The Radio Astronomer's IT Toolkit

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Outline

Scenario: How would you solve this problem?

Your supervisor gives you a data file that they've dug out of the archives. They say that it contains Nobel prize winning data. . . if only you could analyse it. . . you take a look. . .

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```
010.1002587 -78.0749976 3.6 4.7 J0000M32 0.000 D
322.2776209 -64.6831876 3.1 3.6 J0000M52 0.108 C
328.0067189 -68.5874347 2.1 2.5 J0000M48 0.193 D
325.6616556 -67.1618942 1.8 2.0 J0000M48 2.539 B
314.1262894 -55.5638273 9.0 2.8 J0000M60 1.266 A
314.6473335 -56.3390663 3.3 3.5 J0000M60 2.522 C
334.7202054 -71.7342040 1.8 2.3 J0000M40 5.693 B
321.3525638 -63.9139186 2.0 2.1 J0000M52 2.080 B
325.7259722 -67.2143813 2.9 3.0 J0000M48 3.311 D
347.0515173 -75.2447016 2.3 3.4 J0000M36 4.345 C
325.5104290 -67.0742957 2.9 3.1 J0000M48 0.105 C
001.9296920 -77.4361767 5.9 6.9 J0000M32 1.530 B
307.3447442 -41.6675454 1.8 2.1 J0000M76 6.400 B
```

. . . and its 10 000 lines long.

What do you do next?

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4. Write a one line Unix script in a couple of minutes, then move on to the Nobel prize winning research. You solve this kind of problem hundreds of times a day.

The solution/s

- Python solution

```python
types = {'A':0, 'B':0, 'C':0, 'D':0}
for line in open('catalogue.txt'):
  cols = line.split()
  dec = float(cols[1])
  type = cols[-1]
  if dec > -70 and dec < -60:
    types[type] += 1

for type in types:
  print type, types[type]
```

- Shell solution

```
> awk '($2>-70 && $2<-60){print $7}' catalogue.txt | sort
| uniq -c | sort
```

The radio astronomer's IT toolkit

- What IT skills do you need to do your research effectively?
  - A data reduction/processing package
    (e.g. Miriad, AIPS++)
  - A FITS visualisation package
    (e.g. kvis, ds9)
  - A range of Un*x tools
    (e.g. cut, paste, grep, sed, awk, for loops)
  - A scripting language
    (e.g. Python, Perl)
  - A plotting package
    (e.g. IDL, matplotlib)
  - Familiarity with accessing large online resources
    (e.g. NED, SIMBAD, Vizier, ADS)
  - Version control software
    (e.g. Subversion)

The radio astronomer's IT toolkit

- Plus sometimes you need to
  - Write software in C, C++, FORTRAN
  - Read other people's code...
  - Query databases using SQL (e.g. SDSS, 6dF)
  - Use a wiki for collaboration
  - Set up a website
  - Set up a website with forms and cgi scripts
  - Set up a database to share/organise your data
  - Use VO Tools for complex queries

{girls, guys} like {girls, guys} who have skills

Why use scripting?

- Advantages vs. manual processing
  - Speed
  - Reproducibility
  - Documentation
  - Collaboration
- Advantages vs. 'real programming'
  - Speed of development
  - Flexibility
  - Easier for a beginner to understand

However. . .


AND A LEAN, SILENT FIGURE SLOWLY FADES INTO THE GATHERING DARKNESS, AWARE AT LAST THAT IN THIS WORLD, WITH GREAT POWER THERE MUST ALSO COME -- GREAT RESPONSIBILITY!

Problem 1

You have reduced your data and now have 200 FITS files sitting on your computer. You want to measure the peak flux in each image.

```
% foreach i (`ls *.fits`)
>   echo $i
>   fits in=$i op=xyin out=$i.xy
>   maxfit in=$i.xy
> end
```

* These examples use tcsh but the principle is the same in other scripting flavours (e.g. bash)

Problem 1

```
1020-5803.fits.xy
Fits: version 1.1 09-Feb-07
There were no blanked pixels in the input
MAXFIT: version 29-Nov-95

Peak pixel    : (65,63,1) = 4.6736E-01

Fitted pixel : (65.21,63.11,1) = 4.5010E-01

...

Coordinate:
  Axis 1: Fitted RA---NCP  =  10:20:15.719
  Axis 2: Fitted DEC--NCP  = -58:03:53.13
  Axis 3:        FREQ-LSR  = 1.86239759E+01 GHz
...
```

Problem 1

You want extract the peak flux and ignore all other output.

```
% foreach i (`ls *.fits`)
>   echo $i
>   fits in=$i op=xyin out=$i.xy
>   maxfit in=$i.xy | grep Peak
> end
1020-5803.fits
Peak pixel   : (65,63,1) = 4.6736E-01
1350-6135.fits
Peak pixel   : (64,66,1) = 8.3779E-01
...
```

Problem 1

You want to fix up the annoying file names (1020-5803.fits.xy).

```
% foreach i (`ls *.fits | sed 's/.fits//g'`)
>   echo $i
>   fits in=$i.fits op=xyin out=$i.xy
>   maxfit in=$i.xy | grep Peak
> end
1020-5803
Peak pixel    : (65,63,1) = 4.6736E-01
1350-6135
Peak pixel    : (64,66,1) = 8.3779E-01
...
```

Problem 1

You want to make a table of your results.

```
% foreach i (`ls *.fits | sed 's/.fits//g'`)
>   fits in=$i.fits op=xyin out=$i.xy
>   echo -n "$i " >> table.txt
>   maxfit in=$i.xy | grep Peak | cut "-d " -f8 >> table.txt
> end
% cat table.txt
1020-5803 4.6736E-01
1350-6135 8.3779E-01
...
```

Everybody stand back, I know regular expressions!

http://xkcd.com

Problem 2

You want to measure the peak flux for each of your sources and print out an annotation file for kvis with circles proportional to the peak flux.

```
import os
for filename in os.listdir('data'):
    # run maxfit on each image
    (rastr, decstr, peak) = maxfit('data/%s' % filename)

    # convert ra and dec to decimal form
    ra = ra2decimal(rastr)
    dec = dec2decimal(decstr)

    # print a kvis annotation file
    print 'circle %f %f %f' % (ra, dec, 0.02*peak)
```

Problem 2

A function to wrap maxfit to run within Python

```python
def maxfit(filename):
    cmd = 'maxfit in=%s' % filename
    (rastr, decstr, cols) = (None, None, None)
    for line in os.popen(cmd):
        cols = line.split()
        if line.startswith('Peak'):
            peak = float(cols[-1])
        elif 'RA' in line:
            rastr = cols[-1]
        elif 'DEC' in line:
            decstr = cols[-1]
    return (rastr, decstr, peak)
```

Problem 2

Some functions to do coordinate conversions.

```
def ra2decimal(rastr):
  r = rastr.split(':')
  ra = (float(r[0]) + float(r[1])/60.0 + float(r[2])/3600.0)*15
  return ra


def dec2decimal(decstr):
  d = decstr.split(':')
  if d[0].startswith('-') or float(d[0]) < 0:
    dec = float(d[0]) - float(d[1])/60.0 - float(d[2])/3600.0
  else:
    dec = float(d[0]) + float(d[1])/60.0 + float(d[2])/3600.0
  return dec
```

Problem 2: putting it altogether

```
import os
def ra2decimal(rastr):
    ...

def dec2decimal(decstr):
    ...

def maxfit(filename):
    ...

for filename in os.listdir():
    (rastr, decstr, peak) = maxfit(filename)

    ra = ra2decimal(rastr)
    dec = dec2decimal(decstr)

    print 'circle %f %f %f' % (ra, dec, 0.01*peak)
```

Problem 2: results

You want to measure the peak flux for each of your sources, calculate the mean for your sample, and print out an annotation file for `kvis` with circles proportional to the peak flux.

```
> python peakflux.py
circle 155.065496 -58.064758 0.009347
circle 207.676467 -61.586053 0.016756
circle 245.046142 -50.888425 0.079280
circle 250.000575 -48.861683 0.065074
circle 260.079975 -35.912969 0.120744
```

Data reduction scripts

- I have written some scripts to go with tutorial 1
  1. `reduce_ngc253_v1.sh`
     The most basic data reduction script.
  2. `reduce_ngc253_v2.sh`
     A slightly more advanced shell script.
  3. `reduce_ngc253.py`
     Python script with more features.
- These are not the only way to do it — they are meant as a guide to get you started
- http://www.physics.usyd.edu.au/~tara/synthesis
- To run them, do

```
> chmod a+x reduce_ngc253_v1.sh
> ./reduce_ngc253_v1.sh
```

- They assume the raw data is in a directory called `data`

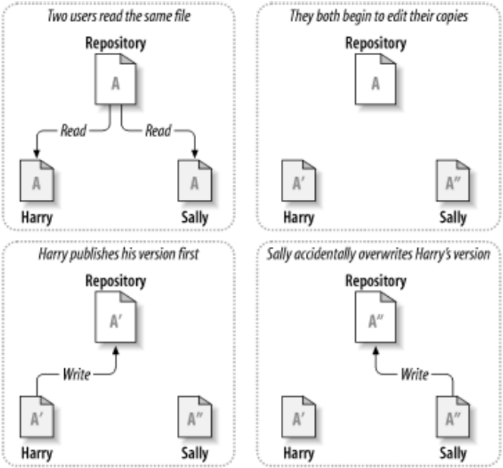
Why should I use version control?

- Works as a constant backup (accessible anywhere at anytime)
- Allows syncing between laptop, work and home desktops
- Allows collaboration on source code, papers, schedule files
- Allows students and supervisors to share code/resources
- Keeps a record of who made changes and why

- Version control works like an e-version of a log book

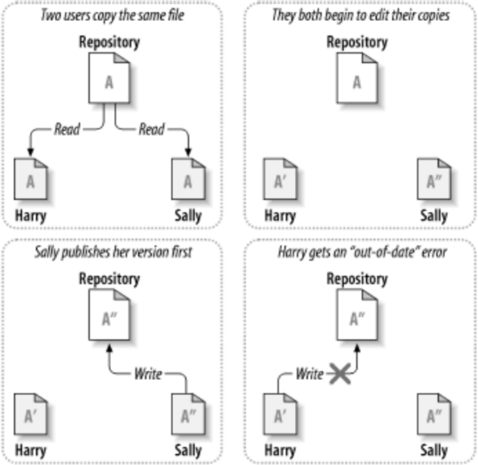
- **It makes you a better coder!**

The problem to avoid



http://svnbook.red-bean.com

The Copy-Modify-Merge solution



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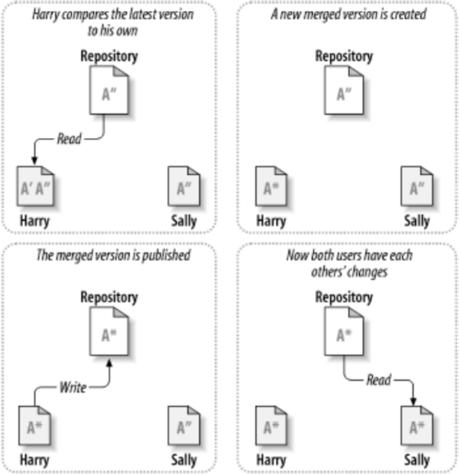

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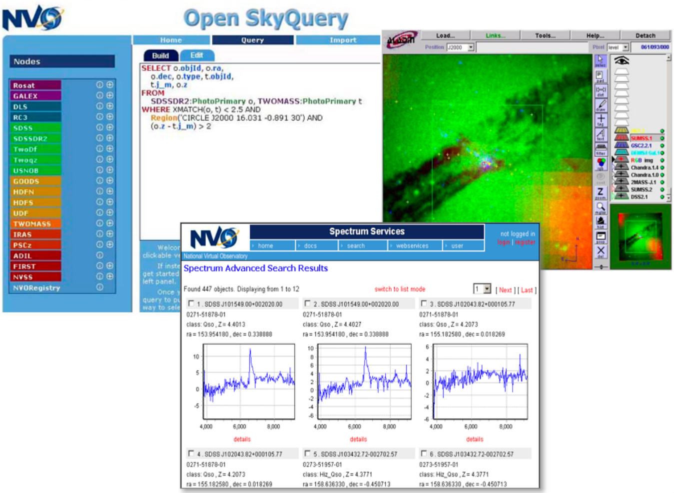
What is the Virtual Observatory?

- We need a way of addressing the data management, analysis, distribution and interoperability challenges of modern astronomy
- The main drivers are
  - Data growth: volume and richness
  - Desire to work online
  - Multi-archive science
  - Large database science

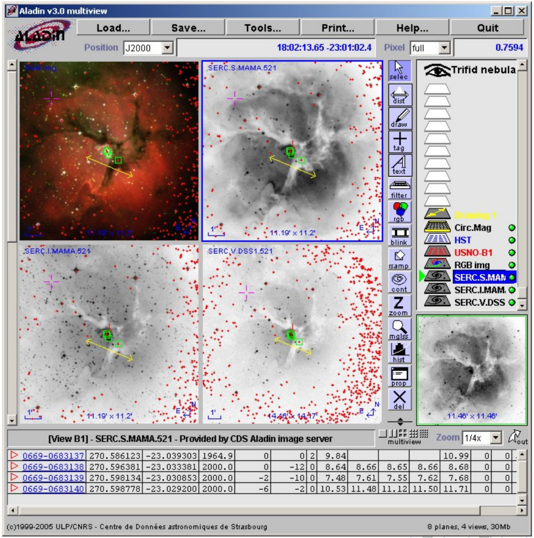
The Virtual Observatory is a distributed collection of

- Data resources
- Software resources
- Computing (grid) resources
- Telescopes

What are VO tools?



An interactive sky atlas: Aladin

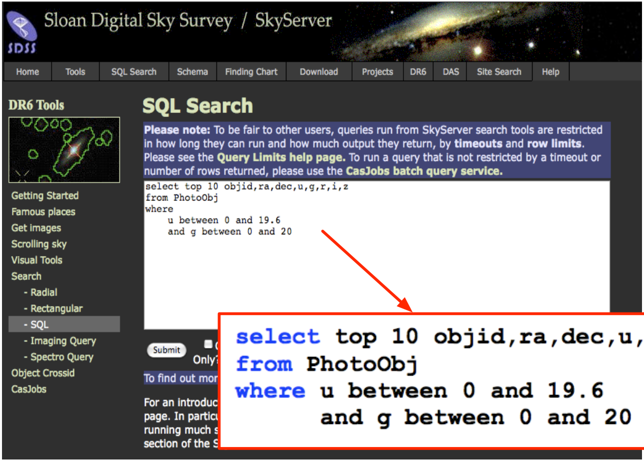


An interactive sky atlas: Aladin

- Visualize digitized astronomical images
- Superimpose entries from catalogues or databases
- Interactively access online data from SIMBAD, NED, Vizier
- Fully VO aware — access other VO resources
- **See demo**
- http://aladin.u-strasbg.fr

- You can also write your own plug-ins (ask Keith Bannister)
- The developers are very keen to get feedback from users — they are happy to make suggested changes!

Querying online databases: SDSS




```sql
select top 10 objid,ra,dec,u,g,r,i,z
from PhotoObj
where u between 0 and 19.6
      and g between 0 and 20
```

http://cas.sdss.org/astrodr6/en/tools/search/sql.asp

Querying online databases: Open Sky Query

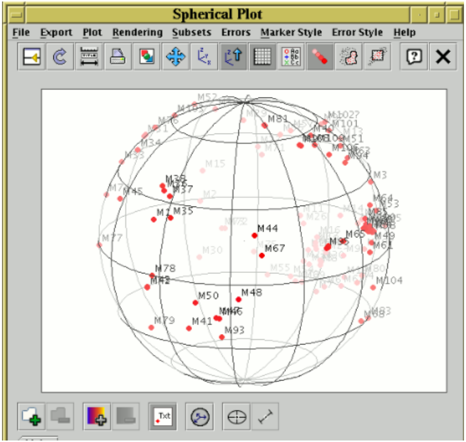
http://openskyquery.net/Sky/SkySite

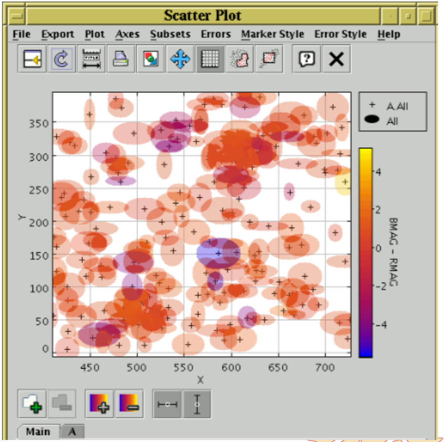
VO enabled plotting

- Many VO tools let you select sources and plot them
- All VO tools allow you to retrieve data as an XML VO table

- TOPCAT is an interactive graphical tool for analysis and manipulation of tabular data
- TOPCAT manifesto: *Does what you want with tables*
- `http://www.star.bris.ac.uk/~mbt/topcat`

VO enabled plotting: TOPCAT





Other tools worth looking at

- DataScope
  heasarc.gsfc.nasa.gov/vo
- SkyView
  http://skyview.gsfc.nasa.gov
- MyADS
  http://myads.harvard.edu
- AstroGrid
  http://www2.astrogrid.org/science
- Google Sky
  http://www.google.com/sky

IT is critical in future astronomy

- IT is becoming increasingly important in ‘everyday’ science
- It is important to learn these skills now!

- Look out for the Astroinformatics Summer School in 2009
- Resources available from the Aus-VO Summer School websites
  http://www.physics.usyd.edu.au/ioa/ausvoss
  http://www.physics.usyd.edu.au/ioa/ausvoss2007