Computer (Cyber) Security
Definition and Challenges

Designing Secure Systems 2017/18

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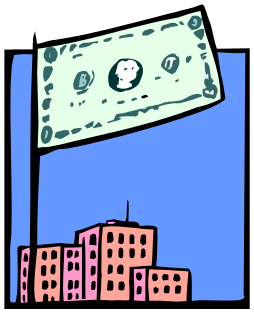
Based on slides by Nicolas Courtois (UCL)

What is security?

Class brainstorm

Security: protect assets



What assets?

- Money [economic security]

But NOT ONLY MONEY

- Life and the quality of life
- Food security
- Freedom, justice, etc…

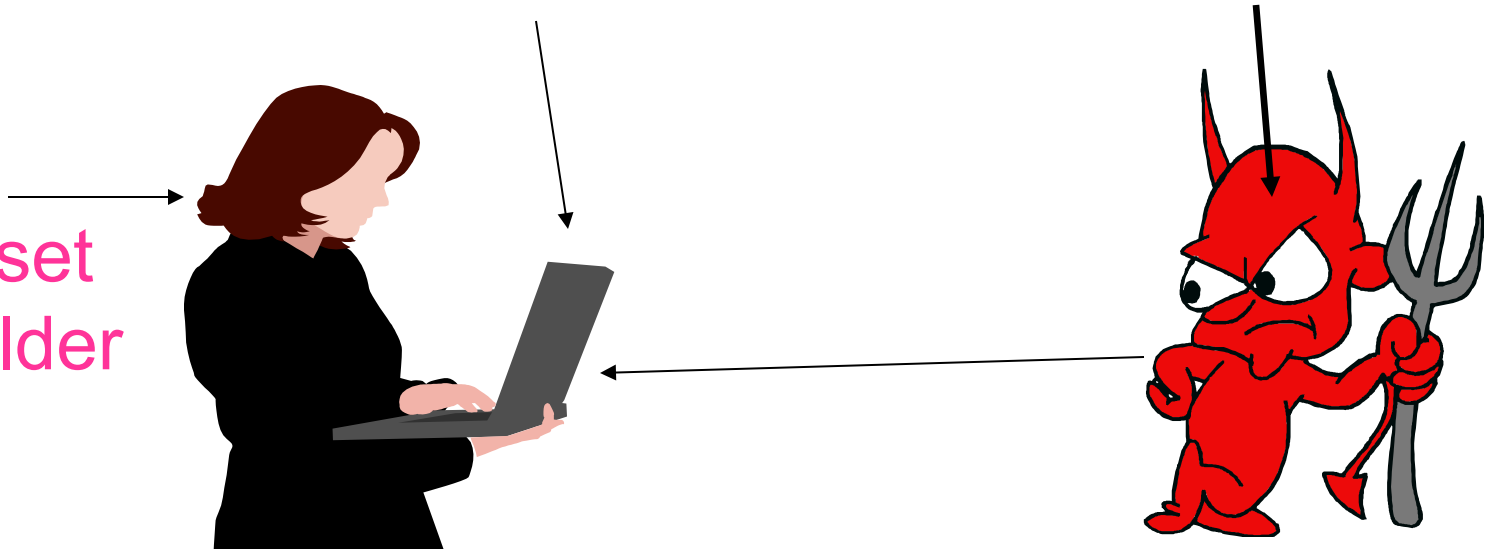
Computer Security

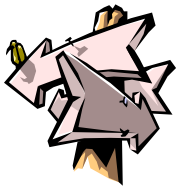
Common Criteria

Common Criteria [ISO15408] :

an international standard for computer security certification

Protecting Digital Assets from Threats





Security ≥ Safety

Difference:

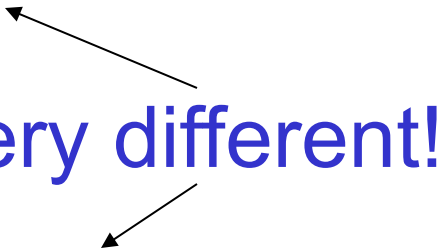
security protects against intentional damages...

Notion of an

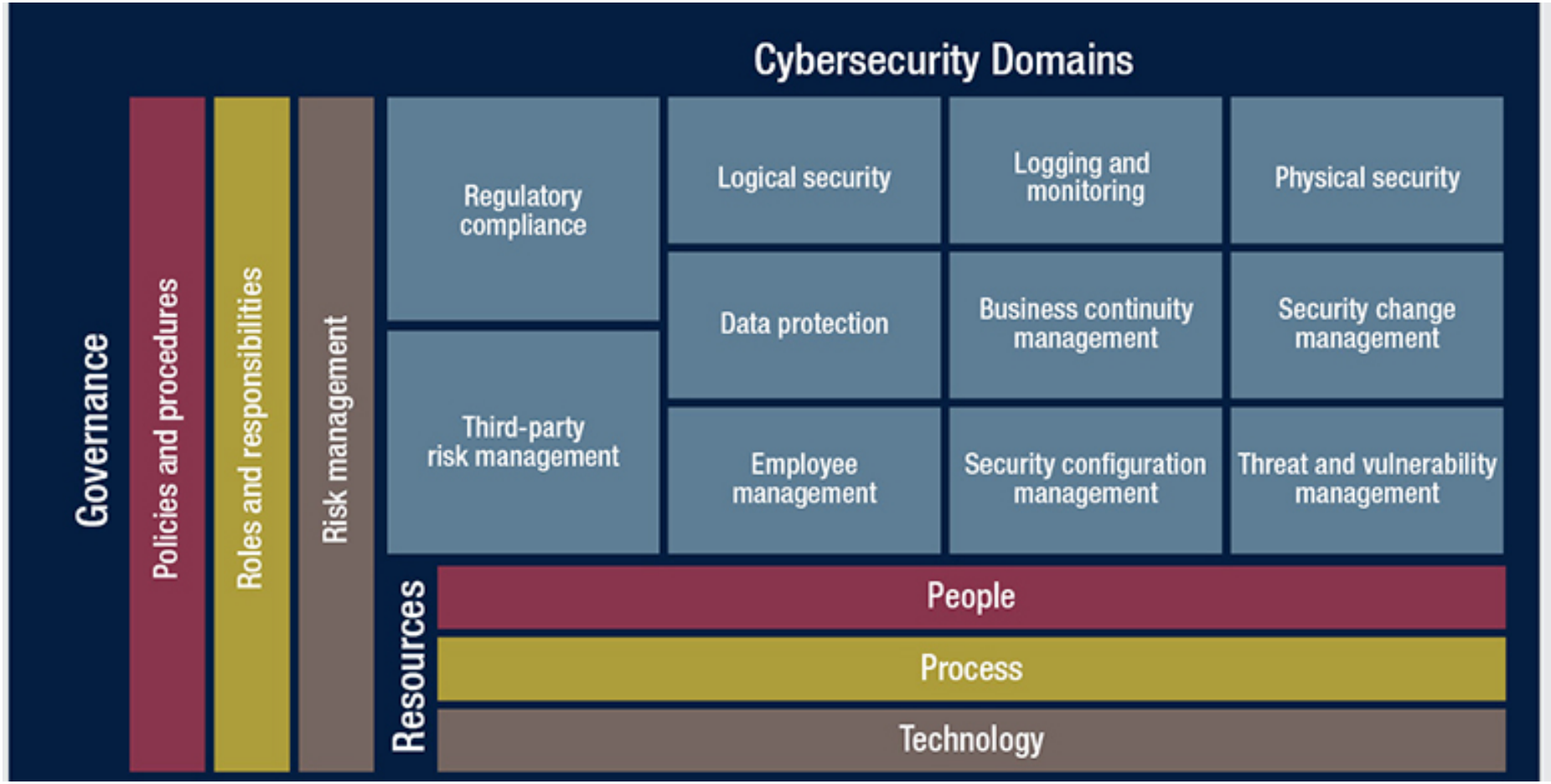
- Attacker / Adversary
- Attack

Dimensions of Computer Security

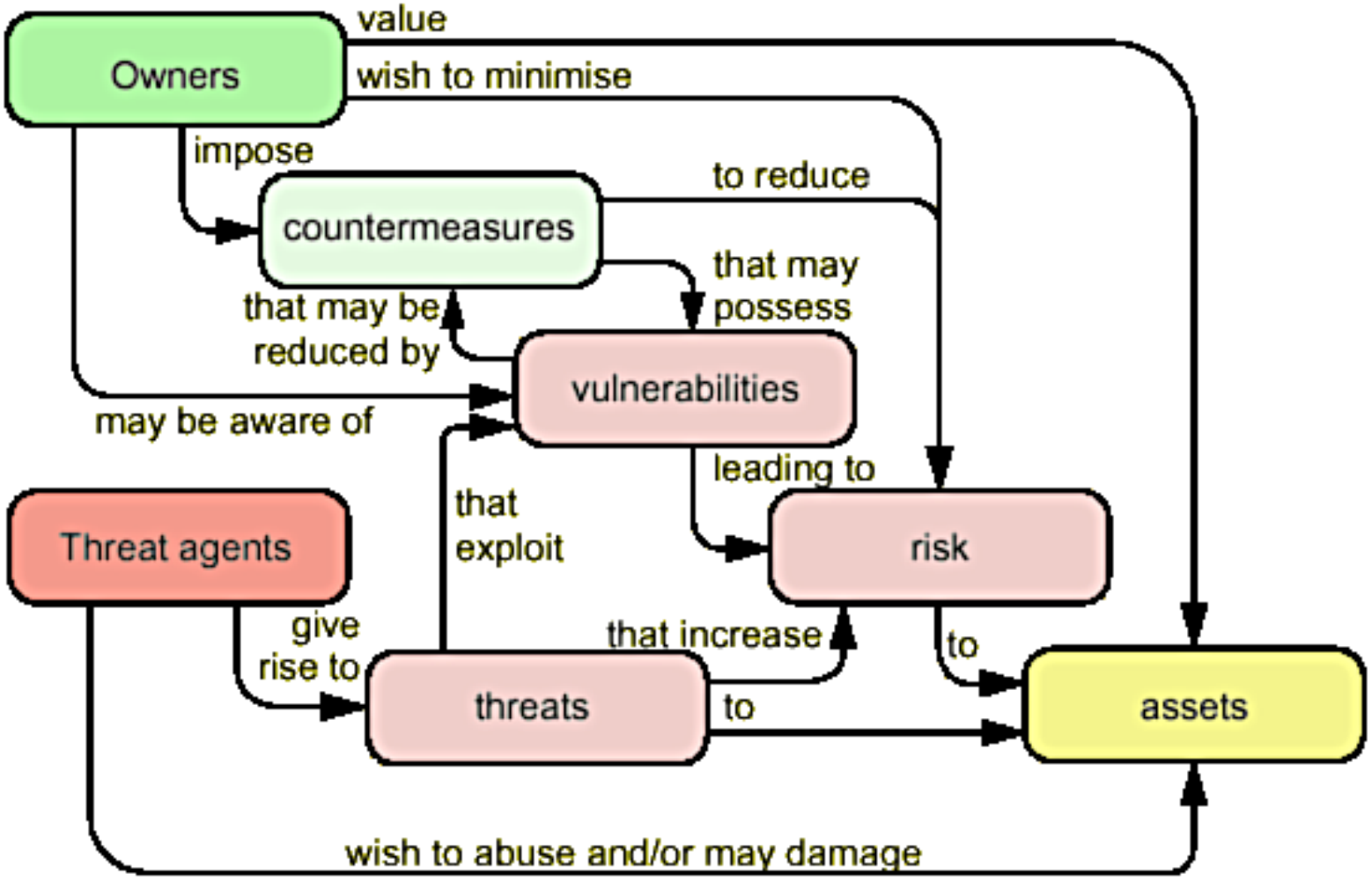
- Physical vs. Logical
- Psychological / Human
- Organizational / Business



Computer Security Dimensions



Computer Security on one slide

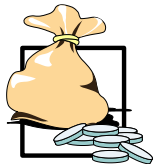


Our Definition of Secure System

Inability for attackers to achieve:

1. Adversarial goal

2. By means of: money, human resources, computing power, memory, risk, expertise... **resources of the adversary**


3. Access to the system

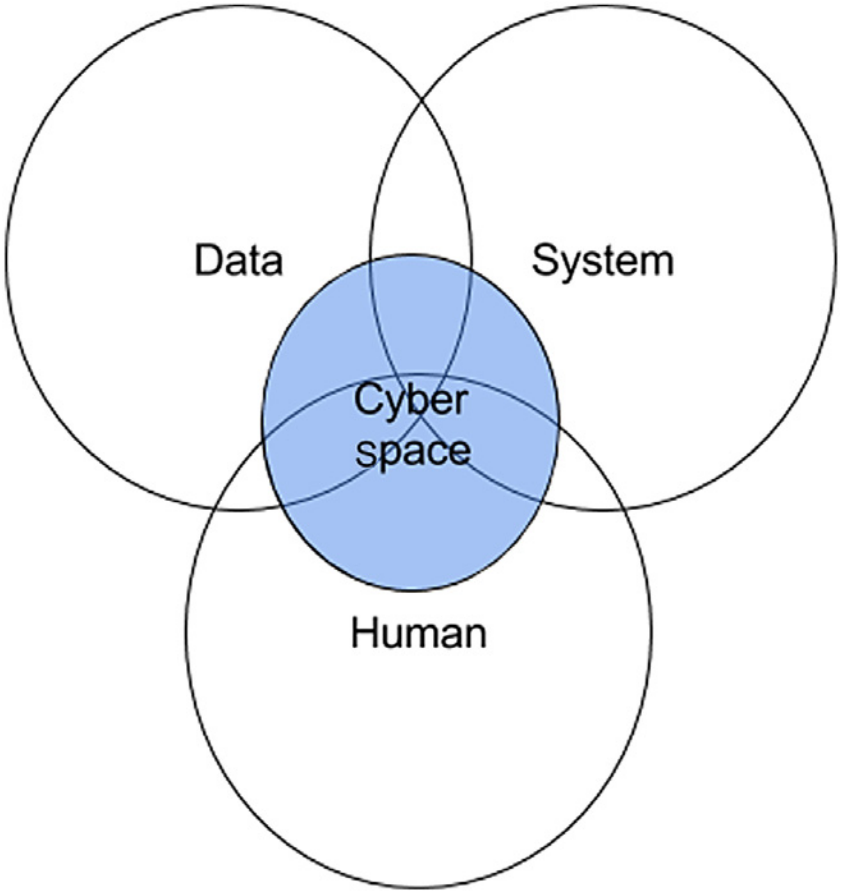
Main Adversarial Goals

Breaching any of:

- Confidentiality
- Integrity
- Authenticity
- Availability
- Accountability

Why is computer security hard?

Class brainstorm



Cyber space at the overlap of data, system, and human

Computer Industry and Security

Tech Background: "Industry Standards" such as:

- Intel CPU
- RAM and hard drives
- C language
- UNIX / Windows
- TCP/IP
- HTTP
- TLS

Social-Econ Background:

Science background:

Computer Industry and Security

"Industry Standards"

Social-Econ Background:

Science background:

- What technology "enablers"(computers) and "disablers" (cryptology,HWSec) can/ cannot achieve?
- How to define / classify security problems and find "good" solutions

Computer Industry and Security

"Industry Standards"

Social-econ background:

- software/hardware economics:
  - which industry dominates which
  - free market triumphs and disasters
- **humans that cannot be bothered to obey the policy…**
- bureaucratic organisations that just cannot get their best interest (?) right
- slow adoption of the technology academics/companies are creating
- adoption barriers
- theory vs. practice
- laws / regulations

Science background:

insecure products!

The Product Development cycle

"Industry Standards"

Social-Econ Background:

Science background:

everything ends up here
rapid obsolescence

Attackers

Vocabulary

Attacker / Adversary / Threat Agent

Who are the attackers?

- Adventurous teenagers
- Petty criminals to organized criminals
- Foreign states
- Industrial spies
- Disgruntled employees
- Competitors
- Researchers
- Terrorists
- …

Attacker means

- Software vulnerabilities
  - Buffer overflow attacks
  - SQL injection attacks
  - Javascript attacks (e.g., XSS)
  - Broken authentication, access control, and session management
- Security misconfiguration

Attacker means continued

- Social engineering
  - Phishing attacks
- Traffic interception (e.g. wireless)
- Hardware/physical attacks
- Ingenuity, hard work, good luck, brute force

Attacker motivation

- Profits and other benefits
  - Crime business
  - Reputation damage
- Political activism, terrorism
- Enjoyment, fame
- Development of science and offensive technology:
  - University researchers
  - Security professionals (defenders)
  - Professional hackers, pen testers, etc…

Recent Trend

The industrialization of hacking:

- division of labour, clear definition of roles
- forming a supply chain
- professional management

Cybercrime actors

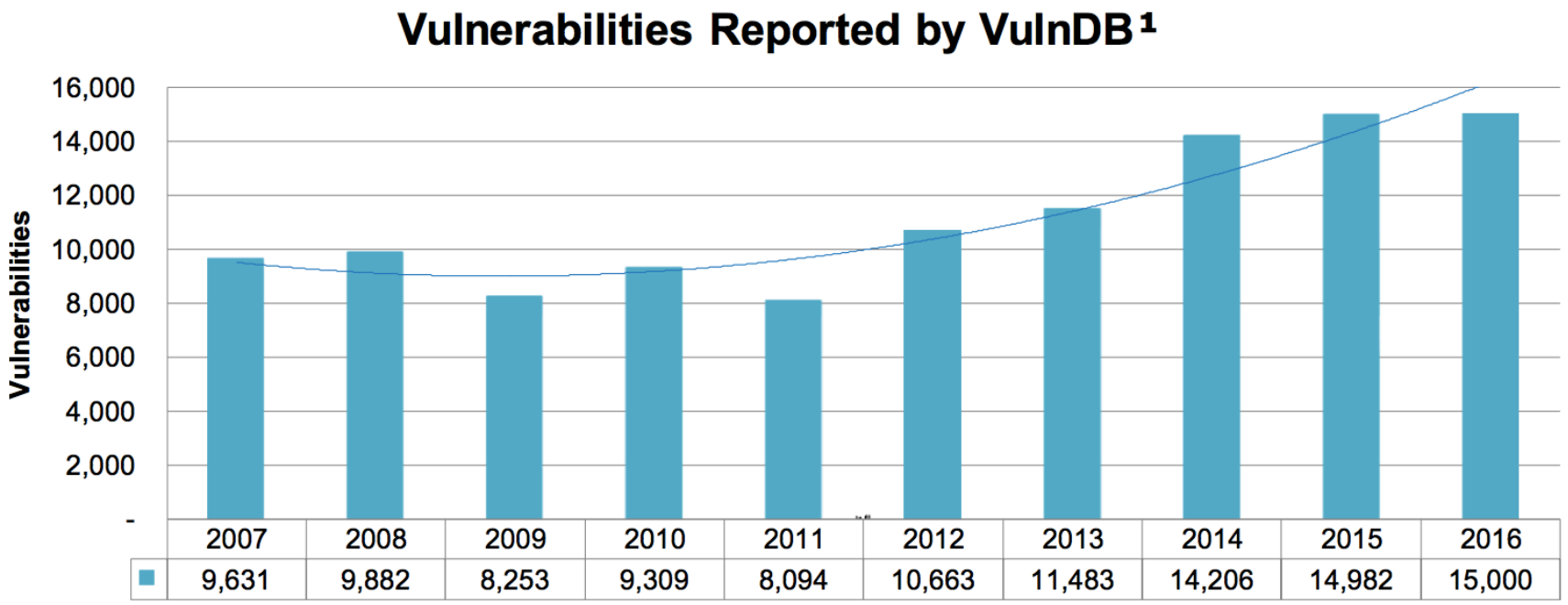
- Exploit developers
  - Very smart people who reverse-engineer software
  - Develop and sell exploits packs and kits
- Botnet masters
  - Develop software and control vast numbers of *zombie machines* (i.e. infected by a bot)
  - Rent out their botnet to other actors
- Spammers
  - Advertise links for other actors
- Phishers
  - Setup scam sites to steal information
  - Work with spammers to spread the attack

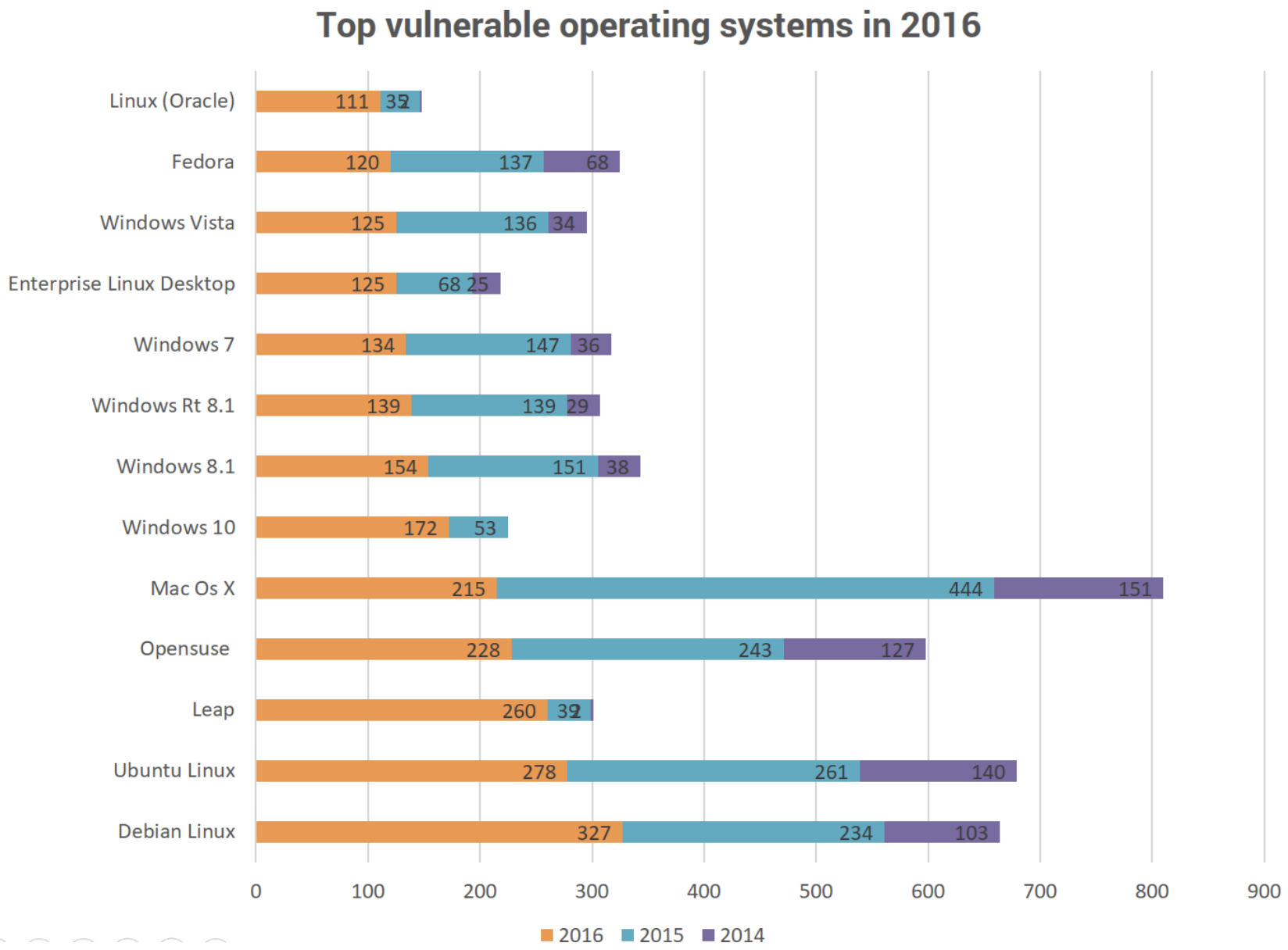
Cybercrime actors contd

- Counterfeiters
  - Run websites selling fake goods
  - Must be able to clear credit cards
- “Bulletproof” Hosting Providers
  - Offer dedicated servers to other actors
  - Hosted in lawless parts of the Internet
- Carders, Cashiers, and Mules
  - Turn stolen bank accounts and credit cards into cash
  - Help launder money
- Crowdturfers
  - Create, verify, and manage fake accounts
  - Solve CAPTCHAS for a fee

Software vulnerabilities

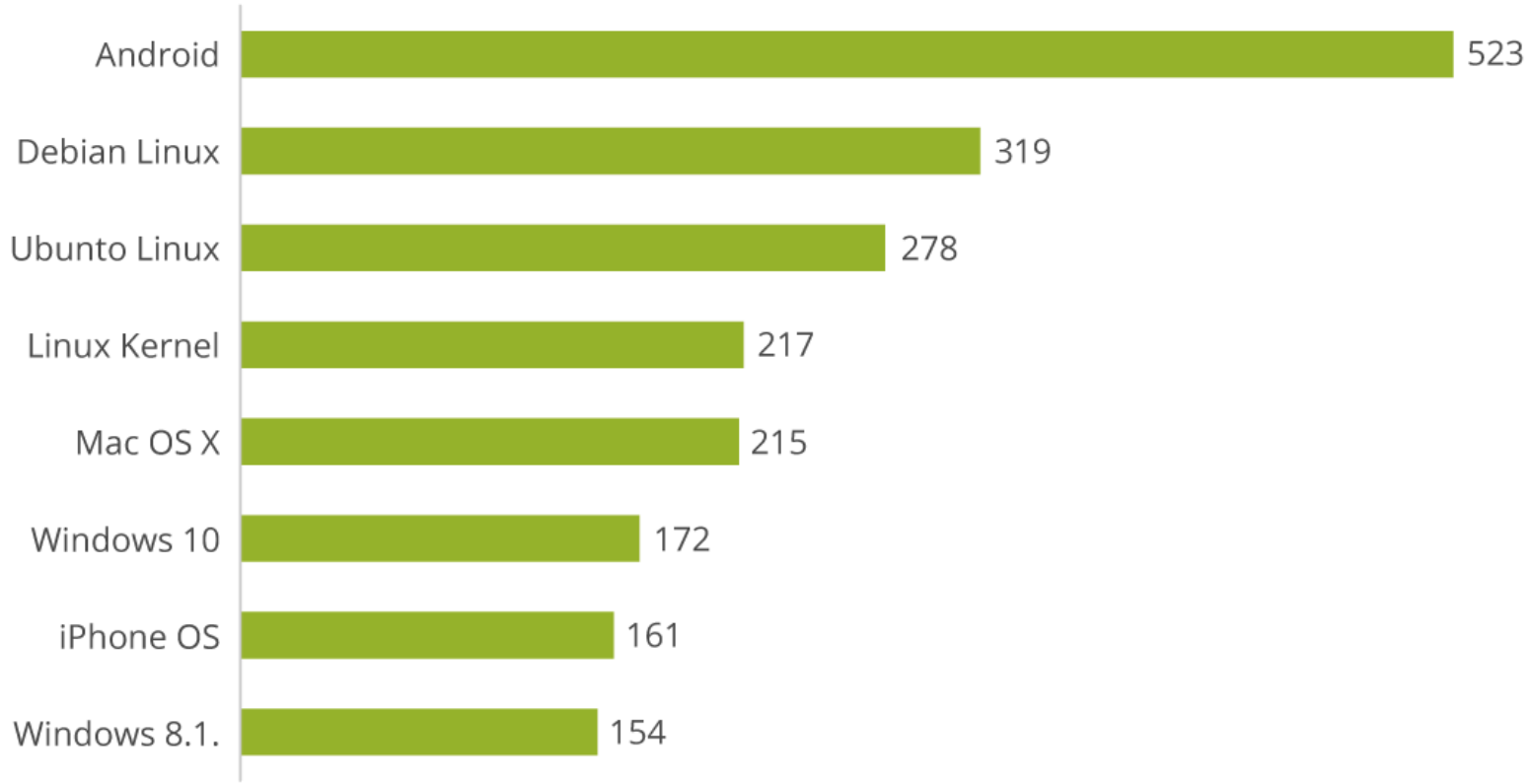
Reported Vulnerabilities stats




Top vulnerable operating systems in 2016
Linux (Oracle)
111
35
2
Fedora
120
137
68
Windows Vista
125
136
34
Enterprise Linux Desktop
125
68
25
Windows 7
134
147
36
Windows Rt 8.1
139
139
29
Windows 8.1
154
151
38
Windows 10
172
53
Mac Os X
215
444
151
Opensuse
228
243
127
Leap
260
32
2
Ubuntu Linux
278
261
140
Debian Linux
327
234
103
0
100
200
300
400
500
600
700
800
900
2016
2015
2014

Android Is The Most Vulnerable Operating System

Number of vulnerabilities by operating system in 2016*



* Vulnerability defined as a mistake in software that can be directly used by a hacker to gain access to a system/network

CompSec and Economics

Question

Why do so many vulnerabilities exist in the first place?

Class brainstorm

Why does commercial security fail?

Claim: the link between "money" and security is still frequently broken today:

- Security is a public good
  - "private" incentives are weak
- Worse than "market for lemons":
  - Not only the customer cannot see the difference between good security and bad

    ~~Frequently~~ Sometimes the manufacturer cannot either

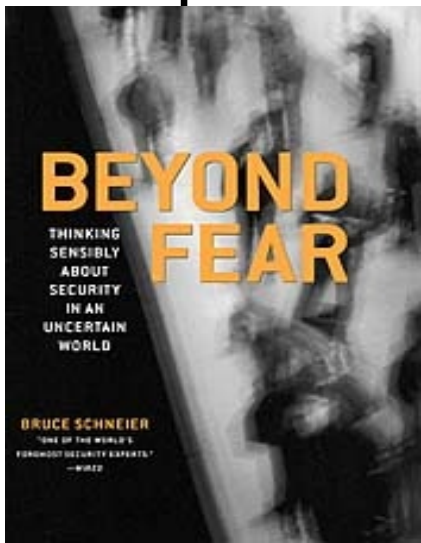
The Very Nature of Security:

Bruce Schneier “Beyond Fear” book [2003], p.1:

Critical to any security decision is the notion of

security trade-offs,

meaning the **costs** – terms of money, convenience, comfort, freedoms, and so on - that inevitably attach themselves to any security system. People make security trade-offs naturally.

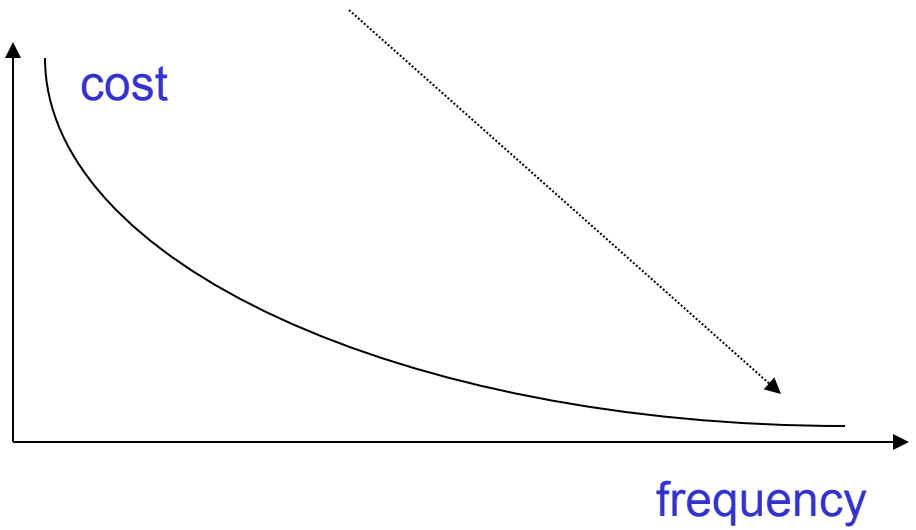


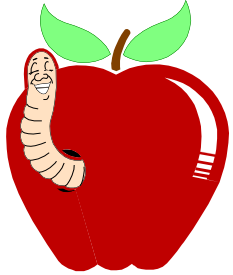
the Long Tail theory

- One bank loses $30M/year
  - not more, risk management!

So they impose security measures on customers. Now:

- 300 M people lose
  1 minute/day
  = 9000/Y





Why Things Happen?

Bugs… or don't care

- Programming with absence of security considerations
  - C/C++ is unsafe
  - Security/cryptography research developed with obsession with security. Both never met
- Economics/business:
  - customers do not see => do not care about security
  - usability: usage burden frustrates users

*Risk

Risk Management = 1+2

A risk is the potential for something unwanted to happen (e.g., loss of C-I-A)

1. Measuring or/and assessing risks

2. Developing strategies and solutions to manage risks:
   - reduce/avoid and
   - handle risks

**Risk Management contd…

handle risks

risk retention

risk transfer

contract…

(e.g. insurance)

hedging

(minimise exposure by some transaction)

Residual Risk = def

what remains after defences are in place…

Defenders

3 Actions of Defenders

- Prevent
- Detect
- Respond

Types of Prevention

- Deter (discourage)
- Hinder (make harder)

Detection and Recovery

Detect

- Monitoring/logging
- Anomaly analysis

Recover

- Incident management
- Forensics
- Change procedures
- Install new technologies

Reasoning about security

Attack trees

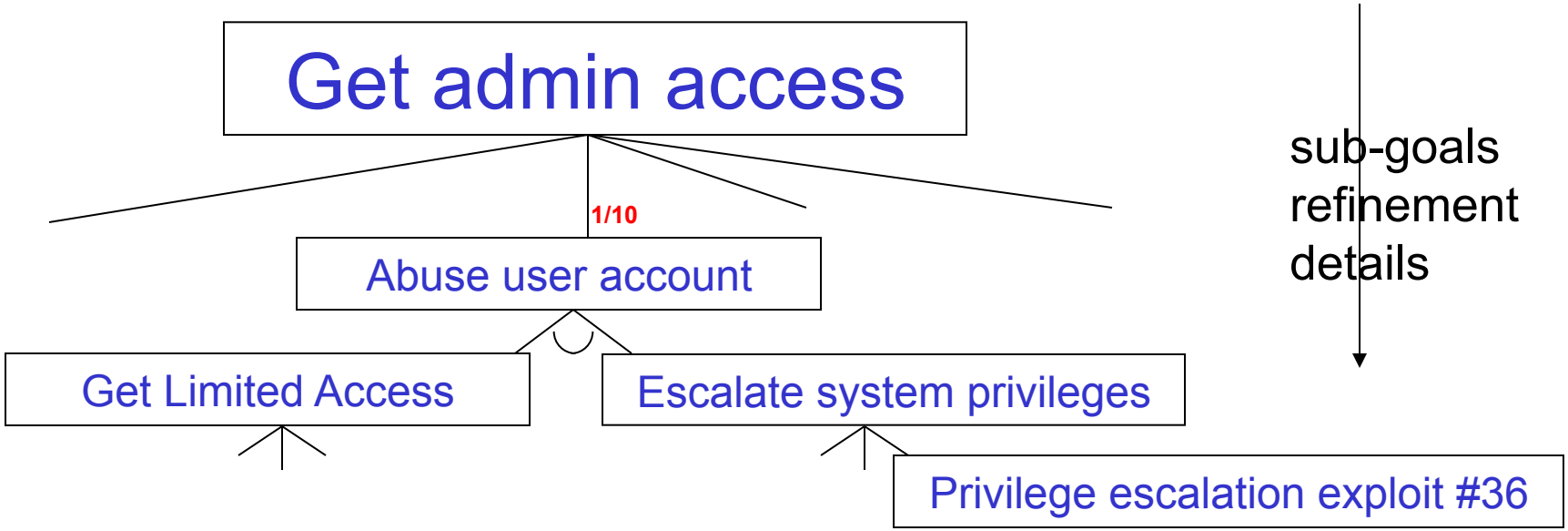
Attack tree

Formal analysis of all known attack avenues.

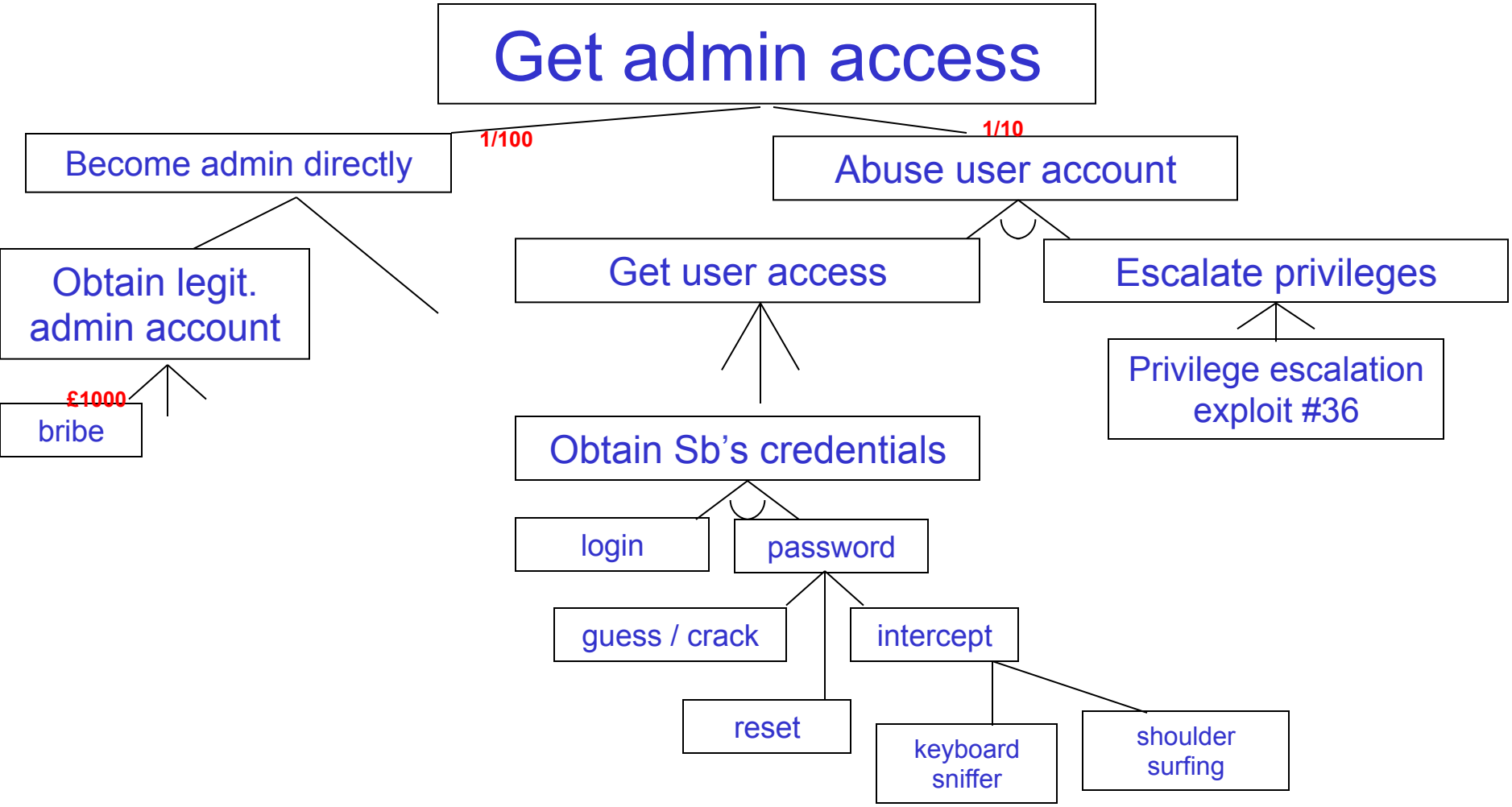
but what about unknown attacks?

A tree with OR nodes and AND nodes.

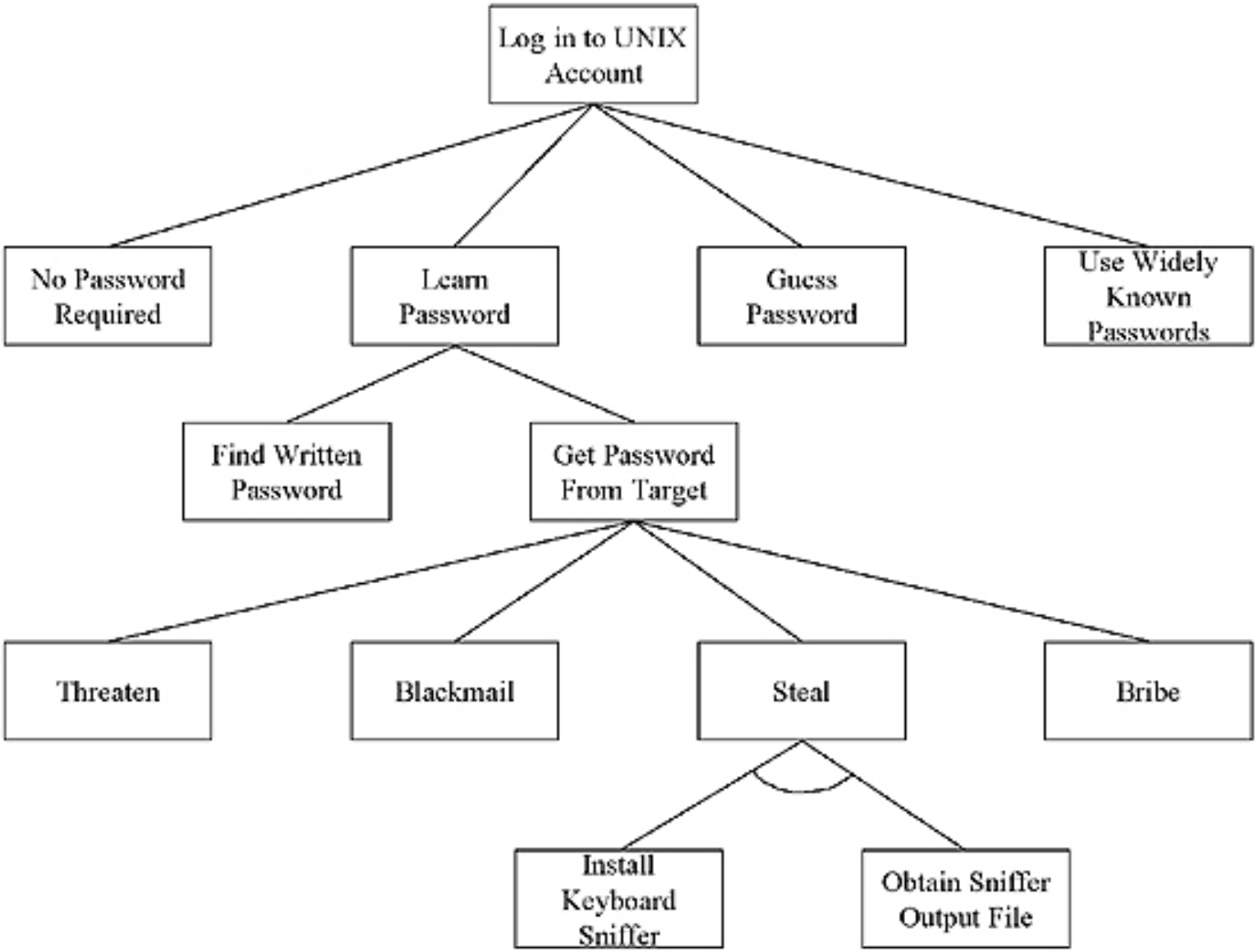
nodes can be labeled with probabilities or cost estimates



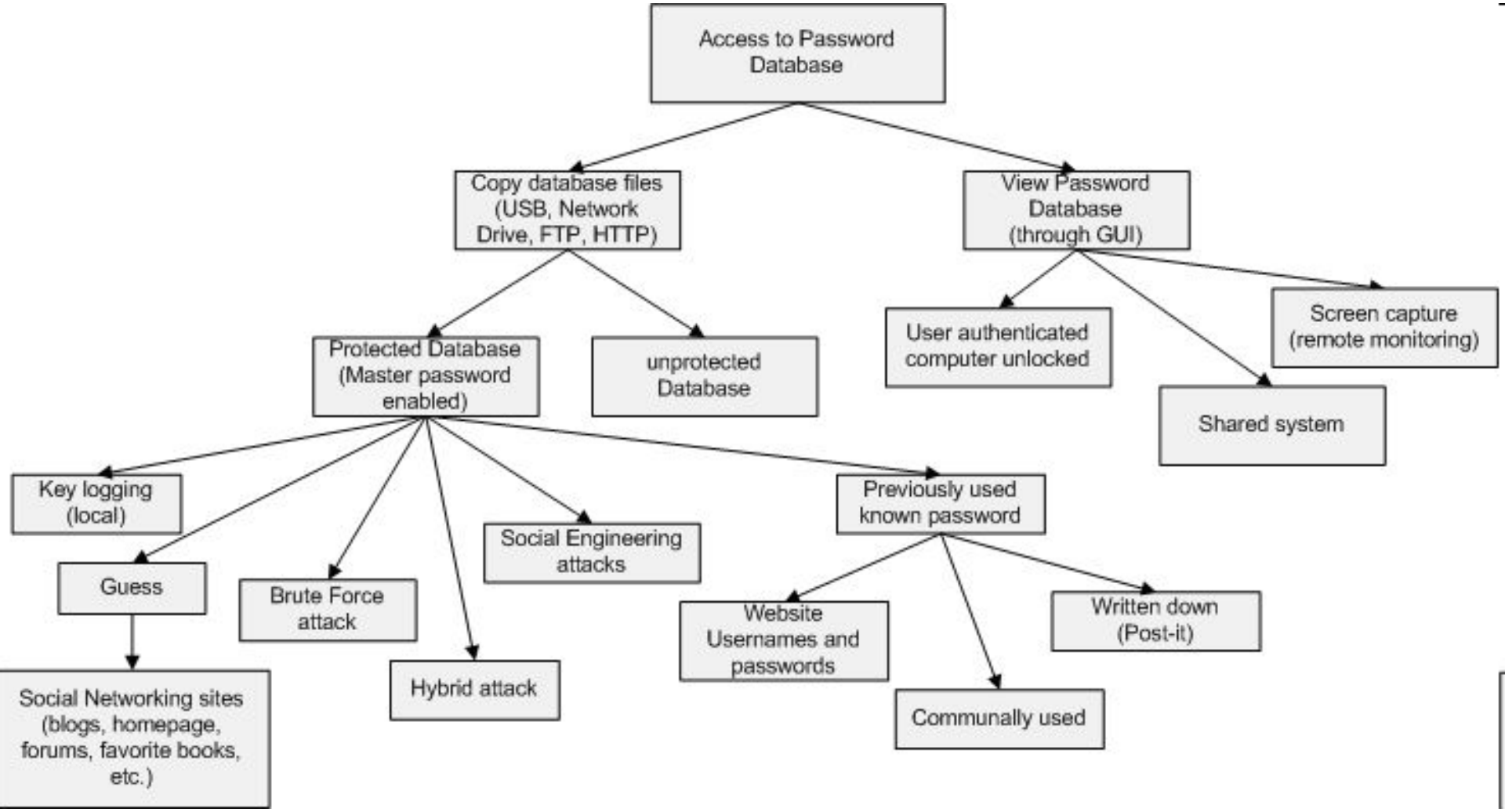
Expanded Example



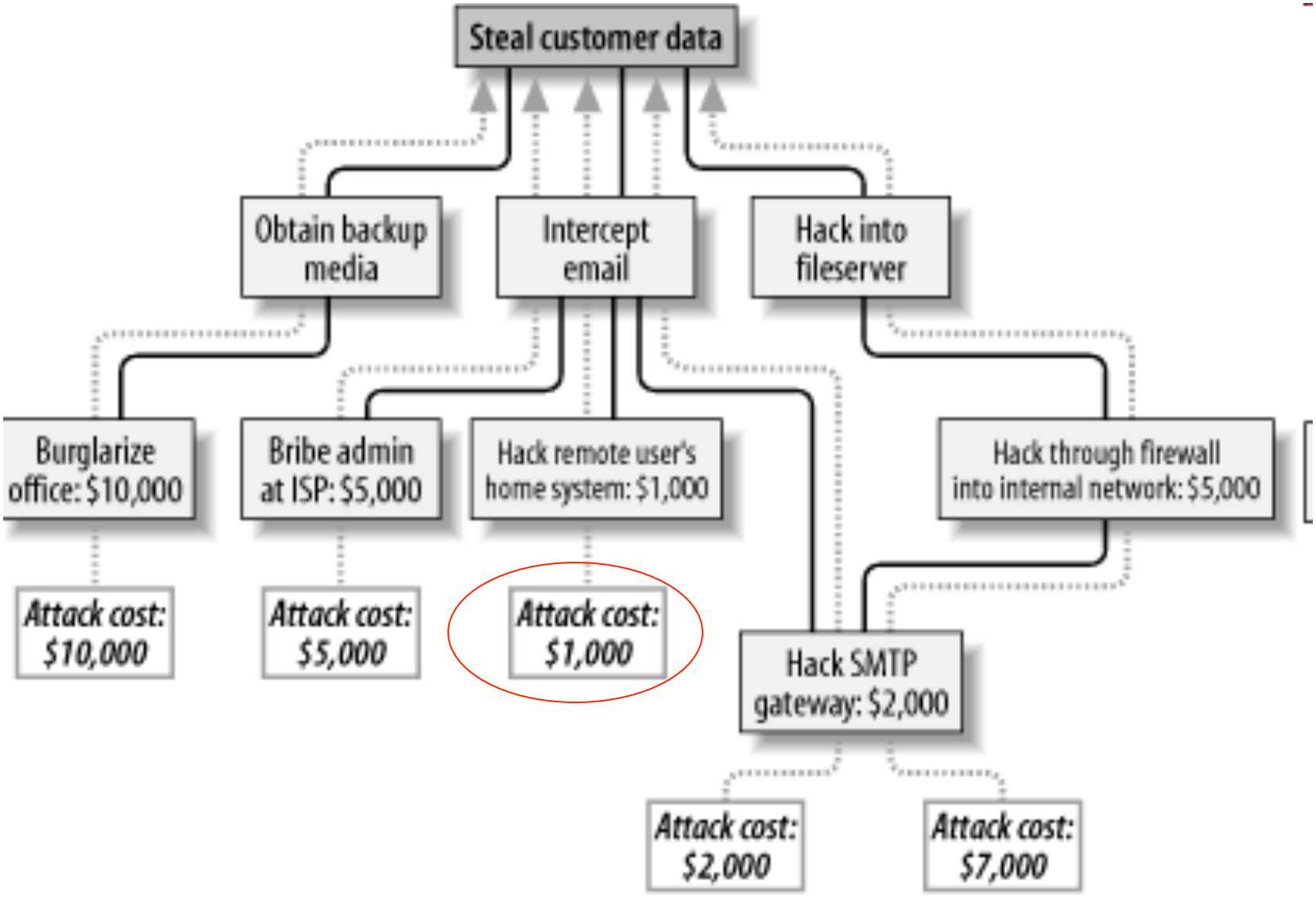
Unix Log In


Log in to UNIX Account
No Password Required
Learn Password
Guess Password
Use Widely Known Passwords
Find Written Password
Get Password From Target
Threaten
Blackmail
Steal
Bribe
Install Keyboard Sniffer
Obtain Sniffer Output File

Accessing Password Database



Stealing Data with Costs



Secrecy vs. Transparency

Open source vs. closed source

and security

Class brainstorm

Secrecy

Very frequently
an obvious
business decision

- Creates entry barriers for competitors
- But also defends against hackers

Kerckhoffs' principle (1883)

"The system must remain secure should it fall in enemy hands …"

"one ought to design systems under the assumption that the enemy will immediately gain full familiarity with them" reformulation by *Claude Shannon*

Kerckhoffs' principle (1883)

Most of the time: incorrectly understood

It doesn't mean that companies should disclose their designs

- Security when disclosed
- Better security when not disclosed

When is open source security good?

- Cryptography
  - AES, RSA, SHA256 etc, heavily tested, not yet broken
  - Compare closed-source crypto
    - Oyster card, car immobilisers, broken in months

Which model is better?

Open and closed security (if Kerckhoffs principle is followed) are more or less equivalent…

more or less as secure: opening the system helps both the attackers and the defenders

Ross Anderson: Open and Closed Systems are Equivalent (that is, in an ideal world). In Perspectives on Free and Open Source Software, MIT Press 2005, pp. 127-142

Ethics

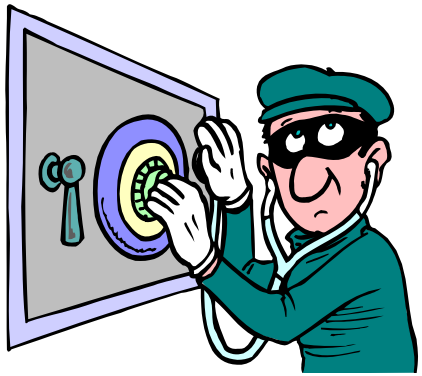
or should Karate classes be legal?

Key Question:

Is actively researching serious security vulnerabilities socially desirable?

- Of Course Yes!

…will tell you every professional hacker and every academic code-breaker…



Bruce Schneier [14 May 2008]:

Problem: A hacker who discovers one [attack] can sell it on the black market, blackmail the vendor with disclosure, or simply publish it without regard to the consequences

Q: […] is it ethical to research new vulnerabilities?

A: Unequivocally, yes. [according to Schneier]

Because:

- Vulnerability research is vital because it trains our next generation of computer security experts

http://www.schneier.com/blog/archives/2008/05/the_ethics_of_v.html

Responsible disclosure

Researchers should disclose vulnerabilities to the system owners, and give them "reasonable time" to fix them

especially if

…these vulnerabilities are likely to be rediscovered

Cf. E. Rescorla. "Is finding security holes a good idea?" In 3rd Workshop on the Economics of Information Security (2004)