Behavioral Cybersecurity

Applications of Personality Psychology and Computer Science

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Dedication

To my partner in life for almost half a century: Savanah Williams. A most incredible woman who inspires me everyday, who has chosen her own incredible paths, and who somehow manages to cope with my difficult challenges; and also to my friends Hamid, Orlando, Martin and Arun, who continue to encourage all my work.

Wayne Patterson

I would like to dedicate this book to my loving family with the hope it inspires the Lindsey generation to pursue solving complex problems by integrating psychology and computer science.

Cynthia E. Winston-Proctor

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Preface

Since the introduction and proliferation of the Internet, problems involved with maintaining cybersecurity have grown exponentially and evolved into many forms of exploitation.

Yet, cybersecurity has had far too little study and research. Virtually all of the research that has taken place in cybersecurity over many years has been done by those with computer science, electrical engineering, and mathematics backgrounds.

However, many cybersecurity researchers have come to realize that to gain a full understanding of how to protect a cyberenvironment requires not only the knowledge of those researchers in computer science, engineering, and mathematics, but those who have a deeper understanding of human behavior: researchers with expertise in the various branches of behavioral science, such as psychology, behavioral economics, and other aspects of brain science.

The authors, one a computer scientist and the other a psychologist, have attempted over the past several years to understand the contributions that each approach to cybersecurity problems can benefit from in this integrated approach that we have tended to call "behavioral cybersecurity."

The authors believe that the research and curriculum approaches developed from this integrated approach provide a first book with this approach to cybersecurity. This book incorporates traditional technical computational and analytic approaches to cybersecurity, and also psychological and human factors approaches.

Among the topics addressed in the book are:

- Introductions to cybersecurity and behavioral science
- Profiling approaches and risk management
- Case studies of major cybersecurity events and "Fake News"
- Analyses of password attacks and defenses
- Introduction to game theory and behavioral economics, and their application to cybersecurity
- Research into attacker/defender personalities and motivation traits
- Techniques for measuring cyberattacks/defenses using cryptography and steganography
- Ethical hacking
- Turing tests: classic, gender, age
- Lab assignments: social engineering, passwords in the clear, privacy study, password meters

The history of science seems to evolve in one of two directions. At times, interest in one area of study grows to the extent that it grows into its own discipline. Physics and chemistry could be described in that fashion, evolving from "natural science." There are other occasions, however, when the underlying approach of one discipline is complemented by a different tradition in a totally separate discipline. The study of computer science can be fairly described as an example of that approach. When the

first author of this book was a doctoral student at the University of Michigan in the 1970s, there was no department of computer science. It was soon born as a fusion of mathematics and electrical engineering.

Our decision to create this book, as well as several related courses, arose from a similar perspective. Our training is in computer science and psychology, and we have observed, as have many other scholars interested in cybersecurity, that the problems we try to study in cybersecurity require not only most of the approaches in computer science, but more and more an understanding of motivation, personality, and other behavioral approaches in order to understand cyberattacks and create cyberdefenses.

As with any new approaches to solving problems when they require knowledge and practice from distinct research fields, there are few people with knowledge of the widely separate disciplines, so it requires an opportunity for persons interested in either field to gain some knowledge of the other. We have attempted to provide such a bridge in this book that we have entitled *Behavioral Cybersecurity.*

In this book, we have tried to provide an introductory approach in both psychology and cybersecurity, and as we have tried to address some of these key problem areas, we have also introduced topics from other related fields such as criminal justice, game theory, mathematics, and behavioral economics.

We are hopeful that the availability of this book will provide source material for courses in this growing area of behavioral cybersecurity. We feel that such courses can be offered in computer science curricula, psychology curricula, or as interdisciplinary courses. The section called "Introduction" provides a roadmap for courses that might be called (a) behavioral cybersecurity for computer science and psychology, (b) behavioral cybersecurity for computer scientists with some background in behavioral science, or (c) behavioral cybersecurity for behavioral scientists with some background in computing.

INTRODUCTION

We entered the computer era almost 75 years ago. For close to two-thirds of that time, we could largely ignore the threats that we now refer to as cyberattacks. There were many reasons for this. There was considerable research done going back to the 1970s about approaches to penetrate computer environments, but there were several other factors that prevented the widespread development of cyberattacks. Thus, the scholarship into the defense (and attack) of computing environments remained of interest to a relatively small number of researchers.

Beginning in the 1980s, a number of new factors came into play. First among these was the development of the personal computer, which now allowed for many millions of new users with their own individual access to computing power. Following closely on that development was the expansion of network computing, originally through the defense-supported DARPAnet, which then evolved into the openly available Internet. Now, and with the development of tools such as browsers to make the Internet far more useful to the world's community, the environment was set for the rapid expansion of cyberattacks, both in number and in kind, so the challenge for cybersecurity researchers over a very short period of time became a major concern to the computing industry.

The world of computer science was thus faced with the dilemma of having to adapt to changing levels of expertise in a very short period of time. The first author of this book began his own research in 1980, in the infancy of what we now call cybersecurity, even before the widespread development of the personal computer and the Internet.

In the attempt to try to address the need for an accelerated development of researchers who can address the problems of cyberattacks, our two authors have recognized that in addition to the traditional expertise required in studying such problems—that is, expertise in computer science, mathematics, and engineering—we also have a great need to address the human behavior, in the first place, of persons involved in cyberattacks or cybercrime of many forms, but also in the behavioral aspects of all computer users, for example, those who would never avoid precautions in their life such as locking their doors, but use the name of their significant other, sibling, or pet as a password on their computer accounts.

As a result, we have embarked on this project in order to introduce into the field an approach to cybersecurity that relies upon not only the mathematical, computing, and engineering approaches but also depends upon a greater understanding of human behavior. We have chosen to call this subject area "behavioral cybersecurity" and have developed and offered a curriculum over the past several years that now has evolved into this textbook, which we hope will serve as a guidepost for universities, government, industry, and others that wish to develop scholarship in this area.

This book is being proposed (1) for use in developing cybersecurity curricula, (2) as support for further research in behavioral science and cybersecurity, and (3) to support practitioners in cybersecurity.

Behavioral Cybersecurity provides a basis for new approaches to understanding problems in one of our most important areas of research—an approach, agreed upon by most cybersecurity experts, of incorporating not only traditional technical computational and analytic approaches to cybersecurity, but also developing psychological and human-factor approaches to these problems.

The confluence of external events—the power of the Internet, increasing geopolitical fears of "cyberterrorism" dating from 9/11, a greater understanding of security needs and industry, and economic projections of the enormous employment needs in cybersecurity—has caused many universities to develop more substantial curricula in this area, and the United States National Security Agency has created a process for determining Centers of Excellence in this field.

Undergraduate enrollments have been increasing to full capacity. However, we feel there is still a gap in the cybersecurity curriculum that we decided to address.

Background

At the 1980 summer meeting of the American Mathematics Society in Ann Arbor, Michigan, a featured speaker was the distinguished mathematician the late Peter J. Hilton. Dr. Hilton was known widely for his research in algebraic topology, but on that occasion, he spoke publicly for the first time about his work in cryptanalysis during World War II at Hut 8 in Bletchley Park, the home of the now-famous efforts to break German encryption methods such as Enigma.

The first author was present at that session and has often cited Professor Hilton's influence in sparking interest in what we now call cybersecurity. Hilton at the time revealed many of the techniques used at Bletchley Park in breaking the Enigma code. However, one that was most revealing was the discovery by the British team that, contrary to the protocol, German cipher operators would send the same message twice, something akin to, "How's the weather today?" at the opening of an encryption session. (This discovery was represented in the recent Academy-Award–nominated film *The Imitation Game*.) Of course, it is well known in cryptanalysis that having two different encryptions of the same message with different keys is an enormous clue in breaking a code. Thus, it is not an exaggeration to conclude that a behavioral weakness had enormous practical consequences, as the Bletchley Park teams have been credited with saving millions of lives and helping end the war.

Contemporary Behavioral Issues in Cybersecurity

This one example, as important as it is in our history, is repeated countless times in our current cyberspace environments. Most cybersecurity experts will concur that the greatest challenge to effective security is the weakness in human behavior in compromising the technical approach, and not the strength of a technical solution. The first point relates to the lack of motivation of computer users in creating secure passwords, therefore providing a motivation for those who would profit from weak passwords to hack into computer systems and networks.

Cybersecurity researchers generally agree that our field has made spectacular gains in developing technically secure protocols, but all of the careful research in this regard can be overcome by honest users who for some reason choose easy-to-guess passwords such as their significant other's or spouse's name—or on the other hand, hackers who can find such easy-to-guess passwords.

It is believed that in order to counter the clever but malicious behavior of hackers and the sloppy behavior of honest users, cybersecurity professionals (and students) must gain some understanding of motivation, personality, behavior, and other theories that are studied primarily in psychology and other behavioral sciences.

Consequently, by building a behavioral component into a cybersecurity program, it is felt that this curricular need can be addressed. In addition, noting that while only 20% of computer science majors in the United States are women, about 80% of psychology majors are women. It is hoped that this new curriculum, with a behavioral science orientation in the now-popular field of cybersecurity, will induce more women to want to choose this curricular option.

Course Structure

In terms of employment needs in cybersecurity, estimates indicate "more than 209,000 cybersecurity jobs in the U.S. are unfilled, and postings are up 74% over the past five years."

It is believed that the concentration in behavioral cybersecurity will also attract more women students since national statistics show that whereas women are outnumbered by men by approximately 4 to 1 in computer science, almost the reverse is true in psychology.

Our objective with this textbook is to encourage many more opportunities to study and research the area of cybersecurity through this approach to behavioral cybersecurity. With a new approach to the skill set needed for cybersecurity employment, it is hoped that an expanded pool of students will seek to follow this path.

It has also not escaped our notice that the field of cybersecurity has been less attractive to women. Estimates have shown that even though women are underrepresented in computer science (nationally around 25%), in the computer science specialization of cybersecurity, the participation of women drops to about 10%.

However, with the development of a new path through the behavioral sciences into cybersecurity, we observed that approximately 80% of psychology majors, for example, are female. We hope that this entrée to cybersecurity will encourage more behavioral science students to choose this path, and that computer science, mathematics, and engineering students interested in this area will be more inclined to gain a background in psychology and the behavioral sciences.

We feel that this textbook can be applicable to three types of courses: first, classes where it is expected or required that the students have at least some background in both the computer and behavioral sciences; a second path could be for students who have primarily a computing background and little knowledge or expertise in the behavioral sciences; and third, a path for those students whose background is primarily in the behavioral sciences and only minimally in the computing disciplines. What follows describes three separate approaches to the use of this textbook that we will designate as:

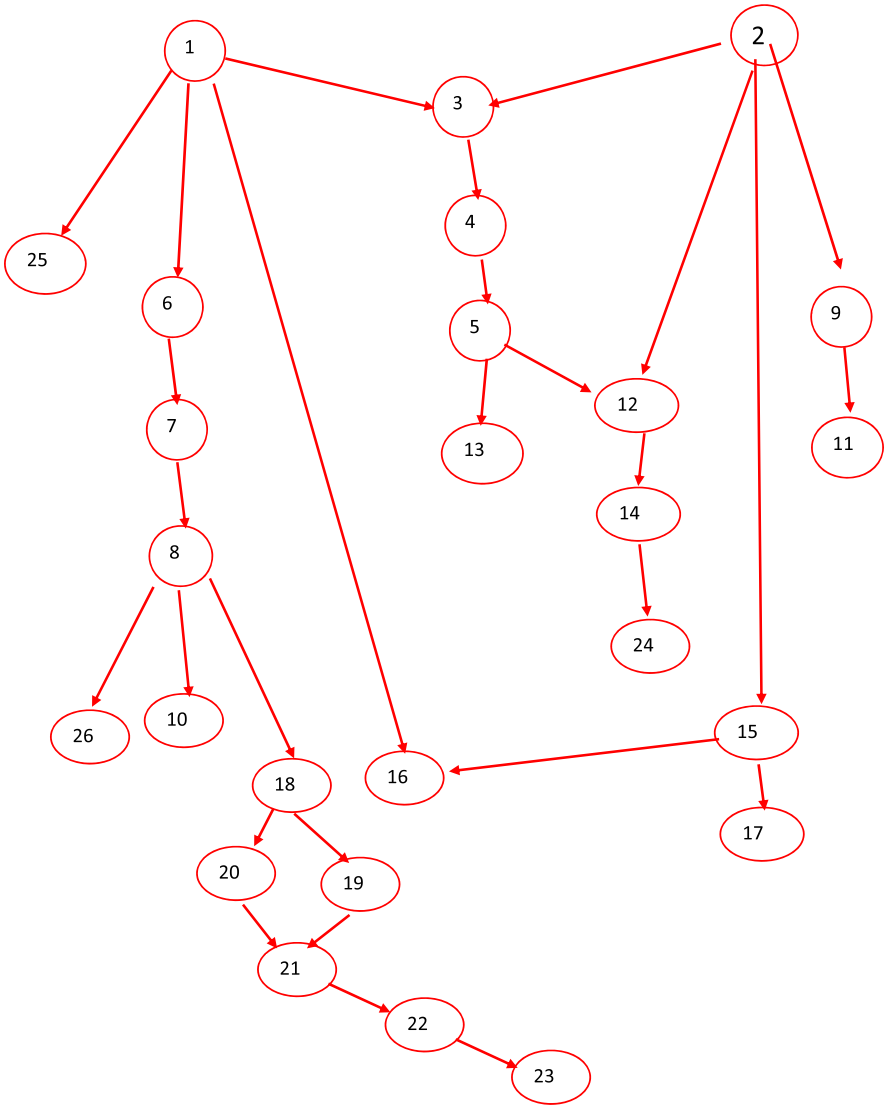
- Behavioral cybersecurity for computer science and psychology
- Behavioral cybersecurity for computer scientists with some background in behavioral science
- Behavioral cybersecurity for behavioral scientists with some background in computing

In the following pages, you will see three chapter selections that may be most appropriate for students with the backgrounds described above. The overall chapters are:

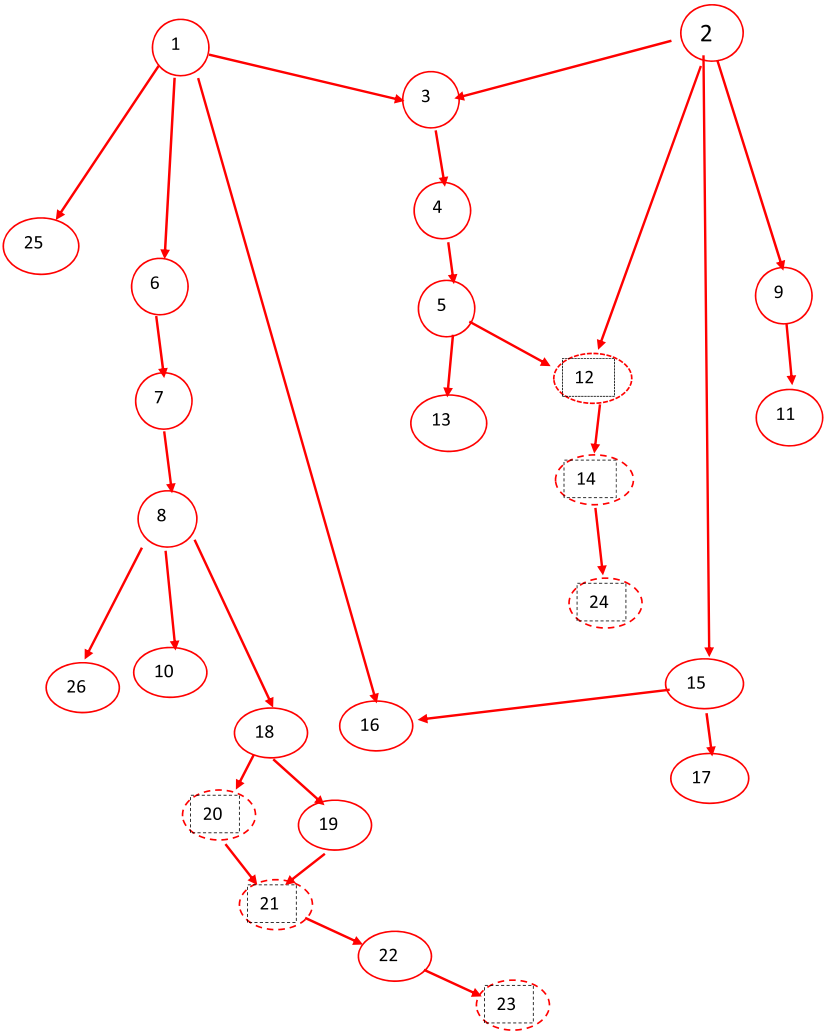
Number	Chapter
0	Preface
1	What Is Cybersecurity?
2	Essentials of Behavioral Science
3	Psychology and Cybersecurity
4	Recent Events
5	Profiling
6	Hack Lab 1: Social Engineering Practice: Who Am I?
7	Access Control
8	The First Step: Authorization
9	Hack Lab 2: Assigned Passwords in the Clear
10	Origins of Cryptography
11	Hack Lab 3: Sweeney Method

12	Hacker Personalities: Case Studies
13	Game Theory
14	Ethical Hacking
15	The Psychology of Gender
16	Turing Tests
17	Personality Tests, Methods, and Assessment
18	Modular Arithmetic and Other Computational Methods
19	Modern Cryptography
20	Steganography
21	Using Cryptography and Steganography in Tandem or in Sequence
22	A Metric to Assess Cyberattacks
23	Behavioral Economics
24	Fake News
25	Potpourri
26	Hack Lab 4: Contradictions in Password Meters
27	Conclusion

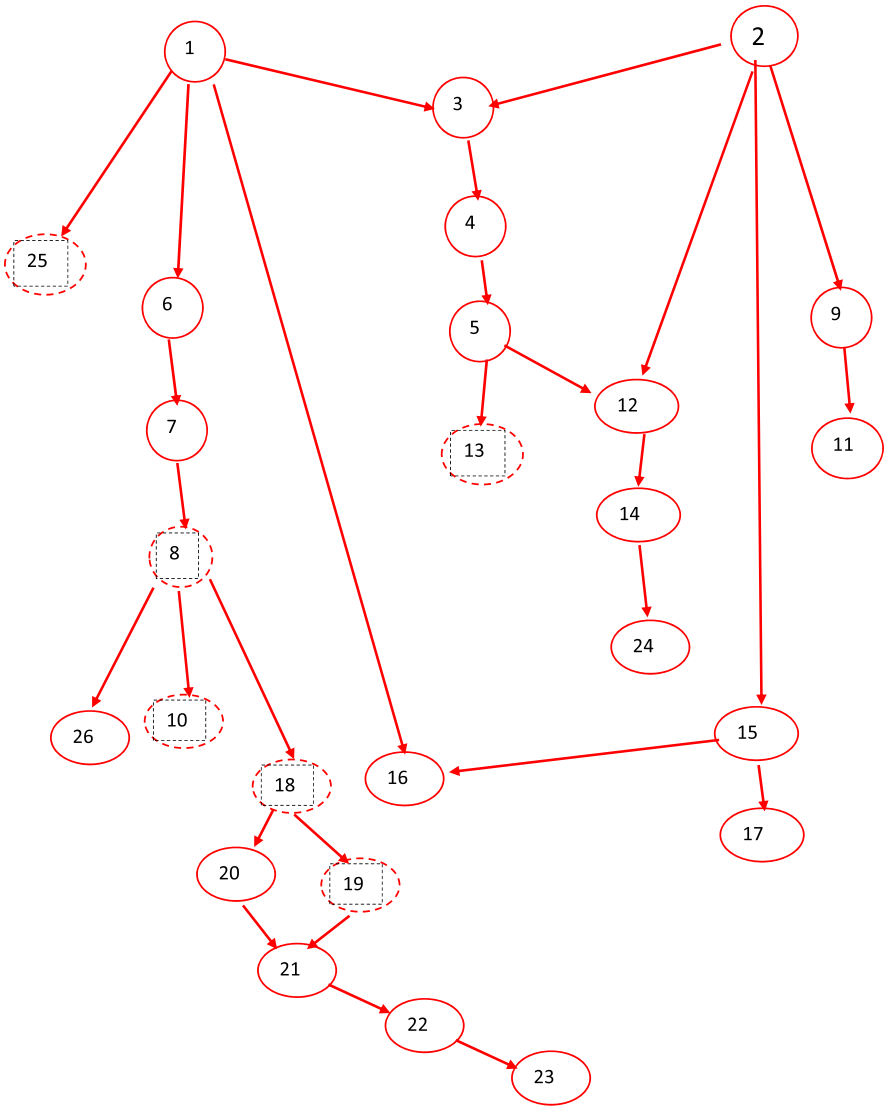
In the diagrams below, the chapters that are noted with dotted lines may be omitted for the particular group concerned.



Behavioral Cybersecurity for Computer Science and Psychology



Behavioral Cybersecurity for Computer Scientists with some background in Behavioral Science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Authors

Dr. Wayne Patterson is a retired professor of computer science from Howard University. He is also currently coprincipal investigator for the National Science Foundation-funded GEAR UP project at Howard, which has supported almost 300 STEM undergrads to do summer research in 15 developing countries. He has also been director of the Cybersecurity Research Center, associate vice provost for Research, and senior fellow for Research and International Affairs in the Graduate School at Howard. He has also been Professeur d'Informatique at the Université de Moncton, chair of the Department of Computer Science at the University of New Orleans, and in 1988, associate vice chancellor for Research there. In 1993, he was appointed vice president for Research and Professional and Community Services, and dean of the Graduate School at the College of Charleston, South Carolina. In 1998, he was selected by the Council of Graduate Schools, the national organization of graduate deans and graduate schools, as the dean in Residence at the national office in Washington, DC. His other service to the graduate community in the United States has included being elected to the presidency of the Conference of Southern Graduate Schools, and also to the Board of Directors of the Council of Graduate Schools. Dr. Patterson has published more than 50 scholarly articles primarily related to cybersecurity; one of the earliest cybersecurity textbooks, *Mathematical Cryptology*; and subsequently three other books. He has been the principal investigator on over 35 external grants valued at over $6,000,000. In August 2006, he was loaned by Howard University to the U.S. National Science Foundation to serve as the Foundation's Program Manager for International Science and Engineering in Developing Countries, and in 2017 was Visiting Scholar at Google.

He received degrees from the University of Toronto (BSc and MSc in Mathematics), University of New Brunswick (MSc in Computer Science), and University of Michigan (PhD in Mathematics). He has also held postdoctoral appointments at Princeton University and the University of California, Berkeley.

Dr. Cynthia E. Winston-Proctor is a widely respected and accomplished narrative personality psychologist and academic. She is professor of Psychology and principal investigator of the Identity and Success Research Laboratory at Howard University. She is also founder of Winston Synergy LLC, a psychology and education consulting firm. Dr. Winston-Proctor earned her BS in psychology from Howard University and her PhD in psychology and education from the University of Michigan. Recognized as an outstanding psychologist, research scientist, and teacher, Dr. Winston-Proctor was awarded the National Science Foundation Early Career Award for scientists and engineers, the Howard University Syllabus of the Year Award, the Howard University Emerging Scholar Award, and a Brown University Howard Hughes Medical Institute Research Professorship. Also, she was elected as a member of the Society of Personology, the oldest and most prominent society for scholars to develop, preserve, and promote theory and research that focuses on the study of individual lives and whole persons. As an academic, she has led the development of curricula across a spectrum

of areas including undergraduate education in psychology, behavioral cybersecurity, qualitative inquiry in psychology, healthy living for women, culturally responsive computational thinking, and African ancestry education. Her theory and method development-focused research and education scholarship have resulted in publications in numerous journals and edited books, including *Culture & Psychology*; *Qualitative Psychology*; *Journal of Research on Adolescence*; *Psych Critiques*; *New Directions in Childhood & Development*; the *Oxford Handbook of Cultural Psychology*; and *Culture, Learning, & Technology: Research and Practice*. Dr. Winston-Proctor's professional service includes serving as an editor on the Editorial Board of the American Psychological Association *Journal of Qualitative Psychology*, president of the Society of STEM Women of Color, member of the Board of Directors of the Alfred Harcourt Foundation, and advisor to the Board of Directors of the Howard University Middle School of Mathematics and Science.

1 What Is Cybersecurity?

For the first 40 years or so of the computer era, the question of security was on the one hand widely ignored, and on the other hand relatively simple to address. The reasons, of course, were that far fewer people had access to computing, and also the environment for the computer user was essentially a corporate or university mainframe computer that had no connectivity with other machines that were outside of that corporate environment.

By the mid-1980s, a number of developments began to occur that changed a relatively simple problem to one of massive proportions. In chronological order, events that radically changed the nature of the security problem were:

1. The invention and proliferation of the personal computer in the early 1980s that brought computing power to the individual user.
2. The remarkable PhD thesis by Fred Cohen (1987) that defined the term "computer virus" and demonstrated how such software could completely gain control of the most secure mainframe environment in a matter of a few hours.
3. In 1984, the primary computing society, the Association for Computing Machinery, awarded its Turing Award to two of the developers of the UNIX operating system, Ken Thompson and Dennis Ritchie. Thompson (1984), in his award acceptance speech, posed the challenging problem for programmers of writing a program whose output would be the code of the program itself. Others began to see that such code could be used to create what has been called a computer worm.
4. By the late 1980s, the network ARPAnet, developed much earlier by the U.S. Defense Advanced Research Production Agency (DARPA), started to expand by leaps and bounds, and, with the development of user-friendly software such as browsers, attracted many more people to the use of the Internet, which evolved from ARPAnet.
5. In 1987, the first widespread attack on multiple computers, called the Internet worm, was launched, and it disabled thousands of computers, mostly on university campuses. A Cornell University computer science graduate student, Robert Morris, was charged with and convicted of this crime—he later went on to become a professor of computer science at MIT (Stoll, 1989).
6. On September 11, 2001, the airplane attacks engineered by Osama Bin Laden on the two World Trade Center towers, the Pentagon, and a fourth that crashed near Pittsburgh raised the concerns in the United States and around the world to a new level and foresaw cybersecurity problems.

Since that time, numerous other attacks have led to cybersecurity stories in almost daily headlines. Julian Assange's organization, WikiLeaks, initially won

international awards for exposing corruption in organizations and governments. U.S. Army Private Bradley Manning (who later, as a trans woman, changed her name to Chelsea Manning) was able to extract many U.S. government classified documents and make them public via WikiLeaks. Edward Snowden, working with the National Security Agency as a contractor, also obtained classified documents and fled to Russia, where he continues to live.

In addition to these actions by individuals or small organizations, in early 2010, an extremely sophisticated worm called Stuxnet was launched (Nakashima and Warrick, 2012). Spread via Windows, it targeted Siemens software and equipment. It only attacked Siemens Supervisory Control and Data Acquisition System (SCADA) computers. It successfully infected five Iranian organizations related to the Iranian government's processing plants for the enrichment of uranium (either for nuclear power or nuclear weapons, depending on your political perspectives). The result was that the Iranian government indicated that the damage to the enrichment infrastructure cost was the equivalent of $10 million and set the Iranian nuclear program back by an estimated 2 years. The Stuxnet virus was sufficiently sophisticated that most studies of this virus concluded that it could only be built by government levels of organization and investment. It was later discovered that in fact Stuxnet was a joint operation of the United States National Security Agency and Israel's Mossad.

More and more attacks were being discovered, ranging from the trivial (launched by what were often called "spy kiddies") to distributed denial of service (DDoS) attacks designed to bring down websites for perhaps a day at a time—such as happened to MasterCard, Bank of America, the U.S. Department of Justice, and many others. In more recent times, types of attacks called ransomware have been developed, whereby an individual computer may be locked by an external attack until a payment is made in order to free up the attacked computer. Recent examples are the ransomware attacks called WannaCry and Petya, as we will discuss later.

With the explosion of cyberattacks in recent years, the importance of the subject has grown almost without bound. In order to gain an understanding of how to combat these threats, it is necessary to study the subject from a number of points of reference. First of all, it is absolutely necessary to understand the approaches available for the design of a healthy defense strategy. However, it should also be noted that a necessary component of understanding the role of defense is also to understand what possible attack strategies there are. And third, what is often omitted in the study of this field is that the technological approaches described here can be compromised by human behavior, which is why this book seeks to understand both the technological and human behavioral issues that are integral to the study of cybersecurity.

Perhaps the most important historical example of the understanding of the role of human behavior is the breaking of what was thought to have been an unbreakable code, the Enigma code of the German forces in World War II. Although this example essentially predates the invention of the digital computer, the importance is such that it bears repeating. Alan Turing, the brilliant British mathematician and to many the founder of computer science, led the group assigned to break the German Enigma code. The British would obtain daily encrypted messages, but soon learned that the key to the encryption would be changed every day at midnight. Since the number of

possible keys was usually in the tens of millions (and their analysis was by hand in the precomputer era), Turing's team was at a loss until it was recognized that certain German cipher operators would begin a day's transmission with the same opening, something akin to "How's the weather today?" (Sony, 2014). It turns out that if a cryptanalyst senses that the same message has been encrypted two different ways, this is a huge step in decrypting an entire message. Once this was realized, the British team was able to break the Enigma messages regularly and continued to do so for the last 4 years of the Second World War without this ability being detected by the Germans. Some historians have concluded that breaking the Enigma code shortened the war by about 2 years and saved on the order of 10 million lives. In essence, the strong cryptographic algorithm of Enigma was defeated by simple human error in following a protocol.

1.1 WHAT IS CYBERSECURITY?

Cybersecurity is a science designed to protect your computer and everything associated with it—the physical environment, the workstations and printers, cabling, disks, memory sticks, and other storage media. But most importantly, cybersecurity is designed to protect all forms of memory, that is, the information stored in your system. Cybersecurity is not only designed to protect against outside intruders, but also both malicious and benign insiders. Of course, the malicious insider often presents the greatest danger, but we also have dangers arising from benign insiders: sharing a password with a friend, failing to back up files, spilling a beverage or food on the keyboard, or natural dangers—the result of a sudden electrical outage, among many other possibilities.

At one time, we could focus on the protection of a single computer. Now, we must consider the entire universe of hundreds of millions of computers to which our machine is connected.

The reason for using the term *cybersecurity* is that at one time, our concern was primarily with a single computer, so if you look back at writings from the 1990s or earlier (Patterson, 1987), you will find that the topics we discussed here tended to be called generically "computer security." But this terminology is clearly out of date, since the number of users whose entire computing environment consists of one machine is dwindling rapidly to zero.

There are three distinct aspects of security: secrecy, accuracy, and availability. Let's consider these in this order.

1.2 SECRECY

A secure computer system does not allow information to be disclosed to anyone who is not authorized to access it. In highly secure systems in government, secrecy ensures that users access only information they're allowed to access. Essentially the same principle applies in industry or academia, since most organizations in society require some level of secrecy or confidentiality in order to function effectively.

One principal difference is that in government systems, including military systems, the rules regarding secrecy may in addition be protected by law.

1.3 ACCURACY: INTEGRITY AND AUTHENTICITY

A secure computer system must maintain the continuing integrity of the information stored in it. Accuracy or integrity means that the system must not corrupt the information or allow any unauthorized malicious or accidental changes to it. Malicious changes, of course, may be affected by an external source, for example, a hacker; however, information may also be changed inadvertently by a less-than-careful user, or also by a physical event such as a fluctuation in an electrical signal.

In network communications, a related variant of accuracy known as authenticity provides a way to verify the origin of data by determining who entered or sent it and by recording when it was sent and received.

1.4 AVAILABILITY

Part of the security requirement for a computer system is availability. In other words, its information must be available to the user at all times.

This means that the computer system's hardware and software keep working efficiently and that the system is able to recover quickly and completely if a disaster occurs.

The opposite of availability is denial of service. Denial of service can be every bit as disruptive as actual information theft, and denial of service has become one of the major threats to the efficient functioning of a computing environment.

1.5 THREATS IN CYBERSECURITY

In describing a scenario for a computing environment that may come under threat, we define three terms:

Vulnerabilities
Threats
Countermeasures

A vulnerability is a point where a system is susceptible to attack. If you were describing a vulnerability in your own home, it might be an unlocked back door.

A threat is a possible danger to the system; for example, a threat could be a person, a thing (a faulty piece of equipment), or an event (a fire or a flood). In the previous example, the threat is a person who exploits the fact that your back door is unlocked in order to gain entry.

Techniques for protecting your system are called countermeasures. To continue the analogy, the countermeasure would consist of locking your back door.

1.6 VULNERABILITIES

In the cybersecurity world, there are many types of vulnerabilities, for example:

Physical vulnerabilities
Natural vulnerabilities

Hardware and software vulnerabilities
Media vulnerabilities
Emanation vulnerabilities
Communications vulnerabilities
Human vulnerabilities

There is a great deal of variation in how easy it is to exploit different types of vulnerabilities. For example, tapping a cordless telephone or a cellular mobile phone requires only a scanner costing perhaps a couple of hundred dollars.

1.7 THREATS

Threats fall into three main categories:

Natural threats
Unintentional threats
Intentional threats

The intentional threats can come from insiders or outsiders. Outsiders can include:

Foreign intelligence agents
Terrorists
Criminals
Corporate raiders
Hackers

1.8 INSIDE OR OUTSIDE?

Although most security mechanisms protect best against outside intruders, many surveys indicate that most attacks are by insiders. Estimates are that as many as 80% of system penetrations are by fully authorized users.

1.9 THE INSIDER

There are a number of different types of insiders: the disgruntled employee, the coerced employee, the careless employee, and the greedy employee. One of the most dangerous types of insiders may simply be lazy or untrained. He or she doesn't bother changing passwords, doesn't learn how to encrypt files, doesn't get around to erasing old disks, doesn't notice a memory stick inserted into the back of the computer, and leaves sensitive printouts in piles on the floor.

1.10 COUNTERMEASURES

There are many different types of countermeasures or methods of protecting information. The fact that in earlier times, our working environment might consist of a single computer—an environment that virtually no longer exists—is the reason

that we have retired the term *computer security* and replaced it with *cybersecurity*, which now consists of at least the following needs for countermeasures. Let's survey these methods:

Computer security
Communications security
Physical security

1.11 COMPUTER SECURITY: THEN AND NOW

In the early days of computing, computer systems were large, rare, and very expensive. Those organizations lucky enough to have a computer tried their best to protect it. Computer security was just one aspect of general plant security. Security concerns focused on physical break-ins; theft of computer equipment; and theft or destruction of disk packs, tape reels, and other media. Insiders were also kept at bay. Few people knew how to use computers; thus, the users could be carefully screened. Later on, by the 1970s, technology was transformed, and with it the ways in which users related to computers and data. Multiprogramming, time-sharing, and networking changed the rules.

Telecommunications—the ability to access computers from remote locations—radically changed computer usage. Businesses began to store information online. Networks linked minicomputers together and with mainframes containing large online databases. Banking and the transfer of assets became an electronic business.

1.12 NEW ABUSES

The increased availability of online systems and information led to abuses. Instead of worrying only about intrusions by outsiders into computer facilities and equipment, organizations now had to worry about computers that were vulnerable to sneak attacks over telephone lines and information that could be stolen or changed by intruders who didn't leave a trace. Individuals and government agencies expressed concerns about the invasion of privacy posed by the availability of individual financial, legal, and medical records on shared online databases.

1.13 THE PERSONAL COMPUTER WORLD

The 1980s saw a new dawn in computing. With the introduction of the personal computer (PC), individuals of all ages and occupations became computer users. This technology introduced new risks. Precious and irreplaceable corporate data were now stored on diskettes, which could now be lost or stolen.

As PCs proliferated, so too did PC networks, electronic mail, chat rooms, and bulletin boards, vastly raising the security stakes. The 1980s also saw systems under attack.

1.14 THE FUTURE

The challenge of the next decade will be to consolidate what we've learned—to build computer security into our products and our daily routines, to protect data without

unnecessarily impeding our access to it, and to make sure that both products and standards grow to meet the ever-increasing scope of challenge of technology.

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