
# 2023

# Class #4 – Domain 3 (part 1)


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CISSP® MENTOR PROGRAM – SESSION FOUR

# FRSECURE CISSP MENTOR PROGRAM LIVE STREAM

THANK YOU!

## Quick housekeeping reminder.

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- Please do not comment about controversial subjects, and please **NO DISCUSSION OF POLITICS OR RELIGION**.
- Failure to abide by the rules may result in disabling chat for you.
- **DO NOT share or post copywritten materials (pdf of book)**


PLEASE... Don't Shoot the....
PIANO PLAYER
HE'S DOING THE BEST HE CAN!

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# SCHEDULE

*[Our plan]*

| Class Number | Date | Topic | Lead Mentor |
|---|---|---|---|
| 1 | 4/10/23 | Introduction | Evan |
| 2 | 4/12/23 | Domain 1: Security & Risk Management | Brad |
| 3 | 4/17/23 | Domains 2 & 3: Asset Security & Security Architecture (p1) | Ryan |
| 4 | 4/19/23 | Domain 3: Security Architecture and Engineering (p2) | Ron |
| | 4/24/23 | BREAK | |
| 5 | 4/26/23 | Domain 3: Security Architecture and Engineering (p3) | Chris |
| 6 | 5/1/23 | Domain 4: Communication and Network Security (p1) | AJ |
| 7 | 5/3/23 | Domain 4: Communication and Network Security (p2) | Brad |
| 8 | 5/8/23 | Domain 5: Identity and Access Management | Ryan |
| | 5/10/23 | BREAK | |
| 9 | 5/15/23 | Domain 6: Security Assessment and Testing | Ron |
| 10 | 5/17/23 | Domain 7: Security Operations (p1) | Chris |
| 11 | 5/22/23 | Domain 7 & 8: Security Operations (p2) & Software Development Security | AJ |
| 12 | 5/24/23 | Review & Exam Preparation | ALL |
| | 5/29/23 | BREAK | |
| 13 | 6/1/23 | Final Exam Preparation | ALL |

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# INTRODUCTION – DOMAIN 3, PART 1

## Agenda –

- Welcome, Reminders, & Introduction
- Questions

- Domain 3 – Security Architecture and Engineering
- Security Architecture
- Security Engineering
- Security Models
- Security Controls
- Systems overview

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# WHOAMI

## Ron Woerner, CISSP, CISM

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Hackers Wanted
TEDx Omaha

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# QUESTIONS.

The most common questions:

## Check your email for links

- Discord channels https://discord.gg/FWfjPnAZ
  - Use it for more in-depth questions / discussions
  - Before you ask a question, check
    - If it's been asked
    - The isc2.com website
- Live session links & recording
- Instructor slide deck https://learn.frsecure.com/
- Other Resources

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# ISC2 RESOURCES

- CISSP Certification Exam Outline
  https://www.isc2.org/Certifications/cissp/Certification-Exam-Outline
- The Ultimate Guide to the CISSP →
  https://cloud.connect.isc2.org/cissp-ultimate-guide
- CISSP Experience Requirements
  https://www.isc2.org/Certifications/CISSP/experience-requirements
- ISC2 Certification References
  https://www.isc2.org/certifications/References

CISSP Study Resources

» Exam Outline
» Official (ISC)² Guide to the CISSP CBK
» Official (ISC)² CISSP Study Guide
» Official (ISC)² CISSP Practice Tests
» CISSP For Dummies
» Official CISSP Study App
» Official CISSP Flash Cards
» Suggested References
» Free CISSP Webcast Series

# GETTING GOING…

## Great job last week! We're through the introduction and Domains 1 & 2

- Shout Out to Ryan Cloutier for last session!

- Every week goes so fast, it's easy to forget what happened. Same for you all?
  - Everyone get some study time in?
- Check-in – Domain 1 & 2
- How many have read Domain 3?
- Questions?

# GETTING GOING…

## Managing Risk!

### Study Tips:

- Study in small amounts frequently (20-30 min)
- Pause the video if needed (we'll be here)
- Flash card and practice test apps help
- Take naps after heavy topics (aka Security Models)
- Write things down, say them out loud
- Use the Discord Channels
- Exercise or get fresh air in between study sessions

going!




# THE BOOK

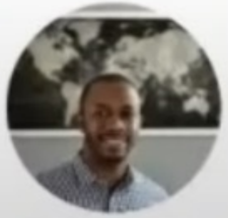
**Title**: The Official (ISC)2 CISSP CBK Reference, 6th Edition.

- ISBN-10: 111978990
- ISBN-13: 978-1119789994


**Do not share electronic versions of the book!**

## About the authors

Follow authors to get new release updates, plus improved recommendations.



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### Arthur J. Deane

Arthur J. Deane, CISSP, CCSP is a Cybersecurity Executive at Capital One. Prior to joining Capital One, he held information security positions at Google and Amazon, where he led security Programs in both companies' Cloud divisions. In addition to his

See more on the author's page ›

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### Aaron Kraus

Aaron Kraus, CISSP, CCSP is a cybersecurity practitioner with over 15 years of experience across diverse industries and countries, and has been both author and technical editor for numerous CISSP and CCSP publications. He is an instructor, course author, and

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# INTRODUCTION

## Before we get too deep into this.

How about a dumb dad joke?

## What do you call a fish wearing a bowtie?

## So-fish-ticated…

😂😂😂

Yeah, I know.
That's dumb.

Let's get to it…

# DOMAIN 2

You read the book, right?

## DOMAIN 2
## Asset Security

TO APPLY AND ENFORCE effective asset security, you must concentrate on inventorying all sources of value, called *assets*. Assets can be tangible or intangible, existing in the form of information stores, databases, hardware, software, or entire networks.

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# DOMAIN 2: ASSET SECURITY

## Topics:

If you read Domain 2 AND it felt a little disjointed, that's because it is (in the book).

Don't worry, we'll help it make sense!

It's okay to jump around between topics. You don't need to read the book sequentially.

← Study tip!

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# DOMAIN 2: ASSET SECURITY

## CISSP Exam Overview

https://www.isc2.org/-/media/ISC2/Certifications/Ultimate-Guides/UltimateGuideCISSP-Web.ashx

You gotta know what you got to keep it secure…
*And* how important it is…

## Domain 2: Asset Security

**2.1 Identify and classify information and assets**

- Data classification
- Asset Classification

**2.2 Establish information and asset handling requirements**

**2.3 Provision resources securely**

- Information and asset ownership
- Asset inventory (e.g., tangible, intangible)
- Asset management

**2.4 Manage data lifecycle**

- Data roles (i.e., owners, controllers, custodians, processors, users/subjects)
- Data collection
- Data location
- Data maintenance
- Data retention
- Data remanence
- Data destruction

**2.5 Ensure appropriate asset retention (e.g., End-of-Life (EOL), End-of-Support (EOS))**

**2.6 Determine data security controls and compliance requirements**

# DOMAIN 2: ASSET SECURITY

## Topics:

- Identify and Classify Information and Assets
- Establish Information and Asset Handling Requirements
- Provision Resources Securely
- Manage Data Lifecycle
- Ensure Appropriate Asset Retention
- Determine Data Security Controls and Compliance Requirements

**Honestly, this domain is a little all over the place and out of order.**
***(déjà vu)***

# DOMAIN 2: ASSET SECURITY

YAY! 👍🏻
Another Domain done!

## Topics:

- Identify and Classify Information and Assets
- Establish Information and Asset Handling Requirements
- Provision Resources Securely
- Manage Data Lifecycle
- Ensure Appropriate Asset Retention
- Determine Data Security Controls and Compliance Requirements

**Questions on Domain 2?**

# DOMAIN 3 SECURITY ARCHITECTURE AND ENGINEERING

You read the book, right?

The Security Architecture and Engineering domain covers topics relevant to implementing and managing security controls across a variety of systems. Secure design principles are introduced that are used to build a security program, such as secure defaults, zero trust, and privacy by design. Common security models are also covered in this domain, which provide an abstract way of viewing a system or environment and allow for identification of security requirements related to the CIANA+PS principles. Specific system types are discussed in detail to highlight the application of security controls in a variety of architectures, including client- and server-based systems, industrial control systems (ICSs), Internet of Things (IoT), and emerging system types like microservices and containerized applications.

# Security Architecture Is

**Design** and organization of the components, processes, services, and controls appropriate to reduce the security risks associated with a system to an acceptable level.

What's the diff?

# Security Engineering Is

**Implementation** of that design

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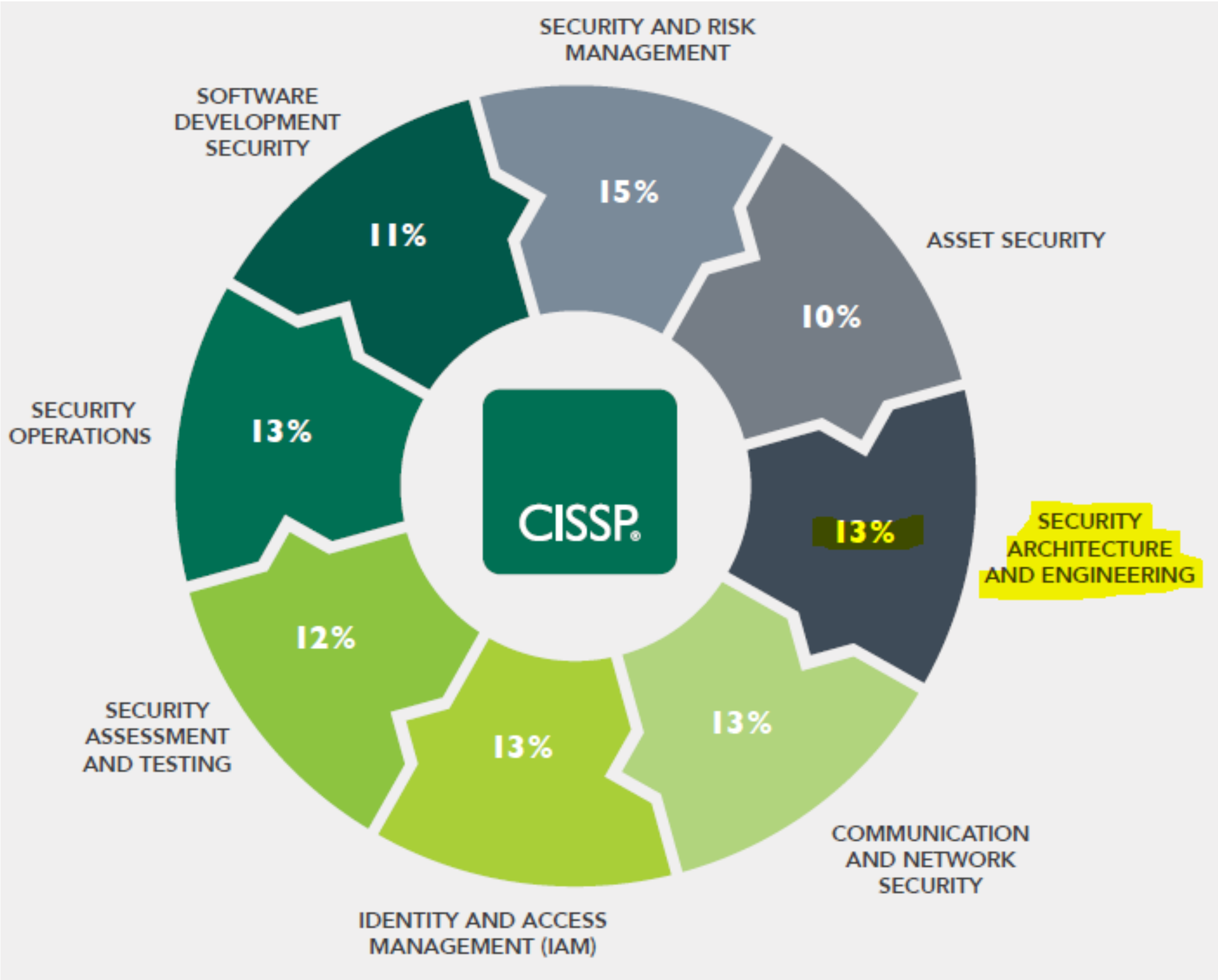
# DOMAIN 3: SECURITY ARCHITECTURE & ENGINEERING

## CISSP Exam Overview

Caution!
Concepts overlap between domains.




https://www.isc2.org/-/media/ISC2/Certifications/Ultimate-Guides/UltimateGuideCISSP-Web.ashx

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# DOMAIN 3: SECURITY ARCHITECTURE & ENGINEERING

Part 1

## CISSP Exam Overview

3.1 **Research, implement and manage engineering processes using secure design principles**

- Threat modeling
- Least privilege
- Defense in depth
- Secure defaults
- Fail securely
- Separation of Duties (SoD)
- Keep it simple
- Zero Trust
- Privacy by design
- Trust but verify
- Shared responsibility

3.2 **Understand the fundamental concepts of security models (e.g., Biba, Star Model, Bell-LaPadula)**

3.3 **Select controls based upon systems security requirements**

3.4 **Understand security capabilities of Information Systems (IS) (e.g., memory protection, Trusted Platform Module (TPM), encryption/decryption)**

3.5 **Assess and mitigate the vulnerabilities of security architectures, designs, and solution elements**

- Client-based systems
- Server-based systems
- Database systems
- Cryptographic systems
- Industrial Control Systems (ICS)
- Cloud-based systems (e.g., Software as a Service (SaaS), Infrastructure as a Service (IaaS), Platform as a Service (PaaS))
- Distributed systems
- Internet of Things (IoT)
- Microservices
- Containerization
- Serverless
- Embedded systems
- High-Performance Computing (HPC) systems
- Edge computing systems
- Virtualized systems

[https://www.isc2.org/Certifications/cissp/Certification-Exam-Outline](https://www.isc2.org/Certifications/cissp/Certification-Exam-Outline)

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# DOMAIN 3: SECURITY ARCHITECTURE & ENGINEERING

Part 2

## CISSP Exam Overview

[https://www.isc2.org/Certifications/cissp/Certification-Exam-Outline](https://www.isc2.org/Certifications/cissp/Certification-Exam-Outline)

### 3.6 Select and determine cryptographic solutions

- Cryptographic life cycle (e.g., keys, algorithm selection)
- Cryptographic methods (e.g., symmetric, asymmetric, elliptic curves, quantum)
- Public Key Infrastructure (PKI)
- Key management practices
- Digital signatures and digital certificates
- Non-repudiation
- Integrity (e.g., hashing)

### 3.7 Understand methods of cryptanalytic attacks

- Brute force
- Ciphertext only
- Known plaintext
- Frequency analysis
- Chosen ciphertext
- Implementation attacks
- Side-channel
- Fault injection
- Timing
- Man-in-the-Middle (MITM)
- Pass the hash
- Kerberos exploitation
- Ransomware

### 3.8 Apply security principles to site and facility design

### 3.9 Design site and facility security controls

- Wiring closets/intermediate distribution facilities
- Server rooms/data centers
- Media storage facilities
- Evidence storage
- Restricted and work area security
- Utilities and Heating, Ventilation, and Air Conditioning (HVAC)
- Environmental issues
- Fire prevention, detection, and suppression
- Power (e.g., redundant, backup)

## Security Architecture

# Introduction

- The goal is protecting confidentiality, integrity, and availability of the systems or business in addition to Privacy and other important principals.
- Conduct a comprehensive risk assessment to gain an accurate idea of the risks to be addressed.
- Once risks are identified and assessed the security architecture can begin.
- Risk treatments
  - Avoid
  - Transfer or share (i.e., insurance or contract)
  - Mitigate (e.g., through security architecture)
  - Accept

## Security Architecture

# Risk assessment

- Initial **risk assessment** identifies the risks to be reduced through the design of a security architecture to incorporate appropriate security controls.
- An assessment must be made to confirm that the resulting **system's risks have been reduced to an acceptable level**.
- Cost associated with certain controls can be prohibitive related to anticipated benefit.
- Decision to reduce certain risks may need to be reconsidered, and those risks treated in another manner, avoided through a system redesign, or the project simply abandoned.

*Reminder the **cost of a security control, must be less than the cost of the risk** being addressed

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

## Introduction

- **Security serves to protect the business**.
  The work of the security architect is to **ensure the business and its interests** at the very least are protected according to applicable standards and laws, as well as meeting any relevant regulatory compliance needs.
- There is a tendency to concentrate on technical security controls and attempt to address all known security issues or requirements.
- *Security for security's sake, while intellectually satisfying, is a disservice to the organization.*
- Always remember we first serve as subject matter experts, aware of relevant regulations or laws and capable of ensuring our organization's compliance wherever change is required.

## Security Architecture

# Introduction

- Organization's security strategy must align with its mission, goals, objectives, and compliance environment.

- Success in security architecture is much more likely when one is aligned with the business and taking a risk management approach to security architecture.

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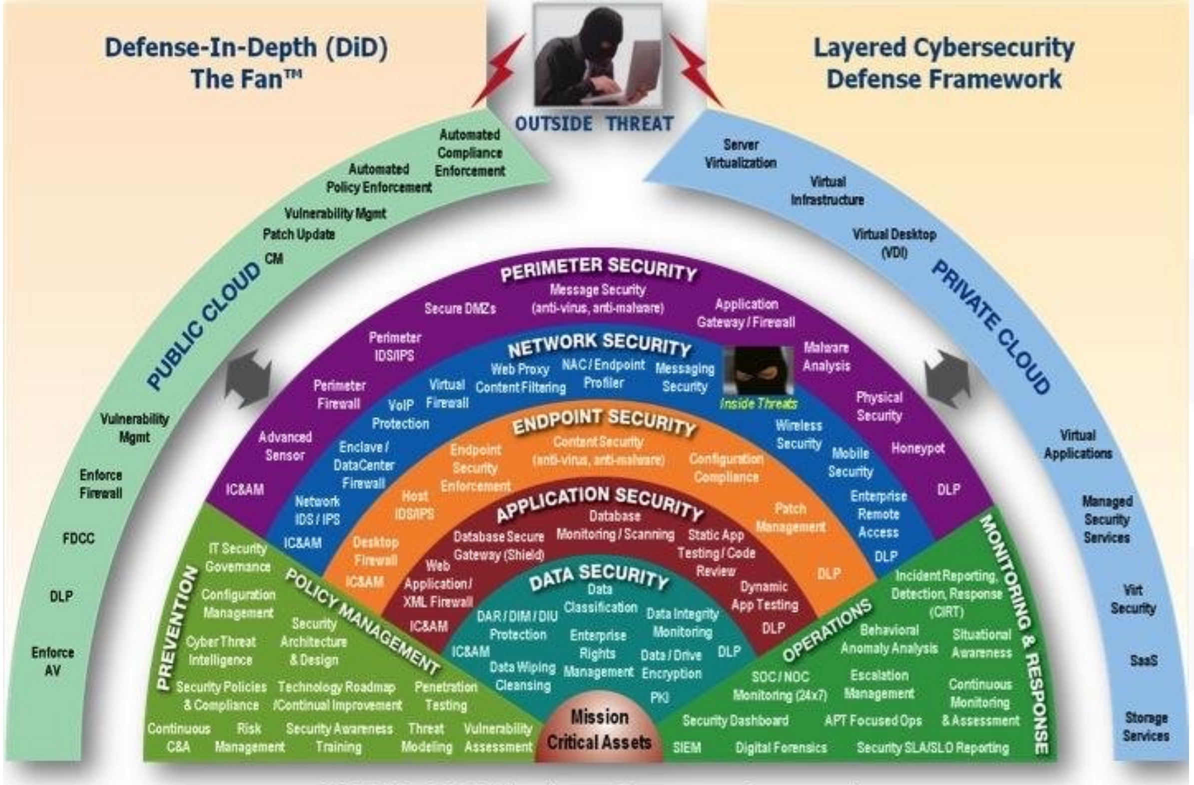
# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

## RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES

- Design / Plan
- Development
- Testing
- Implementation
- Maintenance
- Decommissioning

**Lifecycle**

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# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

## RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES

- It is less expensive to incorporate security when the overall functional system design is developed rather than trying to add it on later (which will often require redesign, if not reengineering, of already developed components).
- The need for security controls is *not* just to prevent the user from performing unauthorized actions, but to prevent components of the system itself from violating security requirements when acting on the user's requests.
- If security is not intrinsic to the overall design, it is not possible to completely mediate all the activities that can compromise security.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES

Fundamental to any security architecture, regardless of the design principles employed, are the basic requirements outlined by James Anderson in Computer Security Technology Planning Study in 1972 (USAF)*:

- Security functions need to be implemented in a manner that prevents their being bypassed, circumvented, or tampered with.
- Security functions need to be invoked whenever necessary to implement the security control. Security functions need to be as small as possible so that defects are more likely to be found.

* Cybersecurity Groundhog Day

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES

ISO/IEC 19249 (5 architectural principles)

- Domain separation
- Layering
- Encapsulation
- Redundancy
- Virtualization

Information technology — Security techniques — Catalogue of architectural and design principles for secure products, systems and applications

https://www.iso.org/standard/64140.html

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES

ISO/IEC 19249 (5 architectural principles)

Domain separation

- Placing components that share similar security attributes, such as privileges and access rights, in a domain.
- Only permitting separate domains to communicate over well-defined and (completely) mediated communication channels (e.g. application programming interfaces, or APIs).

- Real World Examples
  - A network is separated into manageable and logical segments. Network traffic (inter-domain communication) is handled according to policy and routing control, based on the trust level and workflow between segments.
  - Data is separated into domains in the context of classification, categorization, and security baseline. Even though data might come from disparate sources, if that data is classified at the same level, the handling and security of that classification level (domain) is accomplished with like security attributes.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES

ISO/IEC 19249 (5 architectural principles)

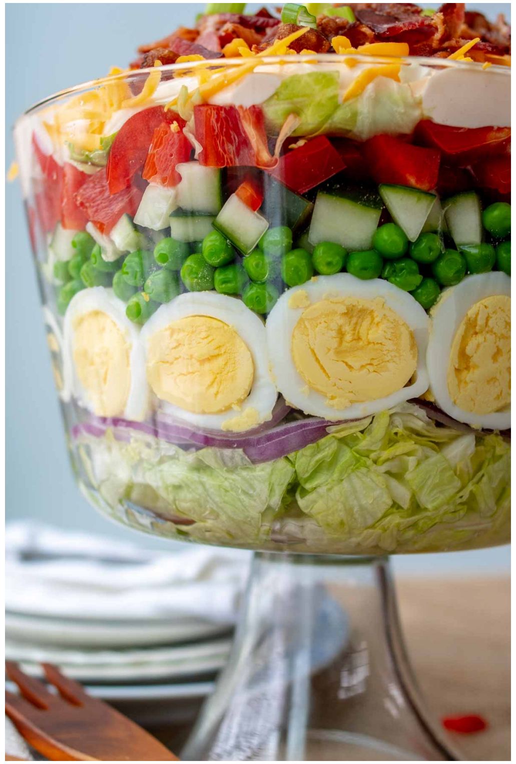
***Layering***

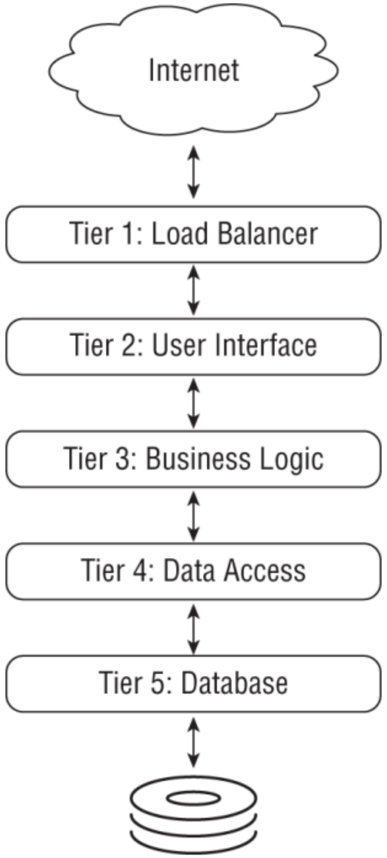
- Hierarchical structuring of a system into different levels of abstraction, with higher levels relying upon services and functions provided by lower levels, and lower levels hiding (or abstracting) details of the underlying implementation from higher levels.
- Layering is seen in network protocols, starting with the classic OSI seven-layer model running from physical through to application layers.
- In software systems, one encounters operating system calls, upon which libraries are built, upon which we build our programs. Within the operating system, higher-level functions (such as filesystem functions) are built upon lower-level functions (such as block disk I/O functions).

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES






# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES

ISO/IEC 19249:2017 (5 architectural principles)

The purpose of layering is to do the following:

- Create the ability to impose specific security policies at each layer
- Simplify functionality so that the correctness of its operation is more easily validated

**From a security perspective:**

- *Higher levels always have the same or less privilege than a lower level*. If layering to provide security controls, it must not be possible for a higher level to bypass an intermediate level.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES

## ISO/IEC 19249:2017 (5 architectural principles)

### *Encapsulation*

- An architectural concept where objects are accessed only through functions that logically separate functions that are abstracted from their underlying object by inclusion or information hiding within higher level objects.
- Encapsulation functions can define the security policy for that object and mediate all operations on that object.
- Encapsulation requires that all access or manipulation of the encapsulated object must go through the encapsulation functions, and that it is not possible to tamper with the encapsulation of the object or the security attributes (e.g., permissions) of the encapsulation functions.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

## RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES

# ISO/IEC 19249:2017 (5 architectural principles)

## *Encapsulation*

- Device drivers can be considered to use a form of encapsulation in which a simpler and consistent interface is provided that hides the details of a particular device.
- Forcing interactions to occur through the abstract object increases the assurance that information flows conform to the expected inputs and outputs.

- An example where encapsulation is used in the real world is the use of the setuid bit. Typically, in Linux or any Unix-based operating system, a file has ownership based on the person who created it, and an application runs based on the person who launched it. A special mechanism, setuid, allows for a file or object to be set with different privileges. Setting the setuid bit on a file will cause it to open with the permission of whatever account you set it to be. The setuid bit controls access, above and beyond the typical operation. That is an example of encapsulation.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES

ISO/IEC 19249:2017 (5 architectural principles)

***Redundancy***

- Designing a system with replicated components, operating in parallel, so that the system can continue to operate in spite of errors or excessive load.
- From a security perspective, redundancy is an architectural principle for addressing possible availability and integrity compromises or issues.
- For redundancy to work, it must be possible for the overall system to detect errors in one of the replicated subsystems.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES

ISO/IEC 19249:2017 (5 architectural principles)

***Redundancy*** *examples*

- High availability solutions such as a cluster, where one component or system takes over when its active partner becomes inaccessible
- Having storage in redundant array of inexpensive disks (RAID) configurations where the data is made redundant and fault tolerant
- Cloud-based storage, where data is replicated across multiple data centers, zones, or regions

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES

ISO/IEC 19249:2017 (5 architectural principles)

***Virtualization***

- Is a form of emulation in which the functionality of one real or simulated device is emulated on a different one. (This is discussed in more detail in the "Understand Security Capabilities of Information Systems" section later in this chapter.)
- More commonly, virtualization is the provision of an environment that functions like a single dedicated computer environment but supports multiple such environments on the same physical hardware.
- Virtualization involves abstracting the underlying components of hardware or software from the end user.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### RESEARCH, IMPLEMENT, AND MANAGE ENGINEERING PROCESSES USING SECURE DESIGN PRINCIPLES

ISO/IEC 19249 (

- Least privilege
- Attack surface minimization
- Centralized parameter validation
- Centralized general security services
- Preparing for error and exception handling

The principle of least privilege asserts that access to information should only be granted on an as-needed basis

The more entry points, the greater the attack surface.

Full parameter validation is especially important when dealing with user input, or input from systems to which users input data.

Simplifying your security services interface instead of managing multiple interfaces is a sensible benefit.

Systems must ensure that errors are detected, and appropriate action taken

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### Review Question

Device drivers can be considered to use a form of _______________ in which a simpler and consistent interface is provided that hides the details of a particular device, as well as the differences between similar devices:

1. Zero Trust
2. Layering
3. Redundancy
4. Encapsulation

Encapsulation is an architectural concept where objects are accessed only through functions that logically separate functions that are abstracted from their underlying object by inclusion or information hiding within higher level objects.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Threat Modeling

Define Threat

Process to identify security threats and vulnerabilities, and prioritize mitigations

Used to reduce risk and guide secure development.

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# DAD JOKE

## Before we get too deep into this.

How about a dumb dad joke?

**I received a verifiable threat against my Boston cream pie**


HAHAHAHA

Moving on…

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Threat Modeling STRIDE (6 categories)

- **Spoofing** Spoofing is an attack during which a person or system assumes the identity of another person or system by falsifying information.
- **Tampering** Data tampering is an attack on the integrity of data by maliciously manipulating data.
- **Repudiation** Repudiation is the ability of a party to deny that they are responsible for performing an action. Repudiation threat occurs when a user claims that they did not perform an action, and there is no evidence to prove otherwise.
- **Information disclosure** Information disclosure — commonly referred to as a data leak — occurs when information is improperly shared with an unauthorized party
- **Denial of service** A denial-of-service (DoS) attack involves a malicious actor rendering a system or service unavailable by legitimate users.
- **Elevation of privilege** Elevation of privilege (or privilege escalation) occurs when an unprivileged application user can upgrade their privileges to those of a privileged user (such as an administrator).

See Adam Shostack's site: https://shostack.org/resources/threat-modeling

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# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Threat Modeling STRIDE (6 categories)

- **Spoofing** ...em assumes the identity of another person or system by falsifying information.
- **Tampering** Data tampering is an attack on the integrity of data by ...
- **Repudiation** ... are responsible for performing an action. Repudiation threat occurs whe... n action, and there is no evidence to prove otherwise.
- **Information disclosure** Information disclosure — commonly referre... information is improperly shared with a...
- **Denial of service** ... actor rendering a system or service unavailable by legitimate users.
- **Elevation of privilege** Elevation of privilege (or privilege escalation) o... user can upgrade their privileges to those of a privileged user (such as an administra...

Strong passwords, multifactor authentication, and digital signatures are common controls to protect against spoofing.

Strong access controls and thorough logging and monitoring are good ways to prevent and detect data tampering.

Digital signatures and secure logging and auditing are the primary controls to provide nonrepudiation.

Encryption, data loss prevention (DLP), and strong access controls are common controls to protect against information disclosure.

System redundancy, network filtering, and resource limits are common protections against DoS attacks.

Strong access control and input validation are common protections against privilege escalation.

See Adam Shostack's site: https://shostack.org/resources/threat-modeling

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# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Threat Modeling STRIDE (6 categories)

- **Spoofing** Spoofing ... em assumes the identity of another person or system by falsifying information.
- **Tampering** Dat...
- **Repudiation** ... ning an action. Repudiation threat occ... dence to prove otherwise.
- **Information d**... information is imprope...
- **Denial of service** denial ... s actor rendering a system or service unavailable by legitimate users.
- **Elevation of privilege** Elevation of privilege (or privilege escalation) o... user can upgrade their privileges to those of a privileged user (such as an administra...

Strong passwords, multifactor authentication, and digital signatures are common controls to protect against spoofing.

... controls and thorough ...itoring are good ways to ...etect data tampering.

...ta loss prevention (DLP), ...ess controls are common ...otect against information disclosure.

System redundancy, network filtering, and resource limits are common protections against DoS attacks.

Strong access control and input validation are common protections against privilege escalation.

**QUESTION TO ASK**

**WHAT CAN GO WRONG??**

See Adam Shostack's site: [https://shostack.org/resources/threat-modeling](https://shostack.org/resources/threat-modeling)

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Threat Modeling DREAD (5 key points)

- **Damage** What is the total amount of damage the threat is capable of causing to your business?
- **Reproducibility** How easily can an attack on the particular threat be replicated?
- **Exploitability** How much effort is required for the threat to be exploited by an attacker?
- **Affected users** How many people, either inside or outside of your organization, will be affected by the security threat?
- **Discoverability** How easily can the vulnerability be found?

Uses a numeric value for rating severity of security threats (1-10)

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Threat Modeling DREAD (5 key points)

- Damage What is the
- Reproducibility
- Exploitability Ho
- Affected users security threat?
- Discoverability

Uses a numeric v

D = 4
R = 3
E = 8
A = 5
D = 9
Risk Sum = 29

*There are many opinions on the relative importance of each of the categories within DREAD, and many security professionals disagree with a model that weights each category equally

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Threat Modeling PASTA (7 steps) (Process for Attack Simulation and Threat Analysis)

- **Define objectives** During this first stage, key business objectives are defined, and critical security and compliance requirements are identified.
- **Define technical scope** During this stage, the boundaries of the technical environment and the scope of all technical assets for which threat analysis is needed are defined. In addition to the application boundaries, you must discover and document all infrastructure, application, and software dependencies.
- **Application decomposition** During this stage, an evaluation of all assets (i.e., the application components) needs to be conducted, and the data flows between these assets need to be identified. As part of this process, all application entry points and trust boundaries should be identified and defined. This stage is intended to establish a clear understanding of all data sources, the parties that access those data sources, and all use cases for data access within the application
- **Threat analysis** This stage is intended to identify and analyze threat information from within the system, such as SIEM feeds, web application firewall (WAF) logs, etc., as well as externally available threat intelligence that is related to the system.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Threat Modeling PASTA (7 steps) (Process for Attack Simulation and Threat Analysis)

- Define objectives During this first stage, key busine... objecti... compliance requirements are identified.

a preliminary business impact analysis (BIA) is conducted to identify potential business impact considerations.

- Define technical scope During th... ...vironment and the scope of all technical assets for which th... ...e application boundaries, you must discover and document all ...pendencies.

The goal is to capture a high-level but comprehensive view of all servers, hosts, devices, applications, protocols, and data that need to be protected.

- Application decomposition During this stage, an evalu... components) needs to be conducted, and the data flows between these a... this process, all application entry points and trust boundaries should be i... intended to establish a clear understanding of all data sources, the partie... use cases for data access within the application.

in other words, who should perform what actions on which components of the application.

- Threat analysis This stage is ... ...ormation from within the system, such as SIEM feeds, web application fir... ...available threat intelligence that is related to the system.

The output of this stage should include a list of the most likely attack vectors for the given application or system.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Threat Modeling PASTA (7 steps) (Process for Attack Simulation and Threat Analysis)

- **Vulnerability analysis** During this stage, all vulnerabilities within the application's code should be identified and correlated to the threat-attack scenarios identified in step 4. Operating system, application, network, and database scans should be conducted, and dynamic and static code analysis results should be evaluated to enumerate and score existing vulnerabilities
- **Attack enumeration** During this stage, attacks that could exploit identified vulnerabilities (from step 5) are modeled and simulated. This helps determine the likelihood and impact of each identified attack vector.
- **Risk and impact analysis** During this final stage, your business impact analysis (from step 1) should be refined based on all the analysis performed in the previous six steps.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Threat Modeling PASTA (7 steps) (Process for Attack Simulation and Threat Analysis)

- **Vulnerability analysis** During thi… …tion's code should be identified and correlated to the threat… …ating system, application, network, and database scans should… …ode analysis results should be evaluated to enumerate and sc…
- **Attack enumeration** During this … …es (from step 5) are modeled and simulated. Thi… …ntified attack vector.
- **Risk and impact analysis** Du… …m step 1) should be refined based on all the analysis performed in the previous six steps.

The primary output of this stage is a correlated mapping of all threat-attack vectors to existing vulnerabilities and impacted assets.

After this stage, your organization should have a strong understanding of your application's attack surface (i.e., what bad things could happen to which assets within your application environment).

Risks should be prioritized for remediation, and a risk mitigation strategy should be developed to identify countermeasures for all residual risks.

# Security Architecture

## Review Question

Ashley wants to use a risk-based threat model that supports dynamic threat analysis to present to company leadership. Which is the best choice?

1. Zero Trust
2. STRIDE
3. PASTA
4. DREAD

The Process for Attack Simulation and Threat Analysis (PASTA) is a risk-based threat model, developed in 2012, that supports dynamic threat analysis. The PASTA methodology integrates business objectives with technical requirements, making the output more easily understood by upper management

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

# Secure Defaults (secure-by-default) (SBD)

- The concept of secure defaults (or secure-by-default) essentially means that systems should be designed with the best security possible without users needing to turn on security features or otherwise think about security configurations.
- Secure-by-default means that a system's default configuration includes the most secure settings possible, which may not always be the most highly functioning settings.
- Systems and applications should be designed such that the end user (or system admin) must actively choose to override secure configurations based on the business's needs and risk appetite.

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

# Separation of Duties (SOD)

- Requires two (or more) actions, actors, or components to operate in a coordinated manner to perform a security sensitive operation.
- Breaking up a process into multiple steps performed by different individuals or requiring two individuals to perform a single operation together (known as dual control) forces the malicious insider to collude with multiple insiders to compromise the system.
- More robust and less susceptible to failure

- *Separation of duties can also be viewed as a defense-in-depth control; permission for sensitive operations should not depend on a single condition.

# WHAT DO SECURITY AND OLYMPIC SPORTS HAVE IN COMMON?

## KNOWING HOW TO FAIL WITHOUT BEING A FAILURE


https://bleacherreport.com/articles/1943889-ice-skating-fails-to-get-you-ready-for-the-olympics

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Fail Securely

- For some systems, a fail-open design, where systems continue to allow access when exceptions occur, may be preferable to ensure that access to important information remains readily available during a system error or exception. Conversely, a **fail-secure** (also known as a fail-safe or fail-closed) system blocks access by default, ensuring that security is prioritized over availability.

- For systems with sensitive data, security controls should be designed such that in the absence of specific configuration settings to the contrary, the default is to not permit the action. Access should be based on permission (e.g., allowed list), not exclusion (e.g., blocked list)

* This is the principle behind “deny all” default firewall rules and also relates to the concept of least privileged

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Fail Securely

- If an error is detected, the system fails in a deny (or safe) state of higher security rather than failing in an open, less secure state.

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

# Keep it Simple

- "Complexity is the worst enemy of security. The more complex you make your system, the less secure it's going to be, because you'll have more vulnerabilities and make more mistakes somewhere in the system. … The simpler we can make systems, the more secure they are." – Bruce Schneier (https://www.schneier.com/)
- *"If complexity is the worst enemy of security, then simplicity must be its ally"* – Evan Francen
- *"Simple is securable, complex is chaos waiting to happen"* –Ryan Cloutier

Keep Information Security Simple (KISS)

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Keep it Simple

- *Complexity is the enemy of security*. The simpler and smaller the system, the easier it is to design, assess, and test. When the system as a whole cannot be simplified sufficiently, consider partitioning the problem so that the components with the most significant risks are separated and simplified to the extent possible. This is the concept behind a security kernel — a small separate subsystem with the security-critical components that the rest of the system can rely upon.
- By separating security functionality into small, isolated components, the task of carefully reviewing and testing the code for security vulnerabilities can be significantly reduced.

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

### Keep

- Complexi … design, assess, and test. Whe … he problem so that the comp … possible. This is the concept b … omponents that the rest of the
- By separa … reviewing and testing the code

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### Review Question

A subject should only be granted the privileges needed to complete an assigned or authorized task is an example of what design principle?

1. Zero Trust
2. Least privilege
3. Attack Surface Minimization
4. Failing safe

The principle of least privilege asserts that access to information should only be granted on an as-needed basis.
Just in time (JIT) / Just Enough Access (JEA)

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

# Trust, but (then) verify

- “Trust, but verify” mantra is widely used to describe situations that require an extra layer of verification and accountability.
- In the information security world, “trust, but verify” has been used to describe the use of perimeter firewalls and other controls that use a party's identity, location, and other characteristics to verify that they are a trusted user or system from a trusted location
- In other words, “trust, but verify” assumes everything behind your corporate firewall is safe and verifies that anything passing through that firewall into your network is safe to allow in essentially, “verify once, trust forever.” This model of security has become less-preferred in recent years, in favor of the Zero Trust model (discussed in the next section).

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Trust, but (then) verify

- Another way to think of this is, inspect what you expect
- Audits are the bedrock of verify
- 3rd parties (partners, cloud providers, or anyone else outside of your organization)
- Trust has to be earned and maintained ("no set-and-forget")

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Research, Impl Design Principles

# Trust, bu

- Another way
- Audits are th
- 3rd parties (p r organization)
- Trust has to

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Zero Trust (coined by John Kindervag, Forrester)

- **Always verify -** Authenticate and authorize every access request based on user identity, location, system health (e.g., patch levels), data classification, user behavior analytics, and any other available data points.
- **Use least privilege access -** Always assign the minimum rights required for the specific access requested, on a Just in Time (JIT) basis.
- **Assume breach -** Instead of trusting devices on your network, assume the worst-case scenario (i.e., that you've already been breached) and minimize the blast radius to prevent further damage.

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

# Zero Trust

The National Institute of Standards and Technology (NIST) Special Publication (SP) 800-207 provides the following zero trust and ZTA operative definition:

> **Zero trust** provides a collection of concepts and ideas designed to minimize uncertainty in enforcing accurate, least privilege per-request access decisions in information systems and services in the face of a network viewed as compromised. **ZTA** is an enterprise's cybersecurity plan that uses zero trust concepts and encompasses component relationships, workflow planning, and access policies. Therefore, a zero trust enterprise is the network infrastructure (physical and virtual) and operational policies that are in place for an enterprise as a product of a ZTA plan.[5]

https://www.nist.gov/publications/zero-trust-architecture

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Zero Trust

- **Identities should always be verified** and secured with strong **multifactor authentication**, or MFA, wherever possible
- **Devices** that access your network should be inspected both for identity verification and also to ensure their health status and compliance with your organization's security requirements prior to granting access.
- Remember that users and devices shouldn't be trusted just because they're on an internal network.
- All internal **communications** should be **encrypted**, access should be limited to least privilege, by policy, and microsegmentation should be employed to contain threats.
- **Microsegmentation** is a network security technique that involves dividing large network segments into smaller zones to isolate resources from one another and minimize lateral movement by users.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Zero Trust

- Detective controls play a big part in a successful zero trust architecture
- Deploy real-time monitoring to help detect and stop attacks and other anomalous behavior
- Real-time analytics can also help inform access decisions by providing real-time context for access requests and supporting JIT permissions

The path to zero trust is an incremental process that may take years to implement.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Zero Trust


- Detective controls play a big
- Deploy real-time monitoring t alous behavior
- Real-time analytics can also time context for access requests and sup

The path to zero trust is an incremental process that may take years to implement.

## CISSP® MENTOR PROGRAM – SESSION FOUR

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

# Zero Trust Maturity Model CISA

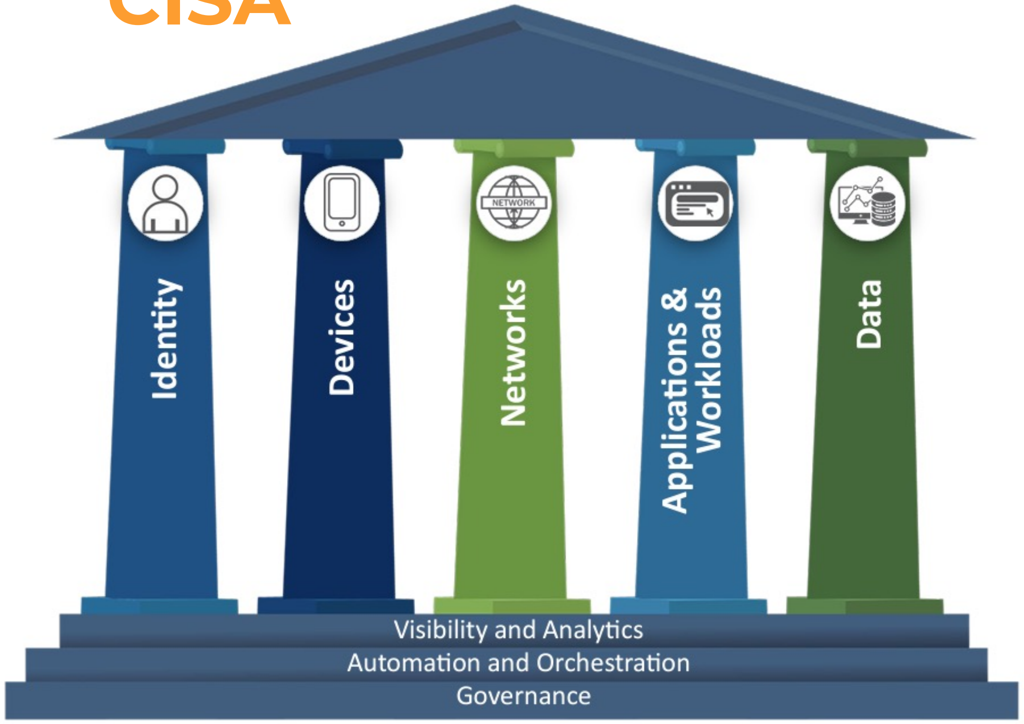
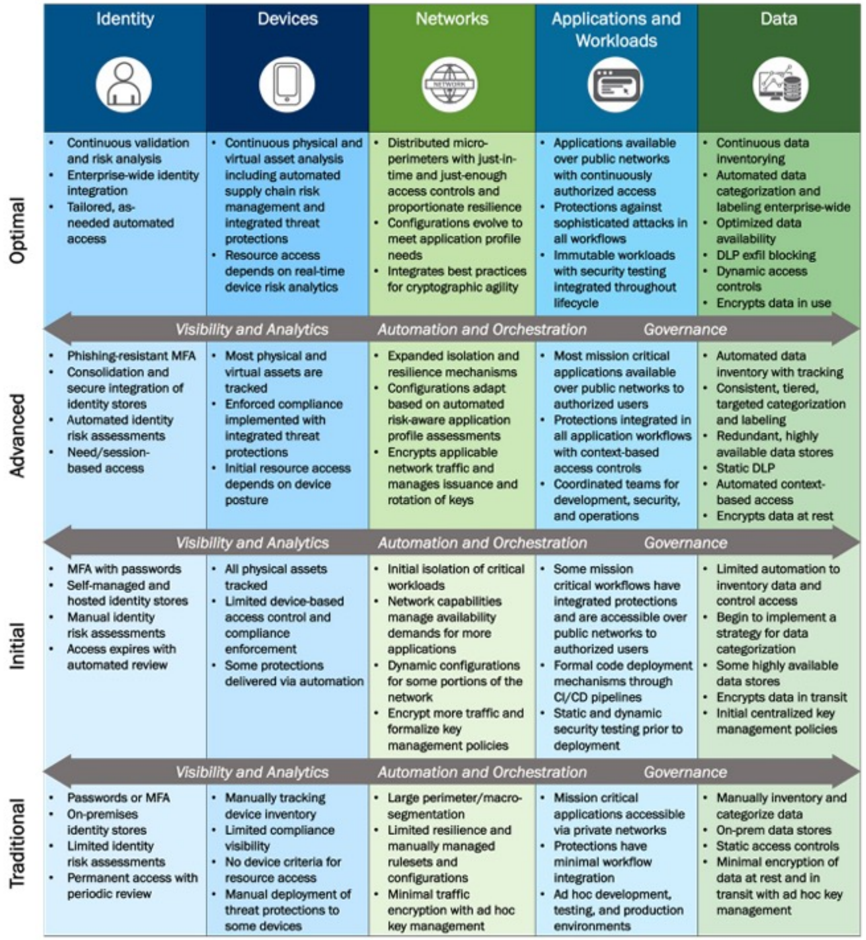



*Figure 1: Zero Trust Maturity Model Pillars*[8]

CISA's ZTMM is one of many paths to support the transition to zero trust.



| | Identity | Devices | Networks | Applications and Workloads | Data |
|---|---|---|---|---|---|
| Optimal | • Continuous validation and risk analysis<br>• Enterprise-wide identity integration<br>• Tailored, as-needed automated access | • Continuous physical and virtual asset analysis including automated supply chain risk management and integrated threat protections<br>• Resource access depends on real-time device risk analytics | • Distributed micro-perimeters with just-in-time and just-enough access controls and proportionate resilience<br>• Configurations evolve to meet application profile needs<br>• Integrates best practices for cryptographic agility | • Applications available over public networks with continuously authorized access<br>• Protections against sophisticated attacks in all workflows<br>• Immutable workloads with security testing integrated throughout lifecycle | • Continuous data inventorying<br>• Automated data categorization and labeling enterprise-wide<br>• Optimized data availability<br>• DLP exfil blocking<br>• Dynamic access controls<br>• Encrypts data in use |
| | Visibility and Analytics | | Automation and Orchestration | | Governance |
| Advanced | • Phishing-resistant MFA<br>• Consolidation and secure integration of identity stores<br>• Automated identity risk assessments<br>• Need/session-based access | • Most physical and virtual assets are tracked<br>• Enforced compliance implemented with integrated threat protections<br>• Initial resource access depends on device posture | • Expanded isolation and resilience mechanisms<br>• Configurations adapt based on automated risk-aware application profile assessments<br>• Encrypts applicable network traffic and manages issuance and rotation of keys | • Most mission critical applications available over public networks to authorized users<br>• Protections integrated in all application workflows with context-based access controls<br>• Coordinated teams for development, security, and operations | • Automated data inventory with tracking<br>• Consistent, tiered, targeted categorization and labeling<br>• Redundant, highly available data stores<br>• Static DLP<br>• Automated context-based access<br>• Encrypts data at rest |
| | Visibility and Analytics | | Automation and Orchestration | | Governance |
| Initial | • MFA with passwords<br>• Self-managed and hosted identity stores<br>• Manual identity risk assessments<br>• Access expires with automated review | • All physical assets tracked<br>• Limited device-based access control and compliance enforcement<br>• Some protections delivered via automation | • Initial isolation of critical workloads<br>• Network capabilities manage availability demands for more applications<br>• Dynamic configurations for some portions of the network<br>• Encrypt more traffic and formalize key management policies | • Some mission critical workflows have integrated protections and are accessible over public networks to authorized users<br>• Formal code deployment mechanisms through CI/CD pipelines<br>• Static and dynamic security testing prior to deployment | • Limited automation to inventory data and control access<br>• Begin to implement a strategy for data categorization<br>• Some highly available data stores<br>• Encrypts data in transit<br>• Initial centralized key management policies |
| | Visibility and Analytics | | Automation and Orchestration | | Governance |
| Traditional | • Passwords or MFA<br>• On-premises identity stores<br>• Limited identity risk assessments<br>• Permanent access with periodic review | • Manually tracking device inventory<br>• Limited compliance visibility<br>• No device criteria for resource access<br>• Manual deployment of threat protections to some devices | • Large perimeter/macro-segmentation<br>• Limited resilience and manually managed rulesets and configurations<br>• Minimal traffic encryption with ad hoc key management | • Mission critical applications accessible via private networks<br>• Protections have minimal workflow integration<br>• Ad hoc development, testing, and production environments | • Manually inventory and categorize data<br>• On-prem data stores<br>• Static access controls<br>• Minimal encryption of data at rest and in transit with ad hoc key management |

*Figure 4: High-Level Zero Trust Maturity Model Overview*

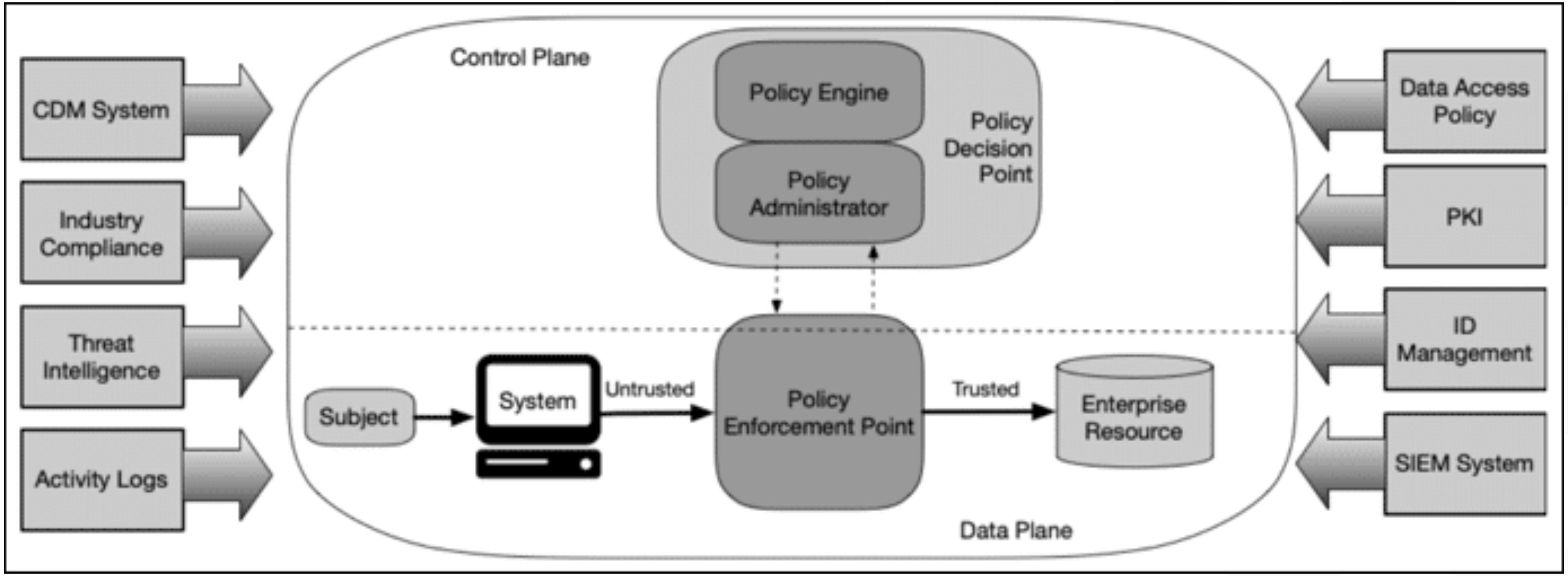
CISA Zero Trust Maturity Model v.2.0 https://www.cisa.gov/zero-trust-maturity-model

CISSP® MENTOR PROGRAM – SESSION FOUR

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Zero Trust - NIST

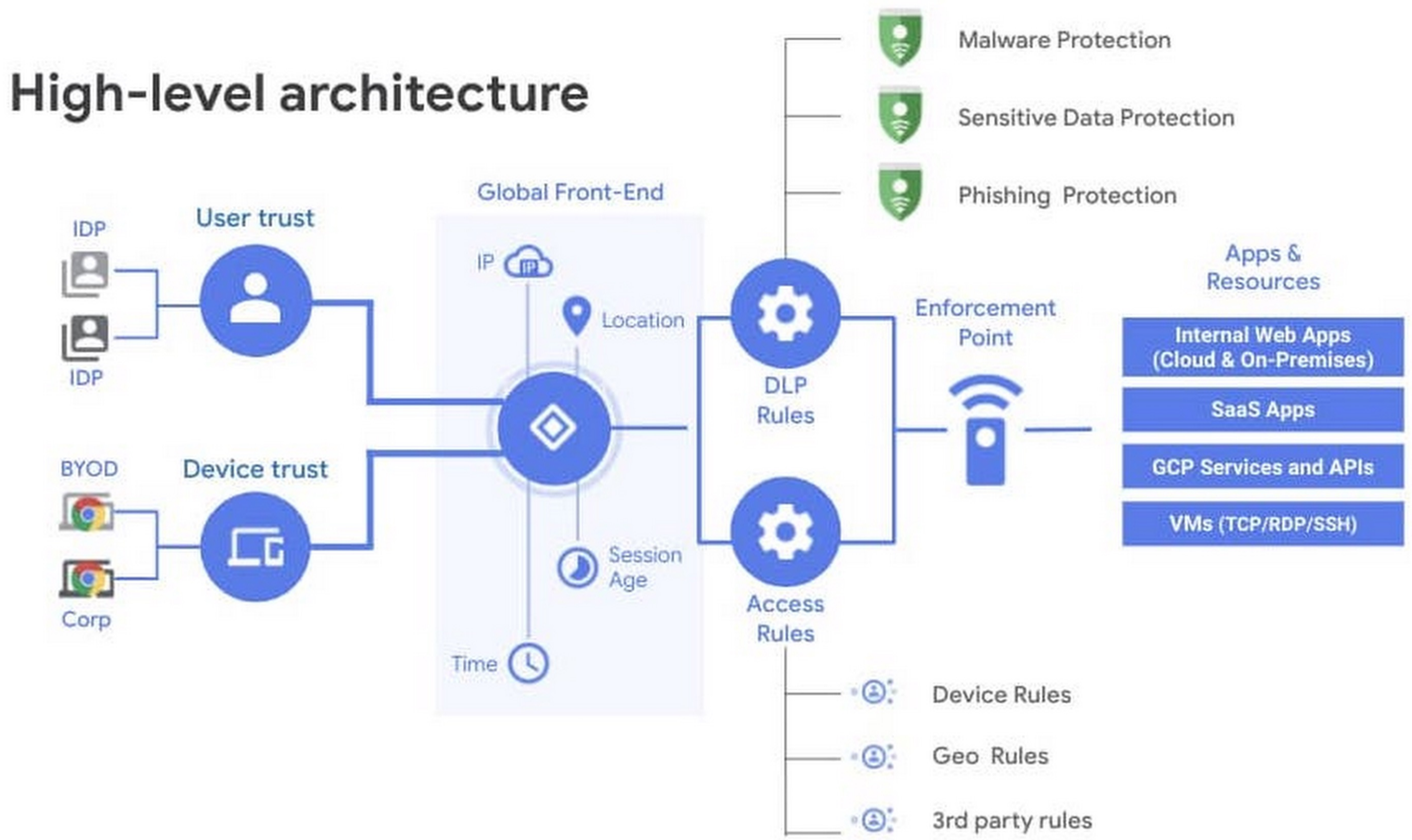



NIST Zero Trust Architecture, SP800-207

https://www.nist.gov/publications/zero-trust-architecture

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

# Zero Trust



# Security Architecture

## Review Question

What is the Zero Trust principle requiring the system to authenticate and authorize every access request based on user identity, location, system health (e.g., patch levels), data classification, user behavior analytics, and any other available data?

1. Continual verification
2. Least privilege access
3. Attack Surface Minimization
4. Failing safe (assume breach)

Always Be Checking (ABC) / Verify identity

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Defense in Depth (layered security)

- Concept of applying multiple, distinct layers of security technologies and strategies to achieve greater overall protection.
- By using combinations of security controls, the impact from the failure of any single control can be reduced if not eliminated.
- Layering is another method of separating system components: security controls are placed between the layers, preventing an attacker who has compromised one layer from accessing other layers.
- Having overlapping security controls such that the failure or compromise of one does not by itself result in an exposure or compromise
- Related to the concept of assumption of breach, which means managing security on the assumption that one or more security controls have already been compromised.

CISSP® MENTOR PROGRAM – SESSION FOUR

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Defense in Depth (layered security)

- Concept of app strategies to achieve greate
- By using comb any single control can be
- Layering is and ontrols are placed betwee one layer from accessing othe
- Having overlap of one does not by itself re
- Related to the security on the assumption th mised.

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Defense in Depth (layered security)

The **assumption of breach mindset** shifts thinking from being simply focused on defending the perimeter (or perimeters) to a **balanced approach** of establishing **multiple defenses** so that the compromise of one control does not immediately lead to a successful breach and of considering detection and mitigation to be as important as prevention

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

# Privacy by Design (PbD)

- **Proactive not Reactive; Preventative not Remedial** - Anticipate and prevent invasive privacy events before they happen, rather than relying on detecting and responding to them once they already occur.
- **Privacy as the Default Setting -** Practical examples include anonymizing or masking personal information, restricting access to personal information to those who absolutely need it (i.e., least privilege), and deleting such information when it is no longer needed.
- **Privacy Embedded into Design -** privacy should be treated as a core functionality of the system
- **Full Functionality — Positive-Sum, not Zero-Sum -** PbD encourages a "win-win" approach to all legitimate system design goals and discourages unnecessary trade-offs being made. Both privacy and security are important — both can and should be achieved.

https://www.ipc.on.ca/wp-content/uploads/resources/7foundationalprinciples.pdf

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

# Privacy by Design (PbD)

What's the difference between security and privacy?

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

# Privacy by Design (PbD)

- **End-to-End Security — Full Lifecycle Protection -** Ensure security and privacy of personal data from cradle to grave; data should be created, managed, and destroyed in a secure fashion. Encryption and authentication are standard at every stage, but you should pay close attention to what security and privacy mechanisms may be required throughout the data lifecycle.

- **Visibility and Transparency — Keep it Open -** This is a "trust, but verify" principle (discussed earlier) that seeks to assure all stakeholders that the system operates securely and maintains data privacy as intended. (e.g., Privacy policy)

- **Respect for User Privacy — Keep it User-Centric -** System architects, developers, and operators must keep the interests of the individual as their utmost priority by providing strong privacy defaults, appropriate notice, and a user-friendly experience. (e.g., by clicking a button or ticking a check box) in order to give consent.

https://www.ipc.on.ca/wp-content/uploads/resources/7foundationalprinciples.pdf

Research, Implement, and Manage Engineering Processes Using Secure Design Principles

# Privacy by Design (PbD)

FYI

- In the United States, the Federal Trade Commission (FTC) has recognized PbD as one of three recommended practices for protecting online privacy. https://www.ftc.gov/news-events/news/speeches/privacy-design-new-privacy-framework-us-federal-trade-commission
- The European Union General Data Protection Regulation (EU GDPR), the largest privacy regulation around the world to-date, includes “data protection by design” and “data protection by default” as part of its requirements. https://gdpr-info.eu/issues/privacy-by-design/

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Research, Implement, and Manage Engineering Processes Using Secure Design Principles

## Shared Responsibility

- The shared responsibility model is a cloud security framework that describes the obligations of a cloud service provider (CSP) and its customers in keeping cloud systems and data secure.

- In a cloud environment, the CSP takes on much of the operational burden, including a great deal of security responsibility — but not all of it.

- The specific breakdown of responsibility varies by cloud provider and by cloud service type.

* Your organization is ultimately responsible and accountable for the security of the cloud

CISSP® MENTOR PROGRAM – SESSION FOUR

# DAD JOKE

## Before we get too deep into this.

How about a dumb dad joke?

I like telling Dad jokes…

HAHAHAHA

Moving on…

## Understand the Fundamental Concepts of Security Models

# Primer on Common Model Components

- **Model -** Is a hypothetical abstraction of a system, simplified to enable analysis of certain aspects of the system without the complexity and details of the entire system being analyzed
- **Security Model -** Is a model that deals with security policy.
- Can be **formal**, intended for mathematical analysis to assist in the verification that a system complies with a specific policy.
- Can be **informal**, serving to illustrate and simplify the assessment of a system without the rigor of a proof
- Can help **reduce ambiguity** and potential **misunderstanding** as to what, exactly, a security architecture is trying to accomplish

## Research, Implement, and Manage Engineering Processes Using Secure Design Principles

# Threat Modeling

Process to identify security threats and vulnerabilities, and prioritize mitigations

Examples from earlier

Used to reduce risk and guide secure development.

## Understand the Fundamental Concepts of Security Models

# Primer on Common Model Components

- **Finite state machine** (or just state machine) - is a conceptual computer that can be in one of a finite number of states. The computer implements a state transition function that determines the next state, given the current state and the next input and that can, optionally, produce output.

- **A lattice is a finite set with a partial ordering -** partial ordering is a binary relation that is reflexive, anti-symmetric, and transitive. Reflexive means that each item in the set is comparable to itself. Anti-symmetric means that no two different elements precede each other.
  Transitive means that if a yields b, and b yields c, then a yields c.

## Understand the Fundamental Concepts of Security Models

# Primer on Common Model Components

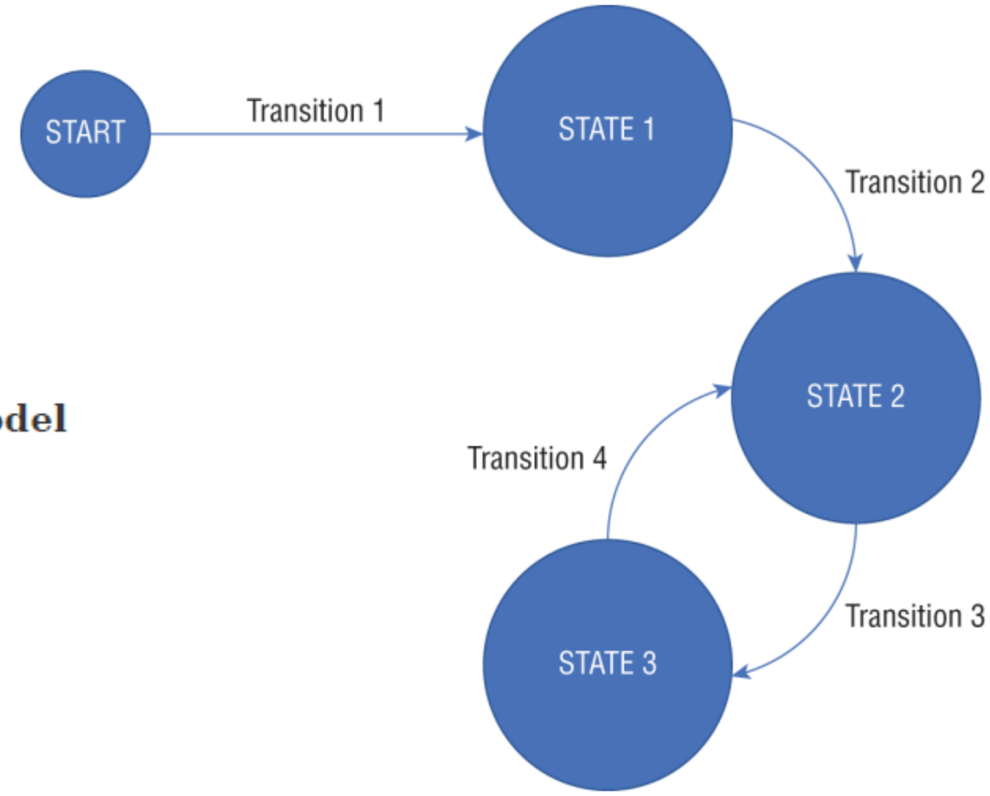



FIGURE 3.2 Finite state model

## Understand the Fundamental Concepts of Security Models

# Primer on Common Model Components

### Lattice security model does the following

- Defines a set of security levels
- Defines a partial ordering of that set
- Assigns every **subject (e.g., user or process) and object (e.g., data) a security level**
- Defines a **set of rules governing the operations a subject can perform on an object** based on the relationship between the security levels of the subject and object

Understand the Fundamental Concepts of Security Models

# Primer on Common Model Components

## Information Flow Model

- An *information flow model* is a type of access control model that defines the flow of information — from one application, device, network to another or even one system to another.
- In these models, objects are assigned a security classification, and the direction or type of flow of these objects is controlled by security policy.

Understand the Fundamental Concepts of Security Models

# Primer on Common Model Components

## Noninterference Model

- A noninterference model is an evolution of the information flow model designed to ensure that objects and subjects on a system don't interfere with other objects and subjects on the same system.
- Under this model, any activities that take place at a higher security level must not impact (or interfere) with activities occurring at a lower level
- The actions of subject A (higher classification) should not affect subject B (lower classification), nor should those actions even be noticed by subject B, in a way that might inform subject B of subject A's actions.
- Without the protection of a noninterference model, subject B might be able to glean the activities of subject A, which may result in information leakage (for example).

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Understand the Fundamental Concepts of Security Models

## Primer on Common Model Components

**Confidentiality Model**

**Bell-LaPadula Model (3 rules)**

**Simple Security Property** (ss property) - **No read up**, this rule prevents a subject from reading an object at a higher security level.

**Star Property** (* property) - **No write down**, this rule prevents a subject from writing to an object at a lower security level.

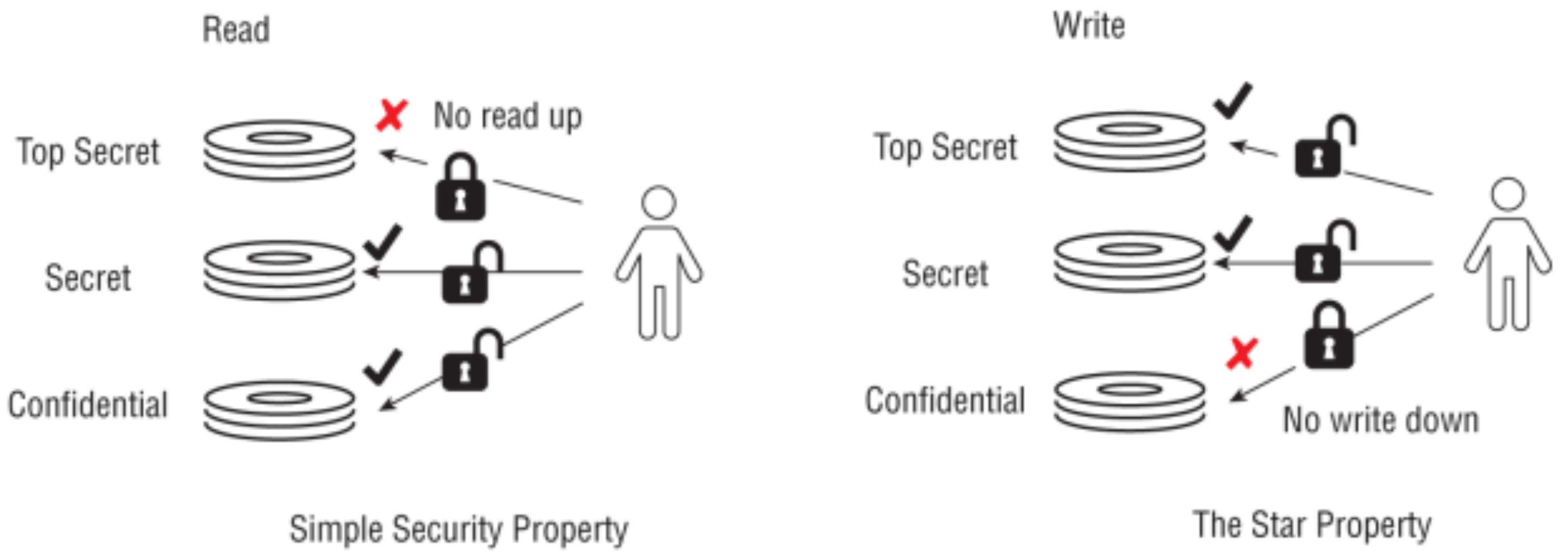
**Discretionary-Security Property -** Subject can perform an operation on an object if **permitted by the access matrix**

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Understand the Fundamental Concepts of Security Models

## Primer on Common Model Components

**Bell-LaPadula Model** (3 rules)



### Understand the Fundamental Concepts of Security Models

# Primer on Common Model Components

## Bell-LaPadula Model (3 rules)

## Issues not well addressed by the Bell-LaPadula Model

- It does not consider risks to the *integrity* of information. Protecting the integrity of objects means preventing the unauthorized, possibly malicious, modification of an object.
- Does not deal with covert channels or the possibility of performing permitted operations in a manner that reveals confidential information through side channels

Understand the Fundamental Concepts of Security Models

# Primer on Common Model Components

## Biba *Integrity* Model

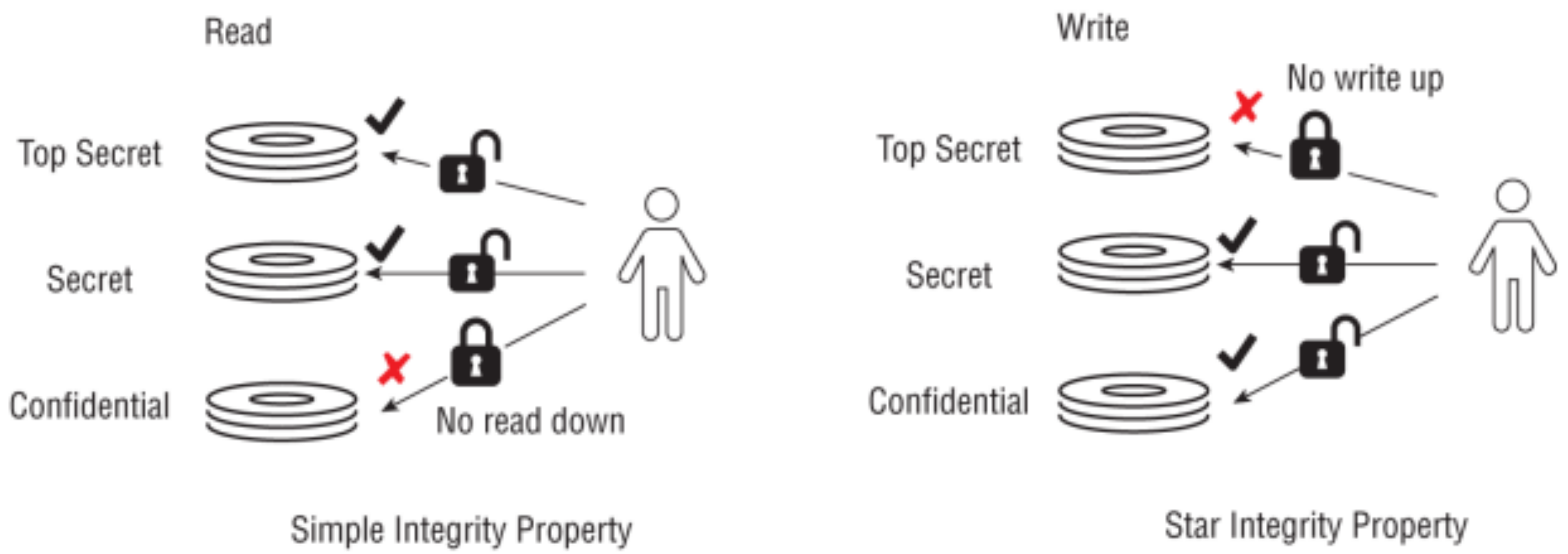
- Simple Integrity Property - **No read down**, this rule prevents compromising the integrity of more secure information from a less secure source. In other words, higher integrity processes could produce untrustworthy results if they read and use data from lower integrity sources.

- Star Integrity Property (* integrity property) - **No write up**, this rule prevents the corruption of more secure information by a less privileged subject.

Understand the Fundamental Concepts of Security Models

# Primer on Common Model Components

## Biba Integrity Model



Understand the Fundamental Concepts of Security Models

# Primer on Common Model Components

## Clark-Wilson Model (2 concepts)

- **Well-formed transactions -** Well-formed transaction is that subjects are constrained to make only those changes that maintain the integrity of the data.
- **Separation of duties -** Aims to make sure that the certifier of a transaction is a different party from the initiator or implementer of the transaction.

Understand the Fundamental Concepts of Security Models

# Primer on Common Model Components

## Clark-Wilson Model

- **Constrained data item (CDI)** - This is the key data type in the Clark– Wilson model, and it refers to data whose integrity must be preserved.
- **Unconstrained data item (UDI) -** This includes all data other than CDIs, typically system inputs.
- **Integrity verification procedures (IVPs) -** These procedures check and ensure that all CDIs are valid.
- **Transformation procedures (TPs) -** These procedures enforce a system's integrity policy and maintain the integrity of CDIs.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Understand the Fundamental Concepts of Security Models

## Primer on Common Model Components

### Brewer-Nash Model

- Simple Integrity Property - **No read down**, this rule prevents compromising the integrity of more secure information from a less secure source. In other words, higher integrity processes could produce untrustworthy results if they read and use data from lower integrity sources.
- Star Integrity Property (* integrity property) - **No write up**, this rule prevents the corruption of more secure information by a less privileged subject.

Understand the Fundamental Concepts of Security Models

# Primer on Common Model Components

## Brewer-Nash Model

- Individual pieces of information related to a single company or client are called objects, in keeping with BLP's usage.
- All objects related to the same company (or client) are part of what is called a company data set.
- All company data sets in the same industry (i.e., that are competitors) are part of what is called a conflict of interest class.

**Ethical wall / Cone of Silence**

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Understand the Fundamental Concepts of Security Models

## Primer on Common Model Components

### Brew

- Indi objects, in ke
- All o company data
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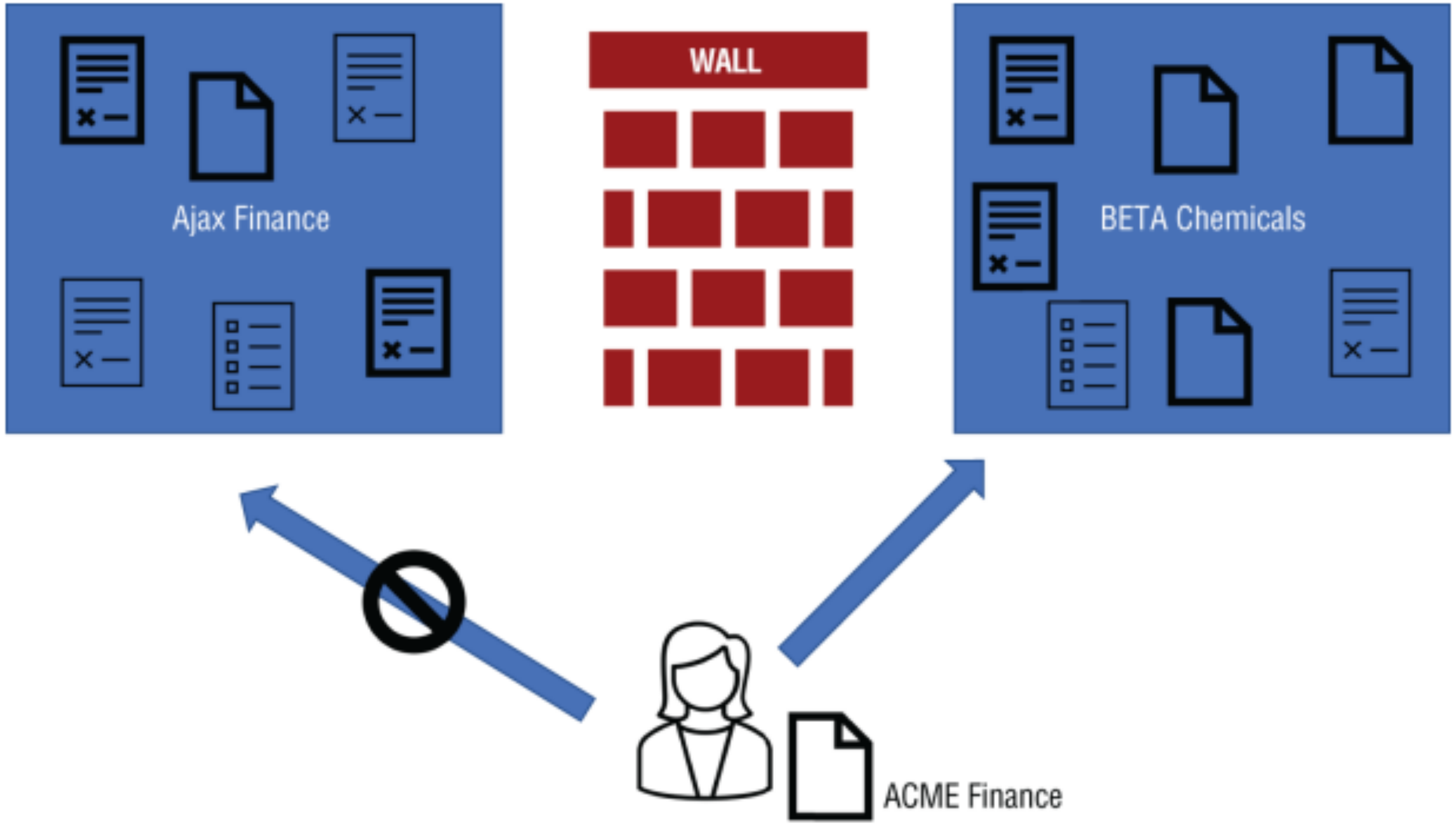

## Understand the Fundamental Concepts of Security Models

# Primer on Common Model Components

### Take-Grant Model (four rules)

- **Take**: Allows a subject to obtain (or take) the rights of another object
- **Grant**: Allows a subject to give (or grant) rights to an object
- **Create**: Allows a subject to generate (or create) a new object
- **Remove**: Allows a subject to revoke (or remove) rights it has on an object

## Security Architecture

### Review Question

This access model uses the concept of a well-formed transaction is that subjects are constrained to make only those changes that maintain the integrity of the data and uses well-formed transactions and separations of duties?

1. Bell-LaPadula
2. Biba
3. Clark-Wilson
4. Noninterference

Clark-Wilson

# QUICK BREAK

## Top cybercrime movies/series for a cloudy weekend

https://www.linkedin.com/posts/fabian-weber55_mr-robot-tv-series-20152019-imdb-activity-7053013614428844032-lfuV

Add your favorite in chat
(or Discord/random)

1. Mr. Robot - https://lnkd.in/efUGXJYY
2. Snowden - https://lnkd.in/e5W2Uesc
3. Who Am I - https://lnkd.in/e8iXtmCw
4. Blackhat - https://lnkd.in/emXbYmJQ
5. Deep Web - https://lnkd.in/e9swJAqH
6. Kill Chain - https://lnkd.in/eheJ-pav
7. Cyber Secrets - https://lnkd.in/eNmcamtA
8. The Great hack - https://lnkd.in/eB5VcqET
9. The Fifth estate - https://lnkd.in/enESJNMv
10. Wargames
11. Sneakers

A list of all movies in this genre:
https://lnkd.in/ejZ9TRS2
(I would not see many of them as halfway educational)

## Select Controls Based Upon Systems Security Requirements

# Selecting Security Controls

- Selecting the security controls appropriate for an information system **starts with an analysis of the security requirements**.
- Should be **defined**, **repeatable**, and **consistent**.
- Review all of the controls to determine those appropriate to **address** the **risks** you have identified.
- Can **demonstrate due care** and **due diligence** in security decision-making.
- A **Framework** is an approach or strategy.
  A **Standard** is a set of quantifiable directions or rules to follow.

Select Controls Based Upon Systems Security Requirements

# Selecting Security Controls

There are a few things to understand about **security frameworks**

- They are **not mandatory**.
- They are **not mutually exclusive** of each other.
- They are **not exhaustive** (i.e., they don't cover all security concerns).
- They are **not** the same as a **standard** or a control list.
- They are **subject to change or update**.

### Select Controls Based Upon Systems Security Requirements

# Selecting Security Controls

- Consider the control and how to implement and adapt it to your specific circumstances (the “Plan” phase)
- Implement the control (the “Do” phase) Assess the effectiveness of the control (the “Check” phase)
- Remediate the gaps and deficiencies (the “Act” phase)

Select Controls Based Upon Systems Security Requirements

# Selecting Security Controls

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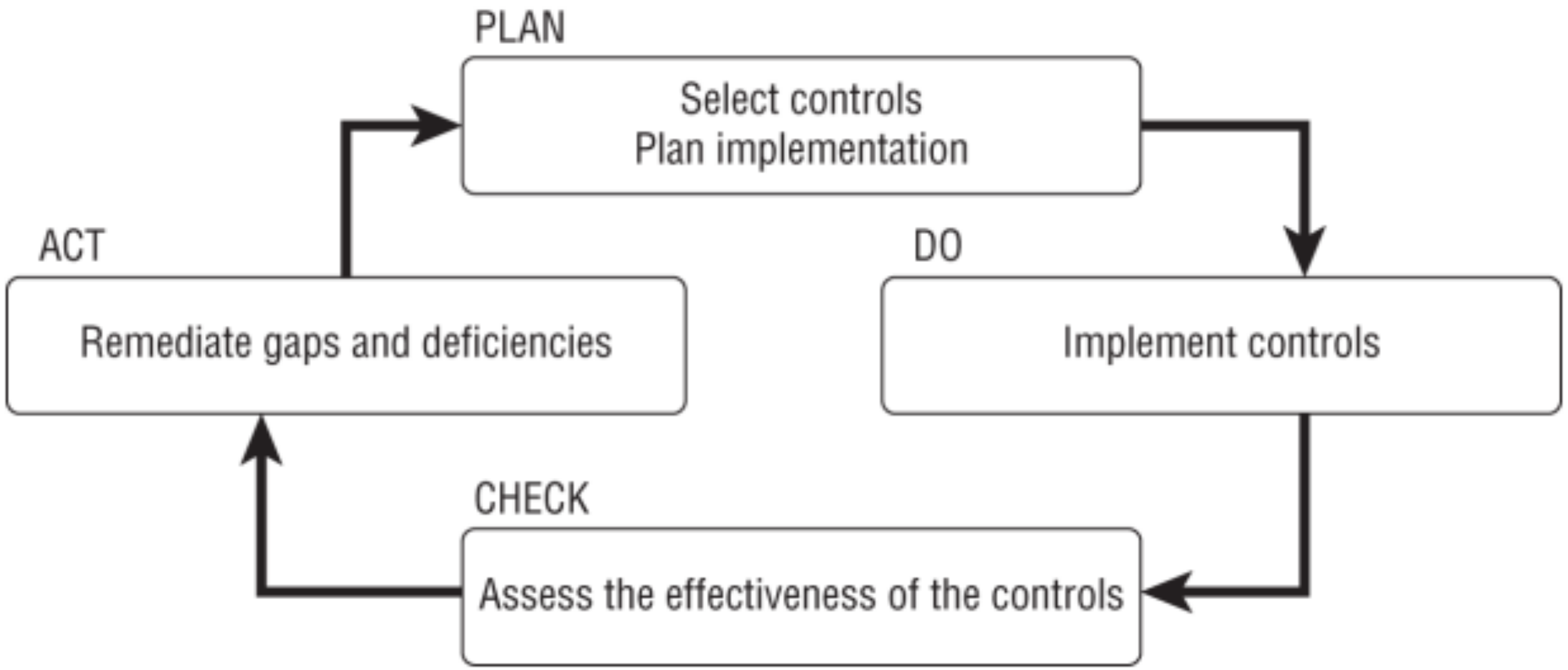


# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Select Controls Based Upon Systems Security Requirements

## Selecting Security Controls, when (re-)assessment is required

- Security incident or breach
- Significant change in organization structure or major staffing change
- New or retired product or service
- New or significantly changed threat or threat actor
- Significant change to an information system or infrastructure
- Significant change to the type of information being processed
- Significant change to security governance, the risk management framework, or policies
- Widespread social, economic, or political change (e.g., COVID-19)

Understanding Security Capabilities of Information Systems

# Foundational Capabilities of Information Systems

- Memory protection
- Trusted Platform Modules (TPMs)
- Cryptographic modules
- Hardware Security Modules (HSMs)

### Understanding Security Capabilities of Information Systems

# Memory Protection

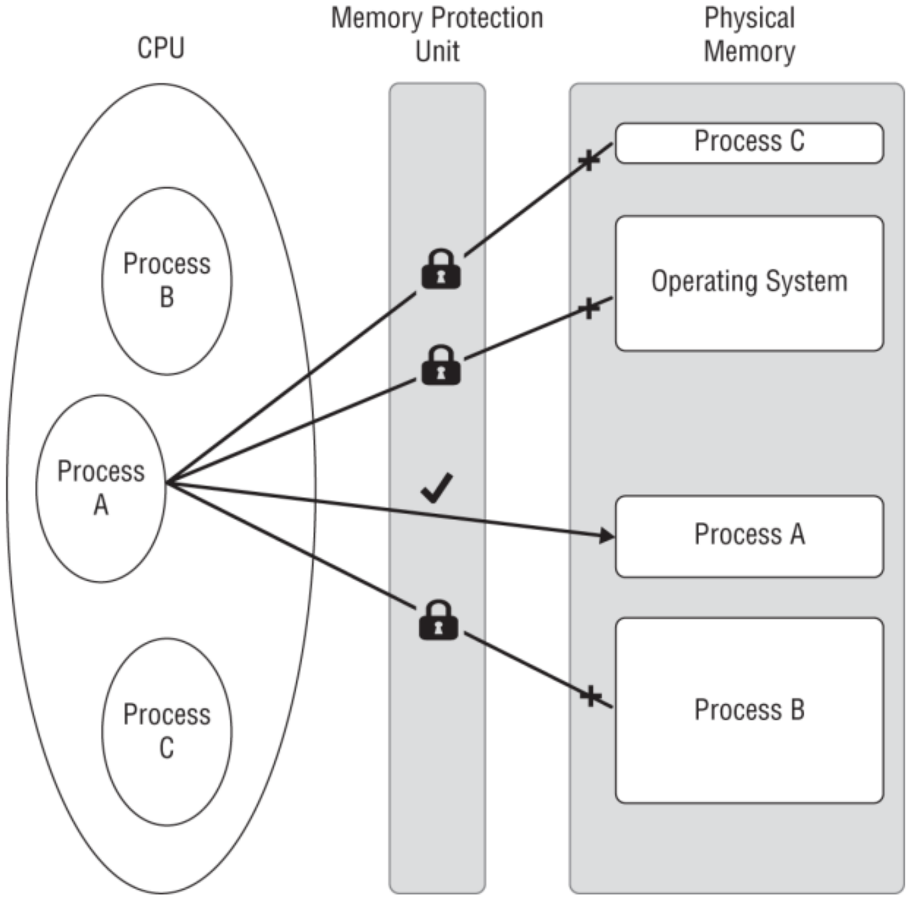
- Foundational security controls on all systems that allows multiple programs to run simultaneously is memory protection.
- Prevents one program from referencing memory not specifically assigned to it.
- If a program attempts to reference a memory address it is not permitted to access, the system blocks the access, suspends the program, and transfers control to the operating system.

Question: What common attack type is prevented with memory protection?

## Understanding Security Capabilities of Information Systems

# Memory Protection

FIGURE 3.7 Operating system memory protection



Understanding Security Capabilities of Information Systems

# Memory Protection – Dual-mode operation

- **Hardware feature** that is required to support memory protection is dual-mode operation.
- Processor can operate in one of (at least) two modes:
  - Privileged (or kernel) mode and
  - Unprivileged (or user) mode
- The *operating system runs in privileged mode*, which grants it permission to set up and control the memory protection subsystem. Privileged mode also permits the operating system to execute special privileged instructions that control the processor environment.
- The *program runs in unprivileged mode*, which limits it to accessing only the specific memory area dictated by the operating system.

### Understanding Security Capabilities of Information Systems

# Memory Protection – ASLR

- *Address space layout randomization* (*ASLR*), seeks to mitigate the risks of **predictable memory address location**. (The location in memory for a known instruction becomes a risk when there is a threat of exploiting that location for an attack.)
- For example, a buffer overflow attack requires knowing two things: the exact amount by which to overflow the memory to facilitate executing malicious code, and where exactly to send the overflow. ASLR defeats the second item by randomizing the location.

### Understanding Security Capabilities of Information Systems

# Memory Protection (*Potential Weaknesses*)

- Proper memory protection **relies upon both** the correct **operation of the hardware** and the correct **design of the operating system** to prevent programs from accessing memory they have not been given permission to access.
- A defect in either can compromise the security provided by memory protection. Note that this protection prevents the direct disclosure of memory contents that are blocked from an unauthorized program, but does not necessarily prevent side-channel exploits from revealing information about memory that is protected from access.
- Attacks that leverage ineffective isolation and memory protection can have catastrophic effects. Spectre and Meltdown exploits in 2018 revealed, flaws in the design of Intel and some other CPU chips permitted clever programming techniques to deduce the contents of memory locations that those programs were not permitted to access directly.

### Understanding Security Capabilities of Information Systems

# Secure Cryptoprocessor

- The challenge with standard microprocessors is that code running with the highest privilege can access any device and any memory location. The security of the system depends entirely on the security of all the software operating at that privilege level. If that software is defective or can be compromised, then the fundamental security of everything done on that processor becomes suspect.
- To address this problem, hardware modules called *secure cryptoprocessors* have been developed that are resistant to hardware tampering and that have a limited interface (i.e., *attack surface*), making it easier to verify the integrity and secure operation of the (limited) code running on the cryptoprocessor.

We'll cover cryptography in session five.

## Understanding Security Capabilities of Information Systems

# Secure Cryptoprocessor (*Services*)

- Hardware-based true random number generators (TRNGs)
- Secure generation of keys using the embedded TRNG
- Secure storage of keys that are not externally accessible
- Encryption and digital signing using internally secured keys
- High-speed encryption, offloading the main processor from the computational burden of cryptographic operations

### Understanding Security Capabilities of Information Systems

# Secure Cryptoprocessor (*Features*)

- **Tamper detection** with automatic destruction of storage in the event of tampering.
- **Chip design features** such as shield layers to prevent eavesdropping on internal signals using ion probes or other microscopic devices.
- **Hardware-based cryptographic accelerator** (i.e., specialized instructions or logic to increase the performance of standard cryptographic algorithms such as AES, SHA, RSA, ECC, DSA, and ECDSA.
- **Trusted boot process** that validates the initial boot firmware and operating system load.

Understanding Security Capabilities of Information Systems

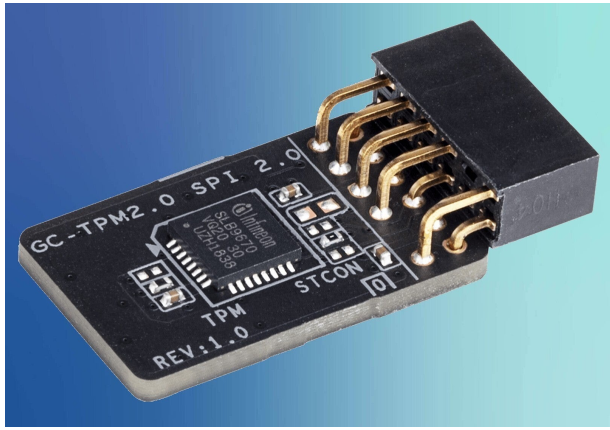
# Secure Cryptoprocessor (*Types*)

- Proprietary, such as Apple's “Secure Enclave” found in iPhones
- Open standard, such as the TPM as specified by the ISO/IEC 11889 standard and used in some laptops and servers
- Standalone (e.g., separate standalone device with external communications ports)
- Smartcards

## Understanding Security Capabilities of Information Systems

# Trusted Platform Module (TPM)

Provides secure storage and cryptographic services as specified by ISO/IEC 11889



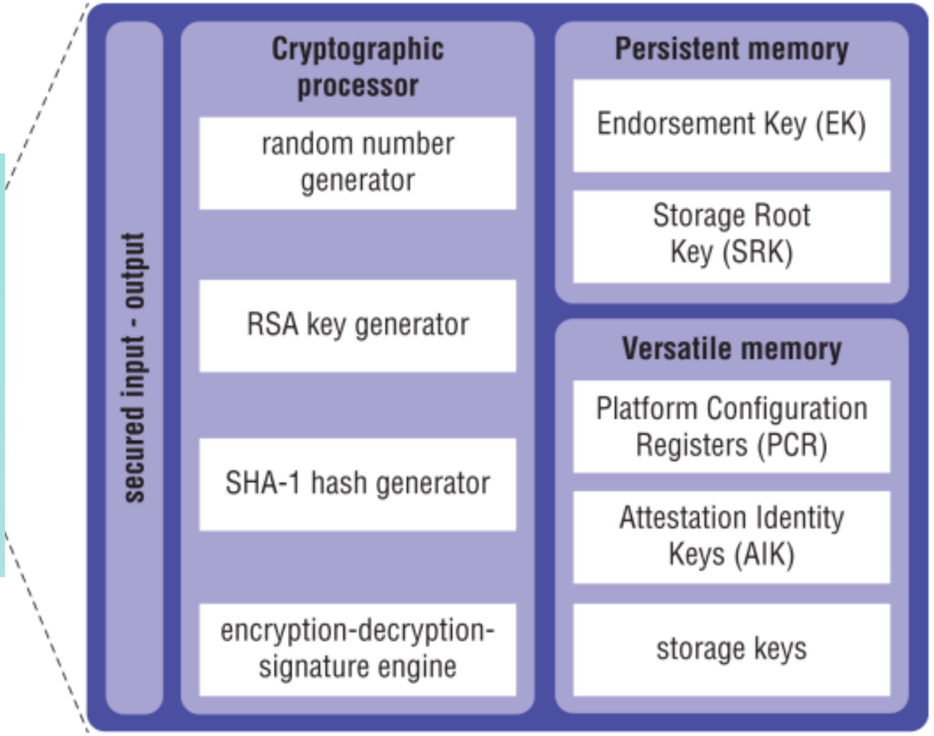




FIGURE 3.8 Trusted Platform Module processes

## Understanding Security Capabilities of Information Systems

# Trusted Platform Module (TPM)

- **Attestation**: Creates a cryptographic hash of the system's known good hardware and software state, allowing third-party verification of the system's integrity
- **Binding**: Encrypts data using a cryptographic key that is uniquely associated with (or bound to) the system
- **Sealing**: Ensures that ciphertext can be decrypted only if the system is attested to be in a known good state

## Understanding Security Capabilities of Information Systems

# Trusted Platform Module

- Generate ***private/public key pairs*** such that the **private key never leaves the TPM** in plaintext - Increasing the security related to the private key.
- **Digitally sign** data using a private key that is stored on the TPM and that never leaves the confines of the TPM. Significantly decreasing the possibility that the key can become known by an attacker and used to forge identities and launch man-in-the-middle (MITM) attacks.
- Encrypt data such that it can **only be decrypted using the same TPM**.
- Verify the state of the machine the TPM is installed on to detect certain forms of tampering (i.e., with the BIOS) and ensure platform integrity.

We'll cover cryptography in session five.

## Understanding Security Capabilities of Information Systems

# Trusted Platform Module (*Potential weaknesses*)

- The endorsement key (EK) is a fundamental component of a TPM's security.
- This key is generated by the TPM manufacturer and burned into the TPM hardware during the manufacturing process.
- User/system owner depends upon the security of the TPM manufacturer to ensure that the PEK remains confidential.
- Flaws in software used in the TPM can expose or make easy to deduce the private keys

Understanding Security Capabilities of Information Systems

# Cryptographic Module

A ***cryptographic module*** is typically a hardware device that implements key generation and other cryptographic functions and is embedded in a larger system

## Understanding Security Capabilities of Information Systems

# Cryptographic Module

*Advantages* of using a cryptographic module as opposed to a cryptographic software library include.

- Separate device that is dedicated to that purpose.
- Isolating security-sensitive functionality with limited interfaces and attack surfaces, it is easier to provide assurances about the secure operation of the device.
- increased availability of noncryptographic dedicated resources.
- Most secure cryptographic modules contain physical security protections including tamper resistance and tamper detection.
- Some cryptographic modules can enforce separation of duties so that certain sensitive operations, such as manipulating key storage, can be done only with the cooperation of two different individuals who authenticate to the cryptographic module separately.

## Understanding Security Capabilities of Information Systems

# Hardware Security Module (HSM)

- Stand alone as an appliance to provide cryptographic services over an externally accessible API (typically over a network or USB connection).
- HSMs are frequently found in certificate authorities (CAs) that use them to protect their root private keys, and payment processors.
- HSMs are also used in many national security applications or other environments.
- HSMs are used by enterprise network backbones as part of encryption management of archives, east-west data movement, and even VPN traffic.

# Security Architecture

## Review Question

This security control seeks to mitigate the risks of predictable memory address location.

1. Trusted Platform Modules (TPMs)
2. Address space layout randomization (ASLR)
3. Hardware Security Modules (HSMs)
4. Buffer Overflow Protection (BOP)

ASLR is a type of memory protection by randomizing memory locations

# Random Dad Joke

**If you're laughing,
You're learning**

"Where did the software developer go?

HAHAHAHA
🤣🤣🤣
Moving on…

# Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Inspection

- Manual
- Automated

## Testing

- White box
- Black box
- Gray box

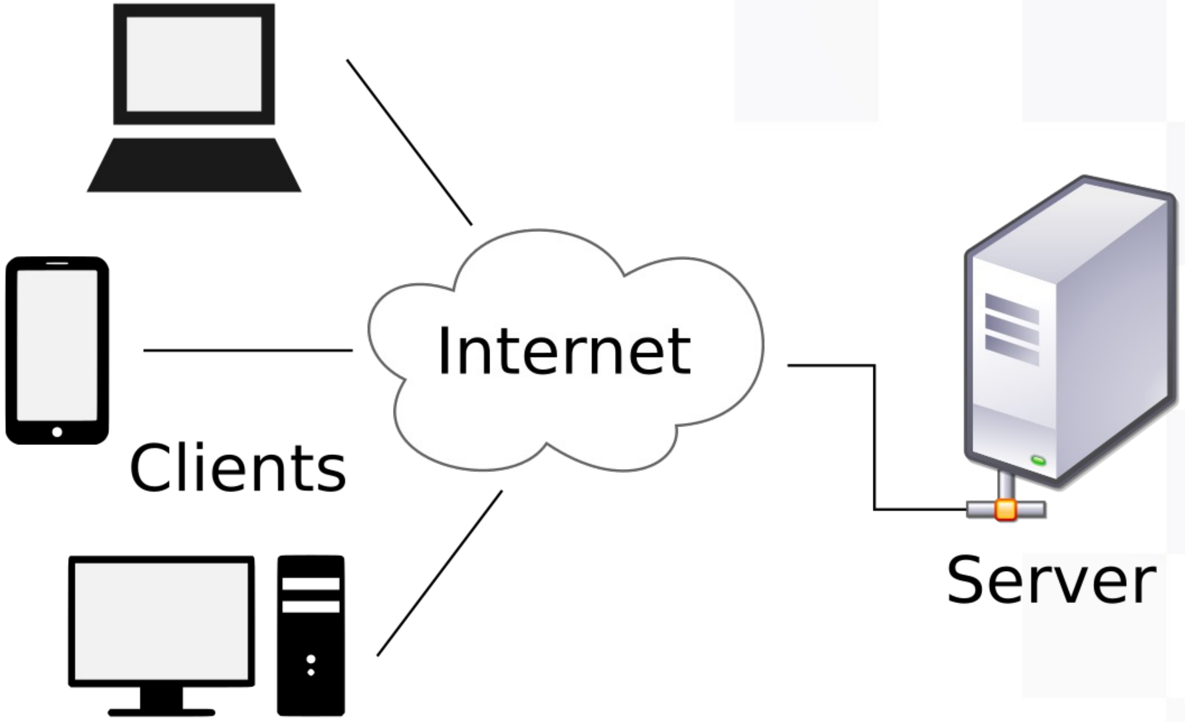
Used in combination

Review Chapter 1 – Risk Analysis

Consider the impact should the vulnerability be exploited by a threat actor, and the likelihood of the vulnerability being exploited

## Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Client – Server Architecture



### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Client-Based Systems

- **Client-related vulnerabilities** can be grouped into **two broad categories**:
  - Client applications
  - Operating Systems

This is now being mixed in cloud & IoT environments

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Client-Based Systems (*vulnerabilities*)

Client-based vulnerabilities may fall into the following categories

- Vulnerabilities related to the insecure operation of the client
  - Storing temporary data on the client system in a manner that is insecure (i.e., accessible to unauthorized users through, for example, direct access to the client device's filesystem)
  - Running insecure (e.g., out-of-date or unpatched) software versions

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Client-Based Systems (*vulnerabilities*)

Vulnerabilities related to communications with the server client software that connects to remote servers but does not take appropriate steps to do the following:

- Validate the identity of the server
- Validate or sanitize the data received from the server
- Prevent eavesdropping of data exchanged with the server
- Detect tampering with data exchanged with the server
- Validate commands or code received from the server before executing or taking action based on information received from the server.

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Client-Based Systems

## To address these vulnerabilities, consider the following

- Evaluate your operating systems and applications for unpatched software or insecure configurations.
- Using a recognized secure protocol (e.g., transport layer security (TLS)) to validate the identity of the server and to prevent eavesdropping of, and tampering with, data communicated with the server.
- Using appropriate coding techniques to ensure that the data or commands received from the server are valid and consistent.
- Using digital signing to verify executable code received from the server prior to execution.

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Server-Based Systems

- The server needs to validate the identity of the client and/or the identity of the user of the client. This can be done using a combination of Identity and Access Management (IAM) techniques along with a secure communications protocol such as TLS, using client-side certificates.
- The server also must validate all inputs and not assume that simply because the commands and data coming from the client are originating from (and have been validated by) the corresponding client-side software, they are valid and have been sanitized.
- The client must be considered untrusted, and it must be assumed that the client-end can insert or modify commands or data before being encrypted and transmitted over the secure (e.g., TLS) link.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Server-Based Systems

- A vulnerability management program is needed to ensure that updates and patches are applied in a timely fashion. This holds true regardless of whether the server-side software is developed in-house or is based in part or completely on software obtained from a third party (such as commercial off-the-shelf software, or COTS).
- Best practices include the server using filesystem ownership and permissions to avoid data leakage, logging and monitoring appropriate information (such as successful and failed login attempts, privileged access, etc.), and capturing forensic information to permit analysis of a possible or actual security incident.
- Finally, threats to the server itself need to be addressed. This may include physical and environmental threats, threats to the communications infrastructure, and server hardening as per industry recommendations.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Server-Based Systems (*Server Harding Guidelines*)

- Installing updates and patches
- Removing or locking unnecessary default accounts
- Changing default account passwords
- Enabling only needed services, protocols, daemons, etc. (conversely, disabling any not needed)
- Enabling logging and auditing Implementing only one primary function per server
- Changing default system, filesystem, service, and network configurations as needed to improve security (including full-disk encryption if appropriate)
- Removing (or disabling) unneeded drivers, executables, filesystems, libraries, scripts, services, etc.

CISSP® MENTOR PROGRAM – SESSION FOUR

# DAD JOKE

## Laughter for Levity

How about a dumb dad joke?

**What did Baby Corn say to Mama Corn?**

HAHAHAHA
🤣🤣🤣
Moving on…

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Database Systems

Securing database systems is a special case of the more general server-based system security discussed in the previous section. If the database is accessible over a network, then all the security controls discussed there apply.

What's a Database?

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Database Systems (*Controls*)

- Consult the CIS's hardening guidelines for the database system being used. These guidelines include several of the recommendations below, and many others.
- Only install or enable those components of the database system that are needed for your application.
- Place data stores and log files on nonsystem partitions.
- Set appropriate filesystem permissions on database directories, data stores, logs, and certificate files.
- Run database services using a dedicated unprivileged account on a dedicated server.
- Disable command history

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Database Systems (*Controls*)

- Do not use environment variables, command line, or database configuration files to pass authentication credentials.
- Do not reuse database account names across different applications. Disable “anonymous” accounts (if supported by the database).
- Mandate that all connections use TLS if access or replication traffic travels over untrusted networks.
- Use unique certificates for each database instance. Use restricted views.
- Ensure that all DBMS vendor-provided sample or test databases are removed or not accessible from user endpoints and clients.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Database Systems (*Controls*)

- Change all default passwords, ensure all accounts have secure passwords, and consider enabling multifactor or certificate-based authentication (where supported).
- Ensure user account permissions have been assigned using the principle of least privilege and in alignment with enterprise-wide access control policies and procedures. Database privileges can be complex and interact in unexpected ways—avoid default roles and define those you need with only the permissions needed for each.
- Disable or remove unneeded accounts, especially those with administrative permissions.
- Manage all accounts according to best practices (see Chapter 5).
- Enable logging of sensitive operations and route logs to your log monitoring and alerting system.
- Use bind variables where possible to minimize injection attack surfaces.

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Database Systems (*Controls*)

- Assign unique admin accounts for each administrator (i.e., do not share admin accounts between more than one admin)
- Enable logging at a sufficiently detailed level to provide the forensic information needed to identify the cause of events related to security incidents (but ensure logging does not include passwords)
- Protect the logs from tampering by database admins, either through permissions on the database system itself or by transmitting the log data in real time to a separate secure logging system.

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Database Systems (*Controls*)

- Consult vendor database documentation for database-specific security controls.
- For databases that are only accessed through application software (e.g., the typical n-tier web server application), run the database on private networks only accessible to the business logic servers that need access.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Database Systems (*Database encryption*)

- **Full-disk encryption (FDE)** at the lowest level protects all the data on the storage media, protecting against the physical theft or loss of the drive itself. It provides no protection from threat actors who have logical access to the system.
  Filesystem-level encryption allows the encryption to occur at the filesystem level.
- **Transparent data encryption (TDE)** protects the data from those who have direct access to the filesystem (i.e., the "root" user), but do not have permission to access the database system and the specific database item.
- **Cell-level encryption (CLE)** encrypts database information at the cell or column level. With this approach, data remains encrypted when read from the database and is decrypted only when requested.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Database Systems (*Database encryption*)

- **Full-disk encryption (FDE)** at the ata on the storage media, protecting against the physical th t provides no protection from threat actors who have logical access to the system. Filesystem-level encryption allows the encryption to occur at the filesystem level.

Provides no protection from threat actors who have logical access to the system.

- **Transparent data encryption (TDE)** protects the data from those who have direct access to the filesystem (i.e., the "root" user), but ess the database system and the specific databas

Does not protect against malicious database administrators or attacks, such as SQL injection, not intended to be used alone

- **Cell-level encryption (CLE)** encrypts database information at the cell or column level. With this approach, data s decrypted only when re

Key management and handling the decryption/encryption requests can add considerable complexity to the application and depending on the types of queries (and whether they include CLE-protected data), the performance can be affected, sometimes drastically.



# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Database Systems

- Application-level encryption is a high-level approach that provides protection even if access to the database system is compromised.
- Business-logic or application layer is responsible for encrypting the data to be protected before it is passed to the database and for decrypting it once it has been retrieved.
- This approach is the most complex, but provides greater security (if properly implemented and managed)
- Handle the encryption/decryption as close to the point of use as possible. (Data-centric security)
- The decision as to which combination of database encryption approaches to use will be influenced by considerations such as:
    - Performance, especially if searches reference data encrypted using CLE.
    - Backups, which will be protected using TDE or CLE, but not necessarily when using FDE (unless the backup is on another FDE-protected drive).
    - Compression as encrypted data does not compress, so the use of encryption may significantly increase the size of backups.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Security Architecture

### Review Question

Chris has concerns about insider threats, especially from system and application administrators. Which security control protects the data from those who have direct access to the filesystem and prevents domain administrators from accessing the database system and the specific database item.

1. Full-disk encryption (FDE)
2. Trusted computing module (TPM)
3. Zero Trust Network Architecture (ZTNA)
4. Transparent data encryption (TDE)

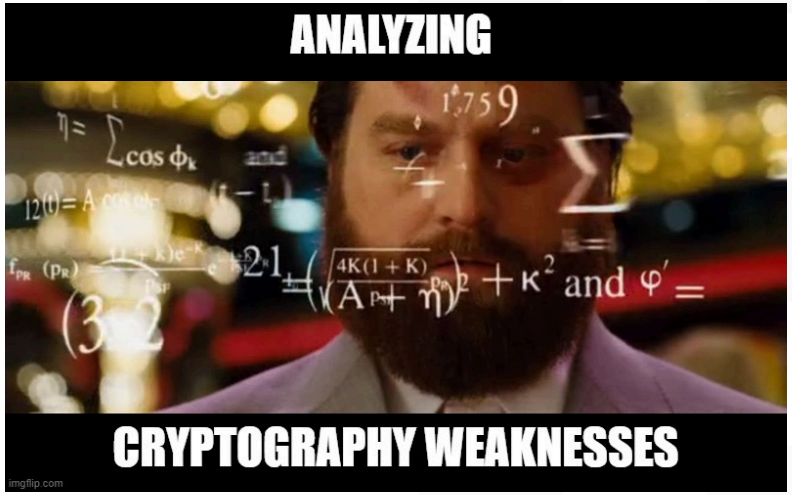
Transparent data encryption (TDE)

## Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Cryptographic Systems

"All cryptography can eventually be broken the only question is how much effort is required." – Bruce Schneier, https://www.schneier.com/

- A number of avenues that can be followed to compromise a cryptographic system.
  - Algorithm and protocol weaknesses
  - Implementation weakness
  - Key management vulnerabilities




*There are countries that strictly regulate the use of cryptography, and countries that, while permitting the unrestricted use of cryptography, regulate the export of cryptographic technology

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Cryptographic Systems (*Algorithm and protocol weaknesses*)

- **Cryptology is hard**, and even the experts get it wrong.
- The cryptographic attack surface includes not only the algorithm, but the **people**, **processes**, and **technology** that implement the cryptographic protections, all of which are potentially vulnerable to attack.
- Cryptanalysis becomes more effective over time, owing to advances in computing, mathematical breakthroughs, and other improvements in cryptanalytic methods.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Cryptographic Systems (*Algorithm and protocol weaknesses*)

- **Crypt**
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Example protocols with weaknesses

- Dual Elliptical Curve Deterministic Random Bit Generator (Dual EC DBRG)
- Wireless Equivalent Privacy (WEP)

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Cryptographic Systems (*Algorithm and protocol weaknesses*)

- **Crypto**
- The cr … but the **peopl** … hic protec
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Time erodes the security of cryptographic protections.

**Plan for the Lifecycle**

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Cryptographic Systems (*Implementation Weaknesses*)

Use industry-standard and tested algorithms, implemented in published libraries. **Don't invent or implement algorithms yourself.**

**Side-channel attack** is the analysis of artifacts related to the implementation of the algorithm, such as the time the algorithm takes to execute, the electrical power consumed by the device running the cryptographic implementation, or the electromagnetic radiation released by the device.

The best defense is to **use standard cryptographic libraries** that have been tested over time for side-channel information leakage.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Cryptographic Systems (*Implementation Weaknesses*)

There are also a number of steps one can take to minimize the possibility of leaking information via side channels.

- Compare secret strings (e.g., keys, plaintext, unhashed passwords) using constant-time comparison routines.
- Avoid branching or loop counts that depend upon secret data.
- Avoid indexing lookup tables or arrays using secret data Use strong (i.e., "cryptographic grade") random number generators.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Cryptographic Systems (*Implementation Weaknesses*)

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- Avoid ir... ographic
grade")

Read the Case Studies in the Book

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Cryptographic Systems (*Key Management Vulnerabilities*)

A number of vulnerabilities that can be introduced through the incorrect use, storage, and management of cryptographic keys.

Keys should be generated in a manner appropriate for the cryptographic algorithm being used.

The proper method to generate a symmetric key is different from a public/private key pair. *NIST SP 800-133, "Recommendation for Cryptographic Key Generation," provides specific guidance.*

Keys should not be reused and should be rotated (replaced) periodically to ensure that the amount of data encrypted using a single key is limited.

Symmetric and private keys depend upon confidentiality to be effective. This means great care must be taken with how the keys are stored to reduce the possibility of their becoming known to unauthorized entities.

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Cryptographic Systems – Key Management

Secure key management is paramount to maintaining cryptography benefits and security

- Key management software
- Key management services provided by cloud service providers
- Dedicated hardware devices that keep the keys stored internally in a tamper-resistant secure device
- Keys should have a defined lifetime
- Account for insider threat (Dual control or SOD)
- Must consider availability (CIA Triad)
- Key operations should be logged
- Automate Key management functions when practical

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Industrial Control Systems (ICS)

**Industrial control systems (ICSs)** are used to **automate industrial processes** and cover a range of control systems and related sensors.

Security in this context concentrates mostly on the integrity and availability aspects of the CIA Triad: integrity of the data (e.g., sensor inputs and control setpoints) used by the control system to make control decisions, and availability of the sensor data and the control system itself.

In addition to integrity, **safety** is a critical consideration for modern industrial control systems, such as those that steer aircrafts, treat our drinking water, and power biomedical systems.

ICS is part of OT
[Operational Technology]

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Industrial Control Systems (ICS)

- Historically, ICSs communicated using proprietary methods and were not connected to local area networks (LANs) or the internet, so security was not a design consideration.

- Today, many industrial control systems have been attached to internet protocol (IP) gateways without much consideration as to the threats such access enables.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Industrial Control Systems (ICS)

There are a number of organizations that provide guidance or regulations related to ICS security:

- ISA/IEC-62443 is a series of standards, technical reports, and related information that define procedures for implementing electronically secure Industrial Automation and Control Systems (IACS).
- The North American Electric Reliability Corporation (NERC) provides a series of guides referred to as the Critical Infrastructure Protection (CIP) standards. NERC CIP standards are mandatory in the United States and Canada for entities involved in power generation/distribution.
- The European Reference Network for Critical Infrastructure Protection (ERNCIP) is an EU project with similar aims to those of NERC CIP.
- NIST and the UK National Centre for the Protection of National Infrastructure (CPNI). See, for example, NIST publication SP800-82.

## Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Industrial Control Systems (ICS)

These are the challenges specific to industrial control

- The difficulty of patching device firmware to address vulnerabilities in the software discovered after placing the device into production in the field
- Failure to change factory-default settings, especially those related to access controls and passwords
- The long production lifetime of industrial systems as compared to IT systems
- The reliance on air-gapped networks as a compensating control without proper supervision of network connections

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Industrial Control Systems (ICS)

With ICSs, patching can be difficult or impossible

- With industrial systems operating nonstop, it may not be feasible to remove an ICS device from operation to update its firmware.
- Similarly, with continuous production being important, the risk of an update breaking something (such as patching the underlying operating system and interfering with the ICS app running on that OS) can be too great (and greater than the perceived risk of running obsolete software). Consider an air traffic control system or an oil and gas pipeline, for example. These systems are hugely important and rely on nearly 100 percent uptime. Often, organizations must weigh the risk of operating an unpatched system with the risk of a patch disrupting service.
- Finally, the location of the ICS device in the field may make the simple matter of reaching the device physically to connect a laptop to install the firmware update a significant undertaking.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Industrial Control Systems (ICS)

*Physical security and compensating controls are key*

- Computers used to maintain and manage industrial systems must never be used for any other purpose
- It is essential to limit and screen permitted traffic accessing the ICS network through the use of carefully configured firewalls and network proxies
- For ICSs that must be remotely accessible, compensating controls such as installing a web proxy or VPN should be considered to add an additional layer of security on top of whatever access controls are implemented on the ICS itself.

CISSP® MENTOR PROGRAM – SESSION FOUR

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

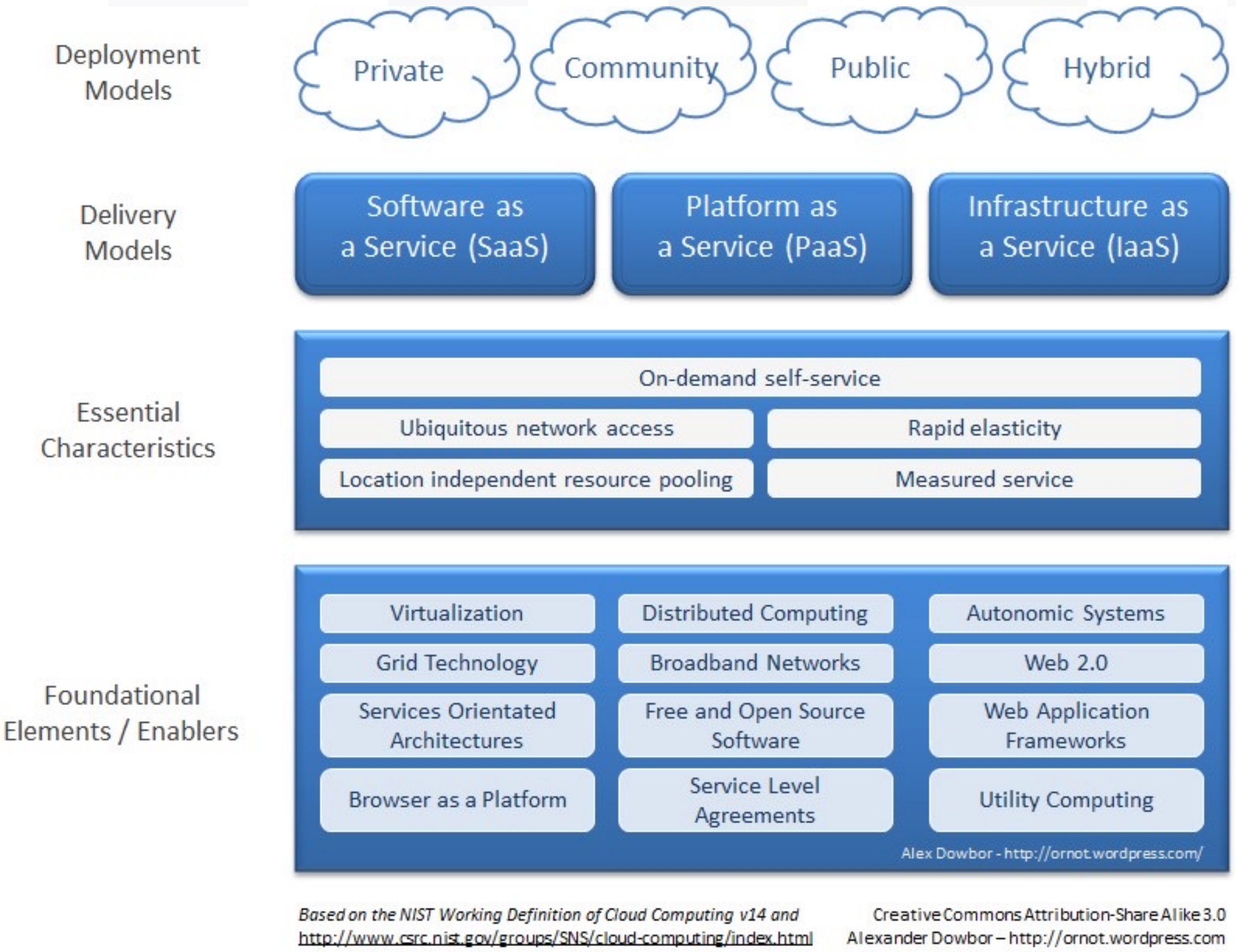
## Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Cloud Based Systems

NIST Cloud websites:
https://www.nist.gov/cloud-computing-virtualization

https://csrc.nist.gov/publications/detail/sp/800-145/final

Put your definition of "Cloud Computing" in chat (or write it down)



Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Cloud Based Systems

According to NIST, "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."

In short, cloud-based systems are remotely located, separately managed systems that are accessible by the internet.

https://www.nist.gov/news-events/news/2011/10/final-version-nist-cloud-computing-definition-published

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Cloud Based Systems

## NIST SP 800-145 and ISO/IEC 17788 define a number of characteristics that describe cloud computing

- Broad network access: Resources (physical and virtual) are accessible and managed over the network.
- Measured service: Users pay only for the services they use.
- On-demand self-service: Users can provision and manage services using automated tools without requiring human interaction.
- Rapid elasticity and scalability: Services can be rapidly and automatically scaled up or down to meet demand.
- Resource pooling and multitenancy: Physical or virtual resources are aggregated to serve multiple users while keeping their data isolated and inaccessible to other tenants.

https://csrc.nist.gov/publications/detail/sp/800-145/final

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Cloud Based Systems

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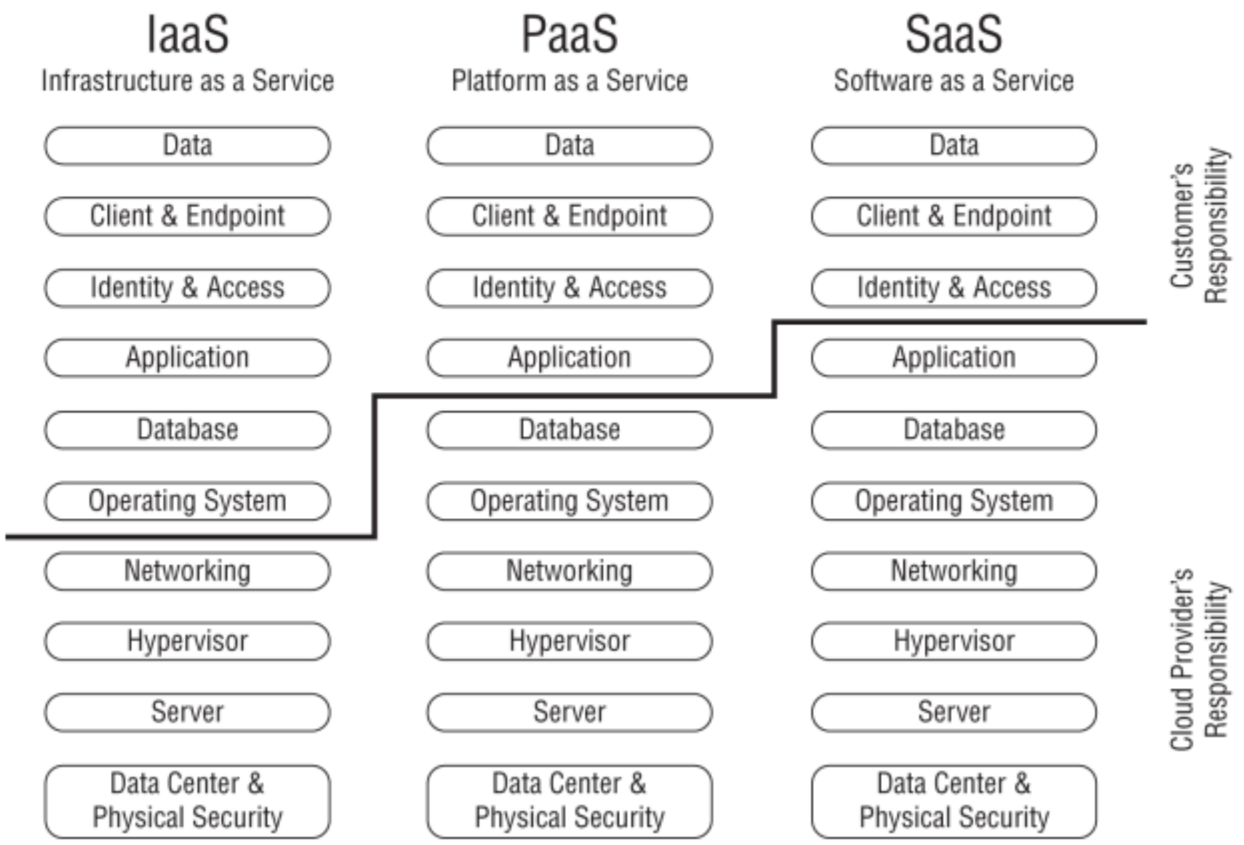
# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Cloud Based Systems

| CLOUD SERVICE MODEL | SERVICE PROVIDED | SERVICE PROVIDER RESPONSIBILITIES | CUSTOMER RESPONSIBILITIES |
|---|---|---|---|
| Software as a service (SaaS) | Software application accessible to the customer over the internet (via a browser or API) | Provide and manage all infrastructure from server and network hardware to applications software | Provide the client device and manage user-specific configuration settings |
| Platform as a service (PaaS) | Web-based framework for developers to create customized applications | Provide and manage all infrastructure from server and network hardware to the libraries and runtime services necessary to run applications | Provide the application and manage the hosting environment |
| Infrastructure as a service (IaaS) | Infrastructure, including servers, network, storage, and operating systems, delivered through virtualization technology | Provide network and server infrastructure to support VMs and other virtualized resources | Provide and manage all components that run on the VM as well as limited aspects of network services |



Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Cloud Based Systems

In particular, the cloud service provider is exclusively responsible for the following.

- Physical security Environmental security
- Hardware (i.e., the servers and storage devices)
- Networking (i.e., cables, switches, routers, firewalls, and internet connectivity)

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Cloud Based Systems

The **cloud service provider and the customer share** responsibility for the following:

- **Vulnerability and patch management**
- **Configuration management**
- **Training**

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Cloud Based Systems

Cloud service can be deployed in a number of ways (known as deployment models)

- **Public cloud -** Available to any customer
- **Private cloud -** Used exclusively by a single customer (may be in-house or run by a third party, on-premise or off)
- **Community cloud -** Used exclusively by a small group of customers with similar interests or requirements (may be managed by one or more of the customers, or a third party, on-premise or off)
- **Hybrid cloud -** A combination of two or more of the above deployment models

*Since many government agencies share similar interests and requirements, the notion of a government cloud (or “GovCoud”) has become an important community cloud concept.

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Distributed Systems

A **distributed system** involves multiple subsystems, possibly distributed geographically, and interconnected in some manner, the *attack surface is much larger* than that of a single system.

It is important to model threats to the overall system and identify the relative risks that need to be addressed.

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Distributed Systems (*Things to consider*)

- The need for encryption and authentication on the connections between the subsystems to ensure attackers cannot intercept, eavesdrop, or **spoof communications between subsystems**.
- The need to protect against **Denial of Service** (DoS) attacks against the communications links or the subsystems themselves.
- The risks from a **lack of homogeneity across subsystems** (e.g., different versions and patch levels of operating systems, middleware, and application software; difficulty of maintaining consistent configurations across disparate and distributed systems) and mechanisms to mitigate those risks.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Distributed Systems (*Things to consider*)

- The need to **maintain consistency should communications be disrupted** (delayed or interrupted) between groups of (normally) connected subsystems (sometimes referred to as the "split-brain" problem)
- The challenge of **ensuring comparable security controls** in the case of geographically distributed components (e.g., physical, environmental, and personnel)
- The requirements of **privacy and data sovereignty regulations** that may limit the transfer of personal data across international borders

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Internet of Things

The term ***Internet of Things (IoT)*** describes a network of physical objects that are embedded with technologies (e.g., sensors and software) that enable them to connect to and exchange data with other devices over the internet.

Examples include household appliances, medical equipment, smart home devices, and so on. Estimates are that the number of such devices in 2020 was somewhere between **20 and 50 billion**, and the rapid expansion of 5G networks is expected to continue to drive IoT growth.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Internet of Things

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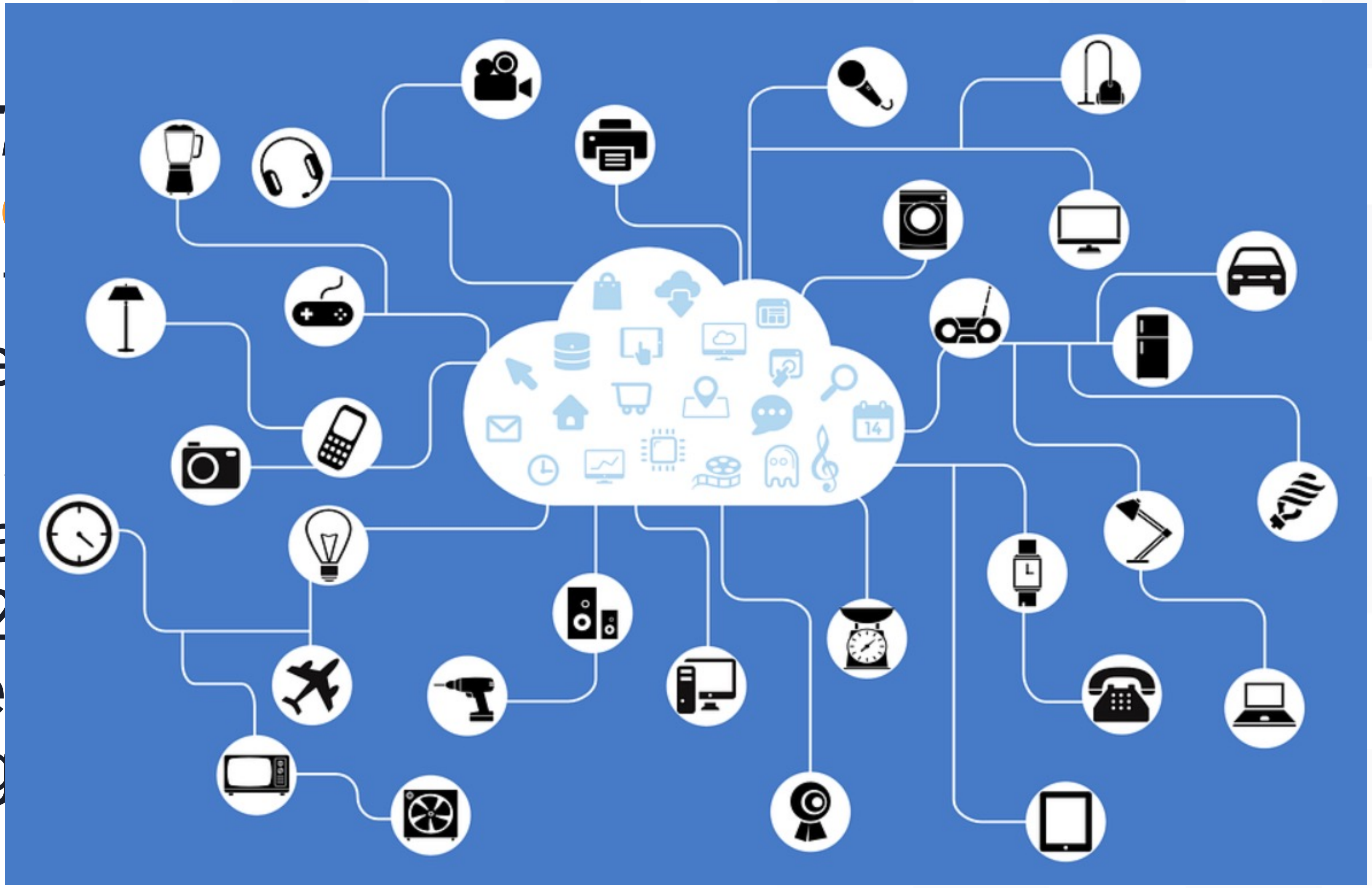


https://www.weforum.org/agenda/2021/03/what-is-the-internet-of-things/

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Internet of Things

The importance of IoT security can be demonstrated through the infamous Mirai distributed denial of service (DDoS) attack.

The Mirai attack (Figure 3.10) involved a worm that searched for vulnerable IoT devices (typically consumer routers and IP-enabled closed circuit television (CCTV) cameras), infected them with a copy of the malware, and then waited for instructions from a command and control (C&C) server as to which target to attack with a DDoS attack.

In late 2016, this botnet took the Krebs on Security blog offline and later attacked the Dyn DNS service, which in turn seriously impacted many of their customers including GitHub, Twitter, Reddit, Netflix, and Airbnb.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Internet of Things

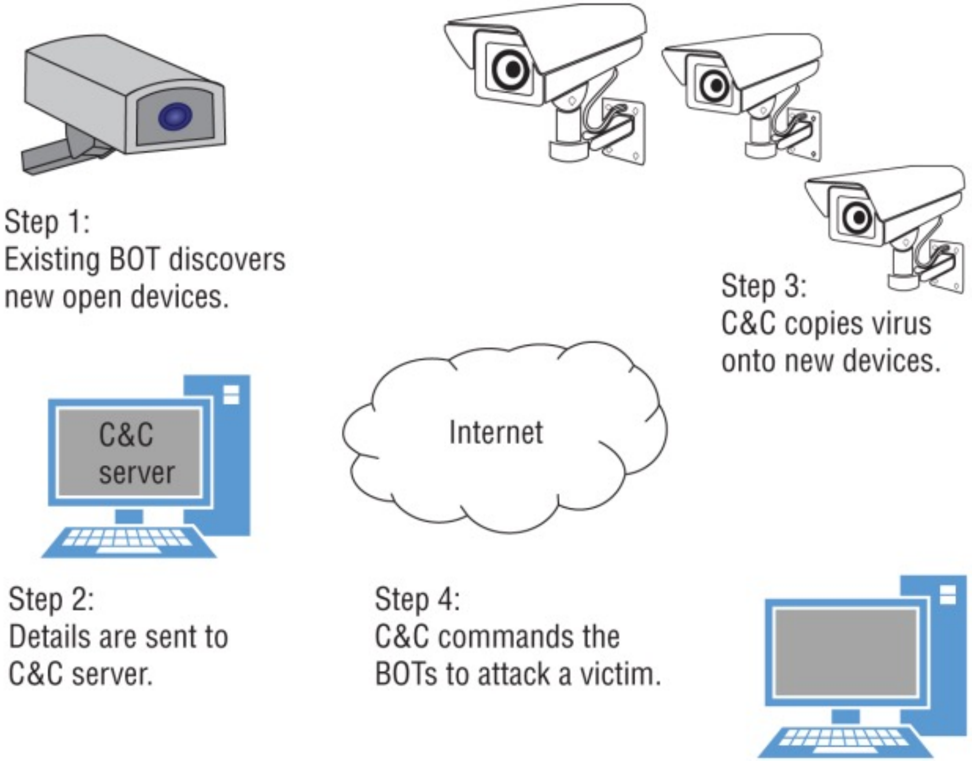



**FIGURE 3.10** Components of the Mirai DDoS BotNet attack

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Internet of Things from a Manufacturer’s Perspective

- During development, you will want to conduct threat modeling to determine likely vulnerabilities and to ensure that appropriate mitigations are deployed
- Review their product's security architecture to determine if the general guidelines outlined earlier in this section have been observed in the design of the firmware.
- Development team will need to pay particular attention to secure software development guidelines such as those from the open web application security project (OWASP) and SANS.
- Quality assurance (QA) team will need to perform active white- and black-box penetration testing.
- Basic security hygiene such as changing default credentials and updating the firmware to patch known vulnerabilities.
- Make implementing the previous two security controls as easy as possible

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Internet of Things from a Manufacturer's Perspective

- Device should refuse to connect to the internet until the user has changed the default admin credentials. It means that your device should update itself automatically (with the consent of the user), and if auto-update has not been enabled, possibly refuse to operate (after sufficient notice) should a patch be available for a high-severity vulnerability being actively exploited in the wild.
- In some cases, IoT devices may refuse to operate without first connecting to the internet for initialization. In these cases, it's best that you keep potentially insecure IoT devices isolated from critical systems or sensitive areas on your network.
- While ease of use is a key factor in the commercial success of IoT devices, one has to draw the line where ease of use is directly connected to ease of compromise.

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Internet of Things from a User's Perspective

- To start, you can protect yourself (and others that might be a target of your compromised devices) through the same two basic security controls previously mentioned
  - Change default credentials as soon as possible, and before you connect the device to the internet.
  - Keep your device updated with the current firmware release, either by enabling auto-update (if supported by your device) or by periodically checking with the manufacturer's website for firmware updates.

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Internet of Things from a User's Perspective

In addition, you can employ security in depth through additional controls:

- Do not place IoT devices on the open internet, but rather behind a firewall so that they are not directly accessible externally.

- Segment your network so that your IoT devices do not have access to other sensitive devices or servers on your internal networks. If you have to be able to access your IoT device externally, then at the very least put the device behind a router that does reverse NAT mapping.

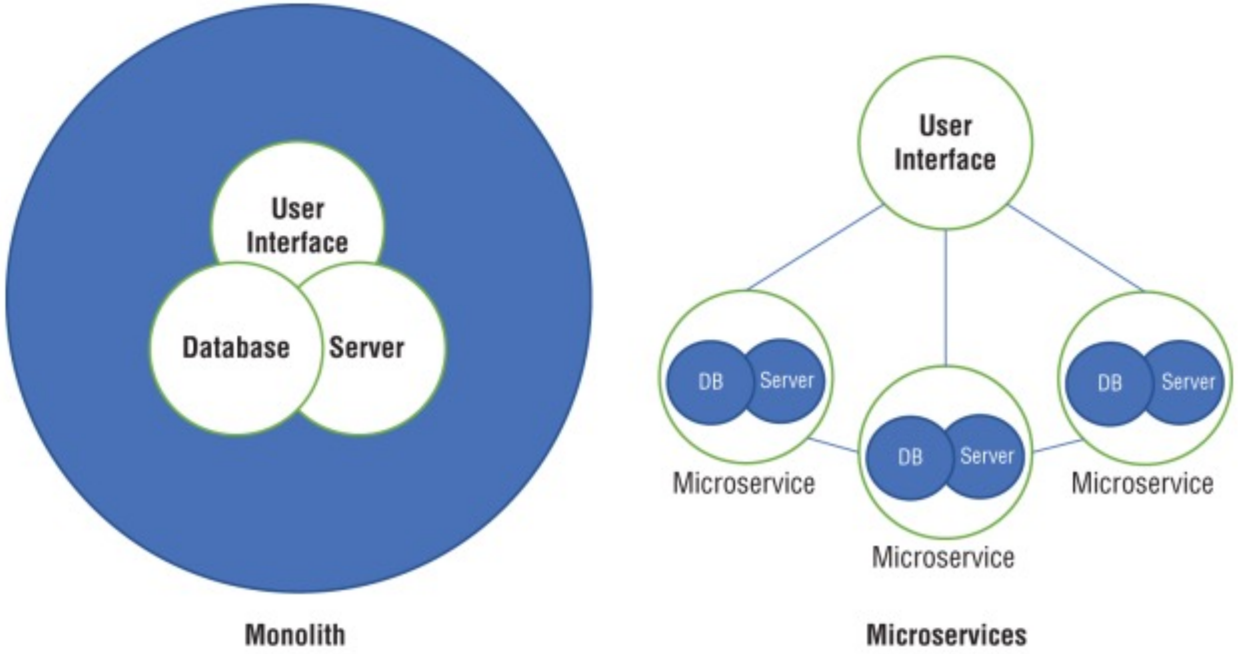
Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Microservices

- **Microservice architecture is a modular software development** style that involves developing a single application as a collection of loosely coupled smaller applications or services (microservices), each running its own processes.
- Microservices are built to be **independently deployable** and **work together** through **lightweight communications protocols**.
- Microservice architectures are **highly distributed and dynamic** and present unique security concerns that must be considered from the first stages of design and throughout the entire development lifecycle. Two key principles to consider when securing microservices are: isolation and defense in depth.
- Monolithic architecture, which involves developing an application as a **single, indivisible unit**, typically with a large codebase that lacks modularity.

## Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Microservices



# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Microservices

- Isolation is a core principle of microservices, and each microservice must be able to be deployed, modified, maintained, and destroyed without impacting the other microservices around it.
- The principle of defense in depth, while important in any architecture, is particularly critical when dealing with microservices
- Defense in depth is a security strategy that calls for multiple layers of security controls to be implemented throughout an application or system.
- It is essential in a microservice architecture to independently monitor and protect each microservice and the communications between each microservice in the overall environment.
- APIs are the most vulnerable part of microservice architecture

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Containerization

- A **container is unit of software that packages up an application and its dependencies** so that the application can be decoupled from its environment and developed, deployed, and run consistently across multiple environments.
- A container uses the operating system's kernel and only the resources required to operate the given application.
- Containers were made popular with the development of the open-source **Kubernetes** platform. Kubernetes and other container platforms are particularly useful in hybrid cloud environments, as they allow developers and users to seamlessly move applications from one cloud to another, or even between cloud and on-prem environments.

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Containerization Security Concerns

- Containerization comes with its own set of security challenges, as container technology is inherently flexible and open. Because containers allow you to rapidly scale up and down resources, asset management and configuration management are perhaps even bigger security concerns than traditional systems.
- Container security risks generally fall into two major categories:
  - Compromise of a container image or the entire container repository
  - Misuse of a container to attack other containers or the host OS
- Your base container image is the most important, because it is used as a starting point for derivative images.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Containerization Security Concerns

- In addition to managing secure image baselines, you must also ensure proper access controls to all of your container images. Use role-based access controls, where possible, to manage access to your container images.
- Securing the host OS that runs your containers is a foundational part of securing your containers.
- Host operating systems should run only the minimally required services necessary to operate the containers and exclude applications like web servers, databases, and others that increase the attack surface
- Proper configuration is also important, and host OSs must be included in your configuration management plans. In addition, communications between containers should be restricted based on the principle of least privilege — only allow containers to communicate with those containers that are absolutely required for operation
- Use orchestration and management tools

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Serverless

- Serverless computing is a cloud computing model that involves the cloud provider managing servers, and dynamically allocating machine resources, as needed.
- Infrastructure management tasks like provisioning and patching are handled by the cloud provider
- Serverless computing comes with some notable security benefits. To start, serverless functions are typically ephemeral (i.e., short lived).
- This short-lived nature creates a moving target that adds a high degree of difficulty for attackers to compromise
- Serverless functions are commonly much smaller codebases than even the smallest containers.

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Serverless

- Effective serverless security is built on ensuring code integrity, tight access permissions, and proper monitoring.
- You should maintain least privileged access for serverless functions, as you do other services — serverless functions should be granted only the access and permissions necessary to execute their task.
- Code should be routinely scanned for vulnerabilities and configuration issues.
- Runtime protection should be used to detect suspicious events or errors that may lead to unexpected behavior or compromise.

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Embedded Systems

Embedded systems are dedicated information processing components built into larger mechanical or electrical systems, intended to provide a limited set of functions.

- Domestic appliances (e.g., dishwashers, clothes washers and dryers, refrigerators, and televisions)
- Office equipment (e.g., printers, scanners, and fax machines)
- Networking devices (e.g., routers, switches, and firewalls)
- Cars and other automobiles
- ATMs
- Medical devices (e.g., heart monitors, glucose meters, and IV infusion pumps)
- Mass transit vehicles, stations, and systems
- Building automation and control systems
- Traffic control and monitoring systems

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Embedded Systems

- Assessing the vulnerabilities in an embedded system ought to start with an enumeration of the attack surfaces available and then examining each.
- This examination can be done in a number of ways, including code inspection, threat modeling, and white- or black-box penetration testing.
- Generally, these attack surfaces will fall into the following categories:
  - User interface (UI, which are buttons or other methods of user input)
  - Physical attacks
  - Sensor attacks
  - Output attacks
  - Processor attacks

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Embedded Systems

- UI attacks involve manipulating the controls of the device in a manner that causes the device to malfunction
- Physical attacks involve the compromise of the embedded system's packaging, either to directly compromise the device or to gain access to parts of the embedded system in order to expose other attack surfaces that may be vulnerable.
- Sensor attacks involve manipulating, or intercepting data from, the sensors the embedded system uses to detect external conditions that are relevant to its operation.
- Output attacks involve manipulating the actuators controlled by the embedded system to bypass the controls imposed by the system.
- Processor attacks involve compromising the processor directly, through means that can range from connecting directly to the processor or memory chips to carefully removing the tops of integrated circuits and using ion beams to probe the chip to obtain or manipulate information within the processor. Processor attacks are normally preceded by a physical attack to gain access to the processor.

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Embedded Systems

- Embedded systems that support firmware updates may be vulnerable to accepting rogue or unauthorized firmware.
- As with IoT devices, a problem is that it is difficult, if not impossible, to upgrade the software in many embedded systems.
- Vulnerabilities that are discovered after the product has shipped may be difficult or impossible to patch.
- The result may be the need for compensating controls to mitigate the risk from the unpatched vulnerability or the need to replace the unit entirely.

# Security Architecture

## Review Question

Pat is developing an application that they want to run on multiple types of operating systems including in the cloud. What should they use so that the application can be decoupled from its environment and developed, deployed, and run consistently across multiple environments?

1. Embedded system
2. Containerization
3. Serverless
4. Microservices

A **container** is unit of software that packages up an application and its dependencies.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

## Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# High-Performing Computing Systems

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# High-Performing Computing Systems

- High-performance computing (HPC) refers to the use of one or more supercomputers, generally for the purpose of highly complex computational science and other mathematically involved applications.
- Generally speaking, HPC systems experience many of the same security concerns as traditional systems and other cloud-based systems.
- HPC's are subject to software vulnerabilities, configuration issues, and compromised credentials.
- Any customized hardware and software present an added threat vector that must be secured.
- As a best practice, HPC systems should be moved to their own physical enclave or logical security zone that is separate from traditional systems.

Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Edge-Computing Systems

- Edge computing is a distributed computing model that brings compute and storage resources closer to the location where it is needed, improving response times and reducing bandwidth.
- The concept of edge computing dates back to the content delivery networks (CDNs) of the 1990s and now extends into the world of cloud computing. CDNs are covered in detail in Chapter 4, “Communication and Network Security.”
- Edge computing allows pseudo-local data processing to minimize data sent over the internet.

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Edge-Computing Systems Security Concerns

- Devices located at the edge, rather than centrally managed in a data center or other tightly managed facility, may not always receive the same diligence as their peers.
- You must be sure to apply the same security rigor to edge devices as your centrally managed devices.
- This includes hardening, patching, and providing the right level of physical security for edge computing systems.
- Data must be encrypted when in transit between edge devices and centralized systems (or the cloud), and VPN tunneling may also be advisable for sensitive data when managing remote systems.

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

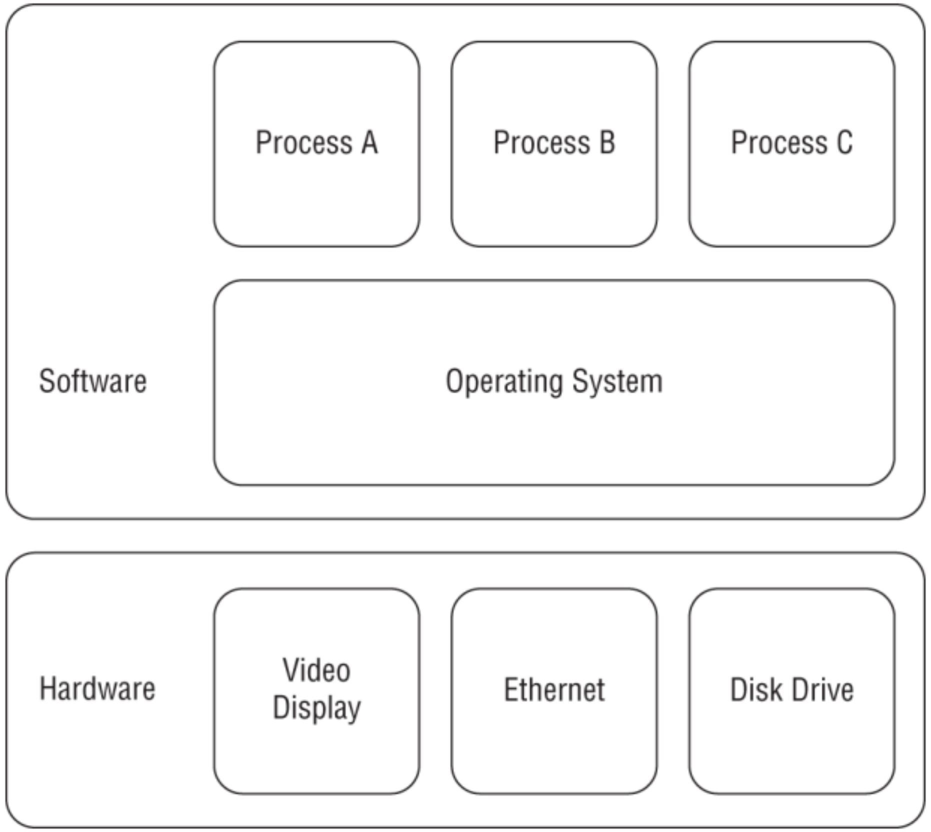
# Virtualized Systems

- Operating systems provide programs with a set of services to enable them to operate more efficiently (and to be more easily designed and run) than if the program had to run on the computer directly.
- The operating system provides a level of abstraction that manages the details of files and directories.
- Virtualization is the act of creating virtual (i.e., not real) compute, storage, and network resources, virtualization allows you to create software versions of hardware.

# DOMAIN 3: SECURITY ARCHITECTURE AND ENGINEERING

### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

## Virtualized Systems



### Assess and Mitigate the Vulnerabilities of Security Architectures, Designs, and Solution Elements

# Virtualized Systems

- VMs, for instance, are software instances of actual computers. Likewise, software-defined networks (SDNs) are software instances of physical networks.
- Virtualization enables multiple operating systems to run on the same computer, each unaware of and unable (in a properly designed system) to affect the other operating systems.
- Virtualization is the primary technology behind cloud computing.

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# Virtualized Systems

- A hypervisor is a computing layer that allows multiple operating systems to run simultaneously on a single piece of hardware.
- There are two types of hypervisors, commonly referred to as Type 1 and Type 2 hypervisors.
    - A Type 1 hypervisor is the sole installation, acting as a bridge between hardware components and VMs.(bare-metal hypervisors)
    - Type 2 hypervisor, relying on a host operating system installed on the hardware.
- Virtualized machines running within the host OS are then called guest machines.

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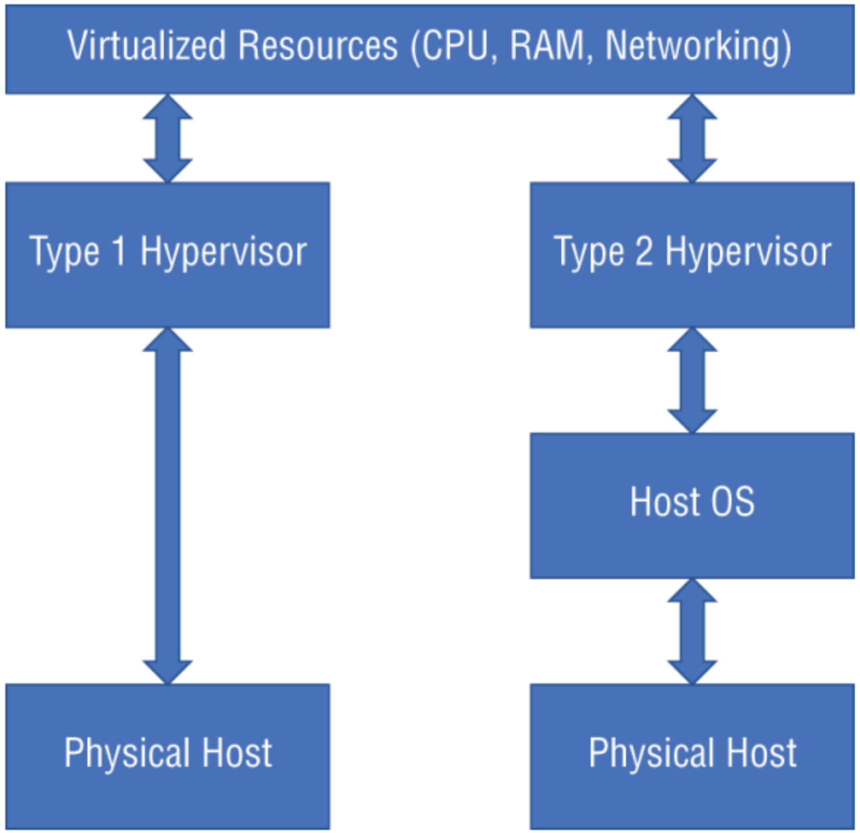
# Virtualized Systems



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# Virtualized Systems Advantages

- More efficient use of the underlying hardware (just as operating systems permitted a single computer to be shared by multiple programs and users)
- Dynamic scaling of infrastructure in response to demand
- Additional separation and isolation between programs and applications running on different operating systems (as opposed to running on the same OS) — supporting the security principles of defense in depth and layers of security outlined earlier

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# Virtualized Systems Potential Weaknesses

- As with memory protection, virtualization depends on the correct operation of both the hardware and the hypervisor.
- Software defects in hypervisors can improperly permit software running on one VM to access data on a different VM on the same computer.
- An exploit known as virtual machine escape, for example, occurs when a program is able to break out of its VM and directly interact with the underlying host operating system.
- Type 2 hypervisors generally have a greater attack surface because of the additional vulnerabilities associated with the host operating system and associated software.
- Type 1 hypervisors generally have embedded operating systems that are hardened and tightly controlled by the vendor.

# Security Architecture

## Review Question

I want to run a virtual machine environment on my desktop. What should I use?

1. Type 1 hypervisor
2. Type 2 hypervisor
3. Microservices
4. Serverless cloud

A **type 2 hypervisor** relies on an underlying operating system.

CISSP® MENTOR PROGRAM – SESSION FOUR

# DAD JOKE

## Before we get toc

How about a dumb dad

**What's either a rea ressive, magical school?**


HAHAHAHA

Moving on…

# SESSION 4 - FIN

NO CLASS – Monday, April 24

## We made it!

### Next Session (Wed, 26 April 2023) - Domain 3 (Security Architecture & Engineering) - Chris

- Cryptography
- Physical security
- …

## Homework:

- Review Domain 2 & Domain 3.
- Take practice tests.
- Review at least two of the references we provided in this class (download for later use).
- Post at least one question/answer in the Discord Channel.

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# WHOAMI

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**2023**

# Class #4 – Domain 3


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