# New Approaches for Building and Operating Distributed Cyberinfrastructure for Large Facilities

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**Large Facilities =>**
**Collaborations =>**
**Multiple institutions =>**

***Distributed Cyberinfrastructure***

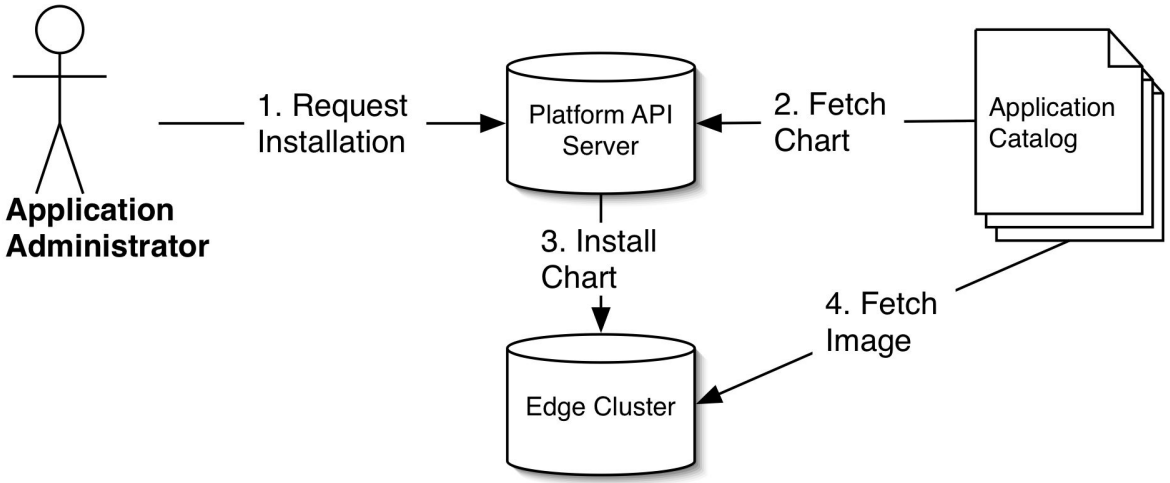

# Experience and lessons

- Various types of distributed infrastructure are necessary to make this work efficiently:
  - Caches to manage data distribution (CVMFS, Squid)
  - Data transfer endpoints (Globus, XRootD, Rucio, iRODS)
  - 'Compute elements' to route batch jobs (OSG HTCondor-CE)
  - others (& future, no yet invented)
- Managing can be difficult when changes must be coordinated among many parties
  - When administrators at each site must be responsible for running services there is a high barrier to starting a new service, or even to make routine updates to existing services

# Evolving our approach...

- Want to move toward a model where site operations and deployment can be operated simply and centrally
- SLATE a purpose-built tool and platform that can get us closer to that "NoOps" model
- Many challenges, may not fully get there, but we can take steps in that direction

# Federated operation

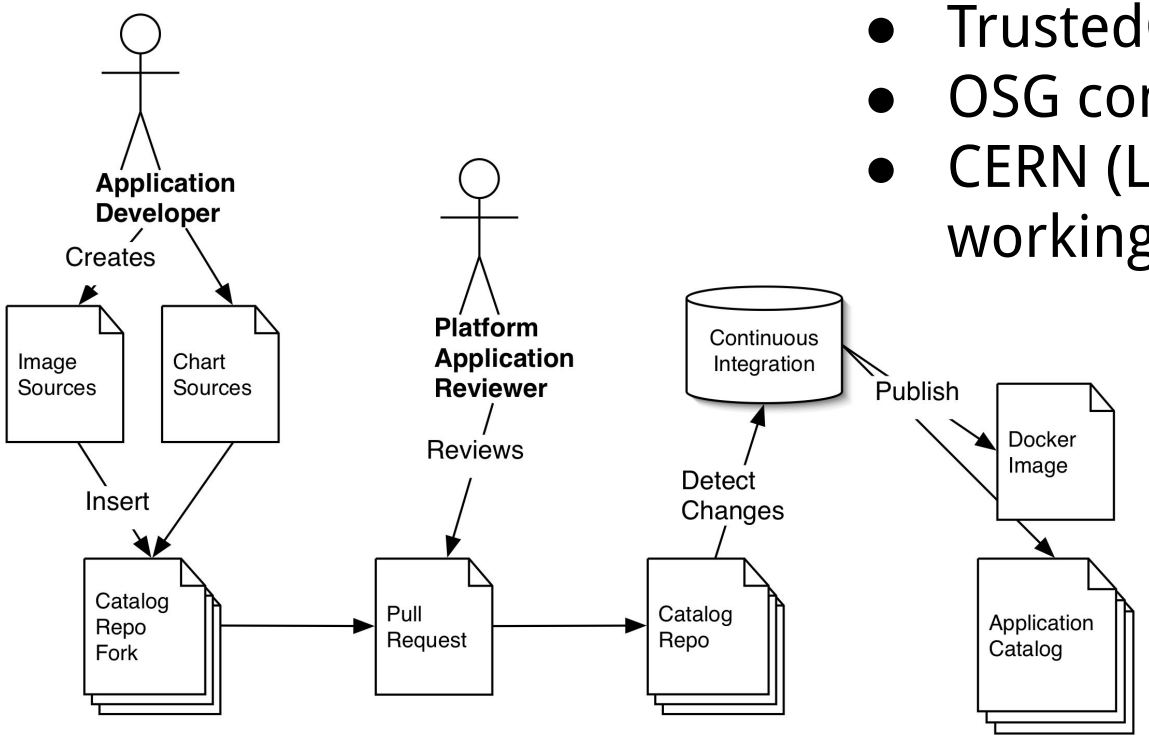


# Eg. Operating a network of caching servers for ATLAS

- OSG announced a vulnerability in Frontier Squid on July 26
  - you *have* all updated right? ☺
- SLATE instances were all updated within the hour, simply via:

```
for i in $(slate instance list | grep squid | awk '{print $4}');
do
   slate instance restart $i
done
```

# … but a new trust model is needed




- TrustedCI engagement ✅
- OSG container security ✅
- CERN (LHC) security working group ✅

# Conclusions

- Federated operations is possible today and is being advanced by a number of teams within trusted domains
- Early experience shows new operational capabilities are possible
- But depends on a credible security and trust model

# Thanks

extra slides follow

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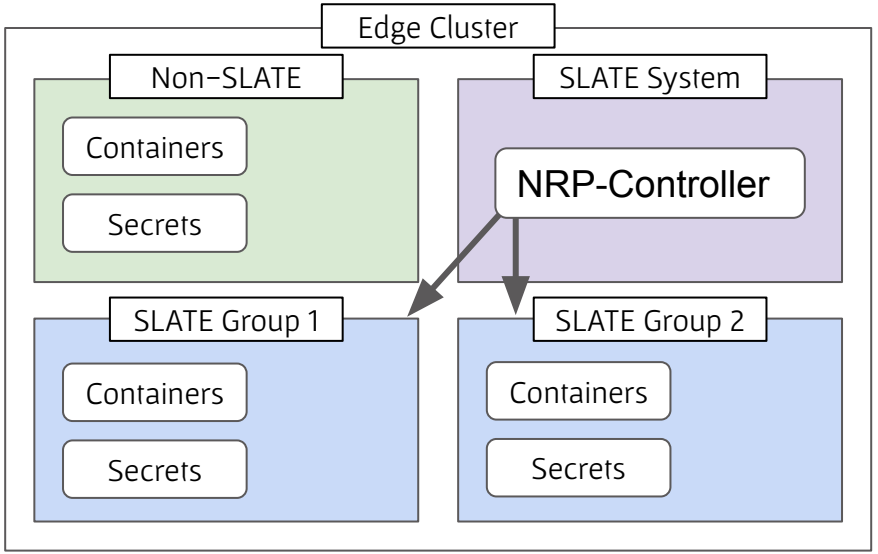
# Trust and Privilege

- Infrastructure services are qualitatively different from the batch jobs that many sites already accept from outside users—they must run persistently, and must often accept network connections from outside
- To admit such services, site administrators need strong guarantees that:
  - Only suitable persons will be able to deploy services
  - Only appropriate software for providing a relevant service will be run
  - Services will use appropriately secure software and configuration
  - External users running services will not interfere with existing uses of resources
- Users running services also want separation between their applications and others'

# Approach to Multi-tenancy

- SLATE uses Kubernetes' namespaces, secrets and implementation of Role-Based Access Control (RBAC)
- The SLATE API server is granted access only to its own subset of namespaces
- SLATE places applications belonging to different user groups into separate namespaces
- Kubernetes forbids containers in one namespace from reading secrets in other namespaces




https://gitlab.com/ucsd-prp/nrp-controller

# Internal Permissions Model

- SLATE organizes users into groups, and permissions apply per-group
- Every participating cluster is administered by a group
  - When a cluster first joins the federation, only its administering group has access
- The administrators of a cluster can:
  - Grant access to other groups to deploy applications on their cluster
  - Set up per-group whitelists of which applications guest groups are authorized to deploy

# Application Packaging

- SLATE makes use of Helm to package applications for Kubernetes
  - Helm is commonly used in the broader Kubernetes community
  - Helm enables templating Kubernetes YAML manifests for more convenient reuse
- Only limited configuration settings for each application are exposed by its Helm chart
  - Hides complexity users don't want to see
  - Can be used to enforce required aspects of configuration
  - Provides a consistent interface which all participants in the federation can inspect and agree on
- SLATE maintains its own catalog of charts, and allows only those applications to be installed

# Application Configuration Example

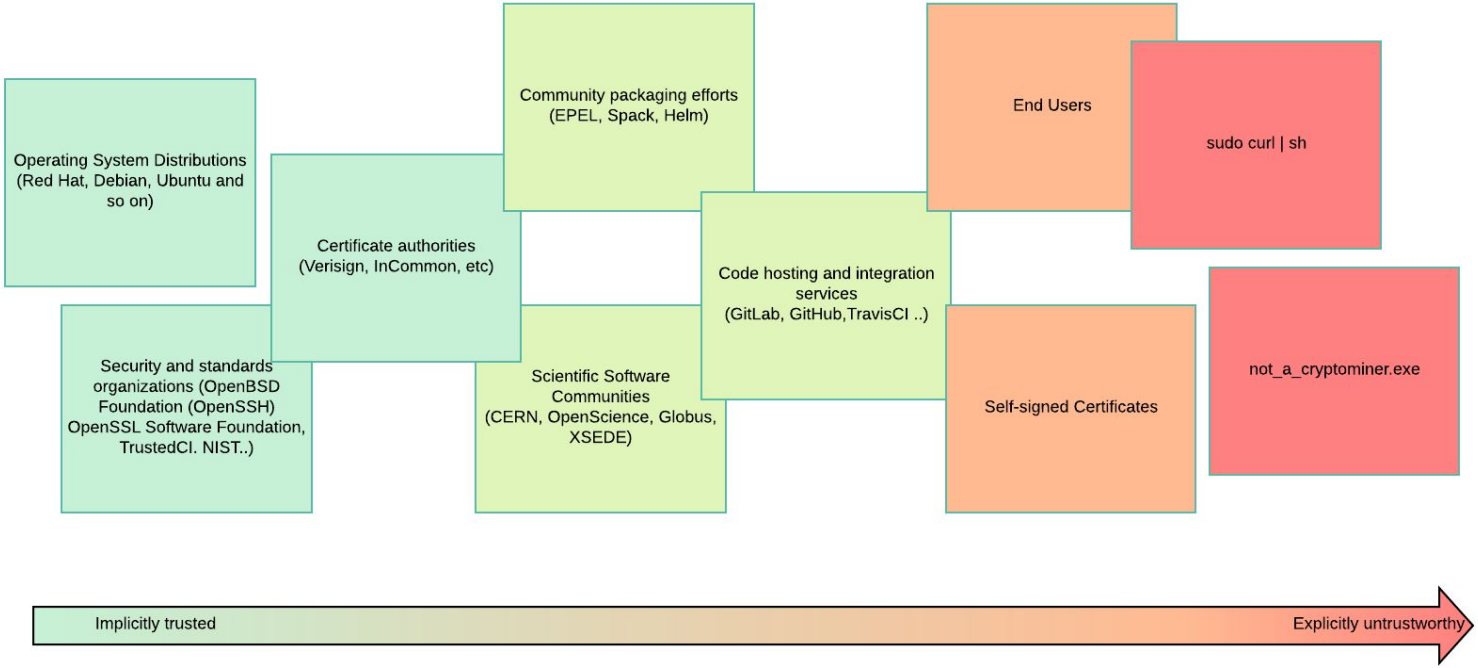
```
# Instance to label use case of Frontier Squid deployment
# Generates app name as "osg-frontier-squid-[Instance]"
# Enables unique instances of Frontier Squid in one namespace
Instance: global

SquidConf:
  # The amount of memory (in MB) that Frontier Squid may use on the machine.
  # Per Frontier Squid, do not consume more than 1/8 of system memory with Frontier Squid
  CacheMem: 128
  # The amount of disk space (in MB) that Frontier Squid may use on the machine.
  # The default is 10000 MB (10 GB), but more is advisable if the system supports it.
  # Current limit is 999999 MB, a limit inherent to helm's number conversion system.
  CacheSize: 10000
  # The range of incoming IP addresses that will be allowed to use the proxy.
  # Multiple ranges can be provided, each separated by a space.
  # Example: 192.168.1.1/32 192.168.2.1/32
  # The default set of ranges are those defined in RFC 1918 and typically used
  # within kubernetes clusters.
  IPRange: 10.0.0.0/8 172.16.0.0/12 192.168.0.0/16
```

# Curation Considerations

- Both Helm charts and the container images they reference must be taken into consideration
- The review process must be deep enough to be able to prevent problems, but not so slow or restrictive that potential users of the platform cannot get appropriate applications into production
  - Reviewer effort is also a limited resource!
- Some trusted sources are needed as a basis
  - The community already trusts major OS distributions (CentOS, Ubuntu, etc.)
  - Some applications are provided by major groups within the wider community which already have their own processes for trustworthy releases (Apache httpd, NGINX)

# Variation in Trust Levels



# Special Challenges of Container Images

- Container images are a snapshot of a system state, so they do not tend to be aware of security patches since their creation
  - This implies that periodic rebuilding of images is necessary, and possibly that containers should be periodically restarted
- Typical distribution mechanisms (Docker) allow the data referred to by a particular image 'tag' to be replaced—an image which was previously reviewed may be replaced by one with different contents
  - THis is why we prefer to have SLATE manage image sources, build and publish the images to a repository itself
- Automated image scanning tools can help with review, but are not a complete answer
  - Only images containing package manager data can be scanned
  - Scans may find large numbers of low-importance vulnerabilities for which no patched packages are available from the base distribution

# Risks of containers as defined by NIST

- Broadly, NIST has identified* 5 areas of risk with application containers:
  - Image Risks
    - Configuration defects, malware, embedded secrets, untrusted software
  - Registry Risks
    - Insecure connections, stale images, insufficient authentication and authorization
  - Orchestrator Risks
    - Unbounded administrative access, unauthorized access, mixed sensitivity of workloads and poor separation between workloads
  - Container Risks
    - Vulnerabilities in the Container runtime, insecure runtime configurations, unbounded network access
  - Host OS Risks
    - Large attack surface, shared kernel, host filesystem tampering, host component vulnerabilties

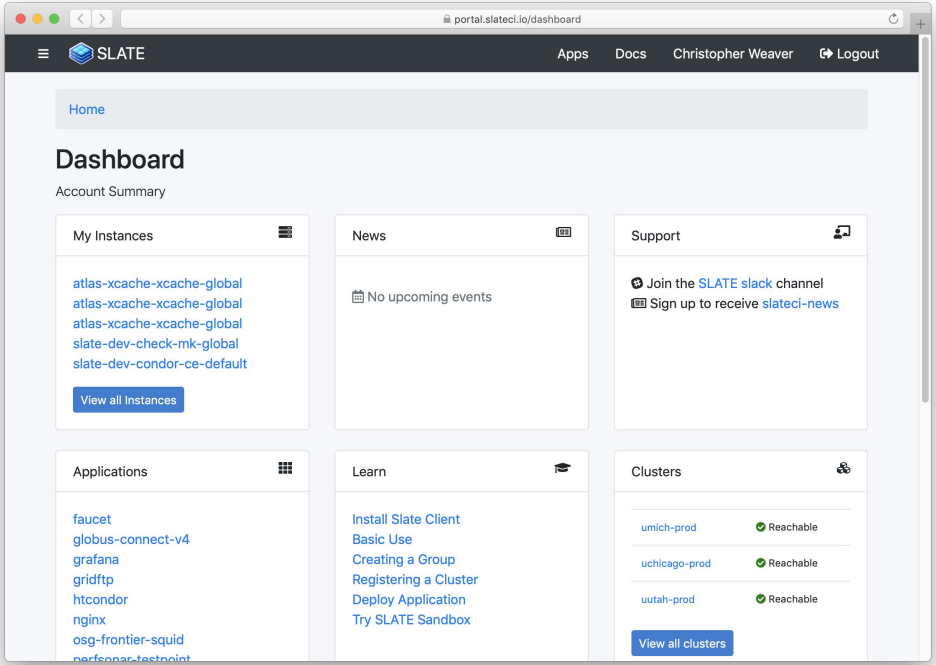
* https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-190.pdf

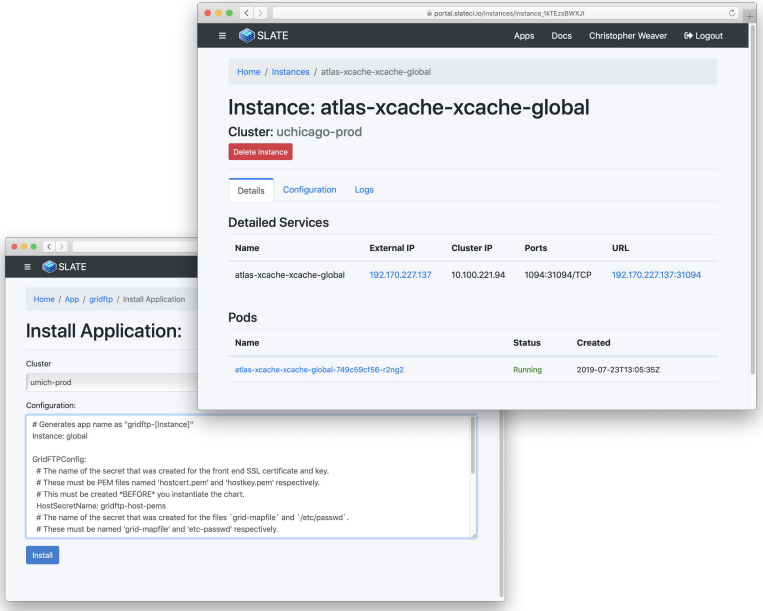
# Risks and Mitigations

- Image Risks
  - SLATE uses a curated application catalog with specific requirements for containers that may be in the catalog.
- Registry Risks
  - The SLATE team is currently considering running a registry independent of the common ones, e.g. DockerHub to have more control over images delivered via the platform
- Orchestrator Risks
  - SLATE allows the operator of the cluster to limit which applications may be launched
  - Additionally, the Kubernetes API need only be open publicly to a few specific IPs for SLATE access
- Container (runtime) Risks / Host OS risks
  - SLATE will offer best-practices for runtime and host configuration, but largely this is left up to the Cluster administrator

* https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-190.pdf

# SLATE Web Interface



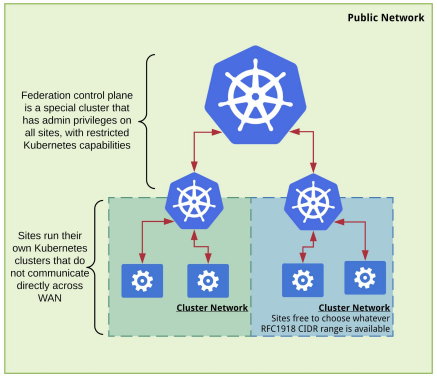

- Almost all SLATE functions are available via the portal

# SLATE Command Line Interface

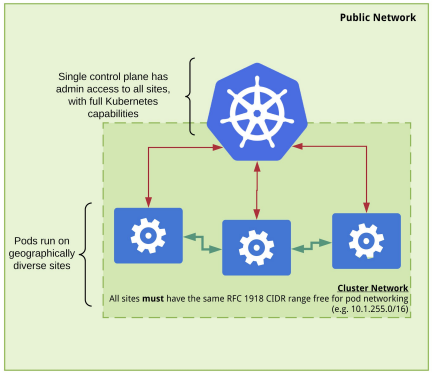
```
# Find the PerfSONAR testpoint application
$ slate app list | grep 'Name\|perfsonar'
Name App Version Chart Version Description
perfsonar-testpoint 4.2.0 1.0.3 Perfsonar Testpoint Deployment
# Get the default configuration
$ slate app get-conf perfsonar-testpoint > ps.yaml
# Customize the configuration
$ vi ps.yaml
# Do the install
$ ./slate app install perfsonar-testpoint --cluster uchicago-prod --group slate-dev --conf ps.yaml
Successfully installed application perfsonar-testpoint as instance slate-dev-perfsonar-testpoint-cnw- test
with ID instance_U-2KiIGqFKs
# Query instance information
$ ./slate instance info instance_U-2KiIGqFKs
Name                          Started                  Group     Cluster       ID
perfsonar-testpoint-cnw-test 2019-Jul-15 18:06:39 UTC slate-dev uchicago-prod instance_U-2KiIGqFKs
Pods:
  slate-dev-perfsonar-testpoint-cnw-test-84596d7c85-ns8xk
    Status: Running
    Created: 2019-07-15T18:06:44Z
    Host: sl-uc-xcache1.slateci.io
    Host IP: 192.170.227.137
# Run a test against the new endpoint
$ pscheduler task rtt --dest 192.170.227.137
Waiting for result...
1       192.170.227.137  64 Bytes  TTL 64  RTT   0.2690 ms
...
0% Packet Loss  RTT Min/Mean/Max/StdDev = 0.117000/0.190000/0.269000/0.051000 ms
```

# Approaches to Kubernetes Federation

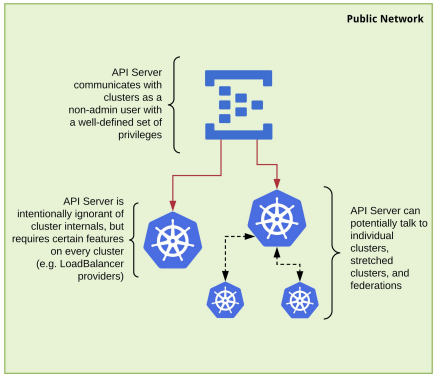
- Native federation (KubeFed) is still not mature (in alpha testing as of July 2019)
- 'Stretched' Kubernetes clusters become unwieldy at large scales, and have implications for networking
- For SLATE, giving users direct `kubectl` access to participating clusters was not a specific goal (and restricting what users can do is much easier without it)



FEDERATION CONTROL PLANE



STRETCHED KUBERNETES (a la PRP)



SLATE PSEUDO-FEDERATION