LEAN-AGILE ACCEPTANCE TEST-DRIVEN DEVELOPMENT

Better Software Through Collaboration

Net Objectives

Lean-Agile Series

KEN PUGH

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"*Lean-Agile Acceptance Test-Driven Development* tells a tale about three fictive project stakeholders as they use agile techniques to plan and execute their project. The format works well for the book; this book is easy to read, easy to understand, and easy to apply."

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"Agile development, some say, is all about pairing, and, yes, I'm a believer in the power of pairing. After reading this book, however, I became a fan of the 'triad'—the customer or business analyst + the developer + the tester, who work collaboratively on acceptance tests to drive software development. I've written some patterns for customer interaction and some patterns for testing and I like what Ken Pugh has chosen to share with his readers in this down-to-earth, easy-to-read book. It's a book full of stories, real case studies, and his own good experience. Wisdom worth reading!"

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“This book provides clear, straightforward guidance on how to use business-facing tests to drive software development. I’m excited about the excellent information in this book. It’s a great combination of the author’s experiences, references to other experts and research, and an example project that covers many angles of ATDD. A wide range of readers will learn a lot that they can put to use, whether they work on projects that call themselves lean or agile or simply want to deliver the best possible software product.”

—*Lisa Crispin, Agile Tester, ePlan Services, Inc., Author of* Agile Testing

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Lean-Agile Acceptance Test-Driven Development

Better Software Through Collaboration

Ken Pugh

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*I'd like to dedicate this book to three people.
My brother Bob inspired me to become an engineer.
I recall one time when he was home from college and presented me
with the N-body problem [Wiki01] and the four color map problem
[Wiki02]. My high school science teacher, Mr. Sanderson, spurred
me on to explore topics such as why there is air. My mechanical
engineering professor at Duke, Dr. George Pearsall, encouraged
exploration. In his strength of materials class, I discovered
why my guitar strings broke. To each of them, I give thanks.*

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About the Author

KATAHDIN
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Kenneth Pugh has over two-fifths of a century of software experience. Previously a principal at Pugh-Killeen Associates, he is now a fellow consultant for Net Objectives. He has developed software applications ranging from radar tracking to financial analysis. Responsibilities have included everything from gathering requirements to testing. After the start of the new millennium, he has worked with teams to create software more effectively with lean and agile processes. He has spoken at numerous national conferences; consulted and taught all over the world; and testified on technology topics. This is his seventh book. In 2006, his book *Prefactoring* won the Jolt Award [DrDobbs01]. In his spare time, he snowboards, windsurfs, and backpacks. Between 1997 and 2003, he completed the Appalachian Trail. The cover photograph of Mount Katahdin, the northern end of the trail, was taken by the author from Abol Bridge in Maine.

Introduction

"Context is all."

Margaret Atwood, *The Handmaid's Tale*

The context for the tale is introduced. A brief background of acceptance test–driven development (ATDD) is presented.

Testable Requirements

Developing software with testable requirements is the theme of this book. A testable requirement is one with an acceptance test. Acceptance tests drive the development of the software. As many development groups have experienced, creating acceptance tests prior to implementing requirements decreases defects and improves productivity. (See the Epilogue for examples.) A triad—the customer/business analyst, developer, and tester—collaborates on producing these tests to clarify what is to be done. In creating a high-quality product, ATDD is as much about this clarification as it is about the actual testing.

As an example, do you have criteria in mind as to whether this book will meet your needs? If you finish this book, how will you know whether it has met those criteria? This book represents an implementation of something that should meet your needs. Because you are reading this book after its completion, you don't have an opportunity to influence the acceptance criteria. But let me list the criteria here and see if this is what you are after.

In English classes, the teacher emphasized that a story should contain a who, what, when, where, why, and how. So I've made that the goal of this book. It explains

- Who creates acceptance tests
- What acceptance tests are
- When the acceptance tests should be created
- Where the acceptance tests are used
- Why acceptance test-driven development is beneficial
- How the acceptance tests are created

By the end of this book, the expectation is that you should understand how testable requirements can make the software development process more enjoyable (or at least less painful) and help in producing higher-quality products., Let's begin with a brief discussion on the why, what, where, and who issues.

Why ATDD Is Beneficial

Let's start with the answer to the why question. Jeff Sutherland, the cocreator of Scrum, has metrics on software productivity [Sutherland01]. He has found that adding a quality assurance person to the team and creating acceptance tests prior to implementation doubles the team's productivity. Your actual results may vary, but teams adopting ATDD have experienced productivity and quality increases. Mary Poppendieck says that creating tests before writing code is one of the two most effective and efficient process changes for producing quality code. (The other is frequent feedback.) [Poppendieck01] Customer-developer-tester collaboration reduces unnecessary loops in the development process. As Jerry Weinberg and Don Gause wrote, "Surprising, to some people, one of the most effective ways of testing requirements is with test cases very much like those for testing the completed system" [Weinberg01].

If you are going to test something and document those tests, it costs no more to document the tests up front than it does to document them at the end. But these are more than just tests. As stated in Chapter 3, "Testing Strategy," "The tests clarify and amplify the requirements." An acceptance test is "an authoritative and reliable source of what the software should do functionally" [Adzic01].

What Are Acceptance Tests?

Acceptance tests, as used in this book, are defined by the customer in collaboration with the developer and tested and created prior to implementation. They are not the traditional user acceptance tests [Cimperman01], which are performed after implementation "by the end user to determine if the system is working according to the specification in the contract." [Answers01] They are also not system tests which are usually independently written by testers by reading the requirements to ensure that the system meets those requirements. [Answers02] All three are related in that they are all black box tests—that is, they are independent of the implementation. It is the time and manner of creation in which they differ.

Where Are Acceptance Tests Used?

The concept of an acceptance test is defined by the intent of the test, not its implementation. You can apply an acceptance test at the unit, integration, or user interface level. You can use it as a validation test, which allows input to or produces outputs from an application installed in the customer's environment. Further, you can use it as a design verification test that ensures a unit or component meets it intended responsibility. In either case, the test makes certain the application is acceptable to the customer.

Who Creates the Acceptance Tests?

This book refers to a triad: the customer, developer, and tester. The power of three people working together [Crispin01] can create the bests acceptance tests.

If the triad writes the tests together, the distinction between user acceptance tests and system tests is practically eliminated. As will be shown, the three roles of customer, developer, and tester may be played by different individuals or by the same individual with different focuses.

What Types of Software Are Covered?

The acceptance tests covered in this book revolve mainly around requirements that have determinable results. These results are typical in business situations. You place an order, and the order total is determinable. On the other hand, you have a requirement to find the shortest possible path that goes through a number of points. For example, you want to determine the shortest driving trip that travels over every road in the United States. For a small number of roads (such as the interstate highways), the result is determinable by brute force. However, for a large number of roads, the answer is not determinable. You can have a test that checks the output of one way of solving the problem against the output of another way. But that does not guarantee that the shortest solution has been found.

How Will We Get to ATDD?

The answers to how and when the acceptance tests should be created are shown by a continuous example throughout this book. Each step in their creation and use is covered. Some books are devoted entirely to a single step and go into much greater detail than does this book. In particular, the references offer links for tools to automate the acceptance tests, to the agile process itself, to requirement elicitation, and to testing the other qualities of a software system (usability, performance, and so on).

The continuous example for Sam's CD Rental Store follows Sam's story in *Prefactoring—Extreme Abstraction, Extreme Separation, Extreme Readability*. That book used the tale as the context for examples of good design. *Prefactoring* covered some of the aspects of developer-customer interaction, because a good design requires understanding the customer's needs. *Prefactoring*'s focus was on the internal software quality. This book's focus is on externally visible quality. The two books complement each other.

Organization

The material is presented in six parts. The first part documents the tale of the triad members—customer, developer, tester—as they create a software system. It shows how acceptance testing permeates the entire process, from the project charter to individual stories. The second part covers details in acceptance testing, as simplification by separation. The third part explores general subjects, such as test presentation and valuation. The fourth part includes case studies from real-life situations. In some instances, the studies have been simplified to show only the relevant parts. The fifth part involves more technical issues, as how to handle test setup. The sixth part offers the appendices, which give additional information on topics as business value and test automation. For those who want to get the quick summary of ATDD and its benefits, read Chapter 25, "Retrospective and Perspective." Those who want to read the experiences of others, see the Epilogue.

Example Tables

The book presents tests with examples in tables rather than in narrative form. These tables follow the concepts of David Parnas, who states, "The tables constitute a precise requirements document" [Parnas01]. Some people prefer free text over tables. Those who prefer the narrative can easily convert tables to this form. The reverse is usually more difficult. Tables are familiar to spreadsheet users. Many business rules have conditions that are more easily tested with a table. From an analysis point of view, you can often find missing conditions by examining the values in a table's columns.

Automation After Communication

I emphasize acceptance tests as customer-developer-tester communication. If you don't have an acceptance test, you have nothing to automate. I do not advocate a particular test automation framework. When you automate an acceptance test that includes its accompanying requirement, you get what many term an executable specification [Melnik02], [Melnik03].

Acceptance tests can be manual. But if they are automated, you can use them as regression tests to ensure that future changes to the system do not affect previously implemented requirements. So the most effective use of the tests is as an executable specification. Appendix C, "Test Framework Examples," shows examples of test automation using several frameworks. The code for the examples is available online at http://atdd.biz.

ATDD Lineage

A Chinese proverb says, "There are many paths to the top of the mountain, but the view is always the same." And many of the paths share the same trail for portions of the journey. Although acceptance testing has been around for a long time, it was reinvigorated by extreme programming [Jefferies01]. Its manifestations include ATDD as described in this book, example-driven development (EDD) by Brian Marick [Marick01], behavior-driven development (BDD) by Dan North [Chelimsky01], story test-driven development (SDD) by Joshua Kerievsky of Industrial Logic [Kerievsky01], domain-driven design (DDD) by Eric Evans [Evans01], and executable acceptance test-driven development (EATDD) [EATDD01]. All these share the common goal of producing high-quality software. They aid developers and testers in understanding the customer's needs prior to implementation and customers being able to converse in their own domain language.

Many aspects are shared among the different approaches. ATDD in this book encompasses aspects of these other approaches. I've documented the parts that come specifically from the other driven developments (DDs), including Brian Marick's examples, Eric Evan's ubiquitous language, and Dan North's given-when-then template. The most visible differences are that the tests here are presented in table format rather than in a more textual format, such as BDD's Cucumber language, and they concentrate on functionality instead of the user interface. This book's version of ATDD matches closely that described by

Lasse Koskela [Koskela01] and Gojko Adzic [Adzic01] and follows the testing recommendations of Jim Coplien [Coplien01].

One of the most well-known DDs is test-driven development (TDD) by Kent Beck [Beck01]. TDD encompasses the developer's domain and tests the units or modules that comprise a system. TDD has the same quality goal as ATDD. The two interrelate because the acceptance tests can form a context in which to derive the tests for the units. TDD helps creates the best design for an application. A TDD design issue would be assigning responsibilities to particular modules or classes to pass all or part of an acceptance test.

Acceptance test driven development:
The answer is 42. Now implement it.

Summary

- Testable requirements have acceptance tests associated with them.
- ATDD involves developing requirement tests prior to implementation.
- ATDD can improve productivity.
- Acceptance tests are developed collaboratively between the customer, developer, and tester.

Chapter 4

An Introductory Acceptance Test

"If you don't know where you're going, you will wind up somewhere else."

Yogi Berra

An example of an acceptance test is presented, along with four ways that you can execute an acceptance test.

A Sample Business Rule

Here is an example from a previous project where Debbie and Tom created tests in collaboration with the customer. The business representative, Betty, presented the two of them with a business rule for giving discounts that she had obtained from one of the stakeholders. The stakeholder wanted to give discounts to the firm's customers based on what type of customer they were. Debbie had already completed implementing a previous requirement that determined the customer type. Here's the rule that Betty gave them:

> If Customer Type is Good and Item Total is less than or equal to $10.00,
>
> Then do not give a discount,
>
> Otherwise, give a 1% discount.
>
> If Customer Type is Excellent,
>
> Then give a discount of 1% for any order.
>
> If Item Total is greater than $50.00,
>
> Then give a discount of 5%.

This rule may seem clear. It uses consistent terms, such as *Customer Type* and *Item Total*. Debbie and Tom had previously gotten from Betty the definitions of those terms [Evans01]. For example, Item Total did not include taxes or shipping. But even with that consistency, there was an issue. Tom and Debbie looked at the rule and tried to figure out what the discount percentage should be if a customer who is good had an order total greater than $50.00. So Betty, Debbie, and Tom made up a table of examples.[1]

Discount Calculation		
Item Total	**Customer Rating**	**Discount Percentage?**
$10.00	Good	0%
$10.01	Good	1%
$50.01	Good	1% ??
$.01	Excellent	1%
$50.00	Excellent	1%
$50.01	Excellent	5%

The answers in this table of examples are going to be used to test the implementation. The first two rows show that the limit between giving a good customer no discount or a 1% discount is $10.00. The "less than or equal to" in the business rule is pretty clear. The tests just ensure that the implementation produced that result. The ?? was put after the 1 in the third example because it was unclear to the triad whether that was the right value. To what type of customer did the last statement in the rule apply?

The fourth row indicates that the discount for an excellent customer starts at the smallest possible Item Total. The fifth and sixth entries show that the discount increases just after the $50.00 point.[2]

Betty took this table back to the stakeholder. He looked it over and said that the interpretation was correct. He did not want to give a 5% discount to good customers. So ?? from that result was removed from that cell. There was now a set of tests that could be applied to the system. The correct discount amount test is not just a single case but includes cases for all possible combinations.

Tom suggested other possibilities. For example, what if Item Total was less than $0.00? Tom asked Betty whether this would ever happen. She said it might

1. See Appendix D, "Tables Everywhere," for an example of putting the rule into a table.

2. There could be even more interpretations of this business rule, as reviewers pointed out. For example, if Customer Rating is any other type than Good or Excellent, what should the discount be?

be possible, because Item Total could include a rebate coupon that was greater than the total of the items. So Tom added the following possibilities.

Discount Calculation		
Item Total	**Customer Rating**	**Discount Percentage?**
$–.01	Good	0%
$–.01	Excellent	1% ??

Tom explained that it didn't seem right to apply a discount percentage that would actually increase the amount that the customer owed. Based on this example, Betty went back to the stakeholder and confirmed that the percentage should be 0% if Item Total is less than 0 for any customer. So the table became as follows.

Discount Calculation		
Item Total	**Customer Rating**	**Discount Percentage?**
$–.01	Good	0%
$–.01	Excellent	0%

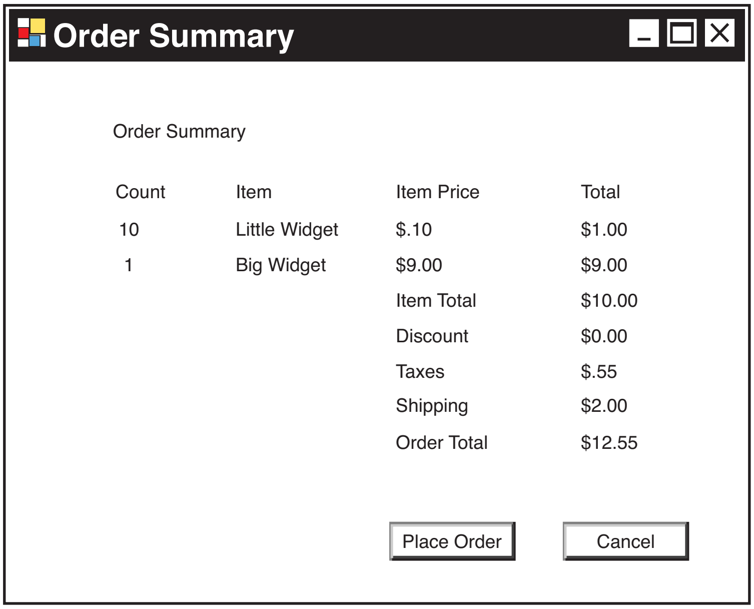
These examples were the acceptance tests for the system. If Debbie implemented these correctly, Betty would be satisfied. Now it was a matter of how Debbie and Tom were going to use these tests to test the system.

Implementing the Acceptance Tests

Tom and Debbie needed to apply these tests to the implementation they were developing. There were at least four possible ways to do this. First, Tom could create a test script that operates manually at the user interface level. Second, Debbie could create a test user interface that allows her or Tom to check the appropriate discount percentages. Third, Debbie could perform the tests using a unit testing framework. Fourth, Tom and Debbie could implement the tests with an acceptance test framework. Following are examples of how they could use each of these possibilities.

Test Script

In this case, the program has a user interface that allows a customer to enter an order. The user interface flow is much like Amazon or other order sites. The user enters an order and a summary screen appears, such as the one in Figure 4.1.



Order Summary

Count	Item	Item Price	Total
10	Little Widget	$.10	$1.00
1	Big Widget	$9.00	$9.00
		Item Total	$10.00
		Discount	$0.00
		Taxes	$.55
		Shipping	$2.00
		Order Total	$12.55

Figure 4.1 *Order Interface*

What Tom would have to do is to create a script that either he or Debbie would follow to test each of the six cases in the Discount Calculation table. He might start by computing what the actual discount amount should be for each case. Unless the Order Summary screen shows this percentage, this value is the only output Tom can check to ensure the calculation is correct. Here is an addition to the table that shows the amounts he needs to look for.

Discount Calculation				
Item Total	**Customer Rating**	**Discount Percentage?**	**Discount Amount?**	**Notes**
$10.00	Good	0%	$0.00	
$10.01	Good	1%	$0.10	Discount rounded down
$50.01	Good	1%	$0.50	Discount rounded down
$.01	Excellent	1%	$0.00	Discount rounded down
$50.00	Excellent	1%	$0.50	
$50.01	Excellent	5%	$2.50	Discount rounded down

The script would go something like this:

1. Log on as a customer who has the rating listed in the table.
2. Start an order, and put items in it until the total is the specified amount in the Item Total column on the test.
3. Check that the discount on the Order Summary screen matches Discount Amount in the table.

Then the test would be repeated five more times to cover all six cases. Either Tom or Debbie would do this once the discount feature and order features are implemented. This test should be run for all possible combinations. That would have been more difficult if there were more discount percentages for more customer types. There's another possible way to run these tests.

Test User Interface

To simplify executing the tests, Debbie could set up a user interface that connects to the discount calculation module in her code. This interface would be used only during testing. But having it would cut down on the work involved in showing that the percentage was correctly determined. The interface might be a command-line interface (CLI) or a graphical user interface (GUI). For example, a CLI might be this:

```
RunDiscountCalculatorTest  <item_total> <customer_type>
```

And when it is run for each case, such as

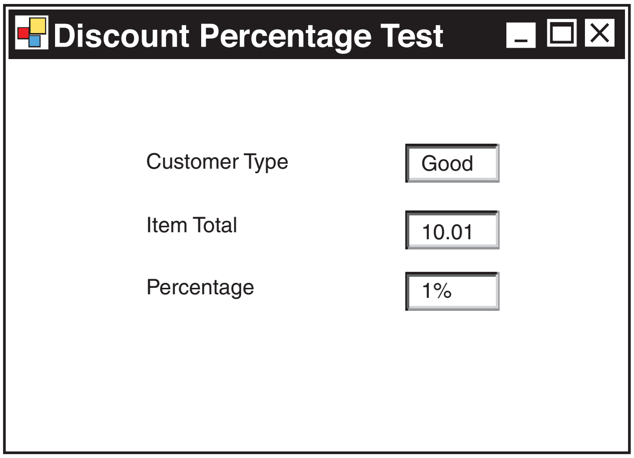
```
RunDiscountCalculatorTest 10,00 Good
```

It would output the result

```
0
```

A GUI, such as what's shown in Figure 4.2, might be connected to the CLI.

Regardless of whether it is a GUI or CLI, the user interface has penetrated into the system. It exposes a test point within the system that allows easier testing. Here's an analogy showing the differences between this method and Tom's original test script. Suppose you want to build a car that accelerates quickly. You know you need an engine that can increase its speed rapidly. If you could only check the engine operation as part of the car, you would need to put the engine in the car and then take the car on a test drive. If you had a test point for the engine speed inside the car, you could check how fast the engine sped up without driving the car. You could measure it in the garage. You'd save a lot of



Discount Percentage Test

Customer Type Good

Item Total 10.01

Percentage 1%

Figure 4.2 *User Interface for Testing*

time in on-the-road testing if the engine wasn't working properly. That doesn't mean you don't need to test the engine on the road. But if the engine isn't working by itself, you don't run the road test until the engine passes its own tests.

If you're not into cars, Figure 4.3 shows a context diagram. The Order Summary screen connects to the system through the standard user interface layer. The Discount Percentage user interface connects to some module inside the system. Let's call that module the Discount Calculator. By having a connection to the inside, a tester can check whether the internal behavior by itself is correct.

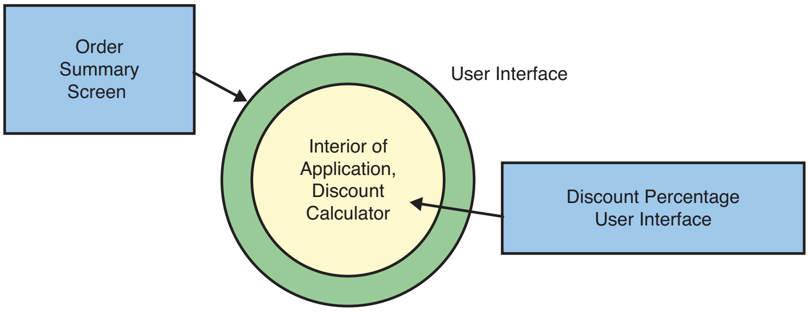

Order Summary Screen
User Interface
Interior of Application, Discount Calculator
Discount Percentage User Interface

Figure 4.3 *Context Diagram*

xUnit Test

The next way to perform the testing is to write the tests for the Discount Calculator in a unit testing framework. The framework used is usually in the language that the program is written in. There is a generic framework called xUnit that has versions for many programming languages. Here's a sample of what these tests look like in Java using Junit [Beck01]. The test would look similar in TestNG [Beust01], but the order of the parameters would be reversed:

```
class DiscountCalculatorTest  {
   @Test
   public void shouldCalculateDiscountPercentageForCustomer() {
      DiscountCalculator dc = new DiscountCalculator();
      assertEquals(0, dc.computeDiscountPercentage(10.0,
         Customer.Good));
      assertEquals(1, dc.computeDiscountPercentage (10.01,
         Customer.Good));
      assertEquals(1, dc.computeDiscountPercentage (50.01,
         Customer.Good));
      assertEquals(1, dc.computeDiscountPercentage(.01,
         Customer.Excellent));
      assertEquals(1, dc.computeDiscountPercentage(50.0,
         Customer.Excellent));
      assertEquals(5, dc.computeDiscountPercentage(50.01,
         Customer.Excellent));
   }
}
```

Any time there is a change in the examples that Betty and the stakeholder use to explain the business rule, Debbie may want these tests to conform to the changed examples. That's a bit of waste. The next testing framework can eliminate that waste.

Automated Acceptance Test

Betty, Debbie, and Tom agreed that the examples in the table accurately reflected the requirements and there would be less waste if the table did not have to be converted into another form for testing. Several available acceptance test frameworks use tables. Some examples are in Appendix C, "Test Framework Examples." With these frameworks, you describe the tests with a table similar to the one for the example.

The following test table works in table-based frameworks, such as the FitNesse and Fit frameworks. A similar style table can be used in narrative-form frameworks, such as Cucumber.[3] The table looks practically like the one that Betty presented to the stakeholder.

3. Fit is the Framework for Integrated Tests, developed by Ward Cunningham [Cunningham01], [Cunningham02]. Fit was incorporated into FitNesse by Bob Martin [Martin01]. Cucumber can be found in [Chelimsky01].

Discount Calculation		
Item Total	**Customer Rating**	**Discount Percentage()**
$10.00	Good	0%
$10.01	Good	1%
$50.01	Good	1%
$.01	Excellent	1%
$50.00	Excellent	1%
$50.01	Excellent	5%

Now when the table is used as a test, the Fit/FitNesse framework executes code that connects to the Discount Calculator. It gives the Discount Calculator the values in Item Total and Customer Rating. The Discount Calculator returns the Discount Percentage. The framework compares the returned value to the value in the table. If it agrees, the column shows up in green. If it does not, it shows up in red. The colors cannot be seen in this black-and-white book. So light gray represents green and dark gray represents red. The first time the test was run, the following table was output.

Discount Calculation		
Item Total	**Customer Rating**	**Discount Percentage()**
$10.00	Good	0%
$10.01	Good	1%
$50.01	Good	Expected 1% Actual 5%
$.01	Excellent	1%
$50.00	Excellent	1%
$50.01	Excellent	5%

With the results shown in the table, it was apparent there was an error in the Discount Calculator. Once it was fixed, Betty saw the passing tests as confirmation that the calculation was working as desired.

An Overall Test

If the discount test is applied using one of the last three forms, there still needs to be a test using the order interface. This ensures that processing an order is correctly connected to the Discount Calculator. The script for an order would be run for a couple of instances. But unless there was a large risk factor involved, the script might just be executed for a few cases, such as the following.

Discount Calculation			
Item Total	Customer Rating	Discount Percentage?	Discount Amount?
$10.01	Good	1%	$0.10
$50.01	Excellent	5%	$2.50

Testing Process

The acceptance test is the original table that Betty, Tom, and Debbie developed to clarify the business rule. This acceptance test can be used at four different levels, as described earlier in this chapter. Because the acceptance test was customer supplied, all four levels are considered acceptance tests in this book. The last two forms are automated by their nature. The second form—an interface to the Discount Calculator—can be automated. The test for an order could also be automated with a little more effort. However, you should still check it manually as well.

Passing the acceptance tests is necessary but insufficient to ensure that the system meets the customer needs. Other tests, such as those for quality attributes and usability (described in Chapter 3, "Testing Strategy"), also need to be passed. See [Meszaros02] for more information.

Summary

- Examples of requirements clarify the requirements.
- The examples can be used as tests for the implementation of the requirements.
- Tests for business rules can be executed in at least these four ways:
    - Creation through the user interface of a transaction that invokes the business rule
    - Development of a user interface that directly invokes the business rule
    - A unit test implemented in a language's unit testing framework
    - An automated test that communicates with the business rule module

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