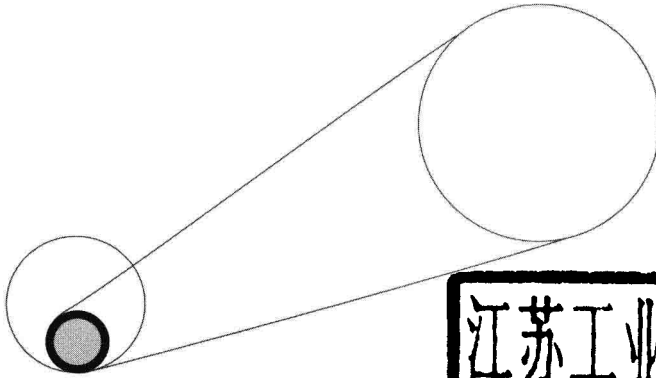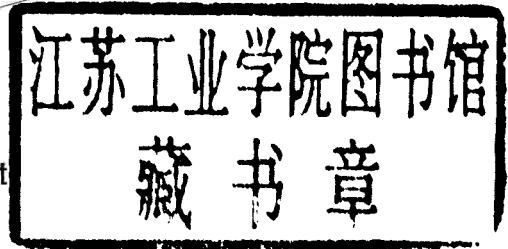O'REILLY®

RFID Essentials

Bill Glover & Himanshu Bhatt

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RFID Essentials
by Bill Glover and Himanshu Bhatt

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Praise for RFID Essentials

"RFID is one of those rare 'change the world' technologies that will force a rethinking of many value-chain strategies. In that context, Bill and Himanshu's comprehensive expert-in-a-book creation should be on the must-read list for strategists and IT professionals who see RFID in their future. Unique competitive advantage erupts from enterprises that couple the RFID technologies laid out in *RFID Essentials* with modern business integration using service-oriented architectures. This is the book to read in order to understand this new landscape."

> —MARK BAUHAUS, SVP: BUSINESS INTEGRATION, IDENTITY, AND APPLICATION PLATFORM SOFTWARE

"RFID, or Radio Frequency Identification, got legs with mandates from giants such as Wal-Mart and the U.S. Department of Defense; however, the use is going beyond the supply chain. Companies are seeing the benefits of RFID in other areas such as asset tracking and drug authentication. No matter what the need, the first step in any engagement is understanding the technology and how it can be used to gain business benefits. This book gives a good foundation on RFID fundamentals and is a must-read if you are considering adopting RFID for your business or applications."

> —JULIE SARBACKER, DIRECTOR, SUN MICROSYSTEMS RFID BUSINESS UNIT

"The authors have done a commendable job of covering a lot of ground in the RFID space, including the infrastructure needed to share the volumes of data RFID will likely generate. While the short-term issues seem focused on read rates and hardware prices, in the end we may see yet another transformational use of the Internet in exchanging data about serialized assets and products."

> —GRAHAM GILLEN, SENIOR PRODUCT MANAGER, VERISIGN

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Preface

LIKE SO MANY OTHERS, THIS BOOK WAS WRITTEN BECAUSE WE COULDN'T FIND ONE LIKE IT. We needed something to hand to all of those people who have come to us asking for "a good book to read on RFID." When we looked for candidates we found some great books, but most were aimed at electrical engineers or top-level managers, with very little for those of us who are in between. This book is for developers, system and software architects, and project managers, as well as students and professionals in all of the industries impacted by Radio Frequency Identification (RFID) who want to understand how this technology works. As the title suggests, this book is about RFID in general and not just the most recent developments; however, because so much is going on in the area of RFID for the supply chain and especially the Electronic Product Code (EPC), we have devoted considerable space to these topics. Regardless of the type of RFID work you may be doing, we think you will find something useful here.

Who This Book Is For

This book is for developers who need to get that first RFID prototype out the door; systems architects who need to understand the major elements in an RFID system; and project managers who need to divide work, set goals, and understand vendor proposals. Students and instructors should find enough detail here to use this book as at least a supplementary

text for a study of RFID. Even those with considerable experience in RFID should find this book a useful update on the latest developments, with enough of the fundamentals to serve as a reference. This book is probably not for anyone who wants either a cursory overview of the technology or a deep discussion of supply chain management, manufacturing, access control, or conspiracy theories. These are all interesting topics in their own right, but this is only one book!

Structure of This Book

There are 11 chapters, 2 appendices, and a glossary in this book. RFID is a broad subject, so while we think all of the sections of the book are necessary to tell the whole story, not every section will appeal to every reader. The book's structure divides neatly into two broad areas of interest: a general overview (the "Everyone" section), which should be of interest to any reader, and a section containing more-technical discussion ("Developers and Architects").

Everyone

Chapters 1 and 2 cover the basics of RFID and give readers a framework for further discussion. Most readers will also want to cover Chapters 9–11 for discussions of key topics in RFID.

Developers and Architects

Anyone who will actually be creating or interfacing with an RFID system or who wants to understand how all of the pieces work should read Chapters 3–8, where we get into the details of tags, readers, middleware, and the RFID information service.

What's in Each Chapter

The chapters proceed in what we hope you will find is a natural progression, starting with an introduction and overview, a chapter on architecture, and then a discussion of each component of that architecture. Following our discussion of all of the pieces, we take a look at the qualities of the entire system that deserve special attention, such as manageability, security, and privacy. We then wrap things up in the final chapter with a look at the future of RFID. Here's a brief tour:

Chapter 1, *An Introduction to RFID*
  Defines RFID and introduces some of the fundamental concepts

Chapter 2, *RFID Architecture*
  Describes the parts of an RFID system, their relationships to each other, and some of the functional and service-level requirements specific to RFID

Chapter 3, *Tags*
  Describes the tags that attach an identity to an item and communicate that identity to readers

Chapter 4, *Tag Protocols*
Examines how tags talk to readers

Chapter 5, *Readers and Printers*
Describes the readers that communicate with tags and connect RFID-tagged items to the network

Chapter 6, *Reader Protocols*
Covers how readers talk to middleware and applications

Chapter 7, *RFID Middleware*
Describes the middleware that manages RFID information and edge devices

Chapter 8, *RFID Information Service*
Examines the storage and use of RFID information

Chapter 9, *Manageability*
Discusses some of the specific concerns related to managing RFID devices on the edge of the network

Chapter 10, *Privacy and Security*
Discusses real concerns regarding the impact of RFID on security and privacy, as well as dispelling some of the myths

Chapter 11, *The Future*
Provides a look at where RFID may take us in the next few years

Appendix A, *EPC Identity Encodings*
Provides additional encodings to complete the discussion of EPC identity encodings introduced in Chapter 4

Appendix B, *References*
Lists resources available for those who want more information on RFID or who would like to become involved in defining the technology as it develops

Glossary
Includes key acronyms and terms to help you sort out some of the jargon used in this field

Conventions Used in This Book

The following is a list of the typographical conventions used in this book:

Italic
Indicates new terms, URLs, email addresses, filenames, file extensions, pathnames, and directories

`Constant width`
Is used for examples and the contents of files

`Constant width italic`
Shows text that should be replaced with user-supplied values

You should pay special attention to notes set apart from the text with the following icons:

NOTE

This is a tip, suggestion, or general note. It contains useful supplementary information about the topic at hand.

WARNING

This is a warning or note of caution, often indicating that your money or your privacy might be at risk.

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http://www.oreilly.com/catalog/rfid

The authors also maintain a site where you can find a list of RFID resources, along with news and updates:

http://www.rfidessentials.com

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Bill would also like to thank his family for tolerating a sleepless, grumpy, and sometimes overwhelmed husband, father, and son for these past months. Thanks to Janise and Rhian, and thank you to Bill's parents, Janet and Bill.

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CONTENTS

An Introduction to RFID

IN TWELFTH NIGHT, SHAKESPEARE WROTE, "Some are born great, some achieve greatness, and some have greatness thrust upon them." RFID is one of the more recent four-letter abbreviations to have greatness thrust upon it in a flurry of industry mandates, governmental legislation, and hyperbole. RFID stands for Radio Frequency Identification, a term that describes any system of identification wherein an electronic device that uses radio frequency or magnetic field variations to communicate is attached to an item. The two most talked-about components of an RFID system are the *tag*, which is the identification device attached to the item we want to track, and the *reader*, which is a device that can recognize the presence of RFID tags and read the information stored on them. The reader can then inform another system about the presence of the tagged items. The system with which the reader communicates usually runs software that stands between readers and applications. This software is called *RFID middleware*. Figure 1-1 shows how the pieces fit together.

Much of the recent interest surrounding RFID has arisen from mandates and recommendations by government agencies such as the U.S. Department of Defense (DoD) and the Food and Drug Administration (FDA), and from a few private sector megacorporations. For instance, in an effort to improve efficiency, Wal-Mart called for its top 100 suppliers to begin providing RFID tags by early 2005 on pallets shipped to its stores. This mandate caused the companies in Wal-Mart's supply chain to focus on implementing RFID

RFID middleware server   Reader   Tagged item

FIGURE 1-1. An RFID system

solutions. Companies worked to decide which tags and readers to use, how to attach tags to (or embed them in) containers or products, and how to test the read rates for RF tags on pallets as they moved through doors and onto trucks. Several companies have announced their support for what are now commonly known as *tag and ship* applications, which tag a product just before shipping it somewhere else, but few of these companies have moved beyond minimum compliance with the mandates to using the information on RFID tags to increase efficiency in their own internal processes.

The mandates have also focused most of these early implementations on tagging, and thus on the physical side of the RFID systems. However, while it is important to both select tags and readers and find just the right arrangement of antennas to recognize tags as they move through docks and conveyor belts, the true benefit (and complexity) of RFID systems doesn't come from reading the tags, but from getting the information from those reads to the right place in a usable form. The first 100 were only the beginning of the Wal-Mart RFID rollout. Many more suppliers will be tagging pallets and cartons and some individual items by the end of 2006. Meanwhile, the biggest news in RFID may surround the ePedigree initiatives aimed at reducing counterfeiting and improving efficiency and safety in the distribution of pharmaceuticals. By then, many more new initiatives will have been launched to apply RFID to other industries in ways we can hardly predict (although we'll try in Chapter 11).

In the pages to come, we explain the essentials of an RFID system, and in order to put these concepts in perspective, we will also briefly discuss the history, current status, and future of the technology. This book will give you the information and understanding you need to take on your first RFID project, but we hope you'll find it just as useful once you become a seasoned veteran in the field.

The Case for RFID

RFID technologies offer practical benefits to almost anyone who needs to keep track of physical assets. Manufacturers improve supply-chain planning and execution by incorporating RFID technologies. Retailers use RFID to control theft, increase efficiency in their supply chains, and improve demand planning. Pharmaceutical manufacturers use RFID systems to combat the counterfeit drug trade and reduce errors in filling prescriptions. Machine shops track their tools with RFID to avoid misplacing tools and to track which

tools touched a piece of work. RFID-enabled smart cards help control perimeter access to buildings. And in the last couple of years, owing in large part to Wal-Mart and DoD mandates, many major retail chains and consumer goods manufacturers have begun testing pallet- and case-level merchandise tagging to improve management of shipments to customers.

Part of what made the growth in RFID technologies possible were the reductions in cost and size of semiconductor components. Some of the earliest RFID tags were as big as microwave ovens, and the earliest readers were buildings with large antennas, as described in Chapter 3. Figure 1-2 shows a modern RFID tag (in the clear applicator) and a reader.

FIGURE 1-2. A tag and reader (image courtesy of Merten G. Pearson, D.V.M.)

Note how the bar code on the applicator matches the code read on the reader. The tag is inside the applicator in this picture and is about the size of a grain of rice. It's very similar to the glass capsule tag shown in Figure 1-3.

FIGURE 1-3. The VeriChip is smaller than a dime (image courtesy of Applied Digital)

Like RFID tags, the size of tag readers is shrinking. While most tag readers are still the size of a large book, smaller and less expensive readers may open up opportunities for many new RFID applications that, over the coming years, could become a normal and mostly unnoticed part of our lives. Figure 1-4 shows one of the smallest readers currently available.

As individuals, we must consider what impact this technology will have on our lives. Such an efficient and unobtrusive tracking mechanism can be used in ways that raise concerns about individual privacy and security. As citizens, we must understand the benefits and
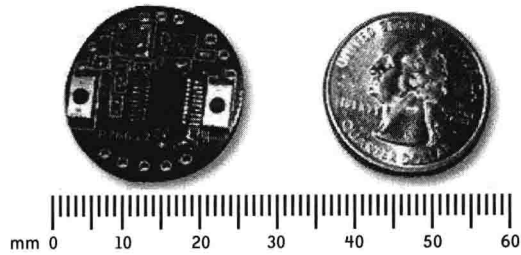
FIGURE 1-4. SkyeTek's SkyeRead M1-mini (image courtesy of SkyeTek)

costs of this technology and its impact on us. Conversely, as developers, we know that "unobtrusive" is a euphemism for "works correctly because a great deal of effort went into design, implementation, and testing." It is our job as managers, architects, and developers to make the technology work so well that it disappears. The following pages will provide an introduction to how RFID works.

Advantages of RFID over Other Technologies

There are many different ways to identify objects, animals, and people. Why use RFID? People have been counting inventories and tracking shipments since the Sumerians invented the lost package. Even some of the earliest uses of writing grew from the need to identify shipments and define contracts for goods shipped between two persons who might never meet.* Written tags and name badges work fine for identifying a few items or a few people, but to identify and direct hundreds of packages an hour, some automation is required.

The bar code is probably the most familiar computer-readable tag, but the light used to scan a laser over a bar code imposes some limitations. Most importantly, it requires a direct "line of sight," so the item has to be right side up and facing in the right direction, with nothing blocking the beam between the laser and the bar code. Most other forms of ID, such as magnetic strips on credit cards, also must line up correctly with the card reader or be inserted into the card reader in a particular way. Whether you are tracking boxes on a conveyor or children on a ski trip, lining things up costs time. Biometrics can work for identifying people, but optical and fingerprint recognition each require careful alignment, similar to magnetic strips. Facial capillary scans require you to at least face the camera, and even voice recognition works better if you aren't calling your passphrase over your shoulder. RFID tags provide a mechanism for identifying an item at a distance, with much less sensitivity to the orientation of the item and reader. A reader can "see" through the item to the tag even if the tag is facing away from the reader.

RFID has additional qualities that make it better suited than other technologies (such as bar codes or magnetic strips) for creating the predicted "Internet of Things."† One cannot,

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* Lawrence K. Lo, "AncientScripts.com: Sumerian," *http://www.ancientscripts.com/sumerian.html.*

† This term was originally attributed to the Auto-ID Center. We will discuss both this term and the Auto-ID Center in more detail later in this book.