Virtualization and deployment management for the KAT-7 / MeerKAT control and monitoring system

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SKA AFRICA
SQUARE KILOMETRE ARRAY

meerkat karoo array telescope

HartRAO

SKA SQUARE KILOMETRE ARRAY

Introduction

- Radio Telescopes in the Karoo
  - KAT-7
  - MeerKAT
- Deployment of CAM subsystem
  - virtualization
  - automated deployment
  - share some experiences
- Work to improve started end 2011
  - Deployment fraught
  - Hardware failure -> extended downtimes
  - Limited development environments
    - quite different from deployments

Requirements

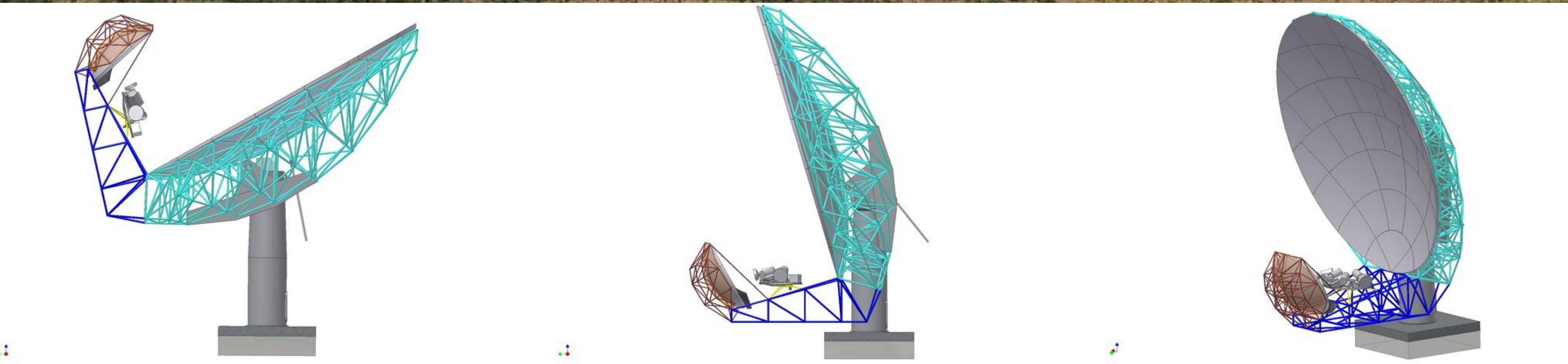
- Deterministic+repeatable system configuration
- Versioned configuration history
  - quick revision roll-back/forward
- Minimize manual steps in deployment
- Minimize downtime
  - CAM software deployment
  - CAM system hardware failure
- Isolate resource usage on a shared server
- Easily deploy development environments
  - similar to site deployment environments
  - limited development hardware resource

Shape of KAT-7 CAM

- Instrument is distributed
  - Karoo Array Telescope Control Protocol (KATCP)
  - Ethernet as fieldbus
- Telescope is Remote
  - Avoid human generated RFI
  - Control via high speed SANReN fibre (ring) network
- Operational Centre in Cape Town
  - Control room 700 km from site
  - Backup and long-term archiving
  - Development
- Mostly coded in the Python language

KAT-7 Array

Future MeerKAT Array



KAT-7 Receptor Receiver

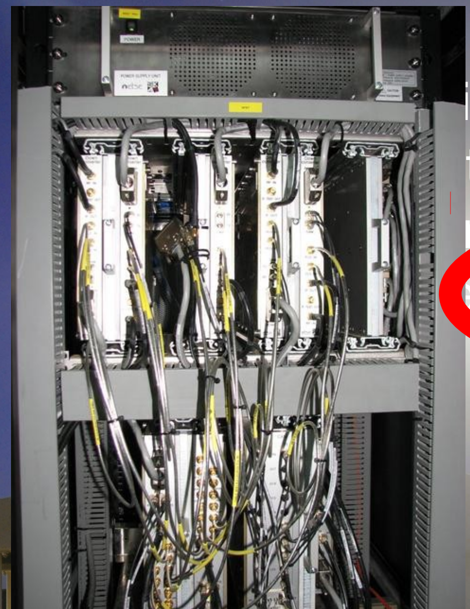
- Receiver Horn Antenna
- RF Low Noise Amplifier (LNA)
- Stirling Cryo cooler with Ion Pump
- RF Noise diode coupler
- RF Amplifier

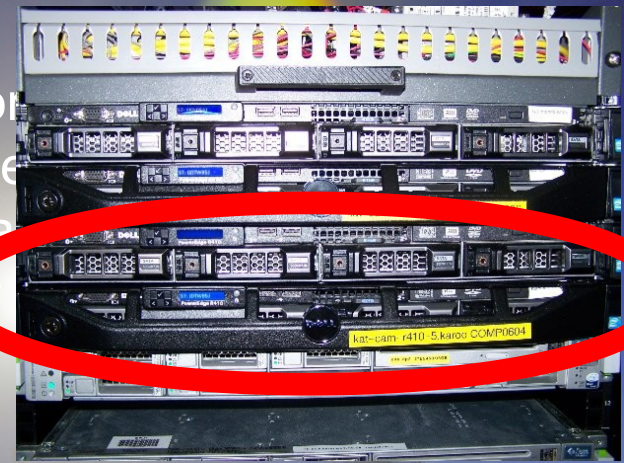
KAT-7 Receptor Pedestal

- Antenna positioner control unit
- RF amplifier/attenuator
- RF to optical transducer
- Pedestal chiller
- Building Management
- Weather station

KAT-7 Compute Container

Inside KAT-7 Compute Container





- Optical to RF transducers
- RF Down-conversion and conditioning
- FPGA based Digital Back End
- Data capture server
- Time/Frequency reference
- CAM Servers
- BMS
- Chiller

• Control Room

Pieces of the Puzzle

- Server Virtualization
- Automated Deployment
- Deployment Configuration Database
- Combined: Hassle-free, deterministic, reliable deployment

Virtualization

- Many Technologies, Many Makers
  - Full virtualization more flexible
  - Containerization more efficient
- Blurring of lines
- Other considerations
  - Familiarity
  - Licensing
  - Supported Host environments

Server Virtualization: Proxmox VE

- Specialized Hypervisor distribution based on Debian GNU/Linux
  - FOSS licensing: no cost, no hassle
- Supports both:
  - Containers: OpenVZ
  - Full virtualization: KVM
- Simple and quick host install
- Easy to use web-based management tools
- Pre-configured base OS containers

Performance

- CAM uses soft-realtime design
  - Only needs enough aggregate CPU throughput
- Similar aggregate CPU utilization on host before and after virtualization
- IO-bound tests using 10 GbE interface
- Using different virtualization options

Test Machine

SUN FIRE X4150
2x Intel(R) Quad-core Xeon(R) E5450 CPUs
16 GB RAM
Gen 1 Myricom Myri10GE 10GbE

Performance results

Config	Rate (Gb/s)	CPU use (%)	Relative rate (%)	CPU / Gb/s (%)
Baseline	5.49	65.8	100.0	12.0
Host	4.80	59.2	87.5	12.3
OVZ exclusive	4.65	61.2	84.7	13.2
OVZ veth	3.72	21.1	67.8	5.8
OVZ venet	3.86	20.3	70.4	5.3
KVM virtio	2.39	60.5	43.6	25.3

- Baseline: Ubuntu 10.04
- CAM uses veth
  - Most flexible
- Only 2x1Gb interfaces in production

Desktop virtualization: Virtualbox

- Simulated system on developer, commissioner workstations
  - Toy-KAT VM
- Variety of workstation OSes
  - Can't take over whole machine for hypervisor
- Virtualbox virtualization host runs on them all
- Also FOSS licensing
- Not production use
  - positive experience

Software Configuration Management

- Automated Deployment Scripts
- Deployment Configuration Database
- Configuration Manager

SW Configuration Management Tech

- Preferred a Python based solution
- Considered existing 'full stack' systems (e.g. Puppet, Chef, Saltstack)
  - Central management server
  - Upfront time investment

Our Sw Conf Management System

- Experimented with Fabric
  - Python based SSH automation library
- Script logic is defined in Python
  - Only requires SSH server on nodes to be managed
- Started capturing node configuration details
  - simple text file in INI-format
- Started implementing a Configuration Manager
  - Parsed the configuration database file
- Fabric library functions to deploy tasks to nodes
- Soon got team buy-in

Configuration Database

- Node network configuration
- Node hosting type
- Assigned node resources
  - number of CPUs
  - RAM
  - Unique container / VM ID number
  - Diskpace, etc.
- Other meta information

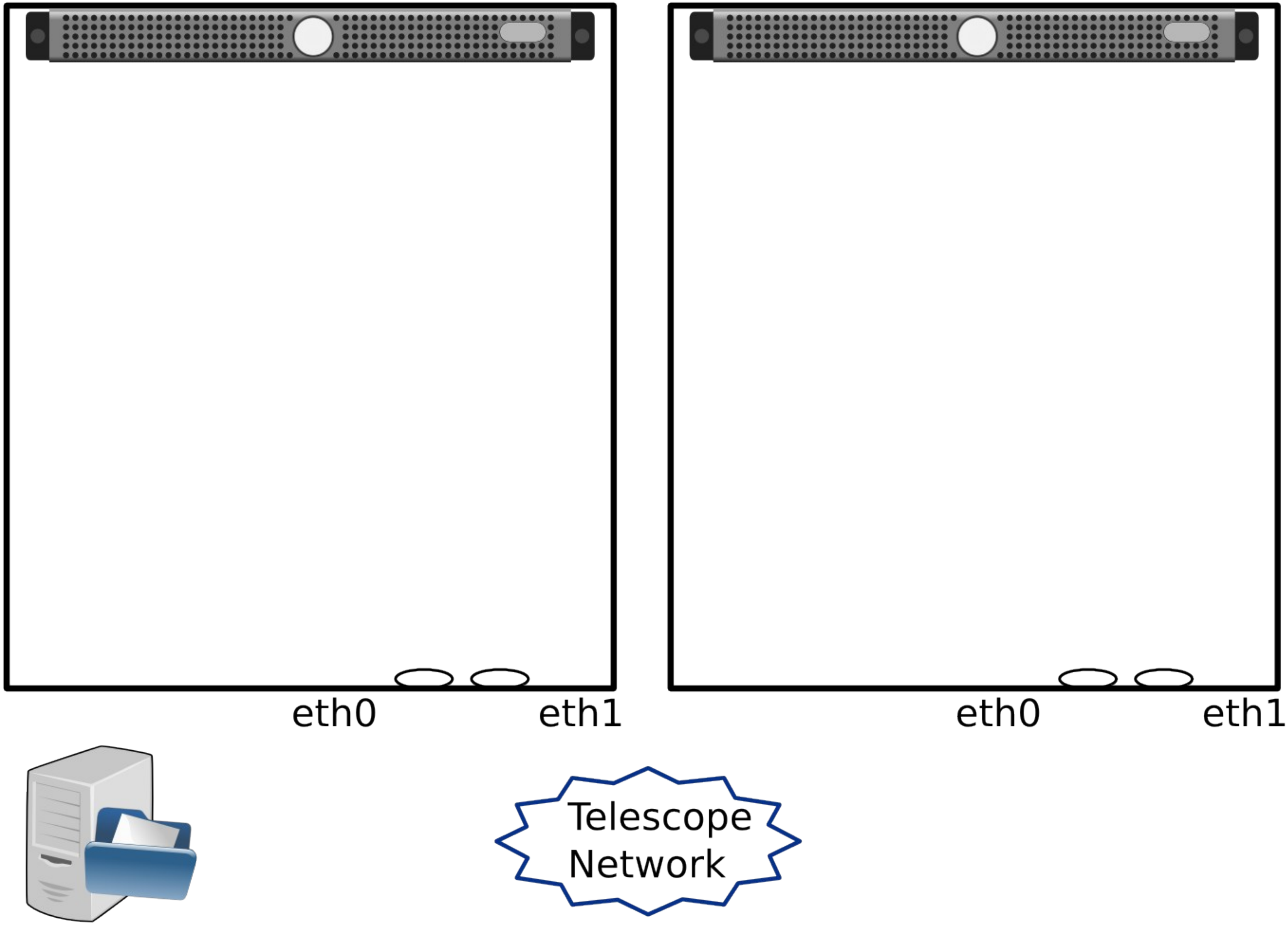
Disposability and Persistentance

- Node containers are treated as disposable
  - Production containers rebuilt at each major release
- Development environments are routinely rebuilt
- Persistent data has to be managed separately
- NAS server, exported via NFS
  - Node NFS mounts configed as part of deployment
  - Potential issues with changing dB schemas
  - Central point for backups

Deployment steps

- Configuring Proxmox hypervisor hosts
- Provisioning
- Configuration

Unconfigured Hosts

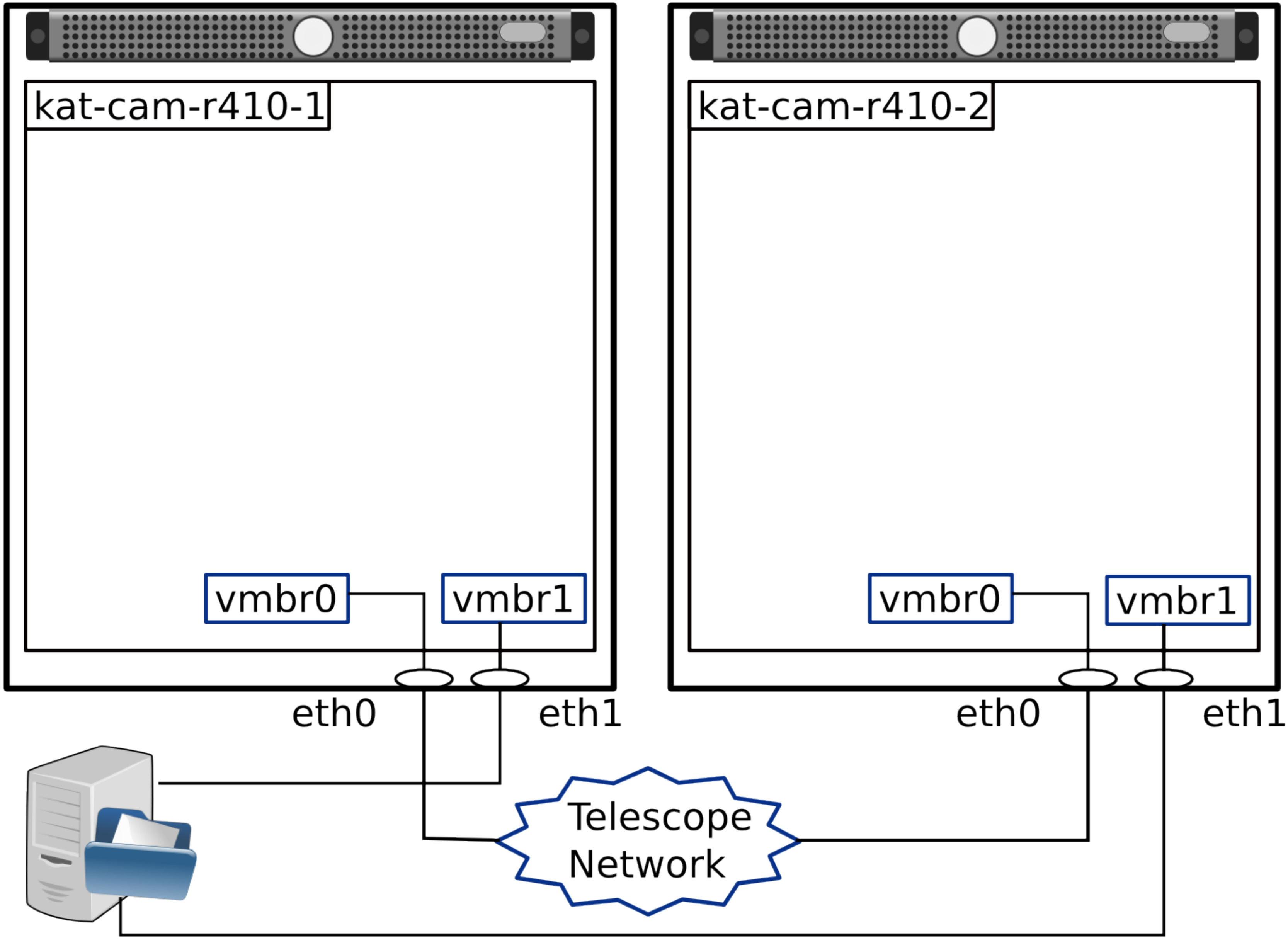


Configuring Proxmox host

- Rarely done
- Install base Proxmox from CD
- Takes about 15 minutes including fab below

```
fab -H root@kat-cam-r410-1,root@kat-cam-r410-2\
    proxmox.configure_host
```

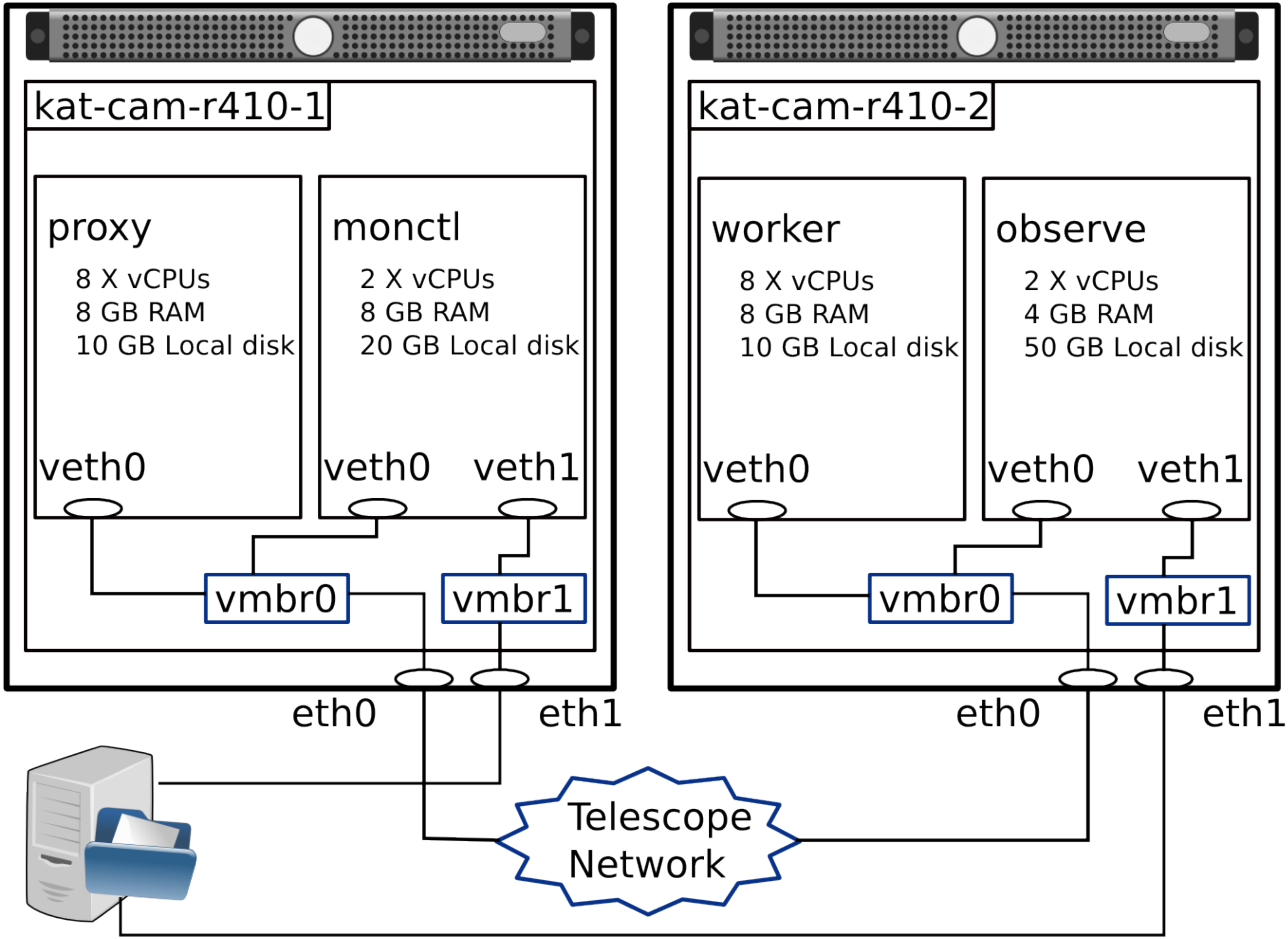
Proxmox installed and configured



Provision Node Containers

fab proxmox.create_containers_by_group:\
karoo_system_nodes,700

Virtual Node Containers Provisioned

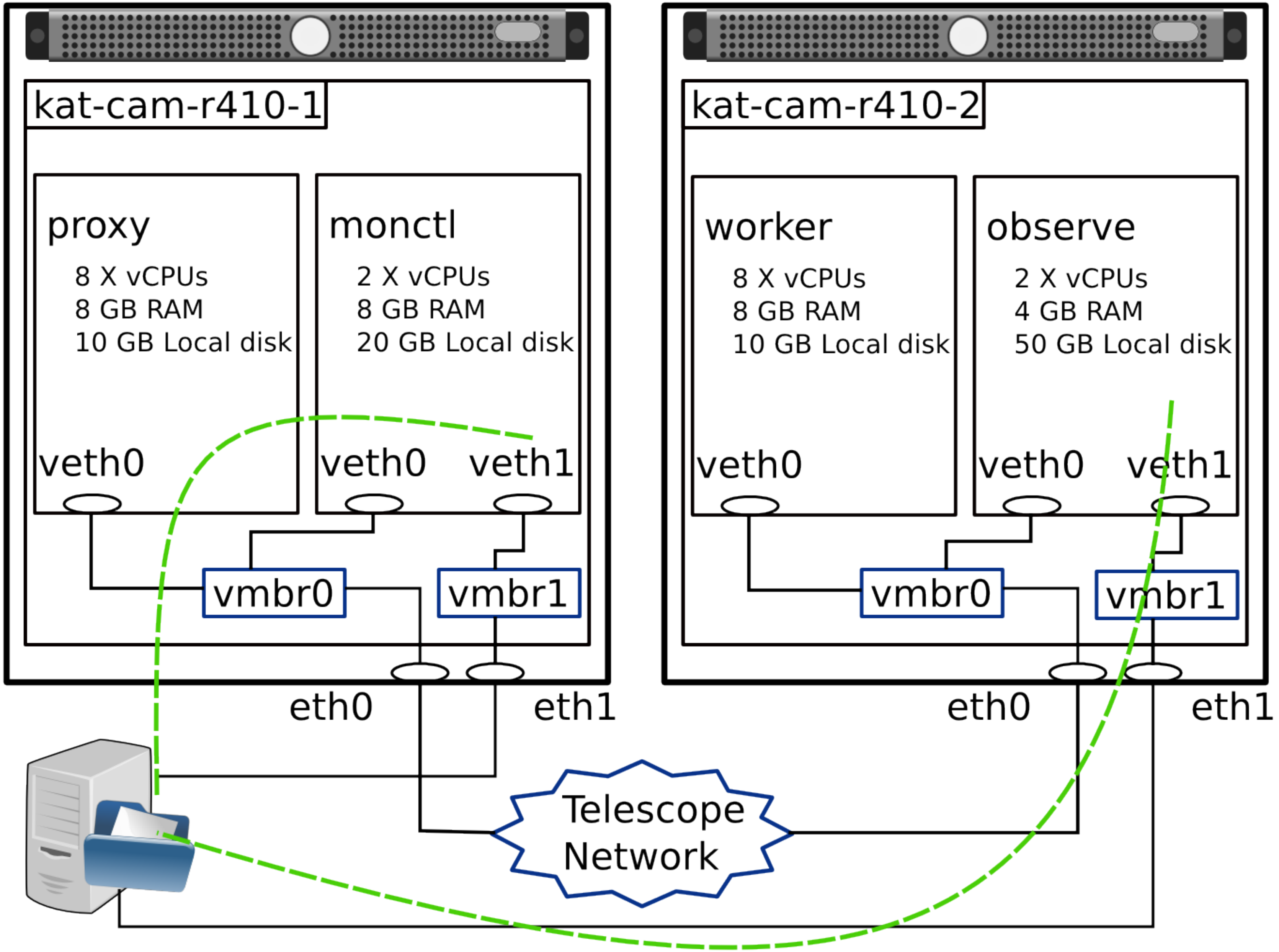


Configure Nodes

```
fab kat_deploy.install_nodes_by_group:\
karoo_system_nodes,karoocamv7-requirements.txt
```

- Install system packages (apt-get install ...)
- Install python packages (pip install ...)
- Configure NFS mounts
- Check out, build, install and configure packages from internal SVN
- Configure web servers, cron jobs, other OS level services as required
- Set up databases (schemas if needed)

Nodes Configured



Some Experiences

- Importance of transitioning from a mostly manual to automated deployment step by step.
- Remaining deployment problems are entered into our issue tracker
  - Deployment issues are prioritised for fixing
- Important to make deployment processes idempotent
- Important to make each step reliable
  - Local copies of internet based resources (PyPI and Ubuntu repositories)
  - Unexpected race conditions when things are not done at 'human' speed
- Usefulness of virtualization to allow testing and experiment with the deployment process -- you can just throw away and re-build a virtual node to test from-scrach deployment.
  - Also means we can test deployment, and not just our software

Conclusion

Most frequently experienced advantages are:

- Easy deployment of realistic development/testing environments
  - including virtual networking mirroring actual configurations)
- Ability to quickly switch between software versions by switching containers

- Have largely met our goals

Future work:

- Deployment to fresh containers in the Continuous Integration process
  - Running full integration test suite on these containers
- Automatic daily building of Toy-KAT VMs
- Converting all legacy configuration scripts to the Fabric framework
- Future MeerKAT deployment should be more of the same
  - more complex network configuration

Thank you!