Research in Cloud Computing

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Talk Objectives

- A high-level discussion of the fundamental challenges and issues/characteristics of cloud computing
- Identify a few security and privacy issues within this framework
- Propose some approaches to addressing these issues
  - Preliminary ideas to think about

Introduction

- Cloud Computing Background
- Cloud Models
- Why do you still hesitate to use cloud computing?
- Causes of Problems Associated with Cloud Computing
- Taxonomy of Fear
- Threat Model

Cloud Computing Background

- Features
  - Use of internet-based services to support business process
  - Rent IT-services on a utility-like basis
- Attributes
  - Rapid deployment
  - Low startup costs/ capital investments
  - Costs based on usage or subscription
  - Multi-tenant sharing of services/ resources
- Essential characteristics
  - On demand self-service
  - Ubiquitous network access
  - Location independent resource pooling
  - Rapid elasticity
  - Measured service
- "Cloud computing is a compilation of existing techniques and technologies, packaged within a new infrastructure paradigm that offers improved scalability, elasticity, business agility, faster startup time, reduced management costs, and just-in-time availability of resources"

From [1] NIST

A Massive Concentration of Resources

- Also a massive concentration of risk
  - expected loss from a single breach can be significantly larger
  - concentration of "users" represents a concentration of threats
- "Ultimately, you can outsource responsibility but you can't outsource accountability."

From [2] John McDermott, ACSAC 09

Cloud Computing: who should use it?

- Cloud computing definitely makes sense if your own security is weak, missing features, or below average.
- Ultimately, if
  - the cloud provider's security people are "better" than yours (and leveraged at least as efficiently),
  - the web-services interfaces don't introduce too many new vulnerabilities, and
  - the cloud provider aims at least as high as you do, at security goals,

  then cloud computing has better security.

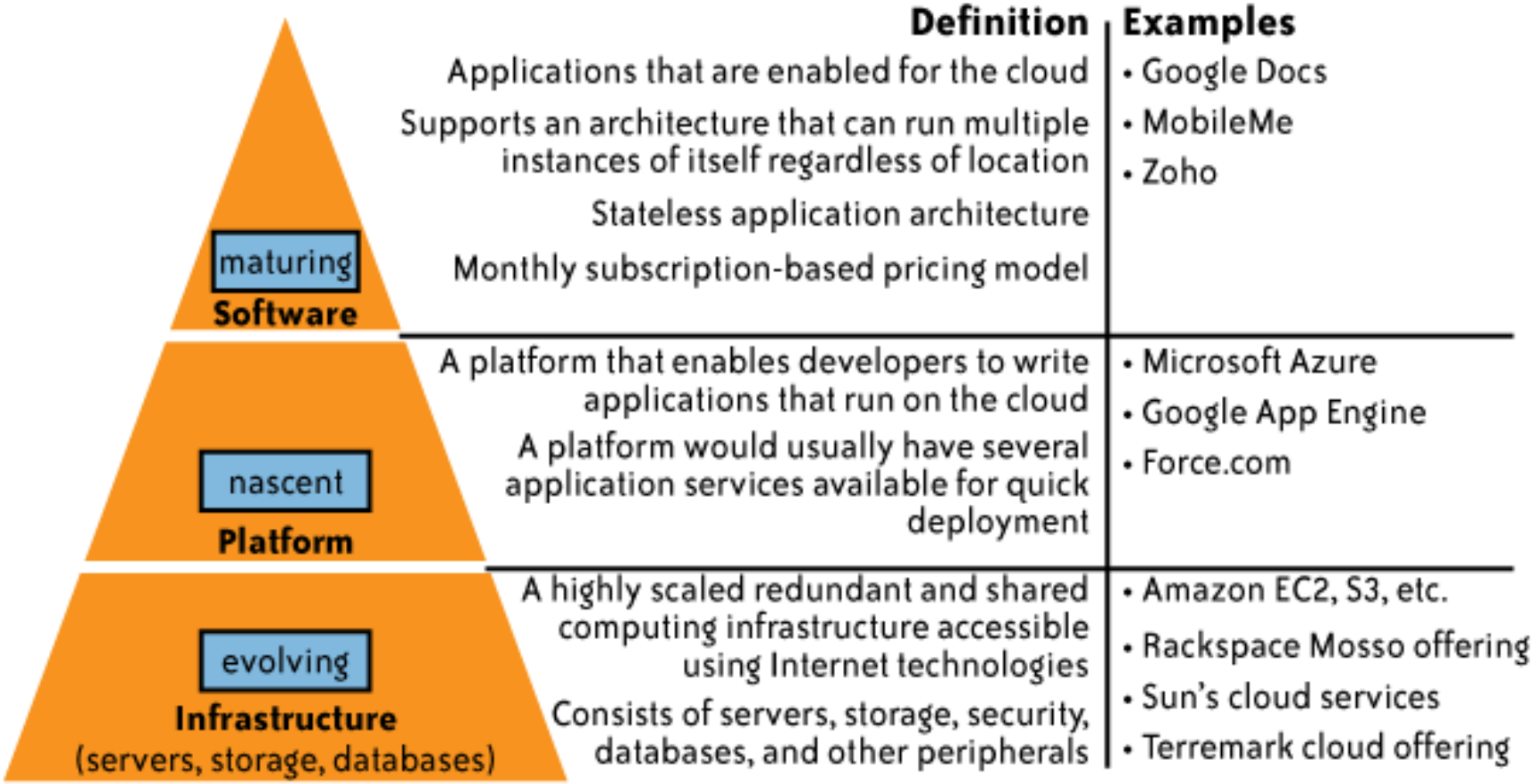
From [2] John McDermott, ACSAC 09

Cloud Models

- Delivery Models
  - SaaS
  - PaaS
  - IaaS
- Deployment Models
  - Private cloud
  - Community cloud
  - Public cloud
  - Hybrid cloud
- We propose one more Model: Management Models (trust and tenancy issues)
  - Self-managed
  - 3rd party managed (e.g. public clouds and VPC)

From [1] NIST

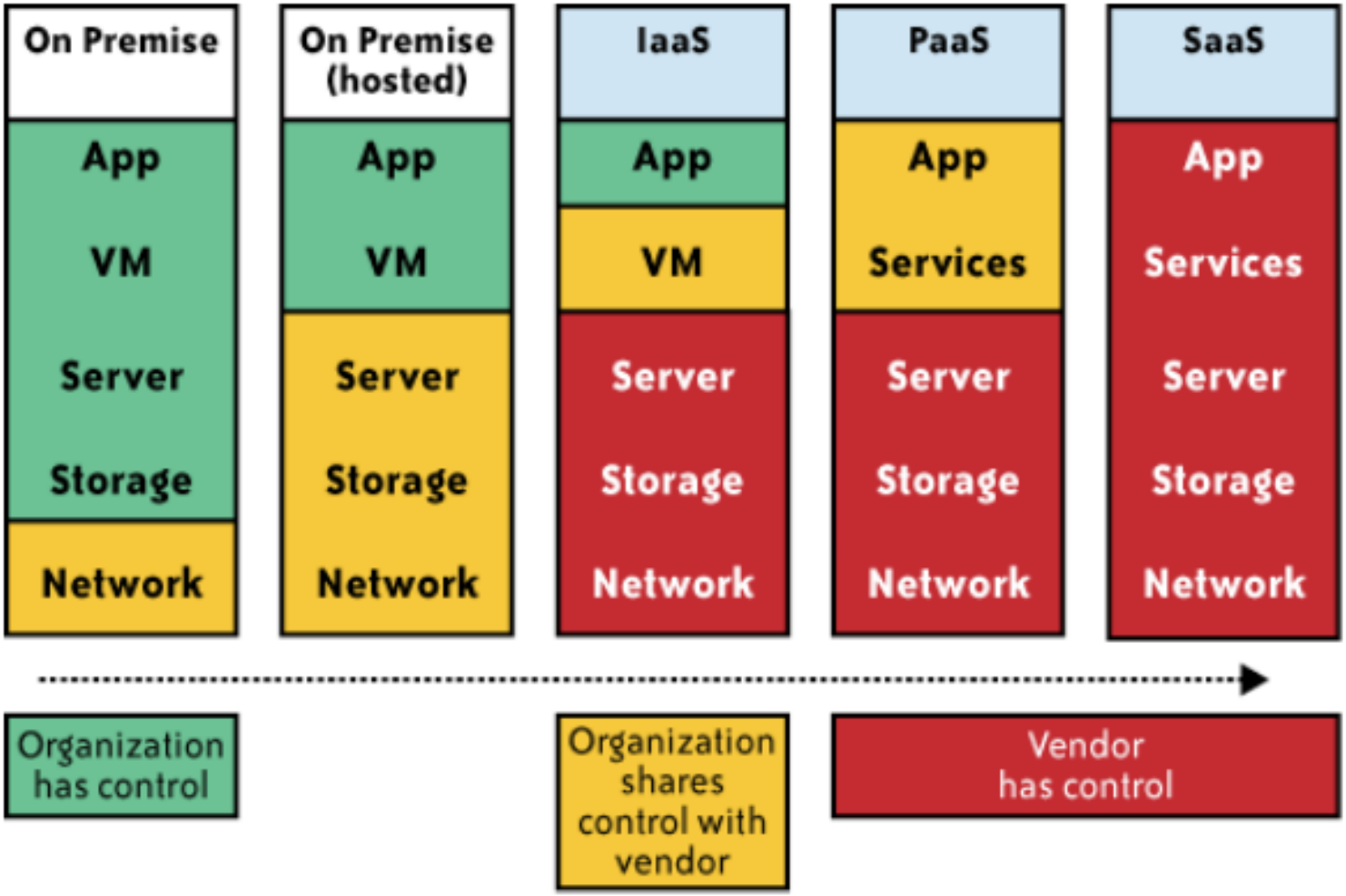
Delivery Models



While cloud-based software services are maturing,
Cloud platform and infrastructure offering are still in their early stages !

From [6] Cloud Security and Privacy by Mather and Kumaraswamy

Impact of cloud computing on the governance structure of IT organizations

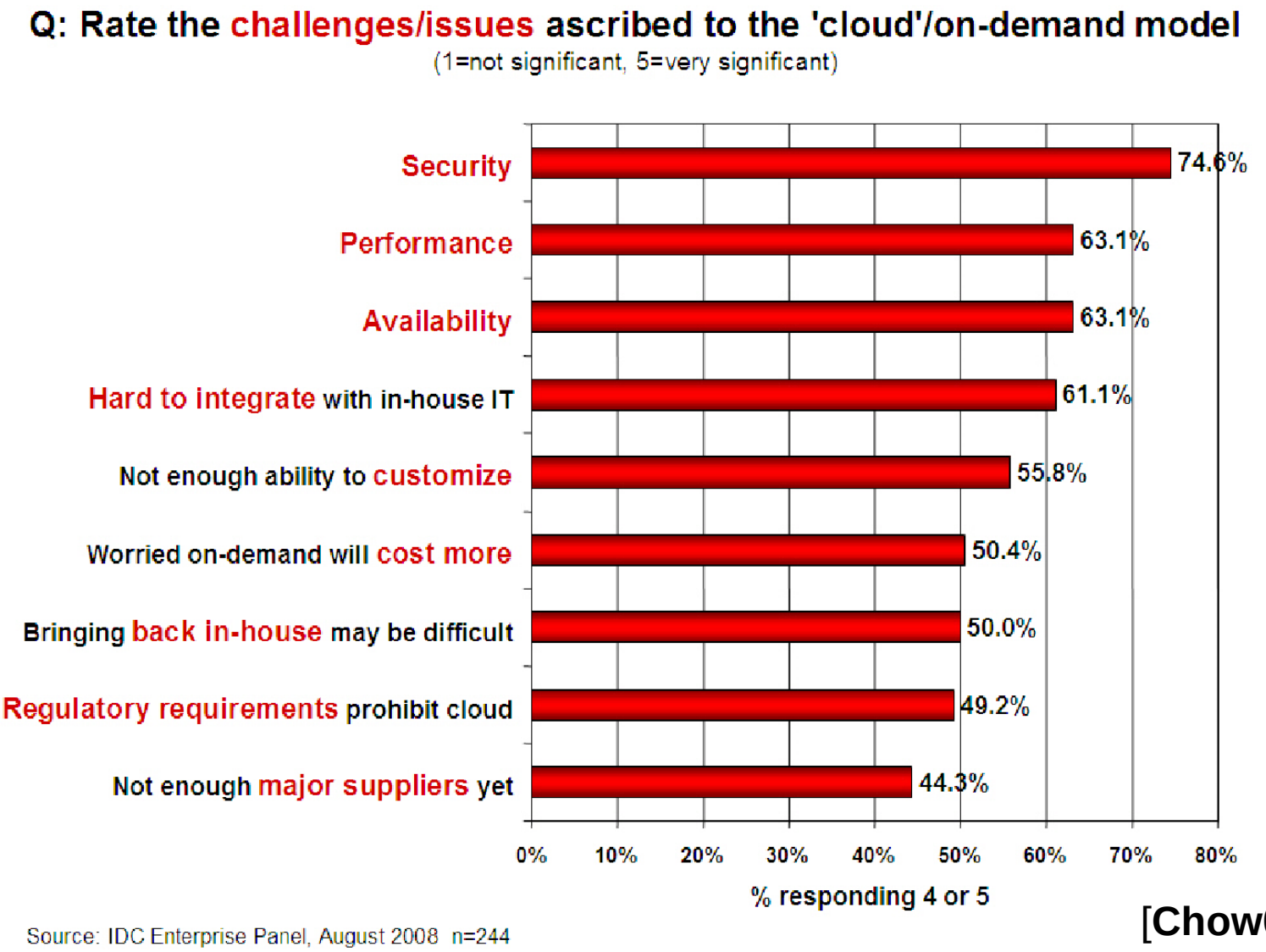


From [6] Cloud Security and Privacy by Mather and Kumaraswamy

If cloud computing is so great, why isn't everyone doing it?

- The cloud acts as a big black box, nothing inside the cloud is visible to the clients
- Clients have no idea or control over what happens inside a cloud
- Even if the cloud provider is honest, it can have malicious system admins who can tamper with the VMs and violate confidentiality and integrity
- Clouds are still subject to traditional data confidentiality, integrity, availability, and privacy issues, plus some additional attacks

Companies are still afraid to use clouds



[Chow09ccsw]

Causes of Problems Associated with Cloud Computing

- Most security problems stem from:
  - Loss of control
  - Lack of trust (mechanisms)
  - Multi-tenancy
- These problems exist mainly in 3rd party management models
  - Self-managed clouds still have security issues, but not related to above

Loss of Control in the Cloud

- Consumer's loss of control
  - Data, applications, resources are located with provider
  - User identity management is handled by the cloud
  - User access control rules, security policies and enforcement are managed by the cloud provider
  - Consumer relies on provider to ensure
    - Data security and privacy
    - Resource availability
    - Monitoring and repairing of services/resources

Lack of Trust in the Cloud

- A brief deviation from the talk
  - (But still related)
  - Trusting a third party requires taking risks
- Defining trust and risk
  - Opposite sides of the same coin (J. Camp)
  - People only trust when it pays (Economist's view)
  - Need for trust arises only in risky situations
- Defunct third party management schemes
  - Hard to balance trust and risk
  - e.g. Key Escrow (Clipper chip)
  - Is the cloud headed toward the same path?

Multi-tenancy Issues in the Cloud

- Conflict between tenants' opposing goals
  - Tenants share a pool of resources and have opposing goals
- How does multi-tenancy deal with conflict of interest?
  - Can tenants get along together and 'play nicely' ?
  - If they can't, can we isolate them?
- How to provide separation between tenants?

- Cloud Computing brings new threats
  - Multiple independent users share the same physical infrastructure
  - Thus an attacker can legitimately be in the same physical machine as the target

Taxonomy of Fear

- Confidentiality
  - Fear of loss of control over data
    - Will the sensitive data stored on a cloud remain confidential?
    - Will cloud compromises leak confidential client data
  - Will the cloud provider itself be honest and won't peek into the data?
- Integrity
  - How do I know that the cloud provider is doing the computations correctly?
  - How do I ensure that the cloud provider really stored my data without tampering with it?

From [5] www.cs.jhu.edu/~ragib/sp10/cs412

Taxonomy of Fear (cont.)

- Availability
  - Will critical systems go down at the client, if the provider is attacked in a Denial of Service attack?
  - What happens if cloud provider goes out of business?
  - Would cloud scale well-enough?
  - Often-voiced concern
    - Although cloud providers argue their downtime compares well with cloud user's own data centers

From [5] www.cs.jhu.edu/~ragib/sp10/cs412

Taxonomy of Fear (cont.)

- Privacy issues raised via massive data mining
  - Cloud now stores data from a lot of clients, and can run data mining algorithms to get large amounts of information on clients
- Increased attack surface
  - Entity outside the organization now stores and computes data, and so
  - Attackers can now target the communication link between cloud provider and client
  - Cloud provider employees can be phished

From [5] www.cs.jhu.edu/~ragib/sp10/cs412

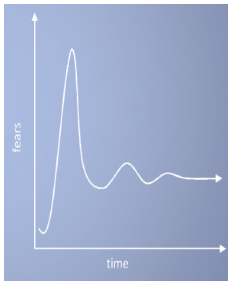
Taxonomy of Fear (cont.)

- Auditability and forensics (out of control of data)
  - Difficult to audit data held outside organization in a cloud
  - Forensics also made difficult since now clients don't maintain data locally
- Legal quagmire and transitive trust issues
  - Who is responsible for complying with regulations?
    - e.g., SOX, HIPAA, GLBA ?
  - If cloud provider subcontracts to third party clouds, will the data still be secure?

From [5] www.cs.jhu.edu/~ragib/sp10/cs412

Taxonomy of Fear (cont.)

Cloud Computing is **a security nightmare** and it can't be handled in traditional ways.
John Chambers
CISCO CEO



- Security is one of the most difficult task to implement in cloud computing.
  - Different forms of attacks in the application side and in the hardware components
- Attacks with catastrophic effects only needs one security flaw

(http://www.exforsys.com/tutorials/cloud-computing/cloud-computing-security.html)

Threat Model

- A threat model helps in analyzing a security problem, design mitigation strategies, and evaluate solutions
- Steps:
  - Identify attackers, assets, threats and other components
  - Rank the threats
  - Choose mitigation strategies
  - Build solutions based on the strategies

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Threat Model

- Basic components
  - Attacker modeling
    - Choose what attacker to consider
      - insider vs. outsider?
      - single vs. collaborator?
    - Attacker motivation and capabilities
  - Attacker goals
  - Vulnerabilities / threats

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What is the issue?

- The core issue here is the levels of trust
  - Many cloud computing providers trust their customers
  - Each customer is physically commingling its data with data from anybody else using the cloud while logically and virtually you have your own space
  - The way that the cloud provider implements security is typically focused on they fact that those outside of their cloud are evil, and those inside are good.
- But what if those inside are also evil?

From [5] www.cs.jhu.edu/~ragib/sp10/cs412

Attacker Capability: Malicious Insiders

- At client
  - Learn passwords/authentication information
  - Gain control of the VMs
- At cloud provider
  - Log client communication
  - Can read unencrypted data
  - Can possibly peek into VMs, or make copies of VMs
  - Can monitor network communication, application patterns
  - Why?
    - Gain information about client data
    - Gain information on client behavior
    - Sell the information or use itself

From [5] www.cs.jhu.edu/~ragib/sp10/cs412

Attacker Capability: Outside attacker

- What?
  - Listen to network traffic (passive)
  - Insert malicious traffic (active)
  - Probe cloud structure (active)
  - Launch DoS
- Goal?
  - Intrusion
  - Network analysis
  - Man in the middle
  - Cartography

From [5] www.cs.jhu.edu/~ragib/sp10/cs412

Challenges for the attacker

- How to find out where the target is located?
- How to be co-located with the target in the same (physical) machine?
- How to gather information about the target?

From [5] www.cs.jhu.edu/~ragib/sp10/cs412