Responsive Storage:
Home Automation for
Research Data Management

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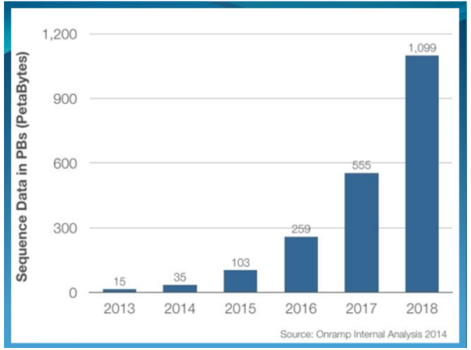
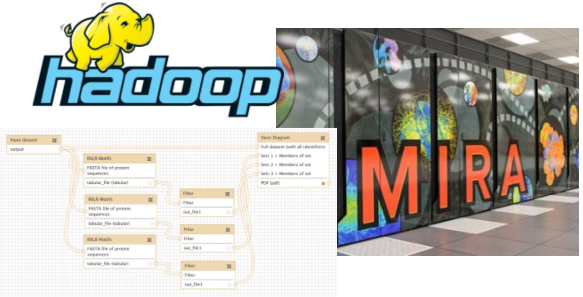
The Problem

- Data generation rates are exploding
- Complex analytics processes
- The data lifecycle often involves multiple organisations, machines, and people



Source: Onramp Internal Analysis 2014



This creates a significant strain on researchers

- Best management practices (cataloguing, sharing, purging, etc.) can be overlooked
- Useful data may be lost, siloed, or forgotten

RIPPLE: A prototype responsive storage solution

Transform static data graveyards into active, responsive storage devices

- Automate data management processes and enforce best practices
- Reliable event-driven execution
- Users focused: simple if-trigger-then-action rules
  - Accessible to all end users, not just admins and expert users
  - Users can set data management policies and then forget about them
- Combine rules into flows to control end-to-end data transformations
- Passively waits for filesystem events (very little overhead)
- Filesystem agnostic – works on both edge and leadership platforms

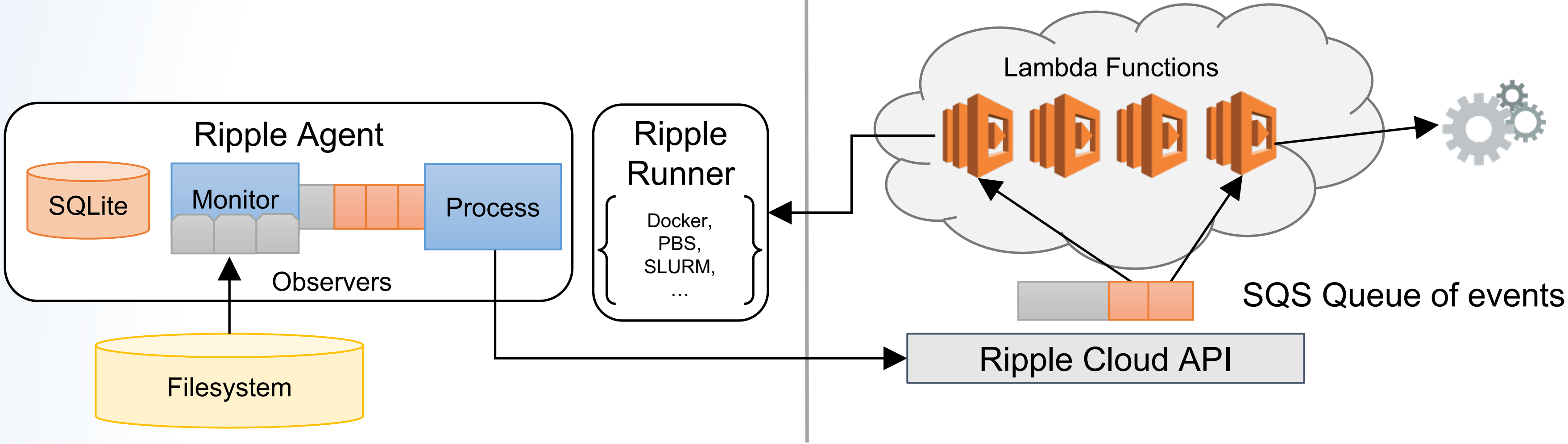
RIPPLE Architecture (updated)

Agent:

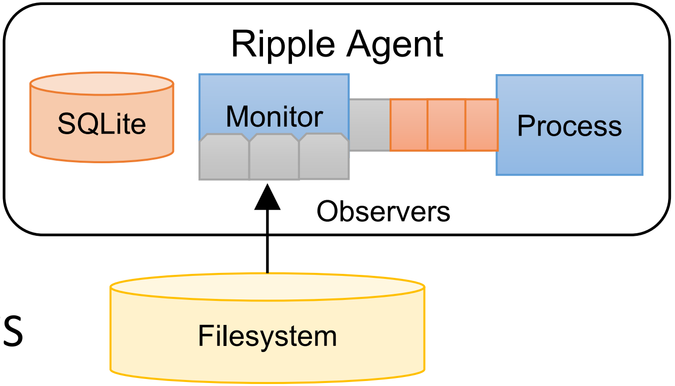
- Sits locally on the machine
- Detects & filters filesystem events
- Facilitates execution of actions
- Can receive new recipes

Service:

- Serverless architecture
- Lambda functions process events
- Orchestrates execution of actions
- Records and manages execution of flows



RIPPLE Agent



Responsible for detecting and reporting events of interest

Filesystem agnostic – uses an appropriate monitor for the FS

- Leverages Python Watchdog observers
  - inotify, polling, kqueue, etc.
- Globus Transfer API detects globus events (transfer, create, delete)

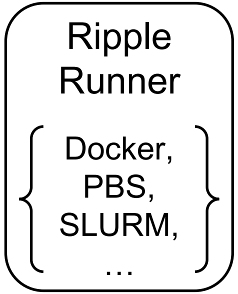
Rules are retrieved from the cloud service and stored in an SQLite database

Hybrid filtering model:

- Local monitor checks events against active rules
- If they match, they are reported to the cloud for processing

RIPPLE Runner

Abstracts execution environments and allows job submission/status checks via API



Ripple Runner

Docker, PBS, SLURM, …

Has a UUID and polls for actions – rules can invoke actions on any runner

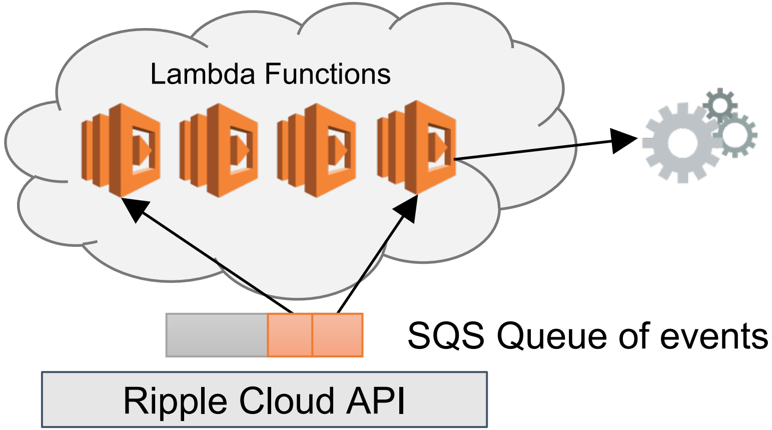
Can be deployed almost anywhere:

- Locally initiate Docker containers, singularity exec commands, and subprocesses to act on local files (metadata extraction, dispatch jobs, etc.)

- Cloud runner (backed by Lambda functions) performs cloud functions: Globus transfers, create shared endpoints, send emails, invoke other Lambda functions etc. This functions an API gateway exposing the runner API and proxying requests through to Lambdas

- HPC systems employ a runner for exposed batch submission (currently just SLURM)

RIPPLE Cloud Service



- Gateway API exposes Ripple service
  - Get rules
  - Report events
  - Update event status
- API either proxies Lambda functions (get rules) or inserts payload into SQS queue.
- Once an event reaches the SQS, it should not be lost
- SQS queue reports to SNS topic, triggering Lambda functions to pull from the queue
  - Dead letter queue after 3 processing failures
- CloudWatch timer triggers “cleanup” and “checkup” functions to process events still on the queue and outstanding jobs

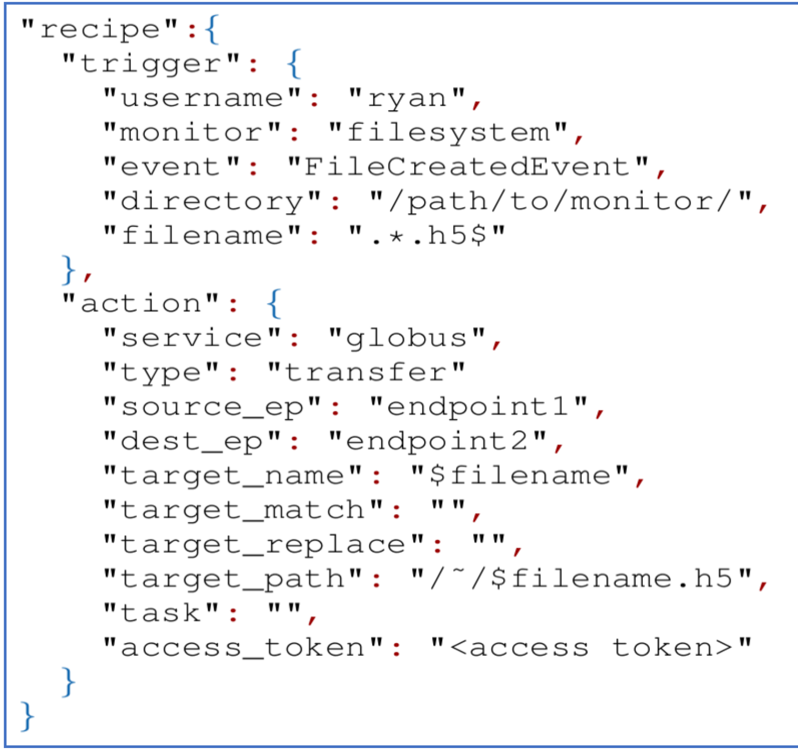
RIPPLE Rules

IFTTT-inspired programming model:

Turn on your lights when you're near home

Triggers describe where the event is coming from (filesystem create events) and the conditions to match (/path/to/monitor/.*.h5)

Actions describe what service to use (e.g., globus transfer) and arguments for processing (source/dest endpoints).



```
"recipe":{
  "trigger": {
    "username": "ryan",
    "monitor": "filesystem",
    "event": "FileCreatedEvent",
    "directory": "/path/to/monitor/",
    "filename": ".*.h5$"
  },
  "action": {
    "service": "globus",
    "type": "transfer"
    "source_ep": "endpoint1",
    "dest_ep": "endpoint2",
    "target_name": "$filename",
    "target_match": "",
    "target_replace": "",
    "target_path": "/~/$filename.h5",
    "task": "",
    "access_token": "<access token>"
  }
}
```

Event Detection

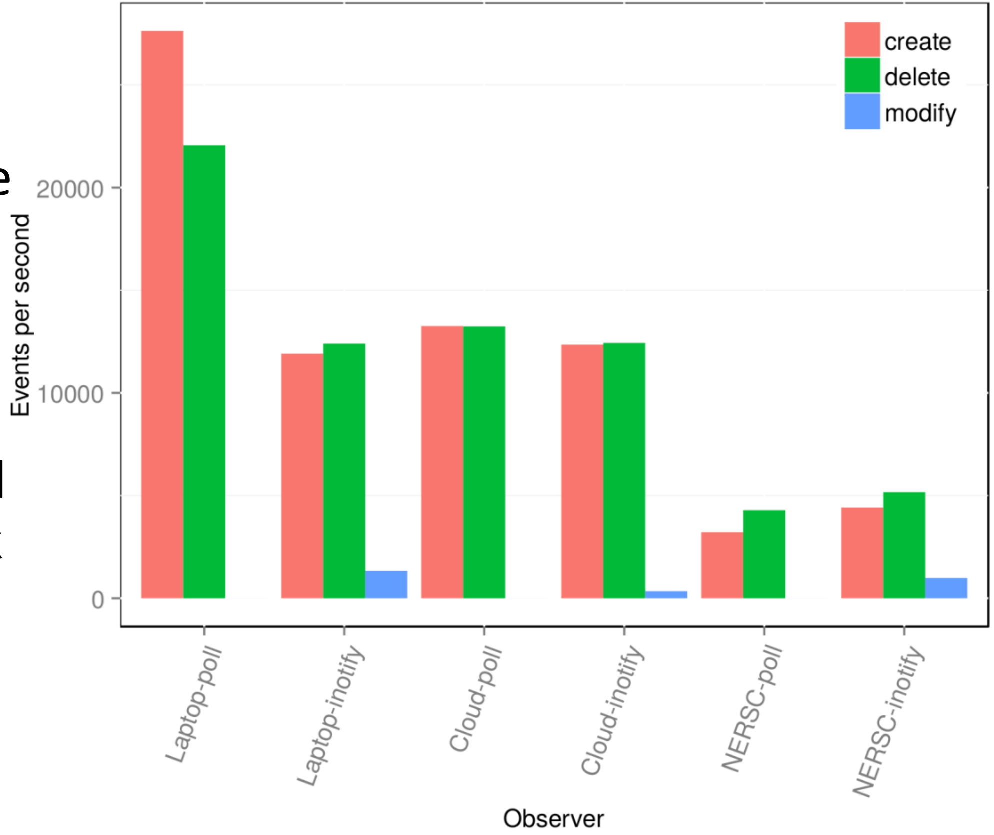
Goal: be able to monitor HPC storage workload (>3 mil events/day)

Inotify vs polling

Create/touch/delete 10,000 files and record event reporting duration (20k total)

Machines:

- Laptop
- c4.xlarge instance
- Edison login node (gpfs)



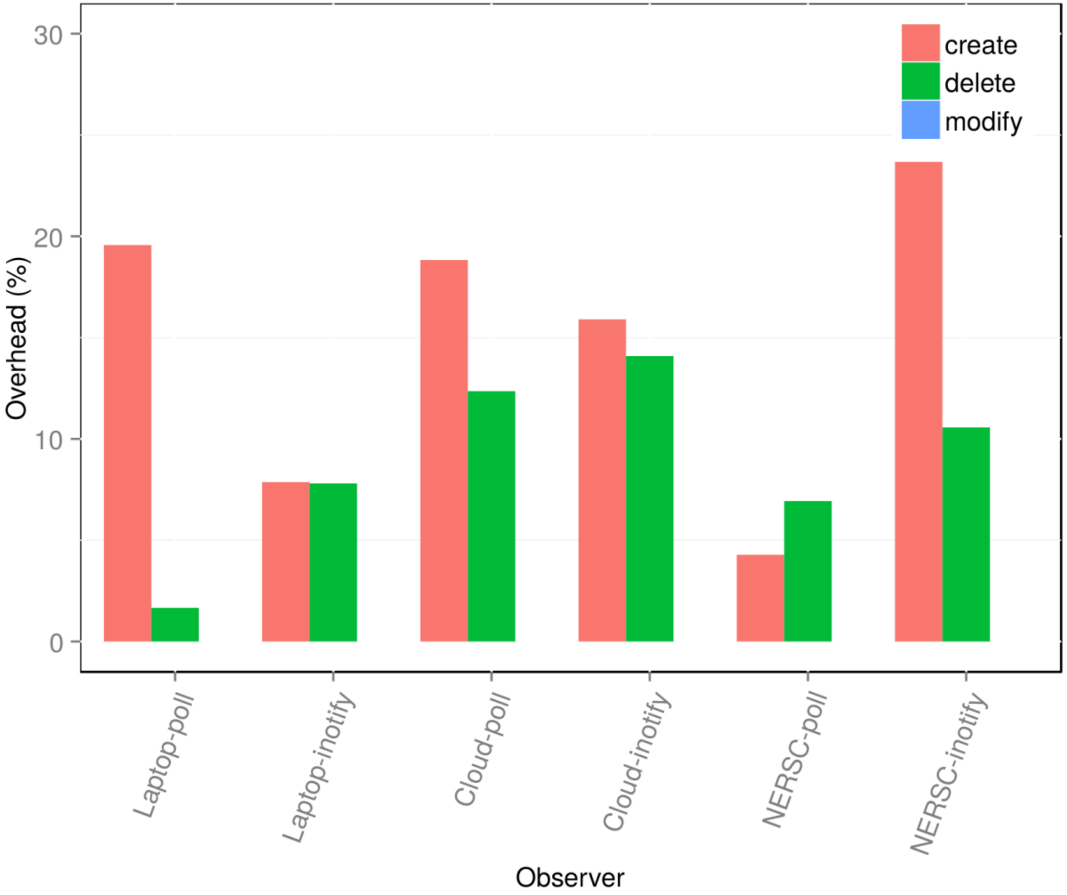
Filtering overhead

Goal: Determine overhead caused by filtering events locally

Measure differences in event/second detection

Filtering requires matching directory path and file extension

Polling is odd as it only polls once every second



Lambda Performance

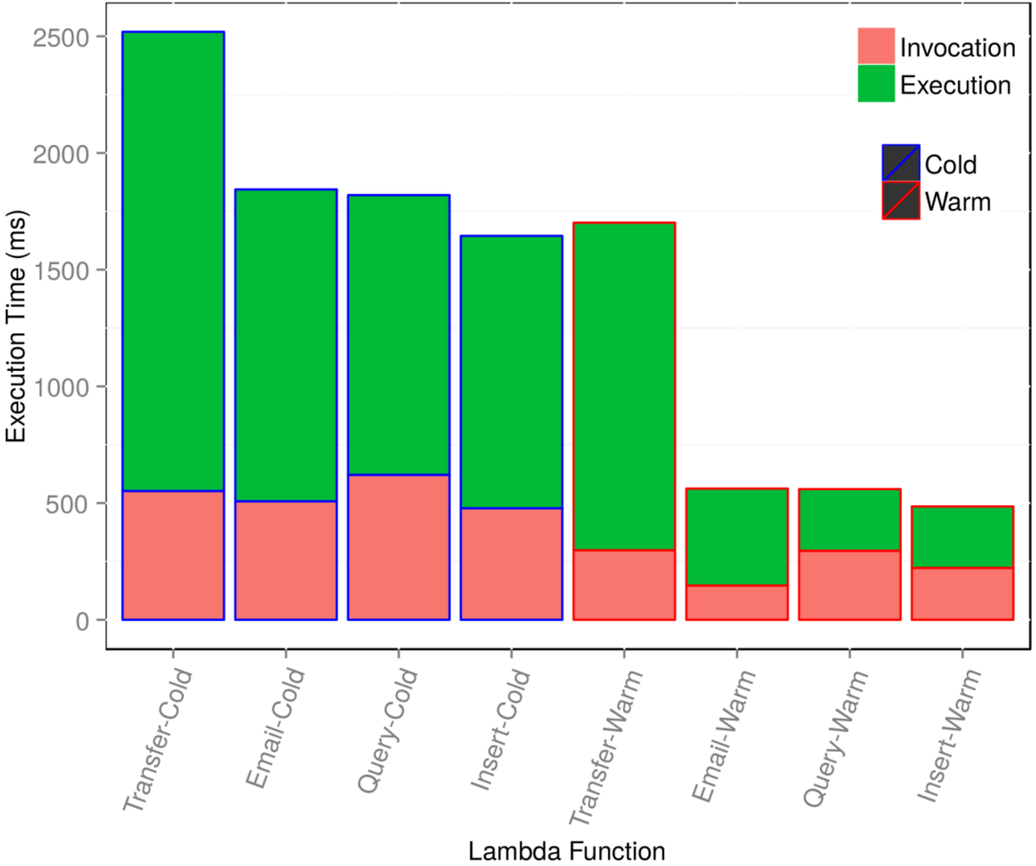
Goal: Understand lambda performance for different tasks

Cold vs Warmed functions

Actions:

- Globus transfer
- SMS email
- DynamoDB insert/query

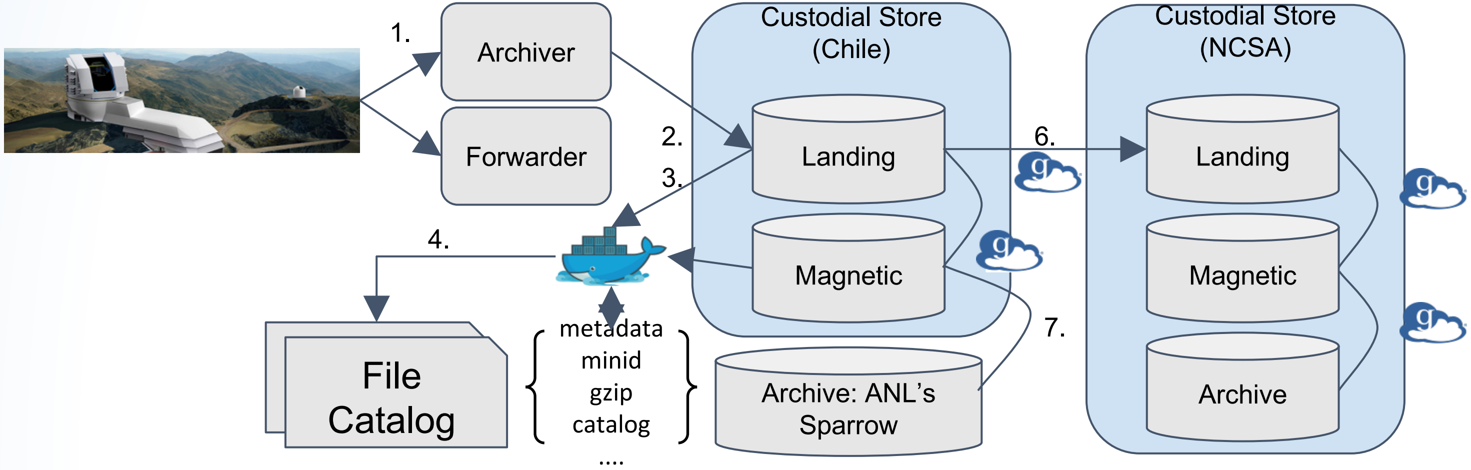
Transfers require a handshake with the Globus service, which also communicates with the endpoints



Use Case: Large Synoptic Survey Telescope

Developed a representative testbed of the LSST storage requirements

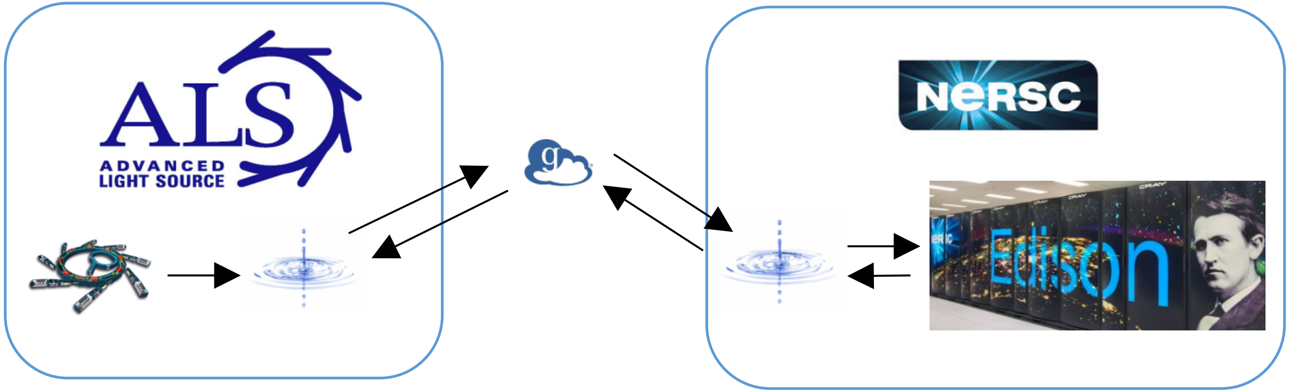
- Automatically propagate data between storage tiers and facilities
- Invoke Docker containers to extract metadata and maintain a file catalog
- Compress and archive files
- Recover deleted/corrupted files when delete and modification events occur



Use Case: Advanced Light Source

Deployed Ripple on an ALS and NERSC machine to automate data analysis

- **At ALS:** Detect new heartbeat beamline data and initiate transfer to NERSC
- **At NERSC:** Extract metadata, create sbatch file, dispatch analysis job to Edison queue, detect result and transfer back to ALS
- **At ALS:** create a shared endpoint, notify collaborators of result via email



New Use Cases

- Automated metadata extraction and ingestion into Globus Search
  - Uses singularity and Apache Tika to extract metadata
  - Metadata is wrapped into gmeta (json) documents and ingested into search
- Offline feedback mechanism for workflows
  - Researchers want a human quality control component
  - Have Ripple send subsets of data to researchers via email to check it
  - Trigger actions based on content of reply messages

Summary

Event-driven automation of data management practices

User focused

Monitoring agent agnostic to underlying filesystem

Serverless event processing and action orchestration

Future Work

More use cases!

More runners

Scalable & high performance event monitors for leadership resources

Programming model for event-based data management

Integration with Globus