

# Cloud Computing Technologies

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# Brief Profile

## Education

- PhD Electronic and Computer Engineering, University of Limerick, Ireland (2015 – 2019)
- MSc Business Information Technology, Southampton Solent University, United Kingdom (2007-2008)
- B.Eng Computer Systems, Mehran University of Engineering and Technology, Pakistan (2002-2006)

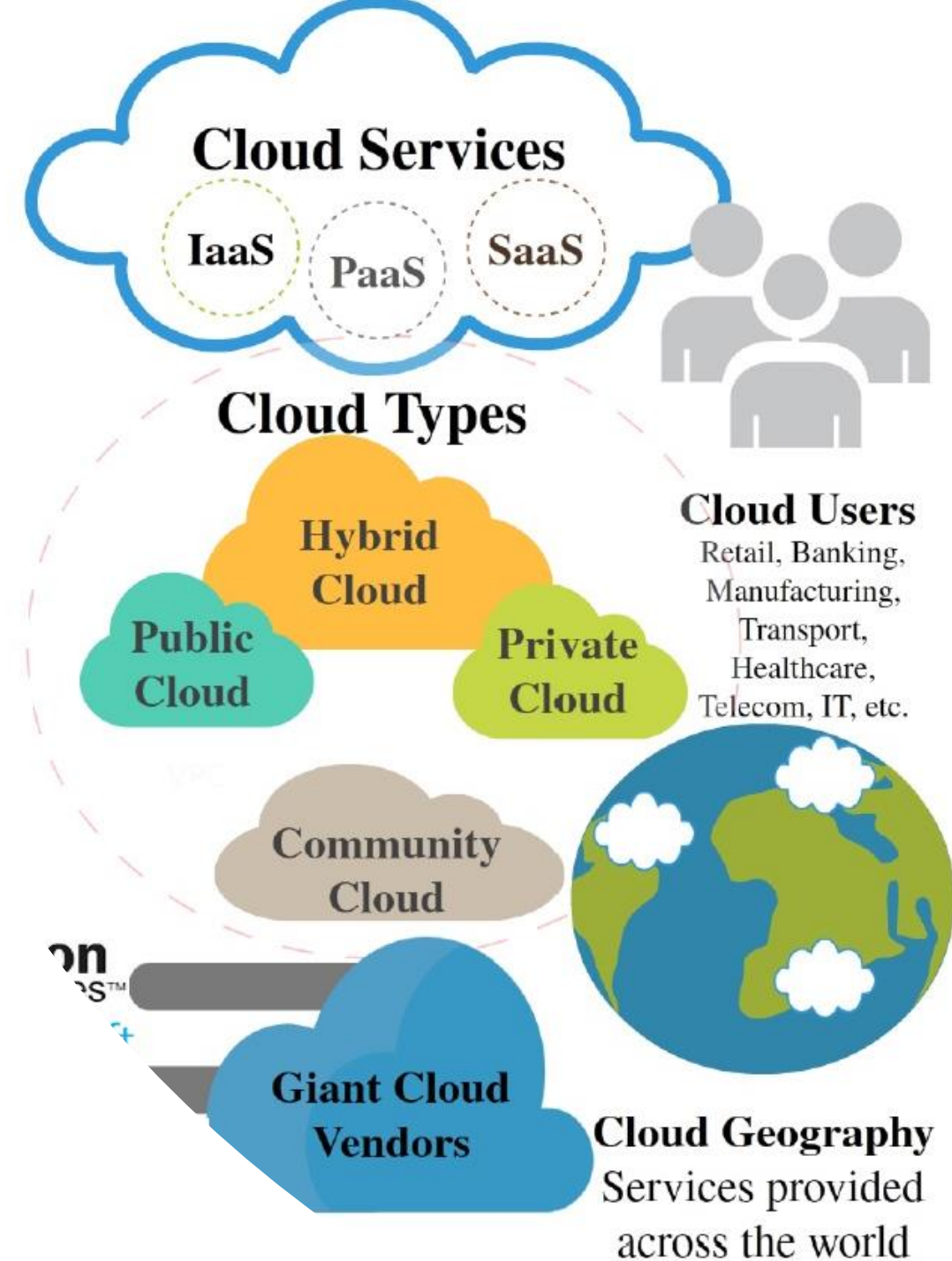
## Expertise/Areas of interest:

- Cloud Computing, Cloud Standardization
- Cybersecurity
- Cloud/Business/IT Standards

# Outline

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- What is Cloud Computing?
- Cloud Computing Features
- Cloud Computing Research Areas:
  - Cloud Computing Security
  - Cloud Computing and Internet of Things (IoT)
  - Cloud Computing QoS and Standardization
    - Frameworks and Toolkits
    - Cloud OMS
    - Cloud Federation and legal issues
  - Cloud Economics
  - Cloud Computing and IIoT
- Pursuing a career in Cloud Computing





# What is Cloud Computing?

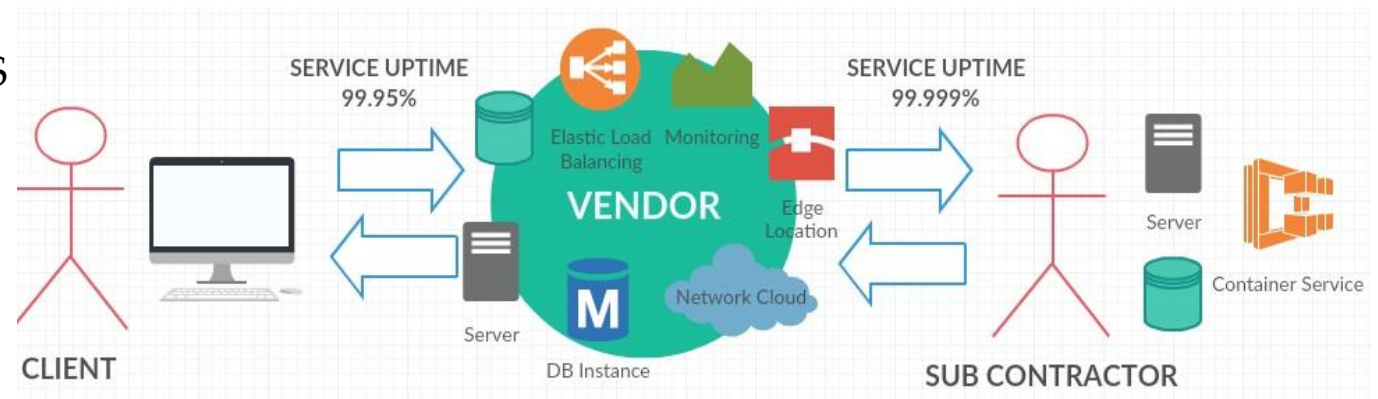


# Securing the Hybrid Cloud while preserving the Data Integrity and Service Level Agreements

- Scope of the project - Securing Hybrid Clouds
  - Existing Issues:
    - (i) Lack of visibility, transparency and control
    - (ii) Measuring & Monitoring the promised QoS
    - (iii) Data Integrity

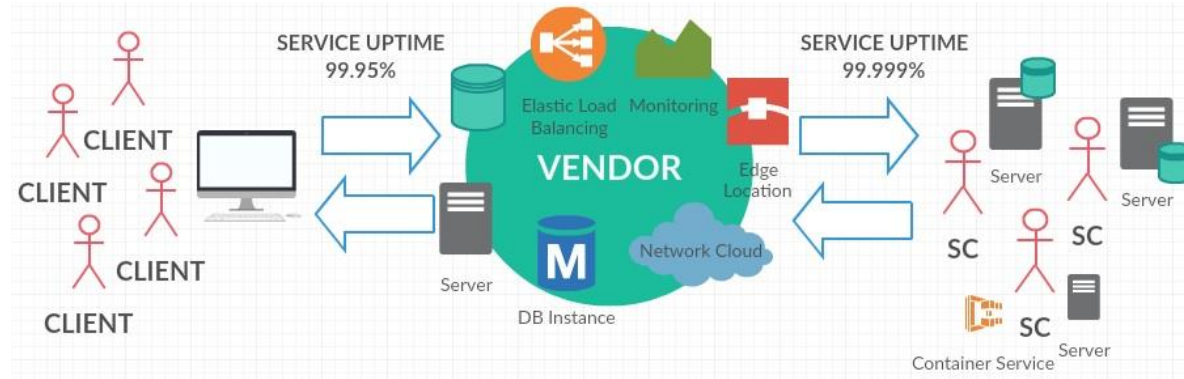
## Scenario #1 One Client & One Subcontractor

- Research Issues:
  - Data Controller (Security, DGRC), DRaaS
  - Third Party Privities
  - Availability, Monitoring & Outages
  - Location, Force Majeure Clause
  - EU Data Protection Laws
  - Vendor Lock-In
  - Scalability & Elasticity



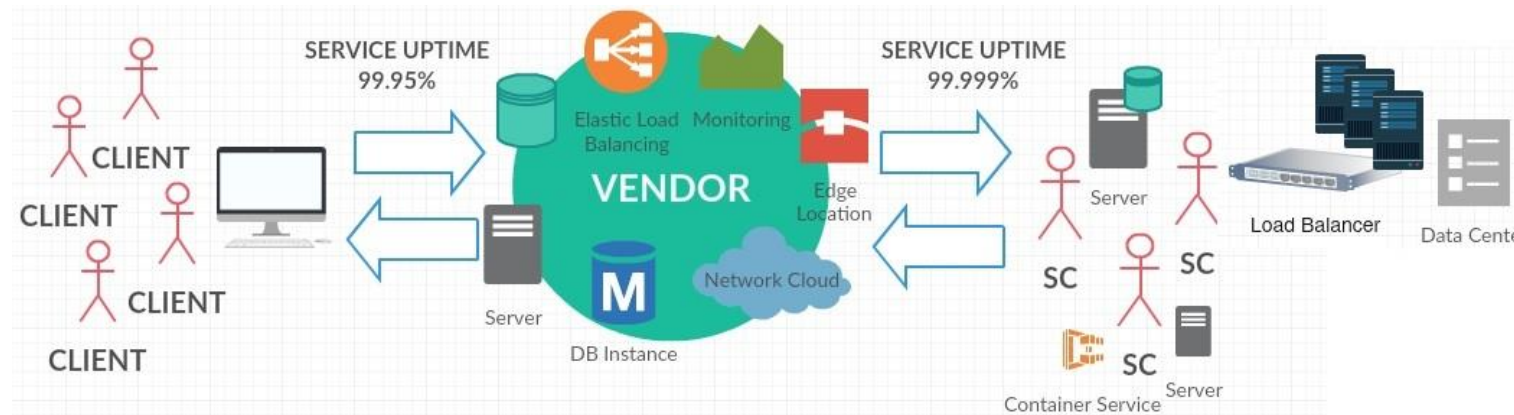
# Securing the Hybrid Cloud while preserving the Data Integrity and Service Level Agreements

## Scenario #2 Multi-tenancy & Multiple Subcontractors



- Sub-contractor Architecture?
- Cloud Performance Management
- Hybrid & Inter-cloud Performance.
- What happens when a subcontractor shuts-down?

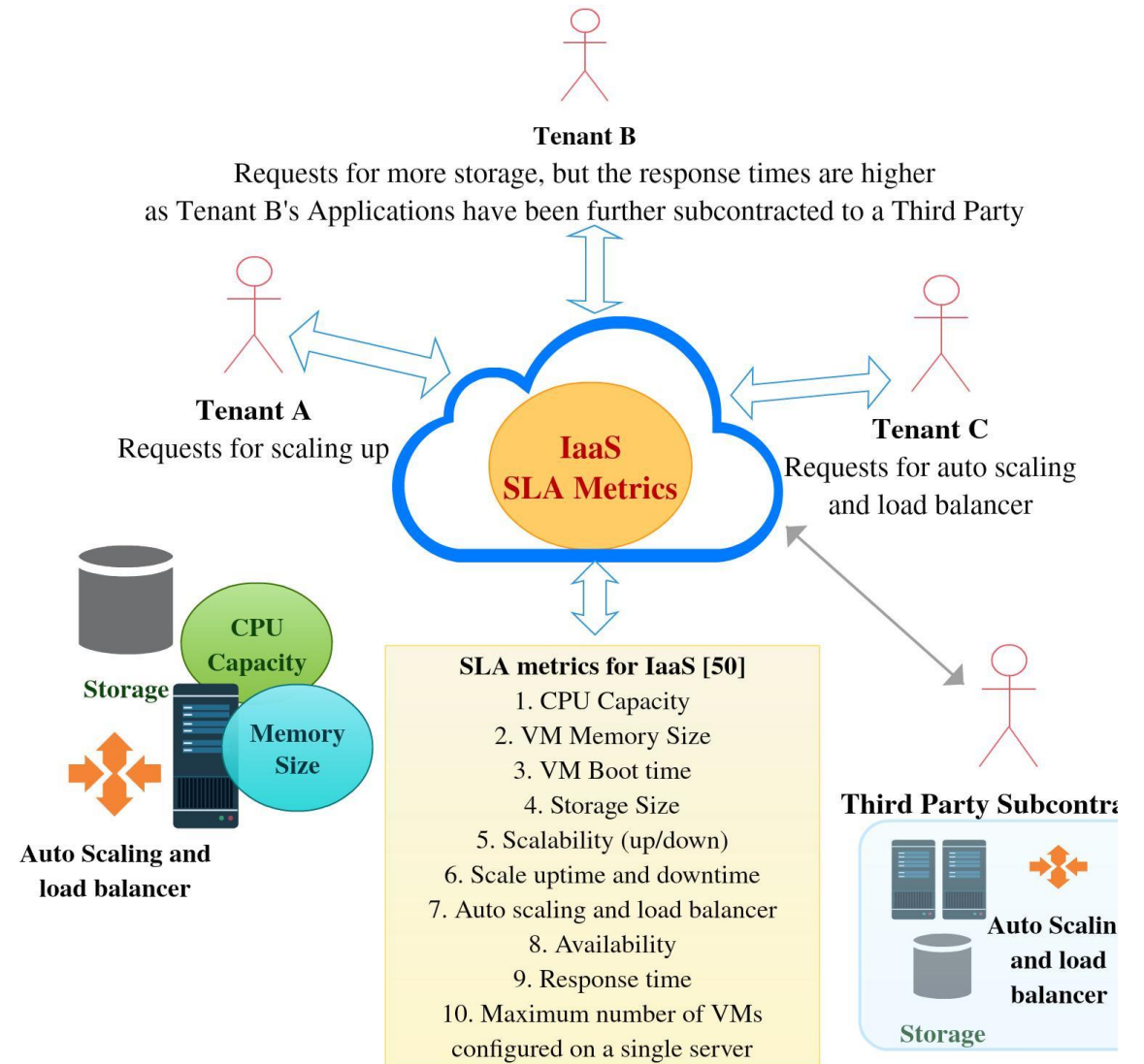
## Scenario #3 Defined Processes Multi-tenancy & Multiple Subcontractors



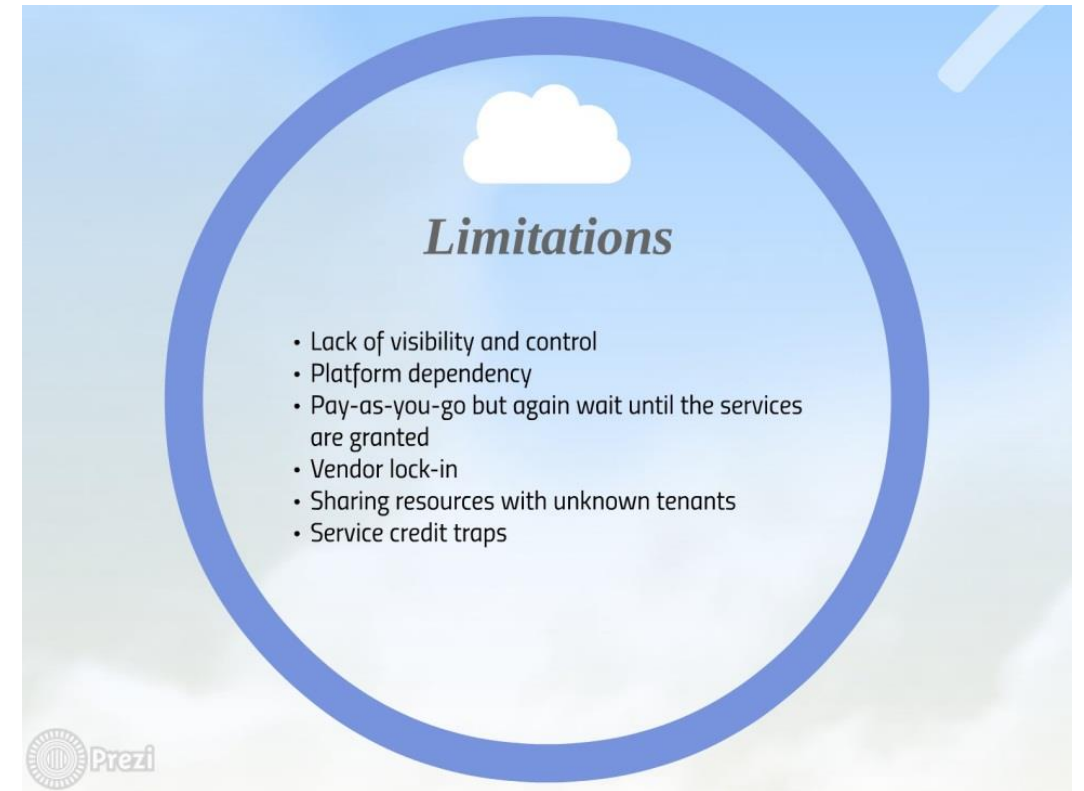
- Instance visibility
- Outage
- Vendor Lock-in
- Elasticity
- Each subcontractor serving different Services in a multitenant environment.

# Cloud Computing Service Level Agreements

- SLA Parameters
- SLA Metrics
  - Response time, Latency, Availability, Resilience, etc.
- SLA Exceptions
  - Hardware failure, Software failure, Network failure, Scheduled downtime, Denial of Service, Monitoring failure, Acts of God, etc.







## Hybrid Cloud Computing Model considering Third Party Sub-contracting

### Published

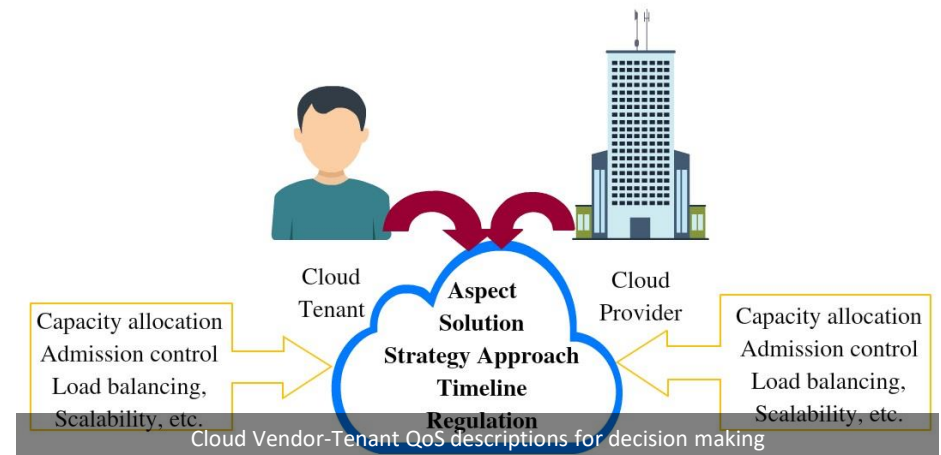
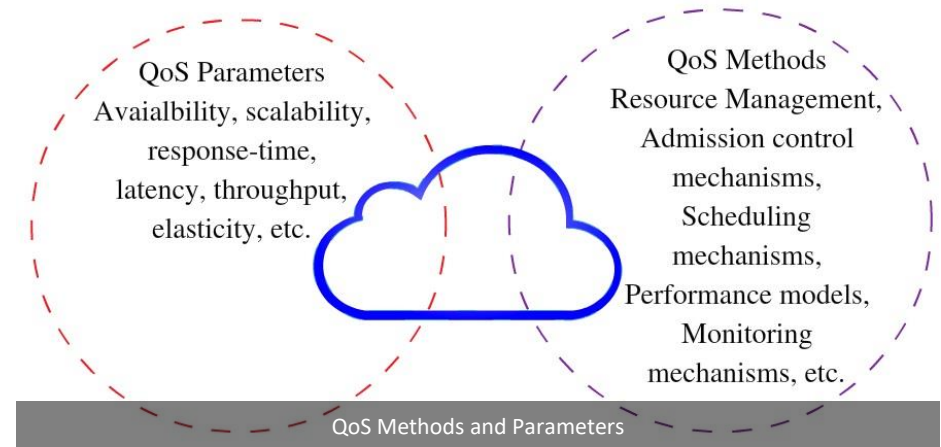
- **Dhirani, L.,** Newe, T. and Nizamani, S. (2016). Tenant - Vendor and Third-Party Agreements for the Cloud: Considerations for Security Provision. International Journal of Software Engineering and Its Applications, 10(12), pp.449-460.
- **Dhirani, L.,** Lightning talk on "Hybrid cloud computing hidden threats" at HEAnet National Conference Galway, 9th - 11th November 2016. Link for the talk <https://conferences.heanet.ie/2016/talks/id/232>



# Decision-making in the Cloud

- SLA Management Tools
- QoS Methods and Parameters
- Why does the cloud need to focus on QoS?
  - Reliability, Conformance, Serviceability, Availability, Timeliness, etc.
- QoS in Cloud
  - Various standards: CSA, ISO, NIST, OCCl, OpenStack, CDMI.
  - Issue: Each vendor implements a different standard.

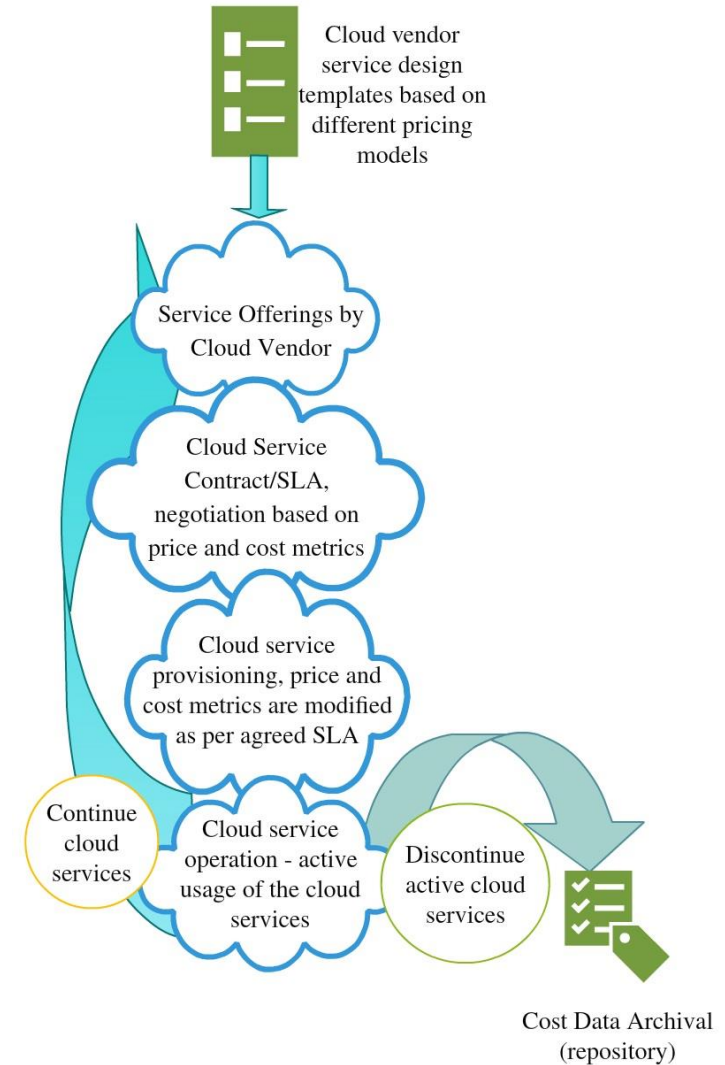
**Published:** Dhirani, L., Newe, T., & Nizamani, S. (2018). Hybrid Cloud Computing QoS Glitches. In 2018 5th International Multi-Topic ICT Conference (IMTIC) (pp. 1-6). IEEE.



# Cloud Cost Management and Pricing Models

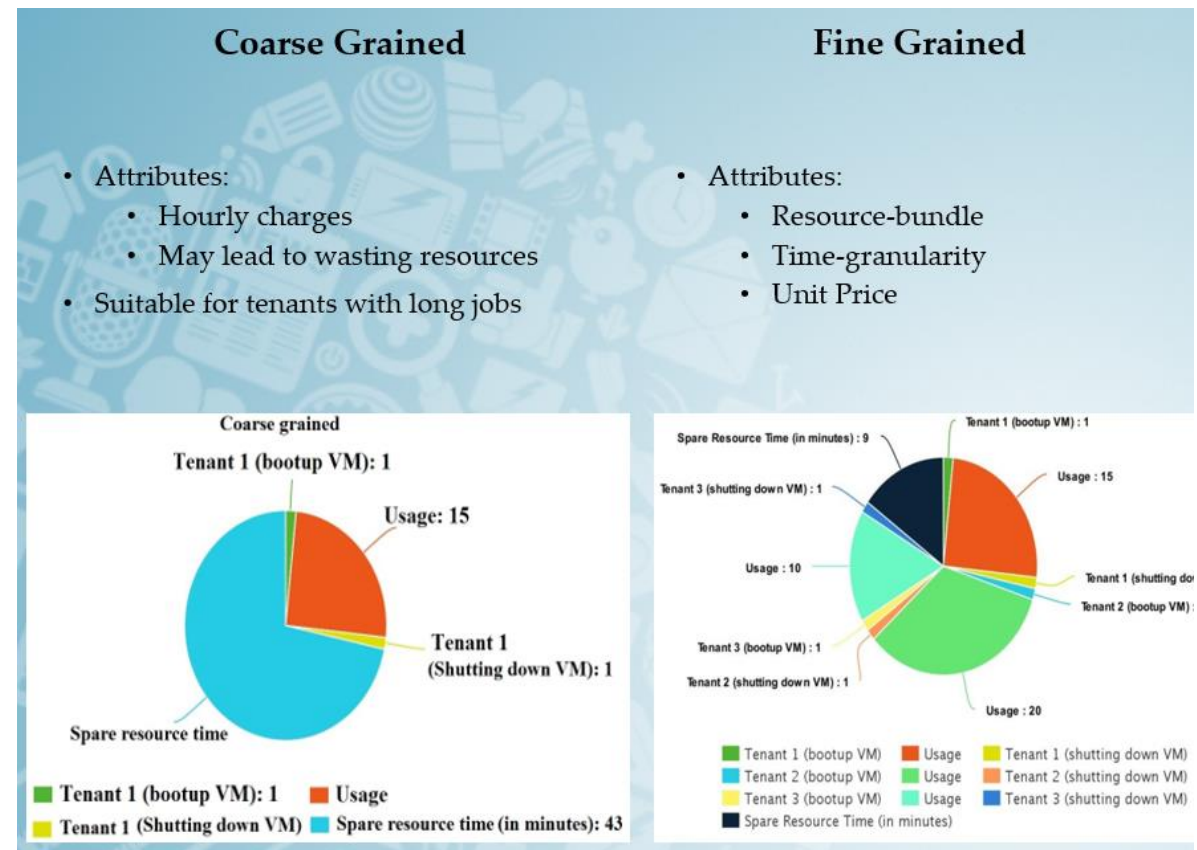
- Cloud Costs
- Usage Metrics
  - Storage, Network, Compute, etc.
  - Each billed metric (reliability, uptime, scalability, etc.)
    - Each metric has multiple sub-metrics
- Pricing Model
  - Reserved, On-demand, On-Spot
  - Virtual Machine Instance (VMI) type
  - Billing period (monthly, bi-annually, annually)

**Published:** Dhirani, L., Newe, T., & Nizamani, S. (2018). Hybrid Cloud Computing QoS Glitches. In 2018 5th International Multi-Topic ICT Conference (IMTIC) (pp. 1-6). IEEE.



# Cloud Computing and IoT fusion: Cost Issues

- IoT Applications and Cloud Computing
- Pricing
  - Types of instances, duration, requirements, etc.
- IoT and Cloud Computing Platforms
  - IoTCloud, OpenIoT, NimBits, OpenPicus, Xively
- IoT Limitations
  - Each operator follows different standards
  - Lack of standard architecture
  - Interoperability, scalability, security, availability and big data.
  - Cloud Computing may overcome the limitations in terms of storage, real-time data processing, capacity, availability and security.





# Can IoT Escape the Cloud QoS and Cost Pitfalls

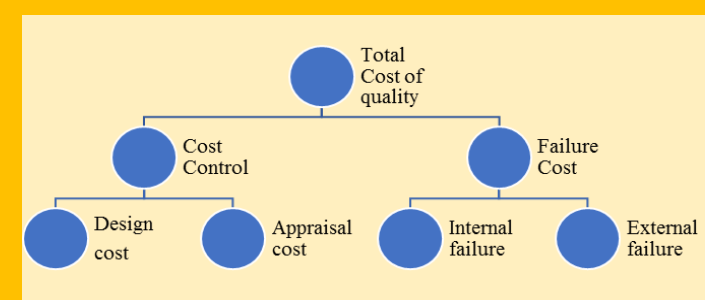
- Cost over-runs on public cloud deployments.
- IoT architectures are sensitive to metered billing because of the huge volume of data they produce.
- Pricing: volume of data, price per Megabyte, registered devices and nominal charge

## AWS vs. Azure IoT costs

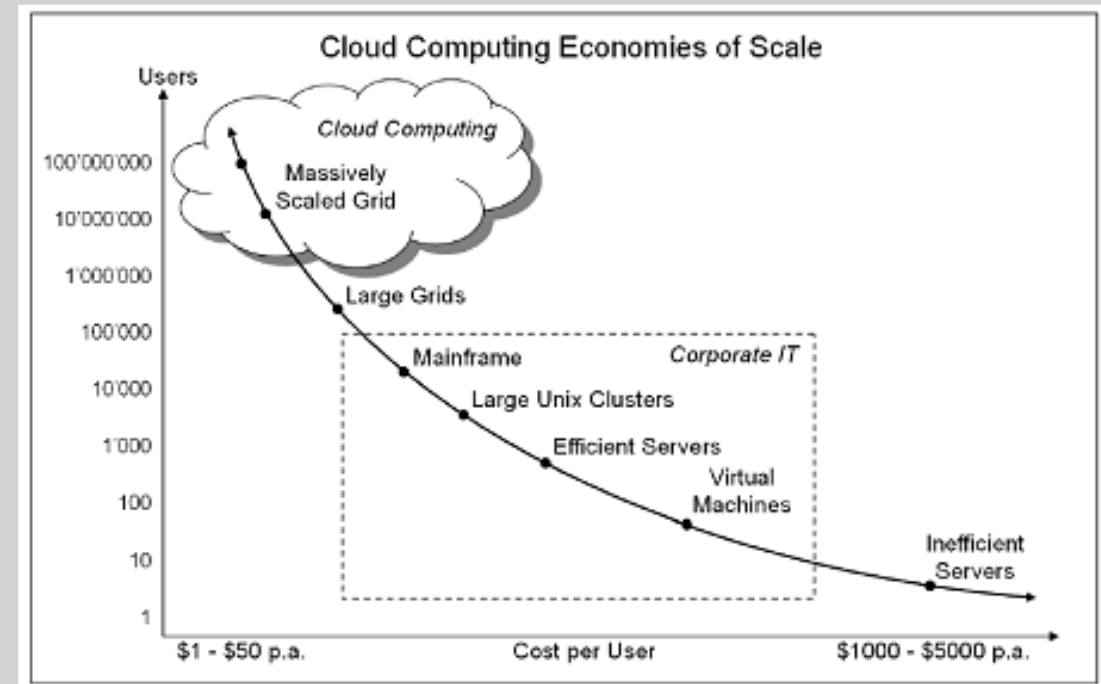
■ THE SHARE OF SIMULATIONS FOR WHICH AWS WAS THE CHEAPEST ■ THE SHARE OF SIMULATIONS FOR WHICH AZURE WAS THE CHEAPEST



# Cloud: ROI



- Enhanced QoS delivered in due time may only grant revenues, other factors driving the ROI, profit, etc. can be absolutely influenced by using cloud services.
- Capacity versus actual utilization
- Usage based pricing
- Measuring and tracking ROI
- Cloud Control Matrix



Adapted from: Judith Hurwitz et. al., Cloud Computing for Dummies, Wiley Publishing, Inc. 2010

# Can IoT Escape the Cloud QoS and Cost Pitfalls

## Example: Enterprise ABCs ROI.

The yearly IT expenses are \$20M and the aim is to retain 30% of the servers, lowering traditional IT expenses to \$5M, and migrate 15% of the applications to cloud servers, which may incur \$2M/annum running costs. The enterprise will discard the remaining 55% of old IT hardware. It also includes a \$10M investment for buying services and migrating applications on the cloud platform. The ongoing expenses of the private cloud are estimated to remain equivalent as of the current infrastructure.

	Total	Year 0	Year 1	Year 2
Current IT Cost		20.0	20.0	20.0
Traditional IT Cost with Cloud Solution		20.0	5.0	5.0
Cloud IT Cost with Cloud Solution			5	5
Decrease in IT Cost	20.0	0.0	10	10
Financial improvement	20.0			
Cost of implementing cloud	10.0			
Investment	10.0			
ROI over 3 years	100%			

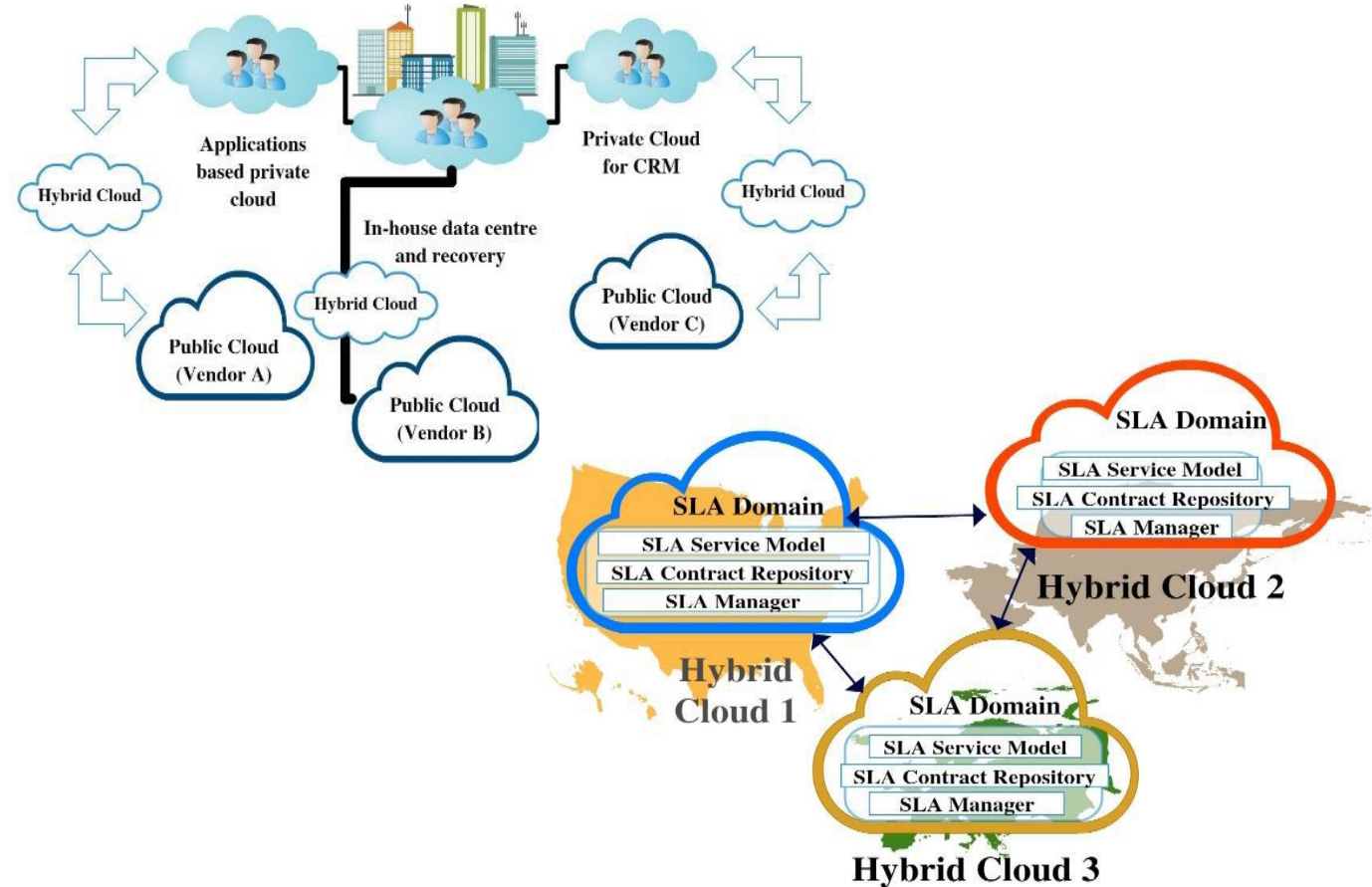
- Cloud QoS limitations:
  - Failure to guarantee the promised service levels
- IoT tenants lock-in situations
- Cloud IoT based costs: communication and networking costs, software asset management, volume and frequency of data to be processed, cold storage, etc.
  - Direct and in-direct QoS costs
- TCO, ROI
- Designed Cloud Framework
  - Reduced QoS gaps
  - Lesser service violations and number of defects
  - Track, benchmark, sustain and improving the QoS Lifecycle
  - May achieve 99.9999997% accuracy



# Federated Hybrid Clouds

## Service Level Agreements and Legal Issues

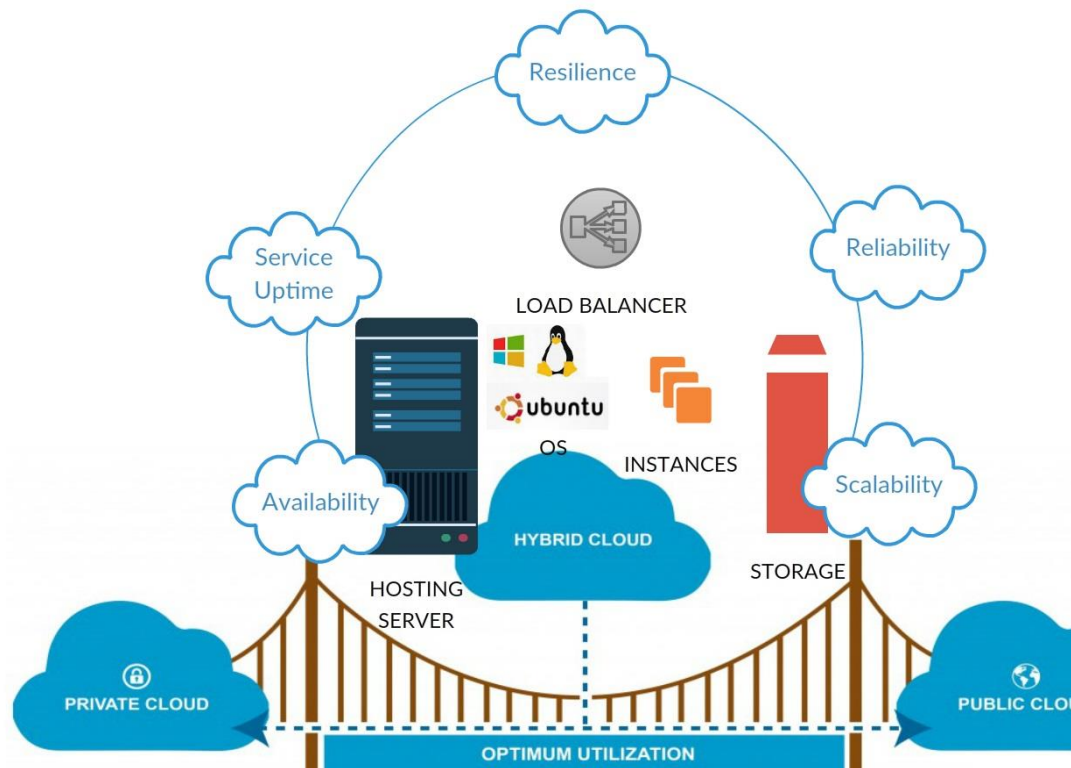
- SLA issues in the Hybrid Cloud Model
  - QoS of the Service Level Objectives
  - Inconsistency and Non-uniformity
  - SLA Management
- Multi-cloud Frameworks
- SLA in Federated Environment
  - Homogenous versus heterogeneous
  - Resource provisioning and billing
- SLA Service Domain
- Cross-Platform monitoring
- SLA Challenges



Hybrid Multi-Cloud federated SLA Architecture

**Published:** Dhirani, L., Newe, T. and Nizamani, S. (2018). Federated Hybrid Clouds: Service Level Agreements and Legal Issues. In proceeding of Springer AISC ISSN Number – 2194-5357. Third International Congress on Information and Communication Technology 2018.

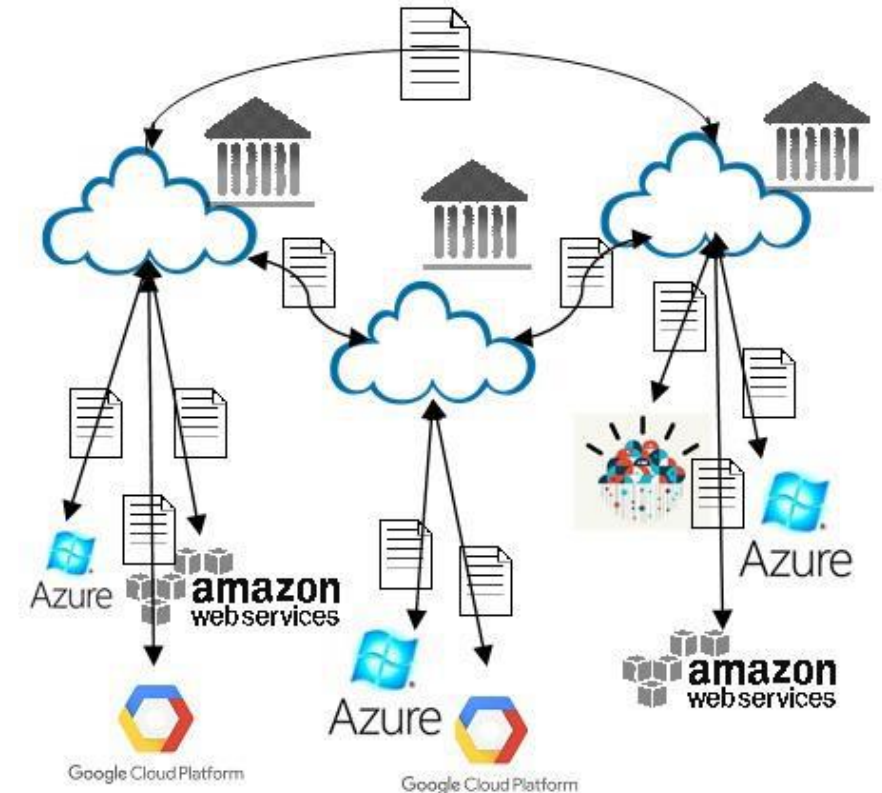
# Legal Issues



- Insight, visibility, Jurisdiction and Control
- Cloud brokering feasibility, policy management and rules
- Incomplete, non-consistent and vague SLA templates
- Illegal use of cloud, termination, renewal and compliance
- Cloud Audit, Accountability and Trust Issues
- Multi-tenancy issues in federated cloud models
- Strategizing the Federated Cloud

# Cloud Federation SLAs

- SLAs involve SLA management and monitoring systems to conduct audits, usage, failover and control
- SLA Monitoring tools:
  - Used for observing service performance levels, threshold, redundancy and violations.
  - Melodic, AWS CloudWatch, Google Slackdriver, IBM Trivoli.
- Hybrid SLA Management
  - Ansible, ManageEngine, IBM-ITOM
  - Microsoft Hybrid IT- Management (OMS)



Complexity of federated hybrid multi-cloud model



# Comparison OMS Versus Local Hybrid IT Management

Minify	Equipment	Estimate cost, billing and SLA Compliance	Pricing	Resources	Specifications
Usage	Log Search	Alert Management	Change Tracking	Malicious IP Detection	Search API
Wire Data		Anti-malware Assessment	Near real-time performance logs	Syslog	Cost

# An Example

## Assessing metrics and sub-metrics

- I have blanked out some of the content as it is subject to copyright – but if you are interested more into understanding the SLA metrics, I would recommend you reading the following:

- Erl, T, Mahmood, Z. and Puttini. R., (2013) *Cloud Computing Concepts, Technology and architecture*: Prentice Hall.
- Erl, T., Cope, R. and Naserpour, A., (2015) *Cloud computing design patterns*: Prentice-Hall.
- Jouini, M., & Rabai, L. (2015). Mean Failure Cost Extension Model towards Security Threats Assessment: A Cloud Computing Case Study. *Journal Of Computers*, 10(3), 184-194. doi: 10.17706/jcp.10.3.184-194

Table 3.1: Generalized SLA Parameters

QoS Metrics (Availability, Reliability, Performance, Scalability, Resiliency) [6]	
Availability Metrics	Availability metric rate (i.e. 99.5%), Downtime/Week, Downtime/Month, Downtime/Year, Outage Duration
Reliability Metrics	
Performance Metrics	
Scalability Metrics	Storage Scalability (Horizontal/Vertical), Server Scalability (Horizontal/Vertical)
Resilience Metrics	Mean-Time to Switch, Mean-Time to Repair, Mean-Time System Recovery

Each parameter may comprise SLA details such as: SLA description, measurement, method and frequency of collection, threshold levels, cloud delivery model and availability for evaluating the SLA QoS.

Metric	Description	Measurement		Threshold
ISTM	Length of time required to initialize a new instance	date/time of instance up – date/time of start request		maximum, 3 minutes average

**SLA Penalty:**

- 
- Service Credits

**Metrics triggered:**

- Average response-time
- 

**Can also be subject to:**

- Availability

# SLA-based issues

- SLA based issues such as:
  - visibility, monitoring, breaches, violations, management, cross platform compatibility, intercloud management, etc. arising in different cloud models and legal challenges which raise concerns over cloud legalization, security and standardization.
- Uniform Cloud Ecosystem, Strategizing the existing federated cloud frameworks and models for reinforcement of SLA monitoring, operational management and QoS
- Lack of proper SLA management and monitoring any cloud platform may fail to fulfill the business need.
- SLA Standardization and Vendor SLAs
  - **Challenge: working with different vendors with exactly same SLAs**
- SLAM tools limitations and complexity
- Possible Solutions
  - In-house tool for ITOM
  - Standardized SLA template
  - PBSLA, RBSLA, RBSLM
  - Automated rule-based SLA/chaining SLA
  - Dynamic SLA



# Cloud Economics and Enterprise Strategy: A bird eye's view

- Enterprise Strategy for Cloud Migration
- Business Models
- Standards
- Cloud Migration: Test, Migrate, Transform
- Cloud Architecture Blueprints
- Evaluating Vulnerabilities and Risk Component
- Cloud Quality Management and SLAs

**Published:** Dhirani, L., Newe, T. and Nizamani, S. (2018). Cloud Computing and Enterprise Strategy: a bird eye's view. International Journal of Engineering & Technology, 7(3.5), pp.360-367.

Table 2. SLA Availability based on different cloud models

Cloud Model	Downtime/week	Downtime/month	Downtime/year
SLA Examples			
IaaS (99.99%)	1.01 minutes	4.32 minutes	8.67 hours
PaaS (99.95%)	5 minutes	21.6 minutes	4.38 hours
SaaS (99.90%)	10.1 minutes	43.2 minutes	8.67 hours
Best SLA (99.999%) [10]	6 seconds	25.9 seconds	5.26 minutes
Weak SLA (99.0%) [10]	1.68 hours	7.2 hours	3.65 days
These SLAs may need to be further classified in situations of federated and multi-cloud architectures.			



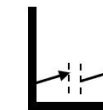
(a) Tenant's demand for computing resources increasing and decreasing based on workload.



(b) Consistent Workload



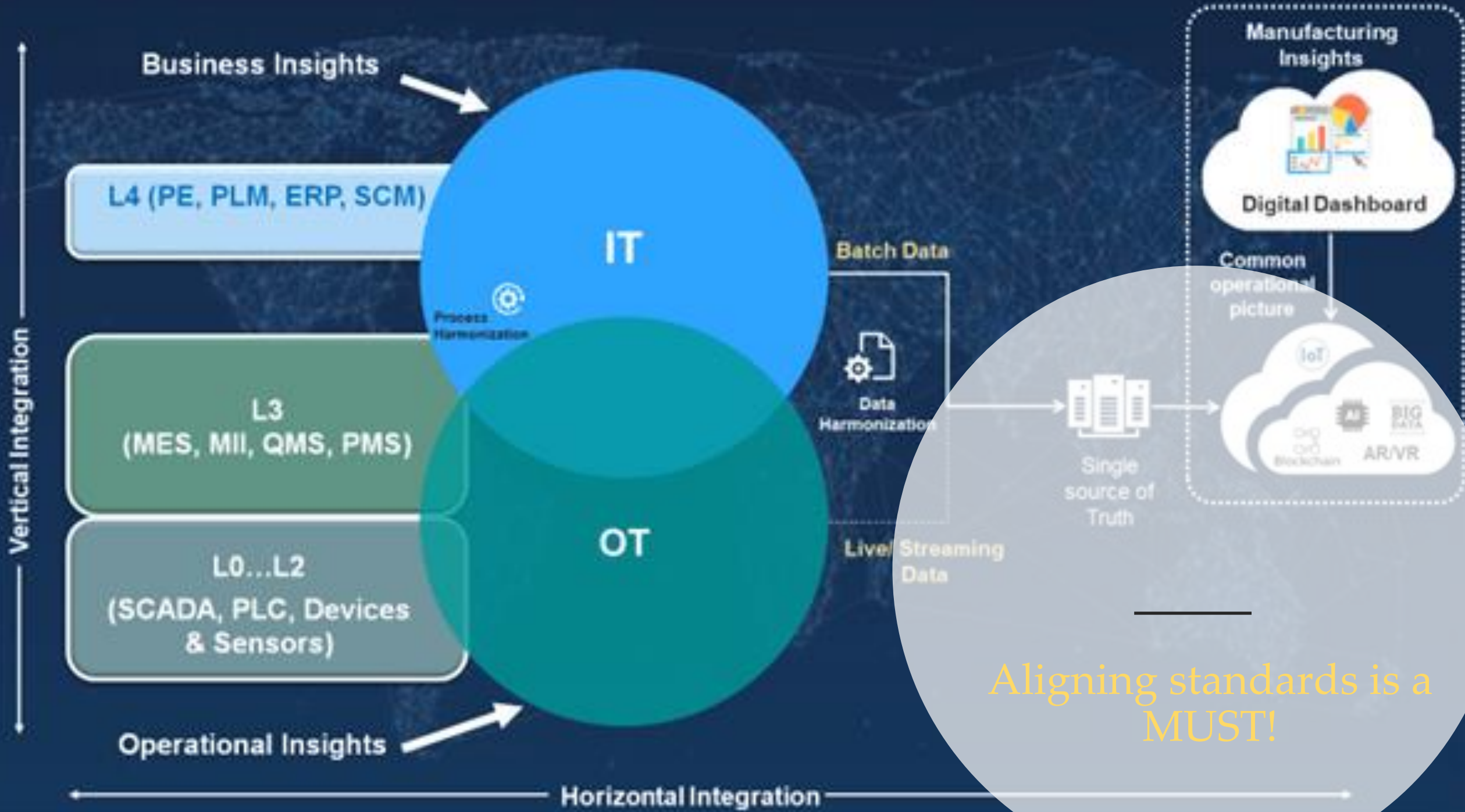
(c) Tenant with fluctuating or random computational requirements

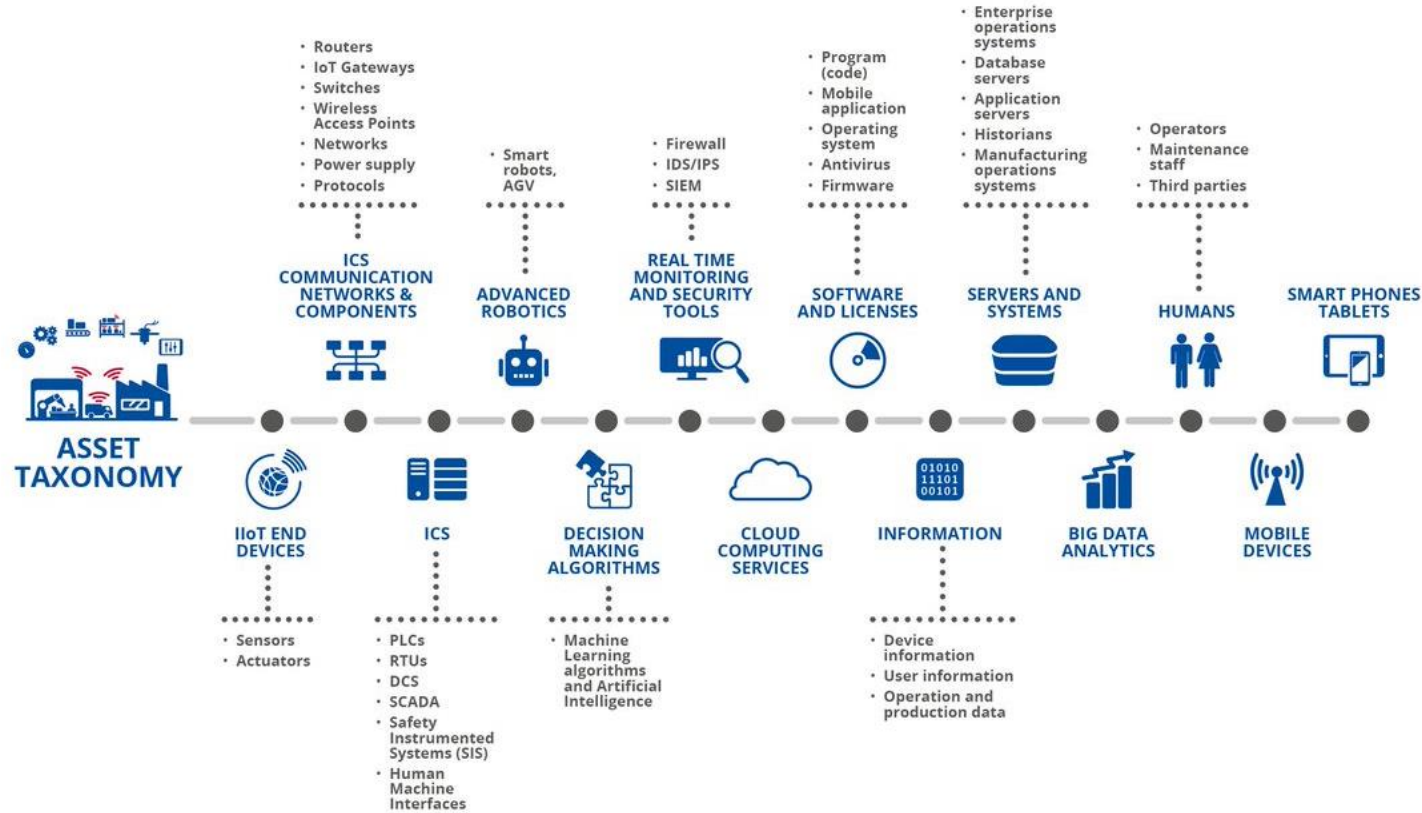


(d) Tenant with very low computational needs and may open and close the VM multiple times

# Why is QoS Important?

- Business-Cloud-IT
- Standards and measures for cloud models
- One size does not fit all
- Unified approach
- QoS in Business
  - TQM, Lean
  - Improved customer retention, reduced costs associated to defects, scrap, re-work, Reduced time-cost.
- QoS in IT
  - ITIL, LeanIT, CMM-I.
- Why does the cloud need to focus on QoS?
  - Reliability, Conformance, Serviceability, Availability, Timeliness, etc.
- QoS in Cloud
  - Various standards: CSA, ISO, NIST, OCCl, OpenStack, CDML.
  - Issue: Each vendor implements a different standard.

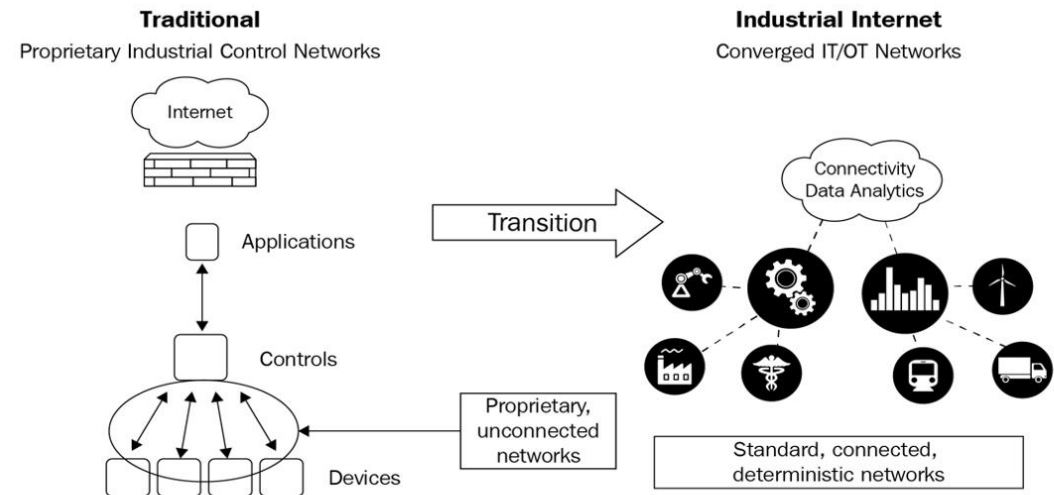




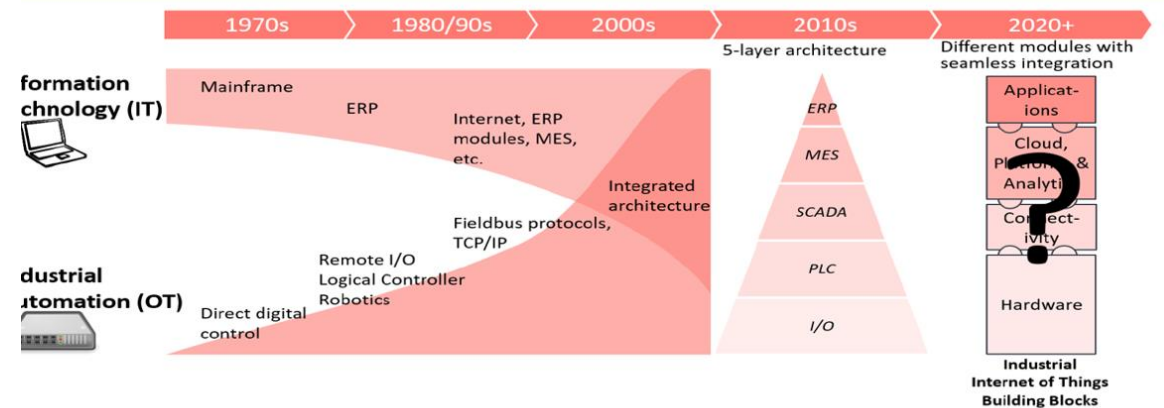
Cloud's role in the bigger picture



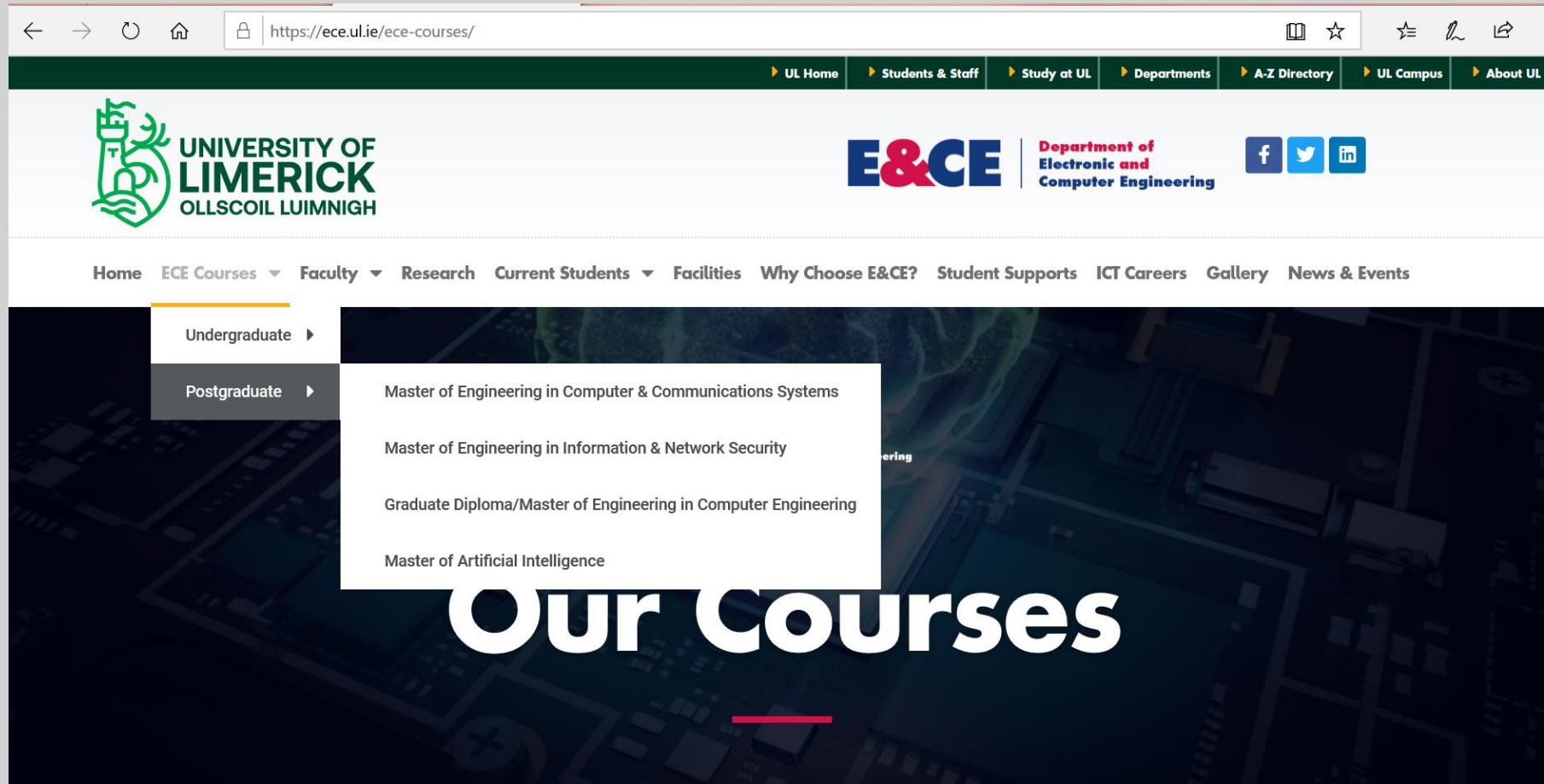
# The future



## The evolution of IT-OT convergence



# Pursuing postgrad at University of Limerick



The background features a series of concentric circles and rings, each composed of small, rectangular blocks or segments. These segments are arranged in a way that creates a sense of depth and movement, resembling a stylized representation of a data center or a complex network. The colors are primarily dark blue and black, with some lighter blue and white highlights that give the impression of light reflecting off the surfaces of the blocks. The overall effect is a high-tech, futuristic aesthetic.

# Pursuing a career in Cloud Computing

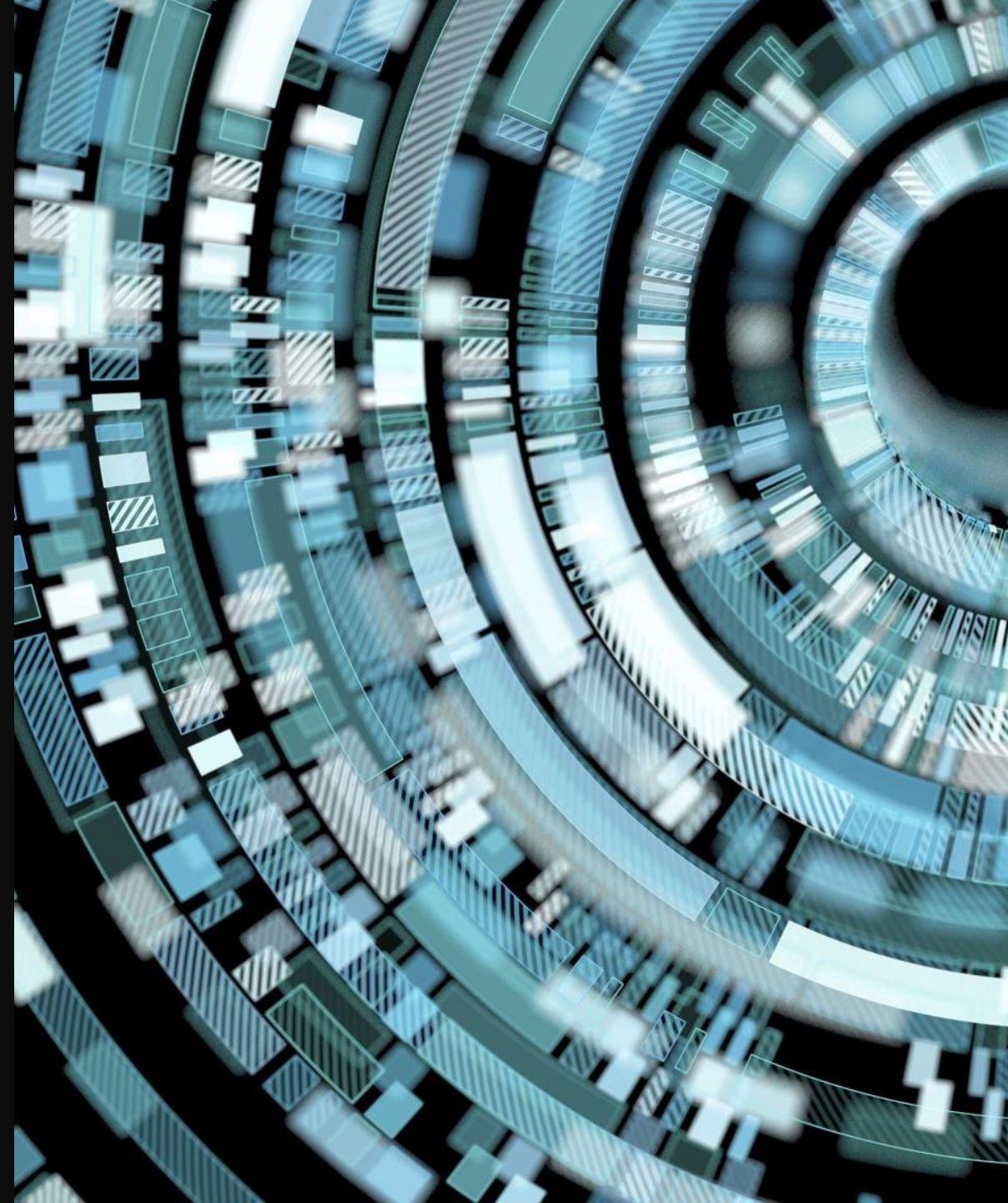
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# Some of the roles which Cloud offers

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- Cloud Analyst
  - Cloud DevOps
  - Cloud Solutions Architect
  - Cloud Support Engineer
  - Cloud Software Architect
  - Data Engineer
  - Data Scientist
  - Cloud Engineer
- 





# List of Publications

Researchgate: [Lubna\\_Dhirani](#)

Linkedin: [lubna-luxmi-dhirani-19b3b99](#)

## BOOK CHAPTERS

- **Dhirani, L.,** Newe, T. and Nizamani, S. (2019). Hybrid Multi-Cloud Demystifying SLAs for Smart City Enterprises using IoT applications. IoT Architectures, Models, and Platforms for Smart City Applications. *IGI Global*. 2019.
- **Dhirani, L.,** Newe, T. and Nizamani, S. (2018). Federated Hybrid Clouds: Service Level Agreements and Legal Issues. In proceeding of Springer AISC ISSN Number – 2194-5357. Third International Congress on Information and Communication Technology 2018.

## JOURNAL PAPERS

- **Dhirani, L.,** Newe, T. and Nizamani, S. (2018). Cloud Computing and Enterprise Strategy: a bird eye's view. *International Journal of Engineering & Technology*, 7(3.5), pp.360-367.
- **Dhirani, L.,** Newe, T. and Nizamani, S. (2016). Tenant - Vendor and Third-Party Agreements for the Cloud: Considerations for Security Provision. *International Journal of Software Engineering and Its Applications*, 10(12), pp.449-460.

## CONFERENCE PAPERS

- **Dhirani, L.,** Newe, T. and Nizamani, S. (2019). Cloud Computing and Enterprise Strategy: a bird eye's view. *In Proceeding of 4th International Conference on RTCSE*, Hawaii, USA. Jan 3-6, 2019.
- **Dhirani, L.,** Newe, T. and Nizamani, S. (2018) Can IoT escape Cloud QoS and Cost Pitfalls." 2018 12th International Conference on Sensing Technology (ICST). IEEE, 2018.
- **Dhirani, L.,** Newe, T., & Nizamani, S. (2018). Hybrid Cloud Computing QoS Glitches. In 2018 5th International Multi-Topic ICT Conference (IMTIC) (pp. 1-6). IEEE.
- **Dhirani, L.,** Newe, T., Lewis, E. and Nizamani, S. (2017). Cloud computing and Internet of Things fusion: Cost issues. 2017 Eleventh International Conference on Sensing Technology (ICST).

## COLLOQUIUMS

- **Dhirani LL,** Securing the Hybrid Cloud while preserving Data Integrity and Service Level Agreements, OFSRC and MMRRRC Annual Colloquium **2018**, University of Limerick.
- **Dhirani LL,** Six Sigma Cloud Model: Improving SLA QoS in the Hybrid Cloud Ecosystem, OFSRC & MMRRRC Annual Colloquium **2017**, University of Limerick.
- **Dhirani LL,** Securing the Hybrid Cloud while preserving Data Integrity and Service Level Agreements, OFSRC & MRRC Annual Colloquium **2016** and **2015**, University of Limerick.

## LIGHTNING TALKS

- **Dhirani, L.** (2018) Hybrid Cloud QoS - The Business Perspective. HEAnet Conference 2018, Ireland. <https://conferences.heanet.ie/2016/talks/id/232>
- **Dhirani, L.** (2016) Hybrid cloud computing hidden threats. HEAnet Conference 2016, Ireland. <https://conferences.heanet.ie/2018/talk/111>

## POSTER PRESENTATIONS

- **Dhirani, L.,** Newe, T., Nizamani, S. (2018). Cloud Economics. 2018 International Conference on Computer Science & Cloud Computing (ICSCC), Spain
- **Dhirani, L.,** Newe, T., Nizamani, S. (2017). Hybrid Cloud Computing: Security Loopholes. Poster presentation NUIGUL-2017, Galway

Googlescholar: <https://scholar.google.com/citations?user=T9y9pgEAAAAJ&hl=en>