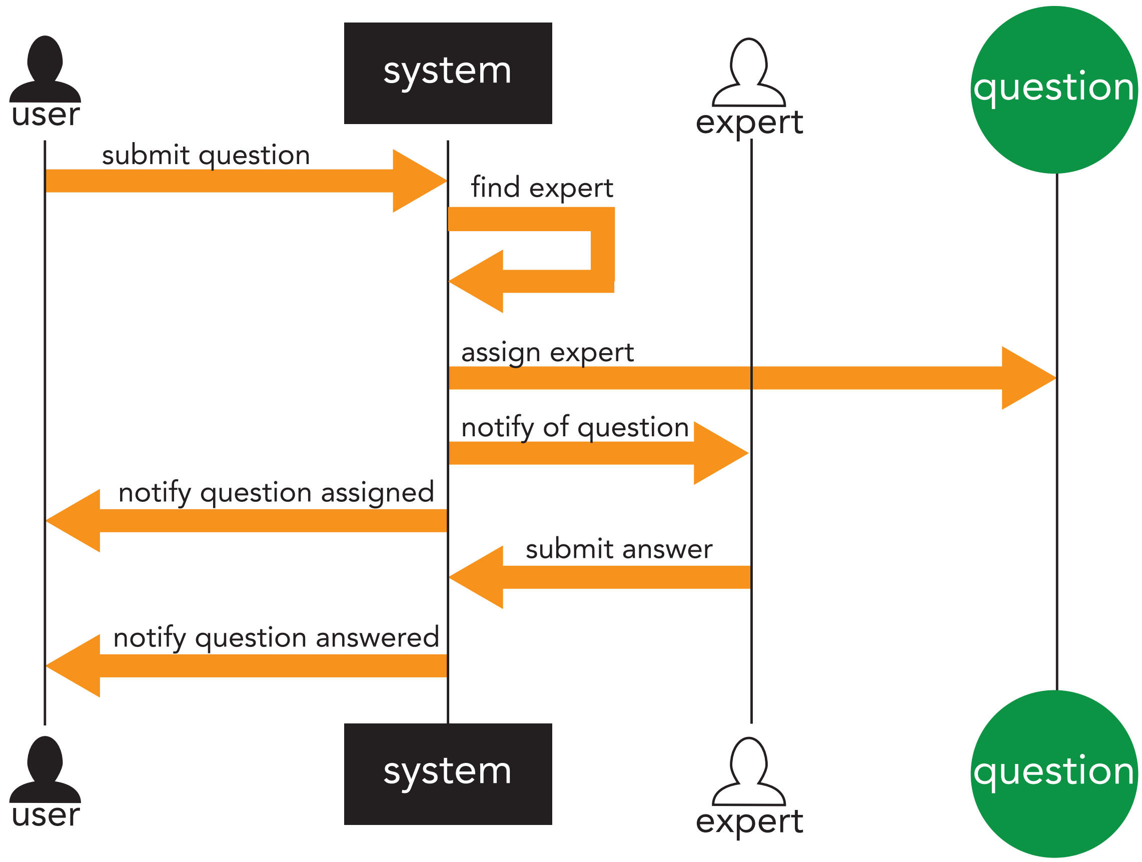
Now our initialization of the context looks like this:

```
def initialize(questioner, question_text)
  @questioner = questioner
  @question = initialize_question(question_text)
  @expert = available_expert
end
```

Defining Interaction

The roles that our objects play contain the details of how they'll interact. The interactions will show us how our system works for a particular scenario and should match the use case we've defined.

We can illustrate any back-and-forth among our objects with an interaction diagram.



This matches the use case we created

1. User submits Question to System.
2. System assigns Question to available Expert.
3. System sends notification to User that Question will be answered.
4. System notifies Expert of Question.
5. Expert submits Answer to the System.
6. System notifies User of Answer.

Creating a diagram allows us to highlight the roles in the use case and focus on the interactions among them. You may find that a combination of text and diagrams work well, or you may prefer one over the other. Creating these gives us the ability to review our understanding of the use case in different ways. Members of our team may help us catch inconsistencies differently, so it's a worthy exercise to explore the text of a use case and then visual interaction diagram.

We can see more clearly what we expect each role to do in our context.

```
module Questioner
  def ask_question(question, expert)
    system.assign_question(question, expert)
    system.notify_questioner('Your question has been queued for an answer from one of our Experts!')
      notify_expert(expert, 'A question awaits your response.')
  end
end
```

```
module Expert
  def answer_question(question, questioner)
    question.add_answer("Sell all your stocks!", :from => self)
    questioner.notify_answered(question)
  end

  def notify_new_question(question)
    Notifier.send_to(self, :question => question) # or some other method specific to the need
  end
end
```

[more coming soon]

Responding to Rails

The power of a well-designed framework can simplify so many aspects of your program. Ruby on Rails' popularity grew in a large part because it highlighted the value of *convention over configuration*. It's far easier to just do what you're supposed to do rather than configure everything before you do what you're supposed to do. So how do we fit ideas like DCI into a framework like Rails?

Answering that depends a bit upon your perspective. Let's first take a look at where we started in our application. In a previous chapter, we had a simple controller hooking into our business logic. It looked like this:

```ruby
class TransfersController < ApplicationController
  respond_to :html
  def create
    transfer = MoneyTransfer.new(params[:account_id],
                                 params[:destination_id])
    account = transfer.execute(params[:amount])
    respond_with account do |format|
      format.html { redirect_to account_transfers_path(account) }
    end
  end
end
```

While this block of code holds less complexity than what we had originally, it's still not as simple as we can get with the options that Rails provides.

In Crafting Rails Applications[32], José Valim walks us through creating Responders to DRY our controllers up. By using Responders, we can offload the behavior of redirection, rendering and other controller responsibilities.

We want to make our controller code even simpler if we can. If we decide later to add responses for XML or JSON or some other type then we'll quickly turn this small controller action into a mental speed bump. We'll need to slow down to understand what's happening or slow down just to find the part we care about. In both code execution and code comprehension we aim for speed.

When the flow of our code is typical, it's OK for the details to be hidden somewhere else. Burying conventional code is a feature. But when we need to understand special decisions or other elements of our program we want them as close to the surface as possible. We would do well to consider what a new level of abstraction gives and what it takes away.

With conventional expectations, we'd rather have our controller be as simple as this:

[32] http://pragprog.com/book/jvrails/crafting-rails-applications

```ruby
class TransfersController < ApplicationController
  respond_to :html
  def create
    transfer = MoneyTransfer.new(params[:account_id],
                                 params[:destination_id])
    respond_with transfer.execute(params[:amount])
  end
end
```

The way Rails conventionally works is that after a create action a user is sent to the representative view of the thing just created. Here we would expect that a user would end up at a view of the transfer. But what happens when we run this code?

It all depends on the return value of the `execute` method.

If we alter that method to return our `account` object we'll get a default responder for the `account`. If it returns a `transfer` object, we'll get a `transfer` responder. This raises the question of where this responsibility belongs. Should the responder be a part of the Context we've created?

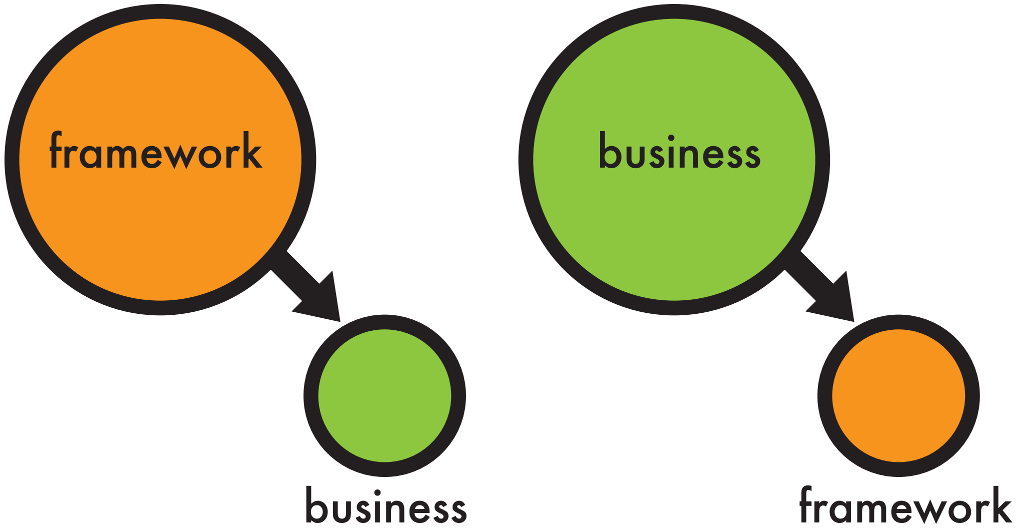
Considering Dependencies

Let's stop and think about dependencies.

While we are discussing responding to Rails, we're evaluating the place of Rails in our application. What does a framework do for us and where does it belong?

Do we stand up a framework to make use of our domain? Or do we build software for our domain around a framework?

The answer comes down to coupling. As long as we have loosely coupled system, where parts of our system share little to no knowledge of each other, we can better arrange the parts as we see fit. If our domain logic requires our framework, then a change in our framework may affect the way our domain objects behave. If our framework requires our domain objects, then the objects of concern retain the behavior we desire.



Diagrams can be both helpful or confusing, so let's look at what this diagram is illustrating along with some code.

We're using arrows to show the direction of dependency between objects. The arrow points to an object which must exist and must be known for the object at the beginning of the arrow to function properly. In code representing the first portion of our diagram, the framework depending on the business logic might look like this:

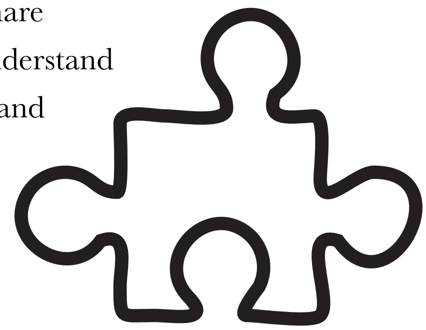
```
class SomeController < ActionController::Base
  def action
    if BusinessClass.logic_method
      redirect_to :some_path
    else
      render :some_other_action
    end
  end
end
```

Rails is a framework that takes care of the parts of our business that we don't want to address. Handling web requests, creating HTTP headers, and other aspects of our platform are a solved problem. So we choose something like Rails and place our trust in it's mature and well-tested code to remove that concern for us. We put the decisions about redirection or rendering in the Rails-based part of our application.

When our needs are simple, this approach is quick and easy to get an application going. But when we want to understand what process `BusinessClass` and `logic_method` represent, we have knowledge of the behavior in **both** `BusinessClass` and `SomeController`. In doing so, we force ourselves to mentally combine these parts to get a complete understanding of the procedure.

Our controller acts as the connection to the framework and now has knowledge not only of `BusinessClass` and `logic_method`. It knows that the method can be evaluated to be `true` or `false` and that there are *two separate behaviors* depending on the return value. That's five aspects of our business process that are tied to a procedure in this controller.

If this procedure in it's entirety is important to our business logic, why would we split knowledge among these objects?



Our objects begin to look a little different when we share knowledge among them like this. When we attempt to understand our program, we need to keep more things in our minds and piece them together by matching up methods and behaviors. Rather than having objects that manage complete responsibilities, we have objects that look more like puzzle pieces which only reveal their process when examined together.

The fact that Rails handles the web for us isn't a good argument for keeping decisions in the controller. The *decision* made by `if` and `else` is relevant to our business process, but the *execution* of it is relevant to our framework. Sometimes the answer to *when* and *where* the program should go next are significant to understanding our goals. With the controller handling these *when* and *where* concerns, they are made explicitly not a part of the business process of our class. Sometimes, however, we want to capture those paths along with the decisions of the procedure. So what can we do?

We can simplify our program and ease our understanding by writing a controller like the following:

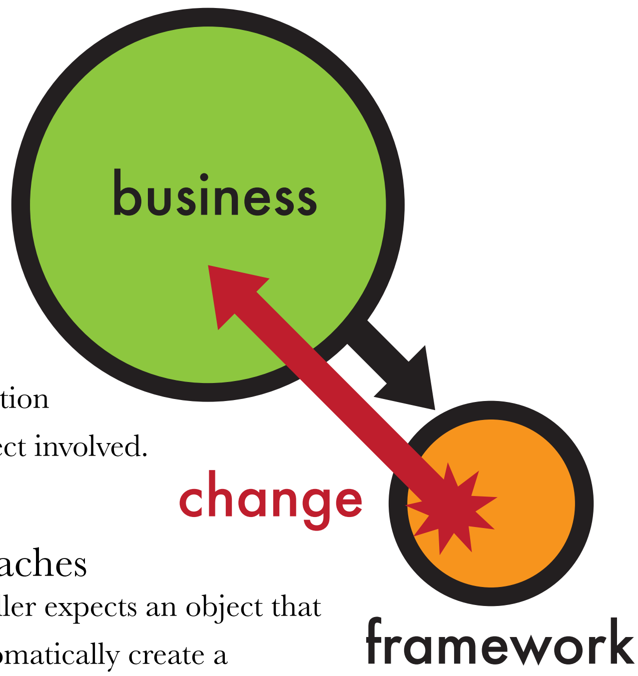
```
class SomeController < ActionController::Base
  def action
    respond_with BusinessClass.logic_method
  end
end
```

When looking at this action you might be left wondering "what happens with success or failure?" That question forces you to look into the `BusinessClass` for the answer. This is intentional.

Now the controller only needs to know two things. It knows about `BusinessClass` and it knows about `logic_method`. The decision of what to do based upon the outcome of that method is left up to the business logic in our application. The execution is left to our controller in `respond_with`.

Often dependency diagrams leave me scratching my head because they don't quite paint the clearest picture. There's something we've left out of our illustration of the relationship between framework and business models.

With a simple change to show the backward relationship we can see the effect of changes made to parts of the system.



Regardless of which part of our system is changing, we piece it together with relationships. When we manage dependencies and try to limit the disparate spread of responsibility, we are managing relationships. It helps us not to think about individual responsibilities alone, but how the execution of those responsibilities affects each object involved.

Alternate Dependency Approaches

By using `respond_with`, our controller expects an object that behaves like a Responder. Rails will automatically create a Responder for us and follow the conventions of going to an appropriate location or perhaps re-render a view with errors.

If the decision made by a Responder is important to our business process, then we may decide that we want to see that decision in plain view. Relying on Rails to create a default responder for us might be hiding important information. Once again we'd need to dig through documentation or framework code to put together several pieces of our puzzle before we had a complete understanding.

One option to handle the behavior is to evaluate the expectations of our framework and agree to the contract that it expects. Rails Responders have several useful features for managing our application flow and take care of everything we'd typically expect. All we need is an object that responds to `call`. This is a simple contract to follow and can be handled easily with a lambda.

In this case our framework, Rails, requires that we either set the responder in arguments:

```
class SomeController < ActionController::Base
  def action
    respond_with BusinessClass.logic_method,
                 :responder => lambda{ ... }
  end
end
```

Or we may set the responder in the controller:

```
class SomeController < ActionController::Base
  self.responder = lambda{ ... }

  def action
    respond_with BusinessClass.logic_method
  end
end
```

Using this feature of Rails makes sense when we're changing conventions. We could have our `BusinessClass` implement a `responder` method and return an object that behaves the way Rails expects. That would allow us to keep the details of a Responder in our `BusinessClass.`

```
class BusinessClass
  class BusinessResponder
    # ...
  end
end
```

This might help keep the concerns of our use case in one place. By doing this, however, we either give up any useful behavior from our framework, or we set our `BusinessResponder` to inherit from `ActionController::Responder` creating an explicit dependency on classes provided by our framework.

Changes to the framework might render our code useless (at least until we spend the time to clean up all our methods). Additionally any decision to make changes to the implementation of our business logic would carry the extra weight of how those decisions could affect our use of the framework.

It may be important, for example, to ensure that after a money transfer, the user is returned to a particular screen. If this is a part of our use case, it helps, of course, to track this decision with the other behavior related to our transfer.

Instead of implementing the interface that our framework expects, we can tell the framework related parts what to do. It's easy to invert the control over what should happen with Dependency Injection[33] where we pass an object to our business model that will carry out a task for handling part of our procedure.

```
class TransfersController < ApplicationController
  def create
    transfer = MoneyTransfer.new(params[:account_id],
                                 params[:destination_id],
                                 self)
    transfer.execute(params[:amount])
  end
end
```

Here we've introduced a `self` reference that we haven't discussed before. The controller in this program handles the request and response flow of the user's action. Our context can use this object to take commands for the response. When we set the responsible object this way, we can alter our transfer procedure to take next steps.

By using Dependency Injection we can keep the decision about success and failure in the business logic. Because the object we provide has it's own responsibilities outside of our context we keep the implementation of those resultant behaviors external as well. The decisions for how to respond, however, are relevant to the use case that our context represents.

By creating a `transfer` object with access to the current controller, our code is able to cover what to do next as a part of our business process. The result is that the object provided will be told what to do when the business rules execute.

---

[33] http://en.wikipedia.org/wiki/Dependency_injection

```ruby
class MoneyTransfer
   def initialize(source_id, destination_id, controller)
     @source = find_account(source_id)
     @destination = find_account(destination_id)
     assign_transferrer(@source)
     @controller = controller
   end

   def execute(amount)
      @source.transfer_to(@destination, amount.to_i,
         failure: ->{ @controller.display_error @source },
         success: ->{ @controller.go_to @source })
      @source
   end

   module Transferrer
      def transfer_to(destination, amount, callbacks)
         transaction do
           self.balance -= amount
           destination.balance += amount
           callbacks[:success].call
         rescue
           callbacks[:failure].call
         end
      end
   end
end
```

Now at the start of this transaction we clearly see what the behavior will be for failure and success. We've put together all the decisions regarding what should happen and we've kept out the implementation of how it should happen.

We haven't covered the tests for these changes yet. In all likelihood there are some things we've forgotten. We've even introduced a `transaction` block and a non-specific `rescue` to handle the failure. We'll look more closely at these things again, but what we can see is how these approaches can keep the concepts of our program together.

Sometimes we want to have Rails do the conventional thing. As our programs grow, however, we often find that we care more about this user flow than we first realized. Starting with the design of the user flow helps us keep a better eye on what is and isn't happening in the application. Keeping these decisions in code tied to objects that represent our business logic makes understanding the use case much easier; ease of communication with stakeholders follows.

Framework Glue

To tie our controller to the behavior we've created here, we'll need to adjust some things. In the `execute` method we tell the `controller` to `go_to` a location. Rails doesn't use this method so we'll need to implement it.

But first, why would we do this? If Rails already has methods for our controller that allow us to `redirect_to` another location or `render` a view, why bother creating some go-between?

Well, there are two reasons. The first is that we should use language that best represents our domain. The various members of our team will better understand what the application is doing when we use terms that aren't specific to our framework. The second reason is that using a different method name helps illustrate the first point. So maybe that's just one reason.

If we blindly rely on our framework, however, we'll allow the implementation details to creep into our domain modeling. If we have a `controller` object from Rails, we might rely too much on it's behavior and find that we have tightly coupled the behavior of our system to the implementation of our framework.

Let's look at a simple example:

```ruby
class BusinessClass
  def logic_method(controller)
    if true
      controller.redirect_to controller.some_special_path
    else
      controller.render :some_controller_action
    end
  end
end
```

This pseudo-code represents what we might find ourselves doing if we heavily rely on the `controller` object that we send. The `controller` is responsible for redirecting, providing a path for a location, and rendering another view marked by some symbol.

It's not so bad that we expect the controller to do all these things, but we expect it to do these things in a very specific way. Our `BusinessClass` maintains knowledge of not only it's own behavior, but that of the external object as well.

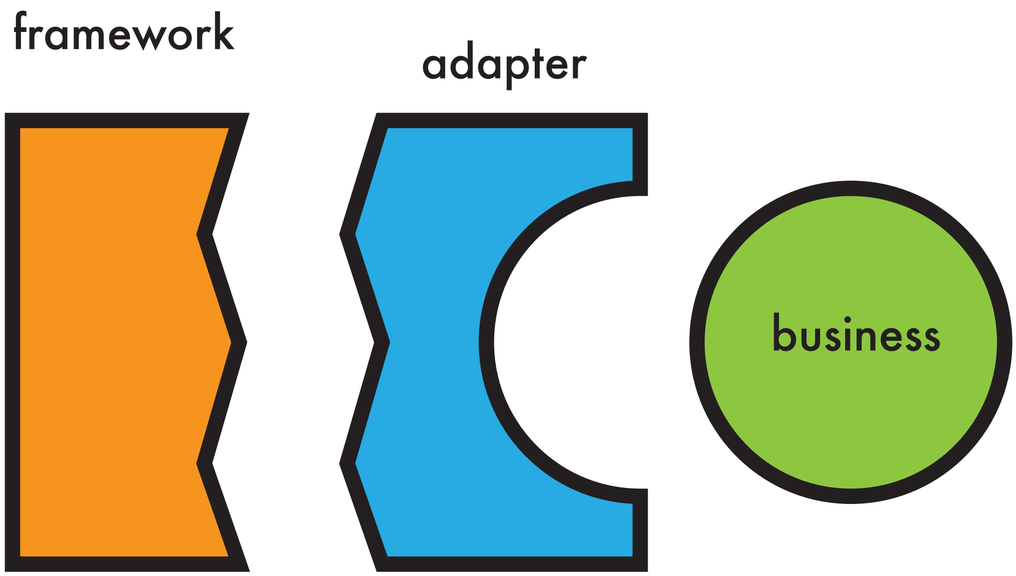
Certainly we can clean this code up with something like `Forwardable`.

```ruby
require ‘forwardable’
class BusinessClass
  extend Forwardable
  def_delegator :@controller, :redirect_to, :some_special_path,
                             :render
  def controller=(object)
    @controller = object
  end

  def logic_method
    if true
      redirect_to some_special_path
    else
      render :some_controller_action
    end
  end
end
```

This, however, only moves things around; it doesn't change the dependency. The class still maintains all the details of the `controller` object.

We've been looking at dependencies but the illustrations haven't been entirely accurate. Our framework is the classes that Rails provides. The controllers in a Rails application act as the glue between our framework and our business logic. In both the `SomeController` and `TransfersController` examples we've discussed the objects function as a proxy between the parts we care about and the parts we don't.



The framework provides behavior for us to handle the concerns of web requests and we may compose or inherit from those objects to adjust to our own needs. But these new objects that we create from the libraries we use in our framework work well as adapters and configuration. It's unlikely that our business logic specifically requires that we address HTTP requests. What's more likely is that the web and Rails provide an excellent delivery mechanism for our business logic.

With all that in mind, it makes communication clearer to focus on the domain first. Since we can view our Rails-based controllers as adapters between our framework and domain, we should adjust to our domain there as well.

```ruby
class TransfersController < ApplicationController
  def create
    # ...
  end

  private
  def go_to(resource_or_action)
    case resource_or_action
    when Symbol then
      render resource_or_action
    else
      redirect_to resource_or_action
    end
  end
end
```

Adding this bit of behavior to our framework glue allows our business logic to use terms that are relevant to our domain. We define those terms as methods and adapt them to our framework. With this approach we are more free to make changes to our framework up to and including changing it completely.

You may determine that this isn't necessary. Rails uses terminology and conventions that are very clear, but blindly accepting a dependency on the behaviors that a framework provides may lead to complicated responsibilities later.

You may find it convenient to create adapters for an interactive console to aid in debugging. If our business process is encapsulated in objects which tell the adapter what to do, all we'll need to provide is a adapter to our Rails console which responds to `go_to` or whatever other domain functions we choose.

East-oriented Code

Without even realizing it we can build systems composed in tightly coupled configurations. We model our applications with objects and then pass information and commands between them. But we often lose sight of exactly who should do what. Despite our best efforts to split apart behaviors into singly responsible objects as the building blocks of our program, the attributes of our objects leak out of tiny cracks in the mortar.

Much of our discussion of building an application has been about breaking apart behavior from data. We bring them together in a context representing our use, but when we do so, we need to consider how this affects our ability to keep our application flexible.

Our system may send a message to an object to mean "do this" and that object may rely on others to aid in the task by ordering "do that." Instead, however, we may choose to query information about objects and then perform some action.

Our objects send messages to move the program along, but this isn't a clear enough description to help us keep things going well. In Ruby, every method is a message being sent, so it's easy to misunderstand the meaning of *sending messages*.

Querying an object for it's values is where problems with coupling arise. We can send a message to command an object to perform, or we can send a message to get values. So what does this querying look like?

```ruby
class ConfirmationsController
  def confirm
    if current_user.admin?
      Notifier.send_admin_confirmation(current_user)
    else
      Notifier.send_confirmation(current_user)
    end
    redirect_to dashboard_url
  end
end
```

Why should the information about a user's status as an admin matter here? This `ConfirmationsController` knows about the user's status and which confirmation to send. We discussed the same in *Responding to Rails* where the `BusinessClass` had knowledge of several responsibilities of objects as well.

This approach has been called the *Feature Envy* smell[34]. When one object seems to care about the internal details (most often the data) of another object. We use our objects as building blocks of our application but code like this leads to cracks in the wall.

Tell, Don't Ask[35] is a strategy for sealing up the cracks between objects. If an OO system drives it's behavior by sending messages to and among objects, then the messages sent should be commands to perform actions. Much like the concept of objects as biological cells that Alan Kay envisioned, our objects inform each other of their needs by sending messages.

What could this be instead? If we tell an object to do something, we don't care about it being an admin or not.

---

[34] http://c2.com/cgi/wiki?FeatureEnvySmell

[35] http://pragprog.com/articles/tell-dont-ask

```
class ConfirmationsController
  def confirm
    current_user.send_confirmation
    redirect_to dashboard_url
  end
end

class User
  def send_confirmation
    if admin?
      Notifier.send_admin_confirmation
    else
      Notifier.send_confirmation
    end
  end
end
```

In this case, we've set the responsibility of the controller to tell the user what to do. It is the job of the user object to determine which confirmation to send. Whether that confirmation requires that the user be an admin is of no concern to the controller.

It's easy to confuse what it means to tell an object what to do with telling an object to provide information. The latter is just asking and projects the responsibility for what to do with the information in the same direction of the information itself.

Directional Programming

James Ladd's East-oriented Code solidifies this concept by helping us think about the direction of information in our programs.

> The structuring of code to an East orientation decreases coupling and the amount of code needed to be written, whilst increasing code clarity, cohesion and flexibility. It is easier to create a good design and structure by simply orienting it East.[36]

This refers to the directions taken by the flow of our code. If we apply a compass to our code, then we can compare the flow of information and execution to the directions of the compass. When we read a method and when it is run, the execution travels South. That is to say it moves downward in the definition. When we make assignments such as `x = 3` the value travels West.

Let's look at a more relevant example of a westward flow.

```
gender_greetings = {
  'male' => 'Mr.',
  'female' => 'Ms.',
  'other' => ''
}
greeting = %{Hello #{gender_greetings[user.gender]} #{user.name}}
```

In this case, our `greeting` message is composed from several values and returned. It's difficult to determine exactly where this procedure ought to live.

Code that travels East avoids return values. Juggling return values can often lead to complicated procedures which check on a value and branch on case or `if`/`else` statements. By focusing on sending messages and traveling eastward with our code, we are forced to consider the role of polymorphism and we are encouraged to keep our objects small.

Here's a simple example of sending the program flow eastward. Let's take a `Question` class and give it the ability to print itself on some receipt.

---

[36] http://jamesladdcode.com/?p=12

```ruby
class Question
  def initialize(text)
    @text = text
  end
  def print_on(receipt)
    receipt.print_title(@text)
    receipt.print_value(answer)
  end
  def answer
    %{...}
  end
end
```

Here we've created a `print_on` method that takes an object for an argument that must implement the `print_title` and `print_value` methods. We can then provide any object that implements those methods as the `receipt`.

```
require 'erb'
class Template
  def print_title(text)
    @title = text
  end
  def print_value(text)
    @value = text
  end
  attr_reader :title, :value

  def to_s
    erb.result(binding)
  end

  private
  def erb
    ERB.new(%{-- #{title} --
  #{value}
})
  end
end
```

Then it's only a matter of tying the two objects together:

```
question = Question.new(%{What is East-oriented Code?})
template = Template.new
question.print_on(template)
puts template
```

We can see that the responsibility of printing values is done in the template. We can provide alternative templates for our output and the details of how to display the values are left entirely up to them:

```
class QuickOut
  def puts(text)
    STDOUT.puts(text)
  end
  alias_method :print_title, :puts
  alias_method :print_value, :puts
end
question.print_on(QuickOut.new)
```

Because we've implemented it this way, we can more easily introduce alternatives:

```
require 'kramdown'
class MarkdownTemplate < Template
  def to_s
    Kramdown::Document.new(erb).to_html
  end
  private
  def erb
    ERB.new(%{
# #{title}

--------------

#{value}
})
  end
end
```

Regardless of our template, the procedure remains the same: `question.print_on(template)`. And in telling the `question` to print on the `template`, the `question` tells the `template` to print the `question` `title` and `answer`.

Rules To Code By

Looking at these examples, we can see that we're following the Tell, Don't Ask principle. We're making use of polymorphism[37] to handle alternative cases where the

[37] http://en.wikipedia.org/wiki/Polymorphism_(computer_science)

exact template we use for this feature isn't important. As long as we can tell an object to perform an action and it has implemented the methods needed, our code works.

Being conscious of our approach can be difficult sometimes. For example, often Ruby programmers consider explicit `return` statements to be a code smell. The language provides implicit returns so that we can leave out the unnecessary boilerplate of specifying what we want to return. A method such as the following returns the value from the expression:

```
class Template
  def print_title(text)
    @title = text
  end
end
template = Template.new
template.print_title('hello') #=> 'hello'
```

That Ruby provides this feature, allows us to more easily take those values and do something with them. That is, we may more easily Ask, and not Tell. Or, we may more easily create cracks in our program where the responsibilities leak out and our procedures begin to mix behaviors in a Westward flow.

Ruby has an advantage over languages that require explicit `return` statements. But when we attempt to ensure that our program flow travels eastward, we would do well to take control over what we do return.

```
class Template
  def print_title(text)
    @title = text
    self
  end
end
template = Template.new
template.print_title('hello') #=> template
```

By returning `self` in our method, we prevent external objects from using information internal to this `Template`. External objects such as the `question` from our example are unable to do anything other than send a command.

This approach does add the benefit that, if we like, we may chain our methods:

```
class Question
  def print_on(receipt)
    receipt.print_title(@title).print_value(answer)
  end
end
```

By forcing our messages to tell, and not ask, it also serves to help protect us against violating the Law of Demeter[38]. The Law of Demeter is a guideline to help our programs keep responsibilities local to an object.

Let's imagine a larger example. With a person, having its own details including an address, we can see how our code can leak knowledge of peripheral objects.

```
class Person < ActiveRecord::Base
  has_one :address
  # with a name attribute
end
class Address < ActiveRecord::Base
  # with number, street, city, province, and postal_code
end
```

Our template can be designed to accept a `person` object and understand information about how to query details about it and its address:

[38] http://en.wikipedia.org/wiki/Law_of_Demeter

```
class WelcomeMessage
  attr_reader :person
  def initialize(person)
    @person = person
  end

  def to_s
  %{
    Welcome, #{person.name}!

    Thanks for signing up.
    We have your address as:
    #{person.address.number} #{person.address.street}
    #{person.address.city}, #{person.address.province}
    #{person.address.postal_code}
  }
  end
```

Here we can plainly see how much knowledge of `person` and `address` are wrapped up inside of `WelcomeMessage`. What would happen if we were to change the implementation of either `address` or `person`? Errors.

We can, of course, reimplement this to initialize with a `person` and an `address` to break up the responsibility chaining of those queries like `person.address.number`, but why add even more for this `WelcomeMessage` class to handle?

But what if we orient our code Eastward? Our `Person` class (in this case) would need some knowledge of how to interact with the template.

```
class Person < ActiveRecord::Base
  has_one :address

  def print_on(template)
    template.print_name(name)
    address.print_on(template)
  end
end
```

And our Address:

```
class Address < ActiveRecord::Base
  def to_s
    %{#{number} #{street}
#{city}, #{province} #{postal_code}
}
  end
  def print_on(template)
    template.print_address(to_s)
  end
end
```

Then our template becomes far simpler:

```
class WelcomeMessage
  def print_name(text)
    @name = text
  end
  def print_address(text)
    @address = text
  end
  def to_s
  %{
    Welcome, #{name}!

    Thanks for signing up.
    We have your address as:
    #{address}
  }
  end
end
```

This small example shows how we can completely remove knowledge of a `person` object and the understanding of what `address` means has been simplified to only a value.

Changes to either the `Person` or `Address` classes of objects will no longer cascade through our `WelcomeMessage` implementation. This case, however, may seem like more code initially, but we've gained a significant amount of flexibility.

"Wait! Wait!" yells our client. "Why are we doing physical address!? I said email address!"

Ah. No problem. No change to our template needed. We'll just change how we interact with the template:

```
class Person
  def print_on(template)
    template.print_name(name)
    template.print_address(email)
  end
end
```

Eastward Thinking

The names we choose for our methods help to communicate our purpose. From the outside a method that describes an action helps us to understand why it exists and how we should expect it to behave.

When reviewing the implementation of a method such as `print_name` you may raise an eyebrow to discover that it is merely setting an instance variable: `@name = text`. So *why*, you might ask, would you not just rely on a setter method such as `name=`?

A setter, or accessor pair, implies that you are working with a data value of an object. External objects don't really need to know the details of data internal to their collaborator. Were we to take cues from the implementation, we might find ourselves implementing the Feature Envy smell again. It's better to consider the commands we send and we can see the value in the `QuickOut` template which didn't actually set any values.

No Return Values?

We've avoided writing code that relies on return values. Mostly.

There are, of course, places where return values are helpful. A factory which creates objects for us, for example, wouldn't be of much use without returning the objects we need. But the objects we create with factories should do their own jobs and be concerned with their own data.

Even in rendering our `ERB` or `Kramdown` templates we've seen the need to implement an *ask* policy where the template content pulls information from the binding of the template object. In a framework like Rack[39] which Rails uses, there is no option to print onto a response object. Our examples used the `to_s` return value to simplify the example. By structuring our code without return values, or with as few as possible, we've pushed the responsibilities away from one object and into another.

This helps us to manage encapsulation; more so, it enforces it. Encapsulation is often referred to as "information hiding" and indeed eastward facing code flow insists that behaviors be hidden. Avoiding return values prevents us from leaking information from objects.

Functional Principles

Uncle Bob Martin describes functional programming as "programming without assignment statements"[40]. That, he admits, is an over simplification but we can see the value of avoiding assignments here. Our eastward focused code avoids assignments and helps us to focus on telling objects to do what we need.

East-oriented code helps us to avoid mutating objects. A common pitfall of programming is weed-like procedures that grow beyond your ability to understand them. This often is caused by setting flags at the beginning of an algorithm to check them later, or nesting `if` and `case` statements for continual processing in one method.

Pointing your program flow eastward doesn't necessarily mean avoiding all mutation of object state, but it does mean that the behavior and responsibilities of your code are more predictable. This predictability of code comes from the boundaries made for handling responsibilities. An East-oriented approach to your objects leaves you with only one option for organizing data and its related behaviors. This boundary helps to maintain and enforce encapsulation which in turn ensures that we get what we expect from organizing our code into classes.

Once the boundary is set for managing behaviors between objects by using an East-oriented approach, it's easier to change not only the internal implementation, but the way in which you return the object. If your code relies on structures like arrays, or hashes, for

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[39] http://rack.github.com

[40] http://blog.8thlight.com/uncle-bob/2012/12/22/FPBE1-Whats-it-all-about.html

example, an East-oriented approach falls in line with a functional style making it easy to return a new array of data rather than altering the one provided.

As we saw in the start of this chapter, it was far easier to understand and will be easier to change code like that we found in the example ConfirmationsController. The boundaries in this code do not clearly break between objects and their responsibilities:

```
class ConfirmationsController
  def confirm
    if current_user.admin?
      Notifier.send_admin_confirmation(current_user)
    else
      Notifier.send_confirmation(current_user)
    end
    redirect_to dashboard_url
  end
end
```

But the alternative makes for a structure which is much easier to extend and much easier to understand:

```
class ConfirmationsController
  def confirm
    current_user.send_confirmation
    redirect_to dashboard_url
  end
end

class User
  def send_confirmation
    if admin?
      Notifier.send_admin_confirmation
    else
      Notifier.send_confirmation
    end
  end
end
```

Eastward Flow and Contextual Separation

Boundaries in our code help us maintain responsibilities in the proper objects. Contexts allow us to do the same by encapsulating the roles and responsibilities of our objects. Roles are an internal implementation detail of Context objects where leaking those details to the outside world explode the possible branching opportunities in code which accesses the details.

East-orientation reduces complexity by removing branching opportunities. Contextual separation reduces complexity by removing opportunities to mingle independent parts of a system. Protecting encapsulation in OOP ensures that our implementation is protected from external interference. Any time we see a Westward flow of information, it's likely a signal of leaking implementation details.

Understanding Context

At the end of a long day I go home to my family. When I arrive, I may have only minutes ago been evaluating the business value of a new feature of my application, but now I'm pretending to be Spiderman. My children care little for my ability to estimate effort to implement features and refactor code libraries. At that moment, I care little for it too.

The things that we do depend entirely upon context. We have an awareness of the world around us and we act accordingly. Any particular task that needs doing isn't relevant everywhere. Any particular skill that each of us has will be used only where it makes sense. For this reason, I'll leave out from this discussion stories of my prowess as Spiderman.

Context is a frame of reference. The value of putting something into the appropriate context is just as much in gathering information as it is exclusion of information. In our programs we can organize our code based up on the concepts that they represent. By lumping together unrelated concepts, or what feels to be too many concepts in one, we'll make our code more difficult to understand. Putting things together implies that they be understood together and separating them implies that they be understood separately.

Never is the value of excluding information more obvious than in an attempt to understand unfamiliar things. Often this is the case with a large codebase. The realization may come when we sit down to share our knowledge and experience with a new team member and our conversation begins with a summary of the system. We dive into our code or into our tests to examine how it all comes together.

Often as we attempt to explain the uses of our software we walk though code scattered about the system and explain how it comes together. We sit with a partner and point out classes that are valuable to this or that procedure. Where our responsibilities have grown too large, we may find ourselves waving our hands to say, "ignore that for now." Moving forward, our partner keeps a mental list of both what matters and what doesn't for a particular feature.

Despite our need for context, we often tackle our programs by the pieces rather than the whole. We take things out of context and assume a future need for reuse. Our individual classes sit in our file system at the ready for whenever we need them.

This is a perfectly natural way to address our needs. It's important to understand individual parts of our system and how they may be used together to create something new. But this breaking apart of our application into finer details is only one aspect of creating an application. The coming together is a contextualization of those features and is an important part of understanding our system.

Psychologist Iain McGilchrist described the way our brains work in *The Master and His Emissary*:

> One of the more durable generalisations of the hemispheres has been the finding that the left hemisphere tends to deal more with pieces of information in isolation, and the right hemisphere with the entity as a whole[41]

These two views of our world are wired into our brains where we understand things both individually and altogether. Regardless of what we do, we will use these two perspectives to understand. It's important, then, to harness this feature of our brains and to consider the context in which we work.

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[41] McGilchrist, Iain. The Master and His Emissary. New Haven: Yale University Press, 2009.

Systems and Responsibilities

A good example of how we use context to understand and manage concepts in our code is using a data clump[42]. A data clump is a collection of two or more bits of information that are consistently used together. You'll find that your data loses its meaning when you remove items from the clump. Date ranges are simple examples of how a data clump puts necessary information into context.

An example of this is to find out if a question was asked between today and one month ago. If our `Question` class implements a query method for this:

```
class Question
  def asked_within?(start_date, end_date)
    (start_date..end_date).cover?(self.asked_date)
  end
end
```

Then we can pass in our desired dates to get the answer:

```
# using ActiveSupport
start_date = 1.month.ago
end_date = Time.now
question.asked_within?(start_date, end_date)
```

Discovering whether a question is within this time frame always requires both a start and end date. This is an indication that we can only understand the feature and indeed only implement it when we have this data clump. To better encapsulate the behavior of these values, we can create a class to manage initializing objects that represent them.

```
DateRange = Struct.new(:start, :end_date)
last_month = DateRange.new(1.month.ago, Time.now)
question.asked_within?(last_month)
```

We can then change our `Question` class to instead take a date range object for the `asked_within?` method, but the `question`'s responsibilities have grown a bit here. A question doesn't have anything to do with comparing dates, so we can move the control of that information into the data clump that represents them.

[42] http://martinfowler.com/bliki/DataClump.html

```
DateRange = Struct.new(:start, :end_date) do
  def contains?(date)
    (start..end_date).cover?(date)
  end
end
```

Struct.new returns a class instance. Inheriting from the result of a new Struct creates an anonymous class in the ancestors of your created class:

[DateRange, #<Class:0x007f885d0be518>, Struct, ...]

Instead of "class DateRange < Struct.new; end" use "DateRange = Struct.new" and avoid an anonymous class in the ancestors:

[DateRange, Struct, ...]

Now, instead of the question managing its date comparison, the date range can do the work.

```
last_month.contains?(question.date_asked)
```

We've veered a bit from the direction of our discussion about context, but this code example shows us how we can use the right hemisphere of our brains to more easily understand an idea. By analyzing the individual parts of this date comparison we have to juggle a bit more in our heads. Considering a range as an individual thing rather than a collection of parts is simpler and we tend not to think of every individual day within a month when doing a mental comparison. A date range is a small system of interacting parts that we better understand as a broader context.

This example shows us the value not only of separating responsibilities, but of bringing objects together. We get more value by putting details into context than we would have if they remained separate.

Grouping Features

A high-level view of a system can help us quickly understand a feature without diving into the details of how it works. We assume that implementation details exist and we assume that they work. This is what makes typical Rails controllers so easy to understand. Grouping CRUD behavior (Create, Retrieve, Update and Delete) together in a controller reflects our understanding of the creation, retrieval, updating, and deleting of data. That is, of course, reflected in the standard methods (new, create, index, show, update, and destroy) where features of a process are grouped by their common relationship to a data resource.

It is an easy task for our right hemisphere to manage the understanding of a typical Rails controller. We don't dive into the individual details of each method on the controller to understand it. Our brains simply lump together the process of input and output from the database.

This CRUD view of our program works well when our process is simple. The features of our system, however, are not always related to simple input and output from a database. With too much thinking in that regard we may find ourselves solving our business problems around database access rather than around the procedures we need.

Our frame of reference is an essential part of our understanding of the world around us. Likewise, in the worlds we create with our programs, our frame of reference matters. What we can learn from how our right and left hemispheres work is the importance of both a higher level frame of reference and a deeper understanding of the details.

Context in our DCI architecture shows us this higher level frame of reference. We read in our code the interactions of our objects and see the environment in which they act. The relationships between our objects are laid out before us in a way that best describes our understanding of a business process.

Being Concerned

A common practice among developers using Rails is to break related features apart into modules and share behavior in relevant classes. A simple example might look like this:

```
class User < ActiveRecord::Base
  include Commentable
  include Taggable
  include Profiled
  include Expert

  # other methods...
end
```

This approach organizes methods into different namespaces based upon their use which can be very helpful when a class is hundreds or thousands of lines long. ActiveSupport provides some syntactic sugar to make writing code to add behavior from these modules much more concise.

Where a standard module might look like this:

```
module Commentable
  def self.included(base)
    base.class_eval{
      has_many :comments
    }
  end

  def add_comment(comment)
    comments << comment
  end
end
```

By using ActiveSupport::Concern, we have something a bit simpler:

```
module Commentable
  include ActiveSupport::Concern

  included do
    has_many :comments
  end

  def add_comment(comment)
    comments << comment
  end
end
```

As a word of warning however, the ActiveSupport::Concern library alters the method signature of the core Ruby Module method "included" to accept a module reference and a block (instead of only the module reference). This may lead to surprising behavior when used with other modules written expecting the original.

This example is very small but illustrates how much simpler it is to define a block to execute when a module is included in another. Avoiding the noise of a local `base` variable and `class_eval` makes the code eminently more readable.

If we use a library like this or if we use plain old modules, our approach still would be tying our code to the notion that the classes of the system are the focus of our program rather than the objects at runtime. While this approach is somewhat convenient from a standpoint of organization of code, the classes which initialize our objects are still just as large. Module inclusion *is* inheritance.

When we discuss our goals and describe what the application does, we frame our conversations around the way it is used. We understand the procedures involved and we think in terms of a particular scenario. Objects in the system have certain responsibilities in each of these scenarios yet the same objects may perform other duties in alternate scenarios. Orally describing the structure of our program often leads us to realize the different responsibilities and to discover the pain points in our architecture.

The ideas in DCI challenge us to write our code in a way that reflects our behavior as stakeholders of the system. Most often, I've found, as programmers we isolate aspects of the system to track down a bug. We ask ourselves or our users to reestablish the context around the behavior of the system so that we may better understand it. Dutifully, we turn to our tests to reestablish the context and create test code to ensure that the bug, or circumstances which lead to the bug, never occurs in the future.

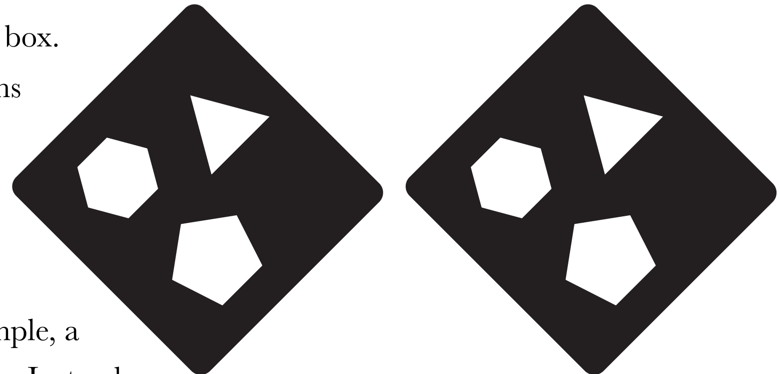
In 1988, Edsger Dijkstra commented on the famous notion that tests indicate the presence of bugs but not their absence:

> It is now two decades since it was pointed out that program testing may convincingly demonstrate the presence of bugs, but can never demonstrate their absence. After quoting this well-publicized remark devoutly, the software engineer returns to the order of the day and continues to refine his testing strategies, just like the alchemist of yore, who continued to refine his chrysocosmic purifications.[43]

Moving our behaviors into modules only serves to organize them based upon classes and namespaces but doesn't give us better insight into the interactions of objects in the system. What a context in our code provides for us is an environment that encapsulates the interactions we expect to see. We endeavor to create working programs and our effort is best placed on activities which lead to clear understanding of our program's behavior so we may avoid bugs altogether.

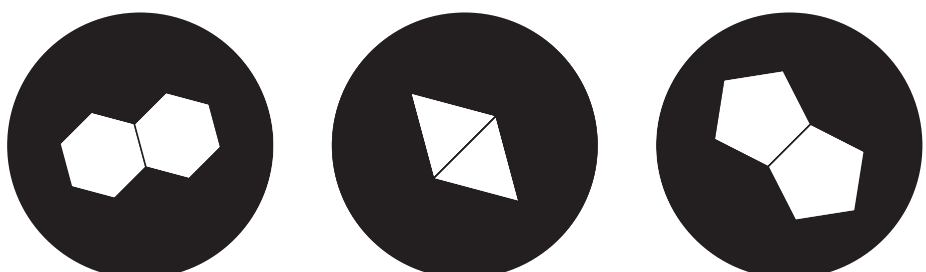
[43] http://www.cs.utexas.edu/users/EWD/ewd10xx/EWD1036.PDF

As a visual expression of the organizational approach using modules, I envision each class as a box. We can pull instances of each class from it's respective box. These class boxes also contains all behaviors required for the program where each has its own unique shape. When we pull a new instance out we expect to get, for example, a `Commentable` shaped instance. Instead, because our box contains every type of behavior, what we get is an instance with every shape. We see every possible behavior for all unrelated uses of the object.



While we may be able to ignore the shapes on the instance that we don't want and go forward using it as we desire, we aren't left with an understanding of the system as a whole.

Instead, I visualize the boxes being mostly empty of behavior. And I see the uses of the system as buckets containing the relevant behaviors. Inside each of our buckets is the relevant shapes for their use. When our objects need to perform some action, we pull them from the appropriate boxes, and place them into the bucket we want to use. Related shapes and behaviors remain close and unrelated are kept elsewhere. This gives me a mental picture of the system in action, rather than a static view of all possibilities at once.



Encapsulating Environments

On some level, objects in our system have an awareness of their environments. Constants and global variables are always accessible. Inside our instances we, of course, have access to our instance variables and methods. But there is a gap here. Global knowledge and instance-level knowledge are not matched with a local environment. Until the appearance of DCI there hasn't been much that helps us encapsulate the interactions of individual objects. Let's take a look at how we can implement an environment for just the handful of objects we need, review the benefits, and the limitations.

In our context object from previous chapters we defined behaviors as modules. We didn't, however, protect them from external systems or objects using them. Ruby allows us to make constants private:

```
class ExpertQuestioning
  module Questioner; end
  module Expert; end

  private_constant :Questioner, :Expert
end
```

By setting the role modules to private constants, they become only available to methods inside the `ExpertQuestioning` context. These behaviors are hidden from access: encapsulated within the context. Accessing `ExpertQuestioning::Questioner` from outside will raise an exception.

Often, most Ruby programmers avoid restricting access to methods and modules like this. So the thought goes: "If I want to use a bit of existing code, why bother stopping me from doing so?"

Allowing access to all of these behaviors makes a lot of sense when the architecture of your system allows for the use of any bit of code anywhere and everywhere. But we've gone in the other direction. We're keeping the behaviors only where they are required and any desire to access to them should cause us to rethink our use cases.

Still, while this restriction of private constants might provide a useful pause when we see an error, there's no requirement that we do this. You and your team may find that you're capable of avoiding access to these roles in your own applications, but be sure to consider restricting access in libraries which you create and make available to external systems.

This restriction does, however, help us to consider the locality of our features. The code and the behavior it implements is local to its use. Ensuring that these behaviors are only used inside the context allows us to tie the code to its reason for existence.

Object Awareness

Encapsulating role modules is not the only part of our creating our local environment. The objects inside our context are aware of globals and instance information, but they're still missing an awareness of each other. A person answering a question should certainly be aware that there is someone asking.

Because a local environment like this does not exist as a feature of Ruby itself, I'll describe the ways in which I have created these environments in my own projects. Over time, I found patterns and worked to solve the problems of making this easy for myself. From that work came two libraries: *Casting*[44] and *Surrounded*[45]. For now, let's keep the discussion relevant to creating these environments and review how Surrounded helps solve some of those problems.

When creating a context object, we initialize with the objects we need to play the roles inside. When this occurs, we want our role players to be aware of each other. Their awareness simplifies the code by allowing our role methods to focus on the procedures we need and rely on the context to provide the relevant objects. Here's what a role method looks like without this:

```
class ExpertQuestioning
  module Expert
    def answer_question(question, questioner)
      question.add_answer("Sell all your stocks!", :from => self)
      questioner.notify_answered(question)
    end
  end
end
```

The `answer_question` method in this instance requires two arguments which are already available and relevant to the context. Our expert's job is to interact with these objects, so why not create an environment where it knows they exist. Here's what this could look like with the assumption that they do exist:

---

[44] https://rubygems.org/gems/casting

[45] http://rubygems.org/gems/surrounded

```
class ExpertQuestioning
  module Expert
    def answer_question
      question.add_answer("Sell all your stocks!", :from => self)
      questioner.notify_answered(question)
    end
  end
end
```

Note here that the `answer_question` method no longer has arguments. The expert will receive knowledge about these other objects from its surroundings. This frees us to focus on the procedures of and changes to our use cases. Changes to the use case and the required objects no longer mean reworking methods from other roles to ensure that our arguments match up. We're able to think in terms of an object telling another to perform an action. We also avoid creating brittle tests which might lock us into testing method implementations rather than testing the expected behavior of our context.

So, given that this is not a language feature, how can we do this?

My approach has been to create an object map, stored in the context, which ties the objects to their roles and behaviors. Each object given to the context as a role player will have access to the map and be able to send messages to other objects in the map. This collection of role players handles the encapsulation for the role player relationships. Objects external to the context will not be in the map and will not be able to *implicitly* access the objects inside. To avoid specific implementation details which may change over time, let's assume that the map is implemented as a hash, storing role names as keys and objects and behaviors as the values.

In a bare implementation, it might look something like this:

```
class ExpertQuestioning
  def initialize(questioner, question)
    @role_map = {}
    @role_map[:questioner] = questioner.extend(Questioner)
    @role_map[:question] = question
  end
end
```

That takes care of the storage of role players. There's a bit left out, however. The objects don't have a way to know about each other. We need to add a way for our role players to understand their environment and to access each other.

We can step into the classes of our objects and provide behavior to have this context awareness. We won't want to add it dynamically like we do our roles because our objects should always be aware of their environments. So here's how this might work:

```
module Surrounded
  def context=(context)
    @context = context
  end

  def context
    @context
  end

  def method_missing(method_name, *args, &block)
    if @context && @context.roles_include?(method_name)
      @context.role(method_name)
    else
      super
    end
  end
end

class User
  include Surrounded
end
```

This implementation is more simplistic than that which Surrounded provides, but it's very similar to how it works. All instances of `User` will have these new methods and will be able to access other objects inside this instance's current context.

While this isn't perfect, it opens up our code to be looser with individual method requirements and puts the responsibility of maintaining required objects into our context. I've added to Surrounded shortcuts which remove some of the common aspects of initializing and configuring contexts. Here's what my contexts end up looking like:

```ruby
class ExpertQuestioning
  extend Surrounded::Context

  initialize(:questioner, :question)

  module Questioner
    def answer_question
      question.add_answer("Sell all your stocks!", :from => self)
      questioner.notify_answered(question)
    end
    # other methods...
  end
end
```

The class method `initialize` is a convenience method for defining common functionality. Using this, it will define an instance method `initialize` to map the arguments to the named roles and apply their behaviors. It will additionally look for constants which are the capitalized version of the role name and apply them to the given object. This common approach to role assignment appeared but the `initialize` class method easily handles these needs and keeps me focused on the parts that matter.

Should we need to break out of this role initialization pattern, we can use the `map_roles` method to take care of assigning objects to their roles while we do the extra work we might need:

```ruby
class ExpertQuestioning
  extend Surrounded::Context

  def initialize(questioner, question)
    map_roles([[:questioner, questioner],[:question, question]])
    @special_value = #... do whatever you need
  end

  module Questioner; end
end
```

We're veering off into discussion of implementation of a particular library, but the value here is to view this as an example of removing information that isn't of immediate importance to our use case. Good frameworks, libraries, and applications will help you where you need their features and get out of your way where you don't. If you find yourself fighting against them, that may be an indication that it's the wrong solution. Let's get back to building our environment.

Restricting Access

The objects inside the context should be able to implicitly access each other and objects outside should not. With the implementation we created here, we don't have that restriction. But Ruby doesn't provide it either. Here's how Surrounded solves it.

For every object initialized from a class that includes `Surrounded`, the instances will use `method_missing` to find other objects in its context.

```
def method_missing(meth, *args, &block)
  context.role?(meth){} || super
end
```

This is similar to the pseudo-code we saw above, but there's one small difference. We try to first get the role of the given method name from the context using the context's `role?` method. Notice that an empty block `{}` is passed to this method along with the instance's missing method name. The context uses this block to ensure that the object accessing the role is also an object playing a role in the context. In other words, if an object outside the context attempts to tell objects inside the context to perform some action, it will fail. Here's how that context `role?` method works:

```
def role?(name, &block)
  return false unless role_map.role?(name)
  accessor = eval('self', block.binding)
  role_map.role_player?(accessor) && role_map.assigned_player(name)
end
```

The first step is to return false if the given name is not a known role. This leads the `method_missing` in the calling object to jump to it's `super` implementation and continue. If the given name is a known role, it evaluates `'self'` with the binding of the provided block. This is what allows us to check that the calling object is a part of this context. Only role players, objects inside the context, may access other objects in the same context.

These are implementation details of how Surrounded is built, but it highlights the work that needs to be done in order for Ruby to support the local environment that we find in context objects from DCI. By creating a structure of objects in this manner, we're free to make changes to the environments and alter the procedures we need without needing to address changes to method signatures. The relevant details required for our system of interacting objects are kept together in a cohesive unit.

Here's the context code again:

```
class ExpertQuestioning
  extend Surrounded::Context

  initialize(:questioner, :question)

  module Questioner
    def answer_question
      question.add_answer("Sell all your stocks!", :from => self)
      questioner.notify_answered(question)
    end
  end
end
```

Triggering Use Cases

The last part of building these local environments is to be able to initiate some activity. It's not enough to merely put it together, we need to tell it to do something.

We've done this before. In our `MoneyTransfer` example, we created an `execute` method, and our `ExpertQuestioning` had its `start` and `finish` methods. These are the triggers for our use cases and these triggers are written the language we use to describe what initiates our use case.

One optimization you might seek is to choose use common method name to attempt to make implementing your contexts easier. I advise against this.

While the convenience of always knowing that you'll use the method `call`, `execute`, `perform`, or some other name is useful for making a decision and moving ahead with more important code, the names you use are more important in communicating the purpose of your application. In creating our programs, we want to use language that describes its use. Our contexts encapsulate the runtime relationships of objects in the system and the words we use to describe triggering their actions serve to communicate purpose. Your contexts will likely have multiple triggers for all the related scenarios, so favor clarity of intent over convention.

This discussion of triggers is relevant whether you'll be using Surrounded or creating your own support for contexts. In the Surrounded library, the `trigger` class method creates a public instance method for the given name, but it ensures that the role players first gain their role methods, perform their interactions, and then lose their role methods.

Here's what our context code looks like:

```
class ExpertQuestioning
  extend Surrounded::Context

  initialize(:questioner, :question)

  trigger :start do
    questioner.ask_question
  end

  module Questioner
    def answer_question
      question.add_answer("Sell all your stocks!", :from => self)
      questioner.notify_answered(question)
    end
  end
end
```

Inheritance, Forwarding and Delegation

Important, in the design of OO systems, is the composition of your objects. The way the system is structured to perform actions and share behavior will affect the way you use it and understand it. Subsequently the structure will also affect the way bugs are introduced, so knowing the ins and outs of different techniques as well as what Ruby can and can't do for you is important.

Simplicity of Inheritance

Inheritance is simple to implement and understand. It's easy to think about inheritance as nested categories. A category has sub-categories and can have a parent category. Every object has the same attributes and behaviors of its parent.

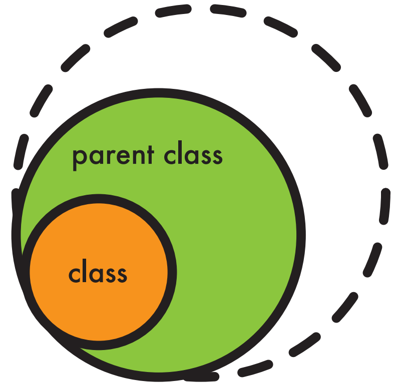
Inheriting features from a parent class is often how we think about our world:

- A Person can walk, talk, eat and many other things.
- A Doctor is a Person, but also understands anatomy and physiology of the human body.

• A Cardiologist is a Doctor who has special abilities and understanding of heart anatomy and physiology.

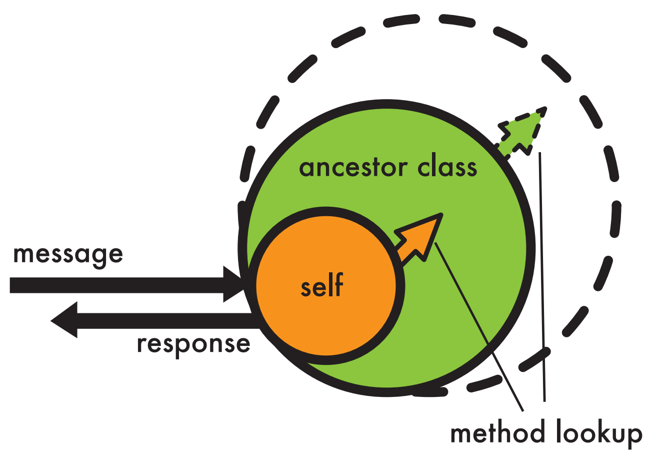
In these three simple examples, we see exactly how easy it is to begin thinking about hierarchy. But if we were to make a program assisting cardiologists, would we first spend our time describing a person? Probably not.

We often think about our world with inheritance in mind. So, when we turn to write our software, we expect the same. When defining what things in our system *are*, inheritance helps us to form a mental model of our categorization of them.



With class inheritance, however, our objects get locked into the implementation defined in their class, or the class' superclass, or even further up the inheritance tree. That doesn't mean that we can't alter the behavior where we need but splitting implementation details among multiple classes may split our focus for what is decidedly related behavior.

In a typical Class-oriented program, an object must find its behavior from its parent or any of its ancestor classes. This approach guides programmers on the path of thinking about broad and static categorization of objects. If an object's behavior is determined by the methods found in its class ancestry, then the behavior must be put in the ancestry... or so we have come to think.



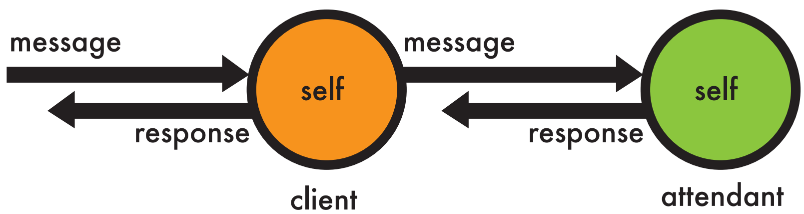
Our systems, however, are a complex network of interacting objects where behavior and responsibilities can be implemented by interaction between objects. Our vision of the system is objects sending messages, so more objects handling more specific aspects fits well with our mental model.

Composition and Forwarding

Rather than lock down the behavior sharing to a single path, we can share code among objects with composition. We can make more objects which handle behavior individually.

Typically this means that we build our objects to call methods or forward certain messages to additional objects which contain more or better information about handling a message. We can refer to the message receiver as the **client** because it will ask another object to handle the behavior much like a client application would send requests to a server.

The other object is often referred to as the **delegate**, but for now let's use the term **attendant**. The attendant will tend to the needs of the client.



The client and attendant are entirely separate objects each with their own identity and state which affects the way the message is handled. The client responds to a message not by performing an algorithm itself, but by passing along the response from an attendant object which handled the message. The attendant might perform an algorithm or it may also forward the message on to its own attendant.

This object collaboration is implemented with one object maintaining an internal reference to another object to forward complete responsibility for responding to a message. Let's look at a simple example of message forwarding with the Forwardable library from Ruby's standard library.

```
require 'forwardable'
class Calculator
  extend Forwardable
  def initialize(account)
    @account = account
  end
  def_delegators :@account, :balance, :balance_on_date
  # or
  delegate [:balance, :balance_on_date] => :@account

  def change_from_date(date)
    balance - balance_on_date(date)
  end
end
account = Account.find(1)
calculator = Calculator.new(account)
```

Here, a `Calculator` will be initialized with an `account` object. When a `calculator` receives the messages `:balance` or `:balance_on_date`, they will be forwarded to its `@account` reference.

The `calculator` acts as a **proxy** for additional behavior and forwards messages to our attendant. The implementation of handling the behavior is managed internally to the object. An attendant object may ultimately handle the response, but to any programs relying on an account object, the interface remains on the account object.

Also in the standard library, we have Delegate which allows the same message forwarding semantics as Forwardable. Let's look at a short example where

```
require 'delegate'
class Calculator < SimpleDelegator
  def change_from_date(date)
    balance - balance_on_date(date)
  end
end
account = Account.find(1)
calculator = Calculator.new(account)
```

Rails has its own way of handling what it calls delegation as well.

```ruby
class Calculator
  delegate :balance, :balance_on_date, :to => :@account
  def initialize(account)
    @account = account
  end
  def change_from_date(date)
    balance - balance_on_date(date)
  end
end
account = Account.find(1)
calculator = Calculator.new(account)
```

The Rails provided option also gives us a way to prefix our messages before they are forwarded. The Rails `delegate` method takes a `:prefix` argument which allows us to alter our method names with a default or specified prefix, turning `balance` to `account_balance`. This helps us to choose names that will give us clues about their behavior as well as give some way to differentiate method calls such as `checking_account_balance` and `savings_account_balance` when forwarding messages to objects with similar interfaces.

There are many ways we can choose to use these features to organize our objects' behavior. The Delegate library also offers a `DelegateClass()` constructor method to control forwarding of messages for class methods. We can use `SingleForwardable` from the Forwardable library for an alternate approach. Beyond these classes and modules from the standard library we can also rely on `method_missing` to manage our own implementation of forwarding messages. Often the one we select, however, has much to do with personal preference.

These different implementations have a few things in common:

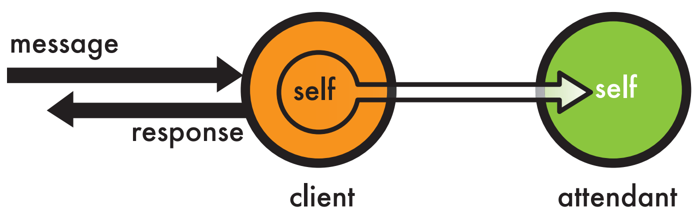
1. They define an association between objects.
2. They forward unaffected messages leaving the method names intact (with an exception from Rails).
3. They **do not** implement delegation.

Consultation is Not Delegation

What is often labelled delegation is anything but. Message recipients which forward messages to an attendant object, often called the delegate, merely act as a proxy for the attendant's implementation of the method call.

Henry Lieberman coined the term **delegation** in *Using prototypical objects to implement shared behavior in object-oriented systems* released with the OOPLSA '86 Conference proceedings on Object-oriented programming systems, languages and applications.[46] Specific to his definition of delegation was the use of prototypes and the dynamic binding of `self` to the original message recipient.

Forwarding and delegation are related but not the same, despite the confusing names used in the Ruby standard library. When the attendant object maintains its own notion of `self`, this is only a forwarded message: a method call. When a message is forwarded from one object to another, it is *delegation* when `self` refers to the original message recipient.



While Ruby does provide us with a Delegate and a Forwardable library, they allow implementations of the same pattern: proxy. Günter Kniesel, in his dissertation *Dynamic Object-Based Inheritance with Subtyping* [47], coined the term **consultation** to refer to this type of message forwarding without dynamic binding of `self`.

In discussion, Lieberman pointed out to me that the addition of a new term is, in his opinion, unnecessary: forwarding messages to another object is merely a method call. I agree, yet there's definitely something here given the widely held confusion. The Ruby standard library calls this delegation, but delegation it is not.

Consultation is a term we can use to properly describe what we are implementing with the Delegate and Forwardable libraries. There are two characteristics that are present in all of these examples that we've discussed.

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[46] http://dl.acm.org/citation.cfm?id=960112.28718

[47] More information at http://javalab.cs.uni-bonn.de/research/darwin/index.html

The first is the connascence of method names between collaborating objects. Connascence refers to the point and type of coupling between objects where a change in one object requires a change in the other[48]. Consultation occurs when the message recipient forwards a message to another object which handles the response to the same message. A `calculator` would receive a `balance` message and forward that message to an `account` which responds to `balance`. Rails' implementation of `delegate` does include a caveat that the message might be prefixed before it is forwarded, but the implementation is still connascent by method name.

The second aspect of consultation is that the message recipient makes no modifications to the algorithm for handling the response. A message of `balance` would be forwarded, unaffected, to the attendant object.

```
delegate :balance :to => :@account
```

Object collaboration breaks from consultation when the message recipient makes alterations to the arguments or the response.

```
def balance
  @account.balance.to_s
end
```

In the end, however, consultation is just a method call.

Diving Into Methods

As we have seen, the core features Ruby gives us merely allow us to follow patterns of object collaboration and consultation. Ruby does have a way to delegate methods but provides no formal assistance in the standard library. Extending an object with a module allows us to preserve the `self` reference inside the method block, but extending an object is **object extension**, not delegation. So what can we do for delegation?

First let's take a look at methods by initializing an object to see what we can do:

[48] See more information about examples of connascence in Ruby at http://blog.rubybestpractices.com/posts/gregory/056-issue-24-connascence.html

```
class Account
  def balance
    100
  end
end
account = Account.new
```

With our account initialized we can use a method called `method` that takes an argument of a method name and returns an instance of a `Method`.

```
balance_method = account.method(:balance)
=> #<Method: Account#balance>
balance_method.methods.sort
=> ["==", "===", "=~", "[]", "__id__", "__send__", "arity", ...]
```

We are able to see information about the method and even execute it without explicitly involving the `account` instance:

```
balance_method.call
=> 100
```

The method can also tell us about its receiver, the object to which it is currently bound:

```
balance_method.receiver
=> #<Account:0x10e5823e8>
balance_method.receiver == account
=> true
balance_method.owner
=> Account
```

Sharing Behavior With Methods

There is seemingly little use of Ruby providing this feature. As an individual instance of a `Method` what more can we do with it than view some information and call it? We can bind it to other objects.

```
unbound_balance_method = balance_method.unbind
=> #<UnboundMethod: Account#balance>
```

`UnboundMethod`s are `Method`s that are not bound to an object. In other words, there is no receiver for an `UnboundMethod`. And these methods may not be called before first being tied to an object for the execution.

```
unbound_balance_method.receiver

NoMethodError: undefined method `receiver' for #<UnboundMethod:
Account#balance

unbound_balance_method.call

NoMethodError: undefined method `call' for #<UnboundMethod:
Account#balance
```

We can bind a method to another object of the same type as the original receiver and then call it.

```
other_account = Account.new

=> #<Account:0x10e4355f8>

unbound_balance_method.bind(other_account).call

=> 100
```

We are restricted, however, from using unbound methods on objects that are not of the same type as the object where the method was defined.

```
class Other

end

other = Other.new

=> #<Other:0x10e36a6c8>

unbound_balance_method.bind(other).call

TypeError: bind argument must be an instance of Account
```

Delegating Methods

With a clearer understanding of delegation and how Ruby handles methods, we can open our code to new ways of sharing behavior. We can finally *delegate* responsibility rather than merely *consult*.

We can create objects with the behaviors we need to act as the delegates for behavior. Let's look at a simple example of what this means.

```
source = Account.find(1)

module Transfer
  def transfer_to(amount, other)
    self.decrement(amount)
    other.increment(amount)
  end
end


destination = Account.find(2)
transfer_method = Transfer.instance_method(:transfer_to).unbind
transfer_method.bind(source).call(200, destination)
```

In Ruby 1.9 the behavior is slightly different and requires an object to first be extended with a module. The following does *not* work in Ruby 2.x.

```
action_account = Account.new
action_account.extend(Transfer)

destination = Account.find(2)
transfer_method = action_account.method(:transfer_to).unbind
transfer_method.bind(source).call(200, destination)
```

This small sample shows us that we can define methods on one object and delegate to it the responsibility of managing the behavior. This dynamic method binding preserves the `self` reference without extending the target object's behavior. We can use this technique of delegating responsibility to overcome problems that may arise when extending object behavior or when using multiple objects to represent data and behavior.

This example doesn't use prototypical inheritance, but we're a bit limited in how Ruby can handle that. We'll dive deeper later and we'll explore using these approaches in the next chapters.

Adjusting to Limitations

Ruby has some limitations in expressing a paradigm like DCI. Objects which gain new features via the `extend` method will never lose them. The implementation of the language may even clear method caches for your application when applying these new features. So what's a concerned developer to do?

First, let's refresh.

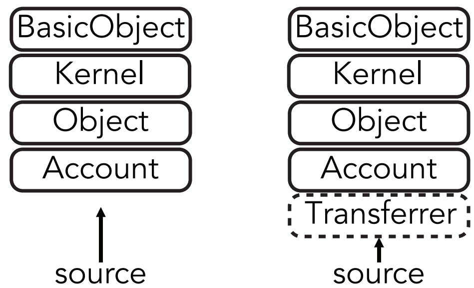
When you extend an object in Ruby, what you're actually doing is including a Module into the singleton class. These bits of code are equivalent:

```
source.extend(Transferrer)
source.singleton_class.send(:include, Transferrer)
```

What's that `singleton_class`? Every object has an anonymous class that may contain instance-specific behavior. By extending the instance, we affect it's singleton class and creating a straight path through the object's ancestors to the methods it needs.

The `Account` class inherits from `Object` (which includes `Kernel`) and `Object` inherits from `BasicObject`. Our account example has a very clear path for understanding the behavior of the object.

```
source = Account.find(123)
source.extend(Source)
```



Because Ruby will cache methods for all objects in your program based upon their classes, altering the behavior of an instance causes Ruby to clear at least part of its method cache to handle the new behavior. This may be a cause for concern related to your application performance, but when you are concerned about performance always rely on hard numbers, not guesswork.

What else can we do? And how does that affect our program?

Wrappers

A common way to attack the problem of adding behavior to objects at runtime is to use wrappers. The `delegate` library offers classes like `SimpleDelegator` to wrap an object and forward any unknown messages to it. With this library, we can implement object collaboration that nearly replaces object extension.

Here's an equivalent example of how SimpleDelegator works:

```
class Wrapper
  def initialize(target)
    @target = target
  end
  attr_reader :target

  def method_missing(method_name, *args, &block)
    target.respond_to?(method_name) ?
      target.__send__(method_name, *args, &block) : super
  end
end
```

Here the `Wrapper` initializes with a collaborator and will send any unknown message that it receives to the collaborator. The clear benefit in this example is that our object of concern is left in its original state. No methods are injected and there's no change to the object's interface.

Our `MoneyTransfer` context can be rewritten to use this approach. Instead of extending objects, we can wrap them:

```
require 'delegate'
class MoneyTransfer
   def initialize(source, destination)
      @source = source
      @destination = destination
      assign_transferrer(@source)
   end

   def execute(amount)
      @source.transfer_to(@destination, amount)
   end

   private

   def assign_transferrer(account)
      # @source.extend(Transferrer) # <-- previous implementation
      Transferrer.new(account)
   end

   # module Transferrer # <-- previous implementation
   class Transferrer < SimpleDelegator
      def transfer_to(destination, amount)
         self.balance -= amount
         destination.balance += amount
      end
   end
end
```

Fortunately enough for us we had pushed the object enhancement down into the `assign_transferrer` method so all we need to do is change the `Transferrer` from a module to a `SimpleDelegator` and wrap the account instead of extending it.

The benefit with wrappers is that we can create a wrapper class that represents only the behavior we want to add to another object. This is the same reason we used modules before but there's a clear separation and no ability to give in to any temptation to merely include the behavior in your class.

This may be tempting:

```
module Transferrer
  # ...
end

class Account
  include Transferrer
end
```

But this just isn't possible:

```
require 'delegate'
class Transferrer < SimpleDelegator
  # ...
end

class Account
  include Transferrer
end
# TypeError: wrong argument type Class (expected Module)
```

So let's see how our tests run. Here they are again:

```ruby
class MoneyTransferTest < ActiveSupport::TestCase

  def setup
    @source = Account.new
    @destination = Account.new

    @source.balance = 2000
    @destination.balance = 0

    Account.expects(:find).with(1).returns(@source)
    Account.expects(:find).with(2).returns(@destination)

    @transfer = MoneyTransfer.new(1, 2)
  end

  test "#execute subtracts the given amount from the source and
       adds it to the destination" do
    @transfer.execute(99)

    assert_equal 1901, @source.balance
    assert_equal 99, @destination.balance
  end

  test "execute returns the source account" do
    assert_equal @source, @transfer.execute(99)
  end

end
```

After our change to our implementation we can run the tests and see if it's still working properly:

```
  1) Error:

MoneyTransferTest#test_#execute_subtracts_the_given_amount_from_the_sou
rce_and_adds_it_to_the_destination:

NoMethodError: undefined method `transfer_to' for #<Account:
0x007fe3bf24e848 @balance=2000>

    app/models/money_transfer.rb:10:in `execute'

    test/models/money_transfer_test.rb:19:in `block in
<class:MoneyTransferTest>'


  2) Error:

MoneyTransferTest#test_execute_returns_the_source_account:

NoMethodError: undefined method `transfer_to' for #<Account:
0x007fe3bf266f38 @balance=2000>

    app/models/money_transfer.rb:10:in `execute'

    test/models/money_transfer_test.rb:26:in `block in
<class:MoneyTransferTest>'
```

What happened!? The method is clearly defined there.

If we look back at the implementation we can see the problem. When we assign the transferrer behavior, we need to also reset the `@source` variable to be the wrapped object.

```
   def execute(amount)
      @source.transfer_to(@destination, amount)
   end


   private


   def assign_transferrer(account)
      @source = Transferrer.new(account)
   end
```

Our execute method was triggering action on the `@source` but our `@source` was still the same object. It wasn't reset to the wrapper object until this change.

Now when we run the tests our code should pass, but it doesn't.

```
  1) Failure:
MoneyTransferTest#test_execute_returns_the_source_account [.../test/models/money_transfer_test.rb:26]:
--- expected
+++ actual
@@ -1 +1 @@
-#<Account:0xXXXXXX @balance=1901>
+99
```

Our `transfer_to` method returns the amount that we transferred instead of returning the source object. With a simple change we can fix this problem.

```
    def transfer_to(destination, amount)
      self.balance -= amount
      destination.balance += amount
      __getobj__
    end
```

And now our tests work properly:

```
# Running tests:


..


Finished tests in 0.006473s, 308.9757 tests/s, 463.4636 assertions/s.
```

Clarity and Disambiguation

We made our tests pass, but what did we just do to make that happen?

That `__getobj__` is a strange looking bit of code.

Creating wrappers with SimpleDelegator is easy. The initialization is already defined, and the magic of `method_missing` is handled for you already. Most of the time you're unlikely to reference the object that you've wrapped but if you needed to, you'd used the `__getobj__` method.

What's troublesome about this code is that it's so unclear. During discussion with our other team members about what needs to happen in our system we'll be using words like source, destination, transfer, balance, amount and many more. When we turn to the code we'll see the same words representing the same ideas. This keeps communication easy and helps us write code that reveals our intentions well. But `__getobj__` sticks out like a sore thumb.

There is almost no value to this method used to represent our object. It is oddly surrounded by underscore characters. It is difficult to pronounce and the word it forms carries no meaning to describe anything in our domain. Everything about it screams implementation detail.

We can get around these objections relatively easily.

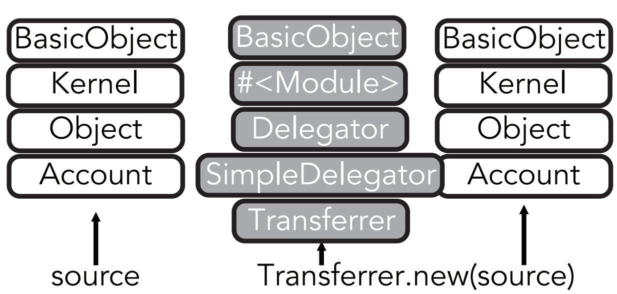
```
class Transferrer < SimpleDelegator
  alias_method :source, :__getobj__
end
```

By using `alias_method` we can define another name for the ugly `__getobj__`. Certainly `source` makes more sense and fits within our domain concepts. It's easy to pronounce and fits into conversation perfectly. With that change our code reads a bit better:

```
   def transfer_to(destination, amount)
      self.balance -= amount
      destination.balance += amount
      source
    end
```

It may read better, but it's still not quite right. There's `self` and `source`, yet they both seem to operate like the same thing.

With a wrapper approach, we're left with two objects each with their own identity. This leaves us with an interesting structure.



In this example, we can see that the method lookup for wrappers has two paths. The *object* may have ancestors which define a method, or the *wrapper* may have ancestors which define a method. The `super` method runs the same named method on the next ancestor class and given that we have two objects (the wrapper and the account) `super` will behave differently depending on where it is defined.

Because of this structure, we're forced to be more explicit about exactly what must be done. Our higher level code ends up dealing with lower level ideas. Code that describes the interaction ends up revealing implementation details. And in the case of `__getobj__` it's a particularly ugly one.

But what about sending back the wrapper itself? What happens if we don't worry about getting the original source object?

```
  def transfer_to(destination, amount)
    self.balance -= amount
    destination.balance += amount
    self
  end
```

The `self` reference is always the current object. When we're working with accounts, the methods for the `source` account should reference `self` and it should be the `source` account. In that way, our code is clear. Our program will be easier to understand for others with fewer parts given to understand.

When we run the tests with this change, they complain:

```
# Running tests:

.F

Finished tests in 0.022416s, 89.2220 tests/s, 133.8330 assertions/s.

  1) Failure:
MoneyTransferTest#test_execute_returns_the_source_account [.../test/
models/money_transfer_test.rb:26]:
No visible difference in the Account#inspect output.
You should look at the implementation of #== on Account or its members.
#<Account:0xXXXXXX @balance=1901>
```

Of course the test fails. It asserts that the result of the `execute` method is the source *account* object. With this new wrapper approach, it returns the *wrapper*.

```
test "execute returns the source account" do
  assert_equal @source, @transfer.execute(99)
end
```

The danger here lies in hiding our intentions. While `method_missing` (the heart of SimpleDelegator wrappers) is a very powerful tool, it helps hide the complexity of multiple objects working together. Hiding complexity can often be good and helps us draw a frame of reference around only the parts we really need. Other times the complexity is either exactly what we want to see, or as in this case, complexity is what we may want to avoid.

One of the downsides in working with wrappers occurs when passing them to other objects to be wrapped. Any of your code is free to initialize new objects wherever necessary and as we've already seen, sometimes sending objects that merely act like the object of concern can cause us to do more mental exercise and change our code to reflect the implementation.

Perhaps inside our transfer, or any other context, we refer to another context where we may run into difficulty. Let's contrive an example where we need to print information about our source account.

```
class MoneyTransfer
   # ...
   def transfer_to(destination, amount)
     self.balance -= amount
     destination.balance += amount
     PrintingTransfer.new(self, STDOUT).execute
     source
   end
   #...
end

class PrintingTransfer
  def initialize(account, receipt)
    @account = PrintableAccount.new(account)
    @receipt = receipt
  end

  def execute
    @account.print_on(@receipt)
  end

  class PrintableAccount < SimpleDelegator
    def print_on(receipt)
      # ...
    end
  end
end
```

In our `MoneyTransfer` context, our wrapped object is passed into the `PrintingTransfer` context to be wrapped. But here, the `PrintableAccount` isn't wrapping an account, it's wrapping a `Transferrer` which wraps the account. We've created a structure where we're now two steps away from the actual object we want.

This could be solved by some simple changes, such as passing in the `source` reference instead of `self`. This forces us to do a little more mental work to understand the code. You may find this approach and the extra work to be acceptable, but be sure to weigh the options and possibilities and how they'll affect your communication and understanding.

CONCERNING SELF

As we saw in the previous chapter, Ruby (as of 2.0) allows us to use UnboundMethods defined on modules to be bound to any object and called. Here's the previous example we saw:

```
source = Account.find(1)

module Transfer
  def transfer_to(amount, other)
    self.decrement(amount)
    other.increment(amount)
  end
end

destination = Account.find(2)
transfer_method = Transfer.instance_method(:transfer_to).unbind
transfer_method.bind(source).call(200, destination)
```

Given that we can add behaviors like this, we're open to more possibilities for managing our roles. Our role playing objects can maintain references to their current role and lean on `method_missing` to apply the method. Let's explore an example.

First, our objects need to understand what role they'll be playing:

```
class Account
  def add_role(mod)
    @role = mod
  end

  def role
    @role
  end
end
```

Once our objects' have access to new behaviors, we can hook them up via `method_missing`:

```
class Account
  def method_missing(method_name, *args, &block)
    role.instance_method(method_name).bind(self).call(*args, &block)
  end
end
```

Instances of `Account` will now be able to add a role using the `add_role` method and any unknown method will be caught by `method_missing`, pulled from the role and applied to the object.

With this simple implementation our objects have very loose coupling to their behavior, although in actual use some adjustments would need to be made. It's important not to take the use of `method_missing` lightly. Applying behavior this way is powerful, but in this code we've made a dead end for method lookup. You may find it more useful to first check that the role implements the method and conditionally apply it or call `super` to let the standard `method_missing` behavior take over.

```
class Account
  def method_missing(method_name, *args, &block)
    if role.instance_methods.include?(method_name)
      role.instance_method(method_name).bind(self).call(*args, &block)
    else
      super
    end
  end
end
```

This gives us the ability to write our behaviors as if they belong to an object without cluttering our data classes with context specific behavior. The notion of `self` can be used in our role methods freeing us to think in terms of the objects of concern in our system.

Using wrappers like SimpleDelegator adds another layer and forces us to consider the difference between the wrapper and the wrapped object. The behavior handled by `method_missing` inside a wrapper hides the fact that we have two objects. The `method_missing` we created here hides the implementation of the behavior but we are conveniently left with only one object and only one `self`. The casting gem is a library which provides behaviors to objects using this technique.

As with any implementation using `method_missing`, it's important to note that any of these behavior methods are found last. If our `Account` class implemented any methods of the same name in our roles, those methods would be used and `method_missing` would never be run. Keeping data classes free from context-specific behavior, however, tends to prevent any problems with method name clashes.

Read more about this technique in the Object Collaboration appendix.

Illusions in Code

The cost of abstraction can often be imperceptible until we've created too much. Evaluating the cost is an exercise in determining what your own values are. Indeed, even labeling "too much" is a subjective evaluation. What often best suits our development is a clearer and flatter hierarchy of objects. In creating a flat system we avoid layers of abstraction which require more work out of our brains. With fewer abstractions, we avoid their costs. Trygve Reenskaug aptly applied the metaphor of illusions to our programs:

> Alan Kay once said that all computing is about creating illusions.
>
> The DCI illusion we are working on is that a Role is synonymous with an object at runtime. ... The goal is to make the DCI programmer's mental model as simple as possible. [49]

Simple mental models are easier to understand and easier to communicate to others. The human needs of our software remain human needs and translating those into code can introduce a number of challenging tasks. Keeping code as simple as possible helps us avoid mental work and allows us to better create the illusion of working with our objects.

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[49] https://groups.google.com/d/msg/object-composition/QgGQxAO9Q_M/lHySBA9cimMJ

Appendix A

Object Collaboration

Understanding the libraries available for managing object composition and collaboration can be helpful in making choices about how to handle our programs. This appendix provides an in-depth sampling of some.

Delegate Standard Library

We've seen SimpleDelegator used to wrap our objects and proxy new behavior using `method_missing`. The `delegate` library, however, is more than just a fancy `method_missing` wrapper.

Easy Wrappers

At its simplest level, `method_missing` provides the power. Here's some sample code:

```
jim = Person.new # some object

class Displayer < SimpleDelegator
  def name_with_location
    "#{__getobj__.name} of #{__getobj__.city}"
  end
end

displayer = Displayer.new(jim)

puts displayer.name_with_location #=> "Jim of Some City"
```

That `Displayer` class initializes with an object and automatically sets it as `@delegate_sd_obj`. You'll also get both a `__getobj__` and a `__setobj__` method to handle the assignment of the `@delegate_sd_obj`.

You may want to alias those methods so they won't be so ugly when you use them: `alias_method :object, :__getobj__`.

Method Missing

Here's an expanded view of how it handles `method_missing`:

```
target = self.__getobj__ # Get the target object
if target.respond_to?(the_missing_method)
  target.__send__(the_missing_method, *arguments, &block)
else
  super
end
```

The actual code is a bit more compact than that, but it's that simple. SimpleDelegator is so simple, in fact, that you can create your own implementation just like this:

```
class MyWrapper
  def initialize(target)
    @target = target
  end
  attr_reader :target

  def method_missing(method_name, *args, &block)
    target.respond_to?(method_name) ? target.__send__(method_name,
*args, &block) : super
  end
end
```

That's not everything, but if all you need is simple use of `method_missing`, this is how it works.

SimpleDelegator Methods

SimpleDelegator adds some convenient ways to see what methods are available. For example, if we have our `jim` object wrapped by `displayer`, what can we do with it? Well if we call `displayer.methods` we'll get back a unique collection of both the object's and wrapper's methods.

Here's what it does:

```
def methods(all=true)
  __getobj__.methods(all) | super
end
```

It defines the `methods` method and uses the union method `|` from Array to make a unique collection. The object's methods are combined with those of the wrapper.

```
['a','b'] | ['c','b'] #=> ['a','b','c']
```

The same behavior is implemented for `public_methods` and `protected_methods` but **not** `private_methods`. Private methods are private, so you probably shouldn't be accessing those from the outside anyway.

Why does it do this? Don't we want to know that the main object and the SimpleDelegator object have methods of the same name?

Not really.

From the outside all we care to know is what messages we can send to an object. If both your main object and your wrapper have methods of the same name, the wrapper will intercept the message and handle it. What you choose to do inside your wrapper is up to you, but all these `methods` lists need to provide is that the wrapper can receive any of those messages.

Handling clone and dup

SimpleDelegator will also prepare clones and dups for your target object.

```
def initialize_clone(obj) # :nodoc:
  self.__setobj__(obj.__getobj__.clone)
end
def initialize_dup(obj) # :nodoc:
  self.__setobj__(obj.__getobj__.dup)
end
```

Read Jon Leighton's post about `initialize_clone`, `initialize_dup` and `initialize_copy` in Ruby[50] for more details about *when* those methods are called.

[50] http://www.jonathanleighton.com/articles/2011/initialize_clone-initialize_dup-and-initialize_copy-in-ruby

Making your own SimpleDelegator

SimpleDelegator inherits almost all of this from Delegator. The only changes that SimpleDelegator makes is 2 convenience methods.

```
  class SimpleDelegator < Delegator
    def __getobj__
      @delegate_sd_obj
    end
    def __setobj__(obj)
      raise ArgumentError, "cannot delegate to self" if self.equal?
(obj)
      @delegate_sd_obj = obj
    end
  end
```

Subtracting all the comments around what those methods mean, that's the entirety of the class definition as it is in the standard library. If you prefer to use your own and call it SuperFantasticDelegator, you only need to make these same getter and setter methods and you've got all that you need to replace SimpleDelegator.

Keep in mind, however, that the `__setobj__` method has some protection in there against setting the target object to the wrapper itself. You'll need to do that too unless you want to get stuck in an endless `method_missing` loop.

Using DelegateClass

The `delegate` library also provides a method called `DelegateClass` which returns a new class.

Here's how you might use it:

```
    class Tempfile < DelegateClass(File)
      def initialize(basename, tmpdir=Dir::tmpdir)
        @tmpfile = File.open(tmpname, File::RDWR|File::CREAT|
File::EXCL, 0600)
        super(@tmpfile)
      end

      # more methods here...
    end
```

This creates a `Tempfile` class that has all the methods defined on `File` but it automatically sets up the message forwarding with `method_missing`.

Inside the `DelegateClass` method it creates a new class with `klass = Class.new(Delegator)`.

Then it gathers a collection of methods to define on this new class.

```
    methods = superclass.instance_methods
    methods -= ::Delegator.public_api
    methods -= [:to_s,:inspect,:=~,:!~,:===]
```

It gets the `instance_methods` from the superclass and subtracts and methods already in the `Delegator.public_api` (which is just the `public_instance_methods`). Then it removes some special string and comparison methods (probably because you'll want to control these yourself and not have any surprises).

Next it opens up the `klass` that it created and defines all the leftover methods.

```
  klass.module_eval do
    def __getobj__  # :nodoc:
      @delegate_dc_obj
    end
    def __setobj__(obj)  # :nodoc:
      raise ArgumentError, "cannot delegate to self" if self.equal?
(obj)
      @delegate_dc_obj = obj
    end
    methods.each do |method|
      define_method(method, Delegator.delegating_block(method))
    end
  end
```

The code is sure to define the `__getobj__` and `__setobj__` methods so that it will behave like SimpleDelegator. Remember, it's copying methods from `Delegator` which doesn't define `__getobj__` or `__setobj__`.

What's interesting here is that it's using `Delegator.delegating_block(method)` to create each of the methods. That `delegating_block` returns a lambda that is used as the block for the method definition. As it defines each of those methods in the `methods` collection, it creates a forwarding call to the target object. Here's the equivalent of what each of those methods will do:

```
target = self.__getobj__
target.__send__(method_name, *arguments, &block)
```

For every method that it gathers to define on this new `DelegateClass` it forwards the message to the target object as defined by `__getobj__`. Pay close attention to that. Remember that I pointed out how you can make your own SimpleDelegator and create your own getter and setter methods? Well DelegateClass creates methods that expect `__getobj__` specifically. So if you want to use `DelegateClass` but don't want to use that method explicitly, you'll need to rely on `alias_method` to name it something else. All of your automatically defined methods rely on `__getobj__`.

Lastly, before returning the `klass`, the `public_instance_methods` and `protected_instance_methods` are defined. There's some interesting things going on in those method definitions, but I'll keep the explanation simple for now.

This Tempfile class that we created is actually exactly how the standard library's Tempfile is defined.

If you're not familiar with it, you can use it like this:

```
require 'tempfile'
file = Tempfile.new('foo')
# then do whatever you need with a tempfile
```

If you dive into that library you'll see:

```
class Tempfile < DelegateClass(File)
```

The `tempfile` library relies on the `delegate` library, but not in the way that you might find in the wild. Often you'll see developers using only the SimpleDelegator class, but as you can see there's a handful of other ways to make use of `delegate` to handle message forwarding for you.

Forwardable Standard Library

The Ruby `forwardable` standard library provides a similar though alternate approach to forwarding than the `delegate` library.

Unlike `Delegator`, `SimpleDelegator`, and `DelegateClass` which provide classes, `Forwardable` is a module that must be added to your own classes. By extending your classes with Forwardable, you have methods available which allow you to define the forwarding rules for objects initialize from your class.

```
class Address
  attr_accessor :street, :postal_code, :name
end
class Person
  extend Forwardable
  attr_accessor :name, :address

  def_instance_delegator :address, :street
  def_instance_delegator :address, :postal_code
  def_instance_delegator :address, :name, :address_name
end
```

This is an example of creating a “delegator” method for instances of this class. These methods provide consultation with external objects and Forwardable allows us to alter the names of the methods we use to forward requests to the attendant object.

```
address = Address.new
address.name = "Home"
address.street = "123 Main. St."
address.postal_code = "22222"
jim = Person.new
jim.name = "Jim"
jim.address = address
jim.postal_code
=> "22222"
jim.street
=> "123 Main. St."
jim.name
=> "Jim"
jim.address_name
=> "Home"
```

Our main `Person` object already has a name but the third argument to the `def_instance_delegator` method allows us to change the message used to get the data from our associated address.

Although it provides additional features, at the heart of Forwardable is the `def_instance_delegator` method. A simplified version of what it does is to 1) accept a method or instance variable name to receive forwarded messages 2) accept a message to be sent to an attendant object, 3) accepts an alternate name for the interface provided by the client object.

```
def def_instance_delegator(accessor, method, alternate = method)
  self.class_eval "
    def #{alternate}(*args, &block)
      begin
        #{accessor}.__send__(:#{method}, *args, &block)
      end
    end
  "
end
```

There's more to it in the actual source than that. In fact, Forwardable goes so far as to ensure that in the event of an exception, the line of your own code is reported as the mark for error, not the line in the library itself. But what we have here shows the basic behavior: send a message to another object and provide an alternate name for the method.

The major difference between the approaches of SimpleDelegator and Forwardable, however, is that Forwardable requires knowledge of the messages ahead of time. Forwardable is useful when you know what messages you want to send because you must specify them. SimpleDelegator is useful when you either don't know or don't care about the names of the messages and merely want all unknown messages to be forwarded.

Creating facades

Forwarding messages for instances is not the only feature from Forwardable. When we add `require "forwardable"` to our code, we'll also have access to the `SingleForwardable` module designed to add behavior to classes, not instances.

An appropriate use for this additional module might be to create a facade for a third-party service. Here's an example:

```
require 'geo_service'
module MyGeo
  extend SingleForwardable
  delegate [:to_address, :to_lat_long] => :GeoService
end
```

In this example, we create our own MyGeo module to handle translation of geolocation data. Despite that we are requiring a GeoService library, our own application code can gather data through the module that we own:

```
MyGeo.to_address(38.84200, -77.10667)
```

This facade protects us from changes to our geolocation service. If we find a better third-party service or the one we use goes out of business, we're able to adjust our own code to handle these changes.

If our GeoService disappears and we replace it with FasterBetterGeo we can even handle alternate naming conventions provided by our new library:

```
require 'faster_better_geo'
module MyGeo
  extend SingleForwardable
  def_delegator :FasterBetterGeo, :to_street_address, :to_address
  def_delegator :FasterBetterGeo, :to_latlong, :to_lat_long
end
```

ActiveSupport Delegation

The ActiveSupport library contains a similar but alternative approach to the Forwardable library.

First, by requiring the ActiveSupport delegation library, you add a delegate method to every module and class in your system. Depending on your needs, this may or may not be how you want to handle message forwarding across your system.

But here's how it's different.

ActiveSupport delegation is designed to support relationships between objects. The `prefix` option allows you to alter the method used for forwarding for multiple methods at a time.

```
require 'active_support/core_ext/module/delegation'
class Address
  attr_accessor :name, :street, :postal_code, :country
end
class Person
  attr_accessor :address
  delegate :name, :street, :postal_code, :country,
           :to => :address, :prefix => true
end
```

The above sample would define methods on instances of `Person` as `address_name`, `address_street`, etcetera. In this way, the method names imply the source of the data. Alternatively, we could define our own prefix to be something other than "address."

Another option available with this library is that it can be configured to output nothing if the attendant object is nil. Suppose, for example, that our program allows for people without address records. We might not want messages like `address_country` to raise an error. Instead, it may be useful to merely return nothing by setting the `allow_nil` option to true.

```
class Person

  attr_accessor :address

  delegate :name, :street, :postal_code, :country,
           :to => :address, :prefix => true, :allow_nil => true

end
```

Lastly, using ActiveSupport for forwarding allows us to simplify the creation of accessor instance methods which return values from the class of the object. Without this, the methods are short:

```
def special_value

  self.class.special_value

end
```

With ActiveSupport delegation, however we can simplify this merely by specifying the class as the `to` option:

```
delegate :special_value, :to => :class
```

Casting

As we saw, all of these libraries provide a way to wrap objects and forward methods from one to the other. The casting gem that I created after exploring delegation and the features of Ruby methods provides a different approach.

The main goal of this library differs from the others by one major change. It is designed to preserve the reference of `self` to the object of concern. The other libraries here manage the forwarding of messages from one object to another, each introducing a second object with its own `self`.

At the most basic level, you Casting provides a convenience for using methods from a module on an arbitrary object. Where Ruby allows us to apply methods from modules:

```
module Greeter
  def hello
    %{hello from #{self}}
  end
end
class Person; end

jim = Person.new
Greeter.instance_method(:hello).bind(jim).call
=> "hello from #<Person:0x007fc57899a030>"
```

Casting allows us to shorten the code by allowing a class to initialize objects which are able to delegate messages to a given delegate object.

```
require ‘casting’
class Person
  include Casting::Client
end
jim = Person.new
jim.delegate(:hello, Greeter)
=> "hello from #<Person:0x007ff2b1953070>"
```

The semantics are different from other libraries. In the Ruby standard library for both SimpleDelegator and Forwardable and in the ActiveSupport::Delegation library the “delegate” term is used to describe forwarding a message to a secondary object and to mark that message to be forwarded at any future time. Casting uses “delegate” to both preserve `self` and to immediately execute the delegated method. It is not a marker for future execution but this library does provide a way to handle that case.

You can opt-in to using `method_missing` to handle future messages. Here’s how you do that:

```
class Person
  include Casting::Client
  delegate_missing_methods
end
```

Once you’ve set the instruction to delegate missing methods, instances of the class will be able to set a delegate.

```
jim = Person.new
jim.cast_as(Greeter)
=> #<Person:0x007ff2b1953070 @__delegates__=[Greeter]>
jim.hello
=> "hello from #<Person:0x007ff2b1953070>"
jim.hello
=> "hello from #<Person:0x007ff2b1953070>"
```

The object continues to respond to messages handled by the delegate until the delegate is removed:

```
jim.uncast
jim.hello
=> NoMethodError: undefined method `hello' for #<Person:
0x007ff2b1953070>
```

Inspecting Client Behavior

A `Casting::Client` object will provide a list of methods available to you for all delegated public, protected, and private instance methods.

```
jim.cast_as(Greeter)
=> #<Person:0x007ff2b1953070 @__delegates__=[Greeter]>
jim.delegated_methods
=> [:hello]
module Extras
  public
  def extra; end

  protected
  def locked_down; end

  private
  def sssshhhhh!; end
end
jim.cast_as(Extras)
=> #<Person:0x007ff2b1953070 @__delegates__=[Extras, Greeter]>
jim.delegated_methods
=> [:extra, :locked_down, :sssshhhhh!, :hello]
```

The client may be cast with multiple delegates at a time and will report it's delegated methods in aggregate:

```
jim.delegated_public_methods
=> [:extra, :hello]
jim.delegated_protected_methods
=> [:locked_down]
jim.delegated_private_methods
=> [:sssshhhhh!]
```