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# Warewulf making cluster installations fast and reliable

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# Introduction

Warewulf is tool for managing beowulf clusters

## Beowulf

- old british poem

## Beowulf cluster

- became popular in the 90.
- use of the shelf hardware
  - 486 & linux
  - **not** Cray & unix
- warewulf is a typo of werewolf

# Introduction

## HPC landscape

### Top five Supercomputers

| | | | | |
|---|---|---|---|---|
| 1 | Frontier | EPYC 64C | AMD MI250X | Slingshot-11 |
| 2 | Aurora | Xeon 9470 | Intel GPU Max | Slingshot-11 |
| 3 | Eagle | Xeon 8480 | NVIDIA H100 | NVIDIA Infiniband |
| 4 | Fugaku | A64FX 48C 2.2GHz | - | Tofu interconnect D |
| 5 | LUMI | EPYC 64C 2GHz | AMD MI250X | Slingshot-11 |

- only Fugaku uses non standard CPU
- others are beowulf clusters with GPUs attached

# Introduction

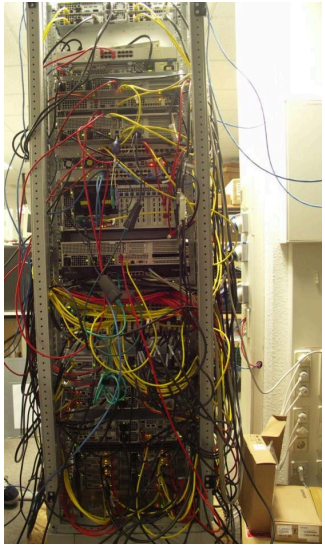
Beowulf cluster

## base components

- management node
- compute nodes
- management network

## optional components

- more compute nodes
- fast network interconnects
- central storage
- bmc/ipmi

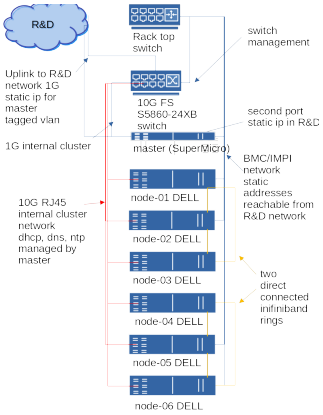


# Introduction

## Beowulf Cluster

### differences to data centers

- compute nodes are cattle
- hierarchical organization
- compute are not updated after boot process
- application come from central storage
- applications are self compiled
- one application can run over several nodes



# Warewulf description

software stack

## warewulf components

### warewulfd delivers

- kernel & modules
- node image
- node configurations

### `wwctl` cmd line tool

- manages node database
- manages node image

## external components

### dhcp server

- ISC dhcpd server
- dnsmasq

### tftp

- kernel tftp
- dnsmasq

## optional

- nfs
- manage `/etc/hosts`

# Warewulf configuration

## database `/etc/warewulf/nodes.conf`

- plain yaml file
- easy backup
- can be version controlled
- external tools support
  - vim, ansible

### profiles

- stores identical values for collection of nodes
- values can be overiden on node basis

```
WW_INTERNAL: 45
nodeprofiles:
  default:
    comment: This profile is automatical
    container name: leap
    network devices:
      default:
        device: eth0
nodes:
  n01:
    profiles:
    - default
    network devices:
      default:
        hwaddr: 52:54:00:4e:cb:1d
        ipaddr: 172.16.130.101
  n02:
```

# Warewulf configuration

## command line database manipulation

### add node

```
wwctl node add n01
    -I 10.10.10.1
```

### modify node

```
wwctl node set n01
    --comment "
   Have fun"
```

### list node

```
wwctl node list
   n01 -a
```

```
NODE FIELD                          PROFILE    VALUE
n01  Id                             --         n01
n01  Comment                        SUPERSEDED Have fun
n01  ContainerName                  default    leap
n01  Ipxe                           --         (default)
n01  RuntimeOverlay                 --         (generic)
n01  SystemOverlay                  --         (wwinit)
n01  Root                           --         (initramfs)
n01  Discoverable                   --         false
n01  Init                           --         (/sbin/init)
n01  Kernel.Args                    --         (quiet crashkernel
n01  Profiles                       --         default
n01  PrimaryNetDev                  --         (default)
n01  NetDevs[default].Type          --         (ethernet)
n01  NetDevs[default].OnBoot        --         (true)
n01  NetDevs[default].Device        default    eth0
n01  NetDevs[default].Hwaddr        --         52:54:00:4e:cb:1d
```

# Warewulf configuration

templates& overlays

## Configuration templates

- based on go templates
- {{.*foo*}} replaced with variable `foo`
- exported go function can be called

## Configuration overlays

- rendered templates packed into overlay
- overlay put ontop of node image

Listing 1: issue.ww

```
Warewulf Node:      {{.Id}}
Container:          {{.Container}}
{{ if .Kernel.Version }}Kernel:
Kernelargs:         {{.Kernel.Args}}

Network:
{{- range $devname, $netdev := .NetDevs}}
    {{$devname}}: {{$netdev.Device}}
    {{$devname}}: {{$netdev.IpCIDR}}
{{if $netdev.Ipaddr6 }}    {{$devname}}:
{{if $netdev.Hwaddr }}    {{$devname}}:
{{end}}
```

# Warewulf configuration

## overlays

warewulf defines two types of overlays

### system overlay

- available on boot
- warewulf boot strap files
- static network configurations:
  - wicked
  - NetworkManager
  - EL scripts
- nfs mounts
- file system mounts

### runtime overlay

- updated on regular base
- can be secured

### user defined overlays

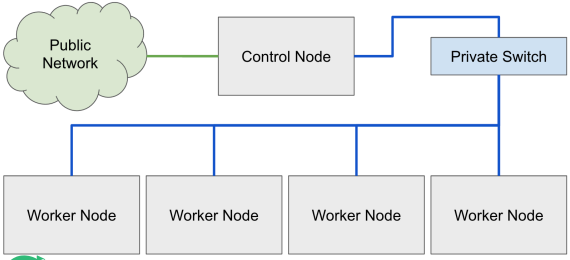
- users are encouraged to create own configuration templates
- can reside in system & runtime overlays

# Warewulf configuration

## security

### assumptions

- private/cluster network is secure
- lateral movement isn't accounted
  - NFS mounts are common, when not **mandatory**




### measurements

- node image & system overlay protected with BIOS UUID
- system overlays **must** be downloaded from privileged port

# Warewulf configuration

## node images

### definition

- complete OS images
- called containers in warewulf
- must be imported from:
  - chroot directory
  - docker registry
  - local `dockerd`
- several different node images can be imported
- node images are vendor independent

### `registry.suse.com`

- SUSE SLE 15SP5

### `registry.opensuse.org`

- openSUSE Tumleweed
- openSUSE Leap 15SP[3-5]

### `ghcr.io`

- openSUSE Leap
- Rocky EL (8&9)
- Debian Bockworm

# Warewulf configuration

## node image examples

### Import the SLE image

```
ww4-host:~> export WAREWULF_OCI_USERNAME=cgoll@suse.com
ww4-host:~> export WAREWULF_OCI_PASSWORD=INTERNAL-USE-ONLY-xxxxxx
ww4-host:~> wwctl container import docker://registry.suse.com/suse/hpc/
    warewulf4-x86_64/sle-hpc-node:latest sle-hpc
```

### Import the Leap image

```
ww4-host:~> wwctl container import container import docker://registry.
    opensuse.org/science/warewulf/leap-15.5/containers/kernel:latest leap
```

# Warewulf configuration

## node image examples

### Execute shell in images

```
wwctl container shell sle-hpc
WARN   : Couldn`t mount /etc/SUSEConnect to /etc/SUSEConnect: no such
    file or directory
WARN   : Couldn`t mount /etc/zypp/credentials.d/SCCcredentials to /etc/
    zypp/credentials.d/SCCcredentials: no such file or directory
[sle-hpc] Warewulf>
```

- SLE registration from outer node is mounted into image

# Warewulf configuration

disk management

## Needs following elements:

- disks
- partitions needs parent disk
- filesystem needs partent partition

## implementation

- call `ignition` with ignition-ww4-disk.service
- **not** in dracut
- **before** `sysroot.mount`

## single parition

```
wwctl node set n01 --diskname /dev/vda --diskwipe --partname scratch --partcreate --fsname scratch --fsformat btrfs --fspath /scratch --fswipe
```

## add swap

```
wwctl node set n01 --diskname /dev/vda --partname swap --partsize=1024 --partnumber 1 --fsname swap --fsformat swap --fspath swap
```

# Warewulf boot

## boot process

### boot with iPXE

- distribution iPXE binaries are used
- `tftp` transfers are small
- `kernel` is extracted from container on the fly
- root fs is the container image configuration overlay added on top
- **no** secure boot