

Construct a CentOS 7 Machine to Interface with a Muon Tomography Station

April 12, 2019



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1 Background

Florida Tech's High Energy Physics Lab operates a muon tomography station (MTS). The MTS uses micropattern gas detectors to track the flight of cosmic ray muons through the detector. The MTS consists of a small cavity surrounded entirely by detectors. Objects containing heavy elements may be placed in this cavity to be imaged by tracking deflections in the incident cosmic ray muons.

A computer is used to interface with the MTS in order to collect and process its data. Because the current machine has become antiquated, a new machine must be built.

2 Choose a New Computer

A member of the research group had recently donated a large quantity of inexpensive machines, so one was adopted for purposes of MTS development. This was done not only to avoid occupying the MTS, but also to provide the ability to test freely.

3 Install an Operating System

The current system is running Scientific Linux 5, so we are installing the latest Scientific Linux, SL7, on the new testing computer.

SL7 has been cleanly installed, now to enable ssh. Turns out ssh is installed and turned on by default in SL7, but it is unreachable via the WiFi. The new machine can be reached, however, by using NAS-1 from the cluster as a bridge between personal machines and the development machine.

4 ROOT

ROOT, a data analysis framework, is one of the key pieces of software required by the MTS's interfacing machine. The latest binary of ROOT is available from root.cern.ch for CentOS 7. Since SL7 and CentOS 7 are closely related, however, the binary was downloaded for use.

To build ROOT, we created a build directory in `/opt/root`, moved into this directory, and used `cmake ..` and `cmake --build` setting the source with `source /opt/root/build.sh`. ROOT can now be run by running the command `root` globally. Now, following the instructions in ROOT's README, we configured root's library with `./configure linux64gcc`. Now ROOT should be properly built and configured.

5 Installing Stefano's Image

Stefano, the former lab member who left the spare computers, created a disk image for us before he left with DATE and SCRIBE preinstalled and ready to go! It's at `/nas1/cmsgem/software/srs_centos7_2.vdi`. Unfortunately, it's a `vdi` file rather than an `iso`, so some conversions need to be done. I'm performing everything on the MTS development machine.

First we need to install some packages: `qemu` and `tklpatch`. Since `vdi` files are VirtualBox images, we need to download VirtualBox to get the conversion tools:

- `cd /etc/yum.repos.d`
- `wget http://download.virtualbox.org/virtualbox/rpm/rhel/virtualbox.repo`
- `yum --enablerepo=epel install dkms`

- `yum install VirtualBox-5.1`

Now that VirtualBox is installed, we can start converting!

Convert VDI to VMDK

```
VBoxManage clonemedium srs_centos7_2.vdi srs_centos7_2.vmdk --format VMDK
```

Convert VMDK to Raw

```
gemu-img convert -f vmdk srs_centos7_2.vmdk -O raw srs_centos7_2.raw
```

Normally, this raw image would be able to be easily mounted, but this one has multiple partitions. Therefore, some extra steps need to be performed.

Prepare Image for Mounting

```
loopdev=$(sudo losetup --show -f srs_centos7_2.raw)
```

The output of this particular command was saved because its output will be used later. Next, the tool `kpartx` needs to be installed:

```
sudo yum install kpartx
```

Map the Image's Partitions

```
sudo kpartx -a $loopdev
```

Now the image is ready to be mounted! A mount point can be quickly created with

```
mkdir srs_centos7_2.mount
```

Mount Image

```
sudo mount /dev/mapper/$(basename $loopdev)p1 srs_centos7_2.mount
```

The mounted image ought to be visible from `df -h` and accessible via the route specified by `df`.

Now a copy may be made of the root file system of the image. Create a directory for the file system, `mkdir srs_centos7_2.rootfs`, then copy the contents of the mounted file system to the new directory:

```
sudo rsync -a -t -r -S -I srs_centos7_2.mount/ srs_centos7_2.rootfs
```

Now that the mount point has been copied over, the original may be unmounted.

6 Installing DATE

We were unable to install DATE on our machine using Stefano's image. We've moved on to try and install DATE manually. Stefano provided us with a link to the CERN forum thread where he asked Brian Dorney for help to do exactly what we're trying to do.

6.1 Installing CERN Repositories

The first thing we need to do is follow the setup instructions from <http://linux.web.cern.ch/linux/centos7/docs/install.shtml>. The first thing that must be done is the configuration of the AFS client. Unfortunately, the necessary command, `locmap` is not installed on our system, nor is it available from any of the installed repositories. I found it and its dependencies from the CERN's Linux website where all of its packages are hosted, http://linuxsoft.cern.ch/cern/centos/7/cern/x86_64/Packages/.

Once those RPMs are downloaded, they may be directly installed with `rpm`, but that command will not automatically install dependencies. To ease the installation process, a yum repository containing the RPMs can be created. A new file, `/etc/yum.repos.d/localCERN.repo` was created, and in it were placed the lines:

```
[localCERN] # the name of the new repository
baseurl = file:///<full path to directory containing RPMs>
enabled=1 # enable the repo be default
gpgcheck=0 # disable package verification
```

While disabling package verification is generally bad practice, we do not have the keys necessary to properly install them. We also know where we got them from, and they are locally installed, so, in this particular case, it should not be a big deal.

Now that the repo has been created, `locmap` can be installed, `sudo yum install locmap`. When the required command, `sudo locmap --configure afs`, is run, it complains that it cannot connect to `xldap.cern.ch` and that the `afs` module is disabled. I've enabled the module with `sudo locmap --enable afs` and tried again to see what would happen, and, while it failed once again to connect to `xldap.cern.ch`, it says that it configured everything!

The next step is to preconfigure the AFS client for CERN by configuring NTP, which must be enabled, `sudo locmap --enable ntp`. Now, it can be configured with `sudo locmap --configure ntp`. Next, the following modules must be enabled using the same command as above: `cvmfs`, `eosclient`, `kerberos`, `lpadmin`, `nscd`, `sendmail`, `ssh`, and `sudo`. A list of every available module and their statuses can be viewed with, `sudo locmap --list`. Now, they must all be configured with, `sudo locmap --configure all`.

Well, turns out the AFS stuff doesn't work, probably because we couldn't connect to the server. Fortunately, we only needed AFS to get the CERN repositories, `yum-alice-daq.cc7_64.repo` and `yum-alice-daq.slc6_64.repo`. I had grabbed `yum-alice-daq.cc7_64.repo` from another computer, but the SLC6 repo was nowhere to be found. This problem was solved by creating the repo file myself by copying the CC7 file, and changing the URLs to point to where the SLC6 RPMs ought to be located. The contents of `yum-alice-daq.cc7_64.repo` are:

```
[main]
[alice-daq-cc7]
name=ALICE DAQ software and dependencies - CC7/64/
baseurl=http://cern.ch/alice-daq/yum-alice-daq.cc7_64/
baseurl=https://yum:daqsoftrpm@alice-daq-yum.web.cern.ch/alice-daq-yum/cc7_64/
enabled=1
protect=1
gpgcheck=0
```

The contents of the newly created `yum-alice-daq.slc6_64.repo` are:

```
[main]
[alice-daq-slc6]
name=ALICE DAQ software and dependencies - slc6/64/
baseurl=http://cern.ch/alice-daq/yum-alice-daq.slc6_64/
```

```
baseurl=https://yum:daqsoftrpm@alice-daq-yum.web.cern.ch/alice-daq-yum/slc6_64/  
enabled=1  
protect=1  
gpgcheck=0
```

Running a quick `sudo yum update` is helpful here, just double check to make sure you're not accidentally installing any SLC6 packages.

6.2 Setting up DATE's Database

Now to install a bunch of things from these repositories! The installation instructions from here, <https://alice-daq.web.cern.ch/products/date-installation-and-configuration> were followed.

The first command `rpm -e mysql-libs mysql mysql-devel postfix` produced some errors, but they are excusable. They appeared because those packages simply are not installed on our machine; the `postfix` one, however, is. While simply `rpm -e postfix` could have been executed with equal effect, it is safe to include the other three packages in case they happened to have been mysteriously installed onto the system.

The next command is `rm -rf /var/lib/mysql/`, but that directory should not exist in the first place, since MySQL is not installed. Now, we must install a bunch of packages (including DATE!):

```
sudo yum install BWidget MySQL-shared MySQL-client MySQL-devel dim smi  
tcl-devel tk-devel curl-devel libxml2-devel pciutils-devel mysqltcl xinetd ksh  
tcsh date
```

With that completed, MySQL server must be installed, `yum install MySQL-server`. This time, a conflict with `mariadb-libs` was encountered, but we can just erase this package, since we don't need it, `yum erase mariadb-libs`.

The next step is to setup MySQL. First, the service must be started, `service mysql start`. Since the root account must be setup first, and the temporary root password is stored in root's home directory, we must switch to root to complete setting up the initial account, `sudo su`. The temporary password is viewed with `cat /root/.mysql.secret`. Copy that password, then paste it when prompted after running, as root, `mysqladmin -u root -h localhost -p password`.

Now that the root account has been created, the user accounts can be added. You may log out of root. First, the `DATE_SITE` environment variable must be cleared, `unset DATE_SITE`, then the date setup script must be executed, `./date/setup.sh`. Afterwards, the MySQL initialization script must be executed to configure the new database, `newMySQL.sh`. While the settings may be changed to whatever best fits the situation, the defaults are sufficient.

Now that the MySQL database is initialized, it must be configured, for DATE, `newDateSite.sh`.

NOTE

To create the required `/dateSite` directory, it will ask for the root password. When prompted, confirm that a minimal configuration is to be created; this is not the default setting. Also confirm that all detectors are to be added and that all trigger class masks ought to be added; these are not the default settings.

6.3 Running DATE

With the base DATE configuration complete, the local configuration can begin. These next few steps must be completed as root (`sudo su`). The path of the `DATE_SITE` must be set:

```
export DATE_SITE=/dateSite
```

the setup script must be executed:

```
. /date/setup.sh
```

and the local configuration command must be run:

```
dateLocalConfig -s
```

Running `dateLocalConfig -s` will result in an error because, in CentOS7, `iptables` has fallen away in favor of `firewalld`. These instructions from StackOverflow, <https://stackoverflow.com/questions/24756240/how-can-i-use-iptables-on-centos-7>, describe how to switch back from `firewalld` to `iptables` so that DATE, built for SLC6, will be happy.

First, `firewalld` needs to be stopped,

```
systemctl stop firewalld
```

and hidden away,

```
systemctl mask firewalld
```

Next, `iptables` must be installed,

```
yum install iptables-services
```

and enabled,

```
systemctl enable iptables
```

followed by

```
systemctl start iptables
```

Running `dateLocalConfig -s` will, again, produce an error, but running it again immediately will work, somehow.

Next, the DIM (Distributed Information Management) name server must be launched (and must be launched after each boot; this will be automated), `/date/runControl/start_dim.sh &`. This returned a “no process found” error, but running it again seemed to work fine. This error comes about because of slightly different paths to `do_start_dim.sh`, whose location can be found with `locate do_start_dim.sh`.

The `infoLoggerServer` must also be started (these commands must be run after each boot; this will be automated):

```
export DATE_SITE=/dateSite
```

```
. /date/setup.sh
```

```
/date/infoLogger/infoLoggerServer.sh start
```

The DAQ ought to be ready to be launched:

```
export DATE_SITE=/dateSite
```

```
cd /date
```

```
. ./setup.sh
```

```
infoBrowser
```

```
runControl/DAQCONTROL.sh
```


7 Installing AMORE

Now, it's time to install AMORE as root (`sudo su`), `yum install amore`. While all of the AMORE tools are installed, they are not part of the `PATH` environment variable, so they cannot be run by `basename` on the normal prompt. Their install location can be found with `locate amoreMysqlSetup`, which will display the full path to one of the tools. The remainder of the tools are in the same directory. In our case, that directory is `/opt/amore/bin/`, so that is what we will add to the `PATH` variable, `PATH=$PATH:/opt/amore/bin`. Be sure to add `export PATH=$PATH:/opt/amore/bin` to both the user's and root's `/.bash_profile`. Now all the AMORE tools are accessible by their basenames.

The next step is to set up the MySQL database for AMORE, `amoreMysqlSetup`. The defaults are sufficient. Now the AMORE site itself needs to be created, `newAmoreSite`, and the defaults are fine. The problem with AMORE now is that the `amore` command, itself, does not work.

The next step is to install the hardware drivers for the MTS hardware. Unfortunately, that is proving difficult. The source for `date-114` does not contain many of the required directories. `date-100`, however, does, so we've uninstalled the latest version of DATE, and installed the old version instead. We've followed all the instructions for configuring DATE again, including rebuilding the MySQL database.

We've come across our first issue: `dateLocalConfig -s` is throwing some `xinetd` errors.

7.1 Troubleshooting AMORE

Another issue is that AMORE doesn't actually work. All of the commands exist, but trying to run `amore` results in an error complaining about being unable to load the shared library `libCore.so.5.34`. Running a `locate libCore.so` reveals that it's a ROOT library, but that only three versions of the file exists: `/usr/lib64/root/libCore.so`, `/usr/lib64/root/libCore.so.6.14`, and `/usr/lib64/root/libCore.so.6.14.04`. Huh, it doesn't look like we have the required file. The `LD_LIBRARY_PATH` environment variable, however, does contain the appropriate paths of `/opt/amore/lib` and `/usr/lib64/root`. It looks like AMORE depends on ROOT 5 rather than ROOT 6, so we've got to downgrade ROOT.

7.1.1 Downgrade ROOT

To downgrade ROOT, the current version must be first uninstalled:

```
sudo yum remove root
```

`yum` will verify that ROOT 6 is to be removed, and it will warn that AMORE will no longer work, since it depends on ROOT. The available versions of ROOT can be checked with:

```
yum --showduplicates list root
```

ROOT 6 is only in the EPEL repository, but ROOT 5 is in the `alice-daq-slc6` repository, so we're going to tell `yum` to install ROOT only using the SLC6 repo:

```
yum --disablerepo=* --enablerepo=alice-daq-slc6 install root
```

`yum` should report that it will install ROOT 5.

Since AMORE was removed when we removed ROOT, it must be reinstalled, `yum install amore`. Now, when `amore` is run, we get the same error, but with a different file, `libAmoreUI.so`, that has only one version. I checked the `LD_LIBRARY_PATH` variable, and it was empty! I put in the path to the AMORE library, `export LD_LIBRARY_PATH='/opt/amore/lib'`. Now we just need to set up AMORE as before.

The first step is to re-add the AMORE binary file to the PATH environment variable by adding the following to the `/.bashrc`, `export PATH=$PATH:/opt/amore/bin`. Now, `amoreMySQLSetup` can be run.

NOTE

It may complain that an AMORE database already exists. That's fine, it can be removed by using MySQL. The MySQL prompt can be accessed with `mysql -u daq -p`, where the username and password are both `daq` by default. Once at the prompt, the available databases can be listed with `show databases;`, the old AMORE database can be removed with `drop database AMORE;`, and the prompt can be exited with `quit`.

The issue now is that `amoreUpdateDB.tcl` is in the wrong place. It complains that `/opt/amore/bin/amoreMySQLSetup` could not find `/bin/amoreUpdateDB.tcl`, which is fine because it's in `/opt/amore/bin/amoreMySQLSetup`. In `/opt/amore/bin/amoreMySQLSetup`, the path to `amoreUpdateDB.tcl` is described as `$AMORE/bin/amoreUpdateDB.tcl`. Since `$AMORE` is blank, I've run `export AMORE=/opt/amore`. After dropping the old AMORE database from MySQL, `amoreMySQLSetup` will run successfully.

When we downgraded ROOT, we also had to reinstall all of its dependencies and rebuild it. The rebuild process was giving us some issues because it cannot be built in the installation directory; it needs to be first placed in the `builddir` directory, then built. Now that ROOT is installed, AMORE may be set up again as normal with `amoreMySQLSetup` and `newAmoreSite`

NOTE

If `newAmoreSite` is not begin run as root, it must be run with

```
sudo env "PATH=\$PATH" newAmoreSite
```

in order for the environment to be properly preserved (`sudo -E newAmoreSite` was ineffective).

When `amore` is run, however, after several ROOT warnings about a bunch of classes already existing in `TClassTable`, it says `terminate called after throwing an instance of 'std::runtime_error'`, then `what()`, the AMORE function that is supposed to print out what caused an error, shows a "Usage" dialogue for some command; it just prints out "Usage:" followed by some flags. Evidently, the issue is that some command is not being executed as expected, or something isn't installed/configured properly.

Let's first try to find which command this "Usage" belongs to. I navigated to `/opt/amore` and grepped for a keyword in one of the flag definitions, `grep -R "<LIBSUFFIX>" *`, and some binary files were matched, `lib/libAmoreCore.so` and `lib/libAmoreDA.a`. To tell `grep` to treat the binary files as text files, the `-a` flag may be used, `grep -aR "<LIBSUFFIX>" *`. Digging into those binaries didn't help a whole lot; I just found the "Usage" text on its own without any context.

Some progress has been made! Joseph has reinstalled a slightly newer version of ROOT, v5.34/38, and the strange ROOT errors from before are all gone! ROOT starts normally! Now let's see how AMORE'll play with the new ROOT.

When redoing the `amoreMySQLSetup` stuff, we ran into some issues. `newAmoreSite` returns a syntax error when run, `/opt/amore/bin/newAmoreSite: line 57: syntax error: unexpected end of file`. I'm going to reinstall AMORE.

After reinstalling ROOT, we tried to run AMORE, and it failed because it couldn't find `libCore.so.5.34`. The file that contains the path to the ROOT libraries is `/etc/ld.so.conf.d/root-x86_64.conf`; it contained `/opt/root/lib`. Unfortunately, no libraries are there. We created another file in that same directory, `/etc/ld/so/conf.d/root.conf`, and put the new path to the libraries (the old library paths were messed up after reinstall): `/opt/root/builddir/lib`. To save this change, run `ldconfig`.

Turns out we still had to build ROOT! We navigated to the ROOT build directory and followed the README for building. ROOT's all good to go, now let's see about AMORE.

I'm reinstalling it. To uninstall AMORE, `yum remove amore.x86_64`, and to install it again, `yum install amore`. Hmm, when it tried to get the package from the SLC6 repository, it encountered an HTTP 403 response. `yum` also gave us an error code of 14, and an [article](#) providing some troubleshooting steps. The article suggests clearing the cache with `yum clean all` followed by `rm -rf /var/cache/yum*`.

Now `yum` just straight up fails; it had been relying on that cached data to go through in the first place. It's complaining about repository configuration, so let's see what's going on with that.

AMORE has been decommissioned by ALICE, but Stefano sent us a copy of it's source on github (<https://github.com/stefanocolafranceschi/amoreSRS>). I cloned the repo, so now we've got it. Time to build it on the MTS dev machine!

There's a `Makefile` in the repository's root directory, so I ran `make` to use it. It's complaining that there's no `/usr/local/etc/Makefile.arch`, so let's investigate that. When the make file in the root directory of the repo is run, it immediately travels to the `src` directory and runs the make file there. The first line in `src/Makefile` includes `Makefile.inc` in the same directory, whose first action is to include `$(shell root-config --prefix)/etc/Makefile.arch`. `root-config --prefix` outputs `/usr/local`, which is where it's getting `/usr/local/etc/Makefile.arch` from. The entire `/usr/local/etc` directory, however, is empty! It's also empty on the old MTS machine, so that's interesting.

There ARE `Makefile.archs` scattered around the MTS development machine, though! The one that appears to be the most interesting is `/etc/root/Makefile.arch`, a self-described "Makefile containing platform dependencies for ROOT based projects.". Since AMORE depends on ROOT, this looks like what we need. `/etc/root` appears to contain all the ROOT configuration rather than `/usr/local`, so I'm gonna set the "root-config" prefix to `/etc/root`. The current prefix configuration can be viewed with `root-config --config`.

Because `root-config` wasn't cooperating when trying to change the prefix via `root-config --prefix=/etc/root`, I found the source code, `/usr/local/bin/root-config`, and changed the prefix setting found in the `configargs` variable. That alone, however, does not solve the problem; the configuration is not saved.

I checked to see how often `root-config --prefix` was used in building AMORE. It's only used once in that one file, so I just manually entered the correct path. The `make` went much further this time, but it still failed. This time it's complaining that `TDATEEventParser.h` doesn't exist. That file is included by `[root of AMORE repo]/src/publisher/SRSPublisher.h`. A `locate TDATEEventParser.h` didn't turn up anything.

The original MTS does, however, have `/opt/amore/include/amore/TDATEEventParser.h`. I used `netcat` to throw the MTS's file into the same directory on the MTS development machine and tried `make` again. Now we have different errors in `SRSPublisher.h`; they are all complaining that "Session" does not have a type.

NOTE

All TCP connections other than at port 22 are blocked by default, so `iptables` must be used to free up a port.