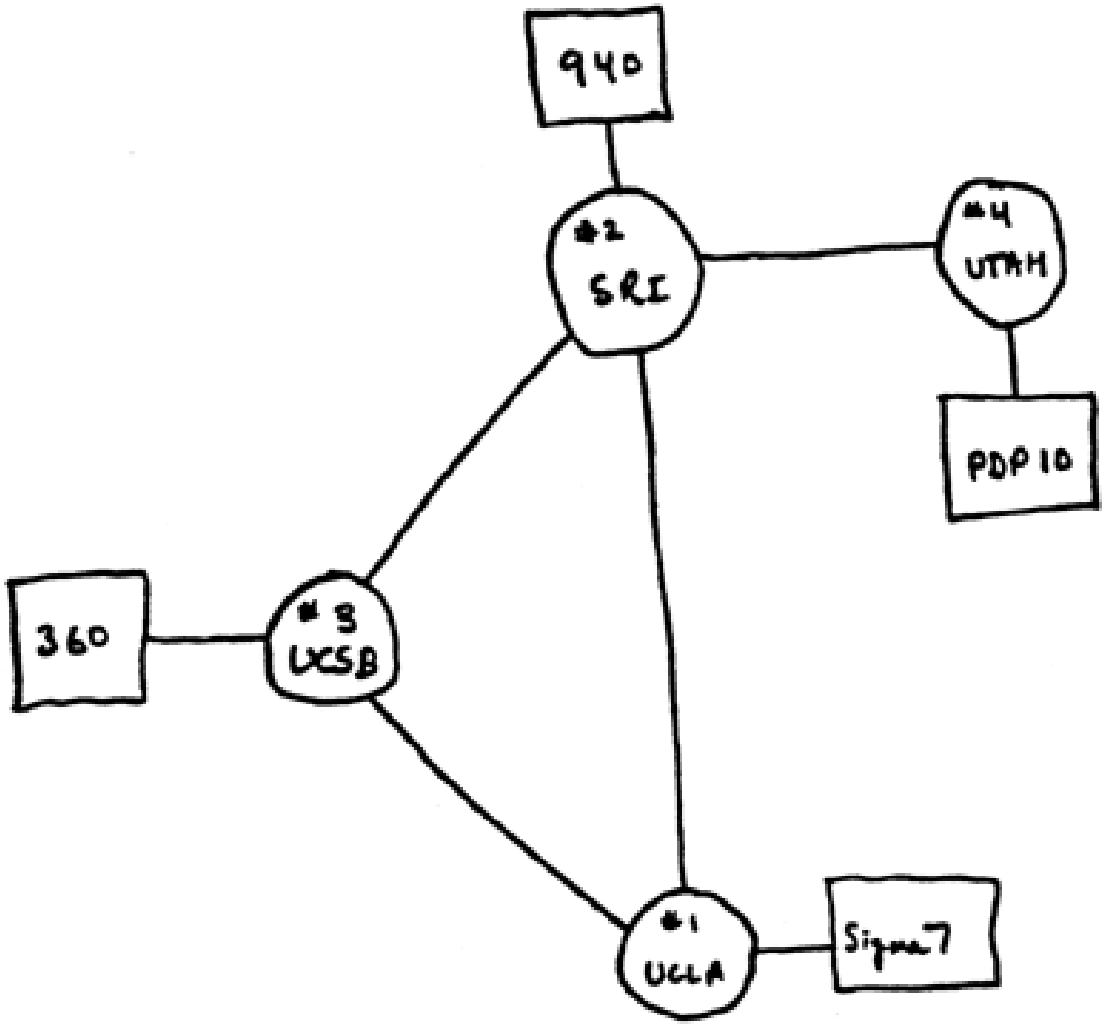
CSE508 Network Security

1/25/2016 **Introduction and Basic Concepts**

Michalis Polychronakis

Stony Brook University

Why care about network security?



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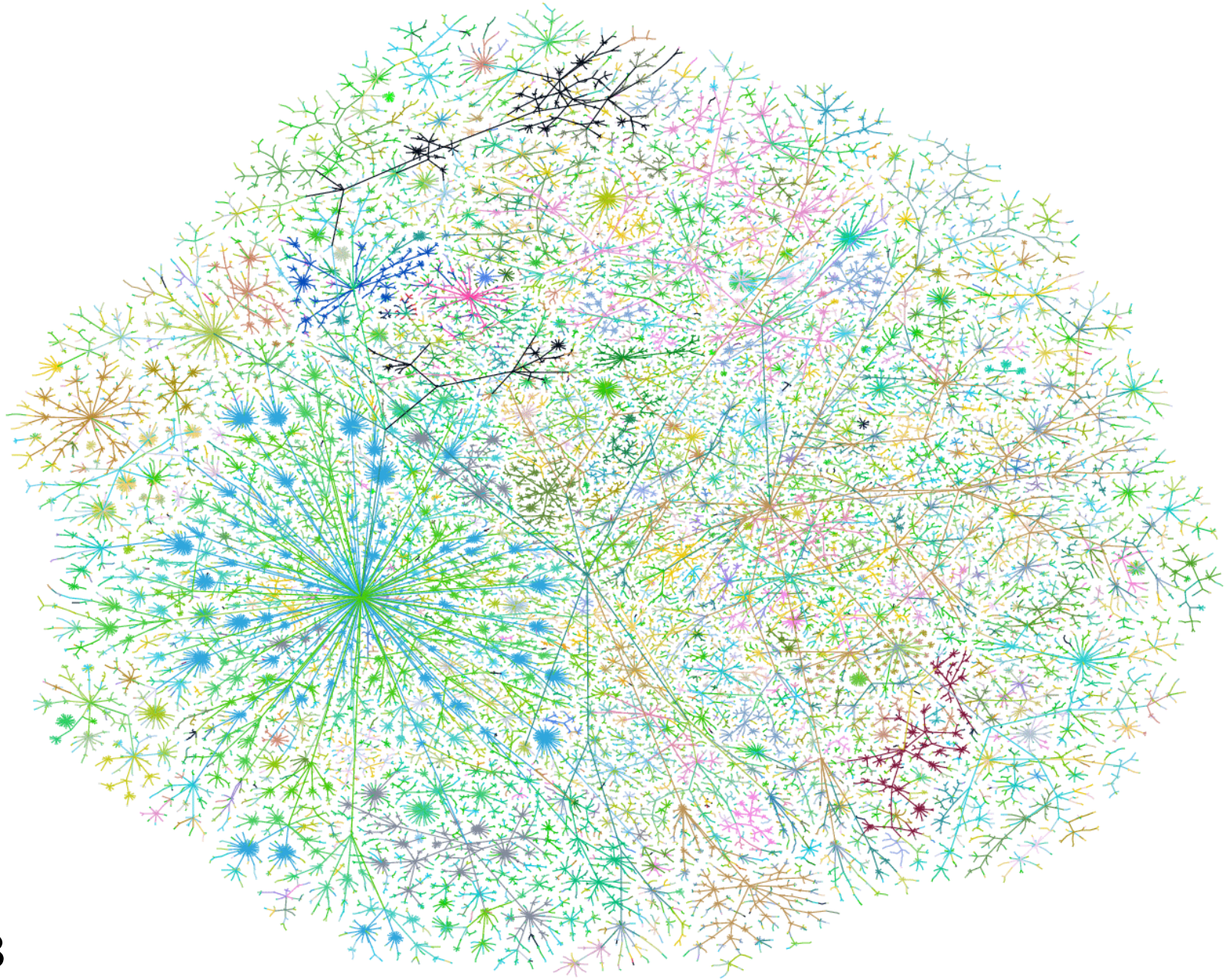

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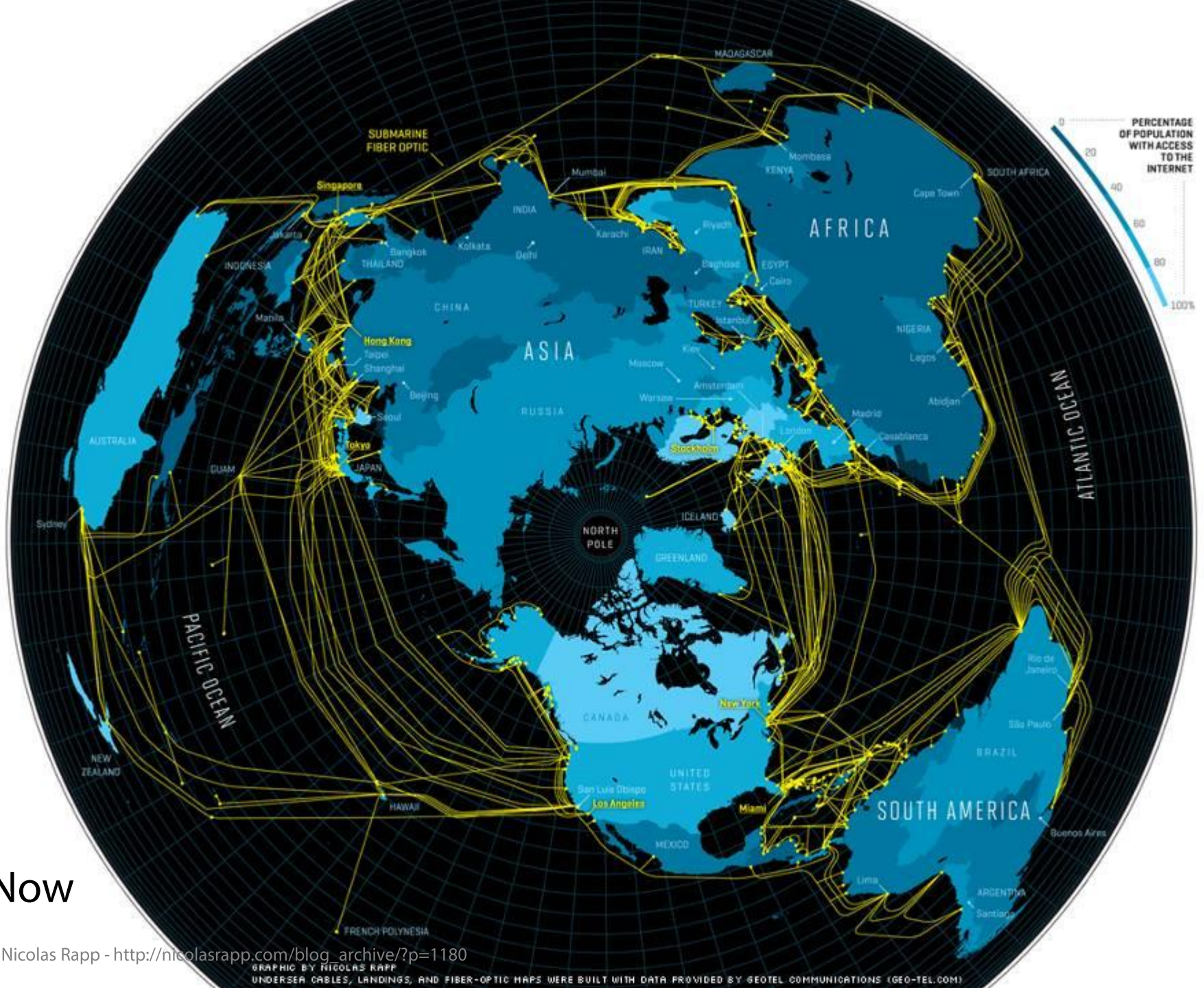

Now

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An increasing part of our business, social, and personal life involves the internet

- Web, email/IM, cloud, social networks, entertainment, …
- Mobile computing
- Cyber-physical systems
- Internet of things

Protecting the security and privacy of our digital interactions is critical

- Most of them involve *networked systems and applications*

UPDATE 2-Home Depot breach bigger than Target at 56 mln cards

Thu Sep 18, 2014 7:12pm EDT

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(Recasts, adds details about costs of breach and likelihood of costs rising, comment from computer security experts, background)

By Jim Finkle and Nandita Bose

(Reuters) - Home Depot Inc Thursday said some 56 million payment cards were likely compromised in a cyberattack at its stores, suggesting the hacking attack at the home improvement chain was larger than last year's unprecedented breach at Target Corp.

Home Depot, in providing the first clues to how much the breach would cost, said that so far it has estimated costs of $62 million. But it indicated that costs could reach much higher.

It will take months to determine the full scope of the fraud, which affected Home Depot stores in both the United States and Canada

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Maggie McGrath Forbes Staff

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JP Morgan Says 76 Million Households Affected By Data Breach

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JPMorgan Chase JPM -2.58%, the nation's largest bank by assets, has revealed the scope of the cyber-attack that compromised its data in mid-August. And while the number of households affected doesn't surpass the 110 million accounts that were compromised in the Target TGT -0.67% data breach in late 2013, it does comprise more than half of all U.S. households.

JPMorgan said in an SEC filing Thursday afternoon that information from 76 million households — the equivalent of 65% of all U.S. households — and 7 million small businesses was compromised in the August cyber-security attack

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BUSINESS DAY

Millions of Anthem Customers Targeted in Cyberattack

By REED ABELSON and MATTHEW GOLDSTEIN FEB. 5, 2015

Outside the Anthem facility in Indianapolis. Anthem said it detected a data breach on Jan. 29, and that it was working with the Federal Bureau of Investigation. Aaron P. Bernstein/Getty Images

Anthem, one of the nation's largest health insurers, said late

Hacking of Government Computers Exposed 21.5 Million People

By JULIE HIRSCHFELD DAVIS JULY 9, 2015

Katherine Archuleta, director of the Office of Personnel Management, right, at hearing before the House Oversight and Government Reform Committee last month. Mark Wilson/Getty Images

Email

WASHINGTON — The Obama administration on Thursday revealed that 21.5 million people were swept up in a colossal breach of government computer systems that was far more damaging than

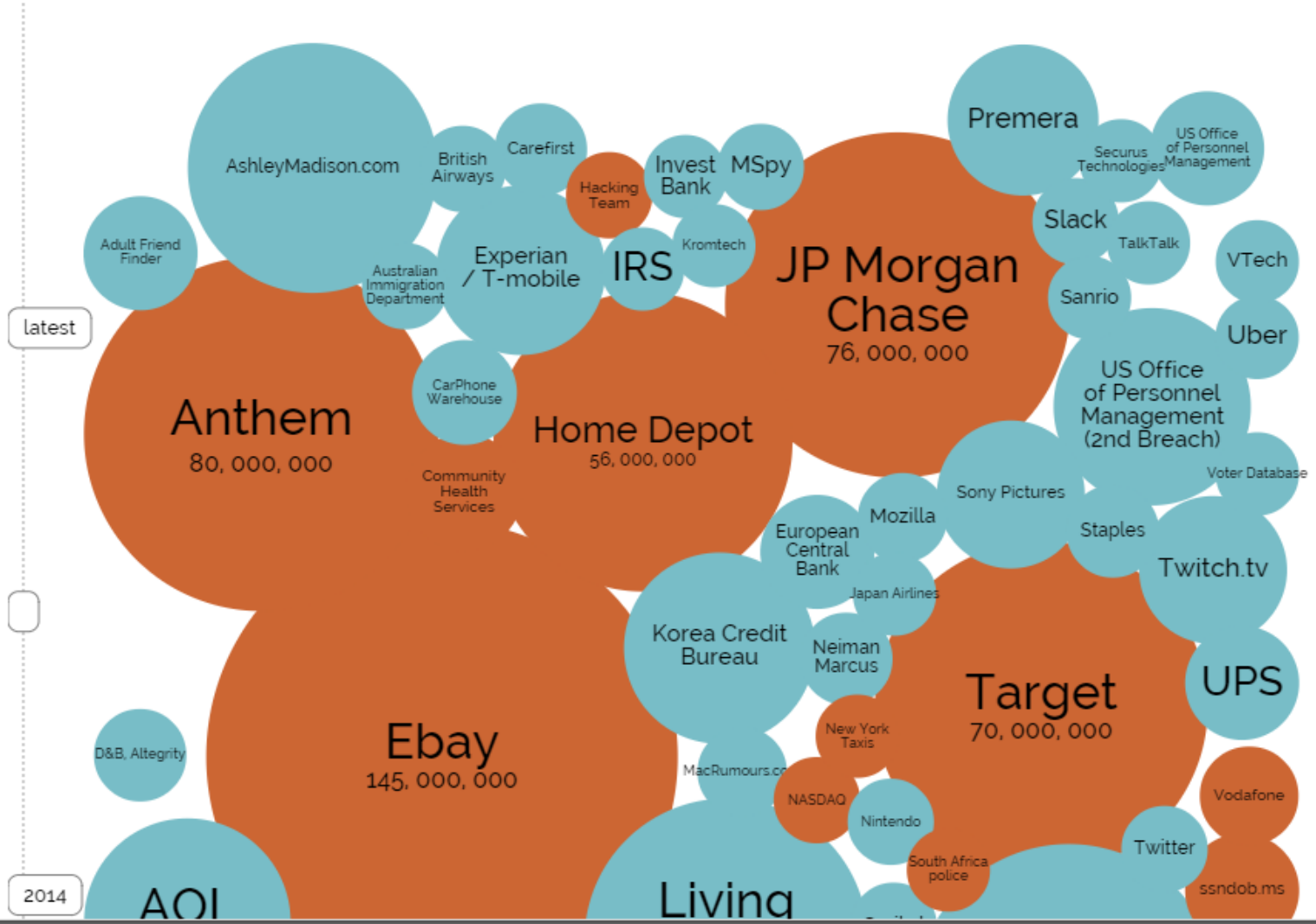
World's Biggest Data Breaches

Selected losses greater than 30,000 records

(updated 2nd October 2015)

interesting story

YEAR | BUBBLE COLOUR: YEAR | METHOD OF LEAK | BUBBLE SIZE: NO OF RECORDS STOLEN | DATA SENSITIVITY | SHOW FILTER



Hackers ground 1,400 passengers at Warsaw in attack on airline's computers

Polish state-owned airline LOT suffers hacking assault on ground systems that causes 10 national and international flights to be cancelled

At no point was the safety of ongoing flights compromised, said a spokesman for LOT Polish airlines. Photograph: East News/REX Shutterstock

Reuters

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Cybercrime

Ukrainian blackout caused by hackers that attacked media company, researchers say

Power company suffered a major attack that led to blackouts across western Ukraine, after an attack on a Ukrainian media company

Alex Hern
@alexhern

Thursday 7 January 2016
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Smokestacks in Dniprodzershynsk, Ukraine. Photograph: John Mcconnico/AP

A power blackout in Ukraine over Christmas and a destructive cyberattack on a major Ukrainian media company were caused by the same malware from the same major hacking group, known as Sandworm, according to security researchers at Symantec.

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Alexander Litvinenko: the man who solved his

Malware

International Space Station attacked by 'virus epidemics'

Malware spread from infected devices in orbit, proving not even computers in space are safe from viruses

Featured comment

In space, no one can see your blue screen.

alanredangel
12 Nov 2013

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An Unprecedented Look at Stuxnet, the World's First Digital Weapon

BY KIM ZETTER 11.03.14 | 6:30 AM | PERMALINK

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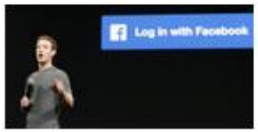

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Hackers Exploit 'Flash' Vulnerability in Yahoo Ads

By DINO GRANDONI AUGUST 3, 2015 9:14 PM 51 Comments

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For seven days, hackers used Yahoo's ad network to send malicious bits of code to computers that visit Yahoo's collection of heavily trafficked websites, the company said on Monday.

The attack, which started on July 28, was the latest in a string that have exploited Internet advertising networks, which are designed to reach millions of people online. It also highlighted growing anxiety over a much-used graphics program called Adobe Flash, which has a history of security issues that have irked developers at Silicon Valley companies.

"Right now, the bad guys are really enjoying this," said Jérôme Segura, a security researcher at Malwarebytes, the security company that uncovered the attack. "Flash for them was a godsend."

The scheme, which Yahoo shut down on Monday, worked like this: A group of hackers bought ads across the Internet giant's sports, news and finance sites. When a computer — in this case, one running Windows — visited a Yahoo site, it downloaded malware code.

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SECURITY

Apple Says It Will Add New iCloud Security Measures After Celebrity Hack

By BRIAN X. CHEN SEPTEMBER 4, 2014 11:32 PM 21 Comments

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NEW YORKER | His name, writes Tim Wu, is Ted Sarandos. - *Natasha Singer*

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Armed With Facebook 'Likes' Alone, Researchers Can Tell Your Race, Gender, and Sexual Orientation

REBECCA J. ROSEN | MAR 12 2013, 2:59 PM ET

But the deeper aspects of your personality remain hard to detect.

VIDEO

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A Canadian inventor believes his tornado machine could solve the world's energy crisis.

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Attention, Shoppers: Store Is Tracking Your Cell

By STEPHANIE CLIFFORD and QUENTIN HARDY JULY 14, 2013

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Like dozens of other brick-and-mortar retailers, Nordstrom wanted to learn more about its customers — how many came through the doors, how many were repeat visitors — the kind of information that e-commerce sites like Amazon have in spades. So last fall the company started testing new technology that allowed it to track customers' movements by following the Wi-Fi signals from their smartphones.

Brick-and-mortar stores are looking for a chance to catch up with their online competitors by using software that allows them to watch customers as they shop, and gather data about their behavior. Video by Erica Berenstein on July 14, 2013.

But when Nordstrom posted a sign telling customers it was tracking them, shoppers were unnerved.

"We did hear some complaints," said Tara Darrow, a spokeswoman for the store. Nordstrom ended the experiment in May, she said, in part because of the comments.

Nordstrom's experiment is part of a movement by retailers to gather data about in-store shoppers' behavior and moods, using video surveillance and signals from their cellphones and apps to learn

AT&T charges $29 more for gigabit fiber that doesn't watch your Web browsing

AT&T goes head to head against Google in KC on fiber and targeted ads.

by Jon Brodkin - Feb 16, 2015 12:38pm EST

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AT&T

AT&T's gigabit fiber-to-the-home service has just arrived in Kansas City, and the price is the same as Google Fiber—if you let AT&T track your Web browsing history.

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Battlefield Hardline review: an odd, cops-and-robbers facade

New twists on old formula help in multiplayer, baffle in single player.

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Dragnets
Tracking Censorship and Surveillance

18
15

Verizon's Zombie Cookie Gets New Life

Verizon is merging its cellphone tracking supercookie with AOL's ad tracking network to match users' online habits with their offline details.

by Julia Angwin and Jeff Larson
ProPublica, Oct. 6, 2015, 1:15 p.m.

15 Comments | Print

This is part of an ongoing investigation:

Dragnets
ProPublica investigates the threats to privacy in an era of cellphones, data mining and cyberwar.

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Dell does a Superfish, ships PCs with easily cloneable root certificates

Root certificate debacle that hit Lenovo now visits the House of Dell.

by Dan Goodin - Nov 23, 2015 12:40pm EST

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Reboots, remakes, and sequels need not apply—Ars' most anticipated games of 2016

Only original ideas allowed in this selection of upcoming titles.

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"Unauthorized code" in Juniper firewalls decrypts encrypted VPN traffic

Backdoor in NetScreen firewalls gives attackers admin access, VPN decrypt ability.

by Dan Goodin - Dec 17, 2015 6:50pm EST

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An operating system used to manage firewalls sold by Juniper Networks contains unauthorized code that surreptitiously decrypts traffic sent through virtual private networks, officials from the company warned Thursday.

It's not clear how the code got there or how long it has been there. An advisory published by the company said that NetScreen firewalls using ScreenOS 6.2.0r15 through 6.2.0r18 and 6.3.0r12 through 6.3.0r20 are affected and require immediate patching. Release notes published by Juniper suggest the earliest vulnerable versions date back to at least 2012 and possibly earlier. There's no evidence right now that the backdoor was put in other Juniper OSes or devices.

"During a recent internal code review, Juniper discovered unauthorized code in ScreenOS that could allow a knowledgeable attacker to gain administrative access to NetScreen devices and to decrypt VPN connections," Juniper Chief Information officer Bob Worrall wrote. "Once we identified these vulnerabilities, we launched an investigation into the matter, and worked to develop and issue patched releases for the latest versions of ScreenOS."

A separate advisory from Juniper says there are two separate vulnerabilities, but stops short of describing either as "unauthorized code." The first flaw allows unauthorized remote administrative

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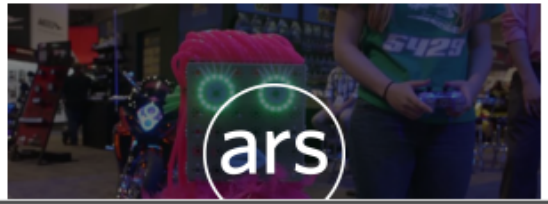

Secret SSH backdoor in Fortinet hardware found in more products

Company warns customers to remove undocumented authentication feature ASAP.

by Dan Goodin - Jan 22, 2016 3:30pm EST

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A recently identified backdoor in hardware sold by security company Fortinet has been found in several new products, many that were running current software, the company warned this week.

The undocumented account with a hard-coded password came to light last week when attack code exploiting the backdoor was posted online. In response, Fortinet officials said it affected only older versions of Fortinet's FortiOS software. The company went on to say the undocumented method for logging into servers using the secure shell (SSH) protocol was a "remote management" feature that had been removed in July 2014.

In a blog post published this week, Fortinet revised the statement to say the backdoor was still active in several current company products, including some versions of its FortiSwitch, FortiAnalyzer, and FortiCache devices. The company said it made the discovery after conducting a review of its products. Company officials wrote:

FURTHER READING

ET TU, FORTINET? HARD-CODED PASSWORD RAISES NEW BACKDOOR EAVESDROPPING FEARS

Discovery comes a month after competitor Juniper disclosed unauthorized code.

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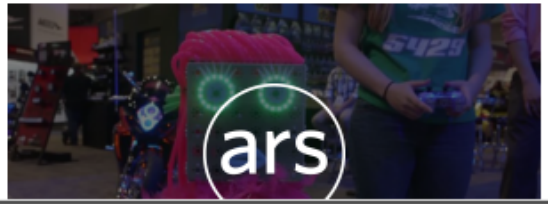

French agency caught minting SSL certificates impersonating Google

Unauthorized credentials for Google sites were accepted by many browsers.

by Dan Goodin - Dec 9 2013, 2:05pm EST

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Want high-end flight sim pedals? Put $500 in a Polish bank account and contact Slaw

Review: "Wait—$500 for *just* the Slaw Device BF 109?" Well, yes, but what pedals!

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FBI Admits It Controlled Tor Servers Behind Mass Malware Attack

BY KEVIN POULSEN 09.13.13 | 4:17 PM | PERMALINK

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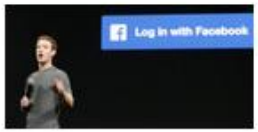

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Network vs. System vs. Computer vs. Information Security

Not always a clear distinction

- Infrastructure
- Protocols
- Applications
- Hosts/devices

Complex interactions

- Core internet protocols/services
- Distributed systems
- Web/cloud applications

There is more

- People
- Physical security

Threats span all these areas

Network Security Arsenal

Cryptography

Wide range of techniques for enabling secure communication

Access Control

Authentication and authorization, firewalls, …

Monitoring

Packet/flow monitoring, intrusion detection, …

Rigorous protocol and system design/implementation

Account for both benign failures and malicious actions
Data corruption, timeouts, dead hosts, routing problems, …
Eavesdropping, modification, injection, deletion, replay, …

Software bugs in network applications turn into **vulnerabilities**

Threats

Exposure of data

Tampering with data

Denial of service

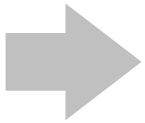
Impersonation

Forbidden access

Exposure of information about individuals

Identification of unknown individuals

Threats	Goals
Exposure of data	Confidentiality
Tampering with data	Integrity
Denial of service	Availability
Impersonation	Authentication
Forbidden access	Authorization
Exposure of information about individuals	Privacy
Identification of unknown individuals	Anonymity



Confidentiality

"The property that information is not made available or disclosed to unauthorized individuals, entities, or processes [i.e., to any unauthorized system entity]." [RFC2828]

Sensitive data must be protected

- In transit: network packets, network connections, email messages, document files, …
- At rest: main memory (buffers, message queues), storage, …

Cryptography is a tool to achieve confidentiality

- Not the only one (e.g., steganography)

Content protection is often not enough

- Data vs. metadata (e.g., phone call content vs. records)

Data Integrity

"The property that data has not been changed, destroyed, or lost in an unauthorized or accidental manner." [RFC2828]

Cryptography is a tool to achieve data integrity

- Intentional or accidental data changes should be detectable

System integrity

"Attribute of an information system when it performs its intended function in an unimpaired manner, free from deliberate or inadvertent unauthorized manipulation of the system." [CNSSI No. 4009]

- Fragile: weak authentication, unauthorized access, …

Availability

"The property of being accessible and useable upon demand by an authorized entity." [CNSSI No. 4009]

Denial of Service (DoS) attacks are the most common way of affecting the availability of networked systems

- Saturation of resources (bandwidth, CPU, memory, …)
- Disruption of configuration or state (routing, DNS, …)
- Jamming, physical damage, …

Malware can do more harm

- Ransomware: encrypt user files and then demand a ransom (Gpcode, cryptolocker, …)
- Just wipe out data/brick the system (Wiper, SMB worm, …)

Authentication

"The process of verifying an identity claimed by or for a system entity." [RFC2828]

Different approaches

- Something you know (password, pin, …)
- Something you have (phone, token, …)
- Something you are (fingerprint, retina, …)

Multi-factor authentication is a good thing!

Cryptography is a tool to achieve authentication

Password theft/leakage is a huge problem

Authorization

"Access privileges granted to a user, program, or process or the act of granting those privileges." [CNSSI No. 4009]

Authorization verifies that a user has the proper privileges to access a resource (presumes successful authentication)

Related term: access control

Access restriction based on various properties: identity, role, labels, date/time, IP address, domain, access frequency, …

One of the core goals of network security:

Keep unauthorized parties from gaining access to resources

Privacy

"The right of an entity (normally a person), acting in its own behalf, to determine the degree to which it will interact with its environment, including the degree to which the entity is willing to share information about itself with others." [RFC2828]

Beyond private data (messages/files):

- Activities (browsing history, daily routine, …)
- Location (3/4G, GPS, WiFi, …)
- Preferences ("likes," Amazon, Netflix, …)
- Health (Fitbit, iWatch, …)
- …

Anonymity

"The state of being not identifiable within a set of subjects, the anonymity set." [Pfitzmann and Köhntopp]

- The larger the anonymity set, the stronger the anonymity

Very different from privacy:

- An anonymous action may be public, but the actor's identity remains unknown (e.g., vote in free elections)

Anonymous communication

- Sender anonymity
- Receiver anonymity
- Unlinkability of sender and receiver

Course Focus (You Got the Idea…)

Internet technologies, protocols, applications, attacks, and defenses, from a practical perspective

Indicative topics

- Core network protocols, eavesdropping, scanning, DoS attacks, firewalls, VPNs, proxies, intrusion detection, forensics, honeypots, encrypted communication, authentication, services and applications, botnets, targeted attacks, privacy, anonymity, …

Attacks and threats!

- Understand the modus operandi of attackers
- Find vulnerabilities, subvert protections, bypass all the things
- Think sideways
- How to secure a system – know what to defend against

Play Fair

Cannot teach defense without offense, but:

Breaking into systems is illegal!

Unauthorized data access is illegal!

Computer Fraud and Abuse Act (CFAA)

http://www.justice.gov/criminal/cybercrime/docs/ccmanual.pdf

Practice on your own systems or controlled environment

Scanning/penetration testing/etc. of third-party systems may be allowed only after getting permission by their owner

Course Information

Mixed format

- Lectures
- Research paper discussions
- Hands-on sessions

Requirements

- Reading assignments of research papers for discussion (both in class and online)
- 4 programming assignments
- Midterm and final exams

Grading

- Participation: 10%
- Assignments: 45%
- Midterm: 15%
- Final: 30%

Schedule (Tentative)

Threat Landscape

Lower Layers

Core Protocols

Denial of Service

Firewalls and Gateways

Encrypted Communication

Authentication

SSL/TLS

Crypto Failures

Schedule (Tentative)

Reconnaissance and Scanning

Intrusion Detection

Malware and Botnets

Honeypots, Deception, and Covert Channels

Email

Spam

Web/Cloud

Tracking/Privacy

Anonymity/Online Freedom

Course web page

http://www.cs.stonybrook.edu/~mikepo/CSE508/

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