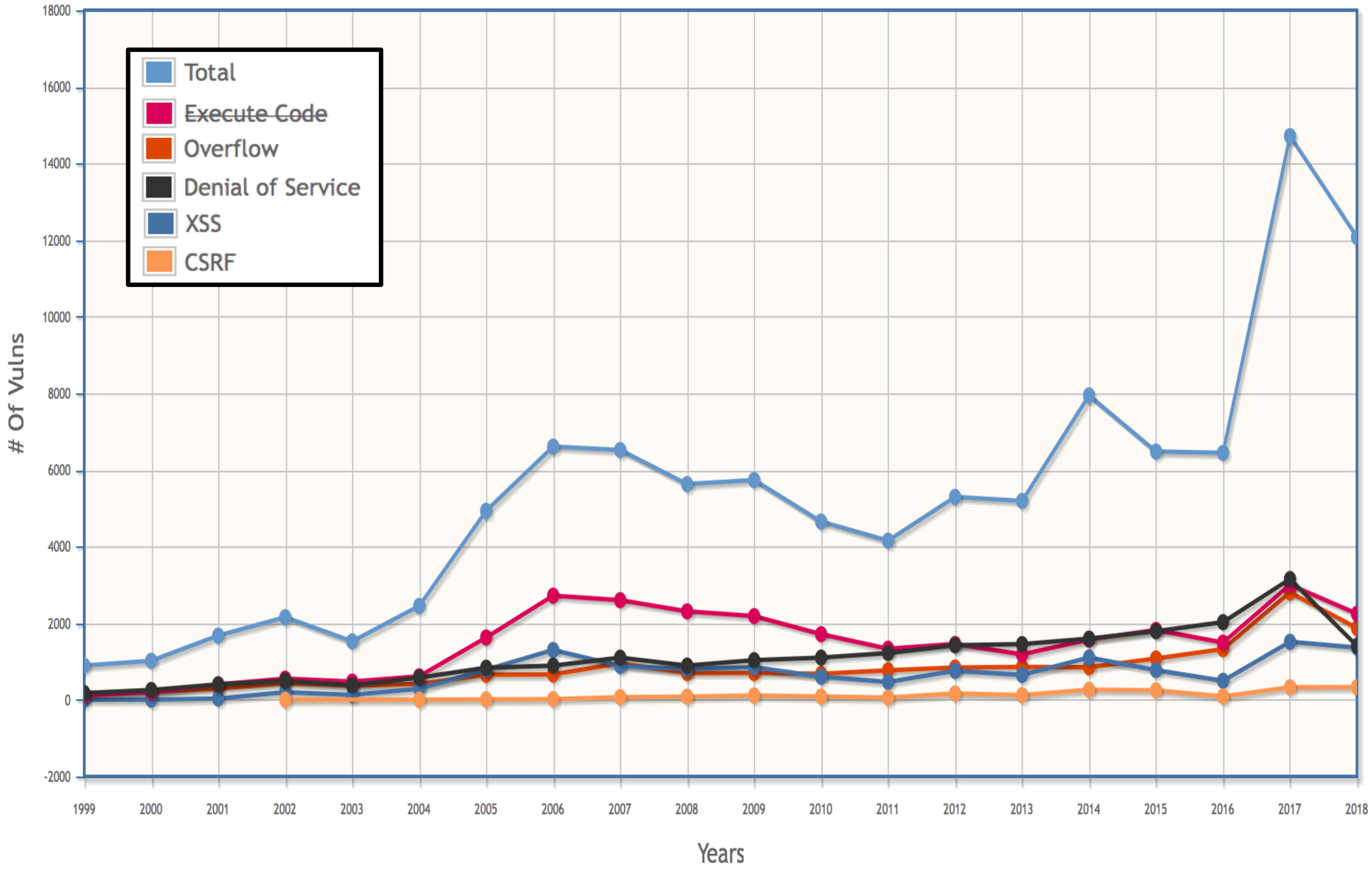
Lecture 3: Threat Models

CS 181S

Fall 2020

Idea 1: Eliminate Vulnerabilities

Vulnerabilities by Year



Bases for Trust

Axiomatic Trust

Analytic Trust

Synthetic Trust

- **Axiomatic Trust:** Trust derived from beliefs that we accept on faith. We might trust some hardware or software, for example, because it is built or sold by a given company. We are putting our faith in the company's reputation.

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Testing

- Goal is to expose existence of faults, so that they can be fixed
  - **Unit testing:** isolated components
  - **Integration testing:** combined components
  - **System testing:** functionality, performance, acceptance

- When do you stop testing?
  - **Bad answer:** when you run out of time
  - **Bad answer:** what all tests pass
  - **Better answer:** when methodology is complete (code coverage, paths, boundary cases, etc.)

Penetration testing

- Experts attempt to attack
  - Internal vs. external
  - Overt vs. covert

- Typical vulnerabilities exploited:
  - Passwords (cracking)
  - Buffer overflows
  - Bad input validation
  - Race conditions / TOCTOU
  - Filesystem misconfiguration
  - Kernel flaws

Fuzz testing

- Generate random inputs and feed them to programs:
  - Crash? hang? terminate normally?
- Of ~90 utilities in '89, crashed about 25-33% in various Unixes
  - Results have been repeated for Windows, Mac OSX
  - Results keep getting **worse** in GUIs but better on command line
- Since then, "fuzzing" has become a standard practice for security testing

- How to generate random inputs:
  - Use grammar to generate inputs
  - Or randomly mutate good inputs in small ways
    - especially for testing of network protocols

Type Checking

```
public class Main {
    public static void main(String[] args) {
        String s = 5;
        System.out.println(s);
    }
}
```

```
$ javac Main.java
Main.java:3: error: incompatible types: int
cannot be converted to String
String s = 5;
          ^
1 error
```

SpotBugs

- Looks for *patterns* in code that are likely faults and that are likely to cause failures
- Categorizes and prioritizes bugs for presentation to developer

Formal Verification

- prove program is correct with respect to some formal specification
- Examples: seL4, CompCert
- Problems: correctness of specification, scale

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- **Synthetic Trust:** Trust derived from modification of the system. Trust in the whole derives from how components are combined. Examples: *OS* isolation, reference monitors, firewalls

Engineering Countermeasures

Attacks
are perpetrated by
threats
that inflict
harm
by exploiting
vulnerabilities
which are controlled by
countermeasures.

Threats

A principal that has potential to cause harm to assets

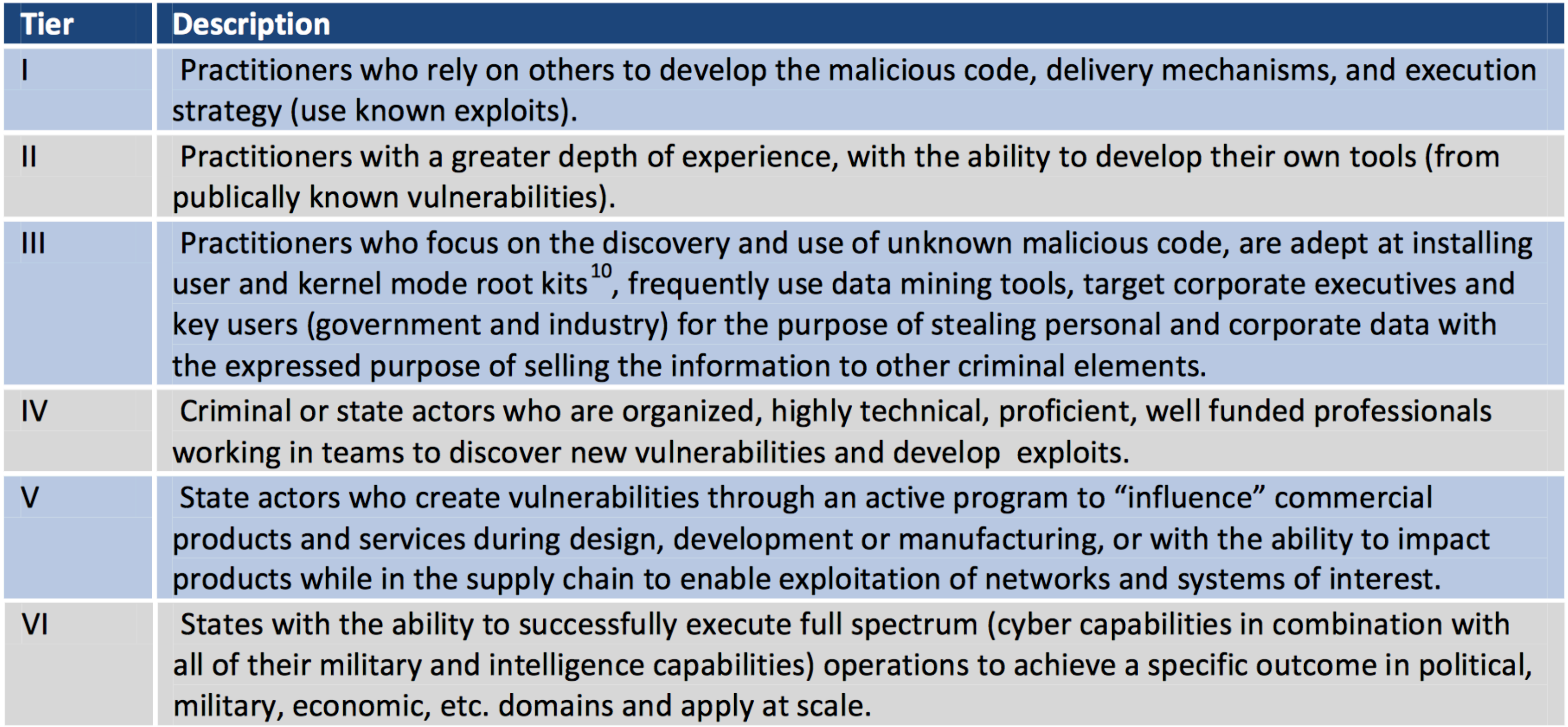
- Adversary or attacker: a human threat, motivated and capable
- Sometimes humans aren't malicious: accidents happen
- Sometimes non-humans cause harm: floods, earthquakes, power outage, hardware failure

Threat Models

- Identify threats of concern to system
  - Especially malicious, human threats
  - What kinds of attackers will system resist?
  - What are their **motivations**, **resources**, and **capabilities**?
- Best if analysis is specific to system and its functionality

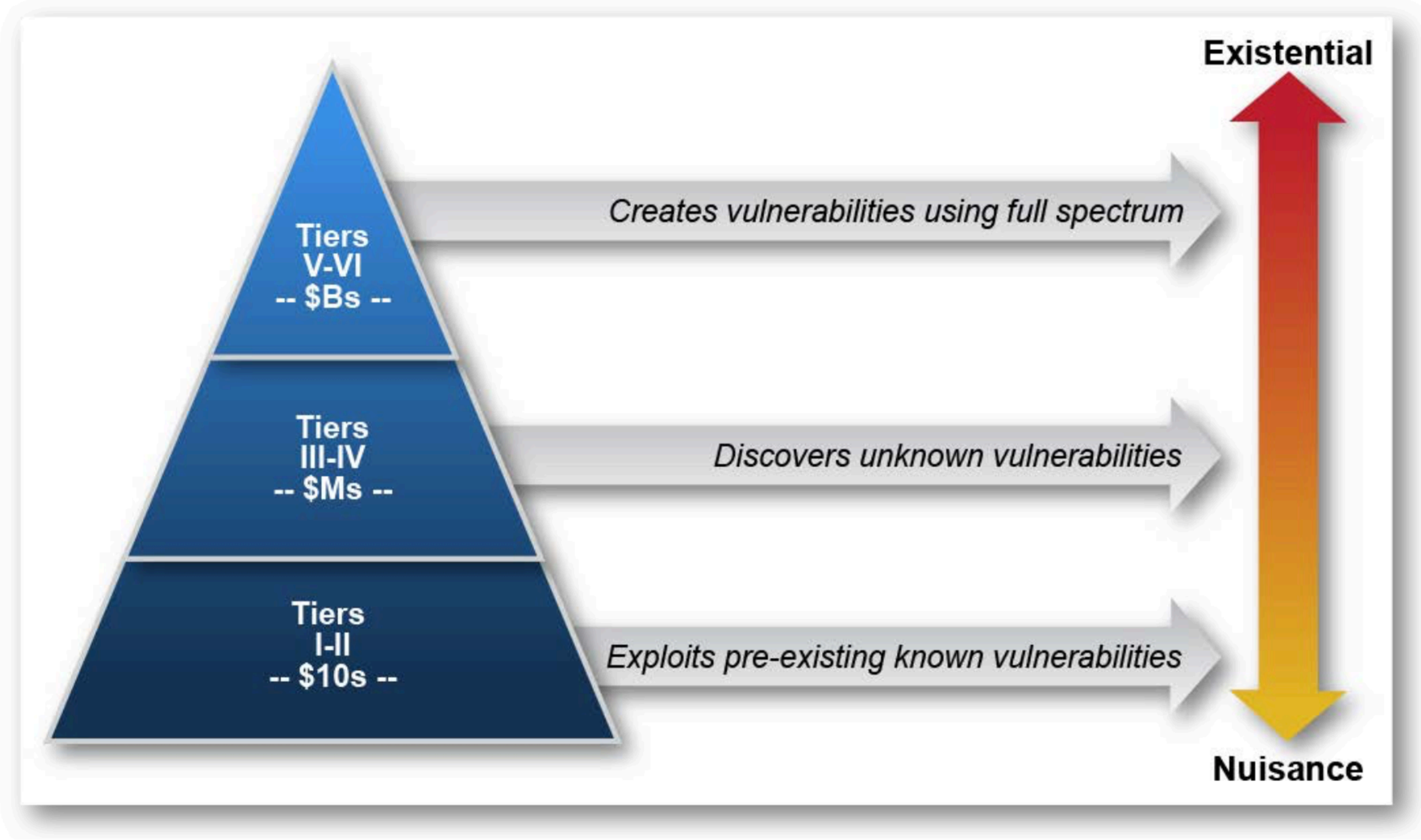
- Non threats?
  - Trusted hardware
  - Trusted environment (e.g., physically secured machine room reachable only by trustworthy system operators)

Threats (DSB)



Tier	Description
I	Practitioners who rely on others to develop the malicious code, delivery mechanisms, and execution strategy (use known exploits).
II	Practitioners with a greater depth of experience, with the ability to develop their own tools (from publically known vulnerabilities).
III	Practitioners who focus on the discovery and use of unknown malicious code, are adept at installing user and kernel mode root kits[10], frequently use data mining tools, target corporate executives and key users (government and industry) for the purpose of stealing personal and corporate data with the expressed purpose of selling the information to other criminal elements.
IV	Criminal or state actors who are organized, highly technical, proficient, well funded professionals working in teams to discover new vulnerabilities and develop exploits.
V	State actors who create vulnerabilities through an active program to “influence” commercial products and services during design, development or manufacturing, or with the ability to impact products while in the supply chain to enable exploitation of networks and systems of interest.
VI	States with the ability to successfully execute full spectrum (cyber capabilities in combination with all of their military and intelligence capabilities) operations to achieve a specific outcome in political, military, economic, etc. domains and apply at scale.

Threats (DSB)


Existential
Tiers
V-VI
-- $Bs --
Creates vulnerabilities using full spectrum
Tiers
III-IV
-- $Ms --
Discovers unknown vulnerabilities
Tiers
I-II
-- $10s --
Exploits pre-existing known vulnerabilities
Nuisance

Exercise 1: DSB Threat Model

- For each of the following systems, how would you classify the threats that are likely to perpetrate attacks against that system using the DSB threat model?
    1. A game app
    2. A social network
    3. A classified government database

Threats (Motives)

- Harm
- Gain

Threats (Motives)

- Inquisitive people, unintentional blunders
- Hackers driven by technical challenges
- Disgruntled employees or customers seeking revenge
- Criminals interested in personal financial gain, stealing services, or industrial espionage
- Organized crime with the intent of hiding something or financial gain
- Organized terrorist groups attempting to influence policy by isolated attacks
- Foreign espionage agents seeking to exploit information for economic, political, or military purposes
- Tactical countermeasures intended to disrupt specific weapons or command structures
- Multifaceted tactical information warfare applied in a broad orchestrated manner to disrupt major military missions
- Large organized groups or nation states intent on overthrowing a government

Exercise 2: Motives Threat Model

- For each of the following systems, how would you classify the threats that are likely to perpetrate attacks against that system according to their motives?
  1. A game app
  2. A social network
  3. A classified government database

Threats (Access)

- Physical access

Cold-boot attack

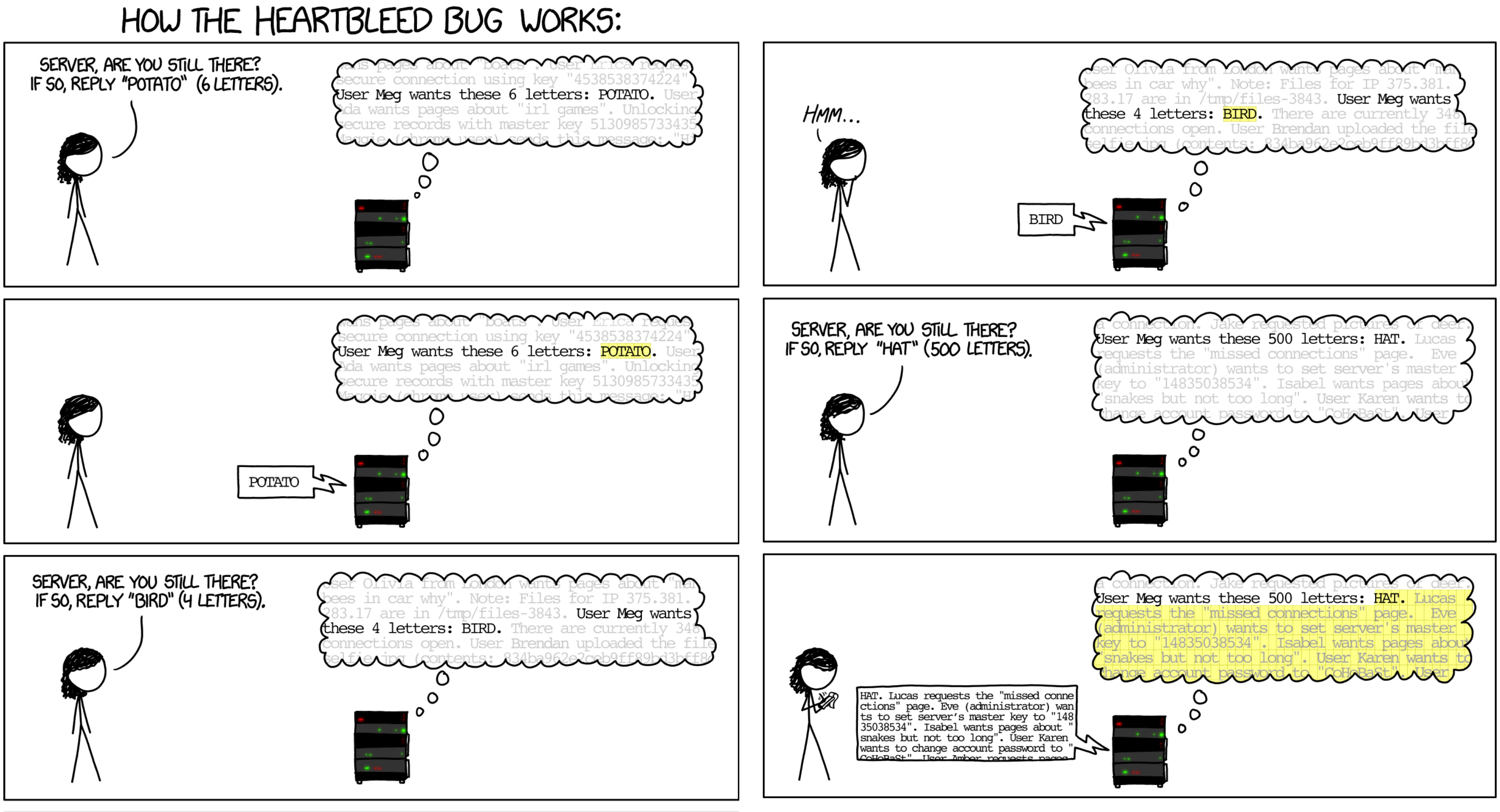
- https://youtu.be/E6gzVVjW4yY

Threats (Access)

- Physical access
- Software access
  - disk access
  - memory access
  - privilege levels

Heartbleed

Heartbleed


HOW THE HEARTBLEED BUG WORKS:
SERVER, ARE YOU STILL THERE? IF SO, REPLY "POTATO" (6 LETTERS).
ants pages about "boats". User Erica reques secure connection using key "4538538374224". User Meg wants these 6 letters: POTATO. User Ada wants pages about "irl games". Unlocking secure records with master key 5130985733435 Maggie (chrome user) sends this message: "H
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POTATO
SERVER, ARE YOU STILL THERE? IF SO, REPLY "BIRD" (4 LETTERS).
ser Olivia from London wants pages about "ma bees in car why". Note: Files for IP 375.381. 283.17 are in /tmp/files-3843. User Meg wants these 4 letters: BIRD. There are currently 346 connections open. User Brendan uploaded the file selfie.jpg (contents: 834ba962e2ceb9ff89bd3bff8
HMM...
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BIRD
SERVER, ARE YOU STILL THERE? IF SO, REPLY "HAT" (500 LETTERS).
a connection. Jake requested pictures of deer. User Meg wants these 500 letters: HAT. Lucas requests the "missed connections" page. Eve (administrator) wants to set server's master key to "14835038534". Isabel wants pages about "snakes but not too long". User Karen wants to change account password to "CoHoBaSt". User
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HAT. Lucas requests the "missed connections" page. Eve (administrator) wants to set server's master key to "14835038534". Isabel wants pages about "snakes but not too long". User Karen wants to change account password to "CoHoBaSt". User Amber requests pages

Speculative Execution

```
int i1, i2;
boolean b1,b2;
boolean[] a1,a2;



if (i1 < a1.length()) {
    boolean bval= a1[i1];
    if(bval){i2= 1;} else{i2= 0;}
    if(i2 < a2.length()){
        b2 = a2[i2];
    }
}
```

Timing

MODE
SPLIT RESET
START STOP
ACCUSPLIT
STOPWATCH
A
10:5323
C
MIN.
SEC.
1/100
PRO SURVIVOR
601X
3V.1

Stuxnet

Threats (Access)

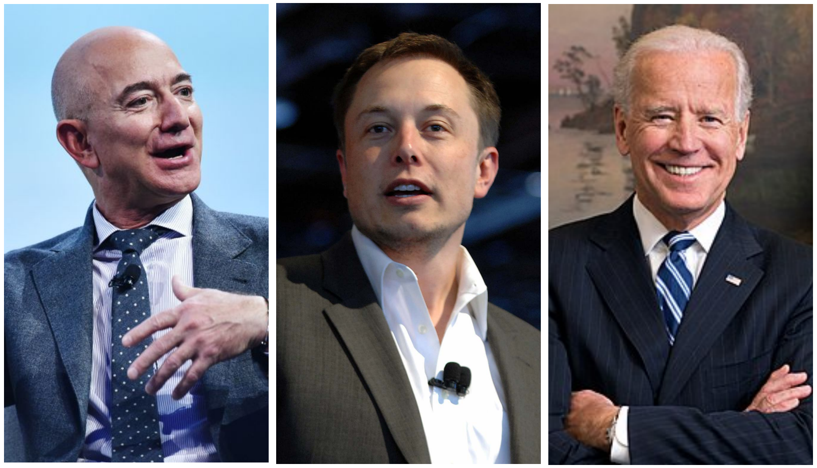
- Physical access
- Software access
  - disk access
  - memory access
  - privilege levels
- Network access

Dyn DDoS

Threats (Access)

- Physical access
- Software access
  - disk access
  - memory access
  - privilege levels
- Network access
- User access

Phishing



Exercise 3: Access Threat Model

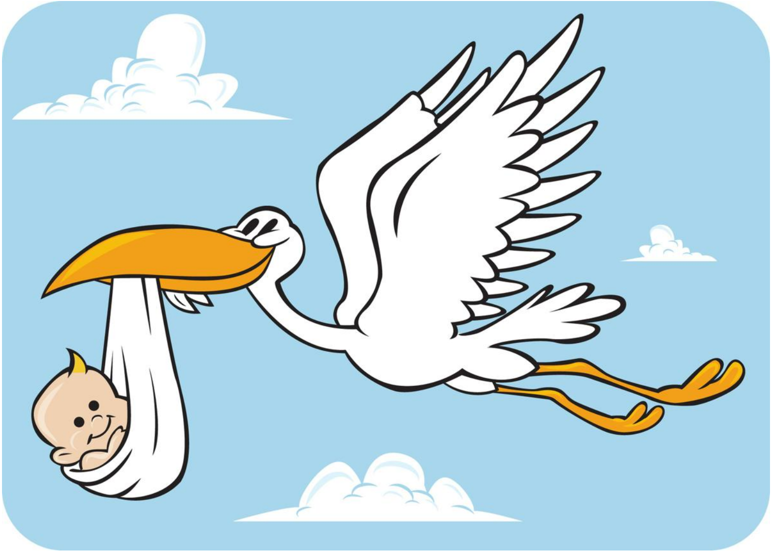
- For each of the following systems, how would you classify the threats that are likely to perpetrate attacks against that system according to their access?
  1. A game app
  2. A social network
  3. A classified government database

Threat Model (Capabilities)

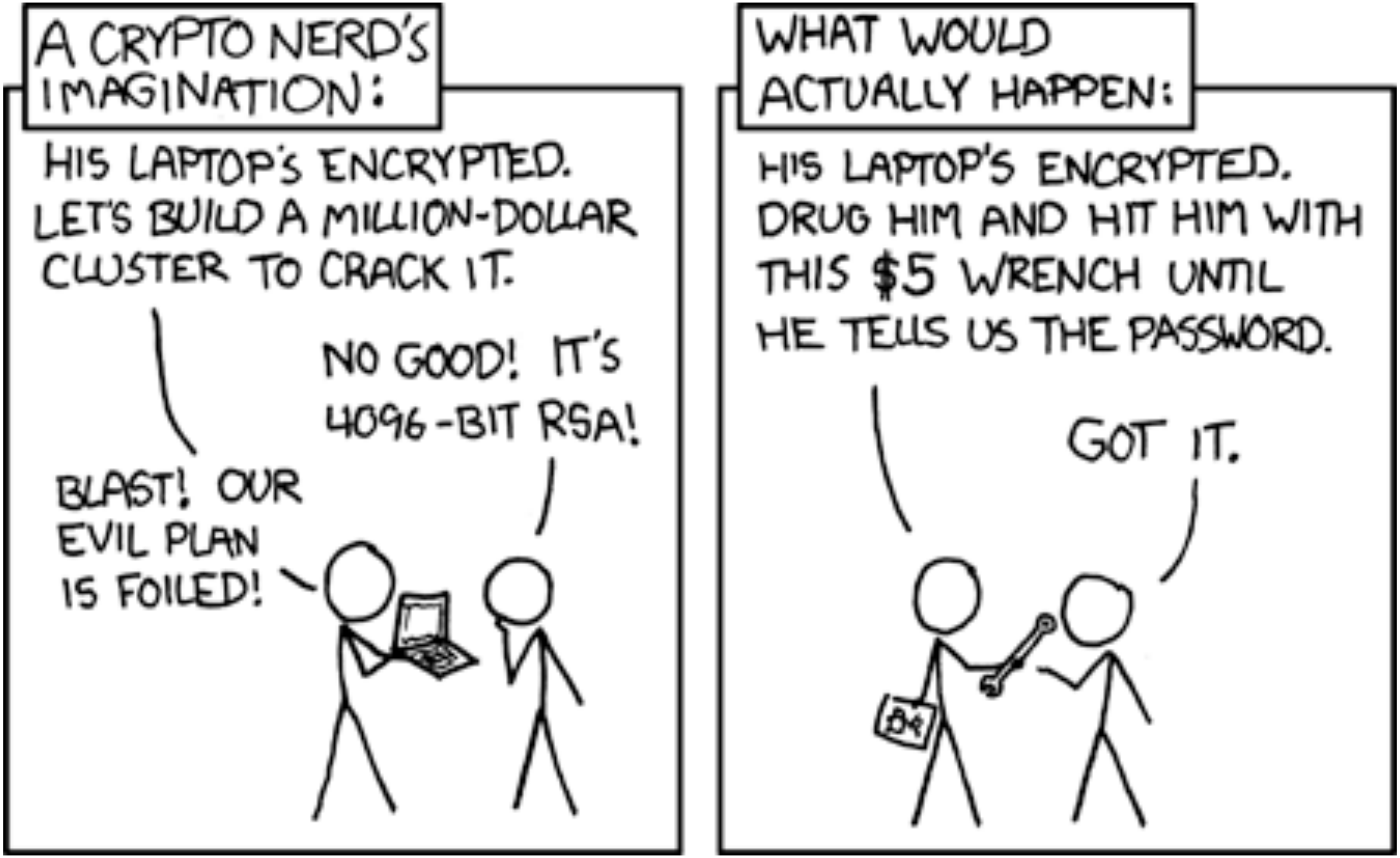
- PPT
- Dolev-Yao

Example

Threat model: The adversary desires to prevent baby deliveries. The adversary has access to radio equipment that transmits and receives on the same frequencies that providence uses for communication with a stork. The adversary also controls weapons systems that can destroy a stork in flight.



Threat Models


A CRYPTO NERD'S IMAGINATION:
HIS LAPTOP'S ENCRYPTED. LET'S BUILD A MILLION-DOLLAR CLUSTER TO CRACK IT.
NO GOOD! IT'S 4096-BIT RSA!
BLAST! OUR EVIL PLAN IS FOILED!
WHAT WOULD ACTUALLY HAPPEN:
HIS LAPTOP'S ENCRYPTED. DRUG HIM AND HIT HIM WITH THIS $5 WRENCH UNTIL HE TELLS US THE PASSWORD.
GOT IT.

Exercise 4: Feedback

1. Rate how well you think this recorded lecture worked
    1. Better than an in-person class
    2. About as well as an in-person class
    3. Less well than an in-person class, but you still learned something
    4. Total waste of time, you didn't learn anything

2. How much time did you spend on this video lecture (including time spent on exercises)?

3. Do you have any comments or suggestions for future classes?