Tech Preview

- Background
- Challenges of cloud
- Solution
- Demo
- Plans
Then: Research in the Cloud 2008

- Uncommon practice and access
- Difficult
- Expensive
- What scientific frameworks?
- CyVerse
  - Data Store (scalable, federated data storage)
  - Discovery Environment (scalable, distributed analytical and data management platform)
  - Atmosphere (scalable, multi/hybrid cloud)
Now: Research in the Cloud 2022

- Common practice and better access
- Slightly easier
- Slightly less expensive to use
- Multi-cloud frameworks
  - Software stacks (e.g. web component with database backends, like jupyter or mlflow)
- Science in the cloud is more sophisticated
98,500 users
1500 publications
11 PBs of data
40,000 trained

Researchers collect data.

Researchers learn more skills.

Labs

Data

Data is shared and analyzed in the cloud

Analysis

Training

● Secure Perimeter (VPN)
● HIPAA Compliant Platforms inside of Perimeter
● XNAT
● Training

● ITAR Compliance
● Receive data from multiple sensors
● Policy-based data visibility and sharing
● Support for multiple teams and data partitioning

CYVERSE® Professional
- Federation with local and commercial cloud and high-performance computing
- Integration with local user identity management systems
- Security compliance

CYVERSE® Health
- Secure Perimeter (VPN)
- HIPAA Compliant Platforms inside of Perimeter
- XNAT
- Training

CYVERSE® Defense
Challenges and Open Questions

- “Cloud” is both overloaded and very specific (vendor and type)
  - AWS, GCP, Openstack (Jetstream), Kubernetes
- Oftentimes science in the cloud is about being opportunistic
  - Cost containment
- Resources are scattered across multiple clouds
  - Storage in one place, compute in another (how to aggregate?)
  - Data proximal compute
- Multi-cloud? Hybrid cloud? Edge cloud and IoT?
- Event-driven?
- Multi-tenancy?
- Sharing?
Pizza-as-a-Service

https://www.linkedin.com/pulse/20140730172610-9679881-pizza-as-a-service/
“order party supplies”

“order a red velvet 3-layer cake”

“reserve band”

“find caterer and order food”

“reserve venue”
"I want this theme"
"I want this type of music"
"I want this type of food"
"I want this venue"
"I want a red velvet 3-layer cake"
"order-party-supplies"
Multi-Cloud Party Planner-as-a-Service

You

CyVerse Cacao

“I want Jupyterhub with NASA data”

“I want RStudio”

“I want Kubernetes”

“We want Eclipse Che”

Workflows
Analysis
Environments
(Declarative Templates)

Cloud

“I want my virtual cluster”
Multi-Cloud Party
Planner-As-A-Service

Collaborator

"I want rstudio"

"I want jupyterhub with NASA data"

"I want my virtual cluster"

"I want Kubernetes"

"I want Eclipse Che"

CyVerse Cacao

Workflows
Analysis
Environments
(Declarative Templates)

IoT

AWS

OpenStack (Jetstream2)

Kubernetes

Any Cloud

Other Researcher

template creator

template creator

template creator

CyVerse Cacao
What is Cacao, really?

An **event-driven multi-cloud** service that enables researchers and educators to effortlessly manage, scale and share their tools and workflows to any research-capable cloud **using declarative templates**.
Characteristics and Capabilities

- Material UI, focused on simplicity, built on Next.js
- Event-driven, cloud native architecture built on Go, Kubernetes, Nats
  - highly extensible: templates & DSLs, future-resistant architecture
  - highly scalable
- Meta/Hybrid-cloud (via integration with declarative templates)
  - Terraform
  - k8s, Argo, openfaas
- Scale to zero and auto-scaling based on metrics**
- Continuous analysis (CI/CD for science)
  - data events, code change events, periodic, external sources
- Git for template and workflow persistence
- OAuth2 and federated identity: Globus and Keycloak
- REST API & CLI
CyVerse Ecosystem

Discovery Environment
- retrieves data for visualization

Data Store
- watches for data events

DataWatch
- registers for events, activates workflows

BYO cloud

Cloud Analysis & Orchestration
- cacao

Researcher
- visualization and interactive analysis, data management

Clouds
- other clouds, edge clouds

BYO cloud integrates with other cloud providers like AWS, Azure, and Google Cloud.

Data retrieval and management flow through DataWatch, which registers for events and activates workflows. The data is then managed by the CyVerse Ecosystem, which includes the Discovery Environment and the Data Store.
Templates in Cacao

- git is first class persistence
  - supports branches/tags
  - subpaths
  - repo changes reloaded
Templates

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- metadata-driven

Templates

- git is first class persistence
  - supports branches/tags
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- metadata-driven
- creation & customization
  - CyVerse curated
  - community-provided
  - easy to create from scratch or fork and modify
Templates

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- creation & customization
  - initially, provided by us
  - community-provided
  - from scratch or fork
- cacao validation, testing, cloud filtering
Templates

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- creation & customization
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- cacao validation, testing, provider filtering

- sharing
  - share via github, gitlab, etc (fork)
  - sharing and search within cacao
Demo

- Take a walkthrough of an early version of Cacao
  - Jetstream 2
  - Basic template that will launch a vm using a terraform+ansible template:


Warning: Demo showing a boring automation of a template will start soon.*

* Unabashedly derived from Al Sweigart, author of “Automate the Boring Stuff” books
Zero-to-Jupyterhub with OAuth
Kubernetes-on-demand
Cloud Management

- **Clouds**
  - **Openstack**
    - Jetstream IU
      - jetstream_indiana_university
      - TG-TRA160000
      - Jetstream Cloud for Indiana University
    - Jetstream-TACC
      - jetstream_TACC
      - TG-TRA160000
      - Jetstream Cloud for TACC
    - Jetstream2
      - jetstream2
      - TG-TRA160000
      - Jetstream2 Cloud
  
- **Kubernetes**
  - CyVerse k8S Continuous Cloud
    - cyverse_kubernetes_continuous_cloud
    - TG-TRA160000
    - CyVerse Kubernetes Cloud for Continuous Analysis

- **Public Clouds**
  - Google Kubernetes Engine (GKE)
    - google_kubernetes_engine
    - TG-TRA160000
    - Google Cloud for Continuous Analysis
  - AWS Elastic Kubernetes Service (EKS)
    - AWS_elastic_kubernetes_service
    - TG-TRA160000
    - CyVerse Kubernetes Cloud for Continuous Analysis
Searchable template catalog
Cacao Projects

**Jetstream 2**: NSF (OpenStack) cloud for science and engineering

**HydroGEN**: ML-based simulation platform to simulate hydrological scenarios with the goal of elastic scaling to AWS

**COALESCE** (COntext Aware LEarning for Sustainable CybEr-agriculture systems): innovation by combining digital agricultural tools, like robotics, and physical tools, like sensors and drones; will have distributed computing needs, including ML compute to the edge (farm sites)

**AIIRA** (AI Institute for Resilient Agriculture): creating and deploying AI-driven predictive digital twins for modeling plants to increase resiliency of the nation’s agricultural systems; MLOps in the cloud
Cacao Benefits for Users

- Bring your own cloud
  - bring your own credentials
  - connect on-premise clouds or IoT (your own Kubernetes cluster)
  - share cloud access
- Federated identity (e.g., Keycloak, Globus)
- Modes of provisioning (on-demand, persistent, event-driven)
- Cloud cost-containment
  - Event-driven
  - Budgeting (notifications or enforcement)
- Programmable, either using API or CLI
- Template reuse
Cacao Benefits for Infrastructure and Template Creators

- Connect to your cloud
- Create templates for your own community or group
  - Store your templates in your own repo
  - Easily fork existing templates and customize
  - Share templates with users
  - Publish templates and have them be searchable
Future & Roadmap

- “Alpha” -- now heavily in development
- Improve the performance of deployments
  - exposing more of the underlying execution of a template as it happens
- Complete integration with other CyVerse services
- Complete and expose event triggers e.g. for data events
- Integrate other template engines and frameworks, esp ML-related ones
- Searchable template catalog, along with template management
- Add OpenStack-specific operations, like instance snapshotting
- Template-Cloud Resource reconciliation (within reason)
Your input is needed

• Share with us!
  • your use cases
  • your template languages that fill a great need (future roadmap)
  • your templates or suggested templates (CyVerse-curated)
• Current focus: terraform+openstack (ansible optional)
• Near future
  • terraform+aws
  • kubernetes native
  • argo
• Beta testers
• Developers needed as well!
Next Steps

When will Cacao be available?
  Cacao (Alpha) will be available very soon

Where?
  Available through Jetstream2

Who can access?
  Those with XSEDE allocation to get access to Jetstream2
# Meet the Team

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Matt Bomhoff</td>
<td>Jeremy Frady</td>
<td>John Wregglesworth</td>
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<tr>
<td>Illyoung Choi</td>
<td>Sarah Roberts</td>
<td>John Xu</td>
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<td>Sean Davey</td>
<td>Mariah Wall</td>
<td>Edwin Skidmore</td>
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</tbody>
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**Students**
- Ryan Schneider
- Terry Melo Cruz

Thank you!