Using NixOS for declarative deployment and testing

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Linux distributions

There are a wide range of Linux distributions available, each having different properties and goals.

fedora debian ubuntu

slackware linux

NixOS

Software deployment

Software deployment

All of the activities that make a software system available for use
Carzaninga et al.

Activities

- Install a Linux distribution with some desired packages
- Adapt/tweak configuration files
- Install custom pieces of software
- Upgrade a system

Deployment scenario

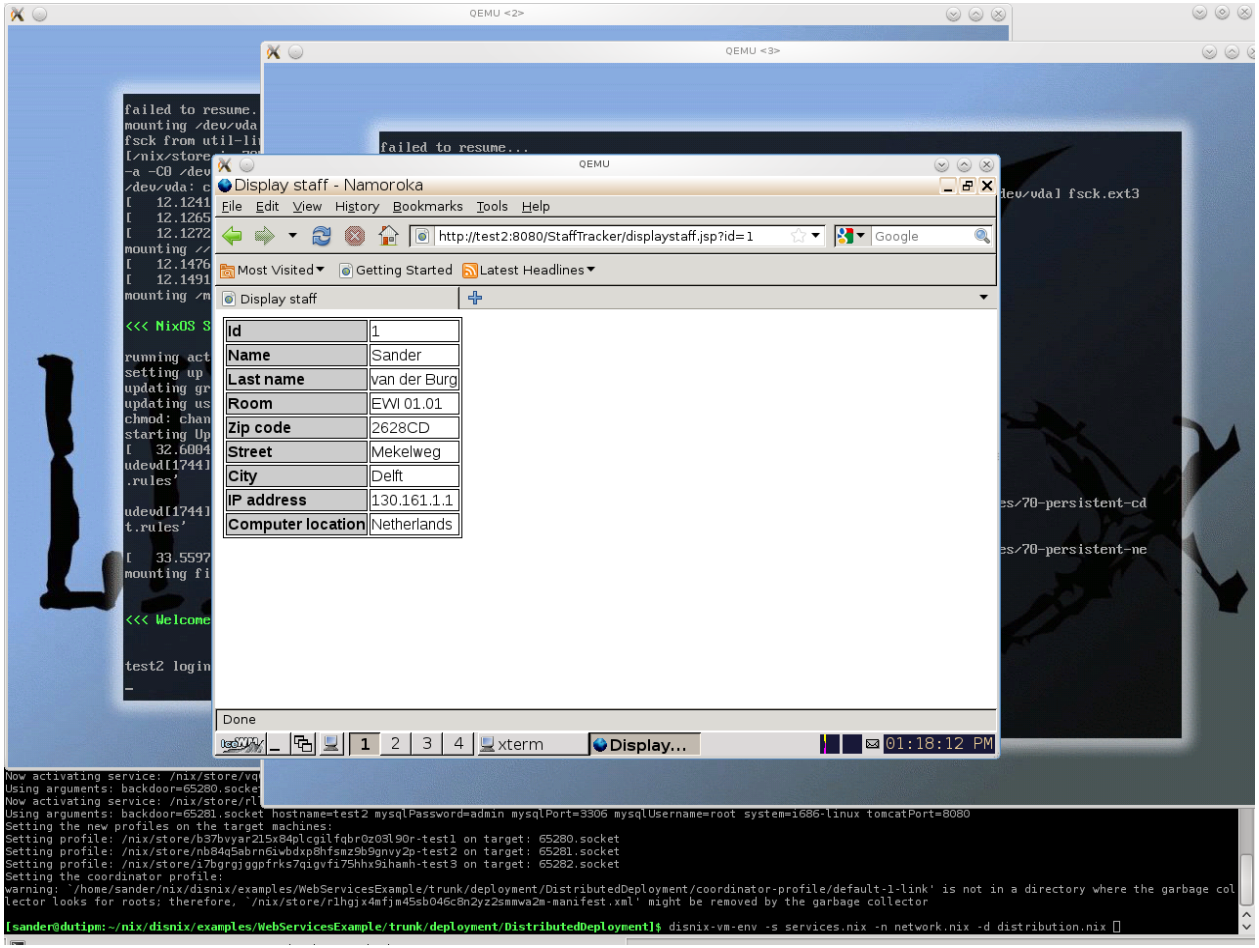
Single installation

Deployment scenario

- Multiple installations
- Machines are connected and dependent on each other

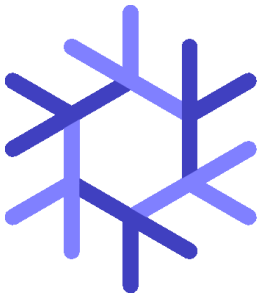
Deployment scenario

Virtual machines



Challenges

- Deploying a single machine is hard
  - Takes some effort
  - Upgrading may break the system
- Deploying a distributed environment is even harder
  - Machines may be dependent on each other, e.g. web application using a database
  - While upgrading, downtimes may occur
- Deploying (a network of) virtual machines is also hard
  - Takes quite some effort to perform system integration tests



NixOS

A GNU/Linux distribution using the Nix package manager

Nix store

Main idea: store all packages in isolation from each other:

`/nix/store/rpdqxnilb0cg...-firefox-3.5.4`

Paths contain a 160-bit **cryptographic hash** of **all** inputs used to build the package:

- Sources
- Libraries
- Compilers
- Build scripts
- ...

```
/nix/store
├─ l9w6773m1msy...-openssh-4.6p1
│  ├─ bin
│  │  └─ ssh
│  └─ sbin
│     └─ sshd
├─ smkabrbibqv7...-openssl-0.9.8e
│  └─ lib
│     └─ libssl.so.0.9.8
├─ c6jbqm2mc0a7...-zlib-1.2.3
│  └─ lib
│     └─ libz.so.1.2.3
└─ im276akmsrhv...-glibc-2.5
   └─ lib
      └─ libc.so.6
```

Nix expressions

openssh.nix

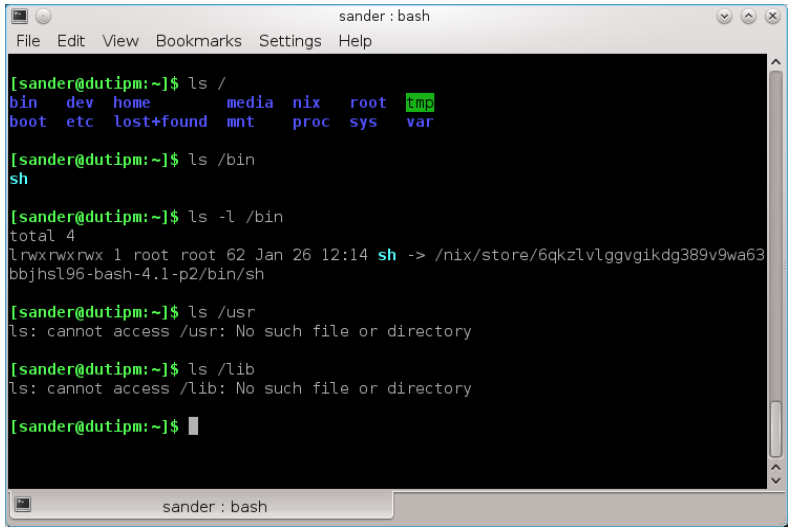
```
{ stdenv, fetchurl, openssl, zlib }:

stdenv.mkDerivation {
  name = "openssh-4.6p1";
  src = fetchurl {
    url = http://.../openssh-4.6p1.tar.gz;
    sha256 = "0fpjlr3bfind0y94bk442x2p...";
  };
  buildCommand = ''
    tar xjf $src
    ./configure --prefix=$out --with-openssl=${openssl}
    make; make install
  '';
}
```

Nix expressions

all-packages.nix

```
openssh = import ../tools/networking/openssh {
  inherit fetchurl stdenv openssl zlib;
};

openssl = import ../development/libraries/openssl {
  inherit fetchurl stdenv perl;
};

stdenv = ...;
openssl = ...;
zlib = ...;
perl = ...;
```

- `nix-env -f all-packages.nix -iA openssh`
- Produces a `/nix/store/l9w6773m1msy...-openssh-4.6p1` package in the Nix store.



- In NixOS, all packages including the Linux kernel and configuration files are managed by Nix.
- NixOS does not have directories such as: `/lib` and `/usr`
- NixOS has a minimal `/bin` and `/etc`
- But NixOS is more then just a distribution managed by Nix

NixOS configuration

/etc/nixos/configuration.nix

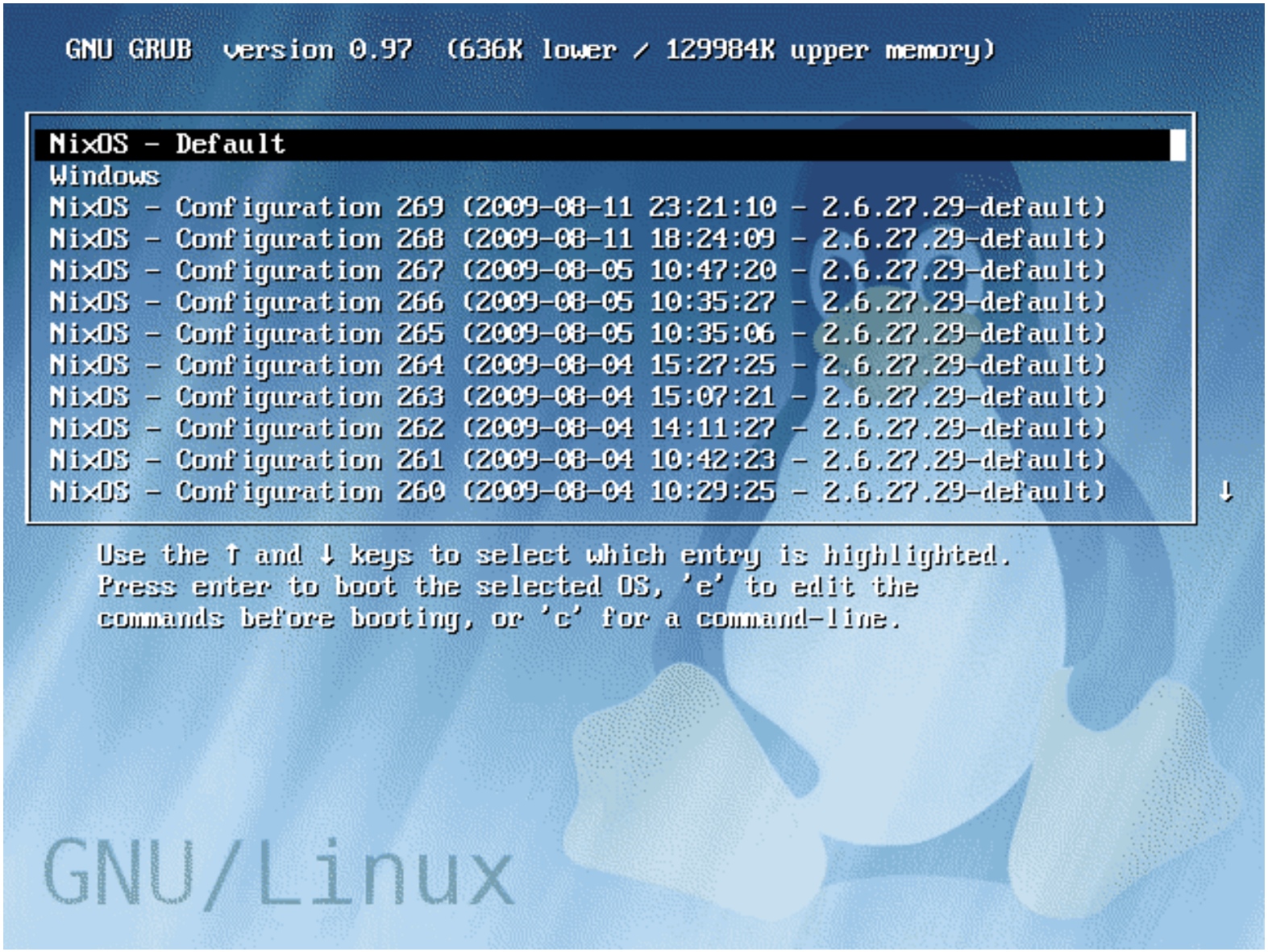
```
{pkgs, ...}:

{
  boot.loader.grub.device = "/dev/sda";

  fileSystems = [ { mountPoint = "/"; device = "/dev/sda2"; } ];
  swapDevices = [ { device = "/dev/sda1"; } ];

  services = {
    openssh.enable = true;

    xserver = {
      enable = true;
      desktopManager.kde4.enable = true;
    };
  };

  environment.systemPackages = [ pkgs.mc pkgs.firefox ];
}
```

NixOS configuration

nixos-rebuild switch

- Nix package manager builds a complete system configuration
  - Includes all packages and generates all configuration files, e.g. OpenSSH configuration
- Upgrades are (almost) atomic
  - Components are stored safely next to each other, due to hashes
  - No files are automatically removed or overwritten
- Users can switch to older generations of system configurations not garbage collected yet

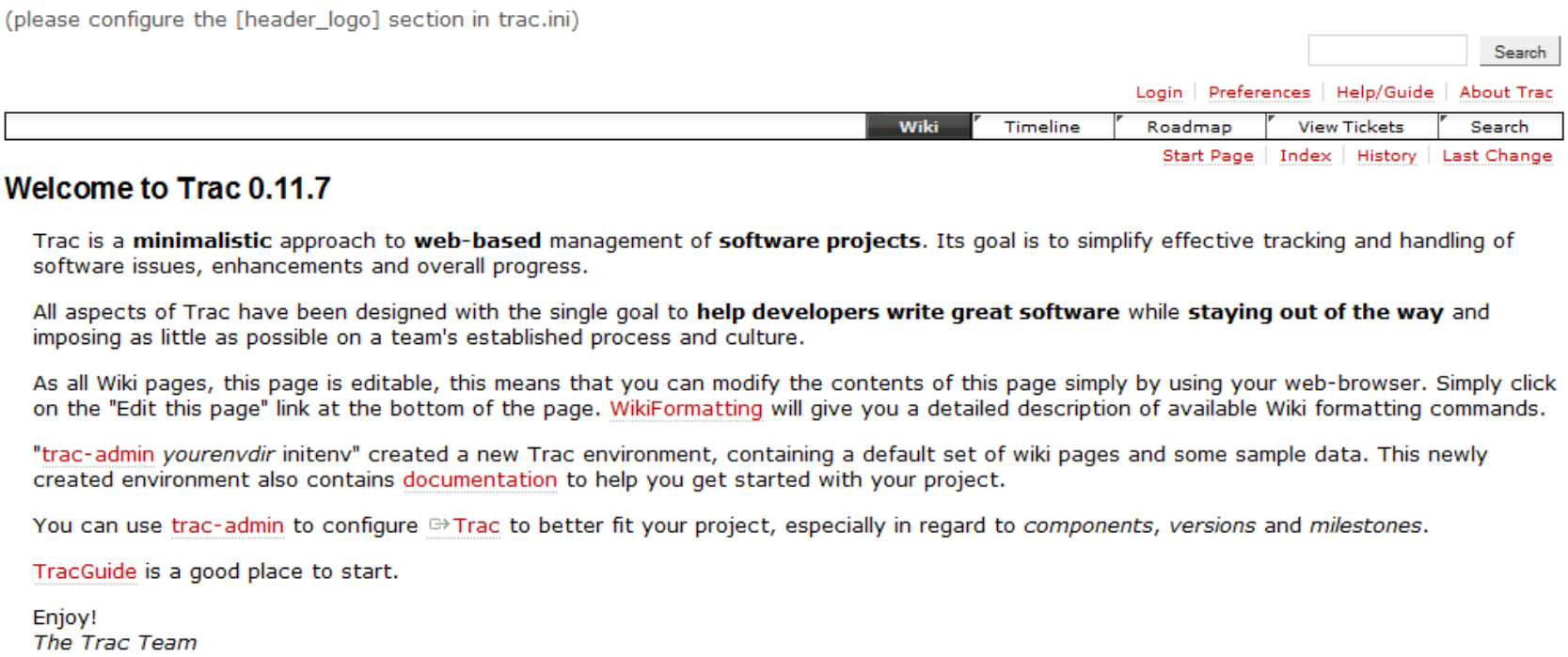
NixOS bootloader



Distributed deployment

- NixOS has good properties for deployment of a single system
- Can we extend these properties to distributed systems?

Motivating example: Trac



Motivating example: Trac

Trac can be deployed in a *distributed* environment:

- Subversion server
- Database server
- Web server

Distributed NixOS configuration

network.nix

```
{ storage = {pkgs, ...}:
    {
      services.nfsKernel.server.enable = true; ...
    };

  postgresql = {pkgs, ...}:
    {
      services.postgresql.enable = true; ...
    };

  webserver = {pkgs, ...}:
    {
      fileSystems = [
        { mountPoint = "/repos"; device = "storage:/repos"; } ];
      services.httpd.enable = true;
      services.httpd.extraSubservices = [ { serviceType = "trac"; } ]; ...
    };

  ...
}
```

Distributed deployment

```
nixos-deploy-network network.nix
```

- Build system configurations by the Nix package manager
- Transfer complete system and all dependencies to target machines in the network
  - Efficient: only missing store paths must be transferred
  - Safe: Existing configuration is not affected, because no files are overwritten or removed
- Activate new system configuration
  - In case of a failure, roll back all configurations
  - Relatively cheap operation, because old configuration is stored next to new configuration

Virtualization

```
nixos-build-vms network.nix; ./result/bin/nixos-run-vms
```

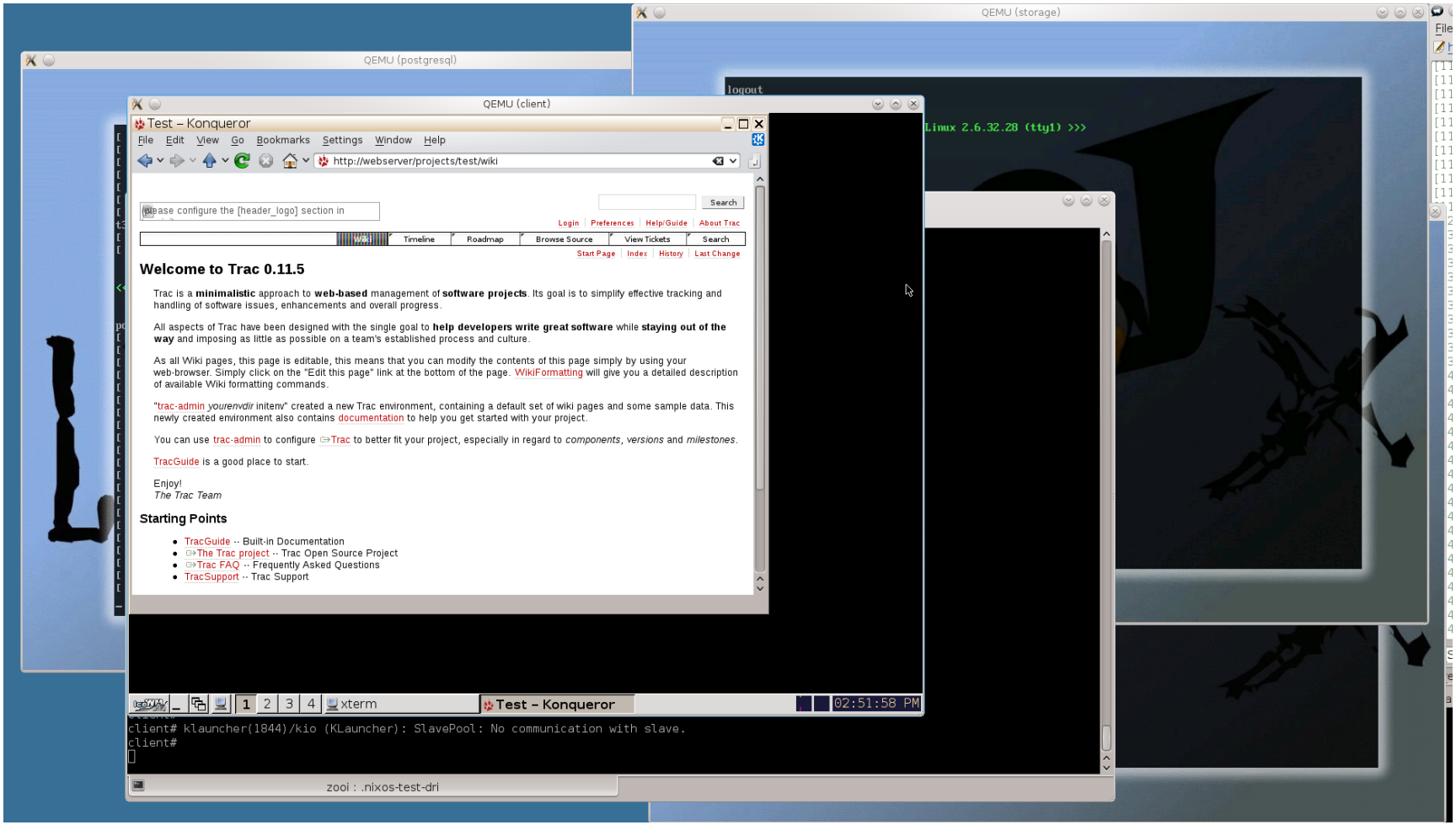
- Builds a network of QEMU-KVM virtual machines closely resembling the network of NixOS configurations
- We don't create disk images
- The VM mounts the Nix store of the host system using SMB/CIFS

Virtualization

```
nixos-build-vms network.nix; ./result/bin/nixos-run-vms
```

- Possible because complete configuration is in the Nix store
- This is efficient and safe due to the nature of the Nix store
  - Components with same hash codes are shared between VMs
  - The hash part of the name isolates components from each other
- Difficult to do for imperative Linux distributions, which have `/etc`, `/usr`, `/lib` directories.

Virtualization



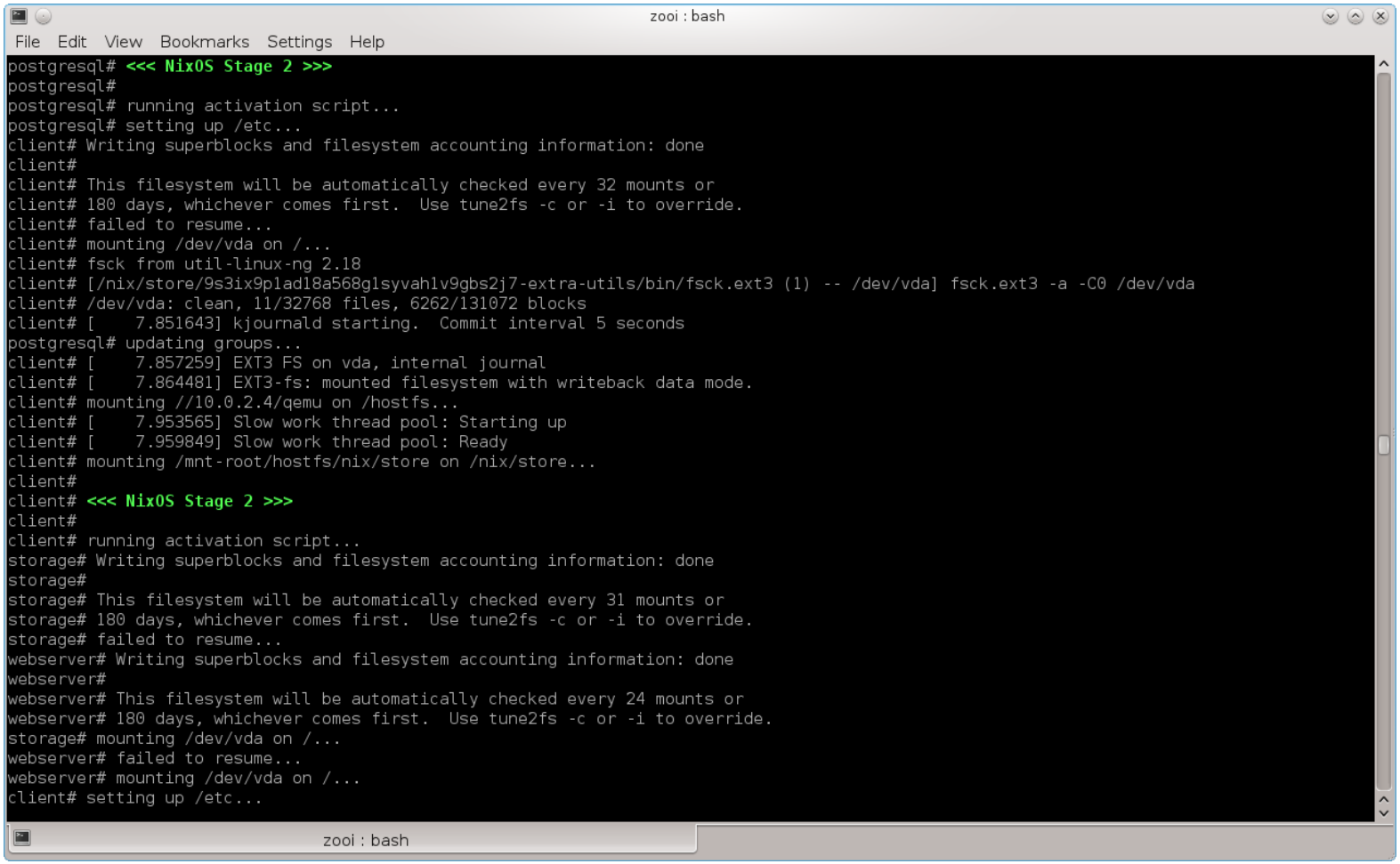
Testing

trac.nix

```
testScript = ''
  $postgresql->waitForJob("postgresql");
  $postgresql->mustSucceed("createdb trac");

  $webserver->mustSucceed("mkdir -p /repos/trac");
  $webserver->mustSucceed("svnadmin create /repos/trac");

  $webserver->waitForFile("/var/trac");
  $webserver->mustSucceed("mkdir -p /var/trac/projects/test");
  $webserver->mustSucceed("trac-admin /var/trac/projects/test initenv ".
    "Test postgres://root\@postgresql/trac svn /repos/trac");

  $client->waitForX;
  $client->execute("konqueror http://webserver/projects/test &");
  $client->waitForWindow(qr/Test.*Konqueror/);

  $client->screenshot("screen");
'';
```

Testing

nix-build tests.nix -A trac



Experience

- Distributed deployment of a Hydra build environment
- Continuous integration and testing of NixOS
  - NixOS installer
  - OpenSSH
  - Trac
  - NFS server
- Continuous integration and testing of various GNU projects
  - Install NixOS system with bleeding edge glibc
- Other free software projects

Related work

- Examples:
  - Cfengine
  - Stork
- Related work uses *convergent* models
- NixOS models are *congruent*

Conclusion

- *NixOS*. A GNU/Linux distribution used to reliably deploy a complete system from a declarative specification
- `nixos-deploy-network`. Efficiently/Reliably deploy a network of NixOS machines
- `nixos-build-vms`. Efficiently generate a network of cheap NixOS virtual machines instances
- NixOS test driver. Perform distributed test cases in a network of NixOS virtual machines

References

- NixOS website: `http://nixos.org`
  - *Nix*. A purely functional package manager
  - *Nixpkgs*. Nix packages collection
  - *NixOS*. Nix based GNU/Linux distribution
  - *Hydra*. Nix based continuous build and integration server
  - *Disnix*. Nix based distributed service deployment
- Software available under free and open-source licenses (LGPL/X11)

References

- Nix package manager can be used on any Linux system, FreeBSD, OpenSolaris, Darwin and Cygwin
- Virtualization features can be used on *any* Linux system running the Nix package manager and KVM.

Questions