Netkit

The poor man’s system for experimenting computer networking

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<tr>
<td>Description</td>
<td>an introduction to the architecture, setup, and usage of Netkit</td>
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about computer networks

- computer networks are (typically) quite complex
  - several devices (computers, routers, etc.)
  - several interfaces
  - several protocols running
  - physical interconnections originate complex topologies
how to perform experiments?

- performing experiments may be unfeasible
- the currently used network cannot be exploited for experiments
  - it hosts services that are critical for the company
  - it would be necessary to coordinate different departments of the company
- network equipments are expensive
  - sometimes, even for performing simple experiments, several equipments should be available in the same test bed
simulation vs. emulation

- emulation and simulation systems put at user’s disposal a virtual environment that can be exploited for tests, experiments, measures

- simulation systems aim at reproducing the performance of a real-life system (latency time, packet loss, etc.)
  - e.g.: ns, real, ...

- emulation systems aim at accurately reproducing the functionalities of a real-life system (configurations, architectures, protocols), with limited attention to performance
netkit: a system for emulating computer networks

- based on uml (user-mode linux)
  - http://user-mode-linux.sourceforge.net/
- each emulated network device is a virtual linux box
  - a virtual linux box is one that is based on the uml kernel
- note: the linux os is shipped with software supporting most of the network protocols
  - hence, any linux machine can be configured to act as a bridge/switch or as a router
user-mode linux

- User-mode Linux is a Linux kernel (inner part of the Linux OS) that can be executed as a user process on a standard Linux box.
- A user-mode Linux process is also called virtual machine (VM), while the Linux box that hosts a virtual machine is called host machine (host).
- Several virtual machines can be executed at the same time on the same host.
uml virtual machines

- each virtual machine has:
  - a console (a terminal window)
  - a memory ("cut" into the memory of the host)
  - a filesystem (stored in a single file of the host filesystem)
  - (one or more) network interfaces

- each network interface can be connected to a (virtual) collision domain

- each virtual collision domain can be connected to several interfaces
emulating a computer network using uml

- basic idea:
  - several virtual machines are created inside a single host machine
  - virtual machines are connected to virtual collision domains and thus can communicate with each other
  - each virtual machine can be configured to play the role of a regular host, of a router, or even of a switch
null
what is netkit?

- a set of tools and commands that can be used to easily set up a virtual computer network
  - (most) commands are implemented as scripts
- a ready-to-use filesystem that is exploited as a pattern for creating the file system of each vm
  - most commonly used networking tools are already installed in this filesystem
- a uml kernel that is used as kernel for the virtual machines
setting up netkit
setting up netkit

- download at http://www.netkit.org/
- hw requirements:
  - i386 32 bit architecture
  - ≥ 600 MHz cpu
  - ~10 MB of memory for each vm (depending on the vm configuration)
  - ~600 MB of disk space + ~1-20 MB for each vm (depending on the usage of the vm)
- sw requirements
  - a linux box
  - works fine on many distributions, see http://www.netkit.org/status.html
  - standard, commonly available system tools (awk, lsof, etc.)
setting up netkit

- download the three files that make up the distribution
  - netkit-X.Y.tar.bz2
  - netkitfilesystem-FX.Y.tar.bz2 (warning: >100MB)
  - netkit-kernel-KX.Y.tar.bz2
setting up netkit

- unpack the downloaded files in the same location
  - `tar xjf netkit-X.Y.tar.bz2`
  - `tar xjf netkit-filesystem-FX.Y.tar.bz2`
    (this may take a while; warning: decompressed size exceeds 600MB)
  - `tar xjf netkit-kernel-KX.Y.tar.bz2`

- warning: graphical file managers may not handle sparse files correctly; in order to correctly decompress packages, it is strongly advised to run the above commands from a terminal
setting up netkit

- configure your shell to set the following environment variables

  - `NETKIT_HOME` must be set to the directory containing the decompressed version of netkit
  - "`$NETKIT_HOME/bin`" must be appended to the `PATH`
  - "`:$NETKIT_HOME/man`" must be appended to the `MANPATH`

- for example (assuming bash is being used)
  - `export NETKIT_HOME=~/netkit2`
  - `export PATH=$PATH:$NETKIT_HOME/bin`
  - `export MANPATH=:$NETKIT_HOME/man`
setting up netkit

- you can check your configuration by entering the netkit directory...
  - cd $NETKIT_HOME
- ...and running the check_configuration.sh script
  - ./check_configuration.sh
- if all the checks succeed, then you are ready to use netkit
using netkit
netkit commands

- netkit provides users with two sets of commands
  - v-prefix commands (vcommands)
  - l-prefix commands (lcommands)
- vcommands act as low level tools for configuring and starting up single virtual machines
- lcommands provide an easier-to-use environment to set up complex labs consisting of several virtual machines
netkit vcommands

- allow to startup virtual machines with arbitrary configurations (memory, network interfaces, etc.)
  - **vstart**: starts a new virtual machine
  - **vlist**: lists currently running virtual machines
  - **vconfig**: attaches network interfaces to running vms
  - **vhalt**: gracefully halts a virtual machine
  - **vcrash**: causes a virtual machine to crash
  - **vclean**: “panic command” to clean up all netkit processes (including vms) and configuration settings on the host machine
netkit lcommands

- ease setting up complex labs consisting of several virtual machines
  - lstart: starts a netkit lab
  - lhalt: gracefully halts all vms of a lab
  - lcrash: causes all the vms of a lab to crash
  - lclean: removes temporary files from a lab directory
  - linfo: provides information about a lab without starting it
  - ltest: allows to run tests to check that the lab is working properly
accessing the “external world” from a virtual machine

- two ways of doing this
  - the directory `/hosthome` inside a virtual machine directly points to the home directory of the current user on the real host
    - read/write access is allowed
  - `vstart` can automatically configure tunnels (“tap interfaces”) by which a virtual machine can access an external network
    - see `man vstart` for more information
preparing a netkit lab
preparing a lab

- A Netkit lab is a set of preconfigured virtual machines that can be started and halted together.

- It may be implemented in (at least) two ways:
  - By writing a single script `lab-script` that invokes `vstart` for each virtual machine to be started.
  - By setting up a standard Netkit lab that can be launched by using the `lcommands` (recommended).
a netkit lab as a single script

- a script (e.g., `lab-script`) invokes `vstart` with some options to start up each virtual machine
- by using the `--exec` option of `vstart`, the same script can be invoked inside vms (e.g., in order to automatically configure network interfaces)
- a check inside `lab-script` can be used to test if we are in the real host or inside a vm
a netkit lab as a single script

example

```bash
vstart pc1 --eth0=0 --eth1=1 --exec=this_script
vstart pc2 --eth0=0 --exec=this_script
vstart pc3 --eth0=1 --exec=this_script
if [ `id -u` == "0" ]; then
    case "$HOSTNAME" in
        pc1)
            ifconfig eth0 10.0.0.1 up
            ifconfig eth1 10.0.0.2 up;;
        pc2)
            ifconfig eth0 10.0.0.3 up;;
        pc3)
            ifconfig eth0 10.0.0.4 up;;
    esac
fi
```
netkit labs using lcommands

- a standard netkit lab is a directory tree containing:
  - a `lab.conf` file describing the network topology
  - a set of `subdirectories` that contain the configuration settings for each virtual machine
  - `.startup` and `.shutdown` files that describe actions performed by virtual machines when they are started or halted
  - [optionally] a `lab.dep` file describing dependency relationships on the startup order of virtual machines
  - [optionally] a `_test` directory containing scripts for testing that the lab is working correctly
lab.conf

- this file describes
  - the settings of the vms that make up a lab
  - the topology of the network that interconnects the vms of the lab
- list of `machine[arg]=value` assignments
  - `machine` is the name of the vm (e.g., `pc1`)
  - if `arg` is an integral number (say `i`), then `value` is the name of the collision domain to which interface `ethi` should be attached
  - if `arg` is a string, then it must be the name of a `vstart` option and `value` is the argument (if any) to that option
example

pc1[0]=A
pc2[0]=A
pc2[1]=B
pc2[mem]=256
pc3[0]=B

pc2 is equipped with 256MB of (virtual) memory
lab.conf

- other optional assignments
  - `machines="pc1 pc2 pc3..."`: explicitly declare the virtual machines that make up the lab
    - by default, the existence of a subdirectory `vm_name` in the lab directory implies that a virtual machine `vm_name` is started
  - `LAB_DESCRIPTION`, `LAB_VERSION`, `LAB_AUTHOR`, `LAB_EMAIL`, `LAB_WEB` descriptors information displayed when the lab is started
lab subdirectories

- netkit starts a virtual machine for each subdirectory, with the same name of the subdirectory itself
  - unless `lab.conf` contains a `machines=` statement
- the contents of subdirectory `vm` are mapped (=copied) into the root (`/`) of `vm`’s filesystem
  - for example, `vm/foo/file.txt` is copied to `/foo/file.txt` inside virtual machine `vm`
  - this only happens the 1st time the vm is started; in order to force the mapping you have to remove the vm filesystem (`.disk` file)
startup and shutdown files

- shell scripts that tell virtual machines what to do when starting up or shutting down
- they are executed inside virtual machines
- `shared.startup` and `shared.shutdown` affect all the virtual machines
- upon startup, a vm named `vm_name` runs
  - `shared.startup`
  - `vm_name.startup`
- upon shutdown, a vm named `vm_name` runs
  - `vm_name.shutdown`
  - `shared.shutdown`
startup and shutdown files

- A typical usage of a `.startup` file is to configure network interfaces and/or start network services.

- Sample of `vm_name.startup`

```bash
ifconfig eth0 10.0.0.1 up
/etc/init.d/zebra start
```
lab.dep

- multiple virtual machines can boot at once (parallel startup)
  - `-p` option of `lstart`
- the startup order of virtual machines can be influenced by establishing dependencies
  - e.g., “pc3 can only boot after pc2 and pc1 are up and running”
- a `lab.dep` file inside the lab directory describes dependencies and automatically enables parallel startup
  - file format is similar to that of a `Makefile`
  - example

```text
pc3: pc1 pc2
```
launching/stopping a lab

- `lcommand -d <lab_directory> [machine...]`
- or
  - enter the lab directory (`cd lab_directory`)  
  - `lcommand`
- where `lcommand` can be one of the following:
  - `lstart`, to start the lab
  - `lhalt`, to gracefully shut down the virtual machines of a lab
  - `lcrash`, to suddenly crash the virtual machines of a lab
- optionally, a list of `machine` names can be given on the command line, in which case only those machines will be affected by the command
removing temporary files

- a running lab creates some temporary files inside both the current directory and the lab directory
- to get rid of them all, use `lclean` after the lab has been halted/crashed
  - notice: `lclean` also removes virtual machine filesystems (.disk files); do not use it if you are going to launch your lab again using the same filesystems
- makes it easier to check that distributed labs work properly
- ltest starts a lab and dumps information about each virtual machine **vm**
  - the output goes into _test/results/vm.default
- [optionally] a script _test/vm.test may contain additional commands to be run inside **vm** in order to dump other information
  - the output goes into _test/results/vm.user
sample of `vm.default` file

[INTERFACES]

lo      Link encap:Local Loopback
inet addr:127.0.0.1  Mask:255.0.0.0
inet6 addr: ::1/128 Scope:Host
UP LOOPBACK RUNNING  MTU:16436  Metric:1

[ROUTE]

Kernel IP routing table
Destination     Gateway         Genmask         Flags   MSS Window  irtt Iface

[LISTENING PORTS]

Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address           Foreign Address         State

[PROCESSES]

  UID COMMAND
  0 init [2]
  0 [ksoftirqd/0]
  0 [events/0]
  .........
ltest

■ when preparing a lab
  ■ launch ltest to dump lab information
  ■ move files _test/results/* to a subdirectory _test/results/good

■ when testing a lab
  ■ launch ltest to dump lab information
  ■ compare (e.g., using `diff`) files _test/results/* with _test/results/good/*
  ■ check if they all match
getting information about a lab

- `linfo` prints summary information about a lab without running it.
- Option `--m` allows to create a sketch of the link-level topology of the lab.
  - Requires the GraphViz library to be installed.
    - http://www.graphviz.org/

```
J -- 2 -- as100r1 -- F
   | 1  |
   v 2  v
    | 0  |
    v 0  v
    as20r1

A -- 0 -- as200r1
```

last update: Oct 2014
more information

- further information can be found...
  - ...inside netkit man pages (you can start from `man netkit`)
  - ...on the web site http://www.netkit.org/