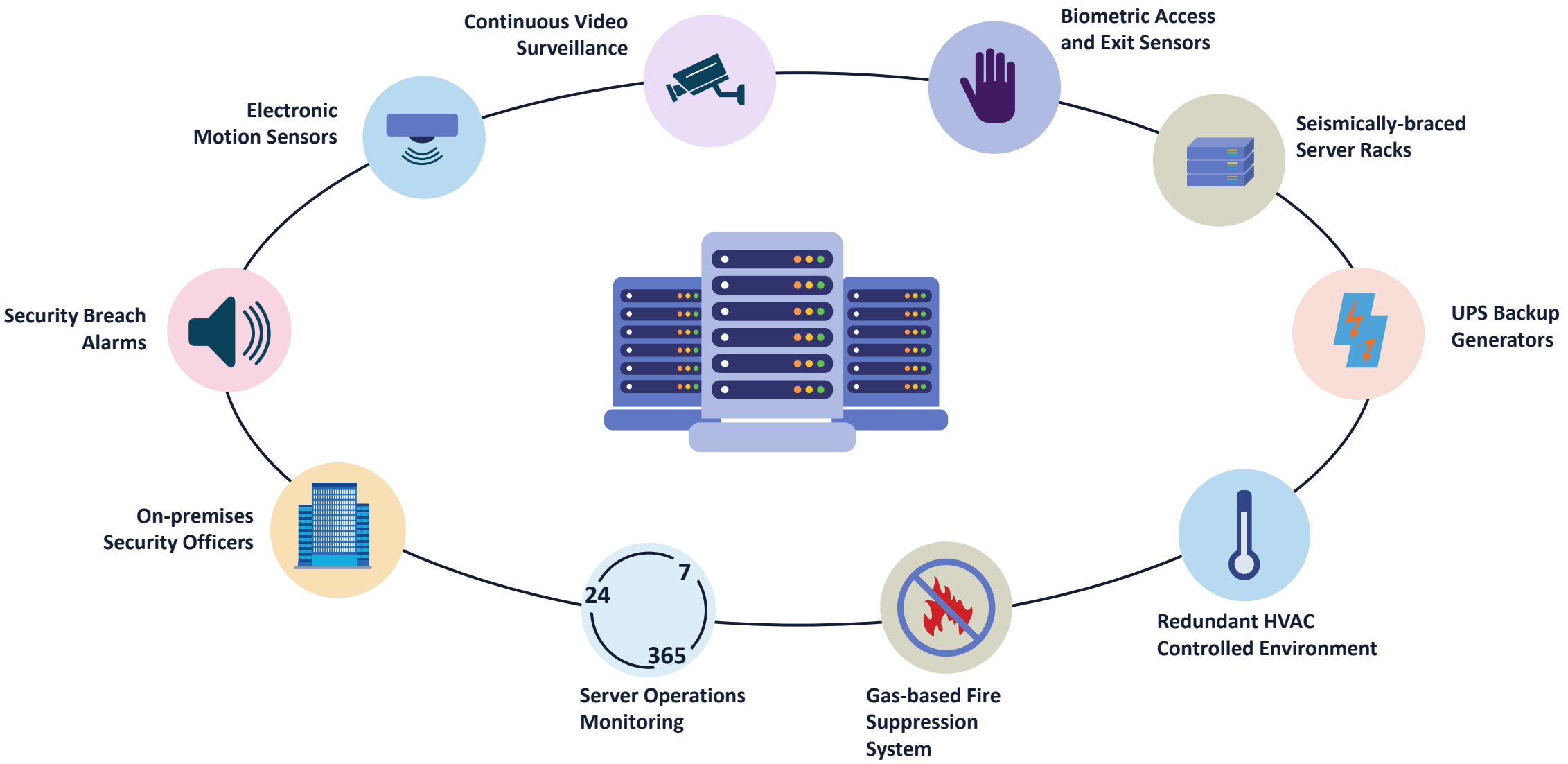
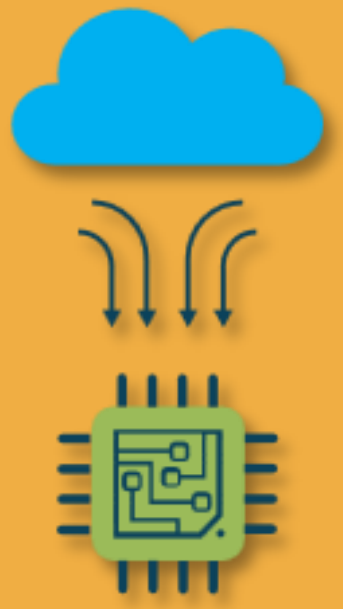
Domain 3

Cloud Platform and Infrastructure Security

Cloud Datacenter Physical Security



Content Distribution (Delivery) Networks



CDN uses Edge Computing

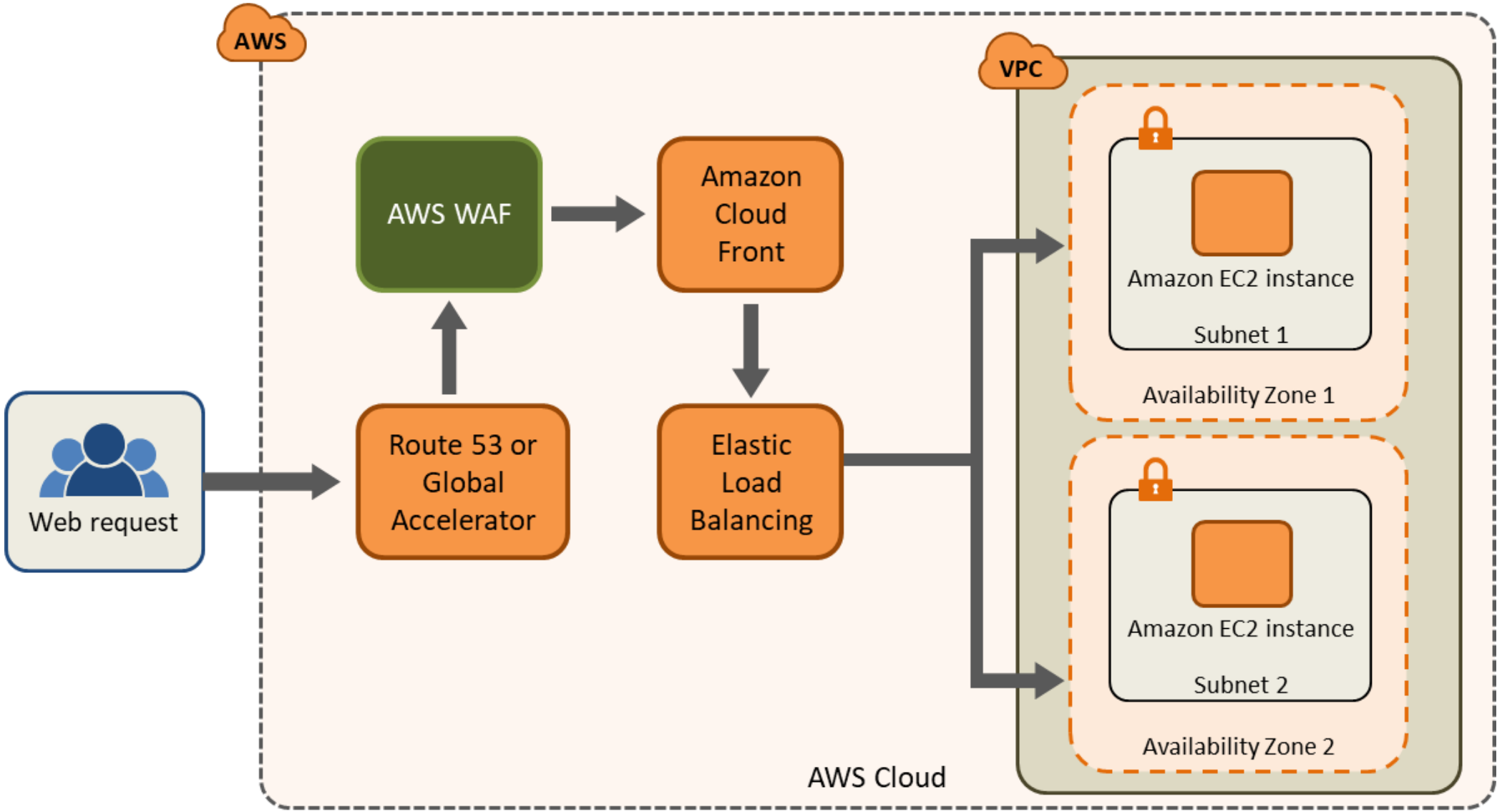
- A CDN is a highly-distributed platform of servers that reduces delays in loading web page content
- It reduces the physical distance between the server and the users around the world
- Without a CDN, origin servers would have to respond to every end user request, resulting in substantial traffic to the origin and subsequent load
- By responding to end user requests using modern edge computing and elastic caching, the CDN offloads traffic from content servers to metro edge locations
- Examples are Cloudflare, Akamai, Fastly, and AWS CloudFront

Content Distribution (Delivery) Networks

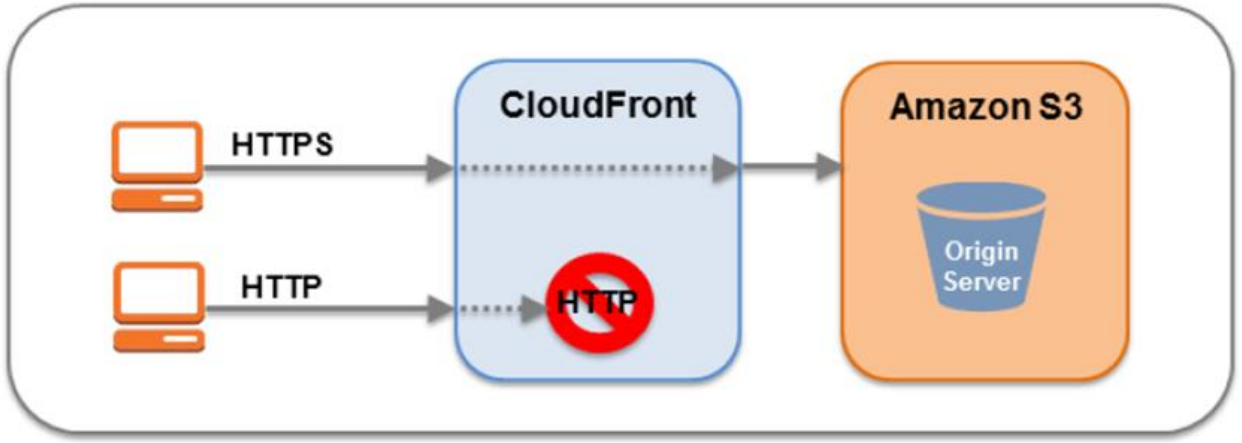
AWS CloudFront

- Amazon CloudFront is a fast CDN service like Akamai
- It securely delivers data, videos, applications, and APIs to customers at metro edge computing locations with low latency, high transfer speeds, and within a developer-friendly environment
- CloudFront is often integrated with AWS Redis ElastiCache at global provider partner locations and various service endpoints
- Functions seamlessly with Route 53, S3 object storage, Elastic Load Balancing, EC2 instances, WAF, and AWS Shield for DDoS protection

CloudFront at Amazon Web Services

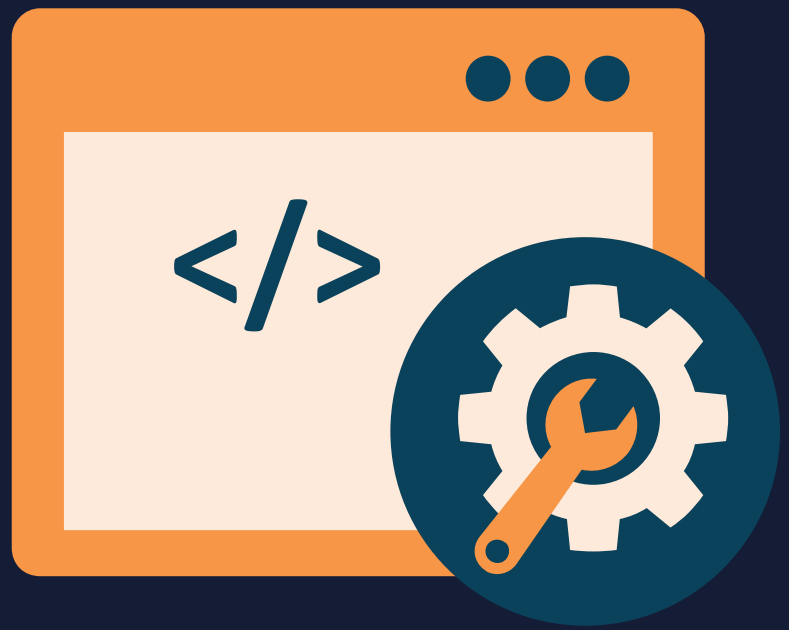


AWS CloudFront Security



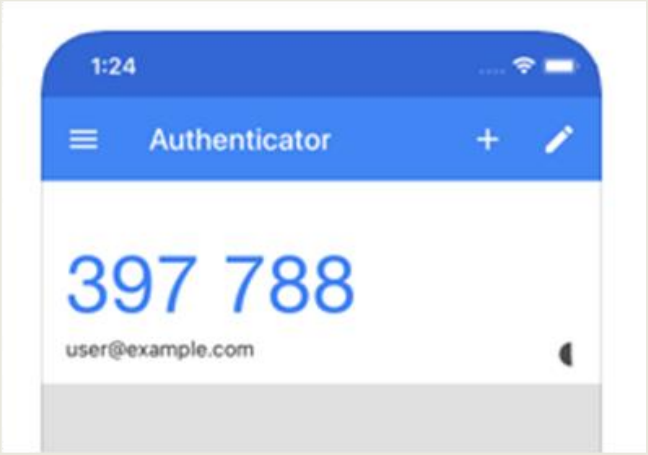
- High-level data center physical security is in place
- **Uses TLSv1.1 and TLSv1.2** protocols for HTTPS connections between CloudFront and the custom origin web server
- Cipher suites use the **ECDHE** protocol on all connections
- **Private Content Feature** controls who can download content from CloudFront
- **Origin Access Identities** can control access to original copies of objects

CSP Management Plane Protection

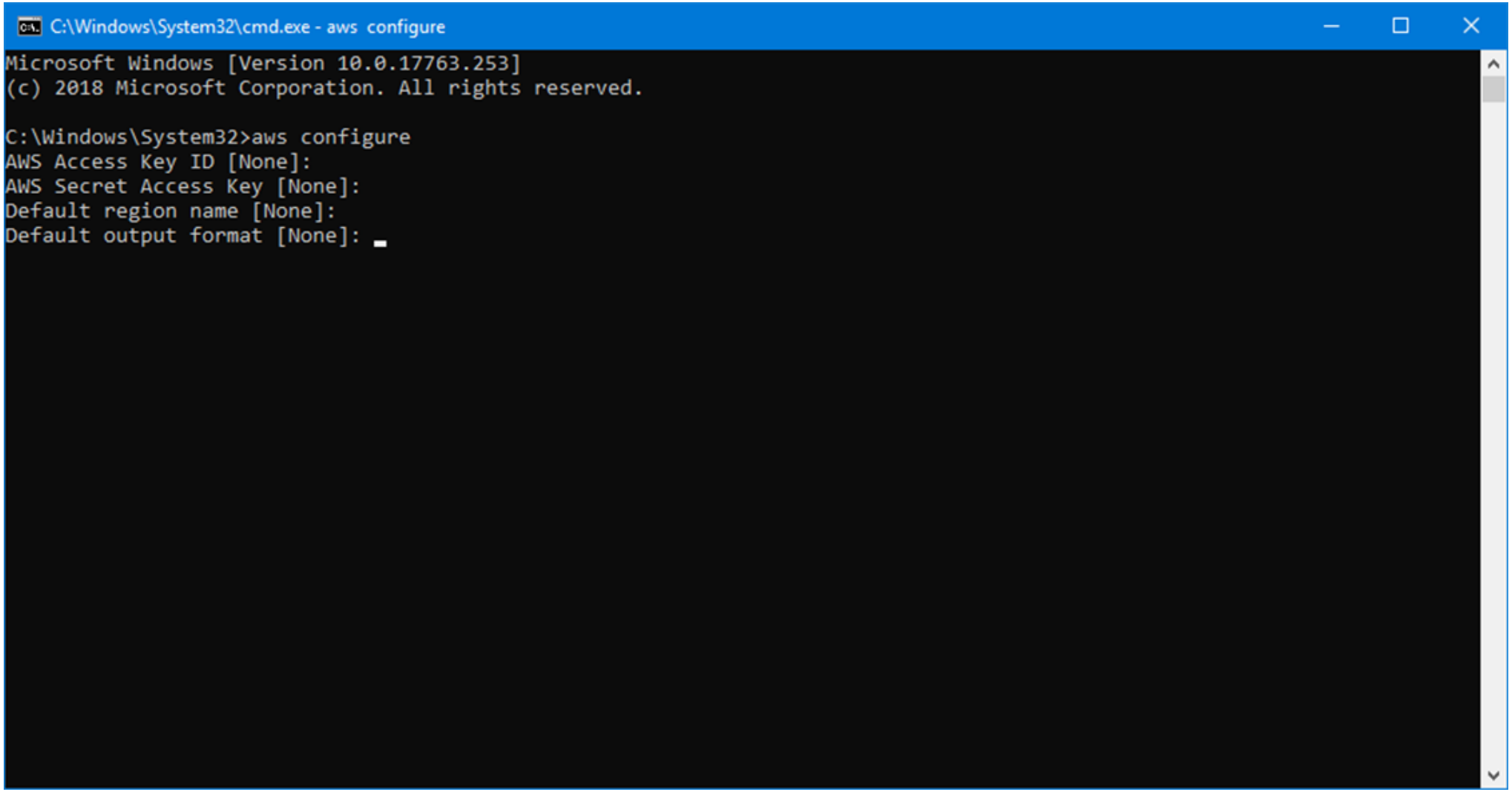


- All CSPs have systems management tools for managing the infrastructure using a graphical portals and IAM
- Can be used with IaaS and SaaS solutions
- Agent software is provided to install on Windows, Linux, and MacOS systems
- SSH2 sessions are setup initially then subsequent management sessions are protected with keys
- Managed services (AWS AppStream) can setup ad hoc management sessions when federated SSO using SAML 2.0 is used
- **Software-defined Networking (SDN) and Zero Trust is the trend**

Use MFA on all Root and Service Accounts



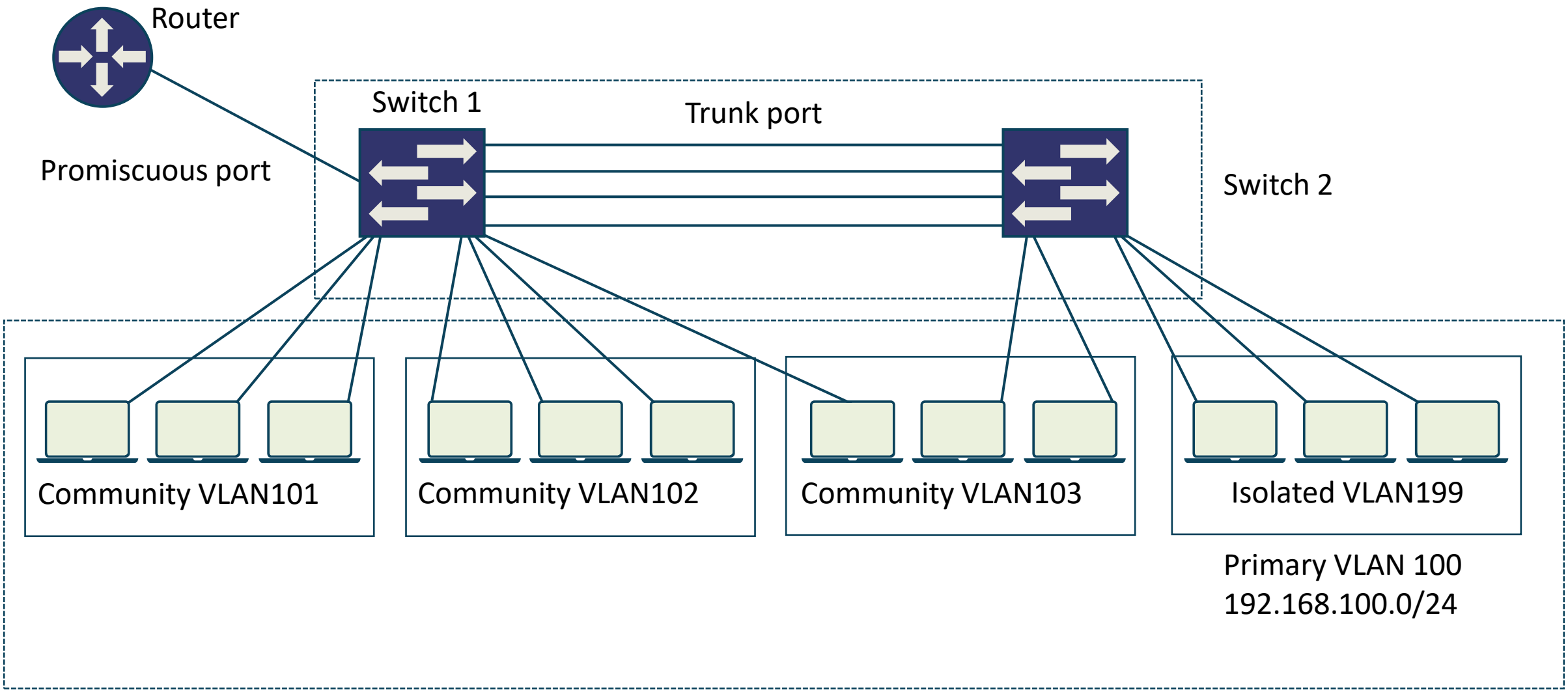
Configuring CLI Access



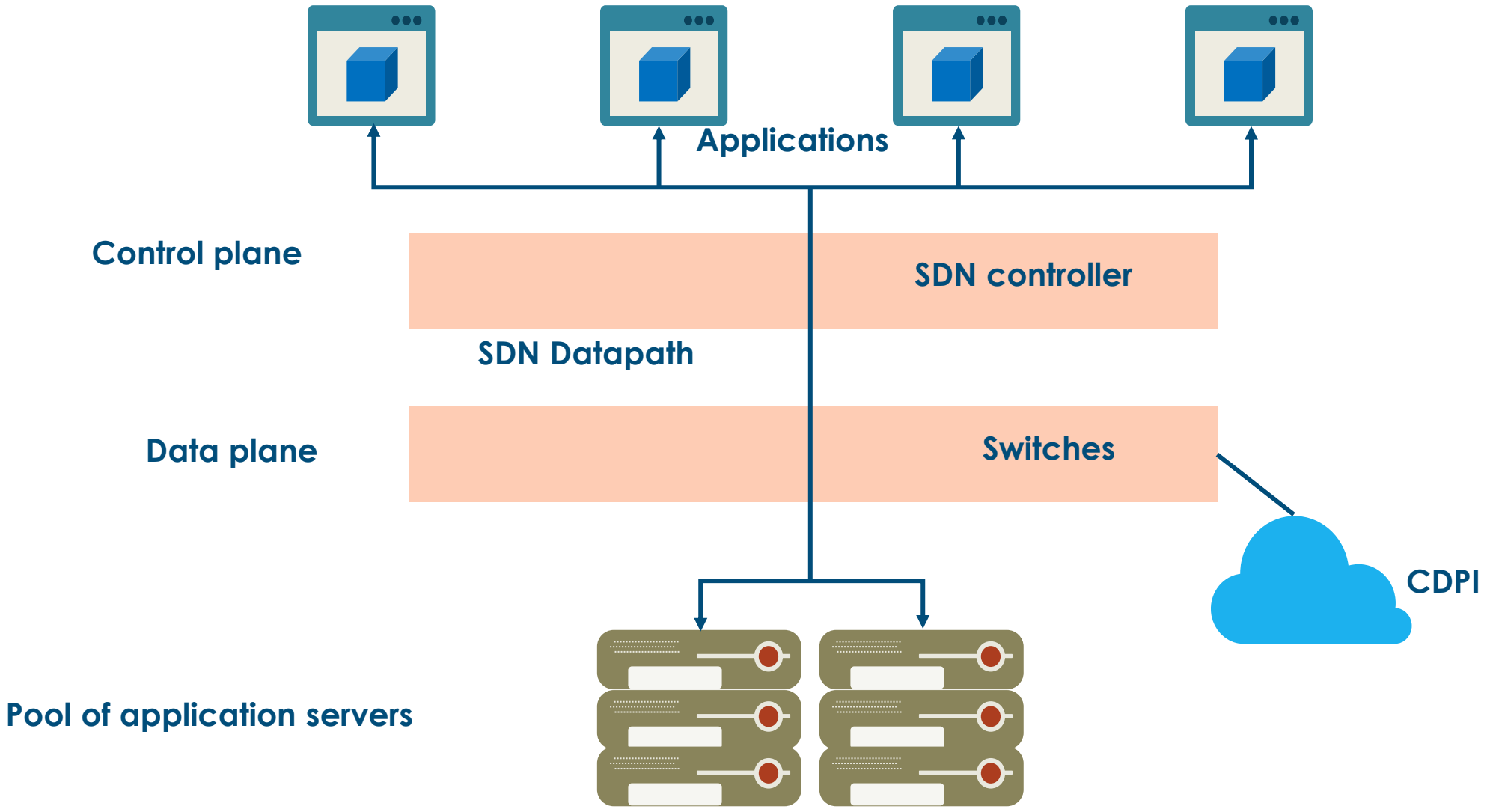
Managed Bastion Services

- Customers can instantiate self-hardened Windows and Linux servers in public subnets for SSH2 and RDP/TLS access to other systems for remote management
- CSPs prefer that customers use managed server-side solutions today where initial SSH2 handshakes are set up then used for subsequent management activities
- Strict least-privilege IAM must be employed

PVLANs for Segmentation and Containment

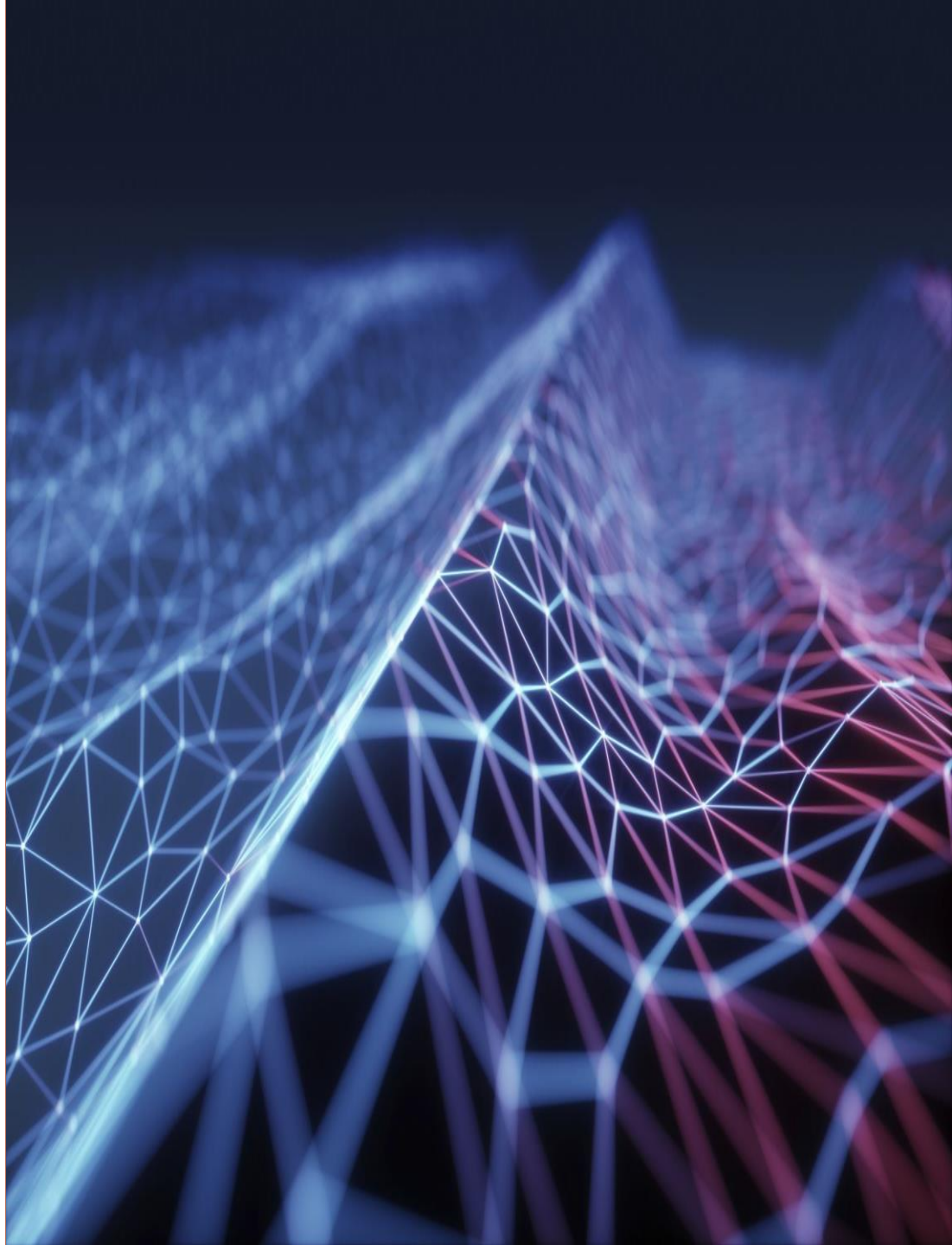


Software-defined Networking (SDN)



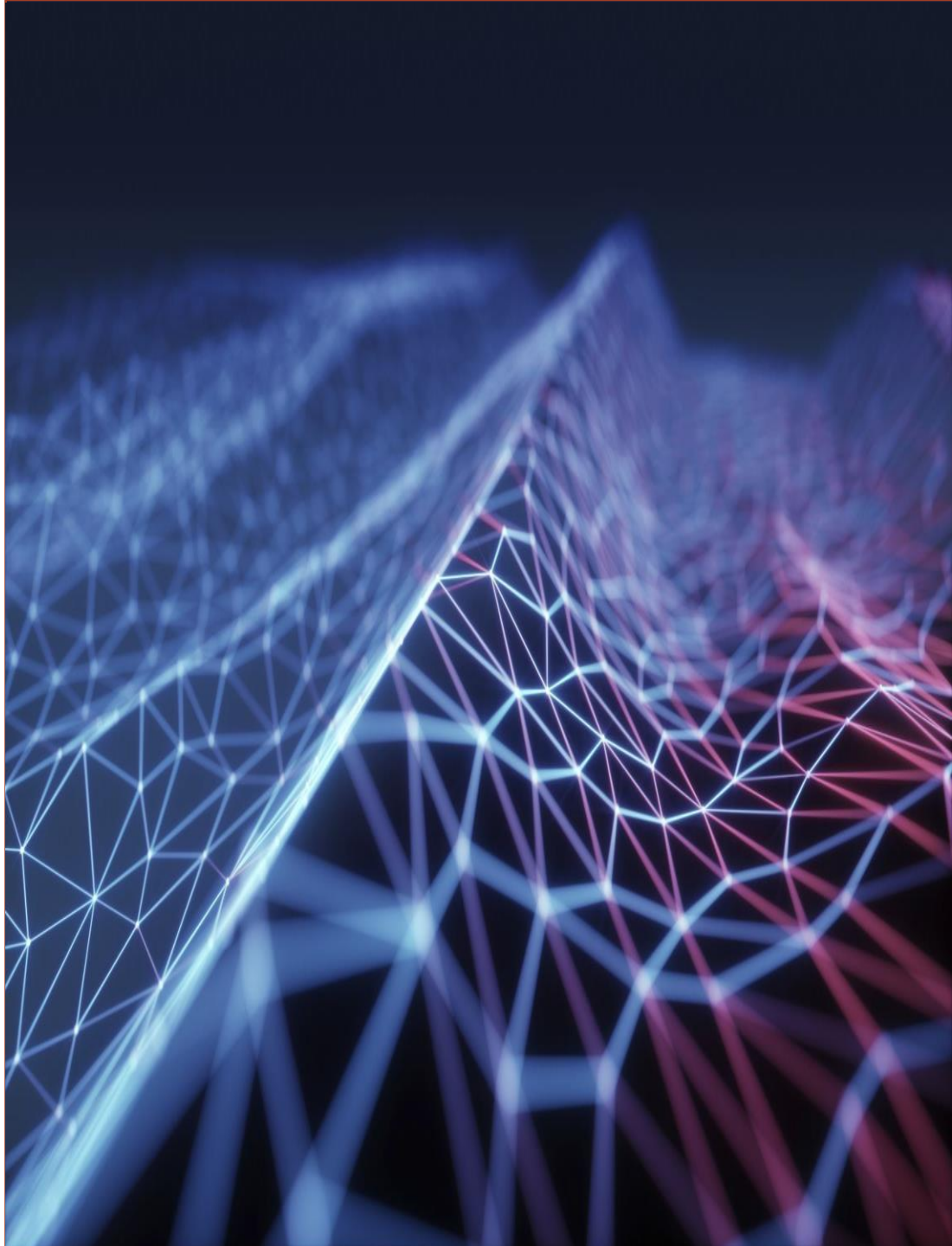
Virtual eXtensible LAN (VXLAN)

- VXLAN is technically an encapsulation protocol that offers data center connectivity using tunneling to stretch Layer 2 connections over a Layer 3 network
- VXLAN solutions from a variety of vendors decouple the physical hardware from the network map in order to support virtualization
  - This uncoupling allows the data center network to be deployed programmatically

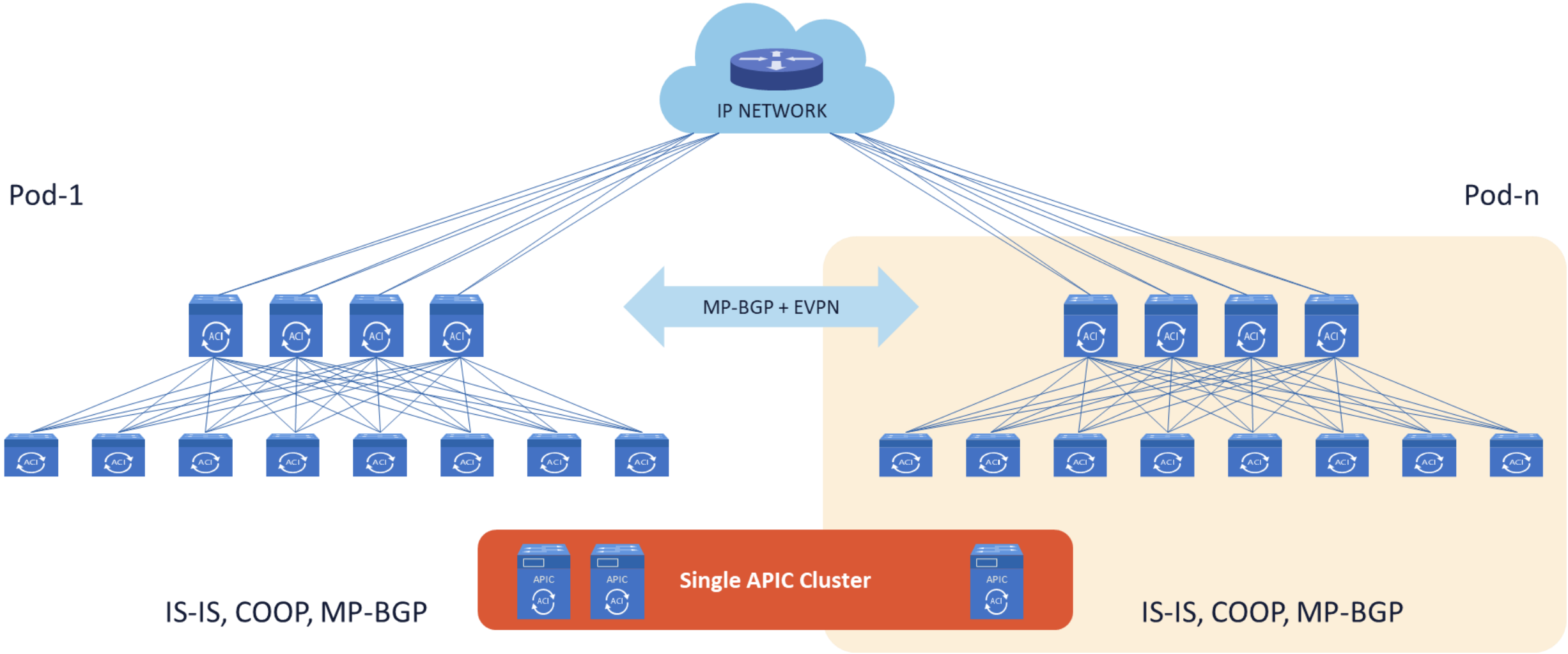


Virtual eXtensible LAN (VXLAN)

- It allows both Layer 2 and Layer 3 transport between VMs and bare-metal servers
- VXLAN supports the virtualization of the data center network while addressing the needs of multi-tenant data centers by offering the necessary scalable segmentation

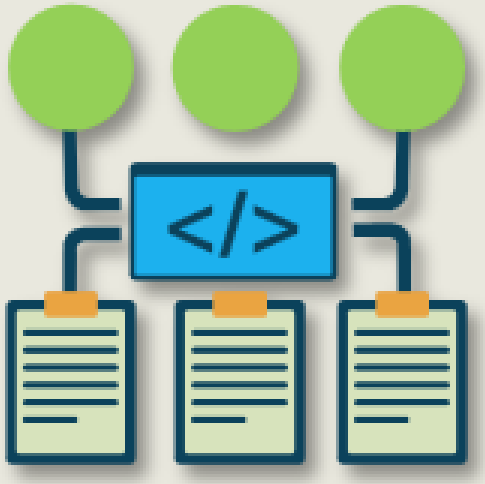


VXLAN and Cisco ACI APIC Architecture



Software-defined Security (SDS)

Used with Software-defined Networks



- Software-defined Security (SDS) is a model in which the information security is highly controlled often using virtualization
- The functionality of network security devices, such as next-gen firewalls, intrusion detection and prevention, identity and access controls, and network segmentation are removed from hardware devices to a software layer
- SDS exploits the software-defined networking (SDN) initiative to enhance network security

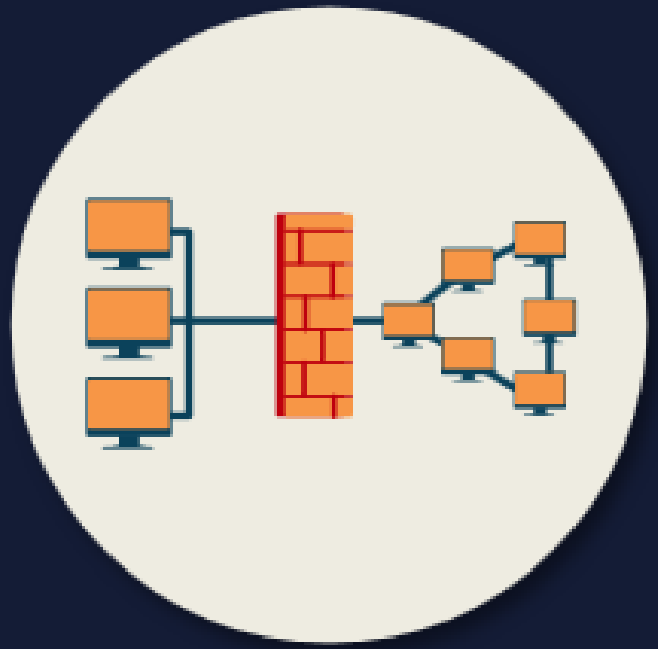
Advantages of SDS

- Offers resourceful and dynamic countermeasures to security attacks
- Separates security away from traditional hardware vulnerabilities
- Ability to dynamically configure existing network nodes allows for rapid attack mitigation from zero-day attacks
- Synchronized view of logical security policies exist within the SDN controller model (not tied to any server or specialized security device)

Advantages of SDS

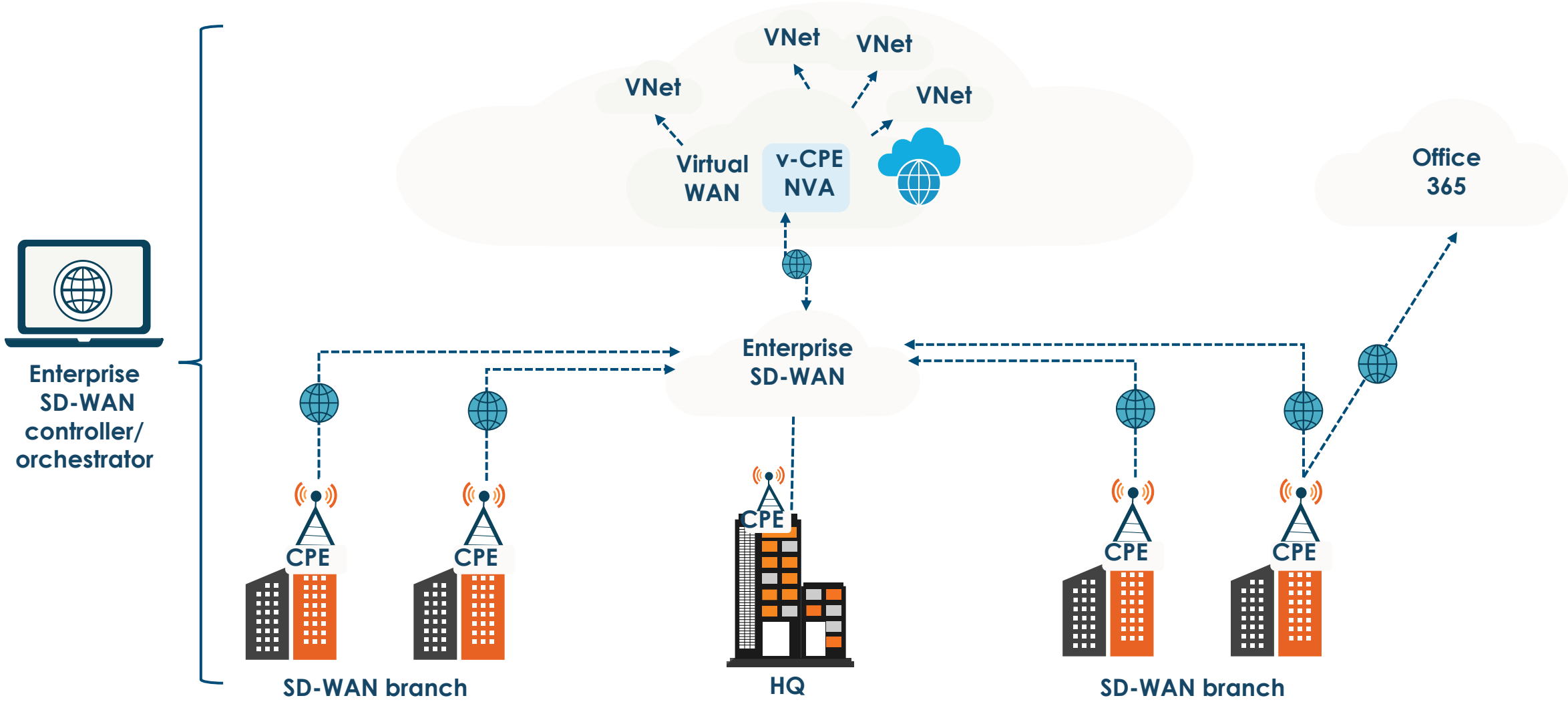
- Visibility of information provided from one source
- Integration with emerging technology to correlate events in a simpler way and respond more efficiently and intelligently to threats
- Enables centralized management of security, which is implemented, controlled, and managed by security software through the SDN controller
- Facilitates IoT & BYOD connectivity and security

Software-Defined WAN



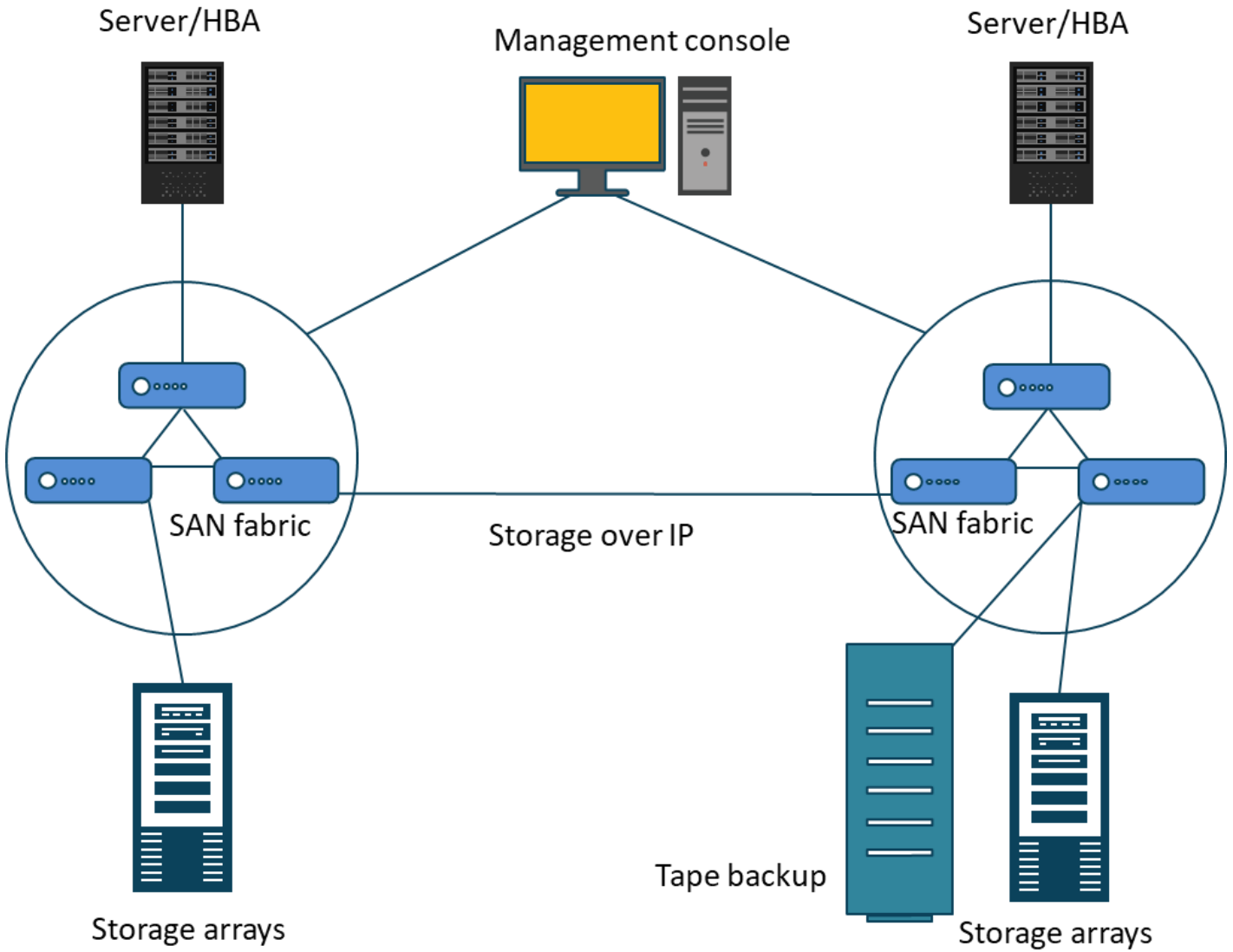
- SD-WAN is an SDN approach that raises network traffic management away from the hardware and premises to next-generation software in the cloud for superior agility, control, and visibility
- It is commonly used with Cloud Providers in metropolitan area solutions
- Incorporates a centralized control function with user-defined application and routing policies to deliver highly secure, robust, application-aware network traffic management

Microsoft Azure SD-WAN Solution

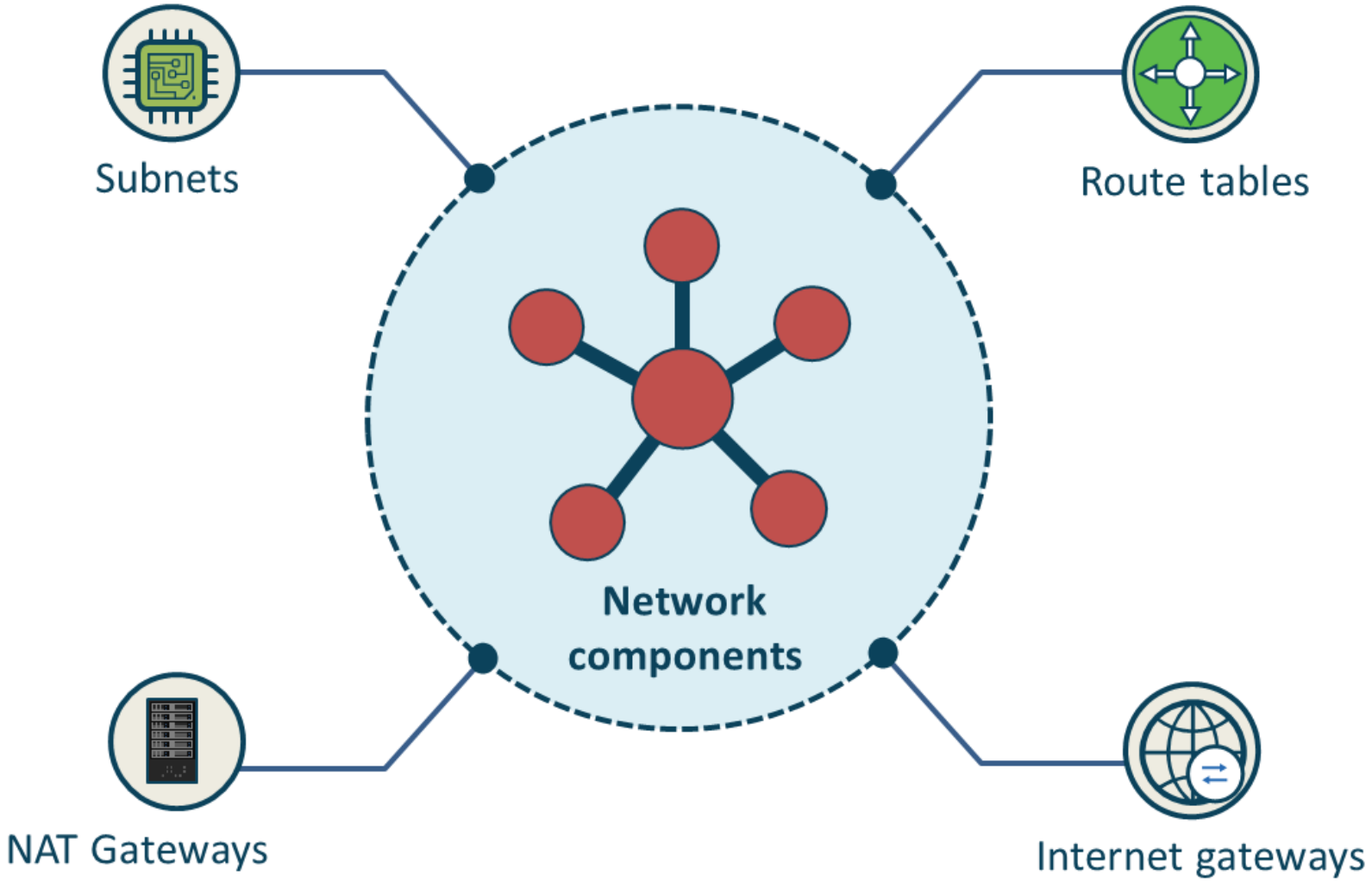


Securing the Storage Area Network (SAN)

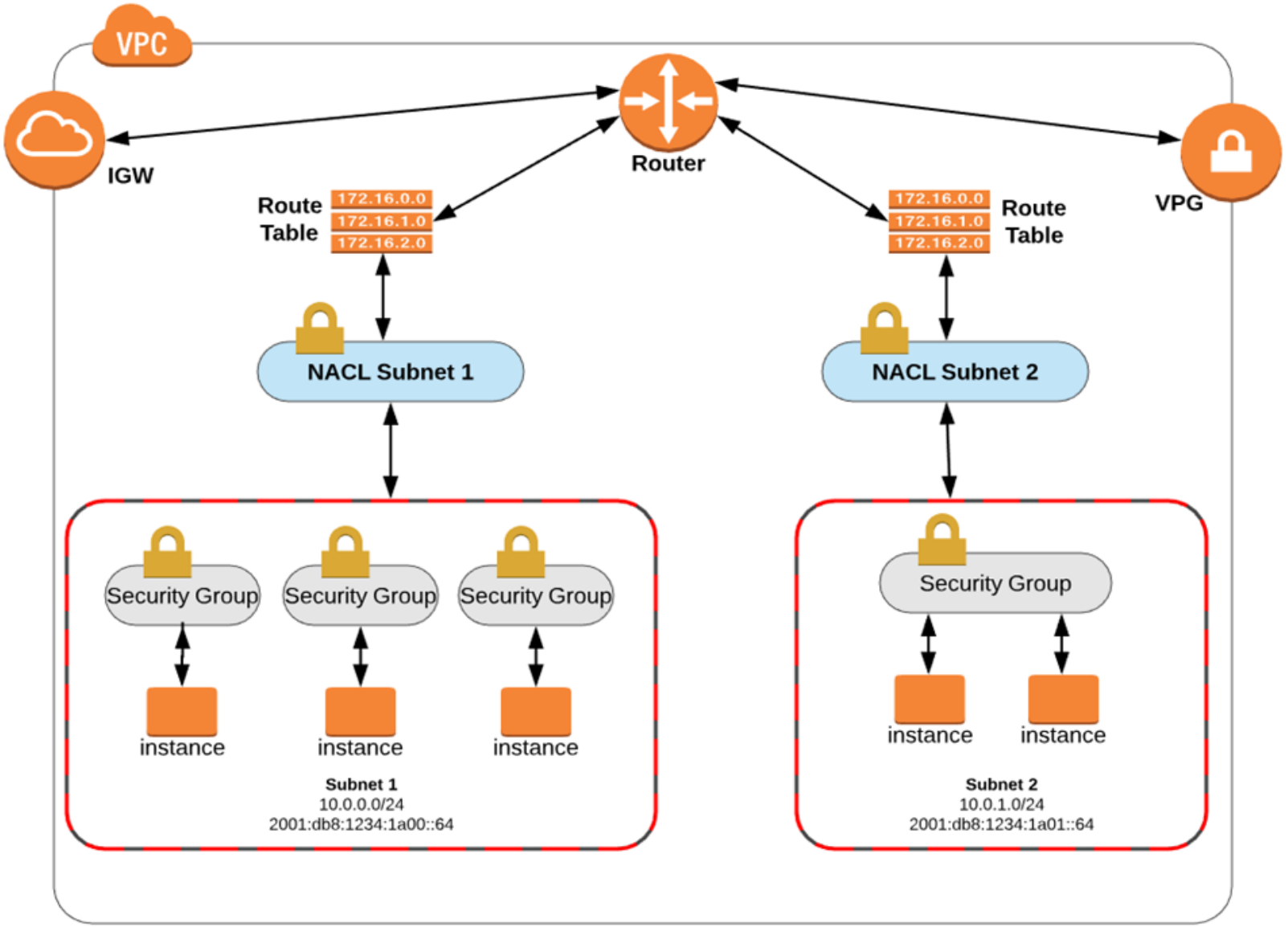
- For securing data in transit, IPsec AH for integrity and origin authentication has been used
- 802.1AE (MACsec) can provide encryption and more on the SAN frames
- Secure management protocols on console or use SDN solutions
- Harden all switches and servers
- Encrypt data at rest with AES-256-GCM



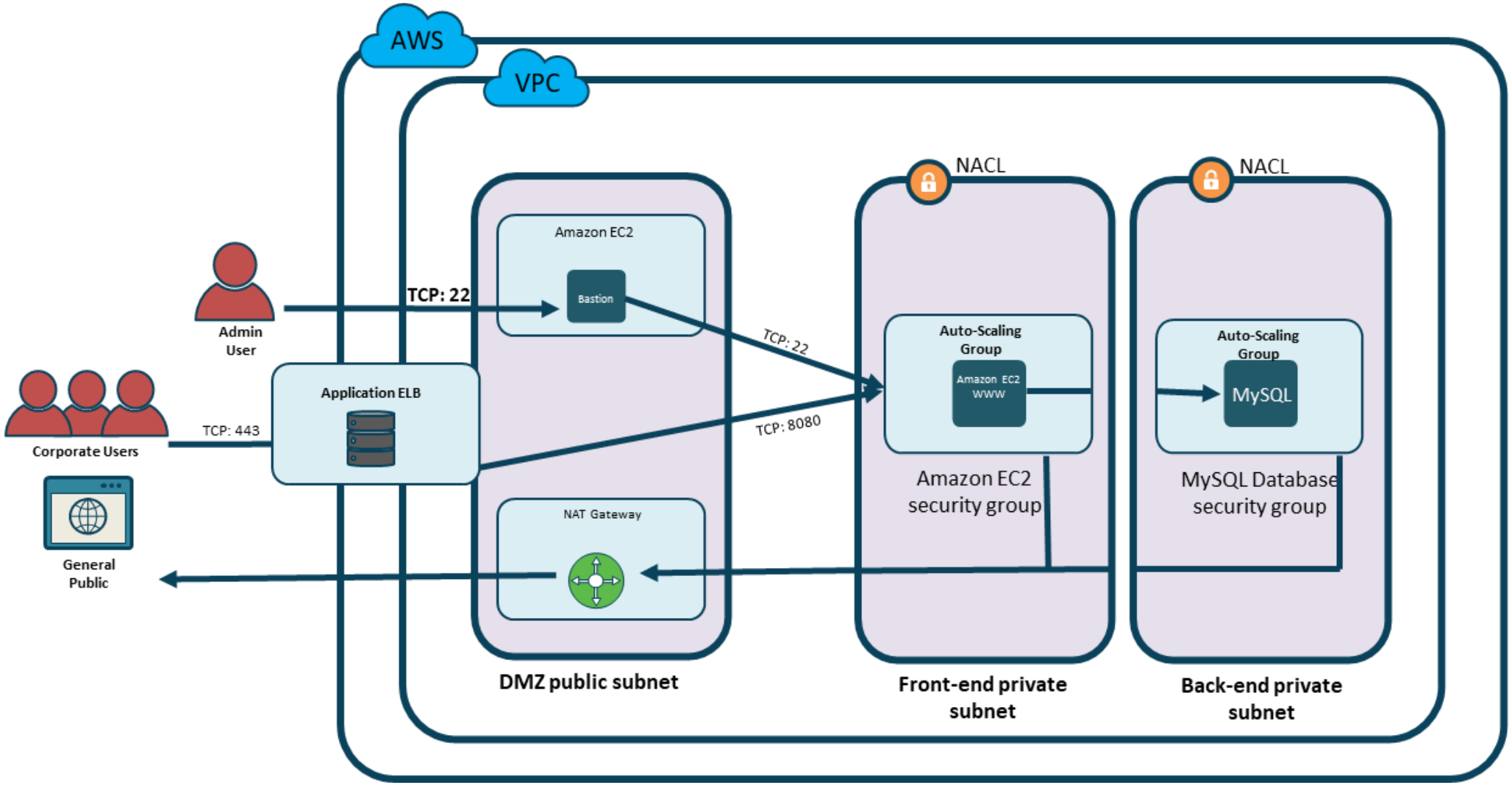
Networking Fundamentals



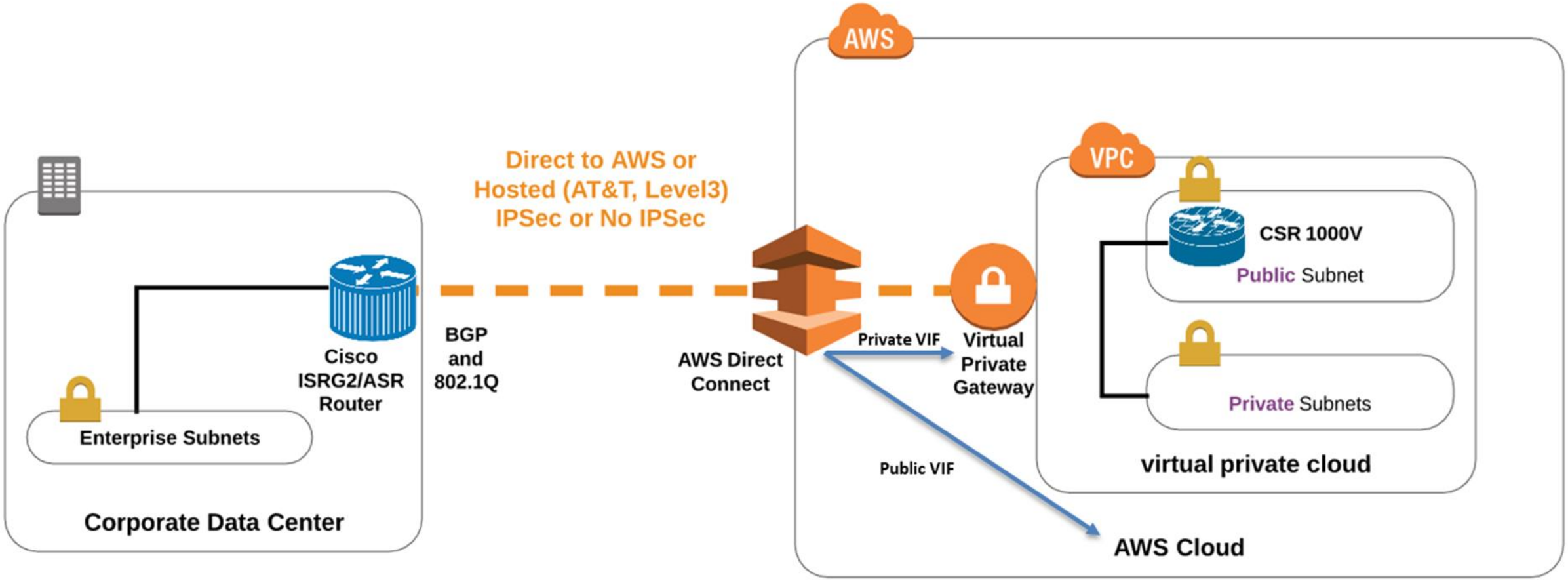
Customer Networking Begins with Design



Customer Networking Begins with Design

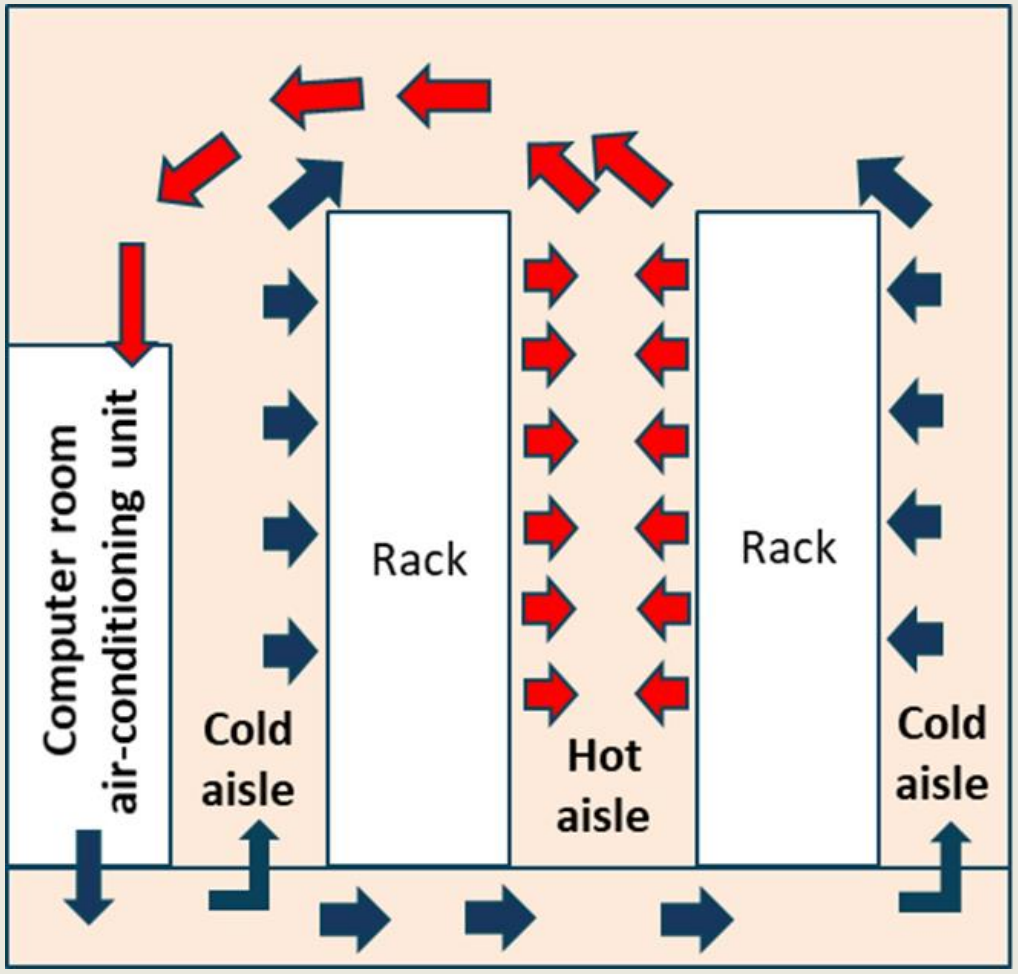


CSP Direct Solutions (for edge and hybrid cloud)



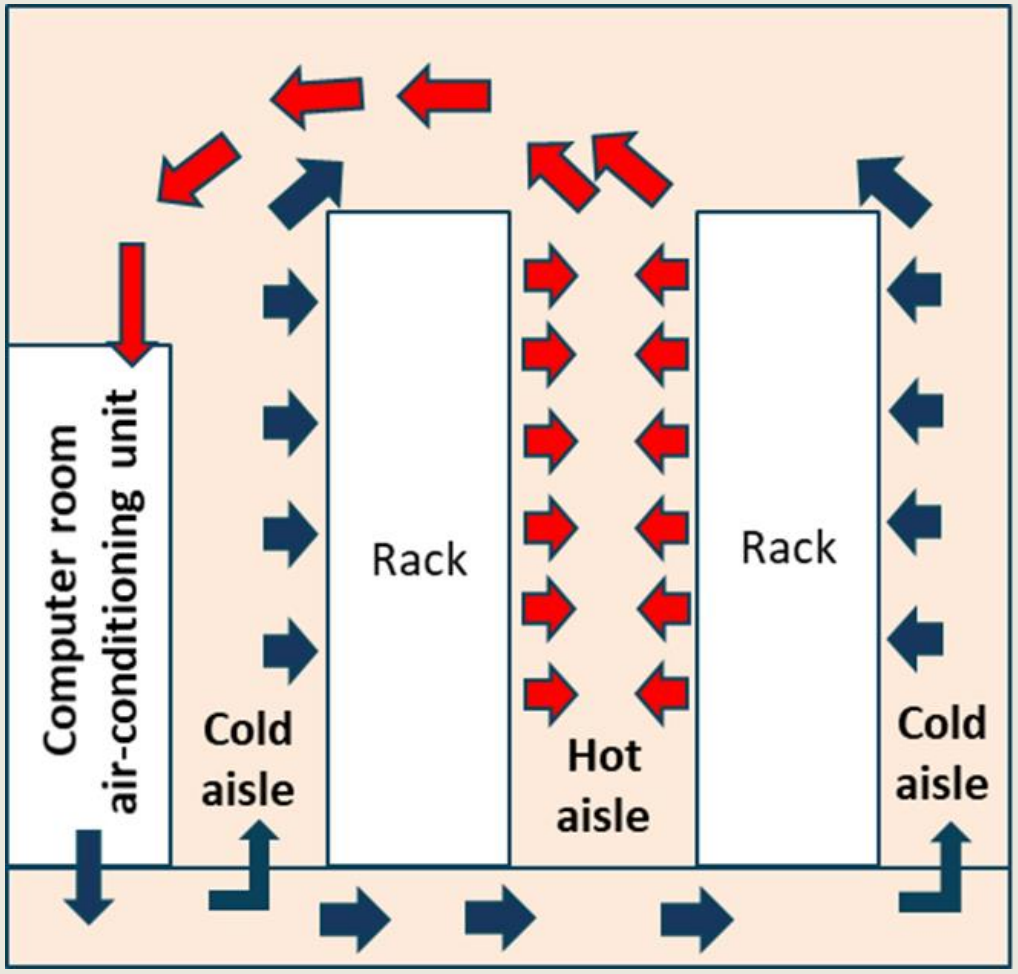
AWS Direct Connect, Azure ExpressRoute, or Google Cloud Interconnect

Datacenter HVAC Design Considerations



- Local climate will impact the HVAC design requirements
- Redundant HVAC systems should be part of the design
- HVAC systems should provide air management that separates the cool air from the heat exhaust of the servers
  - There are racks with built-in ventilation or alternating cold/hot aisles
  - The best design choice will depend on space and building design constraints

Datacenter HVAC Design Considerations

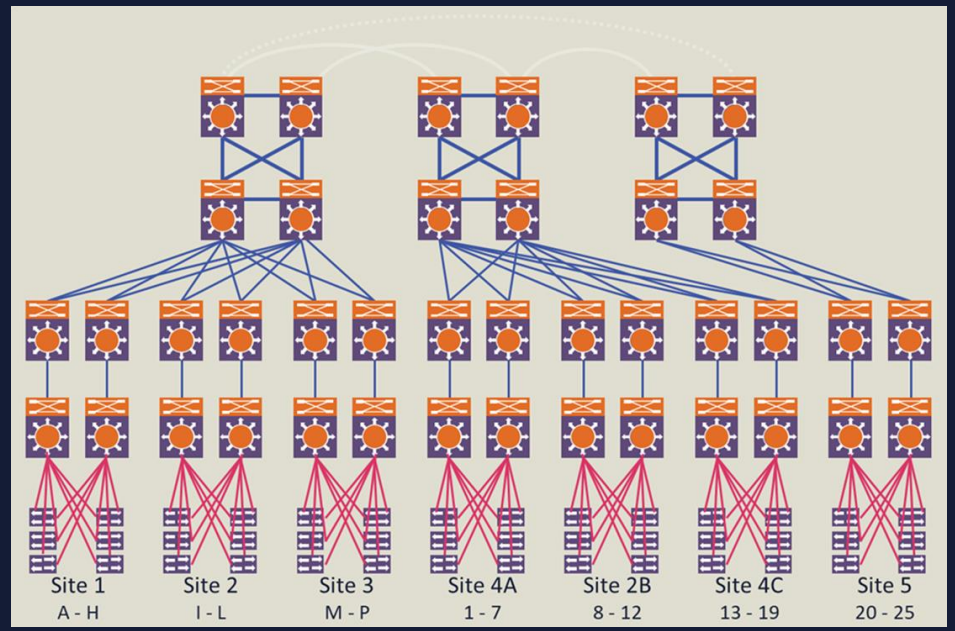


- Consider energy efficient systems when feasible
- **Recommended temp: 72 to 76 degrees**
- **Recommended humidity: 40-60%**
- Backup power supplies should be available to the HVAC system based on business impact analysis (BIA)
- The HVAC system should filter contaminants and dust

Coolers and Chillers

- Adiabatic cooling systems work similarly to dry cooling systems, but with the incorporation of pre-cooling pads
  - Running water over pre-cooling pads and drawing air through the pads depresses the ambient dry bulb of the incoming air
- The depressed dry bulb allows for greater system heat rejection - highly effective in hot, dry environments, while using less water than traditional evaporative units
- Adiabatic units also deliver the needed cooling capacity in a smaller footprint and/or lower fan motor horsepower than a completely dry cooler/condenser

Distribution Frames and Wiring Closets



- Gain visibility into all ethernet and fiber cable runs as well as the security of distribution frame (MDF rooms) rooms and closets
  - Under the floor
  - Above ceiling panels
  - In the walls
- Lock all doors to server rooms and frame rooms
- No window access or use security windows with wire mesh
- Use hardened management stations and environmental controls for temperature, fire, gas, and humidity

Server Rooms and Data Centers

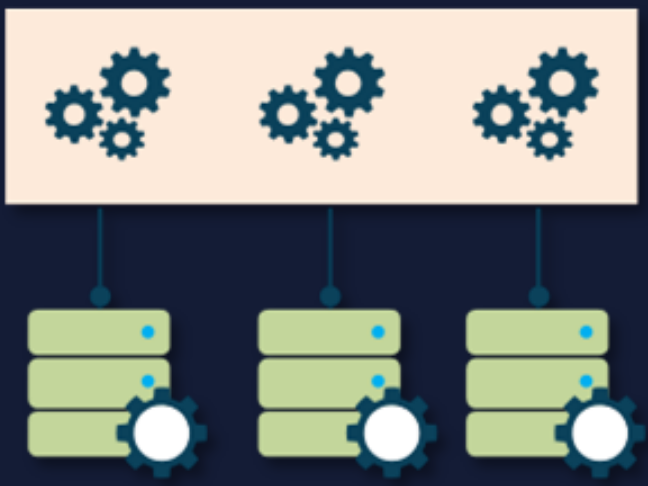
- Access control both at the perimeter and at room ingress points by professional security staff using video surveillance, intrusion detection systems, and more
- Authorized staff should pass biometric dual-factor authentication a minimum of two times to access data center floors
- Implement protective barriers
- **Have redundant and monitored support systems with secure KVM systems**
- Have visibility into high-security compartmentalized areas including all power conduits and water lines

Server Rooms and Datacenters

- When an employee no longer has a business need for data center privileges, access must be immediately revoked, even if they continue to be an employee
- Automatic fire detection and suppression equipment must be used
- The electrical power systems should be fully redundant and maintainable without impact to operations 24/7
- Uninterruptible power supply (UPS) units can provide back-up power for critical and essential loads in the facility in the event of an electrical failure
- Data centers often use generators to provide back-up power for the entire facility

Server Rooms and Data Centers

- Airgap is the physical separation of the control network and other networks
- Separate the highly secure networks from the unsecured networks with physical or logical compartmentalization
- Log and audit all devices and objects entering and exiting facility
- Stop malicious and privileged users from having individual access
- Work with facilities management to integrate blueprints and topological diagrams into IT services



Multi-vendor Pathway Connectivity

- Uninterrupted service and constant access are critical to the daily operation and productivity of the enterprise
- Since downtime leads directly to loss of income, datacenters must be designed for redundant, fail-safe reliability and availability
  - Datacenter reliability is also defined by the performance of the infrastructure
- Cabling and connectivity backed by a trustworthy vendor SLA with guaranteed error-free performance will help avoid poor data transmission in the datacenter
- **There should be redundant connectivity from multiple providers into the datacenter**
  - This will help prevent a single point of failure for network connectivity
  - The redundant paths should deliver the minimum expected connection speeds (10GB/100GB) for datacenter operations

Design Resilient

	P1	P2	P3	P4	P5
	Multi-AZ Deployment	**Static Stability in Region**	**Application Portfolio Distribution**	**Multi-AZ Deployment [Regional DR]**	**Multi-Region Active-Active Deployment**
Design Complexity	Low	Medium	Medium	High	Very High
Cost to Implement	Low	High	Medium	High	High
Operational Effort	Low	Medium	Medium	Medium	Very High
Effort to Secure	Low	Medium	Medium	High	High
Environmental Impact	Low	Medium	Medium	High	High

Lowest — Availability — Highest

Defining Risk

- Inherent (total) risk
  - Risk the organization faces if safeguard is not implemented
- Residual risk
  - Risk that remains once safeguard is in place
- Residual = inherent risk - safeguards (controls)

Risk Assessment

	Event type								
	Accidental Leak	**Espionage**	**Financial fraud**	**Misuse**	**Opportunistic data theft**	**Physical theft**	**Product alteration**	**Sabotage**	**Violence**
Nonhostile									
Reckless insider	X			X			X		
Untrained/distracted insider	X			X			X		
Outward sympathizer	X			X					
Unknown (nonhostile or hostile)									
Supplier	X	X	X	X	X		X		
Partner	X	X	X	X	X		X		
Hostile									
Irrational individual	X			X		X		X	X
Thief		X	X		X	X			
Disgruntled insider	X	X	X	X	X	X	X	X	X
Activist		X		X	X	X	X	X	
Terrorist						X		X	X
Organized crime		X	X		X	X	X		
Competitor		X			X		X	X	
Nation state		X			X		X	X	

Tim Casey et al., "A Field Guide To Insider Threat," PDF file, https://www.nationalinsiderthreatsig.org (IT@Intel, Intel Corporation, October 2015), https://www.nationalinsiderthreatsig.org/itrmresources/Intel%20Insider%20Threat%20Field%20Guide.pdf.

Creating a Risk Register

- Risk Register is also called ledger or log
- Often represented as a scatter plot/table from a database
- Fulfills regulatory compliance
- Repository of identified risks, impact, scenarios, and potential responses

Identified Risks	Root Causes	Probability and Impact	Ranking	Categories	Priorities	Time and Cost Objectives	Potential Responses	Risk Owners	Assumptions

Risk Treatment

Also called risk handling or appetite

- Risk acceptance
  - Do not implement any safeguards
  - Justification in writing is often required
- Risk avoidance
  - Choose not to undertake actions that introduce risk
- Risk transference/sharing
  - Pass the risk to a third-party, such as an insurance company or a cloud service provider
- Risk mitigation
  - Implement safeguards that will eliminate or reduce risk exposure - risk may exist, but impact is reduced

Qualitative Risk Analysis

The most common method used in risk and security

- Descriptive approach using subjective opinions, history, and scenarios to determine risk levels
  - Expert judgement
  - Best practices
  - Experience
  - Intuition
- Often involves interviewing people (Delphi) regarding assets, known risks, known vulnerabilities, common threats, and historical impacts

Qualitative Heat Map

Likelihood			Impact				
			Negligible	Minor	Moderate	Critical	Disastrous
			1	2	3	4	5
	Frequent	5	Medium	Medium	High	High	High
	Likely	4	Medium	Medium	Medium	High	High
	Occasional	3	Low	Medium	Medium	Medium	High
	Seldom	2	Low	Low	Medium	Medium	Medium
	Improbable	1	Low	Low	Low	Medium	Medium

Semi-Quantitative Risk Analysis

Impact

- Negligible = 1 (no impact)
- Minor = 2 (< $1 million)
- Moderate = 3 (≥ $1 million)
- Critical = 4 (≥ $100 million)
- Disastrous = 5 (complete)

Likelihood

- Improbable = 1 (almost never)
- Seldom = 2 (not in 5 years)
- Occasional = 3 (once in last 5 years but not in last year)
- Likely = 4 (once in last year)
- Frequent = 5 (several times a year)

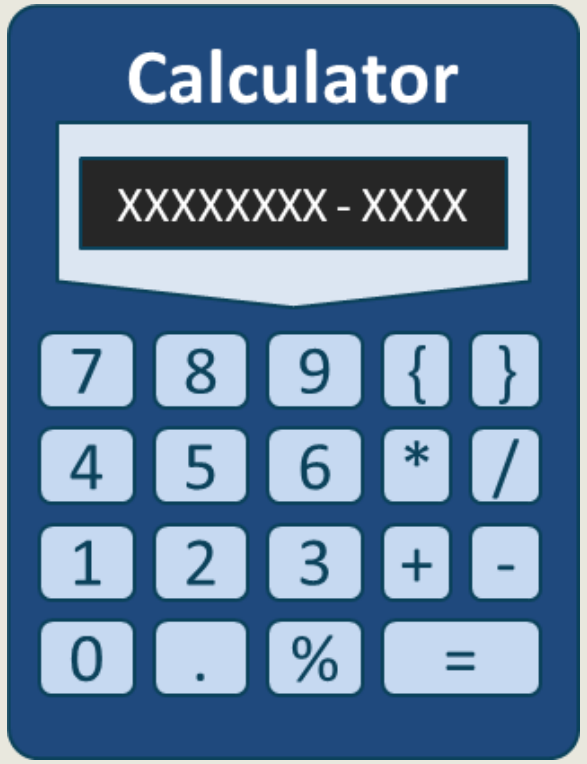
Risk of event = 4 (material impact) X 3 (moderate likelihood) = 12

Quantitative Risk Analysis

Rapidly gaining popularity due to FAIR analysis

- Scientific/mathematical approach to getting monetary and numeric results based on the following:
  - Asset values
  - Impact and magnitude
    - Severity of incident
  - Probability and likelihood of occurrence
    - Threat frequency
  - Costs and effectiveness of safeguards
  - Probabilities based on percentages and calibrated estimation
    - **Goal is to find the 90 percentile**

Classic Quantitative Analysis (Whitman)



- AV (asset value)
  - Value of the asset according to the organization
- EF (exposure factor)
  - Percentage of asset loss caused by identified threat
- SLE (single loss expectancy)
  - Potential loss if attack occurs
  - (Asset value * exposure factor)
- ARO (annualized rate of occurrence)
  - Estimated frequency the threat will occur within a single year
- ALE (annualized loss expectancy) = (SLE * ARO)

Classic Quantitative Analysis (Whitman)

Risk analysis						
Asset	**Threat**	**Asset value**	**Exposure factor**	**Single loss expectancy**	**Annualized rate of occurrence**	**Annualized loss expectancy**
SRV_1	Fire	$15000	100%	$15000	0.1	$1500
SRV_2	Fire	$20000	100%	$20000	0.1	$2000
SRV_1	Flood	$15000	100%	$15000	0.0001	$1.5
SRV_2	Flood	$20000	100%	$20000	0.0001	$2.0
SRV_1	Virus (no AV software)	$15000	10%	$1500	365	$547,500
SRV_1	Virus (with AV software)	$15000	10%	$1500	1	$1500

Cloud Vulnerabilities: The Treacherous 12

1. Data Breaches
2. Weak Identity, Credential and Access Management
3. Insecure APIs
4. System and Application Vulnerabilities
5. Account Hijacking
6. Malicious Insiders

Cloud Vulnerabilities: The Treacherous 12

7. Advanced Persistent Threats (APTs)
8. Data Loss
9. Insufficient Due Diligence
10. Abuse and Nefarious Use of Cloud Services
11. Denial of Service
12. Shared Technology Issues

AWS GuardDuty Findings

- Backdoor
  - Backdoor:EC2/C&CActivity - EC2 - VPC flow logs – high severity
- Behavior
  - Behavior:EC2/NetworkPortUnusual - EC2 - VPC flow logs – medium severity
- Credential Access
  - CredentialAccess:IAMUser/AnomalousBehavior – IAM – CloudTrail - medium
- Crypto Currency
  - CryptoCurrency:EC2/BitcoinTool.B!DNS - EC2 - DNS logs - high
- Defense Evasion
  - DefenseEvasion:IAMUser/AnomalousBehavior – IAM – CloudTrail - medium
- Discovery
  - Discovery:S3/MaliciousIPCaller – S3 - S3 CloudTrail data event - high
- Exfiltration
  - Exfiltration:IAMUser/AnomalousBehavior – IAM - CloudTrail - high
- Impact
  - Impact:EC2/AbusedDomainRequest.Reputation - EC2 - DNS logs - medium

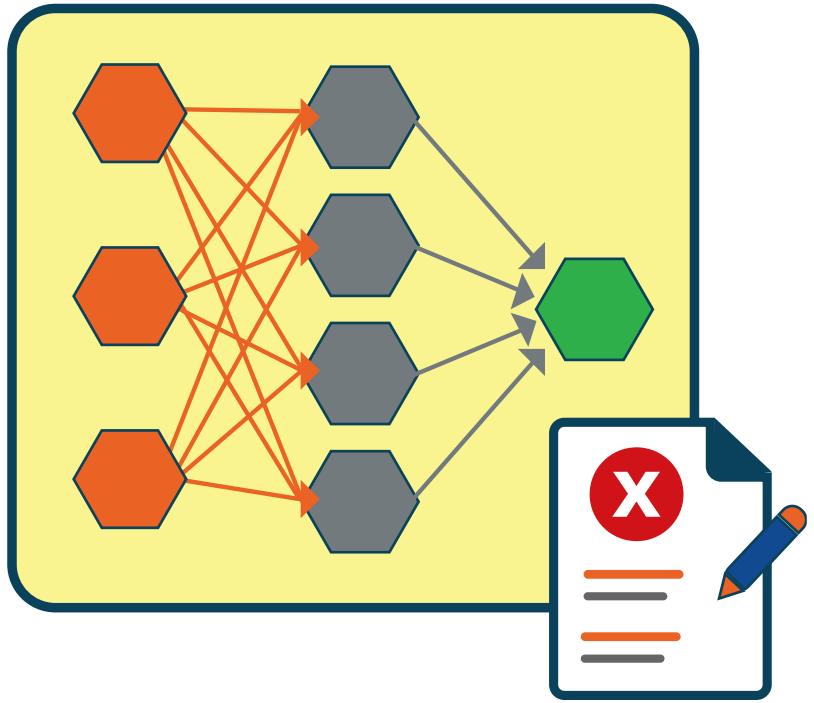
AWS GuardDuty Findings

- Initial Access
  - InitialAccess:IAMUser/AnomalousBehavior – IAM – CloudTrail - medium
- Pen Test
  - PenTest:IAMUser/KaliLinux – IAM - CloudTrail - medium
- Persistence
  - Persistence:IAMUser/AnomalousBehavior – IAM – CloudTrail - medium
- Policy
  - Policy:S3/BucketPublicAccessGranted - S3 – CloudTrail - high
- Recon
  - Recon:EC2/PortProbeEMRUnprotectedPort - EC2 - VPC flow logs - high
- Stealth
  - Stealth:IAMUser/CloudTrailLoggingDisabled – IAM – CloudTrail - low
- Trojan
  - Trojan:EC2/DNSDataExfiltration - EC2 - DNS logs - high
- Unauthorized Access
  - UnauthorizedAccess:S3/TorIPCaller - S3 - S3 CloudTrail data event - high

Countermeasure Strategies

The Cloud Security Triad

- **Identity and access management** (IAM/IdM)
  - Cloud IAM or Federated SSO (token services)
- **Infrastructure security**
  - Network design and automated visibility
  - Firewalls (L3/4 stateless, stateful, and WAF)
  - Secure endpoints and policies
  - Secure management access (digitally signing, SSH2, TLS)
  - S2S and P2S VPN services
  - Managed Threat Management (GuardDuty)
- **Key Management Services (KMS)**
  - Client and server-side



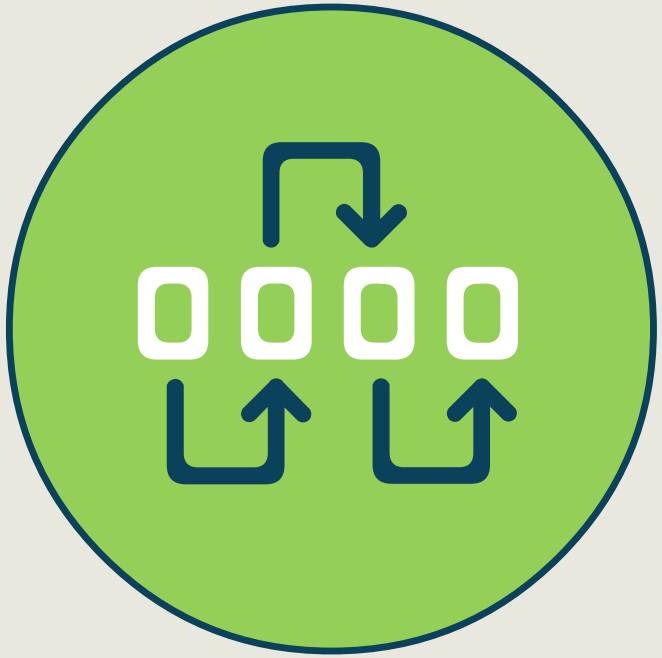
Uptime Institute

Standard bearer for digital Infrastructure performance whose Tier Standard has been used in thousands of sites in more than 100 countries

- **Tier 1**
  - The Basic Site Infrastructure
  - A simpler and less expensive solution with little or no redundancy - only dedicated space for IT systems, UPS for backup and line conditioning, cooling of critical equipment
  - **Problematic personnel activity WILL cause downtime**
  - **All 4 tiers have at least 12 hours of fuel for generators**
- **Tier 2**
  - Redundant Site Infrastructure Capacity Components has additional feature from Tier 1
    - There WILL be downtime for any disconnection from power distribution and lines
    - Problematic personnel activity MAY cause downtime
    - Unplanned component failure or systems MAY cause downtime

Uptime Institute

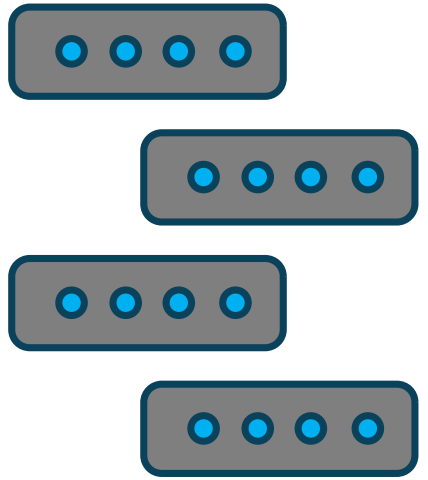
Standard bearer for digital Infrastructure performance whose Tier Standard has been used in thousands of sites in more than 100 countries



- **Tier 3**
  - Concurrently Maintainable Site Infrastructure
  - Dual power supplies for all systems
  - Critical operations can continue if a single component or power element is down for replacement or scheduled maintenance
  - **Unplanned loss of component MAY cause downtime; unplanned loss of single system WILL cause downtime**
- **Tier 4**
  - Fault-Tolerant Site Infrastructure – the optimal data center offering
  - Has features of other tiers included
  - Full redundancy of systems, power, cooling
  - **Loss of a single element will NOT cause downtime**
  - Fully automated visibility and response systems
  - Scheduled maintenance performed without downtime

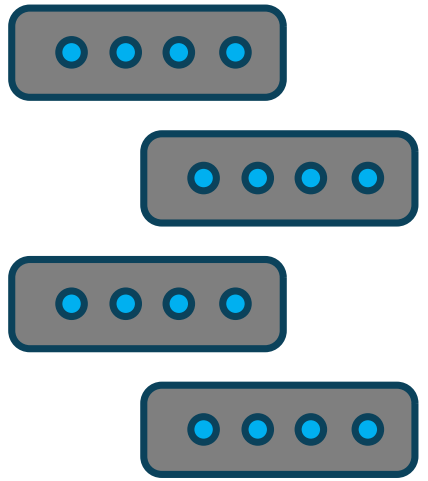
CSA BEST PRACTICES FOR MITIGATING RISKS IN VIRTUALIZED ENVIRONMENTS

- Risk #1 – VM Sprawl
- Risk #2 – Sensitive Data Within a VM
  - Passwords, personal data, bash profiles, bash history files, encryption keys, and license keys, also capture of corresponding data in images and snapshots
- Risk #3 – Security of Offline and Dormant VM
- Risk #4 – Security of Pre-Configured (Golden Image) VM / Active VMs
- Risk #5 – Lack of Visibility Into and Controls Over Virtual Networks
  - Hinders existing security policy enforcement in most organizations
  - Traffic over virtual networks may not be visible to security protection devices, such as network-based intrusion detection and prevention systems, on the physical network



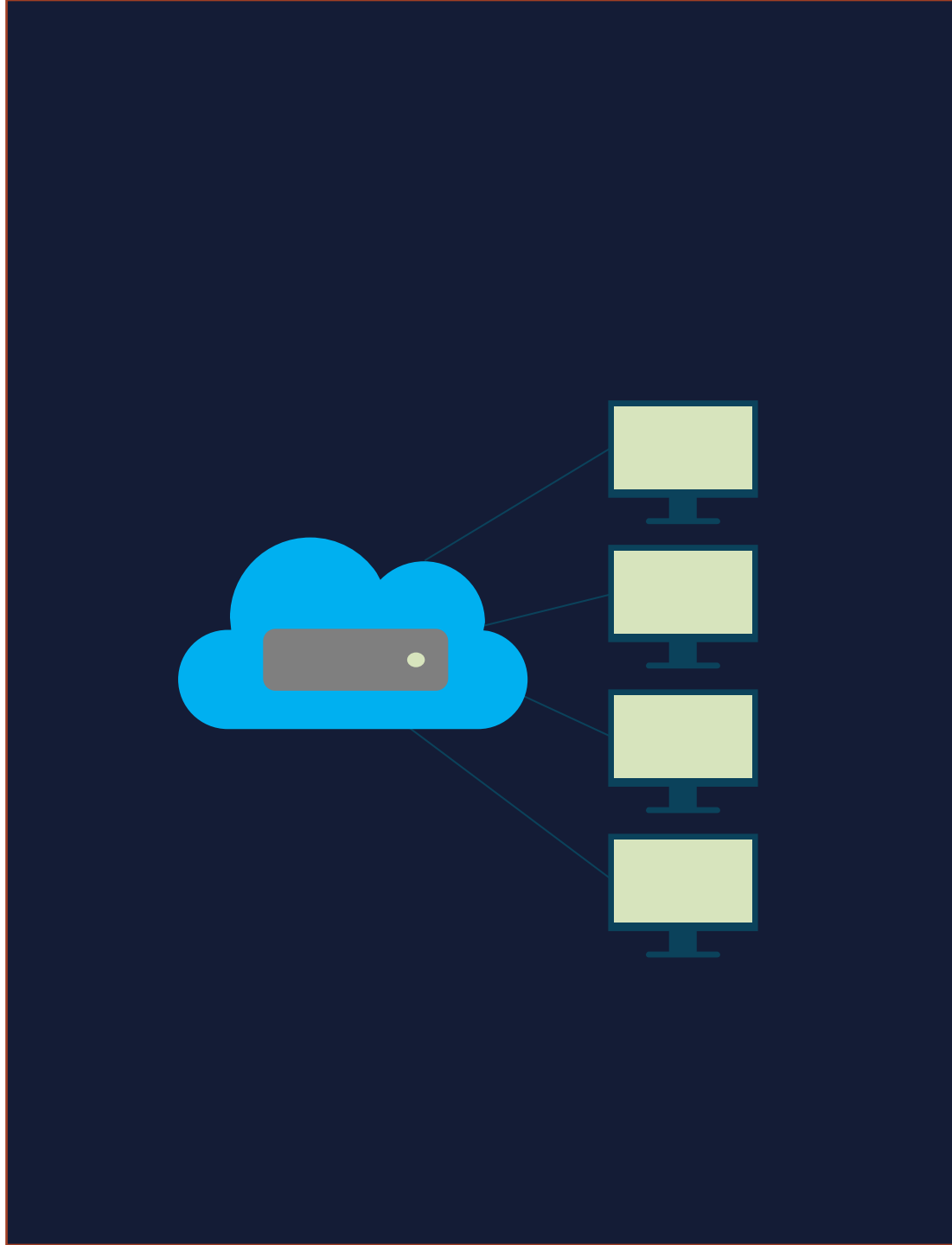
CSA BEST PRACTICES FOR MITIGATING RISKS IN VIRTUALIZED ENVIRONMENTS

- Risk #6 – Resource Exhaustion
  - **Resource-intensive software tends to exhaust resources in a physical server when it is implemented in multiple VMs. For example, *anti-virus and other security software* interrupt every call to disk or memory in order to monitor and prevent security incidents such as hacking or viruses**
- Risk #7 – Hypervisor Security
- Risk #8 – Unauthorized Access to Hypervisor
- Risk #9 – Account or Service Hijacking Through the Self-Service Portal
  - A self-service portal is often used to delegate specific parts of virtual infrastructure provisioning and management to assigned self-service administrators
  - Generous use of self-service portals in cloud computing services will increase susceptibility to security risks, including account or service hijacking
- Risk #10 – Workload of Different Trust Levels Located on the Same Server
- Risk #11 – Risk Due to Cloud Service Provider API



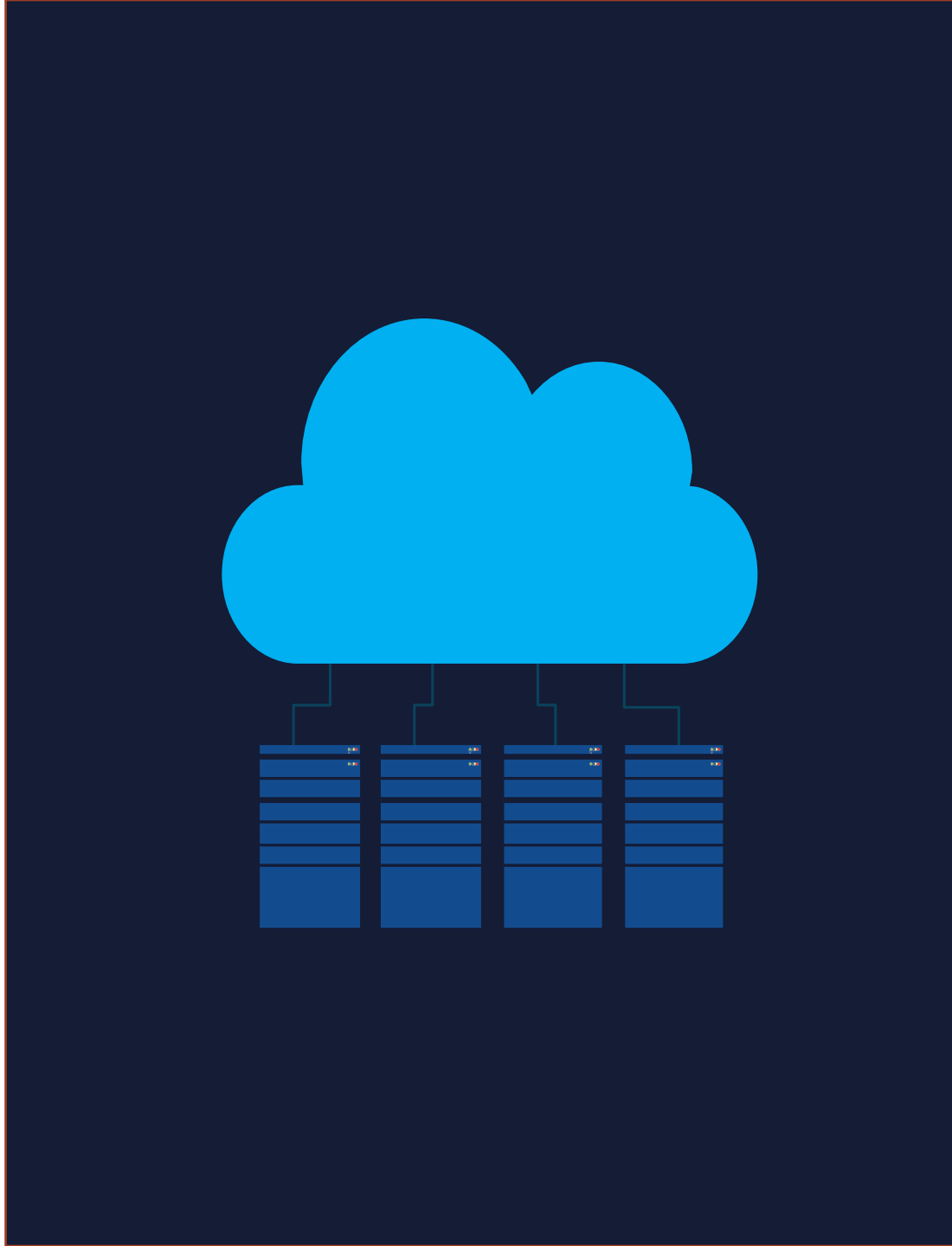
VM Sprawl Mitigation

- Put effective policies, guidelines, and processes in place to govern and control VM lifecycle management
- Control the creation, storage, and use of VM images with a formal change management process and tools
- Keep a small number of known-good—and timely patched—images of a guest OS separately
- Use virtualization products with management solutions to examine, patch, and apply security configuration changes to VMs



Protecting Sensitive Data within a VM

- Encrypt data stored on virtual and cloud servers and release encryption/decryption keys only to authorized physical or virtual servers
- Develop policies to restrict storage of VM images and snapshots
- Ensure that backup and failover systems, including temporary upgrade/patch instances, are cleaned when deleting and wiping
- Use cryptographic checksum protection to detect unauthorized changes to VM images and snapshots
- Identify critical data files within the VM that may need a higher degree of monitoring



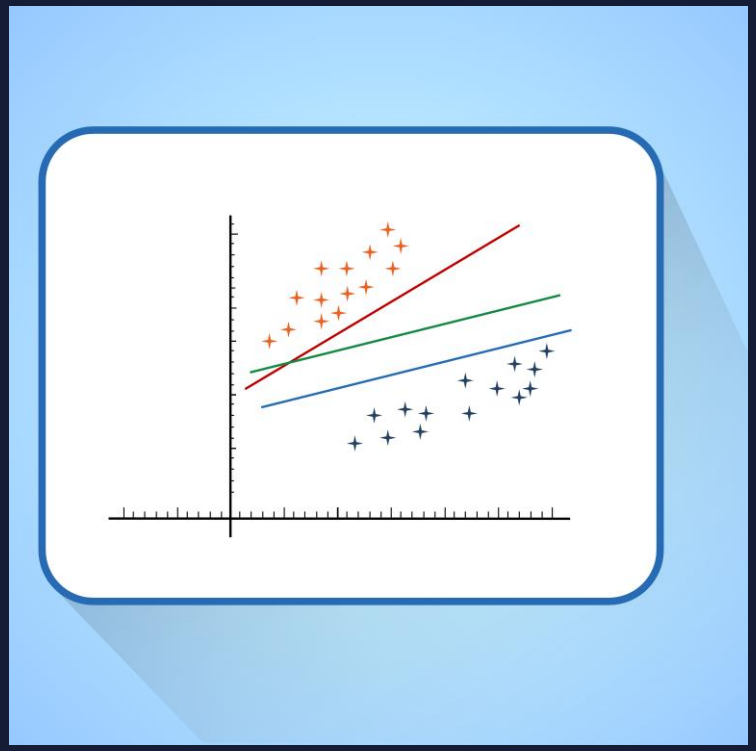
Securing Offline/Dormant VMs and Golden VM

- Ensure proper hardening and protection of VM instances through VM guest hardening
- Augment VM operating systems with built-in security measures, leveraging third-party security technology, such as discovery and monitoring tools, to provide layered security controls
- Consider implementing an integrity checksum mechanism for all VM images
- Encrypt VM images to prevent unauthorized modification
- Implement strict controls and processes around access, creation, and deployment of VM images/instances

Gaining Visibility and Controls of Virtual Networks

- Consider a hypervisor that can monitor each guest operating system (introspection) as it is running if separate tools are not installed to monitor communications between VMs
- Implement security technologies that span physical and virtual environments with a consistent policy management and enforcement framework
- Create consistent security policy and configuration across the physical/virtual network
- Use VM-specific security mechanisms embedded in hypervisor APIs to provide granular monitoring of traffic crossing VM control and data planes such as SDN/OpenFlow

Mitigate Resource Exhaustion



- Implement appropriate resource allocation and/or reservation policies based on classification of VMs based on sensitivity and/or risk level
- Use anti-virus and other security software that is virtualization-aware
- Implement mechanisms to minimize resource contention including staggering the scanning of VMs on the same physical server, using agentless deployment of anti-virus software, implementing distributed storage resources, and implementing a workload affinity policy
- Define and implement a standard operating procedure that detects VMs that are throttled due to resource exhaustion

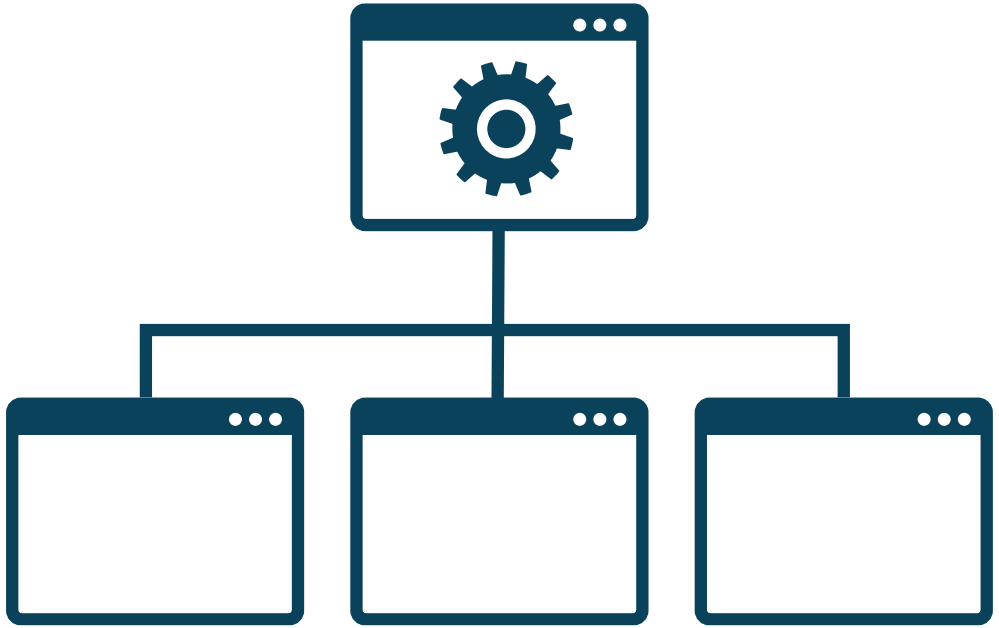
Identification, Authentication and Authorization in Cloud Infrastructure

Demonstration: AWS IAM

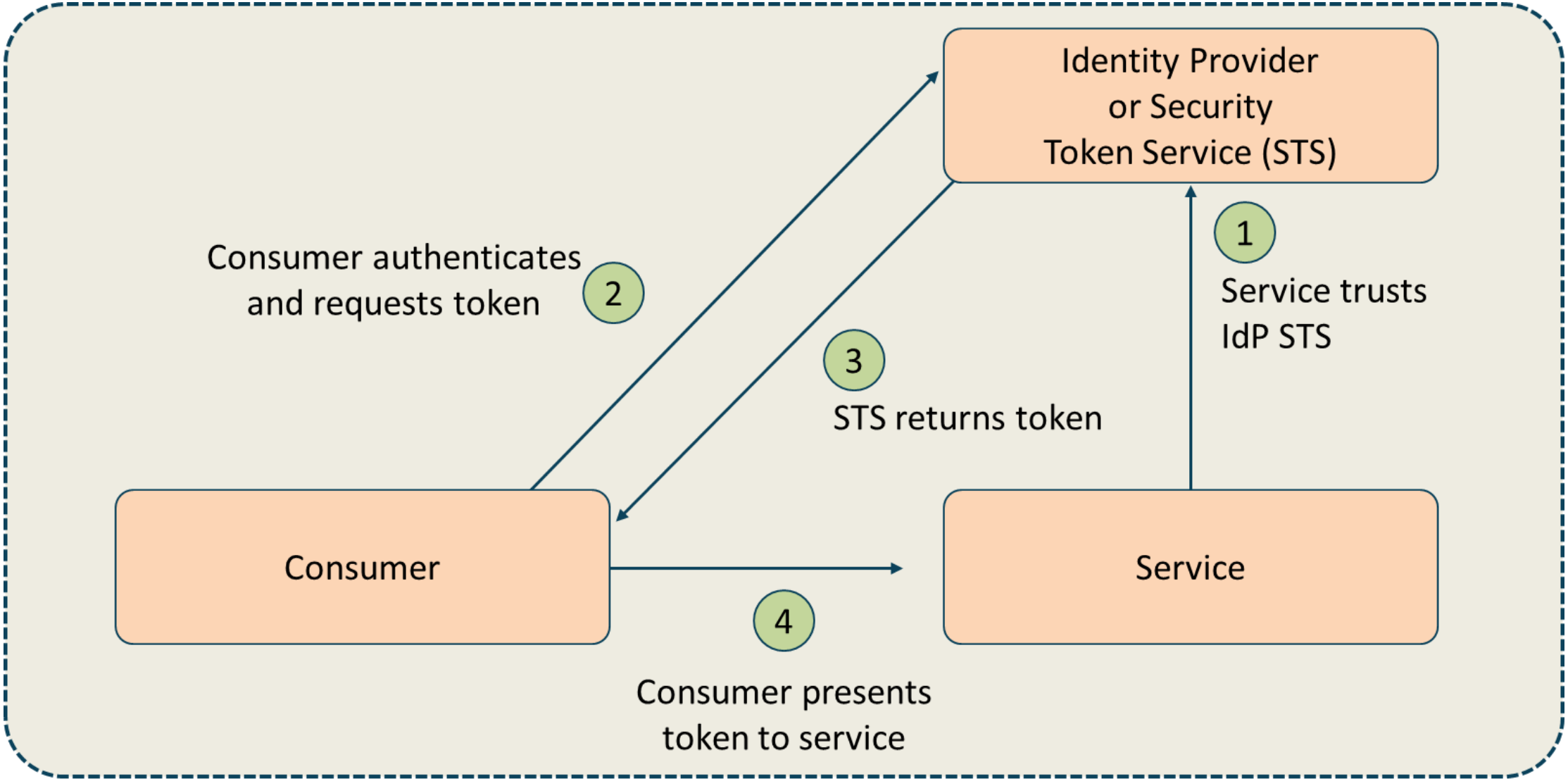
Federation Standards

For federated identity management

- Used to manage identities across different organizations
- Provides single sign-on for multiple organizations and service providers
- Web-of-trust model is where each member of the federation approves each other member
- The third-party identifier model relies on a trusted third-party
  - This is a popular model for the cloud as the identifier can be combined with other services like key management
  - Often outsourced to a Cloud Access Security Broker (CASB) or Managed Security Service Provider



Federated Identity Providers



SAML 2.0

- Security Assertion Markup Language
- SAML is an XML-based open-source SSO standard
- **SAML is used by many cloud SSO connections for thousands of large enterprises, government agencies, and service providers that communicate on the Internet**
- Key advantage of SAML is open-source interoperability
- Some large companies now require SAML for Internet SSO with SaaS applications and other external ISPs

OAUTH

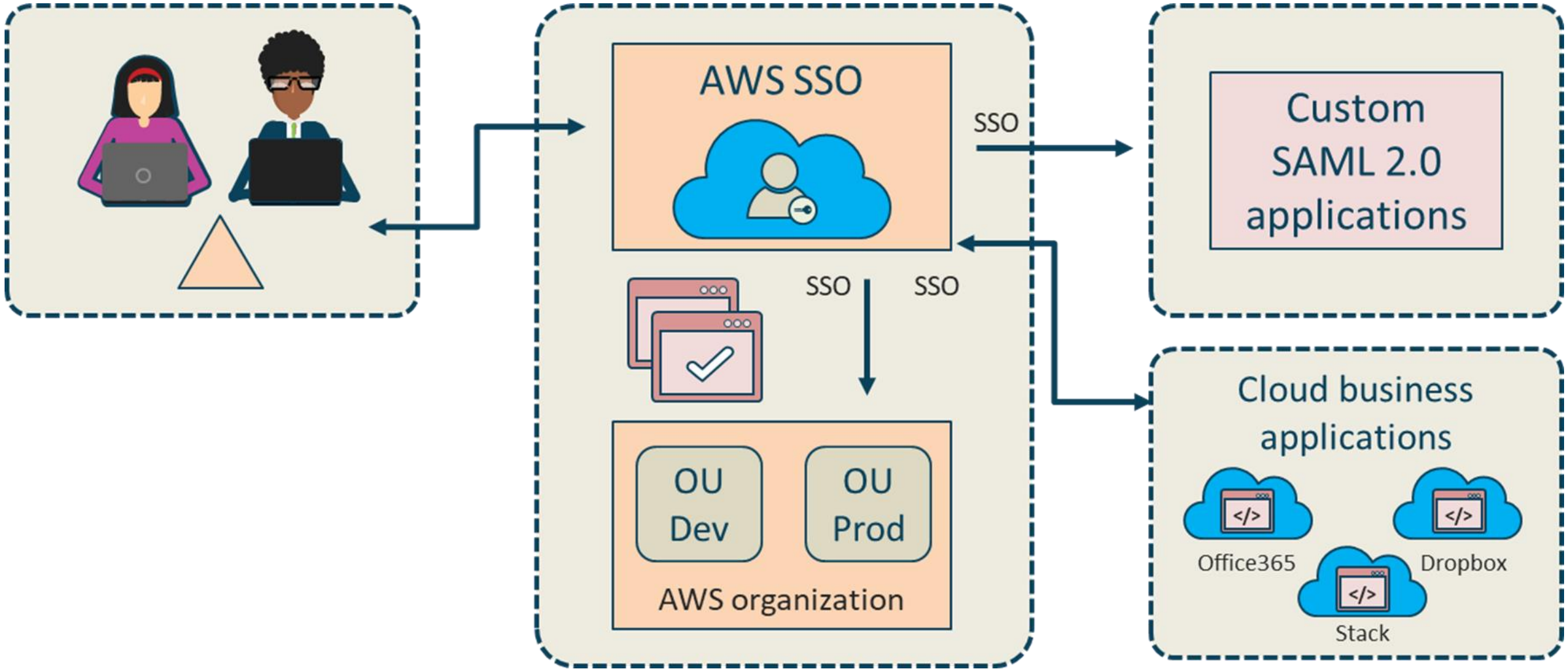
- **OAuth 2.0 is an open authorization framework that allows a third-party application to get limited access to an HTTP service**
- Developers use OAuth to publish and interact with protected data in a safe and secure manner
- Service provider developers can use OAuth to store protected data and give users secure delegated access
- OAuth is designed to work with HTTP and basically allows access tokens to be issued to third-party clients by an authorization server with the approval of the resource owner
- The third party then uses the access token to access the protected resources offered by the resource server

OpenID Connect (OIDC)

Should be used for OAUTH Authentication

- **OpenID Connect 1.0 is a basic identity layer on top of the OAuth 2.0 protocol**
- It verifies the end-user identity using an authorization server
- It can get basic profile information about the user with an interoperable REST-like methodology
- Supports web-based, mobile, and JavaScript clients
- OpenID is extensible as functionality can be added

AWS Identity Center (SSO)



Step-Up Authentication

- Ensures that users can access some resources with one set of credentials but will prompt them for more credentials when they request more access
  - Users want seamless SSO access to certain assets, but organizations may want to further verify their identities before they grant access to anything more sensitive
  - Employees need occasional access to private data that would cause damage if exposed
  - You want to deploy a membership model that limits complete access to your site or service to paying users
  - **You need to add Knowledge-Based Authentication (KBA)**

Audit Mechanisms

Involves tools and techniques

- Various logs (system, application, firewall, etc.)
- Simple Network Management Protocol (SNMP) traps and informs
- NetFlow v5 and v9 collections
- **Security information and event management (SIEM) systems**
- **Security Orchestration, Automation, and Response (SOAR)**
- Next-Generation Intrusion Prevention System (NGIPS) alerts and logs
- Cloud-based ML and AI visibility/analysis

Security Information and Event Management

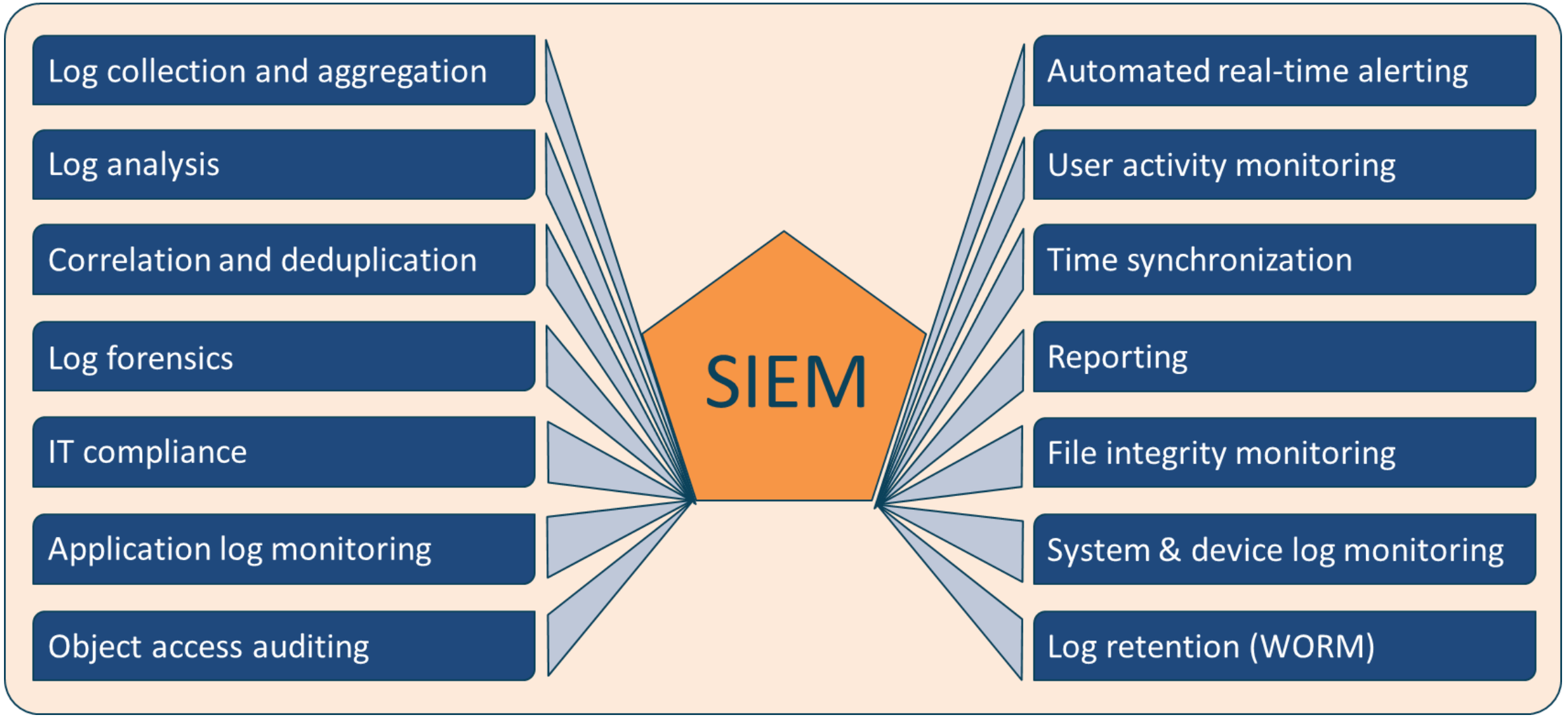
The term SIEM is a combination of security event management (SEM) and security information management (SIM)

Centralize the storage and analysis of logs and other security-related documentation to perform near real-time analysis

Can send filtered data to mining, big query, and data warehousing servers in a data center or at a cloud service provider

Allow security and network professionals to take countermeasures, perform rapid defensive actions, and handle incidents

SIEM


Log collection and aggregation
Log analysis
Correlation and deduplication
Log forensics
IT compliance
Application log monitoring
Object access auditing
SIEM
Automated real-time alerting
User activity monitoring
Time synchronization
Reporting
File integrity monitoring
System & device log monitoring
Log retention (WORM)

Automation and Orchestration

Automation

- IT automation involves generating a single task to run automatically without any human intervention
- Automation could involve sending alerts to a SIEM system, dynamically triggering a serverless function at a cloud provider, or adding a record to a database when a batch job is run
- Enterprises often automate both cloud-based and on-premise tasks

Orchestration

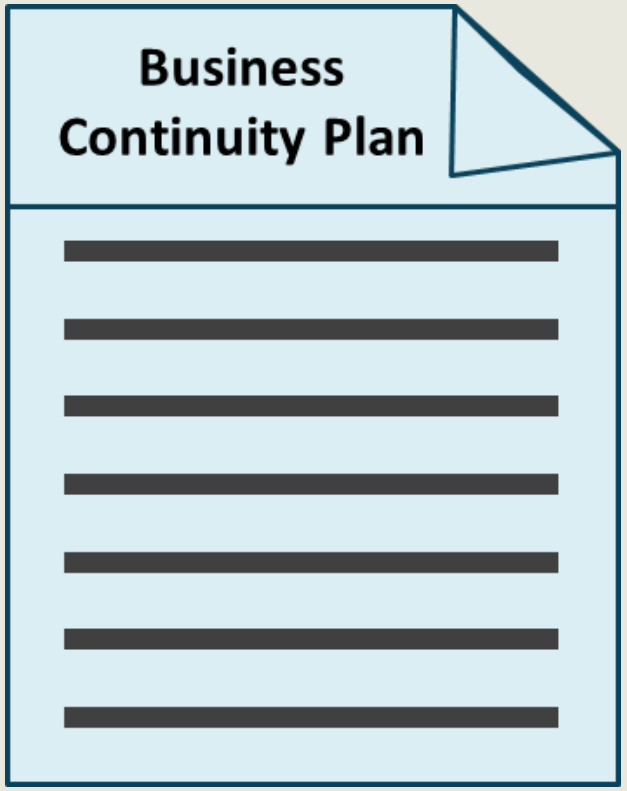
- Orchestration involves managing several or many automated tasks or processes
- As opposed to focusing on one task, orchestration combines all the individual tasks
- Orchestration occurs with various technologies, applications, containers, datasets, middleware, systems, and more

Security Orchestration, Automation, and Response (SOAR)

- SOAR is an assortment of software services and tools
- It allows organizations to simplify and aggregate security operations in three core areas
  - Threat and vulnerability management
  - Incident response
  - Security operations automation
- Security automation involves performing security related tasks without the need for human intervention
- Can be defensive detection, response, and remediation, or offensive vulnerability assessment and penetration testing
- You should automate if the process is routine, monotonous, and time-intensive

BCP/COOP

- Ensures business operates a pre-determined level when disaster strikes
  - Documents approved by executive management
- Outlines risk to business
  - Populates risk register/ledger
  - Requirements to mitigate incidents
- Identifies procedures needed to recover from a disaster
  - What is an acceptable amount of time?
  - How to reduce the impact of the disaster



NIST SP 800-34, Rev 1

BCP according to NIST

1. Develop a continuity planning policy statement
2. Conduct the business impact analysis (BIA)
3. Identify preventive controls
4. Create contingency strategies
5. Develop an information system contingency plan
6. Ensure plan testing, training, and exercises
7. After-action report
8. Ensure plan maintenance

BCP from Ready.gov

Business Impact Analysis

- Develop questionnaire
- Conduct workshop to instruct business function and process managers how to complete BIA
- Receive complete BIA questionnaire forms
- Review BIA questionnaires
- Conduct follow-up interviews to validate information and fill any gaps

Recovery strategies

- Identify and document resource requirements based on BIAs
- Conduct gap analysis to determine gaps between recovery requirements and current capabilities
- Explore recovery strategy options
- Select recovery strategies with management approval
- Implement strategies

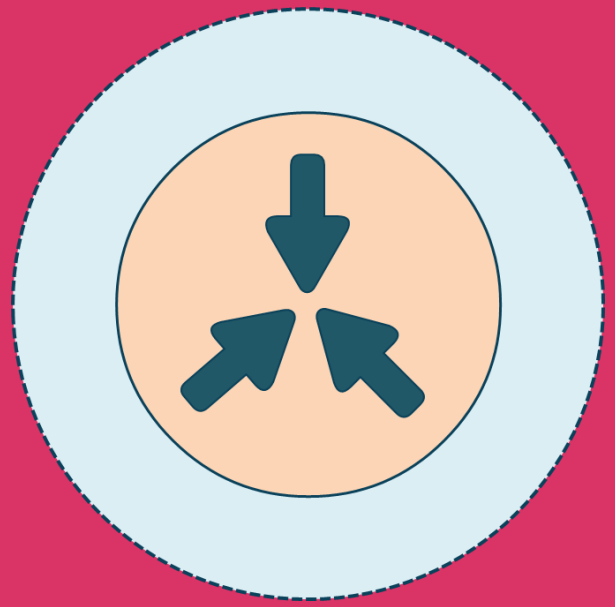
Plan development

- Develop plan framework
- Organize recovery teams
- Develop relocation plans
- Write business continuity and IT disaster recovery procedure
- Document manual workarounds
- Assemble plan
- Validate and gain management approval

Testing & exercises

- Develop testing, exercise, and maintenance requirements
- Conduct training for business continuity team
- Conduct orientation exercises
- Conduct testing and document test results
- Update BCP to incorporate lessons learned from testing and exercises

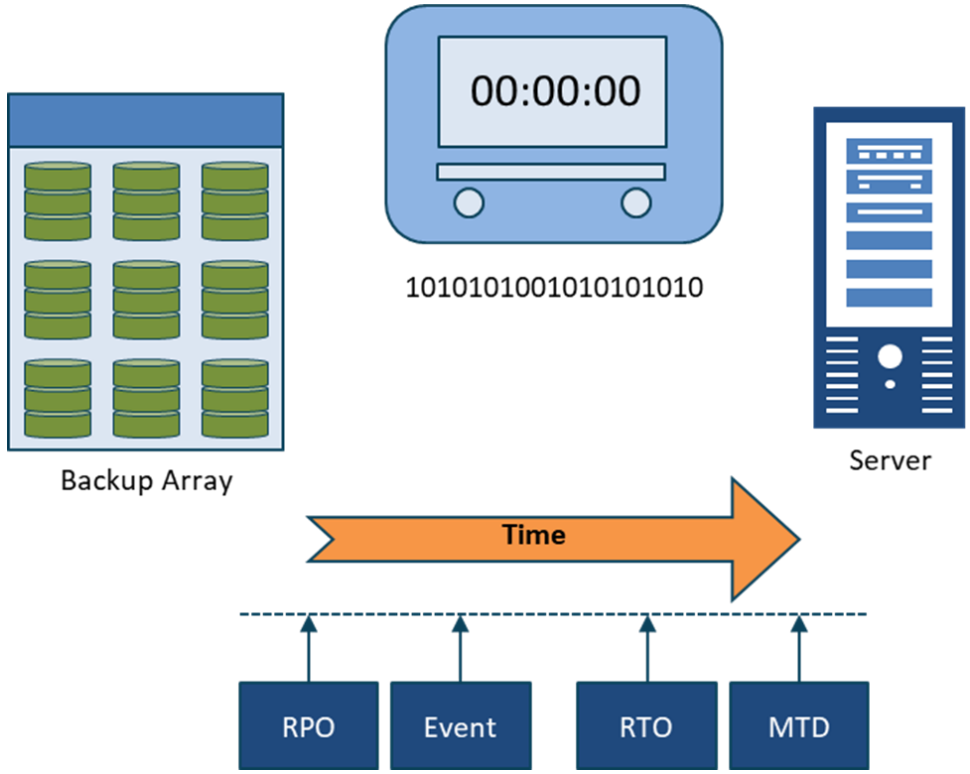
Business Impact Analysis



- The risk assessment aspect of the Business Continuity Plan (BCP) or (COOP)
- Identify critical functions to the business and prioritize them based on need for survival
- Identify the risks associated with the critical functions
- The probability of the risk occurring (likelihood)
- The impact the risk will have (magnitude)
- Identify how to eliminate the risk or reduce the risk

Recovery Time Objective (RTO)

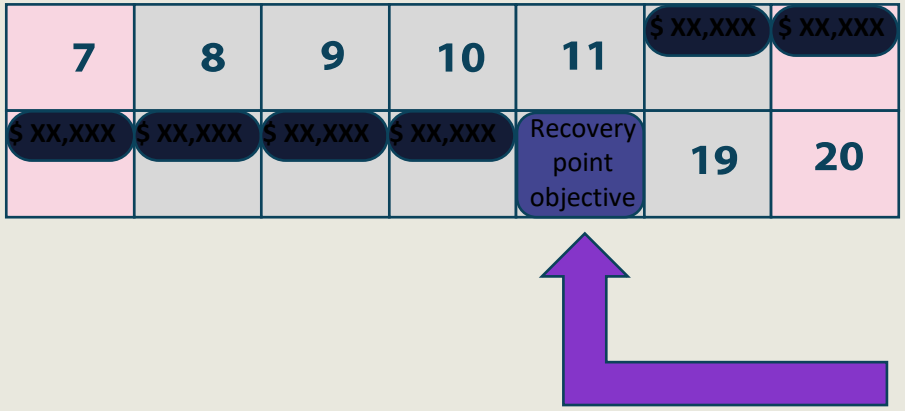
- The amount of time available to recover the resource, service, and function
- Must be equal to or less than Maximum Tolerable Downtime (MTD) or Allowable Downtime
- Any solutions must be accomplished within this time frame, or it is considered loss



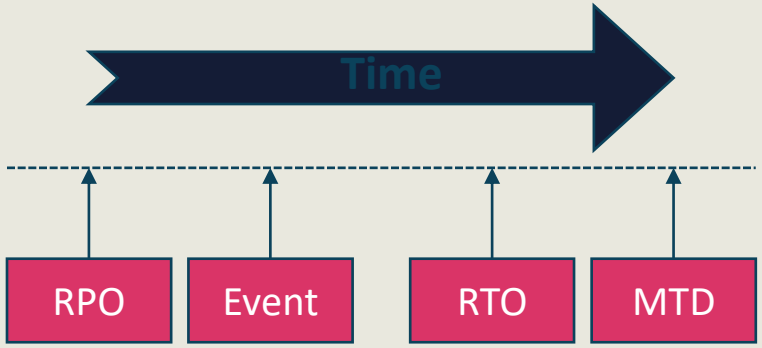
Recovery Point Objective (RPO)

The activity point, relative to a disaster, where the recovery process begins

- Last Known Good Configurations
- Snapshots and Transaction logs
- Recovery volumes
- State Machine Instances



SUN	MON	TUE	WED	THU	FRI	SAT
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

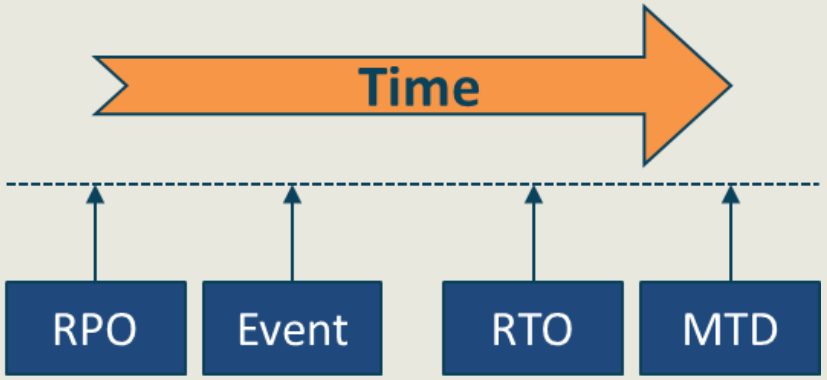


Maximum Tolerable Downtime (MTD)

Absolute maximum amount of time that a resource, service, or function can be unavailable before we start to experience a loss

Factors to consider include:

- finances
- life/safety
- regulatory
- legal/contracts
- reputation
- property



Mean Time Between Failures (MTBF)

- A measure of how reliable a hardware system or component is
- For most devices, the measure is in thousands or tens of thousands of hours between failures
- For example, an SSD drive may have a mean time between failures of 10 years

Mean Time To Repair or Replace (MTTR)

- How long does it take to repair or replace?
  - Measures time to fix or obtain the hot spare
  - Heavily affected by supply chain disruptions
  - Average value predicted based on experience and documentation
  - (Total down time)/(number of breakdowns)

Disaster Recovery Planning (DRP)

- Ensuring that the company can recover to an established baseline of continuity after any kind of high-level incident
- The tasks and processes that will be conducted when a disaster or catastrophe strikes
- Incident can affect a single drive, an entire server, a VLAN, an area of the facility, an entire floor or building, or the entire site or campus

Disaster Recovery Planning (DRP)

- Recovery sites: hot, warm, cold, mobile, cloud, shared
- Order of restoration (most critical to least critical)
- Backups, snapshots, and restores
- Contact information
- Communication plans
- Chain of authority
- Step-by-step instructions
- Locations of documents, software, and keys

Disaster Recovery Site Strategies

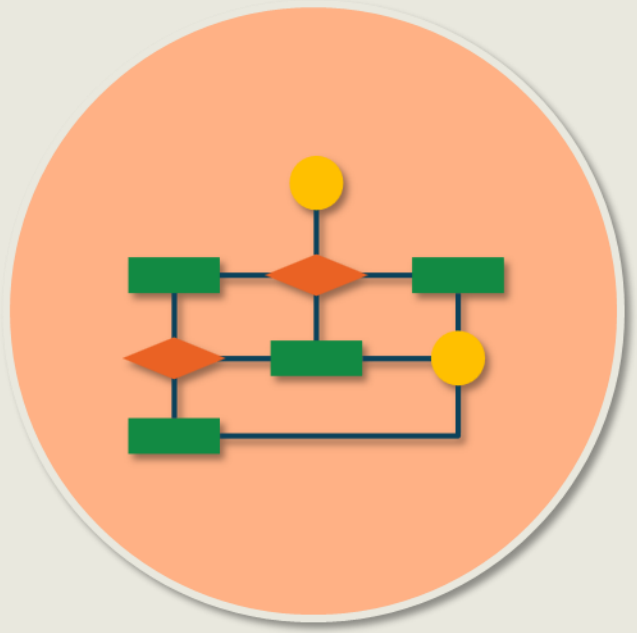
Recovery strategy	Recovery time	Advantages	Disadvantages
Commercial hot site	0 to 24 hours	• Fastest recovery time • Smoothest deployment, as facility, equipment, application software, data, and OS are installed and running • Easy to test when necessary • The optimal solution for recovering on-going operations	• The most expensive solutions often need to replicate all equipment and software, including on-going version and patch management issues • Continuous communication costs to duplicate data are very high • Terms of agreement may limit the duration of use especially if part of shared reciprocal agreement • Vendors will often prioritize only the larger customers in a real-world disaster scenario
Warm site	24 to 48 hours	• Moderately priced • A basic infrastructure is in place to support recovery operations – e.g., wireless network only • Allows for some degree of pre-staging of the necessary hardware, application software, OS software, data, and communications	• Not as easy to test • Recovery time is longer than with hot site and is dependent on the time to locate and restore applications • Facility equipment may not be exactly what is needed • Once the recovery begins delays may occur because of equipment, software, or staffing shortfalls
Cold site	72 plus hours	• Lowest cost solution • Basic infrastructure, power, air, and communication are in place and ready • Can rent the facility for a longer term at lower cost • Costs can be lowered even further using reciprocal agreements	• Longest recovery time • All equipment must be ordered, delivered, installed, and made operational • Worst solution for supporting on-going and mission-critical production operations
Cloud	0 to 24 hours	• Could be a lower cost hot/warm solution in the long run based on economy of scale and multitenancy of cloud provider • Data and applications available immediately • Location-independent • Easy to test	• Security may be an issue based on shared responsibility model • May not be feasible due to compliance and regulations • May not allow enough time for a daily cycle processing window

Test Disaster Recovery Plans

Read-through testing

- Read-through (plan review) is where the business continuity plan owner and business continuity team discuss the business continuity plan
- Look for missing elements and inconsistencies within the plan or with the organization
- A type of checklist test useful to train new members of a team, including the business function owner

Test Disaster Recovery Plans



Tabletop testing

- Participants gather in a room to execute documented plan activities in a stress-free environment
- Can use blueprints, topological diagrams, or computer models to effectively demonstrate whether team members know their duties in an emergency and if they need training
- Documentation errors, missing information, and inconsistencies across business continuity plans can be identified

Test Disaster Recovery Plans

Walkthrough testing

- Planned rehearsal of a possible incident designed to evaluate an organization's capability to manage that incident
- To provide an opportunity to improve the organization's future responses and enhance the relevant competences of those involved
- Often done on a limited basis or by scheduling each department or building separately for fire and active shooter drills

Test Disaster Recovery Plans

Simulation testing

- To determine if business continuity management procedures and resources work in a realistic situation, a simulation exercise is desirable
- May be the most elaborate test most entities ever conduct
- Uses established business continuity resources, such as the recovery site, backup equipment, services from recovery vendors, and transportation
- It can require sending teams to alternate sites to restart technology as well as business functions

Test Disaster Recovery Plans

Parallel testing

- A parallel test involves bringing the recovery site to a state of operational readiness, but maintaining operations at the primary site
- Staff are relocated, backup tapes are transferred, and operational readiness established in accordance with the disaster recovery plan while operations at the primary site continue normally
- May be the most comprehensive test most entities ever conduct

Test Disaster Recovery Plans

Full interruption testing

- Operations are completely shut down at the primary site to fully emulate the disaster
- Enterprise transfers to the recovery site in accordance with the disaster recovery plan
- A very thorough test, which is also expensive (may be cost-prohibitive)
- Has the capacity to cause a major disruption of operations if the test fails

Lessons Learned

From the After-Action Reporting

- Knowledge gained from the process of conducting the program, project, or task included in After-Action Report (AAR)
- Formal sessions usually held at the project close-out, near the completion of the initiative
- Recognized and documented at any point during the life cycle to:
  - share and use knowledge derived from an experience
  - endorse the recurrence of positive outcomes
  - prevent the recurrence of negative outcomes

Domain 4

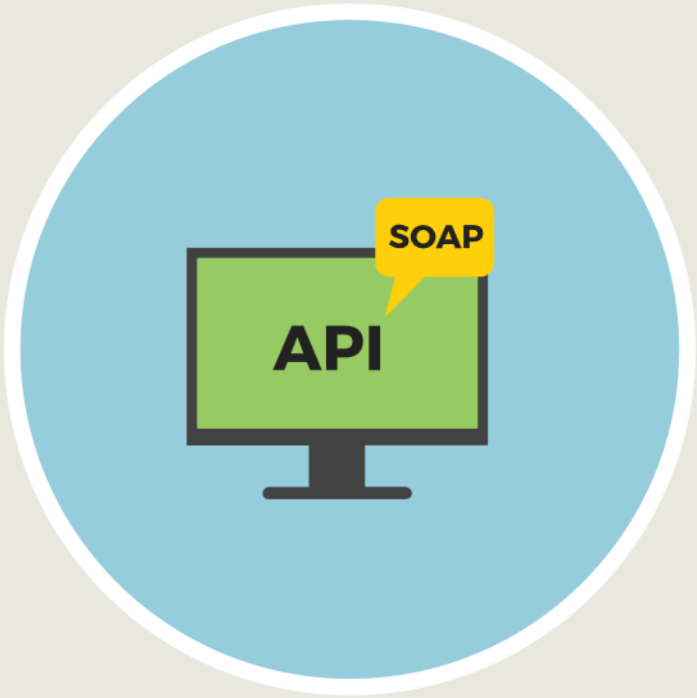
Cloud Application Security

Cloud Development Basics

- Cloud development usually entails Integrated Development Environments (IDEs), application lifecycle management initiatives, and application security testing
- The developer should ask several questions to determine if the proposed application is “Cloud-friendly”
  - What would the impact be if the data or information crossed geographic boundaries?
  - What if an employee of the cloud provider accessed the data or application?
  - What if the program failed to meet the planned results?
  - What if the app is manipulated by a corporate outsider?
  - What if the data or application were modified unexpectedly?
  - What if the application were subject to downtime?

Understanding APIs

SOAP vs. REST-based APIs



- It is important for developers to understand that in most cloud deployments, access is acquired through the means of an Application Programming Interface (API)
- These APIs will utilize tokens instead of traditional usernames and password credentials
- **Simple Object Access Protocol (SOAP)** uses an envelope then HTTP (or FTP/SMTP) to transfer data; only supports XML format; slower; no caching, scalability can be complex; **Used when REST is not feasible**
- **Representational State Transfer (REST)** uses simple HTTP protocol and supports many different data formats like JSON, YAML, XML; Restful APIs are widely used; Performance and scalability are good, and it uses caching as well

Common Pitfalls and Vulnerabilities

- Not all applications are ready for the cloud
- The Initial phases of the decision to use PaaS and introduce a SDLC are often rushed
- On-premise does not always migrate or transfer (and vice-versa)
- Lack of training and awareness of new development techniques
- Lack of guidelines, strategy, and documentation
- Difficulty and complexity of integrating with cloud

Common Web Vulnerabilities – OWASP Top 10

1. A01:2021 - Broken Access Control moves up from the fifth position; 94% of applications were tested for some form of broken access control. The 34 Common Weakness Enumerations (CWEs) mapped to Broken Access Control had more occurrences in applications than any other category.
2. A02:2021 - Cryptographic Failures shifts up one position to #2, previously known as Sensitive Data Exposure, which was broad symptom rather than a root cause. The renewed focus here is on failures related to cryptography which often leads to sensitive data exposure or system compromise.
3. A03:2021 - Injection slides down to the third position. 94% of the applications were tested for some form of injection, and the 33 CWEs mapped into this category have the second most occurrences in applications. Cross-site Scripting is now part of this category in this edition.
4. A04:2021 - Insecure Design is a new category for 2021, with a focus on risks related to design flaws. If we genuinely want to “move left” as an industry, it calls for more use of threat modeling, secure design patterns and principles, and reference architectures.

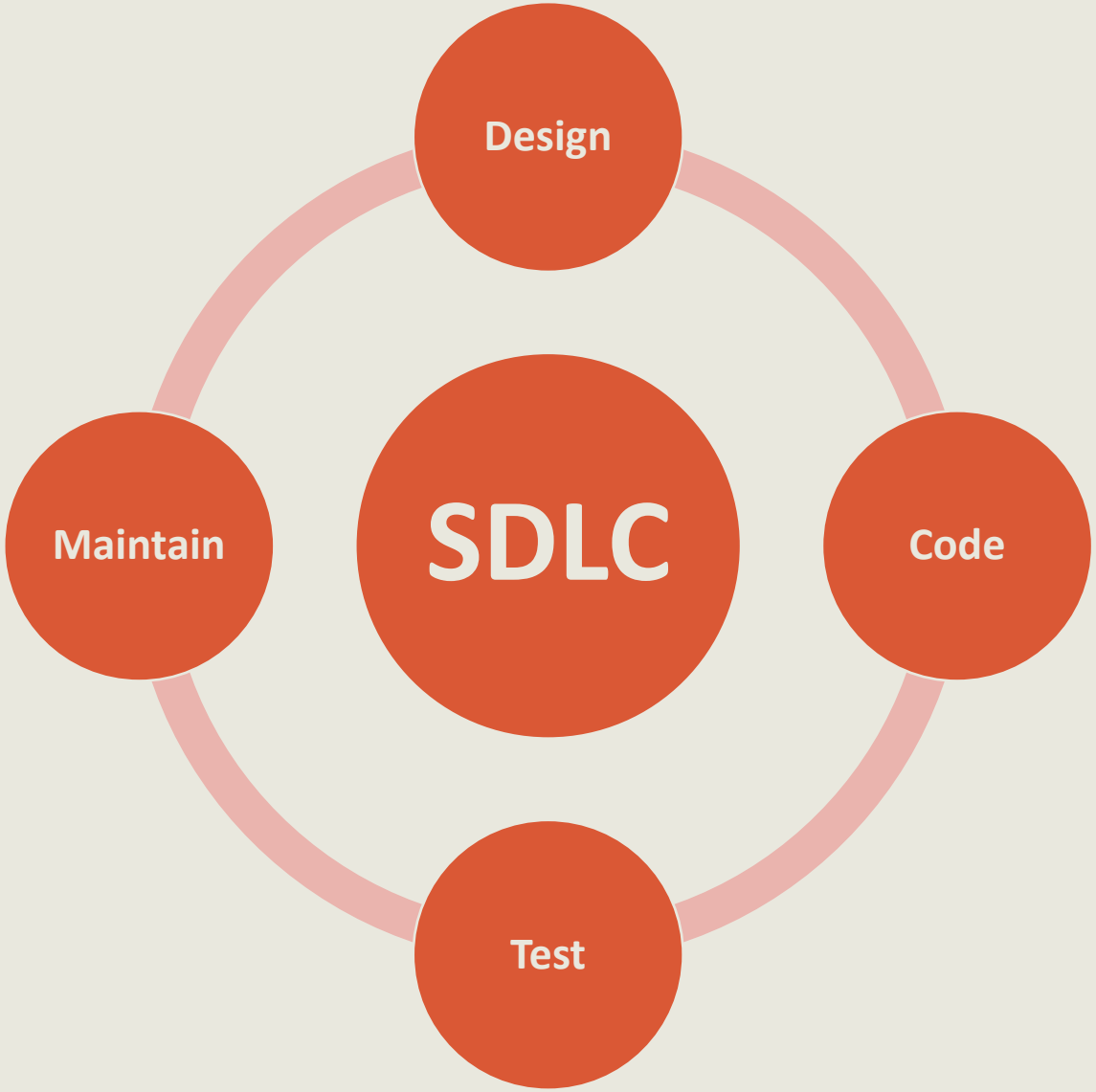
Common Web Vulnerabilities – OWASP Top 10

5. A05:2021 - Security Misconfiguration moves up from #6 in the previous edition; 90% of applications were tested for some form of misconfiguration. With more shifts into highly configurable software, it's not surprising to see this category move up. The former category for XML External Entities (XXE) is now part of this category.
6. A06:2021 - Vulnerable and Outdated Components was previously titled Using Components with Known Vulnerabilities and is #2 in the Top 10 community survey, but also had enough data to make the Top 10 via data analysis.
7. A07:2021 - Identification and Authentication Failures was previously Broken Authentication and is sliding down from the second position, and now includes CWEs that are more related to identification failures. This category is still an integral part of the Top 10, but the increased availability of standardized frameworks has helped.

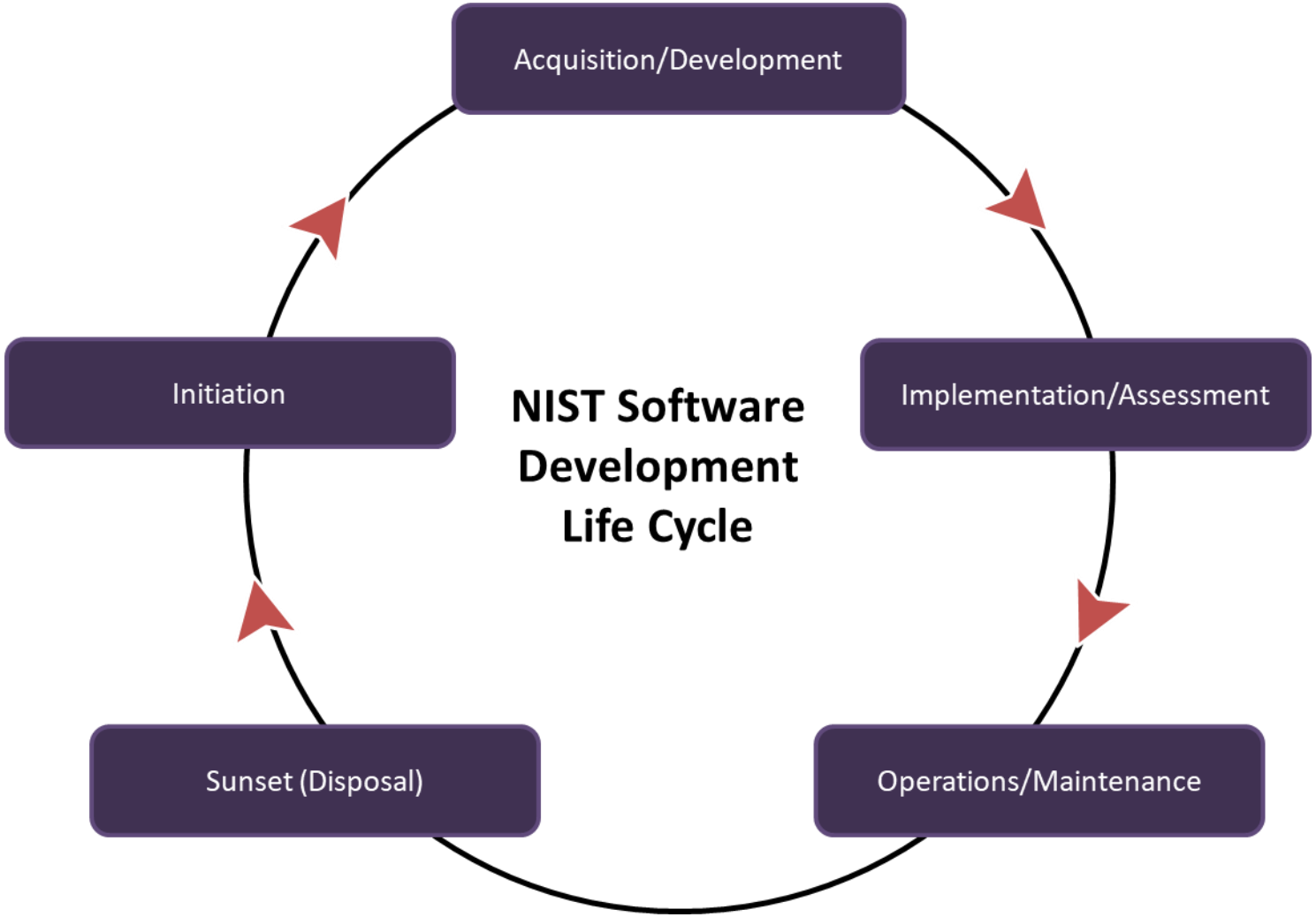
Common Web Vulnerabilities – OWASP Top 10

8. A08:2021 - Software and Data Integrity Failures is a new category for 2021, focusing on making assumptions related to software updates, critical data, and CI/CD pipelines without verifying integrity. One of the highest weighted impacts CVE/CVSS data mapped to the 10 CWEs in this category.
9. A09:2021 - Security Logging and Monitoring Failures was previously Insufficient Logging & Monitoring and is added from the industry survey (#3), moving up from #10 previously. This is expanded to include more types of failures, is challenging to test for, and isn't well represented in the CVE/CVSS data. However, failures in this category can directly impact visibility, incident alerting, and forensics.
10. A10:2021 - Server-Side Request Forgery is added from the Top 10 community survey (#1). This category represents the scenario where the security community members are telling us this is important, even though it's not illustrated in the data at this time.

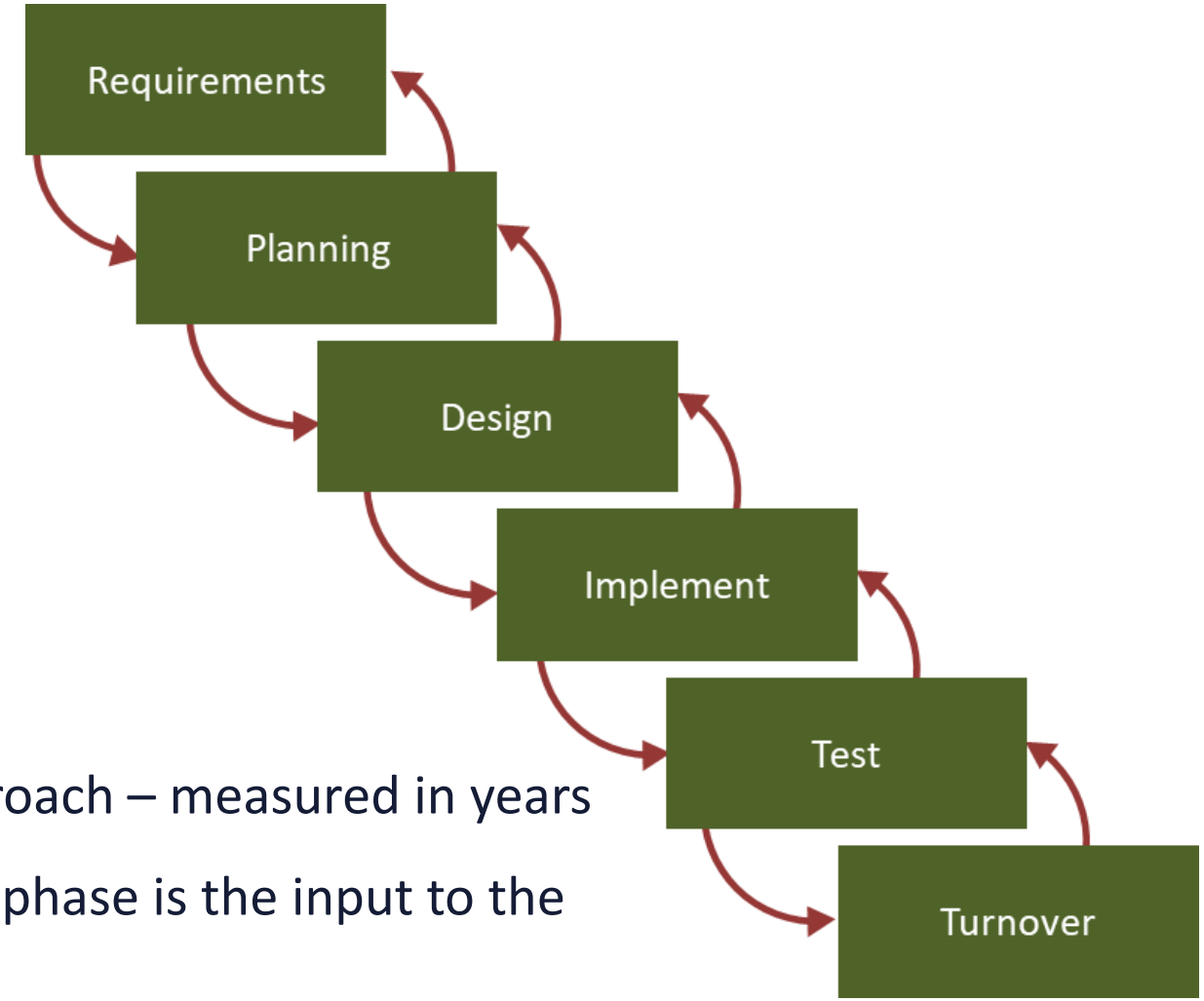
Secure Software Development



NIST Software/System Development Lifecycle



Waterfall Software Development

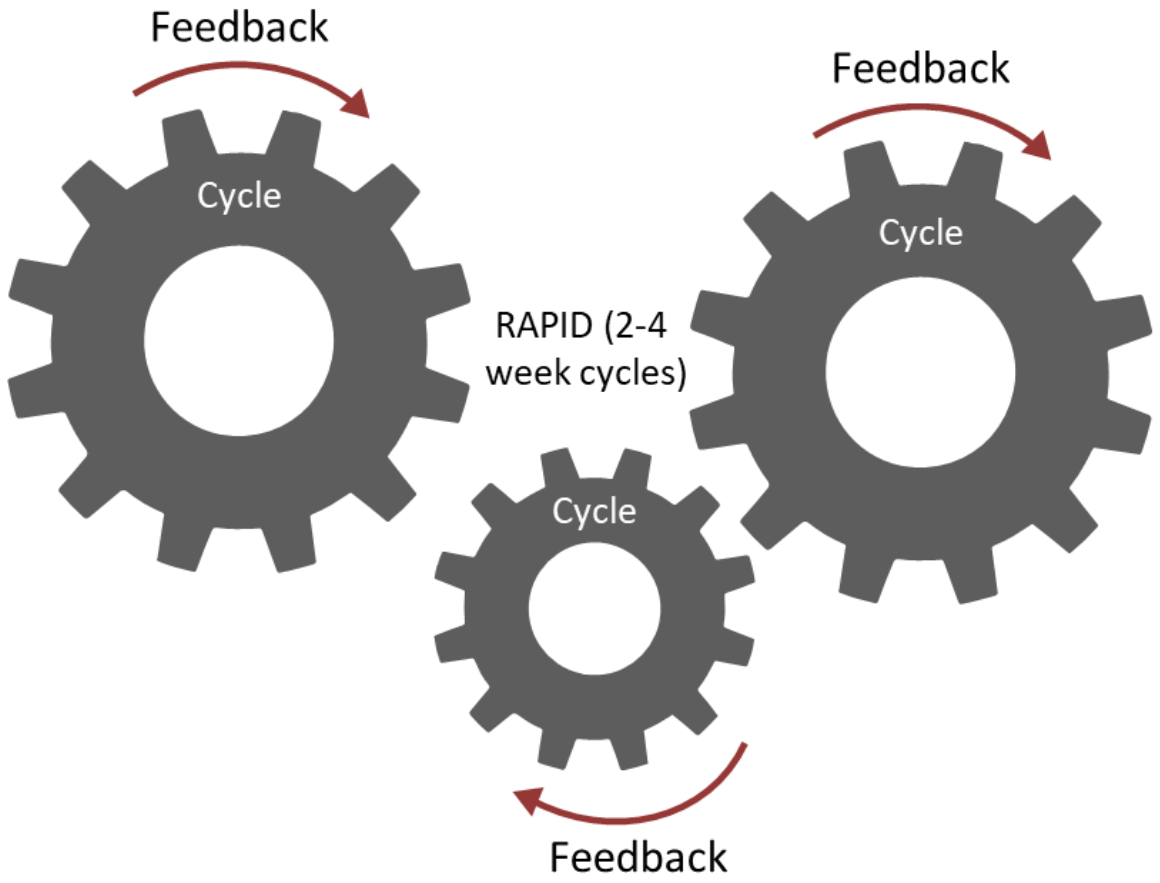


- Sequential approach – measured in years
- Output of each phase is the input to the next phase
- Little flexibility, not adaptable, very predictable, testing done in the end

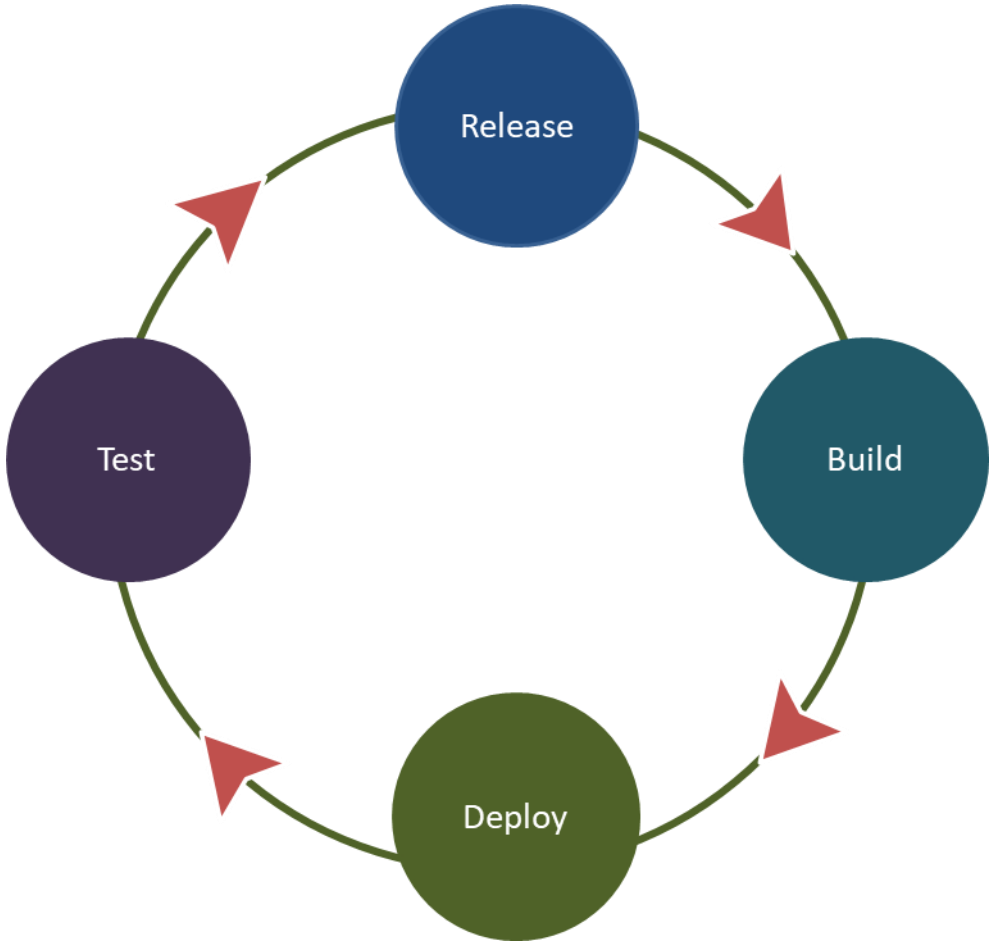
Agile Software Development

Excellent for smaller projects

- Evolutionary approach – measured in weeks
- Collaboration of cross-functional teams
- Very flexible, adaptable, not predictable, testing done during development
- Very high level of customer involvement throughout the project
- Works tightly with Agile Project Management



Continuous Integration (CI) – Continuous Deployment (CD) or CI/CD



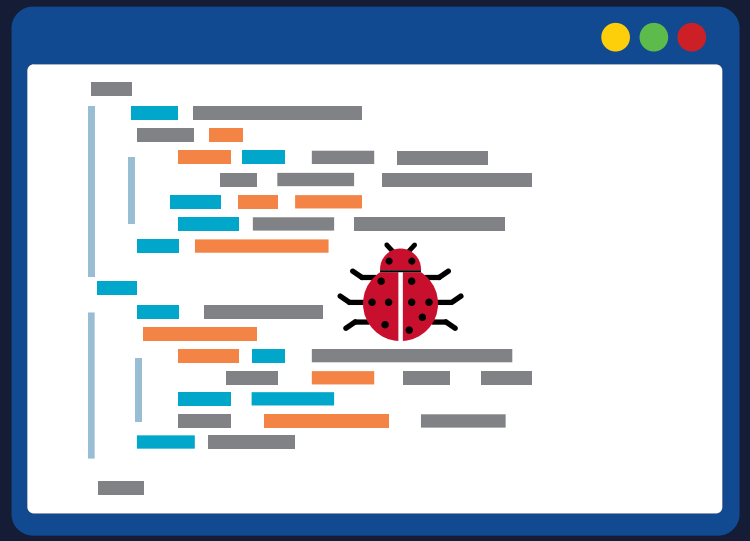
- Continuous Integration (CI) is a development technique that forces developers to integrate code into a shared repository several times a day
- Each check-in is then verified by an automated build, allowing teams to detect problems early
- The goal is to detect and locate bugs and security flaws quickly
- Very popular method at AWS and GCP for developing traditional apps as well as containers and microservices

DevSecOps

Development + Security + Operations

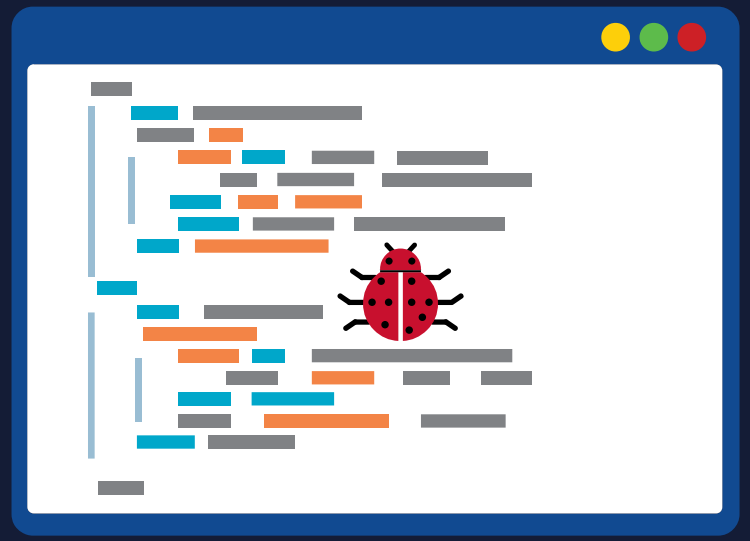
- It is a clipped compound referring to a set of practices that accentuate the collaboration and communication of both software developers and IT professionals that automate the software delivery process
- DevOps is a methodology for building software quickly by linking development and operations
- DevSecOps involves considering application and infrastructure security from the start and automating some security gates to keep the DevOps workflow from slowing down
- Choosing the right tools to integrate security continuously is critical

Source-code Weaknesses



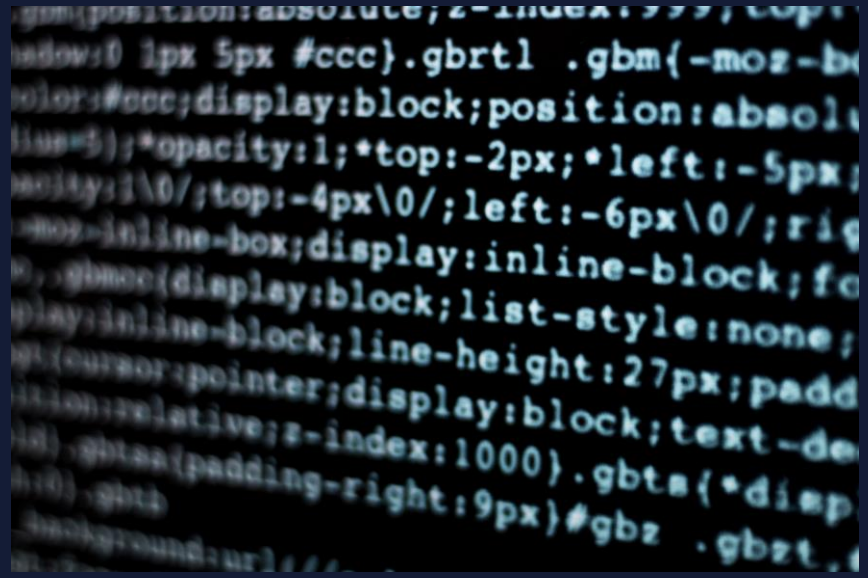
- Code vulnerabilities exist because solid secure development is quite difficult
- Experts often agree that open-source code libraries are far more secure than commercial software
- Most organizations do not have a clearly defined policy to confirm that developers wanting to use a section of software code go through an authorization process

Source-code Weaknesses



- Since open-source components exist in almost all codebases, keeping up with open-source components in your software is an overwhelming task – including tracking the forks, versions, and state of updates to the code

Common Programming Weaknesses



- Poor error handling
- Poor exception handling
- Improper input validation
- Not relying on stored procedures and micro-services
- Unsecure usage of code repositories
- Leaving inoperative dead code
- Redundancy in the code (no normalization)

Threat Modeling

S.T.R.I.D.E.

- STRIDE is a developer-focused threat modeling tool
- Microsoft threat modeling methodology that aligns with their Trustworthy Computing directive of January 2002
- Focus is to help ensure that Microsoft's Windows software developers think about security during the design phase
- Goal is to get an application to meet the security properties of CIA along with authentication, authorization, and non-repudiation
- Once the security SME builds the DFD-based threat model, system engineers or other experts check the application against the STRIDE threat model classification scheme

STRIDE

Threat	Definition	Property	Example
Spoofing	Pretending to be someone else	Authentication	Hack victim's email and to send messages as the victim
Tampering	Changing data or code	Integrity	Software executive file is tampered with by hackers
Repudiation	Claiming not to do a particular action	Non-repudiation	"I have not sent an email to users"
Information Disclosure	Leaking sensitive information	Confidentially	Making credit card information available on the internet
Denial of Service	Non-availability of service	Availability	Web application not responding to user requests
Elevation of privilege	Ability to perform unauthorized action	Authorization	Normal user can delete admin account

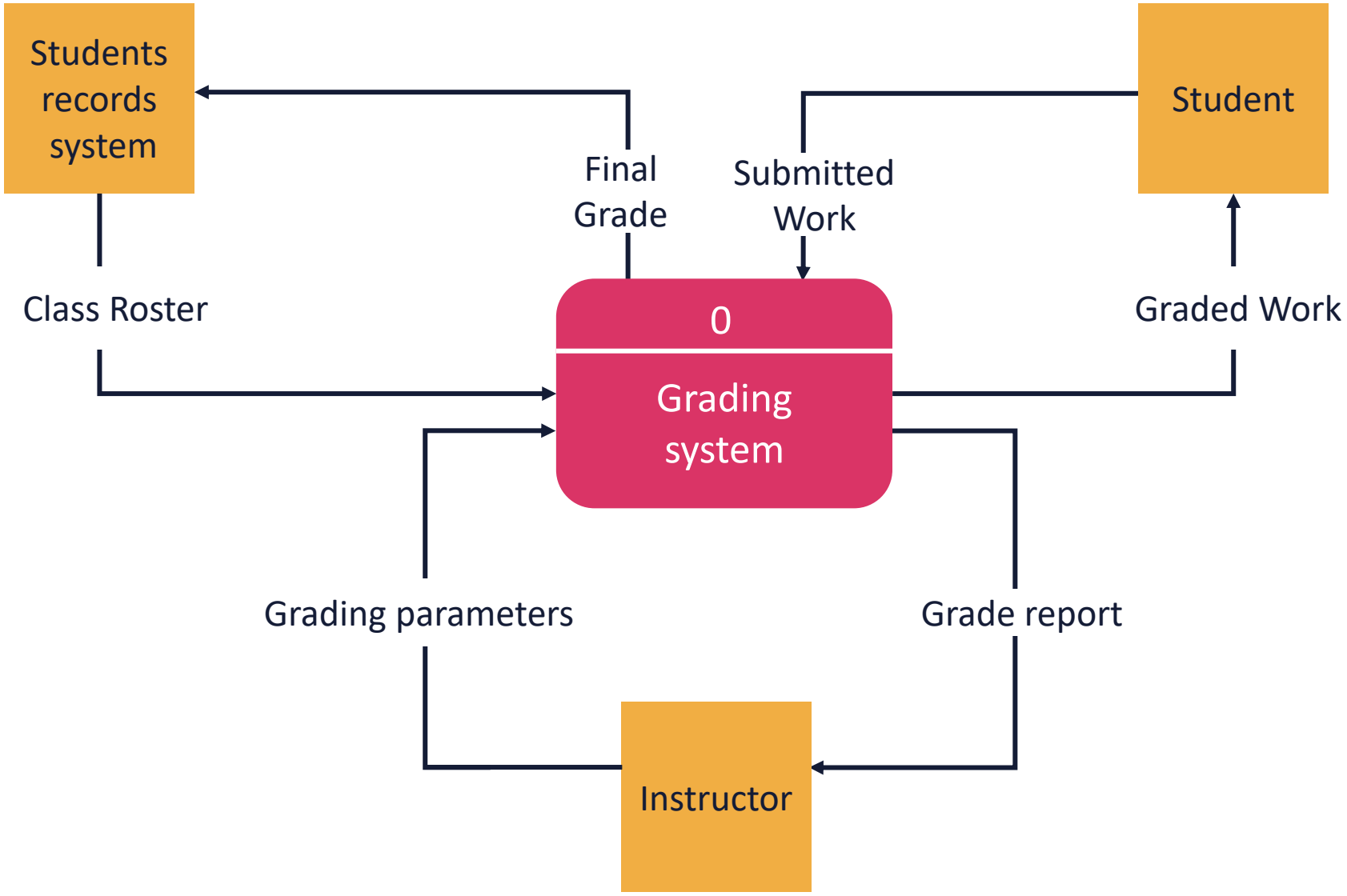
Admin. "STRIDE: Acronym of Threat Modeling System." All About Testing, February 21, 2019. https://allabouttesting.org/stride-acronym-of-threat-modeling-system/.

DREAD

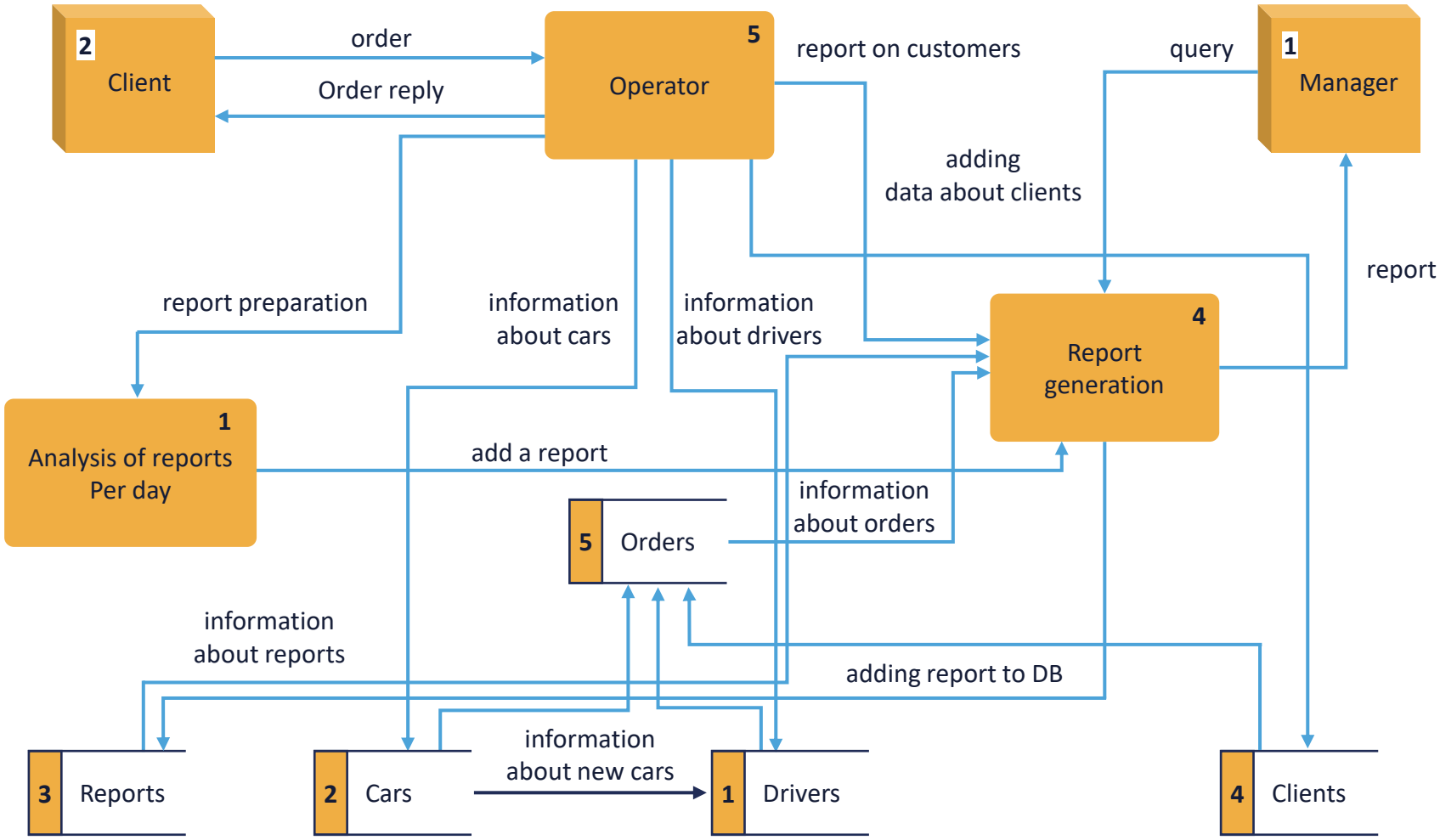
- DREAD is a risk assessment model that can be used to prioritize security threats
- Like the STRIDE model, it was created by Microsoft
- Each risk factor for a given threat can be given a score (for example, 1 to 5 or 1 to 10)
- The sum of all the factors divided by the number of factors represents the overall level of risk for the threat
- A higher score implies a higher risk level and would normally be given a higher priority when determining which threats get the most initial attention

DAMAGE	Impact of an Attack
REPRODUCIBILITY	How Easily the Attack can be Reproduced?
EXPLOITABILITY	How Easy it is to Launch the Attack
AFFECTED USERS	How Many Users will be Impacted
DISCOVERABILITY	How easily the vulnerability can be found

Sample Data Flow Diagram (DFD): basic



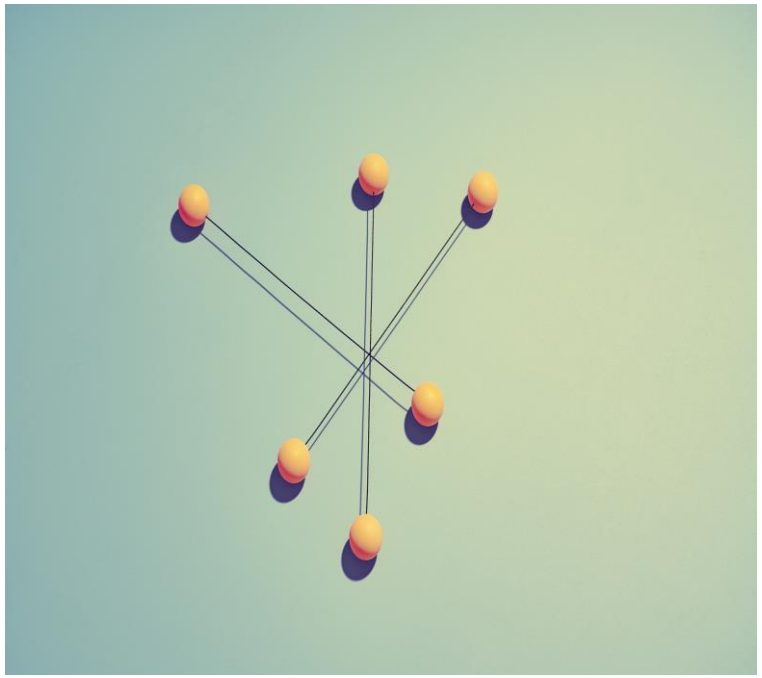
Sample Data Flow Diagram (DFD): complex



ASATM

- **Applied Security Architecture and Threat Models** (ASATM) covers all types of systems, from the simplest applications to complex, enterprise-grade, hybrid cloud architectures
- It describes the many factors and essential information that can impact an assessment such as:
  - When should the security architect begin the analysis?
  - At what points can a security architect add the most value?
  - What are the activities the architect must execute?
  - How are these activities delivered?
  - What is the set of knowledge domains applied to the analysis?
  - What are the outputs?
  - What are the tips and tricks that make security architecture risk assessment easier?

Process for Attack Simulation and Threat Analysis (PASTA)



- PASTA is a relatively new application threat modeling approach
- Offers a seven-step platform-independent process for risk analysis
- Goal is to align business objectives with technical requirements, while considering business impact analysis and compliance requirements
- Combines an attacker-centric perspective on potential threats with asset-centric risk and impact analysis
- Works best for organizations that need to align threat modeling with strategic objectives as it integrates business impact analysis as an integral part of the process and magnifies cybersecurity responsibilities beyond the IT department

Comparing Threat Modeling Methods

	OCTAVE	Trike	P.A.S.T.A	Microsoft	VAST
Implement application security at design time	✓	✓	✓	✓	✓
Identify relevant mitigating controls	✓	✓	✓	✓	✓
Directly contributes to risk management	✓	✓	✓		✓
Prioritize threat mitigation efforts	✓	✓	✓		✓
Encourage collaboration among all stakeholders	✓	✓			✓
Outputs for stakeholders across the organization	✓				✓
Consistent repeatability		✓			✓
Automation of threat modeling process		✓			✓
Integrates into an Agile DevOps Environment					✓
Ability to scale across thousands of threat models					✓

"Threat Modeling Methodologies." ThreatModeler Software, Inc. Accessed June 7, 2021. https://threatmodeler.com/threat-modeling-methodologies-/.

Penetration Testing Frameworks

- **SSAF** - framework provided by Open Information Systems Security Group (OISSG), a not-for-profit organization based in London
- **OSSTMM** - open-source security testing created by ISECOM (Institute for Security and Open Methodologies
- **OWASP** - popular methodology used widely by security professionals, create by a non-profit organization focused on advancing software security
- **PTES** - Penetration Testing Execution Standard (PTES) methodology was developed to cover the key parts of a penetration test
- **NIST** - National Institute of Standards and Technology (NIST) provides a manual that is best suited to improve the overall cybersecurity of an organization

OWASP Application Security Verification Standard (ASVS)

- This project gives developers a list of requirements for secure development
- The standard provides a basis for testing application technical security controls, as well as any technical security controls in the environment, that used to mitigate attacks such as Cross-Site Scripting (XSS) and SQL injection
- The requirements were developed to be used:
  - As a meaningful metric
  - As secure development guidance
  - During the procurement process

SAFECode

- SAFECode is a global nonprofit organization that brings business and technical leaders together to exchange insights on creating, refining and promoting effective and scalable software development
- Software assurance involves developing and employing processes for ensuring that software is:
  - Functioning as intended
  - Free of design defects
  - Without implementation flaws
- They publish the “SAFECode Fundamental Practices for Secure Software Development” to help the industry start or advance their own software assurance programs and encourage secure development practices

Software Assurance

- The key objective of the Software Assurance Program is to shift the security paradigm from patch management to software assurance
- Encourage developers to raise overall software quality and security from the start
- Emphasize the usage of tested standard libraries and modules
- Employ industry-accepted approaches that recognize that software security is fundamentally a software engineering issue that must be addressed systematically throughout the software development life cycle

Code Repository Security

- Your code is only as secure as the methods and systems used to generate it
- Some of the advantages that come with using a secure code repository are version control, peer review, and built-in auditing
- It is critical that the repository (such as GitHub or AWS) is an adequately secure central point of code storage and management
- Attackers can change a code base without your knowledge or permission due to loss/compromise of access credentials or breach of the core service

Code Repository Security

- If appropriate due diligence is applied to security measures, the benefits of using a code repository far outweigh the risks
- Select a repository you trust highly
- Consider the exposure and customer base of your repository
- Protect access credentials
- Separate secret credentials from source code
- Repository access should be revoked quickly when not needed or if compromised

Code Repository Security

- Include open code in your risk model
- Review all code changes
- Realize that external code changes may be malicious
- Protect your identity if using a publicly accessible repository
- Ensure that your code is backed up

Software Configuration Management (SCM)

- Software configuration management (SCM) is a software engineering process to systematically manage, organize, and control the changes in the documents, codes, and other artifacts during the software development life cycle
- The primary goal is to enhance productivity and minimize errors
- SCM is part of the cross-disciplinary field of configuration management (integrated product teams – IPT) and can correctly determine the revision history

Reasons to Use SCM

- There are several people working on applications that are continually updating (CI/CD or Spiral development)
- Multiple versions, branches, micro-services, and programmers are involved in a software project, and the team is geographically dispersed yet is working concurrently

Reasons to Use SCM

- Changes in customer requirements, policy, budget, and schedules need to be accommodated
- Software must be able to run on different platforms and operating systems
- There is a critical need to develop coordination among cross-functional stakeholders
- Need to control the costs involved in making changes to an app

Software Configuration Management (SCM)