'Absolute Beginner's' Guide to

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Anticipatory bail :-) This guide is not an expert's write up on Linux/Cygwin GRASS installation, but rather a new user's experience with setting up these systems. So there could be far more efficient methods of going about the job than outlined here! Acknowledgments to the many excellent tutorials written by GRASS users and developers, powered by the Free Software philosophy.

1. Setting up a Linux system for GRASS

The basic assumption made in this guide is that there is no Linux, Cygwin or GRASS existing in your computer. So the guide deals with setting up Linux (RedHat 7.3 Valhalla 2.4.18-3), Cygwin and GRASS (5.0.0) on a fresh hard disk or on a computer with Windows already installed.

1.1 System requirements

Ideally a computer destined to have a GRASS system should have at least:
- An operating systems like Linux/Intel, Linux/PowerPC, Solaris/SPARC, Solaris/i86, SGI IRIX, HP UX, Mac OS X (Darwin), IBM AIX, BSD-Unix variants, FreeBSD, CRAY Unicos, iPAQ/Linux handhelds and other UNIX compliant platforms (32/64bit), Windows NTFS/Cygnus.
- 200MHz speed processor
- 128-256MB RAM
- 50MB harddisk space for GRASS
- 100MB to 4GB for Linux (depending on the applications that are installed besides GRASS)
- Architectures like Intel x86, Motorola PPC, SGI MIPS, Sun SPARC, Alpha AXP, HP PA-RISC, CRAY.
- 500MB for data
- A good video card, ideally with 3D support
- Linux from Redhat, Debian or Slackware.
- For Debian, Mandrake Tcl/TK is installed but is not found by the executable because some links to dynamic libraries may not be set correctly. Mandrake users have to install grass with the --nodeps option because the link is not found by the package manager (refer http://motivation.ru/cdrom/doc/grass.en.html for details.).

Similar is the case with Suse (http://op.gfz-potsdam.de/GRASS-List/Archive/msg 07619. html).

1.2 Basic software

Besides GRASS the following software need to be present (all these are automatically installed with Linux):

- C-compiler (cc, gcc, egcs etc.) (gcc: http://www.gnu.org/software/gcc/gcc.html)
- zlib compression library, which is pre-installed on most systems and is used for to internally compress GRASS raster files. (libz: http://www.gzip.org/zlib/)
- lexical analyzer generator (flex) (flex: http://www.gnu.org/software/flex/flex.html)
- parser generator (yacc, bison) (bison: http://www.gnu.org/software/bison/bison.html)
- libncurses 4.x/5.x (pre-installed on most systems) (http://www.gnu.org/software/ncurses/ncurses. html, ftp://ftp.gnu.org/pub/gnu/ncurses/)
- dgm/gdbm (dbm.h): GNU dbm is a set of database routines that use extendible hashing and works similar to the standard UNIX dbm routines. (http://www.gnu.org/software/gdbm/gdbm.html)
- X11 window system for graphical output, development libraries (X development libraries, usually an integral part of the Linux distributions) (http://www.xfree.org)

1.3 Configuration of the GRASS system

The Linux/Windows system that was setup for GRASS/Cygwin GRASS in the Fachhochschule Stuttgart, had the following hardware installed for running GRASS (5.0.0 Aug 2002) as well as other software:

- CPU: x86 450 MHz Intel Pentium II, 512 kb cache
- Memory: 256MB
- Network Card: 3Com Etherlink PCI, 100MB/s
- Harddisk capacity: 40GB
- Monitor: True color (32 bit, 1024x768, refresh rate: 70Hz, ELSA ECOMO 19" monitor)
- 3.5" 1.44MB floppy drive
- SCSI CDROM TEAC CD-532S Fast/Ultra SE
- Video Card: 64MB NV17 GE Force4 MX440
- Sound card: Creative SB AWE 64

1.4 Hard disk partitioning in Linux

An outline of how to install Linux and GRASS, set up a dual-booting computer so that the system can have both Linux and Windows as OSs, access Windows files from Linux and vice-versa is presented here (these are my experience, better ways must exist). Invariably the computer you are going to install GRASS and Linux onto will have Windows as its operating system. So it would be a good idea to collect all the relevant information regarding hardware, network addresses and settings while Windows is intact. From the hardware browser in Windows all relevant information can be

obtained. One of the more important information to be collected is the horizontal and vertical frequency of the monitor, Linux sometimes does not properly identify the monitor and its properties. Also you can run the freeware **BGInfo** in Windows (http://www. sysinternals. com/ ntw2k/freeware/ bginfo.shtml) to collect information on IP address, netmask address, network address, hostname, gateway address, primary and secondary DNS etc (Fig. 1). These are needed to set up the internet connection.


```
Boot Time:          9/6/02 11:32 AM
CPU:                450 MHz Intel Pentium II
Default Gateway:    193.196.137.250
DHCP Server:        (none)
DNS Server:         193.196.136.1
Free Space:         C:\ 654.70 MB NTFS
Host Name:          PC211105
IE Version:         5.50.4807.2300
IP Address:         193.196.137.59
Logon Domain:       PC211105
Logon Server:       PC211105
MAC Address:        00-10-5A-30-48-4A
Machine Domain:
Memory:             128 MB
Network Card:       3Com EtherLink PCI
Network Speed:      100 Mb/s
Network Type:       Ethernet
OS Version:         Windows NT 4.0
Service Pack:       Service Pack 5
Snapshot Time:      9/6/02 11:58 AM
Subnet Mask:        255.255.255.0
System Type:        Workstation, ?
User Name:          anprs110
Volumes:            C:\ 4.25 GB NTFS
```

Fig. 1 BGInfo provides information on most aspects of the computer and the network (Note: This screenshot is not of the computer in which Linux is installed.)

1.5 BIOS updating

In case the hard disk of the computer that is being used for installing Linux and GRASS is not upto

the expectations, it can be replaced with a new hard disk. But often the problem of incompatibility between the BIOS and the new hard disk arises. This is mostly because older hard disks are SCSI while the newer ones with more capacity are IDE ones. Thus the older, existing motherboard and the BIOS will support only SCSI hard disks. Even if the new IDE hard disk is supported, most probably the full capacity of the harddisk will not be recognised by the BIOS.

In the computer I was using, the original hard disk was IDE 4.3GB, with a four year old BIOS (ASUS P2B-S ACPI BIOS Revision 1.006 dated July 16, 1999). The new hard disk was of 40GB capacity, but the existing BIOS could only recognise it as a 8.2GB harddisk. To make the BIOS read the full 40GB, the process of upgrading the BIOS had to be done.

Flashing the BIOS. 'Flashing' may have meanings that are not quite close to computing, but when it comes to BIOSs it means thrusting an upgrade over the existing software in the BIOS. Flash ROM is usually used for system BIOS, which initiates hardware devices and sets up necessary parameters for the OS. Unlike EPROM which can be erased by only uv light, flash ROM can be electrically erased and hence its contents can be modified, thus allowing the updating of the BIOS (ASUS 2002; Mueller and Soper, 2002).

For my purpose, I downloaded the newest upgrade of the ASUS P2B-S ACPI BIOS 7-11-1999 Revision 1.006 (it is quite important to know the exact version and dates, these can be found by physically opening the computer and examining the BIOS, so that the relevant upgrade can be downloaded). The software is downloaded to a bootable DOS floppy (only DOS6.2, Win95 or 98) which does not contain CONFIG.SYS and AUTOEXEC.BAT (just rename the two if the floppy has them: I dont know why these two should not be on the floppy). Also from the website of the BIOS vendor (mine was http://www.asus.com.tw/inside/Techref) download to the same floppy the program that will allow you to put the upgrade into the BIOS. This software is called a 'flashing' program, and the process is called 'flashing the BIOS'. Boot from the floppy, run the flashing program (called AFLASH.EXE) from the DOS prompt, and the BIOS will be updated (takes about 5 minutes) and is now ready to accept the new, high capacity IDE hard disk. Now the process of partitioning of the disk and setting up the OSs can be begun.

1.6 The complete steps to have GRASS running on Linux

Checking file systems
• First determine the current operating system, and the file system on the computer
> - e.g., Windows 98 FAT partitions
> > Windows NT NTFS
> > Windows 2000 Professional NTFS or FAT etc.

• Next check the available disk space. For both Windows and Linux (full installation) plus GRASS to be installed along with data, a minimum of 8GB is essential. If only a minimal installation is aimed at then lesser space may be sufficient.

Partitions

• If there is no essential information on the hard disk then it would be ideal to begin with a clean slate

and format the hard disk, with FIPS or FDISK.

• FIPS and FDISK can be created on a DOS boot floppy by the DOS commands

     format a:/s
     copy fdisk.exe a:
     copy format.com a:
     copy autoexec.bat a:

(There may be sites from where ready made boot images can be downloaded.)

• Restart the computer, boot from floppy (go to the BIOS startup sequence, if the computer does not boot from the floppy, change boot sequence to A, CDROM, C)

• From the command prompt run FDISK.

• Partition the disk into two; if one C drive for Windows and the remaining for Linux is needed.

• Carefully decide on the size of the partitions beforehand. Windows with the full Office packages and programming languages would take up about 3GB space. Then if Cygwin GRASS is to be installed it would require another 400-425MB space. Also if some other GIS packages like ArcGIS is to be installed then the Windows partition should have another 1GB of space. Additionally space to hold data could be another 1GB, especially if dealing with satellite imageries. Ideal would be a minimum of 8GB for the Windows partition, so that later on there would not be any problems of lack of space.

• A full system Linux installation (Red Hat 7.3) requires 4.3GB space, and an additional 50MB for GRASS. But additional requirements like plenty of swap space would be essential if there is a lot of raster processing involved. Especially if satellite images are being processed, or if large shape files are processed the RAM would not be able to handle the memory requirements and invariably 'out of memory' messages would crop up. Closing other programs too may not help. All these factors need to be considered before setting up the partitions.

• In short a dual boot computer optimised to handle all types of GIS data from point to vector to raster and large datasets would need at the minimum about 16GB harddisk space.

• The partitioning scheme adopted by me is shown in Fig.2 (this is just something I did and should not be taken as the ideal: nevertheless this scheme works; also take a look at Stein Gjoen's http:// www. linux.org/ docs/ldp/howto/ Multi-Disk-HOWTO-4.html):
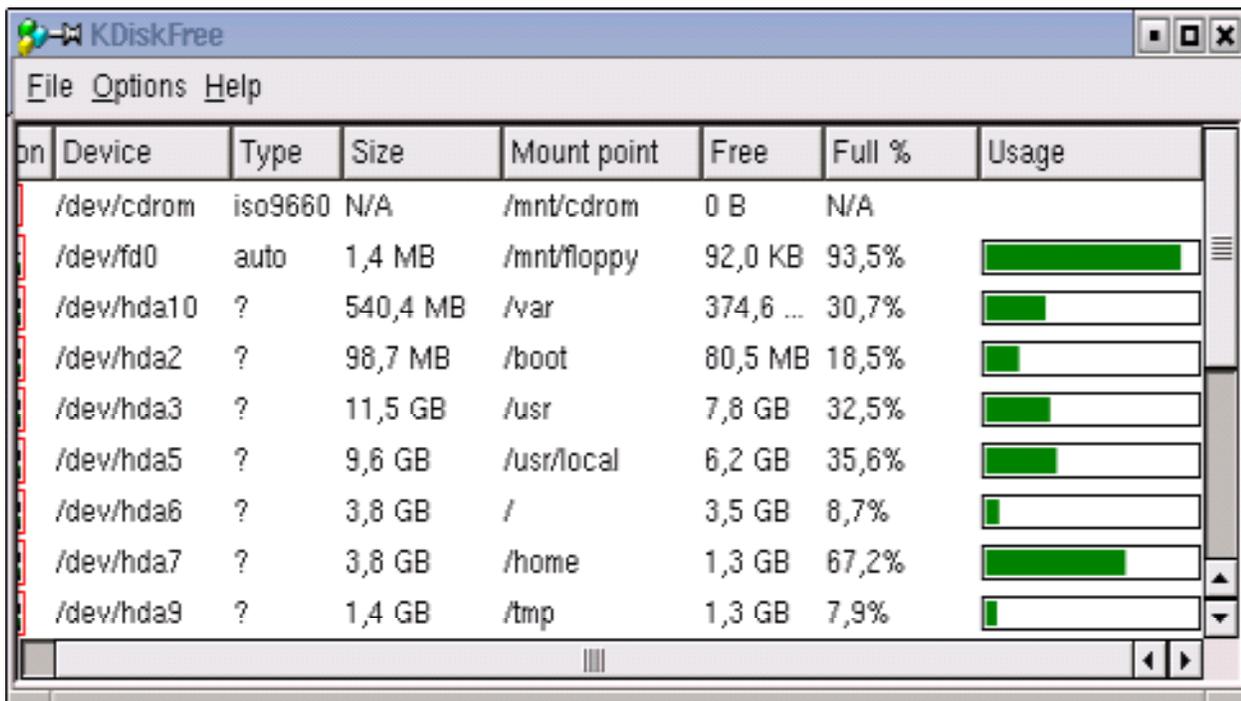
     A 4GB Windows primary partition (in hindsight that was too little space, and Windows based

GIS software could not be installed)

A 36GB Linux partition which is subdivided into

1. The root directory, symbolized by /:3.8GB (*too much space*)
2. The boot directory, /boot : 98.7MB (*The boot sector requires only minimal space.*)
3. The usr directory, /usr : 11.5GB
4. The usr/local dir, /usr/local: 9.6GB
5. The var dir, /var: 540.4MB
6. The home directory, /home: 3.8GB (*could do with more space. esp. if multiuser*)
7. The swap dir, /tmp: 1.4GB

• Usually swap should be twice the RAM size, but as said above, when working with GIS and large raster files, it is better to have a bigger swap. Programs with memory leaks use up RAM. The upper limit is 1.5GB. See Fig. 3 for the details of the memory usage in the computer I was using.

• The home directory stores the users files and often all data, including GRASS data. Also if multiple users are accessing the computer then /home should have space for all to store their individual data.

• Linux stores most of its files in the /usr and /root directories.

• Any new program can be installed into /usr/local

bn	Device	Type	Size	Mount point	Free	Full %	Usage
	/dev/cdrom	iso9660	N/A	/mnt/cdrom	0 B	N/A	
	/dev/fd0	auto	1,4 MB	/mnt/floppy	92,0 KB	93,5%	
	/dev/hda10	?	540,4 MB	/var	374,6 ...	30,7%	
	/dev/hda2	?	98,7 MB	/boot	80,5 MB	18,5%	
	/dev/hda3	?	11,5 GB	/usr	7,8 GB	32,5%	
	/dev/hda5	?	9,6 GB	/usr/local	6,2 GB	35,6%	
	/dev/hda6	?	3,8 GB	/	3,5 GB	8,7%	
	/dev/hda7	?	3,8 GB	/home	1,3 GB	67,2%	
	/dev/hda9	?	1,4 GB	/tmp	1,3 GB	7,9%	

Fig.2 The Linux partitions adopted in the computer. The usage statistics are presented for each partition.
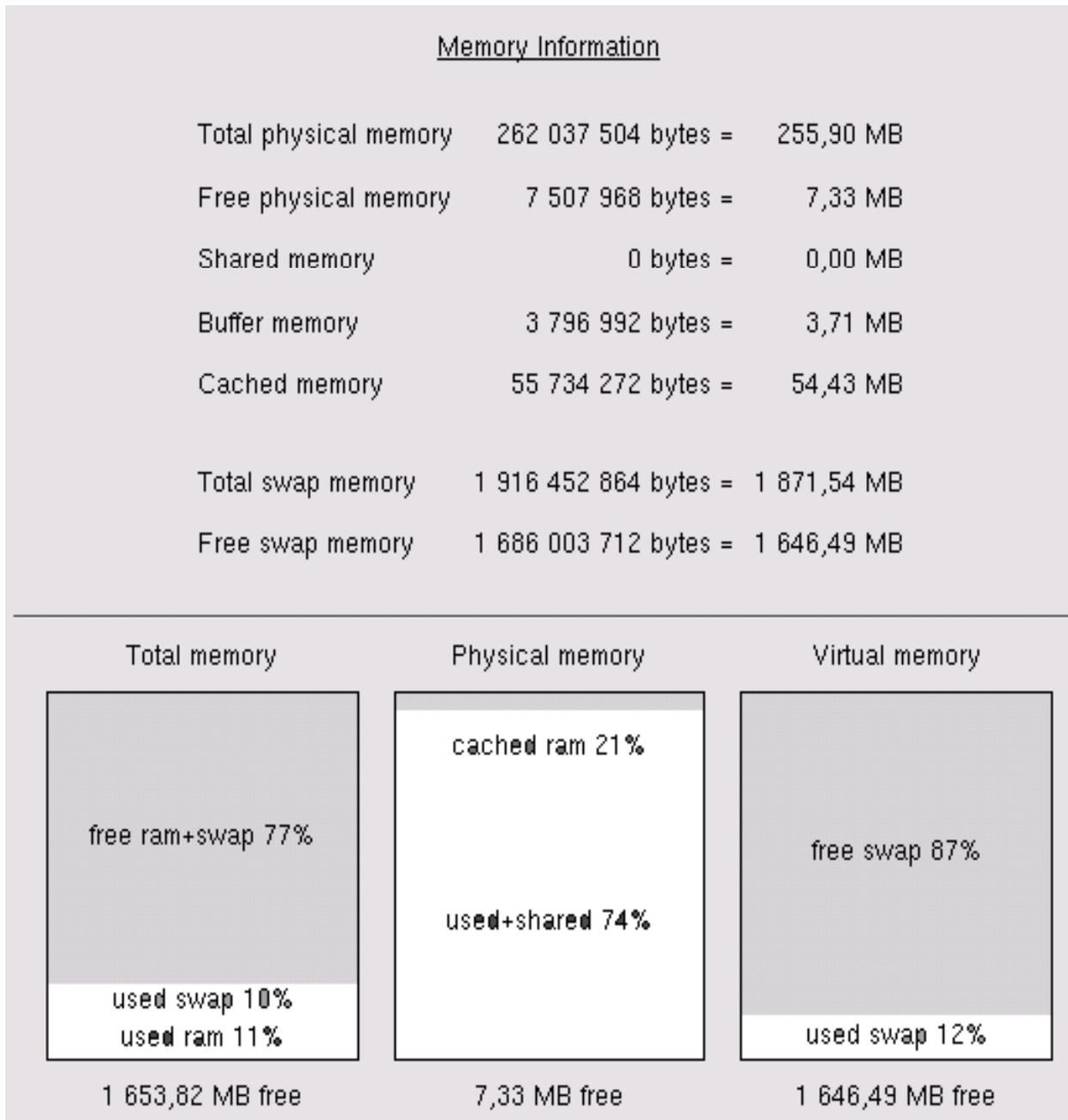
Fig.3 Memory usage in Linux. Screenshot taken when not many programs were running. With GRASS running some raster operations on images the physical memory (RAM) would be completely occupied and processing would rely on swap (virtual memory).

NTFS and Linux ext2 or ext3

• Once the decision about the partitions and the sizes are made, partitioning can start with FDISK. Be aware that: Linux cannot easily access NTFS partitions but can access FAT, but Windows is now moving away from FAT file systems. *More importantly:* **GRASS on Windows works only in NTFS: not on FAT!** So it would be better to choose NTFS for the Windows partitions, and use some tools

• (discussed later) to access the Windows files. Currently it is possible to mount, copy, read, and write Windows files into Linux, but it is advised not to try to write to NTFS from Linux (http://linux-ntfs.sourceforge.net/info/ntfs.html#3.2).

• Use FDISK to specify the NTFS file system, but use Linux's own FIPS or DiskDruid to set up the Linux file systems (named etx2, or ext3), while installing Linux.

• The file systems in the different partitions are shown in Fig.4. There are some free spaces that resulted from incorrect estimation of the disk space requirements. Since these free spaces are between two Linux partitions or not consecutive with a Windows partition, and also because it was created with Disk Druid, it cannot be added to the Windows partitions, but can only be taken into Linux.
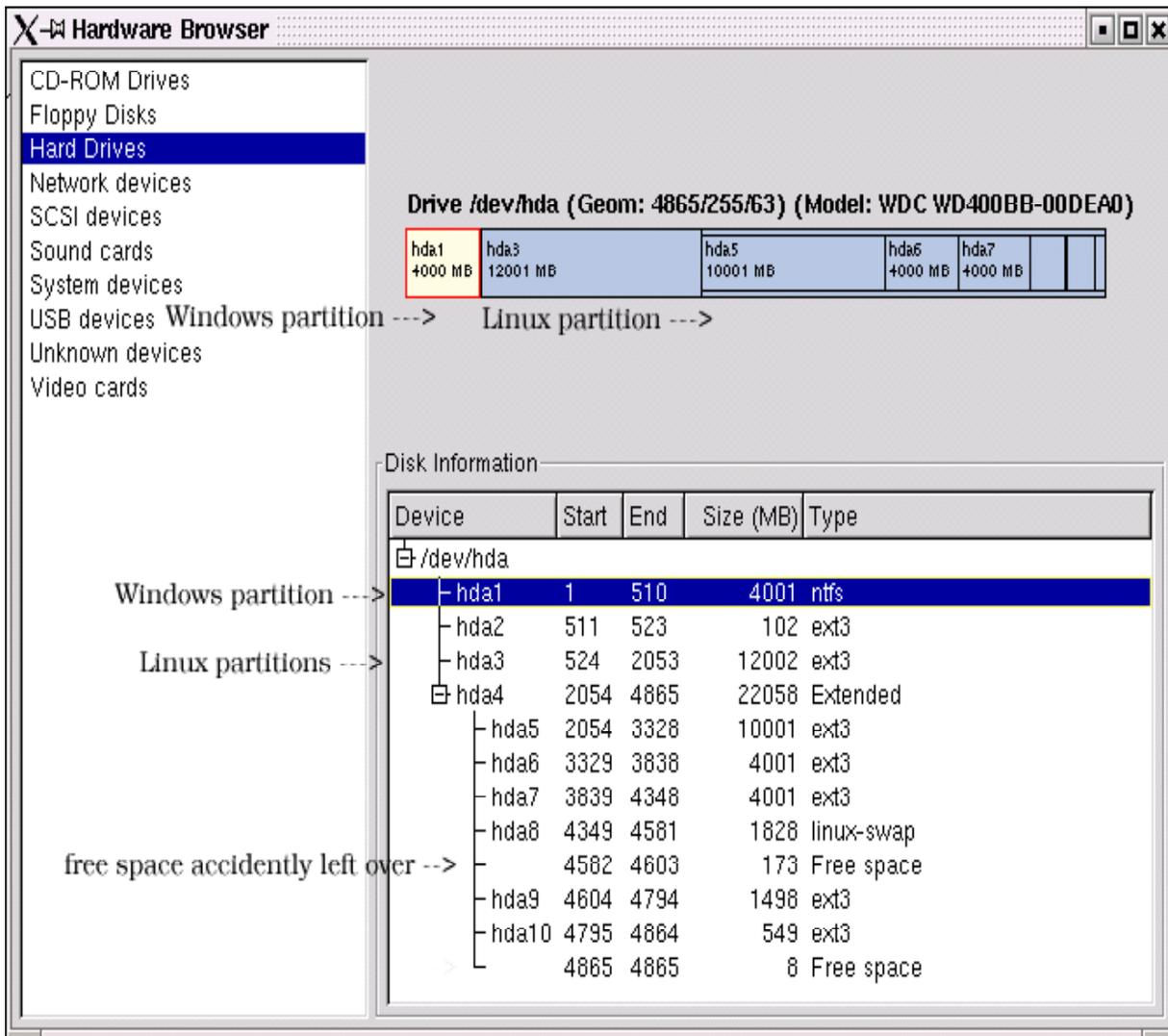

Fig.4 Disk partitions and file types. Windows (4GB) in yellow and Linux (36GB) in blue. About 181MB orphan space, due to incorrect disk space estimations.

• Once partitioning for Windows is over the operating systems can be installed. I opted to install Linux first, but Windows may also be installed first without any problems. The Linux installation disks (used three CDs of Red Hat Linux 7.3) have to be supplied one after the other, the first disk

gives the option to partition the Linux partition with Disk Druid or FIPS (the former is more user friendly). Full installation instructions with screenshots are available at the Redhat site and are really intelligible, so I avoid repetition here (http://www.redhat.com/docs/manuals/ linux/RHL-7.3-Manual/ install-guide/).

Master Boot Record and Lilo

• Since Linux is being installed first, care should be taken to not write the Linux boot loader (LILO or GRUB) to the Master Boot Record (MBR), because NTFS will write the NTLoader (i.e., the Windows boot loader) to the MBR, which is its default location. LILO or GRUB should be written else where, may be in the first sector of the root partition (http://www.tldp. org/HOWTO/mini/Linux+NT-Loader.html). (*But I have found different opinions about writing or not writing to MBR*.)

• After partitioning the hard disk Linux and its associated packages can be installed.

• Once Linux installation is over, Windows can be installed from a bootable CD.

• To connect to the Novell-based LAN network in the Fachhochschule Stuttgart (in Windows) the Novell Client v.4.83 programme was used (free download from http://download.novell.com/ filedist/ctrl).

• Since the MBR will be written over by NTFS, the computer will now boot only from Windows. But Linux can be added to the boot-up menu, by using the Free Software **BootPart** (http://ourworld.compuserve.com/homepages/gvollant/bootpart.htm). The Linux Loader (Lilo) should be at the beginning of the Linux partition (in the root /), then the Linux partition can be added to menu of the NTloader with BootPart.

• The boot.ini file of Windows will now look like this:

[boot loader]

timeout=30

default=multi(0)disk(0)rdisk(0)partition(1)\WINDOWS

[operating systems]

multi(0)disk(0)rdisk(0)partition(1)\WINDOWS="Microsoft Windows 2000 Professional" /fastdetect

C:\software\bootlinx.bin="linux"

Mounting Windows partition in Linux

• To get the Windows partition mounted within Linux (i.e., to access Windows from Linux and to copy files from Windows into Linux and use it just like any other Linux directory, by making the Windows partition appear as another directory in the root directory), the Linux kernel driver has to be modified. Legal tangles with the status of using the NTFS driver has made RedHat leave the driver out of their Linux kernels. The appropriate kernel for the particular hardware and version of Linux can be downloaded from http://linux-ntfs.sourceforge.net/info/redhat.html. The following information is needed for that: Linux release version, name, kernel and processor type.

• The computer I was using had Red Hat Linux release 7.3 (Valhalla) Kernel version 2.4.18-3, on an i686 processor. This information can be obtained by:

[anprs110@pc21114 pradeep]$ *cat /etc/redhat-release*
Red Hat Linux release 7.3 (Valhalla)

[anprs110@pc21114 pradeep]$ *uname -r*
2.4.18-3

[anprs110@pc21114 pradeep]$ *rpm -q --queryformat "%{ARCH}\n" kernel*
i686

• Detailed instructions for installation of the driver is available at http://linux-ntfs.sourceforge.net/info/ redhat.html. To check whether the driver is installed after following those instructions:

[anprs110@pc21114 pradeep]$ *dmesg | grep NTFS*
NTFS driver v1.1.22

• and to see whether the Linux kernel has understood the new file system:

[anprs110@pc21114 pradeep]$ *cat /proc/filesystems*
nodev   rootfs
nodev   bdev
nodev   proc
nodev   sockfs
nodev   tmpfs
nodev   shm
nodev   pipefs
        ext2
nodev   ramfs
        iso9660
nodev   devpts
        ext3
nodev   usbdevfs
nodev   usbfs
nodev   autofs
nodev   binfmt_misc
        vfat
        ntfs
• NTFS is understood and appears in the list. To go on to mount the NTFS file system in Linux:

[anprs110@pc21114 pradeep]$ *mkdir /WinRoot* (note: that this can be any name you wish to give)
[anprs110@pc21114 pradeep]$ *mount /dev/hda1 /mnt/WinRoot -t ntfs -r -o umask=0222*

- There are many options or mounting, the option above will mount with the permission -r-xr-xr-x 1 root root. Now the computer is ready for being used as a dual boot one: with Windows and Linux. Cygwin GRASS can be installed on to the Windows partition and GRASS on to the Linux partition.

LTOOLS
- **Ltools** from FHT Esslingen (http://www.it.fht-esslingen.de/~zimmerma/software/ ltools.html) is a very useful tool to read and write Linux ext2 and ext3 filesystems from Windows (3.x, 9.x or NT) running on the same machine. So whenever Cygwin GRASS cannot do an operation like say for example *r.in.gdal* but you need the output in your Cygwin GRASS, Ltools can be used to copy the results of the same operation done in GRASS under Linux, to Windows. Cygwin GRASS can then work on that.

GRASS download and installation in Linux
- GRASS can be downloaded from http://grass.itc.it/download.html or obtained on CDs (http://grass.itc.it/acquire.html). Either the source code or the precompiled binaries can be downloaded. Also all the manuals can also be downloaded from the same site. Installing GRASS on Linux is fairly straight forward, unlike on Windows. The steps for GRASS binary installation on Linux is detailed here. Installation from source is also not complicated.

- Installation requires that the user be logged in as root. Move into the directory where the GRASS binary file has been stored e.g., /usr/local/ and run the shell script grass5.0.0install.sh (this install shell script also need to be downloaded from the site mentioned above).

[root@pc21114 local]# *sh grass5.0.0install.sh grass5.0.0package_bin.tar.gz*

This will automatically install GRASS files into the appropriate directories. Now the GRASS system is ready for use in Linux.

2. Setting up a Windows/Cygwin system for GRASS

2.1 The Cygwin environment in Windows for GRASS

Installing GRASS on Windows is not as easy as on Linux; this is due to the fact that GRASS was originally written for UNIX and also due to the fact that most of the users and developers are from the Linux community and work is still on with Cygwin GRASS. It is good to know at the outset that GRASS on Windows does not have any resemblance to typical GIS packages on Windows and do not have any extra GUIs. Users tend to think that GRASS on Windows will have such a visage. Actually its appearance is exactly the same as that in Linux.

The prerequisites for GRASS installation on Windows are:
- Windows NT 4.0 (Service Pack3 or higher), Windows 2000 Professional or Windows XP (Windows 9x and Windows ME are unsupported)
- Cygwin, latest release
- NTFS filesystem (FAT does not work.)

• X Window Server and Client
• libraries and additions (see below)

The essential steps before GRASS can run on Windows are enumerated here. (For more details see http://grass.itc.it/grass5/binary/windows_cygnus/cygwin_grass50bininstall.html, http://sources.red hat. com/cygwin/docs.html)

Step1. Download and install Cygwin tools

Download Cygwin tools from http://sources.redhat.com/cygwin/download.html. Due to volume limitations, Cygwin is only available from mirror sites and during installation the choice of site has to be made. Cygwin simulates the Linux environment and provides a Linux-like file structure within Windows. *If in Stuttgart, the nearest mirror site for download is ftp://ftp-stud. fht-esslingen. de/pub/Mirrors/sources.redhat.com/cygwin/.*

• The Cygwin tools are required to run Linux compliant applications on Windows. From the ftp site download the file setup.exe, run it and follow the instructions. (Network Associates, formerly McAfee, anti-virus software should be disabled during setup, due to the chances of the system hanging when processing Cygwin's .tar.bz2 archives.)

• When installing the Cygwin tools, all packages, or at the minimum the following, should be installed (these are the packages that are definitely required for running GRASS, for production use of the Cygwin environment other packages too will be need to be installed).

• ash, bash, bzip2, clear, cygwin, file, fileutils, findutils, gawk, gettext, grep, groff, gzip, inetutils, jpeg, less, libpng, login, man, ncurses, opengl, perl, readline, regex, sed, sh-utils/shellutils, tar, tcltk, tcsh, termcap, texinfo, textutils, tiff, time, unzip, w32api, zip, zlib.

• The directory for installation should have space for the entire cygwin distribution (150MB), the X Window System (65MB) and the GRASS binaries (150MB), plus additional space for data storage.

Step 2. The precompiled X Window (XFree86, X11R6.4) System
• This is essential for the GRASS graphics display (monitors), hence the X Server and the X11 libraries have to be installed. Download from http://sources.redhat. com/cygwin/xfree/. Cygwin/ XFree86 is a port of XFree86 to the Windows operating systems. At least the following packages should be downloaded: DLLs, fonts, Prog, twm, Xterm, Xwin. Refer to the XFree install guide for further details.

Step 3. Download latest binary distribution of Windows GRASS

The site is http://grass.itc.it/grass5/binary/windows_cygnus/
• Specifically the file GRASS5.0.0_CYGWIN_NT-4.0_bin.tar.gz or a newer package should be downloaded. It should be noted that all these files are in the gzipped, tar format, which have to be

unpacked (usually by tar -zxvf *.gz) before installation. Also the script for installing GRASS (grass5.0.0install.sh) should be downloaded from the same site.

- Cygwin distributions of packages consist of standard UNIX .tar.gz or .tar.bz2 files. Cygwin's tar, gzip, bzip2 programs can unpack these files, just like in Linux. This is one reason for installing Cygwin before attempting to install GRASS. Do not use WinZip to unpack tarred, and gzipped or bzipped packages.

Step 4. Download the sunrpc libraries

- Get the package sunrpc-4.0.cygwin1.bin.tar.gz (from http://grass.itc.it/grass5/binary/windows_cygnus/sunrpc/ or from the Department of Neurology of the Ludwig-Maximilians-University in München, Germany (http://www.nefo.med.uni- muenchen.de/~vog/source/xbinokel/cygnus_nt/). These are needed for the remote procedure calls, a requirement within GRASS/Cygwin.

- Open a bash shell window in the Cygwin environment and untar the file sunrpc-4.0.cygwin1.bin.tar. gz untarred from the root directory.

$ *cd /*

    tar xzf sunrpc-4.0.cygwin1.bin.tar.gz

Step 5. Download the precompiled x tcl/tk 8.x libraries and executables

From http://grass.itc.it/grass5/binary/windows_cygnus/wingrass_xserver/. Unpack this file from the root directory.

$ *cd /*

    tar xzf xtcltk-*.tar.gz

Step 6. Actual GRASS installation

- Log into the cygwin shell. Check for sufficient disk space and file permissions. The default installation path of GRASS is /usr/local/grass5.

- cd to the directory where GRASS5 is saved
  $ *cd /usr/local/grass5*

- Run the install shell script

./grass5install.sh GRASS5.0.0_bin.tar.gz

- This installs GRASS under /usr/local/grass5 and stores the start files under /usr/local/bin. All these paths are relative to the Cygwin root (therefore C:\Cygwin or C:\program files\cygwin etc). Do not install the file from the root directory of cygwin as this will result in an error.

• Data to test GRASS (e.g. global_grass5data.tar.gz) can be downloaded from http://grass.itc.it/data.html. The data can be unpacked with

tar -zxvf global_grass5data.tar.gz

into an empty directory. *It is essential that all these are done from within the Cygwin shell.*

Step 7. Starting GRASS 5.0.0

Shell prompt. The GRASS session can be started in the Cygwin shell at the shell prompt (without graphics monitors) by typing

$ *grass5*

The remaining steps are exactly the same as for Linux. GRASS can be used like this within the Cygwin shell for scripting/programming, but in this mode it cannot output graphics to the screen.

Graphical. To enable GRASS with graphical output (i.e. with X Window monitors) and the graphical user interface (tcltkgrass) the XFree86 Server has to be started first. This can be done by running the X Window Server by double-clicking on the startxwin.bat file in your /usr/X11R6/bin directory.

• In the xterminal that starts up, login with

$ *login*

• and type in
 /usr/local/bin/grass5

• This takes you to the GRASS login screen. From here the GRASS session can be begun.

My experience has been that it is easier to set up the XFree86 X11R6.4 system than the StarNet X server. There are also different options to start the X-windows like moving into the /usr/X11R6/bin directory and starting with

$ *startxwin.bat*

or simply with
$ *startx*

or with

$ *sh /usr/X11R6/bin/startxwin.sh*

Problems with starting X Window server. From the open X-windows within the Cygwin environment GRASS can be opened and the tcltkgrass enabled, so that the GUI gets enabled as well as the GRASS monitors. Problems with starting the X Window Server will most probably be due to wrong path specifications. The startxwin.bat file will be under /usr/X11R6/bin. The absolute path need to be specified (e. g., C:\cygwin\usr\X11R6\bin). Similar problems could be encountered while starting the tcltkgrass GUI (with the error message libX11.dll not found). The solution is to ensure that the path /usr/X11R6/bin is specified.

Switching between the Windows and XWindows monitor. Switching between the Windows screen and XWindows is achieved by pressing Alt-Tab.

Ending the X Server session. with ALT-F4.