A decorative graphic consisting of multiple parallel, wavy lines in various colors (purple, blue, orange, grey, green) that flow from the left side of the slide towards the right, creating a sense of movement and depth.

Best Practices for Cloud Security and Privacy

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◆ Best Practices for Cloud Security and Privacy

As organizations embrace various cloud computing offerings it is important to address security and privacy as part of good governance, risk management and due diligence. Failure to adequately handle these requirements can place the organization at significant risk for not meeting compliance obligations and exposing sensitive data to possible data breaches. Fortunately, ISO/IEC, ITU-T and the Cloud Security Alliance (CSA) have been busy developing standards and guidance in these areas for cloud computing, and these materials can be used as a starting point for what some believe is a make-or-break aspect of cloud computing.

This session provides an introduction to cloud computing security concepts and issues as well as identifying key guidance and emerging standards. Specific CSA materials are identified and discussed to help address common issues. The session concludes by providing a security review of the emerging ISO/IEC and ITU-T standards in the cloud space.

Outline

- **Cloud Computing 101**
- Major Cloud Computing Threats & Risks
- Prevailing Cloud Security & Privacy Guidance
- Important Cloud Security & Privacy Resources
- Summary

Cloud Computing...

paradigm for enabling network access to a *scalable* and *elastic* pool of *shareable* physical or virtual resources with *self-service* provisioning and administration *on-demand*

SOURCE: Rec. ITU-T Y.3500 | ISO/IEC 17788:2014, *Information technology – Cloud computing – Overview and vocabulary*

Key Characteristics

(ISO/IEC 17788)

- ◆ **Broad network access** – feature where the physical and virtual resources are available over a network and accessed through standard mechanisms that promote use by heterogeneous client platforms
- ◆ **Measured Service** – feature where the metered delivery of cloud services is such that usage can be monitored, controlled, reported, and billed
- ◆ **Multi-tenancy** – feature where physical or virtual resources are allocated in such a way that multiple tenants and their computations and data are isolated from and inaccessible to one another
- ◆ **On-demand self-service** – feature where a cloud service customer can provision computing capabilities, as needed, automatically or with minimal interaction with the cloud service provider
- ◆ **Rapid elasticity & scalability** – feature where physical or virtual resources can be rapidly and elastically adjusted, in some cases automatically, to quickly increase or decrease resources
- ◆ **Resource pooling** – feature where a cloud service provider’s physical or virtual resources can be aggregated in order to serve one or more cloud service customers

Major Cloud Computing Roles

(ISO/IEC 17788 & ISO/IEC 17789)

➤ Cloud Service Customer

- ◆ *party which is in a business relationship for the purpose of using cloud services*
- ◆ **Sub-roles:** Cloud Service User, Cloud Service Administrator, Cloud Service Business Manager, and Cloud Service Integrator

➤ Cloud Service Provider

- ◆ *party which makes cloud services available*
- ◆ **Sub-roles:** Cloud Service Operations Manager, Cloud Service Deployment Manager, Cloud Service Manager, Customer Support & Care Representative, Cloud Service Business Manager, Cloud Service Security & Risk Manager, Inter-cloud Provider, Network Provider

➤ Cloud Service Partner

- ◆ *party which is engaged in support of, or auxiliary to, activities of either the cloud service provider or the cloud service customer, or both*
- ◆ **Sub-roles:** Cloud Service Developer, Cloud Auditor, and Cloud Service Broker

Cloud Deployment Models

(ISO/IEC 17788)

- **Private Cloud** – cloud deployment model where cloud services are used exclusively by a single cloud service customer and resources are controlled by that cloud service customer
- **Public Cloud** – cloud deployment model where cloud services are potentially available to any cloud service customer and resources are controlled by the cloud service provider
- **Community Cloud** – cloud deployment model where cloud services exclusively support and are shared by a specific collection of cloud service customers who have shared requirements and a relationship with one another, and where resources are controlled by at least one member of this collection
- **Hybrid Cloud** – cloud deployment model using at least two different cloud deployment models

Service Categories vs. Capability Types

(ISO/IEC 17788)

Cloud Service Categories	Cloud Capabilities Types		
	Infrastructure	Platform	Application
Compute as a Service	X		
Communication as a Service		X	X
Data Storage as a Service	X	X	X
Infrastructure as a Service	X		
Network as a Service	X	X	X
Platform as a Service		X	
Software as a Service			X



Washing-machine as a Service (WaaS)

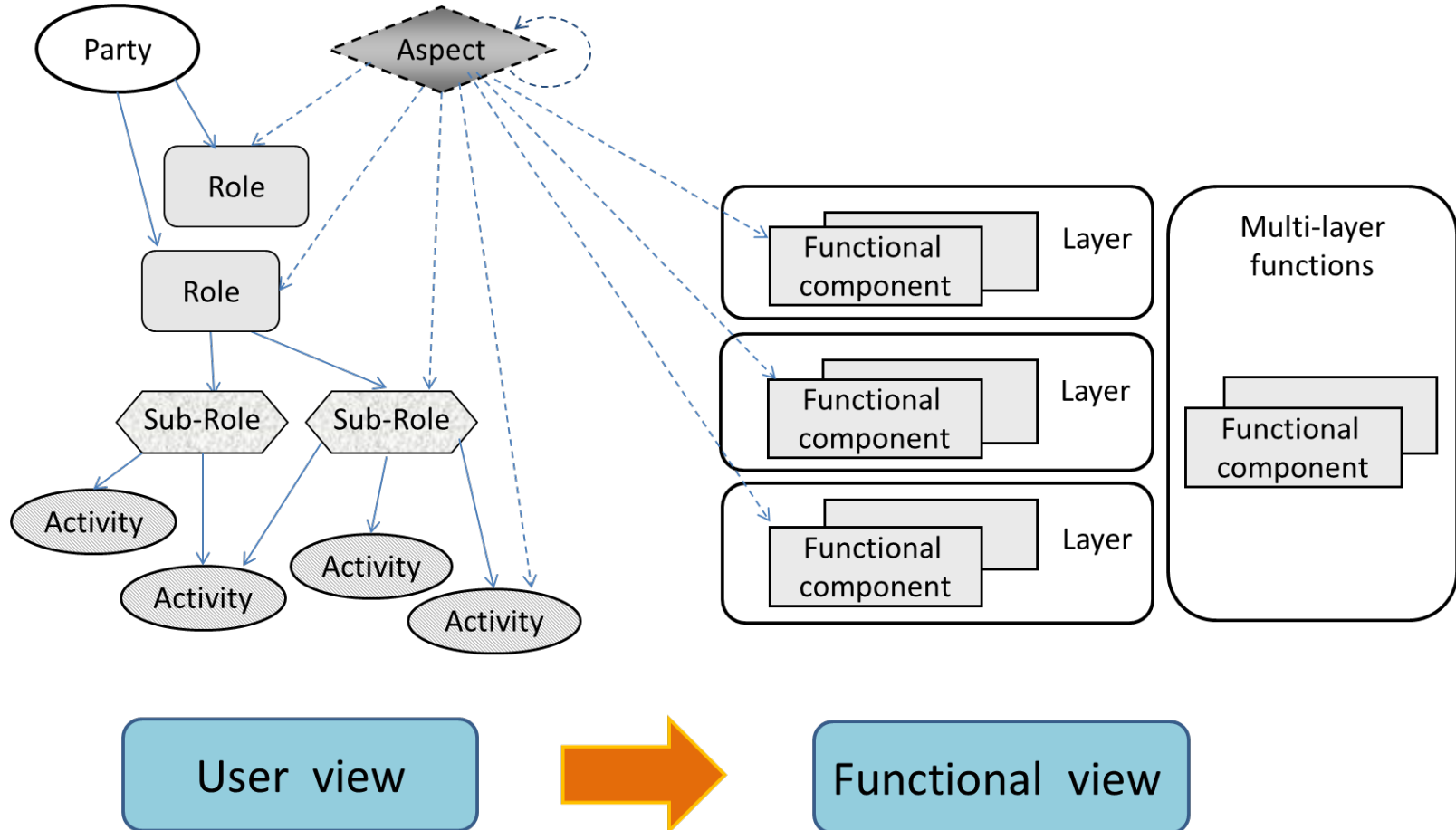
Cross-cutting Aspects

(ISO/IEC 17788)

- Auditability
- Availability
- Governance
- Interoperability
- Maintenance & Versioning
- Performance
- Portability
- Protection of PII
- Regulatory
- Resilience
- Reversibility
- Security
- Service levels and service level agreement

Reference Architecture (1)

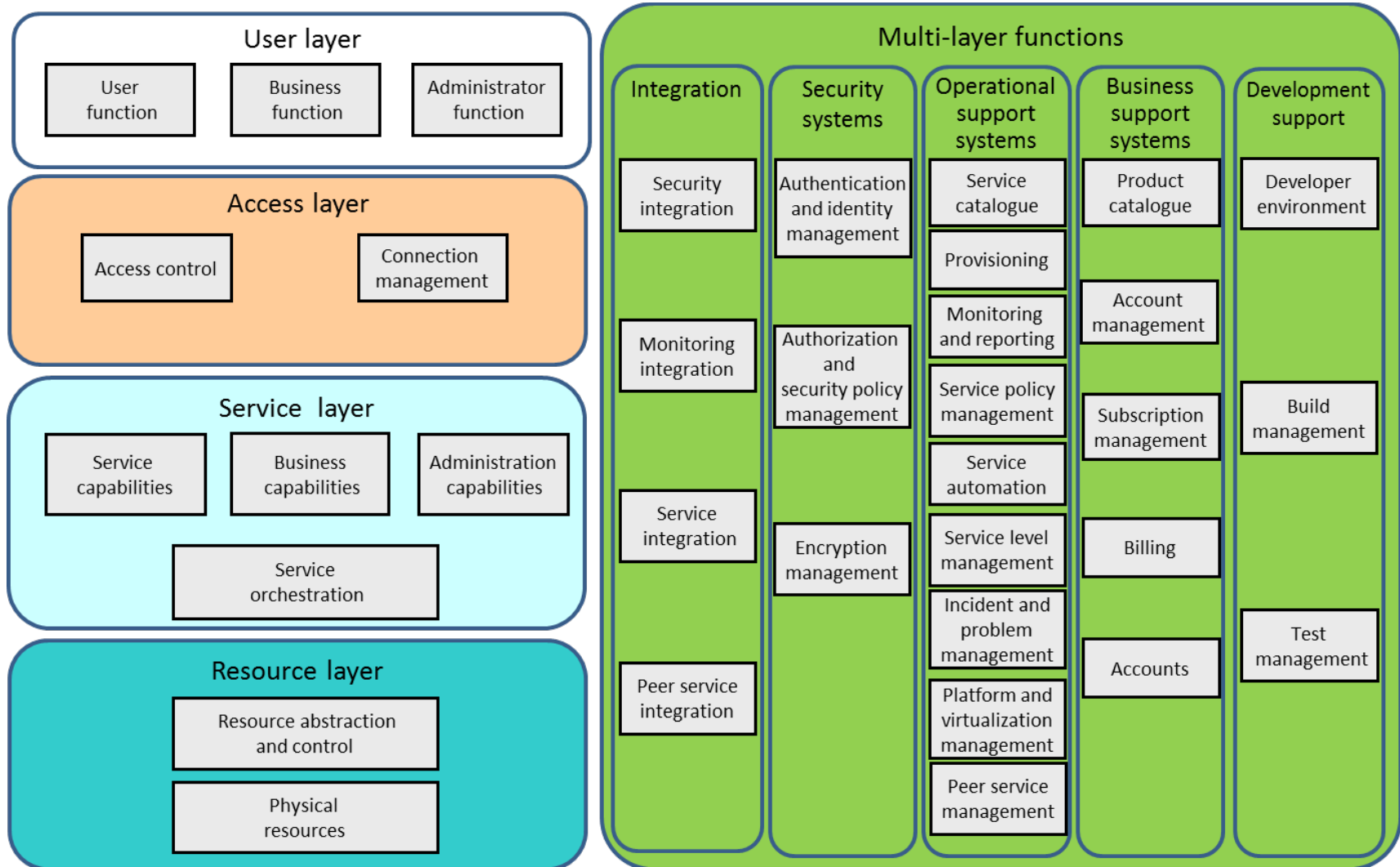
(ISO/IEC 17789)



SOURCE: Rec. ITU-T Y.3502 | ISO/IEC 17789:2014, *Information technology – Cloud computing – Reference architecture*

Reference Architecture (2)

(ISO/IEC 17789)



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- ITU-T X.1601 Threats

- For Cloud Service Customer
 - ◆ Data loss and leakage
 - ◆ Insecure service access
 - ◆ Insider threats

- For Cloud Service Providers
 - ◆ Unauthorized administration access
 - ◆ Insider threats

SOURCE: Recommendation ITU-T X.1601, *Security framework for cloud computing*, Jan-2014

ITU-T X.1601 Challenges

➤ For Cloud Service Customer

- ◆ Ambiguity in Responsibility
- ◆ Loss of Trust
- ◆ Loss of Governance
- ◆ Loss of Privacy
- ◆ Service Unavailability
- ◆ Cloud Service Provider Lock-in
- ◆ Misappropriation of Intellectual Property
- ◆ Loss of software integrity

➤ For Cloud Service Providers

- ◆ Ambiguity in Responsibility
- ◆ Shared Environment

- ◆ Inconsistency and Conflict of Protection Mechanisms
- ◆ Jurisdictional Conflict
- ◆ Evolutionary Risks
- ◆ Bad Migration and Integration
- ◆ Business Discontinuity
- ◆ Cloud Service Partner Lock-in
- ◆ Supply Chain Vulnerability
- ◆ Software Dependencies

➤ For Cloud Service Partners

- ◆ Ambiguity in Responsibility
- ◆ Misappropriation of Intellectual Property
- ◆ Loss of software integrity

CSA Top Threats

- #1: Data Breaches
- #2: Data Loss
- #3: Account Hijacking
- #4: Insecure APIs
- #5: Denial of Service
- #6: Malicious Insiders
- #7: Abuse of Cloud Services
- #7: Insufficient Due Diligence
- #9: Shared Technology Issues

SOURCE: Cloud Security Alliance (CSA), *The Notorious Nine: Cloud Computing Top Threats in 2013*, Feb-2013

ENISA Top Threats

- ❖ Loss of Governance
- ❖ Lock-in (Data reversibility)
- ❖ Isolation Failure (Multi-tenancy)
- ❖ Management Interface Compromise
- ❖ Data Protection (privacy)
- ❖ Insecure or Incomplete Data Deletion
- ❖ Malicious Insider
- ❖ Customers' Security Expectations
- ❖ Availability Chain (Reliance on Internet Connectivity)

SOURCE: European Network and Information Security Agency (ENISA), *Cloud Computing – Benefits, risks and recommendations*, Dec-2012

OWASP Cloud Top 10 Security Risks

- **R01.** Accountability & Data Risk
- **R02.** User Identity Federation
- **R03.** Legal & Regulatory Compliance
- **R04.** Business Continuity & Resiliency
- **R05.** User Privacy & Secondary Usage of Data
- **R06.** Service & Data Integration
- **R07.** Multi-tenancy & Physical Security
- **R08.** Incidence Analysis & Forensics
- **R09.** Infrastructure Security
- **R10.** Non-production Environment Exposure

SOURCE: OWASP, OWASP Cloud - 10 Project, *Initial pre-alpha list of OWASP Cloud Top 10 Security Risks*, Apr-2011

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Cloud Standards Customer Council

Security for Cloud Computing – 10 Steps to Ensure Success

- 01: Ensure effective governance, risk and compliance processes exist
- 02: Audit operational & business processes
- 03: Manage people, roles and identities
- 04: Ensure proper protection of data and information
- 05: Enforce privacy policies
- 06: Assess the security provisions for cloud applications
- 07: Ensure cloud networks and connections are secure
- 08: Evaluate security controls on physical infrastructure and facilities
- 09: Manage security terms in the cloud SLA
- 10: Understand the security requirements of the exit process

SOURCE: Cloud Standards Customer Council, *Cloud Security Standards: What to Expect & What to Negotiate*, Oct-2013, <http://www.cloud-council.org>

Cloud Security (or Insecurity)

- ◆ Core Information Assurance issues to address:
 - ◆ Confidentiality
 - ◆ Integrity
 - ◆ Availability
 - ◆ Possession
 - ◆ Authenticity
 - ◆ Utility
 - ◆ Privacy
 - ◆ Authorized use
 - ◆ Non-repudiation
- ◆ Data loss and/or leakage measures become even more important
- ◆ Data aggregation changes the risk equation
- ◆ Legal and compliance forces require additional due diligence
- ◆ Forced exits and data disposition have to be carefully thought out
- ◆ Incident management become much more complicated

CSA Cloud Security Guidance

Governance	Operations
Governance and Enterprise Risk Management	Traditional Security, Business Continuity and Disaster Recovery
Legal and Electronic Discovery	Data Center Operations
Compliance and Audit	Incident Response, Notification and Remediation
Information Lifecycle Management	Application Security
Portability and Interoperability	Encryption and Key Management
	Identity and Access Management
	Virtualization

NOTE: The governance domains are broad and address strategic and policy issues within a cloud computing environment, while the operational domains focus on more tactical security concerns and implementation within the architecture.

SOURCE: Cloud Security Alliance, *Security Guidance for Critical Areas of Focus in Cloud Computing*, Version 3.0, 2011, <http://www.cloudsecurityalliance.org>

CSA GRC (Government, Risk Management, and Compliance) Stack

- Cloud Controls Matrix (CCM) v3.0.1
 - ◆ Provides mappings on
 - › Architectural relevance (Physical, Network, Compute, Storage, Application, Data and Corporate Governance)
 - › Delivery Models (SaaS, PaaS, IaaS)
 - › Supplier relationships (Service Provider and Tenant)
 - › Scope Applicability
 - ◆ Aligned with ISO/IEC 27001:2013
- CloudAudit
- Consensus Assessments Initiative Questionnaire (CAIQ)
- Cloud Trust Protocol (CTP)

SOURCE: Cloud Security Alliance, GRC Stack,
<https://cloudsecurityalliance.org/research/grc-stack/>

CSA CCM v3 Control Domains

- ◆ Application & Interface Security [4]
- ◆ Audit Assurance & Compliance [3]
- ◆ Business Continuity Management & Operational Resilience [12]
- ◆ Change Control & Configuration [5]
- ◆ Data Security & Information Lifecycle Management [8]
- ◆ Datacenter Security [9]
- ◆ Encryption & Key Management [4]
- ◆ Governance and Risk Management [12]
- ◆ Human Resources [12]
- ◆ Identity & Access Management [13]
- ◆ Infrastructure & Virtualization Security [12]
- ◆ Interoperability & Portability [5]
- ◆ Mobile Security [20]
- ◆ Security Incident Management, E-Discovery & Cloud Forensics [5]
- ◆ Supply Chain Management, Transparency and Accountability [9]
- ◆ Threat and Vulnerability Management [3]

Securing Cloud Storage

ISO/IEC FDIS 27040

- ◆ Ensure that transport security such as IPsec or Transport Layer Security (TLS) is used for all transactions
- ◆ When sensitive data is stored in a third party cloud environment, data at rest encryption (and appropriate key management processes) should be used to prevent access by the unauthorized parties (e.g., cloud service provider personnel, other tenants, adversaries, etc.)
- ◆ Use secure user registrations and strong password authentication to protect access to data
- ◆ Employ access controls that guard against unauthorized access from other tenants while providing appropriate access privileges to users permitted to access the data;
- ◆ Use the provided sanitization capabilities to clear sensitive data from the cloud computing storage

- ◆ Cloud computing implementations often leverage different forms of virtualization, so virtualization security controls should be considered as well

Secure Multi-tenancy

ISO/IEC FDIS 27040

◆ Secure isolation that assures:

- ◆ no tenant can determine the existence or identity of any other tenant;
- ◆ no tenant can access the data in motion (network) of any other tenant;
- ◆ no tenant can access the data at rest (storage) of any other tenant;
- ◆ no tenant can perform an operation that affects an operation performed by another tenant;
- ◆ no tenant can perform an operation that might deny service to another tenant;
- ◆ each tenant can have a configuration that is independent of other tenant's existence and configuration
- ◆ when a resource (compute, storage or network) is decommissioned from a tenant the resource should be sanitized of all data and configuration information; and
- ◆ accountability and traceability measures are available at the tenant level

◆ The following additional security measures should be used as well:

- ◆ encrypted storage that is aligned with the tenants' usage of resources;
- ◆ strong symmetric encryption (i.e., minimum of 128-bits of security strength) to protect data at rest;
- ◆ secure and rapid de-provisioning
- ◆ trusted third-party data storage management (e.g., SNMPv3, SMI-S with TLS , etc.);
- ◆ automated key management providing tenant-controlled key management
- ◆ secure data replication (e.g., data in motion and at rest encryption);
- ◆ protect data from administrators
- ◆ highly available storage networking fabrics (multi-path and diverse path);
- ◆ centralized and secure audit logging (e.g., syslog over TLS);
- ◆ validation and certification of cryptographic modules and other security measures

➤ CSA Security, Trust & Assurance Registry (STAR) Certification

- ◆ Level 1 – STAR Entry - Self Assessment: Publication of the results of a due diligence self assessment based on *CSA Consensus Assessment Initiative (CAI) Questionnaire* and/or *Cloud Control Matrix (CCM)*.
- ◆ Level 2 – STAR Certification / Attestation: Publication of available results of a third party assessment based on CCM v3.0.1 and ISO/IEC 27001:2013 or AICPA SOC2.
- ◆ Level 3 – STAR Continuous: Publication of results of security properties monitoring, based on Cloud Trust Protocol (CTP).
- ◆ Maturity of the Management Capability will also be scored as: “No”, “Bronze”, “Silver” or “Gold” awards

➤ FedRAMP

- ◆ Certification required for cloud suppliers to the U.S. Government
- ◆ Third-party assessments
- ◆ Security criteria based on NIST SP 800-53; as of June 2014, Revision 4 is now required (approximately 72 new Rev. 4 controls).

- Federal Risk and Authorization Management Program (FedRAMP)
- US Government-wide program
 - ◆ provides a standardized approach to security assessment,
 - ◆ authorization, and
 - ◆ continuous monitoring for cloud products and services.
- Relevant for
 - ◆ Cloud Service Providers (CSPs),
 - ◆ Third Party Assessment Organizations (3PAOs),
 - ◆ government employees and contractors working on FedRAMP projects, and
 - ◆ any outside organizations that want to use or understand the FedRAMP assessment process.
- More information at:
<http://www.gsa.gov/portal/category/102371>

FedRAMP Security Controls

- Access Control (AC)
- Awareness & Training (AT)
- Audit & Accountability (AU)
- Assessment & Authorization (CA)
- Configuration Management (CM)
- Contingency Planning (CP)
- Identification & Authentication (IA)
- Incident Response (IR)
- Maintenance (MA)
- Media Protection (MP)
- Physical & Environmental Protection (PE)
- Planning (PL)
- Risk Assessment (RA)
- System & Services Acquisition (SA)
- System & Communications Protection (SC)
- System & Information Integrity (SI)

NOTE: Security controls were selected from the NIST catalog of controls and enhancements as described in Special Publication 800-53 as revised

- Many countries—the U.S. being a notable exception—consider privacy to be a fundamental human right
- Privacy protection laws have been introduced in a significant number of countries
- The types of “protected” data can vary significantly
- Privacy violations can include the unlawful storage of personal data, the storage of inaccurate personal data, or the abuse or unauthorized disclosure of such data
- There may be cross-border restrictions imposed on data
- European Commission’s proposal for cloud:
 - ◆ New rights (to be forgotten/data deletion and data portability)
 - ◆ *Privacy by Default* and *Privacy by Design*
 - ◆ *Security obligations and data breach notification regime*

ISO/IEC 29100 Privacy Principles

- 1. Consent and choice
- 2. Purpose legitimacy and specification
- 3. Collection limitation
- 4. Data minimization
- 5. Use, retention and disclosure limitation
- 6. Accuracy and quality
- 7. Openness, transparency and notice
- 8. Individual participation and access
- 9. Accountability
- 10. Information security
- 11. Privacy compliance

CSA Privacy Level Agreement (1)

(Sale of Cloud Services in the EU)

- 1) Identity of the CSP
- 2) Categories of personal data that the customer is prohibited from sending to or processing in the cloud
- 3) Ways in which the data will be processed
- 4) Data transfer
- 5) Data security measures
- 6) Monitoring
- 7) Third-party audits
- 8) Personal data breach notification

SOURCE: Cloud Security Alliance, *Privacy Level Agreement Outline for the Sale of Cloud Services in the European Union*, February 2013, <https://cloudsecurityalliance.org/research/grc-stack/>

CSA Privacy Level Agreement (2)

(Sale of Cloud Services in the EU)

- 9) Data portability, migration, and transfer-back assistance
- 10) Data retention, restitution, and deletion
- 11) Accountability
- 12) Cooperation
- 13) Law enforcement access
- 14) Remedies
- 15) Complaint and dispute resolution
- 16) CSP insurance policy

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ISO/IEC JTC 1/SC38

(IT – Distribute Application Platforms & Systems)

- **ISO/IEC 17788:2014**
 - ◆ *Cloud computing – Overview and vocabulary*
- **ISO/IEC 17789:2014**
 - ◆ *Cloud computing – Reference architecture*
- **ISO/IEC 17826:2012**
 - ◆ *Information technology - Cloud Data Management Interface (CDMI)*
- **ISO/IEC 19086 (draft)**
 - ◆ Cloud computing – Service Level Agreement (SLA) framework & terminology
 - ◆ Multi-part: overview & concepts, metrics, and core requirements
- **ISO/IEC 19941 (new project)**
 - ◆ *Cloud computing – Interoperability and Portability*
- **ISO/IEC 19944 (new project)**
 - ◆ *Cloud computing – Data Flow and their Flow Across Devices and Cloud Services*

ISO/IEC JTC 1/SC27

(IT – Security techniques)

➤ **ISO/IEC 27017 (draft)**

- ◆ Additional implementation guidance for relevant information security controls specified in ISO/IEC 27002
- ◆ Additional controls and implementation guidance that specifically relate to cloud computing services.

➤ **ISO/IEC 27018:2014**

- ◆ Applies to organizations providing public cloud computing services that act as PII processors (possibly PII controllers)
- ◆ Establishes commonly accepted control objectives, controls and guidelines for implementing controls to protect

➤ **ISO/IEC 27036-4 (draft)**

- ◆ Define guidelines supporting the implementation of Information Security Management for the use of cloud service

➤ **ISO/IEC 27040 (final draft)**

- ◆ Addresses general storage security issues, including cloud storage and CDMI guidance

- ❖ **X.1601 (X.ccsec)** – High-level security framework for cloud computing
- ❖ **X.cc-control (ISO/IEC 27017)** – Guidelines supporting the implementation of information security controls for cloud service providers and cloud service customers of cloud computing services
- ❖ **X.goscc** – Guidelines of operational security for cloud computing
- ❖ **X.sfcse** – Security functional requirements for Software as a Service (SaaS) application environment
- ❖ **X.ccidm** – Requirement of IdM in cloud computing

Cloud Security Alliance (CSA)

- ◆ Security Guidance for Critical Areas of Focus in Cloud Computing
- ◆ Open Certification Framework
- ◆ Cloud Controls Matrix (CCM)
- ◆ Trusted Cloud Initiative (TCI) Reference Architecture Model
- ◆ Top Threats to Cloud Computing
- ◆ Security as a Service (SecaaS) Implementation Guidance
- ◆ Privacy Level Agreement (PLA)

- ◆ Many others...

- ◆ **Special Publication 800-144**, Guidelines on Security and Privacy in Public Cloud Computing
- ◆ **Special Publication 800-145**, The NIST Definition of Cloud Computing
- ◆ **Special Publication 800-146**, Cloud Computing Synopsis and Recommendations
- ◆ **Special Publication 500-291**, NIST Cloud Computing Standards Roadmap
- ◆ **Special Publication 500-292**, NIST Cloud Computing Reference Architecture
- ◆ **Special Publication 500-293**, (Draft). US Government Cloud Computing Technology Roadmap, Volume I High-Priority Requirements to Further USG Agency Cloud Computing Adoption
- ◆ **Special Publication 500-293**, (Draft). US Government Cloud Computing Technology Roadmap, Volume II Useful Information for Cloud Adopters
- ◆ **Special Publication 500-299**, (Draft) NIST Cloud Computing Security Reference Architecture
- ◆ **Interagency Report 7904**, (Draft) Trusted Geolocation in the Cloud: Proof of Concept Implementation

Other Resources

- SNIA Cloud Storage Initiative, <http://www.snia.org/cloud>
- European Network and information Security Agency (ENISA), *Cloud Computing – Benefits, risks and recommendations for information security*, <http://www.enisa.europa.eu/>
- Information Systems Audit and Control Association (ISACA), *Cloud Computing: Business Benefits With Security, Governance and Assurance Perspectives*, <http://www.isaca.org>

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Possible Security Benefits

(Especially for SMBs)

- Centralized data
- Segmented data and applications
- Better logging/accountability
- Standardized images for asset deployment
- Better resilience to attack & streamlined incident response
- More streamlined audit and compliance
- Better visibility to process
- Faster deployment of applications, services, etc.

Cloud Security Tips

- Cloud-based security is not a substitute for existing ICT security...think defense in depth
- Understand the Terms of Service...this is the best you can expect
- Don't put anything in the cloud you wouldn't want someone else to see (government, competitor, or a private litigant)
- Placing consumer data in the cloud could put you at risk of violating the law...where is it?

Final Thoughts

- It is *possible* to engineer solutions across most cloud services today that meet or exceed the security provided within the enterprise...however, the capability to execute may not be a reality!
- The various value propositions of cloud (agility, low cost, scalability, security) are often conflated, suggesting all four can be achieved simultaneously and in equal proportions; this is a fallacy because trade-off are almost always required.

The SNIA Education Committee thanks the following individuals for their contributions to this Tutorial.

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➤ SNIA Security Technical Work Group (TWG)

- ◆ **Focus:** Requirements, architectures, interfaces, practices, technology, educational materials, and terminology for storage networking.
- ◆ http://www.snia.org/tech_activities/workgroups/security/

➤ Storage Security Industry Forum (SSIF)

- ◆ **Focus:** Educational materials, customer needs, whitepapers, and best practices for storage security.
- ◆ <http://www.snia.org/ssif>