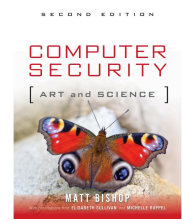
User Security

Chapter 30

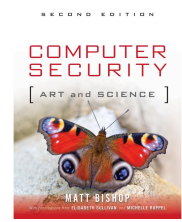


Outline

- Policy
- Access
- Files, devices
- Processes
- Electronic communications

Policy

- Assume user is on Drib development network
  - Policy usually highly informal and in the mind of the user
- Our users' policy:
  - U1 Only users have access to their accounts
  - U2 No other user can read, change file without owner's permission
  - U3 Users shall protect integrity, confidentiality, availability of their files
  - U4 Users shall be aware of all commands that they enter or that are entered on their behalf



Access

- U1: users must protect access to their accounts
  - Consider points of entry to accounts
- Passwords
- Login procedure
- Leaving system

Passwords

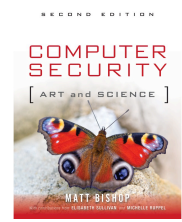
- Theory: writing down passwords is ***BAD***!
- Reality: choosing passwords randomly makes them hard to remember
  - If you need passwords for many systems, assigning random passwords and *not* writing something down won't work
- Problem: Someone can read the written password
- Reality: degree of danger depends on environment, how you record password

Isolated System

- System used to create boot DVD
  - In locked room; system can *only* be accessed from within that room
    - No networks, modems, etc.
  - Only authorized users have keys
- Write password on whiteboard in room
  - Only people who will see it are authorized to see it

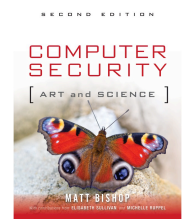
Multiple Systems

- Non-infrastructure systems: have users use same password
  - Done via centralized user database shared by all non-infrastructure systems
- Infrastructure systems: users may have multiple accounts on single system, or may not use centralized database
  - Write down transformations of passwords



Infrastructure Passwords

- Drib devnet has 10 infrastructure systems, 2 lead admins (Anne, Paul)
  - Both require privileged access to all systems
  - root, Administrator passwords chosen randomly
- How to remember? Memorize an algorithm!
  - Anne: “change case of 3rd letter, delete last char”
  - Paul: “add 2 mod 10 to first digit, delete first letter”
- Each gets printout of transformed password



Papers for Anne and Paul

Actual password	Anne's version capitalize 2nd letter, delete last letter	Paul's version delete first letter, add 2 mod 10 to first digit
IbhEpZqYre<7RCPI	IbHEpZqYre<7RCPI$	QIbhEpZqYre<5RCPI
t/?rctp*e(V(R9v-	t/?rCtp*e(V(R9v-p	Rt/?rctp*e(V(R7v-
(tY8t#'M!8J,8?gc	(tY8T#'M!8J,8?gc%	(mtY8t#'M!6J,8?gc
Ym=.P.sIwW*u2F!j	Ym=.p.sIwW*u2F!j(	sYm=.P.sIwW*u0F!j
P8%KJ'TiGx@9P+j.	P8%Kj'TiGx@9P+j.r	aP6%KJ'TiGx@9P+j.
IOKFsnNS=m:1Xuqe	IOkFsnNS=m:1Xuqe,	TIOKFsnNS=m:9Xuqe
kaE6el#:?[ODeSDJ	kae6el#:?[ODeSDJ;	nkaE4el#:?[ODeSDJ
I.Jc&G/+zXXd4(Au	I.JC&G/+zXXd4(Au*	fI.Jc&G/+zXXd2(Au
@pa/63yb*:vaR2UD	@pa/63Yb*:vaR2UD=	@Vpa/43yb*:vaR2UD
8dpq:L9;'5wW<RY7	8dpQ:L9;'5wW<RY7+	g6dpq:L9;'5wW<RY7

Non-Infrastructure Passwords

- Users can pick
  - Proactive password checker vets proposed password
- Recommended method: passwords based on obscure poems or sayings
  - Example: “ttrsvmbi&see+deet22” from first letter of second, fourth words of each line, then last letter of third, fifth word of each line, various non-alphanumerics in there, and age (22) at the end:

    He took his vorpal sword in hand:

    Long time the manxome foe he sought—

    So rested he by the Tumtum tree,

    And stood awhile in thought.

    Third verse of *Jabberwocky*, from *Alice in Wonderland*

Two-Factor Authentication

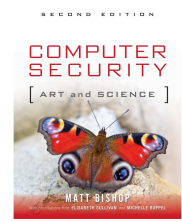
- Every system has a fingerprint scanner
- To log in, user supplies a password and a scan of their fingerprint
  - Both always required before any indication of success or failure

Login Procedure

- User obtains a prompt at which to enter name
- Then comes password prompt
- Attacks:
  - Lack of mutual authentication
  - Reading password as it is entered
  - Untrustworthy trusted hosts

Lack of Mutual Authentication

- How does user know she is interacting with legitimate login procedure?
  - Attacker can have Trojan horse emulate login procedure and record name, password, then print error message and spawn real login
- Simple approach: if name, password entered incorrectly, prompt for retry differed
  - In UNIX V6, it said “Name” rather than “login”

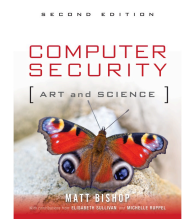


More Complicated

- Attack program feeds name, password to legitimate login program on behalf of user, so user logged in without realizing attack program is an intermediary
- Approach: trusted path
  - Example: to log in, user hits specified sequence of keys; this traps to kernel, which then performs login procedure; key is that no application program can disable this feature, or intercept or modify data sent along this path

Reading Password As Entered

- Attacker remembers it, uses it later
  - Sometimes called “shoulder surfing”
  - Can also read chars from kernel tables, passive wiretapping, etc.
- Approach: encipher all network traffic to defeat passive wiretapping
  - Drib: firewalls block traffic to and from Internet, internal hosts trusted not to capture network traffic
  - Elsewhere: use SSH, SSL, TLS to provide encrypted tunnels for other protocols or to provide encrypted login facilities



Noticing Previous Logins

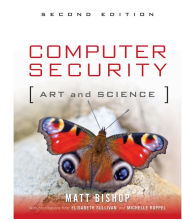
- Many systems print time, location (terminal) of last login
  - If either is wrong, probably someone has unauthorized access to account; needs to be investigated
- Requires user to be somewhat alert during login

Untrustworthy Trusted Hosts

- Idea: if two hosts under same administrative control, each can rely on authentication from other
- Drib does this for backups
  - Backup system logs into workstation as user “backup”
    - If password required, administrator password needs to be on backup system; considered unacceptable risk
    - Solution: all systems trust backup server
- Requires accurate identification of remote host
  - Usually IP address
  - Drib uses challenge-response based on cryptography

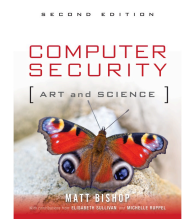
Analysis

- Isolated system meets U1
  - Only authorized users can enter room, read password, access system
- Infrastructure systems meet U1
  - Actual passwords not written down
  - Anne, Paul don't write down algorithms
  - Stealing papers does not reveal passwords
  - Second factor (fingerprint) adds assurance
- Non-infrastructure systems meet U1
  - Proactive password checker rejects easy to guess passwords
  - Even if password is compromised, biometric (fingerprint) prevents authentication



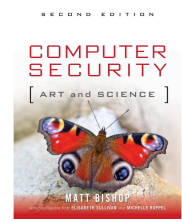
Analysis

- Mutual authentication meets U1
  - Trusted path used when available; other times, system prints time, place of last login
- Protecting passwords meets U1
  - Unencrypted passwords only placed on trusted network; also, system prints time, place of last login
- Trusted hosts meets U1
  - Based on cryptography, not IP addresses; number of trusted systems minimal (backup system only)



Leaving the System

- People not authorized to use systems have access to rooms where systems are
  - Custodians, maintenance workers, etc.
- Once authenticated, users must control access to their session until it ends
  - What to do when one goes to bathroom?
- Procedures used here

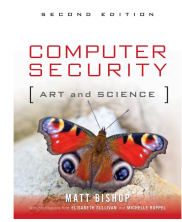


Walking Away

- Procedures require user to lock monitor
  - Example: X window system: *xlock*
    - Only user, system administrator can unlock monitor
  - Note: be sure locking program does not have master override
    - Example: one version of lock program allowed anyone to enter “Hasta la vista!” to unlock monitor

Modems

- Terminates sessions when remote user hangs up
  - Problem: this is configurable; may have to set physical switch
    - If not done, next to call in connects to previous user's session
  - Problem: older telephone systems may mishandle propagation of call termination
    - New connection arrives at telco switch and is forwarded before termination signal arrives at modem
    - Same effect as above
- Drib: no modems connected to development systems



Analysis

- Procedures about walking away meet U1
  - Screen locking programs required, as is locking doors when leaving office; failure to do so involves disciplinary action
  - If screen locking password forgotten, system administrators can remotely access system and terminate program
- Procedures about modems meet U1
  - No modems allowed; hooking one up means getting fired (or similar nasty action)

Files and Devices

- File protection allows users to refine protection afforded their data
  - Policy component U2 requires this
- Users manipulate system through devices, so their protection affects user protection as well
  - Policy components U1, U4 require this

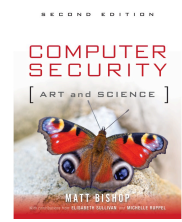
Files

- Often different ways to do one thing
  - UNIX systems: Pete wants to allow Deb to read file *design*, but no-one else to do so
    - If Pete, Deb have their own group, make file owned by that group and group readable but not readable by others
    - If Deb only member of a group, Pete can give group ownership of file to Deb and set permissions appropriately
    - Pete can set permissions of containing directory to allow himself, Deb's group search permission
  - Windows 10: same problem
    - Use ACL with entries for Pete, Deb only:

      { (Pete, full control), (Deb, read) }

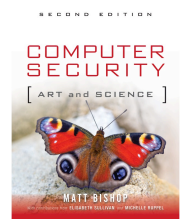
File Permission on Creation

- Use template to set or modify permissions when file created
  - Windows 10: new directory inherits parent's ACL
  - UNIX systems: identify permissions to be denied
    - *umask* contains permissions to be disabled, so can say "always turn off write permission for everyone but owner when file created"



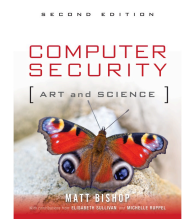
Group Access

- Provides set of users with same rights
- Advantage: use group as role
  - All folks working on Widget-NG product in group *widgetng*
  - All files for that product group readable, writable by *widgetng*
  - Membership changes require adding users to, dropping users from group
    - No changes to file permissions required



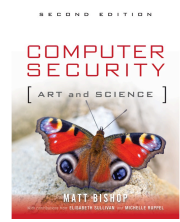
Group Access

- Disadvantage: use group as abbreviation for set of users; changes to group may allow unauthorized access or deny authorized access
  - Maria wants Anne, Joan to be able to read *movie*
  - System administrator puts all in group *maj*
  - Later: sysadmin needs to create group with Maria, Anne, Joan, and Lorraine
    - Adds Lorraine to group *maj*
    - Now Lorraine can read *movie* even though Maria didn't want her to be able to do so



File Deletion

- Is the *name* or the *object* deleted?
- Terms
  - File attribute table: contains information about file
  - File mapping table: contains information allowing OS to access disk blocks belonging to file
  - Direct alias: directory entry naming file
  - Indirect alias: directory entry naming special file containing name of target file
- Each direct alias is alternative name for same file

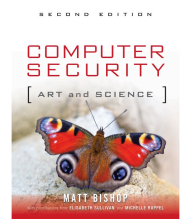


Rights and Aliases

- Each direct alias can have different permissions
  - Owner must change access modes of each alias in order to control access
- Generally false
  - File attribute table contains access permissions for each file
    - So users can use any alias; rights the same

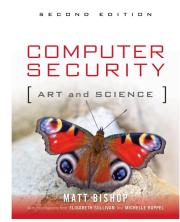
Deletion

- Removes directory entry of file
  - If no more directory entries, data blocks and table entries released too
  - Note: deleting directory entry does *not* mean file is deleted!



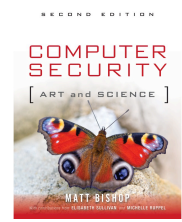
Example

- Anna on UNIX wants to delete file *x*, setuid to herself
  - `rm x` works if no-one else has a direct alias to it
  - Sandra has one, so file not deleted (but Anna's directory entry is deleted)
    - File still is setuid to Anna
- How to do this right:
  - Turn off all permissions on file
  - *Then* delete it
    - Even if others have direct links, they are not the owners and so can't change permissions or access file



Persistence

- Disk blocks of deleted file returned to pool of unused disk blocks
- When reassigned, new process may be able to read previous contents of disk blocks
  - Most systems offer a “wipe” or “cleaning” procedure that overwrites disk blocks with zeros or random bit patterns as part of file deletion
  - Useful when files being deleted contain sensitive data



Direct, Indirect Aliases

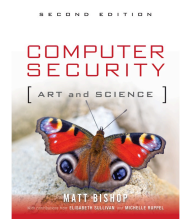
- Some commands act differently on these
  - Angie executes command to add permission to file to let Lucy read it
  - If file name direct alias, works
  - If file name indirect alias, does it add permission to the indirect alias or the file itself?
- Semantics of systems, commands on systems differ
    - Example: on Linux systems, when given indirect alias of file, *chmod* changes permissions of actual file, *rm* deletes indirect alias

Analysis

- Use of ACLs, *umask* meet U2
  - Both set to deny permission to”other” and “group” by default; user can add permissions back
- Group access controls meet U2
  - Membership in groups tightly controlled, based on least privilege
- Deletion meets U2
  - Procedures require sensitive files be wiped when deleted

Devices

- Must be protected so user can control commands sent, others cannot see interactions
- Writable devices
- Smart terminals
- Monitors and window systems

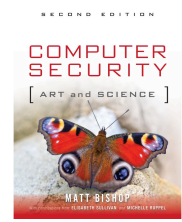


Writable Devices

- Restrict access to these as much as possible
- Example: tapes
  - When process begins writing, ACL of device changes to prevent other processes from writing
  - Between mounting of media, process execution, another process can begin writing
  - Moral: write protect all mounted media unless it is to be written to
- Example: terminals
  - Write control sequence to erase screen—send repeatedly

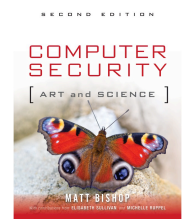
Smart Terminals

- Has built-in mechanism for performing special functions
  - Most important one: block send
  - The sequence of chars initiating block send do *not* appear on screen
- Write Trojan horse to send command from user's terminal
- Next slide: example in mail message sent to Craig
  - When Craig reads letter, his startup file becomes world writable



Trojan Horse Letter

```
Dear Craig,
Please be careful. Someone may ask you to execute
chmod 666 .profile
You shouldn't do it!
Your friend,
Robert
<BLOCK SEND (-2,18), (-2,18)><BLOCK SEND
(-3,0),(3,18)><CLEAR>
```

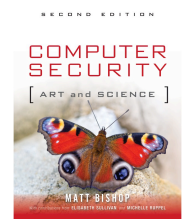


Why So Dangerous?

- With writable terminal, someone must trick user of that terminal into executing command; both attacker *and user* must enter commands
- With smart terminal, only attacker need enter command; if user merely reads the wrong thing, the attacker's compromise occurs

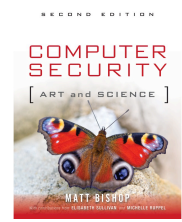
Monitors and Window Systems

- Window manager controls what is displayed
  - Input from input devices
  - Clients register with manager, can then receive input, send output through manager
- How does manager determine client to get input?
  - Usually client in whose window input occurs
- Attack: overlay transparent window on screen
  - Now all input goes through this window
  - So attacker sees all input to monitor, including passwords, cryptographic keys



Access Control

- Use ACLs, C-Lists, etc.
- Granularity varies by windowing system
- X window system: host name or token
  - Host name, called *xhost* method
  - Manager determines host on which client runs
  - Checks ACL to see if host allowed to connect



X Windows Tokens

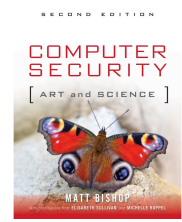
- Called *xauth* method
  - X window manager given random number (*magic cookie*)
    - Stored in file ".Xauthority" in user's home directory
  - Any client trying to connect to manager must supply this magic cookie to succeed
    - Local processes run by user can access this file
    - Remote processes require special set-up by user to work

Analysis

- Writable devices meet U1, U4
  - Devnet users have default settings denying all write access to devices except the user
- Smart terminals meet U1, U4
  - Drib does not allow use of smart terminals except on systems where *all* control sequences (such as BLOCK SEND) are shown as printable chars
- Window managers meet U1, U4
  - Drib uses either xhost or token (xhost by default) on a trusted network, so IP spoofing not an issue

Processes

- Manipulate objects, including files
  - Policy component U3 requires users to be aware of how
- Copying, moving files
- Accidentally overwriting or erasing files
- Encryption, keys, passwords
- Start-up settings
- Limiting privileges
- Malicious logic

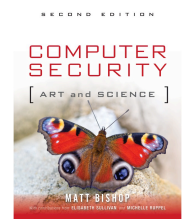


Copying Files

- Duplicates contents
- Semantics determines whether attributes duplicated
  - If not, may need to set them to prevent compromise
- Example: Mona Anne copies *xyzzy* on UNIX system to *plugh:*

```
cp xyzzy plugh
```

  - If *plugh* doesn't exist, created with attributes of *xyzzy* except any setuid, setgid discarded; contents copied
  - If *plugh* exists, attributes not altered; contents copied



Moving Files

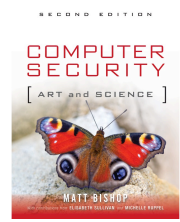
- Semantics determines attributes
- Example: Mona Anne moves *xyzzy* to */tmp/plugh*
  - If both on same file system, attributes unchanged
  - If on different file systems, semantically equivalent to:

```
cp xyzzy /tmp/plugh
rm xyzzy
```

  Permissions may change …

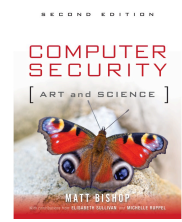
Accidentally Overwriting Files

- Protect users from themselves
- Example: deleting by accident
  - Intends to delete all files ending in ".o"; pattern is "*.o", "*" matching any string
  - Should type `rm *.o`
  - Instead types `rm * .o`
  - All files in directory disappear!
- Use modes to protect yourself
  - Give –i option to rm to prevent this



Encryption

- Must trust system
  - Cryptographic keys visible in kernel buffers, swap space, and/or memory
  - Anyone who can alter programs used to encrypt, decrypt can acquire keys and/or contents of encrypted files
- Example: PGP, a public key encryption program
  - Protects private key with an enciphering key (“pass-phrase”), which user supplies to authenticate file
  - If keystroke monitor installed on system, attacker gets pass-phrase, then private key, then message

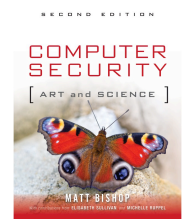


Saving Passwords

- Some systems allow users to put passwords for programs in files
  - May require file be read-protected but *not* use encryption
- Example: UNIX *ftp* clients
  - Users can store account names, host names, passwords in *.netrc*
  - Kathy did so but *ftp* ignored it
  - She found file was readable by anyone, meaning her passwords stored in it were now compromised

Start-Up Settings

- When programs start, often take state info, commands from environment or start-up files
  - Order of access affects execution
- Example: UNIX command interpreter *sh*
  - When it starts, it does the following:
    - Read start-up file */etc/profile*
    - Read start-up file *.profile* in user's home directory
    - Read start-up file named in environment variable **ENV**
  - Problem: if any of these files can be altered by untrusted user, *sh* may execute undesirable commands or enter undesirable state on start

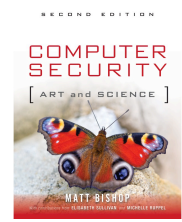


Limiting Privileges

- Users should know which of their programs grant privileges to others
  - Also the implications of granting these
- Example: Toni reads email for her boss, Fran
  - Fran knew not to share passwords, so she made a setuid-to-Fran shell that Toni could use
    - Bad idea; gave Toni too much power
  - On Toni's suggestion, Fran began to forward to Toni a copy of every letter
    - Toni no longer needed access to Fran's account

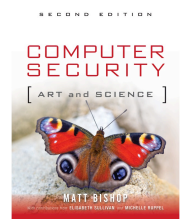
Malicious Logic

- Watch out for search paths
- Example: Paula wants to see John's confidential designs
  - Paula creates a Trojan horse that copies design files to /tmp; calls it *ls*
  - Paula places copies of this in all directories she can write to
  - John changes to one of these directories, executes *ls*
    - John's search path begins with current working directory
  - Paula gets her information



Search Paths

- Search path to locate program to execute
- Search path to locate libraries to be dynamically loaded when program executes
- Search path for configuration files
- …



Analysis

- Copying, moving files meets U3
  - Procedures are to warn users about potential problems
- Protections against accidental overwriting and erasing meet U3
  - Users' startup files set protective modes on login
- Passwords not being stored unencrypted meets U3
  - In addition to policy, Drib modified programs that accept passwords from disk files to ignore those files

Analysis (*con't*)

- Publicizing start up procedures of programs meets U3
  - Startup files created when account created have restrictive permissions
- Publicizing dangers of setuid, giving extra privileges meets U3
  - When account created, no setuid/setgid programs
- Default search paths meet U4
  - None include world writable directories; this includes symbol for current working directory

Electronic Communications

- Checking for malicious content at firewall can make mistakes
  - Perfect detectors require solving undecidable problem
  - Users may unintentionally send out material they should not
- Automated e-mail processing
- Failing to check certificates
- Sending unexpected content

Automated E-mail Processing

- Be careful it does not automatically execute commands or programs on behalf of other users
- Example: WannaCry ransomware, embedded in email attachment
  - When user opens attachment, WannaCry executed, and it begins to encrypt files

Failure to Check Certificates

- If certificate invalid or expired, email signed by that certificate may be untrustworthy
  - Mail readers must check that certificates are valid, or enable user to determine whether to trust certificate of questionable validity
- Example: Someone obtained certificates under the name of Microsoft
  - When discovered, issuer *immediately* revoked both
  - Had anyone obtained ActiveX applets signed by those certificates, would have been trusted

Sending Unexpected Content

- Arises when data sent in one format is viewed in another
- Example: sales director sent sales team chart showing effects of proposed reorganization
  - Spreadsheet also contained confidential information deleted from spreadsheet but still in the file
  - Employees used different system to read file, seeing the spreadsheet data—and also the “deleted” date
- Rapid saves often do not delete information, but rearrange pointers so information appears deleted

Analysis

- Automated e-mail processing meets U4
  - All programs configured not to execute attachments, contents of letters
- Certificate handling procedures meet U4
  - Drib enhanced all mail reading programs to validate certificates as far as possible, and display certificates it could not validate so user can decide how to proceed
- Publicizing problems with risk of “deleted” data meets U4
  - Also, progams have “rapid saves” disabled by default

Key Points

- Users have policies, although usually informal ones
- Aspects of system use affect security even at the user level
  - System access issues
  - File and device issues
  - Process management issues
  - Electronic communications issues