SMART THINGS

Ubiquitous Computing User Experience Design

MIKE KUNIAVSKY

SMART THINGS
UBIQUITOUS COMPUTING USER EXPERIENCE DESIGN

MIKE KUNIAVSKY

AMSTERDAM • BOSTON • HEIDELBERG • LONDON
NEW YORK • OXFORD • PARIS • SAN DIEGO
SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO

ELSEVIER

MK
MORGAN KAUFMANN

Morgan Kaufmann Publishers is an imprint of Elsevier

Notices
Knowledge and best practices in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods or professional practices, may become necessary. Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information or methods described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors assume any liability for any injury and/or damage to persons or property as a matter of product liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

For information on all MK publications visit our website at www.mkp.com

SMART THINGS

"Kuniavsky's latest book is an edifying dissection of things whose functions are multiplied by information. These are devices, interfaces and environments so pervasive they form a realm with its own ontology. In addition, Smart Things is a thorough design guide for innovative practices, methods and techniques, not just for industrial and interface design, but for all disciplines. A must read for design students and practitioners."

—Erik Adigard, former Chrysler Design Award-winner,
co-author and designer *Architecture Must Burn*

"Smart Things is at once a history of design and technology for ubiquitous computing devices and a practical guide for creating such products and experiences. Kuniavsky provides a framework and vocabulary for design that anyone involved in the development of these products should know and understand."

—Irene Au, Director of User Experience, Google

"Smart Things provides an excellent overview of current approaches to interaction design through a collection of case studies, a survey of relevant theories, and a wonderful and often surprising selection of historical examples. It's a thought provoking pleasure to read."

—Leah Buechley, Director of the High-Low Tech Group at the MIT Media Lab.

"Mike Kuniavsky's new book brings his signature clarity and historical perspective to a domain still so poorly understood we can only think of it clumsily, as an "internet of things." Anyone interested in better understanding, or designing for, the world of networked, interactive objects we will all inhabit from now on will find it the indispensible resource."

—Adam Greenfield, founder and Managing Director of Urbanscale LLC, author *Everyware*

"This book explains in no-nonsense language why you should care that computing has become ubiquitous and what the implications are for people who design things. Even better, it lays out suggestions as to how to use this knowledge to make better things. If you've ever wondered how interface, interaction, information, and industrial design overlap, what they have to do with user experience, and how it's all affecting your life, you should read this book."

—Tom Igoe, Associate Professor, NYU, Interactive Telecommunications;
author *Physical Computing* and *Making Things Talk*

"Provocative and pragmatic, Smart Things describes an important new approach to the design of consumer electronics. Its chapters explain why the design of digital products is different than other kinds of design and provide valuable techniques that unify the disciplines of interaction and industrial design."

—Charles L Jones, Vice President, Global Consumer Design, Whirlpool

"Smart Things examines the inspiring and challenging aspects of contemporary design practice in a context where information processes are embedded in the objects, environments, and experiences of our everyday lives. Kuniavsky skillfully outlines concepts, solid techniques, and rich examples that are uniquely attuned to design in the 21st century."

—Jennifer Magnolfi, Senior Integration Architect, Programmable Environments, Herman Miller,
co-author, *Always Building: The Programmable Environment*

"An an age where the net ever shortens the now, it is reassuring to see someone take a longer view of something so happening as smart things. Mike Kuniavsky provides a framework that will be useful today but also many years later."

—Malcolm McCullough, Associate Professor, Taubman College of Architecture
and Urban Planning, University of Michigan; author *Digital Ground*

"Smart Things is a rare artifact from the future that packs immediate practical value. I predict its coverage of multi-scale design will change user experience practice forever. It is the most useful book about the future of design I've read and has changed the way I work. Mike Kuniavsky doesn't just write about the future, he lives there... and now so can you."

—Peter Morville, President, Semantic Studios; author *Ambient Findability*

"Finally a book about ubiquitous computing that covers the broad challenges of designing for user experiences over a vast range of devices, device sizes from micro to meso to macro, and crucially, ecologies of devices. An evocative tour thru past design efforts and devices/systems that beautifully sets the stage for the design challenges we are quickly marching into."

—John Seely Brown, Former Chief Scientist, Xerox Corporation; Former Director, Palo Alto
Research Center (PARC); author *The Social Life of Information and The Power of Pull*

PREFACE

In the cavern of the Nome King Shaggy replaced the wireless telephone in his pocket
and turning to Betsy said in as cheerful a voice as he could muster:

"Well, little comrade, what shall we do next?"

— *L. Frank Baum*, Tik-Tok of Oz, *1914*

Writing about ubiquitous computing is like trying to draw a supersonic plane as it's flying overhead. At best you can try to get the general outline, and leave the details a blur.

This book comes very early in a time of major technological shifts in the world. We're still coming to terms with the changes brought by the Internet and mobile telephony, which are merely the latest examples of an even larger shift brought by the computational manipulation of information. Saying anything about future changes with any degree of certainty is difficult and likely futile.

In 2005, I first proposed this book as a series of descriptive case studies of mobile and ubiquitous computing products. Thinking that it was too early to draw any firm conclusions from a young industry, I thought readers would be interested in extracting design processes and approaches from the material themselves, based on their own needs and perspectives. After spending a year interviewing designers, I changed my mind. Making busy readers (like the designers I was meeting) distill a book of stories into personally useful knowledge was, to put it mildly, a user experience mistake.

I shelved the book and decided to approach the challenge of ubiquitous computing user experience design from a different perspectives: I started ThingM, a ubicomp design and development company, with Tod E. Kurt. As we worked on prototypes and explored new technologies, I kept returning to the interviews and other research I had done for the book. In conjunction with my own design practice, I was seeing the sorts of patterns in the interviews that I had hoped readers would find for themselves in the book. Over time, I reconsidered what a useful book about user experience for ubiquitous computing design should be. It would not be disjointed case studies, but combine all the sources of knowledge and inspiration that I had found useful over the past five years of work in starting both ThingM and the Sketching in Hardware confer-

ence. It would be a mashup of case studies, academic research, ideas that Tod and I developed, the projects and experiences of colleagues, and techniques I have used in my consulting practice over the past fifteen years.

This is that book. It is designed to be practical—with a bit of theory—and theoretically interesting, while grounded in practice. It looks backwards toward the history of technology and human computer interaction as much as it looks forward to the possibilities of new technologies. It recognizes that wheels will forever be reinvented and that *anything* written on paper about technology is immediately outdated. My hope for the book you hold (whether it's actually made of paper or not) is that maybe not all wheels need to be reinvented, and that maybe some technology writing does not become immediately obsolete. We'll see.

Please feel free to send comments, questions, and corrections to me at mikek@orangecone.com.

WHO THIS BOOK IS FOR

This book is primarily a tool for design practitioners, including:

- Interaction designers
- Industrial designers
- Design managers
- Design students
- Design researchers
- People, such as engineers and product managers, who have found themselves in the position where they are doing ubiquitous computing user experience design

Others should feel free (even encouraged!) to use it, but with the knowledge that it won't have the rigor of academic writing or the deep perspectives of works that are narrower in scope. For those works, I recommend the references in the back of the book.

WHAT THIS BOOK IS

This book provides an introduction to a handful of ideas and techniques that may be particularly useful in *ubiquitous computing* user experience design, rather than experience design as it is practiced in software development, Web design, architecture, entertainment, etc. It assumes that readers have familiarity with the techniques in those disciplines and attempts to extend them, not replace them.

I have tried to include as examples a large selection of commercial product designs, academic projects, corporate research prototypes, and technology art. Designers of each face a different set of constraints, so although some of the

underlying technologies are similar, the end results come from very different core assumptions and conditions. All these disciplines are filled with talented designers and technologists who create work that is relevant to everyday experience design. Artists in particular regularly explore technologies further and pose deeper questions long before the other fields.

There are also more references to the history of technology than in most technology design books. Although technology changes, many of the processes that produce it do not. In many ways, the venture capital funded technology development of Thomas Edison's electric lighting system in Menlo Park, New Jersey, is not that different from the venture capital funded development today in Menlo Park, California. Knowing the history of design and innovation provides an important perspective—if only to know what to avoid.

WHAT THIS BOOK IS NOT

Design books are tools that are picked up as needed, scanned, and then put down when billable work calls. Also, every design project is different, with an idiosyncratic set of constraints only understood by the design team.

Thus, this book makes no attempt at describing a single unified process, a list of best practices, or promising a roadmap for success. As a designer, I've found any book that promises those things never delivers them with any degree of consistency. This book is a collection of techniques, approaches, examples, and ideas. I urge you to liberally adapt, invert, and disregard any thinking here that does not fit your specific set of circumstances.

Though there's an extensive reference section, it is not an exhaustive literature review. The fields of ubiquitous computing, human computer interaction, tangible interaction design, and computer supported cooperative work are mature fields with deep back catalogs of research and thought. Many of the works in the reference section are available for free online and they can serve as a starting point for research. I recommend Stefan Poslad's *Ubiquitous Computing Smart Devices, Environments and Interactions* (2009), a very well-researched recent ubicomp book that can serve as a point of entry for research.

Finally, this book makes no attempt to predict the future or claim any accuracy in depicting the present.

HOW THIS BOOK IS ORGANIZED

There are two main sections in this book:

- Chapters 1-13 describe *frameworks* that explain some of the fundamental ways in which the design of ubiquitous computing devices and environments differs from other kinds of design.

■ Chapters 14-19 describe *techniques* for designing ubiquitous computing user experiences. When there is overlap with existing user experience and interaction design practice, the chapters primarily cover how ubicomp design practice is different.

There are also in-depth case studies interspersed throughout the book. These investigate the design process of a handful of commercial products. The products were selected based on three criteria: they were commercial products that the general public could purchase, the design process had been thoroughly documented (or I could get access to principal designers), and they were good illustrations of ideas developed elsewhere in the book. Sadly, after the recession of the past year, many of them also demonstrate that the majority of technology products fail in the marketplace, regardless of the thoroughness of their research and the cleverness of their design and engineering. One of the key messages in the book is that one skill of technology design is managing risk in a highly risky environment. Another message is that nothing is ever an ultimate success or failure. After every design there is always the next design to do better and differently.

ACKNOWLEDGMENTS

Finally, Marcy Swenson took me seriously when I came to her and said "I know you're an executive coach, but I want you to coach me through writing a book." Which she did, along with helping me organize the rest of my life so that I could get the writing done.

Thanks to Maya Gurantz, Alex Creighton, and Kim Karlsrud, who managed to keep me and all of my projects from imploding from distraction.

To everyone whom I may have forgotten: I am so sorry.

As described in Chapter 19, this book was mostly written in Four Barrel Coffee, in San Francisco. Parts were also written at Maxfield's House of Caffeine, Ritual Roasters, and Bean There (and probably twenty other cafés scattered throughout the world).

The music that kept me going was made by: Aesop Rock, Amsterdam Klezmer Band, Arctic Monkeys, Ben Frost, Blonde Redhead, Busdriver, Clinic, Daft Punk, Danger Mouse, Digitalism, El-P, Fever Ray, Grinderman, Gundecha Brothers, HEALTH, Jay-Z, Jóhann Jóhannsson, John Vanderslice, Man Man, Ministry, Neko Case, Nine Inch Nails, Noisia, Paris, Plaid, Santo(i)gold, Sparklehorse, Talib Kweli, The Roots, the xx, Wasfuddin Dagar, Yeasayer, Black Moth Super Rainbow, Ministry, The Black Keys, The Fiery Furnaces, The White Stripes, and These New Puritans.

CONTENTS

FRAMEWORKS

INTRODUCTION: THE MIDDLE OF MOORE'S LAW

The history of technology is a history of unintended consequences, of revolutions that never happened, and of unforeseen disruptions. Take railroads, for instance. In addition to quickly moving things and people around, railroads brought a profound philosophical crisis of timekeeping. Before railroads, clock time followed the sun. "Noon" was when the sun was directly above, and local clock time was approximate. This was accurate enough for travel on horseback or foot, but setting clocks by the sun proved insufficient to synchronize railroad schedules. One town's noon would be a neighboring town's 12:02, and a distant town's 12:36. Trains traveled fast enough that these small changes added up. Arrival times now had to be determined not just by the time to travel between two places, but the local time at the point of departure, which could be based on an inaccurate church clock set with a sundial. The effect was that trains would run at unpredictable times and, with terrifying regularity, crash into each other.

It was not surprising that railroads wanted to have a consistent way to measure time, but what did "consistent" mean? Their attempt to answer this question led to a crisis of timekeeping: Do the railroads dictate when noon is, does the government, or does nature? What does it mean to have the same time in different places? Do people in cities need a different timekeeping method than farmers? The engineers making small steam engines in the early nineteenth century could not possibly have predicted that by the end of the century their invention would lead to a revolution in commerce, politics, geography, philosophy and just about all human endeavors.[1]

We can compare the last twenty years of computer and networking technology to the earliest days of steam power. Once, giant steam engines ran textile mills and pumped water between canal locks. Miniaturized and made more efficient, steam engines became more dispersed throughout industrial countries powering trains, machines in workplaces, and even personal carriages. As computers shrink, they too are getting integrated into more places and contexts than ever before.

We are at the beginning of the era of computation and data communication embedded in, and distributed through, our entire environment. Going far beyond how we now define "computers," the vision of ubiquitous computing

---

[1]See Chapter 2 of O'Malley (1990) for a detailed history of the effect of railroads on timekeeping in America.

Figure 1-1

The adidas_1 shoe, with embedded microcontroller and control buttons. (Courtesy Adidas)

(see Sidebar: The Many Names of Ubicomp) is of information processing and networking as key components in the design of everyday objects (Figure 1-1) using built-in computation and communication to make familiar tools and environments do their jobs better. It is the underlying (if unstated) principle guiding the development of toys that talk back, clothes that react to the environment, rooms that change shape depending on what their occupants are doing, electromechanical prosthetics that automatically manage chronic diseases and enhance people's capabilities beyond what is biologically possible, hand tools that dynamically adapt to their user, and (of course) many new ways for people to be bad to each other.[2]

The rest of this chapter discusses why the idea of ubiquitous computing is important now, and why user experience design is key to creating successful ubiquitous computing (ubicomp) devices and environments.

Sidebar: The Many Names of Ubicomp

There are many different terms applied to what I am calling ubiquitous computing (or ubicomp for short). Each term came from a different social and historical context. Although not designed to be complementary, each built on the definitions of those that came before (if only to help the group coining the term identify themselves). I consider them to be different aspects of the same phenomenon:

- *Ubiquitous computing* refers to the practice of embedding information processing and network communication into everyday, human environments to continuously provide services, information, and communication.
- *Physical computing* describes how people interact with computing through physical objects, rather than in an online environment or on monolithic, general purpose computers.
- *Pervasive computing* refers to the prevalence of this new mode of digital technology.
- *Ambient intelligence* describes how these devices appear to integrate algorithmic reasoning (intelligence) into human-built spaces so that it becomes part of the atmosphere (ambiance) of the environment.

---

[2]This book will not discuss military ubiquitous computing, although it is certainly a major focus of development. The implication of computers embedded into weapons and surveillance devices has been discussed for as long as ubicomp (DeLanda, 1991), if not longer.

■ *The Internet of Things* suggests a world in which digitally identifiable physical objects relate to each other in a way that is analogous to how purely digital information is organized on the Internet (specifically, the Web).

Of course, applying such retroactive continuity (a term the comic book industry uses to describe the pretense of order grafted onto a disorderly existing narrative) attempts to add structure to something that never had one. In the end, I believe that all of these terms actually reference the same general idea. I prefer to use ubiquitous computing since it is the oldest.

1.1 THE HIDDEN MIDDLE OF MOORE'S LAW

To understand why ubiquitous computing is particularly relevant today, it is valuable to look closely at an unexpected corollary of Moore's Law. As new information processing technology gets more powerful, older technology gets cheaper without becoming any less powerful.

First articulated by Intel Corporation founder Gordon Moore, today Moore's Law is usually paraphrased as a prediction that processor transistor densities will double every two years. This graph (Figure 1-2) is traditionally used to demonstrate how powerful the newest computers have become. As a visualization of the density of transistors that can be put on a single integrated circuit, it represents the way semiconductor manufacturers distill a complex industry into a single trend. The graph also illustrates a growing industry's internal narrative of progress without revealing how that progress is going to happen.
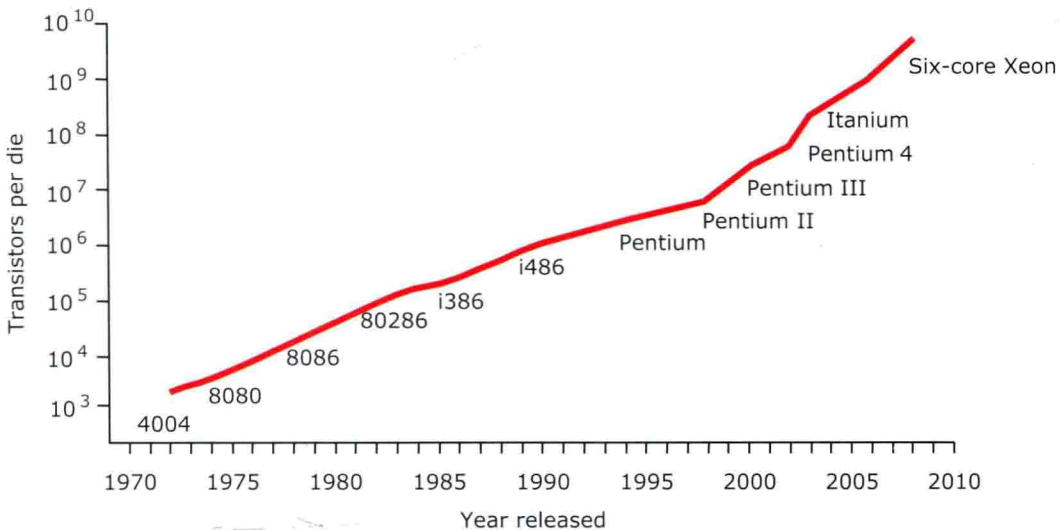

Figure 1-2

Moore's Law. (Based on Moore, 2003)