Cloud Security and Compliance for cloud services development and assessment

Dr. Yuri Demchenko
University of Amsterdam

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Outline

Part 1. Big Data and Cloud Security
- Cloud security models, services and mechanisms
- Cloud Security best practices: AWS and Microsoft Azure

Part 2. Cloud Compliance and (Self-) Assessment
- Compliance standards, Security Controls
- CSA GRC Stack: Governance, Risk Management and Compliance
- PCI DSS Cloud Computing Guidelines

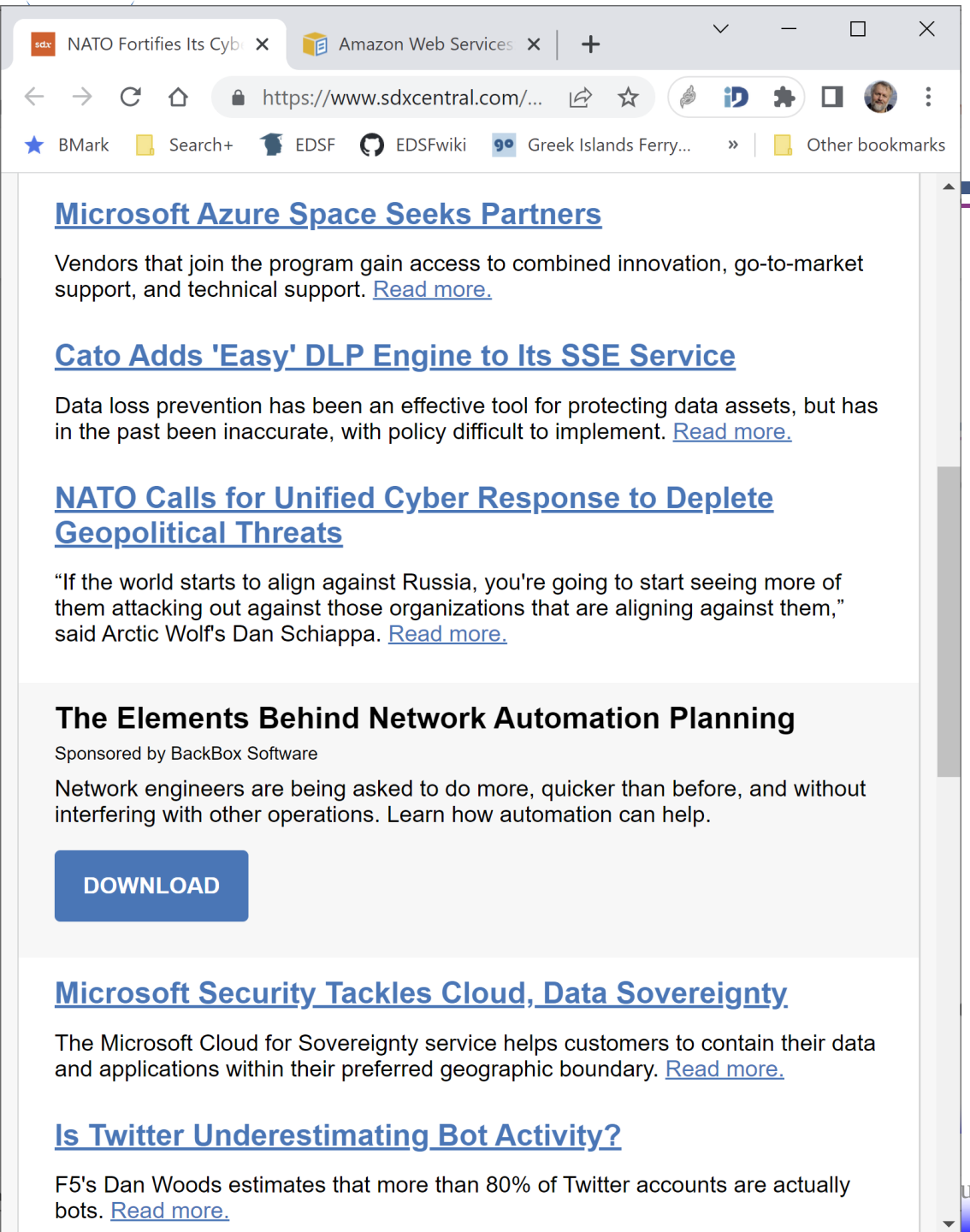
Part 3. Cybersecurity, Privacy protection and regulations (Addendum)
- Privacy related standards
- EU General Data Protection Regulation (GDPR)
- European Cybersecurity regulation

Part 4. Practice
- CSA Consensus Assessment Initiative Questionnaire

- Tutorial and practice materials
  https://drive.google.com/drive/folders/1nCqA0n51bS_98ACUudrAeqM468aZl7hq?usp=sharing

Recent global security attacks

- SolarWind – Software Supply Chain attack
  - Malicious code infiltrated into Windows and apps supply chain
  - Possible access of Windows code repository
  - Caused security update and re-design of Windows codebase
- CodeCov – targeting development process
  - Codecov breach allowed the attackers to export information stored in its users' continuous integration (CI) environments
- Java log4j library – used in most of telecom equipment



Security & Continuous Awareness

SDX Central Newsletters 21 July 2022

- NATO Calls for Unified Cyber Response to Deplete Geopolitical Threats
  - "If the world starts to align against Russia, you're going to start seeing more of them attacking out against those organizations that are aligning against them," said Arctic Wolf's Dan Schiappa.
- Microsoft Security Tackles Cloud, Data Sovereignty
  - The Microsoft Cloud for Sovereignty service helps customers to contain their data and applications within their preferred geographic boundary.

Part 1. Cloud Security and best practices

- Cloud security models, services and mechanisms
- Cloud Security best practices: AWS and Microsoft Azure

Cloud Computing Security – Challenges

- Fundamental security challenges and main user concerns in clouds
  - Data security: Where are my data? Are they protected? What control has cloud provider over data security and location?
  - Identity management and access control: Who has access to my personal/ID data?
  - Trusted execution environment: Are algorithms and data protected during execution on cloud?

- Three main tasks in making cloud secure and trustworthy
  - Secure operation of the cloud (provider) infrastructure
  - User controlled access control (security) infrastructure
    - Provide sufficient amount of security controls for competent user
  - Provide secure environment for data processing and customer application software

- Services on demand: Cloud security infrastructure should provide a framework for dynamically provisioned cloud security services and infrastructure as a part of the main services

Adopting Public Cloud – Security Practices (Cloud Native)

- **Developing a cloud-centric cybersecurity model.**
  - Companies need to make choices about how to manage their perimeter in the cloud and how much they will rearchitect applications in a way that aligns with their risk tolerance, existing application architecture, resources available, and overall cloud strategy.
- **Redesigning a full set of cybersecurity controls for the public cloud.**
  - For each individual control, companies need to determine who should provide it and how rigorous they need to be.
- **Clarifying internal responsibilities for cybersecurity, compared to what providers will do.**
  - Public cloud requires a shared security model, with providers and their customers each responsible for specific functions. Companies need to understand this split of responsibilities—it will look very different from a traditional outsourcing arrangement—and redesign internal processes accordingly.
- **Applying DevOps to Security - DevSecOps – Introducing Security in the development process**
  - If a developer can spin up a server in seconds, but has to wait two weeks for the security team to sign off on the configuration, that attenuates the value of the public cloud's agility. Companies need to make highly automated security services available to developers via APIs, just as they are doing for infrastructure services.

Mentimeter Question 3 What security concepts are you familiar with?

Question 3 What security concepts are you familiar?

1. Authentication or Auhorisation
2. OAuth2.0
3. Trust Management
4. PKI or X509 Certificate, Certification Authority
5. Public key or asymmetric cryptography
6. Blockchain
7. Firewall and firewall policy
8. Exposure, Vulnerability, Intrusion, Incident - meaning and difference
9. Compliance and compliance assessment
10. GDPR

Security Basics: What should you know about Security?

- Password is a basis for secure access but it is not enough to secure your applications and services.
  - There is whole stack of network and infrastructure or platform security services and mechanisms which need to be applied in a consistent way to ensure high system ***dependability*** and ***availability***
- Basis for secure communication and data transfer are the security protocols and security mechanisms
  - Security services are defined for communicating entities and can work at different layers
  - Security mechanisms can be used by services and functional components to achieve one or another aspect of security
- Security is an overloaded term and may mean different aspects

  Network/communication Security - Data Security – Application Security - Operation Security – System Security

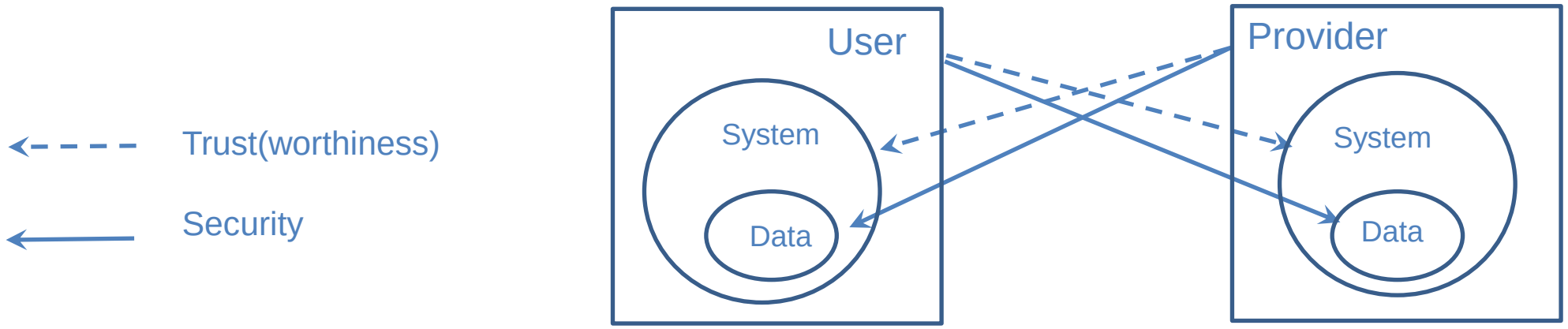
- What kind of data to protect
  - **Application Data – Personal Data (User ID, personal information) – Software – Infrastructure management data**
- Data security must be considered for at least 3 aspects

  Data in transfer (Communication) – Data in-rest (Stored) – Data at run-time (Processed)

- Relations between Security and Trust
  - Trust or trust relations is a foundation of the security protocols and services

Different sides of Security and Trust

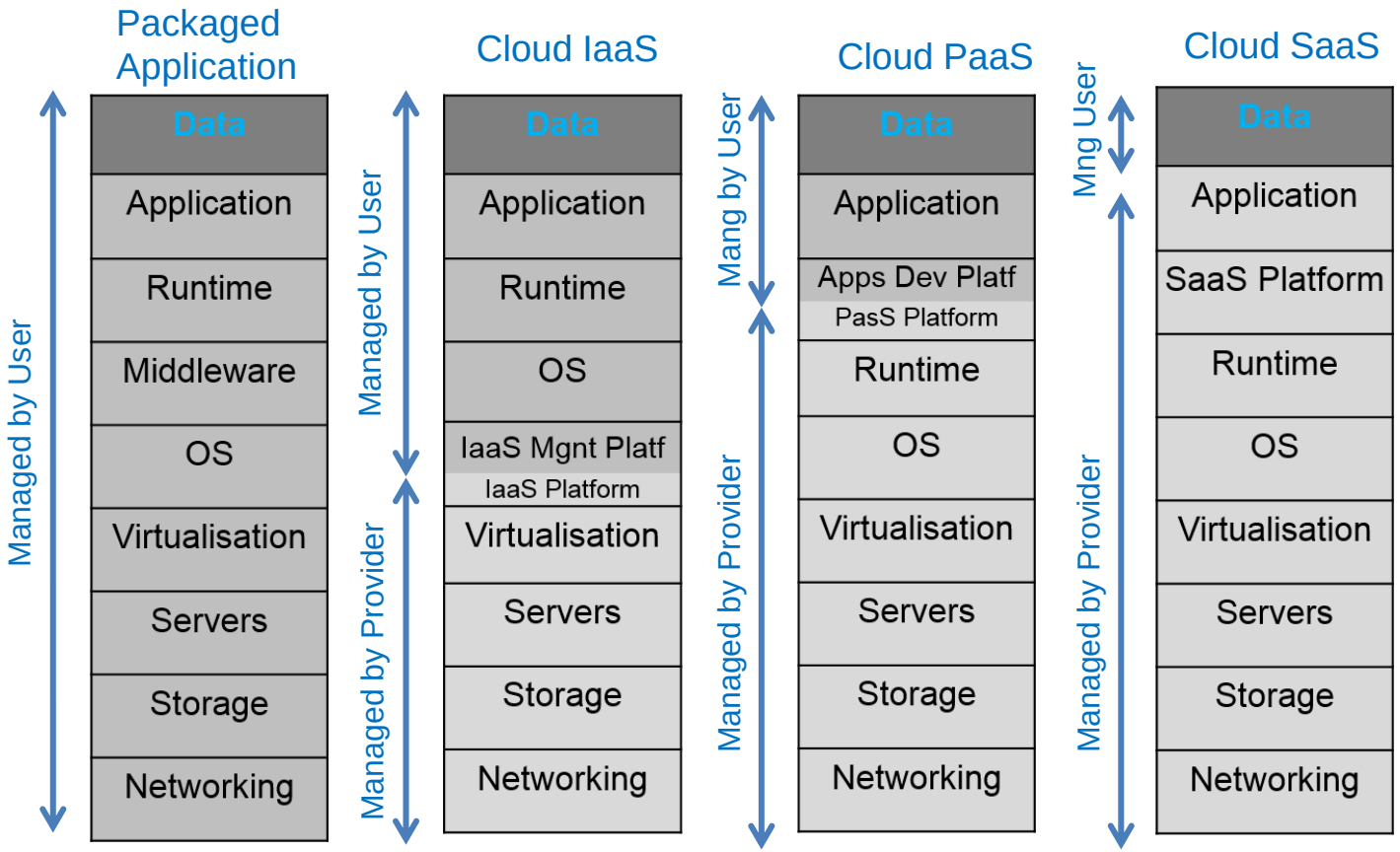
- Modern paradigm of remote distributed services and online/downloadable digital content provisioning makes security and trust relations between User and Provider more complex
- User and Service Provider – the two actors concerned with own Data/Content security and each other System/Platform trustworthiness
- Two other aspects of security/trust
  - Data stored vs Data processed
  - System Idle vs Active (running User session)



Cloud Environment and Issues to be addressed

- Virtualised services and environment
- On-demand provisioning and dynamic scalability: Resources and Accounts provisioning
- Multi-tenant platform security and multi-user services access control
  - Tenants' storage and runtime separation in cloud
  - Fine grained access control in the tenants' applications
- New cloud oriented security services models
  - Provider – Customer/Tenant – Services - User of services
    - Enterprise as a Customer, and employees as Users
- Uncontrolled execution and data storage environment
  - Promising homomorphic/elastic encryption (still at research stage)
  - Emerging Confidential Computing and Intel SGX architecture
- Security services are provisioned on-demand (as part of virtualised infrastructure) and require bootstrapping with the customer services and trust domain
  - **Bootstrapping** cloud and customer trust domains to ensure trusted environment for data processing and storage
- Integration with customer legacy security services and infrastructure
  - Campus/office local network/accounts

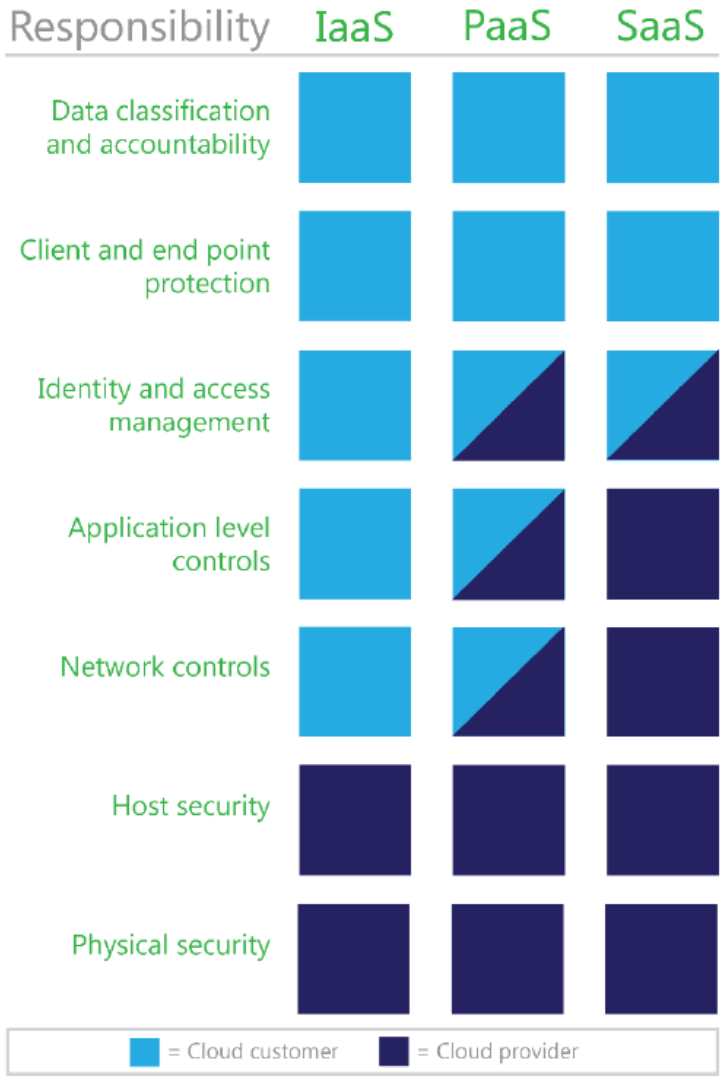
Responsibilities Split in IaaS, PaaS, SaaS



Security management responsibilities split between Customer and Provider for IaaS, PaaS, SaaS service models

- Updating firmware and software for platform and for customer managed components
- Firewall is intrusion prevention is a responsibility of the cloud provider
- Certification and compliance of the cloud platform doesn't imply security and compliance of the customer controlled components

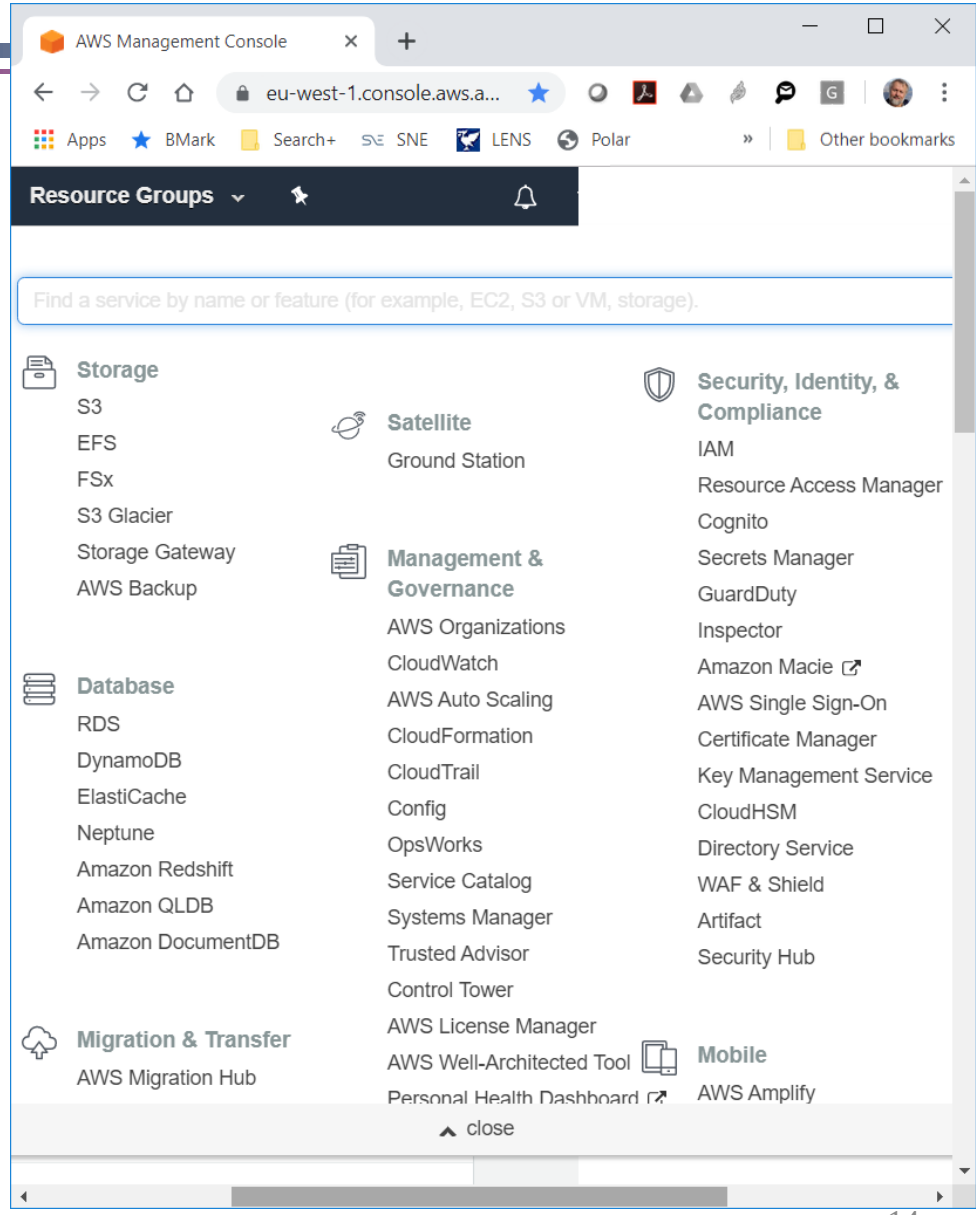
Data Protection Obligations by CSP and Customers (PCI DSS model)



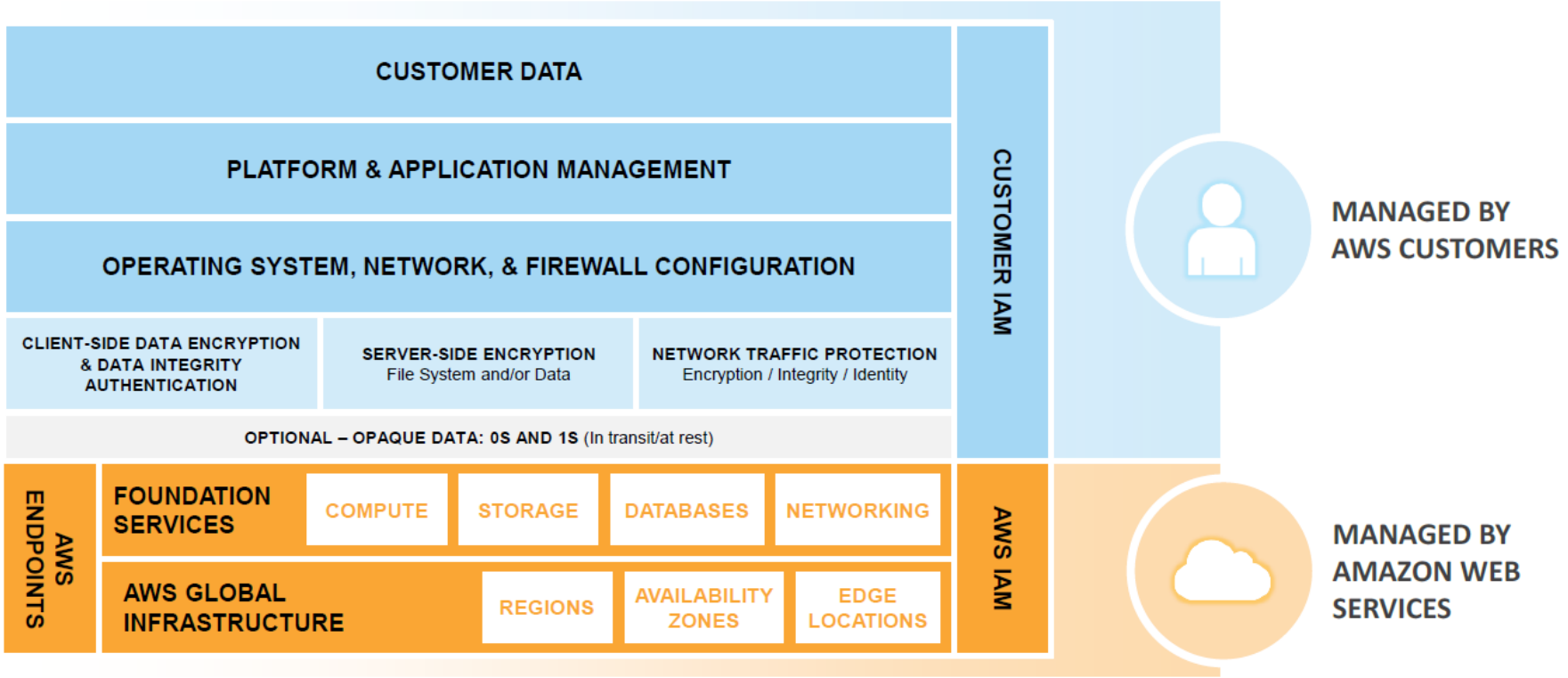
- Although customers are responsible for classifying their data, **cloud providers should make written commitments** to customers about the privacy of the customer data stored within their cloud.
- These commitments should include **information about privacy and security practices, data use limitations, and regulatory compliance**.
- Cloud providers should make **certifications and audit reports** that demonstrate compliance with key standards and regulations
- Customers should not migrate data to a cloud provider that cannot address their data protection needs.

Case Study: AWS Security Mechanisms

- VPC – Virtual Private Cloud
  - VPN – Virtual Private Network
    - Private and Public subnets
  - VPG – VPN Private Gateway
  - IGW – Internet Gateway
- HTTPS and TLS/SSL, SSH, PKI
- AIM – Access and Identity Management
- Other security services
  - AWS SSO
  - Cognito – Identity Federation
  - Macie - Data visibility security service
  - CloudHSM - Managed hardware security module (HSM)



Example: Security responsibility sharing in AWS IaaS infrastructure services



AWS Identity and Access Management (IAM) over Amazon EC2 and S3 infrastructure services

- For other cloud service models PaaS and SaaS the responsibility of AWS goes up to OS, network and firewall for PaaS, and also includes the application platform and container for SaaS.
  - However, the responsibility for data remains with the customer.

[ref] Todorov, D. & Ozkan, Y. (November 2013) 'AWS security best practices', Amazon Web Services [Online]. Available from: http://media.amazonwebservices.com/AWS_Security_Best_Practices.pdf

AWS Security – Shared Responsibility Model

AWS implements the ***Shared Responsibility Model*** that splits responsibility for the security of different layers and components between AWS as a provider and a customer or tenant.

AWS as a cloud provider ensures the security of the cloud infrastructure and cloud platform services:

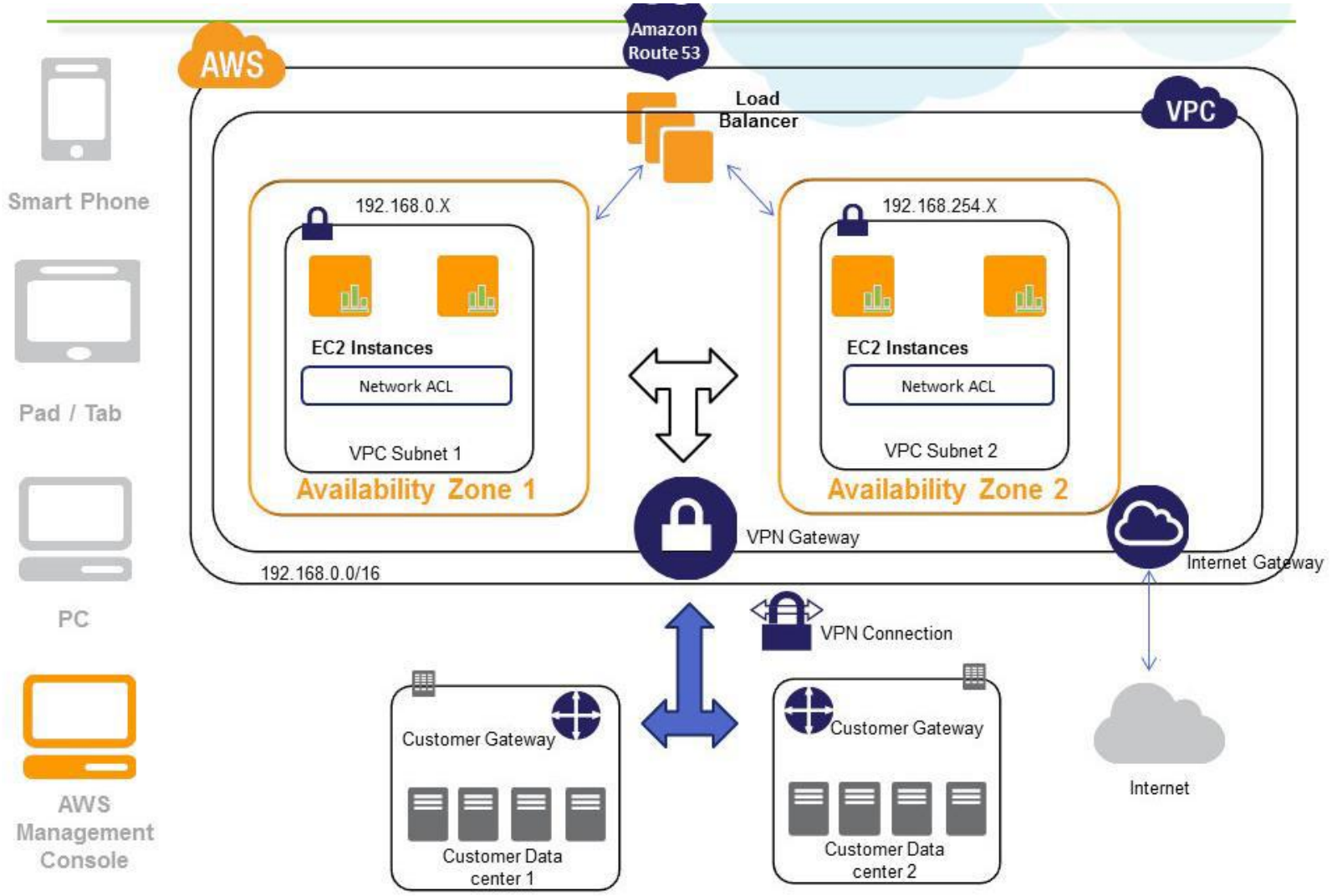
- Facilities
- Physical security of datacentre
- Network infrastructure
- Virtualisation platform and infrastructure

While **the customer** is responsible for security of the following components:

- Amazon Machine instances, OS, and applications
  - Note, the customer is responsible for security update and patching of the guest OS and installed applications
- Data in transit, data at rest, and data stores
- Credentials, policies and configurations
- Comply with the Acceptable Use Policy (AUP), ensure correct use of the cloud platform

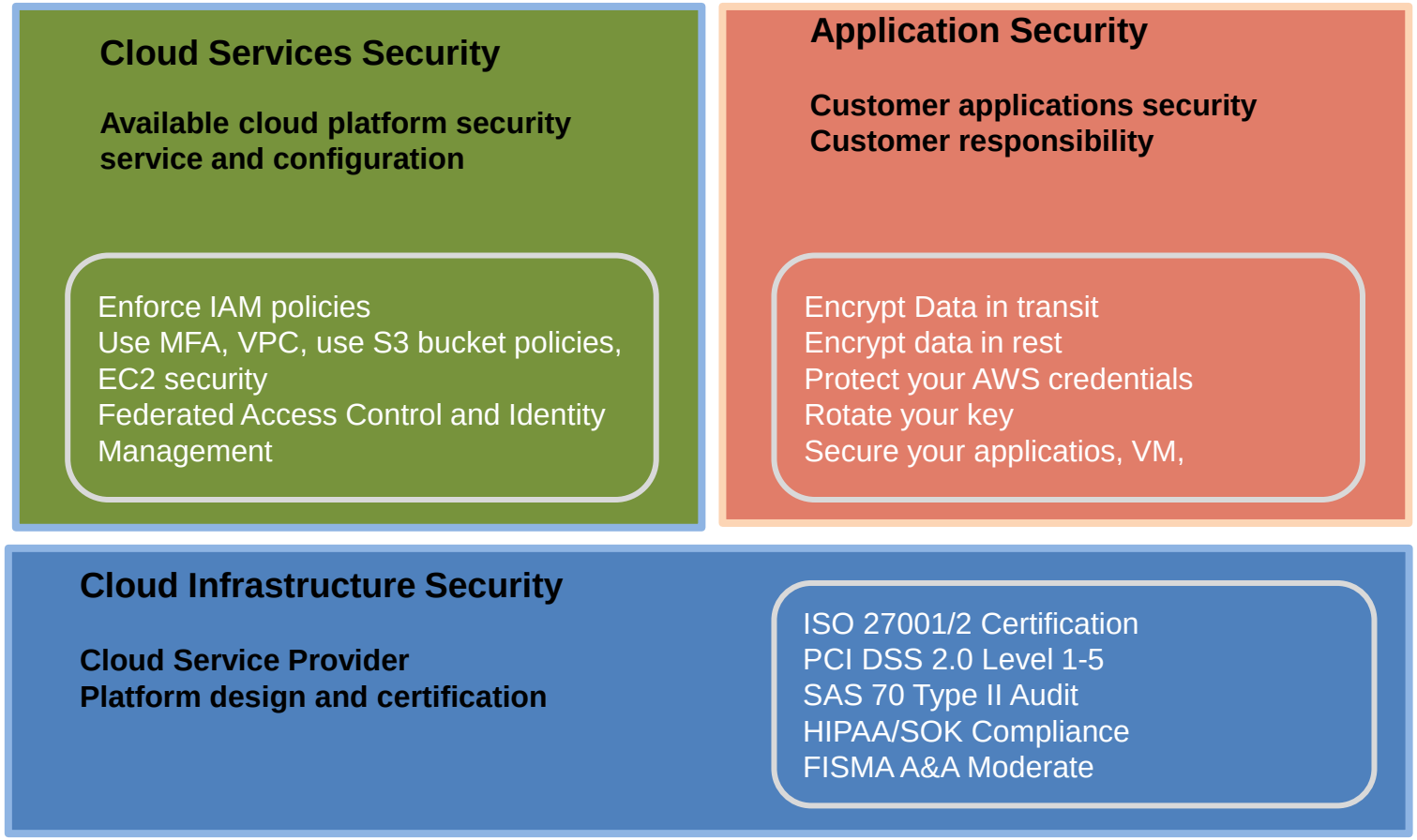
AWS VPC Structure

Spanning Availability Zones but Limited to Region



- VPC is a key security service and mechanism in ensuring secure and trusted customer environment in public cloud
- Can span multiple Availability Zones but limited to Region

Amazon Web Services Security Model



Security is declared as one of critical importance to AWS cloud that is targeted to protect customer information and data from integrity compromise, leakage, accidental or deliberate theft, and deletion.

- The AWS infrastructure is designed with the high availability and sufficient redundancy to ensure reliable services operation.

AWS Security Recommendations: Customer side

Recommended **security best practices** at each layer

- Protect your Amazon account
- Control internal access to AWS resources
- Limit external access to your cloud
- Protect data in transit and at rest
- Secure data assets
- Secure your compute assets (OS, instances, App)
- Backup for easy recover
- Keep track of your cloud resources (using monitoring service)

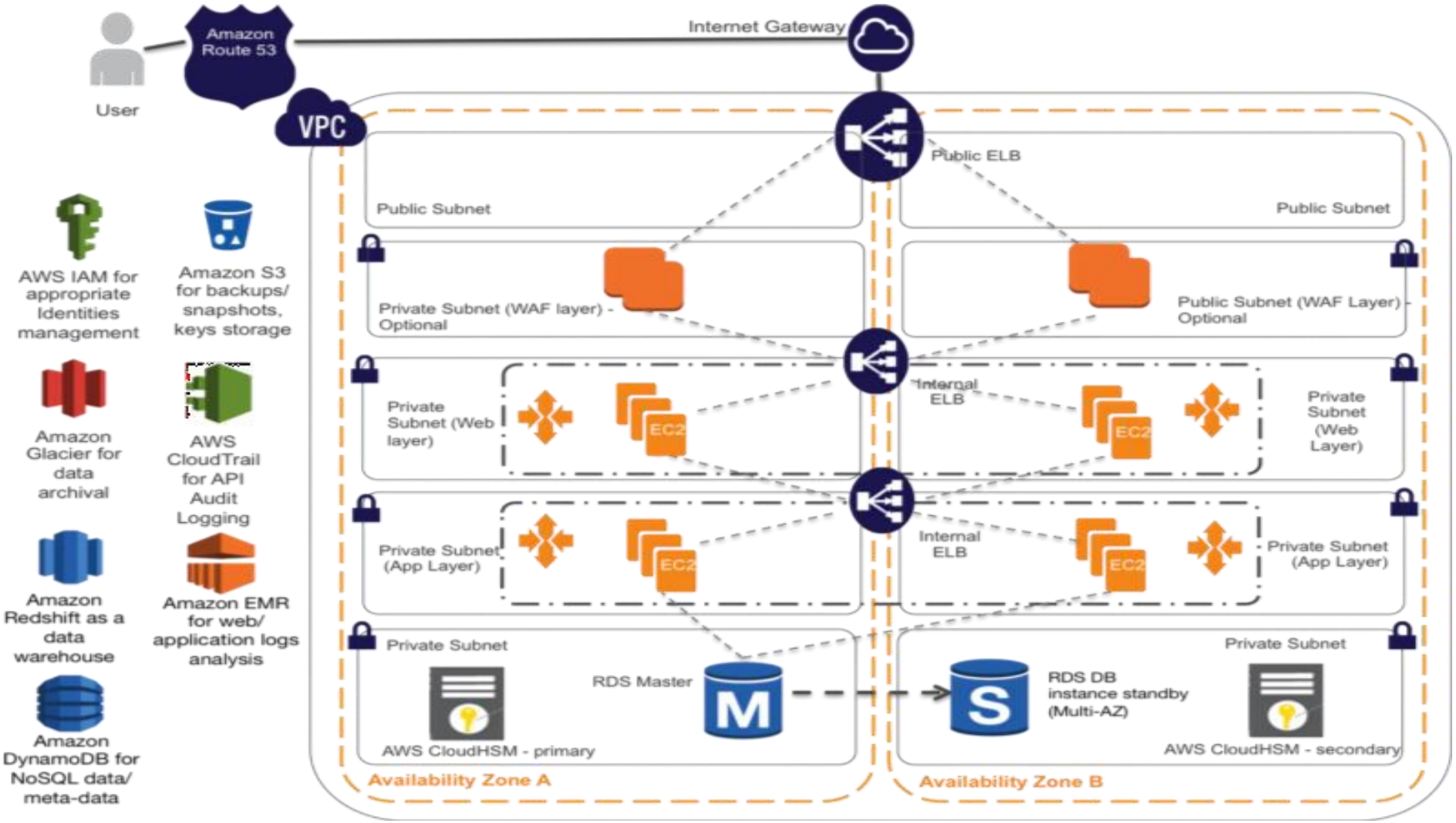
Security methods for customer cloud infrastructure

- Virtual Private Cloud (VPC) to create a secure environment for your cloud services in AWS
- Security zoning and network segmentation based on security groups, Network Access Control Lists, host based firewalls
- Network security and secure access for users and applications
- Threats protection layer in traffic flow to ensure protection against Denial of Service (DoS) attacks

[ref] D.Todorov, Y.Ozkan. AWS Security Best Practices. November 2013 [online] http://bit.lu/aws- security-best-practices-new

Example Applied Security Recommendations: Architecting **Healthcare Application for HIPAA Compliance**: VPC and Multiple Private Subnets

https://aws.amazon.com/blogs/startups/architecting-your-healthcare-application-for-hipaa-compliancepart-1/

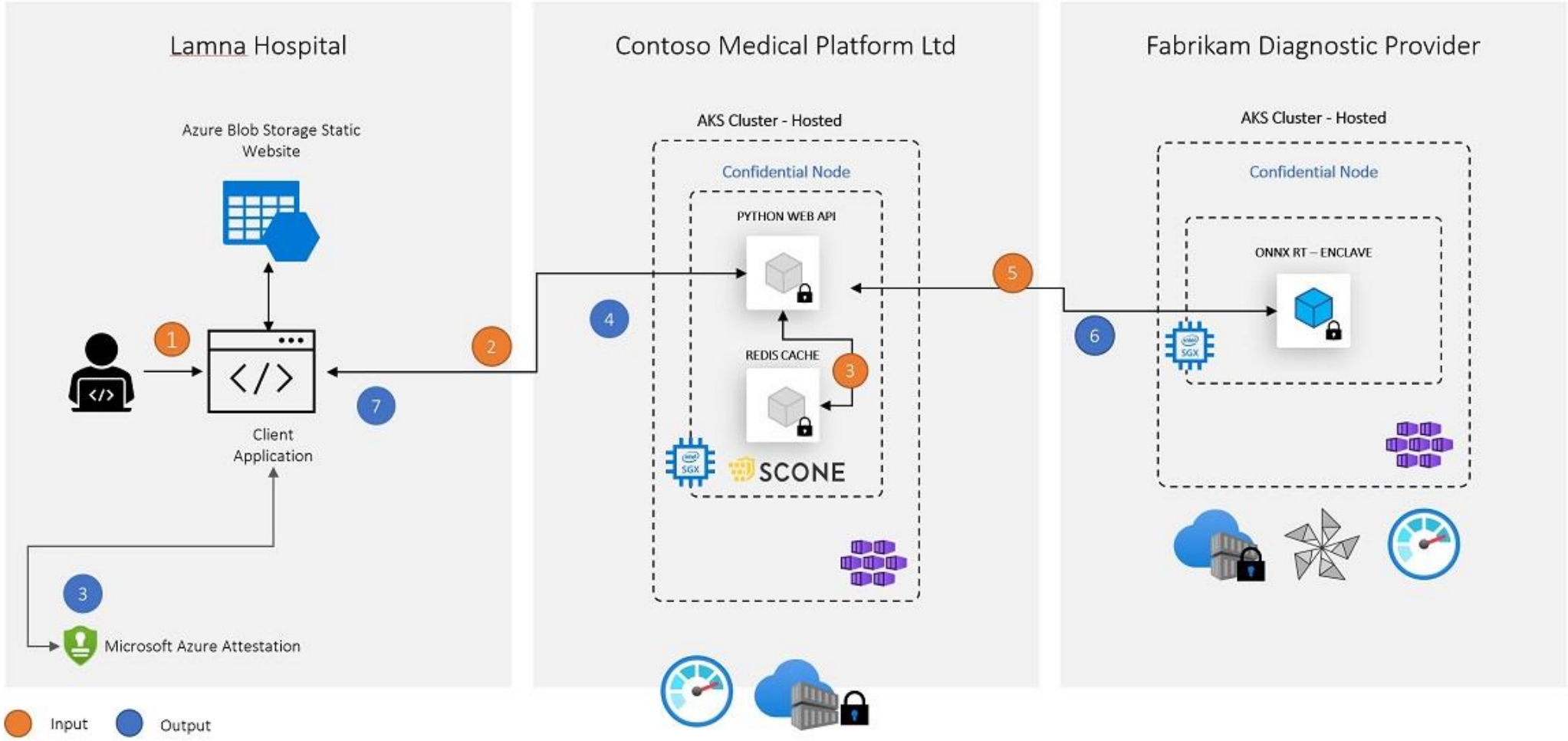


- VPC and Security Group are sufficient for strict Healthcare security compliance

Azure Confidential Computing

Confidential Healthcare Platform Demo

[Ref] https://techcommunity.microsoft.com/t5/microsoft-security-and/confidential-containers-nodes-now-supported-on-azure-kubernetes/ba-p/1726992



- AKS – Azure Kubernetes Service
- SCONE
- Open Enclave port
- ONNX – Open Neural Network eXchange
- Azure Attestation

Part 2. Cloud Compliance

- Compliance standards, Security Controls
- CSA GRC Stack: Governance, Risk Management and Compliance

Security and Compliance

- Security is commonly defined as a set of technical, physical, and administrative controls in order to ensure **normal operation of a system or application**
  - Security is often associated with the CIA triad Confidentiality, Integrity, Availability
  - Appropriate level of security requires organizations to take measures and comply to the numerous security controls

- Compliance is a **certification or confirmation** that the system or an organization meets the requirements of specified standards, established legislation, regulatory guidelines or industry best practices that can be jointly defined as compliance framework
  - A compliance framework can include business processes and internal controls the organization has in place to adhere to these standards and requirements
  - The framework should also map different requirements to internal controls and processes to eliminate redundancies

- Why it is important for cloud?
  - When moving to cloud, the organization moves from internal security and operational environment/context (that may not be formally defined) to external operational security that will become a part of SLA (or business requirement) with CSP
- Problem with achieving compliance for cloud based applications/solutions
  - Audit requirements are not designed for virtualised distributed environment
  - Lack of visibility in cloud: large CSP such as Amazon and Google are “walled/curtained gardens”
  - Requirements to allow CSP audit may involve Non-Disclosure Agreement (NDA) and risk of provider lock-in

Regulatory requirements to be considered for cloud compliance – General Standards

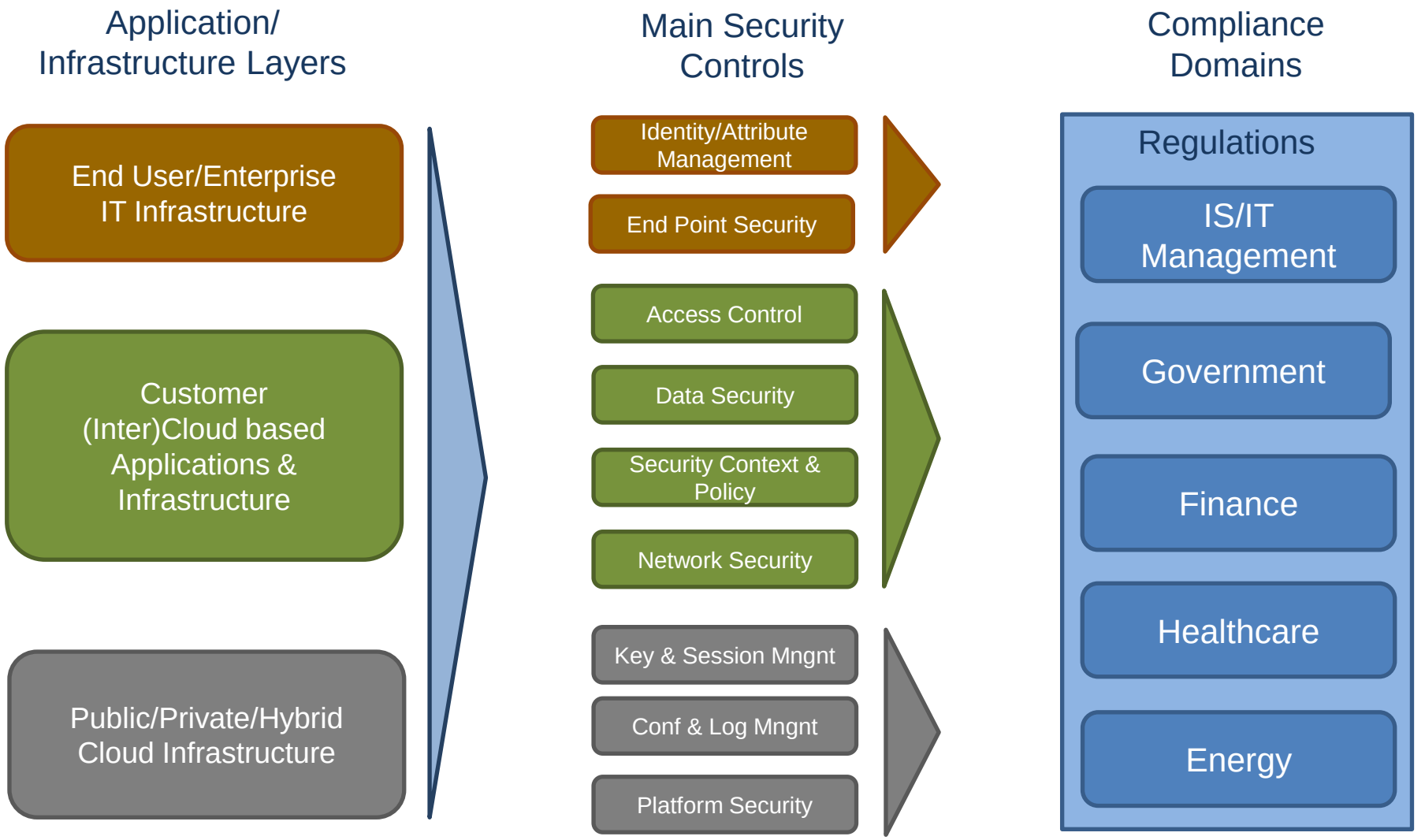
General standards and recommendations

- **ISO/IEC 27001:2005 Certification on security infrastructure**
  - Industry standard: the risk-based information security management program that follows a plan-do-check-act process
- NIST SP 800-53 Security Controls and ISO/IEC 15408 Evaluation Criteria
- HIPAA/HITECH - The U.S. Health Insurance Portability and Accountability Act (HIPAA) and Health Information Technology for Economic and Clinical Health (HITECH)
  - Act created by the US federal government include provisions to protect patients' private information.
- NIST SP 800-144 Guidelines for Security and Privacy in Cloud Computing
- Cloud Security Alliance (CSA) Security Guidance for Critical Area of focus in Cloud Computing
- ENISA Cloud Computing Security Risk Assessment
- **EU GDPR – General Data Protection Regulation**
- **EU Cybersecurity Certification (ENISA)**

Industry and Governmental Regulatory Requirements (USA)

- Service Organisation Control SOC 1 (SSAE 16/ISAE 3402) and SOC 2 and 3 (AT 101)
  - SOC 2 is a detailed attestation report (often restricted) for service organizations that contains strict standards for security, availability, processing integrity, confidentiality, and privacy.
  - SOC 3 is a general purpose report which summarizes the SOC 2 audit
- Sarbanes Oxley Act (SOX) also known as "Corporate and Auditing Accountability and Responsibility Act" set enhanced standards for all US public company boards, management and public accounting firms.
  - According to SOX act, top management must individually certify the accuracy of financial information.
- The Federal Information Security Management Act of 2002 (FISMA)
  - Describes security requirements for the protection of information and information systems in Federal systems
- Department of Defense Information Certification Accreditation Process (DIACAP)
- Federal Risk and Authorization Management Program (FedRAMP)
  - As of June 6, 2014, US federal agencies must utilize only cloud providers assessed and authorized through FedRAMP. List of authorized cloud providers is published:
    - Authorisation: AWS East-West US and AWS Governmental Community Cloud, SalesForce, USDA
    - Provisional Authorisation: Akamai, AT&T, IBM, Hewlett-Packard, Lockheed Martin, Microsoft Azure, Oracle

Mapping Compliance and Cloud Infrastructure Components



Security and Compliance Questions

The main questions that security and compliance auditors would ask you

- Where is our data going to reside?
  - Specifying location of data
- Who is going to look after it?
- Who is going to be able to see it?
- Is it going to be the people that manage the infrastructure for us?
- Is it going to be internal and external people?
- And if we use a public cloud how secure is that cloud platform for us?
  - Cloud compliance and certification
- Is the cloud going to be segregated from other organisations' data?
  - Cloud multitenancy

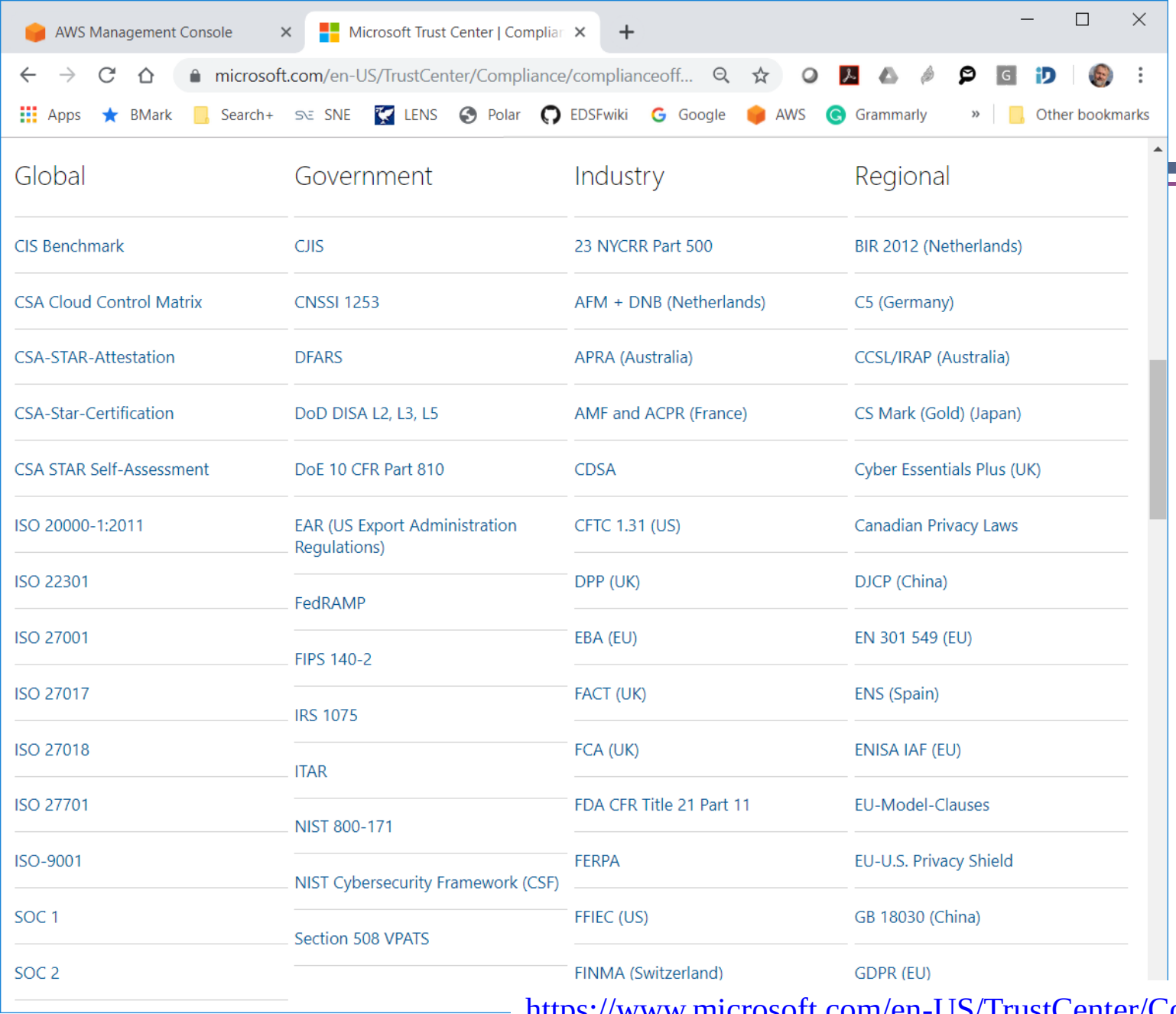
Case study: Certification/Compliance by Amazon AWS Cloud

The AWS cloud infrastructure has been designed and managed in alignment with regulations, standards, and best-practices including:

- ISO/IEC 27001:2005
- SOC 1, SOC2, SOC3
- FIPS 140-2
- CSA
- PCI DSS Level 1
- HIPAA
- ITAR
- DIACAP and FISMA
- FedRAMP (SM)
- MPAA

Amazon Cloud is certified for hosting US Governmental services
http://aws.amazon.com/compliance/

Case study: Compliance by Microsoft Azure



Microsoft services/infrastructure meets the following key certifications, attestations and compliance capabilities

- Current compliance offerings
- Office 365 compliance documentation
- Service Trust Portal
- Microsoft Services Risk Assessment
- Audit Reports

https://www.microsoft.com/en-US/TrustCenter/Compliance/complianceofferings

A Complete Cloud Security Governance, Risk, and Compliance (GRC) Stack

https://cloudsecurityalliance.org/research/grc-stack/

Delivering	← Stack Pack →	Description
Continuous monitoring … with a purpose		Cloud Trust Protocol (CTP) • Common technique and nomenclature to request and receive evidence and affirmation of current cloud service operating circumstances from cloud providers
Claims, offers, and the basis for auditing service delivery		• Common interface and namespace to automate the Audit, Assertion, Assessment, and Assurance (A6) of cloud environments
Pre-audit checklists and questionnaires to inventory controls		Consensus Assessments Initiative (CAI) • Industry-accepted ways to document what security controls exist
The recommended foundations for controls		Cloud Control Matrix (CCM) • Fundamental security principles in specifying the overall security needs of a cloud consumers and assessing the overall security risk of a cloud provider

CSA3.0 Security Guidance for Critical Area of Focus in Cloud Computing – Cloud Controls Matrix

The CSA3.0 defines 13 domains of the security concerns (controls) for Cloud Computing that are divided into two broad categories that define corresponding security controls.

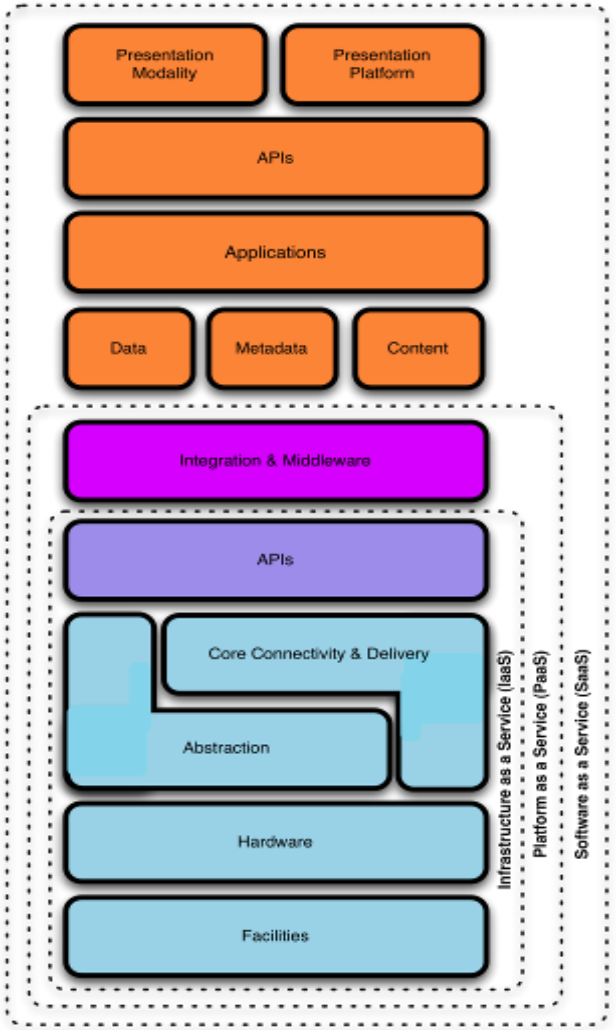
Governance domains

1. Governance and Enterprise Risk Management
2. Legal Issues: Contracts and Electronic Discovery
3. Compliance and Audit
4. Information Management and Data Security
5. Portability and Interoperability

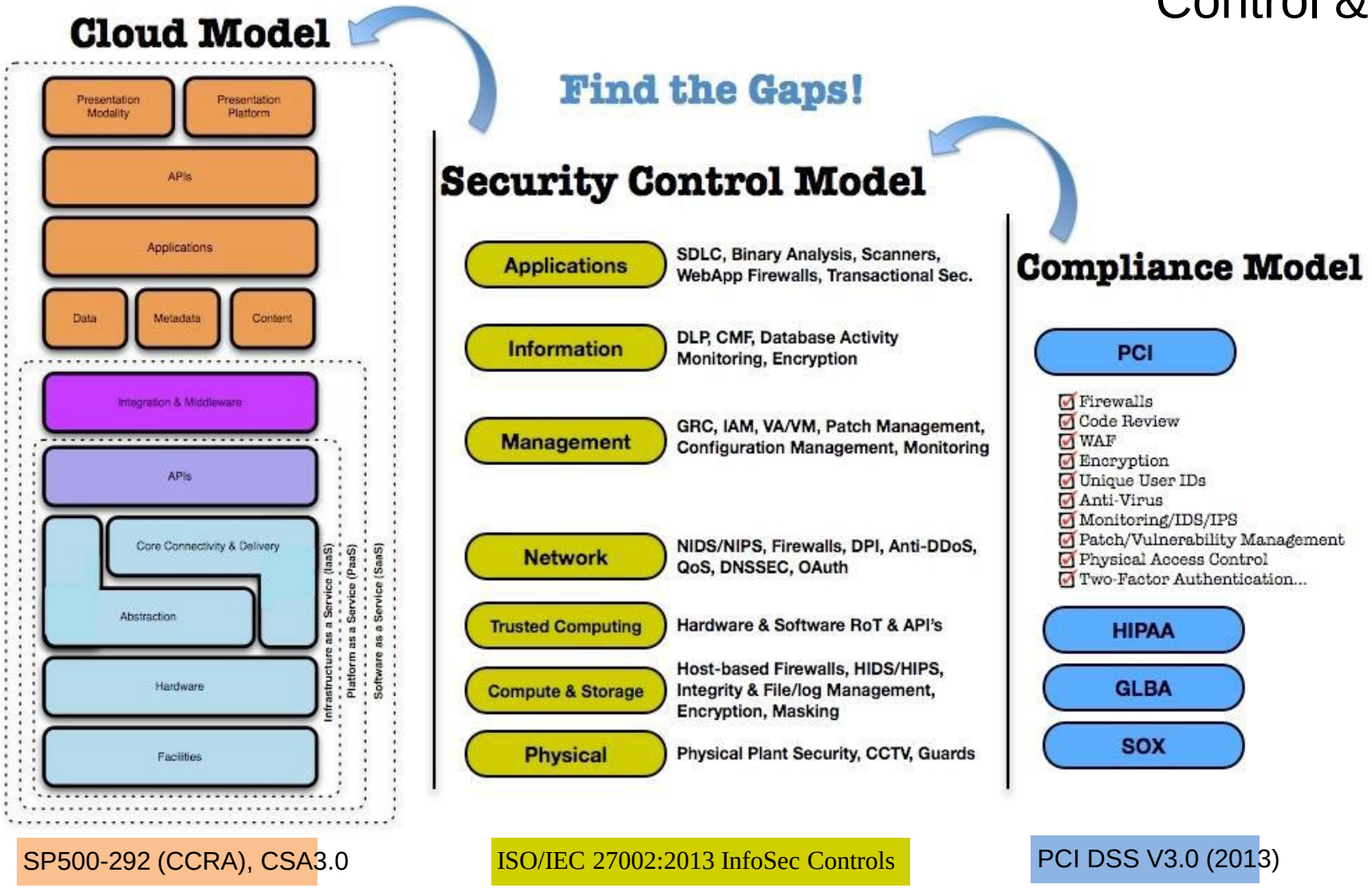
Operational Domains

6. Traditional Security, Business Continuity and Disaster Recovery
7. Data Center Operations
8. Incident Response, Notification and Remediation
9. Application Security
10. Encryption and Key Management
11. Identity and Access Management
12. Virtualization
13. Security as a Service

CSA3.0 Cloud Services Model



CSA3.0: Mapping the Cloud Model to the Security Control & Compliance



SP500-292 (CCRA), CSA3.0

ISO/IEC 27002:2013 InfoSec Controls

PCI DSS V3.0 (2013)

Note the link and mapping between Cloud Model, Security Control Model specialized Compliance Model

[ref] Security Guidance for Critical Areas of Focus in Cloud Computing V3.0 (2013)
https://cloudsecurityalliance.org/download/security-guidance-for-critical-areas-of-focus-in-cloud-computing-v3/

What is the Cloud Controls Matrix (CCM)?

- Baseline control framework specifically designed for managing risk in the **Cloud Supply Chain**:
  - Addressing the inter and intra-organizational challenges of persistent information security by clearly delineating control ownership.
  - Providing an anchor point and common language for balanced measurement of security and compliance postures.
  - Providing the holistic adherence to the vast and ever evolving landscape of global data privacy regulations and security standards.
- Serves as the basis for new industry standards and certifications.

CCM Control Groups:

1. Compliance (CO)
2. Data Governance (DG)
3. Facility Security (FS)
4. Human Resources (HR)
5. Information Security (IS)
6. Legal (LG) .
7. Operations Management (OM)
8. Risk Management (RI)
9. Release Management (RM)
10. Resiliency (RS)
11. Security Architecture (SA)

98 security controls in total

CSA Consensus Assessment Initiative

- A cloud supply chain risk management and due diligence questionnaire
- ~ 280 yes/no questions that map directly to the **CCM**, and thus, in turn, to many industry standards.
- Can be used by both CSPs for self-assessment or by potential customers for the following purposes
  - to identify the presence of security controls and practices for cloud offerings
  - procurement negotiation
  - contract inclusion
  - to quantify SLAs
- For potential customers, the CSA **Consensus Assessment Initiative Questionnaire (CAIQ)** is intended to be part of an initial assessment followed by further clarifying questions of the provider as it is applicable to their particular needs.
  - v1.1 published in Sept 2011; v3.0.1 is available from 2014, v3.1 updated in 2020

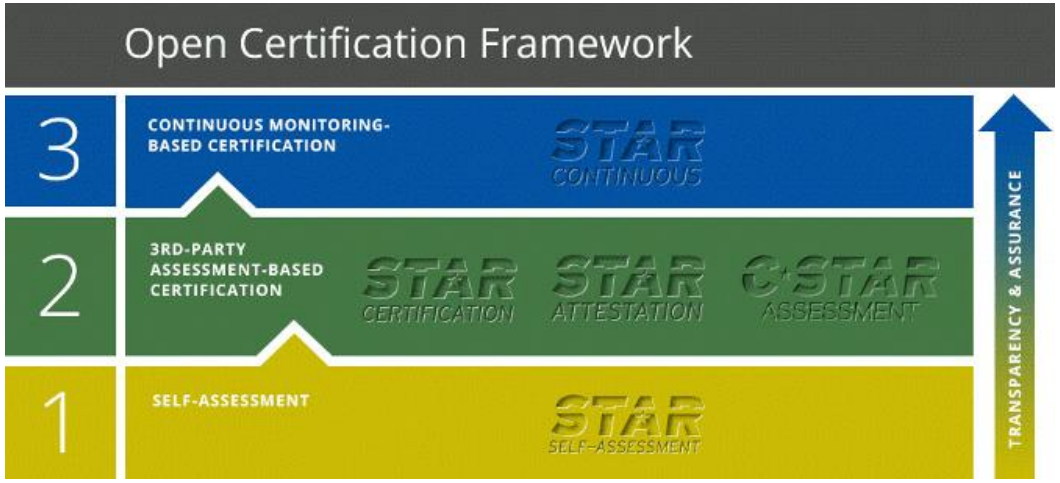
CAIQ Guiding Principles

The following are the principles that the working group utilized as guidance when developing the CAIQ:

- The questionnaire is organized using CSA 13 governing & operating domains divided into “control areas” within CSA’s Control Matrix structure
- Questions are to assist both cloud providers in general principles of cloud security and clients in vetting cloud providers on the security of their offering and company security profile
- CAIQ not intended to duplicate or replace existing industry security assessments but to contain questions unique or critical to the cloud computing model in each control area
- Each question should be able to be answered yes or no
- If a question can’t be answered yes or no then it was separated into two or more questions to allow yes or no answers.
- Questions are intended to foster further detailed questions to provider by client specific to client’s cloud security needs. This was done to limit number of questions to make the assessment feasible and since each client may have unique follow-on questions or may not be concerned with all “follow-on questions

CSA STAR: Security, Trust and Assurance Registry

- Public Registry of Cloud Provider self assessments
  - https://cloudsecurityalliance.org/star/#_registry
- Leverages GRC Stack Projects
  - Consensus Assessments Initiative Questionnaire
  - Provider may substitute documented Cloud Controls Matrix compliance
- Voluntary industry action promoting transparency
- Free market competition to provide quality assessments
- Documents the security controls provided by various cloud computing offerings
- Encourage transparency of security practices within cloud providers
- Permanent effort to drive transparency, competition, innovation and self regulation with agility – crowdsourcing cloud security



CCM Cloud Controls Matrix

CAI Consensus Assessments Initiative

CSA STAR Assessment and Certification

Open Certification Framework – Current Practice

https://cloudsecurityalliance.org/star/#star_m

CSA STAR Compliance Levels

LEVEL ONE: CSA STAR Self-Assessment

- CSA STAR Self-Assessment is a free offering that documents the security controls provided by CSPs, thereby helping users assess the security of cloud providers
- Cloud providers either submit a completed The Consensus Assessments Initiative Questionnaire (CAIQ), or to submit a report documenting compliance with Cloud Controls Matrix (CCM).

LEVEL TWO: CSA STAR Attestation

- CSA STAR Attestation is a collaboration between CSA and the AICPA to provide guidelines for CPAs to conduct SOC 2 engagements using criteria from the AICPA (Trust Service Principles, AT 101) and the CSA Cloud Controls Matrix.

LEVEL TWO: CSA STAR Certification

- The CSA STAR Certification is a rigorous third party independent assessment of the security of a cloud service provider.
- The technology-neutral certification leverages the requirements of the ISO/IEC 27001:2005 management system standard together with the CSA Cloud Controls Matrix.

LEVEL THREE: CSA STAR Continuous Monitoring

- Currently under development and scheduled for 2015 release, CSA STAR Continuous Monitoring enables automation of the current security practices of cloud providers.

Listing at https://cloudsecurityalliance.org/star/#star_m

STAR Listing Process

- Provider fills out CAIQ or customizes CCM
- Uploads document at /star repository
- CSA performs basic verification
  - Authorized listing from provider
  - Delete SPAM, “poisoned” listing
  - Basic content accuracy check
- CSA digitally signs and posts at /star
- Does not provide: automation, 3rd party assessment, relative/absolute scoring, real-time controls monitoring, etc
- Ultimate assurance is real time GRC (enabled by CloudAudit) complemented by CSA STAR and 3rd party attestation.

Why not certification or 3rd party assessment?

- Complex to do certification right
  - Many uses of cloud, many customer needs
  - Different risk profiles for each
- CSA is supporting broad industry consortia and standards bodies
  - ISO, ITU-T
  - Common Assurance Maturity Model (CAMM – 3rd Party assessment)
  - GRC Stack aligns with common requirements (e.g. PCI/DSS, HIPAA, FedRAMP, 27001, CoBIT, etc)
- Self assessment & transparency complements all
  - STAR could be part of SSAE 16 SOC II report (SAS 70 replacement)

Recent CSA Publications – Interesting reading

- **Top Threats to Cloud Computing: The Egregious 11 (2019)**
  https://cloudsecurityalliance.org/download/artifacts/top-threats-to-cloud-computing-egregious-eleven/
  https://cloudsecurityalliance.org/download/artifacts/top-threats-egregious-11-deep-dive/
  - Contains stories about recent cloud breaches: all due to customer lame design and compromised credentials
- Top Threats to Cloud Computing: Deep Dive (2018)
  https://cloudsecurityalliance.org/download/artifacts/top-threats-to-cloud-computing-deep-dive/
  - A case study analysis for The Treacherous 12 Top Threats to Cloud Computing and relative industry breach analysis
- Information Security Management through Reflexive Security (2019)
  https://cloudsecurityalliance.org/download/artifacts/information-security-management-through-reflexive-security/
  - Achieving Reflexive Security through integration of security < development and Operations
- The Six Pillars of DevSecOps (2019)
  https://cloudsecurityalliance.org/artifacts/six-pillars-of-devsecops/
  - Achieving Reflexive Security through integration of security < development and Operations
- Cloud Octagon Model (2019)
  https://cloudsecurityalliance.org/artifacts/top-threats-to-cloud-computing-egregious-eleven
  - Model for Improving Accuracy and Completeness of cloud computing Risk Assessment
-

4. Security Issue: Insufficient Identity, Credential, Access and Key Management

From **Top Threats to Cloud Computing: The Egregious 11 (2019)**

Identity, credential, access management systems include tools and policies that allow organizations to manage, monitor and secure access to valuable resources. Examples may consist of electronic files, computer systems and physical resources, such as server rooms and buildings.

Cloud computing introduces multiple changes to traditional internal system management practices related to identity and access management (IAM). It isn't that these are necessarily new issues. Rather, they are more significant issues when dealing with the cloud because cloud computing profoundly impacts identity, credential and access management. In both public and private cloud settings, CSPs and cloud consumers are required to manage IAM without compromising security.

Security incidents and data breaches can occur due to the following:

- Inadequate protection of credentials
- Lack of regular automated rotation of cryptographic keys, passwords and certificates
- Lack of scalable identity, credential and access management systems
- Failure to use multifactor authentication
- Failure to use strong passwords

HISTORY OF RANKING

New Top Threat

SECURITY RESPONSIBILITY

- ☑ Customer
- ☒ Cloud Service Provider
- ☒ Both

ARCHITECTURE

- ☒ Appli
- ☒ Info
- ☒ Meta
- ☑ Infra

CLOUD SERVICE MODEL

- ☒ Software as a service (SaaS)
- ☑ Platform as a service (PaaS)
- ☑ Infrastructure as a service (IaaS)

Examples: Anecdotical

- Accountancy firm Deloitte experienced a major data breach due to weak identity, credential and access management on Sept. 25, 2017, when the company announced it had detected a breach of its global email server due to a poorly secured administrator email account. The compromise occurred in March 2017 and supposedly gave attackers privileged, unrestricted access "to all areas." The administrator account required only a single password and did not employ a two-step verification process. The attackers allegedly controlled the server since October/November of 2016. Deloitte's 244,000 staff utilized the Microsoft Azure

- Attackers recently scraped GitHub for cloud service credentials and hijacked an account to mine virtual currency. The cloud service provider credentials included in a GitHub project were discovered and misused within 36 hours of the project going live.

- In June 2014, the AWS account of Code Spaces—a former code-hosting service company—was compromised when it failed to protect its administrative console with multi-factor authentication. The business was forced to close after the destruction of its assets.
- 2017 marked the rise of cloud account-targeted campaigns, in particular for Microsoft Office 365.
- In April 2010, an Amazon cross-site scripting (XSS) bug enabled credential theft and in 2009, numerous Amazon systems were hijacked to run Zeus botnet nodes.

Research topics in Cloud Security

- Federated Identity Management and Access Control in hybrid enterprise-CSP infrastructure + Identity provisioning
- Cloud Access and Security Brokers: Security with Trusted Third Party
- VPC infrastructure security model and analysis
- Bootstrapping cloud based VPC and enterprise or applications trust domains
  - Leveraging **Zero Trust model** in networking security
  - Leveraging TPM and Trusted Computing Platform Architecture
- Data protection in clouds at all stages of data processing (Data Lifecycle)
  - Data Sovereignty and Data Ownership attribute/property
  - Computationally Enforceable Policies and data provenance: Mapping to CCM/CAIQ
  - Data Management Infrastructure for AI and Digital Twins
  - Blockchain enabled data provenance in multi-platform multi-cloud environment
- Personal information protection in cloud based multitenant multi-tier applications
- Cloud infrastructure to enable GDPR + FAIR data principles

Part 4. Hands On Exercise/Lab & Self-study

Cloud Compliance Assessment tools

- CSA CAIQ and CCM
  - CSA Cloud Controls Matrix (CCM) v3.0.1

    https://cloudsecurityalliance.org/research/ccm/

    https://downloads.cloudsecurityalliance.org/initiatives/ccm/ccm-v3.0.1.zip
  - CSA Consensus Assessment Initiative Questionnaire (CAIQ) v3.0.1

    https://cloudsecurityalliance.org/research/cai/

    https://cloudsecurityalliance.org/download/consensus-assessments-initiative-questionnaire-v3-0-1/

- PCI DSS Self Assessment Questionnaire (SAQ)
  - https://www.pcisecuritystandards.org/document_library?category=saqs#results
  - Questionnaire is designed for different categories of user: from full outsourcing cards operations to card payment service

- STAR Registry - https://cloudsecurityalliance.org/star/registry/
  - Check few cloud providers, make conclusion, ask questions, discuss with the group
  - For example, Zoom Video Communications https://cloudsecurityalliance.org/star/registry/zoom-video-communications-inc/

Summary and take away

- Cloud Security impose new security challenges
- Cloud Security is based on the core security principles and models
- Shared responsibility is the basic model cloud security
- Cloud compliance provides a basis for wider cloud services adoption and inter-cloud integration.
- Compliance is supported by numerous standards, legislation, regulatory guidelines and industry best practices that jointly define a compliance framework
  - Knowing major cloud compliance standards is necessary for correct cloud services design, deployment and operation
  - CCM and CAIQ provide bridge between technical and legal/regulatory domains

References: General standards and regulatory requirements related to security and privacy

General Regulatory Requirements for Cloud Compliance

- ISO/IEC 27001:2005 Certification on security infrastructure (http://www.bsigroup.com/en-GB/iso-27001-information-security/)
- Payment Card Industry Data Security Standard (PCI- DSS) and PCI DSS Cloud Computing Guidelines (https://www.pcisecuritystandards.org/pdfs/PCI_DSS_v2_Cloud_Guidelines.pdf)
- NIST SP 800-144 Guidelines for Security and Privacy in Cloud Computing (http://csrc.nist.gov/publications/nistpubs/800-144/SP800-144.pdf)
- NIST SP 800-53 Revision 4, Security and Privacy Controls for Federal Information Systems and Organizations, April 2013. http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-53r4.pdf

The major industry and government related documents:

- Service Organisation Control SOC 1 (SSAE 16/ISAE 3402) and SOC 2 and 3 (AT 101) (http://www.aicpa.org/interestareas/frc/assuranceadvisoryservices/pages/serviceorganization'smanagement.aspx), including
- Sarbanes Oxley Act (SOX, https://www.sec.gov/about/laws/soa2002.pdf) also known as "Corporate and Auditing Accountability and Responsibility Act"
- HIPAA/HITECH (The U.S. Health Insurance Portability and Accountability Act (HIPAA) and HITECH (Health Information Technology for Economic and Clinical Health) http://www.hhs.gov/ocr/privacy/hipaa/administrative/statute/hipaastatutepdf.pdf)
- The Federal Information Security Management Act of 2002 (FISMA, http://csrc.nist.gov/drivers/documents/FISMA-final.pdf)
- Federal Risk and Authorisation Management Program (FedRAMP) (http://www.gsa.gov/portal/category/102383)
  - Directory of Compliant Cloud Systems - http://cloud.cio.gov/fedramp/cloud-systems
- Department of Defense Information Certification Accreditation Process (DIACAP) (http://www.prim.osd.mil/Documents/DIACAP_Slick_Sheet.pdf)

References: Cloud Security and Big Data Security Standards and BCP

- Cloud Security Alliance https://cloudsecurityalliance.org/
  - Security Guidance for Critical Areas of Focus in Cloud Computing V3.0 (2013) https://cloudsecurityalliance.org/download/security-guidance-for-critical-areas-of-focus-in-cloud-computing-v3/
  - Expanded Top Ten Big Data Security and Privacy Challenges. CSA Report, 16 June 2013. https://downloads.cloudsecurityalliance.org/initiatives/bdwg/Expanded_Top_Ten_Big_Data_Security_and_Privacy_Challenges.pdf
  - CSA Enterprise Architecture: The Security and Risk Management domain. https://research.cloudsecurityalliance.org/tci/index.php/explore/security_risk_management/
- European Union Agency for Network and Information Security
  - ENISA Cloud Computing Risk Assessment (2010) http://www.enisa.europa.eu/act/rm/files/deliverables/cloud-computing-risk-assessment
  - ENISA Threat Landscape 2013, Overview of current and emerging cyber-threats, 11 December 2013 https://www.enisa.europa.eu/activities/risk-management/evolving-threat-environment/enisa-threat-landscape-2013-overview-of-current-and-emerging-cyber-threats/at_download/fullReport

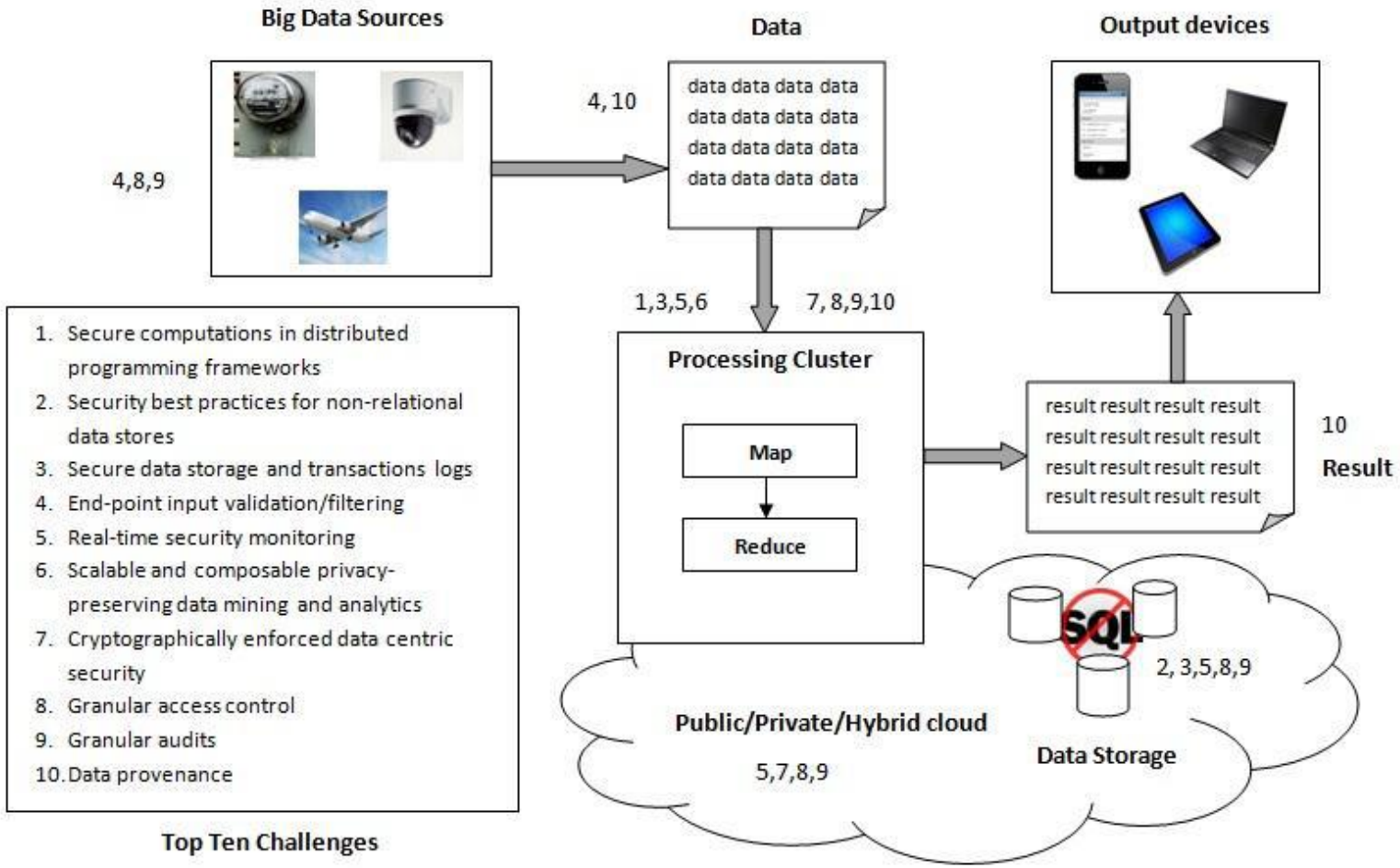
Additional Information

- Big Data security

Big Data Security

- Expanded Top Ten Big Data Security and Privacy Challenges. CSA Report, 16 June 2013.
  - https://downloads.cloudsecurityalliance.org/initiatives/bdwg/Expanded_Top_Ten_Big_Data_Security_and_Privacy_Challenges.pdf
- CSA Big Data Security and Privacy Handbook: 100 Best Practices in Big Data Security and Privacy at
  - https://cloudsecurityalliance.org/download/big-data-security-and-privacy-handbook/
  - 10 recommendations are provided for each of CSA Top Ten Big Data Security Challenges

CSA Top Ten Big Data Security and Privacy Challenges



Expanded Top Ten Big Data Security and Privacy Challenges. CSA Report, 16 June 2013.
https://downloads.cloudsecurityalliance.org/initiatives/bdwg/Expanded_Top_Ten_Big_Data_Security_and_Privacy_Challenges.pdf

CSA Top Ten Big Data Security Challenges by Functional Groups (1)

Cloud Security Alliance also published ‘Expanded Top Ten Big Data Security and Privacy Challenges’ document as early as in June 2013.

Top Ten challenges are grouped into four functional groups:

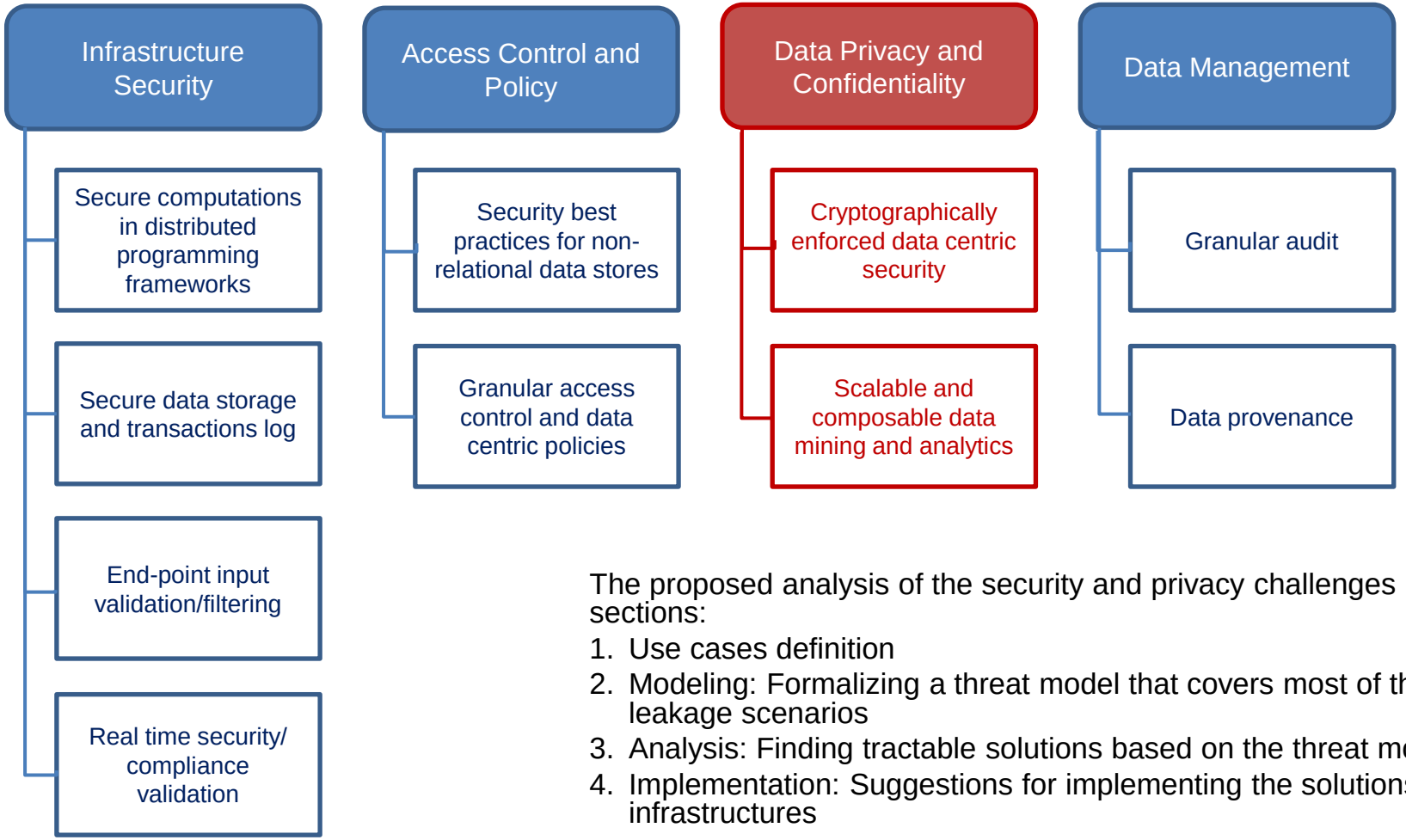
A. Infrastructure security
- TT01. Secure computations in distributed programming frameworks
- TT03. Secure data storage and transactions logs
- TT04. End-point input validation/filtering
- TT05. Real-time security/compliance monitoring

B. Access control and policy
- TT02. Security best practices for non-relational data stores
- TT08. Granular access control and data centric access policies

C. Data Privacy and Confidentiality
- ***TT06. Scalable and composable privacy-preserving data mining and analytics***
- ***TT07 Cryptographically enforced data centric security***

D. Data Management
- TT09. Granular audits
- TT10. Data provenance, data lineage

CSA Top Ten Big Data Security Challenges by Functional Groups (2)



The proposed analysis of the security and privacy challenges includes the following sections:

1. Use cases definition
2. Modeling: Formalizing a threat model that covers most of the cyber-attack or data-leakage scenarios
3. Analysis: Finding tractable solutions based on the threat model
4. Implementation: Suggestions for implementing the solutions in existing infrastructures

CSA TT5. Real-Time Security/Compliance Monitoring Best Practices in the Big Data Security

- ***A. Infrastructure security***

Use case:

Most industries and government agencies will benefit from **real-time security analytics**. Common uses include utilizing the technology to answer questions such as, “Who is accessing which data from which resource at what time,” “Are we under attack,” or “Is there a breach of compliance standard C because of action A?”

5.1 Apply big data analytics to detect anomalous connections to cluster

5.2 Mine logging events

5.3 Implement front-end systems

5.4 Consider cloud-level security

5.5 Utilize cluster-level security

5.6 Apply application-level security

5.7 Adhere to laws and regulations

5.8 Reflect on ethical considerations

5.9 Monitor evasion attacks

5.10 Track data-poisoning attacks

CSA Top Ten TT07. Cryptographically Enforced Data-Centric Security

- ***C. Data Privacy and Confidentiality***

Use case:

On-demand provisioned and distributed character of the Big Data infrastructure, especially if it is cloud based, make it **practically unfeasible** to achieve full protection of data at all infrastructure layers and during the whole data lifecycle, unless data remain encrypted all time.

7.1 Construct system to search, filter for encrypted data

7.2 Secure outsourcing of computation using fully homomorphic encryption

7.3 Limit features of homomorphic implementation

7.4 Apply relational encryption to enable comparison of encrypted data

7.5 Reconcile authentication and anonymity

7.6 Implement identity-based encryption

7.7 Utilize attribute-based encryption and access control

7.8 Use oblivious RAM for privacy preservation

7.9 Incorporate privacy-preserving public auditing

7.10 Consider convergent encryption for deduplication

CSA Top Ten TT10.0 Data Provenance

- ***D. Data Management***

Use case:

Several key security applications require a digital record with details about its creation. Examples include detecting **insider trading for financial companies** or determining the **accuracy of the data source for research** investigations. These security assessments are time-sensitive in nature and require fast algorithms to handle the provenance metadata containing this information. In addition, data provenance complements **audit logs** for compliance requirements, such as PCI or Sarbanes-Oxley.

10.1 Develop infrastructure **authentication** protocol
10.2 Ensure accurate, periodic status updates
10.3 Verify data integrity
10.4 Ensure consistency between **provenance and data**
10.5 Implement effective encryption methods
10.6 Use access control
10.7 Satisfy data independent persistence
10.8 Utilize dynamic **fine-grained access control**
10.9 Implement scalable **fine-grained access control**
10.10 Establish flexible revocation mechanisms