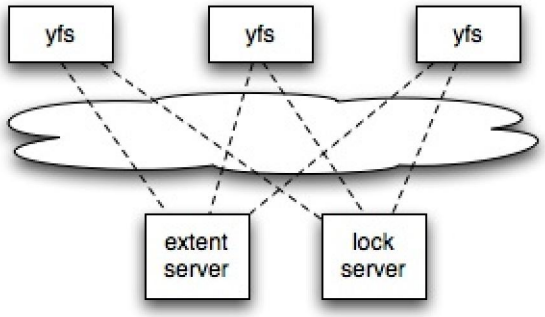
6.824 - Spring 2012

Lab Information

Lab overview

In this sequence of labs, you'll build a multi-server file system called Yet Another File System (`yfs`) in the spirit of Frangipani. At the end of all the labs, your file server architecture will look like this:



You'll write a file server process, labeled `yfs` above, using the FUSE toolkit. Each client host will run a copy of `yfs`. Each `yfs` will create a file system visible to applications on the same machine, and FUSE will forward application file system operations to `yfs`. All the `yfs` instances will store file system data in a single shared "extent" server, so that all client machines will see a single shared file system.

This architecture is appealing because (in principle) it shouldn't slow down very much as you add client hosts. Most of the complexity is in the per-client `yfs` program, so new clients make use of their own CPUs. The extent server is shared, but hopefully it's simple and fast enough to handle a large number of clients. In contrast, a conventional NFS server is pretty complex (it has a complete file system implementation) so it's more likely to be a bottleneck when shared by many NFS clients.

Lab assignments

Collaboration Policy

You must write all the code you hand in for the programming assignments, except for code that we give you as part of the assignment. You are not allowed to look at anyone else's solution, and you are not allowed to look at code from previous years. You may discuss the assignments with other students, but you may not look at or copy each others' code.

Programming Environment

You should be able to do Lab 1 on any Unix-style machine, including your own Linux/FreeBSD desktops, MacOS laptops, or any Athena SunOS/Linux workstation.

For Labs 2 and beyond, you'll need to use a computer that has the FUSE module, library, and headers installed. You should be able to install these on your own machine by following the instructions at fuse.sourceforge.net; we outline instructions for Ubuntu/Debian machines. However, the **official** programming environment for this class will be the Athena Linux machines (you can find a list of Athena Linux workstation locations here). What we mean by official is that we will be testing your assignments using that environment, so please make sure your code passes the tests on an Athena Linux machine.

Note that if you have your own FreeBSD or MacOS machines that you prefer to use for programming, you should be able to use them for the majority of the work. However, there are minor annoying differences between FUSE on Linux and FUSE on other operating systems that may cause your code to fail our tests when it seems to pass for you. As an example, on Linux FUSE passes file creation operation to the file system using the MKNOD call, while on other systems it uses CREATE. Please ensure that your assignment passes the tests in the Athena Linux environment, and there shouldn't be any problems when we test it.

Athena Linux Machines Without FUSE

Some Athena Linux workstations do not have FUSE installed on them by default. We have created a 6.824 locker that includes all the necessary FUSE files, as well as installation scripts. Note that you must be root to run these scripts. To install FUSE on an Athena Linux workstation, do the following:

```
% attach 6.824
% tellme root
% su -
  [Now enter the root password shown in the previous command to become root]
% /mit/6.824/install-fuse.sh
% exit
```

Now you should be able to compile your FUSE-based programs and run them without any problems. When you are finished with a session and are about to log out, MIT asks that you please clean up after yourself by uninstalling the FUSE programs. Do this as follows:

```
% tellme root
% su -
  [Now enter the root password shown in the previous command to become root]
% /mit/6.824/uninstall-fuse.sh
% exit
```

Installing FUSE on Ubuntu/Debian

To setup FUSE on your local machine, you will need the header files and the utilities. Install them like this:

```
sudo aptitude install libfuse2 fuse-utils libfuse-dev
```

Next, you need to make sure the fuse module is loaded:

```
% ls -l /dev/fuse
  crw-rw-rw- 1 root fuse 10, 229 2010-02-11 06:02 /dev/fuse
```

If your `ls` output matches the above output, then you can skip the `modprobe` step. If you do not see the above output, try running `modprobe`:

```
% sudo modprobe fuse
```

Finally, you need to add yourself to the fuse group to be able to mount FUSE file systems:

```
% sudo adduser {your_user_name} fuse
```

Make sure to logout of you current session to refresh your group list. When you logged in again, typing groups at the command line should show fuse as one of the groups:

```
% groups
  alex users fuse admin
```

Linux VMWare image with FUSE

We've created a VMWare Linux image based on the Debian 4.0r0 server image from Thought Police. It has FUSE pre-installed on it, and should have everything you need to compile and run the labs. You can download it here:

6.824-debian-40r0-i386.zip (566 MB)
Non-root account: username=notroot, password=6.82fork

Root account: password=6.82fork

You should be able to run this with VMWare Player, which is available for free from VMWare. We have tested it on Windows and Linux; it should work for Intel Macs as well, but we haven't verified this (though be aware there is no free VMWare Player for Mac).

Note that the official environment for the labs is still the Athena Linux workstations, and that's where we will be testing your code. However this VMWare image is using the same version of FUSE and roughly the same operating system version; please note, though, that it appears that to create a file, the VMWare Linux/FUSE combo in the kernel uses the CREATE operation, rather than the MKNOD sent by the Athena Linux/FUSE combo, so you must test your labs at least once on an Athena Linux machine before submitting. Also note that we don't really have the energy or expertise to debug any VMWare problems you might have. This is just meant to be helpful for those of you who don't have personal Linux machines, and find it inconvenient to sit at an Athena workstation.

There has been at least one report that running the code in VMWare is much slower than running it directly on hardware, and as a result, RPCs timeout more often even when RPC_LOSSY is unset. Be on the lookout for errors related to this.

You may find that the network doesn't work when you boot the image up for the first time. This is a known problem with the Thought Police image. To fix this, run the following command as root:

```
$ rm /etc/udev/rules.d/z25_persistent-net.rules && reboot
```

--!>

Aids for working on labs

There are a number of resources available to help you with the lab portion of this course:

- **C++ Standard Template Library**:

  You will use C++ STL classes such as map and string a lot, so it's worth while to be familiar with the methods they offer; have a look here.

- **pthreads**:

  All the labs use the POSIX threads API (pthreads). A comprehensive guide to programming with pthreads can be found here: http://www.llnl.gov/computing/tutorials/pthreads/

- **FUSE**:

  The labs use the FUSE interface to plug the lab file system into the operating system. See the FUSE website for more information.

- **Debugging and Core files**:

  `printf` statements are often the best way to debug. You may also want to use `gdb`, the GNU debugger. You may find this gdb reference useful. Below are a few tips.

  If your program crashes and leaves a core dump file, you can see where the crash occured with `gdb program core`, where `program` is the name of the executable. Type `bt` to examine the call stack at the time of the crash.

  If you know your program is likely to have a problem, you can run it with gdb from the beginning, using `gdb program`. Then type `run`.

  If your program is already running (or it is hard to start with gdb due to complex start-up scripts), you can attach gdb to it by typing `gdb program 1234`, where `1234` is the process ID of your running program.

  While in gdb, you can set breakpoints (use the gdb command `b`) to stop the execution at specific points, examine variable contents (`print ...`), get a list of threads (`info threads`), switch threads (`thread X`), etc.

  To apply a given gdb command to all threads in your program, prepend `thread apply all` to your command. For example, `thread apply all bt` dumps the backtrace for all threads.

  Look at the GDB manual for full documentation.

Questions or comments regarding 6.824? Send e-mail to *6.824-staff@pdos.csail.mit.edu*.

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