Institute for the Wireless Internet of Things

at Northeastern University

GPUs Overview

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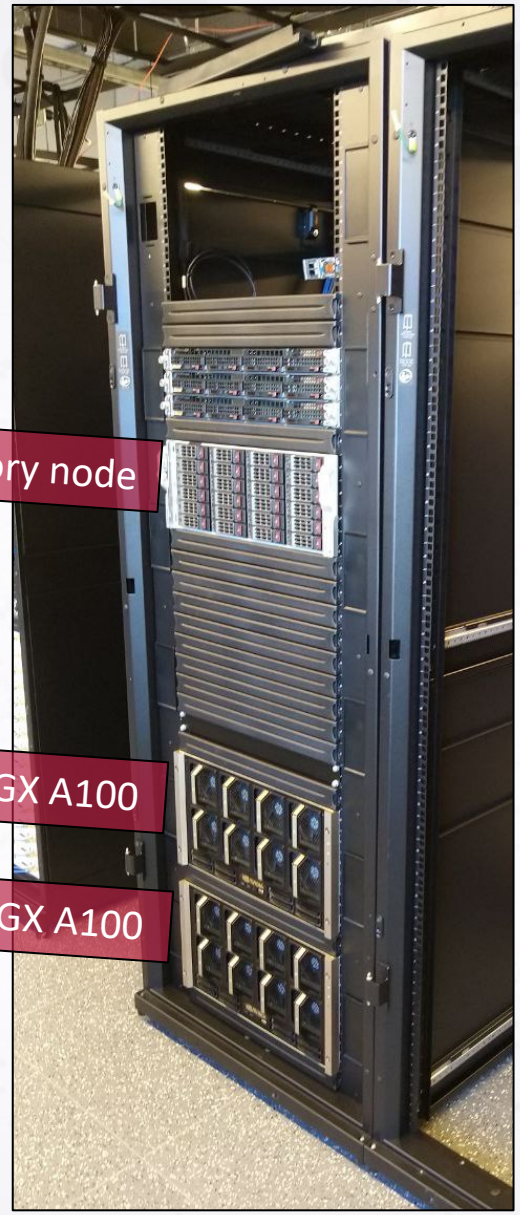
AI Jumpstart Integration

MASSACHUSETTS TECHNOLOGY COLLABORATIVE

- Build GPU-accelerated software-defined, cloud-native applications for the 5G vRAN
  - 2x NVIDIA DGX A100 (8 GPUs each, 40GB RAM)
  - 1x Large memory node (6 GPUs, 3TB of RAM)
  - 1x MLX InfiniBand switch

8 NVIDIA A100 GPU 40 GB

Mellanox InfiniBand switch



Large memory node

NVIDIA DGX A100

NVIDIA DGX A100

How do we **integrate** the new rack into Colosseum?

HashiCorp Nomad

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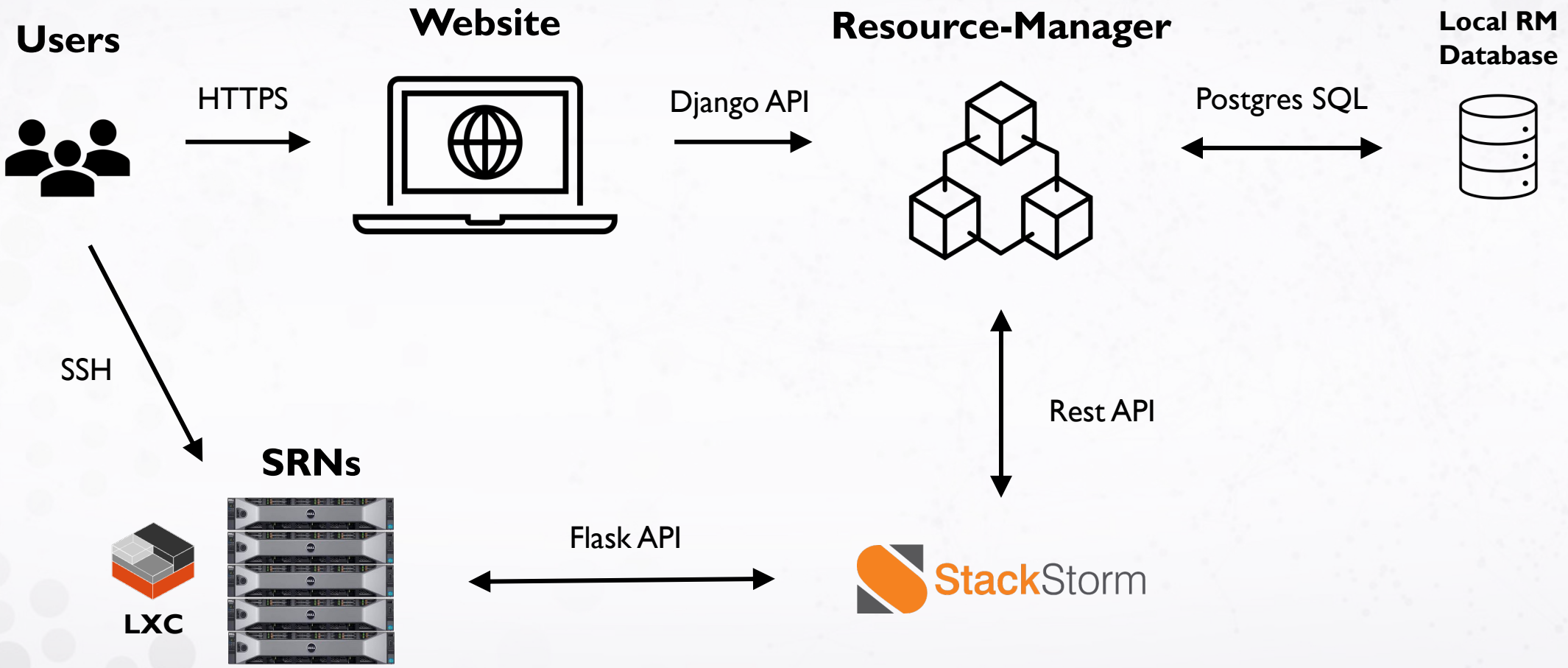
Current SRN reservation flow diagram



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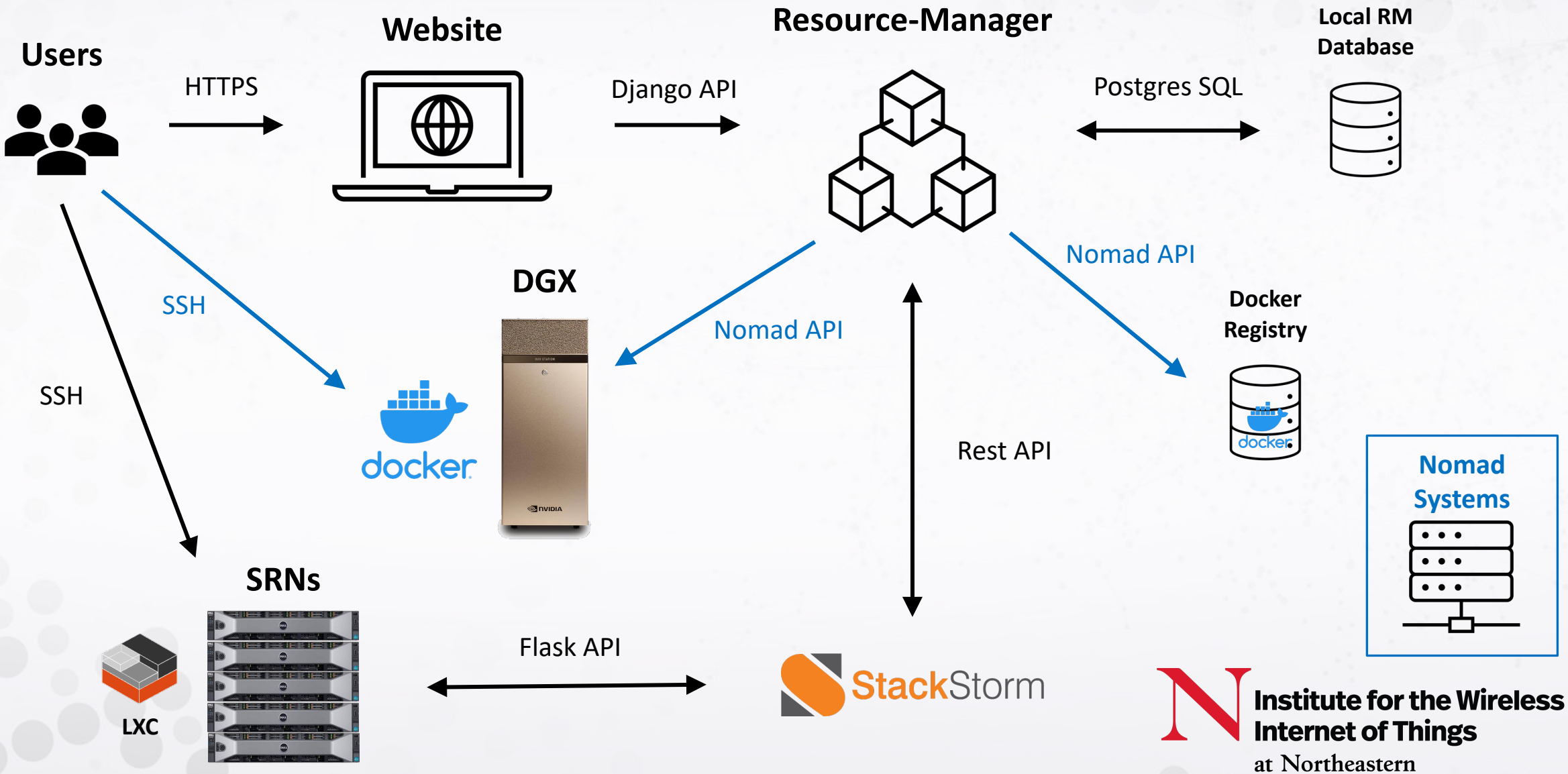
New GPU Reservation Flow Diagram



Nomad: Overview

HashiCorp Nomad

- Workload **orchestrator** to deploy and manage containers.
- Built-in support for **GPU** workloads and device plugins.
- **HashiCorp** ecosystem (Vault, Consul…). Vault Consul
- Compare to the more popular kubernetes:
  - Smaller scope
  - More simple and lightweight
  - More scalable (5k vs 10k nodes)
  - Flexible workload support
  - Consistent deployment

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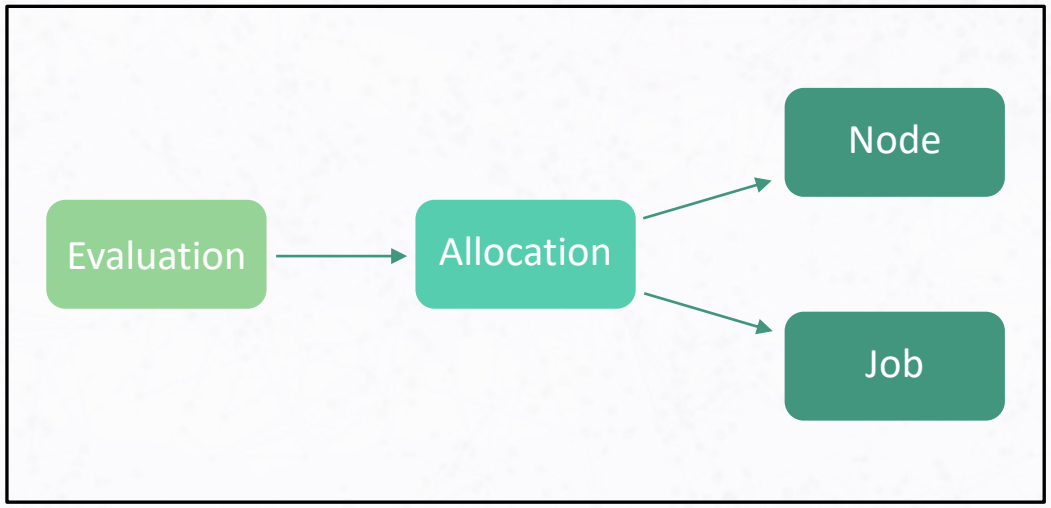
Nomad: Working principles

HashiCorp Nomad

- Interface with Nomad via **RESTful** HTTP API.
- 5 main Nomad concepts:
  - **Job**: declarative description of tasks.
  - **Node**: servers to schedule tasks.
  - **Allocation**: tasks and nodes mapping.
  - **Deployment**: allocations trackers.
  - **Evaluation**: scheduling and status.



- Support of tokens and ACLs for **authentications**.

More info: *https://www.nomadproject.io/api-docs*

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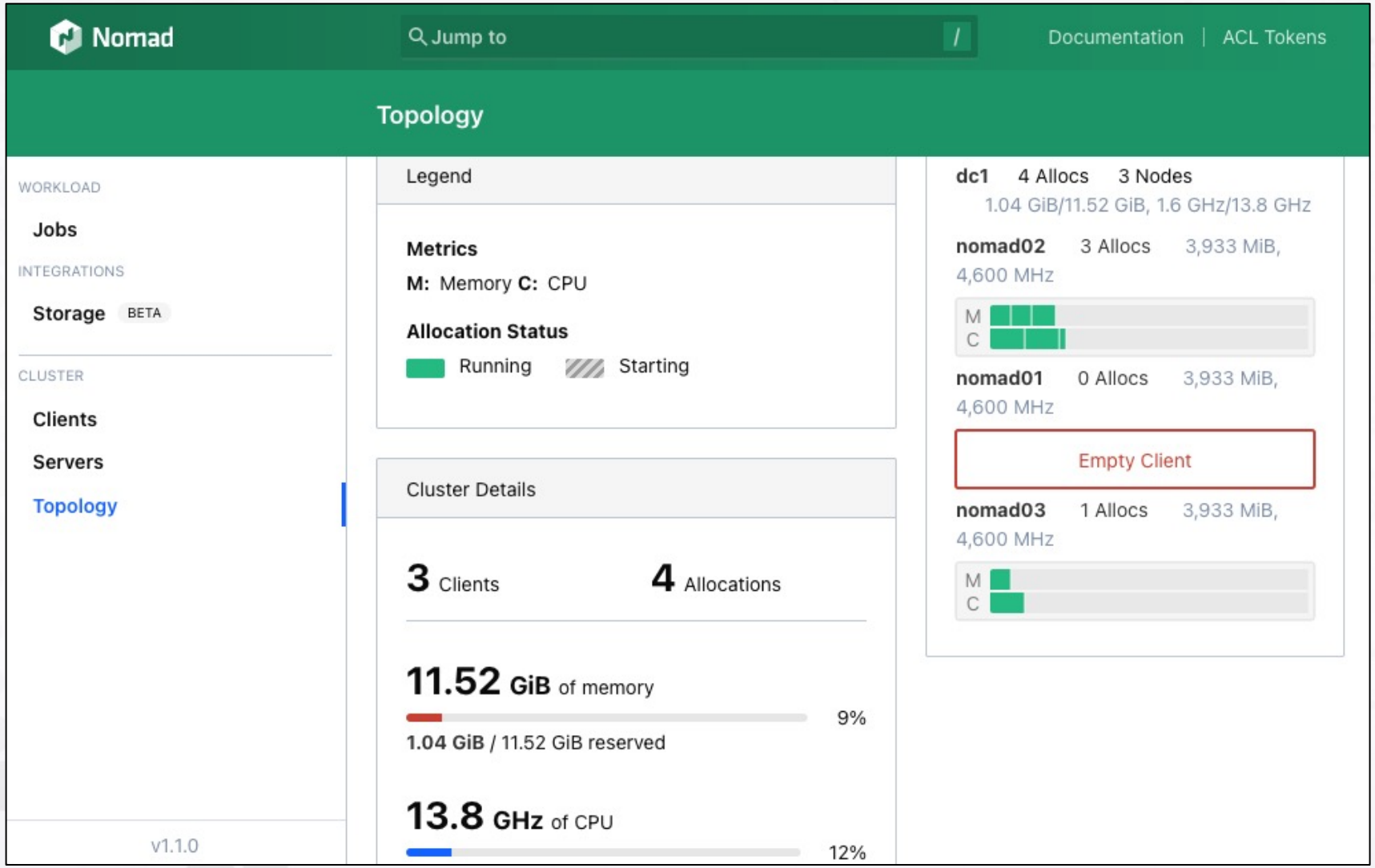
Nomad: GUI and Job example

HashiCorp Nomad



Example_job.nomad

```
job "gpu-test2" {
  datacenters = ["colosseum"]
  type = "service"
  constraint {
    attribute = "${attr.unique.hostname}"
    regexp    = "dgx1"
  }
  group "smi" {
    task "smi" {
      driver = "docker"
      config {
        image = "nvidia/cuda:11.0-base"
        command = "nvidia-smi"
      }
      resources {
        device "nvidia/gpu" {
          count = 1
        }
      }
      network {
        port "web" {
          static = 81
          to = 5001
}}}}}
```

Nomad is also being considered to run and manage all **Colosseum** containers.

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Nomad Ecosystem Implementation

Main Entities

HashiCorp Nomad

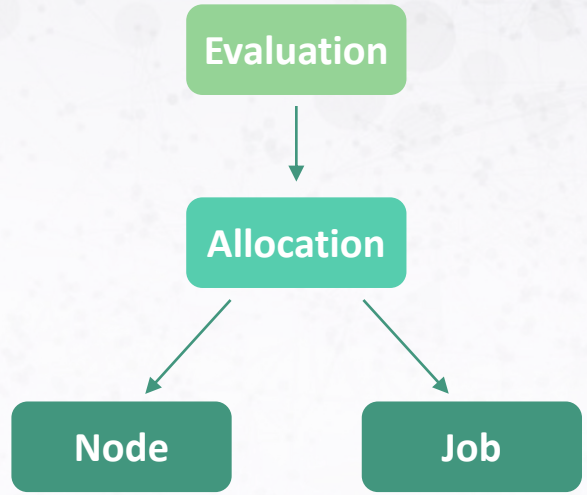
- Workload orchestrator
- Container manager
- Simple, light, scalable

HashiCorp Consul

- Service mesh tool
- Service discovery/check
- Secure connectivity

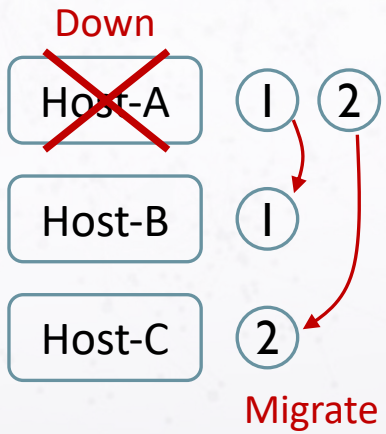
traefik

- Reverse proxy
- Load balancer
- Completely integrated



Environment	Dev	Stage	Prod
Consul Servers	3	5	7
Nomad Servers	3	5	7
Nomad Workers (CPU)	4	4	4
Nomad Workers (GPU)	1	2	2

Servers	3	5	7
Quorum	2	3	4
Failure Tolerance	1	2	3



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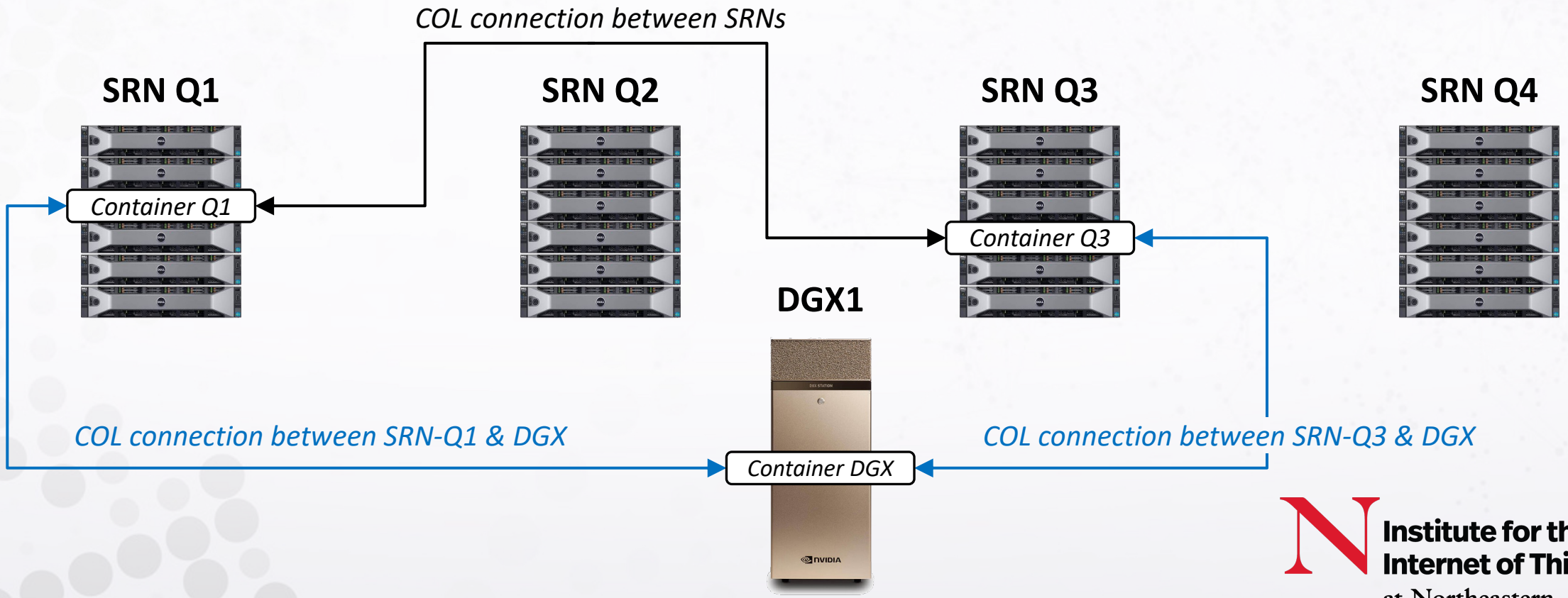
Possible use case examples

1. **Training** of large-scale datasets collected on Colosseum.
   - **Current** data flow: Generate ➔ Export ➔ Train ➔ Import ➔ Use
   - **New** data flow: Generate ➔ Train ➔ Use
   - Much **faster** and more **efficient**.

2. **Real-time** AI-driven signal processing for the full 5G protocol stack.
   - **Online training** for the O-RAN xApps.
   - Efficient **real-time tuning** of several users' parameters.
   - Highly **scalable**.

Possible use case examples

3. **Direct link** between USRP and GPU to immediately process IQ samples.
   - Need consideration on constrain **limits** (latency, number of users…).
   - Architectural **challenges** to be solved.



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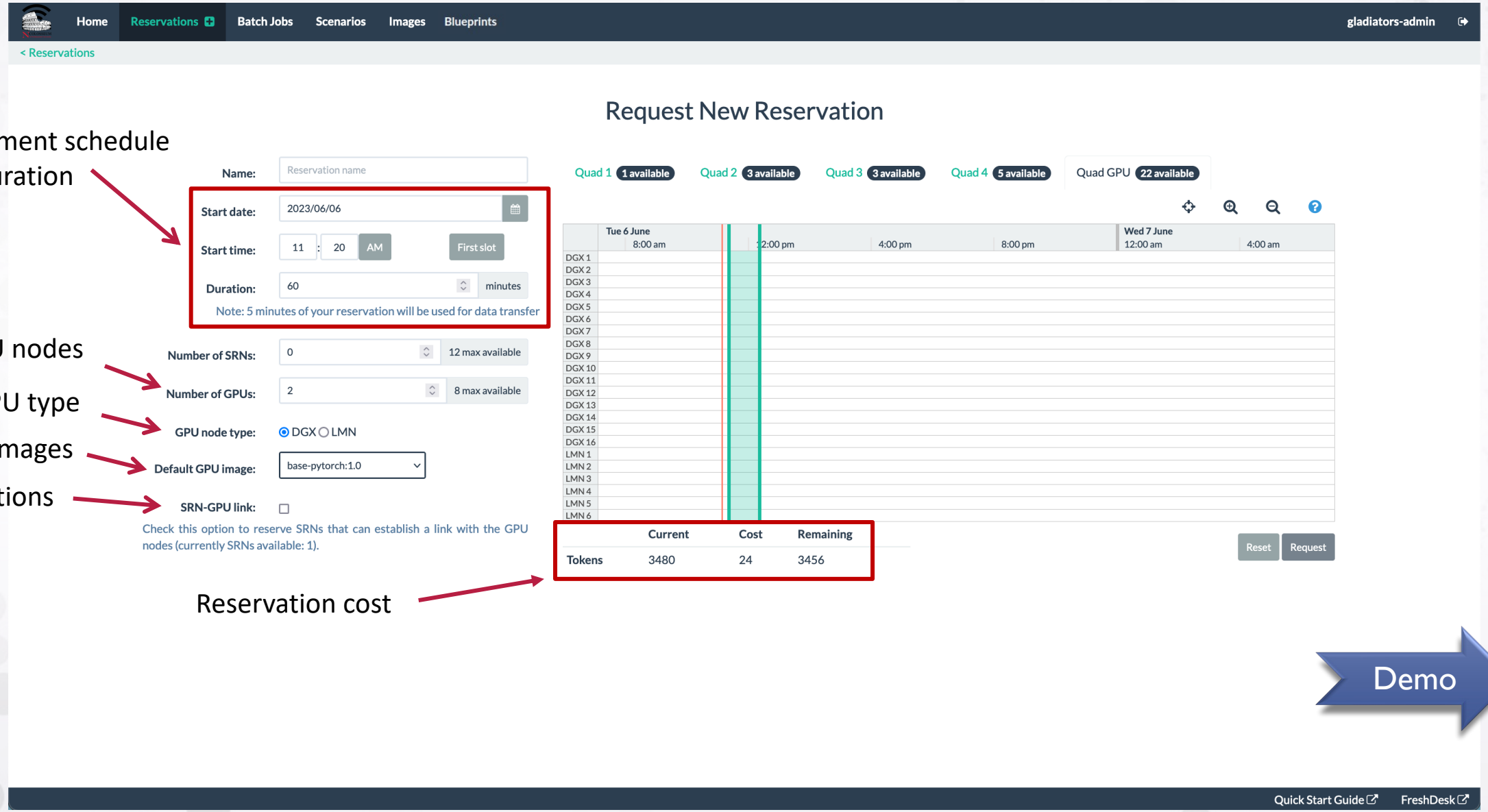
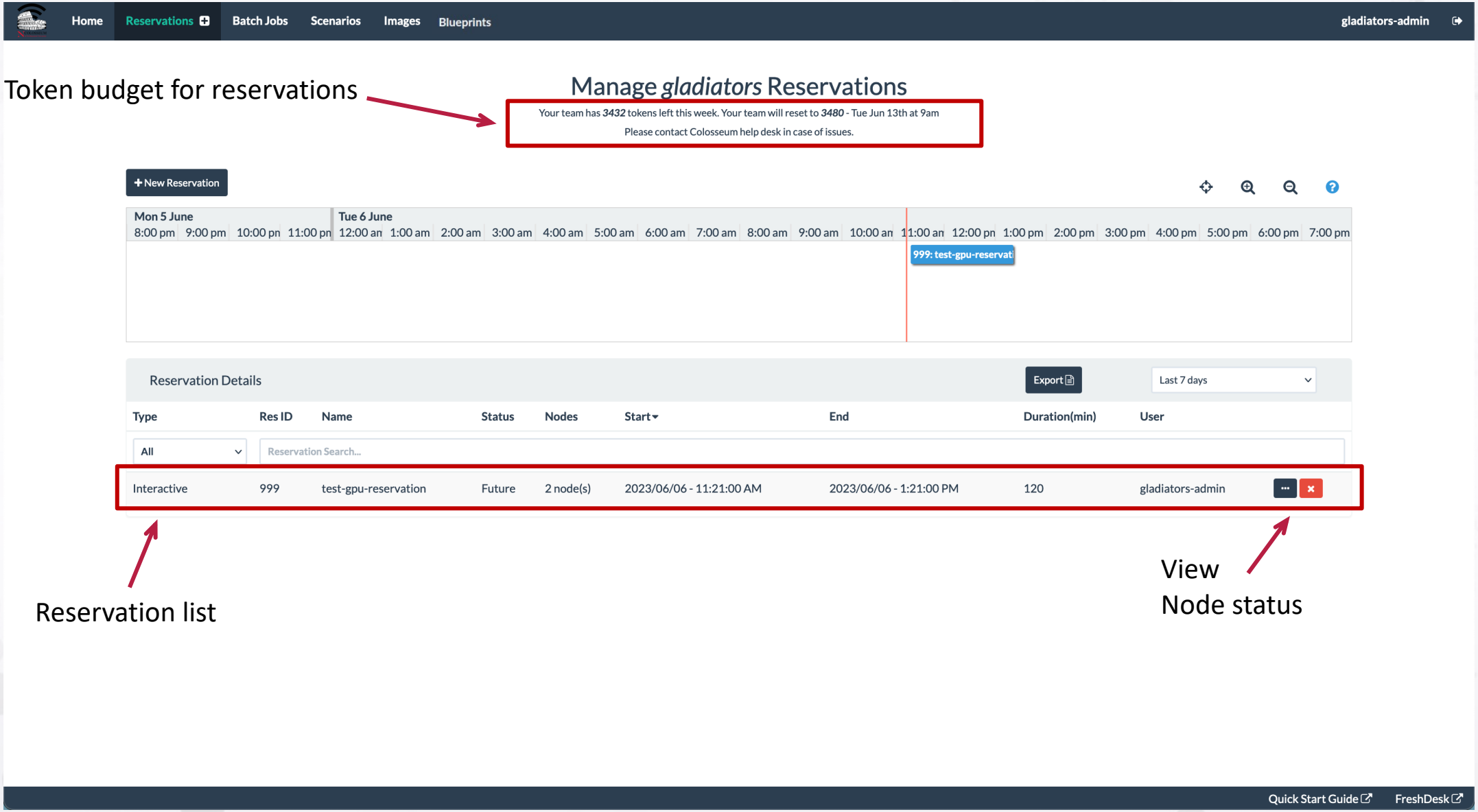
Start a GPU Reservation

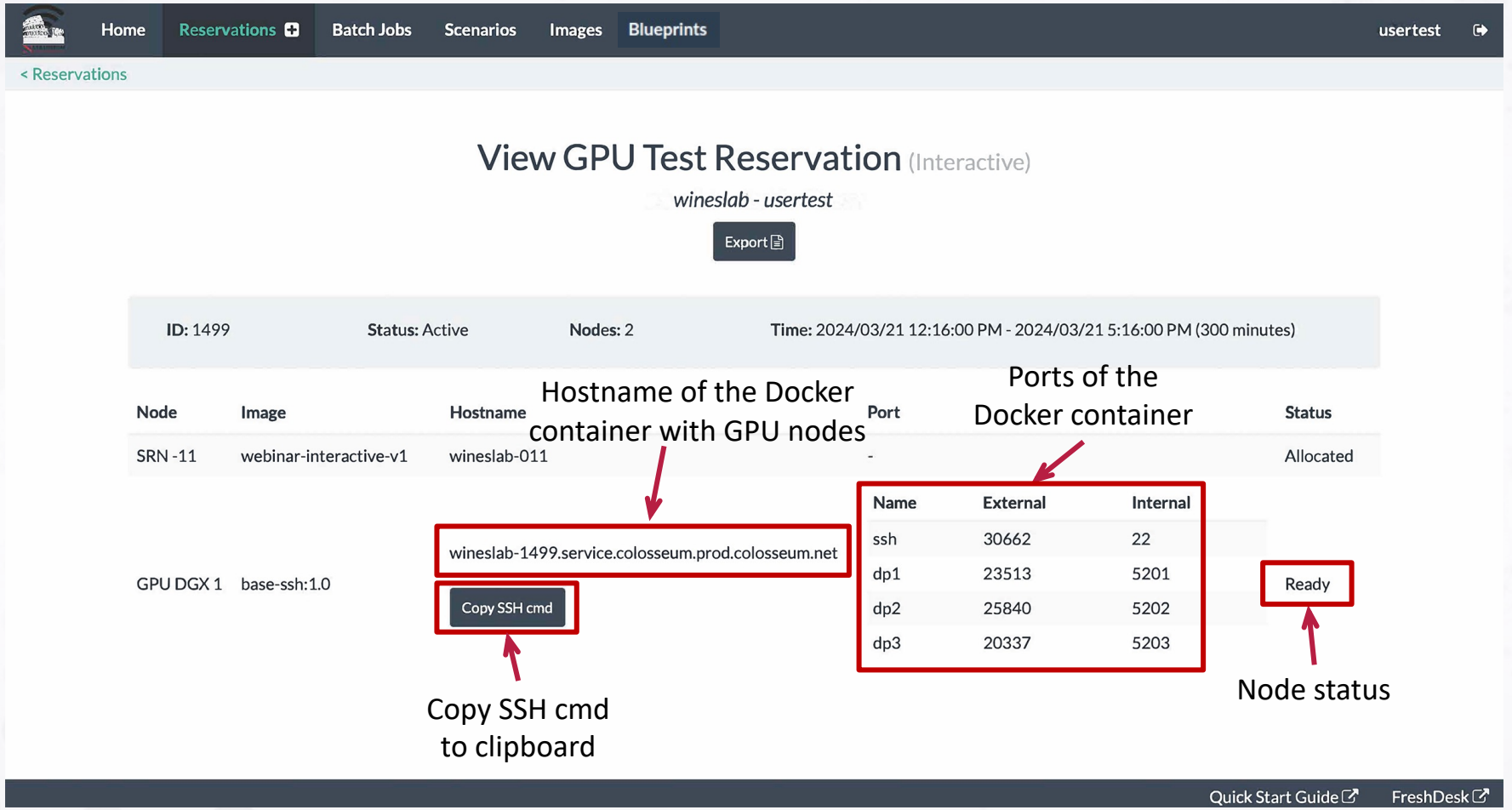


Demo

View Existing Reservations



View Reservation Details

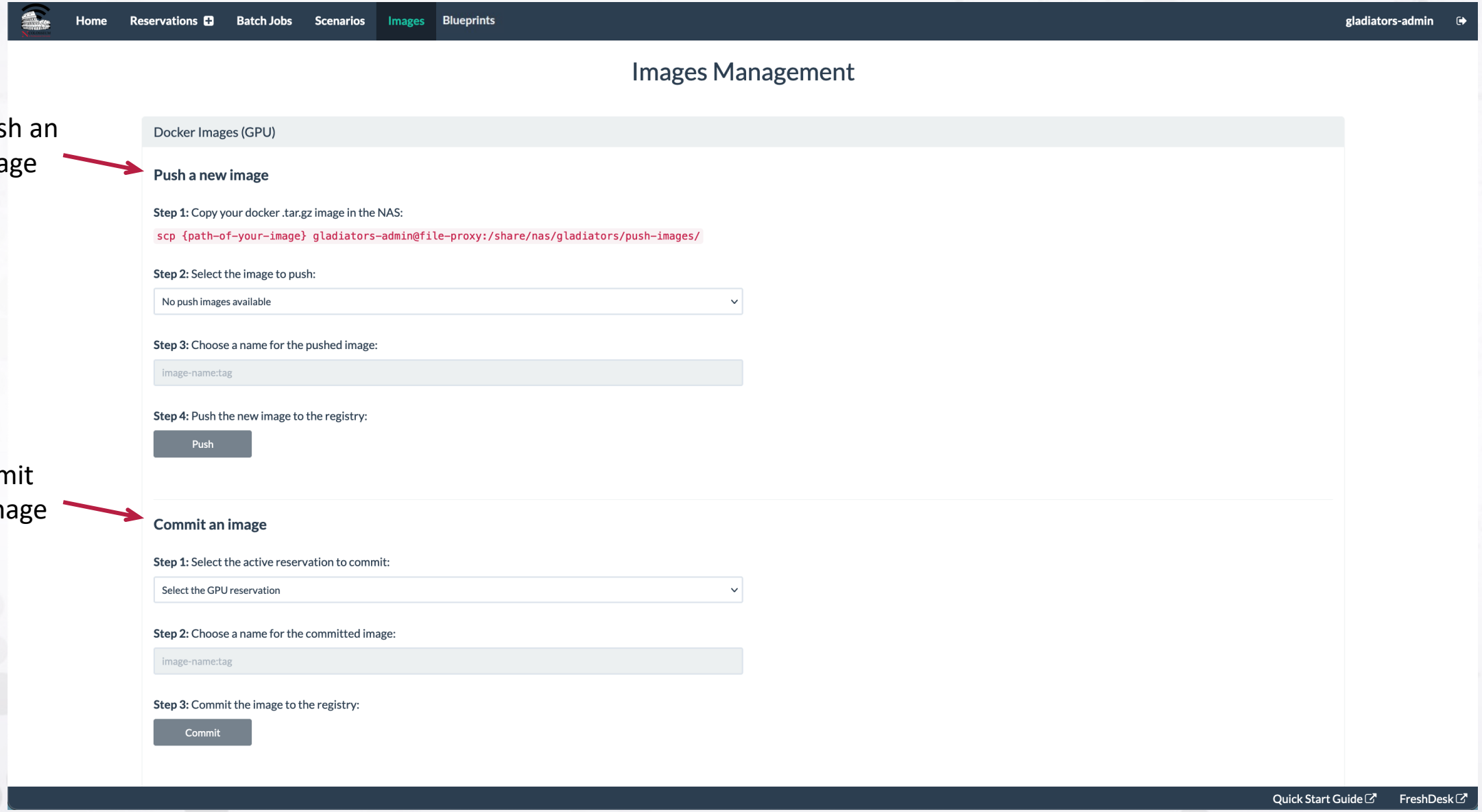


2 types of ports:

- **ssh**: to ssh into the container.
- **dp** (dynamic port): to interact with external apps from SRNs (e.g., iPerf server).

Login example (from your pc): *ssh wineslab-1499.service.colosseum.prod.colosseum.net –p 30662*

Images Management



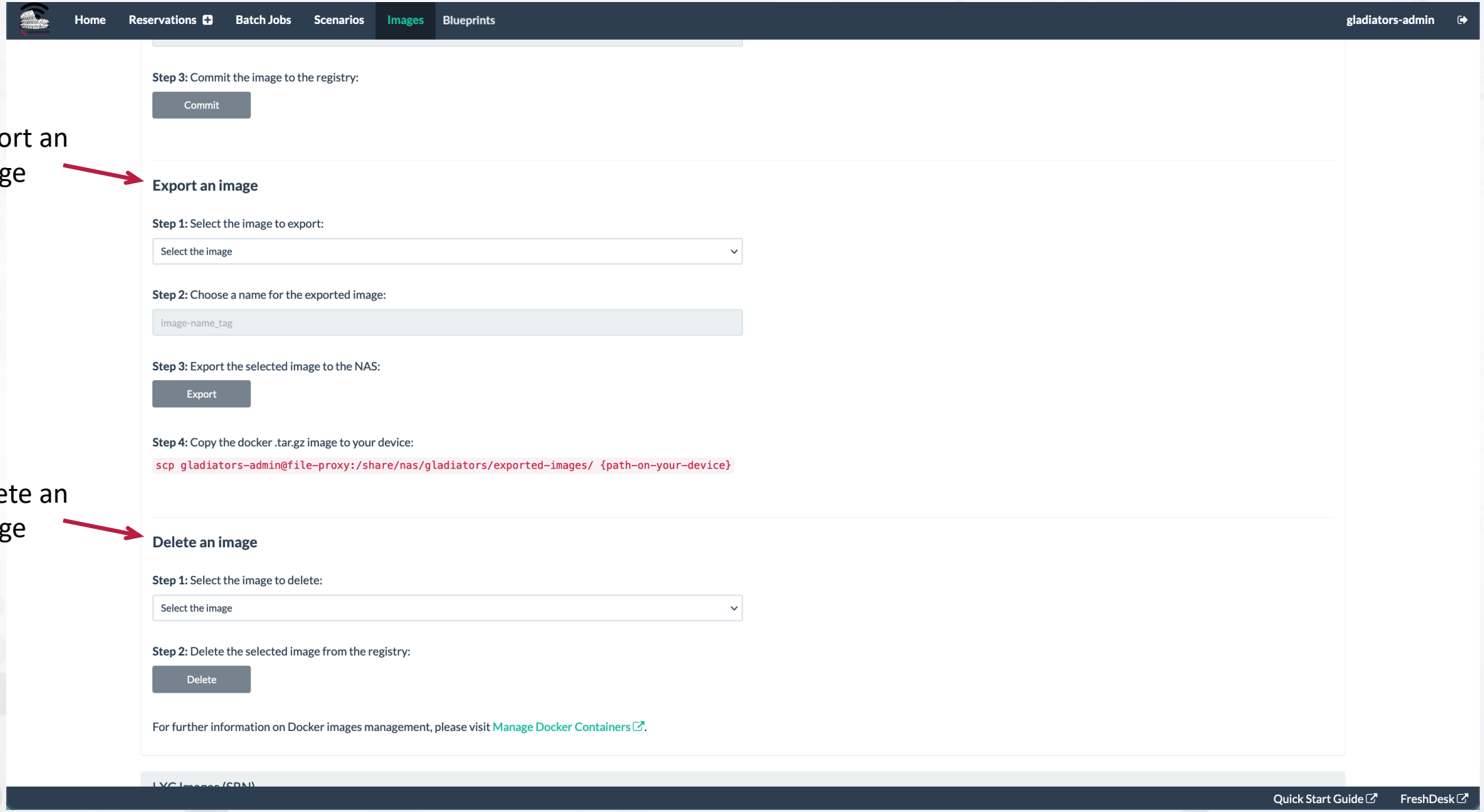
Push an image

Commit an image

Images Management

Export an image

Delete an image



GPU Links to Colosseum Resources and Documentations

- Colosseum Home Page
  - http://colosseum.net
  - https://northeastern.edu/colosseum
- Colosseum Experiment Portal
  - https://experiments.colosseum.net
  - https://experiments.colosseum.net/images
- GitHub Colosseum Sample Dockerfiles
  - https://github.com/colosseum-wiot/colosseum-dockerfiles/
- Freshdesk Guides
  - Logging into a GPU: Link
  - Manage Docker containers: Link
  - Connecting GPU and SRN Reservations: Link

GPU Assignment

GPU Assignment

- We are going to follow an example from Pytorch

Steps to Follow

1. Reserve a time slot for 1 DGX GPU
2. Pick the Pytorch image from common images
3. Connect to the Container using ssh

Steps to Follow

- `wget` the the code and the dataset on your container
- check the `nvidia-smi` for GPUs availability
- Run the code and have fun using `python`
- You can check the results by
  - VS Code / PyCharm
  - scp / rsync

LVX VERITAS VIRTVS

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Thank You! (Questions?)

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