SAFE Architecture Guide

Places in the Network: Secure Cloud

June 2019

SAFE
SIMPLIFIES SECURITY

Contents

Overview

The Secure Cloud is a place in the network (PIN) where a company centralizes data and performs services for business. Cloud service providers host data center services in the Secure Cloud. This guide addresses Secure Cloud business flows and the security used to defend them. The focus of this guide in on the security controls necessary to provide **"security FOR the cloud"**.

The Secure Cloud is one of the seven places in the network within SAFE. SAFE is a holistic approach in which Secure PINs model the physical infrastructure and Secure Domains represent the operational aspects of a network.

The Secure Cloud architecture guide provides:

- Business flows for the cloud
- Cloud threats and security capabilities
- Business flow security architecture
- Design examples and a suggested components

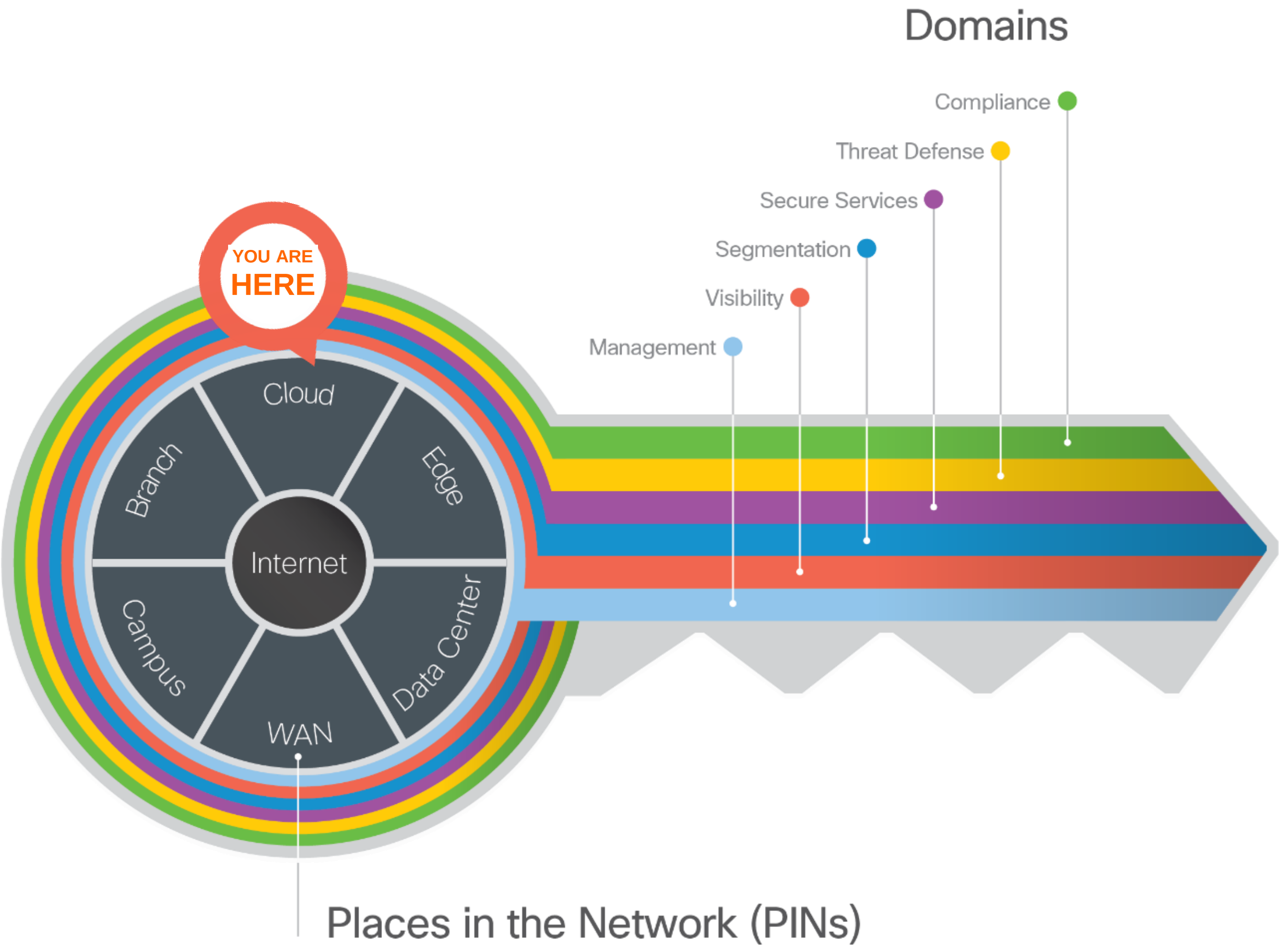


Figure 1 The Key to SAFE. *SAFE provides the Key to simplify cybersecurity into Secure Places in the Network (PINs) for infrastructure and Secure Domains for operational guidance.*

SAFE simplifies security by starting with business flows, then addressing their respective threats with corresponding security capabilities, architectures, and designs. SAFE provides guidance that is holistic and understandable.

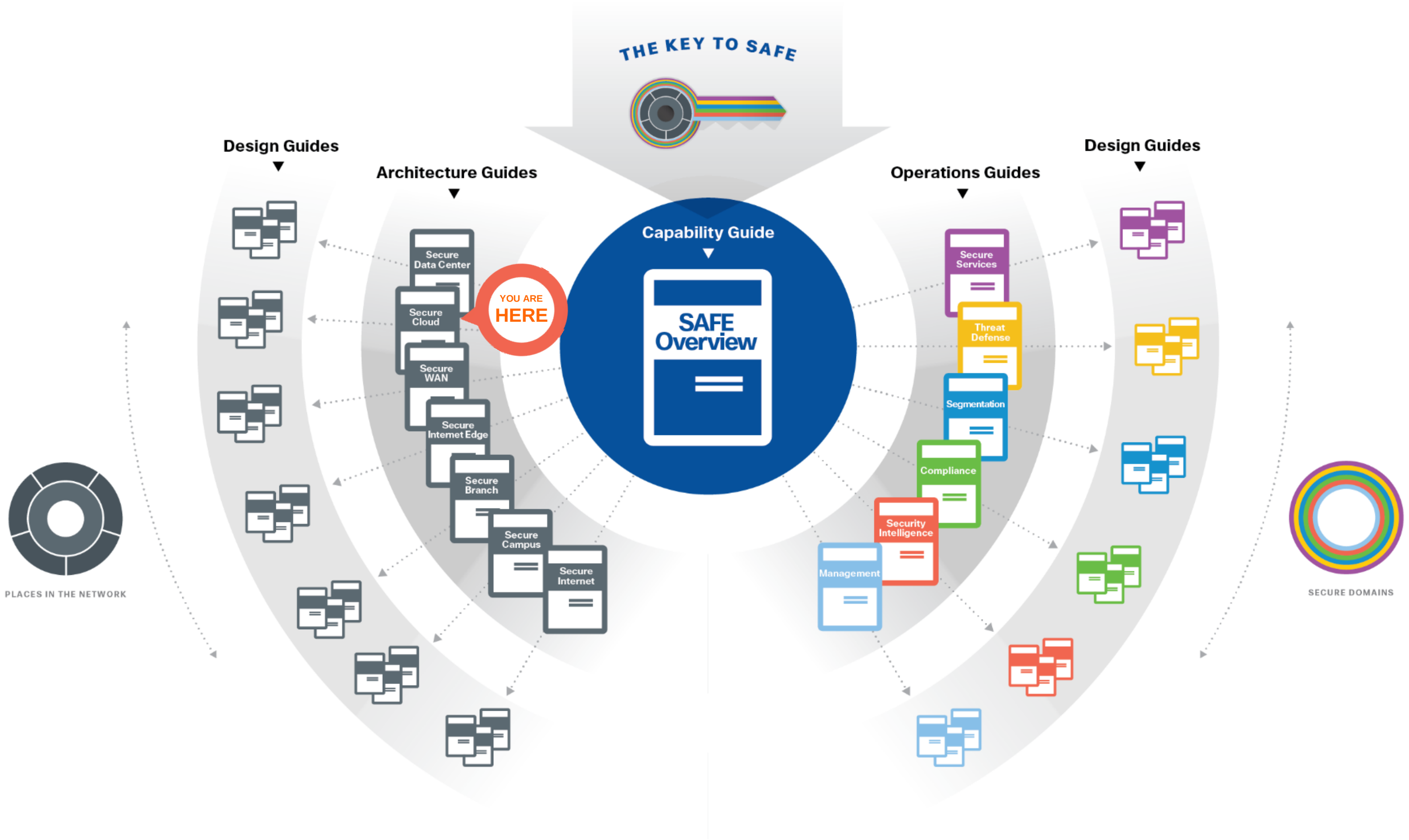


Figure 2 *SAFE Guidance Hierarchy*

Cloud Taxonomy

The Internet is a collection of interconnected Information Technology (IT) and clouds. Terms of clouds varies by context, ownership and integration.

Table 1 Common Cloud Terms and Definitions.

Cloud Term	Definition
Cloud	Cloud computing enables 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.
Public Cloud	A style of computing where scalable and elastic IT-enabled capabilities are provisioned as a service to customers using Internet technologies.
Private Cloud	A style of computing where scalable and elastic IT-enabled capabilities are provisioned over IT infrastructure that is on-prem.
Hybrid Cloud	A style of computing where scalable and elastic IT-enabled capabilities are provisioned services out of multiple, private and public cloud availability zones. Workloads are actively ported between these zones for reasons including cost, performance and availability.
Multicloud	A style of computing where scalable and elastic IT-enabled capabilities are provisioned services out of multiple, private cloud and public cloud availability zones. Workloads are not ported between these zones.
Hybrid IT	Hybrid IT is when an enterprise adds cloud-based services to complete their entire pool of IT resources. A hybrid IT model enables organizations to lease a portion of their required IT resources from a public/private cloud service provider.

Cloud Services

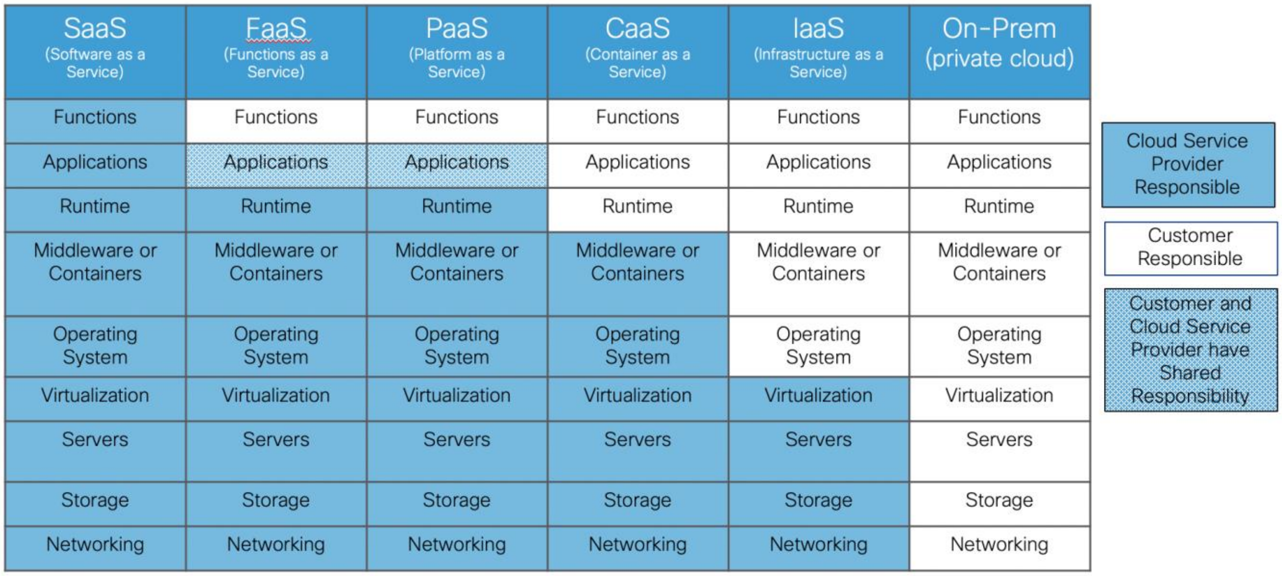
Cloud Service Providers (CSP) provide public cloud services. CSPs deliver a variety of cloud services that can provide business application delivery. The following table lists the cloud service types, definitions and the corresponding SAFE PIN Architecture Guide the cloud service is covered under.

Table 2 Cloud Service Type, Definition and SAFE PIN coverage

Cloud Service Type	Definition	SAFE PIN Architecture Guide
Software as a Service (SaaS)	Software that is deployed over the internet, A provider licenses an application to customers either as a service on demand, through a subscription, in a "pay-as-you-go" model, or (increasingly) at no charge when there is opportunity to generate revenue from streams other than the user, such as from advertisement or user list sales.	Secure Internet
Functions as a Service (FaaS)	A cloud computing service that provides a platform allowing customers to develop, run, and manage application functionalities without the complexity of building and maintaining the infrastructure typically associated with developing and launching an application. Also referred to as Serverless.	Secure Cloud
Platform as a Service (PaaS)	A computing platform that allows the creation of web applications quickly and easily and without the complexity of buying and maintaining the software and infrastructure underneath it.	Secure Cloud
Container as a Service (CaaS)	A cloud service that allows software developers and IT departments to upload, organize, run, scale, manage and stop containers by using container-based virtualization.	Secure Cloud
Infrastructure as a Service (IaaS)	A way of delivering Cloud Computing infrastructure – servers, storage, network and operating systems – as an on-demand service. Rather than purchasing servers, software, datacenter space or network equipment, clients instead buy those resources as a fully outsourced service on demand.	Secure Cloud
On-Prem	IT services are provisioned over private IT infrastructure for the dedicated use of a single organization. The customer owns all costs for hosting the applications in a location they own.	Secure Data Center

Cloud Responsibility

The customer selects the cloud service model which best serves the business need. The following figure represents the responsibility model between the Cloud Service Provider and the Customer.



SaaS (Software as a Service)	FaaS (Functions as a Service)	PaaS (Platform as a Service)	CaaS (Container as a Service)	IaaS (Infrastructure as a Service)	On-Prem (private cloud)
Functions	Functions	Functions	Functions	Functions	Functions
Applications	Applications	Applications	Applications	Applications	Applications
Runtime	Runtime	Runtime	Runtime	Runtime	Runtime
Middleware or Containers	Middleware or Containers	Middleware or Containers	Middleware or Containers	Middleware or Containers	Middleware or Containers
Operating System	Operating System	Operating System	Operating System	Operating System	Operating System
Virtualization	Virtualization	Virtualization	Virtualization	Virtualization	Virtualization
Servers	Servers	Servers	Servers	Servers	Servers
Storage	Storage	Storage	Storage	Storage	Storage
Networking	Networking	Networking	Networking	Networking	Networking

Cloud Service Provider Responsible

Customer Responsible

Customer and Cloud Service Provider have Shared Responsibility

Figure 3 *Cloud Service Shared Responsibility Model*

On the far left, the Software as a Service (SaaS) cloud service has the cloud service provider being responsible for all costs. On the far right, the On-Prem cloud service (i.e. private cloud) is a traditional data center deployment where the customer is responsible for all costs. The cloud services between them have varying ownership responsibility. A customer needs to evaluate the service level agreements for all cloud services under consideration.

Runtime is a responsibility highlighted because with an On-Prem or IaaS deployment the customer owns runtime even if the servers sit idle. In a PaaS or FaaS deployment, a customer would only pay for the runtime that they used.

Business Flows

The SAFE model is based on ten business flows as described in the SAFE Overview Guide. SAFE's color-coded business flows illustrate the security needed for each role. These flows depict the attack surface, ensuring that controls are easily accounted for.

The Secure Cloud provides business services to the company's users.

- Employees in the branch, campus, and remote locations require access to applications, collaboration services (voice, video, email), and the Internet
- Systems communicate east/west within the cloud service, as well as with other cloud services or on-premise data centers

The three business flows this architecture guide focuses on describing the capabilities required to secure the Secure Cloud PIN are depicted in Figure 4.

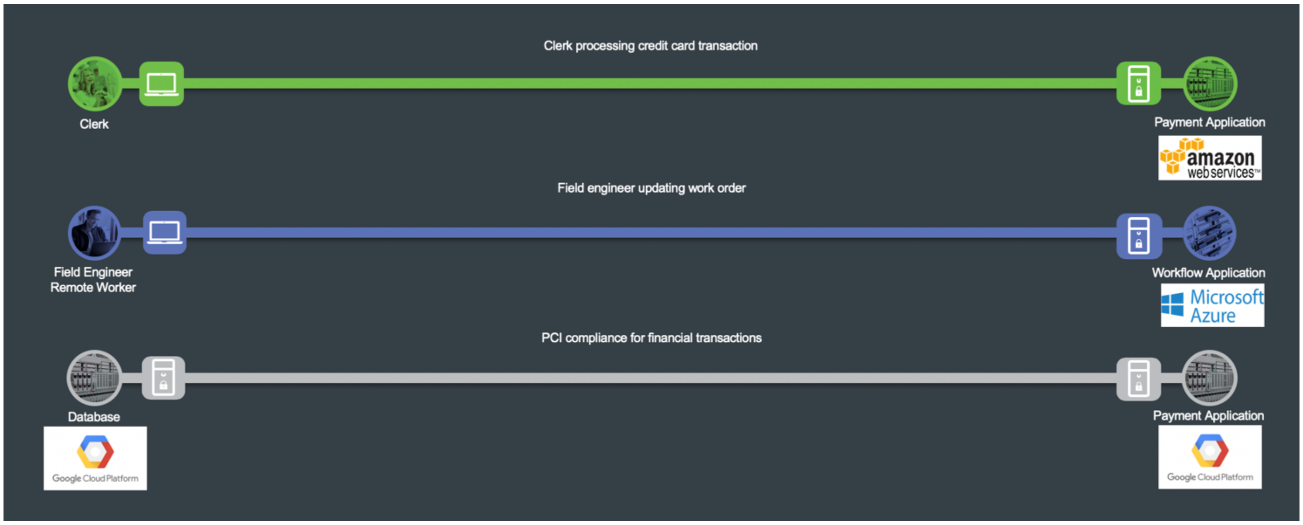


Figure 4 *Cloud business use cases are color coded to define where they flow*

The green business flow is an example of a secure application, depicted by a clerk in the branch accessing a payment application hosted in the cloud (Amazon Web Services). The capabilities in the branch are documented in the Secure Branch architecture guide.

The blue business flow is an engineer connected directly to the Internet accessing a secure workflow application hosted in the cloud (Microsoft Azure).

Lastly, the gray business flow represents the east-west traffic between a database server and a payment application hosted in Google Cloud Platform. The business requires visibility and control capabilities for the traffic between the hosted applications.

Functional Controls

Functional Controls are common security considerations that are derived from the technical aspects of the business flows.

Secure Applications	Applications require sufficient security controls for protection.
Secure Remote Access	Secure remote access for employees and third-party partners that are external to the company network.
Secure East/West Traffic	Data moves securely; internally, externally, or to third-party resources.

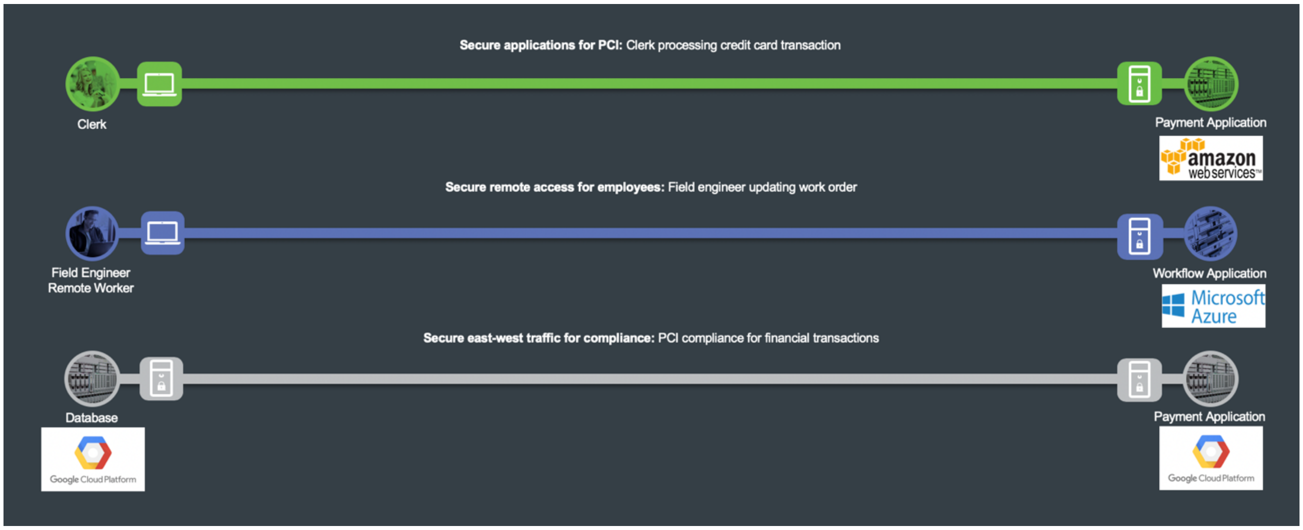

Secure applications for PCI: Clerk processing credit card transaction
Clerk
Payment Application
amazon web services
Secure remote access for employees: Field engineer updating work order
Field Engineer Remote Worker
Workflow Application
Microsoft Azure
Secure east-west traffic for compliance: PCI compliance for financial transactions
Database
Google Cloud Platform
Payment Application
Google Cloud Platform

Figure 5 *Cloud business flows map to functional controls based on the types of risk they present*

Capability Groups

Cloud security is simplified by grouping capabilities into three groups which align to the functional controls: Foundational, Business, and Access. Each flow requires the access and foundational groups. Business activity risks require appropriate capabilities to control or mitigate them.

For more information regarding capability groups and functional controls, refer to the SAFE overview guide.

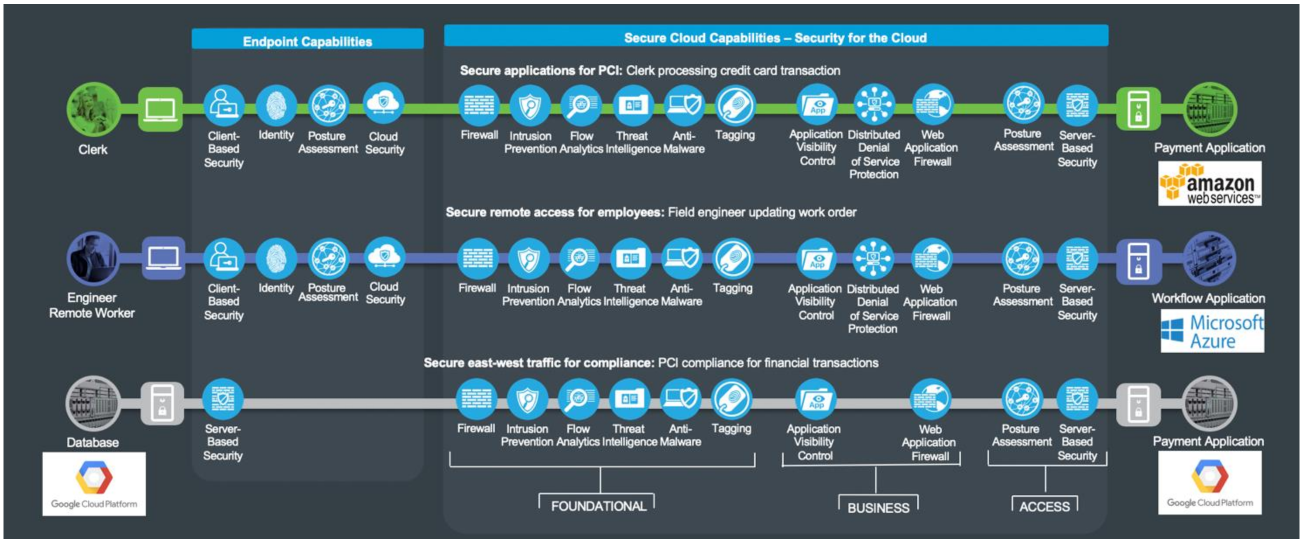


Figure 6 *The Secure Cloud Business Flow Capability Diagram*

Secure Cloud threats and capabilities are defined in the following sections.

Threats

Cloud services contain the majority of business information assets and intellectual property. These are the primary goals of targeted attacks and require the highest level of investment to secure. The cloud assets have four primary threats:

Data extraction (data loss)
The unauthorized ex-filtration or theft of a company's intellectual property, innovation, and proprietary company data.

Unauthorized network access
Unauthorized access gives attackers the potential to cause damage, such as deleting sensitive files from a host, planting a virus, and hindering network performance with a flood of illegitimate packets.

Malware propagation
Assets in the data center are targets for east/west contamination between servers, and north/south from employees, partners, or customer devices on the network. Applications that process credit card transactions and Internet of Things devices are the most prevalent targets.

Botnet cultivation
The resources of a server farm are a valuable target for botnet cultivation. Botnets are networks made up of remote controlled computers, or "bots." They are used to steal data, send spam, or perform other attacks.

The defense is explained throughout the rest of the document.

Security Capabilities

The attack surface of the cloud is defined by the business flows, and includes the people and the technology present. The security capabilities that are needed to respond to the threats are mapped in Figure 7. The cloud security capabilities are listed in Table 3. The placement of these capabilities is discussed in the architecture section.

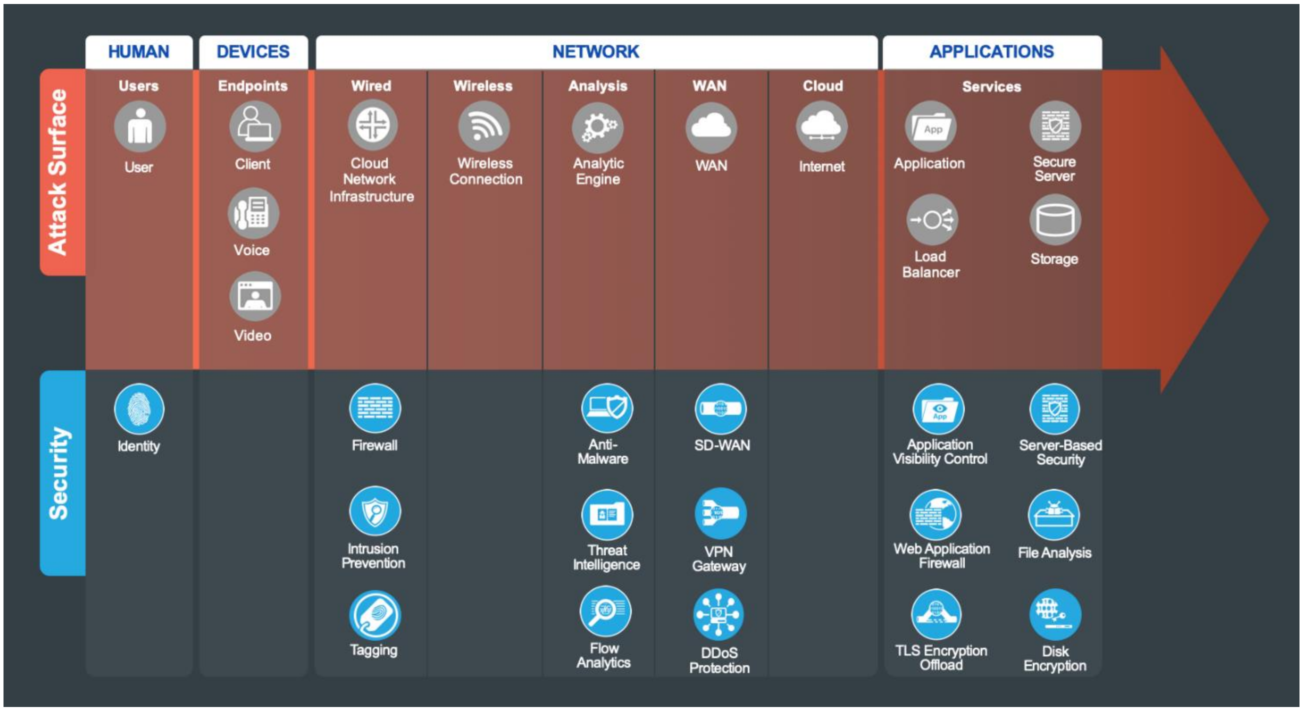


Figure 7 *Secure Cloud Attack Surface and Security Capabilities*

Table 3 Secure Cloud Attack Surface, Security Capability, and Threat Mapping. Products that implement these capabilities can be found in Table 4 in Appendix B.

Secure Cloud Attack Surface		
Human	**Security Capability**	**Threat**
Users: Employees, third parties, customers, and administrators.	**Identity:** Identity-bases access.	Attackers or disgruntled admins accessing restricted information resources.
Devices	**Security Capability**	**Threat**
Clients: Devices such as PCs, laptops, smartphones, tablets.	**N/A:** Covered in Internet, Campus and Branch PINs.	Compromised administrator systems obtaining elevated access.
Voice/Video: Phone and teleconferencing	**N/A:** Covered in Secure Services domain.	Attackers accessing private information.
Autonomous Device: Building controls.	**N/A:** Covered in IoT Threat Defense	Attackers taking over systems
Network	**Security Capability**	**Threat**
Cloud Network Infrastructure: Routing and switching capabilities required to host business services in the cloud.	**Firewall:** Stateful filtering and protocol inspection between segments in the virtual private cloud.	Unauthorized access and malformed packets between and within application in the cloud.
	Intrusion Prevention: Blocking of attacks by signatures and anomaly analysis.	Attacks using worms, viruses, or other techniques.
	Tagging: Software-based segmentation using native cloud capabilities	Unauthorized access and malicious traffic between segments.

Network (continued)	Security Capability	Threat
Analysis:	**Anti-Malware:** Identify, block, and analyze malicious files and transmissions.	Malware distribution across networks or between servers and devices.
	Threat Intelligence: Contextual knowledge of emerging hazards.	Zero-day malware and attacks.
	Flow Analytics: Network traffic metadata identifying security incidents.	Traffic, telemetry, and data exfiltration from successful attacks.
WAN:.	**Virtual Private Network (VPN) or SD-WAN:** Encrypted communication tunnels.	Easily collecting information and identities.
	VPN Gateway or Concentrator: Encrypted remote access.	Exposed services and data theft.
	DDoS Protection: Protection against scaled attack forms.	Massively scaled attacks that overwhelm services.

Applications	Security Capability	Threat
Applications: Management, servers, database, load balancer.	**Application Visibility Control:** Inspects network communications.	Unauthorized access and malformed packets connecting to services.
	Web Application Firewall: Advanced application inspection and monitoring.	Attacks against poorly developed applications and website vulnerabilities.
	File Analysis: Inspects and analyzes suspicious files.	Zero-day malware and attacks.
	TLS Encryption Offload: Accelerated encryption of data services.	Theft of unencrypted traffic.
Storage: Cloud storage.	**Disk Encryption:** Encryption of data at rest.	Theft of unencrypted data.
Servers:	**Server-based Security:** Security software for servers with the following capabilities:	Viruses or malware compromising systems.
	Anti-Malware: Identify, block, and analyze malicious files and transmissions.	Malware distribution across servers.

Applications (continued)	Security Capability	Threat
Servers:	**Cloud Security:** Security services from the cloud	Redirection of session to malicious website.
	Flow Analytics: Network traffic metadata identifying security incidents.	Traffic, telemetry, and data exfiltration from successful attacks.
	Application Dependency Mapping:	Exploiting a misconfigured firewall policy
	Vulnerability Assessment and Software Inventory:	Exploiiting unpatched or outdated applications.
	Process Anomaly Detection & Forensics:	Exploiting privileged access to run shell code.
	Tagging: Grouping for Software Defined Policy	Unauthorized access and malicious traffic between segments.
	Policy Generation, Audit, and Change Management:	Targeted attacks taking advantage of known vulnerabilities.
	Host-based Firewall: Provides micro-segmentation and policy enforcement.	Unauthorized access and malformed packets connecting to server.
	Disk Encryption: Protect information at rest.	Unauthorized access to system-stored data.

Management		Security Capability		Threat	
	Management, Control, and Monitoring		**Analysis/Correlation:** Security event management of real-time information		Diverse and polymorphic attacks.
			Anomaly Detection: Identification of infected hosts scanning for other vulnerable hosts.		Malware distribution across servers.
			Identity/Authorization: Centralized identity and administration policy.		Viruses compromising systems.
			Logging/Reporting: Centralized event information collection.		Redirection of session to malicious website.
			Monitoring: Network traffic inspection.		Unauthorized access and malformed packets connecting to server.
			Policy/Configuration: Unified infrastructure management and compliance verification.		Targeted attacks taking advantage of known vulnerabilities.
			Vulnerability Management: Continuous scanning, patching, and reporting of infrastructure.		Unauthorized access to system-stored data.

Architecture

SAFE underscores the challenges of securing the business. It enhances traditional network diagrams to include a security-centric view of the company business. The Secure Cloud architecture is a logical grouping of security and network technology that supports business use cases.

SAFE business flow security architecture depicts a security focus. A SAFE logical architecture can have many different physical designs.

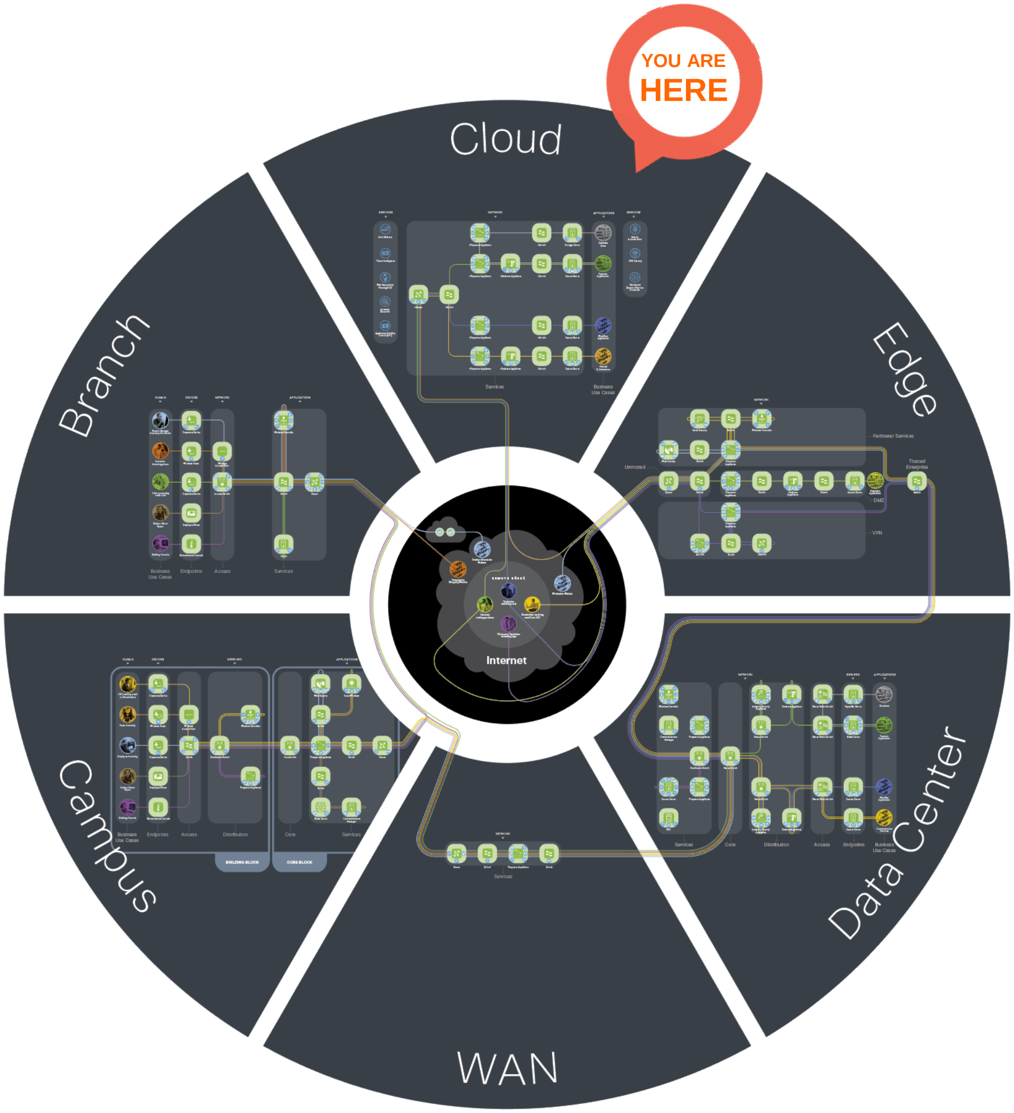


Figure 8 *SAFE Model. The SAFE Model simplifies complexity across a business by using Places in the Network (PINs) that it must secure.*

Secure Cloud

The Secure Cloud architecture has the following characteristics:

- Visibility with centralized management, analytics, and shared services
- A core connecting distribution and application-centric layers
- Software-defined network segmentation
- Software-defined application segmentation
- Virtual servers requiring secure network access connectivity

Humans and devices are part of the attack surface, but are not part of the architecture within the secure cloud.

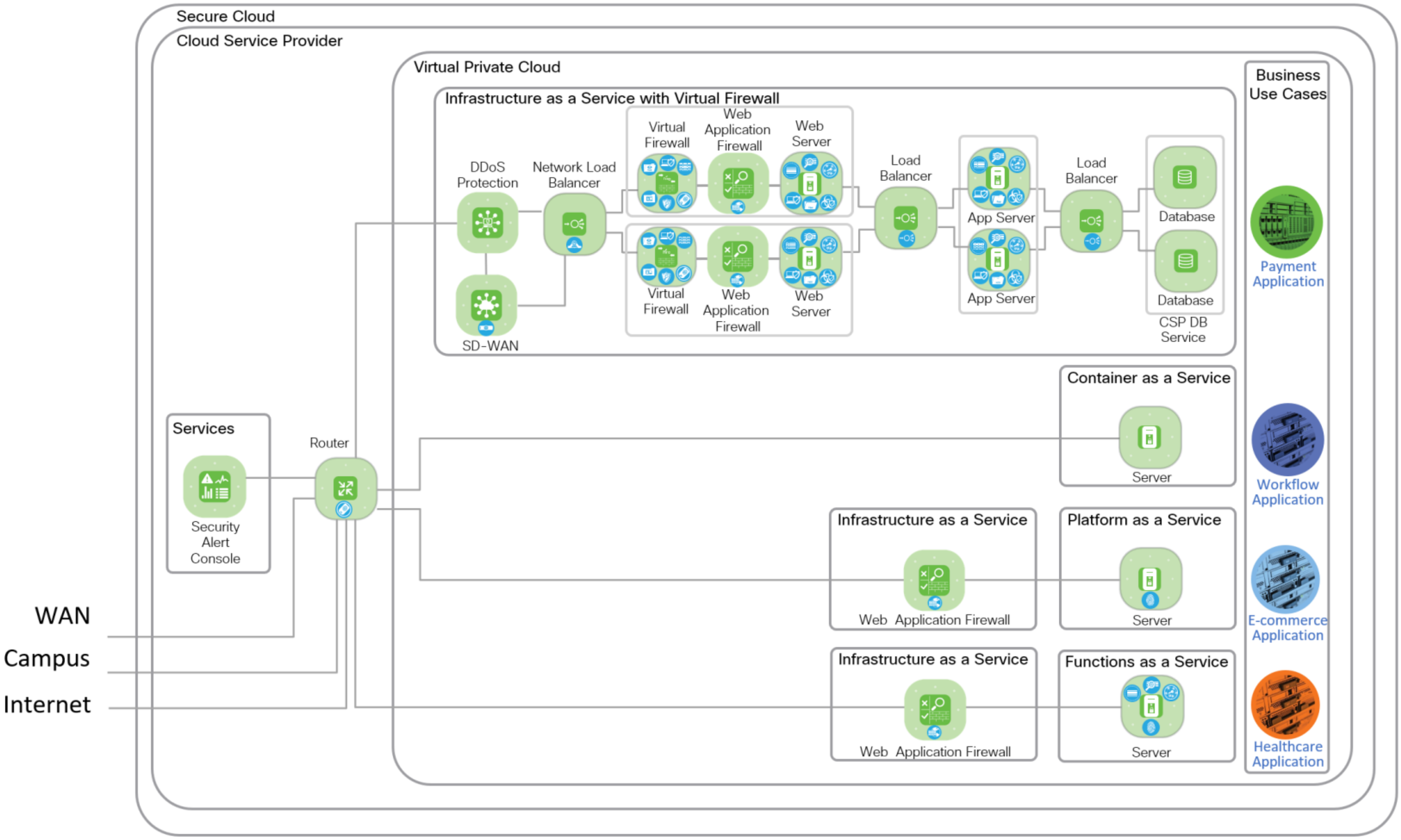


Figure 9 ***Secure Cloud PIN***. *The Secure Cloud business flows and security capabilities are arranged into a logical architecture. Business use cases flow through the green architecture icons with the required blue security capabilities*

Attack Surface

The Secure Cloud attack surface (Figure 7) consists of Humans, Devices, Network, and Applications. A successful breach gives an attacker the "keys to the kingdom."

Security includes these considerations:

- Human administrators can be located anywhere
- Network security is required for applications hosted in public cloud
- Applications and data contain vital company information
- Application orchestration centralizes control of security, network, and server elements into a single critical target

The sections below discuss the security capability that defends the threats associated with each part of the attack surface.

Humans

Typically, humans are administrators for the secure data center, secure cloud and public SaaS applications.

No amount of technology can prevent successful attacks if the administrators themselves are compromised. Administrators that are disgruntled (fired, demoted, bullied, ideology), compromised (blackmail, threats, bribery), or have had their credentials stolen (phishing, key logger, password reuse) are the single biggest risk in the security of a company.

Administrators have a higher level of access than normal users which requires additional controls:

- Multi-factor authentication
- Limited access to job function
- Logging of administrator changes
- Dedicated, restricted workstations
- Removal of old administrator accounts

The primary security capability is Identity. One of the primary threats is "Unauthorized Network Access". A strong Identity solution is required to mitigate against this threat.

Devices

The administrator's device (i.e. laptop, tablet) is used to access tools that administrators use to control and monitor systems that maintain and secure the business applications whether they are secure data center, secure cloud or public SaaS applications. Administrators connect to centralized management systems using secure connectivity with strong encryption (SSH, TLS, VPN) and multi-factor authentication from a variety of devices.

The primary security capabilities are Client-Based Security and Posture Assessment for the device. Client-Based Security includes VPN client, Anti-Malware and Secure Internet Gateway capabilities.

Network

The network is located in a virtual private cloud hosted by a cloud service provider. The foundational capabilities: Firewall, Intrusion Prevention and Tagging are required for protecting the application in the cloud. The cloud service providers offer default firewall capabilities for the various cloud service types they offer. For IaaS deployments, Firepower Threat Defense Virtual (FTDv) provides extensive L4-L7 firewall protection capabilities with integrated intrusion prevention in the same virtual machine. The tagging capability will vary by cloud service and could include: VLANs, VXLANs or Security Group Tags (TrustSec).

The foundational capabilities include Anti-Malware, Threat Intelligence and Flow Analytics. One of the primary threats is “Malware propagation” and anti-malware detection of network traffic is required. To mitigate against this threat, the anti-malware solution should operate in-line with the traffic. Advanced Malware Protection for Networks (AMP4N) is enabled FTDv, as well as many of the Cisco security products.

Threat Intelligence is required and all Cisco security products are connected to Talos Intelligence to stay current with cyber threats. Analysis of the traffic is key to visibility, you can’t protect yourself unless you can see it. Stealthwatch cloud is recommended to analyze the traffic to and within the virtual private cloud hosting the applications, and can aggregate different CSPs analytics as well as on-prem data centers.

The business capabilities include Distributed Denial of Service Protection and we have partners in the Appendix B that offer this capability.

Applications

The servers are the endpoints in the cloud that host web services, applications, and databases. The access capabilities to secure them are Server-Based Security and Posture Assessment. Server-Based Security requires Anti-Malware, Host Based Firewall, Posture Assessment and Patching, Cloud Security, and Disk Encryption.

Tetration provides the Host Based Firewall capability including micro-segmentation, tagging for software defined policy, and enforcement. Tetration is also provides Posture Assessment and Patching.. The Anti-Malware capability is required and Cisco’s Advanced Malware Protection for Endpoints (AMP4E) is recommended.

To secure access to applications beyond foundational and access capabilities, business capabilities must be deployed to manage business risks introduced by the business practice. The primary security capabilities Application Visibility Control, Web Application Firewall, TLS Offload and File Analysis.

Summary

Today's companies are threatened by increasingly sophisticated attacks. Public Cloud services hosting business applications are targeted because they store the company's data.

Cisco's Secure Cloud architecture defend the business against corresponding threats using an architectural approach that overcomes the limitations of a point product offering.

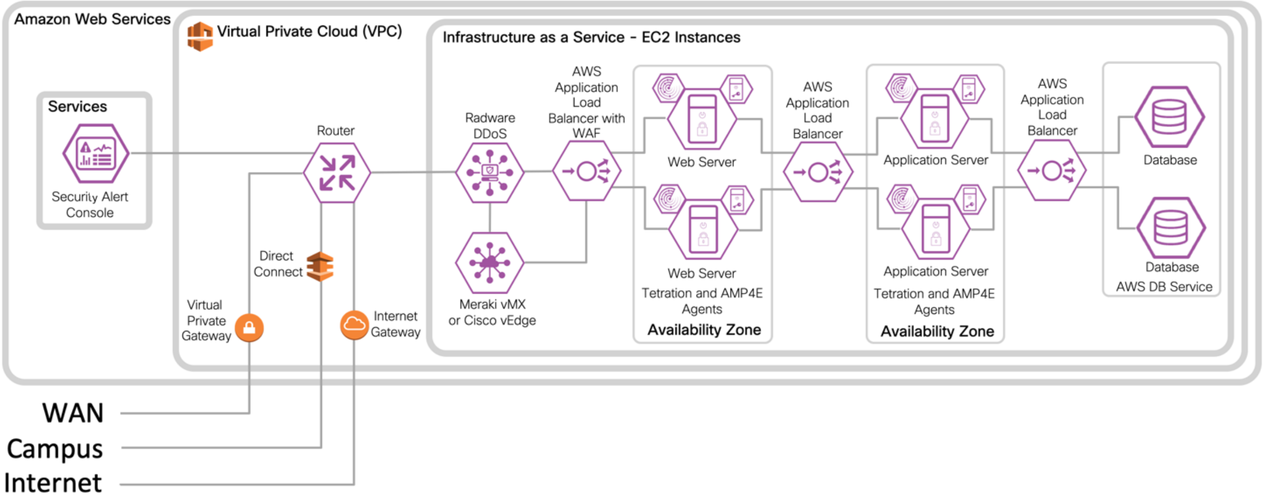
SAFE is Cisco's security reference architecture that simplifies the security challenges of today and prepares for the threats of tomorrow.

Appendix A – Proposed Designs

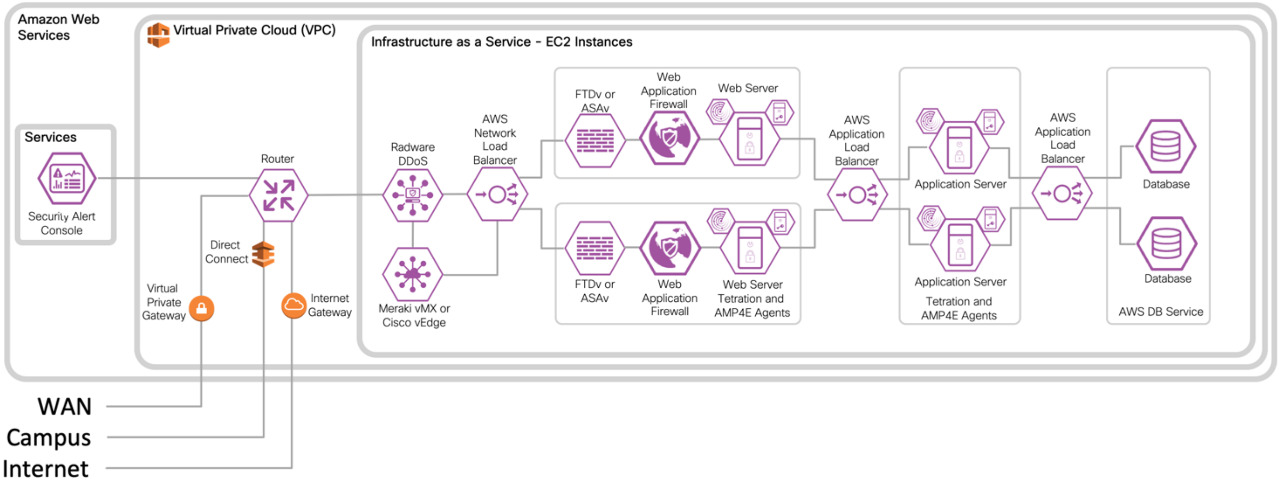
This Appendix includes some proposed design examples for Amazon Web Services, Microsoft Azure, and Google Cloud Platform.

Amazon Web Services

IaaS Design with 3-Tier Web Application

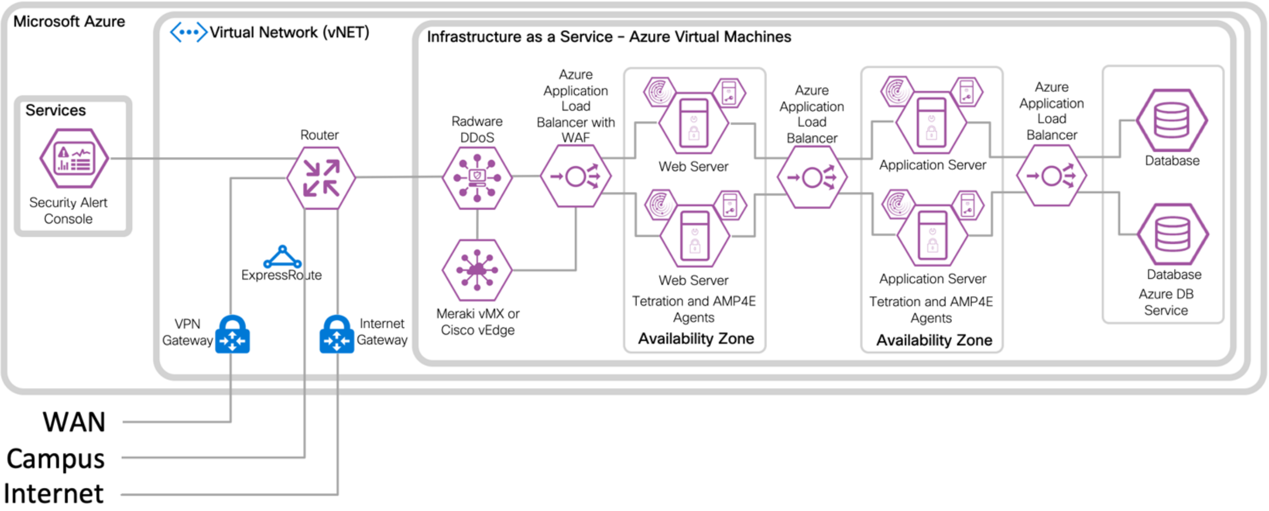


IaaS with Virtual Firewall Design with 3-Tier Web Application

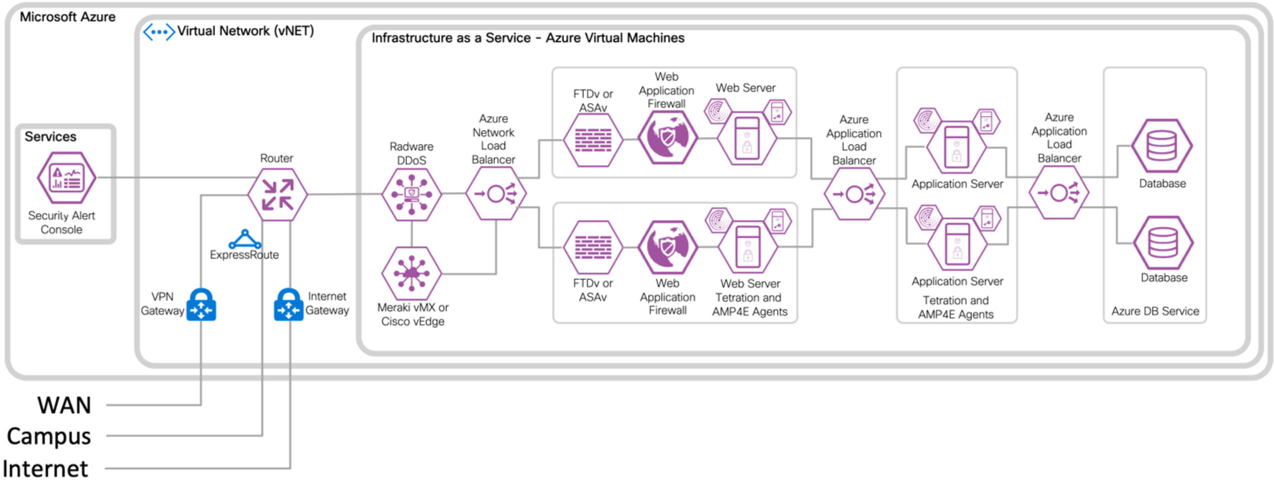


Microsoft Azure

IaaS Design with 3-Tier Web Application

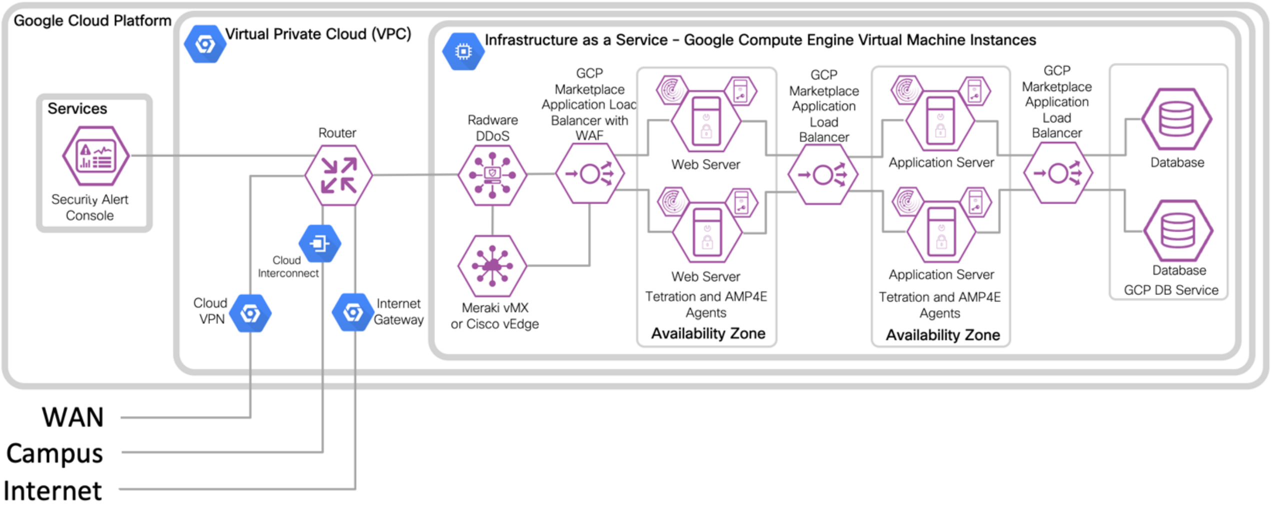


IaaS with Virtual Firewall Design with 3-Tier Web Application

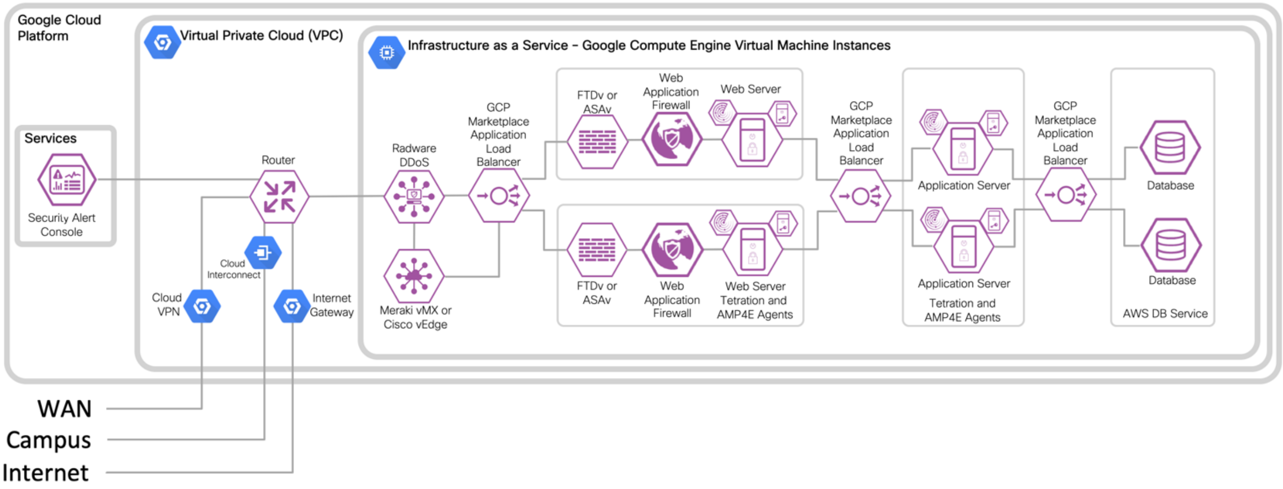


Google Cloud Platform

IaaS Design with 3-Tier Web Application


Google Cloud Platform
Virtual Private Cloud (VPC)
Infrastructure as a Service – Google Compute Engine Virtual Machine Instances
Services
Security Alert Console
Router
Cloud Interconnect
Cloud VPN
Internet Gateway
Radware DDoS
Meraki vMX or Cisco vEdge
GCP Marketplace Application Loac Balancer with WAF
Web Server
Web Server
Tetration and AMP4E Agents
Availability Zone
GCP Marketplace Application Load Balancer
Application Server
Application Server
Tetration and AMP4E Agents
Availability Zone
GCP Marketplace Application Load Balancer
Database
Database
GCP DB Service
WAN
Campus
Internet

IaaS with Virtual Firewall Design with 3-Tier Web Application


Google Cloud Platform
Virtual Private Cloud (VPC)
Infrastructure as a Service – Google Compute Engine Virtual Machine Instances
Services
Security Alert Console
Router
Cloud Interconnect
Cloud VPN
Internet Gateway
Radware DDoS
Meraki vMX or Cisco vEdge
GCP Marketplace Application Load Balancer
FTDv or ASAv
Web Application Firewall
Web Server
FTDv or ASAv
Web Application Firewall
Web Server Tetration and AMP4E Agents
GCP Marketplace Application Load Balancer
Application Server
Application Server Tetration and AMP4E Agents
GCP Marketplace Application Load Balancer
Database
Database
AWS DB Service
WAN
Campus
Internet

Appendix B - Suggested Components

Table 4 SAFE Design Components for Secure Cloud

Secure Cloud Attack Surface		Security Capability	Suggested Cisco Components
Human	Users	Identity	Duo Meraki Mobile Device Management
Devices	Endpoints	Client-Based Security	AnyConnect Advanced Malware Protection (AMP) for Endpoints Cisco Umbrella
		Posture Assessment	AnyConnect Agent Duo Identity Services Engine (ISE) Meraki Mobile Device Management
Network	Cloud Network Infrastructure	Firewall	Firepower Threat Defense Virtual Adaptive Security Appliance Virtual Cloud Services Router
		Intrusion Prevention	Firepower Threat Defense Virtual Firepower NGIPS Virtual
		Tagging	VLANs/VXLANs TrustSec ACI Anywhere

Secure Cloud Attack Surface		Security Capability		Suggested Cisco Components
Network (continued)	Analysis		Anti-Malware	Cisco AMP for Networks
			Threat Intelligence	Talos Threat Intelligence Cognitive Threat Analytics Cisco Threat Response
			Flow Analytics	Stealthwatch Cloud
	WAN		Virtual Private Network (VPN) or Software Defined WAN (SD-WAN)	Meraki Virtual MX vEdge Router Cloud Services Router Firepower Threat Defense Virtual Adaptive Security Appliance Virtual
			VPN Gateway or Concentrator	Firepower Threat Defense Virtual Adaptive Security Appliance Virtual
			DDoS Protection	Cisco Partners: Radware

Secure Cloud Attack Surface		Security Capability	Suggested Cisco Components
Applications	Application	Application Visibility Control	Meraki Virtual MX Firepower Threat Defense Virtual Adaptive Security Appliance Virtual
	Application	Web Application Firewall	Cisco Partners: Radware AVI Networks CSP WAF
	Application	File Analysis	Cisco Threat Grid
	Application	TLS Encryption Offload	Cisco Partners: Radware AVI Networks CSP Load Balancer
	Storage	Disk Encryption	Cisco Partners: Cloud Storage Provider
	Server	Server-Based Security	
		Anti-Malware	Cisco AMP for Endpoints
		Cloud Security	Umbrella
		Flow Analytics	Tetration
		Application Dependency Mapping	Tetration
		Vulnerability Assessment and Software Inventory	Tetration

Secure Cloud Attack Surface		Security Capability	Suggested Cisco Components
Applications (continued)	Server (continued)	Process Anomaly Detection & Forensics	Tetration
		Tagging	Tetration
		Policy Generation, Audit, and Change Management	Tetration
		Host-based Firewall.	Tetration
		Disk Encryption	Cisco Partners: Cloud Storage Provider
Management	Management, Control, and Monitoring	Analysis/Correlation	Cisco Threat Response Stealthwatch Cloud
		Anomaly Detection	Cisco Threat Response Stealthwatch Cloud
		Identity/Authorization	Duo Meraki Mobile Device Manager
		Logging/Reporting	Stealthwatch Cloud
		Monitoring	Stealthwatch Cloud AppDynamics
		Policy/Configuration	Cisco Defense Orchestrator Tetration
		Vulnerability Management	Meraki Dashboard Stealthwatch Cloud Tetration

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