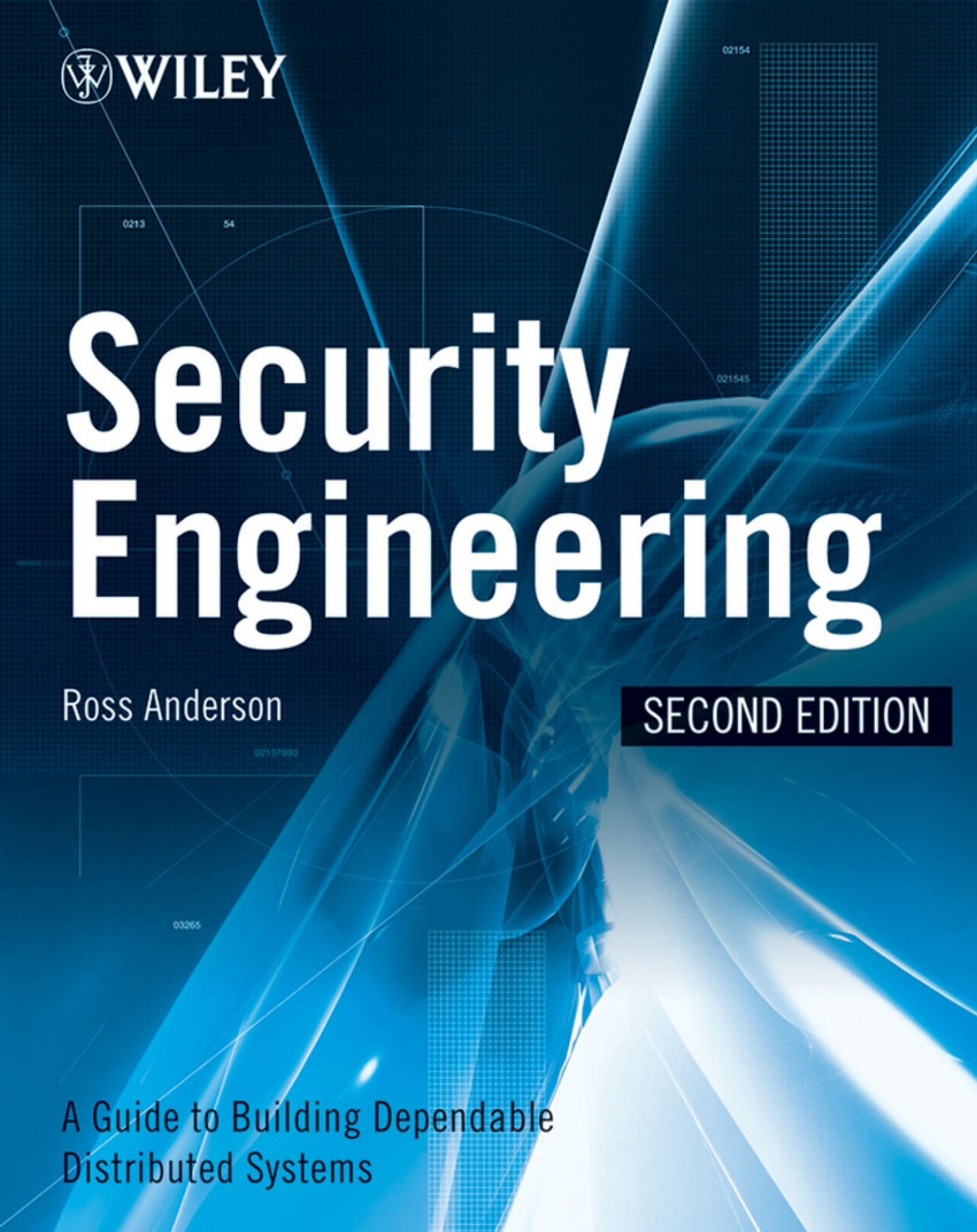
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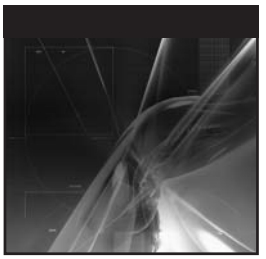

# Security Engineering

## A Guide to Building Dependable Distributed Systems Second Edition

Ross J. Anderson

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# Contents at a Glance

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# Preface to the Second Edition

The first edition of *Security Engineering* was published in May 2001. Since then the world has changed.

System security was one of Microsoft's lowest priorities then; it's now one of the highest. The volume of malware continues to increase along with the nuisance that it causes. Although a lot of effort has gone into defence — we have seen Windows NT replaced by XP and then Vista, and occasional service packs replaced by monthly security patches — the effort put into attacks has increased far more. People who write viruses no longer do so for fun, but for profit; the last few years have seen the emergence of a criminal economy that supports diverse specialists. Spammers, virus writers, phishermen, money launderers and spies trade busily with each other.

Cryptography has also moved on. The Advanced Encryption Standard is being embedded into more and more products, and we have some interesting developments on the public-key side of things too. But just as our algorithm problems get solved, so we face a host of implementation issues. Side channels, poorly designed APIs and protocol failures continue to break systems. Applied cryptography is harder than ever to do well.

Pervasive computing also opens up new challenges. As computers and communications become embedded invisibly everywhere, so problems that used to only afflict 'proper computers' crop up in all sorts of other devices too. What does it mean for a thermometer to be secure, or an air-conditioner?

The great diversity of intelligent devices brings with it a great diversity of interests and actors. Security is not just about keeping the bad guys out, but increasingly concerned with tussles for power and control. DRM pits the content and platform industries against consumers, and against each other; accessory control is used to tie printers to their vendors' cartridges, but leads

to antitrust lawsuits and government intervention. Security also interacts with safety in applications from cars through utilities to electronic healthcare. The security engineer needs to understand not just crypto and operating systems, but economics and human factors as well.

And the ubiquity of digital devices means that 'computer security' is no longer just a problem for a few systems specialists. Almost all white-collar crime (and much crime of the serious violent sort) now involves computers or mobile phones, so a detective needs to understand computer forensics just as she needs to know how to drive. More and more lawyers, accountants, managers and other people with no formal engineering training are going to have to understand system security in order to do their jobs well.

The rapid growth of online services, from Google and Facebook to massively multiplayer games, has also changed the world. Bugs in online applications can be fixed rapidly once they're noticed, but the applications get ever more complex and their side-effects harder to predict. We may have a reasonably good idea what it means for an operating system or even a banking service to be secure, but we can't make any such claims for online lifestyles that evolve all the time. We're entering a novel world of evolving socio-technical systems, and that raises profound questions about how the evolution is driven and who is in control.

The largest changes, however, may be those driven by the tragic events of September 2001 and by our reaction to them. These have altered perceptions and priorities in many ways, and changed the shape of the security industry. Terrorism is not just about risk, but about the perception of risk, and about the manipulation of perception. This adds psychology and politics to the mix. Security engineers also have a duty to contribute to the political debate. Where inappropriate reactions to terrorist crimes have led to major waste of resources and unforced policy errors, we have to keep on educating people to ask a few simple questions: what are we seeking to prevent, and will the proposed mechanisms actually work?

*Ross Anderson*
Cambridge, January 2008

# Foreword

In a paper he wrote with Roger Needham, Ross Anderson coined the phrase ''programming Satan's computer'' to describe the problems faced by computer-security engineers. It's the sort of evocative image I've come to expect from Ross, and a phrase I've used ever since.

Programming a computer is straightforward: keep hammering away at the problem until the computer does what it's supposed to do. Large application programs and operating systems are a lot more complicated, but the methodology is basically the same. Writing a reliable computer program is much harder, because the program needs to work even in the face of random errors and mistakes: Murphy's computer, if you will. Significant research has gone into reliable software design, and there are many mission-critical software applications that are designed to withstand Murphy's Law.

Writing a *secure* computer program is another matter entirely. Security involves making sure things work, not in the presence of random faults, but in the face of an intelligent and malicious adversary trying to ensure that things fail in the worst possible way at the worst possible time . . . again and again. It truly is programming Satan's computer.

Security engineering is different from any other kind of programming. It's a point I made over and over again: in my own book, *Secrets and Lies*, in my monthly newsletter *Crypto-Gram*, and in my other writings. And it's a point Ross makes in every chapter of this book. This is why, if you're doing any security engineering . . . if you're even *thinking* of doing any security engineering, you need to read this book. It's the first, and only, end-to-end modern security design and engineering book ever written.

And it comes just in time. You can divide the history of the Internet into three waves. The first wave centered around mainframes and terminals.

Computers were expensive and rare. The second wave, from about 1992 until now, centered around personal computers, browsers, and large application programs. And the third, starting now, will see the connection of all sorts of devices that are currently in proprietary networks, standalone, and non-computerized. By 2003, there will be more mobile phones connected to the Internet than computers. Within a few years we'll see many of the world's refrigerators, heart monitors, bus and train ticket dispensers, burglar alarms, and electricity meters talking IP. Personal computers will be a minority player on the Internet.

Security engineering, especially in this third wave, requires you to think differently. You need to figure out not how something works, but how something can be made to not work. You have to imagine an intelligent and malicious adversary inside your system (remember Satan's computer), constantly trying new ways to subvert it. You have to consider all the ways your system can fail, most of them having nothing to do with the design itself. You have to look at everything backwards, upside down, and sideways. You have to think like an alien.

As the late great science fiction editor John W. Campbell, said: ''An alien thinks as well as a human, but not like a human.'' Computer security is a lot like that. Ross is one of those rare people who can think like an alien, and then explain that thinking to humans. Have fun reading.

*Bruce Schneier*
January 2001