Exploiting Software Vulnerabilities

Vulnerability Management and Assessment

Universidad Zaragoza

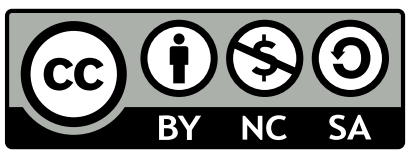
Dept. of Computer Science and Systems Engineering
University of Zaragoza, Spain

Course 2022/2023

Master's Degree in Informatics Engineering

University of Zaragoza

Seminar A.22, Ada Byron building



Outline

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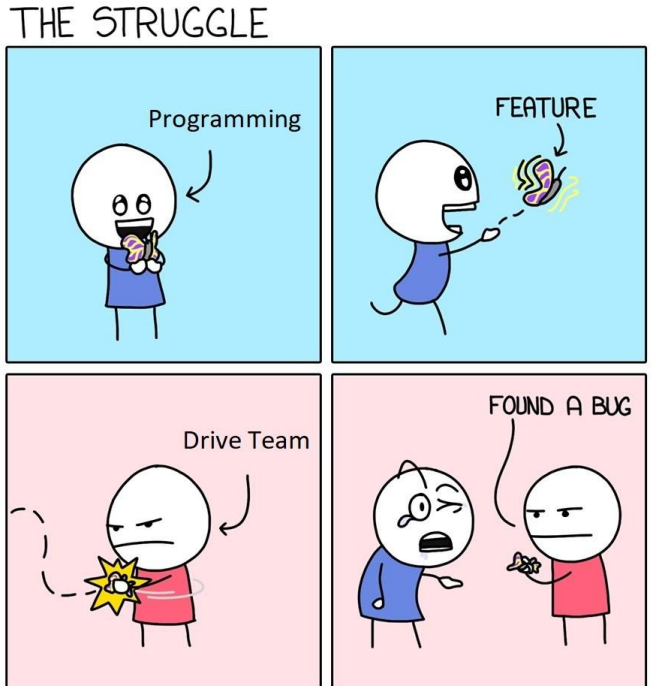
Introduction



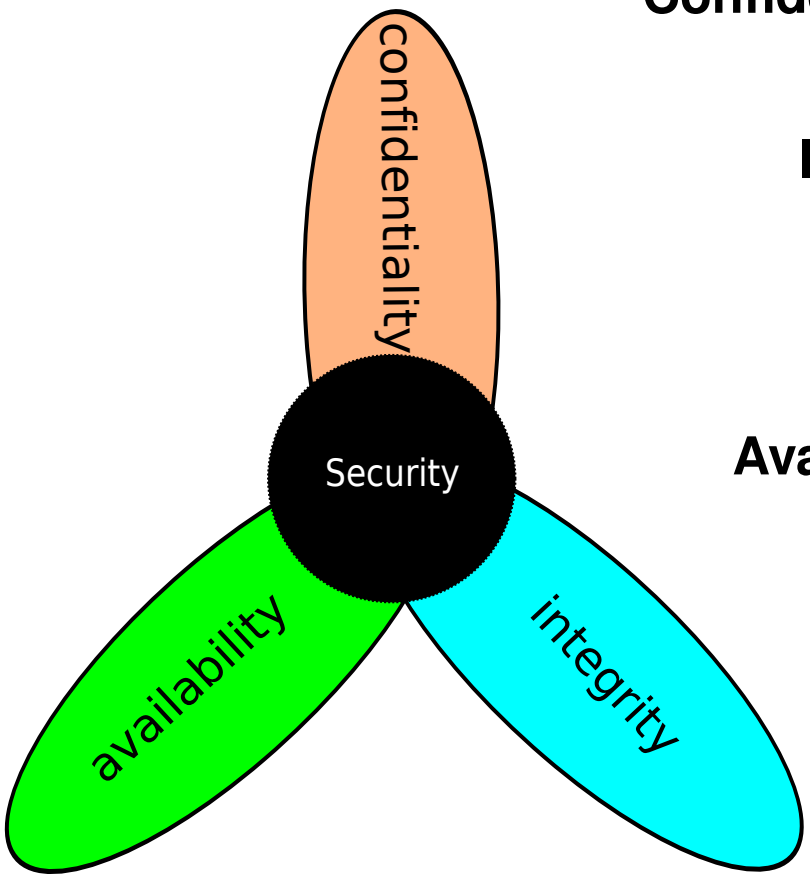
Definition of vulnerability

- **Software or design flaw**
- **Allows an intruder to reduce the security of information on a system**
- **Requirements**:
  - A weakness in the system
  - An adversary's access to that weakness
  - Ability of the adversary to exploit the weakness using a tool or a technique

Credits: https://www.reddit.com/r/FRC/comments/ay7tri/its_not_a_bug_its_a_feature/

Introduction

The CIA triad of infosec



Confidentiality *Information is not accessed by unauthorized persons*

Integrity *Information is not altered by unauthorized persons in an undetectable way by authorized users*

Availability *Reliable (and timely) access and use of information, while preventing unauthorized retention of information*

- **Other attributes**: authenticity, authorization, accountability, non-repudiation/anonymity

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Security challenges

- **Lack of security awareness**
- **Sophistication of attack tools and methodologies**
  - Little or no knowledge or skills are required to carry out some attacks
  - Script-kiddies – *hackers de botón gordo*
- **Complexity of the systems**
- **Growth of interconnected and heterogeneous devices** (e.g., IoT)
- **Lack of vulnerability/patch management processes**

There is **ALWAYS** a trade-off between security and usability

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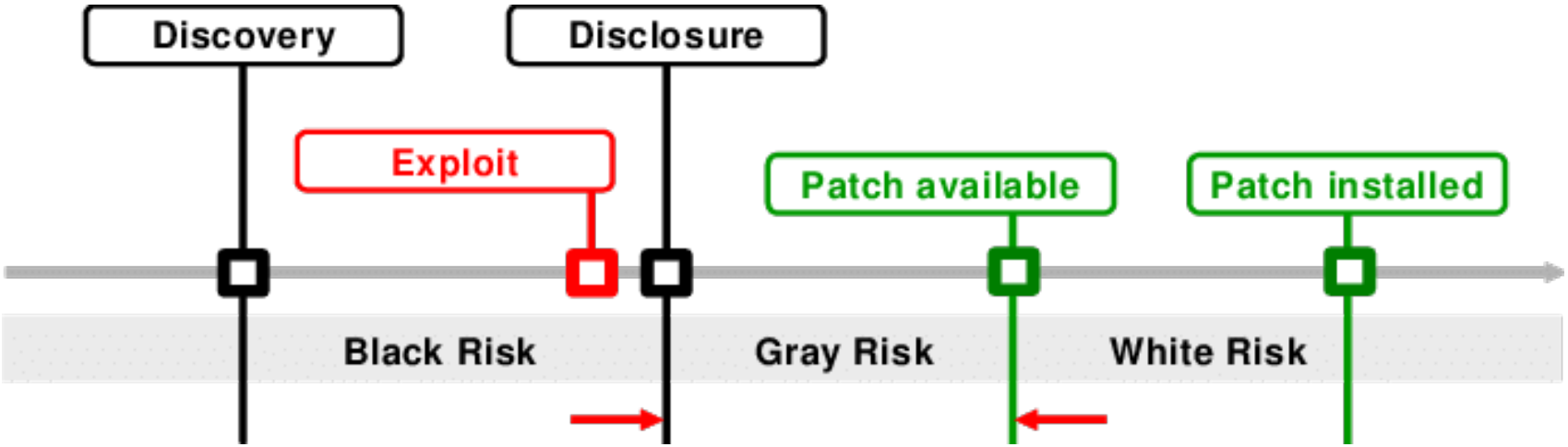
Life-cycle of a vulnerability



Zero-day vulnerability (0-day)

- **Unknown to the software vendor (and to the public) until disclosed**

Credits: *0-Day Patch Exposing Vendors (In)security Performance*, S. Frei, B. Tellenbach, B. Plattner, BlackHat EU 2008

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Bug bounty programs

Get a bug if you find a bug.

Show us a bug in our VRTX® real-time operating system and we'll return the favor. With a bug of your own to show off in your driveway.

There's a catch, though.

Since VRTX is the only microprocessor operating system completely sealed in silicon, finding a bug won't be easy.

Because along with task management and communication, memory management, and character I/O, VRTX contains over 100,000 man-hours of design and testing.

And since it's delivered in 4K bytes of ROM, VRTX will perform for you the way it's performing in hundreds of real-time applications from avionics to video games.

Bug free.

So, to save up to 12 months of development time, and maybe save a loveable little car from the junkyard, contact us. Call (415) 326-2950, or write Hunter & Ready, Inc., 445 Sherman Avenue, Palo Alto, California 94306.

Describe your application and the microprocessors you're using—Z8000, Z80, 68000, or 8086 family. We'll send you a VRTX evaluation package, including timings for system calls and interrupts. And when you order a VRTX system for your application, we'll include instructions for reporting errors.*

But don't feel bad if in a year from now there isn't a bug in your driveway.

There isn't one in your operating system either.

HUNTER ◆ READY

VRTX

Operating Systems in Silicon.

*Call or write for details. But, considering our taste in cars, you might want to accept our offer of $1,000 cash instead. © 1983 Hunter & Ready, Inc.

Further reading: *Bounties Mount for Bugs*, P. Marks, Communications of the ACM, Aug 2018.

Introduction

Types of vulnerability disclosures

- **Non-disclosure**
  - **Keep the vulnerability a secret** instead of contacting the software vendor or a computer security coordinating authority
  - **The number of undisclosed vulnerabilities is unknown**

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- **Full disclosure**
  - **Inform the community at large**, without first checking with the software vendor
  - **Minimal documentation**: how found, software products (with versions) affected, and how to exploit or mitigate it
  - **Controversial method**
    - Rapid acknowledgement and patch of software vendors
    - Increase the risk of widespread exploitation

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- **Responsible disclosure** (aka partial/limited disclosure)
  - Usually accompanied by a **test suite to verify that future releases do not contain similar bugs**
  - **Inform software vendor and wait for a response** (depends on their disclosure policy)
  - **If no response, go to full disclosure**

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What I have to do?

- **Contact a CERT/CC or the software vendor involved**
  - CERT/CC stands for Computer Emergency Response Team/Coordination Center
  - There are many CERTs (all countries and large organizations have one)
  - **Software vendors now provide direct communication with their security teams** to handle vulnerability discoveries
  - **Each CERT/vendor may have different disclosure policies**
  - **Industrial systems usually have special disclosure processes**, due to their critical activity (e.g., `https://www.cisa.gov/coordinated-vulnerability-disclosure-process`)

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- **Get a CVE** (Common Vulnerabilities and Exposures)
  - MITRE, ZDI, etc
  - Known syntax: CVE-YYYY-ID
    - *Example*: Zerologon vulnerability `https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2020-1472`
  - **Useful to unequivocally identify a vulnerability**

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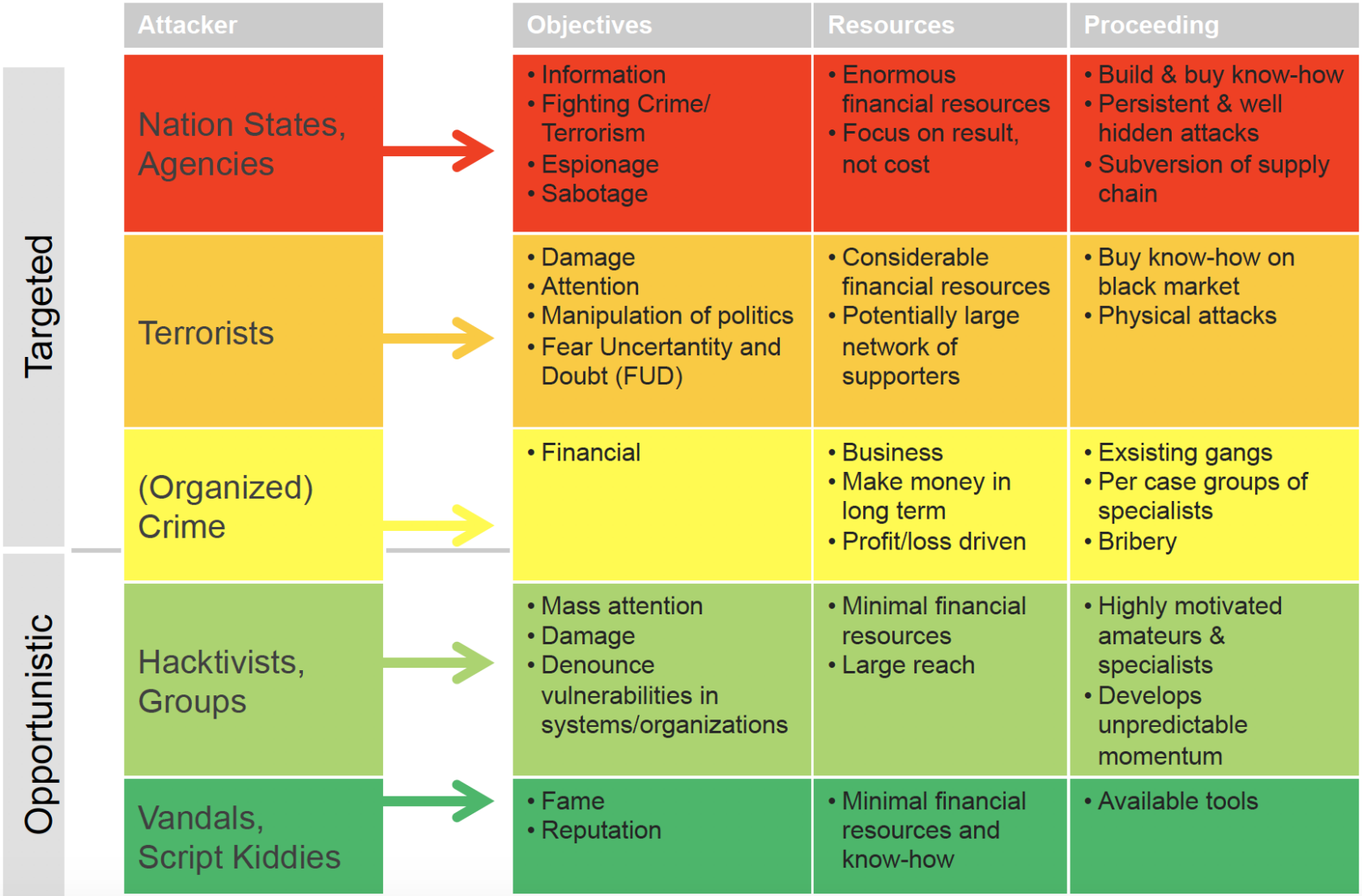
Actors and attackers



Credits: *(IN)SECURITY, RISK & THE LIFECYCLE OF VULNERABILITIES*, Dr. Stefan Frei, ETH

Introduction

Adversaries / attackers

- **Hacktivists**
  - **Individuals or groups of hackers**
  - Main motivation: **promoting a political agenda, a religious belief, or a social ideology**
- **Internal threats** (insiders)
  - **Current or former (upset) employees**. It can also arise from third parties (contractors, temporary workers, clients)
  - Different types: malicious, accidental, negligent
  - Main motivation (of malicious insiders): **money, espionage, gain strategic advantage**
  - *Examples*: (taken from `https://www.varonis.com/blog/insider-threats/`)
    - On Tesla, a malicious insider sabotaged systems and sent proprietary data to third parties
    - On Facebook, a security engineer abused his access to harass women
    - On Coca-Cola, a malicious insider stole a hard drive full of worker's personal data
    - On Suntrust Bank, a malicious insider stole personal data (including account information) for 1.5M customers and provided it to a criminal organization

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Introduction

Adversaries / attackers

- **Cyber criminals** – *the traditional mob moves to the digital world*
  - **Individuals or groups of people who use technology to commit cybercrimes**
  - Main motivation: **generate profits by different means** (stealing confidential company or personal data, sabotage, scam, etc.)
  - **The most prominent and active type of attacker**
- **State-sponsored attackers**
  - Individuals or groups of people who have **particular objectives aligned with the political, commercial or military interests of their country of origin**
  - **Highly trained hackers**, specialized in detecting and exploiting vulnerabilities
  - **Most dangerous attacker**: no resource limit

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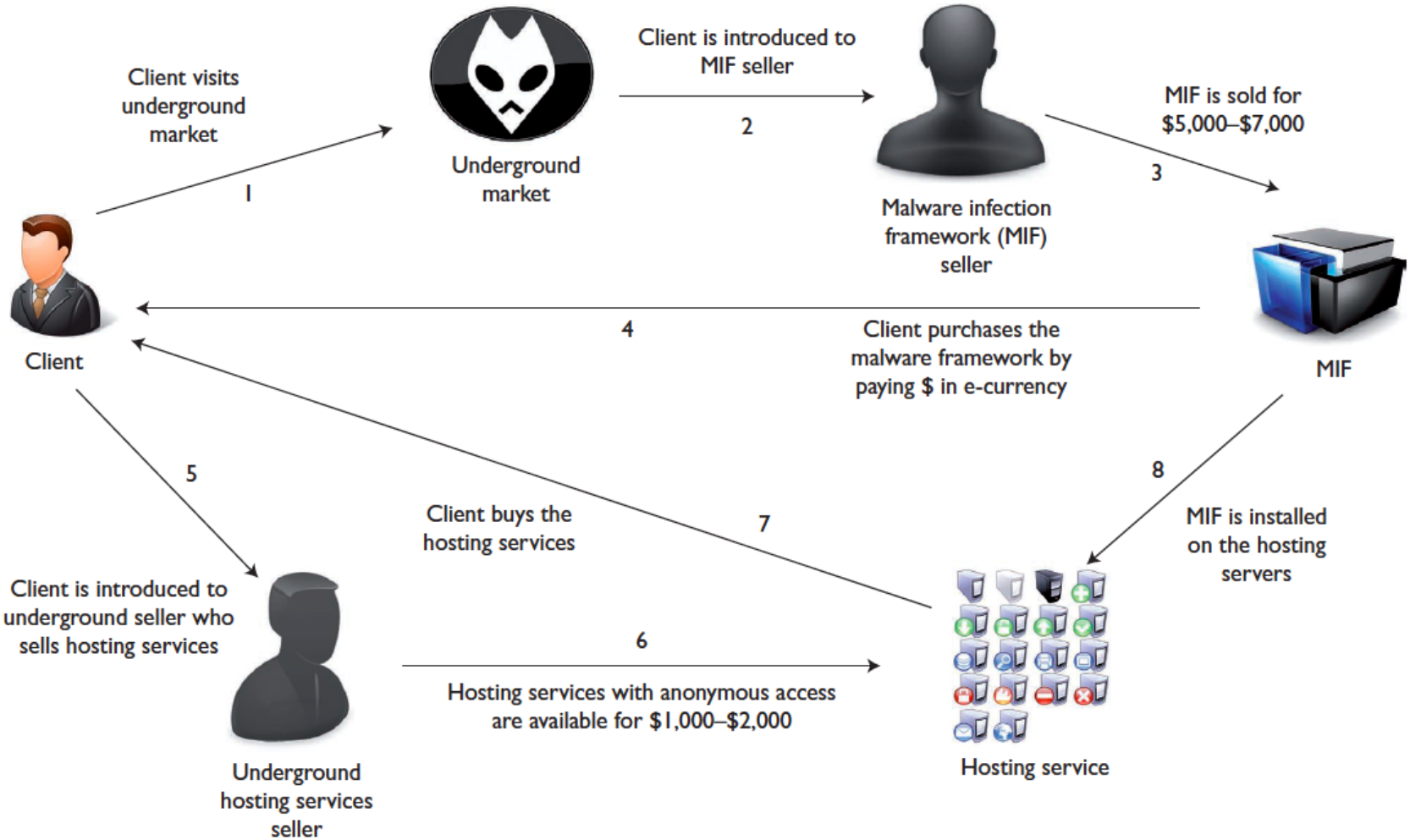
Further reading: *Cyber Guerilla*, Jelle van Haaster, Rickey Gevers and Martijn Sprengers, Syngress, 2016

Introduction

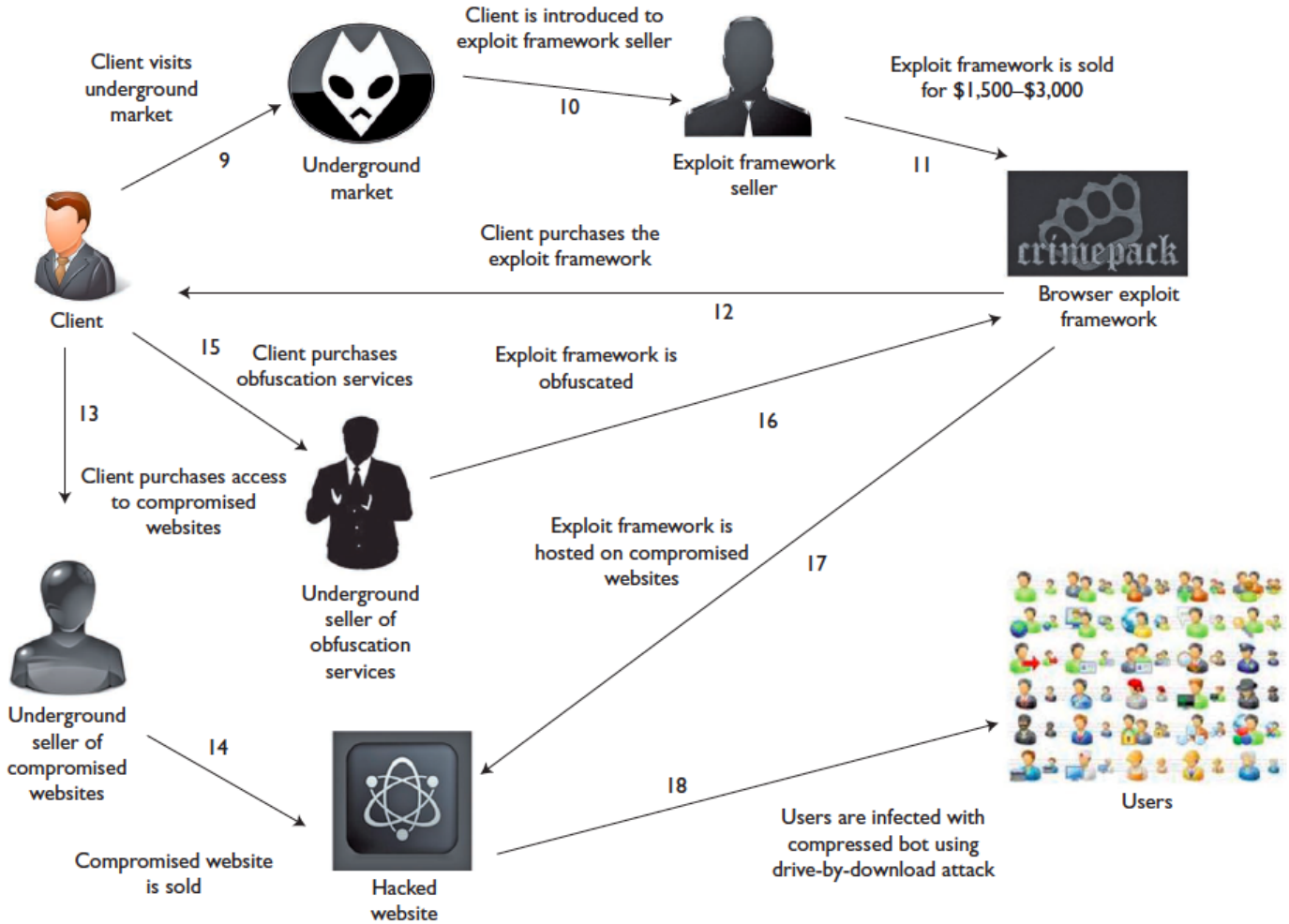
Cybercrime lifecycle – cycle 1



Credits: Sood, A. K.; Bansal, R. & Enbody, R. J. *Cybercrime: Dissecting the State of Underground Enterprise*. IEEE Internet Computing, 2013, 17, 60–68.

Introduction

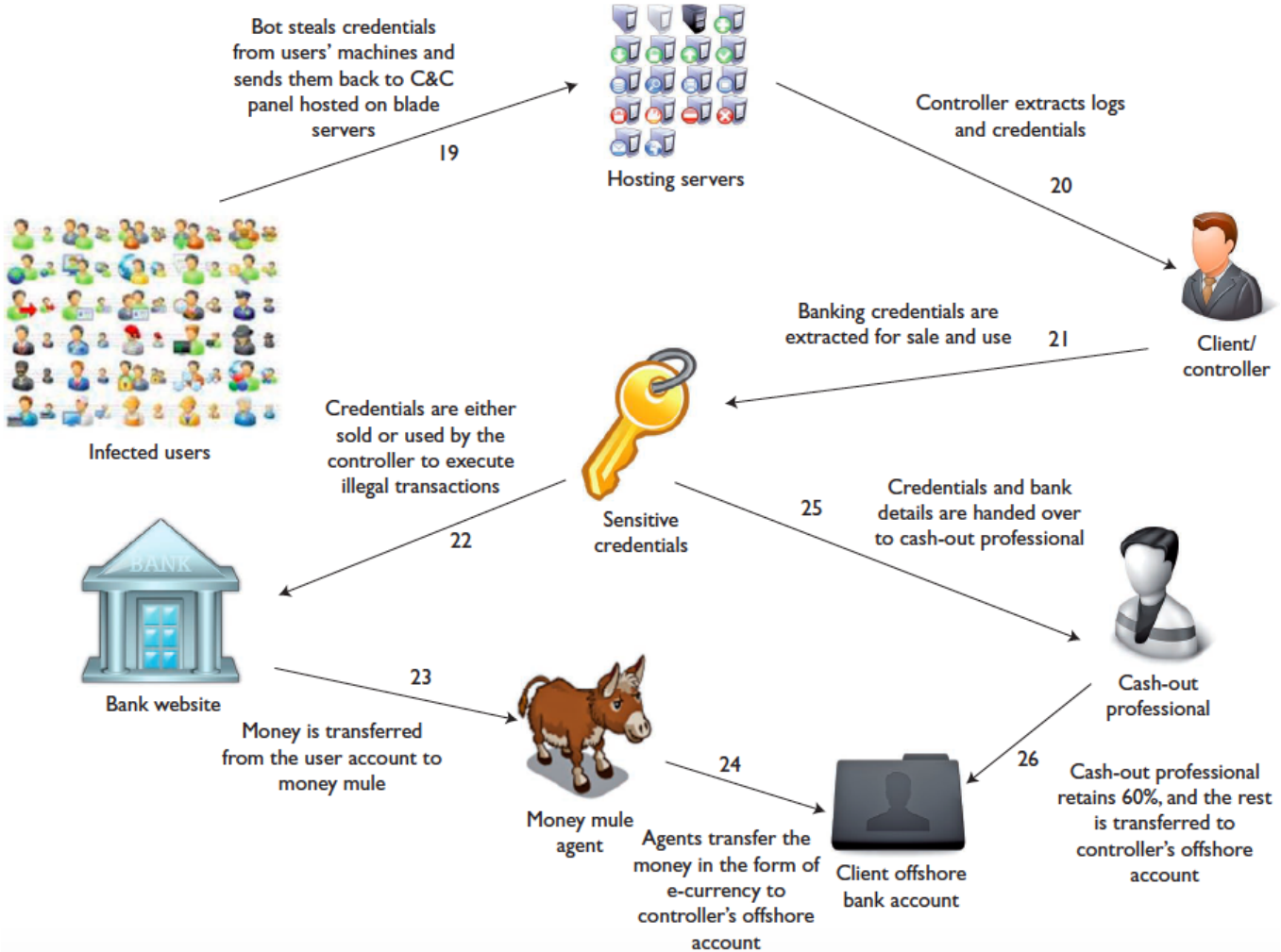
Cybercrime lifecycle – cycle 2



Credits: Sood, A. K.; Bansal, R. & Enbody, R. J. *Cybercrime: Dissecting the State of Underground Enterprise*. IEEE Internet Computing, 2013, 17, 60–68.

Introduction

Cybercrime lifecycle – cycle 3



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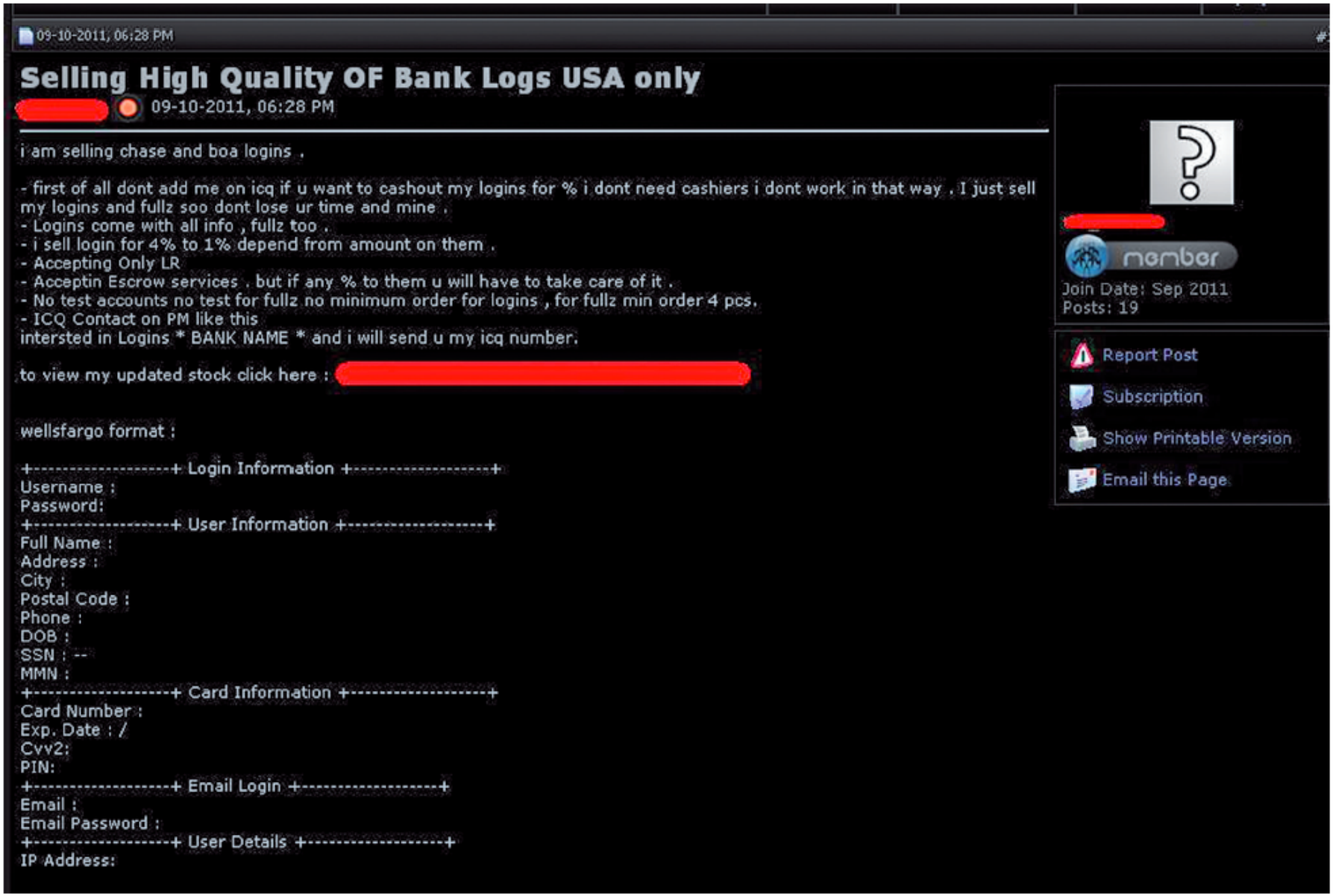
Some examples about the underground market



09-10-2011, 06:28 PM

Selling High Quality OF Bank Logs USA only

[redacted] 09-10-2011, 06:28 PM

i am selling chase and boa logins .

- first of all dont add me on icq if u want to cashout my logins for % i dont need cashiers i dont work in that way . I just sell my logins and fullz soo dont lose ur time and mine .
- Logins come with all info , fullz too .
- i sell login for 4% to 1% depend from amount on them .
- Accepting Only LR
- Acceptin Escrow services . but if any % to them u will have to take care of it .
- No test accounts no test for fullz no minimum order for logins , for fullz min order 4 pcs.
- ICQ Contact on PM like this

intersted in Logins * BANK NAME * and i will send u my icq number.

to view my updated stock click here : [redacted]

wellsfargo format :

+----------+ Login Information +----------+
Username :
Password:
+----------+ User Information +----------+
Full Name :
Address :
City :
Postal Code :
Phone :
DOB :
SSN : --
MMN :
+----------+ Card Information +----------+
Card Number :
Exp. Date : /
Cvv2:
PIN:
+----------+ Email Login +----------+
Email :
Email Password :
+----------+ User Details +----------+
IP Address:

[redacted]
member
Join Date: Sep 2011
Posts: 19

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Introduction

Some examples about the underground market

Experts at BitDefender have discovered a Cryptolocker/Cryptowall Ransomware Kit offered for sale at $3,000, source code included.

Yesterday I wrote about a new Ransomware-as-a-service, the FAKBEN, surfaced from the criminal underground, requesting customers 10 percent profit cut. In the previous days I reported other cases involving ransomware, such as a malicious code that infected the UK Parliament, an off-line ransomware and a Linux.Encoder1 ransomware revealing the decryption key.

The cybercrime is looking with increasing interest to ransomware, today I want to write about the availability of the source code of Cryptolocker/Cryptowall in the underground.

According to Bitdefender, a Cryptolocker/Cryptowall Ransomware Kit is offered for sale for $3,000, including its source code.

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Credits: http://securityaffairs.co/wordpress/41977/cyber-crime/ransomware-kit-for-sale.html

Introduction

Some examples about the underground market

HOSTMAN Ransomware

Price: Basic – USD 9.95(Limited use) Big – USD 49.95(Unlimited use)

Ransomware Affiliate Network

Price: FREE

Profits: 25/75 Split, 25% - Ransomware Author 75% - Affiliate

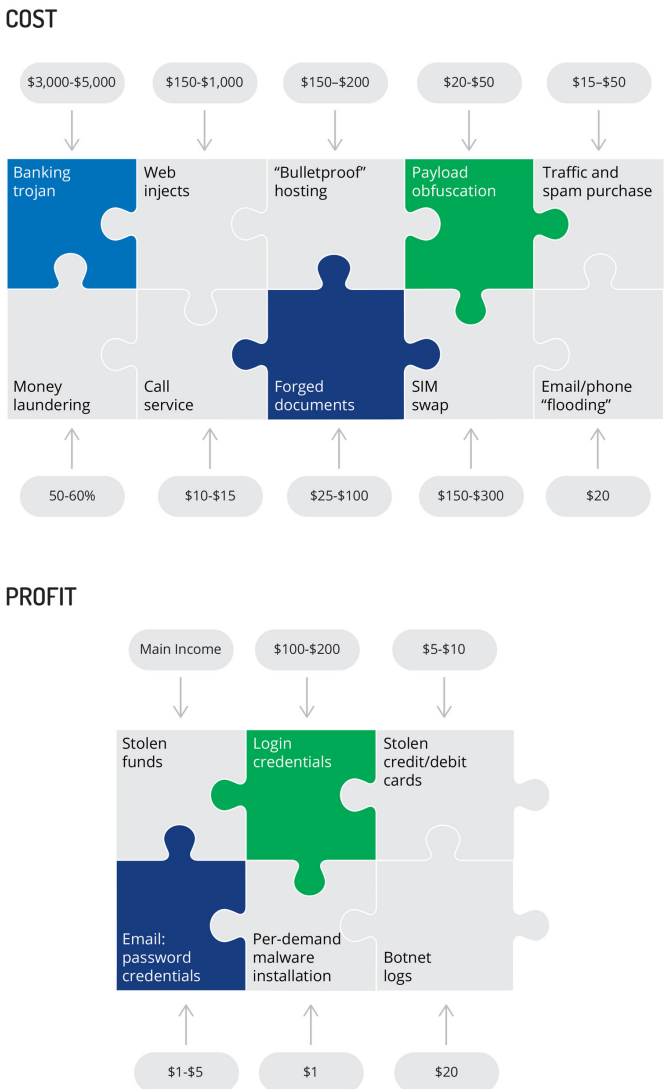
For 100,000+ installations per month:

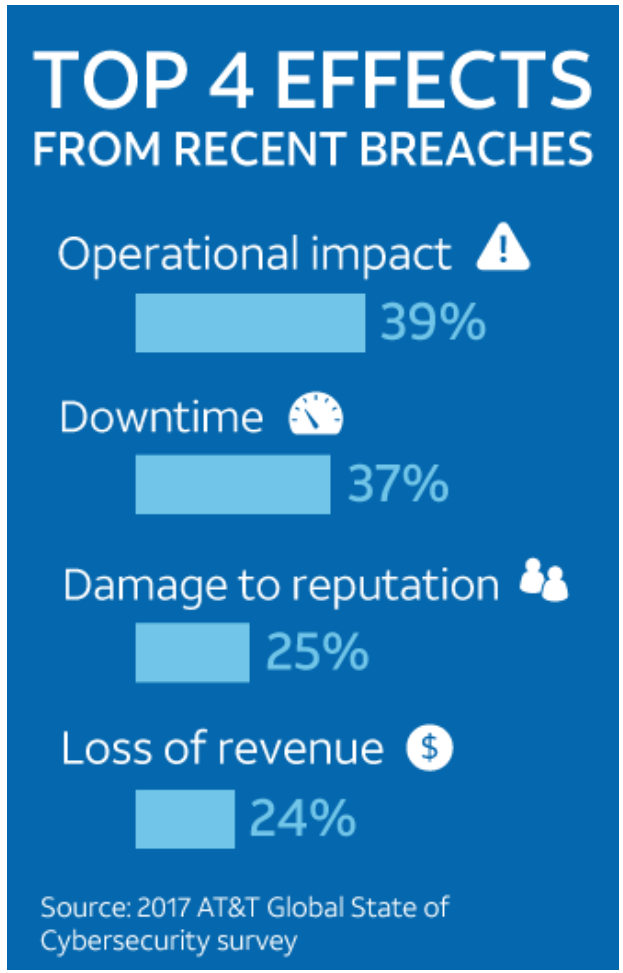
15/85 Split, 15% - Ransomware Author 85% - Affiliate

Credits: https://blog.fortinet.com/

Introduction

Estimating the costs and benefits of cybercrime (2017)

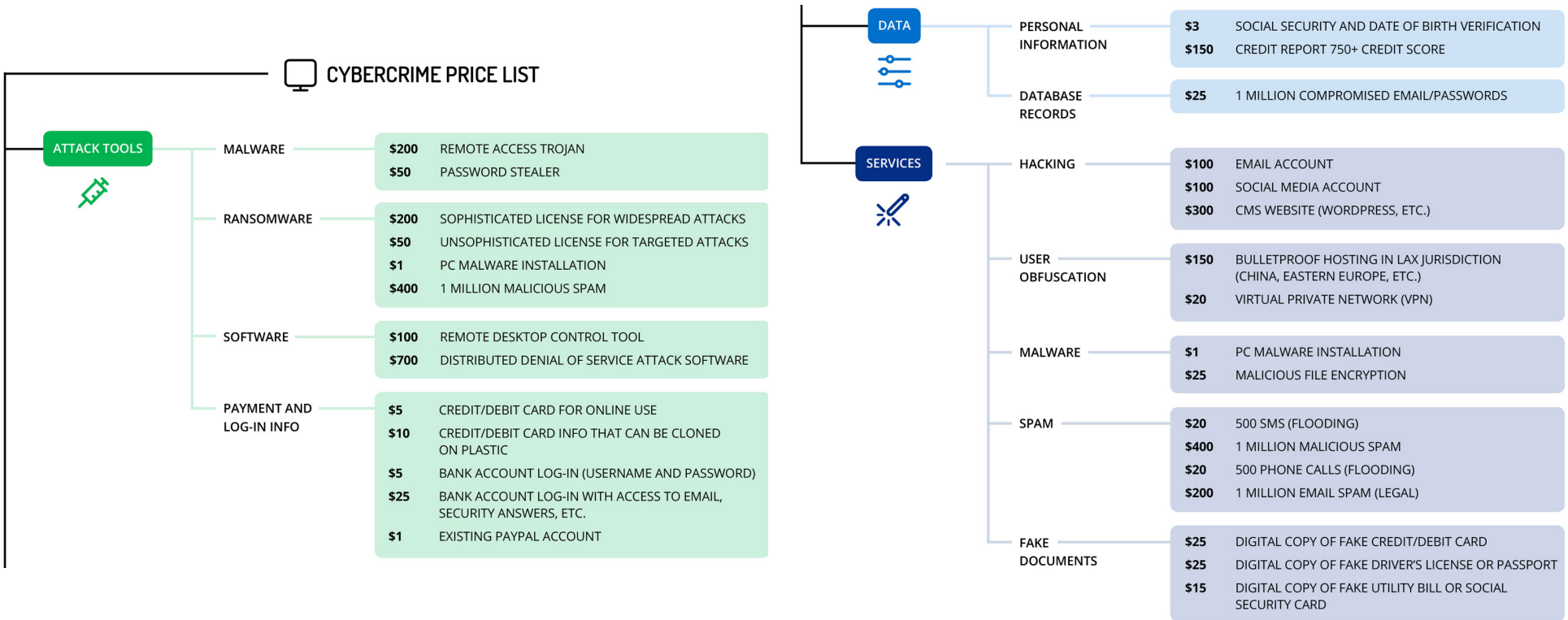




Credits: `https://www.recordedfuture.com/cyber-operations-cost/`

Introduction

Let's go shopping, folks! (2017)



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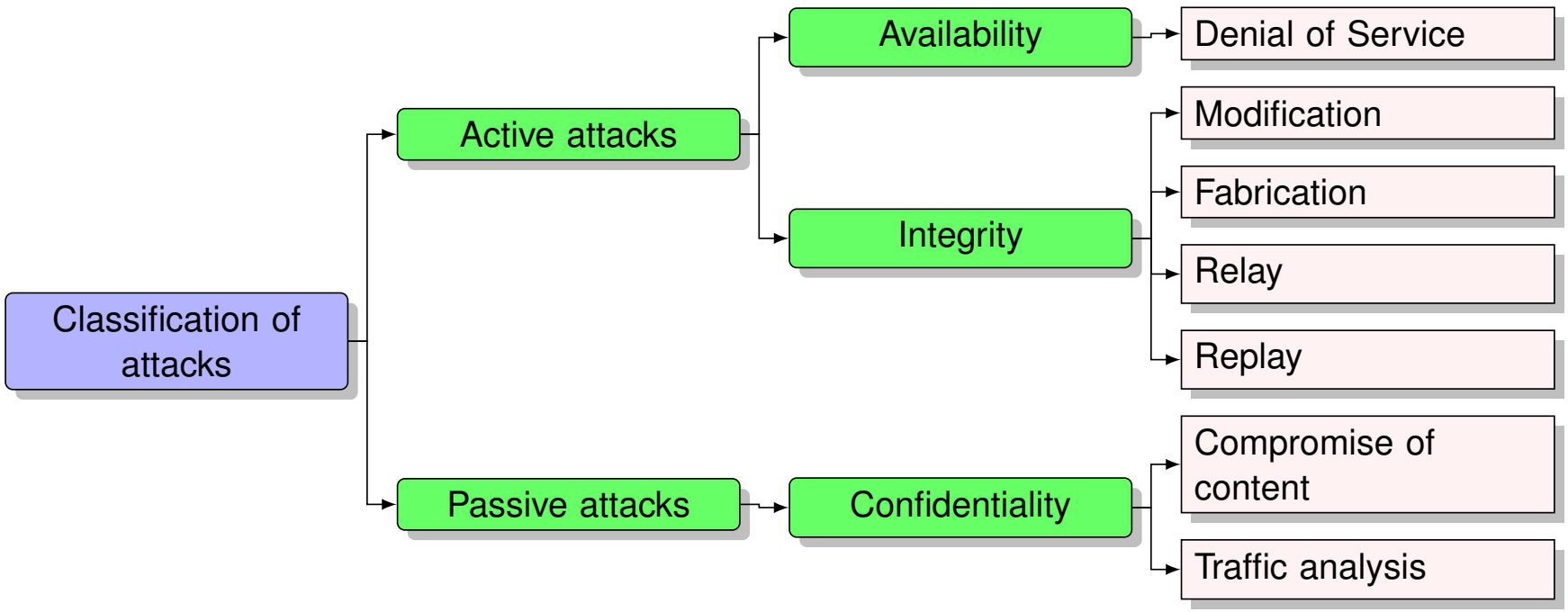
Introduction

Classification of attacks



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Outline

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Ethical concerns

Vulnerability research

- *Some concerns...*
  - We are testing systems and analyzing products created and maintained by someone else
  - **But we help others to prevent or mitigate damage to third parties due to vulnerable products and operations...**

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Ethical concerns

Vulnerability research

- *Some concerns...*
  - We are testing systems and analyzing products created and maintained by someone else
  - **But we help others to prevent or mitigate damage to third parties due to vulnerable products and operations...**
- *What about legality?*
  - State and federal computer intrusion statutes or intellectual property rights are violated
  - **But vulnerability research helps us anticipate the problems...**
  - When the disclosure is legally mandated, irreparable damage has generally occurred

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Ethical concerns

Code of conduct

- **Duty not to harm**
- *Before starting your research...*
  - **Reveal intent and investigation**
  - **Seek legal advice**
- *During and after your research...*
  - **Responsible data handling**
  - **Report serious vulnerabilities**

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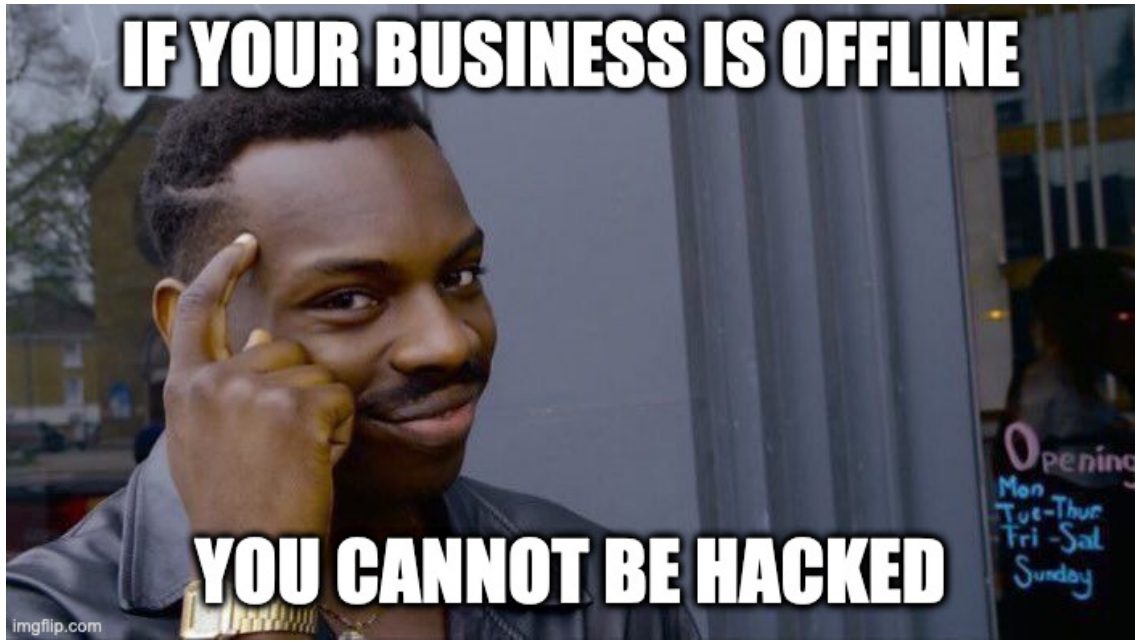
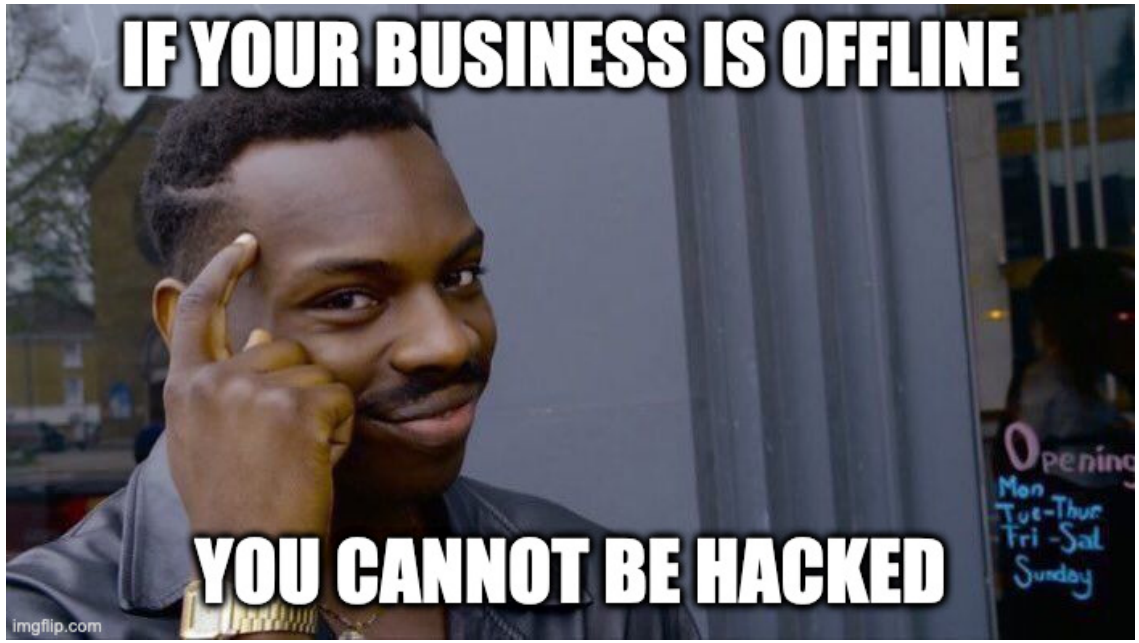
Vulnerability Management and Assessment



Absolute security does not exist

- **There are always trade-offs**: usability, social, financial, etc...
- TAKE-HOME MESSAGE: **the correct security metric is RONI** (Return Of Non Investment)
  - You cannot calculate the return on your security spending, but you can calculate your loss from not investing in security after an incident occurs

Vulnerability Management and Assessment



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What are you willing to give up to get the level of security that you want?

- **Vulnerability management helps make decisions**

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Vulnerability Management and Assessment

Vulnerability management

- **Identification of vulnerabilities in systems**
- **Assessment of risks associated with these vulnerabilities**

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Vulnerability Management and Assessment

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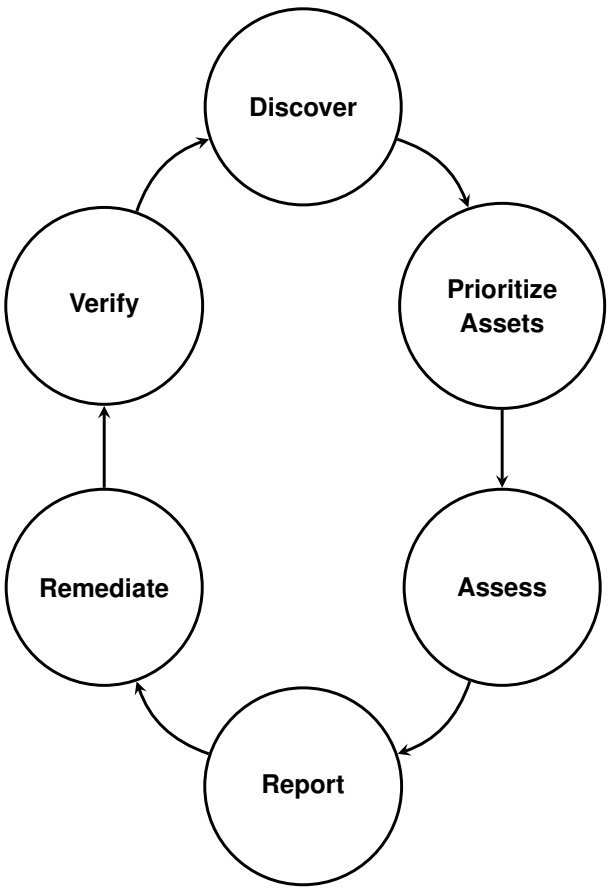
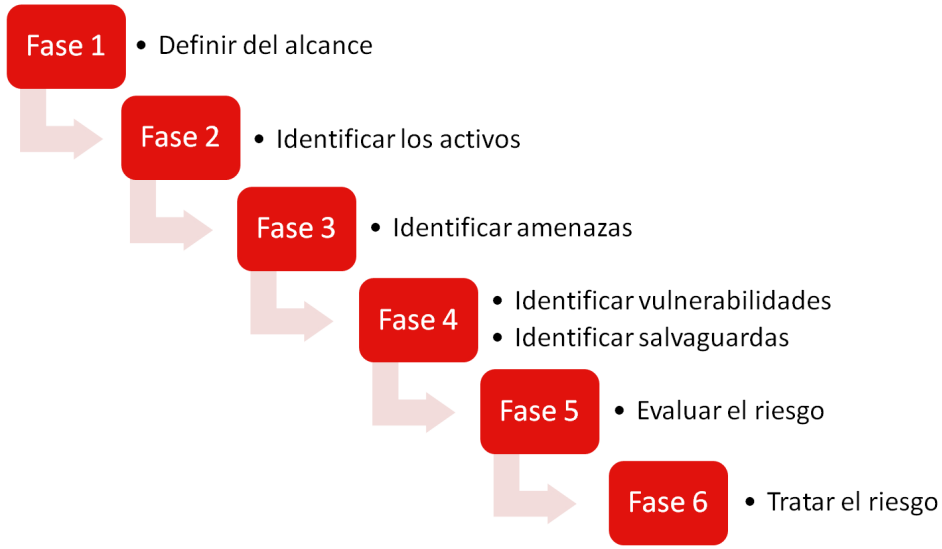


- **Discover**: inventory all assets and identify vulnerabilities
- **Prioritize assets**: categorize assets into groups, assigning a value based on their importance for the operation of your business
- **Assess**: determine a baseline risk profile
- **Report**: measure the level of risk associated with assets, in accordance with the current security policies
- **Remediate**: prioritize and fix vulnerabilities
- **Verify**: audit the system to verify that threats no longer exist

Vulnerability Management and Assessment

Risk analysis process



- **Identify threats**. The use of standard methodologies such as MAGERIT v3 can help (see `https://administracionelectronica.gob.es/pae_Home/pae_Documentacion/pae_Metodolog/pae_Magerit.html`)
- **Manage risk**. Four possibilities:
  - *Transferring the risk to a third-party* (i.e., buying an insurance)
  - *Avoid the risk*
  - *Accept risk* (be careful with this)
  - *Mitigate (decrease) risk*

Credits: `https://www.incibe.es/protege-tu-empresa/blog/analisis-riesgos-pasos-sencillo`

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Vulnerability Management and Assessment

Vulnerability assessment

- **Systematic review of security weaknesses in a system**
- **Assessing the system for known vulnerabilities, prioritizing them, and recommending action** (remediation, mitigation, avoidance)

Vulnerability Management and Assessment

Vulnerability assessment

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Types of assessments

- **External analysis**: focused on components accessible to external users
- **Internal scans**: any system component on the internal network (not exposed to external users)
- **Environmental scans**: focused on specific operational technologies used by the organization (e.g., cloud services, mobile devices, etc.)

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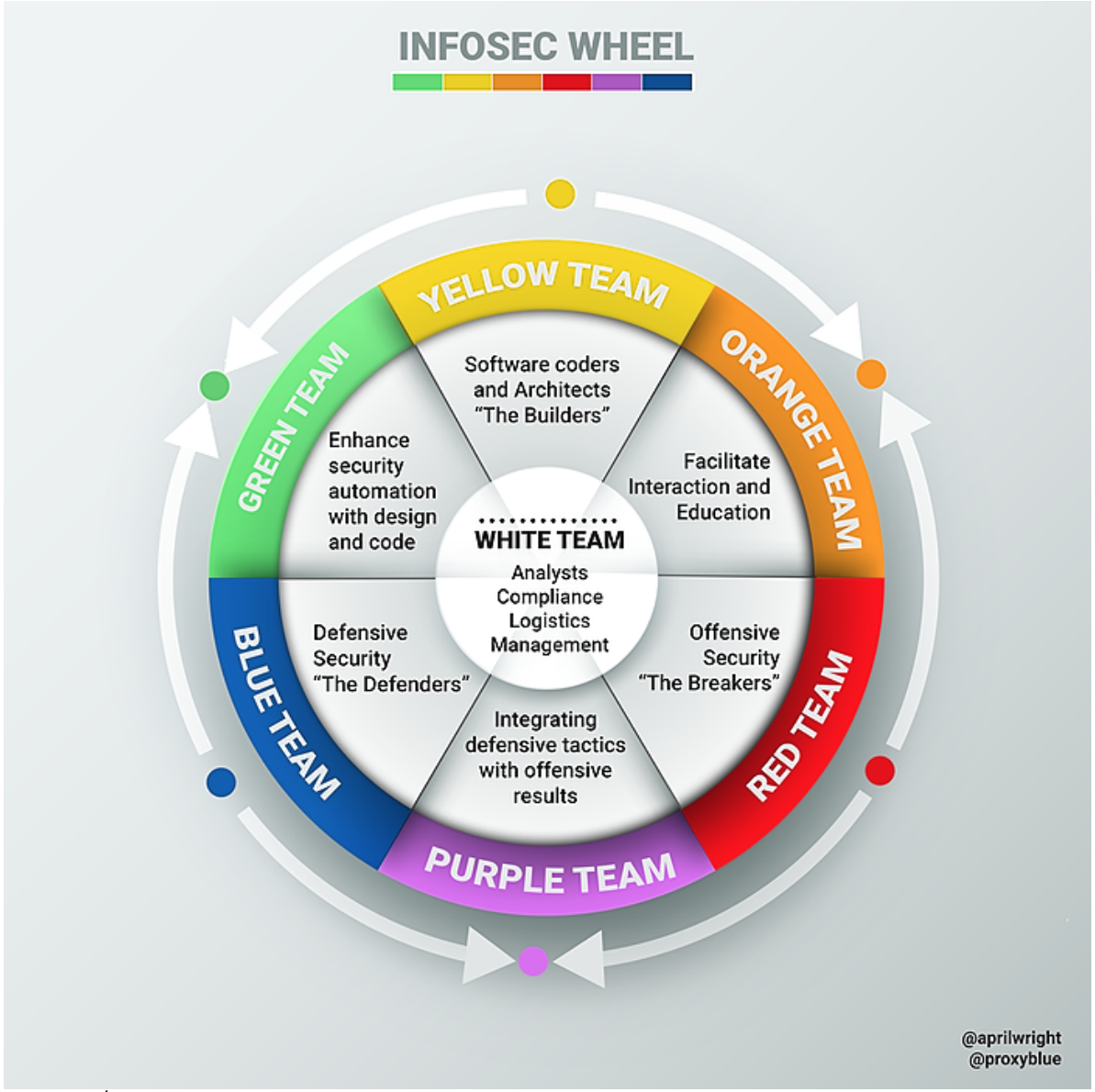
Vulnerability Management and Assessment

Red, blue, and... even purple?



Credits: https://hackernoon.com/

Vulnerability Management and Assessment

Vulnerability assessment reports

- **The shorter, the better: it will be straight to the point**
- Aimed at the management and security staff of an organization
- **Common structure**:
  - Executive summary
  - Introduction: scope, extent and limitations
  - Laws, regulations, and policies
  - Identification of assets
  - Threat assessment
  - Audit process
  - Summary

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Vulnerability Metrics

Common Vulnerability Scoring System (CVSS)

- **Metric to assess the criticality of vulnerabilities**
- Recognized and tested internationally for years
- **Three groups of metrics**
  - **Base Metric Group**
  - **Temporal Metric Group**
  - **Environmental Metric Group**
- **Proposed by FIRST**
  - "[Joint] incident response and security teams from every country across the world to ensure a safe internet for all"
- **Online calculator**: `https://www.first.org/cvss/calculator/3.1`

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Vulnerability Metrics

CVSS v3.1

Base Score

Attack Vector (AV)

Network (N) | Adjacent (A) | Local (L) | Physical (P)

Attack Complexity (AC)

Low (L) | High (H)

Privileges Required (PR)

None (N) | Low (L) | High (H)

User Interaction (UI)

None (N) | Required (R)

Scope (S)

Unchanged (U) | Changed (C)

Confidentiality (C)

None (N) | Low (L) | High (H)

Integrity (I)

None (N) | Low (L) | High (H)

Availability (A)

None (N) | Low (L) | High (H)

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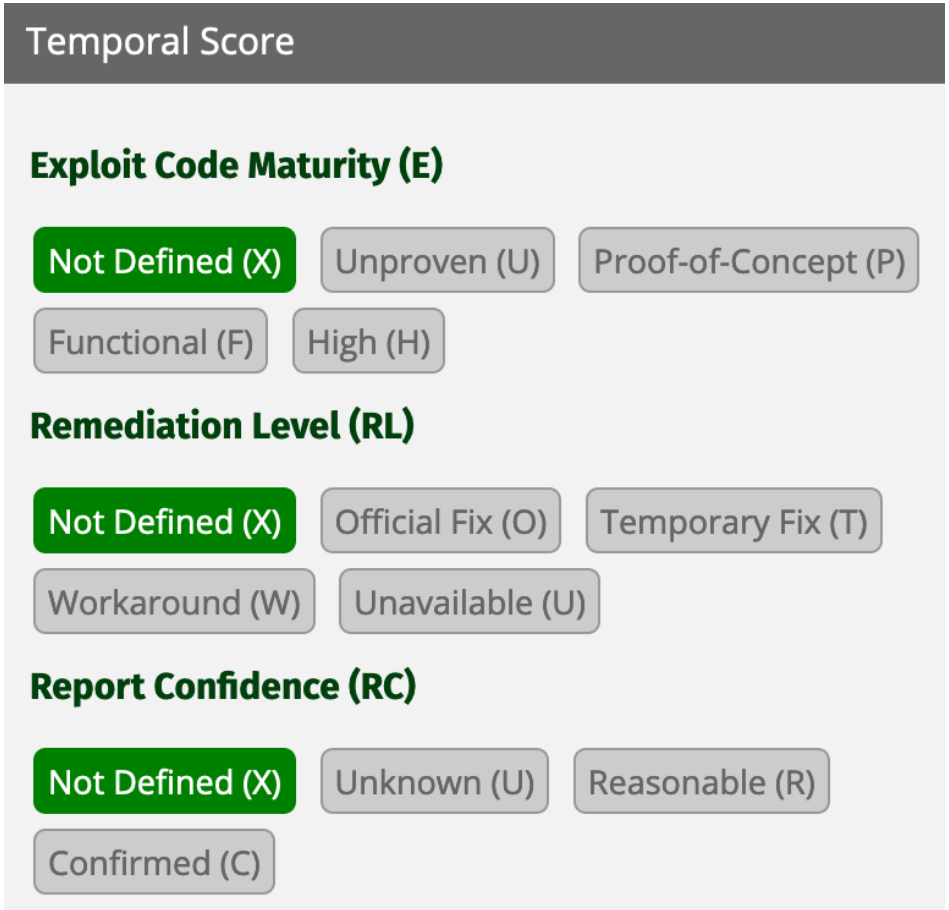
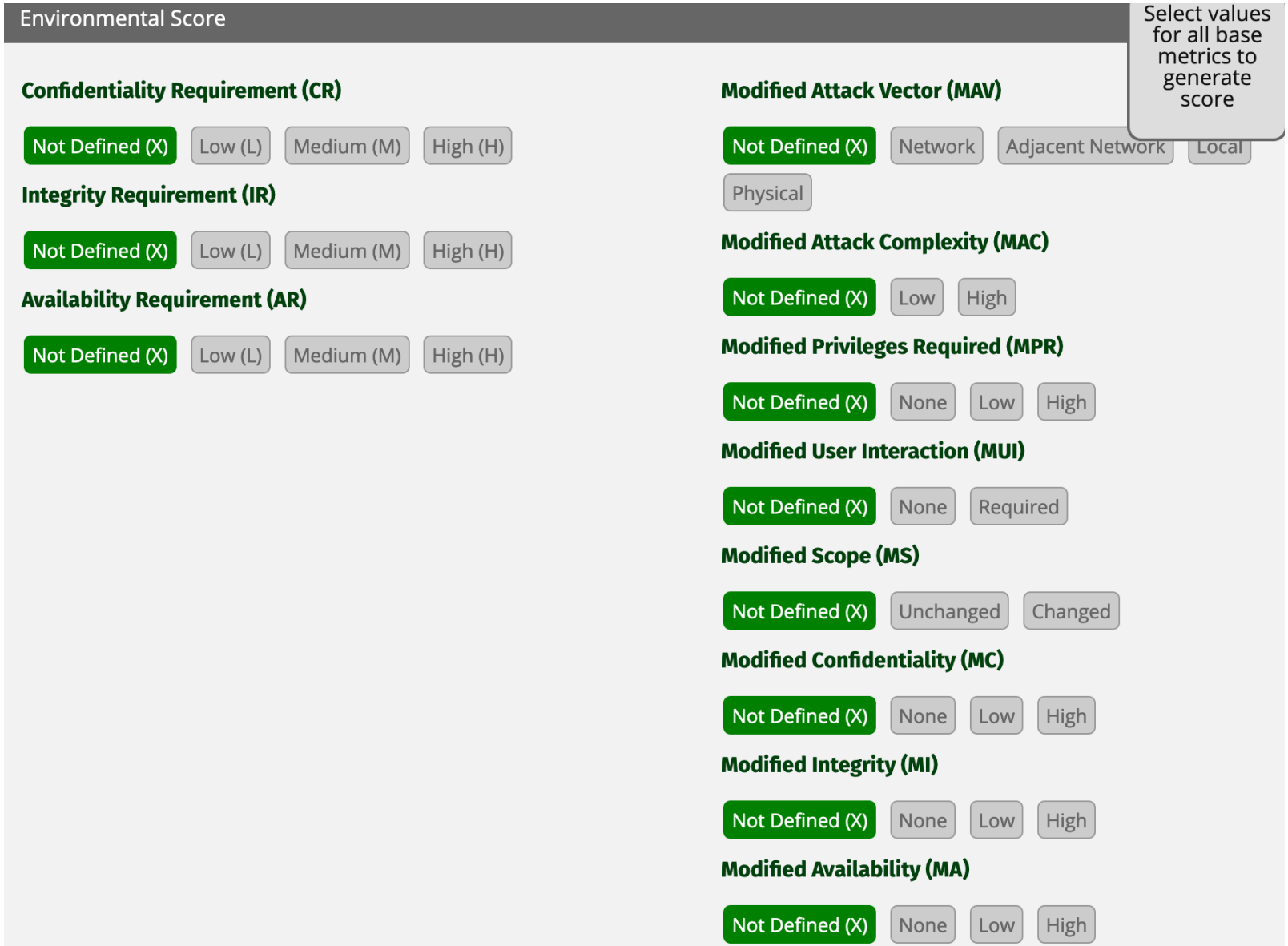
Vulnerability Metrics

CVSS v3.1



Vulnerability Metrics

CVSS v3.1



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Vulnerability Metrics
CVSS v3.1

- **Qualitative criteria severity rating scale** from version 3.0
- Good for prioritizing vulnerabilities (as part of vulnerability assessment)

Score	Severity
0	None
[0.1, 3.9]	Low
[4.0, 6.9]	Medium
[7.0, 8.9]	High
[9.0, 10]	Critical

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Dept. of Computer Science and Systems Engineering
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Course 2022/2023

Master's Degree in Informatics Engineering

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