Lessons Learned while Exploring Cloud-Native Architectures for NASA EOSDIS Applications and Systems

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Earth Science Instruments on ISS:
RapidScat, CATS, LIS, SAGE III (on ISS), TSIS-1; OCO-3, ECOSTRESS, GEDI, CLARREO-PF
EOSDIS Archive Growth *Estimate* (Prime + Extended)

Lots of assumptions in this chart. Subject to change...
ExCEL Efforts and Project Prototypes

NGAP
NASA Compliant General Application Platform (NGAP), an operational, dev-ops, and sandbox AWS cloud based operating environment.

ASF WOS Prototype
AWS/NGAP Web Object Storage (WSO) prototyping large volumes of mission data dynamically between AWS S3, S3-IA, and Glacier object storage. Managed out of Alaska Satellite Facility.

Earthdata Search Client to Cloud
NASA Earth Science data search by keyword and advanced filters such as time and space.

Cumulus
Prototype addressing core EOSDIS capabilities including data ingest, archive, management, and distribution of large volumes of EOS data.

Getting Ready for NISAR (GRFN)
Integrated prototype of science product generation and delivery from a DAAC system focused on coupling ASF DAAC and JPL ARIA systems.

CATEES
Easy-to-use Python tools packaged to support EOSDIS cross-DAAC science workflows and analytics over large volumes of EOS data in AWS.

ECC to Cloud Study
Earth Code Collaborative (ECC) study to determine cloud ready capabilities to migrate into AWS/NGAP platform.
ExCEL Efforts and Project Prototypes Continued

**GIBS in the Cloud**
Migrating GIBS to the AWS/NGAP Cloud based on recommendations made in the “GIBS in the Cloud Study”

**Earthdata Login to Cloud Study**
Study to determine and recommend migrating the Earthdata Login into AWS/NGAP cloud environment

**CMR to Cloud**
Migration of the Common Metadata Repository into the AWS/NGAP platform based on recommendations made in the CMR to Cloud study.

**OPeNDAP/HDF Cloud Studies**
Study to determine and recommend a cloud native integration of OPeNDAP accessing HDF5 and netCDF4 data on AWS/NGAP platform.

**NEXUS**
Prototype to accelerate end-user analysis of remote sensing data, highly parallel to better enable science discovery

**Network Prototypes**
Network prototypes to support to test security, monitoring, logging, and to perform R&D testing to support all ExCEL project prototypes.
**(01) Full Scale Deployment (?)**

Full scale enterprise deployment of EOSDIS services and infrastructure to the cloud.

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**(02) Partial Deployment (?)**

Select deployment of EOSDIS services and/or infrastructure to the cloud.

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**Determining Project Success**

Project success is determined by viable outcomes of fully completed project prototypes and business analysis.  

- or -

Technical and business results of the ExCEL project needed for strategic decision on EOSDIS and the cloud.

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**(03) Cloud Stand-down (?)**

No EOSDIS services or infrastructure operationally migrated to the cloud.

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**(04) Decision Point (?)**

More prototyping required, or cloud hybrid, or other next steps based on ExCEL prototyping and business analysis results.
Lessons Learned

- Technical
- Psycho-Social
- Cost
Technical Lesson 1

ENABLE CLOUD NATIVE ARCHITECTURES BY STRONGLY PREFERING CLOUD SERVICES
GIBS-in-the-Cloud Ingest and Processing

Infrastructure

- AWS
- Scheduler (66 LoC)
- Dispatcher (106 LoC)

Product Config

Handlers

Generation

MRF Gen
The Big 4

1. EC2 Instances
   - More instances *running* = more cost

2. EBS Storage
   - More EBS* = more cost

3. Data Transfer
   - Notably: egress, egress, and egress

4. S3 Storage
   - More storage = more cost

* EBS storage has costs associated even when not in use by a running EC2 instance
Ingest: MODAPS Tiles

Discover
- Product Config
- Scheduler
- Discover HTTP Tiles
- Provider

Sync
- Sync HTTP URLs
- Source Image Storage

Process
- Generate MRF
- MRF Locks
- MRF Storage

Execution Flow
- Data store
- Data fetch
The Big 4... but server-less

1. EC2 Instances
   - Zero to heavily reduced instances

2. EBS Storage
   - Less EC2 generally means less EBS

3. Data Transfer
   - Notably: egress, egress, and egress

4. S3 Storage
   - More storage = more cost

* EBS storage has costs associated even when not in use by a running EC2 instance
AWS HAS VERY LOW INTERNAL LATENCY – BUT TRUST NOTHING.
On premises implementation showed consistent performance during load testing vs more sporadic latencies in AWS.
Technical Lesson 3

INVOLVE SECURITY FROM THE VERY BEGINNING
Layer security throughout the architecture

- ECC (Code testing, tracking, deployment)
- NGAP Base AMI (Secure)
- NGAP Builder (Creates “slug” from ECC-hosted codebases)
- NGAP-compliant AMI (Application)
- NGAP Services (Monitoring, Logging, Security, Autoscaling, Billing, etc.)

NASA Office of the CIO (AWS Reseller)

ESDIS “blessed” component
Cost Lesson 1

MODELING TOTAL COST OF OWNERSHIP (TCO) IS EXTREMELY COMPLICATED
<table>
<thead>
<tr>
<th>NGAP Application Profile</th>
<th>Application Name</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC2 Instance Type</td>
<td>m4.xlarge; Tenancy: Shared; CPUs: 4; Memory: 16 GiB; Storage: EBS only; Cost: $0.239/Hours</td>
<td>8</td>
</tr>
<tr>
<td>EC2 Instance OS Disk Size (GB)</td>
<td>General Purpose SSD</td>
<td>30</td>
</tr>
<tr>
<td>EC2 Instance OS Disk Type</td>
<td>Provisioned IOPS</td>
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</tr>
<tr>
<td>EC2 Disk Provisioned IOPS</td>
<td>Provisioned</td>
<td></td>
</tr>
<tr>
<td>EC2 Disk IO Rate (million)</td>
<td>Provisioned</td>
<td></td>
</tr>
<tr>
<td>EC2 Number of Instances</td>
<td>DBS.m1.xlarge; CPUs: 4; Memory: 15 GiB</td>
<td>2</td>
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<tr>
<td>EC2 Utilization Rate (% of day)</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>RDS DB Engine (No RTO)</td>
<td>PostgreSQL</td>
<td></td>
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<tr>
<td>RDS Deployment Option</td>
<td>Multi-AZ</td>
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<tr>
<td>RDS Instance Type</td>
<td>Provisioned IOPS</td>
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<tr>
<td>RDS Disk Type</td>
<td>Provisioned</td>
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<tr>
<td>RDS Storage Capacity (GB)</td>
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<tr>
<td>RDS Provisioned IOPS</td>
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<tr>
<td>RDS IO Rate (million)</td>
<td>Provisioned</td>
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<tr>
<td>AWS Lambda Usage (million requests per month)</td>
<td>Provisioned</td>
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<tr>
<td>AWS Lambda Memory Requirement (GB)</td>
<td>Provisioned</td>
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<tr>
<td>AWS Lambda Average Duration per Request (Seconds)</td>
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<tr>
<td>S3 Storage (TB)</td>
<td>Provisioned</td>
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<tr>
<td>S3 PUT, POST, GET, or LIST Requests per month</td>
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<tr>
<td>Cloudfront Egress (GB)</td>
<td>Provisioned</td>
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<td>DynamoDB Writes per Second</td>
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<tr>
<td>DynamoDB Reads per Second</td>
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<td>DynamoDB Storage (GB)</td>
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<td>DynamoDB Stream Requests (per month)</td>
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<td>SQS Requests per Month (Each &lt;= 64kb, A 100kb message is 2 requests)</td>
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<td>SNS Mobile Push Messages</td>
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<td>SNS HTTPS</td>
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<td>SNS Egress</td>
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<td>CloudWatch Dashboards</td>
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<td>CloudWatch Detailed Monitoring EC2</td>
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<td>CloudWatch Custom Metric</td>
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<td>CloudWatch Alarms</td>
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<td>CloudWatch API Requests</td>
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<td>CloudWatch Logs Ingested (GB)</td>
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<tr>
<td>CloudWatch Logs Archived (GB)</td>
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<tr>
<td>CloudWatch Egress</td>
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<td>Environment Scaling</td>
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<td>Production Regions</td>
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<tr>
<td>UAT/Production Cost Ratio</td>
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<tr>
<td>SIT/Production Cost Ratio</td>
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<tr>
<td>CloudWatch Data</td>
<td>Provisioned</td>
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**NOVEMBER 1\textsuperscript{st}-3\textsuperscript{rd} Announcements!**

Most Recent Announcements from AWS

<table>
<thead>
<tr>
<th>Date</th>
<th>Announcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov 03</td>
<td>Now run real-time stream processing at scale with Apache Flink on Amazon EMR</td>
</tr>
<tr>
<td>Nov 03</td>
<td>AWS CodePipeline Introduces AWS CloudFormation Deployment Action</td>
</tr>
<tr>
<td>Nov 03</td>
<td>Continuously Deliver Changes to AWS CloudFormation Stacks with AWS CodePipeline</td>
</tr>
<tr>
<td>Nov 03</td>
<td>Amazon Lumberyard Beta 1.6 now available, introduces Twitch Metastream and more</td>
</tr>
<tr>
<td>Nov 02</td>
<td>Amazon RDS for Oracle now supports 11g to 12c Major Version Upgrade</td>
</tr>
<tr>
<td>Nov 02</td>
<td>AWS Directory Service for Microsoft Active Directory (Enterprise Edition) is now available in the US East (Ohio) Region</td>
</tr>
<tr>
<td>Nov 02</td>
<td>Amazon CloudWatch Events is now available in the China (Beijing) AWS region</td>
</tr>
<tr>
<td>Nov 02</td>
<td>Amazon SES Now Provides Fine-Grained Email Sending Metrics</td>
</tr>
<tr>
<td>Nov 02</td>
<td>Backup to AWS with HP Data Protector 9.07 using Storage Gateway VTL</td>
</tr>
<tr>
<td>Nov 01</td>
<td>Swift Web Applications on the AWS Cloud: Quick Start Reference Deployment</td>
</tr>
</tbody>
</table>
This is before considering...

- User behavior
- Staff cost savings
- Development cost savings
- Inter-region costs
- Data lifecycle modeling
- Application migration costs – both in and out
- Managing “consumption” based cost model
Cost Lesson 2

EXPLORE ALTERNATIVE ARCHITECTURES FOR POSSIBLE COST SAVINGS
Basic S3 Egress
S3 with CloudFront
S3 through Direct Connect to On-premises Distribution Pipe
Request Limiting using Lambda and API Gateway
Egress costs range more than 13x across those models.
Psycho-Social

GO HANDS-ON QUICKLY
EED2 HACKFEST 2016
CAPABLE OF SPENDING ENTIRE ANNUAL BUDGET

EED2 HACKFEST 2016
MOST LIKELY TO GO INTO OPERATIONS

EED2 HACKFEST 2016
MOST INNOVATIVE

EED2 HACKFEST 2016
MOST POINTS
Psycho-Social

UNDERSTAND THE OPERATIONS TEAM’S NEEDS
Current procedures may not translate directly

- Tailing / Grepping logs
- SSHing into machines to start / stop /restart services
- Monitoring specific hostnames
- Existing “operations” scripts
- Current dashboards vs AWS Console
Understand WHY they do what they do – you may need to find another way to do it.
Summary

• Enable cloud native architectures by strongly preferring cloud services
• AWS has very low internal latency, but trust nothing.
• Involve security from the very beginning
• Modeling TCO is extremely complicated
• Explore alternative architectures for possible cost savings
• Go hands-on quickly
• Incorporate Operations’ Needs
Questions?

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