# Introduction

# CS642: Computer Security

Professor Ristenpart

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# Computer security:
# understanding and improving the behavior of computing technologies in the presence of adversaries

Target/victim computing systems

Attackers

Security engineers

Computer systems:

- Operating systems
- Networks / Internet
- Web (2.0)
- Software applications
- iPhones
- Embedded systems
- …

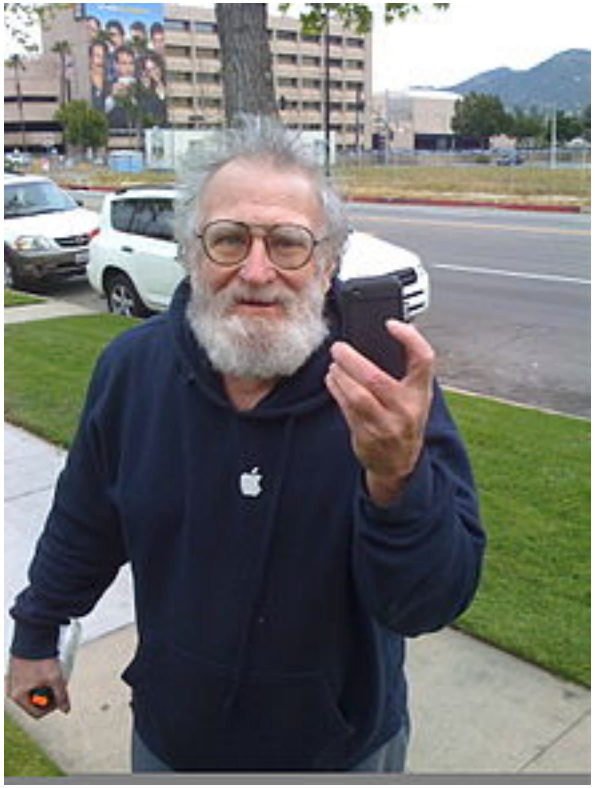
We will not even attempt to be exhaustive

# Security goals

- Confidentiality
  - data not leaked
  - encryption, access controls
- Integrity
  - data not modified
  - message integrity checks, access controls
- Authenticity
  - data comes from who we think it does
  - digital signatures, passwords
- Availability
  - services operating when needed
  - redundancy

Adversaries:

- “31337” script kiddies
- Criminals
- “hacktivists”
- Dissidents (if you are an oppressive regime)
- Nation states
- …



# John "Captain Crunch" Draper

Phreaking

**Targets:**
AT&T phone system

**Escapades:**
> 2600Hz Cap'n Crunch whistle
> Blue box
> Worked at Apple, taught Wozniak and Jobs

**Read more:**
http://en.wikipedia.org/wiki/John_Draper

Kevin “Condor” Mitnik

Free LA bus rides, breaking into corporate systems

**Made off with:**

> 1 year prison, 3 years supervision
> Consulting career
> Book deal

**Read more:**
http://en.wikipedia.org/wiki/Kevin_Mitnick

# Julian “Mendax” Assange

Hacker in early 90’s

**Targets:**

> Nortel
> USAF 7th Command
> Wikileaks

**Made off with:**

> Free stay at Ecuadorian embassy

**Read more:**

http://en.wikipedia.org/wiki/Julian_Paul_Assange

Albert “soupnazi” Gonzalez

Committed various electronic crimes
while also a FBI/USSS informant

**Targets:**
Heartland Payment Systems, TJX, others

**Made off with:**
> 130,000,000 credit card numbers
> $2mil in cash
> 15-20 years in jail

**Read more:**
http://en.wikipedia.org/wiki/Albert_Gonzalez

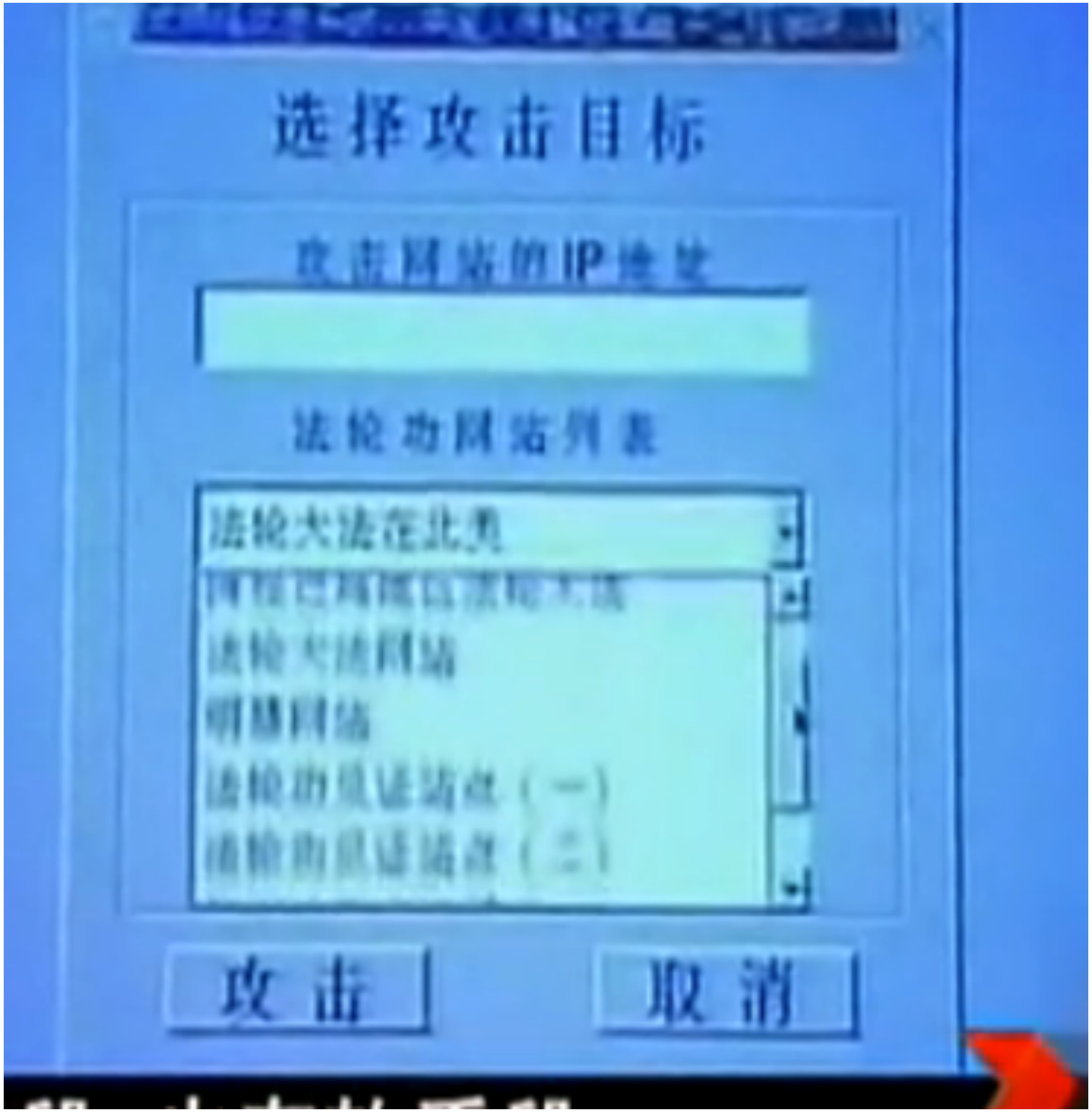
# Russian Business Network

St. Petersberg Internet hosting company involved in numerous criminal activities

Started as legitimate ISP (2006)
Hosts malware, spammers, phishing sites
Alleged operator of Storm botnet
Accused of involvement in DoS on Estonia

**Makes off with:**
> Supposedly ~$150mil per year

**Read more:**
http://en.wikipedia.org/wiki/Russian_Business_Network



选择攻击目标

攻击网站的IP地址

法轮功网站列表

法轮大法在北美

网络世界推崇法轮大法

法轮大法网站

明慧网站

法轮功见证站点（一）

法轮功见证站点（二）

# People’s Liberation Army and/or Chinese government

Widely accused of participating in attacks against Falung Gong websites, US companies

Google said China originated attacks in Operation Aurora

Great Firewall of China

**Makes off with:**
> Allegedly, lots of intellectual property
> Strict control over Internet usage

**Read more:**
http://en.wikipedia.org/wiki/Operation_Aurora
http://en.wikipedia.org/wiki/Internet_censorship_in_the_People's_Republic_of_China

# Olympic Games

# US (and Israeli) governments

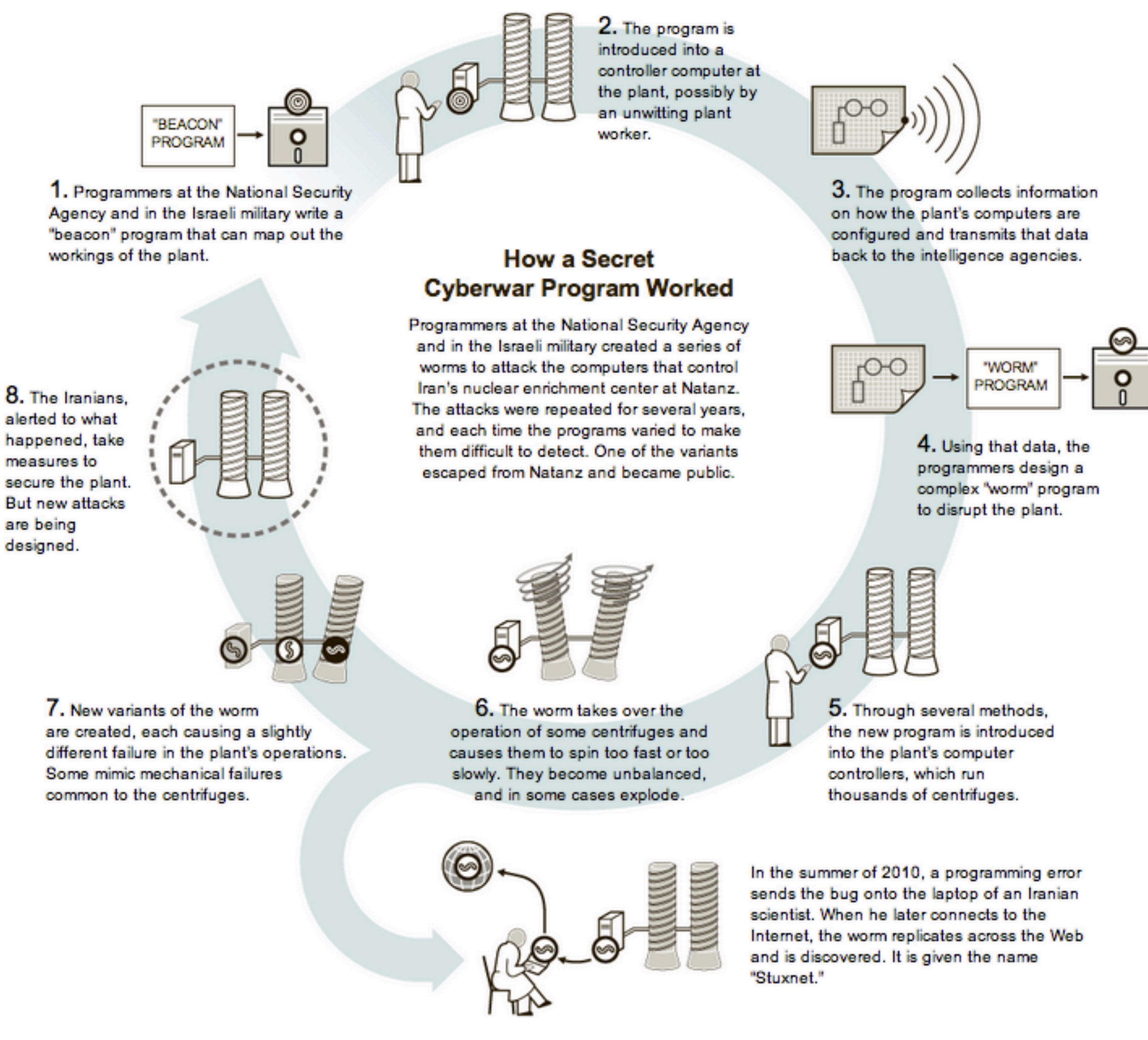
Widely accused of developing Stuxnet worm that attacked and temporarily disabled Iranian nuclear reactors

**Makes off with:**

> Slowed down nuclear reactors

> First use of "cyberweapons" targeting physical damage

**Read more:**
http://www.nytimes.com/2012/06/01/world/middleeast/obama-ordered-wave-of-cyberattacks-against-iran.html?pagewanted=all



## How a Secret Cyberwar Program Worked

Programmers at the National Security Agency and in the Israeli military created a series of worms to attack the computers that control Iran's nuclear enrichment center at Natanz. The attacks were repeated for several years, and each time the programs varied to make them difficult to detect. One of the variants escaped from Natanz and became public.

1. Programmers at the National Security Agency and in the Israeli military write a "beacon" program that can map out the workings of the plant.

2. The program is introduced into a controller computer at the plant, possibly by an unwitting plant worker.

3. The program collects information on how the plant's computers are configured and transmits that data back to the intelligence agencies.

4. Using that data, the programmers design a complex "worm" program to disrupt the plant.

5. Through several methods, the new program is introduced into the plant's computer controllers, which run thousands of centrifuges.

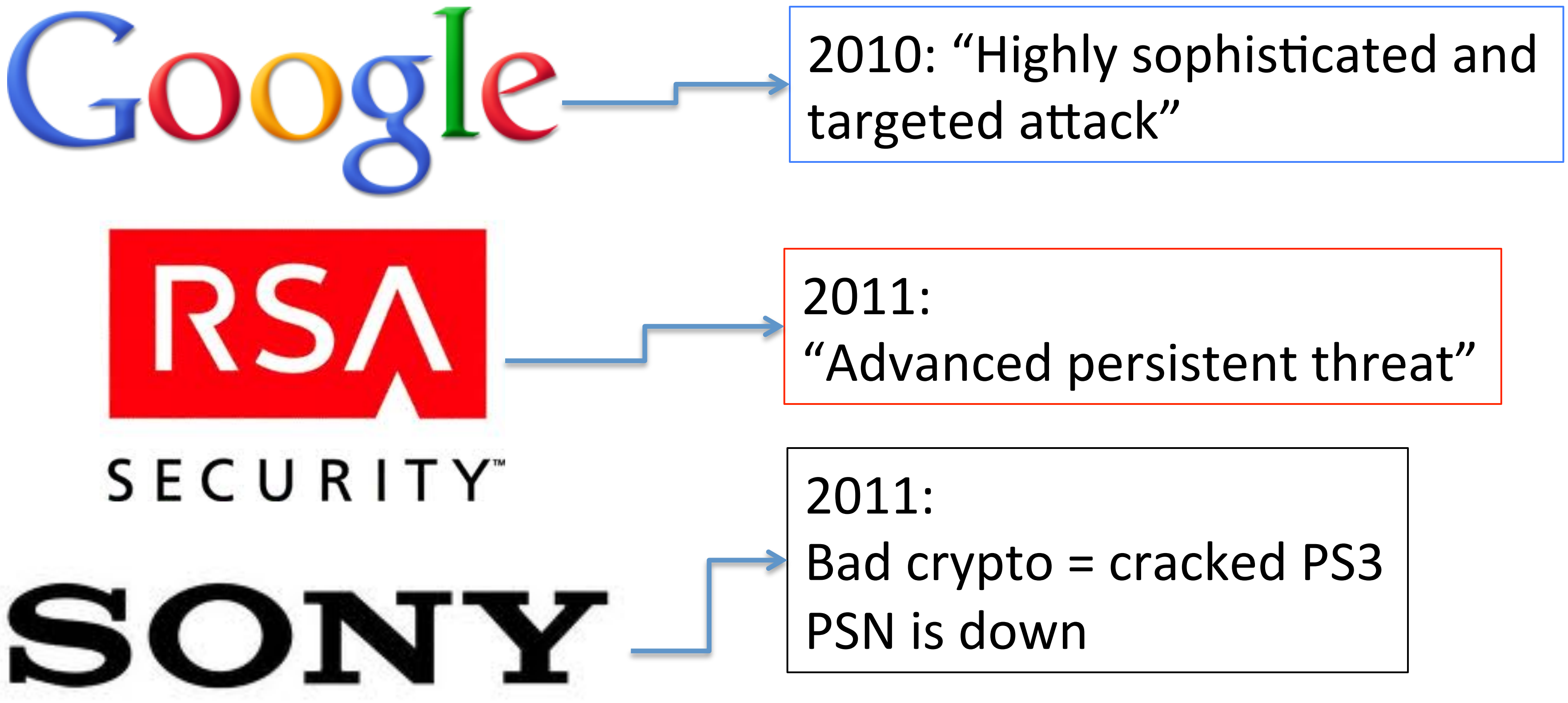
6. The worm takes over the operation of some centrifuges and causes them to spin too fast or too slowly. They become unbalanced, and in some cases explode.

7. New variants of the worm are created, each causing a slightly different failure in the plant's operations. Some mimic mechanical failures common to the centrifuges.

8. The Iranians, alerted to what happened, take measures to secure the plant. But new attacks are being designed.

In the summer of 2010, a programming error sends the bug onto the laptop of an Iranian scientist. When he later connects to the Internet, the worm replicates across the Web and is discovered. It is given the name "Stuxnet."

Source: New York Times



2010: “Highly sophisticated and targeted attack”

2011:
“Advanced persistent threat”

2011:
Bad crypto = cracked PS3
PSN is down

# Themes in this course

- Understanding threats
- Security evaluations (thinking like an attacker)
- Defensive technologies
- Advancing our technical skills
  - x86 assembly, low-level programming
  - networking
  - cryptography
  - web security

# Anatomy of an example attack in 2011

http://arstechnica.com/tech-policy/news/2011/02/anonymous-speaks-the-inside-story-of-the-hbgary-hack.ars/1

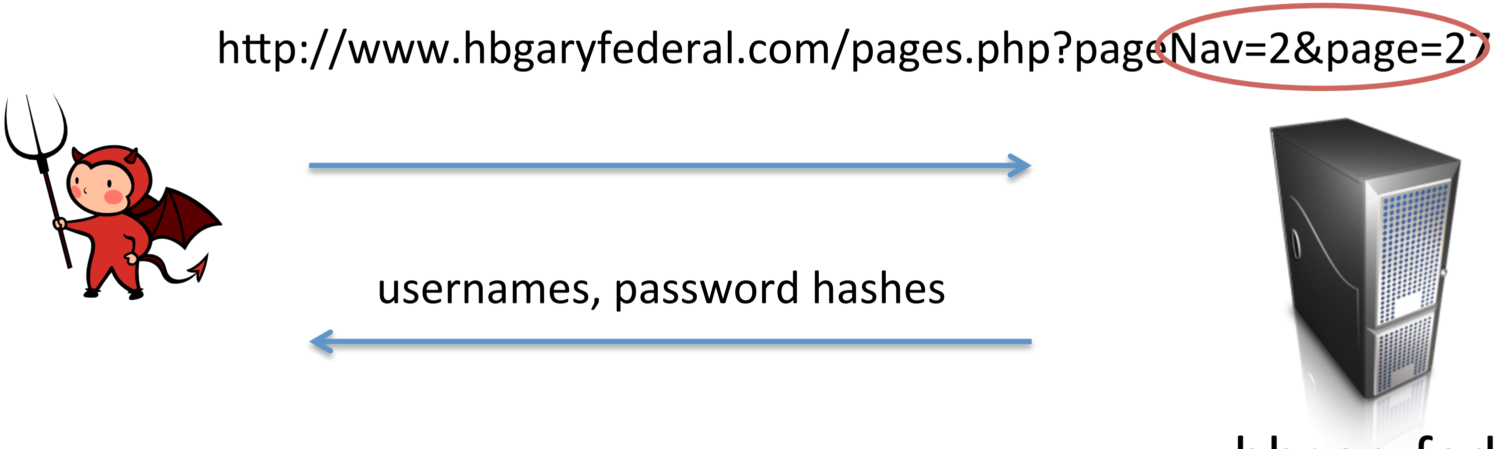
# Anonymous vs HBGary

rootkit.com

hbgaryfederal.com

Ran by Greg Hoglund,
owner of HBGary / HBGary Federal

# Anonymous vs HBGary



http://www.hbgaryfederal.com/pages.php?pageNav=2&page=27

usernames, password hashes

hbgaryfederal.com

SQL injection attack

Runs a CMS

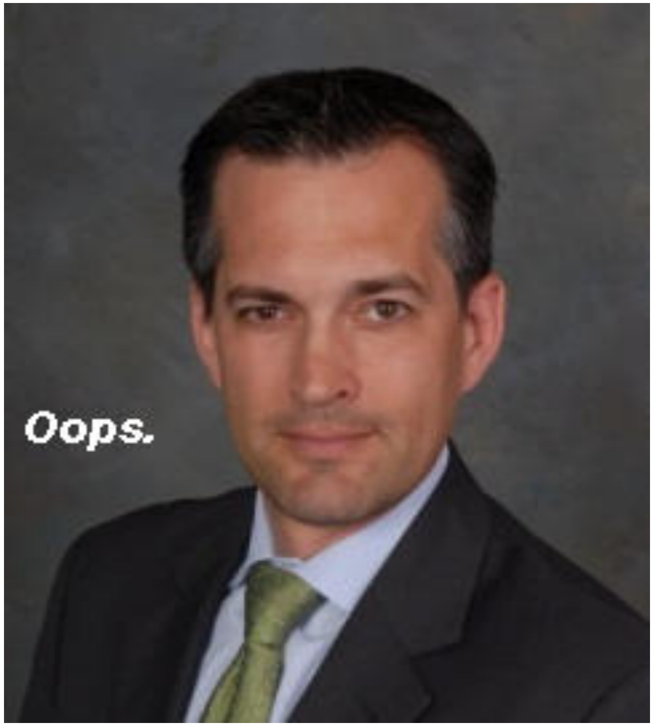
h = Hash(pw)

Given h, recover pw by brute force attack
if pw is “simple” enough

Aaron Barr's (CEO of HBGary) and Ted Vera (COO) had passwords only 6 digits, lower case letters and numbers

JohntheRipper easily inverts hashes of such passwords

http://www.openwall.com/john/



# Anonymous vs HBGary

login: ted
password: tedrox12

hbgaryfederal.com

Runs a CMS

This gave user level account

Exploit a privilege escalation vulnerability in the glibc linker on Linux

http://seclists.org/fulldisclosure/2010/Oct/257

Now have root access on hbgaryfederal.com (and more?)
Delete gigabytes of data, grab emails, take down phone system

# Anonymous vs HBGary

login: aaron
password:  aaronb34

google apps

This gave access to Aaron’s gmail account, since he used same password here

Aaron was administrator for companies’ email on google apps

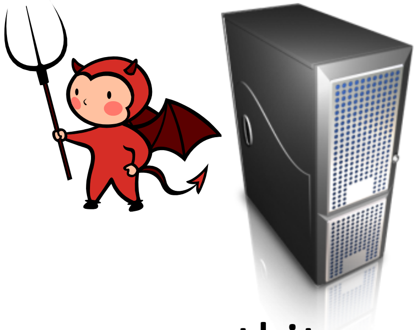
Runs a CMS

Read Greg Hoglund’s emails

# Anonymous vs HBGary

From: Greg
To: Jussi
Subject: need to ssh into rootkit
im in europe and need to ssh into the server. can you drop open up firewall and allow ssh through port 59022 or something vague?
and is our root password still 88j4bb3rw0cky88 or did we change to 88Scr3am3r88 ?
thanks

“social engineering”



# Recap:

- SQL injection

Web security

- Password cracking

Crypto / OS security

- Privilege escalation via setuid program

Low-level software security

- Social engineering

You are on your own

# This course: 4 parts

- Low-level software security
- Network security
- Cryptography
- Web, E-crime, cloud/virtualization, hardware, ethics/law

# We will learn how systems break

Security currently is an arms race between attack and defense

Security engineers must understand attack vectors in order to improve systems' security

# “The price of greatness is responsibility”
Winston Churchill

Black hat:

cracker, a criminal

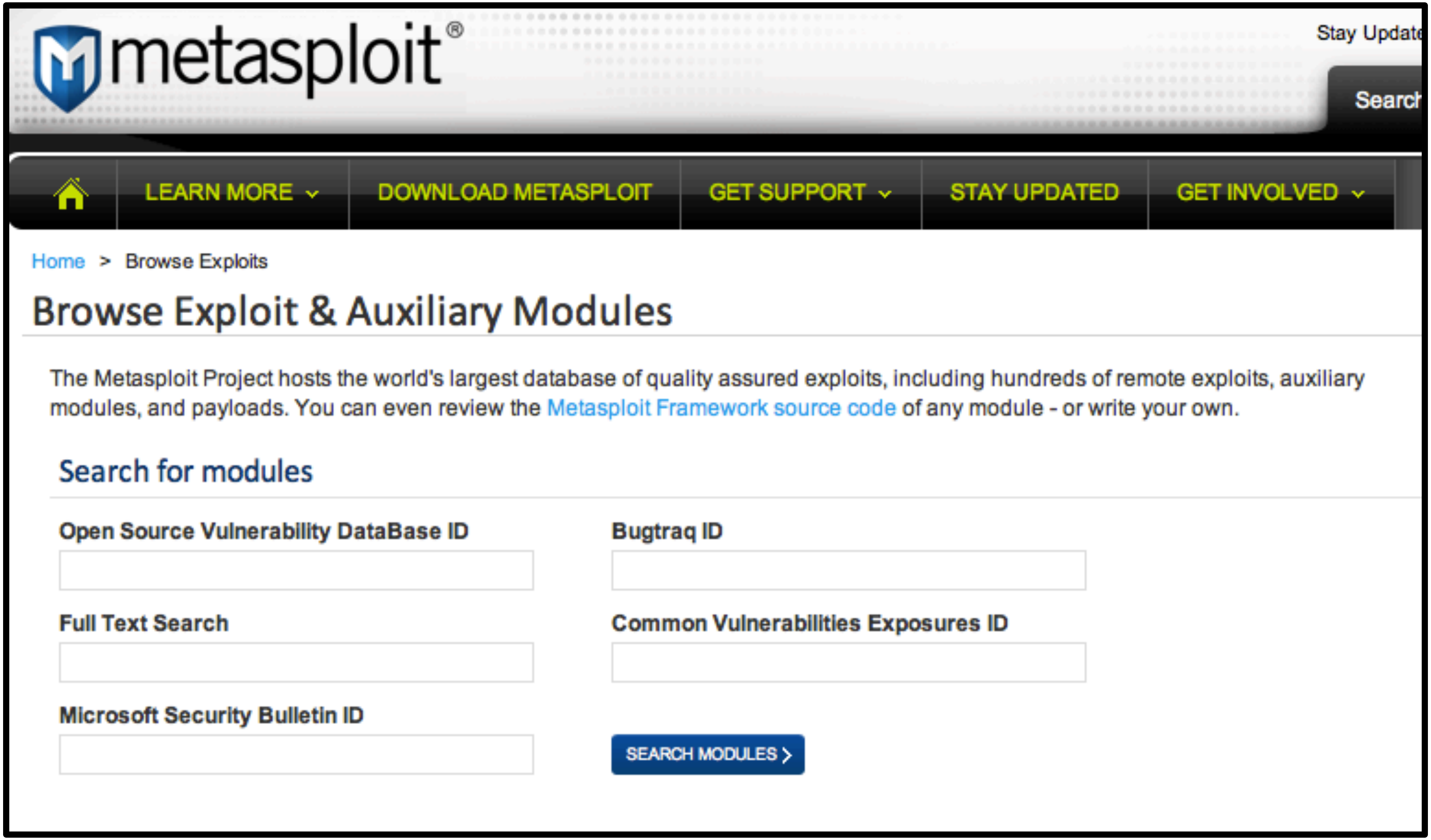
Grey hat:

sometimes criminal, or at least “bending the law”

White hat:

ethical hacker, working within legal framework to perform security evaluations

# Being a script kiddie is easy … and stupid



## Browse Exploit & Auxiliary Modules

The Metasploit Project hosts the world's largest database of quality assured exploits, including hundreds of remote exploits, auxiliary modules, and payloads. You can even review the Metasploit Framework source code of any module - or write your own.

### Search for modules

Open Source Vulnerability DataBase ID

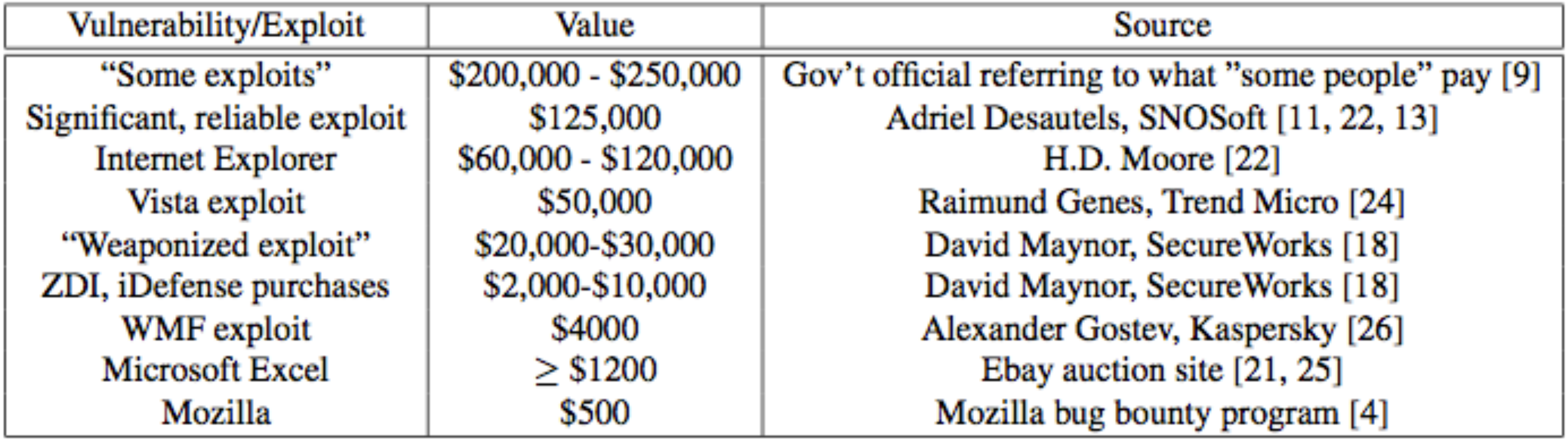
Bugtraq ID

Full Text Search

Common Vulnerabilities Exposures ID

Microsoft Security Bulletin ID

# Reverse engineering and Zero days



| Vulnerability/Exploit | Value | Source |
|---|---|---|
| "Some exploits" | \$200,000 - \$250,000 | Gov't official referring to what "some people" pay [9] |
| Significant, reliable exploit | \$125,000 | Adriel Desautels, SNOSoft [11, 22, 13] |
| Internet Explorer | \$60,000 - \$120,000 | H.D. Moore [22] |
| Vista exploit | \$50,000 | Raimund Genes, Trend Micro [24] |
| "Weaponized exploit" | \$20,000-\$30,000 | David Maynor, SecureWorks [18] |
| ZDI, iDefense purchases | \$2,000-\$10,000 | David Maynor, SecureWorks [18] |
| WMF exploit | \$4000 | Alexander Gostev, Kaspersky [26] |
| Microsoft Excel | $\geq$ \$1200 | Ebay auction site [21, 25] |
| Mozilla | \$500 | Mozilla bug bounty program [4] |

Table 1: Estimates on exploit values.

The Legitimate Vulnerability Market. Inside the Secretive World of 0-day Exploit Sales
by Charlie Miller

# The law and ethics

- Abuse of security vulnerabilities
  - is against University of Wisconsin policies.

    **I will report anyone who "crosses the line" to the relevant university authorities**

    **http://www.cio.wisc.edu/policies.aspx**
  - runs afoul of various laws.
- Abuse of security vulnerabilities is unethical
  - Think about what you're doing and the price it has on yourself, the victims, and society in general

# Rules of thumb

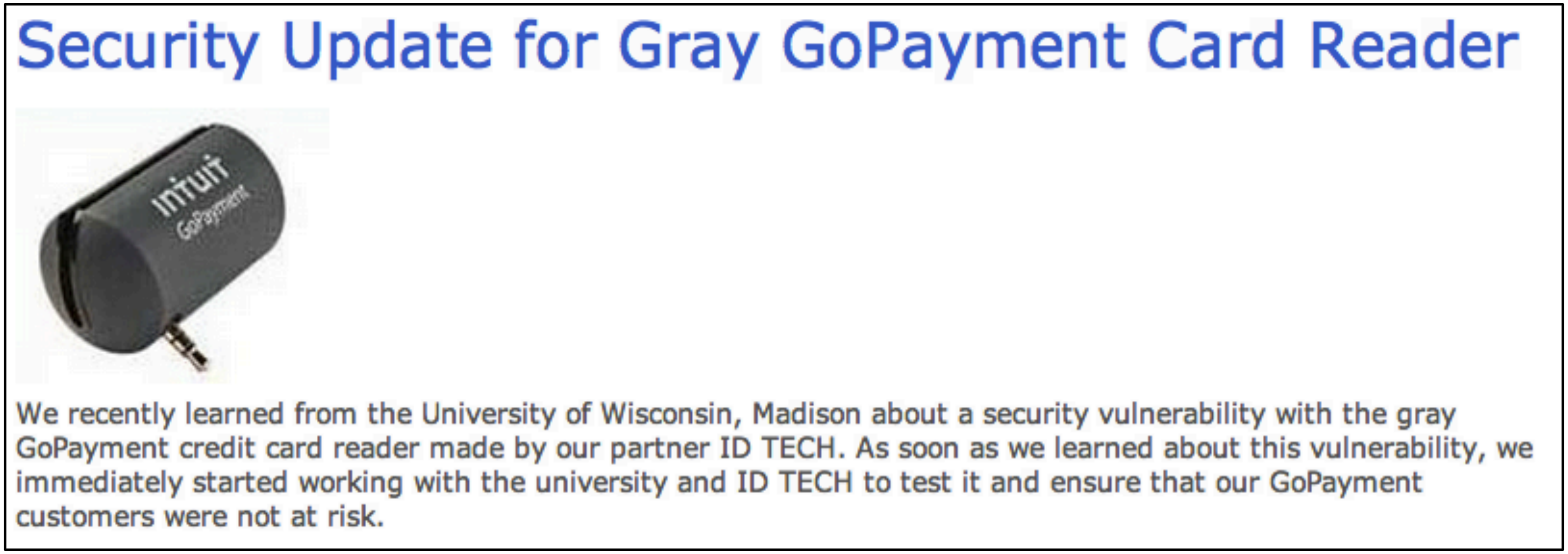
- When in doubt … don't.
  - Come ask me
- You must have explicit (written) permission from a system owner before performing any penetration testing
  - Homework assignments will generally be on your own system
  - We will give explicit permission to hand us exploits for us to test

# Responsible disclosure

- **Full disclosure** means revealing everything about a vulnerability including an example exploit
- **Responsible disclosure** (generally) refers to ensuring potential victims are aware of vulnerabilities before going public

# CERT/CC process (2000)

- Reporter notifies CERT
- CERT notifies vendor
- 45 days later, CERT makes vulnerability public
- CERT acts as (potentially anonymous) communications channel between reporter/ vendor



## Security Update for Gray GoPayment Card Reader

We recently learned from the University of Wisconsin, Madison about a security vulnerability with the gray GoPayment credit card reader made by our partner ID TECH. As soon as we learned about this vulnerability, we immediately started working with the university and ID TECH to test it and ensure that our GoPayment customers were not at risk.

http://security.intuit.com/alert.php?a=51

- Notified companies when we had a draft of paper finished
- Worked with them to ensure they could fix vulnerabilities
- Full disclosure at presentation at workshop

| Vulnerability Class | Channel | Implemented Capability | Visible to User | Scale | Full Control | Cost |
|---|---|---|---|---|---|---|
| Direct physical | OBD-II port | Plug attack hardware directly into car OBD-II port | Yes | Small | Yes | Low |
| Indirect physical | CD | CD-based firmware update | Yes | Small | Yes | Medium |
| | CD | Special song (WMA) | Yes* | Medium | Yes | Medium-High |
| | PassThru | WiFi or wired control connection to advertised PassThru devices | No | Small | Yes | Low |
| | PassThru | WiFi or wired shell injection | No | Viral | Yes | Low |
| Short-range wireless | Bluetooth | Buffer overflow with paired Android phone and Trojan app | No | Large | Yes | Low-Medium |
| | Bluetooth | Sniff MAC address, brute force PIN, buffer overflow | No | Small | Yes | Low-Medium |
| Long-range wireless | Cellular | Call car, authentication exploit, buffer overflow (using laptop) | No | Large | Yes | Medium-High |
| | Cellular | Call car, authentication exploit, buffer overflow (using iPod with exploit audio file, earphones, and a telephone) | No | Large | Yes | Medium-High |

Checkoway et al.
**Comprehensive Experimental Analysis of Automobile Attack surfaces**

# Administrative stuff

- http://pages.cs.wisc.edu/~rist/642-fall-2012/
- Homework assignments (ugrad: 70%, grad: 50%)
- Final (ugrad: 20%, grad: 20%)
- Project (ugrad: extra credit, grad: 20%)
- Participation (ugrad: 10%, grad: 10%)

# Homeworks

- Some problem sets will allow teams of up to 2
- Collaboration policy:
  - no collaboration with people outside team
  - using the web for general information is encouraged
  - Googling for answers to questions is not
  - Cheating will be reported to university authorities
- Need access to virtualization software

# Final

- Last year was a take-home final. Probably same this year

# Project

- Grad students are required to do a term project culminating in a short presentation last week of term
- Broad scope. Aim is to get your feet wet in research:
  - Literature review on some topic of interest
  - In-depth analysis of some computing system
  - Be creative
  - I'll announce deadline for project proposals soon

# Participation

- Speak up in class
- Be prepared to comment on readings. My suggestion:
  - Skim readings before class
  - Read in depth selectively later

# Other courses at Wisconsin

- CS 435 (Prof. Jha, this term)
  - “Intro to cryptography”
- CS 838 (Prof. Ristenpart, last Spring 2011)
  - “Applied cryptography”

# A warm up: security principles

Saltzer and Schroeder.
The protection of information in computer systems.
Proceedings of the IEEE, 1975

1) Economy of mechanism
2) Fail-safe defaults
3) Complete mediation
4) Open design
5) Separation of privilege
6) Least privilege
7) Least common mechanism
8) Psychological acceptability

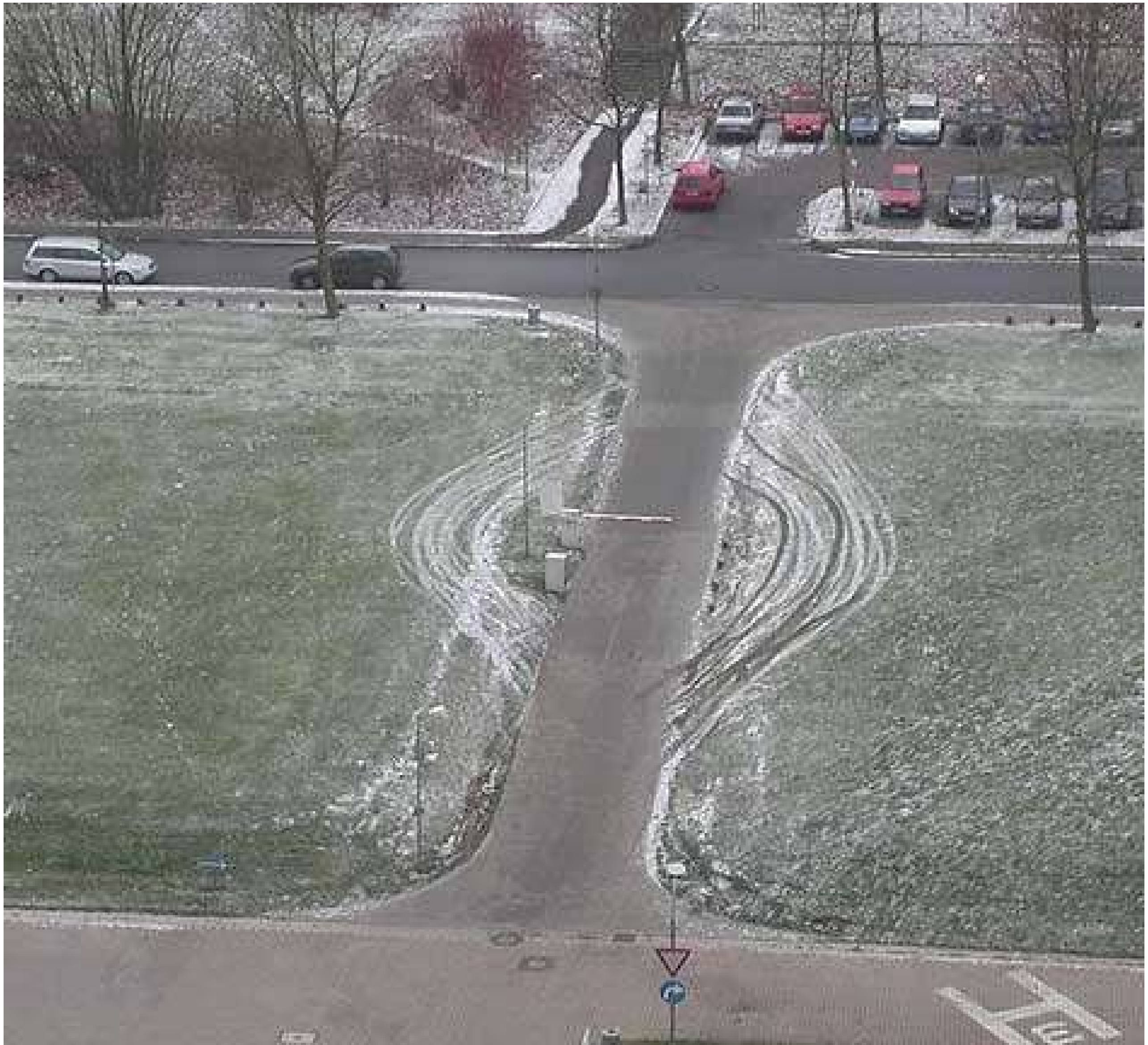
# Economy of mechanism

# Fail-safe defaults

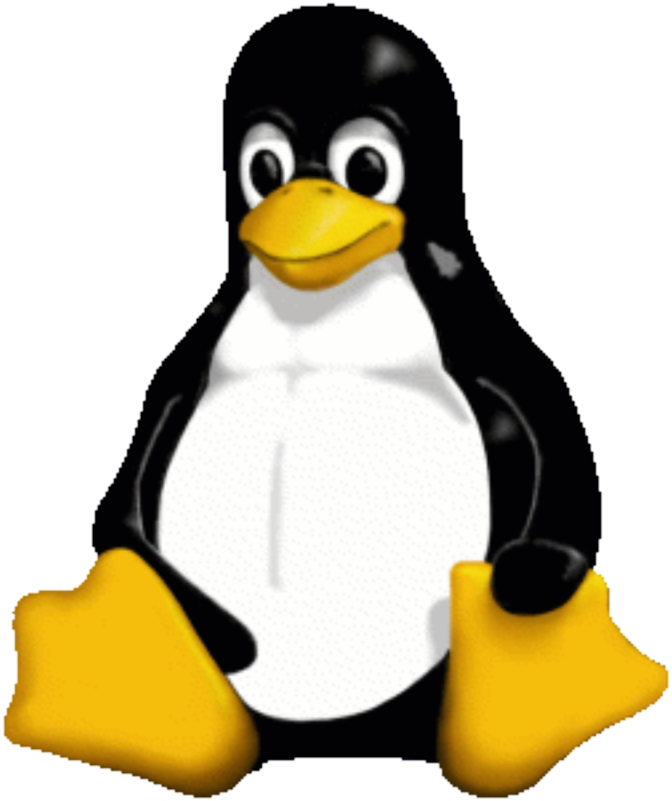
```
isAdmin = true;
try {
    codeWhichMayFail();
    isAdmin = isUserInRole( “Administrator” );
}
catch (Exception ex) {
    log.write( ex.toString() );
}
```

(Example from https://www.owasp.org/index.php/Secure_Coding_Principles)

# Complete mediation

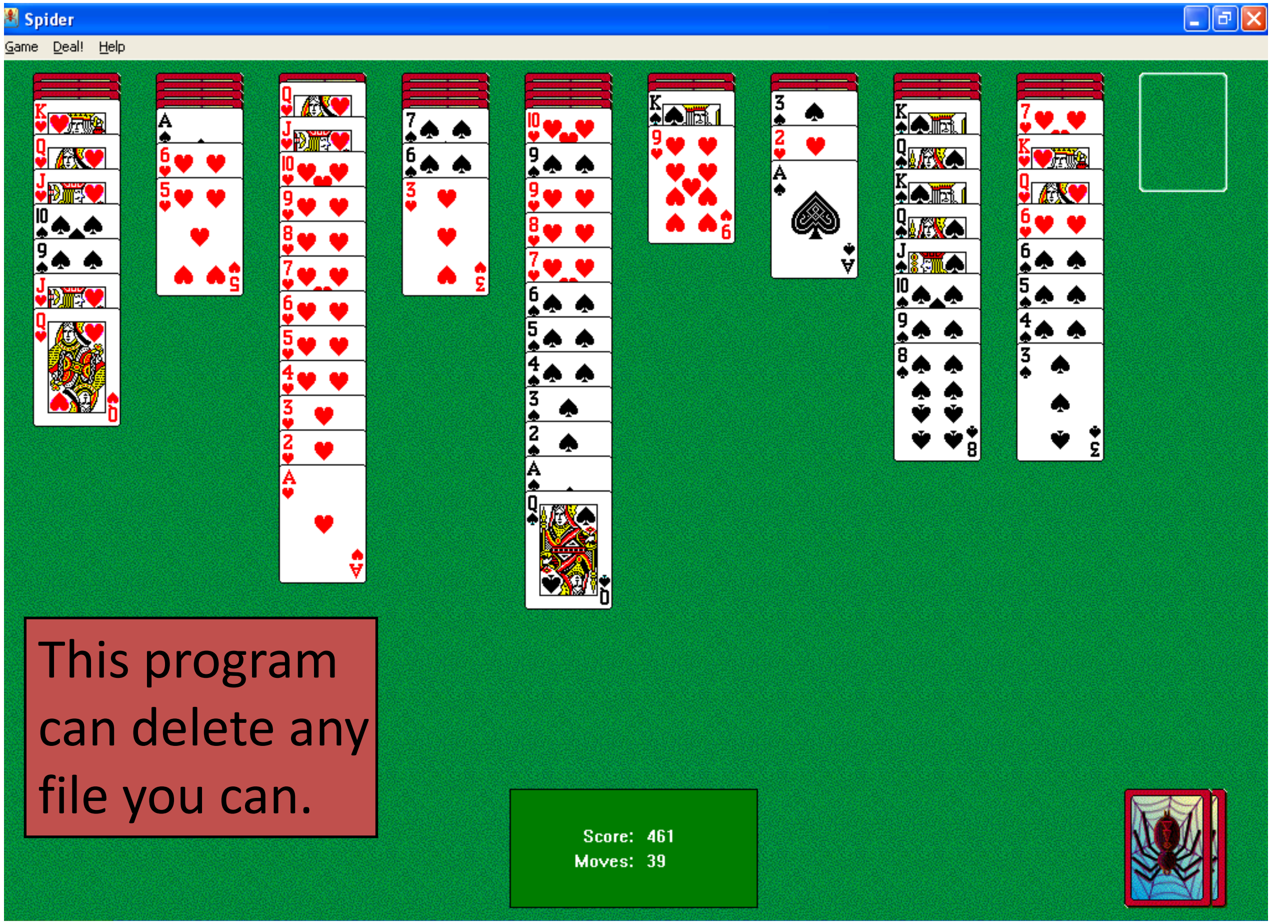


# Open design
## (avoid “security by obscurity”)



# Separation of privilege

# Least privilege



Score: 461
Moves: 39

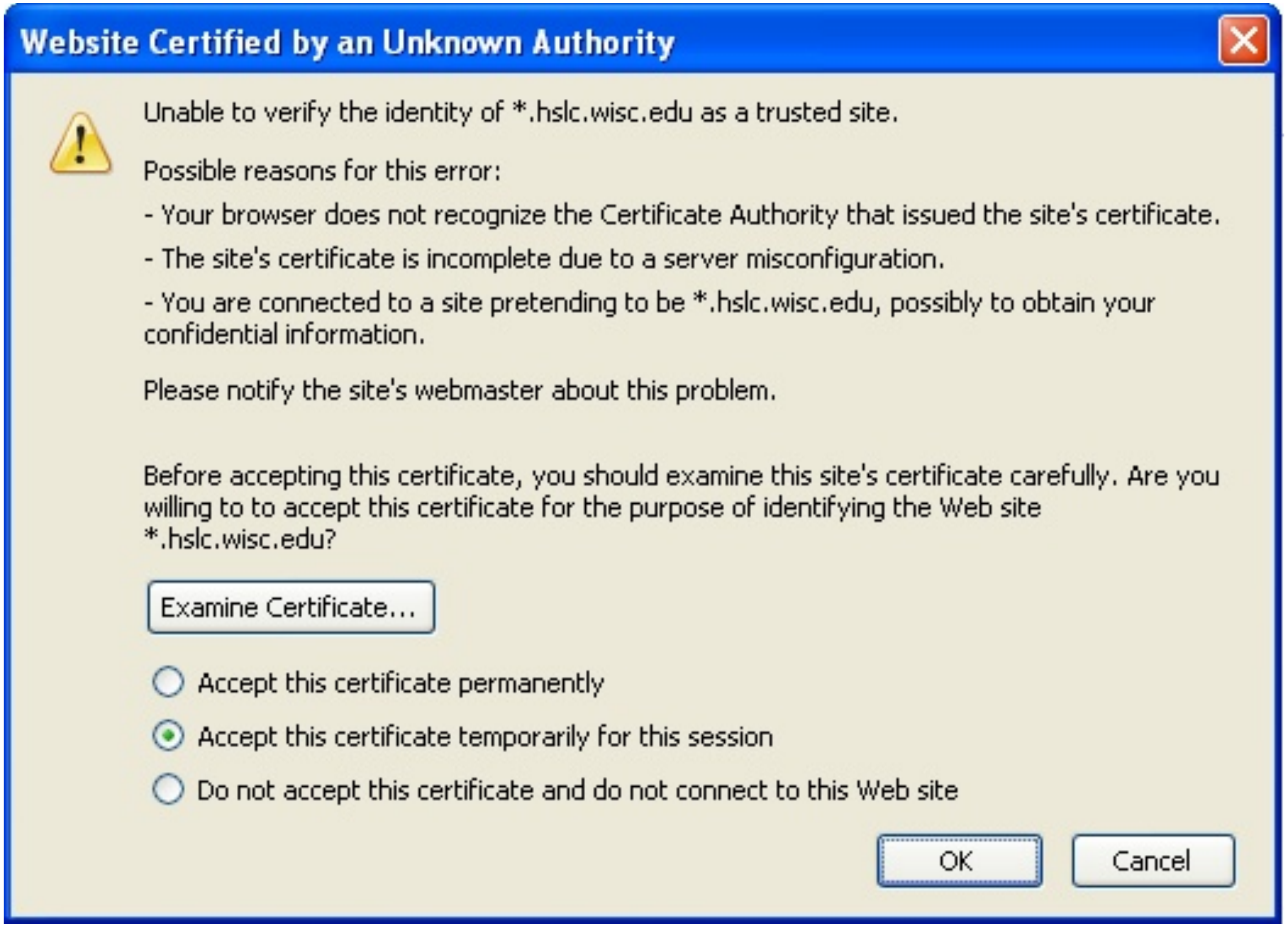
This program can delete any file you can.

(Courtesy of UCB CS161 slides)

# Least common mechanism

## (isolation)

# Psychological acceptability
## (consider human factors)



Unable to verify the identity of *.hslc.wisc.edu as a trusted site.

Possible reasons for this error:

- Your browser does not recognize the Certificate Authority that issued the site's certificate.

- The site's certificate is incomplete due to a server misconfiguration.

- You are connected to a site pretending to be *.hslc.wisc.edu, possibly to obtain your confidential information.

Please notify the site's webmaster about this problem.

Before accepting this certificate, you should examine this site's certificate carefully. Are you willing to to accept this certificate for the purpose of identifying the Web site *.hslc.wisc.edu?

○ Accept this certificate permanently

● Accept this certificate temporarily for this session

○ Do not accept this certificate and do not connect to this Web site

# Principles from 1970’s

- Do you think they are relevant today?
- A bit… abstract
- Recur over and over again

# US Cyber Command

USCYBERCOM plans, coordinates, integrates, synchronizes and conducts activities to: direct the operations and defense of specified Department of Defense information networks and; prepare to, and when directed, conduct full spectrum military cyberspace operations in order to enable actions in all domains, ensure US/Allied freedom of action in cyberspace and deny the same to our adversaries.

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CO
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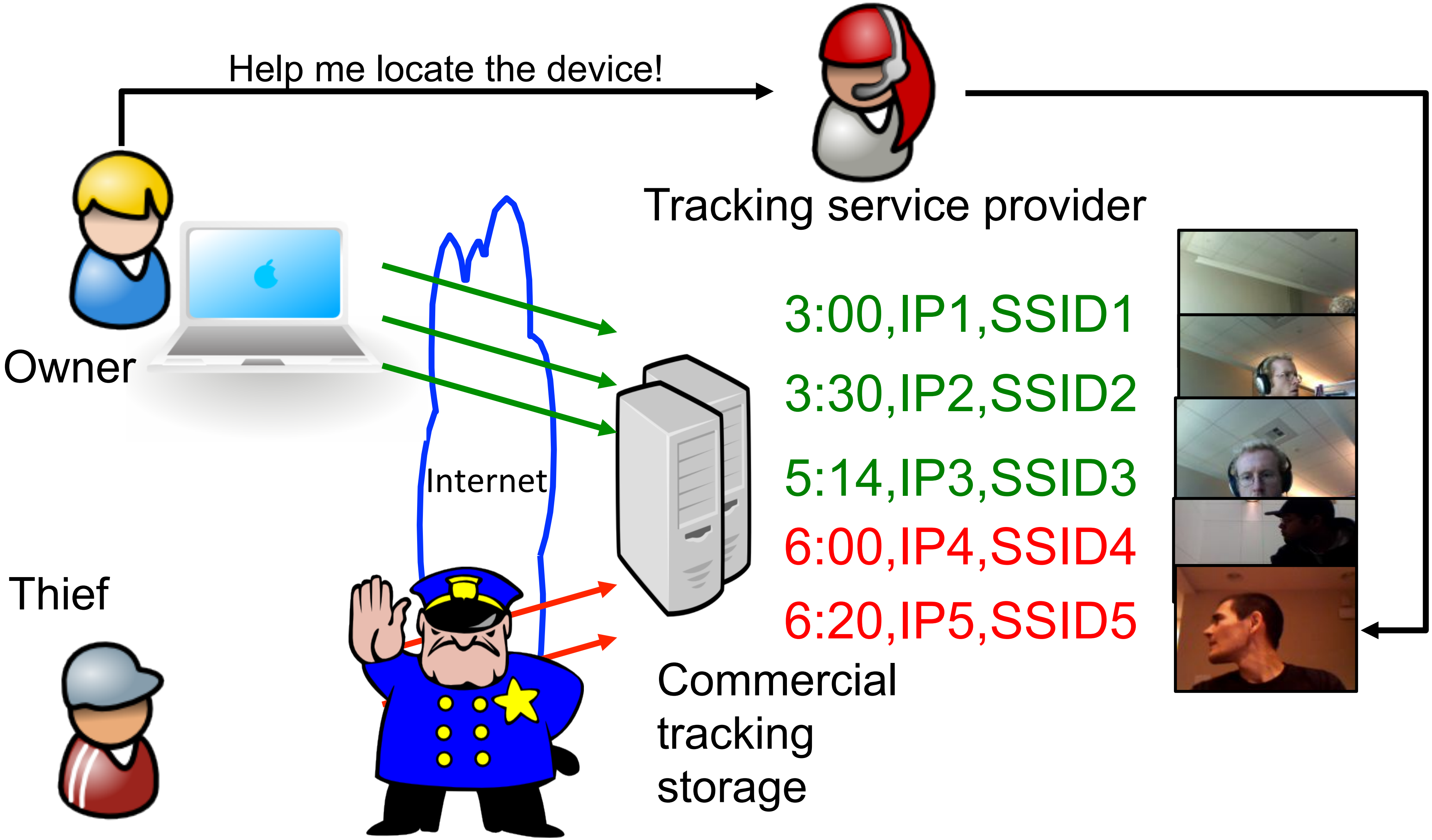
# Ethics, the law, and strange situations



Help me locate the device!

Tracking service provider

Owner

Internet

Thief

3:00,IP1,SSID1

3:30,IP2,SSID2

5:14,IP3,SSID3

6:00,IP4,SSID4

6:20,IP5,SSID5

Commercial tracking storage

http://thisguyhasmymacbook.tumblr.com/post/5821960131/
guy-driving-away-with-my-macbook

# Ethics, the law, and strange situations

“Couple Can Sue Laptop-Tracking Company for Spying on Sex Chats”
http://www.wired.com/threatlevel/2011/08/absolute-sued-for-spying/

Absolute® Software

LOJACK®
Get it. And get it back.™