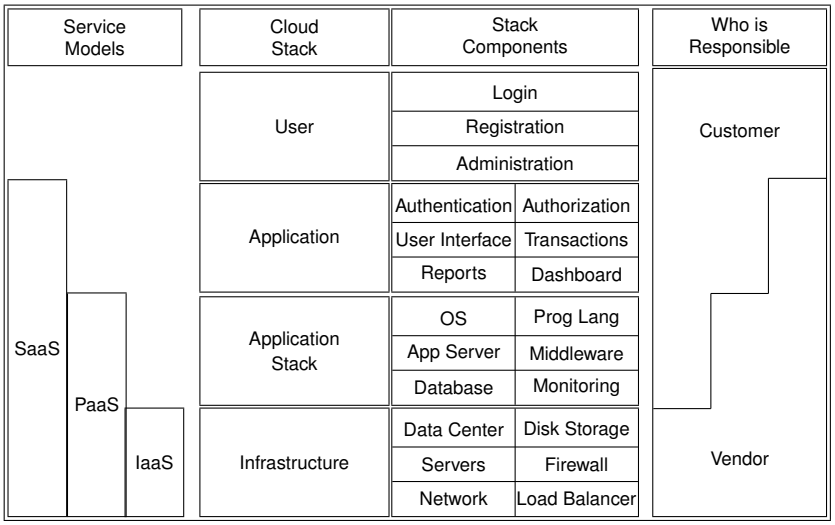
Cloud Models/Architecture

- Three cloud service models
  1. Infrastructure as a Service (IaaS)
  2. Platform as a Service (PaaS)
  3. Software as a Service (SaaS)
- Provide a level of abstraction to reduce the effort required by consumer to build and deploy systems
- Cloud stack



  - Bottom layer
    - Traditional data center
    - Possibly some virtualization

Infrastructure as a Service (IaaS)

- Physical assets: servers, network devices, storage disks
- Traditional model requires IT team to build and support all infrastructure requirement for the organization
  - Install servers
  - Develop/install appropriate software
  - Ensure security
  - Update security and software by applying patches
- Cloud service model provides levels of abstraction and automation for those tasks
  - Virtual availability of hardware to substitute for servers, firewalls, and load balancers
  - Virtual machines allow users to obtain similar functionality to preexisting hardware while eliminating data center space and recurring physical support costs including maintenance, power consumption, and expertise to operate the hardware
  - Put together infrastructure demanded by user, including servers, storage, networks, and data center
  - User can deploy and run on multiple VMs, running guest OSes for specific applications

  - User does not manage the underlying cloud infrastructure but can specify when to request/release a needed resource
- NIST definition of IaaS
  - Capability provided to consumer to enable
    * Processing
    * Storage
    * Networks
    * Other fundamental computing resources
  - Consumer should be able to deploy and run arbitrary software, including OS and applications
  - Consumer *does not* manage or control underlying cloud infrastructure
  - Consumer has control over OS, storage, and deployed applications, and possibly limited control over networking components (host firewalls)
- Cloud Security Alliance (CSA) model of IaaS
  - Delivers computer infrastructure (platform virtualization environment) as a service, plus raw storage and networking
- Tasks for physical data center and infrastructure are abstracted and available as a collection of services
  - Services accessed from web-based management consoles
  - Developers design and code entire applications
  - Admins install and manage/patch the developed applications
  - No physical infrastructure to manage
    * No procurement cycle to evaluate and purchase physical hardware
    * No need for physical data center to host hardware
  - Virtual infrastructure available as a metered service with pay-as-you-use model
  - Consumers focus on application development and deployment rather than managing data center and infrastructure
- Major IaaS providers include Amazon AWS, Windows Azure, Google Compute Engine, Rackspace Open Cloud, IBM SmartCloud Enterprise, and HP Enterprise Converged Infrastructure

Platform as a Service (PaaS)

- Application infrastructure
  - Access to OS and associated services
  - Way to deploy applications to the cloud
- PaaS sits on top of IaaS as the next level of abstraction
  - Enables the user to deploy user-built applications on a virtualized cloud platform
  - Handles platform-level services such as caching, asynchronous messaging, and database scaling
  - Includes middleware, databases, development tools, and some runtime support such as Web 2.0 and Java
  - Platform includes both hardware and software integrated with specific programming interfaces
  - Allows developers to focus on business logic and not worry about underlying IT plumbing
- NIST definition of PaaS
  - Capability provided to consumer to
    * Deploy onto cloud consumer-created or acquired applications created using software utilities supported by the provider

  - Consumer *does not* manage the underlying cloud infrastructure, including networks, servers, OS or storage
  - Consumer controls deployed applications, and possibly configuration settings for the application-hosting environment
- CSA model of PaaS
  - Delivery of computing platform and solution stack as a service
  - Facilitate deployment of applications without the cost and complexity of buying underlying hardware/software
  - Services available entirely from Internet
- PaaS vendors
  - Manage the application platform
  - Provide developers with tools for development
  - Controls the amount of computing power available to developer or consumer
    - May throttle the amount of compute power to a service customer to ensure that the platform scales equally for everyone
- Developers
  - Constrained by tools provided by vendor
  - Have no control over lower-level software controls such as memory and thread allocation, or amount of cache
- Major PaaS providers include Engine Yard, Red Hat OpenShift, Google App Engine, Heroku, AppFog, Windows Azure Cloud Services, Amazon AWS, and Caspio

Software as a Service (SaaS)

- Application execution, provided on demand to user
- Consumer configures application-specific parameters and manages users
- Browser-initiated application software
- Common applications include customer relationship management (CRM), enterprise resource planning (ERP), payroll, and accounting
- Useful for non-core functions
  - No need to support application infrastructure
  - No need to provide maintenance
  - No requirement to hire staff to manage it
- On customer side, no upfront investment in servers or software licensing
- On provider side, low costs compared to conventional hosting of user applications
- NIST definition of SaaS
  - Capability provided to consumer
    - To use provider's applications running on a cloud infrastructure
    - Applications accessible from various client devices through a thin client interface – web browser or a program
  - Consumer *does not* manage or control underlying cloud infrastructure (network, servers, OS, storage), or even individual application capabilities except limited user-specific application configuration settings

- Major SaaS vendors include Abiquo, AccelOps, Akamai, AppDynamics, MeghaWare, Cloud9, Oracle, Salesforce.com, and SAP

Deployment models

- NIST visual model of cloud computing

Essential Characteristics	Broad Network Access	Rapid Elasticity	Measured Service	On-Demand Self-Service
	Resource Pooling			
Service Models	SaaS	PaaS	IaaS	
Deployment Models	Public	Private	Hybrid	Community

- Public cloud
  - Available to general public
  - Owned and provisioned by an organization selling cloud services
  - NIST definition
    - Cloud infrastructure provisioned for open use by general public
    - Maybe owned, managed, and operated by some combination of a business, academic, or government organization
  - Multitenant environment
  - Resources used from a shared grid of commodity resources
  - Users unaware of physical location of resources or data center
    - Users access resources through an abstraction layer on top of the physical hardware
    - Virtual compute resources created by APIs in the abstraction
  - Advantages of public clouds
    - Utility pricing
      - Pay for the resources consumed
      - Scale up or scale down as per need
      - No procurement of physical hardware, except for the hardware to connect to the cloud
      - No wasted compute cycles
    - Elasticity
      - Endless pool of resources
      - Configure software solutions to dynamically increase/decrease resources to handle peak loads
      - React to traffic spikes in real-time
    - Core competency
      - Outsourced data center and infrastructure management
      - More time on core competence
  - Risks of public clouds
    - Control
      - Reliance on vendor for performance and uptime
      - Outage at cloud vendor could adversely affect services
    - Regulatory issues
      - PCI DSS – Payment Card Industry Data Security Standard

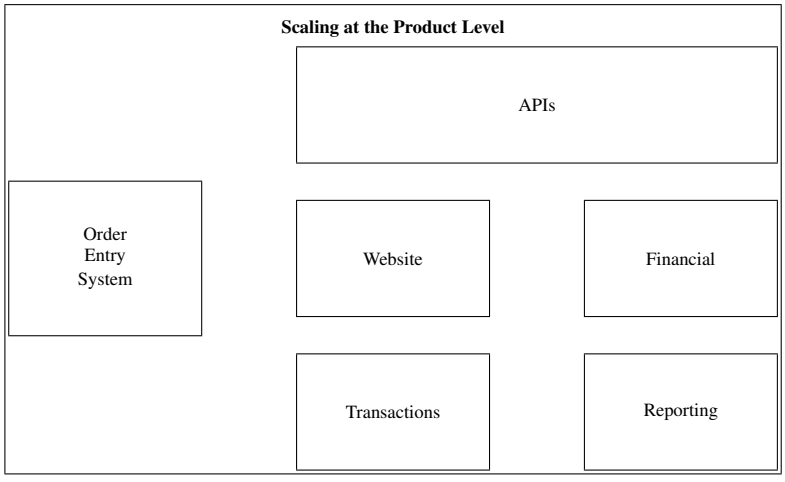
            - HIPAA – Health Information Portability and Accountability Act
            - Data privacy issues
            - May be solved by leveraging certified SaaS solutions for components that are hard to audit in public cloud
        - Limited configurations
            - May not be able to access specific hardware to solve intensive computational problems

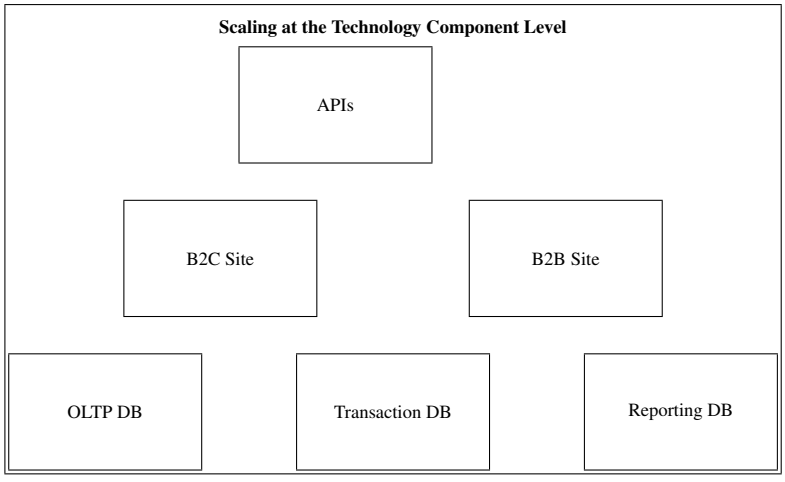
- Private cloud
    - Hosted within an organization's firewall, managed by the organization
    - Created and controlled by the enterprise
    - NIST definition
        - Cloud infrastructure provisioned for exclusive use by a single organization with multiple consumers or business units
        - May be owned, managed, and operated by the organization, a third party, or some combination
        - May exist on or off premises
    - Deploy in a single-tenant environment and not comingled with other customers
    - Costs more than sharing in public cloud environment, but more control and security
    - Reduce regulatory risks
- Hybrid cloud
    - Combination of public and private clouds
    - Management responsibilities divided between public cloud provider and the business renting it
    - NIST definition
        - Composition of two or more distinct cloud infrastructures (private, community, or public)
        - The clouds remain unique entities but bound together by standardized or proprietary technologies to enable data/application portability
        - Cloud bursting for load balancing between clouds

Cloud computing worst practices

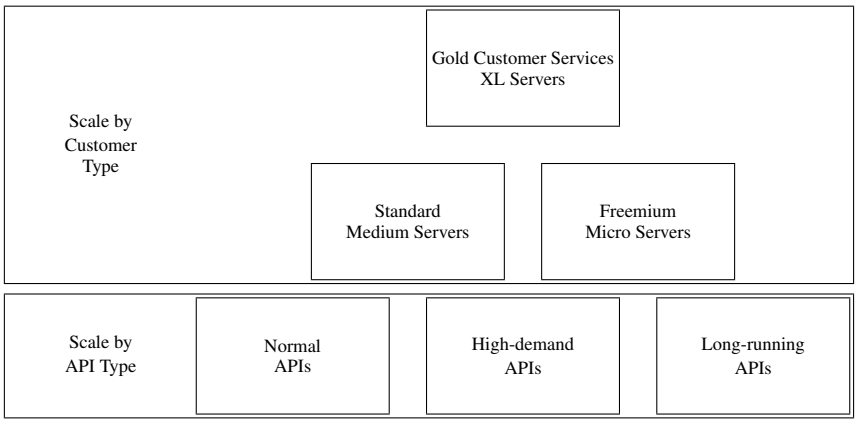
- Avoiding failure when moving to cloud
    - Understanding and embracing new technology
    - Necessary architecture and design of applications vs development
    - Unrealistic expectations
        - Aggressive due dates
        - Large scope
        - Human resources
- Migrating applications to the cloud
    - Will migrating existing applications to the cloud cut down costs?
    - Tightly coupled architecture (software/hardware/environment)
    - Cloud computing applications require loosely coupled architecture
    - Legacy applications
        - Not meant to be scaled up/down automatically
        - Use vertical scaling
            - Add more hardware (CPU/memory/disk) or replace existing hardware with more powerful hardware

        - Software changes achieved by changing configuration files
        - Applications tightly coupled with hardware for performance
        - Migrating an application from existing hardware requires major reengineering to remove hardware dependencies
    - System not responsive to unanticipated spikes in workload
- Hosting vs cloud
    - Hosting used when a company does not want to manage and maintain infrastructure
    - Hosting does not provide the characteristics of cloud computing
        - Broad network access
        - Elasticity
        - Measured service
        - On-demand self-service
        - Resource pooling
    - Vertical scaling but responsibility given to infrastructure provider
- Horizontal scaling in the cloud
    - Additional infrastructure running in conjunction with existing infrastructure
    - Scaling out instead of scaling up
    - Performed at multiple layers of architecture
    - Add nodes by
        - Server farm type





        - Customer type
        - Application domain type



    - Stateful vs stateless system design
        - Stateless service does not maintain any history of requests
            - Only aware of the transaction information
            - Maintains application state on the client and not server
            - No dependency on infrastructure
            - Loan service request to evaluate credit rating of a customer applying for loan
            - Service has no record of information on customer
            - After processing, it does not store any information within session and does not have any information on customer

- Misguided expectations
    - Some examples (Instagram and Netflix) overhype the situation
        - Success will require vision, talent in the team, and ability to execute
    - Successfully running legacy applications complicate the issue
    - Architecting vs cost saving
    - Cost depreciation of assets over the year
        - Buy in advance to account for perceived surges in traffic and growth over time
        - *Correct architecture* to scale up/down and turn off extra cloud services
        - Align cost with revenue (pay-as-you-go)
    - Moving code repository into cloud
        - $3,000 fixed cost for server vs 50 cents per hour for the cloud
        - Cloud cost comes to $4,380 per year
    - Must set realistic goals and expectations
        - Proper analysis
        - Design to optimize, monitor, and audit cloud service consumption
        - Closely monitor the costs from the cloud service provider

- Misinformed about cloud security
    - Extreme views
        - Do not place anything on public cloud
            - Build private clouds
            - Need to develop competence in security and infrastructure

        * Security is the responsibility of cloud vendors
            · May leave big holes in deployed software
    - Lack of experience personnel to build secure applications for the cloud
        * Security expertise is ever changing and evolving
    - Cloud vendors may host resources and data for a large number of companies
        * Makes them a huge target for cybercriminals
    - Cloud vendors provide just perimeter security
        * Application security still the responsibility of client
        * Responsibility with architect to encrypt data, manage keys, and implement good password policies
    - Good security can enable public cloud to be more secure than private data centers
        * Most of the security breaches are inside jobs
        * A number of those happen due to carelessness
            · Lost, stolen, or misplaced assets – thumb drives, disks, documents, devices, laptops
    - Planning for security
        * Designed into software
        * Security best practices applied in data centers must be applied in cloud as well
        * May need additional steps to pass regulatory audits such as HIPPA
    - Typically, security is a core competency with cloud providers
        * Leverage security as a service from cloud providers
        * Must know security risks with a combination of technology, process, and governance
- Favorite vs appropriate vendor
    - Going with your existing biases may not be correct
    - Microsoft Azure (PaaS) for .NET applications
    - For scaling requirements, IaaS provider may be a better choice compared to a PaaS
        * PaaS providers have thresholds enforced within architecture layers to ensure that one customer does not consume too many resources
        * Fewer such limitations with IaaS
- Outages and out-of-business scenarios
    - Everything can and will fail
    - Design for failure
    - Cause and effect of lock-in with proprietary technology
    - If the cloud vendor fails, the service disappears
    - Best practices leveraging SaaS or PaaS database technology
        * Access to data outside of service provider
        * Snapshots of data backups, a daily extract, or some method to store recoverable data independent of service and provider
    - Outage within zones
        * Avoided by using multiple zones
        * AWS provides multiple zones within a region and multiple regions across the globe
        * SLA of 99.95% uptime implies a downtime of 20 minutes and 9 seconds per month, or about 4 hours per year
        * Impact of downtime on average business: $5,000 per minute or $300,000 per hour
- Impact of organizational change

  - Buying virtual services vs physical assets; is procurement ready for that?
  - Paying for on-demand service
  - Forecasting usage in the future vs real-ime autoscaling for capacity planning
  - Securing data outside of corporate firewalls
  - Proof-of-concept by storing some noncritical data with a cloud service provider
  - Technological problem vs people problem
    * Resistance to change
    * People *told* to change vs *nudged* to change

- Skills shortage
  - Existing skills centered on applications and available hardware
    * Optimization and security; on-premises virtualization
  - Stateless and loosely-coupled cloud architectures
  - Integration with multiple cloud-based solutions with other vendors, partners, and customers
  - Significant change from the perspectives of architecture, business process, and people
  - Application security skills to ensure safety of data and intellectual property outside of corporate firewalls
  - Close cooperation between system administration and development teams
    * System administrators as part of release management lifecycle

- Misunderstanding customer requirements
  - Business requirements vs IT preferences
  - Security and privacy requirements; regulatory constraints

- Unexpected costs
  - Governing process of consuming cloud resources
    * SaaS for storage and applications
    * Different tiers of service based on number of users and amount of storage, or amount of compute power
  - SaaS services
    * Free repositories vs payment based
    * Charge per user or per seat (floating license)
    * Charge monthly or transaction based (email campaign)
    * Triggers to avoid surprises
  - PaaS services
    * Allows developers to focus on business requirements while platform handles the infrastructure
    * Handling scaling during peak times
    * Make sure that PaaS does not consume huge amount of infrastucture, possibly using triggers as above
  - IaaS services
    * Server sprawl
    * Different groups creating multiple servers
    * Automatic allocation of servers to groups
    * May not be able to shut down the servers as they may be running some critical applications

Architecture

- Development phase vs analysis of business and technical requirements

Importance of asking questions

- Value of enterprise architecture
  - Perform the necessary discovery steps before diving headfirst into cloud
  - Do not select a vendor before due diligence
  - Answer the following questions
    - **Why.** What problems are we trying to solve? What are the business goals and drivers?
    - **Who** needs this problem solved? **Who** are all the actors involved (internal/external)?
    - **What** are the business and technical requirements? **What** legal and/or regulatory constraints apply? **What** are the risks?
    - **Where** will these services be consumed? Are there any location-specific requirements (regulations, taxes, usability concerns, language/locale issues)?
    - **When** are these services needed? What is the budget? Are there dependencies on other projects/initiatives?
    - **How** can the organization deliver these services? What is the readiness of the organization, the architecture, the customer?
  - Other factors
    - Is the project being built from scratch from the ground up?
    - Is the project a migration of a legacy system?
    - A combination of the two?
    - Does the cloud provider provide any migration services?
    - Types of users and data
      - Social networking site vs medical records site

Business architecture

- Business architecture diagram to show touchpoints and business functions across the enterprise
  - Work on different components
  - Level of visibility into the overall vision of the enterprise

Identify the problem statement (Why)

- What problem are we trying to solve?
- Business drivers to leverage cloud computing services within organization
  - No-brainer for a startup building new in cloud
  - Bigger problem for established companies with large investment in physical infrastructure
  - Reducing infrastructure costs?
  - May replace non-core-competency processes, such as payroll, human resources, and accounting, by SaaS
  - May leverage cloud for storage, backup/recovery, provisioning testing and development environments on demand, or integrate with external APIs such as maps

Evaluate user characteristics (Who)

- Internal and external users; people or systems
- Understand the characteristics of users such as demographics, location, type of actor (person/business/government), type of business (social media/health/manufacturing)
- Need to account for privacy, regulations, usability, risk, and more

Identify business and technical requirements (What)

- Drives the discovery of functional and nonfunctional requirements
- Functional requirements
  - What data the system must process
  - How the screens should operate
  - How the workflow operates
  - What are the system outputs
  - Who has access to each part of the system
  - What regulations must be adhered to
- Nonfunctional requirements
  - Usability – Requirements for end users and systems using the platform
  - Performance – Ability to respond to user and system requests
  - Flexibility – Ability to change the speed of business with minimal code change
  - Capability – Ability to perform current and future business functions
  - Security – Requirements for security, privacy, and compliance
  - Traceability – Logging, auditing, notification, and event processing
  - Reusability – Level of reuse required both internally and externally
  - Integrability – Integrate with various systems and technologies
  - Standardization – Specific industry standards
  - Scalability – Scale to meet demands
  - Portability – Deploy on various hardware and software platforms
  - Reliability – Uptime and SLAs, along with recovery mechanisms

Visualize the service consumer experience (Where)

- Impact of laws relative to user locale
  - Point of consumption
  - Point of data storage
  - Restrictions on data transfer into or out of a country
- Hybrid cloud solutions
  - Public IaaS or PaaS services for majority of processing needs
  - Sensitive data in a private cloud or in-house data center
- Access mechanism for the services (devices and touchpoints)

- Effects of time zones

Identify project constraints (When and with What)

- Budget and expected delivery dates
- Compromise between architecture decisions and business goals/deadlines
- Mandate to use a certain vendor
- Prototyping vs production systems

Understand current state constraints (How)

- Organizational readiness
  - Resources in house?
  - Capital expenditure (buy up-front) or operational expenditure (pay-as-you-go)
- Resistance within ranks