



5th Planetary Data Workshop &
2nd Planetary Science Informatics and Data
Analytics Meeting

Cloud Processing of PDS Archival Products with Amazon Web Services, Kubernetes, and Elasticsearch

Kevin Grimes – kevin.m.grimes@jpl.nasa.gov

Co-Authors: Rishi Verma, James Michael McAuley,
Tariq Soliman, Anil Natha, Zachary M. Taylor

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Jet Propulsion Laboratory
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Cloud Processing of PDS Archival Products

Overview

- Introduction
- Architecture
- Deployment
- Conclusions
- Future Work
- References

Introduction

Overview

- PDS Imaging Node
- Existing backend architecture
- Motivation to evolve

Introduction

PDS Imaging Node

- Cartography and Imaging Sciences Node (IMG) of the NASA Planetary Data System (PDS)
- Home to nearly 2 PB of digital image archives
- Diverse collection of images
 - Both orbital and landed missions
 - Over 20 million images takes from the surface of Mars
 - Nearly 5 million images taken of Mars's surface from orbit
 - Images of Saturn, Jupiter, and Beyond
 - Original, raw experiment data and derived products
 - Differing coordinate systems



Introduction

Existing backend architecture

- **Image Atlas**
 - Primary tool for discovering data in IMG's archives
 - JavaScript webapp running on-premises
 - Interacts directly with Apache Solr backend
- *Data access*
- *Search*

The screenshot shows the PDS Image Atlas interface. At the top left is the NASA/JPL logo and text. To the right is the title "PDS Image Atlas". Below the title is a search bar with placeholder text: "Perform a text search like *mars crater* or *cassini rings*, or a more advanced search like *TARGET_NAME:enceladus*". To the right of the search bar are "Search" and "≡" buttons. The main area has a sidebar on the left containing a "Show results for" dropdown set to "Mission", a "Narrow your search by selecting a facet below" section, and two buttons: "Spacecraft" and "Instrument". The main content area displays search results for "Mission". It includes a header with "Results: 24", "Page: 1", and a navigation bar with page numbers and a total count of 3442917. Below this are buttons for "Thumbnail View", "List View", "Select field to sort by: START_TIME", "Hide Missing Browse", "Select All Images", "On Page", and "In Query". The main view shows three rows of image thumbnails, each with a file name (e.g., JNCE_2020313_30R00108_V01) and download icons.

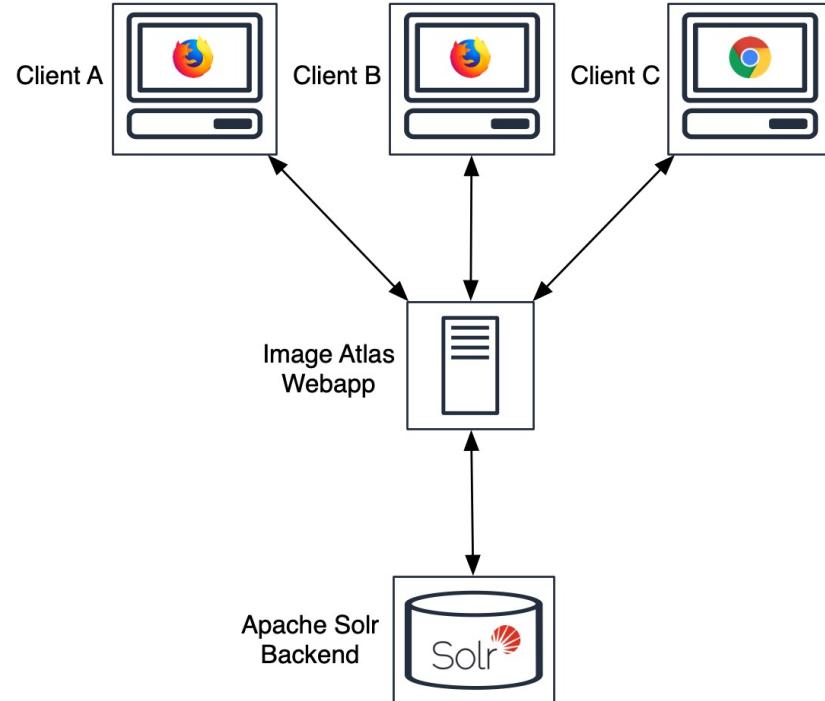
<https://pds-imaging.jpl.nasa.gov/search>

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<https://pds-imaging.jpl.nasa.gov/search>



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Existing backend architecture

- *Image Atlas*
- **Data access**
 - Data products served over HTTPS
 - Simple HTML frontend rendering archives as they exist on disk
- *Search*

<https://pds-imaging.jpl.nasa.gov/data>



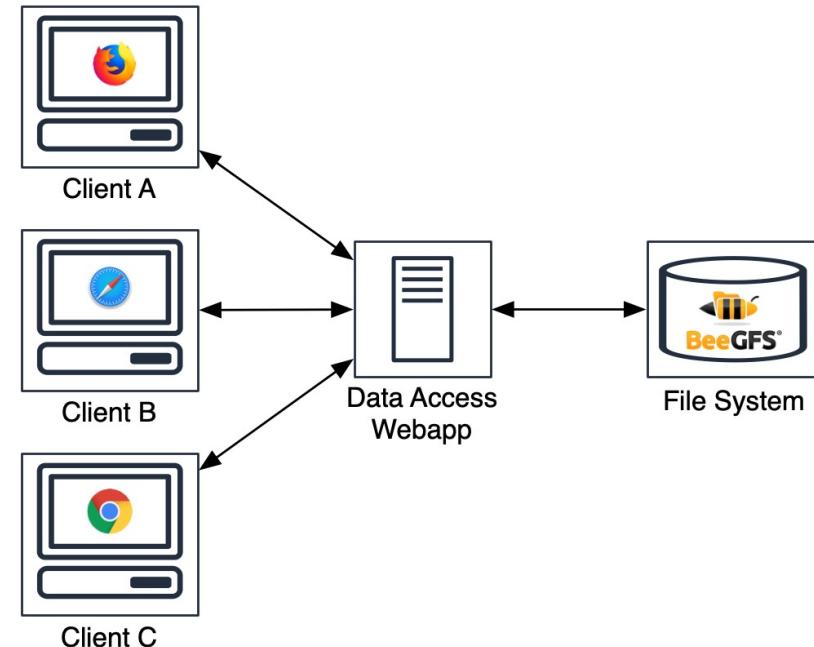
PDS Imaging Node
Jet Propulsion Laboratory U.S. Geological Survey

Name	Last modified	Size	Description
Parent Directory		-	
carto/	2015-11-10 15:01	-	
cassini/	2021-02-04 23:10	-	
clem1-l-h-5-dim-mosaic-v1.0/	2015-07-17 10:10	-	
clem1-l-n-5-dim-nir-v1.0/	2015-07-16 13:02	-	
clem1-l-u-5-dim-basemap-v1.0/	2015-07-17 10:04	-	
clem1-l-u-5-dim-uvvis-v1.0/	2015-07-17 10:06	-	
clem1-l_e_y-a_b_u_h_l_n-2-edr-v1.0/	2016-05-04 09:16	-	
clementine/	2016-07-25 21:04	-	
co-e_v_j-issna_isswa-2-edr-v1.0/	2007-07-12 09:22	-	
co-e_v_l_s-vims-2-qube-v1.0/	2019-09-18 11:29	-	
co-s-issna_isswa-2-edr-v1.0/	2019-09-18 11:29	-	
co-ssa-radar-3-abdr-csv-v1.0/	2019-09-18 09:57	-	
co-ssa-radar-3-abdr-summary-v1.0/	2019-09-18 11:29	-	

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<https://pds-imaging.jpl.nasa.gov/data>

Introduction

Existing backend architecture

- *Image Atlas*
- *Data access*
- **Search**
 - Solr endpoint exposed to internet
 - Powerful functionality
 - Diverse content indexed
 - 40+ million PDS labels
 - “Common” metadata
 - Machine-learning enhanced metadata

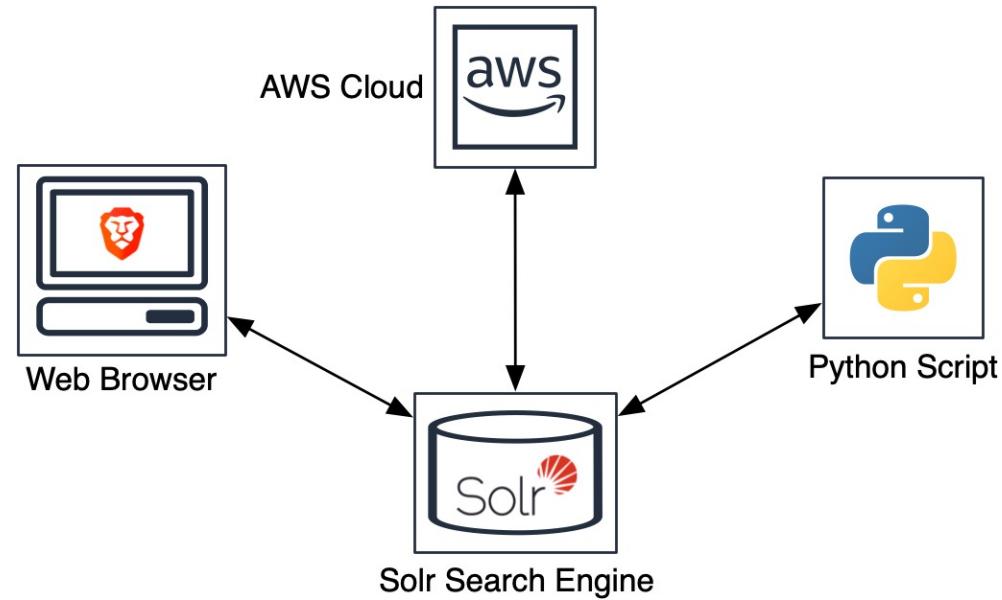
```
{
  "responseHeader": {
    "zkConnected": true,
    "status": 0,
    "qTime": 11,
    "params": {
      "q": "ATLAS_MISSION_NAME:magellan",
      "facet.field": "CENTER_LATITUDE"
    }
  },
  "response": {
    "numFound": 72818,
    "start": 0,
    "maxScore": 6.2685275,
    "docs": [
      {
        "FILE_NAME": "browse.img",
        "TARGET_NAME": "VENUS",
        "INSTRUMENT_ID": "RADAR",
        "ATLAS_LABEL_URL": "https://pds-imaging.jpl.nasa.gov/pds/prod?q=OFSN=%3D+data/magellan/mg_0001/f60n334/browse.lbl+AND+RT=%3D+PDS_LABEL",
        "CENTER_LONGITUDE": 333.642,
        "A_AXIS_RADIUS": 6051.92,
        "ATLAS_PRODUCT_TYPE": "MIDR",
        "PRODUCT_TYPE": [
          "MIDR",
          "MIDR"
        ],
        "DESCRIPTION": "N/A",
        "NUMBER_OF_LINES": 1024,
        "MISSION_PHASE_NAME": "PRIMARY_MISSION",
        "UPPER_LEFT_LONGITUDE": 327.333,
        "ATLAS_VOLUME_URL": "https://pds-imaging.jpl.nasa.gov/data/magellan/mg_0001",
        "B_AXIS_RADIUS": 6051.92,
        "VOLUME_ID": "mg_0001",
        "MAP_PROJECTION_TYPE": "SINUSOIDAL",
        "UPPER_LEFT_LATITUDE": 62.5452,
        "ATLAS_MISSION_NAME": "Magellan",
        "ATLAS_SPACERCAFT_NAME": "Magellan",
        "IMAGE_ID": "F_MIDR_60N334_1",
        "PRODUCT_ID": "F_MIDR_60N334_1",
        "identifier": [
          "F_MIDR_60N334_1"
        ],
        "ATLAS_DATA_URL": "https://pds-imaging.jpl.nasa.gov/pds/prod?q=OFSN=%3D+data/magellan/mg_0001/f60n334/browse.img+AND+RT=%3D+RAW",
        "FILE_PATH": "/mit/pddata/magellan/mg_0001/f60n334",
        "ATLAS_BROWSER_URL": "https://pds-imaging.jpl.nasa.gov//data/magellan/mg_0001/extras/browse/f60n334/browse.img.jpeg",
        "ATLAS_PRIMARY_TARGET_NAME": "Venus",
        "LOWER_RIGHT_LATITUDE": 57.4555,
        "UPPER_RIGHT_LONGITUDE": 339.95
      }
    ]
  }
}
```

<https://pds-imaging.jpl.nasa.gov/solr>

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 - Machine-learning enhanced metadata



<https://pds-imaging.jpl.nasa.gov/solr>

Introduction

Motivation to evolve

Requirements

- Image Atlas
 - Multiple data stores
 - Availability issues
 - Cumbersome upgrades
- Data access
 - Store on multiple file systems (and object stores!)
 - Manage cloud egress costs
- Search
 - Easier than Solr API's learning curve
 - Easier to impose structure on search results

Solutions

- AWS Cloud
 - Managed services
 - Only pay for what you use
- Microservices architecture
 - Decoupled components
 - Developed in isolation
 - Communication via APIs
- Containerization
 - Easy to scale
 - Ephemeral
 - Orchestration frameworks

Cloud Processing of PDS Archival Products

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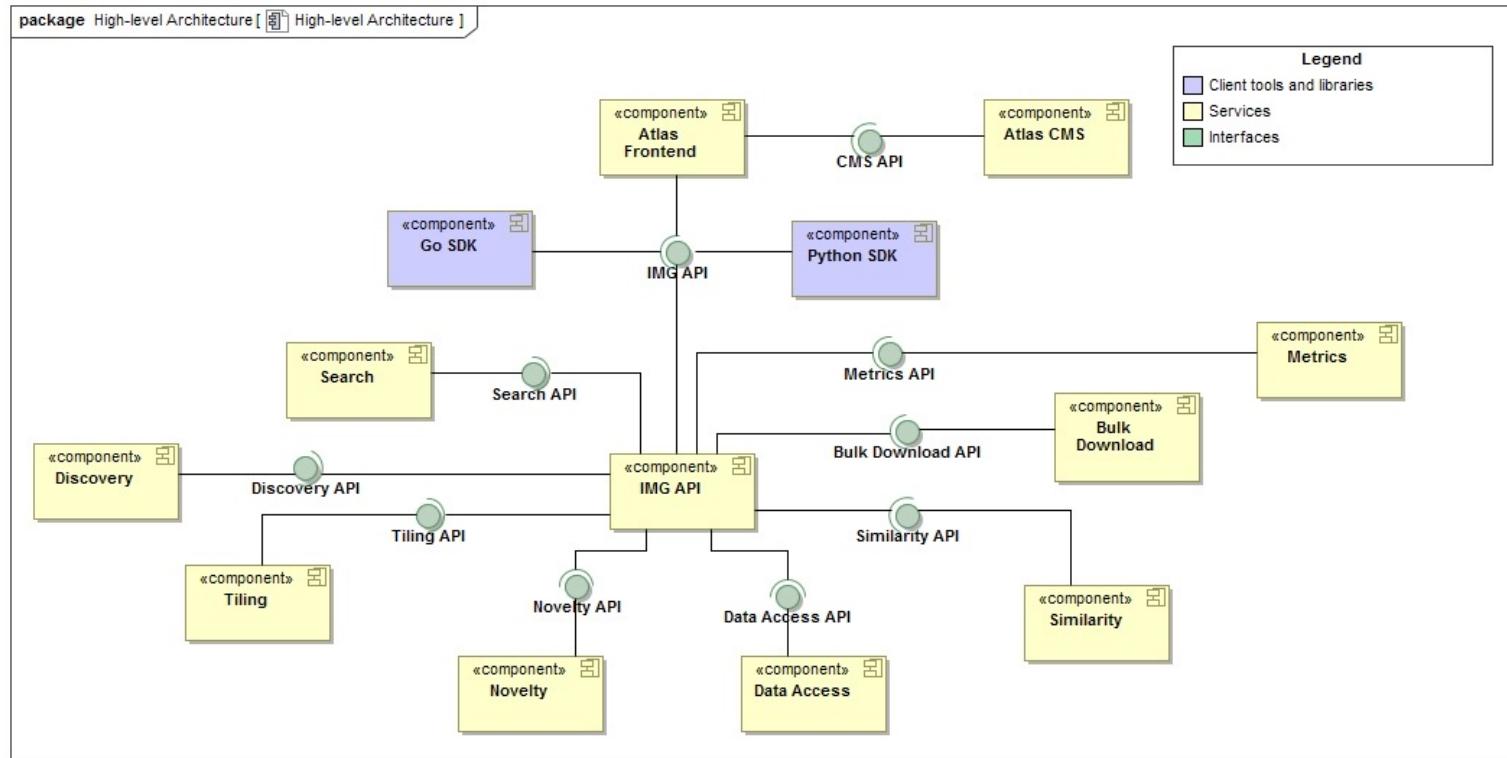
Architecture

Overview

- PDS IMG API
- Data Access API
- Search API
- Image Atlas client

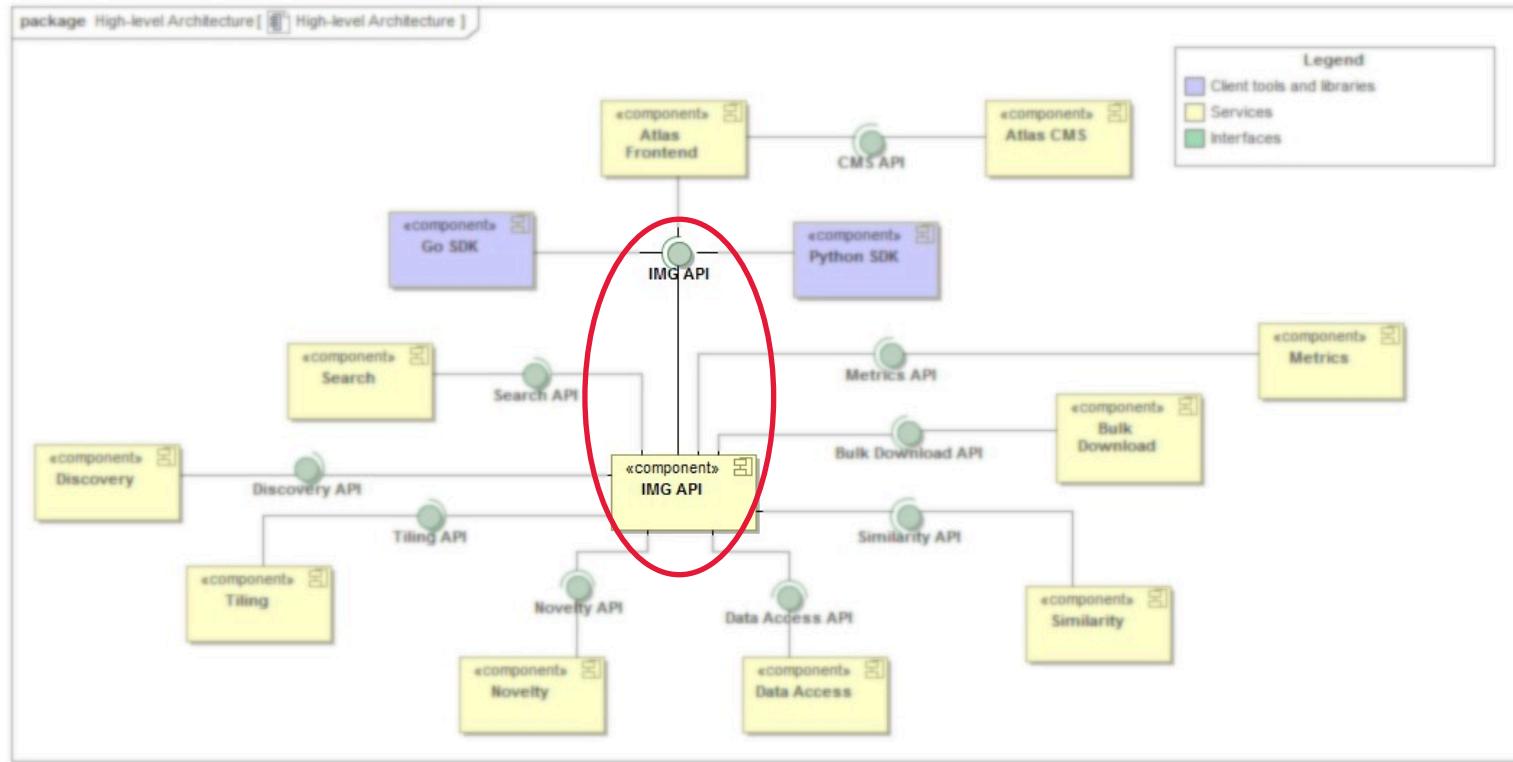
Architecture

Overview



Architecture

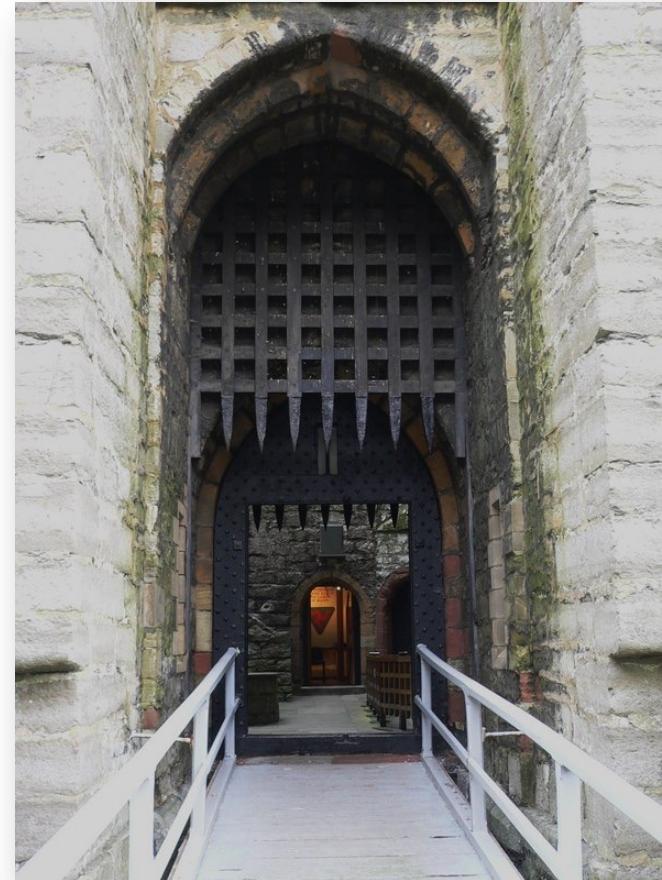
PDS IMG API



Architecture

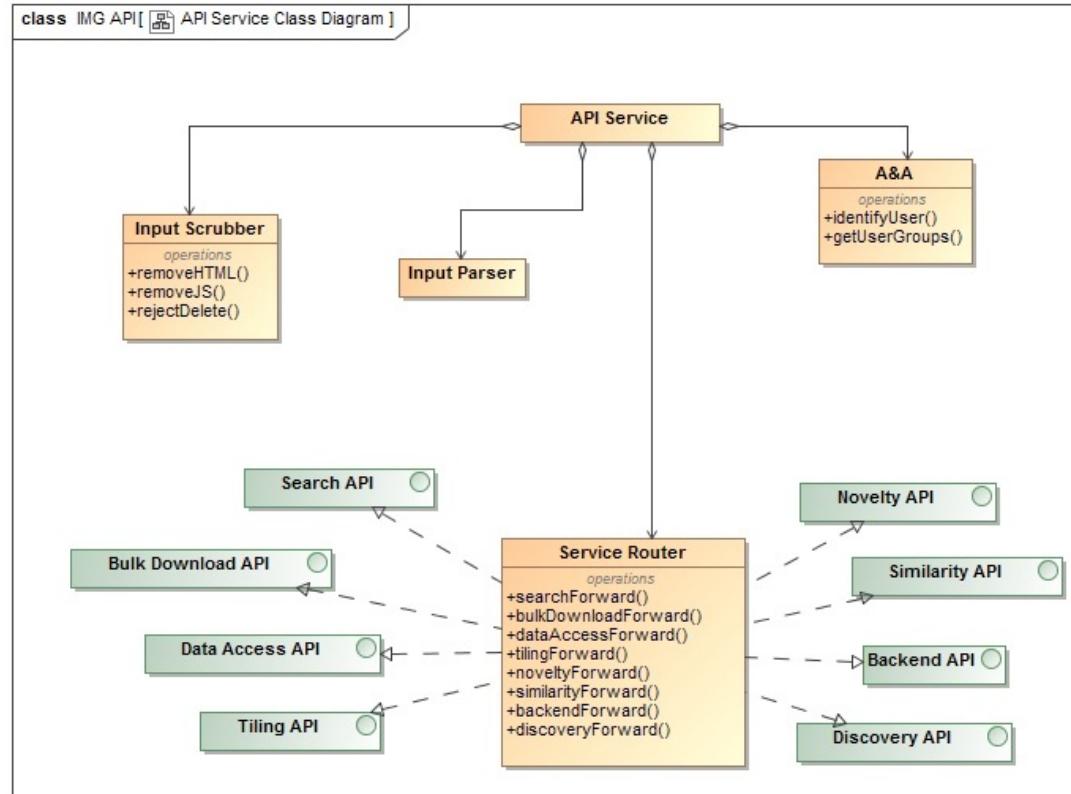
PDS IMG API

- Only service that allows direct incoming network traffic from users
- Single entry point to service network
- Imposes A&A
- Simple webapp defined by OpenAPI 3.0
- Internals of API service mesh can change without impacting user syntax



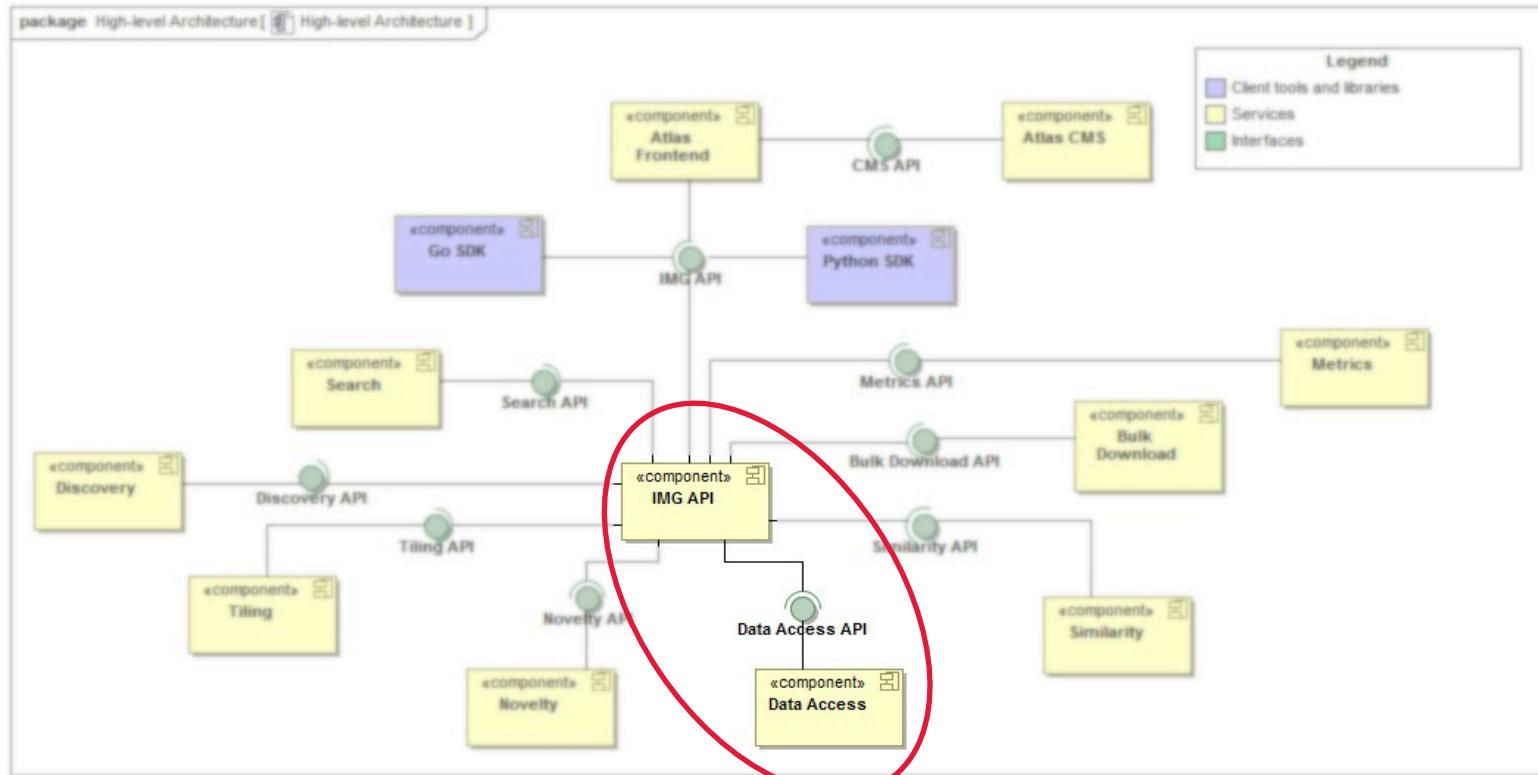
Architecture

PDS IMG API



Architecture

Data Access API



Architecture

Data Access API

- Data stored on JPL premises, other data nodes, and in Amazon S3
- Need a way to route to multiple locations from a single URL
- Manage egress costs (taxpayer money) via user access control, maintaining unfettered access to data for all legitimate use
- Implementation inspired by Earth Science's TEA:
<https://github.com/asfadmin/thin-egress-app>



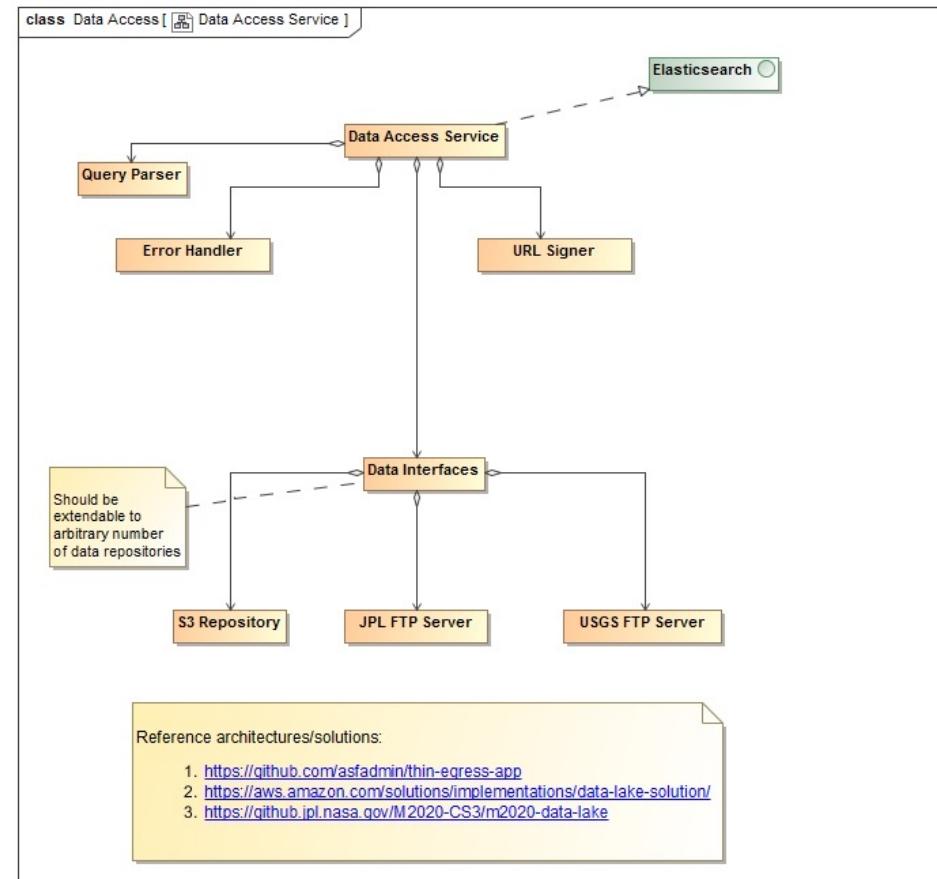
Architecture

Data Access API

1. GET /data/cassini/{}
302
<https://pds-imaging.jpl.nasa.gov/data/cassini/{}>

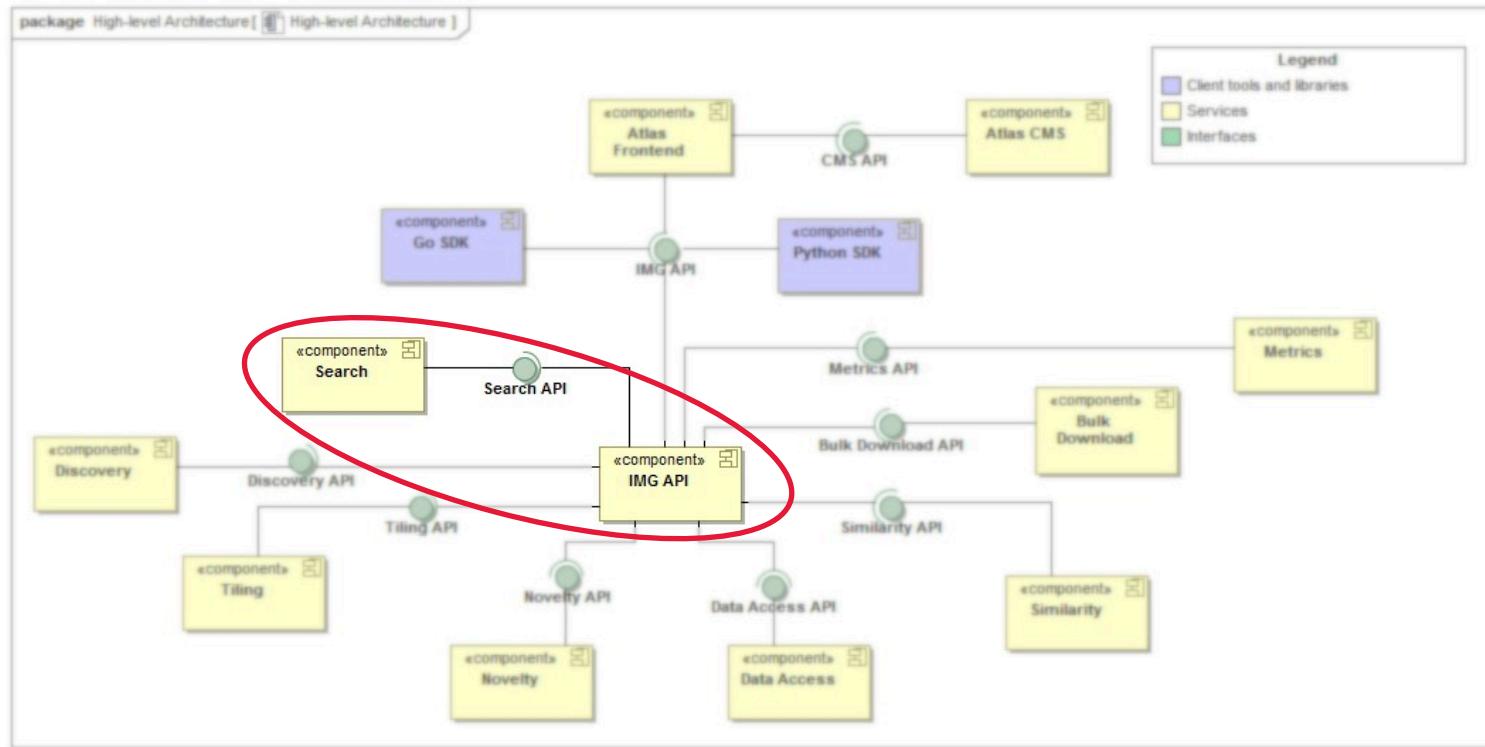
2. GET /data/m20/{}
302
<https://s3.amazonaws.us-west-2.com/m20data/{}>

3. GET /data/lroc/{}
302
<https://astrogeology.usgs.gov/lro/lroc/{}>



Architecture

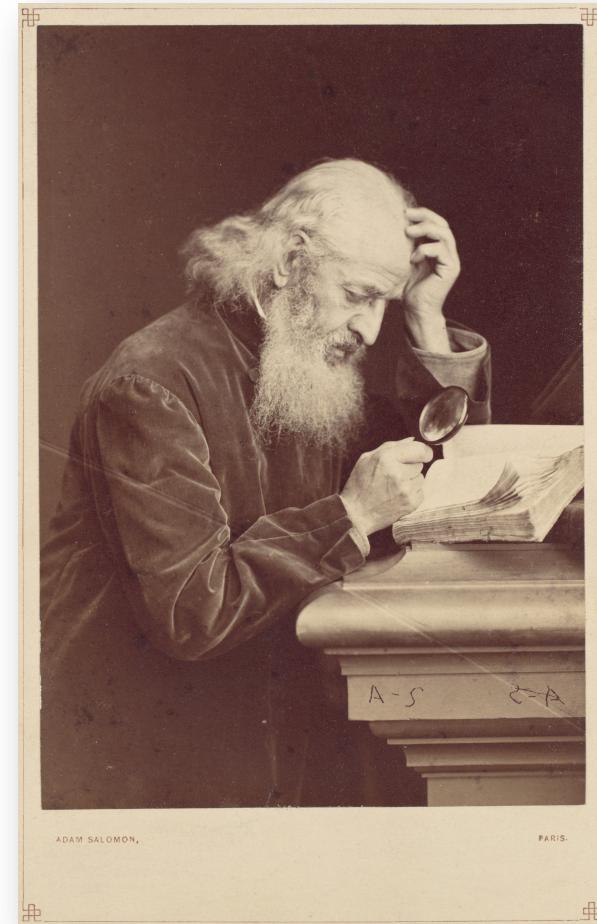
Search API



Architecture

Search API

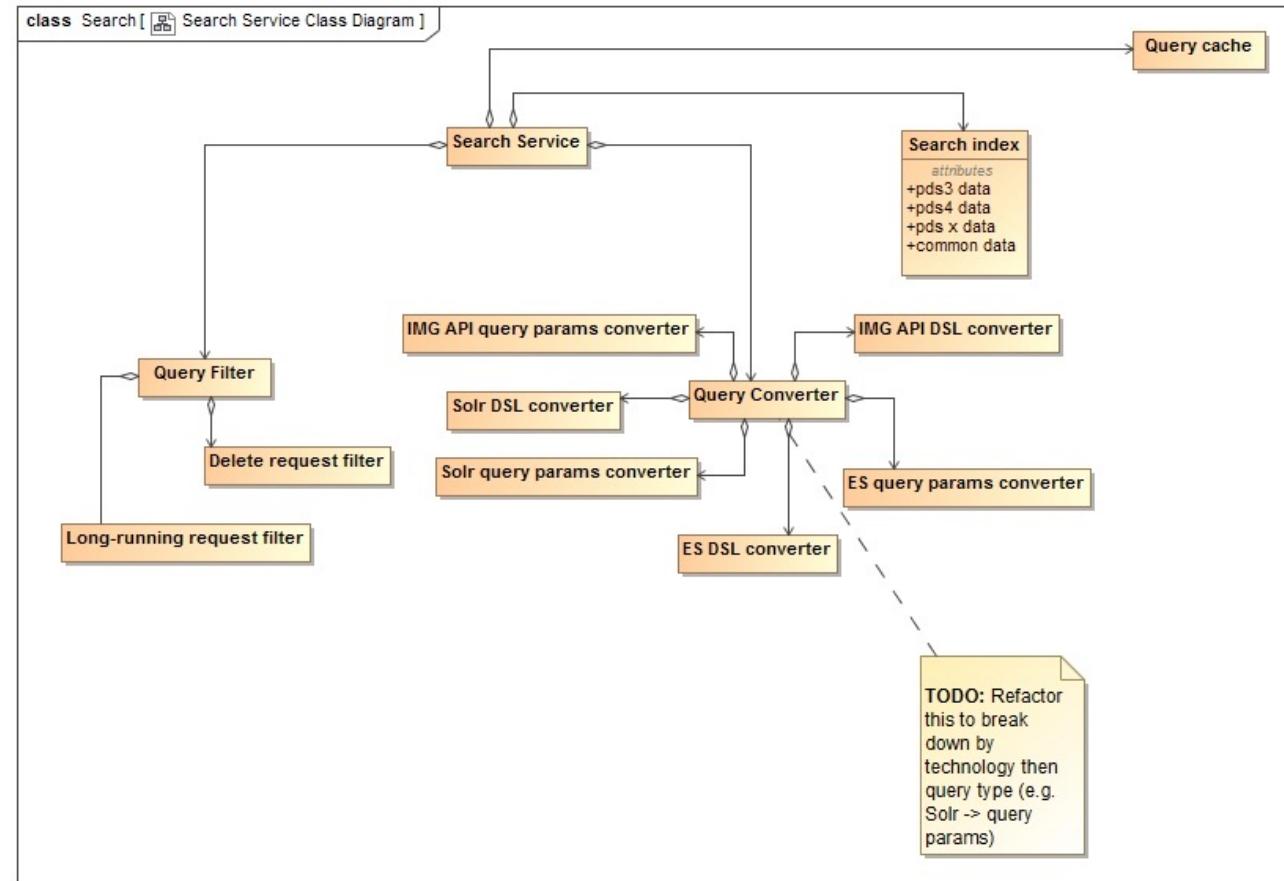
- Multiple search indexes breaking up data
- Indexes mirroring PDS3/PDS4 label contents
- Index for Atlas search
- Indexes for machine learning metadata
- Search API abstracts away Elasticsearch indexes into a simple-to-use API



Architecture

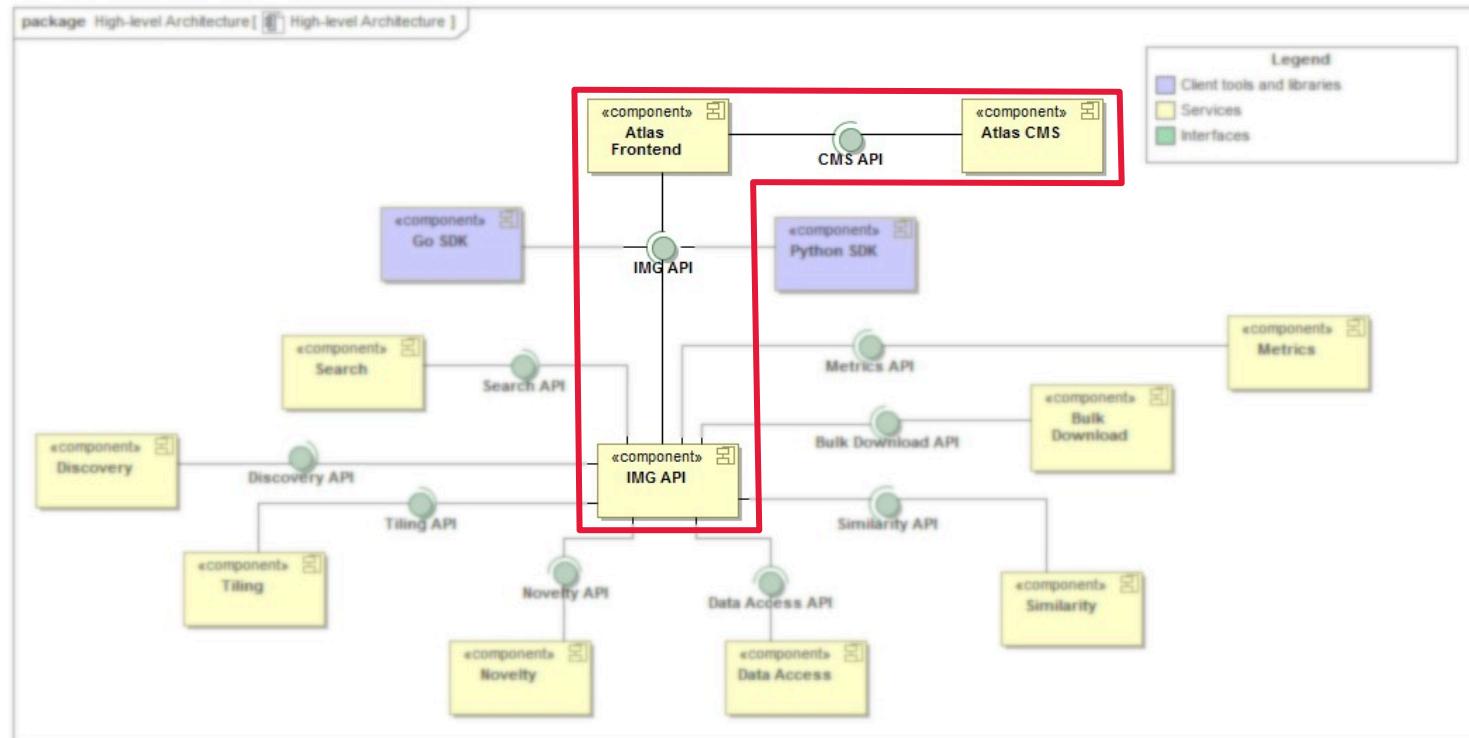
Search API

1. GET /search?mission:cassini →
200
https://es.amazonaws.us-west-2.com/cassini/_search
 2. GET
/search?mission:m20&has:craters
200
https://es.amazonaws.us-west-2.com/m20/_search
https://es.amazonaws.us-west-2.com/m1_ldd/_search



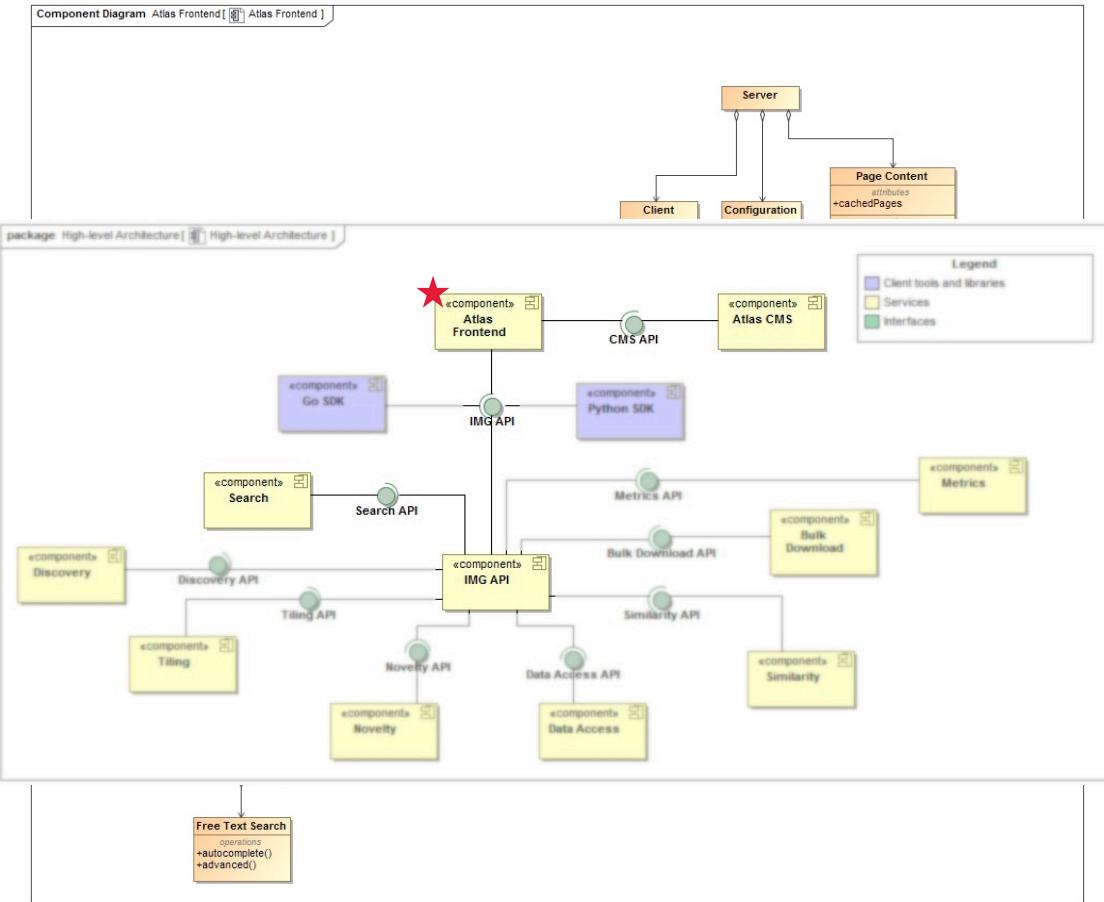
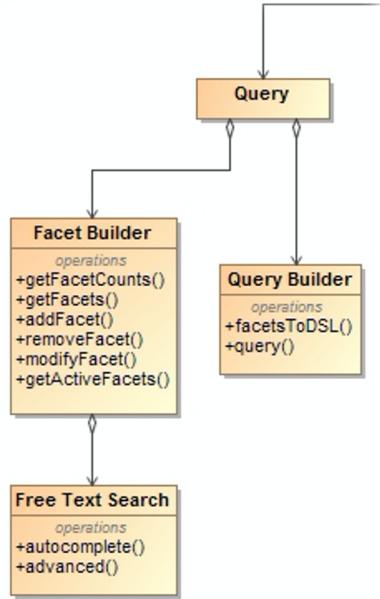
Architecture

Image Atlas client



Architecture

Image Atlas Client



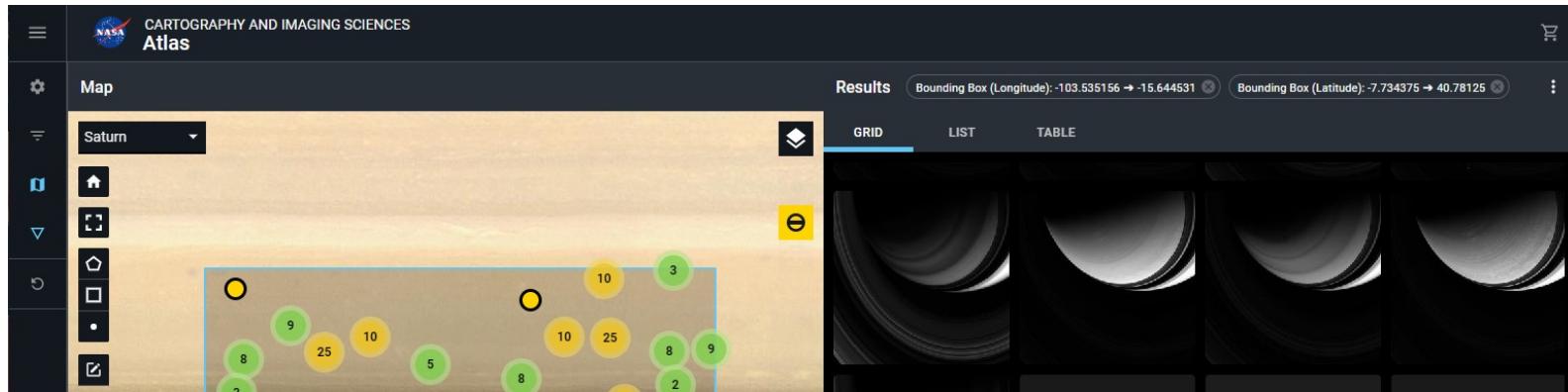
Architecture

Image Atlas client

- Redesign of existing Atlas III
- Uses PDS IMG API for search
- Stores state in database
- Just another client of PDS IMG API

Hi! Wanna learn more about what the cool new Atlas can do?

Be sure to tune in to the "Searching the Stars with Atlas IV" talk!



Cloud Processing of PDS Archival Products

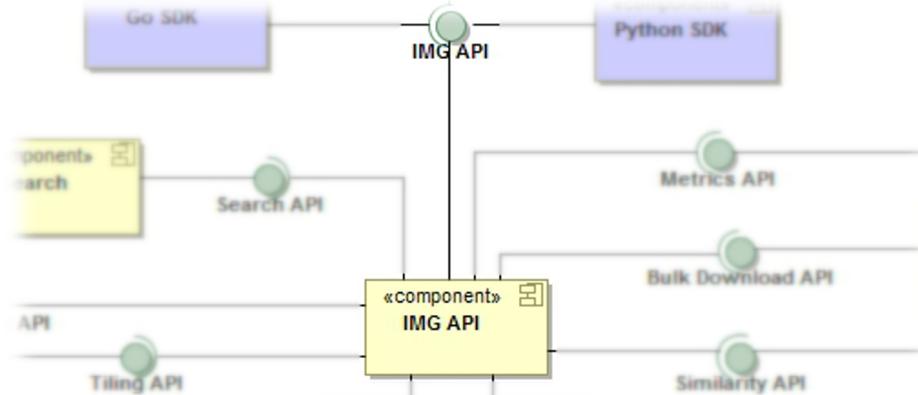
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Deployment

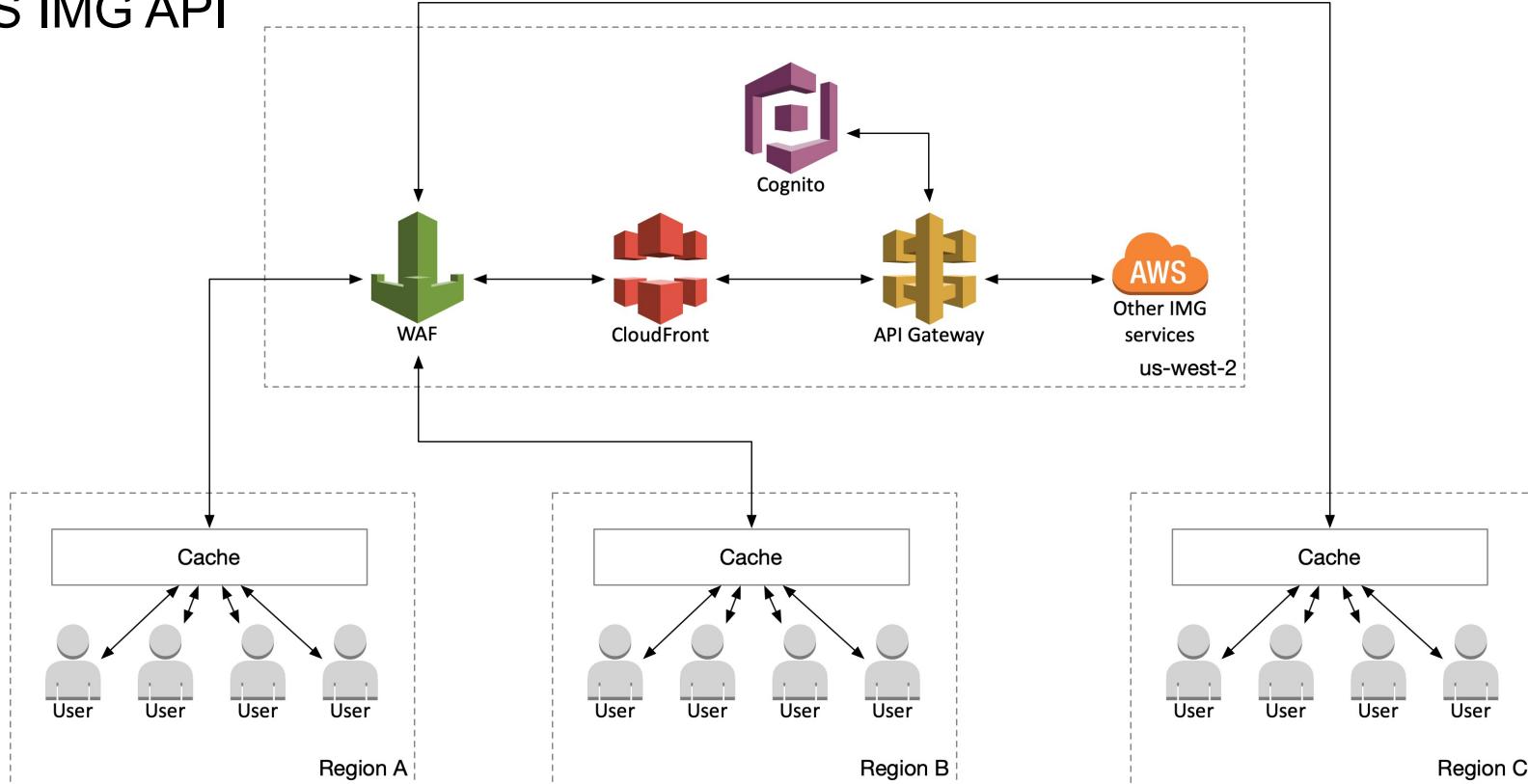
PDS IMG API

- CloudFront caching at the edge
 - Request caching
 - Per-geographical region basis
- WAF
 - Prevents application abuse
 - Configurable throttling and bypasses
- API Gateway (using OpenAPI 3.0 standard)
 - Routes requests to appropriate service
 - Supports versioning
- Amazon Cognito (tokens)
 - Integrates with different identity providers (JPL LDAP, Google, Facebook)



Deployment

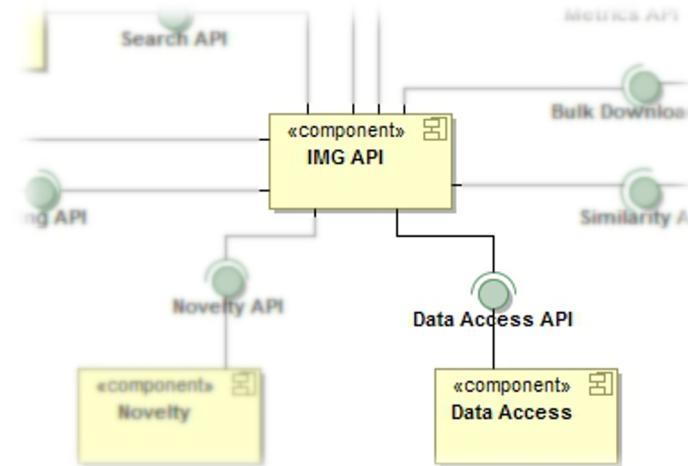
PDS IMG API



Deployment

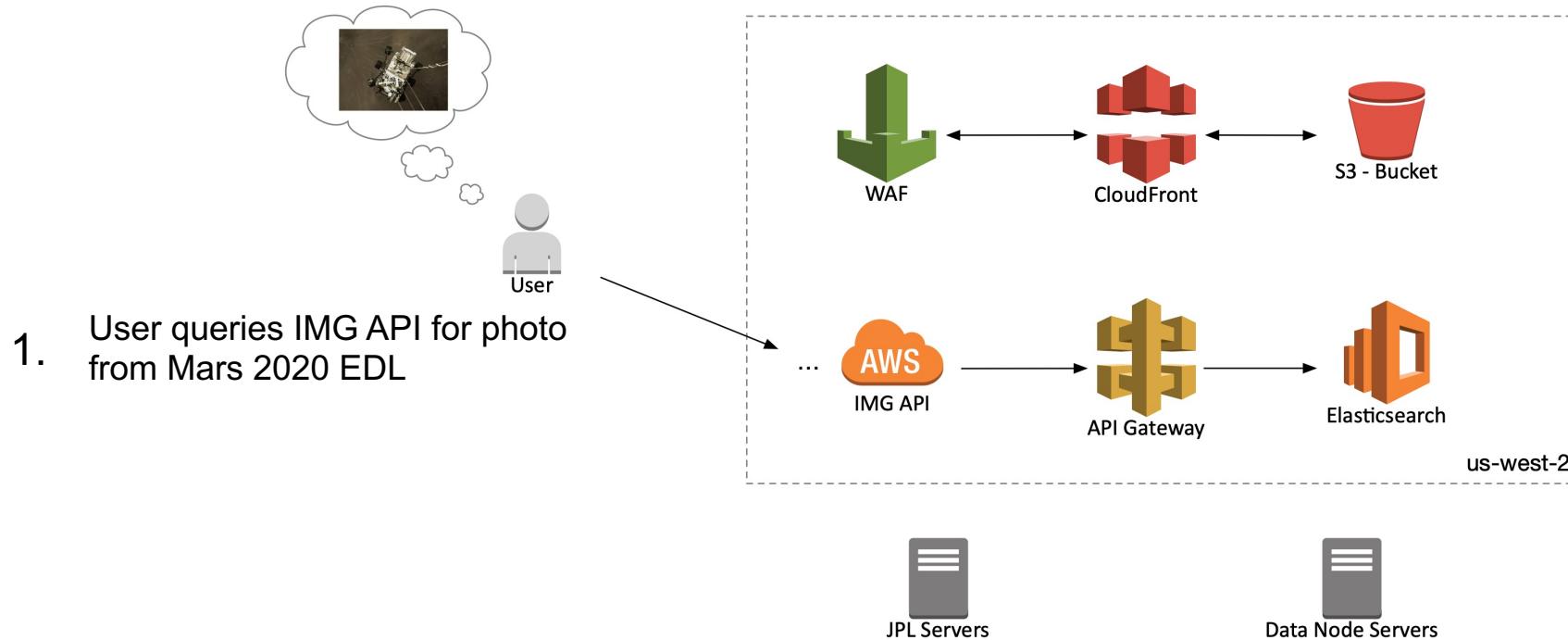
Data Access API

- CloudFront
 - Caching at edge
 - Data caching
 - API calls vs. multimedia transfer
 - URL signing
- WAF
 - Prevent abusive asset transfer
 - “No, you can’t just download the whole archive, sorry”
- S3 & BeeGFS for storage
- API Gateway (w/ OpenAPI 3.0) for routing



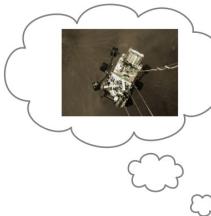
Deployment

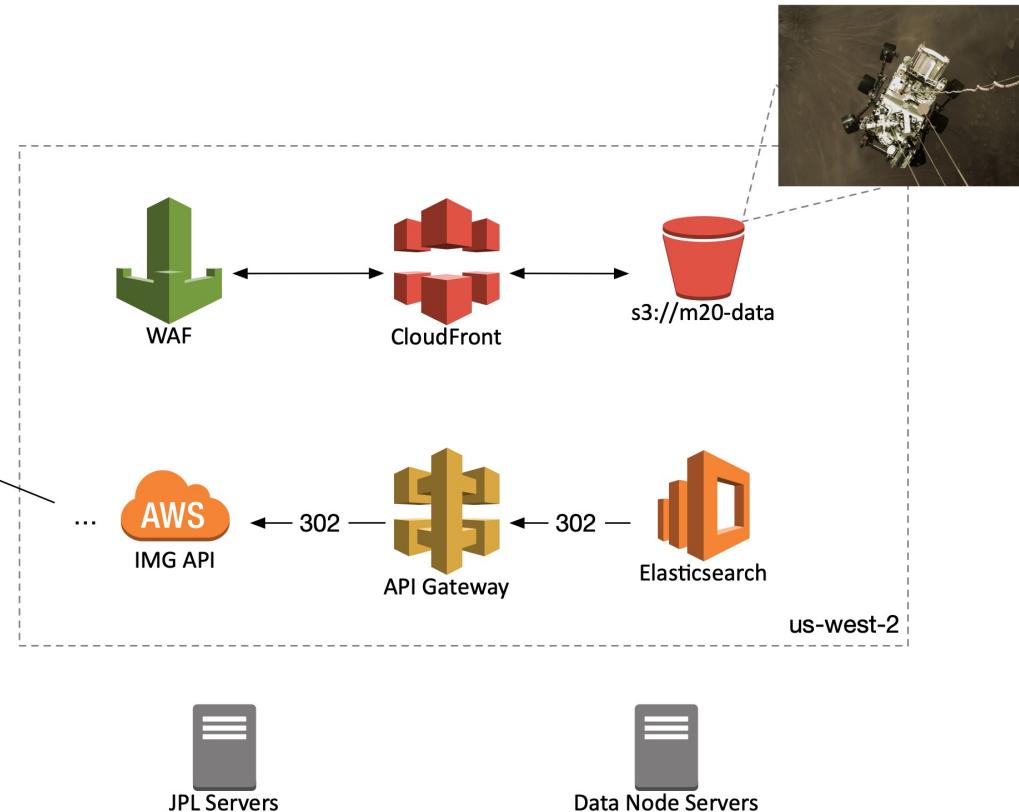
Data Access API



Deployment

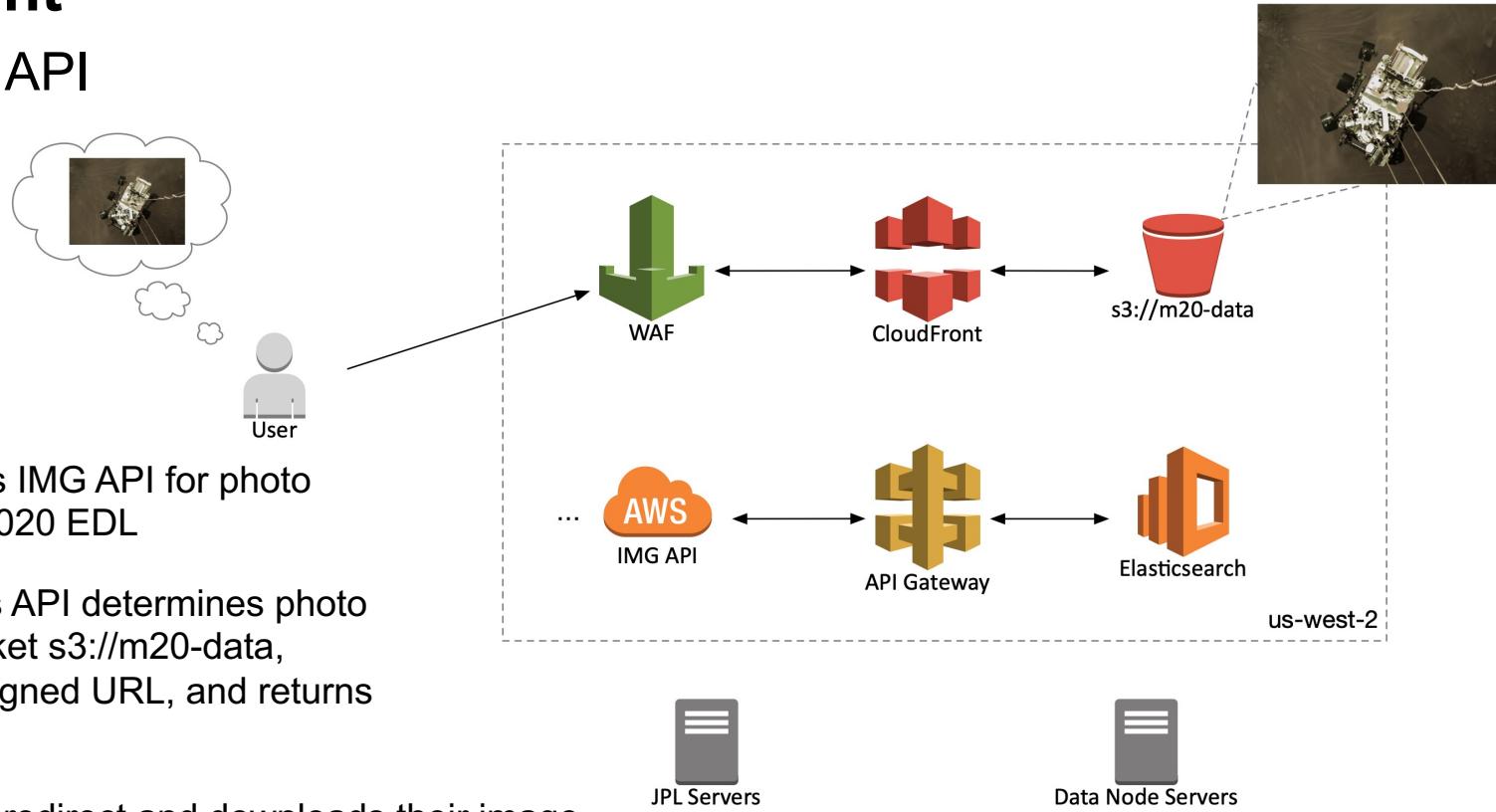
Data Access API

- 
- A user icon is shown thinking about a Mars rover photo, represented by a thought bubble containing a small image of a Mars rover.
1. User queries IMG API for photo from Mars 2020 EDL
 2. Data Access API determines photo is in S3 bucket s3://m20-data, generates signed URL, and returns 302 to user



Deployment

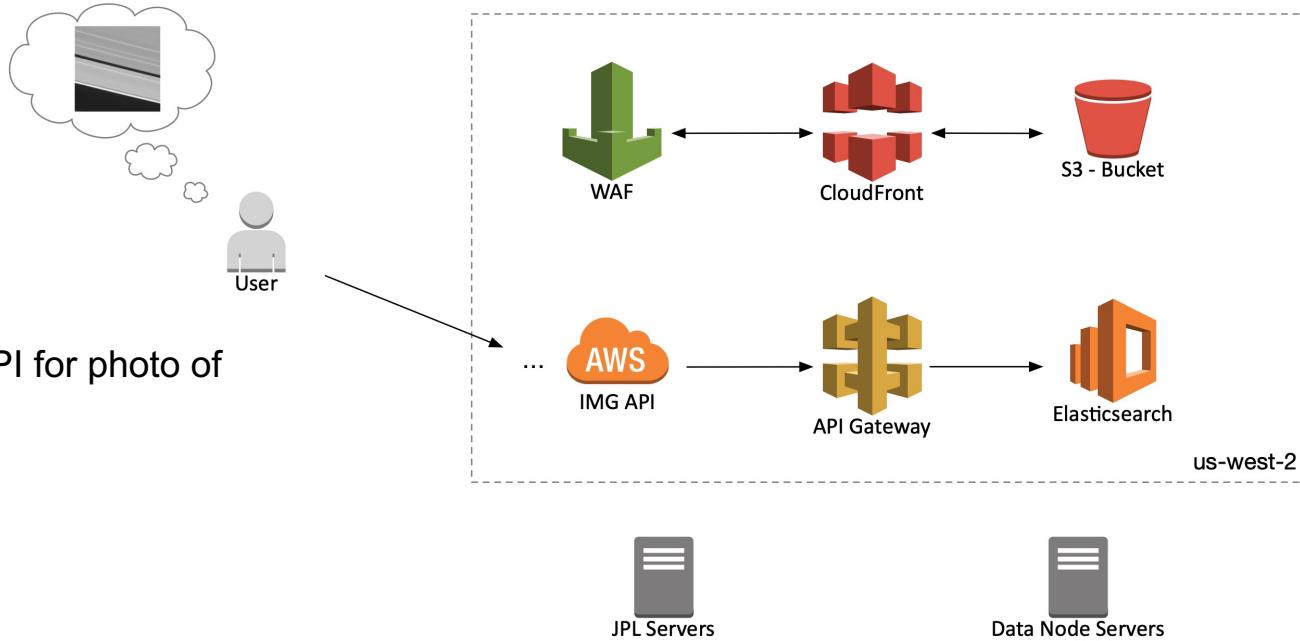
Data Access API



Deployment

Data Access API

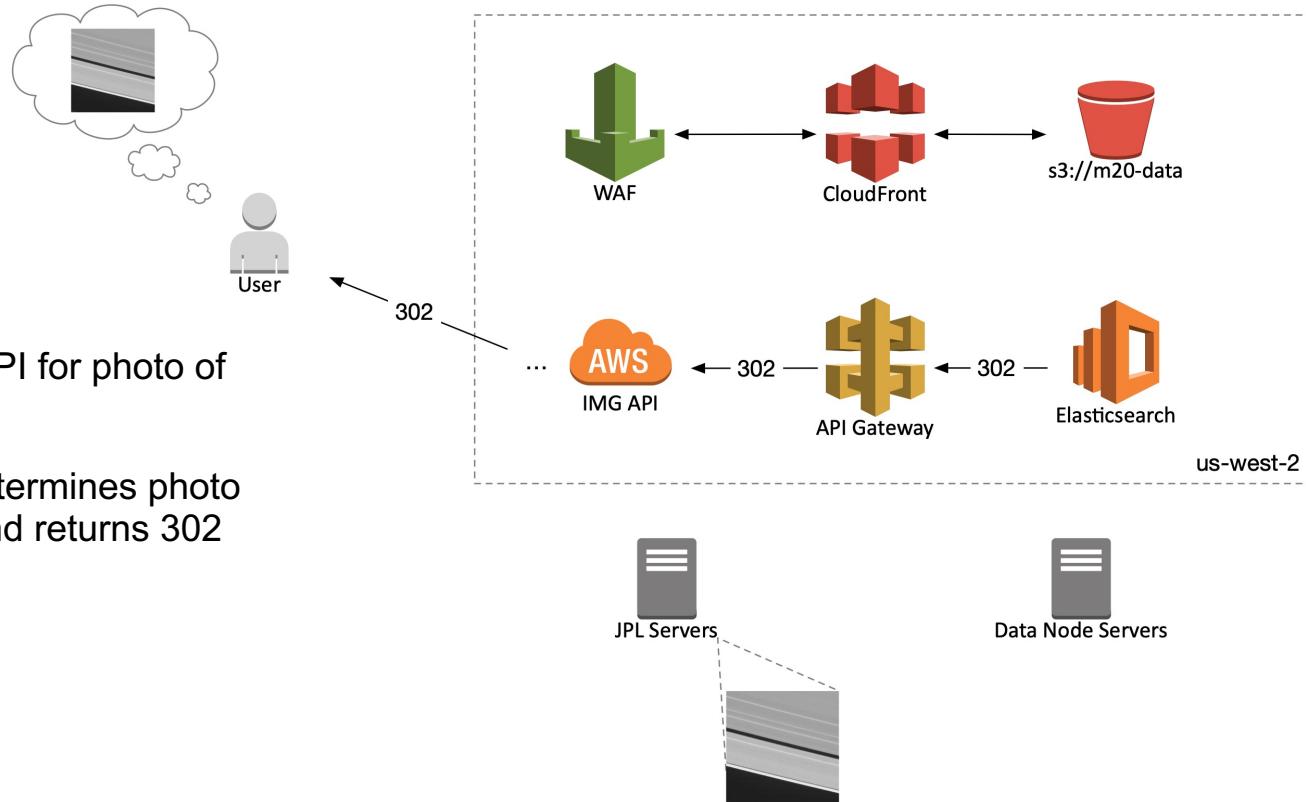
1. User queries IMG API for photo of Saturn's a-ring



Deployment

Data Access API

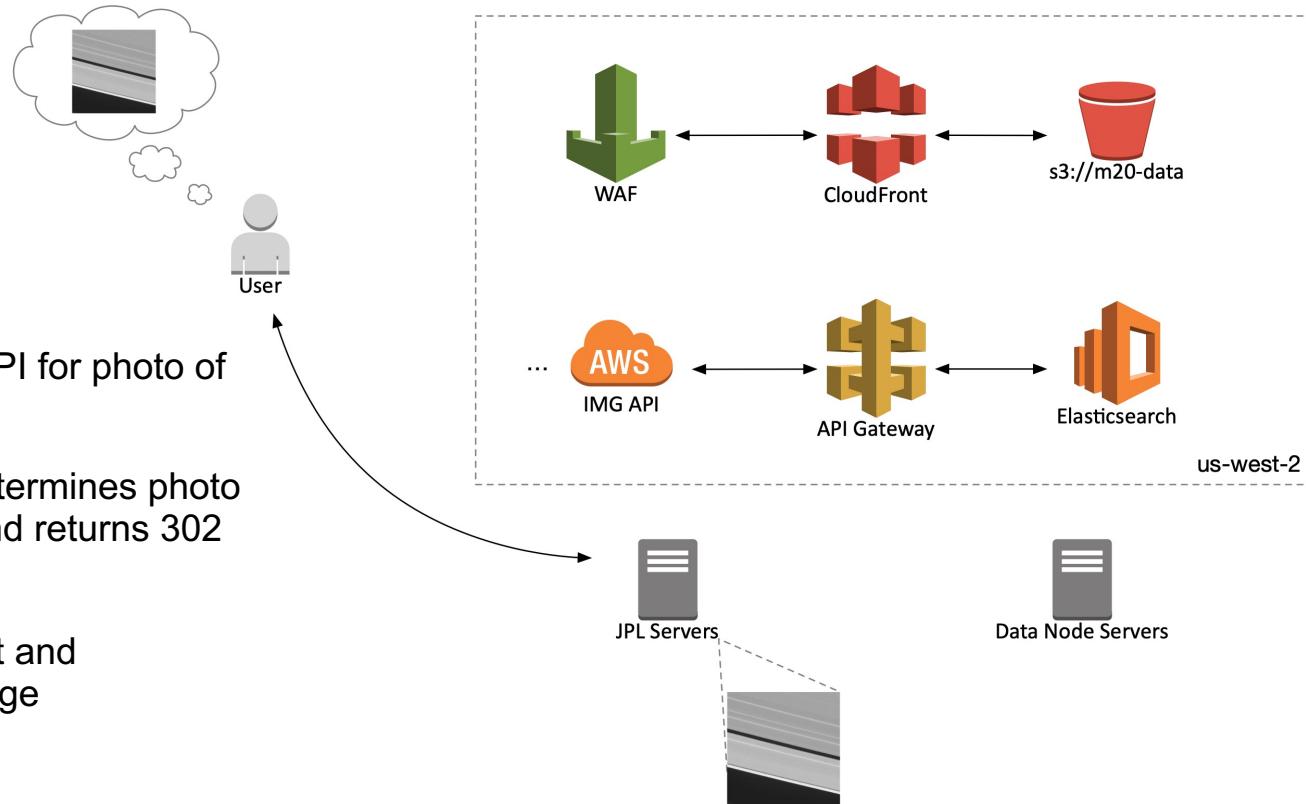
1. User queries IMG API for photo of Saturn's a-ring
2. Data Access API determines photo is on JPL servers and returns 302 to user



Deployment

Data Access API

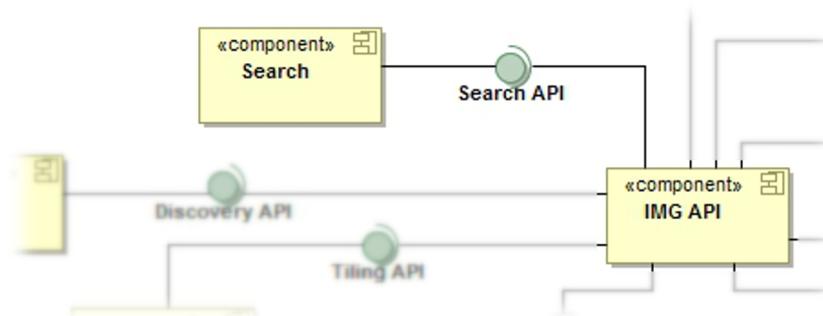
1. User queries IMG API for photo of Saturn's a-ring
2. Data Access API determines photo is on JPL servers and returns 302 to user
3. User follows redirect and downloads their image



Deployment

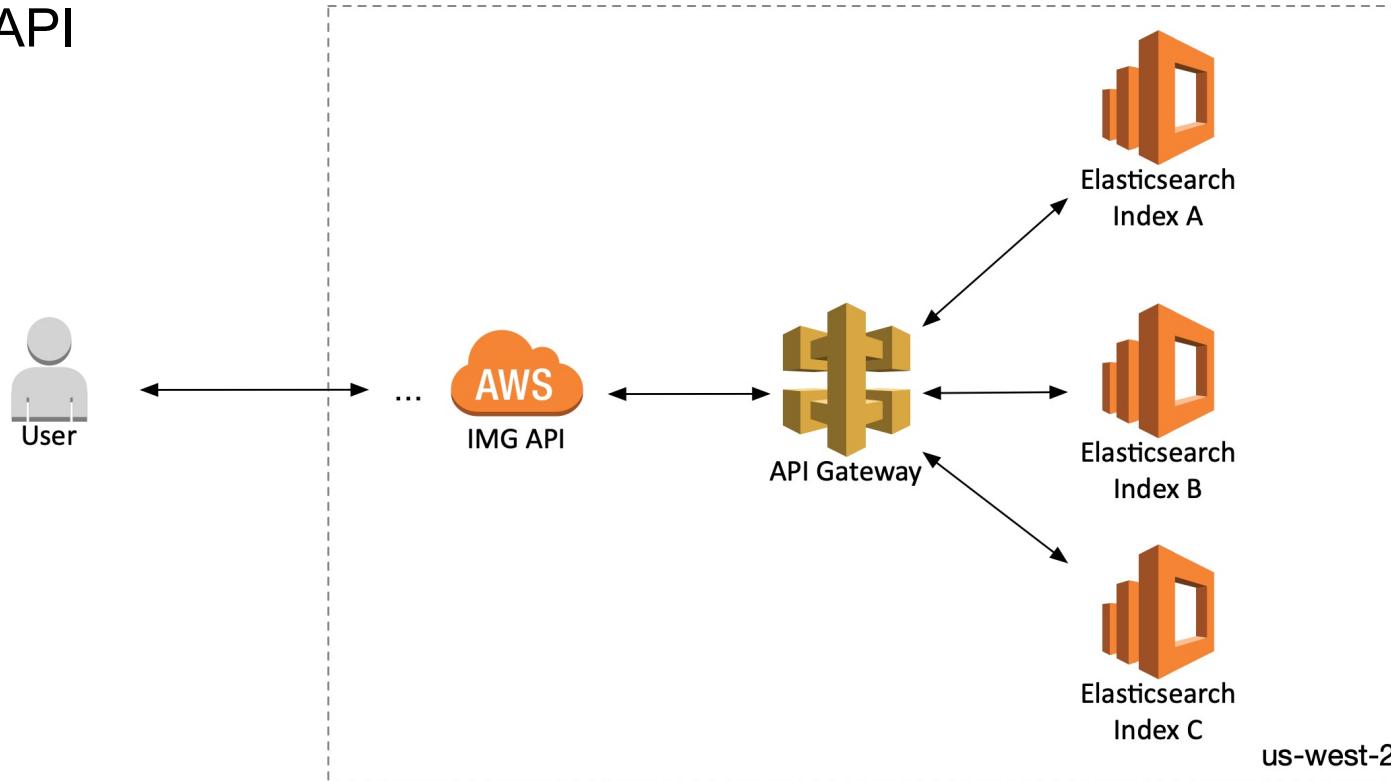
Search API

- CloudFront
- API Gateway
 - Routes to appropriate ES index
- Managed Elasticsearch
 - Single-button upgrades
 - Easy to setup and maintain



Deployment

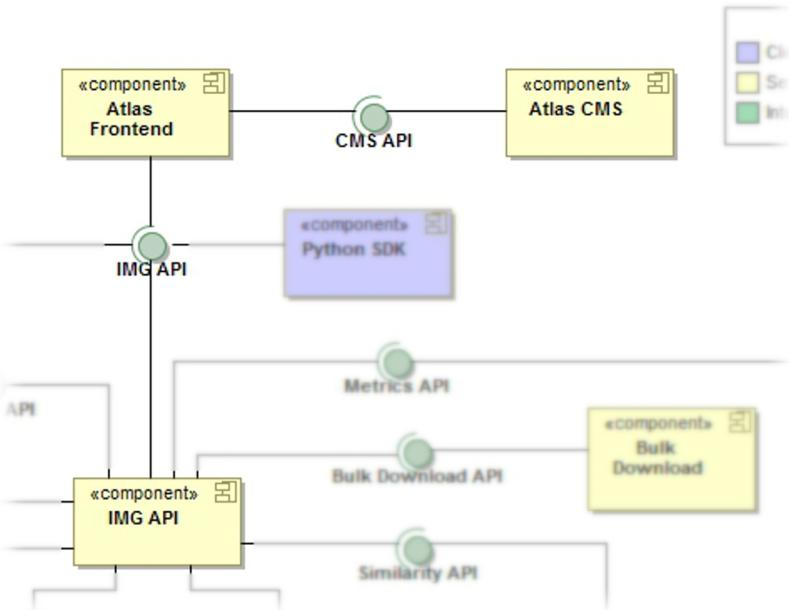
Search API



Deployment

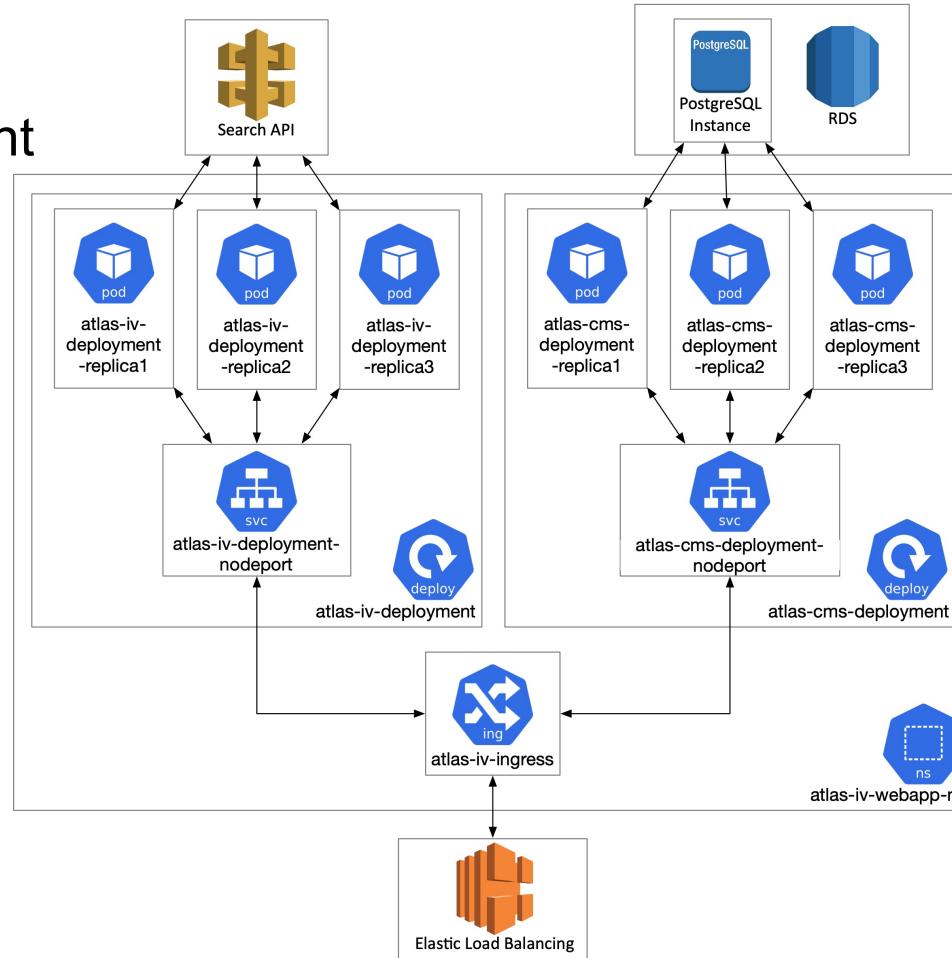
Image Atlas Client

- ReactJS application built into a Docker image
- Wrapped in a Kubernetes Deployment
- Stores some state in Strapi CMS
- Queries Search API for image products to render
- Kubernetes manifests packaged as a Helm chart
- Deployed using AWS's Elastic Kubernetes Service (EKS)



Deployment

Image Atlas Client



Cloud Processing of PDS Archival Products

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Conclusions

- Microservice architectures enable diverse applications to interact with each other and form a complete system
- Cloud computing is entirely feasible for data archival workloads
- Serving data from the cloud can be cost-efficient if the proper safeguards are put in place

It's me again! Want to know more about how much it costs to run a system like this?

Be sure to tune in to the "Experiments in Transferring, Validating, and Releasing Mars 2020 Mission Archival Multi-Media and Imagery Data Deliveries in the Cloud"!



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Future Work

- Integrate with PDS API being developed by ENG
- Develop SDKs to interact with various API features (Python libraries, Go modules, etc)
- Additional API work
 - Bulk download
 - Metrics

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References

- “PIA24428: High-Resolution Still Image of Perseverance’s Landing”. <https://photojournal.jpl.nasa.gov/catalog/PIA24428>. NASA/JPL-Caltech.
- “PDS Imaging Node”. <https://pds-imaging.jpl.nasa.gov>. NASA/JPL-Caltech
- “Firefox logo”. https://commons.wikimedia.org/wiki/File:Firefox_Logo,_2017.png. The Mozilla Foundation, MPL 2 <<https://www.mozilla.org/en-US/MPL/2.0/>>, via Wikimedia Commons.
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- “Signpost”. [https://commons.wikimedia.org/wiki/File:Signpost_\(3199024949\).jpg](https://commons.wikimedia.org/wiki/File:Signpost_(3199024949).jpg). Tim Green from Bradford, CC BY 2.0.
- “Thinking with magnifying glass”. https://commons.wikimedia.org/wiki/File:-Bearded_Man_with_Magnifying_Glass_Examining_a_Manuscript-_MET_DP111349.jpg. Metropolitan Museum of Art, CC0.
- “Clippy”. Microsoft. Public domain.

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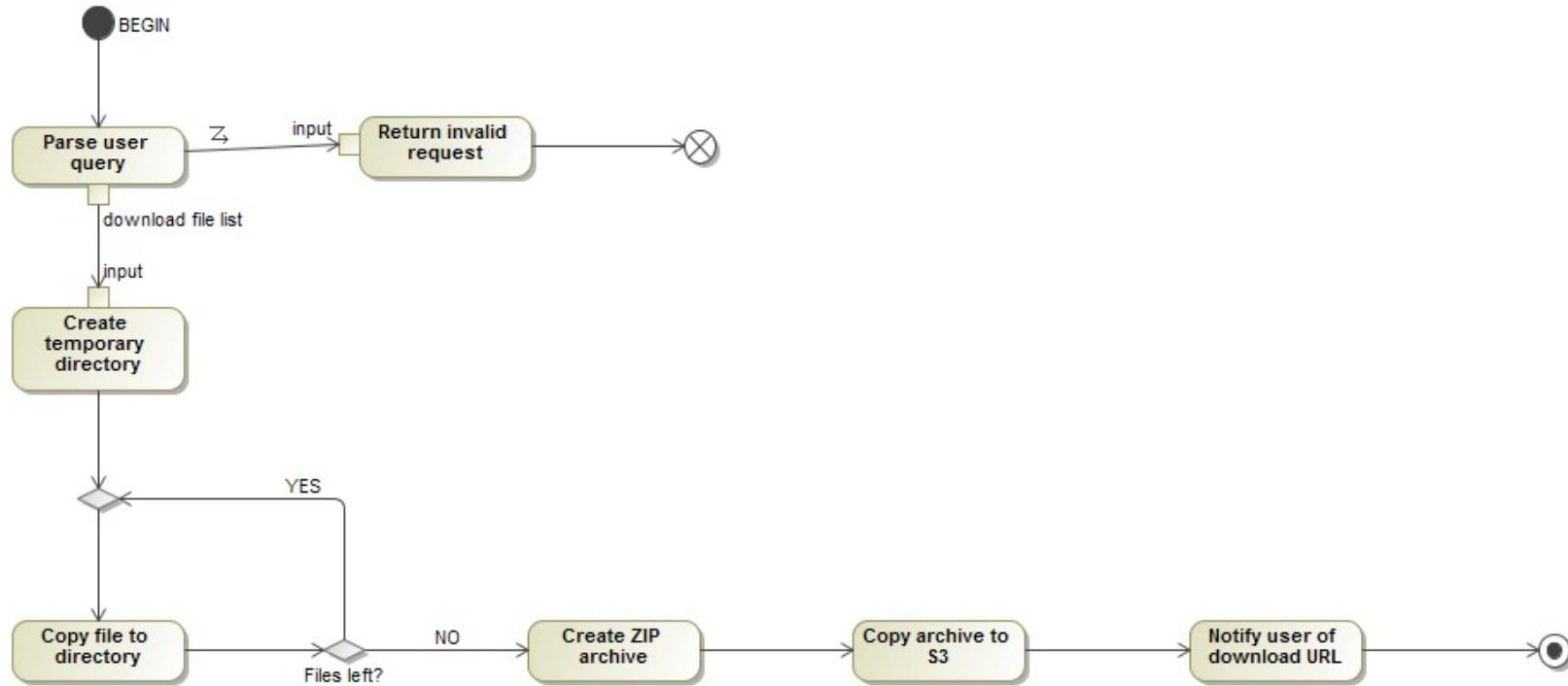


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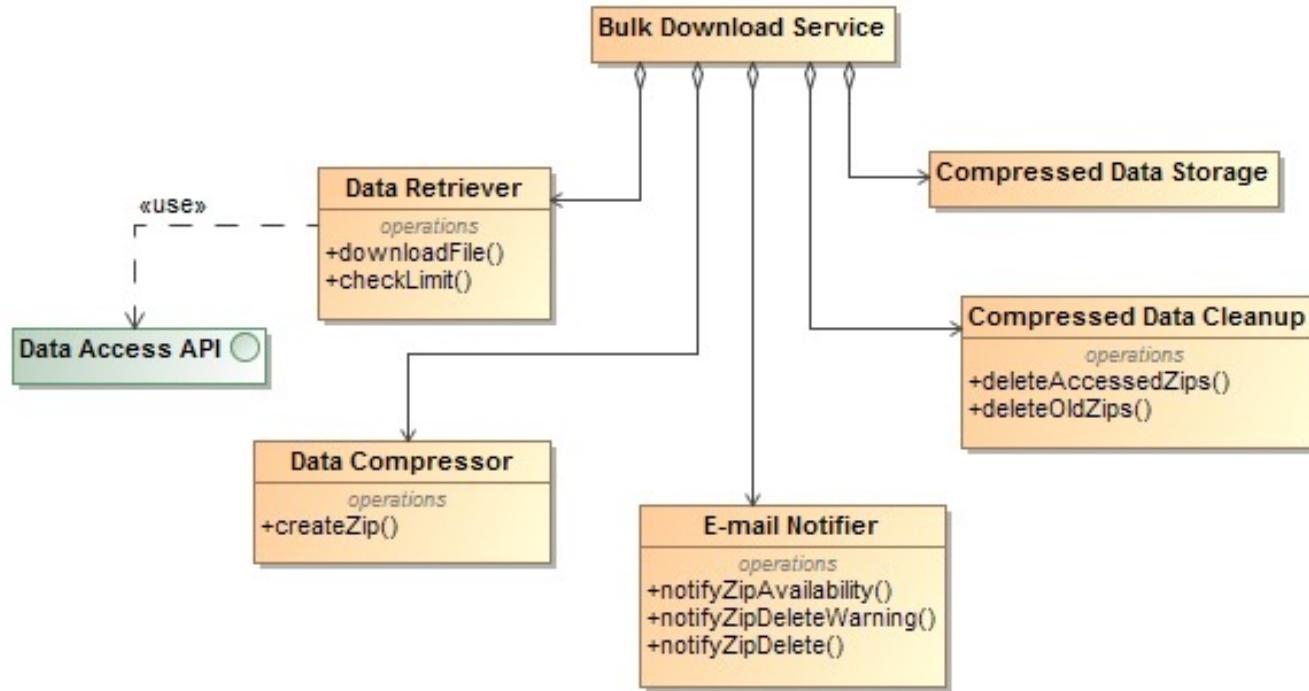
jpl.nasa.gov

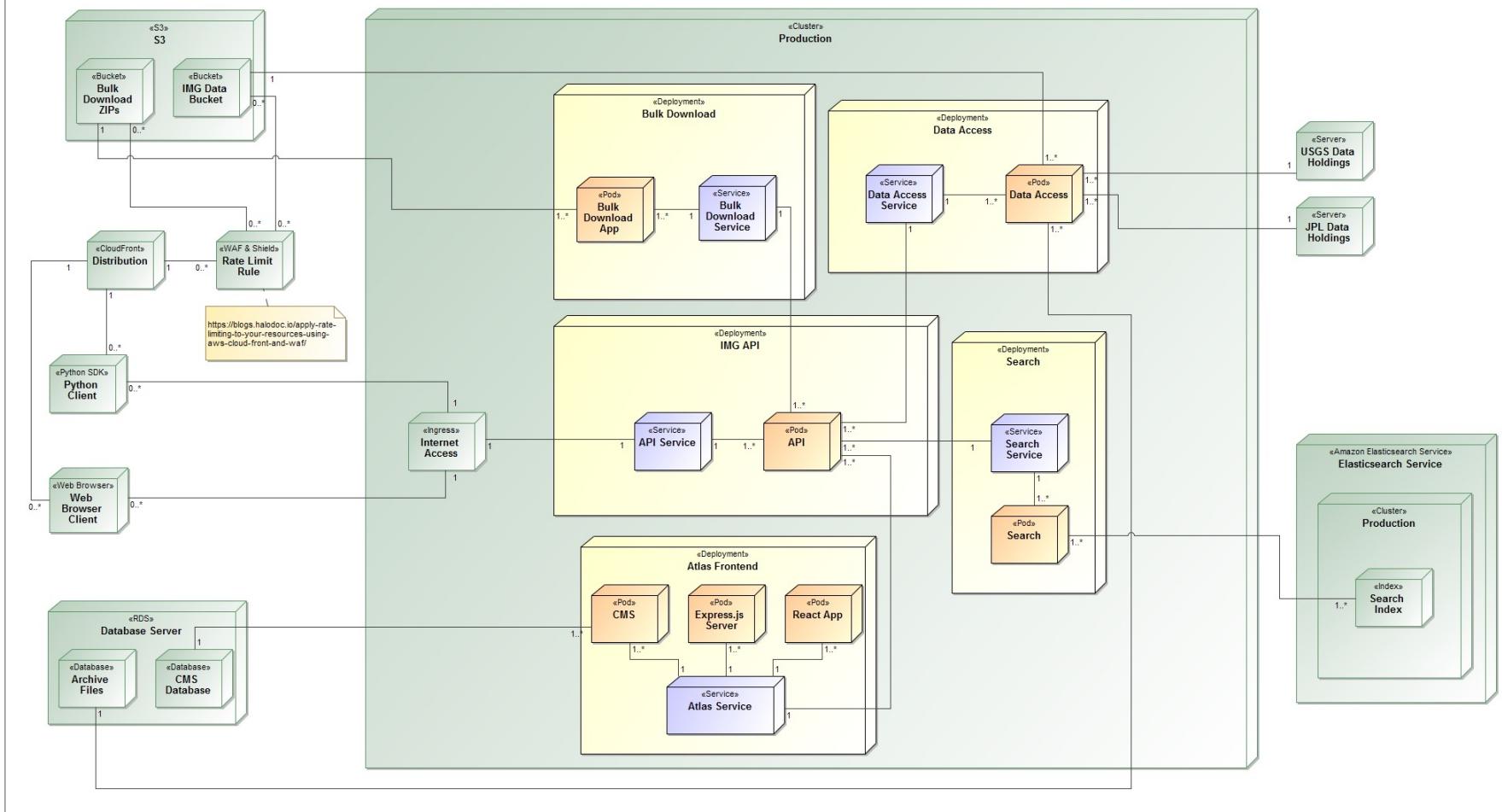
Backup

activity Bulk Download Activity Diagram [ Bulk Download Activity Diagram]



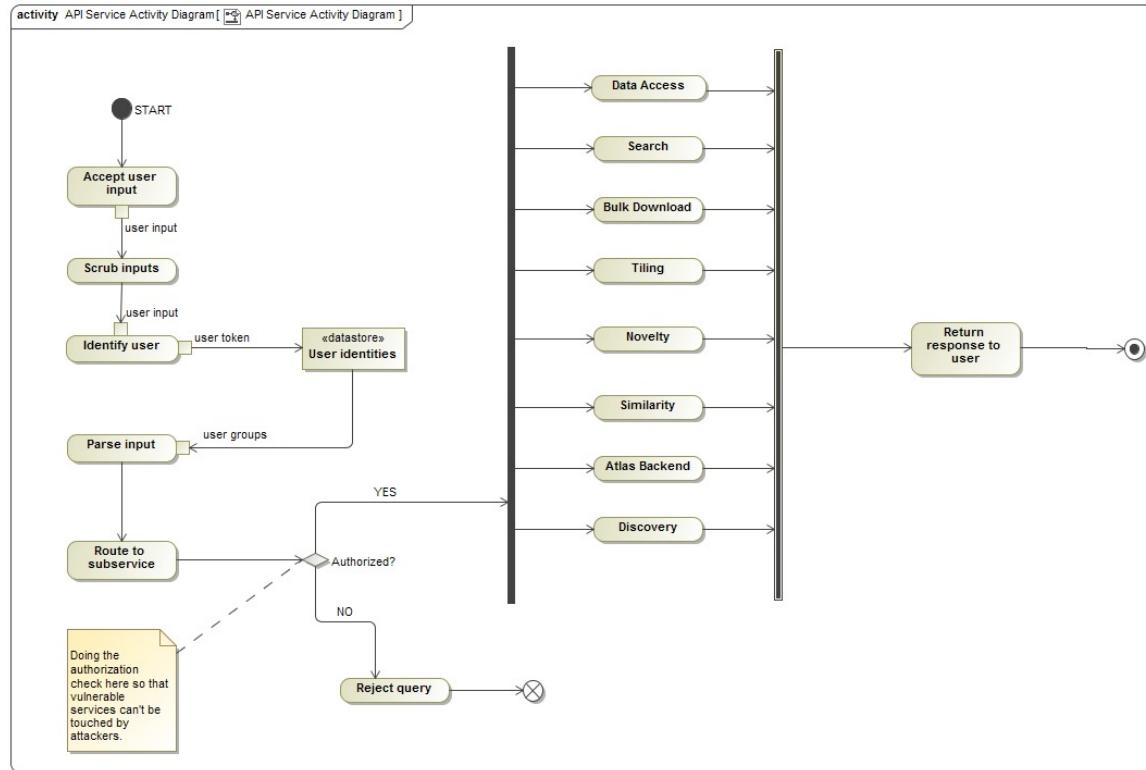
```
class Bulk Download [ Bulk Download ]
```





Architecture

PDS IMG API



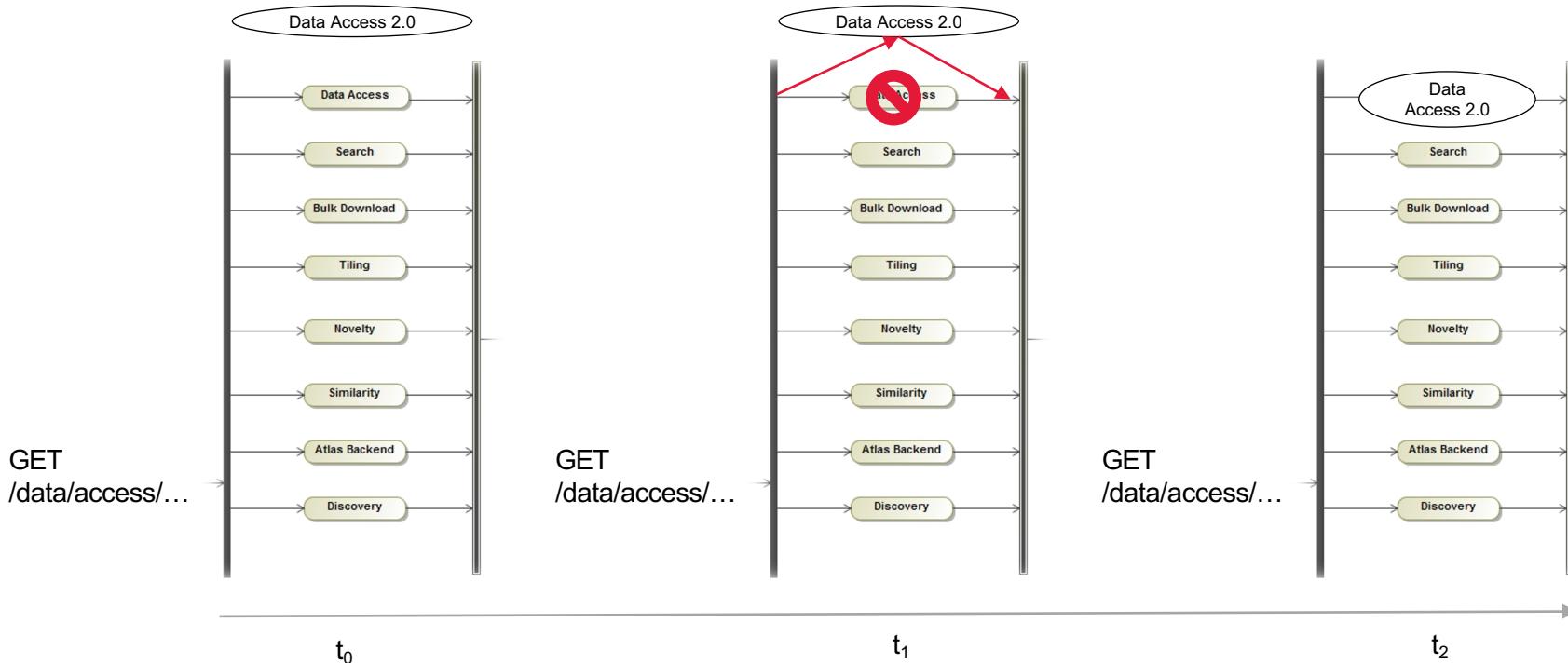
Architecture

PDS IMG API

Scenario: upgrade “Data Access Service” from v1.0 to v2.0

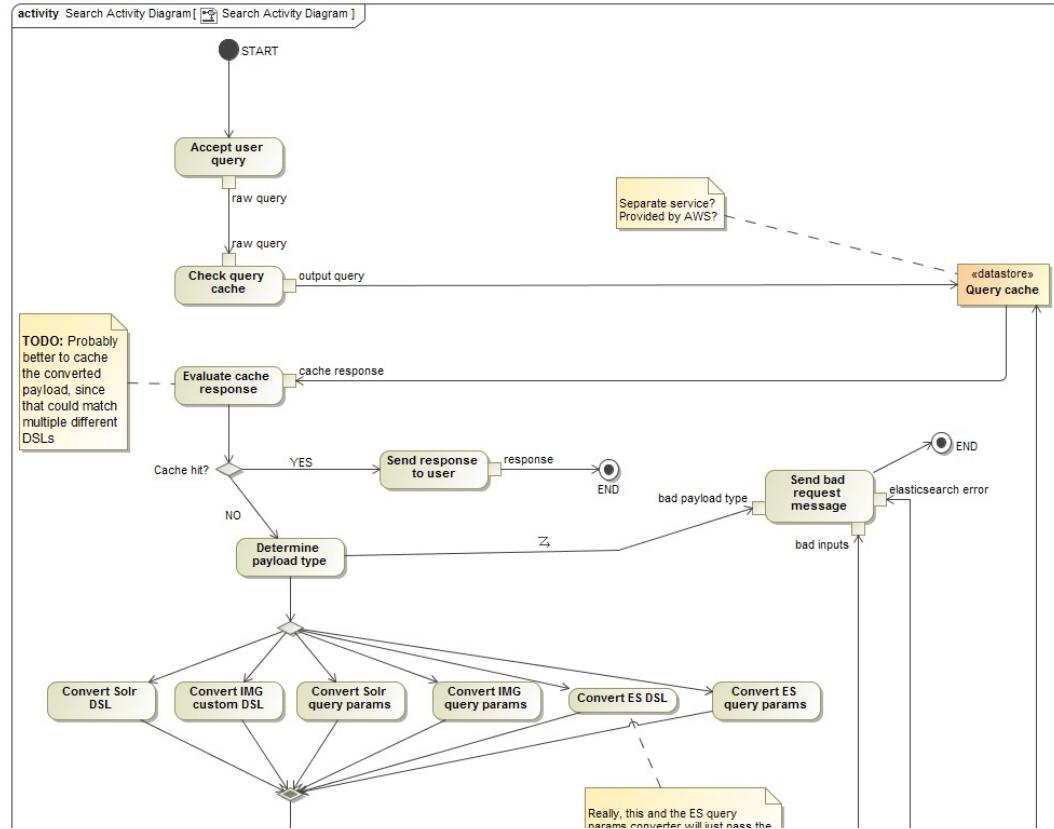
Architecture

PDS IMG API



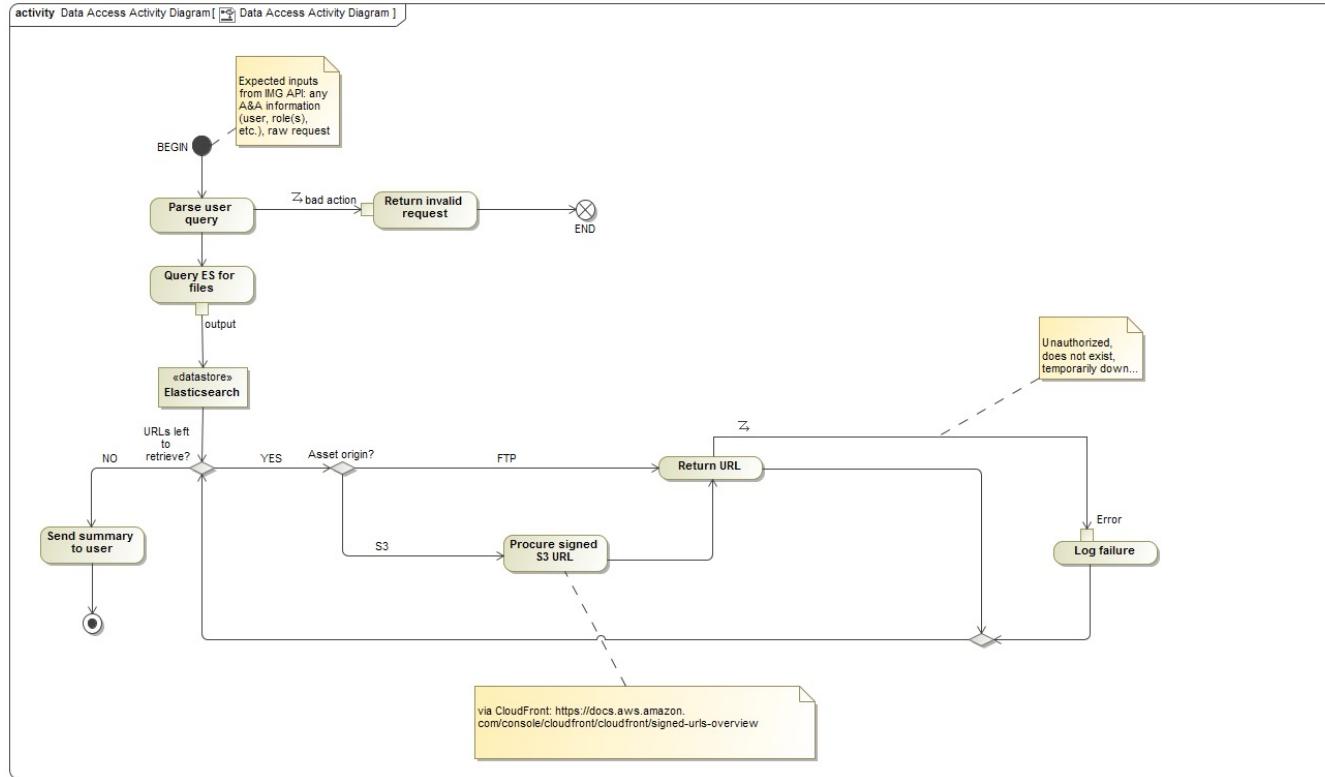
Architecture

Search API



Architecture

Data Access API





Jet Propulsion Laboratory
California Institute of Technology

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