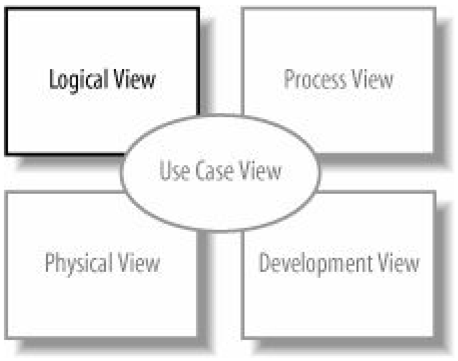
# Chapter 7. Modeling Ordered Interactions: Sequence Diagrams

Use cases allow your model to describe what your system must be able to do; classes allow your model to describe the different types of parts that make up your system's structure. There's one large piece that's missing from this jigsaw; with use cases and classes alone, you can't yet model how your system is actually going to its job. This is where interaction diagrams , and specifically sequence diagrams, come into play.

Sequence diagrams are an important member of the group known as interaction diagrams. Interaction diagrams model important runtime interactions between the parts that make up your system and form part of the logical view of your model, shown in Figure 7-1.

**Figure 7-1. The Logical View of your model contains the abstract descriptions of your system's parts, including the interactions between those parts**



Sequence diagrams are not alone in this group; they work alongside communication diagrams (see Chapter 8) and timing diagrams (see Chapter 9) to help you accurately model how the parts that make up your system interact.

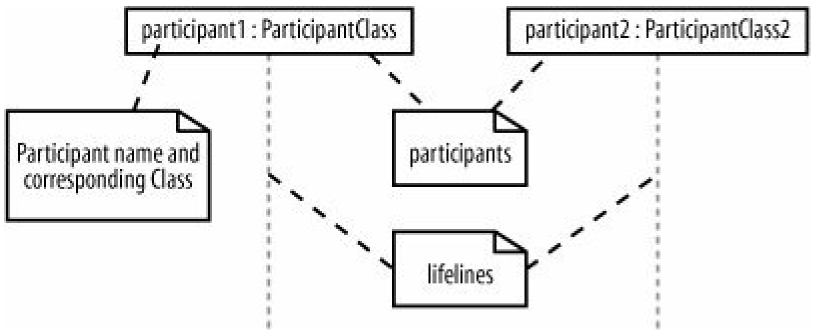
Sequence diagrams are the most popular of the three interaction diagram types. This could be because they show the right sorts of information or simply because they tend to make sense to people new to UML.

Sequence diagrams are all about capturing the order of interactions between parts of your system. Using a sequence diagram, you can describe which interactions will be triggered when a particular use case is executed and in what order those interactions will occur. Sequence diagrams show plenty of other information about an interaction, but their forté is the simple and effective way in which they communicate the order of events within an interaction.

## 7.1. Participants in a Sequence Diagram

A sequence diagram is made up of a collection of participantsthe parts of your system that interact with each other during the sequence. Where a participant is placed on a sequence diagram is important. Regardless of where a participant is placed vertically, participants are always arranged horizontally with no two participants overlapping each other, as shown in Figure 7-2.

**Figure 7-2. At its simplest, a sequence diagram is made up of one or more participantsonly one participant would be a very strange sequence diagram, but it would be perfectly legal UML**


participant1 : ParticipantClass
participant2 : ParticipantClass2
Participant name and corresponding Class
participants
lifelines

Each participant has a corresponding lifeline running down the page. A participant's lifeline simply states that the part exists at that point in the sequence and is only really interesting when a part is created and/or deleted during a sequence (see "Participant Creation and Destruction Messages" later in this chapter).

### 7.1.1. Participant Names

Participants on a sequence diagram can be named in number of different ways, picking elements from the standard format:

```
name [selector] : class_name ref decomposition
```

The elements of the format that you pick to use for a particular participant will depend on the information known about a participant at a given time, as explained in Table 7-1.

**Table 7-1. How to understand the components of a participant's name**

| Example participant name | Description |
|---|---|
| admin | A part is named `admin`, but at this point in time the part has not been assigned a class. |
| : ContentManagementSystem | The class of the participant is `ContentManagementSystem`, but the part currently does not have its own name. |
| admin : Administrator | There is a part that has a name of `admin` and is of the class `Administrator`. |
| eventHandlers [2] : EventHandler | There is a part that is accessed within an array at element 2, and it is of the class `EventHandler`. |
| : ContentManagementSystem ref cmsInteraction | The participant is of the class `ContentManagementSystem`, and there is another interaction diagram called `cmsInteraction` that shows how the participant works internally (see "A Brief Overview of UML 2.0's Fragment Types," later in this chapter). |

The format used when creating names for your participants is totally up to youor maybe your company's style guide. In this book, we lowercase the first word in the participant name to make sure that there is as little confusion as possible with the name of a class. However, this is just our conventionsimilar to the conventions used when naming objects and classes in Javaand is not something specified by UML.

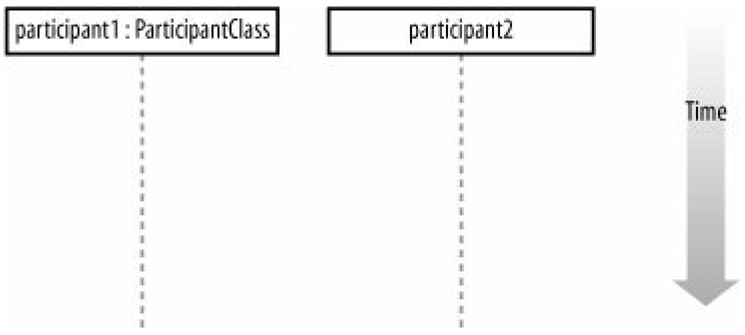
### What Happened to Objects?

In UML 1.x, participants on an interaction diagram were usually software objects in the traditional object-oriented programming sense. Each object was an instance of a class, and the object name was underlined to indicate this. Because UML 2.0 is more of a general system modeling language, it makes much more sense to think of it in terms of system parts interacting with each other rather than software objects. This is why we've used the term "participant" to describe a part that is involved in the interactions on a sequence diagram. A participant could still be a software object, a la UML 1.x, but it could equally be any other part of the system in keeping with the spirit of UML 2.0.

## 7.2. Time

A sequence diagram describes the order in which the interactions take place, so time is an important factor. How time relates to a sequence diagram is shown in Figure 7-3.

**Figure 7-3. Time runs down the page on a sequence diagram in keeping with the participant lifeline**



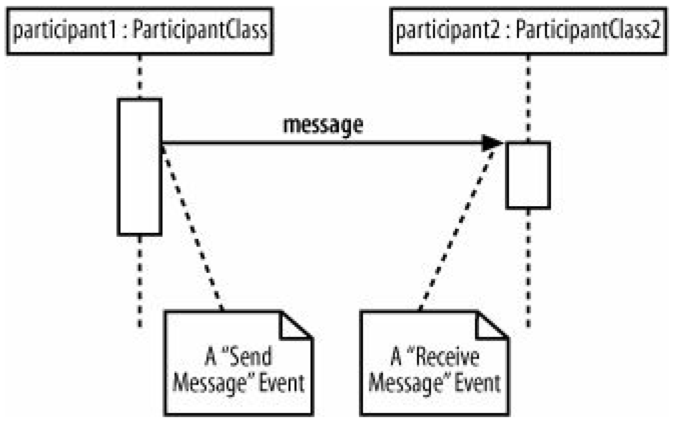
Time on a sequence diagram starts at the top of the page, just beneath the topmost participant heading, and then progresses down the page. The order that interactions are placed down the page on a sequence diagram indicates the order in which those interactions will take place in time.

Time on a sequence diagram is all about ordering, not duration. Although the time at which an interaction occurs is indicated on a sequence diagram by where it is placed vertically on the diagram, how much of the vertical space the interaction takes up has nothing to do with the duration of time that the interaction will take. Sequence diagrams are first about the ordering of the interactions between participants; more detailed timing information is better shown on timing diagrams (see Chapter 9).

## 7.3. Events, Signals, and Messages

The smallest part of an interaction is an event. An event is any point in an interaction where something occurs, as shown on Figure 7-4.

**Figure 7-4. Probably the most common examples of events are when a message or signal is sent or received**

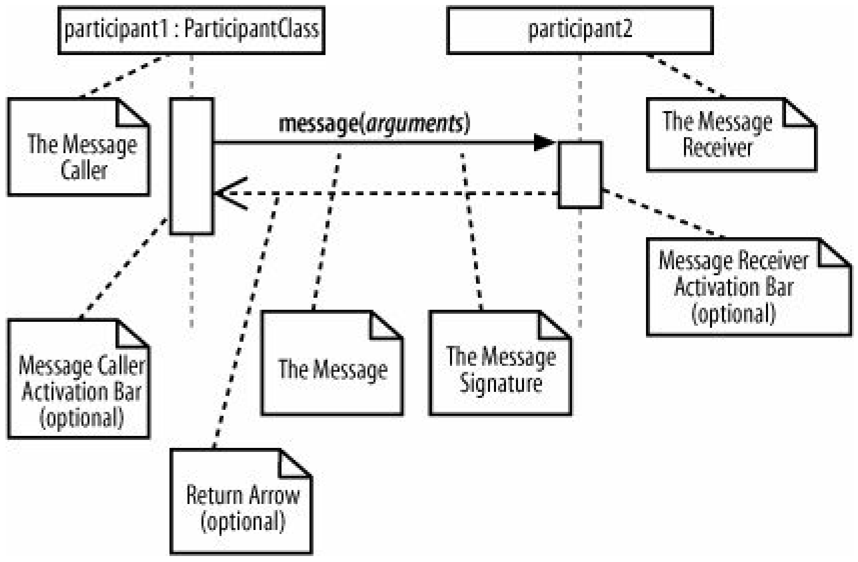

participant1 : ParticipantClass
participant2 : ParticipantClass2
message
A "Send Message" Event
A "Receive Message" Event

Events are the building blocks for signals and messages. Signals and messages are really different names for the same concept: a signal is the terminology often used by system designers, while software designers often prefer messages.

In terms of sequence diagrams, signals and messages act and look the same, so we'll stick to using the term "messages" in this book.

An interaction in a sequence diagram occurs when one participant decides to send a message to another participant, as shown in Figure 7-5.

**Figure 7-5. Interactions on a sequence diagram are shown as messages between participants**



Messages on a sequence diagram are specified using an arrow from the participant that wants to pass the message, the Message Caller, to the participant that is to receive the message, the Message

Receiver. Messages can flow in whatever direction makes sense for the required interactionfrom left to right, right to left, or even back to the Message Caller itself. Think of a message as an event that is passed from a Message Caller to get the Message Receiver to do something.

### 7.3.1. Message Signatures

A message arrow comes with a description, or signature. The format for a message signature is:

```
attribute = signal_or_message_name (arguments) : return_type
```

You can specify any number of different arguments on a message, each separated using a comma. The format of an argument is:

```
<name>:<class>
```

The elements of the format that you use for a particular message will depend on the information known about a particular message at any given time, as explained in Table 7-2.

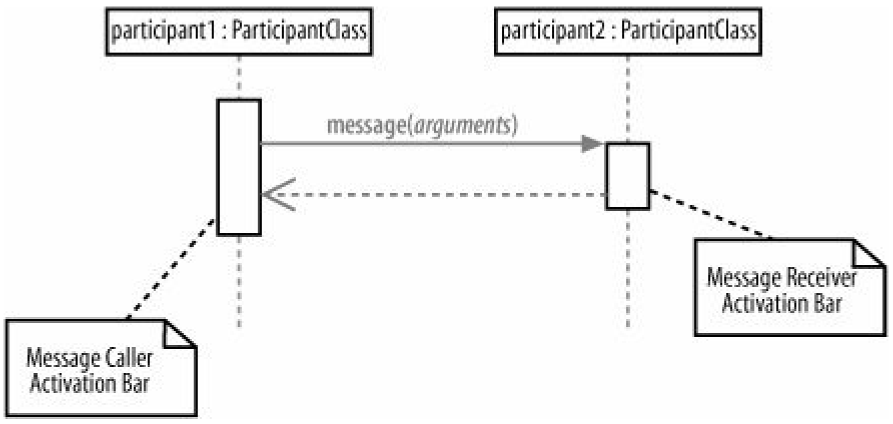
**Table 7-2. How to understand the components of a message's signature**

| Example message signature | Description |
|---|---|
| doSomething( ) | The message's name is `doSomething`, but no further information is known about it. |
| doSomething(number1 : Number, number2 : Number) | The message's name is `doSomething`, and it takes two arguments, `number1` and `number2`, which are both of class `Number`. |
| doSomething( ) : ReturnClass | The message's name is `doSomething`; it takes no arguments and returns an object of class `ReturnClass`. |
| myVar = doSomething( ) : ReturnClass | The message's name is `doSomething`; it takes no arguments, and it returns an object of class `ReturnClass` that is assigned to the `myVar` attribute of the message caller. |

## 7.4. Activation Bars

When a message is passed to a participant it triggers, or invokes, the receiving participant into doing something; at this point, the receiving participant is said to be active. To show that a participant is active, i.e., doing something, you can use an activation bar, as shown in Figure 7-6

**Figure 7-6. Activation bars show that a participant is busy doing something for a period of time**


participant1 : ParticipantClass
participant2 : ParticipantClass
message(*arguments*)
Message Receiver Activation Bar
Message Caller Activation Bar

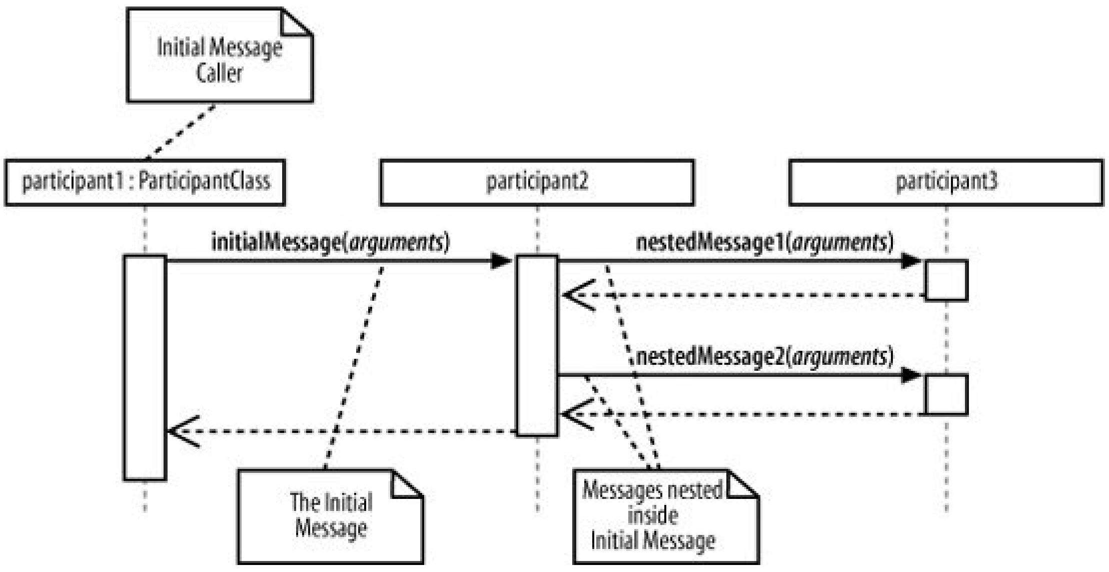
An activation bar can be shown on the sending and receiving ends of a message. It indicates that the sending participant is busy while it sends the message and the receiving participant is busy after the message has been received

Activation bars are optionalthey can clutter up a diagram.

## 7.5. Nested Messages

When a message from one participant results in one or more messages being sent by the receiving participant, those resulting messages are said to be nested within the triggering message, as shown in Figure 7-7.

**Figure 7-7. Two nested messages are invoked when an initial message is received**


Initial Message Caller
participant1 : ParticipantClass
participant2
participant3
initialMessage(*arguments*)
nestedMessage1(*arguments*)
nestedMessage2(*arguments*)
The Initial Message
Messages nested inside Initial Message

In Figure 7-7, `participant1` sends `initialMessage(..)` to `participant2`. When `participant2` receives `initialMessage(..)`, `participant2` becomes active and sends two nested messages to `participant3`. You can have any number of nested messages inside a triggering message and any number of levels of nested messages on a sequence diagram.

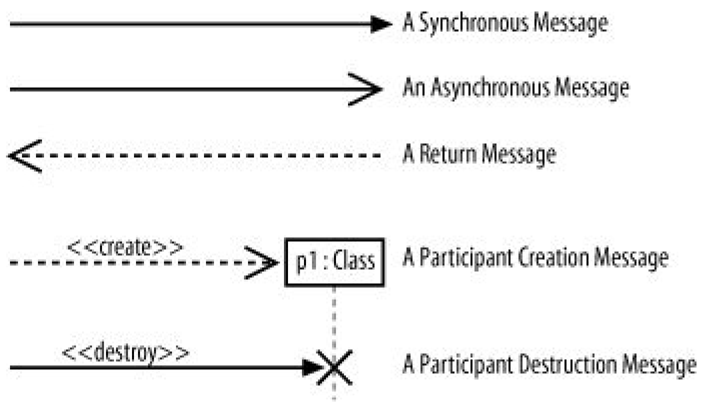
## 7.6. Message Arrows

The type of arrowhead that is on a message is also important when understanding what type of message is being passed. For example, the Message Caller may want to wait for a message to return before carrying on with its worka synchronous message. Or it may wish to just send the message to the Message Receiver without waiting for any return as a form of "fire and forget" messagean asynchronous message.

Sequence diagrams need to show these different types of message using various message arrows , as shown in Figure 7-8.

To explain how the different types of messages work, let's look at some simple examples where the participants are actually software objects implemented in Java.

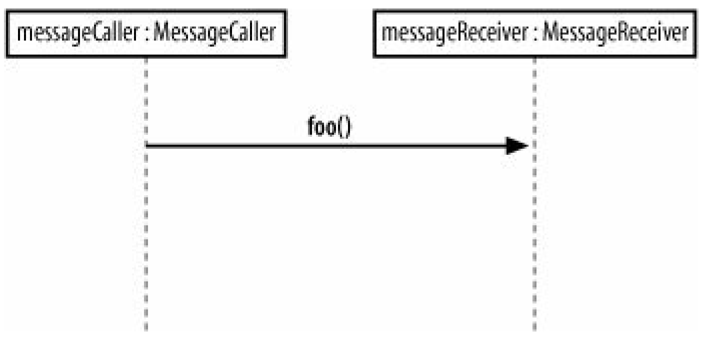
**Figure 7-8. There are five main types of message arrow for use on sequence diagram, and each has its own meaning**



### 7.6.1. Synchronous Messages

As mentioned before, a synchronous message is invoked when the Message Caller waits for the Message Receiver to return from the message invocation, as shown in Figure 7-9.

**Figure 7-9. The messageCaller participant makes a single synchronous message invocation on the messageReceiver participant**


messageCaller : MessageCaller
messageReceiver : MessageReceiver
foo()

The interaction shown in Figure 7-9 is implemented in Java using nothing more than a simple method invocation, as shown in Example 7-1.

**Example 7-1. The messageCaller object makes a regular Java method call to the foo( ) method on the messageReceiver object and then waits for the messageReceiver.foo( ) method to return before carrying on with any further steps in the interaction**

```
public class MessageReceiver
{
   public void foo(  )
   {
      // Do something inside foo.
   }
}

public class MessageCaller
{
   private MessageReceiver messageReceiver;

   // Other Methods and Attributes of the class are declared here

   // The messageRecevier attribute is initialized elsewhere in
   // the class.

   public doSomething(String[] args)
   {
      // The MessageCaller invokes the foo(  ) method

      this.messageReceiver.foo(  ); // then waits for the method to return

      // before carrying on here with the rest of its work
   }
}
```

### 7.6.2. Asynchronous Messages

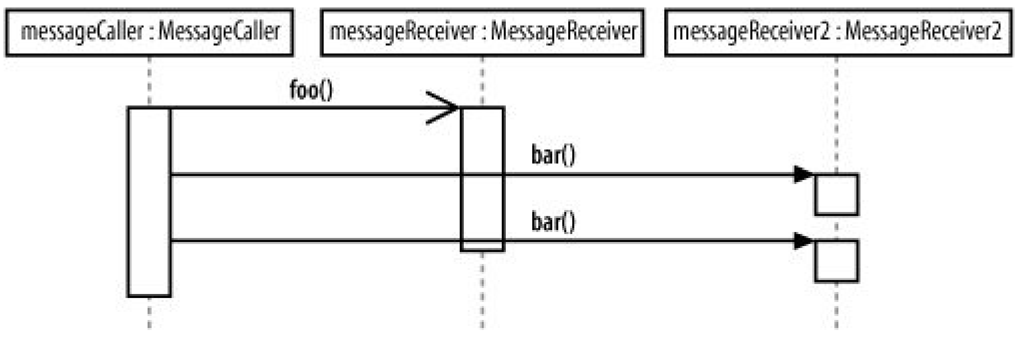
It would be great if all the interactions in your system happened one after the other in a nice simple order. Each participant would pass a message to another participant and then calmly wait for the message to return before carrying on. Unfortunately, that's not how most systems work. Interactions can happen at the same point in time, and sometimes you will want to initiate a collection of interactions all at the same time and not wait for them to return at all.

For example, say you are designing a piece of software with a user interface that supports the editing and printing of a set of documents. Your application offers a button for the user to print a document. Printing could take some time, so you want to show that after the print button is pressed and the document is printing, the user can go ahead and work with other things in the application. The regular synchronous message arrow is not sufficient to show these types of interactions. You need a new type of message arrow: the asynchronous message arrow.

An asynchronous message is invoked by a Message Caller on a Message Receiver, but the Message Caller does not wait for the message invocation to return before carrying on with the rest of the interaction's steps. This means that the Message Caller will invoke a message on the Message Receiver and the Message Caller will be busy invoking further messages before the original message returns, as shown in Figure 7-10.

A common way of implementing asynchronous messaging in Java is to use threads, as shown in Example 7-2.

**Figure 7-10. While the foo( ) message is being worked on by the messageReceiver object, the messageCaller object has carried on with the interaction by executing further synchronous messages on another object**


messageCaller : MessageCaller
messageReceiver : MessageReceiver
messageReceiver2 : MessageReceiver2
foo()
bar()
bar()

If you're not too familiar with how threads work in Java, check out Java in a Nutshell , Fifth Edition (O'Reilly) or Java Threads (O'Reilly). See "Applying Asynchronous Messages" later in this chapter for a practical example of asynchronous messages.

**Example 7-2. The operation1( ) asynchronous message invokes an internal thread on the message receiver that in turn spurs the message, immediately returning the flow of execution to the messageCaller**

```
public class MessageReceiver implements Runable {

   public void operation1( ) {
      // Receive the message and trigger off the thread

      Thread fooWorker = new Thread(this);
      fooWorker.start(); // This call starts a new thread, calling the run( )
                         // method below

      // As soon as the thread has been started, the call to foo( ) returns.

   }

   public void run( ) {
      // This is where the work for the foo( ) message invocation will
      // be executed.
   }
}

public class MessageCaller
{
   private MessageReceiver messageReceiver;

   // Other Methods and Attributes of the class are declared here

   // The messageRecevier attribute is initialized elsewhere in
   // the class.

   public void doSomething(String[] args) {
      // The MessageCaller invokes the operation1( ) operation

      this.messageReceiver.operation1( );

      // then immediately carries on with the rest of its work
   }
}
```

### 7.6.3. The Return Message

The return message is an optional piece of notation that you can use at the end of an activation bar to show that the control flow of the activation returns to the participant that passed the original message. In code, a return arrow is similar to reaching the end of a method or explicitly calling a `return` statement.

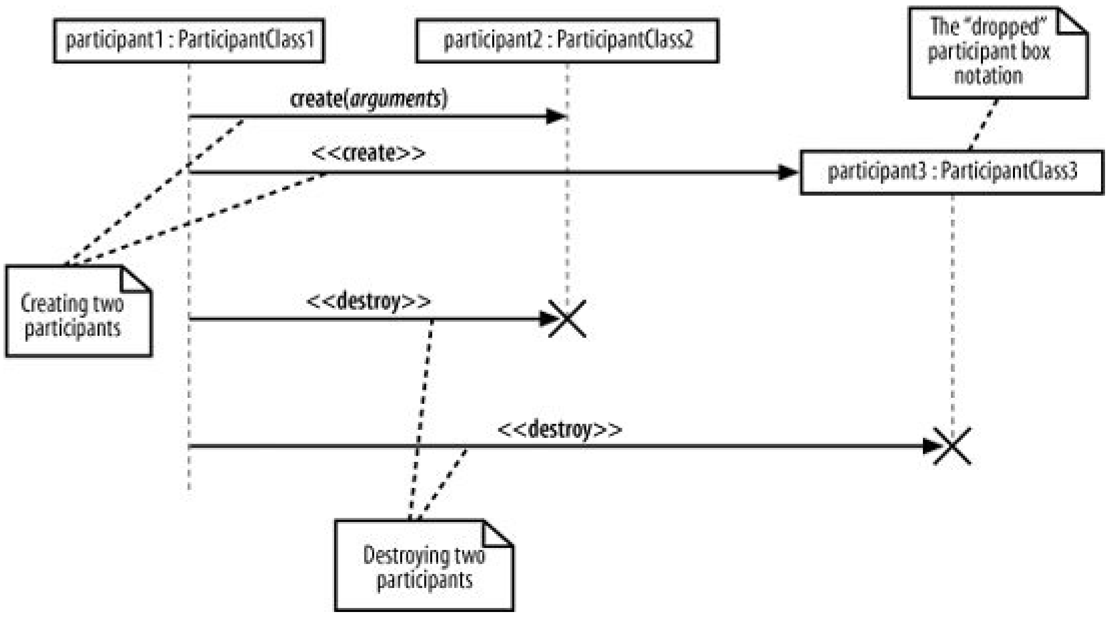
You don't have to use return messages sometimes they can really make your sequence diagram too busy and confusing. You don't have to clutter up your sequence diagrams with a return arrow for every activation bar since there is an implied return arrow on any activation bars that are invoked using a synchronous message.

Although a message will often be passed between two different participants, it is totally normal for a participant to pass a message to itself. Messages from an object to itself are a good way of splitting up a large activation into smaller and more manageable pieces and, in terms of software, can be thought of as being very similar to making a method call to the `this` reference in Java and C#.

### 7.6.4. Participant Creation and Destruction Messages

Participants do not necessarily live for the entire duration of a sequence diagram's interaction. Participants can be created and destroyed according to the messages that are being passed, as shown in Figure 7-11.

**Figure 7-11. Both participant2 and participant3 are created throughout the course of this sequence diagram**


participant1 : ParticipantClass1
participant2 : ParticipantClass2
The "dropped" participant box notation
create(*arguments*)
<<create>>
participant3 : ParticipantClass3
Creating two participants
<<destroy>>
<<destroy>>
Destroying two participants

To show that a participant is created, you can either simply pass a `create(..)` message to the participant's lifeline or use the dropped participant box notation where it is absolutely clear that the participant does not exist before the create call is invoked. Participant deletion is shown by the ending of the participant's lifeline with the deletion cross.

Software participant creation in Java and C# is implemented using the `new` keyword, as shown in Example 7-3.

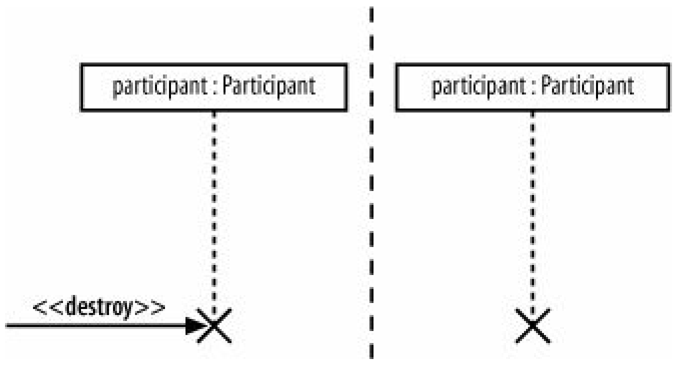
**Example 7-3. The MessageCaller creates a new MessageReceiver object simply by using the new keyword**

```
public class MessageReceiver {
   // Attributes and Methods of the MessageReceiver class
}

public class MessageCaller {

   // Other Methods and Attributes of the class are declared here

   public void doSomething(  ) {
      // The MessageReceiver object is created
      MessageReceiver messageReceiver = new MessageReceiver(  );
   }
}
```

With some implementation languages, such as Java, you will not have an explicit destroy method , so it doesn't make sense to show one on your sequence diagrams. Example 7-3 is one such case where the `messageReceiver` object will be flagged for destruction when the `doSomething( )` method completes its execution. However, no additional messages have to be passed to the `messageReceiver` to make it destroy itself since this is all handled implicitly by the Java garbage collector.

In these cases, where another factor such as the garbage collector is involved, you can either leave the object as alive but unused or imply that it is no longer needed by using the destruction cross without an associated `destroy` method, as shown in Figure 7-12.

**Figure 7-12. Using an explicit destroy message or implying that a participant has been discarded using just a destruction cross**

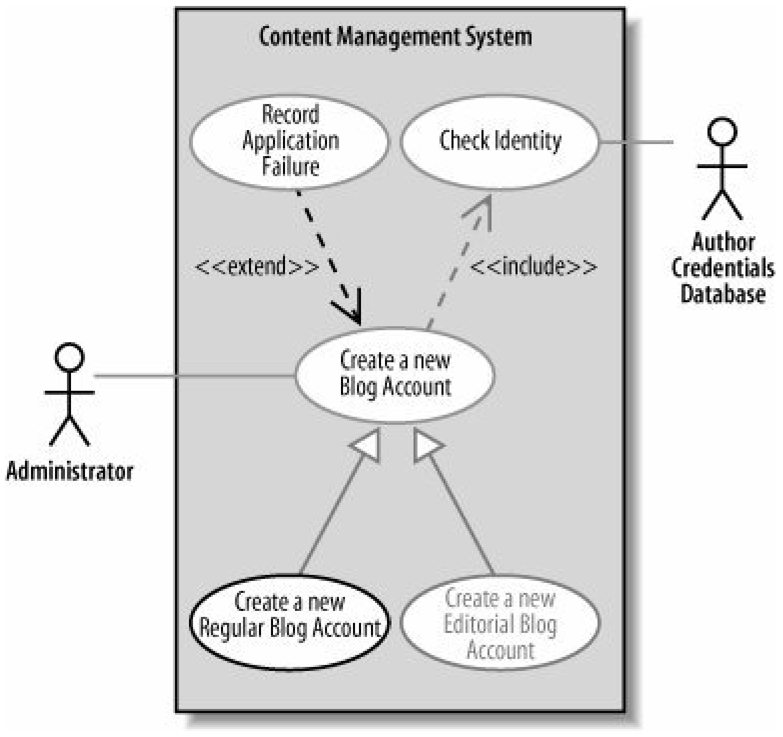


## 7.7. Bringing a Use Case to Life with a Sequence Diagram

It's time to take a closer look at a sequence. Specifically, let's look at a sequence diagram that is going to model the interactions that need to occur to make the `Create a new Regular Blog Account` use case happen.

Figure 7-13 should look familiar; it is just a quick reminder of what the `Create a new Regular Blog Account` use case looks like (see Chapter 2).

**Figure 7-13. The Create a new Regular Blog Account use case diagram**


Content Management System
Record Application Failure
Check Identity
<<extend>>
<<include>>
Author Credentials Database
Create a new Blog Account
Administrator
Create a new Regular Blog Account
Create a new Editorial Blog Account

Briefly, the `Create a new Regular Blog Account` use case is a special case of the `Create a new Blog Account` use case. It also includes all of the steps provided by the `Check Identity` use case and may optionally execute the steps provided by the `Record Application Failure` use case, if the application for a new account is denied. Figure 7-13 is a pretty busy use case diagram, so feel free to jump back to Chapter 2 to remind yourself of what is going on.

### Supporting the Dropped Title Box Technique

It is a sad fact that many standard UML tools do not support the dropped title box technique for showing participant creation or the cross notation for participant destruction. For example, you will often find that your tool does not allow you to place the participant's title box anywhere else but at the top of the diagram. In these cases, the best approach is to show that the creation or deletion message invokes the object being created and to rely on the reader of the diagram to realize that you mean that the participant is being created (a note to this effect is often helpful too). Unfortunately, this approach is not the best use of UML, but sometimes it is all you can get the tool to do.

### 7.7.1. A Top-Level Sequence Diagram

Before you can specify what types of interaction are going to occur when a use case executes, you need a more detailed description of what the use case does. If you've already completed a use case description, you already have a good reference for this detailed information.

Table 7-3 shows the steps that occur in the `Create a new Regular Blog Account` use case according to its detailed description.

**Table 7-3. Most of the detailed information that you will need to start constructing a sequence diagram for a use case should already be available as the Main Flow within the use case's description**

| Main Flow | Step | Action |
|---|---|---|
| | 1 | The Administrator asks the system to create a new blog account. |
| | 2 | The Administrator selects the regular blog account type. |
| | 3 | The Administrator enters the author's details. |
| | 4 | The author's details are checked using the Author Credentials Database. |
| | 5 | The new regular blog account is created. |
| | 6 | A summary of the new blog account's details are emailed to the author. |

Table 7-3 actually shows all of the steps involved in the `Create a new Regular Blog Account` use case, including any steps that it has inherited from `Create a new Blog Account` or reused from `Check Identity`. This has been done just so you can easily see all of the Main Flow steps in one place.

In practice, you would probably just look up all three use case descriptions separately without actually going to the bother of actually merging them.

Table 7-3 only shows the Main Flowthat is the steps that would occur without worrying about any extensionsbut this is a good enough starting point for creating a top-level sequence diagram, as shown in Figure 7-14.

**Figure 7-14. This sequence diagram shows the actors that interact with your system and your system is shown simply as a single part in the sequence**

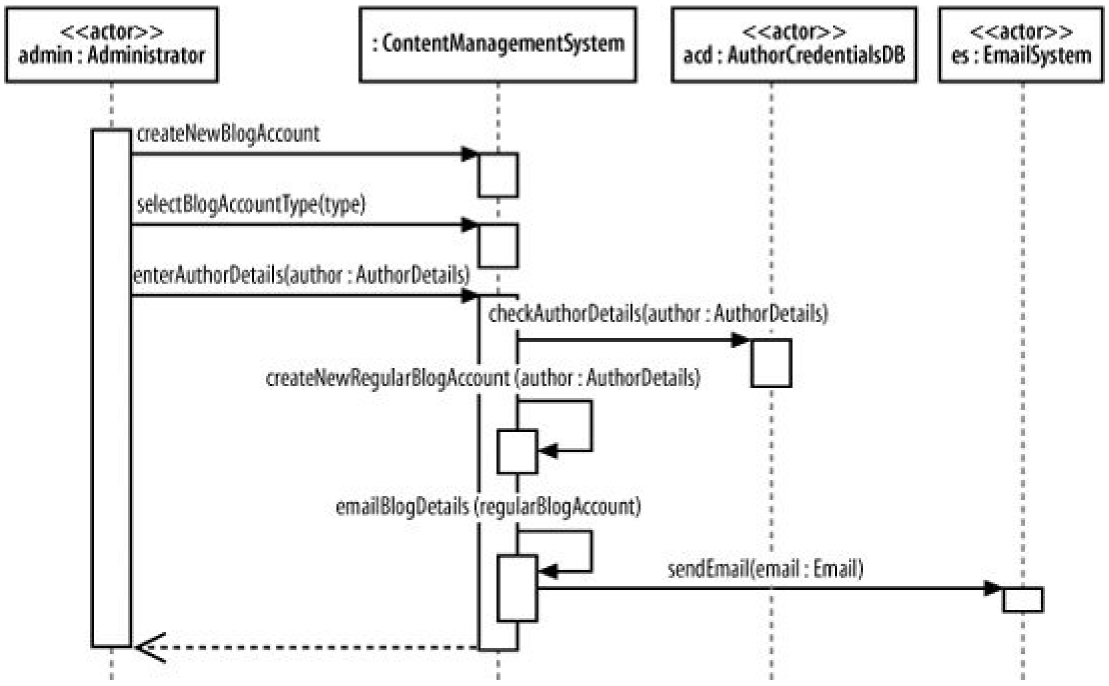
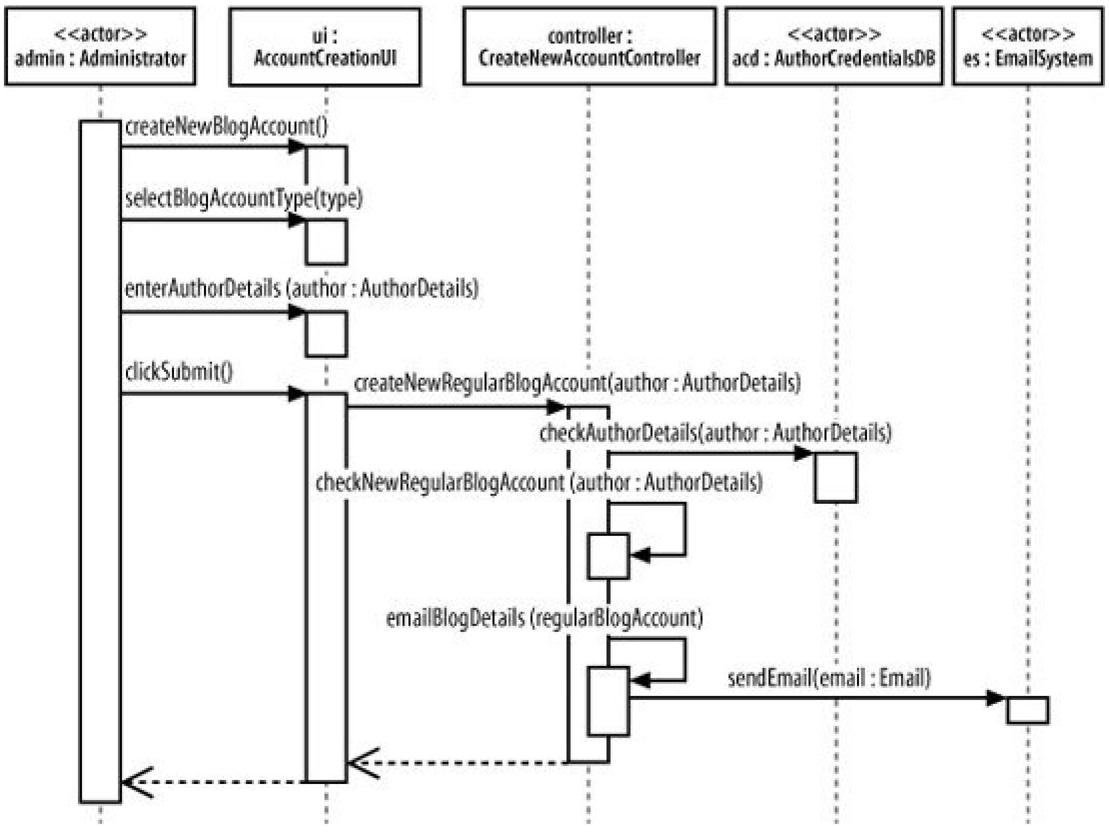

<<actor>> admin : Administrator
: ContentManagementSystem
<<actor>> acd : AuthorCredentialsDB
<<actor>> es : EmailSystem
createNewBlogAccount
selectBlogAccountType(type)
enterAuthorDetails(author : AuthorDetails)
checkAuthorDetails(author : AuthorDetails)
createNewRegularBlogAccount (author : AuthorDetails)
emailBlogDetails (regularBlogAccount)
sendEmail(email : Email)

Figure 7-14 focuses on the participants and messages that are involved in the use case. The same use case was modeled in Chapter 3 as an activity diagram, which focused on the processes involved rather than the particpants.

### 7.7.2. Breaking an Interaction into Separate Participants

At this point, Figure 7-14 shows only the interactions that must happen between the external actors and your system because that is the level at which the use case description's steps were written. On the sequence diagram, your system is represented as a single participant, the `ContentManagementSystem`; however, unless you intend on implementing your content management system as a single monolithic piece of code (generally not a good idea!), it's time to break apart `ContentManagementSystem` to expose the pieces that go inside, as shown in Figure 7-15

**Figure 7-15. Adding more detail about the internals of your system**


<<actor>>
admin : Administrator
ui :
AccountCreationUI
controller :
CreateNewAccountController
<<actor>>
acd : AuthorCredentialsDB
<<actor>>
es : EmailSystem
createNewBlogAccount()
selectBlogAccountType(type)
enterAuthorDetails (author : AuthorDetails)
clickSubmit()
createNewRegularBlogAccount(author : AuthorDetails)
checkAuthorDetails(author : AuthorDetails)
checkNewRegularBlogAccount (author : AuthorDetails)
emailBlogDetails (regularBlogAccount)
sendEmail(email : Email)

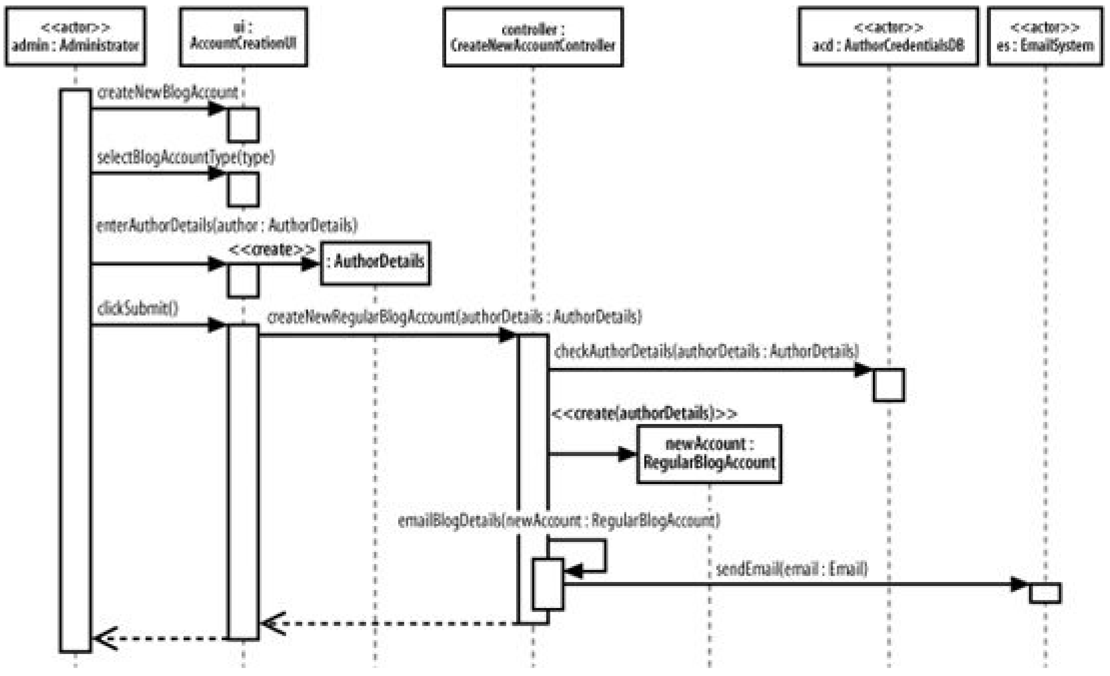
Sequence diagrams can get much more complicated by simply adding a couple of extra participants and some more detailed interactions. In Figure 7-15, the original sequence diagram has been refined so that the single `ContentManagementSystem` participant has been removed and in its place, more detail has been added showing the actual participants that will be involved.

Work on sequence diagrams invariably goes on throughout the life of your system's model, and even getting the right participants and interactions in a detailed sequence diagram at the beginning can be hard work. Keeping your sequence diagrams up to date is also a challenge (see "Managing Complex Interactions with Sequence Fragments" later in this chapter); therefore, expect to spend some time working with your sequence diagrams until you get things right.

### 7.7.3. Applying Participant Creation

Something critical is missing from the sequence diagram shown in Figure 7-15. The title of the use case in which the sequence diagram is operating is `Create a new Regular Blog Account`, but where is the actual creation of the blog account? Figure 7-16 adds the missing pieces to the model to show the actual creation of a regular blog account.

**Figure 7-16. Showing the lifelines of your sequence diagram's participants**


<<actor>> admin : Administrator
ui : AccountCreationUI
controller : CreateNewAccountController
<<actor>> acd : AuthorCredentialsDB
<<actor>> es : EmailSystem
createNewBlogAccount
selectBlogAccountType(type)
enterAuthorDetails(author : AuthorDetails)
<<create>>
: AuthorDetails
clickSubmit()
createNewRegularBlogAccount(authorDetails : AuthorDetails)
checkAuthorDetails(authorDetails : AuthorDetails)
<<create(authorDetails)>>
newAccount : RegularBlogAccount
emailBlogDetails(newAccount : RegularBlogAccount)
sendEmail(email : Email)

Participant lifelines are particularly useful when showing that a participant has been created. In Figure 7-16, the `AuthorDetails` and `RegularBlogAccount` participants are not in existence when the sequence diagram begins but they are created during its execution.

The `AuthorDetails` and `newAccount:RegularBlogAccount` participants are created by corresponding `create` messages. Each create message connects directly into the title box for the participant being created, passing any information needed when creating the new participant. By dropping the participant's title box to the point where the `create` message is actually invoked, the diagram can clearly show the point where the participant's lifeline begins.

### 7.7.4. Applying Participant Deletion

Let's say that the `authorDetails:AuthorDetails` participant is no longer required once the `newAccount:RegularBlogAccount` has been created. To show that the `authorDetails:AuthorDetails` participant is discarded at this point, you can use an explicit `destroy` message connected to the destruction cross, as shown in Figure 7-17.

### 7.7.5. Applying Asynchronous Messages

So far, all of the messages on our example sequence diagram have been synchronous; they are executed one after the other in order, and nothing happens concurrently. However, there is at least one message in the example sequence that is a great candidate for being an asynchronous message, as shown in Figure 7-18

**Figure 7-17. Showing that a participant is discarded using the destruction cross**

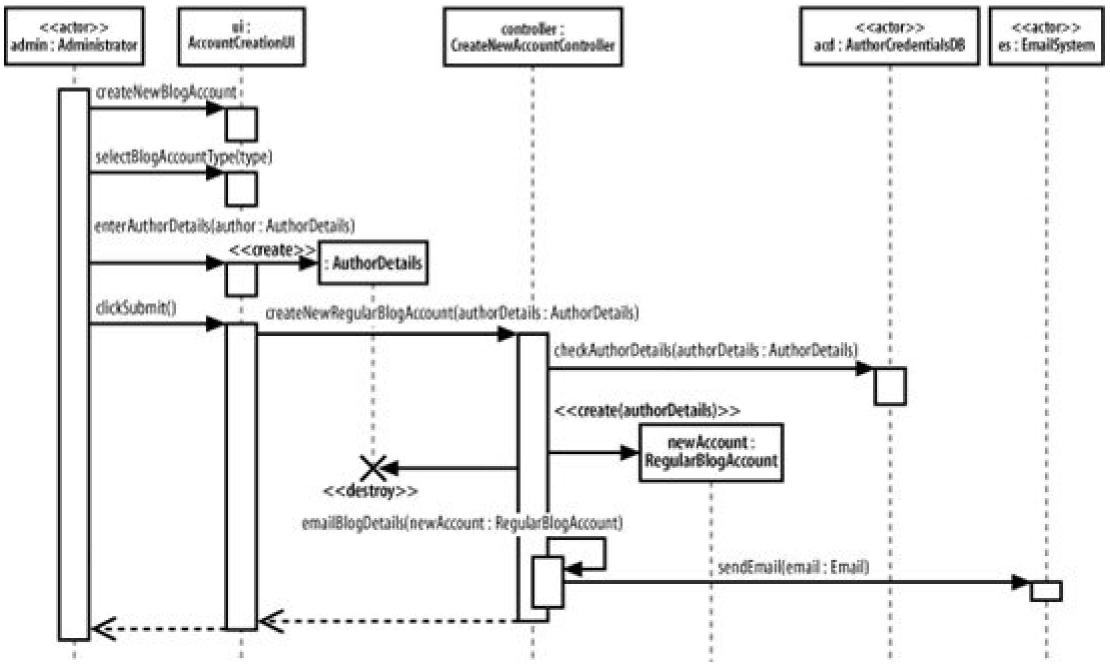
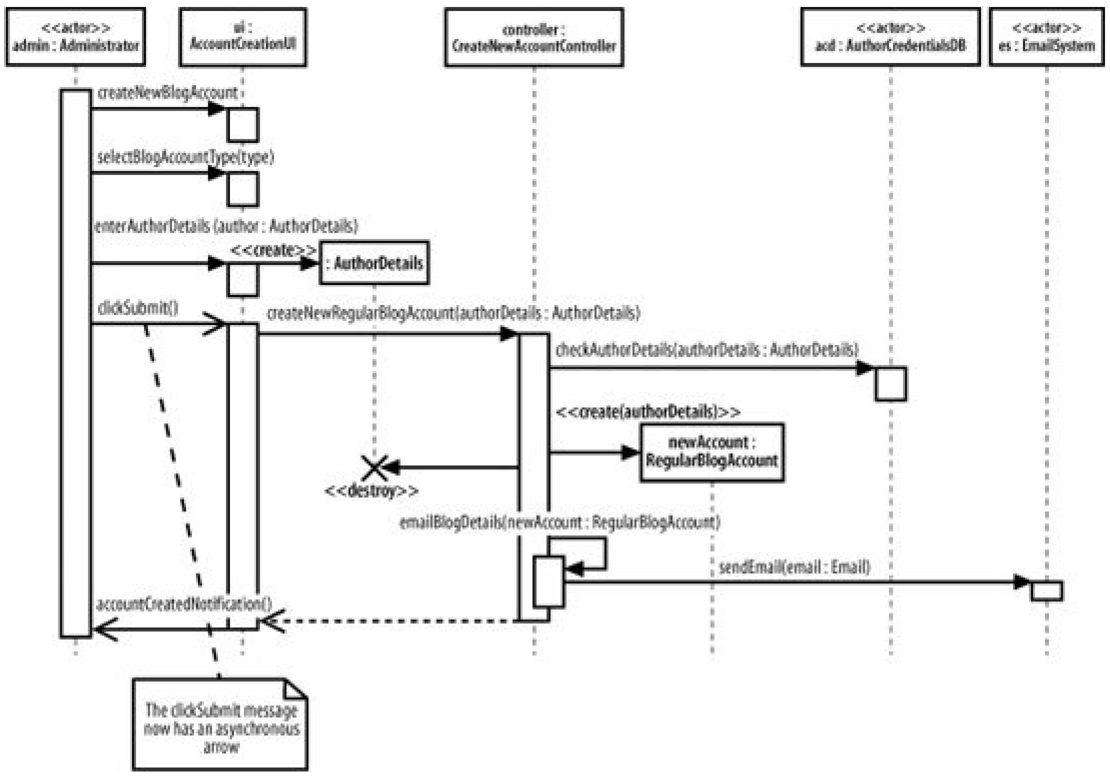

<<actor>> admin : Administrator
ui : AccountCreationUI
controller : CreateNewAccountController
<<actor>> acd : AuthorCredentialsDB
<<actor>> es : EmailSystem
createNewBlogAccount
selectBlogAccountType(type)
enterAuthorDetails(author : AuthorDetails)
<<create>>
: AuthorDetails
clickSubmit()
createNewRegularBlogAccount(authorDetails : AuthorDetails)
checkAuthorDetails(authorDetails : AuthorDetails)
<<create(authorDetails)>>
newAccount : RegularBlogAccount
<<destroy>>
emailBlogDetails(newAccount : RegularBlogAccount)
sendEmail(email : Email)

**Figure 7-18. The clickSubmit( ) message will currently produce some irregular behavior when the admin creates a new account**


<<actor>> admin : Administrator
ui : AccountCreationUI
controller : CreateNewAccountController
<<actor>> acd : AuthorCredentialsDB
<<actor>> es : EmailSystem
createNewBlogAccount
selectBlogAccountType(type)
enterAuthorDetails (author : AuthorDetails)
<<create>>
: AuthorDetails
clickSubmit()
createNewRegularBlogAccount(authorDetails : AuthorDetails)
checkAuthorDetails(authorDetails : AuthorDetails)
<<create(authorDetails)>>
newAccount : RegularBlogAccount
<<destroy>>
emailBlogDetails(newAccount : RegularBlogAccount)
sendEmail(email : Email)
accountCreatedNotification()
The clickSubmit message now has an asynchronous arrow

In Figure 7-18, when the `Administrator` clicks on the submit button the system freezes, until the new blog account has been created. It would be useful to show that the user interface allows the `Administrator` to carry on with other tasks while the content management system creates the new account. What we need is for the `clickSubmit( )` message to be asynchronous.

Converting the `clickSubmit( )` from a synchronous to an asynchronous message means that the sequence diagram now shows that when the new regular blog account information is submitted, the user interface will not lock and wait for the new account to be created. Instead, the user interface allows the `Administrator` actor to continue working with the system.

For the `Administrator` to receive feedback as to whether the new blog account has been created, the simple return arrow has to be replaced with a new `accountCreationNotification( )` asynchronous message since asynchronous messages do not have return values.

## 7.8. Managing Complex Interactions with Sequence Fragments

Most of what you've seen in this chapter will have been pretty familiar to anyone who has used sequence diagrams in UML 1.x. But now it's time for something completely different.

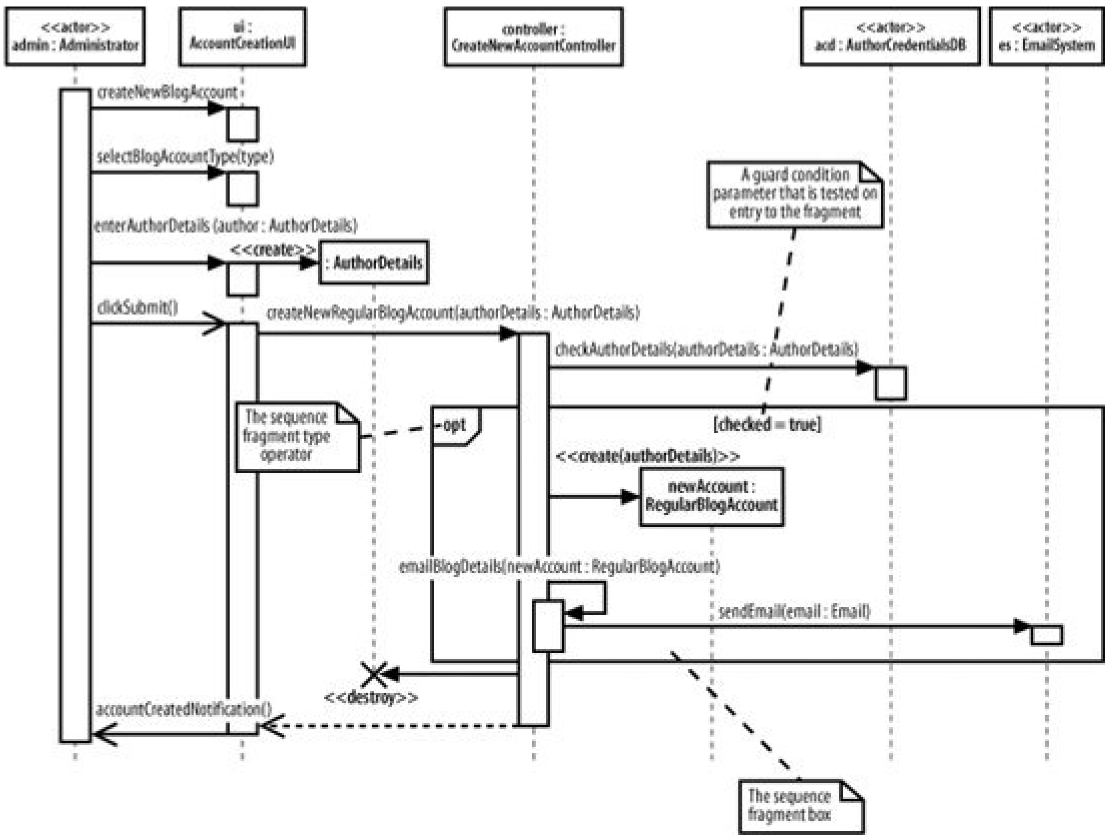
In the bad old days of pre-UML 2.0, sequence diagrams quickly became huge and messy, and contained far too much detail to be easily understood or maintained. There were no built-in, standard ways to show loops and alternative flows, so you had to "grow your own" solutions. This tended to contribute to the size and complexity of the sequence diagrams rather than helping to manage it.

Something new was needed to help the modeler work with the detail that a sequence diagram needed to capture, allowing her to create organized and structured sequence diagrams that showed complex interactions such as loops and alternate flows. The answer from the UML 2.0 designers was the sequence fragment.

A sequence fragment is represented as a box that encloses a portion of the interactions within a sequence diagram, as shown in Figure 7-19.

A sequence fragment's box overlaps the region of the sequence diagram where the fragment's interactions take place. A fragment box can contain any number of interactions and, for large complex interactions, further nested fragments as well. The top left corner of the fragment box contains an operator. The fragment operator indicates which type of fragment this is.

**Figure 7-19. A sequence fragment located as part of a larger sequence diagram, with notes to indicate the fragment box, any parameters, and its operator**


<<actor>> admin : Administrator
ui : AccountCreationUI
controller : CreateNewAccountController
<<actor>> acd : AuthorCredentialsDB
<<actor>> es : EmailSystem
createNewBlogAccount
selectBlogAccountType(type)
enterAuthorDetails (author : AuthorDetails)
<<create>>
: AuthorDetails
clickSubmit()
createNewRegularBlogAccount(authorDetails : AuthorDetails)
checkAuthorDetails(authorDetails : AuthorDetails)
A guard condition parameter that is tested on entry to the fragment
The sequence fragment type operator
opt
[checked = true]
<<create(authorDetails)>>
newAccount : RegularBlogAccount
emailBlogDetails(newAccount : RegularBlogAccount)
sendEmail(email : Email)
<<destroy>>
accountCreatedNotification()
The sequence fragment box

In Figure 7-19, the operator is `opt`, which means that this is an optional fragment. All the interactions contained within the fragment box will be executed according to the result of the fragments guard condition parameter.

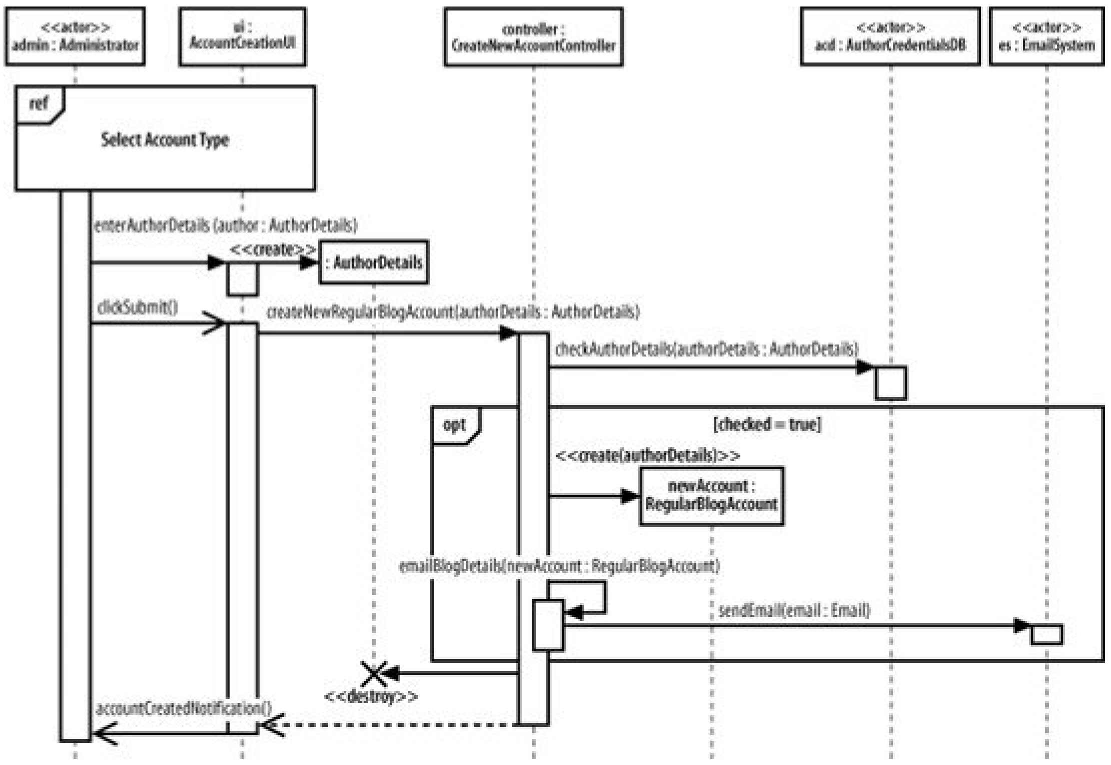
Some fragment types do not need additional parameters as part of their specification, such as the `ref` fragment type discussed in the next section, but the guard condition parameter is needed by the `opt` fragment type to make a decision as to whether it should execute its interactions or not. In the case of the opt fragment type, the interactions that the fragment contains will be executed only if the associated guard condition logic evaluates to true.

### 7.8.1. Using a Sequence Fragment: The ref Fragment

The `ref` type of sequence fragment finally alleviates some of the maintenance nightmare presented by the huge sequence diagrams that are often created for complex systems. In Figure 7-20, the `ref` fragment represents a piece of a larger sequence diagram.

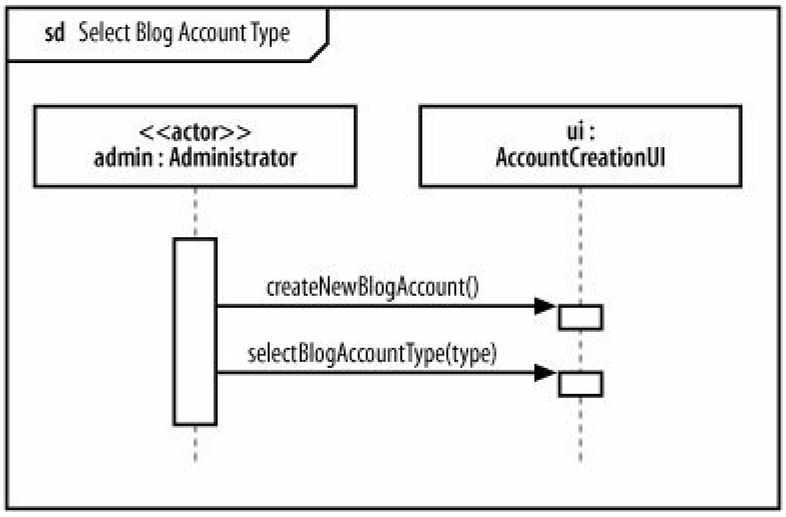
The interactions by which the `Administrator` actor selects a blog account type for creation are now contained within the referenced sequence fragment. Figure 7-21 shows how the referenced fragment can be expressed on a separate sequence diagram.

**Figure 7-20. Capturing the interactions used to select an account type within a ref sequence fragment**



<<actor>> admin : Administrator
ui : AccountCreationUI
controller : CreateNewAccountController
<<actor>> acd : AuthorCredentialsDB
<<actor>> es : EmailSystem
ref
Select Account Type
enterAuthorDetails (author : AuthorDetails)
<<create>>
: AuthorDetails
clickSubmit()
createNewRegularBlogAccount(authorDetails : AuthorDetails)
checkAuthorDetails(authorDetails : AuthorDetails)
opt
[checked = true]
<<create(authorDetails)>>
newAccount : RegularBlogAccount
emailBlogDetails(newAccount : RegularBlogAccount)
sendEmail(email : Email)
<<destroy>>
accountCreatedNotification()

**Figure 7-21. A referenced sequence diagram that contains the new account selection interactions**



sd Select Blog Account Type
<<actor>> admin : Administrator
ui : AccountCreationUI
createNewBlogAccount()
selectBlogAccountType(type)

Along with managing the sheer size of large sequence diagrams, the `ref` fragment also presents an opportunity to reuse a set of common interactions. Several `ref` fragment boxes can reference the same set of interactions, thereby reusing the interactions in multiple places.

The `ref` fragment type works in a very similar manner to the `<<include>>` use case relationship. See Chapter 2 for more about the `<<include>>` use case relationship.

### 7.8.2. A Brief Overview of UML 2.0's Fragment Types

UML 2.0 contains a broad set of different fragment types that you can apply to your sequence diagrams to make them more expressive, as shown in Table 7-4.

**Table 7-4. The fragment family and explanations why each type might be useful when creating sequence diagrams**

| Type | Parameters | Why is it useful? |
|---|---|---|
| ref | None | Represents an interaction that is defined elsewhere in the model. Helps you manage a large diagram by splitting, and potentially reusing, a collection of interactions. Similar to the reuse modeled when the `<<include>>` use case relationship is applied. |
| assert | None | Specifies that the interactions contained within the fragment box must occur exactly as they are indicated; otherwise the fragment is declared invalid and an exception should be raised. Works in a similar fashion to the `assert` statement in Java. Useful when specifying that every step in an interaction must occur successfully, i.e., when modeling a transaction. |
| loop | min times,<br><br>max times,<br><br>[guard_condition] | Loops through the interactions contained within the fragment a specified number of times until the guard condition is evaluated to false. Very similar to the Java and C# `for(..)` loop. Useful when you are trying execute a set of interactions a specific number of times. |
| break | None | If the interactions contained within the break fragment occur, then any enclosing interaction, most commonly a loop fragment , should be exited. Similar to the `break` statement in Java and C#. |
| alt | [guard_condition1] ...<br><br>[guard_condition2] ...<br><br>[else] | Depending on which guard condition evaluates to true first, the corresponding sub-collection of interactions will be executed. Helps you specify that a set of interactions will be executed only under certain conditions. Similar to an `if(..) else` statement in code. |
| opt | [guard_condition] | The interactions contained within this fragment will execute only if the guard condition evaluates to true. Similar to a simple `if(..)` statement in code with no corresponding `else`. Especially useful when showing steps that have been reused from another use case's sequence diagrams, where `<<extend>>` is the use case relationship. |
| neg | None | Declares that the interactions inside this fragment are not to be executed, ever. Helpful if you are just trying to mark a collection of interactions as not executed until you're sure that those interactions can be removed. Most useful if you happen to be lucky enough to be using an Executable UML tool where your sequence diagrams are actually being run. Also can be helpful to show that something cannot be done, e.g., when you want to show that a participant cannot call `read( )` on a socket after `close( )`.Works in a similar fashion to commenting out some method calls in code. |
| par | None | Specifies that interactions within this fragment can happily execute in parallel. This is similar to saying that there is no need for any thread-safe locking required within a set of interactions. |
| region | None | Interactions within this type of fragment are said to be part of a critical region. A critical region is typically an area where a shared participant is updated. Combined with parallel interactions, |

| | | |
|---|---|---|
| | | specified using the par fragment type, you can model where interactions are not required to be thread- or process-safe (par fragment) and where locks are required to prevent parallel interactions interleaving (region fragment ). Has similarities synchronized blocks and object locks in Java. |

Sequence fragments make it easier to create and maintain accurate sequence diagrams. However, it's worth remembering that no fragment is an island; you can mix and match any number of fragments to accurately model the interactions on a sequence diagram. Be wary if your diagrams become huge and unwieldy even when you are using fragments, since you might simply be trying to model too much in one sequence.

We've given you a brief overview of sequence diagram fragments here. All the different sequence diagram fragment types are a big subject in their own right and are a little beyond the scope of this book. For a more in-depth look at the different types of sequence diagram fragments, see UML 2.0 in a Nutshell (O'Reilly).

## 7.9. What's Next?

Sequence diagrams are closely related to communication diagrams. So closely, in fact, that many modelers often don't know when to use sequence versus communication diagrams. Chapter 8 describes communication diagrams and concludes with a comparison between the two, providing some tips about when to use which diagram type.

Sequence and communication diagrams are both interaction diagrams; timing diagrams are yet another type of interaction diagram. Timing diagrams specialize at showing time constraints involved with interactions, which is especially useful for real-time systems. Timing diagrams are covered in Chapter 9.

If your sequence diagram is getting cluttered with too many messages, step back and look at interaction diagrams on a higher level with interaction overview diagrams. Interaction overview diagrams model the big picture perspective on interactions that occur within your system. Interaction overview diagrams are described in Chapter 10.