November 10, 2015

Dear Reader,

In the following package of material, you will find documentation outlining our planning efforts for the HUIT Cloud & DevOps program. The material is intended to provide a high-level, strategic outline of our approaches for the following five areas:

- Overview: The Plan for the Plan
- Current-State Services
- Future-State Services
- Service Transition
- Cloud Migration

In total, these documents explain the “case for the cloud” for HUIT, and review the service, technology, process, and people changes that are necessary for successful implementation. The next step associated with the effort is to develop a coordinated implementation, staffing, and change management plan that maps process, dependencies, and delivery milestones for impacted organizations.

Thank for you taking the time to review our strategy.

Kind Regards,

Cloud & DevOps Working Group and Program Team
Cloud & DevOps ‘Plan for the Plan’
The Case for Cloud & DevOps
Agenda

● Purpose and Intended Outcomes
● About Cloud & DevOps
● What is the Cloud?
● Value of the Cloud
● What is DevOps?
● Value of DevOps
● Getting There from Here
● Service Transition: Infrastructure and Application Services
● Migration Approach
● Managing Change
Purpose and Intended Outcomes

Purpose
To summarize cloud computing and DevOps methodologies, explain their value, and examine how cloud and DevOps can provide value and efficiencies within HUIT.

Intended Outcomes
● Knowledge of cloud and DevOps key concepts
● Awareness of the potential for value offered by cloud and DevOps
● Understanding of a migration approach and service transition plan within HUIT, as well as critical aspects of change management
About Cloud & DevOps

Cloud computing and DevOps methodologies are two major IT industry-wide transformations that have been underway for many years.

These two trends have an impact on the way we build and/or operate applications:

- This affects the work we do in application groups, such as ATS
- This impacts large portions of our infrastructure services

We can either ...

- Embrace these trends and capitalize on the benefits that they offer
- Hang on to our current practices for as long as we can
About Cloud & DevOps

Both cloud and DevOps each have value on their own, but the value of the two together is greater than the sum of the individual parts.

Ultimately, the value of cloud and DevOps working together lies in:

- A reduction in operating costs
- Increased speed, flexibility, and reliability
What is the Cloud?

“The Cloud” incorporates two fundamental ideas:

“Off-Premise”
- Using others’ data centers, servers, etc.

Advanced Capabilities
- Access to new technical capabilities not available in traditional data centers that deliver higher value to Harvard

There are two key cloud models to highlight:

Infrastructure as a Service (IaaS)
- Servers in the cloud (e.g. AWS)

Software as a Service (SaaS)
- Applications in the cloud (e.g. Facebook, Office 365, Gmail)
An Analogy: Digital Photography

Cloud computing is to data-center computing as film photography is to digital photography ...

<table>
<thead>
<tr>
<th>Film Camera</th>
<th>Digital Camera</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The good:</strong> Camera lens, camera functionality</td>
<td><strong>The good:</strong> Camera lens, camera functionality</td>
</tr>
<tr>
<td><strong>The bad:</strong> Can’t edit, each print costs money, each print takes time</td>
<td><strong>The better:</strong> On-the-fly editing, delete bad prints, immediate viewing</td>
</tr>
</tbody>
</table>

... and similarly, the cloud introduces on-demand self-service, rapid elasticity, and improved integration.
Value of the Cloud

Cost
● Some reduction in operating cost as part of the transition
● Cloud costs are directly tied to usage — today, we often pay for peak usage rather than actual usage

Speed
● Ability to meet new or changing needs in minutes or hours, not days or weeks

Flexibility
● Ability to adjust to changing conditions such as seasonal spikes, or extreme conditions and other disasters

Reliability
● Ability to create systems that are more resilient, secure, and standardized
What is DevOps?

“DevOps” means applying three important concepts that change the way applications are developed and operated.

**Agile**
- Deliver value fast and frequently
- Correct the course if necessary
- Understand risk and challenges more quickly
- Reduce wasted efforts

**Automation**
- Use tools in order to remove as much human-factor risk as possible

**Integrated, multidisciplinary teams**
- Teams structured to include all skills necessary to develop and operate a system
What is DevOps?

The current model:

- Org 1: Bus. Analyst
- Org 2: Developer
- Org 3: ICAPS
- Org 4: DBAs
- Org 5: Systems
- Org 6: Network

The DevOps model:

- Integrated Service Team: Bus. Analysts, Developers, DevOps Engineers

Agile
Value of DevOps

**Cost**
- Team integration means less redundant management
- Labor cost goes down as a result of automation

**Speed**
- Agile methodologies and automation dramatically increase the speed of delivery
- Integrated teams mean faster and more efficient collaboration

**Flexibility**
- Agile methodologies and automation allow for quicker adjustments

**Reliability**
- Automation removes a category of human errors while promoting or even forcing standardization
- Integrated teams are more self-sufficient and accountable
Getting There from Here

Current State

- Application Services
- Infrastructure Services

Future State

- New Application Services
- New Operations

Transition of our services to new models and Migration of our systems to the cloud
Service Transition: Infrastructure

Infrastructure services will evolve, remain the same, or be deprecated.

**Current Services**
- Storage & Archive
- Data Protection (Backups)
- Networking

**Future Services**
- Crimson Cloud
  - Storage as a Service
- Data Protection
  - Snapshots, Self-Healing
- Networking
  - + Increased Extranet Connectivity

**Deprecated Services**
- Systems and Database Management
- Physical & Virtual Hosting
- ICAPS
- Ops & Production Services

**Crimson Cloud**
- IaaS + PaaS
- Cloud Center of Excellence
Migration Approach Summary

There are two methods to migrate an application to the cloud as IaaS: replatforming, or “lift and shift.” HUIT application teams can migrate via one of these options either through the Cloud & DevOps program, or on their own.

<table>
<thead>
<tr>
<th>Replatform</th>
<th>Lift and Shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Replaces application functionality with cloud services</td>
<td>● Copies the application “as is” to the cloud</td>
</tr>
<tr>
<td>● Requires developer commitment and cloud service expertise to implement</td>
<td>● Requires research on existing connections through</td>
</tr>
<tr>
<td>application changes</td>
<td>discovery process</td>
</tr>
<tr>
<td>● Operational support model shifts to cloud program team and embedded</td>
<td>● Enables fast migration timelines using a migration</td>
</tr>
<tr>
<td>DevOps resource when staffed</td>
<td>toolset</td>
</tr>
<tr>
<td></td>
<td>● Known operational support model leveraging the</td>
</tr>
<tr>
<td></td>
<td>infrastructure team</td>
</tr>
</tbody>
</table>
Implementing organizational change of this magnitude without impacting service delivery requires a coordinated approach:

**Define Needs**
- Problem statement/opportunity
- Scope
- Urgency

**Identify Options**
- Possibilities
- Dependencies
- Impact

**Decide**
- SLT Admin Subgroup
- CIO

**Implement**

**Communicate**
- Big Group, Executive Committee

**Include**
- Pilots (ATS), Jetstream teams, embedded DevOps

**Train**
- IT Academy track, targeted training by role

Assess cultural considerations at each step
Cloud & DevOps ‘Plan for the Plan’
SOC, NOC, and ATS Current State
Agenda

● Purpose and Intended Outcomes

● ATS Services: Current State
  ○ FAS and College Systems
  ○ Central Administration Systems
  ○ Office of President & Provost Systems
  ○ ATS Practices

● Infrastructure Services: Current State
  ○ SOC Services
  ○ NOC Services
Purpose and Intended Outcome

Purpose
To provide a financial and staffing overview of the current state of the SOC, NOC, and ATS.

Intended Outcome
- Understanding of current-state financial and staffing climate for the NOC, SOC, and ATS
ATS Services: Current State

Current State

Application Services

Infrastructure Services

FAS and College Systems

Central Administration Systems

Office of President & Provost Systems

ATS Practices
ATS Services: Current State

Current State

Application Services

FAS and College Systems
- Aurora
- College
- GSAS

Central Administration Systems
- AA&D
- HR
- Museum
- Sponsored Research

Office of President & Provost
- Office of the President & Provost
- Research Office

ATS Practices
- ServiceNow
- Atlassian
- Salesforce

Infrastructure Services

ATS Services: Current State

- Athletics
- FAS Admin
- App Arch

- Finance
- Student Financial
- Data Mgt/BI

- Release Mgt
- Data & Arch
NOC/SOC Services: Current State

Current State

Application Services

Infrastructure Services

SOC Services

NOC Services
NOC/SOC Services: Current State

Current State

Application Services

Infrastructure Services

SOC Services
- Physical Hosting
- Virtual Hosting
- Data Protection
- Systems Mgmt (Wintel/Linux)
- Operations and Production
- Storage and Archive
- Database and Application Management

NOC Services
- Data Center Networking
- Data Center Firewall
- Data Center Load Balancing
- Extranet Connectivity
Cloud & DevOps ‘Plan for the Plan’
Future-State Service Strategy
Agenda

- Purpose and Intended Outcomes
- Drivers for Cloud Services
- Cloud Services Future State
- User Segments and Requirements
- Crimson Cloud Service: IaaS, PaaS, and SaaS
- Cloud Center of Excellence
- IT Provider Services
  - Network and Security
  - Billing and Account Management
- Cloud Operations Services
  - Operations
  - Disaster Recovery
- Application Team Impact
- ITSM Impact
- End-State Tools
Purpose and Intended Outcomes

Purpose
Describe the future state for cloud services within HUIT, including proposed cloud services, the organization tasked with governing these services, and the extension of operations to support cloud services.

Intended Outcomes
● Understanding of the future state for HUIT cloud services
● Awareness of the oversight organization and model for cloud services
● Knowledge of the infrastructure and operations organization services
Drivers for Cloud Services

Illustrate an understanding of diverse user needs for cloud solutions

- Create a suite of service offerings that are deliberately crafted based on known user needs and behaviors

Provide value differentiation over “direct-to-vendor” offerings

- Incorporate organizational best practices for security and networking into the delivery process for cloud resources, enabling teams who deploy to the cloud to navigate complex policies
- Introduce automation to empower application teams to deliver functionality without needing in-depth understanding of a specific vendor

Provide a means to estimate, trace, and recover costs in a meaningful way

- Bundling and mapping costs for specific resources, tools, and technologies to services helps facilitate long-term financial planning and enables the organization understand TCO

Define the transition from current-state services to future-state hosting

- Clearly define and articulate how infrastructure hosting services will evolve with the introduction of the new cloud hosting delivery model
Drivers for Cloud Services ... as a Service
All systems services remain, but are structured as integrated teams with embedded DevOps.
## User Segments and Requirements

<table>
<thead>
<tr>
<th>User</th>
<th>Characteristics</th>
<th>Requirements</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Sufficient</td>
<td>Little to no need for centralized service offerings. Has “full stack” dev team and/or skills to independently support the entire application development lifecycle. Team is familiar with or has potential to implement and support cloud offerings without assistance.</td>
<td>Autonomy in creation, maintenance and support of apps and resources. Prefers access to advisory services and/or information to get reusable artifacts and design validation.</td>
<td>Crimson Cloud IaaS</td>
</tr>
<tr>
<td>Agility-Seeking</td>
<td>Motivated by efficiency and quick delivery of resources. Seeks speed above all else and has a low tolerance for complex or cumbersome processes.</td>
<td>Favors automation for provisioning and maintaining cloud resources. Seeks “ease of use” and self-service. Favors bundled options that are workflow-enabled and require minimal customization or ongoing support.</td>
<td>Crimson Cloud PaaS</td>
</tr>
<tr>
<td>Storage-Seeking</td>
<td>Need to store large amounts of information and share it with others. Wants tiered storage capacity that is flexible and on demand to meet their ever-growing data needs.</td>
<td>Seeks file share options for sharing files across departments or groups. Needs flexible, cost-effective storage.</td>
<td>Crimson Cloud Storage</td>
</tr>
<tr>
<td>Reliability-Seeking</td>
<td>Prioritizes application availability. Demands stability and resiliency in the form of uptime, low RTO, and low RPOs. Examples include enterprise and mission-critical applications.</td>
<td>Seek automated recovery options for compute and data. Require disaster recovery to ensure business functions available in a crisis.</td>
<td>SaaS</td>
</tr>
</tbody>
</table>
Cloud Services by User Segment

- **Self-Sufficient**
  - Crimson Cloud
    - Infrastructure as a Service
    - Platform as a Service
    - Storage as a Service
  - SaaS

**Cloud IT Provider Services** (Mandatory)
- Managed Cloud Network & Security: Cloud Connectivity, VPC Management, Firewall-Controlled Access
- Billing & Account Management Service: Consolidated Billing, Account Management, IAM

**Cloud Operational Services** (Choose needed)
- Cloud Operations: Monitoring, Auditing, Logging, Scheduling
- Disaster Recovery Service: Cloud-to-Cloud, On-Prem to Cloud, Cloud Backup

**Cloud Center of Excellence**
- Best Practices
- Design Patterns
- Cloud SMEs
- DevOps Training & Support
- Vendor Management
- Knowledge Share
Crimson Cloud: IaaS

Self-service capabilities enable users to rapidly provision resources; automation and standardized templates improve service quality and reduce time to delivery.

Features
- Fast, automatic resource generation
- Tested templates/scripts from a central knowledge store
- Full self-service access to provision/remove resources

Target Audiences
- Application development teams
- Students and faculty

Use Cases
- Faculty member hosting statistical probability app
- Student needing compute resources for class assignment
- Partner org hosting production app with periodic spikes
- App team needing dynamic storage to develop business-critical application
Crimson Cloud: PaaS

Users can develop, deploy, and manage end-to-end cloud resources and supporting toolsets with no worry about underlying infrastructure.

Features

● Self-service access to a fully integrated cloud platform
● SLA provided by direct from selected PaaS vendor
● Centrally negotiated contract lowers costs, standardizes terms/conditions

Target Audiences

● Partner org with small, development-focused team
● Faculty member hosting information for a class

Use Cases

● Partner org with app with constantly-changing content
● Student building a website for a class
● Partner org that can hire developers, but has difficulty finding qualified DevOps engineers
● Deadline-driven team needing to reduce deployment time
Crimson Cloud: STaaS

From application storage to file shares to archive cold storage, Crimson Cloud’s storage service will provide cost-effective, scalable, on-demand storage capabilities.

Features
- Multi-tier storage (EBS, S3, Glacier, etc.)
- File sharing (NFS/CIFS protocols; Elastic File Share)

Target Audiences
- Business units
- Students and professors
- Application teams

Use Cases
- An application that requires storage for its database
- Business units that need a shared file system for document storage
- Organization requiring secure storage to backup and archive data for compliance
<table>
<thead>
<tr>
<th>Service</th>
<th>Roles</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crimson Cloud IaaS</td>
<td>● Crimson Cloud Product Owner</td>
<td>Develops and supports establishment of the Crimson Cloud service; provides Tier 3 support for the cloud</td>
</tr>
<tr>
<td></td>
<td>● DevOps Engineer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Developers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● BA/QA</td>
<td></td>
</tr>
<tr>
<td>Crimson Cloud PaaS</td>
<td></td>
<td>Expertise, best practices, and standards for using PaaS will exist within the Cloud Center of Excellence, but there will be no centralized support team</td>
</tr>
<tr>
<td></td>
<td>● Cloud Storage Senior Engineer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Cloud Storage Engineer</td>
<td></td>
</tr>
<tr>
<td>Crimson Cloud STaaS</td>
<td></td>
<td>Supports multiple storage options; works closely with DR product owner to ensure that storage and data are well designed</td>
</tr>
</tbody>
</table>
Cloud Center of Excellence

The Cloud Center of Excellence will provide best practices, standards, and technical oversight for all Harvard cloud services. This team of cloud architects and subject matter experts will provide the University with leadership, support, guidance, and training.
## Cloud Services: End-State Staff

<table>
<thead>
<tr>
<th>Service</th>
<th>Roles</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud Center of Excellence</td>
<td>• Cloud Architecture Manager</td>
<td>Experienced cloud architects in Harvard’s cloud deployments.</td>
</tr>
<tr>
<td></td>
<td>• Cloud Architect</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Infrastructure SME — part of Enterprise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Architecture</td>
<td>Infrastructure SMEs are the best technical resources from 60 Oxford who want</td>
</tr>
<tr>
<td></td>
<td></td>
<td>to remain focused on infrastructure (Windows, Linux, Storage/DB). Provides Tier 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>support for the cloud.</td>
</tr>
</tbody>
</table>
Network & Security

- Provides the foundational services required for any HUIT cloud application, as well as the core network and infrastructure security required for any application hosted in an external cloud

Billing & Account Management

- Integrates a partner organization into the consolidated billing process and high-level account management to cloud services provider; service also includes integration with HarvardKey identity and access management
This service (required for all cloud-hosted production applications) provides foundational services needed for any HUIT cloud app, including the core network required for any application hosted in an external cloud.

Features
- Fully-managed network connection to external cloud provider
- High-speed, redundant network connectivity (Direct Connect for AWS)
- Enables connectivity to defined cloud and/or on-premise resources
- Routing and DNS support for cloud network integration

Target Audiences
- All IaaS and PaaS offerings must use this service
- Project teams with experience implementing and managing cloud infrastructure

Use Case
- Partner organization hosting applications fully supported by project team, but needing reliable connectivity and the ability to access internal Harvard resources (such as an internal database)
IT Provider Services: Billing & Account Management

This service integrates a partner organization into the consolidated billing process and high-level account management to cloud services provider.

Features
- Consolidated billing to produce greater savings and volume discounts
- Governance over root-level cloud provider access
- Integration with HarvardKey identity services for all accounts
- Guidance on the mandatory tagging of resources to simplify

Target Audience
- All partners using Crimson Cloud services

Use Case
- Partner organization using either IaaS or PaaS offerings
## IT Provider Services: End-State Staff

<table>
<thead>
<tr>
<th>Service</th>
<th>Roles</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network and Security</td>
<td>● No impact</td>
<td>Supports DirectConnect and entire security architecture framework for AWS; builds upon current tools</td>
</tr>
<tr>
<td>Billing and Account Management</td>
<td>● Billing Manager</td>
<td>Supports the billing system, manages the billing process, projects revenue</td>
</tr>
<tr>
<td></td>
<td>● Billing Analyst</td>
<td></td>
</tr>
</tbody>
</table>
Cloud Operations Services

Cloud Operations
● A suite of next-generation operational services and tools that provide application teams with the ability to manage, optimize, and assess production application workloads; will also extend and enhance on-prem capabilities to cloud resources

Disaster Recovery
● A suite of service offerings to offer an appropriate level of DR for all applications that require it; primary offerings will be on-premise-to-cloud and cloud-to-cloud DR
Cloud Operations Services

Services and tools that enable app teams to manage, optimize, and assess production application workloads. Cloud Operations will extend and enhance on-premise capabilities to cloud resources.

Features
- Monitoring
- Auditing
- Logging
- Scheduling

Target Audiences
- Application teams with compliance requirements
- Production applications with high service levels and on-call requirements
- App teams continuously optimizing for cost and performance

Use Cases
- An application team needing a means to identify the root cause of a service outage
- An application team that wants to spin up a new environment without creating downtime
Cloud Operations Services

Monitoring
Advanced cloud monitoring will expand the current server monitoring service to cloud resources, with application performance and diagnostics information available as an optional service.

Logging
Current logging service will evolve and become a standard component for all cloud systems; tiered services will provide customers with options to meet their application or compliance requirements.

Auditing
Cloud auditing will become standard on all cloud systems, and will monitor cloud resources for a wide range of security-related configuration items, including security groups, S3 policies, and IAM users.

Scheduling
There is currently no known job schedule outside of Maestro that meets requirements; in the future, as new technology for the cloud is developed, we anticipate the service will use a specific cloud job scheduler.
Disaster Recovery

Design and support services required to recover applications or services to cloud resources.

Features:
- **Cloud-to-Cloud**: Applications already deployed in the cloud can recover within the same cloud provider or across different cloud providers.
- **On-Premise-to-Cloud**: Applications remaining on-premise will use CloudEndure to ensure application redundancy.

Target Audiences:
- Mission-critical applications
- Enterprise applications

Service Tiers:

<table>
<thead>
<tr>
<th>On-Prem-to-Cloud</th>
<th>Backup &amp; Restore</th>
<th>Cloud-to-Cloud</th>
<th>Not Available</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*AWS-specific
# Disaster Recovery

<table>
<thead>
<tr>
<th>DR Service</th>
<th>Description</th>
<th>Protects Against</th>
<th>Cost</th>
<th>RPO</th>
<th>RTO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Protection</strong></td>
<td>Uses CloudEndure to build standby application for reconstitution at remote AWS data center</td>
<td>Disaster at Harvard data center</td>
<td>$</td>
<td>&lt;24 hr</td>
<td>&lt;1 hr</td>
</tr>
<tr>
<td><strong>Multi-AZ Cloud Architecture</strong></td>
<td>Design services to use good cloud design principles for horizontal scaling and data protection using multi-AZ architecture</td>
<td>Individual data center or AZ failure/ degradation</td>
<td>$</td>
<td>~0</td>
<td>~0</td>
</tr>
<tr>
<td><strong>Cold Storage</strong></td>
<td>Copy all data and configuration to secondary region for cold storage (code+config+data) Full environment build required and data can also be sent to secondary</td>
<td>Extended regional failure</td>
<td>$$</td>
<td>&lt;1 hr</td>
<td>&lt;8 hr (staff limited)</td>
</tr>
<tr>
<td><strong>Hot-Hot-Hot</strong></td>
<td>Multi-region active production running at full scale</td>
<td>Regional failure or degradation</td>
<td>$$$$</td>
<td>&lt;15 min</td>
<td>&lt;30 min</td>
</tr>
</tbody>
</table>
# Cloud Operations Services: End-State Staff

<table>
<thead>
<tr>
<th>Service</th>
<th>Roles</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disaster Recovery</strong></td>
<td>● DR Product Owner</td>
<td>Manages DR communication, evaluates ongoing solutions, works with Crimson Cloud and storage product owners to define implementation approaches, manages testing across HUIT service teams</td>
</tr>
<tr>
<td><strong>Cloud Operations</strong></td>
<td>● Cloud Operations Director</td>
<td>Manages, tracks, and reports on monitoring, auditing, and logging; partners with ITSM team on incidents to ensure that event reporting is appropriate; partners with application teams to meet application needs</td>
</tr>
<tr>
<td></td>
<td>● Cloud Operations Tools Developer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Cloud Operations Optimization Engineer</td>
<td></td>
</tr>
</tbody>
</table>
Application Teams: Overview

This section provides an overview of the service impact associated with application teams or ITSM, including the impact of both the embedded DevOps engineer and the newly introduced services as part of the cloud. The examples that follow relate to HUIT’s ATS program, but in all cases the models work across application teams.

Critical concepts for application teams include:

- Embedded DevOps
- Release management
- Developer toolset
- Application team structure
- ITSM process impact
Cloud & DevOps Impact on Application Teams

- Embedded DevOps engineers managed and cost-allocated to application teams
- Common cloud services and multi-tenancy established
- Scaled Agile Framework practices incorporated into the establishment of infrastructure
- Embedded architects and the establishment of standard infrastructure patterns
- Defined integration approaches for application connectivity within the cloud
- QA automation and deployment integration
- Automated, continuous deployment and changes to release management
- Defined and published operational support models
Sample Application Team: ATS

**ATS Project Services**
- Release Managers

*Communities of Practice:*
- Project Managers
- CRMs
- Product Owners
- Business Analysts
- Scrum Masters

**ATS Technical Operations**
- Data Architects
- Software Architects

*Communities of Practice:*
- Software Developers
- QA Engineers
- Application Support

**HUIT Arch & Engineering**
- Embedded DevOps
- Enterprise Architects

*Communities of Practice are accountable for best practices, with a full-time role and input in team rating*
Release management evolves to provide an expansion of services to orchestrate automated release engineering processes. The auditable release engineering processes replace manual release validation with automated deployment packages.
This service provides a set of shared development tools teams across the University can use, including a set of common functions all groups use as part of the application development process.

Features

- Atlassian suite (JIRA, Confluence, Fisheye, Crucible, HipChat)
- Enterprise GitHub
- Data masking tool
- Automation tools (Puppet, Ansible)
- ServiceNow

Target Audiences

- Development teams

Use Cases

- A development team wishing to create a de-identified copy of production data to securely use in lower environments
- Teams that want to create a wiki for project collaboration
- A developer who wants to create a script to automate a repetitive manual process
## Application Teams: End-State Staff

<table>
<thead>
<tr>
<th>Service</th>
<th>Roles</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATS Embedded DevOps</td>
<td>● DevOps Engineer</td>
<td>Teams remain as defined earlier, with the addition of embedded DevOps personnel</td>
</tr>
<tr>
<td>Embedded DevOps for Other App Teams</td>
<td>● DevOps Engineer</td>
<td>Teams remain as defined earlier, with the addition of embedded DevOps personnel</td>
</tr>
<tr>
<td>ATS Release Management</td>
<td>● Release Engineer</td>
<td>Provides broad release engineering support across ATS, and is integrated into the release management process; trains other release managers in release engineering</td>
</tr>
<tr>
<td>ATS Developer and Service Management Toolset</td>
<td>● Toolset Lead</td>
<td>Provide HUIT-wide development and service support tools, as well as tool patches and upgrades and operational support; assesses organizational fit and works with Cloud CoE for selection</td>
</tr>
</tbody>
</table>
## ITSM: Cloud Impact

<table>
<thead>
<tr>
<th>ITIL Lifecycle</th>
<th>Processes</th>
<th>Cloud Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Service Strategy</strong></td>
<td>Service portfolio</td>
<td>Assess different cloud providers and their services.</td>
</tr>
<tr>
<td><strong>Service Design</strong></td>
<td>Service catalog, service level</td>
<td>Introduce new services identified; establishing new features with these services will occur at fairly rapid pace.</td>
</tr>
<tr>
<td><strong>Service Transition</strong></td>
<td>Change management</td>
<td>Breaks the centralized control, but not the centralized repository of information; autoscaling “just happens.”</td>
</tr>
<tr>
<td><strong>Service Operation</strong></td>
<td>Event management, incident management, problem management, service requests</td>
<td>Increase pace of activity and response; reduce focus on determination of problem and increase rapid creation for response. Automate process for event and request response from ServiceNow to incite cloud change.</td>
</tr>
<tr>
<td><strong>Service Improvement</strong></td>
<td>Service reporting and quality</td>
<td>Improve service metering capabilities.</td>
</tr>
</tbody>
</table>
**End-State Tools (1/2)**

Tools are based on the current rapidly-evolving marketplace, and are therefore expected to be subject to change.

<table>
<thead>
<tr>
<th>Service</th>
<th>Tool</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR</td>
<td>CloudEndure</td>
<td>DR purposes only</td>
</tr>
<tr>
<td>Account Mgt</td>
<td>Security Monkey</td>
<td>AWS account management</td>
</tr>
<tr>
<td>Billing</td>
<td>Cloud Allocation 360</td>
<td>Dynamic cost/billing analysis for both on-premise and cloud</td>
</tr>
<tr>
<td>Developer Toolset</td>
<td>Github (Enterprise)</td>
<td>Advanced version control system</td>
</tr>
<tr>
<td>Developer Toolset</td>
<td>VictorOps</td>
<td>Automated incident paging</td>
</tr>
<tr>
<td>Logging</td>
<td>Splunk</td>
<td>Centralized and consolidated monitoring</td>
</tr>
</tbody>
</table>
## End-State Tools (2/2)

<table>
<thead>
<tr>
<th>Service</th>
<th>Tool</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monitoring</strong></td>
<td>New Relic</td>
<td>App monitoring, including dashboard and transaction introspection, automated alerting, and trend analysis</td>
</tr>
<tr>
<td></td>
<td>Zenoss Service Dynamics, Nagios XI</td>
<td>Event management console</td>
</tr>
<tr>
<td></td>
<td>Nagios</td>
<td>Detailed system monitoring and alerting</td>
</tr>
<tr>
<td><strong>Scheduling</strong></td>
<td>IBM Tivoli Workload Scheduler (Maestro)</td>
<td>Automated script scheduling and batch processing</td>
</tr>
<tr>
<td><strong>Release Management</strong></td>
<td>Bamboo (Atlassian)</td>
<td>Automated release management</td>
</tr>
</tbody>
</table>
Cloud & DevOps ‘Plan for the Plan’
Service Transition Strategy
Agenda

- Purpose and Intended Outcomes
- Goals for Cloud Service Transition
- Cloud Change Principles
- ATS Services: Current and Future State
- ATS Transition
- Infrastructure Services Current and Future State
- Infrastructure Transition: Staff
- Infrastructure Transition: Project Development
Purpose and Intended Outcomes

Purpose
To outline principles and goals for cloud service transition, examine ATS as a case study, and discuss staff and process transitions for infrastructure at Harvard.

Intended Outcomes

- Understanding of our goals for cloud service transition
- Knowledge of transition as instantiated within ATS
- Awareness of infrastructure transition goals, processes, and options
Goals for Cloud Service Transition

Organizational Goals

● Reduce inefficiencies through consolidating redundant roles
● Create and implement a common Agile framework across organizations
● Break down silos by developing common HUIT-wide standards and tools

Infrastructure Goals

● Decentralize operational support and create T-shaped professionals by implementing embedded architects and DevOps engineers
● Develop cloud service offerings and transition from a traditional data center to the cloud
Cloud Change Principles

- Use ATS as lead adopters for all application teams
- Define and communicate an embedded DevOps vision and its benefits for the team
- Perform changes in small increments
- Identify owners of organizational change within ATS to drive progress and remove obstacles
- Define owners of process changes within the Cloud & DevOps program team
- Provide training and actively communicate with ATS team members throughout the change process
- Develop a regular, recurring reporting process to capture progress and identify course corrections
ATS Services: Current and Future State

The future state of ATS relies upon the addition of embedded DevOps resources, as well as close collaboration with data management integration services and the Cloud Center of Excellence.
ATS Transition: Defining an Approach

Broad process changes are required, but they cannot be implemented all at once across the organization.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Expected Outcomes</th>
<th>Lead Adopter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development Process</td>
<td>Consolidate and optimize ATS development, deploy, and support processes</td>
<td>Create the ability to share resources across ATS</td>
<td>OPP</td>
</tr>
<tr>
<td>Embedded DevOps</td>
<td>Introduce new roles and evolve support structures as a result</td>
<td>Create the ability for service teams to be independent service teams</td>
<td>FAS and College Systems</td>
</tr>
</tbody>
</table>
The Development Process: Today vs. Tomorrow

As a result of this change process, code development will also evolve.
Our goal is to develop consistent project management, Agile, QA, and release management processes across HUIT.

**Assess and Plan**
Work across teams to assess adoption viability and needs
Develop strategy and implementation plan for rollout of changes

**Train**
Train staff and prepare for implementing changes

**Implement**
Identify upcoming releases to implement changes
Implement changes while working through Agile delivery process

**Evolve**
Build and implement automated QA functionality
Build and implement release engineering functionality
Build and implement auditing

**Mature**
Continue to guide new Agile teams and expand Agile skills
Incorporate program increment planning
**ATS Transition: Embedded DevOps**

Introduce embedded DevOps and Jetstream teams, accompanied by operational support changes.

**Plan**
- Define vision and expected outcomes
- Define development strategy for Jetstream creation
- Develop training plan

**Align Staff**
- Align Jetstream staff to the FAS and College System Portfolio
- Create formal relationship with the ATS team and the Jetstream team

**Train**
- Joint completion of Cloud & DevOps training program
- ATS team trains Jetstream on application development methodology/architectures for FAS/College Systems

**Implement**
- Migrate 210 FAS servers using lift-and-shift approach
- Transition Jetstream team into embedded DevOps for FAS
- Transition operational support for any migrated system

**Evolve**
- Enhance monitoring and notification for migrated applications
- Validate that training curriculum is appropriate
- Find opportunities to refine process
- Replatform applications
Infrastructure Services: Impact to the Service Catalog

Infrastructure services will evolve, remain the same, or be deprecated.

Current Services
- Storage & Archive
- Data Protection
- Backups
- Networking

Future Services
- Crimson Cloud
  - Storage as a Service
- Data Protection
  - Snapshots, Self-Healing
- Networking
  - + Increased Extranet Connectivity

Deprecated Services
- Systems and Database Management
- Physical & Virtual Hosting
- ICAPS
- Ops & Production Services

Cloud Center of Excellence
Infrastructure Transition: Defining an Approach

Infrastructure as an organization does not exist in the future state; the overarching goal is to build the skills and supporting services to create the capability to enable DevOps.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Outcomes</th>
<th>Lead Adopter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff</td>
<td>Transition sysadmin staff into new roles needed for the cloud</td>
<td>Build expertise and capability to support cloud services</td>
<td>Jetstream team, Cloud &amp; DevOps program staff</td>
</tr>
<tr>
<td>Project Development</td>
<td>Complete associated projects with Infrastructure to enable future cloud services</td>
<td>Completed infrastructure services that utilize the cloud</td>
<td>Infrastructure teams (varies)</td>
</tr>
</tbody>
</table>
Infrastructure Transition: Staff

Create a clearly defined plan for transitioning staff

- Incorporate Jetstream transition to app teams as migrations take place
- Include backfill of cloud program staff as they migrate into different roles
- Identify a DR product owner

In support of migrations, the Cloud & DevOps program will drive transition of Infrastructure staff to enable cloud skills

- Lift and shift
  - Skills to transfer existing applications to cloud environments
  - Application awareness
  - Replatforming within application teams
- Replatforming
  - Skills to assess existing application designs
  - Skills to refactor applications to conform to cloud standards
  - Skills to QA revised applications
Infrastructure Transition: Staff

Training paths for Jetstream and program teams have established progressions and criteria for end-state roles. However, team members can also work towards meeting criteria to move into other roles.

<table>
<thead>
<tr>
<th>Sample Criteria</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development</td>
<td>Crimson Cloud</td>
</tr>
<tr>
<td>Cloud Storage</td>
<td>StaaS</td>
</tr>
<tr>
<td>Atlassian</td>
<td>ATS Toolset</td>
</tr>
<tr>
<td>Monitoring Config</td>
<td>Ops Tools</td>
</tr>
<tr>
<td>Usage Analytics</td>
<td>Ops Optimization</td>
</tr>
<tr>
<td>Cloud design</td>
<td>CoE Architect</td>
</tr>
<tr>
<td>Infrastructure architecture</td>
<td>CoE SME</td>
</tr>
<tr>
<td>Cloud config</td>
<td>DevOps Engineer</td>
</tr>
<tr>
<td>Specific skills associated with role</td>
<td>Independent roles</td>
</tr>
<tr>
<td></td>
<td>(Release Engineer, DR)</td>
</tr>
</tbody>
</table>
Infrastructure Transition: Cloud Jetstream Teams

Create small teams of cross-functional infrastructure teams to embed with application teams to support the portfolio in the cloud.

**Staff Assessment**

- Review staff database for staff to move into next Cloud Jetstream
- Assess operations impact and transition activity as needed

**Implement**

- Create Jetstream team for HUIT organizations
- Distribute application/server portfolio to align with Jetstream teams

**Train**

- Train Jetstream teams on assigned applications
- Train Jetstream teams on AWS fundamentals

**Execute**

- Validate discovery material with Jetstream teams
- Build skills through hands-on active migration of applications

**Embed**

- Embed staff into application teams
- Provide DevOps engineering mentorship through the cloud program team

**Support**

- Work with app teams, Cloud CoE on replatform plan
- Provide ongoing training and mentorship through cloud program team
Infrastructure Transition: Cloud Program Team

Migrate staff into a central cloud migration team to replatform applications and learn development skills.

**Staff Assessment**
- Review staff database for staff to move into the cloud program team
- Assess operations impact and transition activity as needed

**Implement**
- Identify app migrations and mentor for staff
- Integrate into cloud program product teams

**Train**
- Train staff on AWS fundamentals
- Train staff on Agile
- Train staff on programming fundamentals

**Execute**
- Build skills through hands-on migration and replatforming
- Build advanced skills through the establishment of new applications and tools

**Transition**
- Transition staff into Crimson Cloud role or appropriate role
- Develop product support skills associated with establishing a service

**Support**
- Evolve training based on market changes
- Establish new cloud services
Crimson Cloud will be structured as a product development and support team:

- strong product owner to define service strategy and manage development
- Development and DevOps engineers to implement self-service capabilities
- Close work with Cloud CoE to ensure services are aligned to best practices and standards

**Why is this important?**

Crimson Cloud will own all aspects of the cloud hosting service and be responsible for delivery of cloud services.

**Crimson Cloud Working Group**

Regular sessions with user community will gather feedback on features, functionality, issues, and concerns.
## Infrastructure Transition: Project Development

The projects below require coordination between the cloud and infrastructure teams.

<table>
<thead>
<tr>
<th>Project</th>
<th>Definition</th>
<th>Outcomes</th>
<th>Leading Team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduler Service</td>
<td>Evaluate Maestro for cloud viability and migrate or replace with cloud alternative</td>
<td>Scheduler service that allows direct application team scheduling updates</td>
<td>Operations</td>
</tr>
<tr>
<td>Data Protection</td>
<td>Evaluate risk and approach for providing ongoing protection of Harvard data in the cloud</td>
<td>Document outlining protection methods for Harvard data; establish associated services</td>
<td>Data Protection</td>
</tr>
<tr>
<td>Storage Strategy</td>
<td>Integrate storage strategy and cloud StaaS definition into coherent project implementation</td>
<td>Storage strategy document and associated implementation plan</td>
<td>Storage and Archive</td>
</tr>
<tr>
<td>Billing</td>
<td>Assess long-term viability of Slash system and either migrate or replace with alternative</td>
<td>Billing solution supported by multiple staff</td>
<td>Cloud and DevOps</td>
</tr>
<tr>
<td>Cloud Network Firewall</td>
<td>Establish centralized firewall approach to protect cloud assets</td>
<td>Cloud network firewall that allows Level 4 data to be hosted in the cloud</td>
<td>Extranet Connectivity</td>
</tr>
<tr>
<td>GoldenGate</td>
<td>Establish a database integration service</td>
<td>Direct database replication service</td>
<td>Database</td>
</tr>
<tr>
<td>Network Simplification</td>
<td>Migrate the existing complex ACL and network layered approach into a simplified approach that takes advantage of cloud technologies</td>
<td>Simplified network structure and associated service updates</td>
<td>Data Center Networking</td>
</tr>
</tbody>
</table>
Infrastructure Transition: Project Development

All projects should follow standard project methodology. Below are extra steps to coordinate projects with the cloud team and architecture.

Create Team
- Identify project managers for each project (scrum masters)
- Identify team members from Infrastructure and cloud program to work with scrum master

Gather Requirements
- Identify any cloud dependencies and scheduling needs for the project
- Identify external consulting needs where resource contention exists

Plan and Design
- Define vision and approach for future state of technology
- Review design with cloud leadership
- Validate impact to funding model

Implement
- Execute and validate project against requirements
Cloud & DevOps ‘Plan for the Plan’
Cloud Migration Approach
Agenda

● Purpose and Intended Outcomes
● Current Challenges
● Migration Approach Options
  ○ Replatforming
  ○ “Lift and Shift” and Jetstream
  ○ Cloud Migration Consultants
  ○ Organic Transition
● Recommendations
Purpose and Intended Outcomes

Purpose
To highlight observations from HUIT’s current migration approach, describe alternative approach options that were considered, and provide a recommendation for a future migration approach.

Intended Outcomes
● Understand the current migration constraints
● Describe alternative migration approach options
● Review and compare migration approaches
● Outline recommendations
Current Challenges

Replatforming has encountered multiple constraints, impacting our ability to meet program goals.

Velocity of migrations not sufficient to meet the program goals

- Current process migrates approximately 2-3 apps per two-week sprint
- Speed of migrations has increased as team gains more experience, but still not enough to meet program goals

Identifying applications to migrate is challenging

- Developing a backlog of applications has been difficult

Training DevOps engineers takes substantial time

- A considerable amount of time will be required to train the number of staff necessary to support the end state

Currently unable to migrate applications with Level 4 data

- Infrastructure changes required to support Level 4 data have not yet been implemented
Migration Approach Options

There are four identified approaches for migrating code into the cloud environment. Their commonalities and differences are defined below.

<table>
<thead>
<tr>
<th>Approach</th>
<th>Codebase</th>
<th>Migration by</th>
<th>Tools</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replatform</td>
<td>Optimized for cloud</td>
<td>Cloud program team</td>
<td>Evolving Crimson Cloud toolset</td>
<td>Crimson Cloud toolset, migrated applications</td>
</tr>
<tr>
<td>Lift and Shift</td>
<td>Unchanged</td>
<td>Cloud program team</td>
<td>CloudEndure</td>
<td>Codebase in cloud, ready for independent replatforming efforts</td>
</tr>
<tr>
<td>Migration Consultants</td>
<td>Optimized for cloud</td>
<td>Consultants</td>
<td>Proprietary</td>
<td>Codebase in cloud, but ongoing support is dependent upon consulting</td>
</tr>
<tr>
<td>Organic</td>
<td>Varied</td>
<td>Application team</td>
<td>Varied</td>
<td>“Have and have not” silos, distributed approaches</td>
</tr>
</tbody>
</table>
Migration Approach: Replatforming

The Process
Applications are updated to maximize the utility of cloud features, and are then deployed to the cloud by this team. All new applications follow this process.

Staffing
Cloud & DevOps program team platforms all applications

Benefits
- Applications replatformed for the cloud see improvements in **quality**, improved alerting, and increased **reliability**
- **Crimson Cloud tools** — A library of reusable toolsets to maximize automation abilities of all application teams

Challenges
- Limited number of DevOps engineers available to support replatforming; currently 8 engineers included in Wave 1
- Changes to the application infrastructure, requires time and work from application and DevOps teams
- Ongoing operations support model is not sustainable
Migration Approach: Lift and Shift (1/2)

The Process
The application, infrastructure, and cloud program teams jointly identify dependencies, plan, and migrate apps. Application teams validate the migration was successful; embedded team members provide ongoing support.

Staffing
Infrastructure team staff will be assessed and split into support teams to drive migrations using CloudEndure.
Migration Approach: Lift and Shift (2/2)

Benefits

- This approach reduces migration time, allowing us to decommission on-premise servers more quickly and reduce hosting costs.
- Allows existing staff to manage migrated servers with limited knowledge of cloud technologies — this accelerates migration but extends timeframe to both train and replatform application.

Challenges

- The discovery process to determine application dependencies is intensive and potentially time-consuming.
- Replatforming is dependent upon the application team prioritization and support for embedded infrastructure teams.

Application Teams

Jetstream

Engagement → Discovery → Migration → Testing/Validation

Application Teams

Re-platform (as required)
Migration Approach: Jetstream

“Jetstream” teams are small, cross-functional groups made up of sysadmins and DBAs from the SOC. These teams will have all of the skills necessary to support applications while also migrating them to the cloud using “lift and shift” methods. Benefits of Jetstream teams include ...

Provide app support and migrations
- Performed in parallel
- Part of the application team
- Build application culture first

Increase migration velocity
- “Like for like” migrations

Cloud exposure to more staff, faster
- Effectively extends our training time

Gradual expansion of skills
- Teams develop replatforming skills
Migration Approach: Cloud Migration Consultants

The Process
Hire a third-party vendor to migrate applications to the cloud. The vendor will define and manage the process based on their best practices and methods.

Staffing
Migration will be staffed by vendor, but will still require significant help from application teams, network, and security to reconcile dependencies and integration into Harvard's network.

Benefits
Delivery-focused vendor will accelerate the timeframe.

Challenges
- HUIT loses in-house skills to support migrated applications, requiring us to rely on the vendor for support until HUIT is able to hire in necessary skillsets
- Overall increased cost for migrating applications

Warning: Vendor-Dependent Process!
Migration Approach: Organic Transition (“Do Nothing”)

The Process
Partner organizations are responsible for migrating on-premise apps and resources, with schedule controlled by partner organizations.

Staffing
Partner organizations are responsible for staffing.

Benefits
● No need for a dedicated Cloud & DevOps program

Challenges
● Inconsistency in app migrations lead to information silos
● Increase in security risk due to inconsistent cloud deployments
Recommendation: Hybrid Approach

After analyzing these migration approaches’ strengths and weaknesses, we have decided to adopt a consolidated approach that offers the increased velocity and collaboration of lift and shift with the flexibility and cloud optimization of replatforming. The default approach is lift and shift, but there are instances where replatforming is appropriate.
Benefits of a Hybrid Approach

Expands the number of staff that participate in the cloud program
• Lift and shift enables the SOC and application teams to learn and apply basic cloud and AWS technologies
• Program team can focus on reusable artifacts and future-state services

Initial lift-and-shift phase provides agility and flexibility to app teams
• Offers a streamlined approach to provision resources faster in order to address technical debt (e.g. outdated operating systems)
• Provides basic assurance that an application can run “as is” in the cloud; eliminates “too many changes at once”
• Reduces network complexity
• Enables teams to plan for replatforming according to partner timelines and with the support of an embedded resource

HUIT can save costs and meet program goals with current support levels
• Allows for increased pace of decommissioning on-premise infrastructure
• Application support model remains “as is” until support resources are embedded into the team
Staff Transitions: Lift and Shift/Replatforming

Please see the handouts for details of the staff transition approach.
Migration Workflow: Lift and Shift

1. Application Discovery

2. Install Agent
   Replication Begins

3. Configure Target Cloud Network

4. Enter Application Stack Details

5. Create & Test Replica App(s)

6. Does Replica App Work?
   yes
   no

7. Cutover

8. Retire On-Premise Infrastructure

Harvard Data Centers

Amazon Data Centers