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Unclas

5/5/89

Director, FBI

Legat, Paris

SAC, WMFO

UNSUBS; UNAUTHORIZED USE OF GOVERNMENT  
COMPUTER SYSTEMS, INC., LAWRENCE BERKELEY LABS,  
BERKELEY, CALIFORNIA;  
FBW;  
OO: WMFO

Re Paris teletype to Director dated 3/10/89.

Reference teletype requested information pertaining to  
above-captioned case.

Enclosed for receiving offices are three newspaper  
articles which appeared in "The Washington Post." The enclosed  
articles are self-explanatory.

Enclosures (3) *pl*

*Pull*  
*AK 196A-999\**

b3  
b6  
b7C  
b7E

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GENERAL INDEXING		
<input checked="" type="checkbox"/> Automated		
WF: <input type="checkbox"/> Pos <input checked="" type="checkbox"/> Neg	<input checked="" type="checkbox"/> Pos	<input checked="" type="checkbox"/> Neg
<input type="checkbox"/> Manual Search		
WF: <input type="checkbox"/> Pos <input type="checkbox"/> Neg	AA: <input type="checkbox"/> Pos	<input type="checkbox"/> Neg

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# COMMUNICATIONS

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**IN THIS ISSUE** Stalking the Willy Hacker



About the cover:  
This month's cover was inspired by  
Clifford Stoll's exclusive account of  
"Stalking the Willey Hacker," beginning  
on page 484. Cover by Angelica Group,  
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# STALKING THE WILY HACKER

*An astronomer-turned-sleuth traces a German trespasser on our military networks, who slipped through operating system security holes and browsed through sensitive databases. Was it espionage?*

CLIFFORD STOLL

In August 1986 a persistent computer intruder attacked the Lawrence Berkeley Laboratory (LBL). Instead of trying to keep the intruder out, we took the novel approach of allowing him access while we printed out his activities and traced him to his source. This trace back was harder than we expected, requiring nearly a year of work and the cooperation of many organizations. This article tells the story of the break-ins and the trace, and sums up what we learned.

We approached the problem as a short, scientific exercise in discovery, intending to determine who was breaking into our system and document the exploited weaknesses. It became apparent, however, that rather than innocuously playing around, the intruder was using our computer as a hub to reach many others. His main interest was in computers operated by the military and by defense contractors. Targets and keywords suggested that he was attempting espionage by remotely entering sensitive computers and stealing data; at least he exhibited an unusual interest in a few, specifically military topics. Although most attacked computers were at military and defense contractor sites, some were at universities and research organizations. Over the next 10 months, we watched this individual attack about 450 computers and successfully enter more than 30.

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LBL is a research institute with few military contracts and no classified research (unlike our sister laboratory, Lawrence Livermore National Laboratory, which has several classified projects). Our computing environment is typical of a university: widely distributed, heterogeneous, and fairly open. Despite this lack of classified computing, LBL's management decided to take the intrusion seriously and devoted considerable resources to it, in hopes of gaining understanding and solution.

The intruder conjured up no new methods for breaking operating systems; rather he repeatedly applied techniques documented elsewhere. Whenever possible he used known security holes and subtle bugs in different operating systems, including UNIX,<sup>1</sup> VMS,<sup>2</sup> VM-TSO,<sup>3</sup> EMBOS,<sup>4</sup> and SAIL-WAITS. Yet it is a mistake to assume that one operating system is more secure than another. Most of these break-ins were possible because the intruder exploited common blunders by vendors, users, and system managers.

Throughout these intrusions we kept our study a closely held secret. We deliberately remained open to attacks, despite knowing the intruder held system manager privileges on our computers. Except for alerting management at threatened installations, we commun-

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VMS is a registered trademark of Digital Equipment Corporation.  
VM-TSO is a registered trademark of International Business Machines Corporation.  
EMBOS is a registered trademark of ELYSI.

cated with only a few trusted sites, knowing this intruder often read network messages and even accessed computers at several computer security companies. We remained in close touch with law-enforcement officials, who maintained a parallel investigation. As this article goes to press, the U.S. FBI and its German equivalent, the *Bundeskriminalamt* (BKA), continue their investigations. Certain details are therefore necessarily omitted from this article.

Recently, a spate of publicity surrounded computer break-ins around the world [23, 33, 37]. With a few notable exceptions (e.g., [24, 36]), most were incompletely reported anecdotes [7], or were little more than rumors. For lack of substantive documentation, system designers and managers have not addressed important problems in securing computers. Some efforts to tighten security on common systems may even be misdirected. We hope that lessons learned from our research will help in the design and management of more secure systems.

How should a site respond to an attack? Is it possible to trace the connections of someone trying to evade detection? What can be learned by following such an intruder? Which security holes were taken advantage of? How responsive was the law-enforcement community? This article addresses these issues, and avoids such questions as whether there is anything intrinsically wrong with browsing through other people's files or with attempting to enter someone else's computer, or why someone would wish to read military databases. Nonetheless, the author holds strong opinions on these subjects.<sup>1</sup>

## DETECTION

We first suspected a break-in when one of LBL's computers reported an accounting error. A new account had been created without a corresponding billing address. Our locally developed accounting program could not balance its books, since someone had incorrectly added the account. Soon afterwards, a message from the National Computer Security Center arrived, reporting that someone from our laboratory had attempted to break into one of their computers through a MILNET connection.

We removed the errant account, but the problem remained. We detected someone acting as a system manager, attempting to monitor accounting records. Realizing that there was an intruder in the system, we installed line printers and recorders on all incoming ports, and printed out the traffic. Within a few days, the intruder showed up again. We captured all of his keystrokes on a printer and saw how he used a subtle bug in the Gnu-Emacs text editor [40] to obtain system-manager privileges. At first we suspected that the culprit was a student prankster at the nearby University of California. We decided to catch him in the act, if possi-

ble. Accordingly, whenever the intruder was present, we began tracing the line, printing out all of his activity in real time.

## ORGANIZING OUR EFFORTS

Early on, we began keeping a detailed logbook, summarizing the intruder's traffic, the traces, our suspicions, and interactions with law-enforcement people. Like a laboratory notebook, our logbook reflected both confusion and progress, but eventually pointed the way to the solution. Months later, when we reviewed old logbook notes, buried clues to the intruder's origin rose to the surface.

Having decided to keep our efforts invisible to the intruder, we needed to hide our records and eliminate our electronic messages about his activity. Although we did not know the source of our problems, we trusted our own staff and wished to inform whoever needed to know. We held meetings to reduce rumors, since our work would be lost if word leaked out. Knowing the sensitivity of this matter, our staff kept it out of digital networks, bulletin boards, and, especially, electronic mail. Since the intruder searched our electronic mail, we exchanged messages about security by telephone. Several false electronic-mail messages made the intruder feel more secure when he illicitly read them.

## MONITORS, ALARMS, AND TRAFFIC ANALYSIS

We needed alarms to instantly notify us when the intruder entered our system. At first, not knowing from which port our system was being hit, we set printers on all lines leading to the attacked computer. After finding that the intruder entered via X.25 ports, we recorded bidirectional traffic through that set of lines. These printouts proved essential to our understanding of events; we had records of his every keystroke, giving his targets, keywords, chosen passwords, and methodologies. The recording was complete in that virtually all of these sessions were captured, either by printer or on the floppy disk of a nearby computer. These monitors also uncovered several other attempted intrusions, unrelated to those of the individual we were following.

Off-line monitors have several advantages over moni-

## What Is a Hacker?

The term hacker has acquired many meanings, including, a creative programmer, one who illicitly breaks into computers, a novice golfer who digs up the course, a taxicab driver, and ditch-digger. Confusion between the first two interpretations results in the perception that one need be brilliant or creative to break into computers. This may not be true. Indeed, the person we followed was patient and plodding, but hardly showed creative brilliance in discovering new security flaws.

To point out the ambiguity of the word hacker, this paper uses the term in the title, yet avoids it in the text.

Alternatives for describing someone who breaks into computers are: the English word "Cracker," and the Dutch term "Computerredebrenk" [14], (literally, computer peace disturber). The author's choices include "varmint," "reprobate," "swine," and several unprintable words.

<sup>1</sup>For old readers: if you have forgotten Thompson's article "Reflections on Trusting Trust" [33] drop this article and run to your nearest library. Consult his moral alongside the disk case study presented here.

tors embedded in an operating system. They are invisible to an intruder with system privileges. More, they gave printouts of the intruder's activities on a local area network (LAN), letting us see his attempts to enter other closely linked computers. A monitor that records keystrokes within an operating system consumes computing resources and may slow down other processes. In addition, such a monitor must use highly privileged software and may introduce new security holes into the system. Besides taking up resources, on-line monitors would have warned the intruder that he was being tracked. Since printers and personal computers are ubiquitous, and because RS-232 serial lines can easily be sent to multiple receivers, we used this type of off-line monitor and avoided tampering with our operating systems.

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*From the intruder's viewpoint, almost everyone except LBL detected his activity. In reality, almost nobody except LBL detected him.*

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The alarms themselves were crude, yet effective in protecting our system as well as others under attack. We knew of researchers developing expert systems that watch for abnormal activity [4, 35], but we found our methods simpler, cheaper, and perhaps more reliable. Backing up these alarms, a computer loosely coupled into our LAN periodically looked at every process. Since we knew from the printouts which accounts had been compromised, we only had to watch for the use of these stolen accounts. We chose to place alarms on the incoming lines, where serial line analyzers and personal computers watched all traffic for the use of stolen account names. If triggered, a sequence of events culminated in a modem calling the operator's pocket pager. The operator watched the intruder on the monitors. If the intruder began to delete files or damage a system, he could be immediately disconnected, or the command could be disabled. When he appeared to be entering sensitive computers or downloading sensitive files, line noise, which appeared to be network glitches, could be inserted into the communications link.

In general, we contacted the system managers of the attacked computers, though in some cases the FBI or military authorities made the contact. Occasionally, they cooperated by leaving their systems open. More often, they immediately disabled the intruder or denied him access. From the intruder's viewpoint, almost everyone except LBL detected his activity. In reality, almost nobody except LBL detected him.

Throughout this time, the printouts showed his interests, techniques, successes, and failures. Initially, we were interested in how the intruder obtained system-manager privileges. Within a few weeks, we noticed him exploring our network connections—using ARPANET and MILNET quite handily, but frequently need-

ing help with lesser known networks. Later, the monitors showed him leapfrogging through our computers, connecting to several military bases in the United States and abroad. Eventually, we observed him attacking many sites over Internet, guessing passwords and account names.

By studying the printouts, we developed an understanding of what the intruder was looking for. We also compared activity on different dates in order to watch him learn a new system, and inferred sites he entered through pathways we could not monitor. We observed the intruder's familiarity with various operating systems and became familiar with his programming style. Buried in this chatter were clues to the intruder's location and persona, but we needed to temper inferences based on traffic analysis. Only a complete trace back would identify the culprit.

#### TRACE BACKS

Tracing the activity was challenging because the intruder crossed many networks, seldom connected for more than a few minutes at a time, and might be active at any time. We needed fast trace backs on several systems, so we automated much of the process. Within seconds of a connection, our alarms notified system managers and network control centers automatically, using pocket pagers dialed by a local modem [42]. Simultaneously, technicians started tracing the networks.<sup>2</sup>

Since the intruder's traffic arrived from an X.25 port it could have come from anywhere in the world. We initially traced it to a nearby dial-up Tymnet port, in Oakland, California. With a court order and the telephone company's cooperation, we then traced the dial up calls to a dial-out modem belonging to a defense contractor in McLean, Virginia. In essence, their LAN allowed any user to dial out from their modem pool and even provided a last-number-redial capability for those who did not know access codes for remote systems.

Analyzing the defense contractor's long-distance telephone records allowed us to determine the extent of these activities. By cross-correlating them with audit trails at other sites, we determined additional dates, times, and targets. A histogram of the times when the intruder was active showed most activity occurring at around noon, Pacific time. These records also demonstrated the attacks had started many months before detection at LBL.

Curiously, the defense contractor's telephone bills listed hundreds of short telephone calls all around the United States. The intruder had collected lists of modem telephone numbers and then called them over

<sup>2</sup> The monitoring and trace-back efforts mixed frustration with excitement. The computer was hit at 4:00 A.M., by 4:02, the author was out of bed, logs into several computers, and talking with the FBI. Telephone technicians in Germany, as well as network controllers in Europe and stateside, awaited a signal, so we had to eliminate false alarms, yet spread the word immediately. Several intimate evenings were spoiled by the intruder setting off the alarm and a Halloween party was delayed while unwinding a particularly convoluted connection.

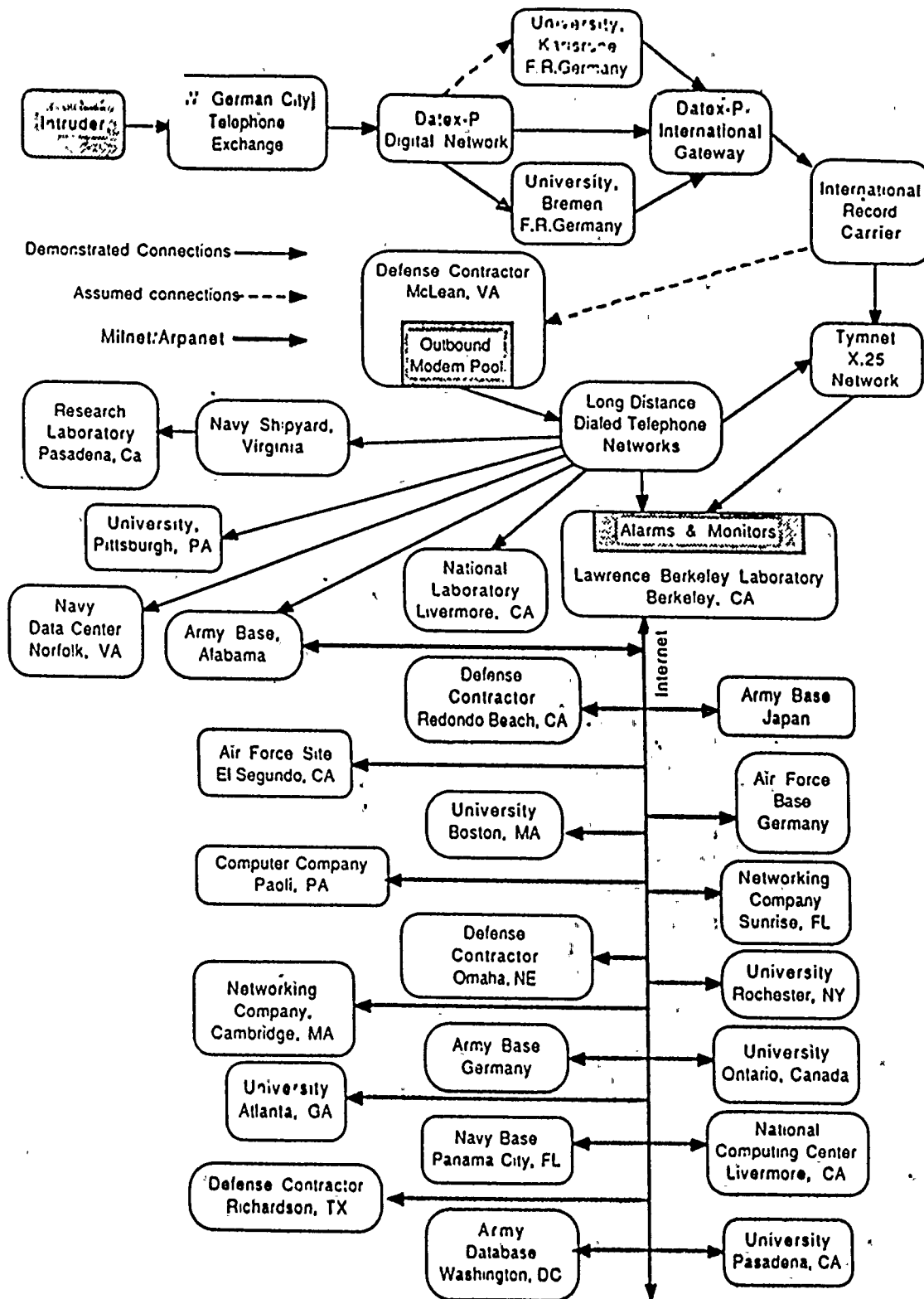


FIGURE 1. Simplified Connectivity and Partial List of Penetrated Sites



these modems. Once connected, he attempted to log in using common account names and passwords. These attempts were usually directed at military bases; several had detected intruders coming in over telephone lines, but had not bothered to trace them. When we alerted the defense contractor officials to their problem, they tightened access to their outbound modems and there were no more short connections.

*We baited the intruder by creating several files of fictitious text . . . [that] appeared to be memos about how computers were to support research for SDI.*

After losing access to the defense contractor's modems, the still undeterred intruder connected to us over different links. Through the outstanding efforts of Tymnet, the full X.25 calling addresses were obtained within seconds of an attack. These addresses pointed to sources in Germany: universities in Bremen and Karlsruhe, and a public dial-up modem in another German city. When the intruder attacked the university in Bremen, he acquired system-manager privileges, disabled accounting, and used their X.25 links to connect around the world. Upon recognizing this problem, the university traced the connections to the other German city. This, in turn, spurred more tracing efforts, coordinating LBL, Tymnet, the university, and the German Bundespost.

Most connections were purposely convoluted. Figure 1 summarizes the main pathways that were traced, but the intruder used other connections as well. The rich connectivity and redundant circuits demonstrate the intruder's attempts to cover his tracks, or at least his search for new networks to exploit.

Besides physical network traces, there were several other indications of a foreign origin. When the intruder transferred files, we timed round-trip packet acknowledgments over the network links. Later, we measured the empirical delay times to a variety of different sites and estimated average network delay times as a function of distance. This measurement pointed to an overseas origin. In addition, the intruder knew his way around UNIX, using AT&T rather than Berkeley UNIX commands. When stealing accounts, he sometimes used German passwords. In retrospect, all were clues to his origin, yet each was baffling given our mind-set that "it must be some student from the Berkeley campus."

#### A STINGER TO COMPLETE THE TRACE

The intruder's brief connections prevented telephone technicians from determining his location more precisely than to a particular German city. To narrow the search to an individual telephone, the technicians needed a relatively long connection. We baited the intruder by creating several files of fictitious text in an

obscure LBL computer. These files appeared to be memos about how computers were to support research for the Strategic Defense Initiative (SDI). All the information was invented and steeped in governmental jargon. The files also contained a mailing list and several form letters talking about "additional documents available by mail" from a nonexistent LBL secretary. We protected these bogus files so that no one except the owner and system manager could read them, and set alarms so that we would know who read them.

While scavenging our files one day, the intruder detected these bogus files and then spent more than an hour reading them. During that time the telephone technicians completed the trace. We celebrated with milk shakes made with homegrown Berkeley strawberries, but the celebration proved premature. A few months later, a letter arrived from someone in the United States, addressed to the nonexistent secretary. The writer asked to be added to the fictitious SDI mailing list. As it requested certain "classified information," the letter alone suggested espionage. Moreover, realizing that the information had traveled from someone in Germany to a contact in the United States, we concluded we were witnessing attempted espionage. Other than cheap novels, we have no experience in this area and so left this part of the investigation to the FBI.

#### BREAK-IN METHODS AND EXPLOITED WEAKNESSES

Printouts of the intruder's activity showed that he used our computers as a way station; although he could become system manager here, he usually used LBL as a path to connect to the ARPANET/MILNET. In addition, we watched him use several other networks, including the Magnetic Fusion Energy network, the High Energy Physics network, and several LANs at invaded sites.

While connected to MILNET, this intruder attempted to enter about 450 computers, trying to log in using common account names like *root*, *guest*, *system*, or *field*. He also tried default and common passwords, and often found valid account names by querying each system for currently logged-in accounts, using *who* or *finger*. Although this type of attack is the most primitive, it was disarmingly successful: In about 5 percent of the machines attempted, default account names and passwords permitted access, sometimes giving system-manager privileges as well.

When he succeeded in logging into a system, he used standard methods to leverage his privileges to become system manager. Taking advantage of well-publicized problems in several operating systems, he was often able to obtain root or system-manager privileges. In at least one case, he searched file structures for keywords like "nuclear," "sdi," "kh-11," and "norad." After exhaustively searching for such information, he scanned for plaintext passwords into other systems. This proved remarkably effective: Users often leave passwords in files [2]. Electronic mail describing log-in sequences with account names and passwords is commonly saved at for-

sign nodes, allowing a file browser to obtain access into a distant system. In this manner he was able to obtain both passwords and access mechanisms into a Cray supercomputer.

Typical of the security holes he exploited was a bug in the Gnu-Emacs program. This popular, versatile text editor includes its own mail system, allowing a user to forward a file to another user [40]. As distributed, the program uses the UNIX Set-User-ID-to-Root feature; that is, a section of the program runs with system-manager privileges. This movemail facility allows the user to change file ownership and move files into another's directory. Unfortunately, the program did not prevent someone from moving a file into the systems area. Aware of this hole, the intruder created a shell script that, when executed at root level, would grant him system privileges. He used the movemail facility to rename his script to masquerade as a utility periodically run by the system. When the script was executed by the system, he gained system-manager privileges.

This intruder was impressively persistent and patient. For example, on one obscure gateway computer,

Throughout this time the intruder tried not to destroy or change user data, although he did destroy several tasks and unknowingly caused the loss of data to a physics experiment. Whenever possible, he disabled accounting and audit trails, so there would be no trace of his presence. He planted Trojan horses to passively capture passwords and occasionally created new accounts to guarantee his access into computers. Apparently he thought detection less likely if he did not create new accounts, for he seemed to prefer stealing existing, unused accounts.

#### INTRUDER'S INTENTIONS

Was the intruder actually spying? With thousands of military computers attached, MILNET might seem inviting to spies. After all, espionage over networks can be cost-efficient, offer nearly immediate results, and target specific locations. Further, it would seem to be insulated from risks of internationally embarrassing incidents. Certainly Western countries are at much greater risk than nations without well-developed computer infrastructures.

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*Was the intruder actually spying? With thousands of military computers attached, MILNET might seem inviting . . . espionage over networks can be cost-efficient, offer nearly immediate results, and target specific locations.*

---

he created an account with system privileges that remained untouched until six months later, when he began using it to enter other networked computers. On another occasion, he created several programs that gave him system-manager privileges and hid them in system software libraries. Returning almost a year later, he used the programs to become system manager, even though the original operating-system hole had been patched in the meantime.

This intruder cracked encrypted passwords. The UNIX operating system stores passwords in publicly readable, but encrypted form [26]. We observed him downloading encrypted password files from compromised systems into his own computer. Within a week he reconnected to the same computers, logging into new accounts with correct passwords. The passwords he guessed were English words, common names, or place-names. We realized that he was decrypting password files on his computer by successively encrypting dictionary words and comparing the results to password file entries. By noting the length of time and the decrypted passwords, we could estimate the size of his dictionary and his computer's speed.

The intruder understood what he was doing and thought that he was not damaging anything. This, alas, was not entirely true. Prior to being detected, he entered a computer used in the real-time control of a medical experiment. Had we not caught him in time, a patient might have been severely injured.

Some may argue that it is ludicrous to hunt for classified information over MILNET because there is none. Regulations [21] prohibit classified computers from access via MILNET, and any data stored in MILNET systems must be unclassified. On the other hand, since these computers are not regularly checked, it is possible that some classified information resides on them. At least some data stored in these computers can be considered sensitive,<sup>3</sup> especially when aggregated. Printouts of this intruder's activities seem to confirm this. Despite his efforts, he uncovered little information not already in the public domain; but that included abstracts of U.S. Army plans for nuclear, biological, and chemical warfare for central Europe. These abstracts were not classified, nor was their database.

The intruder was extraordinarily careful to watch for anyone watching him. He always checked who was logged onto a system, and if a system manager was on, he quickly disconnected. He regularly scanned electronic mail for any hints that he had been discovered, looking for mention of his activities or stolen log-in names (often, by scanning for those words). He often changed his connection pathways and used a variety of different network user identifiers. Although arrogant from his successes, he was nevertheless careful to cover his tracks.

<sup>3</sup>An attempt by the National Security Council [34] to classify certain public databases as "sensitive" met with widespread objections [11].

Judging by the intruder's habits and knowledge, he is an experienced programmer who understands system administration. But he is by no means a "brilliant wizard," as might be popularly imagined. We did not see him plant viruses [18] or modify kernel code, nor did he find all existing security weaknesses in our system. He tried, however, to exploit problems in the UNIX/*usr/spool/at* [36], as well as a hole in the *vi* editor. These problems had been patched at our site long before, but they still exist in many other installations.

Did the intruder cause damage? To his credit, he tried not to erase files and killed only a few processes. If we only count measurable losses and time as damage, he was fairly benign [41]. He only wasted systems staff time, computing resources, and network connection time, and racked up long-distance telephone tolls and international network charges. His liability under California law [6], for the costs of the computing and network time, and of tracking him, is over \$100,000.

But this is a narrow view of the damage. If we include intangible losses, the harm he caused was serious and deliberate. At the least, he was trespassing. Invading others' property and privacy; at worst, he was conducting espionage. He broke into dozens of computers, extracted confidential information, read personal mail, and modified system software. He risked injuring a medical patient and violated the trust of our network community. Money and time can be paid back. Once trust is broken, the open, cooperative character of our networks may be lost forever.

#### AFTERMATH: PICKING UP THE PIECES

Following successful traces, the FBI assured us the intruder would not try to enter our system again. We began picking up the pieces and tightening our system. The only way to guarantee a clean system was to rebuild all systems from source code, change all passwords overnight, and recertify each user. With over a thousand users and dozens of computers, this was impractical; especially since we strive to supply our users with uninterrupted computing services. On the other hand, simply patching known holes or instituting a quick fix for stolen passwords [27] was not enough.

We settled on instituting password expiration, deleting all expired accounts, eliminating shared accounts, continued monitoring of incoming traffic, setting alarms in certain places, and educating our users. Where necessary, system utilities were compared to fresh versions; new utilities built. We changed network-access passwords and educated users about choosing nondictionary passwords. We did not institute random password assignment, having seen that users often store such passwords in command files or write them on their terminals.

To further test the security of our system, we hired a summer student to probe it [2]. He discovered several elusive, site-specific security holes, as well as demonstrated more general problems, such as file scavenging. We would like to imagine that intruder problems have ended for us; sadly, they have not, forcing us to continue our watch.

#### REMAINING OPEN TO AN INTRUDER

Should we have remained open? A reasonable response to the detection of this attack might have been to disable the security hole and change all passwords. This would presumably have insulated us from the intruder and prevented him from using our computers to attack other Internet sites. By remaining open, were we not a party to his attacks elsewhere, possibly incurring legal responsibility for damage?

Had we closed up shop, we would not have risked embarrassment and could have resumed our usual activities. Closing up and keeping silent might have reduced adverse publicity, but would have done nothing to counter the serious problem of suspicious (and possibly malicious) offenders. Although many view the trace back and prosecution of intruders as a community service to network neighbors, this view is not universal [22].

Finally, had we closed up, how could we have been certain that we had eliminated the intruder? With hundreds of networked computers at LBL, it is nearly impossible to change all passwords on all computers. Perhaps he had planted subtle bugs or logic bombs in places we did not know about. Eliminating him from LBL would hardly have cut his access to MILNET. And, by disabling his access into our system, we would close our eyes to his activities; we could neither monitor him nor trace his connections in real-time. Tracing, catching, and prosecuting intruders are, unfortunately, necessary to discourage these vandals.

#### LEGAL RESPONSES

Several laws explicitly prohibit unauthorized entry into computers. Few states lack specific codes, but occasionally the crimes are too broadly defined to permit conviction [38]. Federal and California laws have tight criminal statutes covering such entries, even if no damage is done [47]. In addition, civil law permits recovery not only of damages, but also of the costs to trace the culprit [6]. In practice, we found police agencies relatively uninterested until monetary loss could be quantified and damages demonstrated. Although not a substitute for competent legal advice, spending several days in law libraries researching both the statutes and precedents set in case law proved helpful.

Since this case was international in scope, it was necessary to work closely with law-enforcement organizations in California, the FBI in the United States, and the BKA in Germany. Cooperation between system managers, communications technicians, and network operators was excellent. It proved more difficult to get bureaucratic organizations to communicate with one another as effectively. With many organizational boundaries crossed, including state, national, commercial, university, and military, there was confusion as to responsibility. Most organizations recognized the seriousness of these break-ins, yet no one agency had clear responsibility to solve it. A common response was, "That's an interesting problem, but it's not our bailiwick."

Overcoming this bureaucratic indifference was a continual problem. Our laboratory notebook proved useful

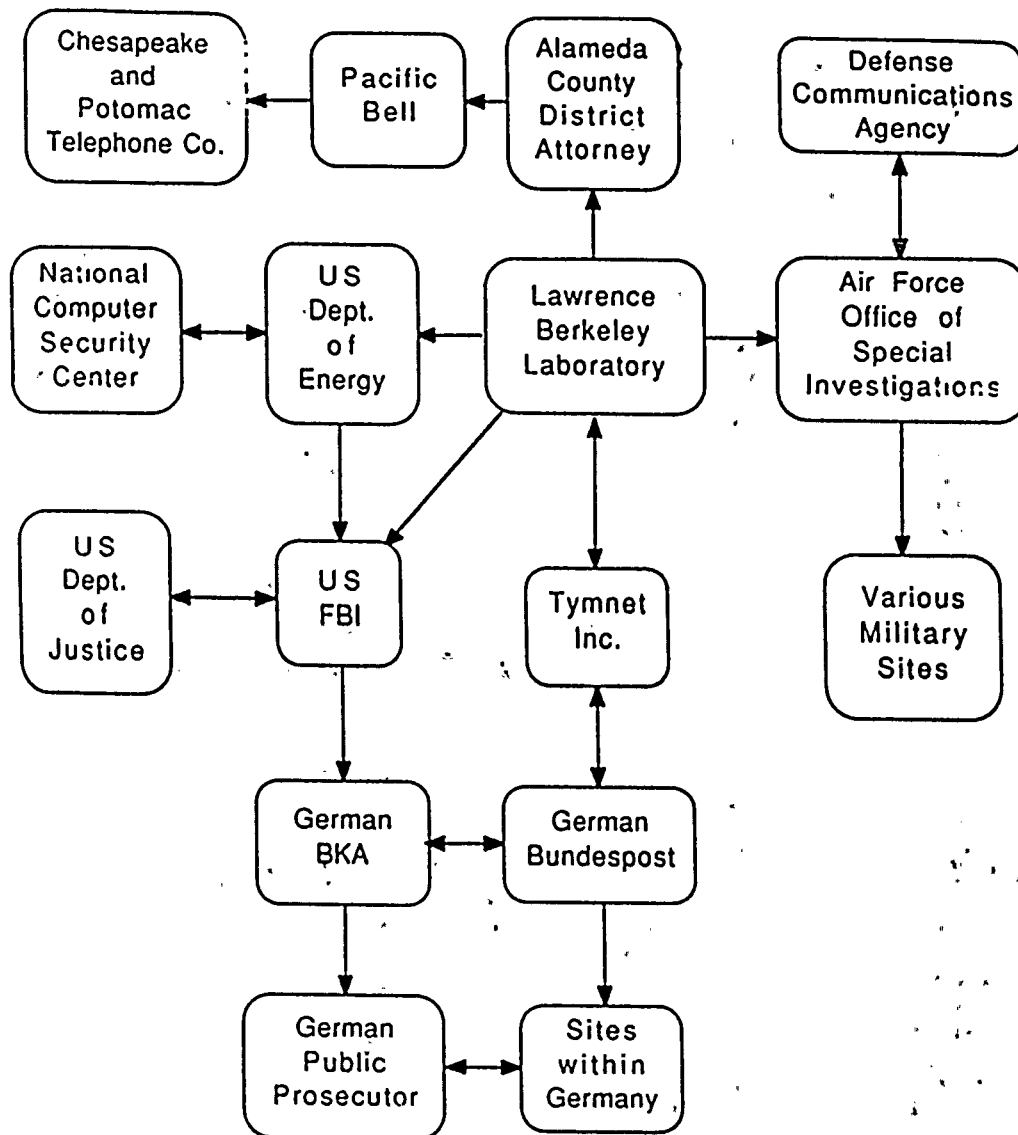


FIGURE 2. Simplified Communications Paths between Organizations

In motivating organizations: When individuals saw the extent of the break-ins, they were able to explain them to their colleagues and take action. In addition, new criminal laws were enacted that more tightly defined what constituted a prosecutable offense [6, 38, 47]. As these new laws took effect, the FBI became much more interested in this case, finding statutory grounds for prosecution.

The FBI and BKA maintained active investigations. Some subjects have been apprehended, but as yet the author does not know the extent to which they have been prosecuted. With recent laws and more skilled personnel, we can expect faster and more effective responses from law-enforcement agencies.

#### ERRORS AND PROBLEMS

In retrospect, we can point to many errors we made before and during these intrusions. Like other academic organizations, we had given little thought to securing our system, believing that standard vendor provisions were sufficient because nobody would be interested in us. Our scientists' research is entirely in the public domain, and many felt that security measures would only hinder their productivity. With increased connectivity, we had not examined our networks for cross-links where an intruder might hide. These problems were exacerbated on our UNIX systems, which are used almost exclusively for mail and text processing, rather than for heavy computation.

### The Intruder versus the Tracker

Skills and techniques to break into systems are quite different from those to detect and trace an intruder. The intruder may not even realize the route chosen; the tracker, however, must understand this route thoroughly. Although both must be aware of weaknesses in systems and networks, the former may work alone, whereas the latter must forge links with technical and law-enforcement people. The intruder is likely to ignore concepts of privacy and trust during a criminal trespass; in contrast, the tracker must know and respect delicate legal and ethical restrictions.

Despite occasional reports to the contrary [19], rumors of intruders building careers in computer security are exaggerated. Apart from the different skills required, it is a rare company that trusts someone with such ethics and personal conduct. Banks, for example, do not hire embezzlers as consultants. Donn Parker, of SRI International, reports (personal communication, September 1987) that job applications of several intruders have been rejected due to suspicions of their character and trustworthiness. On March 16th, the *Washington Post* reported the arrest of a member of the German Chaos computer club, prior to his giving a talk on computer security in Paris. Others who have broken into computers have met with physical violence [33] and have been ostracized from network activities [3]. A discipline that relies on trust and responsibility has no place for someone technically competent yet devoid of ethics.

Password security under Berkeley UNIX is not optimal; it lacks password aging, expiration, and exclusion of passwords found in dictionaries. Moreover, UNIX password integrity depends solely on encryption; the password file is publicly readable. Other operating systems protect the password file with encryption, access controls, and alarms.

We had not paid much attention to choosing good passwords (fully 20 percent of our users' passwords fell to a dictionary-based password cracker). Indeed, we had allowed our Tymnet password to become public, foolishly believing that the system log-in password should be our only line of defense.

out of state, we experienced frustration in getting federal law-enforcement support. Finally, after tracing the intruder abroad, we encountered a whole new set of ill-defined interfaces between organizations. The investigation stretched out far beyond our expectations. Naïvely expecting the problem to be solved by a series of phone traces, we were disappointed when the pathway proved to be a tangle of digital and analog connections. Without funding to carry out an investigation of this length, we were constantly tempted to drop it entirely.

A number of minor problems bubbled up, which we were able to handle along the way. For a while this intruder's activity appeared similar to that of someone breaking into Stanford University; this confused our investigation for a short time. Keeping our work out of the news was difficult, especially because our staff is active in the computing world. Fortunately, it was possible to recover from the few leaks that occurred. At first, we were confused by not realizing the depth or extent of the penetrations. Our initial confusion gave way to an organized response as we made the proper contacts and began tracing the intruder. As pointed out by others [25, 36], advance preparations make all the difference.

### LESSONS

As a case study, this investigation demonstrates several well-known points that lead to some knotty questions. Throughout this we are reminded that security is a human problem that cannot be solved by technical solutions alone [48].

The almost obsessive persistence of serious penetrators is astonishing. Once networked, our computers can be accessed via a tangle of connections from places we had never thought of. An intruder, limited only by patience, can attack from a variety of directions, searching for the weakest entry point. How can we analyze our systems' vulnerability in this environment? Who is responsible for network security? The network builder? The managers of the end nodes? The network users?

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*Vendors distribute systems with default accounts and backdoor entryways left over from software development. Since many customers buy computers based on capability rather than security, vendors seldom distribute secure software.*

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Once we detected the intruder, the first few days were confused, since nobody knew what our response ought to be. Our accounting files were misleading since the system clocks had been allowed to drift several minutes. Although our LAN's connections had been saved, nobody knew the file format, and it was frustrating to find that its clock had drifted by several hours. In short, we were unprepared to trace our LAN and had to learn quickly.

We did not know who to contact in the law-enforcement community. At first, assuming that the intruder was local, our district attorney obtained the necessary warrants. Later, as we learned that the intruder was

The security weaknesses of both systems and networks, particularly the needless vulnerability due to sloppy systems management and administration, result in a surprising success rate for unsophisticated attacks. How are we to educate our users, system managers, and administrators?

Social, ethical, and legal problems abound. How do we measure the harm done by these penetrators? By files deleted or by time wasted? By information copied? If no files are corrupted, but information is copied, what damage has been done? What constitutes unreasonable behavior on a network? Attempting to illicitly log in to a foreign computer? Inquiring who is currently

logged in there? Exporting a file mistakenly made world readable? Exploiting an unpatched hole in another's system?

Closing out an intruder upon discovery may be a premature reflex. Determining the extent of the damage and cooperating with investigations argue for leaving the system open. How do we balance the possible benefits of tracking an intruder against the risks of damage or embarrassment?

Our technique of catching an intruder by providing bait and then watching what got nibbled is little more than catching flies with honey. It can be easily extended to determine intruders' interests by presenting them with a variety of possible subjects (games, financial data, academic gossip, military news). Setting up alarmed files is straightforward, so this mechanism offers a method to both detect and classify intruders. It should not be used indiscriminately, however.

ing to memorize them are more likely to write such passwords into files. How can we make secure remote procedure calls and remote batch job submissions?

Passwords are at the heart of computer security. Requirements for a quality password are few: Passwords must be nonguessable, not in a dictionary, changed every few months, and easily remembered. User-generated passwords usually fail to meet the first three criteria, and machine-generated passwords fail the last. Several compromises exist: forcing "pass phrases" or any password that contains a special character. There are many other possibilities, but none are implemented widely. The Department of Defense recommends pronounceable machine-generated words or pass phrases [5]. Despite such obvious rules, we (and the intruder) found that poor-quality passwords pervaded our networked communities. How can we make users choose good passwords? Should we?

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*Whereas the commercial sector is more concerned with data integrity, the military worries about control of disclosure . . . we expect greater success for the browser or data thief in the commercial world.*

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Files with plaintext passwords are common in remote job entry computers, yet these systems often are not protected since they have little computational capability. Such systems are usually widely networked, allowing entry from many sources. These computers are fertile grounds for password theft through file scavenging since the passwords are left in easily read command procedures. These files also contain instructions to make the network connection. Random character passwords make this problem worse, since users not wish-

#### Legal Constraints and Ethics

As communities grow, social and legal structures follow. In our networked community, there is frustration and confusion over what constitutes a crime and what is acceptable behavior. Legal constraints exist, but some do not recognize their applicability. Richard D'Ippolito laments:

Our view of computer crimes has not yet merged with society's view of other property crimes; while we have laws against breaking and entering, they aren't widely applied to computer crimes. The property owner does not have to provide "perfect" security, nor does anything have to be taken to secure a conviction of unauthorized entry. Also, unauthorized use of CPU resources (a demonstrably saleable product) amounts to theft. There still seems to be the presumption that computer property, unlike other property, is fair game . . . We deserve the same legal presumption that our imperfectly protected systems and work are private property subject to trespass and conversion protection. [12]

The "ACM Code of Professional Conduct" also leaves little doubt:

An ACM member shall act at all times with integrity . . . shall always consider the principle of the individual's privacy and to minimize the data collected, limit authorized access, [and] provide proper security for the data. . . . [1]

Vendors usually distribute weakly protected systems software, relying on the installer to enable protections and disable default accounts. Installers often do not care, and system managers inherit these weak systems. Today, the majority of computer users are naive; they install systems the way the manufacturer suggests or simply unpackage systems without checking. Vendors distribute systems with default accounts and backdoor entryways left over from software development. Since many customers buy computers based on capability rather than security, vendors seldom distribute secure software. It is easy to write procedures that warn of obvious insecurities, yet vendors are not supplying them. Capable, aware system managers with plenty of time do not need these tools—the tools are for novices who are likely to overlook obvious holes. When vendors do not see security as a selling point, how can we encourage them to distribute more secure systems?

Patches to operating-system security holes are poorly publicized and spottily distributed. This seems to be due to the paranoia surrounding these discoveries, the thousands of systems without systems administrators, and the lack of channels to spread the news. Also, many security problems are specific to a single version of an operating system or require systems experience to understand. Together, these promote ignorance of problems, threats, and solutions. We need a central clearinghouse to receive reports of problems, analyze their importance, and disseminate trustworthy solutions. How can we inform people wearing white hats about security problems, while preventing evil people from learning or exploiting these holes? Perhaps zero-knowledge proofs [20] can play a part in this.

Operating systems can record unsuccessful log ins. Of the hundreds of attempted log ins into computers at-

tached to Internet, only five sites (or 1-2 percent) contacted us when they detected an attempted break-in. Clearly, system managers are not watching for intruders, who appear as neighbors, trying to sneak into their computers. Our networks are like communities or neighborhoods, and so we are surprised when we find unneighborly behavior.

Does security interfere with operational demands? Some security measures, like random passwords or strict isolation, are indeed onerous and can be self-defeating. But many measures neither interfere with legitimate users nor reduce the system's capabilities. For example, expiring unused accounts hurts no one and is likely to free up disk space. Well thought out management techniques and effective security measures do not bother ordinary users, yet they shut out or detect intruders.

### INTERNET SECURITY

The intruder's successes and failures provide a reasonable snapshot of overall security in the more than 20,000 computers connected to Internet. A more detailed analysis of these attacks is to be published in the *Proceedings of the 11th National Computer Security Conference* [43]. Of the 450 attacked computers, half were unavailable when the intruder tried to connect to them. He tried to log into the 220 available computers with obvious account names and trivial passwords. Of these 220 attempted log ins, listed in increasing importance,

- 5 percent were refused by a distant computer (set to reject LBL connects).
- 82 percent failed on incorrect user name/passwords.
- 8 percent gave information about the system status (who, sysstat, etc.).
- 1 percent achieved limited access to databases or electronic-mail shells.
- 2 percent yielded normal user privileges and a programming environment, and
- 2 percent reached system-manager privileges.

Most attempts were into MILNET computers (Defense Data Network address groups 26.l,j,k). Assuming the population is representative of nonmilitary computers and the last three categories represent successful pene-

### Should This Have Been Published?

The very act of publishing this article raises questions. Surely it creates a new set of problems by exposing widely distributed notes to some amoral readers. Worse, it describes ways to track such individuals and so suggests avoidance techniques, possibly making other intrusions more difficult to track and prosecute.

In favor of publishing, Maj. Gen. John Paul Hyde of the U.S. Joint Chiefs of Staff informed the author that "to stimulate awareness of the vulnerabilities of networks, along with the complexities of tracking a distant intruder, papers such as this should be widely distributed. It's obvious that inattention to established security practices contributed to the success of this intruder; systems with vigilant security programs detected and rejected unauthorized accesses."

trations, we find that about 5 percent of Internet computers are grossly insecure against trivial attacks. This figure is only a lower limit of vulnerability, since military computers may be expected to be more secure than civilian systems. Further, cleverer tactics for entering computers could well lead to many more break-ins.

Whereas the commercial sector is more concerned with data integrity, the military worries about control of disclosure [8]. With this in mind, we expect greater success for the browser or data thief in the commercial world.

In a different set of penetrations [37], NASA experienced about 130 break-ins into its nonclassified, academic computers on the SPAN networks. Both the NASA break-in and our set of intrusions originated in West Germany, using similar communications links and searching for "secret" information. Pending completion of law enforcement and prosecution, the author does not make conjectures as to the relationships between these different break-ins.

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*Considering the [NASA] break-ins with the present study... break-in success rates of 3-20 percent may be expected in typical network environments.*

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Between 700 and 3000 computers are reachable on the SPAN network (exact figures depend on whether LANs are counted). In that incident the break-in success rate was between 4 and 20 percent. Considering the SPAN break-ins with the present study, we find that, depending on the methods chosen, break-in success rates of 3-20 percent may be expected in typical network environments.

### CONCLUSIONS AND COMMENTS

Perhaps no computer or network can be totally secure. This study suggests that any operating system will be insecure when obvious security rules are ignored. For the intruder's widespread success, it appears that users, managers, and vendors routinely fail to use sound security practices. These problems are not limited to our site or the few dozen systems that we saw penetrated, but are networkwide. Lax system management makes patching utility software or tightening a few systems ineffective.

We found this intruder to be a competent, patient programmer, experienced in several operating systems. Alas, some system managers violate their positions of trust and confidence. Our worldwide community of digital networks requires a sense of responsibility. Unfortunately, this is missing in some technically competent people.

Some speak of a "hacker ethic" of not changing data [37]. It is astounding that intruders blithely tamper with someone else's operating system, never thinking

they may destroy months of work by systems people, or may cause unforeseen system instabilities or crashes. Sadly, few realize the delicacy of the systems they fool with or the amount of systems staff time they waste.

The foreign origin of the source, the military computers entered, and the keywords searched suggest international espionage. This author does not speculate as to whether this actually was espionage, but does not doubt that someone took the opportunity to try.

lers, Network Rangers, or various contributors to 2600 Magazine, it reflects the self-destructive folly of their apparent cleverness.

Tracking down espionage attempts over the digital networks may be the most dramatic aspect of this work. But it is more useful to realize that analytic research methods can be fruitfully applied to problems as bizarre as computer break-ins.

It seems that everyone wants to hear stories about

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*Tracking down espionage attempts over the digital networks may be the most dramatic aspect of this work. But it is more useful to realize that analytic research methods can be fruitfully applied to problems as bizarre as computer break-ins.*

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Break-ins from abroad seem to be increasing. Probably this individual's intrusions are different from others only in that his efforts were noticed, monitored, and documented. LBL has detected other attempted intrusions from several European countries, as well as from the Orient. Individuals in Germany [37] have claimed responsibility for breaking into foreign computers. Such braggadocio may impress an unenlightened public; it has a different effect on administrators trying to maintain and expand networks. Indeed, funding agencies have already eliminated some international links due to these concerns. Break-ins ultimately destroy the network connectivity they exploit. If this is the object of such groups as the German Chaos Club, Data Travel-

someone else's troubles, but few are willing to write about their own. We hope that in publishing this report we will encourage sound administrative practices. Vandals and other criminals reading this article will find a way to rationalize breaking into computers. This article cannot teach these people ethics; we can only hope to reach those who are unaware of these miscreants.

An enterprising programmer can enter many computers, just as a capable burglar can break into many homes. It is an understandable response to lock the door, sever connections, and put up elaborate barriers. Perhaps this is necessary, but it saddens the author, who would rather see future networks and computer communities built on honesty and trust.

#### Computer Security Resources

Much has been published on how to make a secure operating system, but there is little literature about frontline encounters with intruders. Computer security problems are often aired over Internet, especially the "UNIX-wizards," "info-vax," and "security" conferences. A lively, moderated discussion appears in the *Risks Forum* [12] addressing social issues relating to computer system risks. Private security conferences also exist; their "invitation only" membership is evidence of the paranoia surrounding the field. There are also private, anonymous, and pirate bulletin boards. These seldom have much useful information—their puerile contents apparently reflect the mind-sets of their contributors, but they do indicate what one segment of the population is thinking.

Perhaps the best review of problems, technology, and policy is presented in "Defending Secrets, Sharing Data" [32]. Whitten provides an excellent introduction to systems problems in "Computer Insecurity, Infiltrating Open Systems" [48]. Although slightly dated, the January 1983 issue of *Computer* [16] is devoted to secure computer systems, with a half-dozen good articles on the subject. See the especially cogent review article on secure operating systems [15]. Recent work concentrates on secure networks; an entire issue of *Network* is devoted to it [17]. Also see D. Denning's *Cryptography and Data Security* [9], and *Computer Security: An Introduction*, by R. Kemmerer at U.C. Santa Barbara.

Journals of interest include *Computer Security Journal*, *Computers and Security*, *Computer Fraud and Security Bulletin*, *ACM SIGPLAN Notices*, *Computer Security Newsletter*,

*Computer Law Journal*, and, of course, *Communications of the ACM*. Several semiunderground journals are devoted to illicitly entering systems; these are often short lived. The best known is *2600 Magazine*, named after a frequency used to steal long-distance telephone services.

Current research in computer security covers information theory, cryptology, graph theory, topology, and database methods. An ongoing debate rages over whether cryptographic protection or access controls are the best choice. Since it is tough to prove an operating system is secure, a new field of research has sprung up examining ways to formally verify a system's security.

The standard for secure operating systems is the Orange Book, "DoD Trusted Computer System Evaluation Criteria" [29], from the NCSC. This document sets levels of security, ranging from class D (minimal protection) through C (discretionary protection), B (mandatory access controls), and A (formally verified security controls). Since the Orange Book is not easy to comprehend, the NCSC has published an explanatory document [30]. There is also a document giving the technical rationale behind the explanatory document [28]. Some networks link classified computers, and these systems' security is being studied and standardized (see [31]).

UNIX security is covered by Grampp and Morris in [13] and by Wood and Kochan in [49]. Wood and Kochan's book is a good guide for system managers and users, although much of the book is spent on program listings. More recently, *Unix Review* presented several articles on securing



UNIX [45]. In that issue Smith's article is especially appropriate, as he describes in detail how secure systems are weakened by poor system administration [39]. Carole Hogan also examines Unix problems in her report, *Protection Imperfect*, available from Lawrence Livermore Labs, L-60; Livermore, CA.

Operating systems verified to Orange Book security ratings include security documentation. For an example of a well-written manual, see [10] the DEC VMS System security manual. Building a secure operating system is challenging and M. Gasser has written a book with just that title, available from Van Nostrand and Reinhold.

Should you have computer security worries, you may wish to contact either the National Bureau of Standards (NBS) Institute for Computer Science and Technology (Mail Stop Tech-A216, Washington, DC 20234) or the NCSC (Mail Stop C4, 9800 Savage Road, Ft. Meade, MD 20755). Both set standards and certify secure computers, as well as conduct research in secure networks. Jointly, NBS and NCSC sponsor

the annual "National Computer Security Conference." Recently, Federal Law 100-235 has shifted civilian computer security research from the NCSC to the NBS, apparently wishing to separate military and civilian policy.

With luck, you will never be confronted by a break-in. If you are, you can contact your local police, the FBI, or the U.S. Secret Service. Within the U.S. Air Force, computer security problems are handled by the Air Force Office of Special Investigations, at Bolling AFB, Washington, D.C. Within other military branches, such problems go to the respective investigative services. MILNET and ARPANET problems should be reported to the Security Office of the Defense Communications Agency, which will contact the Network Operations Center at BBN Communications. You do not need a court order to trace a call on your own line [46]. Most telephone companies have security departments that operate trace backs. For a variety of ways to respond to a break-in, see "What do you Feed a Trojan Horse" [42].

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CR Categories and Subject Descriptors: C.2.0 [Computer-Communication Networks]: General—security and protection, C.2.3 [Computer-Communication Networks]: Network Operations—network monitoring, public networks; K.4.1 [Computers and Society]: Public Policy Issues—transborder data flow; K.4.2 [Computers and Society]: Social Issues—abuse and crime involving computers; K.6.m [Management of Computing and Information Systems]: Miscellaneous—security, K.7.m [The Computing Profession]: Miscellaneous—ethics  
 General Terms: Management, Security  
 Additional Key Words and Phrases: Espionage, hacker, intruder

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RR HQ WFO

DE PAR #0577 0691454

ZNR UUUUU

R 101500Z MAR 89

FM PARIS (196A-218)(P)

TO DIRECTOR, FBI/ROUTINE/

FBI WMFO/ROUTINE/

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CITE: //5230//

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CC: WMFO.

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INTERNATIONAL PRESS CONCERNING WHAT APPEARS TO BE CAPTIONED  
MATTER, AND HAS RECEIVED A FOLLOW-UP INQUIRY FROM [REDACTED]

ANY INFORMATION AVAILABLE WOULD BE APPRECIATED.

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AIRTEL

3/27/89

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ATTN: SSA [REDACTED] CI-1E Unit

FROM: SAC, WMFO [REDACTED] (C) (CI-7)

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UNSUB;  
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BERKELEY LABORATORY, BERKELEY, CALIFORNIA;  
[REDACTED]

OO:WMFO

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Case closed at WMFO 3/6/89.

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FRIDAY, MARCH 3, 1989

# German Computer Hackers Held for Spying for Soviets

*KGB Said to Gain Access to Pentagon Data*

By Robert J. McCartney  
Washington Post Foreign Service

BONN, March 2—Authorities have arrested three West German computer hackers on suspicion that they carried out international electronic espionage and sold sensitive data to the Soviet intelligence service, the KGB, judicial officials said today.

The ARD television network—which made public the breakup of the spy ring after one of its affiliates carried out a 10-month investigation—said the hackers helped the KGB gain access to computer data banks of the Pentagon, the nuclear arms laboratory at Los Alamos,

N.M., and the National Aeronautics and Space Administration.

The KGB also received computer passwords and other materials from nuclear, space and commercial electronic data banks in West Germany, France, Switzerland, Britain and Japan, ARD said.

"If current suspicions are confirmed, what we very surely have is a new quality of espionage against our data systems," said Gerhard Boeden, the nation's chief of domestic counterespionage, in an interview with ARD.

Existing western computer systems are "not sufficiently" secured, said Boeden, who is president of the

See HACKERS, A33, Col. 1

# Computer Hackers Held For Spying for Soviets

HACKERS, From A1

Federal Constitutional Protection Office. The agency is roughly equivalent to the FBI.

Spokesmen for the Interior Ministry and the Federal Prosecutor's Office did not deny the detailed ARD report. But they provided only sketchy information on grounds that an investigation is under way.

A government spokeswoman in Bonn declined to comment this evening on a report by the West German news agency DPA quoting unidentified government security sources as saying the case was "extremely grave."

In Washington, the Pentagon issued a one-sentence statement saying: "Until possibly affected components of the Department of Defense have had a chance to analyze the report, we have no reaction."

The hackers apparently provided the Soviets with opportunities to obtain North Atlantic Treaty Organization military secrets and information about sensitive high technology, DPA quoted the sources as saying.

ARD described the affair as the most serious case of Soviet Bloc espionage to be discovered in West Germany since 1974, when chancellor Willy Brandt resigned after a close personal aide was found to be an East German spy.

Two men have been arrested in Hanover and a third in West Berlin, judicial officials said. Authorities have searched at least six residences in West Berlin, Hanover and Hamburg and confiscated a substantial quantity of evidence, they said.

ARD reported that two KGB agents obtained top-secret computer data from the three hackers in exchange for money and drugs.

The KGB was believed to have used computer passwords and other information obtained from the hackers to penetrate the U.S. Defense Department staff data bank OPTIMIS and U.S. military supply depot computers, ARD said.

It also was suspected that the Soviets penetrated computers of the West European nuclear research center CERN in Geneva; the European Space Agency; the Max Planck Institute for Nuclear Physics in Heidelberg, West Germany; the French arms and electronics company Thomson, and other West European and Japanese electronics companies, ARD said.

It said the hackers are believed to have helped the Soviets obtain access to western technology for manufacturing silicon chips, which are the central components of modern computers.

The hackers received several hundred thousand dollars, as the Soviets paid about \$3,000 for each computer disk, ARD said.

The hackers traveled to West Berlin, and then crossed into the eastern sector of the city via subway beneath the Berlin Wall to meet their Soviet contacts, the network said.

ARD reported that five persons

had been arrested, but this was not immediately confirmed. DPA said the searches were carried out today, but it was unclear when the arrests were made.

The network showed an apartment, with bags and personal belongings piled on the floor, that it said had been suddenly deserted by suspected computer spies.

The group of hackers met in Hanover in 1985, ARD said. Later they began cooperating with two KGB agents, at first freely and later under pressure and threats from the Soviets, it said. One of the hackers used drugs, and the Soviets exploited his dependency, ARD said.

*Washington Post staff writer Evelyn Richards added in Washington:*

The ARD affiliate's investigation began in April 1988. That is the same month that U.S. computer security authorities revealed that West German hackers seeking information on spy satellites and nuclear weapons had penetrated more than 30 computers at U.S. universities, military installations and laboratories.

No one was prosecuted, but the primary intruder has been identified as a Hanover computer programmer, according to Clifford Stoll, the U.S. scientist who watched electronically for more than a year as the hacker tried to gain access to some 450 computers. Among the computers penetrated was OPTIMIS.

The intrusions, which were into unclassified computer systems, were made only after the hackers were connected, via a telephone call inside West Germany, to various data networks that eventually tied them into Milnet, an unclassified network used by the Pentagon. From Milnet, the hackers attacked hundreds of military and commercial networks, attempting to discover, by trial and error, passwords and programming flaws that would grant them access.

Stoll said Thursday that he had electronically observed the 1988 hacker peruse information about biological warfare plans, space shuttle missions and Navy missiles. FBI and West German authorities aided in tracking the suspects.

The primary intruder used the pseudonym Speer, whom a West German magazine identified last spring as programmer Marcus Hess of Hanover. It was not immediately known if Hess was one of those arrested in West Germany Thursday.

During his investigations in 1988, Stoll planted bogus information about the Star Wars space defense system in the computers and gave an address to write for further information. A request for the information came from Pittsburgh, Pa.

The potential for electronic espionage to be conducted through U.S. computer networks has long been a concern among Pentagon officials. A government computer security expert said Thursday that if the links to the KGB are substantiated, it would be the "first time [authorities] have traced [computer break-ins] back to a foreign intelligence service."

# Computer Detective Followed Trail to Hacker Spy Suspect

*Work Called Key to West German's Arrest*

By Evelyn Richards  
and R. Jeffrey Smith  
Washington Post Staff Writers

The long, twisting path that led this week to the arrest of West German computer programmer Marcus Hess on suspicion of electronic espionage apparently began with a 75-cent accounting discrepancy.

It was that small-change imbalance in the August 1986 billing records that grated on astronomer Clifford Stoll, then working with a computer system at Lawrence Berkeley Laboratory, a government-funded energy research facility in California. Stoll was trying to balance the books—to charge computer users for the time they spent on the system—but he kept coming up

with 75 cents worth of time no one claimed.

Stoll, 38, didn't suspect that his detective work would last 18 months and lead West German investigators to Hess, a programmer from Hanover who is one of several people now under investigation for allegedly providing Soviet agents with sensitive data gleaned from U.S. computer systems.

West German authorities yesterday formally accused an unidentified computer hacker of spying and said that a total of eight young men from a Hanover-based operation were suspected of selling data to the Soviets from 1986 to 1988. [Details on Page A16.] Hess was released yesterday after authorities decided they

See HACKER, A16, Col. 1

# 75-Cent Discrepancy Led to Spy Suspect

HACKER, From A1

did not have enough evidence to continue holding him, but he remains under "serious suspicion" of espionage, a spokesman said.

A U.S. government official said Stoll's "work and his vigilance was key" to the West German investigation and subsequent arrests.

Incriminating information collected by Stoll was passed to an investigative team at the Defense Department and then to the authorities in West Germany, the official said. The Federal Bureau of Investigation provided technical assistance in the case.

"The tough problems are the little tiny ones," said Stoll, now on leave at Harvard University. "I recognize that the big things like \$1 million are going to be the easy ones to solve. It's the little problems that you do research on."

For months, Stoll turned computer detective. He was determined to find out who had opened an account on his computer system and used the 75 cents worth of time. Because the hacker had gained access to the Lawrence Berkeley computer system, Stoll could watch the mystery visitor's moves. Acting like a burglar going door to door, the hacker methodically attempted to break into computer systems at military and research installations.

Starting with a local telephone call in Hanover, the hacker was able to forge electronic links for months through European telephone lines, across the Atlantic and into U.S. networks without betraying his identity, Stoll later learned. Indeed, because of a flaw in Lawrence Berkeley's computer system, the hacker was able to masquerade as a legitimate user there and thus gain a pathway to more sensitive computers.

In spring 1988 that hacker was named in the West German magazine *Quick* as Mathias Speer. According to Stoll, the hacker was Marcus Hess.

[West German authorities said in Bonn yesterday that Speer and Hess were the same individual, Washington Post correspondent Robert McCartney reported. Alexander Prechtel, a spokesman for West German prosecutors, said, "We know about the 1988 story. We don't have evidence linking that (*Quick*) story to this case, although the same person is involved in both."]

The dates provided by officials describing the espionage activities—fall 1986 to spring 1988—match the period during which Stoll monitored the mysterious hacker. West German authorities listed a number of computer installations cracked by the hacker or hackers—most of them in Europe—while Stoll observed the hacker trying to break into systems in the United States and Asia.

Soon after Stoll encountered the accounting error, another incident piqued his interest: The National Computer Security Center, a unit of the highly secret National Security Agency, reported that someone from Lawrence Berkeley Laboratory had tried to break into an NSA computer. Stoll and his colleagues at first suspected a student prankster at the nearby University of California, but events over the coming months would cause them to realize the intruder was no amateur.

Equipping himself with a pocket pager that would alert him when the unauthorized user entered the Berkeley computer, Stoll was able to watch, keystroke by keystroke, as the anonymous user probed computer systems linked to Milnet, a nationwide computer network linking military installations and defense contractors and administered by the Pentagon. "I watched every damned thing he typed," Stoll said. "I was watching over his shoulder."

The hacker was persistent, according to Stoll, trying



Clifford Stoll helped to lay a trap for computer hackers.

to crack computers at U.S. Army bases in Alabama and Georgia; Navy facilities in Norfolk and Panama City, Fla.; an Air Force space division unit in El Segundo, Calif.; defense contractors Mitre Corp. and Unisys; and the Jet Propulsion Lab in Pasadena, Calif., to name just a few. He tried 450 computers and successfully entered about 30. It was unclear yesterday whether these incidents figured in the West German charges.

Once inside the systems, the hacker seemed to know exactly what he wanted; he would search for keywords like "KH-11," "NORAD," "nuclear" and "SDI." Stoll said he watched the intruder read sensitive information about chemical warfare plans in Europe, naval missiles and space shuttle missions. Floor plans for some military installations also were there for the taking.

But Stoll's Lawrence Berkeley colleague, physics professor Leroy Kerth, said yesterday that the trespasser retrieved only mundane material available from other public sources.

"I can remember him reading electronic mail between people discussing travel plans or contract negotiations, none of which had anything to do with anything classified," Kerth said. "Certainly nothing I saw go by was anything that you could get another way with a lot less effort. It wasn't anything that could give anybody any advantage."

The intruder's identity remained a mystery until Stoll and his colleagues laid a trap. They inserted a bogus document purporting to be about the Strategic Defense Initiative into the Lawrence Berkeley computer. The hacker couldn't resist the bait and, because he stayed on the line so long to read and copy it, authorities were able to trace the call to a Hanover address.

With the origin of the calls known, Stoll was able to piece together how the hacker entered U.S. computer systems. By making a local call in Hanover, the hacker reached a European data network known as Datex.

From Datex, he tapped into a library computer in West Germany's University of Bremen, and by manipulating software in that system was able to appear as if he were an authorized user with special privileges.

He then ordered the Bremen computer to telephone a U.S. computer network called Tymnet, which in turn connected the hacker to the Lawrence Berkeley computer. The hacker, exploiting a hole in the software, was able to make himself appear as a legitimate Lawrence Berkeley user, and with that identity had access to Milnet.

*Washington Post* correspondent Robert J. McCartney in Bonn contributed to this report.



# West German Charged With Espionage in

## Computer Intrusion Investigation

By Robert J. McCartney  
Washington Post Foreign Service

BONN, March 3—West German authorities today formally charged a 34-year-old computer hacker with espionage and said that a total of eight young men from a computer infiltration group were suspected of selling sensitive computer data to the Soviets from 1986 to 1988.

Judicial investigators said there was not enough evidence at present to support spying charges against two other West Germans arrested yesterday in the case, in which hackers allegedly penetrated U.S. and other western computer systems containing sensitive military, nuclear and space research information.

Prosecutors refused to name the suspect charged in the case but identified one of the other two as Marcus

Hess, about 25, who is believed to have attempted to gain access to a number of official U.S. computer systems from 1986 to 1988. These included at least three reportedly penetrated by the group, which prosecutors said was based in the northern city of Hanover.

Though not formally charged with spying in the case, the third man, who also was not identified, was retained in custody on an earlier charge of desertion from the West German Army, investigators said. Prosecutors said both he and Hess remained under "serious suspicion" of espionage in the case.

Authorities and computer experts in Bonn and Washington, meanwhile, expressed cautious and somewhat contradictory views of the seriousness of the computer intrusions.

West German Interior Minister Friedrich Zimmermann said the arrests were "a severe blow" to the KGB

and that the case revealed a "new dimension" in Eastern Bloc intelligence gathering. The Federal Prosecutor's Office said it was possible that the KGB had used the computer passwords, access codes and programs allegedly supplied by the hackers for further penetration of western data banks beyond that accomplished by the hackers.

Both the Interior Ministry and the prosecutor's office said, however, that the hackers were believed to have gained access only to the periphery of some of the computer systems. "As far as we can say today, it's not very serious," prosecutor's office spokesman Alexander Prechtel said in a telephone interview. "As far as we know, they were not able to penetrate up to the core of these computer systems." There also was no evidence that the Soviets used any data received from the hackers to obtain additional information from sensitive U.S., West European and Japanese computer systems, Prechtel said. Nevertheless, this remained a "a theoretical possibility," he said.

[In Washington, staff writer R. Jeffrey Smith reported that according to a knowledgeable government official, "there is a lot of basis to explore" possible ties between the West German hackers and Soviet intelligence operatives, but that "we do not know . . . absolutely" that the Soviets were involved.

[Still, the official said, "sensitive but unclassified" information may have been compromised "right up to the threshold of some important classified data banks." He said the government had made only a "preliminary" judgment that no classified data was leaked.

[A U.S. defense official said the Pentagon had just begun to evaluate "partial" information it has received about the case and could not yet say the "degree to which systems may have been compromised."]

Two of the eight hackers have told investigators that members of the group passed data to Soviet commercial representatives based in East Berlin who were believed to be KGB intelligence agents, Prechtel said.

Several West German-based computer security experts said information released about the case so far

suggests that authorities were very slow in responding to reports since late 1987 that sensitive western computer banks are susceptible to penetration.

If a detailed report about the case aired on West German television is true, said Hamburg University computer expert Klaus Brunnstein, then the Hanover hackers "have been in sensitive data banks."

"They have been at least very near to developments in U.S. space-war technology. They have been at least very near to computer-chip designs," Brunnstein said in a telephone interview. Official West German spokesmen have not denied many details of the extensive report telecast by ARD, one of West Germany's two public broadcast networks.

The Hamburg Chaos Computer Club, a group of hackers who have warned West German intelligence officials in the past about the potential for hostile penetration of important western computers, issued a statement today saying the Hanover case suggests that authorities did not take the danger seriously.

The Chaos club informed federal counterintelligence authorities in August 1987 that unidentified hackers had entered several sensitive U.S. and West European data banks, a club spokesman said.

Two of the banks entered then—those of the U.S. National Aeronautics and Space Administration and West Germany's air and space research agency—also reportedly were penetrated by the Hanover hackers. In addition, three other computer systems reportedly targeted by the Hanover intruders were identified as having been targets of the suspect, Hess. The three were the U.S. Defense Department's OPTIMIS personnel data bank, and systems of the Jet Propulsion Laboratory at Pasadena, Calif. and the national Lawrence Livermore laboratory in Livermore, Calif. Hess is suspected to have attempted to enter 450 U.S. and other data banks from 1986 to 1988 and to have succeeded in getting into more than 30, according to information made public in April 1988 by U.S. computer expert Clifford Stoll. Spokesman Prechtel said there was no evidence linking Stoll's revelations last year to the Hanover intruders' activities.

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TO: DIRECTOR, FBI  
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FBW  
OO: WMFO

This entire communication is classified "Secret"

Attached is a copy of an article captioned, "Stalking the Wily Hacker" in the May 1988 issue of "Communications of the ACM," which was furnished to Legat by [redacted] by the Assistant Director in Charge.

[redacted] has no interest other than being prepared for similar problems [redacted] FBIHQ and/or WMFO is requested to furnish us any information which we can disseminate to [redacted]

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Legat was personally contacted by the #2 individual in [redacted] to discuss this article, and they would appreciate any information, guidance we can furnish.

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