Cloud Data Architecture

Nov. 14, 2017

CenturyLink Business

TOP 3
COMMUNICATIONS PROVIDER

#158
OF FORTUNE 500

48,000
EMPLOYEES WORLDWIDE

33,000
BUSINESS & GOVERNMENT CLIENTS

A PARTNER YOU CAN DEPEND ON

58
GLOBAL DATA CENTERS

20%
WORLD'S INTERNET TRAFFIC

98%
FORTUNE 500

$18.1B
IN ANNUAL REVENUES

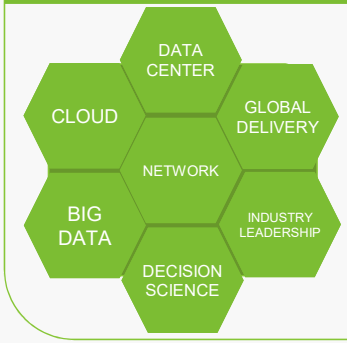
Why CenturyLink – Our Key Differentiators

Leaders in the Connected World

of world's **INTERNET TRAFFIC**

CenturyLink is a **world leader** in managing the increasing size of the world's data creation and flow

Full Scale End-to-End Solutions



CenturyLink uses leading core capabilities to deliver **full scale end-to-end solutions** for our customers

Breadth and Depth of Experience

Banking	Cloudera
Healthcare	Azure
Retail	AWS
Telco	AI
Insurance	Deep Learning

⋮

CenturyLink's leading experience **across industries, technologies, and cutting edge advances** allows for comprehensive solutions delivery

Trusted Industry Partner

FORTUNE 500 companies are our customers

The Fortune 500 relies on CenturyLink as a **trusted industry partner** for overcoming business and technology challenges

Leading Partnerships and Solutions

SAP · cloudera · amazon.com · Microsoft · cisco · hp invent

CenturyLink's **strong industry partnerships** are enabling the delivery of new solutions, such as Big Data as a Service

Global Cybersecurity Experts

Advise government entities on cybersecurity initiatives and emergency preparedness

Hold leadership positions on major government security councils

Contribute to national response plans and security framework development.

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Presenters

- Pete Stiglich
  - Sr. Lead Data Architect, CenturyLink Data Governance and Monetization
  - Past president, DAMA Phoenix
  - CDP, CBIP certifications
  - AWS Technical Professional, Hortonworks Architecture Professional
  - Data Management trainer, writer, presenter
  - 25+ years data management experience

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Presenters

- Fred Hazboun
  - Senior Lead Cloud Architect, CenturyLink
  - AWS Certified Solution Architect
  - Has evaluated and benchmarked dozens of cloud vendors based on different criteria to help clients find the best solution for their environment (AWS, Azure, Google Cloud, Rackspace, IBM)
  - Manages thousands of servers for clients in datacenters around the world
  - Knowledge of different databases, and many different operating systems
  - Experience with DevOps and automation deployment tools such as Chef & Cloud Foundry

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Agenda

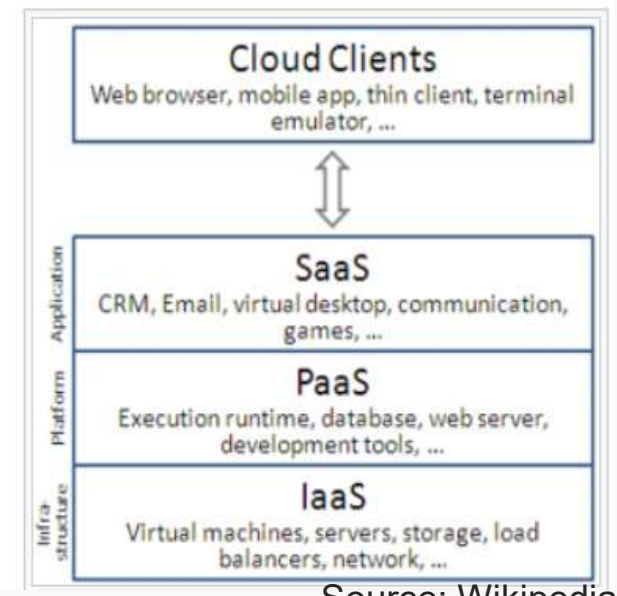
- What is the Cloud?
- Benefits / costs of moving to the cloud
- Cloud migration strategy
- How to decide what to move to the cloud
- Managing the multi-platform cloud (demo)
- Cloud case studies

What is the Cloud?

- Applications, services, infrastructure, and data that are remotely hosted and accessed via the Internet, often by leveraging offerings by one or more of the cloud providers (AWS, Azure, CenturyLink, Google, etc.)

- Encompasses
  - SaaS – Software as a Service
  - PaaS – Platform as a Service
  - IaaS – Infrastructure as a Service

  - DaaS – Data as a Service
  - DaaS - Desktop as a Service



Source: Wikipedia

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What is the Cloud?

- SaaS – Software as a Service - entire application outsourced to the cloud – don't have to manage the code, hardware, OS, database, upgrades.
  - E.g., Google Apps, MS Office 365, Salesforce
- PaaS – Platform as a Service – computing platform – OS, programming language execution, database, webserver
  - e.g., run MapReduce programs on AWS EMR
- IaaS – Infrastructure as a Service – basically a virtual server where you have much of the system admin responsibility.
  - E.g., AWS EC2, MS Azure
- DaaS – Data as a Service - data available via services in the cloud using REST (e.g., Odata)/Web Services/ODBC/JDBC calls. Manage the data in one place, make it available to multiple apps.
  - Includes Cloud BI
  - E.g., DOMO, Google Analytics, Oracle REST Data Services (ORDS)

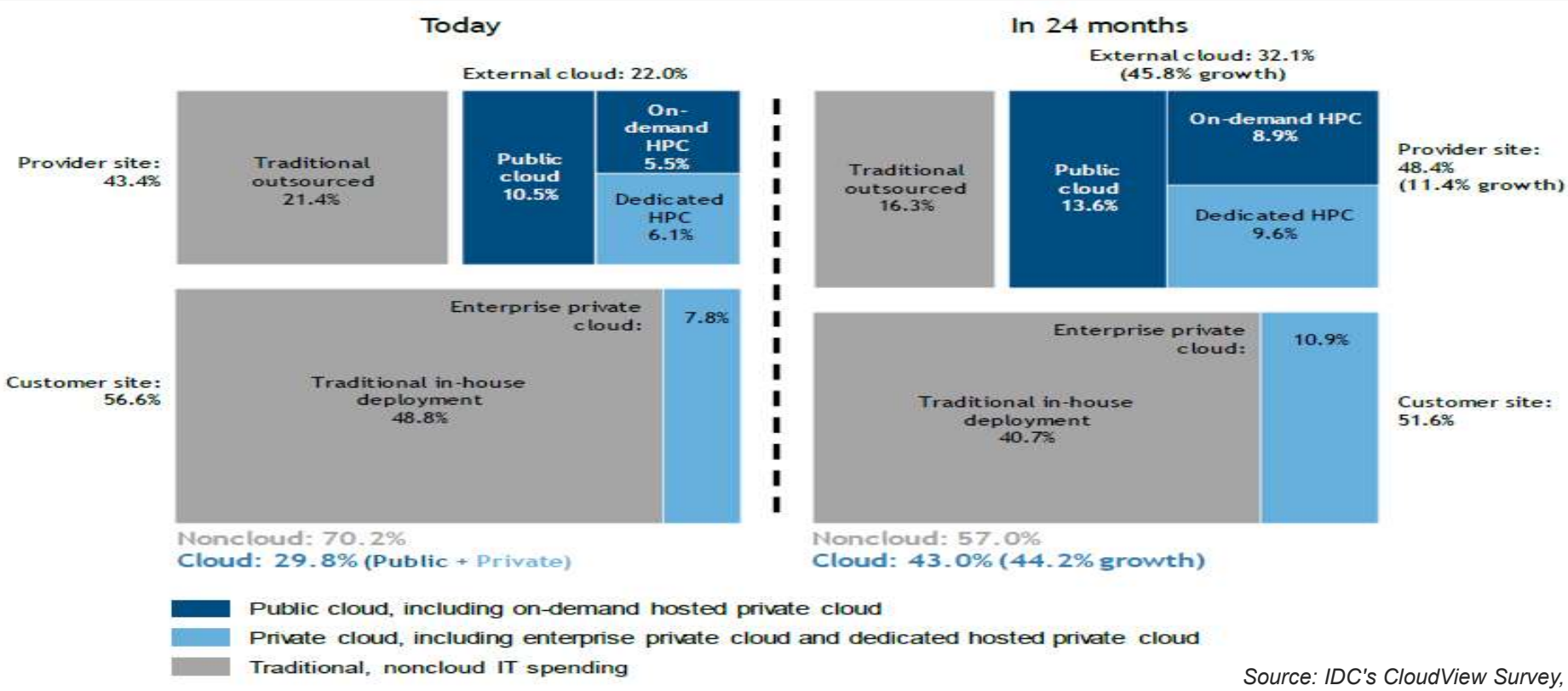
What is the Cloud?

- **Private Cloud:** The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them; and it may exist on or off premises.
- **Public Cloud:** The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider.
- **Hybrid Cloud:** The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).

http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf

What is the Cloud?

- **Cloud growth**



Source: IDC's CloudView Survey, January 2016

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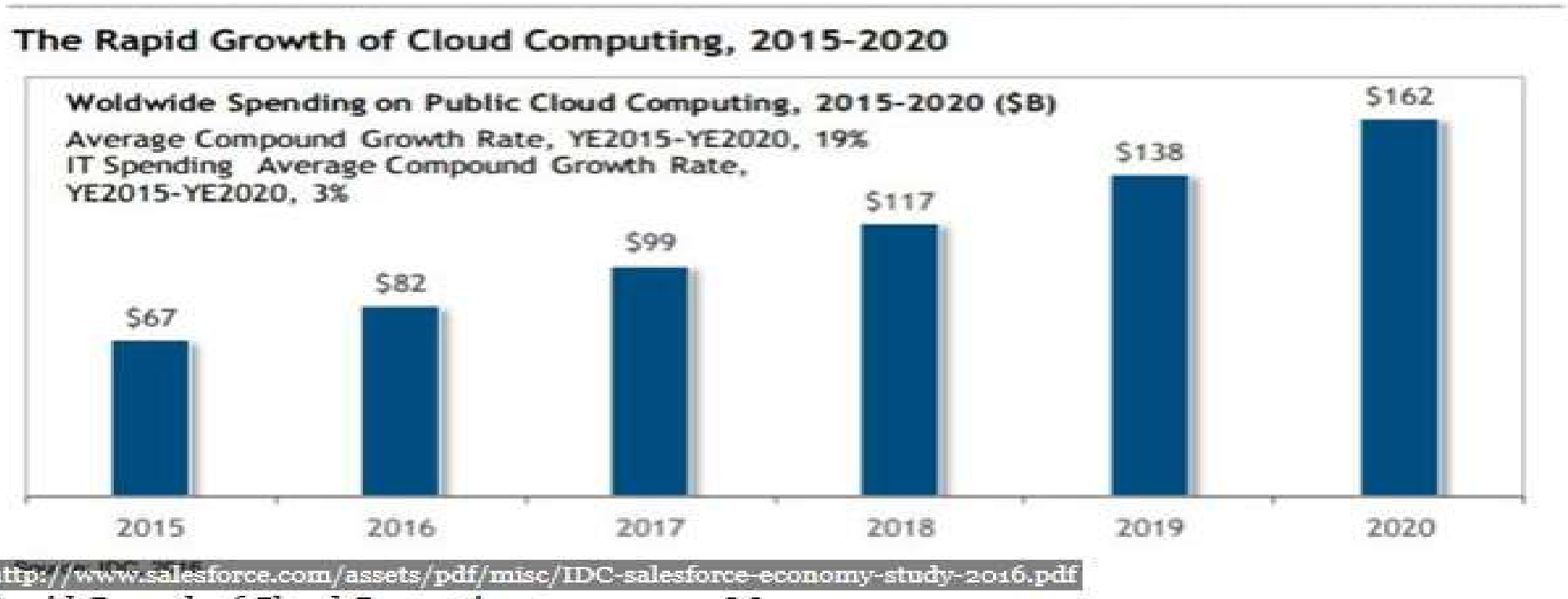
What is the Cloud?

- **Cloud growth**



Rapid Growth of Cloud Computing, 2015–2020 [-]

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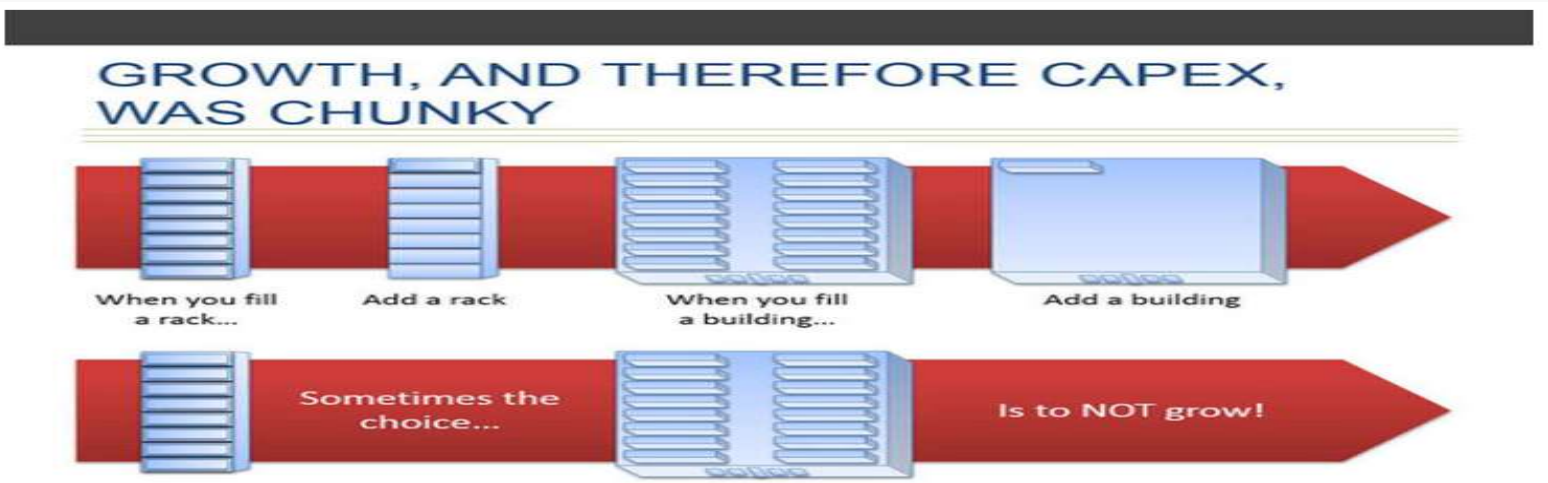
Why move to the Cloud?

- Reduced IT costs - don't have to buy/install/configure a bare-metal server, have raised floors, etc..
- Faster deployment - spin up a new server in minutes
- Increased performance – rapidly allocate additional resource e.g., for peak demand times. Can upgrade server to a server with more powerful CPU's, more memory, etc., quickly
- Improved scalability – add more disk space, more nodes (e.g., HDInsight, Elastic MapReduce) rapidly
- Availability – data/applications can be setup for cold/hot/warm/active-active failover across different geographical regions
- Reduced administration – Cloud vendors are very good at what they do, can care of many sys admin activities for you (e.g., patches, backups), expertise in security/networking, outstanding physical security, don't have to worry about physical plant, etc.
    - Allows you to focus more on business goals

Why move to the Cloud?

- Enable rapid growth in your business / new capabilities, etc.
  - Before the Cloud much of IT expense (new servers, physical plant, etc.) was CAPEX – with the Cloud can operationalize many of these expenses
  - Often requiring time-consuming approval processes, large $ outlays for resources that might not get fully utilized
  - With Cloud - easier to try new things / fail fast – rather than stifling innovation due to computing resource limitations, lengthy acquisition process



http://www.zdnet.com/article/rethinking-capex-and-opex-in-a-cloud-centric-world/

Why move to the Cloud?

- So the Cloud is the silver bullet that will solve all my problems, right?
  - No.. Still need to have solid requirements (functional and non-functional), architectural design (including data architecture), Cloud vendor and offering selection, testing (including disaster recovery testing)
  - A poorly designed database in the Cloud can still have performance issues – can throw more resources ($'s) at it rapidly, but might not necessarily solve all performance issues
  - Important to have a solid data strategy and architecture – otherwise can rapidly loose control of data assets.
  - Create an environment that is more compliant with PCI, SOX or HIPAA audits

Why NOT move to the Cloud?

- Regulatory or security restrictions
  - Compliance reasons (PCI, HIPAA, SOX)
  - Security and encryption reasons
  - Becoming less of a concern
  - Might be addressed with a private cloud where network traffic doesn't go across the internet
- All else being equal, if you have sufficient capital, can save money over time by avoiding recurring cloud charges
- Need strong network capacity – if not, slow connections can spell disaster (especially for transaction processing)

How much does the Cloud cost?

- Need to understand pricing model of the cloud services – e.g., per compute hour, per GB stored, per GB data transferred out, etc.
- Cloud vendors have free calculators to help determine costs
- Be sure to have a strategy for monitoring to prevent/identify Cloud charges beyond budget

- **Don’t underestimate the internal spend for:**
  - Baselining current state
  - Identifying requirements / determining strategy (data strategy, migration strategy)
  - Migration (moving data and apps/services to the cloud)
  - Changes for upstream / downstream processing (e.g., connections)
  - Testing
  - Monitoring

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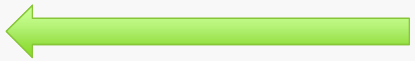
- Cloud migration strategy 
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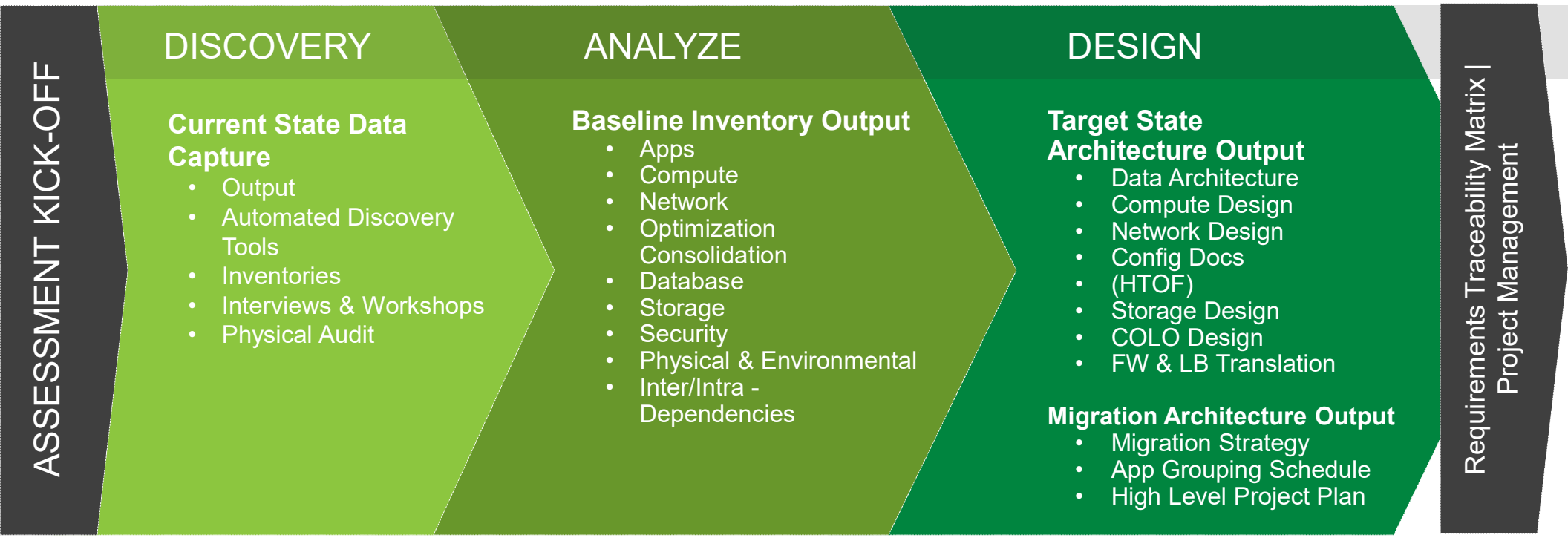
Cloud Migration Planning and Design



Develop a data strategy and roadmap

- Large scale migration to the cloud should be preceded by development of a data strategy (or a refresh of existing strategy)
  - Otherwise massive opportunity for **SGDS** (Same Garbage, Different Server), risks of improper access, etc.
- Development (or refresh) of reference architecture for Enterprise Information Management *(Data Governance, Metadata Management, Data Architecture, Data Quality, Master Data Management, etc.)*
- Understand changes to Data Governance and Stewardship
  - Who will decide what can be migrated to the Cloud?
  - How will Data Stewards be able to track data assets in the Cloud?
  - How will data policies / privacy / access controls be enforced?
- Understand how data architecture changes (e.g., modeling for NoSQL)
  - Conceptual and Logical Data Modeling largely the same, Physical Data Modeling changes
  - How will naming standards, value domains be enforced?

Develop a data strategy and roadmap

- How will moving to the Cloud affect your Data Warehouse and Business Intelligence platforms?
- Should these be migrated to the Cloud as is or be re-architected?
- BI vendors – different levels of Cloud support from 100% Cloud (e.g., DaaS) or leverage PaaS / IaaS for components of your BI stack
- Will you incur data transfer charges if your BI client is on a local desktop but the database server is in the Cloud?
- ETL / ELT – does your ETL tool support NoSQL or new databases (e.g., AWS Redshift)? Are there opportunities for clustering (adding Cloud based server nodes to ETL engine)?
- Data Lake – good candidate to be moved to Cloud so that new nodes can be rapidly added to scale up

CLOUD MIGRATION STRATEGY PROCESS

- Establish governance model for all levels of resources
- Setup communications plan
- Callout resource requirements
- Identify all required resources
- Initiate processes for in-scope services

- Deploy automated collection tools
- Gather and consolidate customer-provided data sources
- Conduct workshop sessions with customer SMEs for application and infrastructure KT
- Perform data center walkthrough for physical audits

- Infrastructure requirements validation
- Application to infrastructure mapping
- Infrastructure usage analysis for optimization and/or consolidation
- Interdependency analysis

- Target State Architecture – logical and physical
- Firewall and Load balancer rule translation
- Configuration documentation for implementation
- Migration strategy
- Application grouping schedule
- Milestone proje plan

- Document requirements mapped to design outputs
- Present outputs for customer review and acceptance

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Degrees of Cloud Transformation

- Lift/Shift/Optimize & Manage
  - Move machines to colocation facility, Migrate VMs or greenfield builds of workloads, optimize CPU/RAM and add monitoring and management
- Migrate to PaaS
  - Move databases to DB as a services, upload code to web PaaS offerings (Elastic Beanstalk, App Engine)
- Scripted Deployment
  - Using vendor cloud or open source scripts to automate environments.
- Containerization
  - Refactoring applications with Docker/Kubernetes/CAM to implement micro-services across cloud platforms
- Server-less Computing
  - Migrating applications to vendor specific compute platforms i.e. Lambda, Google Cloud Functions, Azure Functions

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Defining your cloud migration strategy

- High level view # of workloads & resources, application descriptions and groupings, current utilization, OS versions, security and compliance requirements, criticalities…
  - First pass approximation of cloud platforms that fit workloads
  - What degree of workload transformation is needed, beneficial and appropriate?
  - Migration approaches (greenfield builds, VM image “lift and shift”, database transformations…)
- Define a short list of most likely options, magnitude of effort, roadmap and timeline

Defining your cloud migration strategy

- Develop a Cloud managed services “center of excellence” to oversee Cloud migration
- Cloud “Center of Excellence” (COE) should lead development of your Cloud strategy
- COE should develop standards, architecture, cost models, and toolsets for rationalizing migrations, ensuring best practices, manage Cloud expenses & chargeback
- **Maintain visibility into assets located in the Cloud with CMDB / metadata repository**
- Minimize duplication of effort, data, services, infrastructure, etc.

Defining your cloud migration strategy

- Data migration
  - Greenfield vs. brownfield
    - Greenfield builds
      - Create a new application in a clean environment, which could be a new cloud provider, a new VPC or a new region.
      - You are not bringing old data or old processes, but starting with a new deployment of code
      - Greenfield deployments are great for testing out a scenario or doing a POC to test an application, and can easily be destroyed when completed since no major changes were made to your existing environment
      - A great way to start fresh with new software and processes, and move away from issues older software could cause
      - Advantage is that a company will usually see cost savings once they optimize their workload into the Cloud by using specific tools that the Cloud can offer such as RDS, NoSQL, Hadoop databases, or vertical scaling capabilities
      - Disadvantage is that extra manpower will be needed or, outsourced to a 3rd party to help with a new deployment
    - Brownfield migrations
      - Taking an existing environment and moving it to another environment (i.e. the Cloud) without major changes
      - Usually companies that don't have the staff or time to make changes to their environment will use a brownfield migration
      - Disadvantage is that you bring all the old problems you had before into a new environment
      - Disadvantage is your costs could be higher if you are using old techniques in a new cloud provider
    - Lift & Shift
      - Taking a physical server and moving it to a different colocation facility
    - Some tools can be used to analyze and migrate data, such as ATAData and Rackware

What type of data store for my application?

- RDBMS – still the default data store for most types of applications
  - Row based *(all column values for a row stored together on the same data page)*
    - E.g., AWS RDS (Oracle, SQL Server, MySQL) & Aurora, Azure SQL Database Service, Google Cloud SQL (MySQL)
  - Columnar *(data stored in columns e.g., data page stores data for a single column, in row order)*
    - E.g., AWS Redshift, Azure SQL Warehouse

What type of data store for my application?

- NoSQL
  - Key Value Pair - IoT, gaming, web, etc.
    - (e.g., AWS Dynamo, Azure Redis Cache)
  - Document store (e.g., JSON, XML) - content management, messaging, web
    - E.g., AWS Dynamo, Azure Cosmos DB
  - Wide Column – highly flexible (e.g., variable number of columns) – Big Data, fast updates
    - (e.g., Hbase, Cassandra)
  - Graph – social networking, recommendations, machine learning, complex mappings
    - (e.g., Neo4J, OrientDB)

Preparing to move to the Cloud

- Capture a baseline of workloads and utilization, databases, application and infrastructure dependencies, etc.

- How's your enterprise metadata repository and enterprise architecture these days?
  - If it's in good shape should be able to rapidly visualize impact analyses, information supply chains, application, data, and infrastructure dependencies
  - If not, well… you'll need to invest time and money to identify this information
    - Sure would be nice to not have to reinvent the wheel – ***may be a good time to invest in metadata management/CMDB if your company is serious about large scale migration to the cloud!***

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Preparing to move to the Cloud

- Moving to the cloud provides a good opportunity to identify duplicative data sets, application functionality in order to reduce footprint, costs, management efforts for the migrated apps, data, infrastructure, etc.
- Is the duplication due to application or connectivity limitations? An option may be to break out functionality / data into cloud based microservices which can scale more easily
- Have a solid and repeatable test plan in place
- Understand security requirements and security capability of the cloud vendors
  - Cloud vendors have very strong security, but still need to understand the requirements and responsibilities of your organization to ensure proper security and data management in place

Preparing to move to the Cloud

- If multiple cloud vendors and multiple platforms within a cloud vendor (e.g., AWS Redshift and AWS Elastic MapReduce for Big Data) important to maintain visibility to what and where your cloud assets are
- Need to understand risk of cloud vendor lock-in e.g., will I be able to port apps, services, data, and infrastructure to other cloud vendors, bring back in house?
- Need to determine non-functional requirements e.g., availability / failover

Preparing to move to the Cloud

- Getting your data ready
  - If brownfield – minimal or no data reorganization / restructuring needed
  - A CRUD matrix invaluable – regardless of brownfield or greenfield
    - Need to know what processes, applications "Create, Read, Update, or Delete" data
    - Especially moving an enterprise database, many dependencies to consider at least for connectivity
    - Don't want to move a database and have application connections fail

Preparing to move to the Cloud

- Getting your data ready
  - If you are reorganizing / restructuring your data, what do you need to know (for your sources and target)?
    - **Keys (primary and natural)**
    - Datatypes
    - Mandatory / optional fields
    - Relationship cardinality
    - Data Definitions
    - **In other words, <u>you need a solid data model (conceptual, logical, and physical)</u>**
    - **Know how the data will be persisted physically - applying right data technology for the data and application**

Preparing to move to the Cloud

- Getting your data ready
  - If “brownfield” - will just throwing more CPU, memory at the problem in the cloud be feasible from a cost and performance perspective?
  - E.g., just shifting an RDBMS to an IaaS server won’t necessarily increase performance (e.g., might have some increased network latency)
  - This might be good time to look at partitioning, indexing, other performance characteristics of the database to ensure SLA’s maintained

Preparing to move to the Cloud

- Moving your data to the cloud
  - Multiple options depending on the size of your data. Might not (depending on vendor) need to pay to get data into the cloud – but still need to consider mechanics of getting the data there. What if you need to move to a new cloud vendor – might have to pay $$'s to download all your data from your existing vendor
  - **Physically ship storage**
    - (e.g., AWS Import/Export Snowball, Azure Import/Export Service, Google Offline Media Import/Export)
  - **Over the wire**
    - Streams (e.g., AWS Kinesis Firehose, Azure Event Hubs)
    - Database Migration Service (AWS, Azure) – port schema and data from one RDBMS to another
    - ETL (e.g., AWS Glue, Azure Data Factory)

Preparing to move to the Cloud

- Backup / Archival
  - Cloud vs. tape can be significantly less expensive, be retained longer, and can have shorter recovery time
  - Backups should be to a separate geographical region
  - Hadoop (e.g., Cloudera Live, AWS EMR, HDInsight) a good option for an archive store – to store ALL your data

Managing server infrastructure

- Pets vs. Cattle
  - Pets
    - In the server service model, physical servers are treated like pets.
      - Servers have easy to remember names
      - Servers are taken care of with software updates and patches
      - Servers get regular maintenance and hardware upgrades (more memory or additional disk space)
      - If a server goes down, you nurse it back to health
  - Cattle
    - In the Cloud Service Model, Cloud instances are treated like cattle.
      - They are given random numbers, named after IP addresses, or a location, the actual name is not important
      - Cloud servers are not built until they are needed, and usually start working at 100% utilization after they are deployed
      - There is no need to regularly update software, your Cloud Service provider handles that, and you assume you will receive the latest OS when a new server is deployed
      - If a Cloud server goes down or is not responding, you get rid of it, and build a new one

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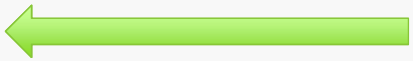

How to decide what to move to the Cloud

- Legacy apps – would probably require significant re-architecture and so more expensive to migrate
  - Is there any planned upgrades or new functionality needed? This can influence decision – do we keep putting money into technology that is/will be obsolete soon?
- Can the same SLA's be met? An existing well-tuned application might not be the best candidate (especially transaction processing)
  - Does the cost savings for technical infrastructure savings realized by moving to the cloud **significantly** offset the labor costs (internal, consulting) and recurring charges?
  - Risks – even for the same RDBMS, cloud versions of the database might have functionality restrictions
- Security concerns (real or perceived). Maybe co-location (moving existing servers to a 3rd party data center) a better option.
- Will there be significant/prove-able ROI?
- Culture / Staff skillsets – is the organization ready? Do you have the skillsets to manage Cloud migration?

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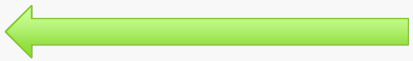
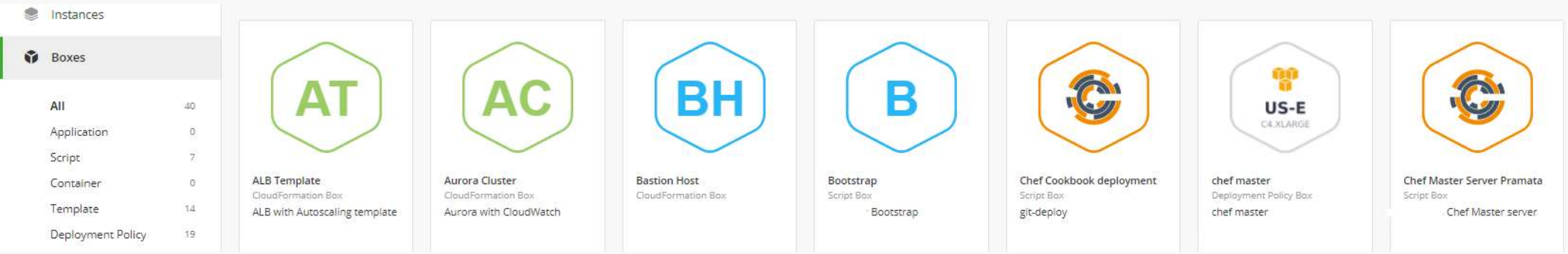


Managing multiple cloud environments

- Some of the benefits of a multi-cloud and cloud-agnostic platform for managing applications and workloads across different hosted infrastructures:
  - Easily connects to your existing Cloud provider
    - Allows you the flexibility to choose additional Cloud providers if the cost is better for the services they offer.
    - You are not locked into one Cloud provider, and can leverage the advantage of multiple providers as needed.
    - You can create deployment policies, so your servers are created were you want, and how you want.
  - Easily monitor your environment
    - You can watch your deployment in real-time, make modifications to code in real-time, manage other users builds, and terminate environments at a pre-determined time.
  - Create a full deployment environment
    - Leverage PowerShell and Bash shell scripts, Python, etc.
    - You can make network and hardware changes through the tool
  - Single Pane Dashboard
    - You can view your spending to optimize your cost, manage other members, and terminate instances if they are no longer needed.

Multi-cloud management

- Using a multi-cloud management tool, a script deployment can be created, then it can be replicated to servers in different Cloud environments



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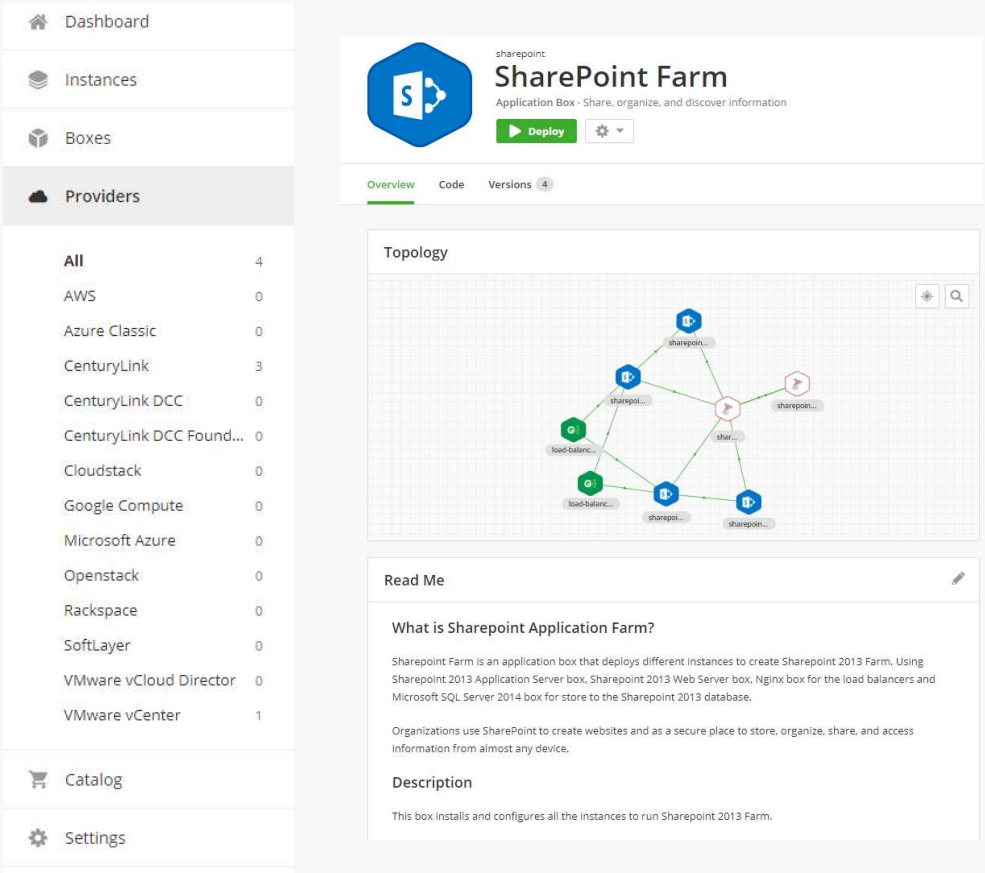
Multi-cloud management



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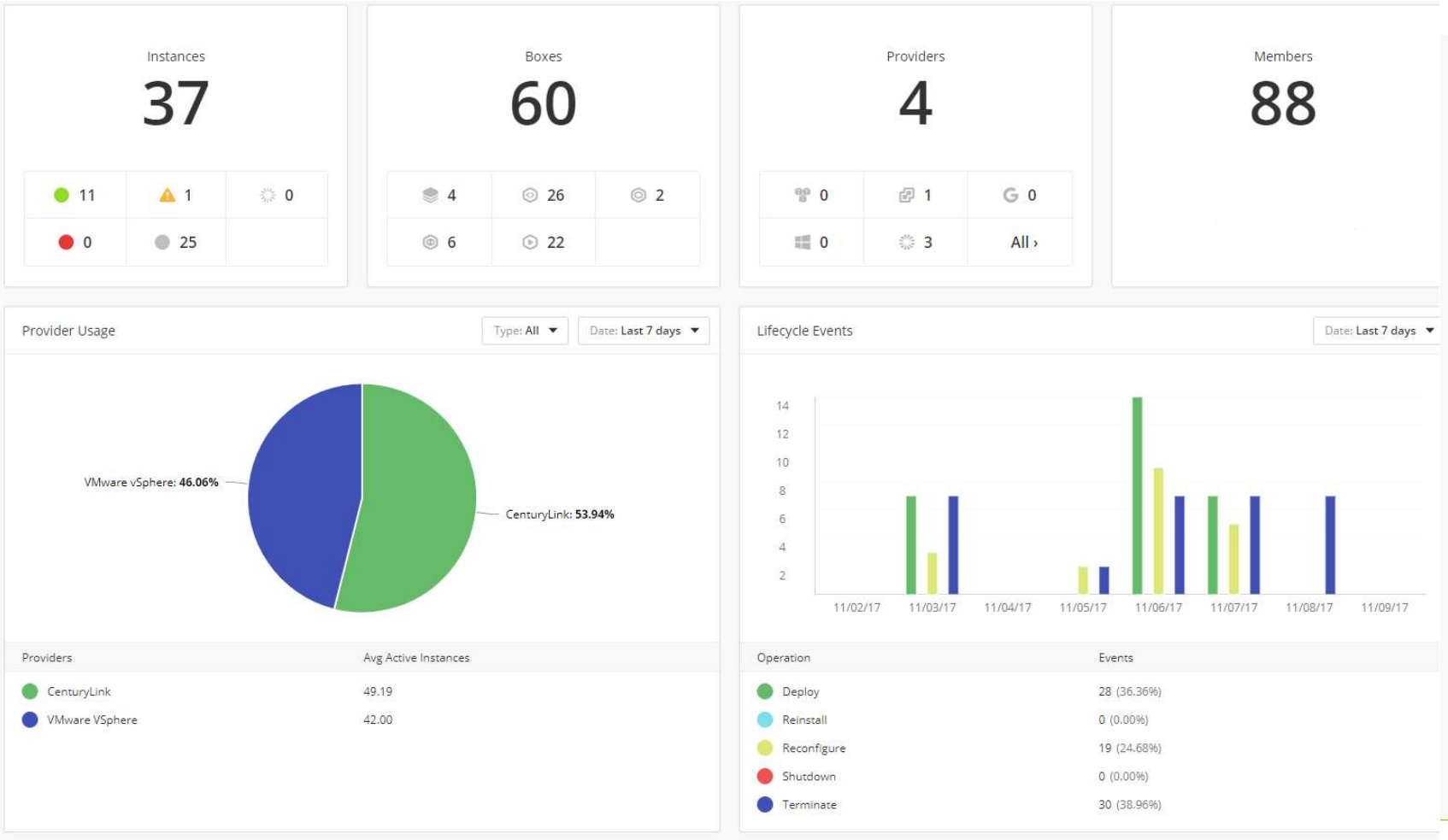
Multi-cloud management



A dashboard that highlights the most important information needed at login

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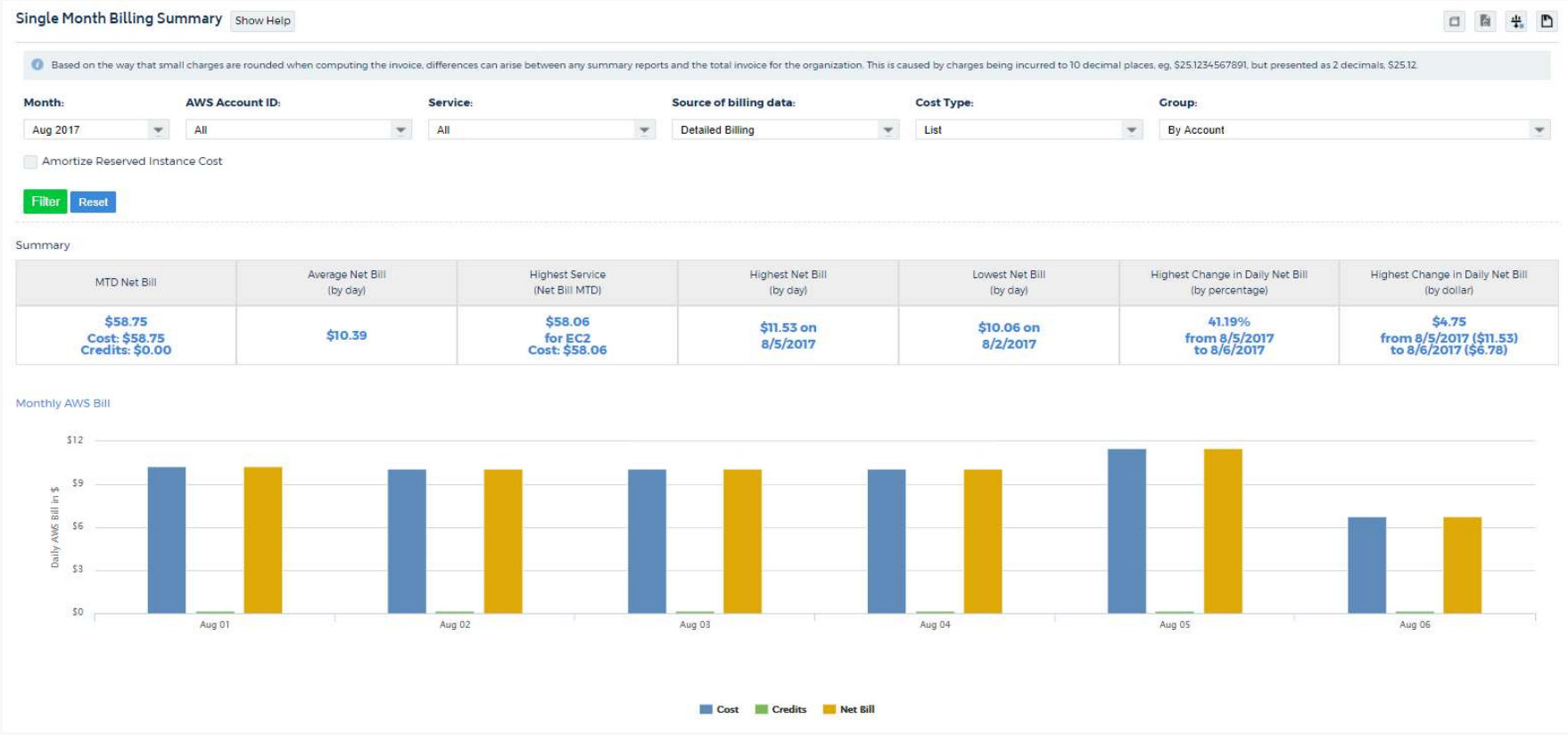
Multi-cloud management

- Cost savings and analysis



After analyzing a cloud environment the tool can recommend ways to save money.

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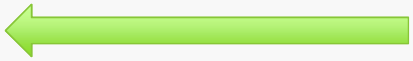

Cloud Migration Case Studies

- State of Arizona agency
  - Had dis-integrated data on an AS/400 which was hard to work with (took a long time answer an analytics question) and expensive to maintain the infrastructure
  - State of Arizona has a “cloud first” (but not only) strategy for IT
  - Provisioned 2 Amazon EC2 servers – one for SQL Server and one for QlikSense (BI application)
  - Re-architected / integrated their sales, retailer, and game data into a dimensional data mart
  - During the project, initial sizing estimates had to be revised – minimal disruption to upgrade servers and add disk space
  - **Business users now able to rapidly visualize and analyze their data without requiring IT to write a program**
  - **Can eventually move away from having to support AS/400 and the physical plant**

Cloud Migration Case Studies

- Large docu-sign company
  - Company had needed to manage their code deployments and installations. Each client required multiple servers, and different versions of an install script to run and join the existing infrastructure.
  - This was accomplished through a CAM Template that deployed a Chef Master Server. Once a node was created and bootstrapped to the Master Server, a customized cookbook that was created for each client was run on a node. The recipe downloaded the latest code, connected the node to the backend database, and allowed the node to be part of a larger environment that accepted document requests.
  - Any changes to the code can be done in the Cookbook so that the recipe will push it out to the nodes the next time they check-in.

Cloud Migration Case Studies

- Large soda manufacturer
  - Initially in a VMWare based cloud provider. Decided to move to a full cloud provider with server management that made sure that instances would be patched and updated.
  - Project consisted of moving 5,000 server instances. Tools were used to take an snapshot of the current image, then migrate the data to the new location.
  - A direct network connection was put in place to access the servers quicker than going over the public internet.
  - Enhanced security, encrypted filesystems and virus scanners were installed to protect the server.
  - The company was able to see advantages by being able to expand their web server farm to other locations and different datacenters around the world.

Cloud management Case Studies

- Large cloud big-data management company
  - Company had large amount of servers deployed in AWS, but there was little oversight on what the servers were used for, and any developer could spin-up a cloud instance, but would not shutdown or terminate them when they were done
  - The company also had over 6000 AWS AMI images deployed for their end users. These AMI images contained customized software for a particular client. Some clients were using them for years, so the company had keep them updated. It was a large task to manage the infrastructure.
  - Benefits were able to be used to place governance in instance deployment, and limiting who has access to create new images. The auto-terminate feature was helpful to shutdown test images that were no longer needed, and setting a time limit on new servers.
  - Setting up version control to test out new AMI images with different scenarios and use cases that clients would use.
  - The company saved over 40% of month using these features over not having any cloud management capabilities

Summary

Summary

- Cloud-based solutions will be increasingly more common – part or all of the technology & data stack can be put in the Cloud
  - **Infrastructure, platform, data, desktops, software**
- Moving to the cloud can reduce costs, increase scalability, enable new functionality. Enables rapid deployment of new servers / services, can minimize administration.
- Your cloud strategy needs to be in alignment with your **data strategy** *(e.g., ensuring solid data governance, metadata management in place)*
- Cloud migration a good opportunity to identify and improve your data assets – rather than SGDS (same garbage different server)
- If you are doing large scale Cloud migrations – using managed services / center of excellence for Cloud management important.
- Investigate management tools especially when dealing with multiple cloud platforms, many services

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- 1000+ Network Specialists
- 200+ IT Architects

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