CSU NUPAC Tutorials
2019

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I’m borrowing a lot of the material from Harinder Bawa (CSU Fresno)
SHELLS

• The shells is a part of the interface for control of linux

• There are a number of options, the two most common are:
  - tc (or c) shell (tcsh)
  - bourne shell (bash)

• Change your shell with chsh

  - Pick a shell and stick to it, but can be useful for a new account somewhere.
ENVIRONMENT VARIABLES

- Much of your Linux environment is set by environment variables
- These are accessed via the $ sign
  - eg $HOST
- To view your environment use `env`
  - Prints out all your environment variables
  - Use `echo` to view an individual one
    - `Echo $HOST`
SETTING ENVIRONMENT VARIABLES

• You can set your environment variables using
  ▪ `setenv(tc shell)`
  ✓ `setenv ROOTSYS /user/local/root`
  ▪ `export (bash shell)`
  ✓ `export ROOTSYS=/user/local/root`
  ▪ This creates the variable if it doesn’t already exist or updates if it does
• Typically the environment variables you set yourself will be to tell programs where to find things.
YOUR PATH

• Your path is an environment variable
  - $PATH (check by echo $PATH)
• It contains all the directories that your OS will look in to find the programs you want to run
  - The path should contain “.” to ensure that you don’t need to specify it while running local program
• Entries are separated by “:”
• Update your path with
  setenv PATH /newdir:$PATH
INTRODUCTION TO ROOT
WHAT IS ROOT?

- ROOT is an object oriented framework
- It has a C/C++ interpreter (CINT) and C/C++ compiler (ACLIC)
- ROOT is used extensively in High Energy Physics for “data analysis”
  - Reading and writing data files
  - Calculations to produce plots, numbers and fits.

WHY ROOT?

- It can handle large files (in GB) containing N-tuples and Histograms
- Multiplatform software
- Its based on widely known programming language C++
- Its free
The Analysis Chain in High Energy Physics

1. Raw Data
2. Simulated Raw Data
3. Reconstruction
4. Reconstructed Data (DST)
5. High-Level Reconstruction
6. Condensed Data (ROOT Trees)
7. Analysis Code
8. Histograms, Plots
9. Journal Publication
10. Simulation
11. 4-Vectors
12. Monte Carlo Generator

Dr. Harinder Bawa
• As with everything in this course there is good documentation on the WEB

• In the case of ROOT there is one specific place. http://root.cern.ch

• This is the place to download root from should you need it.

• There is lots of documentation and examples.

• Few examples are in $ROOTSYS/tutorial
OBJECT ORIENTED CONCEPTS

- Class: the description of a “thing” in the system
- Object: instance of a class
- Methods: functions for a class

Members: “has a” relationship to the class.
- Inheritance: “is a” relationship to the class.
ROOT INSTALLATION

• Installation of Root is little tricky. One need to follow exact instructions but not guaranteed (Depends upon version of ROOT and Ubuntu (Linux))

• Before we start ROOT Installation, we need to install pre-requisite and make sure it installs that!

• https://root.cern.ch/build-prerequisites
Use `sudo apt-get install _package_` or use the graphical "Synaptic Package Manager" program.

**Required packages:**
```
sudo apt-get install git dpkg-dev cmake g++ gcc binutils libx11-dev libxpm-dev \ libxft-dev libxext-dev
```

**Optional packages:**
```
sudo apt-get install gfortran libssl-dev libpcre3-dev \ xlibmesa-glu-dev libglew1.5-dev libftgl-dev \ libmysqlclient-dev libfftw3-dev libcfitsio-dev \ graphviz-dev libavahi-compat-libdnssd-dev \ libldap2-dev python-dev libxml2-dev libkrb5-dev \ libgsl0-dev libqt4-dev
```
Setting up libcdt5 (2.36.0-ubuntu3.1) ...
Setting up libggraph6 (2.36.0-ubuntu3.1) ...
Setting up libpathplan4 (2.36.0-ubuntu3.1) ...
Setting up libvgv6 (2.36.0-ubuntu3.1) ...
Setting up libxvxdot4 (2.36.0-ubuntu3.1) ...
Setting up libgraphviz-dev (2.36.0-ubuntu3.1) ...
Setting up graphviz-dev (2.36.0-ubuntu3.1) ...
Setting up libavahi-compat-libdnssd-dev (2.6.31-1ubuntu1.1) ...
Setting up libdm-dev:amd64 (2.4.07-1ubuntu8.14.04.1) ...
Setting up libfhw3-bin (3.3.3-7ubuntu3) ...
Setting up libfhw3-bin:amd64 (3.3.3-7ubuntu3) ...
Setting up mesa-common-dev (18.1.1-0ubuntu9.1) ...
Setting up libx11-xcb-dev:amd64 (2.1.6.2-1ubuntu2) ...
Setting up libxcb-dri3-dev:amd64 (1.10-2ubuntu1) ...
Setting up libxcb-render0-dev:amd64 (1.10-2ubuntu1) ...
Setting up libxcb-shape0-dev:amd64 (1.10-2ubuntu1) ...
Setting up libxcb-xfixes0-dev:amd64 (1.10-2ubuntu1) ...
Setting up libxcb-sync-dev:amd64 (1.10-2ubuntu1) ...
Setting up libxcb-present-dev:amd64 (1.10-2ubuntu1) ...
Setting up libxsmm-fence-dev:amd64 (1.1-2) ...
Setting up libxcb-dr12-0-dev:amd64 (1.10-2ubuntu1) ...
Setting up libxcb-glX0-dev:amd64 (1.10-2ubuntu1) ...
Setting up x11proto-xext-dev (7.3.0-1) ...
Setting up x11proto-fixes-dev (1:5.0-2ubuntu2) ...
Setting up libxfixes-dev:amd64 (1:5.0.1-1ubuntu1.1) ...
Setting up x11proto-damage-dev (1:1.2.1-2) ...
Setting up libxdamage-dev:amd64 (1:1.1.4-1ubuntu1) ...
Setting up libxext-dev:amd64 (2:1.3.2-1ubuntu8.8.14.04.1) ...
Setting up x11proto-xfixes-dev (2.3.1-2) ...
Setting up libxfixes-dev:amd64 (1:1.1.3-1) ...
Setting up x11proto-dr12-dev (2.8-2) ...
Setting up x11proto-gl-dev (1.4.17-1) ...
Setting up libgl1-mesa-dev (10.1.3-0ubuntu6.6) ...
Setting up libglu1-mesa-dev (9.0.0-2) ...
Setting up libftgl-dev (2.1.3-rc5-4ubuntu1) ...
Setting up libgdev:amd64 (1.10.0-3) ...
Setting up libgs10-dbi (1.16-0ubuntu1) ...
Setting up libgs10-dev (1.16-4ubuntu1) ...
Setting up libnysqclient-dev (5.5.54-0ubuntu8.14.04.1) ...
Setting up libqt4-dev:amd64 (4:4.8.5+git192-g085f851+dfsg-2ubuntu4.1) ...
Setting up qt4-linguist-tools (4:4.8.5+git192-g085f851+dfsg-2ubuntu4.1) ...
Setting up qt4-qmake (4:4.8.5+git192-g085f851+dfsg-2ubuntu4.1) ...
Setting up libqt4-dev (4:4.8.5+git192-g085f851+dfsg-2ubuntu4.1) ...
Setting up libqt4-opengl-dev (4:4.8.5+git192-g085f851+dfsg-2ubuntu4.1) ...
Setting up libqt4-webkit2-dev (2.3.2-0ubuntu7) ...
Setting up libxml2-dev:amd64 (2.9.14+dfsg1-3ubuntu4.8) ...
Setting up libldap2-dev:amd64 (2.4.41-1ubuntu10.3) ...
Setting up libnss3-dev (1.2.1-1) ...
Setting up libnss3-dev:amd64 (1.2.1-1) ...

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DOWNLOAD ROOT IN MAINLY 2 WAYS

• **Sources from released versions:**  * https://root.cern.ch/downloading-root

✓ROOT's sources can be downloaded for each of the releases and unpacked with

✓$ wget https://root.cern.ch/download/root_<ver>.source.tar.gz

✓$ tar -zxf root_<version>.source.tar.gz

* Source:  https://root.cern.ch/get-root-sources
The purpose of **Git** is to manage a project, or a set of files, as they change over time. **Git** stores this information in a data structure called a **repository**

**Direct Git repository access:**

- The main advantages of using the trunk are:
  - You get the most recent features
  - You can easily benefit from bug fixes should you find one
  - To fix or extend ROOT you can change ROOT's sources yourself and send the changes (git diff) as feedback
  - The entire ROOT source can be obtained from our public Git repository:

```
$ git clone http://root.cern.ch/git/root.git
```
FOLLOWING STEPS WILL WORK ON ALL SYSTEMS

• Next we will move to the directory where we will install ROOT:

  • $ cd /usr/local/ (Recommended)

• To download the ROOT files run the following command:

  • $ sudo git clone https://github.com/root-mirror/root.git

• Next we will change the ownership of the folder root with:

  • $ sudo chown -R "username“:”groupname” root

Or command line magic

  • $sudo chown -R $(whoami):$(id -g -n $(whoami)) root
SOMETIMES LIFE IS NOT SO EASY

```
SOMETIME LIFE IS NOT SO EASY:

```

```
Setting up libbtwebklt-dev (2.3.2-8ubuntu7) ...
Setting up libxln2-dev-amd64 (2.3.1-dfsg1-3ubuntu4.8) ...
Setting up libbladap2-dev-amd64 (2.4.31-1+mun2ubuntu8.3) ...
Processing triggers for libbc-bin (2.19-0ubuntu6.6) ...
hbawa@yogao-03-linux:~$ sudo git clone https://github.com/root-mirror/root.git
sudo: git: command not found
hbawa@yogao-03-linux:~$ sudo apt-get install git
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  account-plugin-windows-live libb-2.0-2 libbupstart1 python-pexpect
  python-renderpm python-reportlab python-reportlab-accel
Use 'apt-get autoremove' to remove them.
The following extra packages will be installed:
  git-man libb-error-perl
Suggested packages:
  glit-daemon-run glit-daemon-sysvinit glit-doc glit-el glit-enall glit-gut glitk
glitch web glit-arch glit-bzr glit-cvs glit-medawiki glit-svn
The following NEW packages will be installed:
  glit-man libb-error-perl
0 upgraded, 3 newly installed, 0 to remove and 489 not upgraded.
Need to get 3,385 kB/3,386 kB of archives.
After this operation, 21.9 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://us.archive.ubuntu.com/ubuntu/ trusty-updates/main git-man all 1:1.9.1-1ubuntu8.3 [669 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu/ trusty-updates/main git-amd64 1:1.9.1-1ubuntu8.3 [5,066 kB]
Fetched 3,385 kB in 2s (1,754 kB/s)
Selecting previously unselected package libb-error-perl.
(Reading database ... 289783 files and directories currently installed.)
Preparing to unpack .../libb-error-perl_0.17-1.1_all.deb ...
Unpacking libb-error-perl (0.17-1.1) ...
Selecting previously unselected package git-man.
Preparing to unpack .../git-man_1+3a1.9.1-1ubuntu8.3_all.deb ...
Unpacking git-man (1:1.9.1-1ubuntu8.3) ...
Selecting previously unselected package git-gl.
Preparing to unpack .../git-gl-1+3a1.9.1-1ubuntu8.3_all.deb ...
Unpacking git-gl (1:1.9.1-1ubuntu8.3) ...
Processing triggers for man-db (2.6.7.1-1ubuntu1) ...
Setting up libb-error-perl (0.17-1.1) ...
Setting up git-man (1:1.9.1-1ubuntu8.3) ...
Setting up git-gl (1:1.9.1-1ubuntu8.3) ...
hbawa@yogao-03-linux:~$ sudo git clone https://github.com/root-mirror/root.git
Cloning into 'root'...
remote: Counting objects: 567078, done.
remote: Compressing objects: 100% (218/218), done.
remote: Total 567078 (delta 86), reused 1 (delta 1), pack-reused 566887
Receiving objects: 100% (567078/567078), 826.86 MB | 9.68 MB/s, done.
Resolving deltas: 100% (418178/418188), done.
Checking connectivity... done.
hbawa@yogao-03-linux:~$ sudo git clone https://github.com/root-mirror/root.git
```
cd root

./configure --all
BUILDING ROOT:

- `make`

```bash
g++ -m64 -o -DNDEBUG -Wl,-as-needed -Wl, -o bin/h2root main/src/h2root.o \
/usr/lib/gcc/x86_64-linux-gnu/4.8/libgfortran.so /usr/lib/gcc/x86_64-linux-gnu/4.8/libgfortranbgnl.a \
-lm -ldl -pthread -rdynamic 
gfortran -m64 -o2 -DNDEBUG -fpic -m64 -std=legacy -o main/src/g2root.o -c /usr/local/root/main/src/g2root.f 2>&1 | sed -e s/\n\nWarning: Ignore: Actual argument contains too few elements for dummy argument 'r' (3/300) at (1) 
/usr/local/root/main/src/g2root.f:728.29:

call toreals(3,pmixt,creals,nrr) 
1

Warning: Ignore: Actual argument contains too few elements for dummy argument 'r' (100/200) at (1) 
/usr/local/root/main/src/g2root.f:730.28:

call toreals(npar0,dummypars(1),creals,nrr) 
1

Warning: Ignore: Actual argument contains too few elements for dummy argument 'r' (94/200) at (1) 
gfortran -m64 -o2 -DNDEBUG -Wl,-as-needed -Wl, -as-needed -o bin/g2root main/src/g2root.o \
-llib lib/libmincern.a \
/usr/lib/gcc/x86_64-linux-gnu/4.8/libgfortran.so /usr/lib/gcc/x86_64-linux-gnu/4.8/libgfortranbgnl.a \
-lm -ldl -pthread -rdynamic
```

Generating PCH for core/base core/thread io/io math/mathcore net/net math/matrix hist/hist tree/tree graf2d/graf graf2d/ 
gpad graf3d/g3d gtu/gtu math/mn/mlt hist/histpnter tree/treeplayer tree/treeviewer math/physics graf2d/postscript core 
/r/int/math/maa mtx hist/spectrum hist/spectrumpnter gtu/ftptnl graf2d/x11 graf2d/x11ttf graf3d/gl graf2d/ 
d/astmage graf2d/astmage graf2d/gv/tz bindings/pyroot math/genvec/math/genvec/math/mathmore hist/hbook tmva/tmva 
tmva/tmva hist/math/genetic

```
root [0]
Processing hsimple.C...
hsimple : Real Time = 0.05 seconds Cpu Time = 0.06 seconds
(class Title =0x1acedc0

===================================================================
ROOT BUILD SUCCESSFUL.
===================================================================
*** Run 'source bin/thlsroot.[c]sh' before starting ROOT
```

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Root we downloaded using “git” check out the latest version of root.

Sometime, Ubuntu/linux is old enough to be compatible with libraries. For eg : cmake needs to be higher than 3.8 but Ubuntu 14.04 have 2.8

One can choose little older version(specific tag) of ROOT

$ cd root

$ git tag -l

$ git checkout -b v6-04-02 v6-04-02
ENV. VARIABLES
ENV. VARIABLES

New SHELL

```
hbawa@yogao-03-linux:~$ echo $ROOTSYS

hbawa@yogao-03-linux:~$ echo $PATH
/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:/usr/games:/usr/local/games

hbawa@yogao-03-linux:~$ echo $LD_LIBRARY_PATH

hbawa@yogao-03-linux:~$ echo $PYTHONPATH

hbawa@yogao-03-linux:~$ exit
```
SETTING UP ROOT

• You need to have the environment variable ROOTSYS set to the root install directory.

export $ROOTSYS=/usr/local/root (Typical path)

• Set root in our PATH

export PATH=$PATH:$ROOTSYS/bin

• Also need to use LD_LIBRARY_PATH

  This tells programs where to look for libraries

export LD_LIBRARY_PATH=$ROOTSYS/lib:$LD_LIBRARY_PATH

• You may define your root settings in ~/.rootlogon.C

• History of all commands are stored in ~/.root_hist
PUT PERMANENTLY IN SHELL (BASH)

alias li='ls -alF'
alias la='ls -A'
alias l='ls -CF'

# Add an 'alert' alias for long running commands. Use like so:
# sleep 10; alert
alias alert=notify-send --urgency=low -i "$( [[ $TIMESTAMP = "[0-9]*"] && echo \"\$\" ]] & echo error)" "$([history|tail -n1|sed -e \"\" | s/\"[^\"]*\"/\"\"/g]"$[[s/\"\"/\"\"/g]" & echo error)

# Alias definitions...
# You may want to put all your additions into a separate file like
# ~/.bash_aliases, instead of adding them here directly.
# See /usr/share/doc/bash-doc/examples in the bash-doc package.
if [ -f ~/.bash_aliases ]; then
  . ~/.bash_aliases
fi

export ROOTSYS=/usr/local/root
export PATH=$ROOTSYS/bin:$PATH
export LD_LIBRARY_PATH=$ROOTSYS/lib:$LD_LIBRARY_PATH
export PYTHONPATH=$ROOTSYS/lib:$PYTHONPATH

# enable programmable completion features (you don't need to enable
# this, if it's already enabled in /etc/bash.bashrc and /etc/profile
# sources /etc/bash.bashrc).
if [ -f /usr/share/bash-completion/bash_completion ]; then
  if ! /usr/share/bash-completion/bash_completion; then
    . /usr/share/bash-completion/bash_completion
  else
    . /etc/bash_completion
  fi
fi

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```
hbawa@yoga-03-linux:~$ echo $ROOTSYS

hbawa@yoga-03-linux:~$ echo $PATH
/usr/local/sbin:/usr/local/blin:/usr/sbin:/usr/blin:/bin:/usr/games:/usr/local/games

hbawa@yoga-03-linux:~$ echo $LD_LIBRARY_PATH

hbawa@yoga-03-linux:~$ echo $PYTHONPATH

hbawa@yoga-03-linux:~$ vi .bashrc

hbawa@yoga-03-linux:~$ source .bashrc

hbawa@yoga-03-linux:~$ echo $ROOTSYS
/usr/local/root

hbawa@yoga-03-linux:~$ echo $PATH
/usr/local/root/bin:/usr/local/sbin:/usr/local/blin:/usr/sbin:/usr/blin:/bin:/usr/games:/usr/local/games

hbawa@yoga-03-linux:~$ echo $LD_LIBRARY_PATH

hbawa@yoga-03-linux:~$ echo $PYTHONPATH

hbawa@yoga-03-linux:~$ root
```

Welcome to ROOT 6.04/06
(c) 1995-2014, The ROOT Team
Built for linuxx86_64gcc
From tag v6-04-06, 13 October 2015
Try 'help', 'demo', 'license', 'credits', 'exit'.

root [0]
THE FRAMEWORK ORGANIZATION
LAUNCHING AND QUITING ROOT

• To launch root: simply root
• You should see a splash screen appear, and then root start up in your terminal
• root –l (without logo)
• root –b (without browser) *Used in running root remotely (using ssh)
• To quit root, simply type “.q”
USER INTERFACES

- Macros and Programs
- Graphic User Interface (GUI)
- Command Line Interpreter (CINT)

Example of macro to read data from an ASCII file and create a...
GUI: BROWSING A FILE

• To easily browse a file we use TBrowser

• Command : TBrowser b

• This makes a TBrowser object called b and then you can quickly look into the contents of the rootfile by clicking the contents.(can be histograms/tree etc)

**Ex:** open following rootfile in root and look whats inside.

http://zimmer.fresnostate.edu/~hbawa/rootfiles/user.bawa.7531825._000086.tree.root
DISPLAYING A HISTOGRAM

- Open the root file
- Browse the file
- Display the histograms
- The Canvas

Divide Canvas
BASIC NAVIGATION BY CLICKING

• **Left Click**
  – select the object
  – drag the object
  – resize the object

• **Right Click**
  – context menu
  – class::name
  – methods

• **Middle Click**
  – activate canvas
  – freezes event status bar
DRAW PANEL
FIT PANEL

![FIT PANEL Diagram](image-url)
Editor
Adding Arrow
Adding Text
MODIFYING THE STATBOX
MODIFYING THE STATBOX

The Canvas in the Browser
- Setting the (7) statistics options
  - default = 1111

If I use: 111111 then
RANGE OF HISTOGRAM

yStar

<table>
<thead>
<tr>
<th>htemp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entries</td>
</tr>
<tr>
<td>500002</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>0.0007854</td>
</tr>
<tr>
<td>RMS</td>
</tr>
<tr>
<td>0.8715</td>
</tr>
</tbody>
</table>

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2/27/2018
Announcements

- Due to time change in the US, I won’t be able to hold the Tuesday sessions at 9am Pacific time for the next three weeks.
- The sessions will be prerecorded and uploaded before Tuesday 9am Pacific time.
- Thursday sessions will not be affected.