TCSS 562: SOFTWARE ENGINEERING FOR CLOUD COMPUTING

Cloud Computing Concepts and Models

Wes J. Lloyd
Institute of Technology
University of Washington - Tacoma

OBJECTIVES

- Term project proposal
- Cloud Computing Concepts and Models
  - Roles and boundaries
  - Cloud characteristics
  - Cloud delivery models
  - Cloud deployment models

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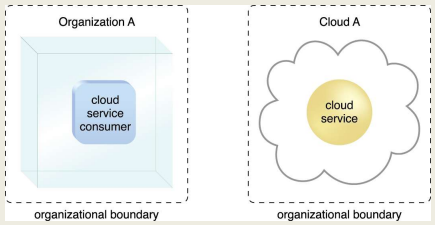
ROLES

- **Cloud provider**
  - Organization that provides cloud-based resources
  - Responsible for fulfilling SLAs for cloud services
  - Some cloud providers "resell" IT resources from other cloud providers
    - Example: Heroku sells PaaS services running atop of Amazon EC2
- **Cloud consumers**
  - Cloud users that consume cloud services
- **Cloud service owner**
  - Both cloud providers and cloud consumers can own cloud services
  - A cloud service owner may use a cloud provider to provide a cloud service (e.g. Heroku)

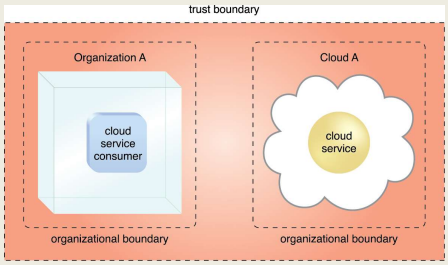
ROLES - 2

- **Cloud resource administrator**
  - Administrators provide and maintain cloud services
  - Both cloud providers and cloud consumers have administrators
- **Cloud auditor**
  - Third-party which conducts independent assessments of cloud environments to ensure security, privacy, and performance.
  - Provides unbiased assessments
- **Cloud brokers**
  - An intermediary between cloud consumers and cloud providers
  - Provides service aggregation
- **Cloud carriers**
  - Network and telecommunication providers which provide network connectivity between cloud consumers and providers

ORGANIZATION BOUNDARY



TRUST BOUNDARY



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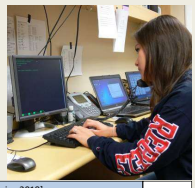
CLOUD CHARACTERISTICS

- On-demand usage
- Ubiquitous access
- Multitenancy (resource pooling)
- Elasticity
- Measured usage
- Resiliency

- Assessing these features helps measure the value offered by a given cloud service or platform

ON-DEMAND USAGE

- The freedom to self-provision IT resources
- Generally with automated support
- Automated support requires no human involvement
- Automation through software services interface



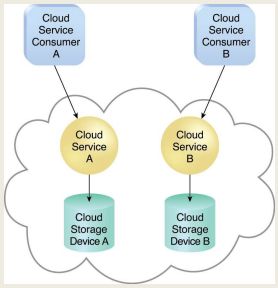
UBIQUITOUS ACCESS

- Cloud services are widely accessible
- Public cloud: internet accessible
- Private cloud: throughout segments of a company's intranet
- 24/7 availability

MULTITENANCY

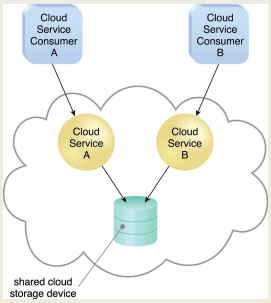
- Cloud providers pool resources together to share them with many users
- Serve multiple cloud service consumers
- IT resources can be dynamically assigned, reassigned based on demand
- Multitenancy can lead to performance variation

SINGLE TENANT MODEL

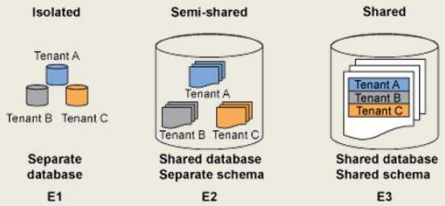


MULTITENANT MODEL

- Resource is "multiplexed" and share amongst multiple users
- Goal is to increase utilization
- Often server resources are underutilized
- There are many "sunk costs" whether usage is 0% or 100%
- Cloud computing tries to maximize "sunk cost" investments

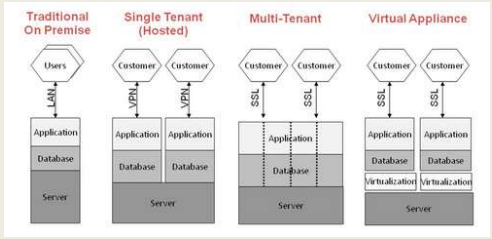


MULTITENANT DATABASE



MULTITENANCY OF RESOURCES

- Where is the multitenancy?

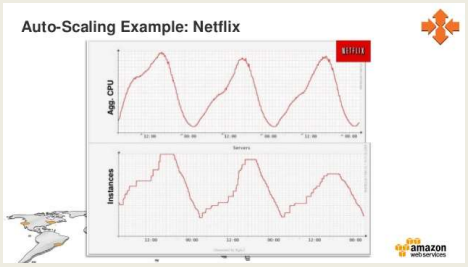


ELASTICITY

- Automated ability of cloud to transparently scale resources
- Scaling based on runtime conditions or pre-determined by cloud consumer or cloud provider
- Threshold based scaling
  - `CPU-utilization > threshold_A, Response_time > 100ms`
  - Application agnostic vs. application specific thresholds
  - Why might an application agnostic threshold be non-ideal?
- Load prediction
  - Historical models
  - Real-time trends

PREDICTABLE DEMAND

- Example:

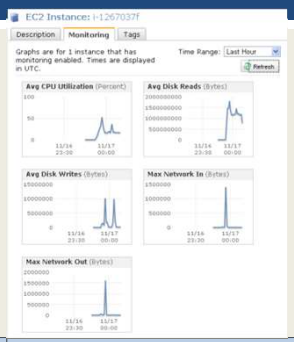


MEASURED USAGE

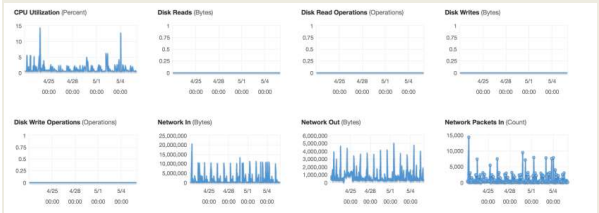
- Cloud platform tracks usage of IT resources
- For billing purposes
- Enables charging only for IT resources actually used
- Can be time-based (minute, hour, day)
- Can be throughput-based (MB, GB)

- Not all measurements are for billing
- Some measurements can support auto-scaling
- For example CPU utilization

EC2 CLOUDWATCH METRICS

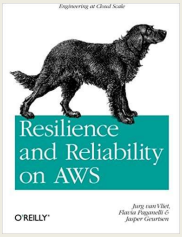


EC2 CLOUDWATCH METRICS



RESILIENCY

- Distributed redundancy across physical locations
- Used to improve reliability and availability of cloud-hosted applications
- Very much an engineering problem
- No "resiliency-as-a-service" for user deployed apps
- Unique characteristics of user applications make a one-size fits all service solution challenging



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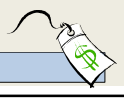
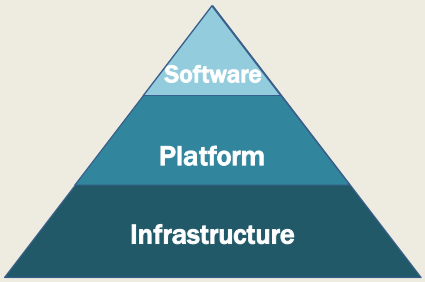
CLOUD DELIVERY MODELS

- What is the appropriate level of **abstraction**?
- How should applications be deployed?
  - IaaS, PaaS, SaaS, DbaaS, FaaS
- How do we ensure Quality-of-Service?
  - Performance, Availability, Responsiveness, Fault Tolerance
- How is ***scalability*** provided?
- How do we minimize hosting costs?
  - How do we estimate hosting costs?



CLOUD DELIVERY MODELS



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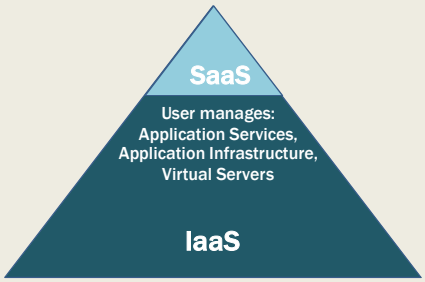

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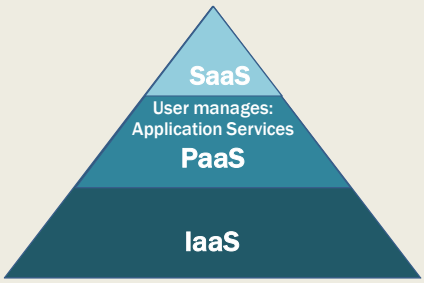

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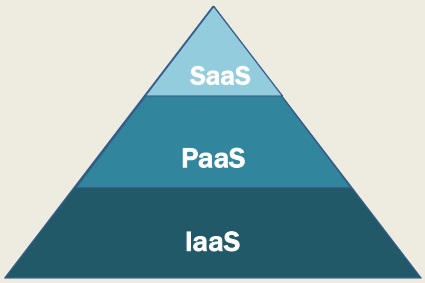
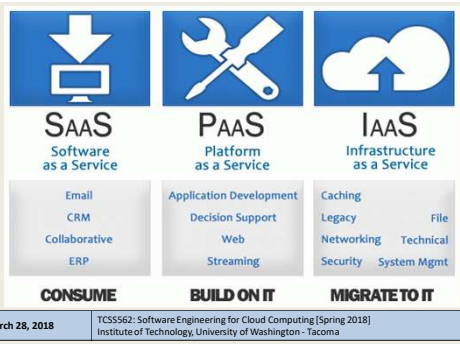
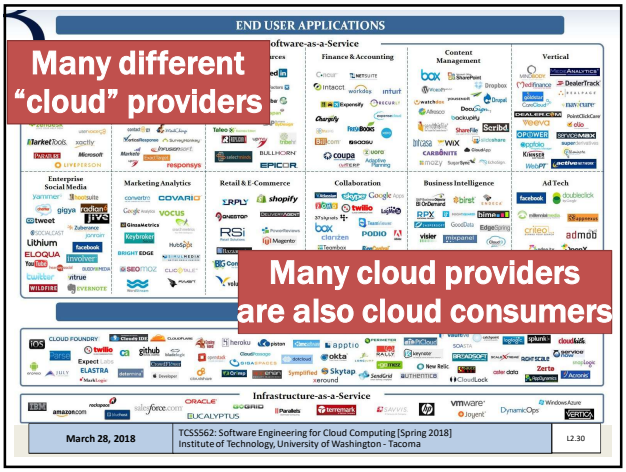


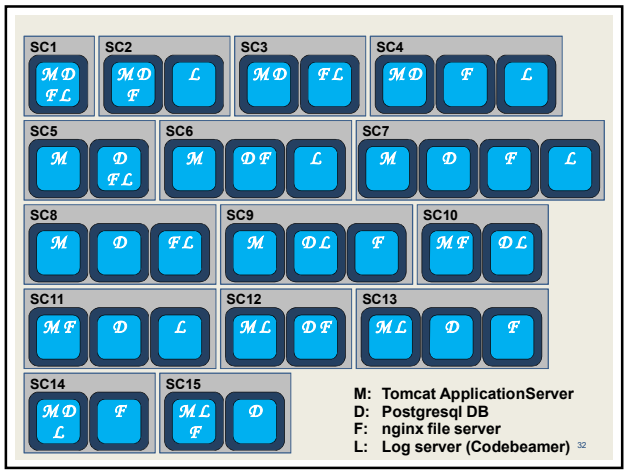
EXAMPLE CLOUD SERVICES

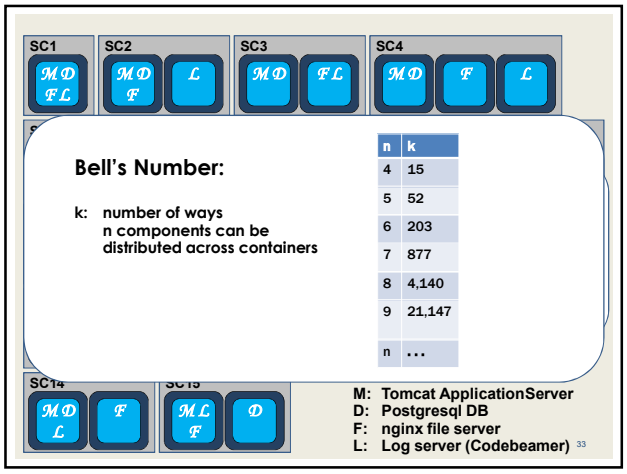


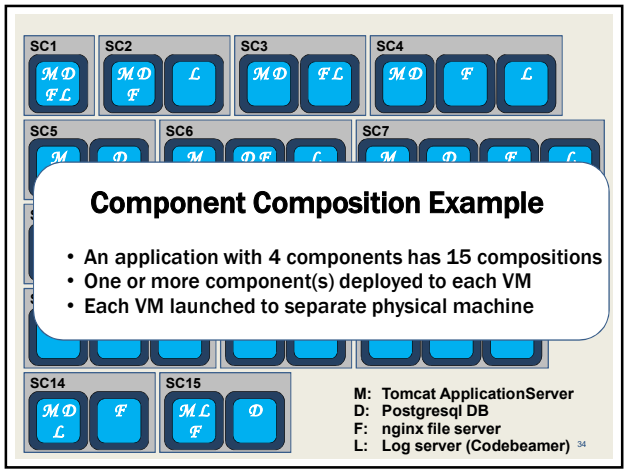


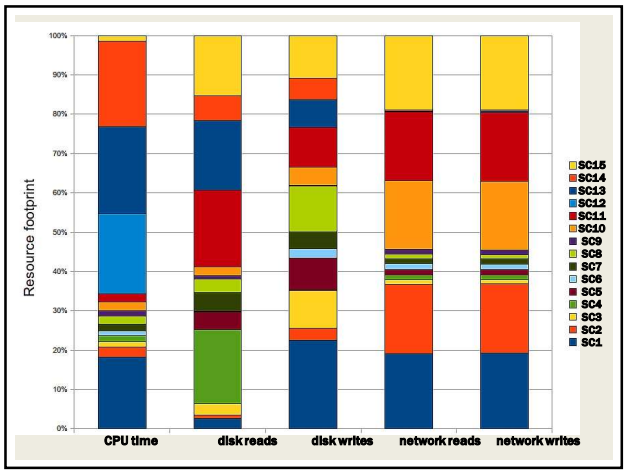
INFRASTRUCTURE-AS-A-SERVICE

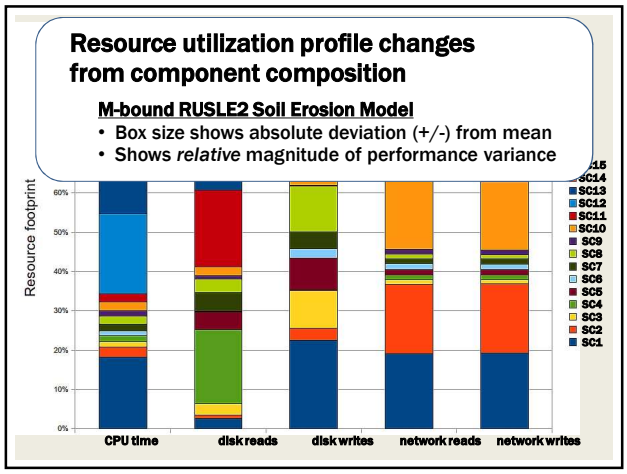
- Compute resources, on demand, as-a-service
  - Generally raw "IT" resources
  - Hardware, network, containers, operating systems
- Typically provided through virtualization
- Generally not-preconfigured
- Administrative burden is owned by cloud consumer
- Best when high-level control over environment is needed
- Scaling is generally **not** automatic…
- Resources can be managed in bundles
- AWS CloudFormation: Allows specification in JSON/YAML of cloud infrastructures

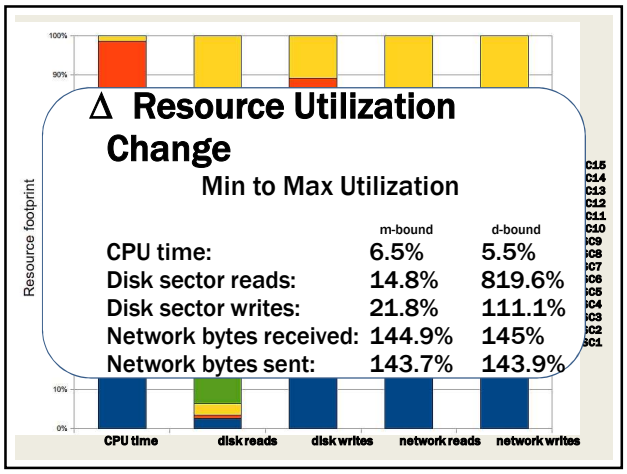




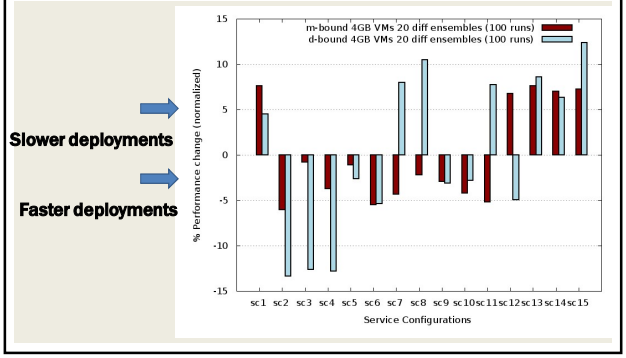








PERFORMANCE IMPLICATIONS OF APPLICATION DEPLOYMENTS



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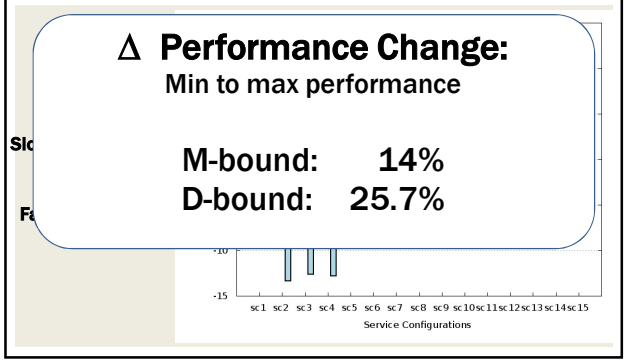
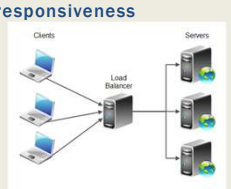


PLATFORM-AS-A-SERVICE

- Predefined, ready-to-use, hosting environment
- Infrastructure is further obscured from end user
- Scaling and load balancing may be automatically provided and automatic
- Variable to no ability to influence responsiveness

- Examples:
- Google App Engine
- Heroku
- AWS Elastic Beanstalk
- AWS Lambda (FaaS)



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USES FOR PAAS

- Cloud consumer
  - Wants to extend on-premise environments into the cloud for "web app" hosting
  - Wants to entirely substitute an on-premise hosting environment
  - Cloud consumer wants to become a cloud provider and deploy its own cloud services to external users
- PaaS spares IT administrative burden compared to IaaS

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SERVERLESS COMPUTING

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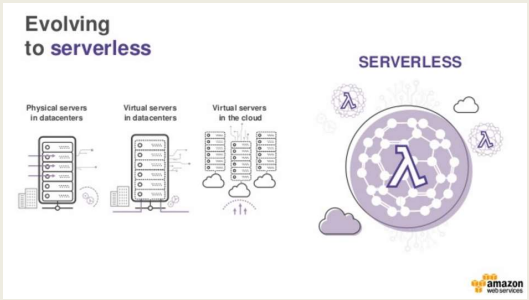
SERVERLESS COMPUTING - 2



SERVERLESS COMPUTING - 3

- New cloud platform for hosting application code
- Every cloud vendor provides their own:
  - AWS Lambda, Azure Functions, Google Cloud Functions, IBM OpenWhisk
- Similar to platform-as-a-service
- Replace opensource web container (e.g. Apache Tomcat) with abstracted vendor-provided **black-box** environment

SERVERLESS COMPUTING - 4

- Many challenging features of distributed systems are provided automatically
- ***Built into the platform:***
- Highly availability (24/7)
- Scalability
- Fault tolerance

SERVERLESS COMPUTING

AWS Lambda Demo

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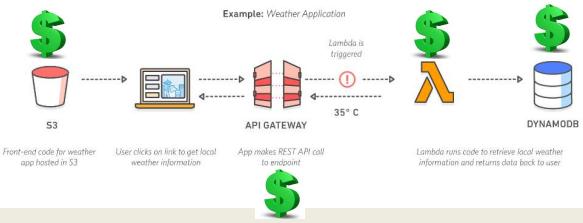
SERVERLESS SOFTWARE ARCHITECTURE

- Every service with a different pricing model

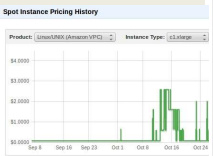


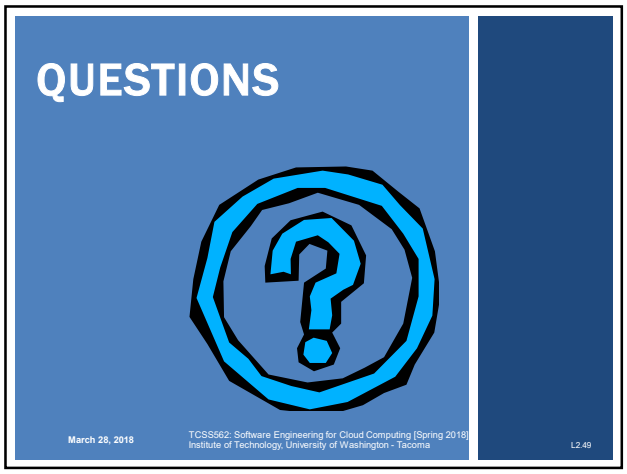
IAAS BILLING MODELS

- Virtual machines as-a-service at ¢ per hour
- No premium to scale:

```
      1000 computers   @     1 hour
  =      1 computer   @  1000 hours
```

- Illusion of infinite scalability to cloud user
- As many computers as you can afford
- Billing models are becoming increasingly granular
  - By the minute, second, 1/10th sec
- Auction-based instances: Spot instances →




QUESTIONS
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