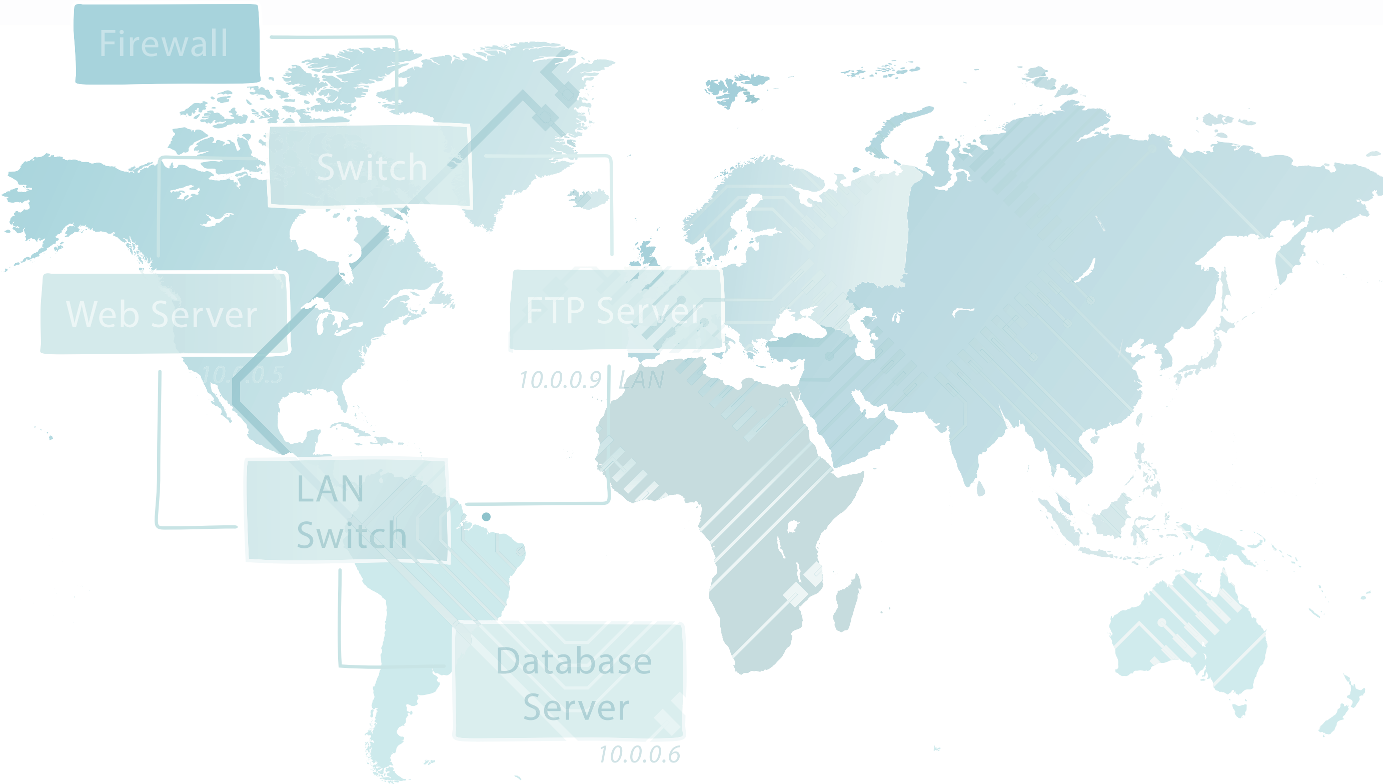
CLOUD SECURITY

A Comprehensive Guide to Secure Cloud Computing



Ronald L. Krutz and Russell Dean Vines

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Ronald L. Krutz
Russell Dean Vines

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I thank God for His greatest gift of all—my family.

— Ronald L. Krutz

Dedicated to Elzy, for now and forever.

— Russell Dean Vines

About the Authors

Ronald L. Krutz is a senior information system security consultant. He has over 30 years of experience in distributed computing systems, computer architectures, real-time systems, information assurance methodologies, and information security training. He holds B.S., M.S., and Ph.D. degrees in Electrical and Computer Engineering and is the author of best selling texts in the area of information system security.

He co-authored the *CISSP Prep Guide* for John Wiley and Sons and is co-author of the Wiley *Advanced CISSP Prep Guide*, the *CISSP Prep Guide, Gold Edition*, the *Security+Certification Guide*, the *CISM Prep Guide*, the *CISSP Prep Guide, 2nd Edition: Mastering CISSP and ISSEP,* the *Network Security Bible,* the *CISSP and CAP Prep Guide, Platinum Edition: Mastering CISSP and CAP,* the *Certified Ethical Hacker (CEH) Prep Guide,* and the *Certified Secure Software Lifecycle Prep Guide.* He is also the author of *Securing SCADA Systems* and of three textbooks in the areas of microcomputer system design, computer interfacing, and computer architecture. Dr. Krutz has seven patents in the area of digital systems and has published over 40 technical papers.

Dr. Krutz also serves as consulting Editor for John Wiley and Sons Information Security Certification Series, is a Distinguished Visiting Lecturer in the University of New Haven Henry C. Lee College of Criminal Justice and Forensic Sciences, and is an Adjunct Professor in Midway College, Kentucky.

Dr. Krutz is a Registered Professional Engineer in Pennsylvania.

Russell Dean Vines has been in the information systems industry for over 20 years, and has a unique ability to disseminate complex security issues to a wider audience, from CEOs to home Internet surfers.

He is also the author or co-author of 10 previous books, including the *CISSP Prep Guide*, which reached #25 on Amazon's best-sellers list. He co-authored the *Advanced CISSP Prep Guide*, the *CISSP Prep Guide, Gold Edition,* the *Security+Certification Guide,* the *CISM Prep Guide,* the *CISSP Prep Guide, 2nd Edition: Mastering CISSP and ISSEP,* the *CISSP and CAP Prep Guide, Platinum Edition: Mastering CISSP and CAP,* and the *Certified Ethical Hacker (CEH) Prep Guide.* He is also the author of *Wireless Security Essentials,* and *Composing Digital Music for Dummies.*

In addition to being a Certified Information Systems Security Professional (CISSP), Mr. Vines is a Certified Information Systems Manager (CISM), a Certified Ethical Hacker (CEH), certified in CompTIA's Security+ program, and is a Payment Card Industry (PCI) Qualified Security Assessor (QSA). Russ also has vendor security certifications from RSA, Websense, McAfee, Citrix, VMware, Microsoft, and Novell, and has been trained in the NSA's Information Assurance Methodology (IAM).

Mr. Vines is a frequent contributor to Web and trade publications; discusses Information Security Threats and Countermeasures as a member of SearchSecurityChannel.com's Ask the Experts panel, frequently speaks at industry events such as Comdex and Networld+Interop, and teaches CISSP, CEH, and Websense classes.

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— Ronald L. Krutz

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— Russell Dean Vines

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Foreword

Whenever we come upon something new, we try to understand it. A good way of understanding new things is to look for something from our experience that can serve as a metaphor. Sometimes this process works well, sometimes not.

Computer security has long labored under the metaphor of physical security. It stands to reason that we would assume that millennia of experience with keeping physical assets safe would serve us in keeping digital assets safe as well.

Much of our thinking in computer security has therefore been concerned with putting important things someplace "safe" and then controlling access to it. I distinctly recall a conversation with a security analyst at the beginning of the PC network era. When asked how to ensure the security of data on a PC, he said, "Simple. Put the data on the PC. Put the PC in a safe. Put the safe at the bottom of the ocean."

We have been challenged over the years with coming up with safe places that allowed access. We have been challenged with even figuring out what "safe" might mean in a world where risks could come from anywhere, including inside our own organizations.

In today's world, the physical security metaphor continues to deteriorate. We've all seen a movie or TV show where some critical piece of data becomes key to the plot. The location of the next terrorist attack is kept on a single USB that is subject to theft, deterioration, or any other number of physical ills designed to increase the drama. That is simply not the nature of data. Data is viral. Where did this data come from? It was never on a hard drive? No one ever emailed anybody about the attack? Can't somebody plug the damn key in and make a YouTube video about it so that everyone can see it?

As we move to this new era of cloud computing, the last vestiges of our physical world metaphors are swept way. We need to understand data access and validation in a new way — perhaps in the way they should have been understood all along. Data security needs to be understood as something new, requiring new and innovative solutions.

Security professionals are perhaps rightfully overwhelmed by this challenge. Despite increased spending, the average firm finds itself less secure than it was five years ago. Advancements in security tools and techniques have not kept pace with risks and attack vectors. How can the security community respond to these ever-increasing threats when the additional requirements of virtualization and agility drive data assets up into a nebulous "cloud"?

One thing we do know for sure: Security will not drive or control this change. Any business requirement for lower costs and increased agility of cloud computing will eventually rule the day. Security professionals have attempted to slow the growth of several technology initiatives over the years in an attempt to control the risks. E-mail, instant messaging, and web browsing are some that come to mind immediately. We know from past experience, however, that implementing appropriate controls generally works far better than attempting to simply stop these initiatives.

As security professionals, it is incumbent on us to generate innovations in our concepts of data security and integrity. We need tools and processes that recognize the ephemeral nature of data and the reality that physical locational controls simply will not work going forward. With a little hard work, we can achieve security models that minimize risk and enable this new method of computing. We don't need to give up on security; we simply need to abandon some of our metaphors.

This book serves as a guide for doing just that. As security professionals, we may not want to embrace the cloud, but we're certainly going to have to learn to live with it.

Ken Phelan
CTO Gotham Technology Group

Introduction

Cloud computing provides the capability to use computing and storage resources on a metered basis and reduce the investments in an organization’s computing infrastructure. The spawning and deletion of virtual machines running on physical hardware and being controlled by hypervisors is a cost-efficient and flexible computing paradigm.

In addition, the integration and widespread availability of large amounts of “sanitized’ information such as health care records can be of tremendous benefit to researchers and practitioners.

However, as with any technology, the full potential of the cloud cannot be achieved without understanding its capabilities, vulnerabilities, advantages, and trade-offs. This text provides insight into these areas and describes methods of achieving the maximum benefit from cloud computation with minimal risk.

Overview of the Book and Technology

With all its benefits, cloud computing also brings with it concerns about the security and privacy of information extant on the cloud as a result of its size, structure, and geographical dispersion. Such concerns involve the following issues:

- Leakage and unauthorized access of data among virtual machines running on the same server
- Failure of a cloud provider to properly handle and protect sensitive information

- Release of critical and sensitive data to law enforcement or government agencies without the approval and/or knowledge of the client
- Ability to meet compliance and regulatory requirements
- System crashes and failures that make the cloud service unavailable for extended periods of time
- Hackers breaking into client applications hosted on the cloud and acquiring and distributing sensitive information
- The robustness of the security protections instituted by the cloud provider
- The degree of interoperability available so that a client can easily move applications among different cloud providers and avoid "lock-in"

Cloud users should also be concerned about the continued availability of their data over long periods of time and whether or not a cloud provider might surreptitiously exploit sensitive data for its own gain.

One mitigation method that can be used to protect cloud data is encryption. Encrypting data can protect it from disclosure by the cloud provider or from hackers, but it makes it difficult to search or perform calculations on that data.

This book clarifies all these issues and provides comprehensive guidance on how to navigate the field of cloud computing to achieve the maximum return on cloud investments without compromising information security.

How This Book Is Organized

The text explores the principal characteristics of cloud computing, including scalability, flexibility, virtualization, automation, measured service, and ubiquitous network access, while showing their relationships to secure cloud computing.

The book chapters proceed from tracing the evolution of the cloud paradigm to developing architectural characteristics, security fundamentals, cloud computing risks and threats, and useful steps in implementing secure cloud computing.

Chapter 1 defines cloud computing and provides alternative views of its application and significance in the general world of computing. Following this introduction, the chapter presents the essential characteristics of cloud computing and traces the historical architectural, technical, and operational influences that converged to establish what is understand as cloud computing today.

Chapter 2 looks at the primary elements of the cloud computing architecture using various cloud-based computing architecture models. In this chapter we'll examine cloud delivery models (the SaaS, PaaS, and IaaS elements of the SPI framework), cloud deployment models (such as private, community, public, and hybrid clouds), and look at some alternative cloud architecture models, such as the Jericho Cloud Cube.

Chapter 3 explores the fundamental concepts of cloud computing software security, covering cloud security services, cloud security principles, secure software requirements, and testing concepts. It concludes by addressing cloud business continuity planning, disaster recovery, redundancy, and secure remote access.

Chapter 4 examines cloud computing risks and threats in more detail. We'll examine cloud computing risk to privacy assurance and compliance regulations, how cloud computing presents a unique risk to "traditional" concepts of data, identity, and access management (IAM) risks, and how those risks and threats may be unique to cloud service providers (CSPs).

Chapter 5 helps identify management challenges and opportunities. Security management must be able to determine what detective and preventative controls exist to clearly define the security posture of the organization, especially as it relates to the virtualization perimeter. We'll look at security policy and computer intrusion detection and response implementation techniques, and dive deeply into virtualization security management issues.

Chapter 6 addresses the important cloud computing security architectural issues, including trusted cloud computing, secure execution environments, and microarchitectures. It also expands on the critical cloud security principles of identity management and access control and develops the concepts of autonomic systems and autonomic protection mechanisms.

Chapter 7 presents cloud life cycle issues, together with significant standards efforts, incident response approaches, encryption topics, and considerations involving retirement of cloud virtual machines and applications.

Chapter 8 recaps the important cloud computing security concepts, and offers guidance on which services should be moved to the cloud and those that should not. It also reviews questions that a potential user should ask a cloud provider, and lists organizations that provide support and information exchange on cloud applications, standards, and interoperability. Chapter 8 concludes with advice on getting started in cloud computation and a "top ten" list of important related considerations.

Who Should Read This Book

Cloud Security: *A Comprehensive Guide to Secure Cloud Computing* is designed to be a valuable source of information for those who are contemplating using cloud computing as well as professionals with prior cloud computing experience and knowledge. It provides a background of the development of cloud computing and details critical approaches to cloud computing security that affect the types of applications that are best suited to the cloud.

We think that *Cloud Security*: *A Comprehensive Guide to Secure Cloud Computing* would be a useful reference for all of the following:

- Professionals working in the fields of information technology or information system security
- Information security audit professionals
- Information system IT professionals
- Computing or information systems management
- Senior management, seeking to understand the various elements of security as related to cloud computing
- Students attending information system security certification programs or studying computer security

Summary

We hope *Cloud Security*: *A Comprehensive Guide to Secure Cloud Computing* is a useful and readable reference for everyone concerned about the risk of cloud computing and involved with the protection of data.

Issues such as data ownership, privacy protections, data mobility, quality of service and service levels, bandwidth costs, data protection, and support have to be tackled in order to achieve the maximum benefit from cloud computation with minimal risk.

As you try to find your way through a maze of security minefields, this book is mandatory reading if you are involved in any aspect of cloud computing.

CHAPTER

1

Cloud Computing Fundamentals

Out of intense complexities intense simplicities emerge.
—Winston Churchill

Cloud computing evokes different perceptions in different people. To some, it refers to accessing software and storing data in the "cloud" representation of the Internet or a network and using associated services. To others, it is seen as nothing new, but just a modernization of the time-sharing model that was widely employed in the 1960s before the advent of relatively lower-cost computing platforms. These developments eventually evolved to the client/server model and to the personal computer, which placed large amounts of computing power at people's desktops and spelled the demise of time-sharing systems.

In 1961, John McCarthy, a professor at MIT, presented the idea of computing as a utility much like electricity.[1] Another pioneer, who later developed the basis for the ARPANET, the Department of Defense's Advanced Research Projects Agency Network, and precursor to the Internet, was J.C.R. Licklider. In the 1960s, Licklider promulgated ideas at both ARPA and Bolt, Beranek and Newman (BBN), the high-technology research and development company, that envisioned networked computers at a time when punched card, batch computing was dominant. He stated, "If such a network as I envisage nebulously could be brought into operation, we could have at least four large computers, perhaps six or eight small computers, and a great assortment of disc files and magnetic tape units—not to mention remote consoles and teletype stations—all churning away."[2]

The conjunction of the concepts of utility computing and a ubiquitous worldwide network provided the basis for the future evolution of cloud computing.

What Is Cloud Computing?

In an October, 2009 presentation titled "Effectively and Securely Using the Cloud Computing Paradigm,"[3] by Peter Mell and Tim Grance of the National Institute of Standards and Technology (NIST) Information Technology Laboratory, cloud computing is defined as follows:

> *Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable and reliable computing resources (e.g., networks, servers, storage, applications, services) that can be rapidly provisioned and released with minimal consumer management effort or service provider interaction.*

This cloud model is composed of five essential characteristics, three service models, and four deployment models. The five essential characteristics are as follows:

- On-demand self-service
- Ubiquitous network access
- Resource pooling
- Location independence
- Rapid elasticity
- Measured service

The service models are as follows:

- Cloud Software as a Service (SaaS)—Use provider's applications over a network.
- Cloud Platform as a Service (PaaS)—Deploy customer-created applications to a cloud.
- Cloud Infrastructure as a Service (IaaS)—Rent processing, storage, network capacity, and other fundamental computing resources.

The deployment models, which can be either internally or externally implemented, are summarized in the NIST presentation as follows:

- Private cloud—Enterprise owned or leased
- Community cloud—Shared infrastructure for specific community
- Public cloud—Sold to the public, mega-scale infrastructure
- Hybrid cloud—Composition of two or more clouds

These characteristics and models are covered in detail in Chapter 2.