

Make: PROJECTS

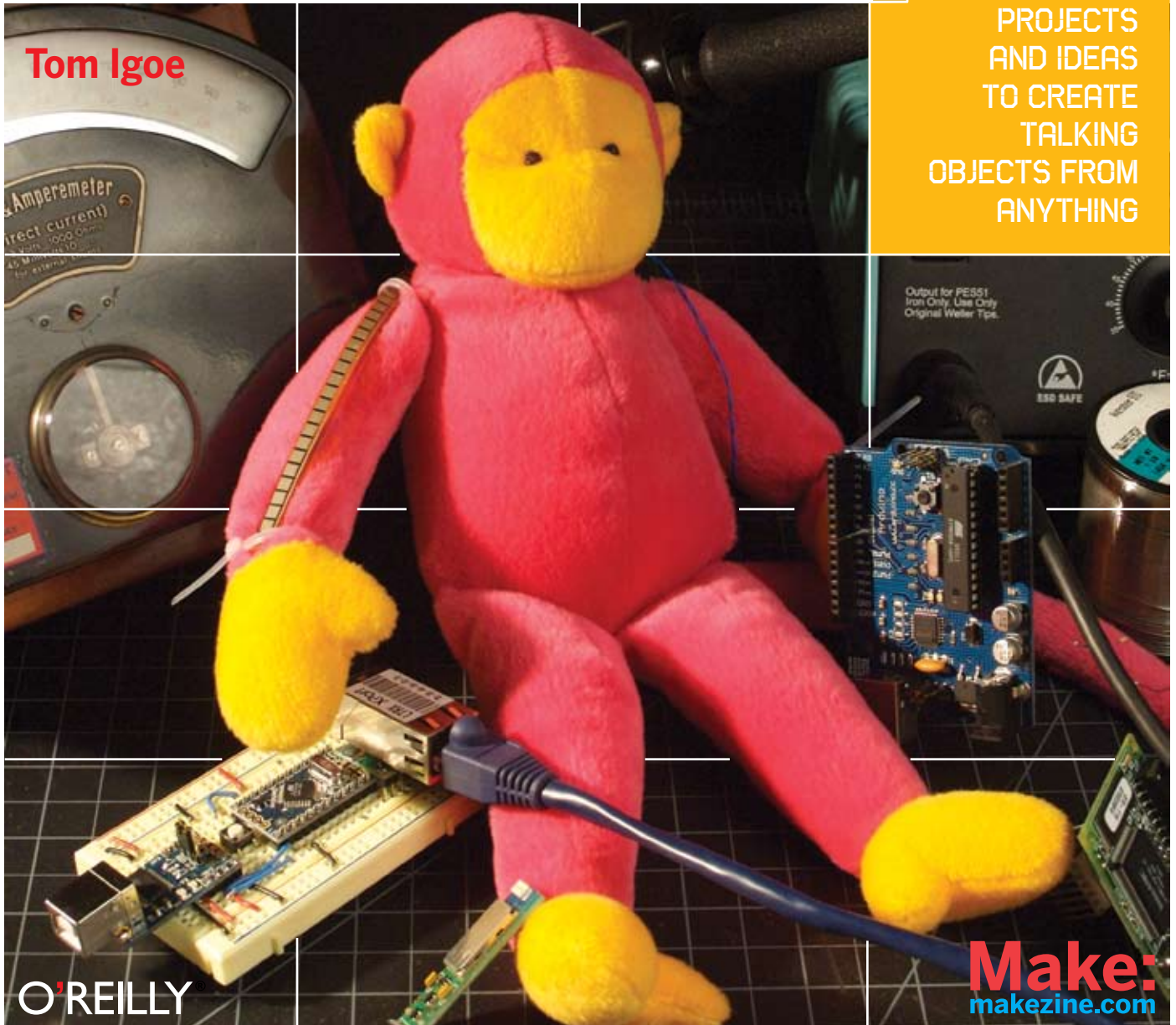
# Making Things Talk



Practical  
Methods for  
Connecting  
Physical Objects

Tom Igoe

PROJECTS  
AND IDEAS  
TO CREATE  
TALKING  
OBJECTS FROM  
ANYTHING



O'REILLY

Make:  
makezine.com

# Making Things Talk

by Tom Igoe

Copyright © 2007 O'Reilly Media, Inc. All rights reserved. Printed in U.S.A.

Published by Make:Books, an imprint of Maker Media, a division of O'Reilly Media, Inc.  
1005 Gravenstein Highway North, Sebastopol, CA 95472.

O'Reilly books may be purchased for educational, business, or sales promotional use.  
For more information, contact our corporate/institutional sales department:  
800-998-9938 or [corporate@oreilly.com](mailto:corporate@oreilly.com).

## Print History

September 2007  
First Edition

**Publisher:** Dale Dougherty  
**Associate Publisher and Executive Editor:** Dan Woods  
**Editor:** Brian Jepson  
**Copy Editor:** Nancy Kotary  
**Creative Director:** Daniel Carter  
**Designer:** Katie Wilson  
**Production Manager:** Terry Bronson  
**Indexer:** Patti Schiendelman  
**Cover Photograph:** Tom Igoe

The O'Reilly logo is a registered trademark of O'Reilly Media, Inc. The MAKE: Projects series designations, Making Things Talk, and related trade dress are trademarks of O'Reilly Media, Inc.

Many of the designations used by manufacturers and sellers to distinguish their products are claimed as trademarks. Where those designations appear in this book, and O'Reilly Media, Inc. was aware of the trademark claim, the designations have been printed in caps or initial caps.

While every precaution has been taken in the preparation of this book, the publisher and authors assume no responsibility for errors or omissions, or for damages resulting from the use of the information contained herein.

Please note: Technology, and the laws and limitations imposed by manufacturers and content owners, are constantly changing. Thus, some of the projects described may not work, may be inconsistent with current laws or user agreements, or may damage or adversely affect some equipment.

Your safety is your own responsibility, including proper use of equipment and safety gear, and determining whether you have adequate skill and experience. Power tools, electricity, and other resources used for these projects are dangerous unless used properly and with adequate precautions, including safety gear. Some illustrative photos do not depict safety precautions or equipment, in order to show the project steps more clearly. These projects are not intended for use by children.

Use of the instructions and suggestions in Making Things Talk is at your own risk. O'Reilly Media, Inc., disclaims all responsibility for any resulting damage, injury, or expense. It is your responsibility to make sure that your activities comply with applicable laws, including copyright.

ISBN-10: 0-596-51051-9

ISBN-13: 978-0-596-51051-0

This excerpt is protected by copyright law. It is your responsibility to obtain permissions necessary for any proposed use of this material. Please direct your inquiries to [permissions@oreilly.com](mailto:permissions@oreilly.com).

# Contents

<b>Preface</b> .....	<b>VIII</b>
Who This Book Is For .....	X
What You Need To Know .....	XI
Contents of This Book .....	XI
On Buying Parts .....	XII
Using Code Examples .....	XIII
Using Circuit Examples .....	XIII
Acknowledgments .....	XIV
We'd Like to Hear from You .....	XV
<b>Chapter 1: The Tools</b> .....	<b>16</b>
It Starts with the Stuff You Touch .....	18
It's About Pulses .....	18
Computers of All Shapes and Sizes .....	19
Good Habits .....	20
Tools .....	21
Using the Command Line .....	28
It Ends with the Stuff You Touch .....	47
<b>Chapter 2: The Simplest Network</b> .....	<b>48</b>
Layers of Agreement .....	50
Making the Connection: The Lower Layers .....	52
Saying Something: The Application Layers .....	56
Project 1: Monski Pong .....	56
Flow Control .....	68
Project 2: Wireless Monski Pong .....	71
Project 3: Negotiating in Bluetooth .....	75
Conclusion .....	78
<b>Chapter 3: A More Complex Network</b> .....	<b>80</b>
Network Maps and Addresses .....	81
Clients, Servers, and Message Protocols .....	87
Project 4: A Networked Cat .....	94
Conclusion .....	113

<b>Chapter 4: Look Ma! No Computer</b> .....	<b>114</b>
Introducing Network Modules .....	116
Project 5: Hello Internet! .....	118
An Embedded Network Client Application .....	126
Project 6: Networked Air Quality Meter .....	126
Serial-to-Ethernet Modules: Programming and Troubleshooting Tools .....	139
Conclusion .....	145
<b>Chapter 5: Communicating in (Near) Real Time</b> .....	<b>146</b>
Interactive Systems and Feedback Loops .....	148
Transmission Control Protocol: Sockets & Sessions .....	149
Project 7: A Networked Game .....	150
Conclusion .....	174
<b>Chapter 6: Wireless Communication</b> .....	<b>176</b>
Why Isn't Everything Wireless? .....	178
Two Flavors of Wireless: Infrared and Radio .....	179
Project 8: Infrared Transmitter-Receiver Pair .....	181
Project 9: Radio Transmitter-Receiver Pair .....	186
Project 10: Duplex Radio Transmission .....	193
An XBee Serial Terminal .....	198
Project 11: Bluetooth Transceivers .....	207
What About Wi-Fi? .....	217
Buying Radios .....	217
Conclusion .....	218
<b>Chapter 7: The Tools</b> .....	<b>220</b>
Look, Ma: No Microcontroller! .....	222
Who's Out There? Broadcast Messages .....	223
Project 12: Reporting Toxic Chemicals in the Shop .....	228
Directed Messages .....	246
Project 13: Relaying Solar Cell Data Wirelessly .....	250
Conclusion .....	259
<b>Chapter 8: How to Locate (Almost) Anything</b> .....	<b>260</b>
Network Location and Physical Location .....	262
Determining Distance .....	265
Project 14: Infrared Distance Ranger Example .....	266
Project 15: Ultrasonic Distance Ranger Example .....	268
Project 16: Reading Received Signal Strength Using XBee Radios .....	273
Project 17: Reading Received Signal Strength Using Bluetooth Radios .....	276
Determining Position Through Trilateration .....	277
Project 18: Reading the GPS Serial Protocol .....	278
Determining Orientation .....	284
Project 19: Determining Heading Using a Digital Compass .....	284
Project 20: Determining Attitude Using an Accelerometer .....	288
Conclusion .....	293

<b>Chapter 9: Identification</b> .....	<b>294</b>
Physical Identification .....	296
Project 21: Color Recognition Using a Webcam .....	298
Project 22: 2D Barcode Recognition Using a Webcam .....	303
Project 23: Reading RFID Tags in Processing .....	308
Project 24: RFID Meets Home Automation .....	316
Network Identification .....	326
Project 25: IP Geocoding .....	328
Project 26: Email from RFID .....	333
Conclusion .....	340
<b>Appendix A: And Another Thing</b> .....	<b>342</b>
Other Useful Protocols .....	344
Proxies of All Kinds .....	347
Mobile Phone Application Development .....	352
Other Microcontrollers .....	356
New Tools .....	358
<b>Appendix B: Where to Get Stuff</b> .....	<b>360</b>
Hardware .....	362
Software .....	366
<b>Appendix C: Program Listings</b> .....	<b>368</b>
<b>Index</b> .....	<b>419</b>