Computer security

Knut Omang
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(includes content by: Vera Goebel, Matija Pužar, Željko Vrba and Andrew Tannenbaum)

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Today: Computer security

- Types of threats
- Prevention of unauthorized access
  - Standard OS measures
- Outside attack categories
- Dangers lurking on the inside
- OS strategies and defenses

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What is computer security?

Very broad term:

- File system security
- Network security
- Data integrity
- Data confidentiality
- Data loss
- Physical security
- Social engineering

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Threat model

- Understanding the threats:
  - What are we protecting?
  - From whom are we protecting it?
- ideally, the system should be *designed* for security!
- A chain is not stronger than it's weakest link
  - Where is additional resources best spent?
- The simplest is often the best

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Security goals and threats

Goal	Threat
Data confidentiality	Exposure of data
Data integrity	Tampering with data
System availability	Denial of service
Resource protection	Misuse of resources

Some resource types:
- Money
- Computer resources
- Network bandwidth
- Call charges
- Credentials/trust/identities
- …

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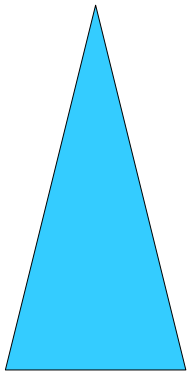
Types of threat

- Casual prying by non-technical users
- Script-kiddies
- Snooping by insiders
- Determined attempt to make money
- Commercial, military or government espionage



level of effort/cost needed to protect the system

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Trends…

- Better and easier to use encryption tools
- Increasingly complex systems
- Web applications
  - advanced content
  - mix of script/program - server side/client side
- More and more at stake (?)

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Preventing unauthorized access

- Contributes to all goals
  - but don't forget fire/earthquake or a malevolent user
- Initial system access: authentication
- Per user access: differentiation
  - Need-to-know..

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OS security models

- None (single-user OS, e.g. DOS)
- Classical UNIX: (owner,group,others) rights
  - each user is a member of at least one group
- VMS -> Windows NT
  - users and groups in a list – Access Control List (ACLs)
  - Domain users/groups

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Authentication

- Protecting access to the system
- Identifies user and his/her actions
- Something the user knows
  - username + password, pass-phrase
- Something the user has
  - physical object (magnetic card, smartcard)
- Something the user is
  - physical characteristics (biometrics)

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UNIX permissions

```
-rw-r--r--    1 zvrba    ifi-a00     96031 2005-06-12 21:20 workplan.pdf
drwx--x--x    2 zvrba    ifi-a00      1024 2005-11-05 16:34 www_docs/
-rw-------    1 zvrba    ifi-a00      2402 2005-10-12 08:05 xorg.conf
```

owner, group, others; **r**ead, **w**rite, e**x**ecute; sometimes surprising semantics (e.g. delete files you don't own)

SUID, SGID and sticky bits

Newer:

- ACLs on files (getfacl, setfacl commands)
- Permissions to expose socket (ex.Secure Linux)

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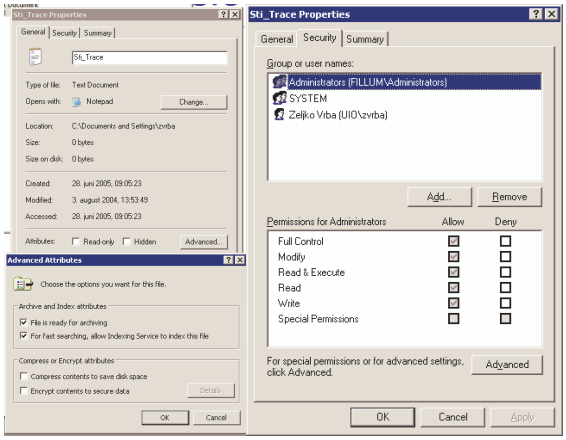
Windows permissions



both users and groups in the ACL!

security descriptors for each **object**

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Theory: Bell-LaPadula

- Solve the confinement problem (information leakage)
- each object has a classification (label)
- each subject has a clearance and a security level
- two fundamental axioms:
  - the simple security property
    - Level k can only read objs at levels <= k
  - the *-property
    - Level k can only write objs at levels >= k

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(Accidental) data loss

Common Causes

1. Acts of God: fires, floods, wars
2. Hardware or software errors: CPU malfunction, bad disk or memory, program bugs
3. Human errors: data entry, wrong tape mounted

Often cause more damage than intruders!
BACKUP! (data and location)

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File system encryption

- encryption: data forever lost if key (or passphrase) is lost; **backup!**
- individual file vs. partition encryption
- transparent vs. non-transparent (separate program)
- windows upgrades and reinstallations can destroy the original EFS key!

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System integrity

- Integrity of all system components (configuration files, binaries, etc.)
  - Trust that critical parts of system behaves as intended
- Discretionary access controls
  - Users can choose what to allow to who
- Mandatory access controls
  - the administrator can override and set policies for access

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Outside attacker categories

- Network service scans
  - Scan for vulnerable services
  - Attack vulnerability
- Network interception attacks
  - sniffing
  - man-in-the-middle
- Trojan horses/viruses
  - Email/web pages/CD-roms with embedded malware
  - Mobile code
- Theft/destruction..

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Network service scans+attacks

Look for known program versions with weaknesses, then exploit..

- Basic services:
  - Morris worm: finger daemon, buffer overflow
  - Code Red Worm: Buffer overflow + Microsoft IIS
  - Sendmail, Exchange, Bind, Apache
- Web applications
  - injection flaws
    - print ”select sensitive_data from account where user = ’$user’ ”
    - Steve Jobs & friends: sinus tone generator
  - cross site scripting:
    - Blog entries/im’s/comments that introduces new elements
  - Lots and lots more…
- Strikingly often instances of missing input validation!

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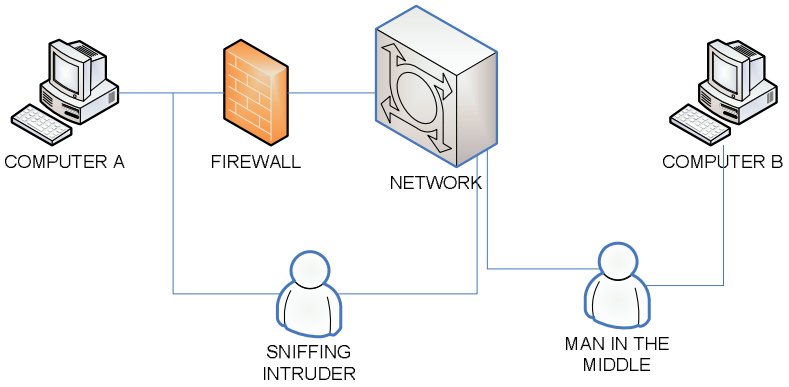
Network interception attacks



data sniffing and/or modification; replay and man-in-the-middle attacks

use ssh, gpg/pgp and https: provide both data integrity and confidentiality

a question of **trust!**

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Spoofing and phishing

- Spoofing: Masquerading as someone trusted
- Phishing: Using spoofing to trick user/program to give away sensitive information:
  - frequent PayPal spam
  - Fake login GUIs (or ATM frontends ...)
  - DNS spoofing/forging (+ bank application…)

Countermeasures:

- check Received:-mail headers and URLS
- never reveal sensitive data unless the query is expected (and even then be cautious!)
- Be critical to browser plugins and requests for more privileges..
- Run web browser with few privileges...

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Increasing use of mobile code

- Postscript
- Document macros/additions
- Applets
- Browser plugins..
- ...

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Denial-of-service attacks

- A service is overwhelmed with bogus traffic that effectively inhibits normal operation
- Stateful firewalls properly configured may help somewhat
  - But cannot always distinguish good from bad traffic (ex. http)
    - Example: Russia-Georgia war
- Distributed Denial-of-service and botnets
  - Hard to fully protect against
  - DDos + src address spoofing -> backscatter

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Insider attacks

- Password guessing
- Login spoofing
- Spyware
  - key logging, identity theft,…
- Opening up the system
  - Root kits
  - Trap doors
  - Logic bombs
- Providing confidential info to 3rd parties
  - Covert channels
    - Steganography: Images, empty disks with 'white noise'

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Password guessing

- Alphabet size
- Simple one-way encryption
  - /etc/passwd
- One-way encryption with n-bit random value
  - n-bit "salt" (Unix: n=12)
- Protected passwd + lookup delay
  - /etc/shadow

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What is the problem with this .profile?

....

PATH=.:$HOME/bin:/usr/bin:/bin:/usr/local/bin:/sbin:/usr/sbin
export PATH

....

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Reasonable defaults

Make it easy(iest) to be secure – examples:

- Mandatory access control policies
  - Not possible to disable password or use 3-letter dictionary word or first name
- Umask/default file protection
- Make use of mount options
  - /usr read-only
  - /var read-write, noexec, nodev
  - nosuid where applicable

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Mandatory access controls

- Linux
  - grsecurity (http://www.grsecurity.org)
  - SELinux (http://www.nsa.gov/selinux)
  - can cause compatibility problems with "badly behaved" software
- FreeBSD
  - MAC (http://www.freebsd.org/doc/en_US.ISO8859-1/books/handbook/mac.html)
  - BIBA and MLS policies
- Proactive: confine damage if break-in occurs

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Physical security

- Often neglected, but:
  - physical access is unrestricted access
  - do you trust your system administrator?
- Precautions:
  - data encryption (only cold storage safe!)
  - remove all recording devices
  - Faraday cage

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Defenses

- Firewalls
- Service logging/alerting
- Intrusion protection software
  - tripwire
  - antivirus software
- Write-only storage for integrity checks
- Multiple layers (like ancient cities with fortresses..)
- Code signing

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Firewall/NAT devices

- Software package on desktop
- Separate box
- Filtering traffic in both directions
- Typical home fw setup
  - network address translation (NAT)
  - everything above port 1024 is ok
  - traffic must be initiated from inside
  - well known insecure services blocked for outgoing as well

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Typical firewall functions

- Masquerade/NAT
  - Make all inside machines appear to come from same IP(s)
- Block services
  - Inside AND outside!
- Interaction with services
  - "Universal Plug and Play" - uPnP support
  - Other schemes for auto-modify..
- Different protocol levels
  - IP layer
  - Layer 4: TCP/UDP/IPsec
  - ALGs (ftp,SIP,IPsec/TCP,IPTV, ...)

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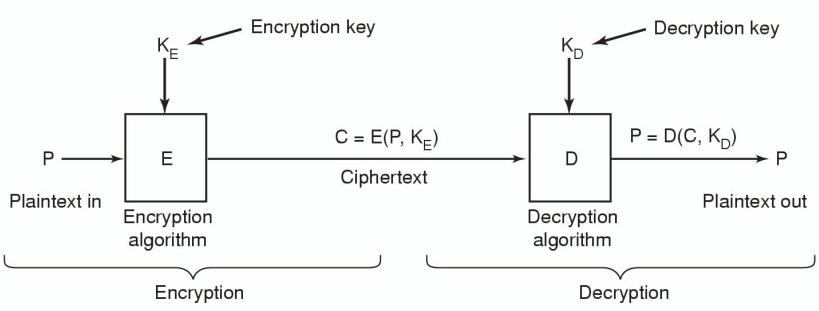
Cryptography



an important **foundation**, but far from enough; **secure protocols** are also needed. **NEVER design your own, use proven and tested solutions, e.g. OpenSSL (http://www.openssl.org)**

random numbers often forgotten, but crucial part of secure system (fatal Netscape flaw)

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Symmetric cryptography

- One key both for encryption and decryption
- Good algorithm is **publicly reviewed**
  - DES (being phased out, replaced by AES/Rijndael)
  - IDEA, Blowfish, Twofish, Serpent, etc.
- Problem: secure key exchange

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Asymmetric cryptography (1)

- All users pick (public, private) *key pair*
  - public key cryptography
- Digital signatures and encryption
  - public key: encryption/verification
  - private key: decryption/signing
- algorithms:
  - DSA, RSA (1024 bits min. secure today)
  - ECC has smaller key size

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Asymmetric cryptography (2)

- Slow; mixed scheme is used:
  - *random symmetric* key for bulk encryption
  - encrypted by public key of recipient
- Trust problems
  - Is the key owner really he who claims to be?
  - hierarchical: X509 certificate authorities (e.g. Verisign) and why should we trust them?
  - other: ssh (personal verification)
- Key distribution: public servers (e.g. LDAP) and how trustworthy they are?

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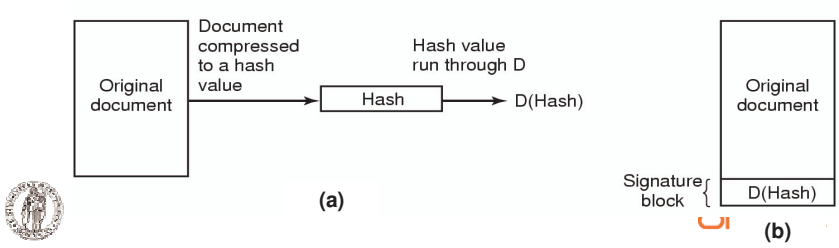
Digital signatures

- rely on one-way hash functions as cryptographic primitive
  - SHA-0, and MD5 (**both broken!**)
  - SHA-1 (considerabely weakened), SHA256, etc.
  - RIPEMD 160
- ensure **data integrity** and **authenticity**



Hardware support

- "Dongles"
- Trusted Platform Module (TPM)
- Macrovision, CD software copy protection, DVD, Blu-ray?

- Where is the control?
- 'Security' of vendors vs security for the sys.owner...
  - Security of continued operation...

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Threat model revisited

- Understanding the threats:
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- A chain is not stronger than it's weakest link
  - Where is additional resources best spent?
- The simplest is often the best
- Trade-offs...

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Security vs simple to use

- How many passwords can *you* remember?
- What will happen if network access is forbidden but needed to work efficiently?
  - hospitals/patient data
  - Laptops? Home networks?
- Windows: functionality vs. Security
  - What is the first settings people change after installing windows?
  - What privileges to grant the ordinary user..
  - Ever experienced a slow windows box due to virus protection software?
- What do you do if your favorite game does not work with the firewall?
  - Campus pathways…
  - Tanenbaum: "Features are the enemy of security"

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Secure system design

1. System design should be public
   - security by obscurity does not work
2. Reasonable defaults (no/minimum access)
3. Check for current authority, not only at the beginning
4. Give each process/subprocess least privilege possible
5. Protection mechanism should be
   - simple, uniform
   - well supported by system – security is not an add-on feature
6. Scheme should be psychologically acceptable

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