https://crypto.stanford.edu/cs155

CS155

Computer Security

Course overview

Acknowledgments: Lecture slides are from the Computer Security course taught by Dan Boneh at Stanford University. When slides are obtained from other sources, a a reference will be noted on the bottom of that slide. A full list of references is provided on the last slide.

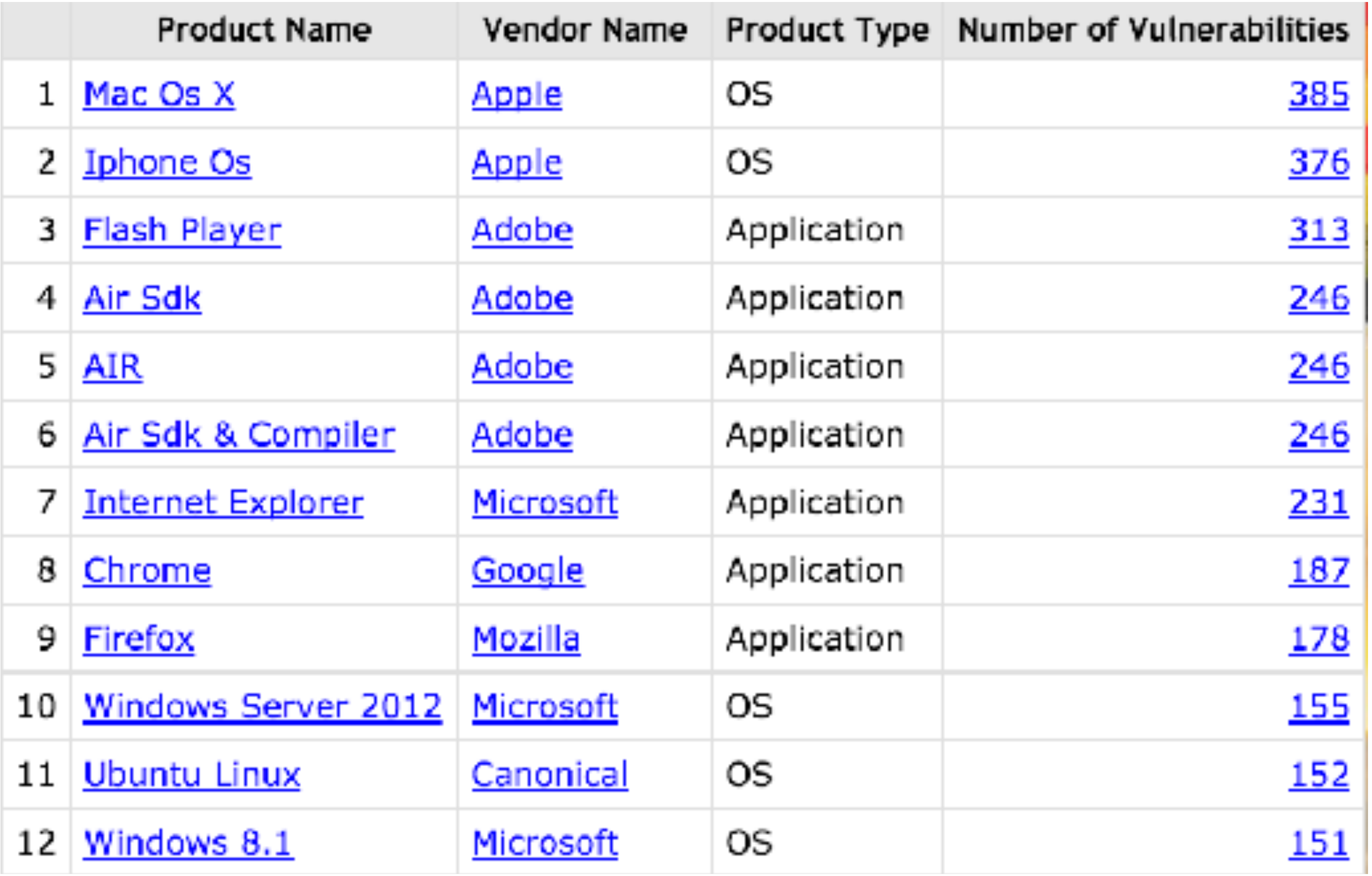
The computer security problem

- **Lots of buggy software**
- **Social engineering is very effective**
- **Money can be made from finding and exploiting vulns.**

1. Marketplace for vulnerabilities
2. Marketplace for owned machines (PPI)
3. Many methods to profit from owned machines

current state of computer security

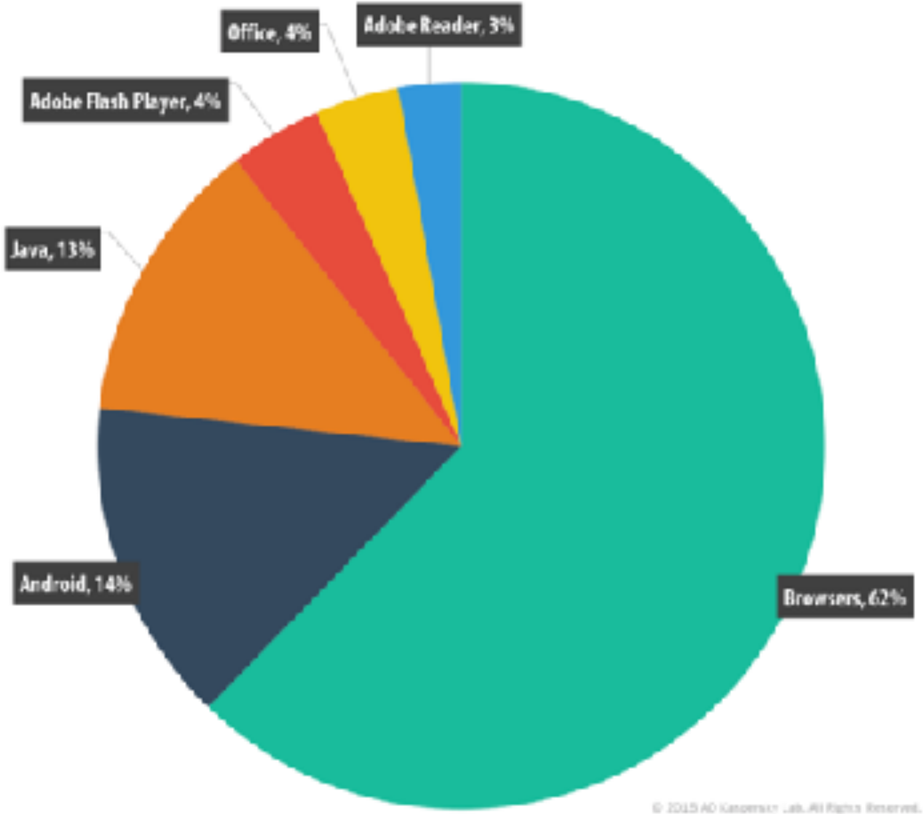
Lots of vulnerability disclosures (2015)



	Product Name	Vendor Name	Product Type	Number of Vulnerabilities
1	Mac Os X	Apple	OS	385
2	Iphone Os	Apple	OS	376
3	Flash Player	Adobe	Application	313
4	Air Sdk	Adobe	Application	246
5	AIR	Adobe	Application	246
6	Air Sdk & Compiler	Adobe	Application	246
7	Internet Explorer	Microsoft	Application	231
8	Chrome	Google	Application	187
9	Firefox	Mozilla	Application	178
10	Windows Server 2012	Microsoft	OS	155
11	Ubuntu Linux	Canonical	OS	152
12	Windows 8.1	Microsoft	OS	151

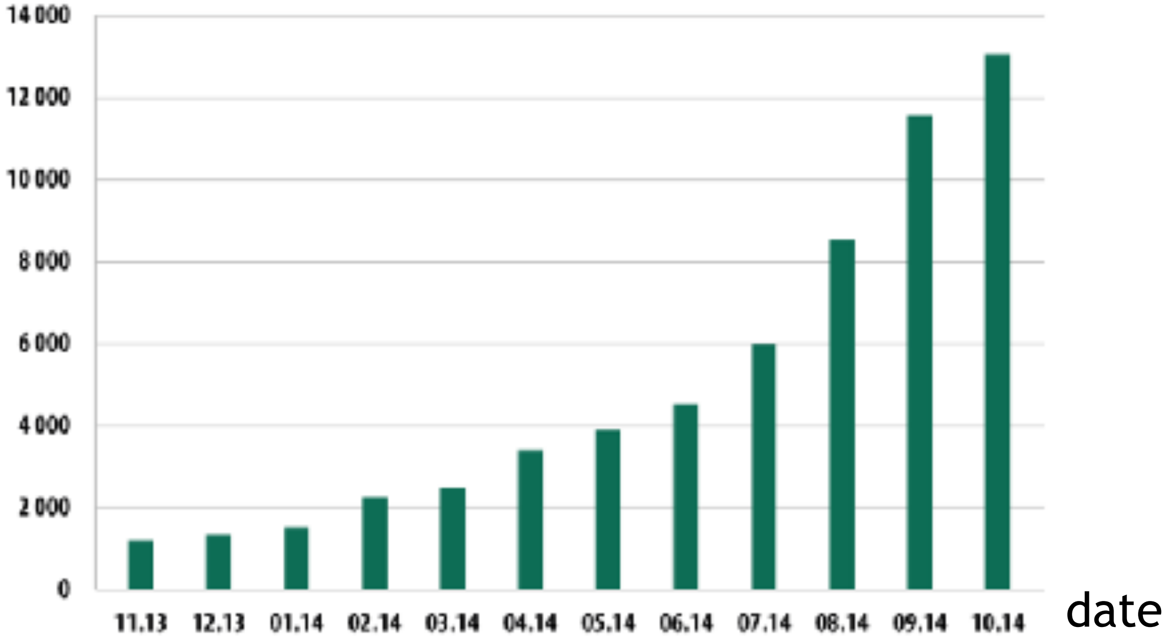
source: www.cvedetails.com/top-50-products.php?year=2015

Vulnerable applications being exploited



Source: Kaspersky Security Bulletin 2015

Mobile malware (Nov. 2013 – Oct. 2014)



The rise of mobile banking Trojans (Kaspersky Security Bulletin 201

Introduction

Sample attacks

Why own machines:

1. IP address and bandwidth stealing

Attacker’s goal: look like a random Internet user

Use the IP address of infected machine or phone for:

- **Spam** (e.g. the storm botnet)

  Spamalytics: 1:12M pharma spams leads to purchase
  1:260K greeting card spams leads to infection

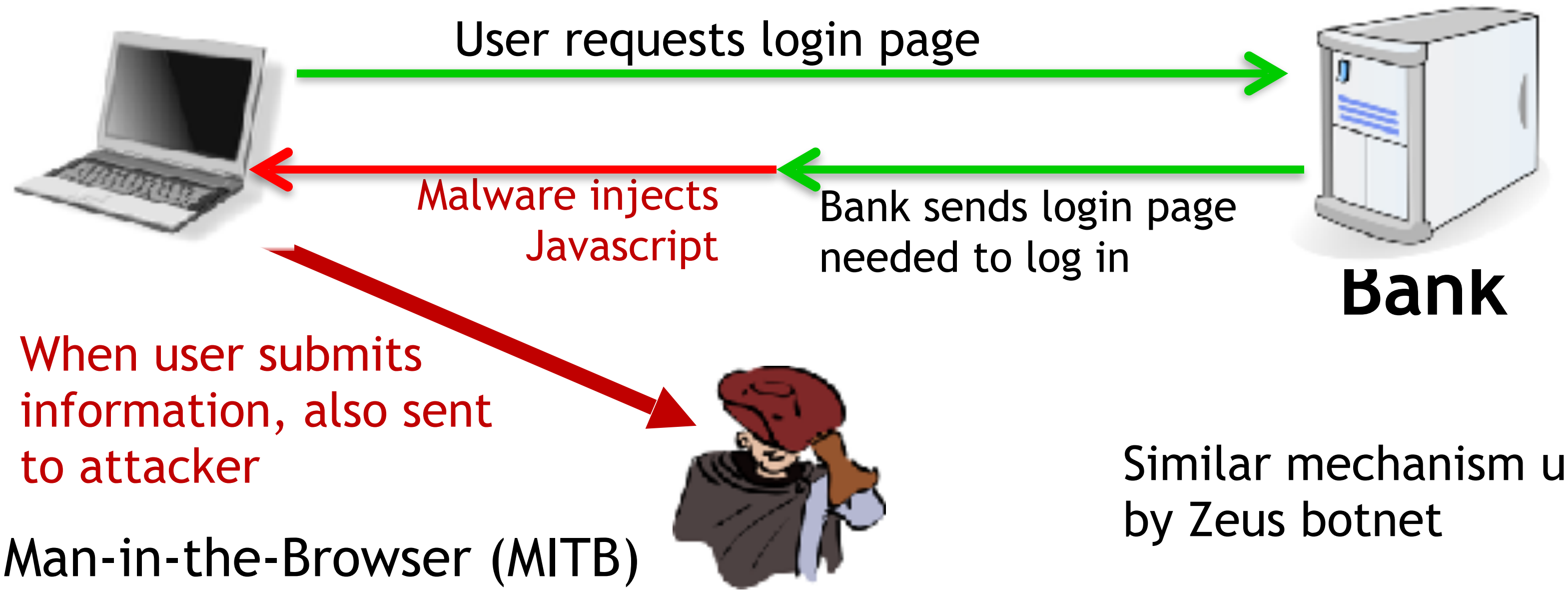
- **Denial of Service:** Services: 1 hour (20$), 24 hours (100$)

- **Click fraud** (e.g. Clickbot.a)

Why own machines:
2. Steal user credentials and inject ads

keylog for banking passwords, web passwords, gaming pwds.

Example: SilentBanker (and many like it)



User requests login page

Bank sends login page needed to log in

Malware injects Javascript

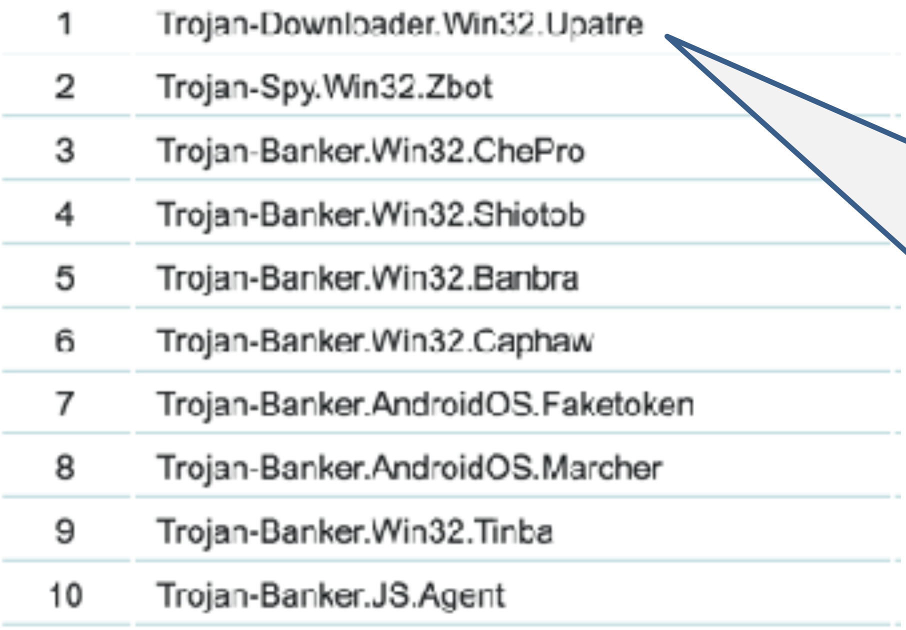
Bank

When user submits information, also sent to attacker

Man-in-the-Browser (MITB)

Similar mechanism used by Zeus botnet

Lots of financial malware

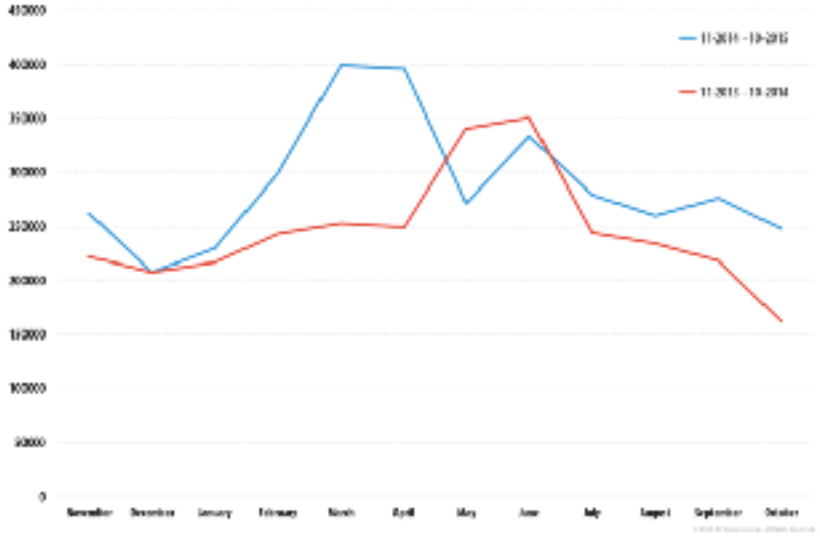


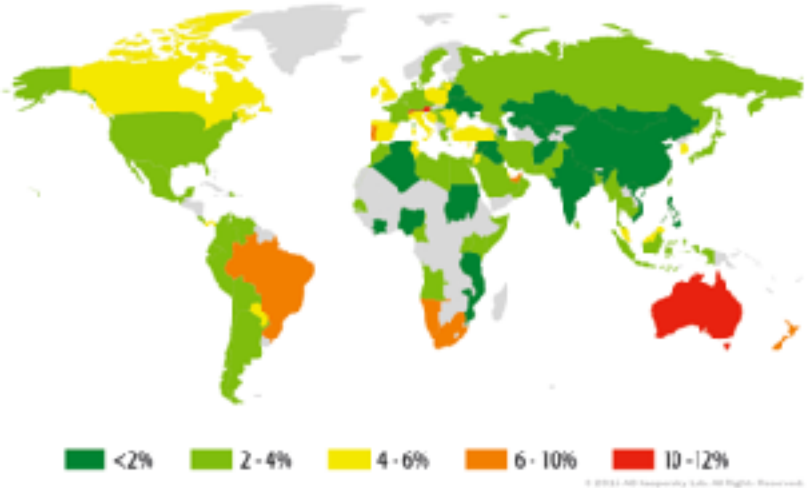
1	Trojan-Downloader.Win32.Upatre
2	Trojan-Spy.Win32.Zbot
3	Trojan-Banker.Win32.ChePro
4	Trojan-Banker.Win32.Shiotob
5	Trojan-Banker.Win32.Banbra
6	Trojan-Banker.Win32.Caphaw
7	Trojan-Banker.AndroidOS.Faketoken
8	Trojan-Banker.AndroidOS.Marcher
9	Trojan-Banker.Win32.Tinba
10	Trojan-Banker.JS.Agent

- size: 3.5 KB
- spread via email attachments
- also found on home routers

Source: Kaspersky Security Bulletin 2015

Users attacked: stats



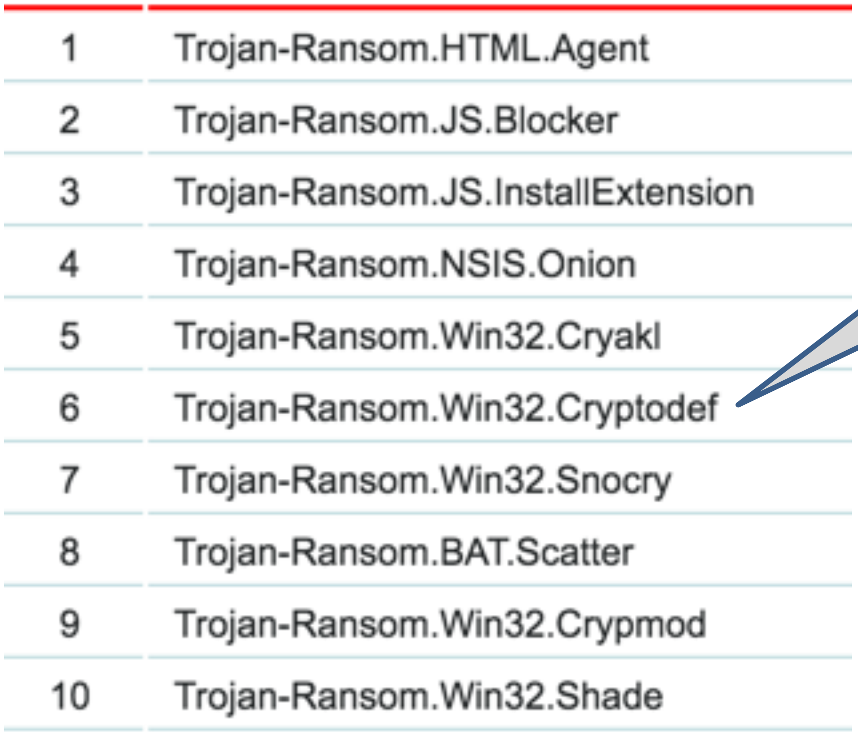


≈ 300,000 users worldwide

A worldwide problem

Source: Kaspersky Security Bulletin 2015

Why own machines: 3. **Ransomware**



1	Trojan-Ransom.HTML.Agent
2	Trojan-Ransom.JS.Blocker
3	Trojan-Ransom.JS.InstallExtension
4	Trojan-Ransom.NSIS.Onion
5	Trojan-Ransom.Win32.Cryakl
6	Trojan-Ransom.Win32.Cryptodef
7	Trojan-Ransom.Win32.Snocry
8	Trojan-Ransom.BAT.Scatter
9	Trojan-Ransom.Win32.Crypmod
10	Trojan-Ransom.Win32.Shade

CryptoWall (2014-)

- targets Windows
- spread by spam emails

≈ 200,000 machines in 2015

A worldwide problem.

Why own machines:
4. Spread to isolated systems

Example: **Stuxtnet**

Windows infection ⇒

Siemens PCS 7 SCADA control software on Windows ⇒

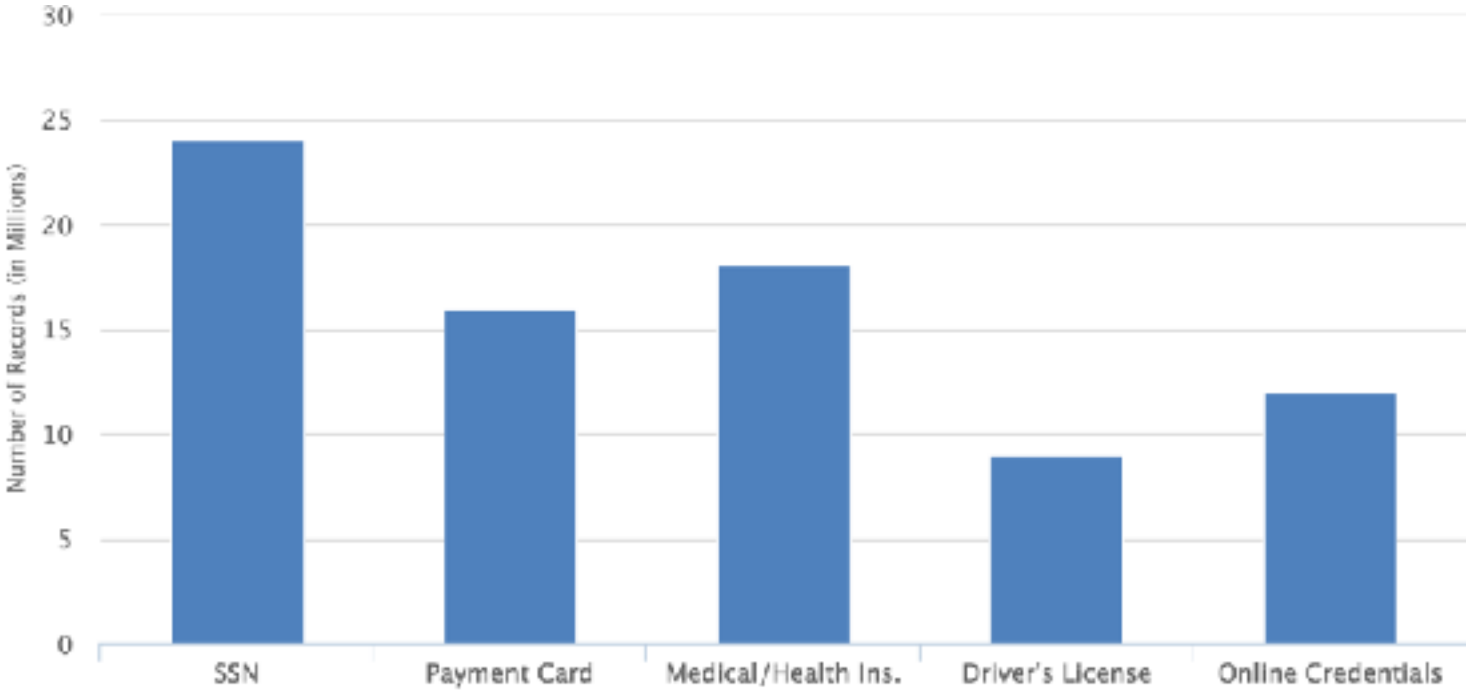
Siemens device controller on isolated network

More on this later in course

Server-side attacks

- Financial data theft: often credit card numbers
  - Example: Target attack (2013), ≈ 140M CC numbers stolen
  - Many similar (smaller) attacks since 2000
- Political motivation:
  - Aurora, Tunisia Facebook (Feb. 2011), GitHub (Mar. 2015)
- Infect visiting users

Types of data stolen (2012-2015)



Source: California breach notification report, 2015

Example: Mpack

- PHP-based tools installed on compromised web sites
  - Embedded as an iframe on infected page
  - Infects browsers that visit site

- Features
  - management console provides stats on infection rates
  - Sold for several 100$
  - Customer care can be purchased, one-year support contract

- Impact: 500,000 infected sites (compromised via SQL injection)
  - Several defenses: e.g. Google safe browsing

Insider attacks: example

Hidden trap door in Linux (nov 2003)

- Allows attacker to take over a computer
- Practically undetectable change (uncovered via CVS logs)

Inserted line in wait4()

```
if ((options == (__WCLONE|__WALL)) && (current->uid = 0))
            retval = -EINVAL;
```

Looks like a standard error check, but …

See: http://lwn.net/Articles/57135/

Many more examples

- Access to SIPRnet and a CD-RW: 260,000 cables ⇒ Wikileaks

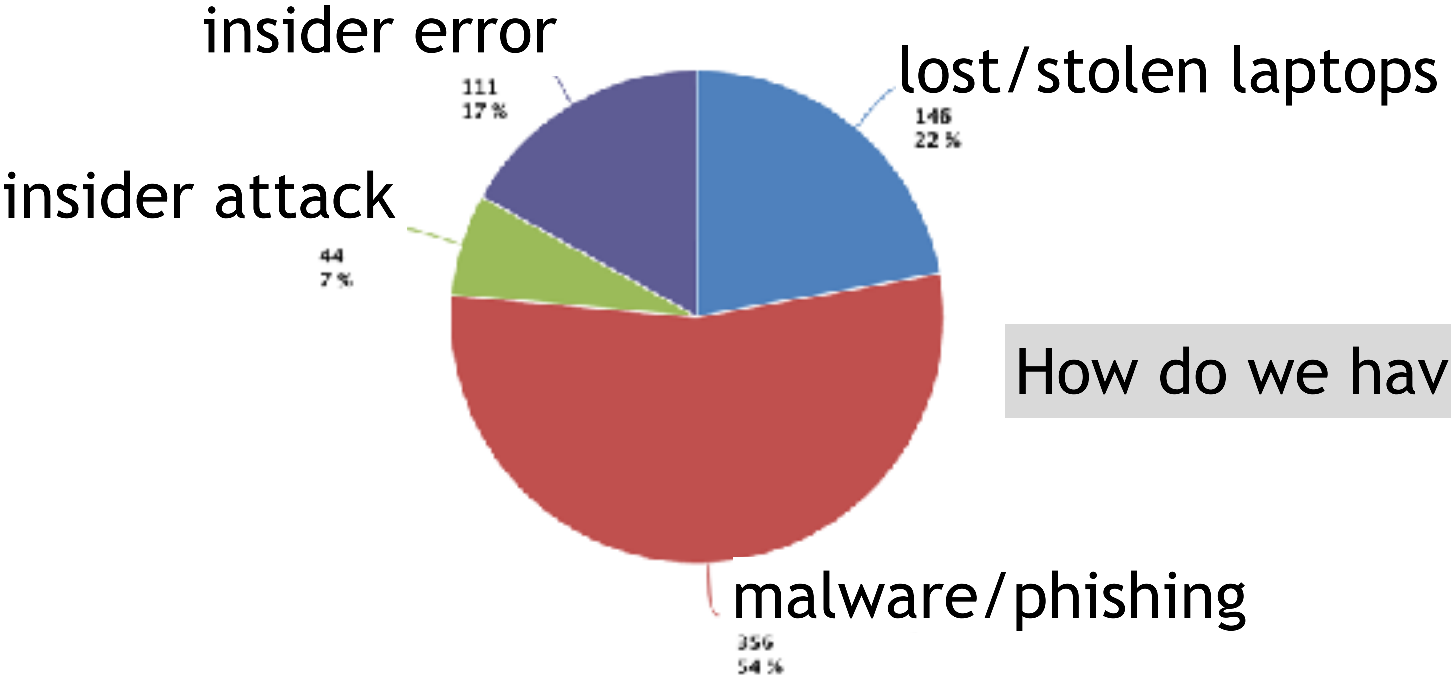
- SysAdmin for city of SF government.
  Changed passwords, locking out city from router access

- Inside logic bomb took down 2000 UBS servers

⋮

Can security technology help?

How companies lose data



How do we have this data?

Source: California breach notification report, 2015

Introduction

The Marketplace for Vulnerabilities

Marketplace for Vulnerabilities

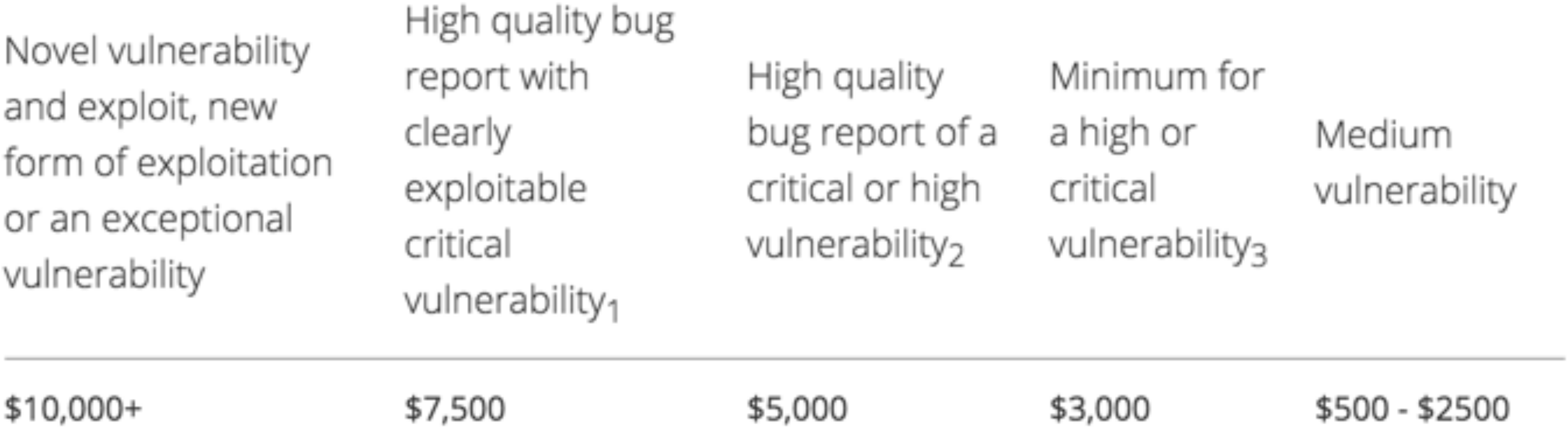
Option 1: bug bounty programs (many)

- Google Vulnerability Reward Program: up to $20K
- Microsoft Bounty Program: up to $100K
- Mozilla Bug Bounty program: $7500
- Pwn2Own competition: $15K

Option 2:

- Zero day initiative (ZDI), iDefense: $2K – $25K

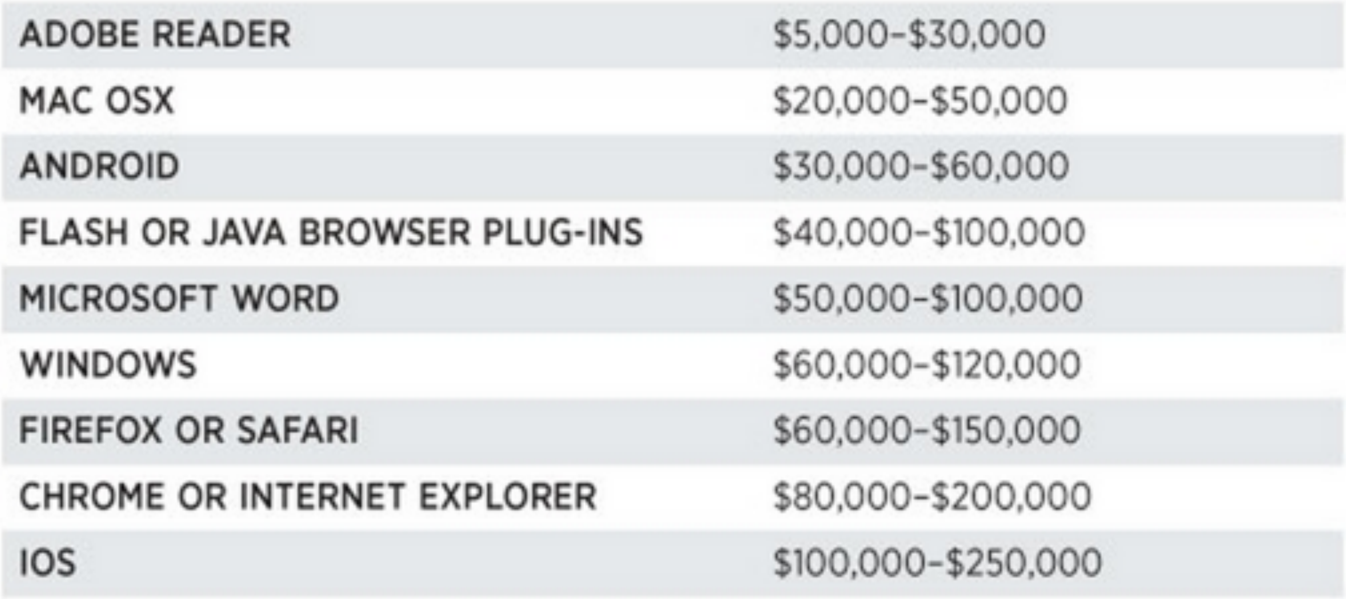
Example: Mozilla



Novel vulnerability and exploit, new form of exploitation or an exceptional vulnerability	High quality bug report with clearly exploitable critical vulnerability[1]	High quality bug report of a critical or high vulnerability[2]	Minimum for a high or critical vulnerability[3]	Medium vulnerability
$10,000+	$7,500	$5,000	$3,000	$500 - $2500

Marketplace for Vulnerabilities

Option 3: black market

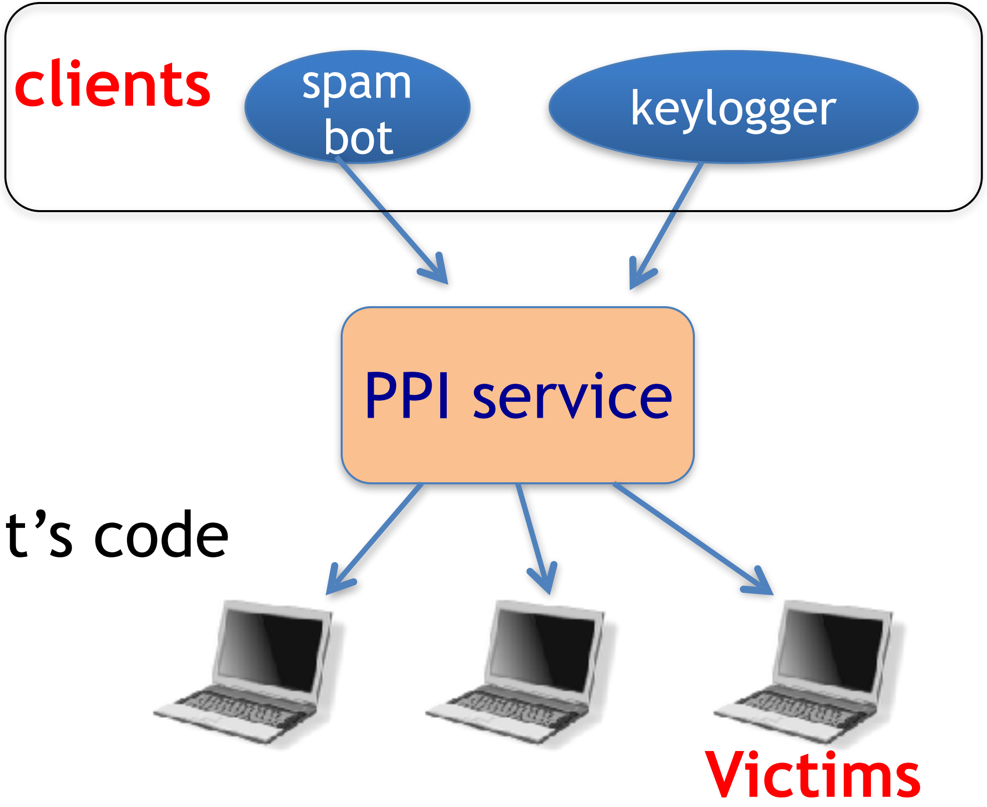


ADOBE READER	$5,000–$30,000
MAC OSX	$20,000–$50,000
ANDROID	$30,000–$60,000
FLASH OR JAVA BROWSER PLUG-INS	$40,000–$100,000
MICROSOFT WORD	$50,000–$100,000
WINDOWS	$60,000–$120,000
FIREFOX OR SAFARI	$60,000–$150,000
CHROME OR INTERNET EXPLORER	$80,000–$200,000
IOS	$100,000–$250,000

Source: Andy Greenberg (Forbes, 3/23/2012)

Marketplace for owned machines

Pay-per-install (PPI) services

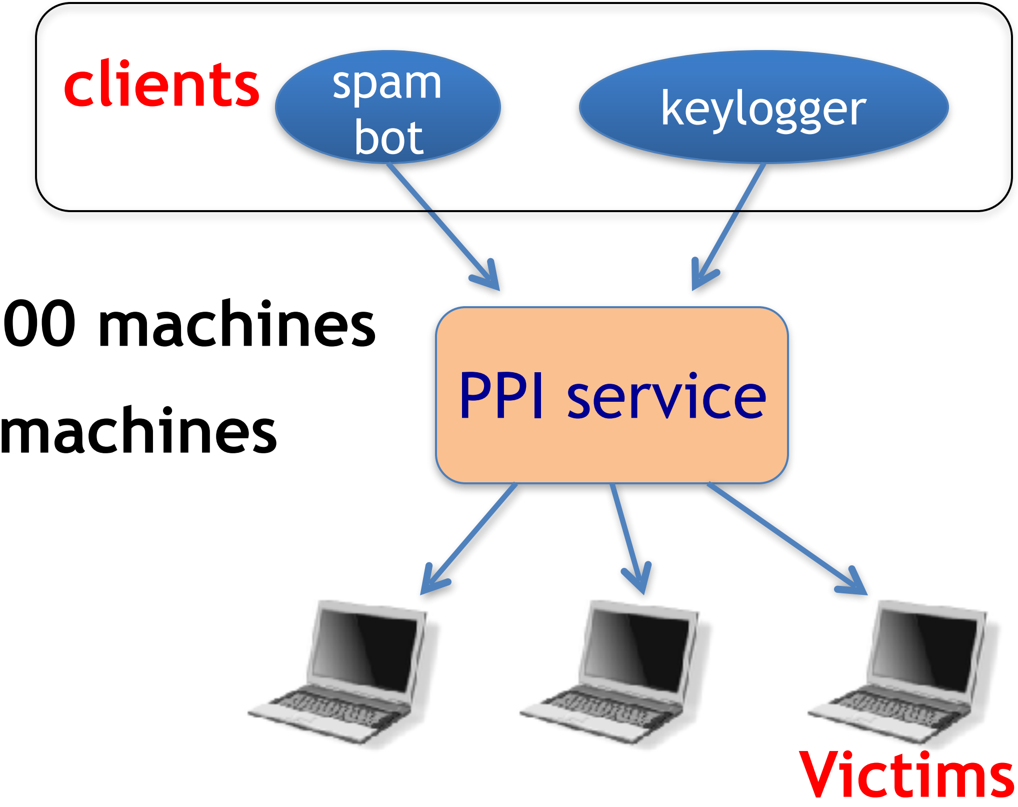


PPI operation:

1. Own victim's machine
2. Download and install client's code
3. Charge client

Source: Cabalerro et al. (www.icir.org/vern/papers/ppi-usesec11.pdf)

Marketplace for owned machines



Cost: **US - 100-180$ / 1000 machines**

Asia - 7-8$ / 1000 machines

Source: Cabalerro et al. (www.icir.org/vern/papers/ppi-usesec11.pdf)

This course

Goals:

- Be aware of exploit techniques
- Learn to defend and avoid common exploits
- Learn to architect secure systems

This course

Part 1: **basics** (architecting for security)

- Securing apps, OS, and legacy code
  Isolation, authentication, and access control

Part 2: **Web security** (defending against a web attacker)

- Building robust web sites, understand the browser security model

Part 3: **network security** (defending against a network attacker)

- Monitoring and architecting secure networks.

Part 4: **securing mobile applications**

Don’t try this at home !

Ken Thompson’s clever Trojan