# Edubuntu, Linux Terminal Server and thin clients

## Magic on your LAN

Robert Pogson

You walk into the room. It’s cool and quiet. You see thirty new workstations giving great service. Your cost of hardware was CAD$350 for each workstation, CAD$10 to connect it to an existing 100Mbps LAN, and about CAD$60 for a share of a server in another room (CAD$1 = US$0.87). Your software costs were only some download and CD burn time and forty minutes for installation. Your operating costs are virtually nil. The server runs for months without a reboot. The workstations have nothing but network boot loaders. You back up only one machine, the server. The workstations use twenty watts each and have no fans. Magical? Yes. Magic? No. Arthur C. Clarke once made the comment that “technology sufficiently advanced is indistinguishable from magic”. A stock server or a custom-built server made from off-the-shelf parts has taken the place of the mainframe in a client/server arrangement. Moore’s Law makes the hardware cheap. GNU/Linux makes it free to use to its potential. This is old but capable technology made easy to install thanks to the GNU/Linux revolution.

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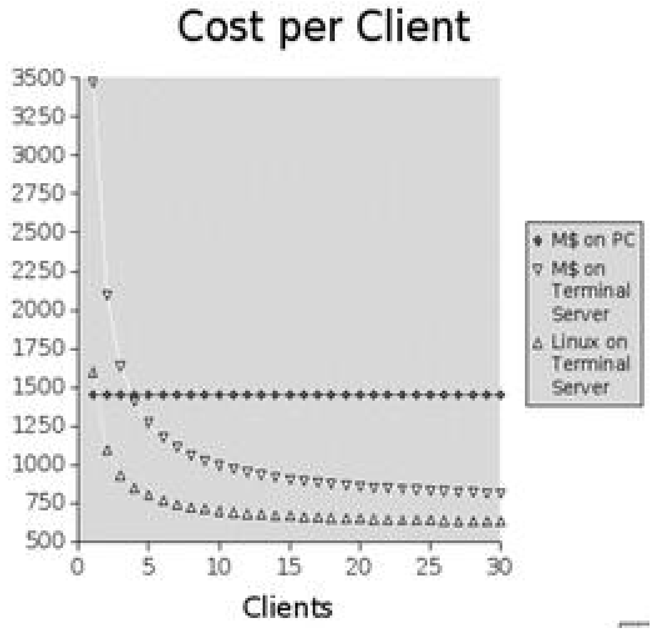
What you have are workstations of fanless, diskless clients connected to LCD monitors, mice and keyboards. The low-powered clients do little except relay inputs and graphics between the user and the server via the X Window System. The server is a reasonably powerful PC with extra memory and storage. You get away with having thirty users at once running on the server because recent CPUs have the power and the typical user typing and clicking uses up only a small percentage of such a CPU and uses the power in short bursts. By investing a little more on the server, everyone gets to share in the benefit and it is never wasted. The first time a user loads a program the server caches it in memory for any subsequent users. This is a much better system than paying per-user licence fees, installing and maintaining software on hard drives on each client and keeping all the disks and fans turning. You do not need to chase dust bunnies on these fanless units. You save hundreds of dollars in electrical energy over the lengthy lifetime of this equipment and you do not need to listen to all those pointless whirring sounds.

How can you get this all to work without resorting to magic or hiring a magician? LTSP, the Linux Terminal Server Project (`http://www.ltsp.org/`) is a free software project intended to make the setup easy. The clients configure via DHCP (Dynamic Host Configuration Protocol) and download a minimal GNU/Linux operating system from the server using TFTP (Tiny File Transfer Protocol). The GNU/Linux operating system for the client boots and uses a file system on the server and the memory of the client to do everything. The initial network boot can be done by a ROM (Read Only Memory) resident program on the client. Most PCs since 1998 have this capability built into the BIOS

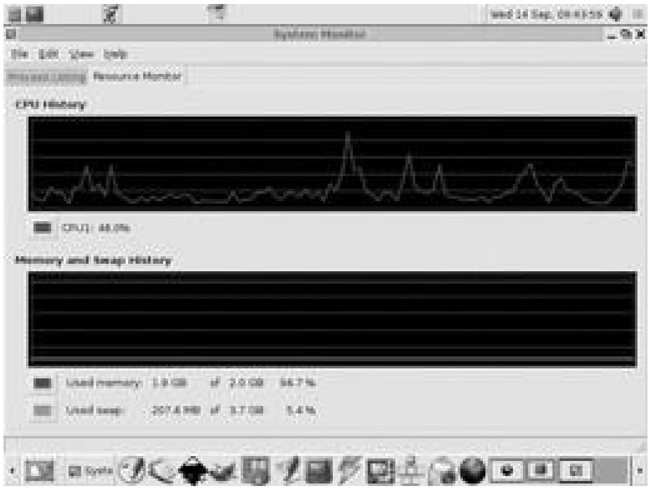
Cost per client



if there is a Network Interface Controller (NIC) built into the motherboard. The BIOS setup may mention PXE, Pre-Execution Environment or network in the booting section. Others can incorporate a boot loader in a socket on the NIC into the BIOS of the PC, or boot from a floppy, USB device, hard drive or CD.

The only software installation required is on the server. You can use a GNU/Linux distribution designed for use in schools and by teachers with modest expertise. Because the LTSP scripts can be a hassle for a novice, the folks who made Edubuntu (Ubuntu plus a few packages and configurations for schools) put in automatic installation of the simplest, and most common setup, the server running a private LAN with your clients. This works well for a classroom, a computer lab, an office or a small school. Except for multimedia intensive stations the LTSP concept works for about thirty clients from a single 32 bit CPU with 2 GB RAM. Using a dual-core 64 bit CPU and 4 GB RAM, one server can handle sixty clients. With multiple servers or multiple socket motherboards the system will scale to well over one hundred clients. You only have to eliminate bottlenecks on the LAN by using a gigabit per second connection between server and switch. 100Mbps works well from switch to client. 10Mbps works, too, but there are noticeable delays.

CPU utilization versus time with nine users



CPU1: 46.0%

Used memory: 1.9 GB of 2.0 GB 94.7 %

Used swap: 207.4 MB of 3.7 GB 5.4 %

## What an LTSP Server wants

The specs for an LTSP server are pretty simple:

- 512 MB RAM for the idling system with all of its services
- 50 MB per client to hold user data and the first copy of common applications
- 100 MHz of 32 bit processing power or about 75 MHz of 64 bit power per client. AMD or Intel work, but AMD gives more computing power per watt and has an on-chip memory controller in 64 bit. The competition between these two makes price/performance good for our use. It is important to select components that match motherboard/CPU/memory/NICs if you build from parts.
- A gigabit NIC for the private LAN (100 megabit is OK for small LANs with patient users, random boots or client always on)
- 10/100 baseT NIC for the ISP

The gigabit NIC is optional unless you want to save seconds on the boot over the network when everyone shows up to work in the same minute and transfers 4 MB of kernel. Many motherboards come with a gigabit NIC and they are cheap. The following examples don't include a monitor, keyboard, mouse, CDROM drive or video card which are only needed for installation. The BIOS can be set up to boot on restoration of power and to ignore lack of a keyboard. The X configuration can be set to use a dummy driver when the video card is absent. The server can be maintained remotely by SSH (Secure SHell) or LTSP. A backup hard drive with USB connection is also recommended.

An example of a server good for up to sixty clients:

- AMD Opteron 170 dual core 2 MB cache CAD$519
- 4 GB ECC DDR333 RAM CAD$500
- ASUS A8N-E motherboard CAD$125
- ATX case and power supply w/400-500 W capacity CAD$200+
- 10/100 baseT NIC CAD$15
- dual 200 GB hard drives SATA CAD$210
- Total CAD$1570

A good server for up to thirty clients could use the same setup but with an AMD64 3200 processor and 2 GB non-ECC RAM, costing about CAD$1000.

For up to 10 clients, and modest services, use a recent desktop PC with 1 GB of RAM and an extra NIC.

For 120 clients, use a dual socket Opteron motherboard with suitable processors and 6 GB ECC registered RAM costing about CAD$4300 or more:

- AMD Opteron 275 dual core 2 MB cache 2 × CAD$1353 = CAD$2706
- ASUS K8N-DL motherboard CAD$287
- ATX case and 500 W power supply CAD$250
- 10/100 baseT NIC CAD$15
- dual 200 GB hard drives SATA CAD$210
- 6 GB DDR400 ECC registered RAM 6 × CAD$150 = CAD$900
- Total CAD$4368

Another alternative is dual 60 client servers giving more flexibility, speed, and some redundancy for lower cost but more maintenance. This would require networking of the file system, which is a little more complex than an Edubuntu installation. The dual core processors need an SMP (Symmetric Multi Processor) kernel installed. If you install with that CPU it may be automatically configured. If you add a dual core processor, you'll need to install the right kernel manually. The command `sudo apt-get install linux-amd64-k8-smp` will install the latest kernel for AMD64 on a VIA K8 chipset for multiple processors. Of course, if you have a different architecture, you can look it up on the Ubuntu web site (`http://packages.ubuntu.com`).

## What an LTSP client wants

If you can keep the fans turning, almost any PC will do. PCs with fans use more power than is necessary and act as vacuum cleaners, accumulating dust bunnies that jam fans, and interfere with flow of air over chips and heat sinks. 64 MB and 100 MHz is enough. Configure the BIOS to boot from the network. Most PCs made before 1998 will not automatically do a network boot, so you will need to install a bootloader on the hard drive, floppy or CD. You can use a Universal Boot Disc from ThinStation (`http://thinstation.sourceforge.net/wiki/index.php/ThIndex`) which comes with drivers for most common NICs or you can custom make a bootloader from Rom-O-Matic (`http://rom-o-matic.net`). Pick your NIC and choose your output format, `.zdsk` for a bootable floppy image or `.liso` for a bootable CD image. There are more advanced options available. You can create the floppy discs on your server with the command: `sudo dd if=image_file of=/dev/fd0`. With a cdburner, you may use the cdrecord command from the commandline (terminal) or a graphical interface like nautilus-cd-burner which can be accessed from the "Go" menu item of the file browser. Click on "CD creator". You drag and drop or copy and paste the file icon for the CD image file to the window.

If there are not enough old machines to use as clients, or the space saving convenience of LCD monitors and ultra-low-power clients is desired, one can shop in a very competitive market. Chip maker VIA Technologies, Inc. makes a family of CPUs (`http://www.via.com.tw/en/products/mainboards/partner_products.jsp`) that serve very well as thin clients and use so little power they don't need fans. If you are adventurous, you may purchase a mini-motherboard with an Epia CPU installed. The low powered versions need no fans and the motherboard is 17 cm × 17 cm and can fit into a tiny case that bolts to the back of an LCD monitor. Such motherboards are available for about CAD$110. A power supply that converts 12 V DC or 110 V AC to ATX costs about CAD$50 for the fanless kind. You can put this in a cheap case for less than CAD$50 and add CAD$30 of RAM and you get a client costing CAD$240 plus a monitor, keyboard, mouse and fifteen minutes of your time. This will save you about CAD$150 from the price of a complete thin client. Still, an old used machine may be bought for less than CAD$100.

## Installing Edubuntu on the server

To install Edubuntu, obtain a CD by download (`http://wiki.edubuntu.org/EdubuntuInstallNotes`). Burn the file appropriate to your hardware to a 700 MB CD.

Edubuntu installs all of the software with only a few questions relating to LTSP:

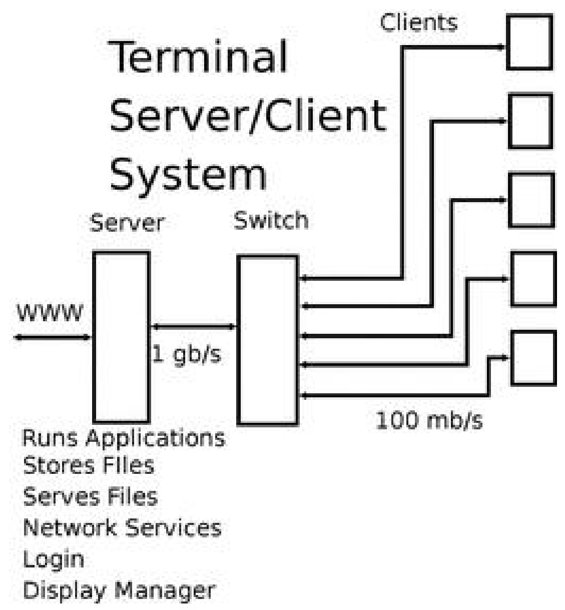
- Primary network interface: `eth0` or `eth1`? Usually `eth1` will be on the motherboard and `eth0` in the expansion slots.
- What is the IP address? Use something in 192.168.0.x and you get good defaults with no editing required. Typically, choose 192.168.0.254 or 192.168.0.1, to leave lots of space for printers, clients and so on
- What is the netmask? Use 255.255.255.0
- What is the gateway? Leave blank or use IP address of gateway to the WWW
- Name server address? I usually install my own name server, but a novice should use the one for WWW connections or leave this blank

To set up the other NIC for WWW access, do so from the GUI once you log in. Since the clients run on the server, they will have internet access. One complication for this is that the DHCP (Dynamic Host Configuration Protocol) server, which you are setting up to serve your private LAN, needs to be told to ignore DHCP requests on the `eth1` interface. The default behaviour is to listen on all interfaces. To change this, edit as root `/etc/default/dhcp` using the command: `sudo gedit /etc/default/dhcp`. Add these lines:

```
# On what interfaces should the DHCP server (dhcpd)
  serve DHCP requests?
# Separate multiple interfaces with spaces,
  e.g. "eth0 eth1"
INTERFACES="eth0"
```

You will then need to restart the DHCP server with the command: `sudo /etc/init.d/dhcp restart`.

Typical LAN

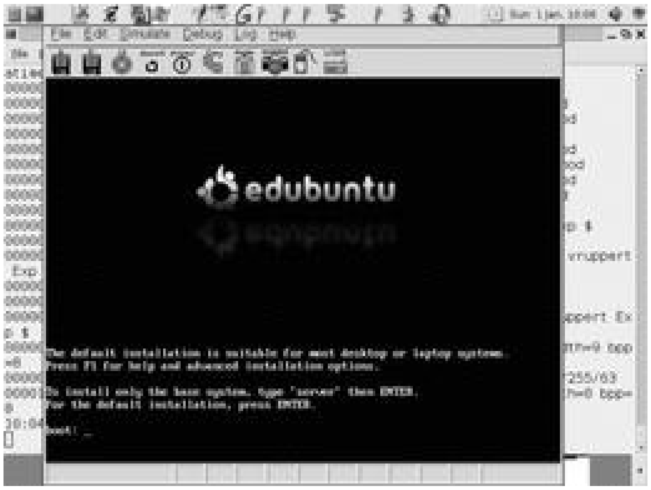


Your private LAN will likely need several connections to `eth0`. Typically, this is done by connecting `eth0` to a network switch. I recommend that `eth0` be connected to a gigabit per second port, if your switch has one. That way, the server can send data for several clients to the switch and the switch gives the data to the clients at their rates. This is mostly important for booting or animation. If a group walks in and everyone boots, you may save many seconds by using this gigabit connection. For a NIC on the PCI bus, 1Gbps uses most of the capacity of the bus for short bursts, so avoid putting many other extensions on the PCI bus with your gigabit NIC. Many motherboards have a gigabit NIC (likely, `eth1`) built-in and connected to a bus other than the PCI bus. Check your manual to be sure. A big advantage of the 64 bit motherboards is that the NIC on the motherboard, the IDE and SATA drives may all do transfers at once. On most 32 bit boards, someone will have to wait because the PCI bus has a much smaller bandwidth.

Managed switches with two gigabit ports and 24 10/100 automatic ports such as ASUS GIGAX1024P are quite inexpensive. For a classroom, an eight port switch will do.

Bandwidth problems are unlikely if the gigabit connection is used. The typical cable subscriber can stream pretty well and this is hundreds of times the bandwidth from the server and ten times the bandwidth from the switch. With

Step 1: Press `Enter` at the boot screen



```
The default installation is suitable for most desktop or laptop systems.
Press F1 for help and advanced installation options.

To install only the base system, type 'server' then ENTER.
For the default installation, press ENTER.

boot: _
```

this arrangement many users all feel they have complete control of the server. It is magical the first time you see it. The plain X protocol used to connect the screen of the user to the server does some unnecessary chattering. So setups with lots of activity may benefit from compression and redundancy removal with the NX protocol. Free software for NX (`http://freenx.berlios.de/`) has become available and it's still developing rapidly. The 64 bit version may be available in 2006.

## Conclusion

Anyone can set up a Linux Terminal Server on a good machine in under an hour with Edubuntu and connect it to a private LAN with a bunch of clients. Given sufficient resources on the server, this is a very cost effective solution for a home, classroom, computer lab, and offices of small to medium size. A large organization will have to choose between a very expensive hot server or a cluster of lesser machines sharing the load. The latter is almost certainly less expensive to purchase, but may require somewhat more maintenance.

## Images of the installation of Edubuntu default

These images were screenshot captures made during the installation simulated by the Bocks emulator (`http://bochs.sourceforge.net/`).

## Further information

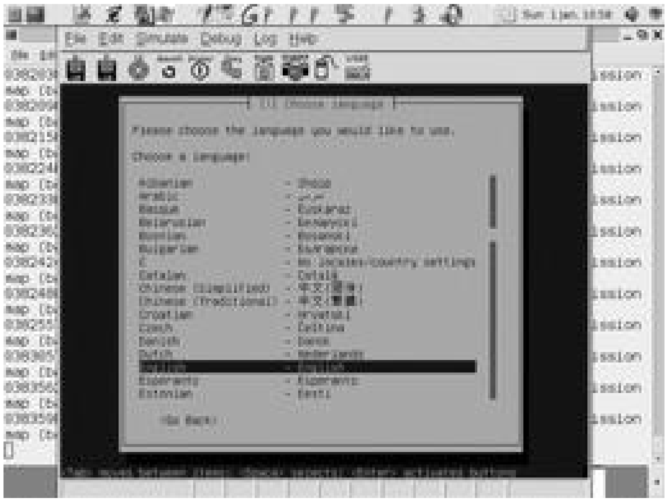
- Skolelinux (`http://developer.skolelinux.no/dokumentasjon/newdriftbok/newdriftbok.html.en`)—A massive book for a Norwegian distro
- The Edubuntu Cookbook (`http://wiki.edubuntu.org/EdubuntuDocumentation/EdubuntuCookbook`)
- The Linux Terminal Server Project (`http://ltsp.org`)—Original LTSP material adapted by Edubuntu and K12LTSP
- The K-12Linux Project (`http://k12ltsp.org`)—All about LTSP in schools
- PXE documentation (`http://www.argontechnology.com/docs/pdf/pxe.pdf`)—All about PXE
- ROM-o-matic (`http://rom-o-matic.net/`)—A dynamic site for generating boot floppies/CDs/ROMs using EtherBoot
- The EtherBoot Project (`http://etherboot.org`)—A system for generating the boot loaders if needed.

## Copyright information

## About the author

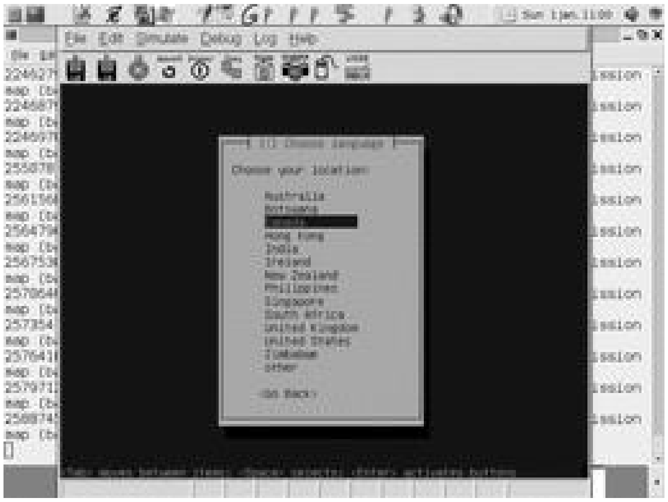
Robert Pogson has worked with computers since 1968 as a student, accelerator technician, inventor, and teacher. The revelation in 1999 that PCs rarely crashed without some help from software lead to his adoption of free software on GNU/Linux. Since 2003 he has been using a Linux Terminal Server in remote northern Canadian schools using available PCs in labs and classrooms.

Step 2: Choose language



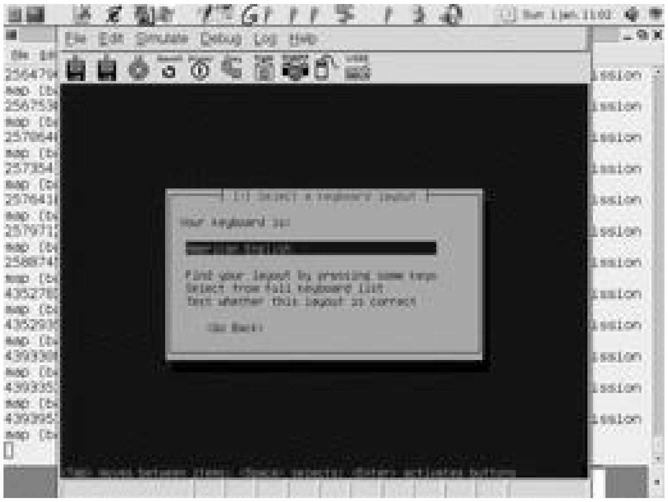
```
[!] Choose language

Please choose the language you would like to use.

Choose a language:

  Albanian               - Shqip
  Arabic                 - عربي
  Basque                 - Euskaraz
  Belarusian             - Беларуская
  Bosnian                - Bosanski
  Bulgarian              - Български
  C                      - No localization/country settings
  Catalan                - Català
  Chinese (Simplified)   - 中文(简体)
  Chinese (Traditional)  - 中文(繁體)
  Croatian               - Hrvatski
  Czech                  - Čeština
  Danish                 - Dansk
  Dutch                  - Nederlands
  English                - English
  Esperanto              - Esperanto
  Estonian               - Eesti

    <Go Back>

<Tab> moves between items; <Space> selects; <Enter> activates buttons
```

Step 3: Choose location



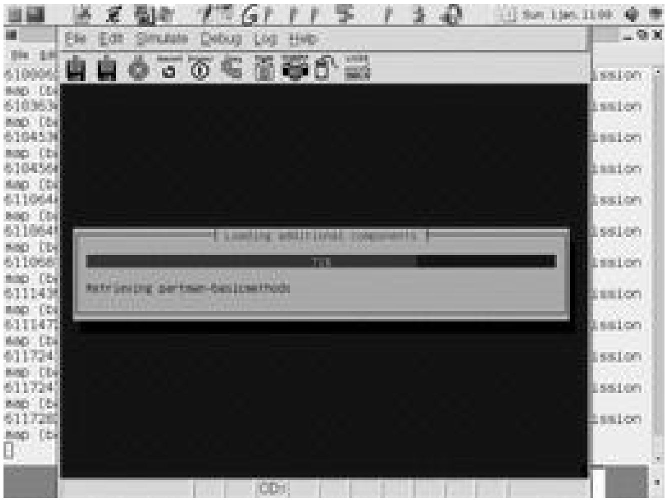
```
[!] Choose language

Choose your location:

      Australia
      Botswana
      Canada
      Hong Kong
      India
      Ireland
      New Zealand
      Philippines
      Singapore
      South Africa
      United Kingdom
      United States
      Zimbabwe
      other

    <Go Back>

<Tab> moves between items; <Space> selects; <Enter> activates buttons
```

Step 4: Choose keyboard layout



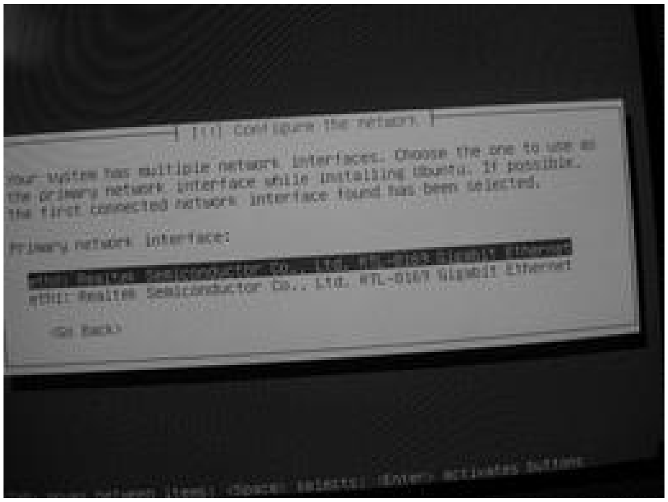
```
[!] Select a keyboard layout

Your keyboard is:

  American English

  Find your layout by pressing some keys
  Select from full keyboard list
  Test whether this layout is correct

    <Go Back>

<Tab> moves between items; <Space> selects; <Enter> activates buttons
```

Step 5: Watch informational messages



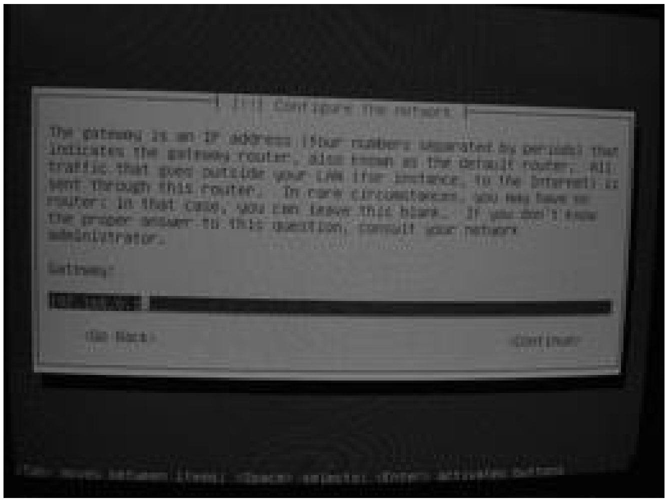
```
[ Loading additional components ]

                    77%

Retrieving partman-basicmethods
```

Step 6: Choose NIC



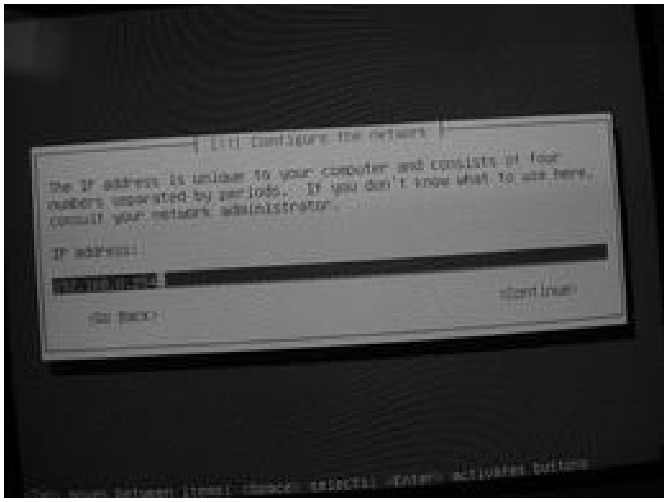
```
[!!] Configure the network

Your system has multiple network interfaces. Choose the one to use as
the primary network interface while installing Ubuntu. If possible,
the first connected network interface found has been selected.

Primary network interface:

  eth0: Realtek Semiconductor Co., Ltd. RTL-8169 Gigabit Ethernet
  eth1: Realtek Semiconductor Co., Ltd. RTL-8169 Gigabit Ethernet

    <Go Back>

<Tab> moves between items; <Space> selects; <Enter> activates buttons
```

Step 7: Choose gateway (optional)



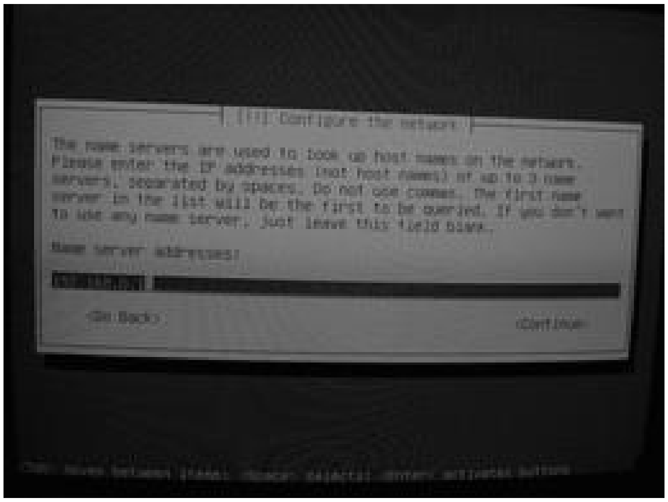
```
[!!] Configure the network

The gateway is an IP address (four numbers separated by periods) that
indicates the gateway router, also known as the default router. All
traffic that goes outside your LAN (for instance, to the Internet) is
sent through this router. In rare circumstances, you may have no
router; in that case, you can leave this blank. If you don't know
the proper answer to this question, consult your network
administrator.

Gateway:

[illegible]

    <Go Back>                                          <Continue>

<Tab> moves between items; <Space> selects; <Enter> activates buttons
```

Step 8: Choose IP address of your server on LAN



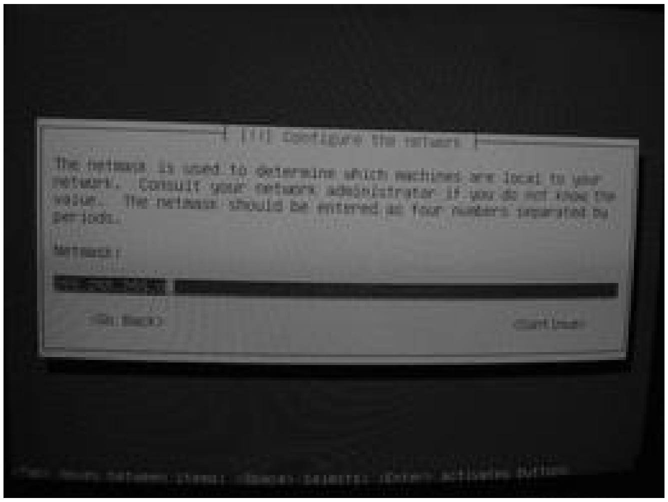
```
[!!] Configure the network

The IP address is unique to your computer and consists of four
numbers separated by periods.  If you don't know what to use here,
consult your network administrator.

IP address:
[illegible]

    <Go Back>                                          <Continue>

<Tab> moves between items; <Space> selects; <Enter> activates buttons
```

Step 9: Choose nameserver



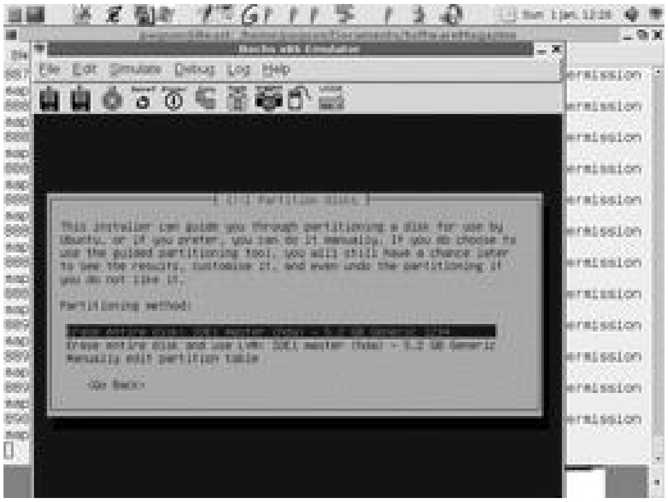
```
[!!] Configure the network

The name servers are used to look up host names on the network.
Please enter the IP addresses (not host names) of up to 3 name
servers, separated by spaces. Do not use commas. The first name
server in the list will be the first to be queried. If you don't want
to use any name server, just leave this field blank.

Name server addresses:
[illegible]

    <Go Back>                                          <Continue>

<Tab> moves between items; <Space> selects; <Enter> activates buttons
```

Step 10: Choose netmask



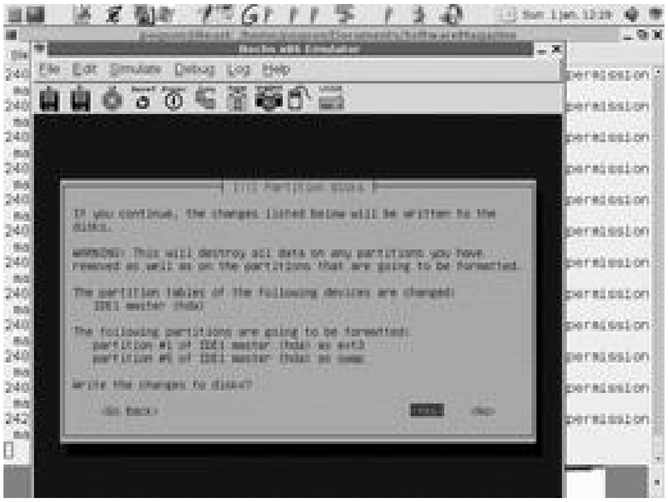
```
[!!] Configure the network

The netmask is used to determine which machines are local to your
network.  Consult your network administrator if you do not know the
value.  The netmask should be entered as four numbers separated by
periods.

Netmask:
[illegible]

    <Go Back>                                          <Continue>

<Tab> moves between items; <Space> selects; <Enter> activates buttons
```

Step 11: Partitioning choices



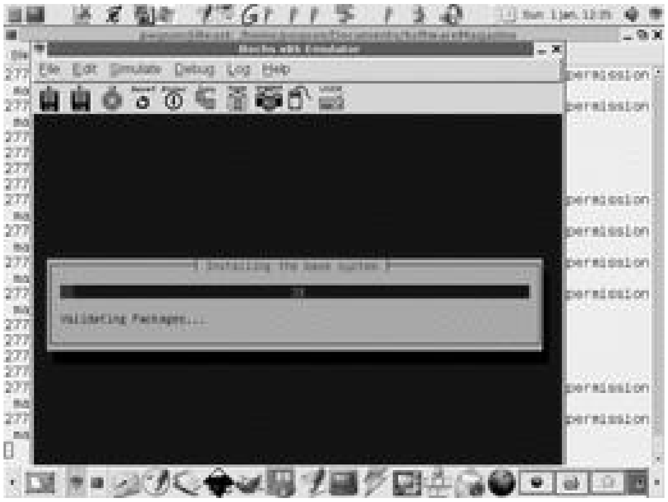
```
[!!] Partition disks

This installer can guide you through partitioning a disk for use by
Ubuntu, or if you prefer, you can do it manually. If you do choose to
use the guided partitioning tool, you will still have a chance later
to see the results, customise it, and even undo the partitioning if
you do not like it.

Partitioning method:

  Erase entire disk: IDE1 master (hda) - 5.2 GB Generic [illegible]
  Erase entire disk and use LVM: IDE1 master (hda) - 5.2 GB Generic
  Manually edit partition table

    <Go Back>
```

Step 12: Accept partition



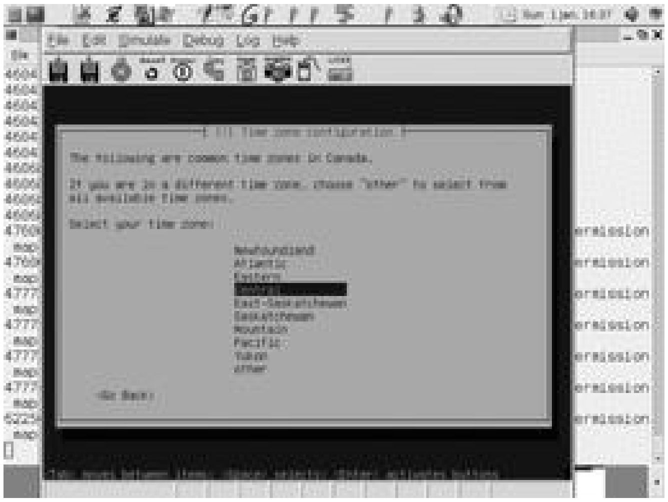
```
[!!] Partition disks

If you continue, the changes listed below will be written to the
disks.

WARNING: This will destroy all data on any partitions you have
removed as well as on the partitions that are going to be formatted.

The partition tables of the following devices are changed:
   IDE1 master (hda)

The following partitions are going to be formatted:
   partition #1 of IDE1 master (hda) as ext3
   partition #5 of IDE1 master (hda) as swap

Write the changes to disks?

    <Go Back>                                   <Yes>     <No>
```

Step 13: Installing base system



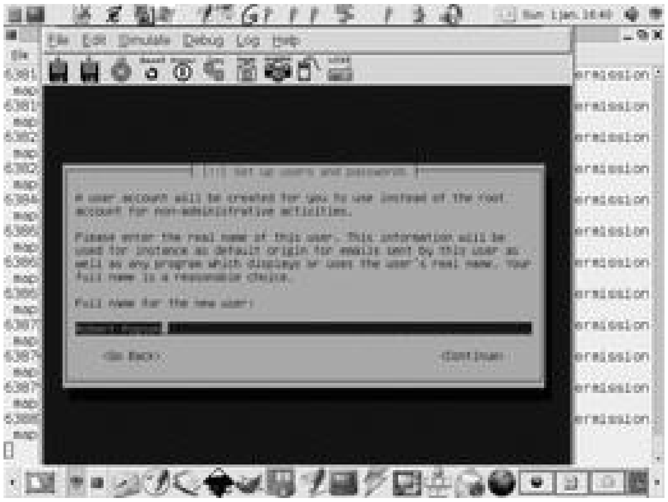
```
Installing the base system

                    [illegible]

Validating Packages...
```

Step 14: Choose timezone



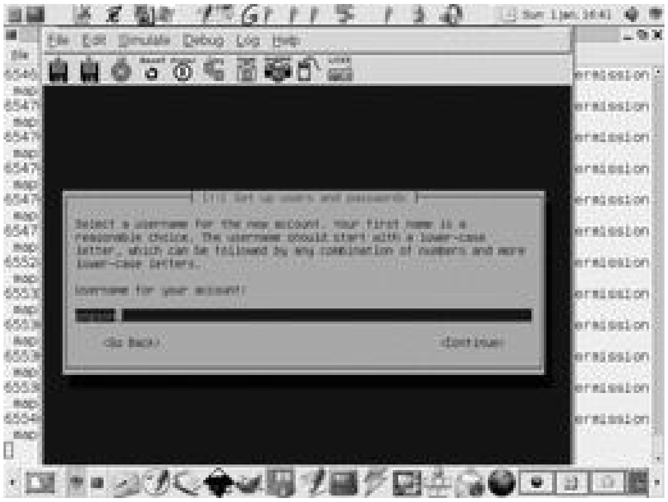
```
┤ [!!] Time zone configuration ├

The following are common time zones in Canada.

If you are in a different time zone, choose "other" to select from
all available time zones.

Select your time zone:

                    Newfoundland
                    Atlantic
                    Eastern
                    Central
                    East-Saskatchewan
                    Saskatchewan
                    Mountain
                    Pacific
                    Yukon
                    other

    <Go Back>

<Tab> moves between items; <Space> selects; <Enter> activates buttons
```

Step 15: Choose normal user



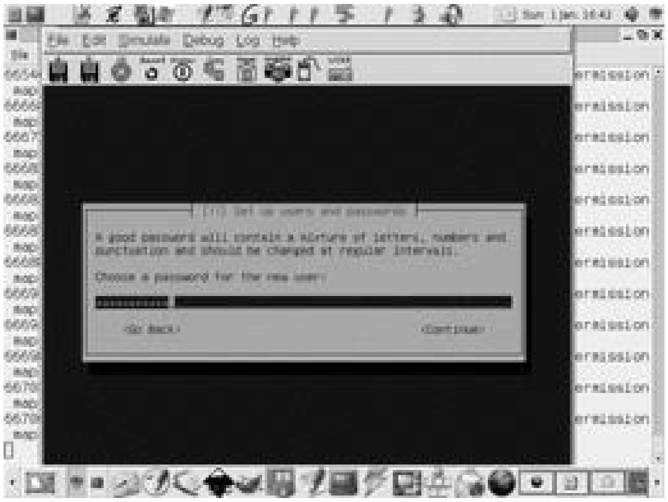
```
┤ [!!] Set up users and passwords ├

A user account will be created for you to use instead of the root
account for non-administrative activities.

Please enter the real name of this user. This information will be
used for instance as default origin for emails sent by this user as
well as any program which displays or uses the user's real name. Your
full name is a reasonable choice.

Full name for the new user:

    <Go Back>                                        <Continue>
```

Step 16: Choose user ID



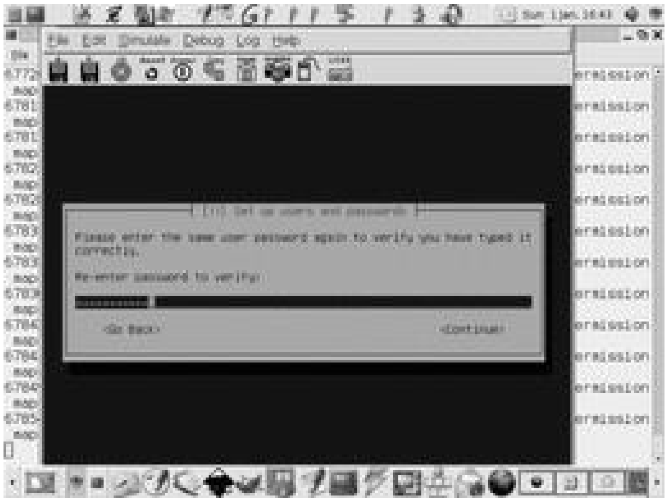
```
┤ [!!] Set up users and passwords ├

Select a username for the new account. Your first name is a
reasonable choice. The username should start with a lower-case
letter, which can be followed by any combination of numbers and more
lower-case letters.

Username for your account:

    <Go Back>                                        <Continue>
```

Step 17: Choose user password



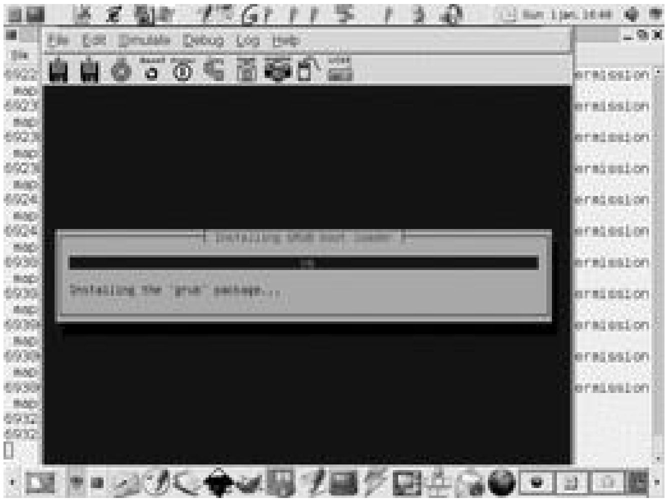
```
┤ [!!] Set up users and passwords ├

A good password will contain a mixture of letters, numbers and
punctuation and should be changed at regular intervals.

Choose a password for the new user:

**********

    <Go Back>                                        <Continue>
```

Step 18: Verify user password



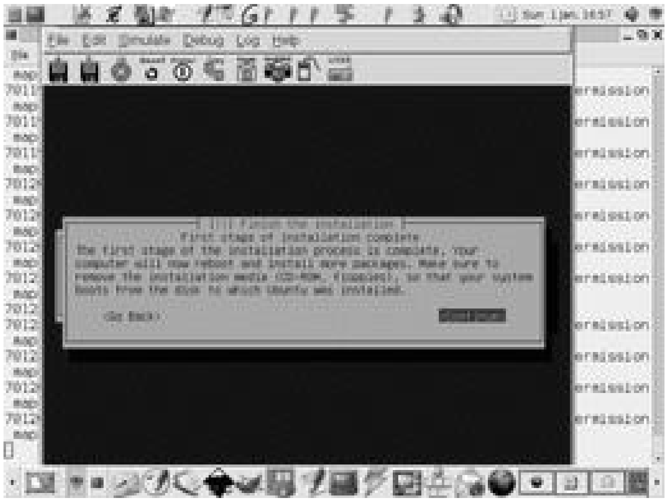
```
┤ [!!] Set up users and passwords ├

Please enter the same user password again to verify you have typed it
correctly.

Re-enter password to verify:

**********

    <Go Back>                                        <Continue>
```

Step 19: Install GRUB (GRand Unified Bootloader)



```
┤ Installing GRUB boot loader ├

                              0%

Installing the 'grub' package...
```

Step 20: First stage done (reboot)

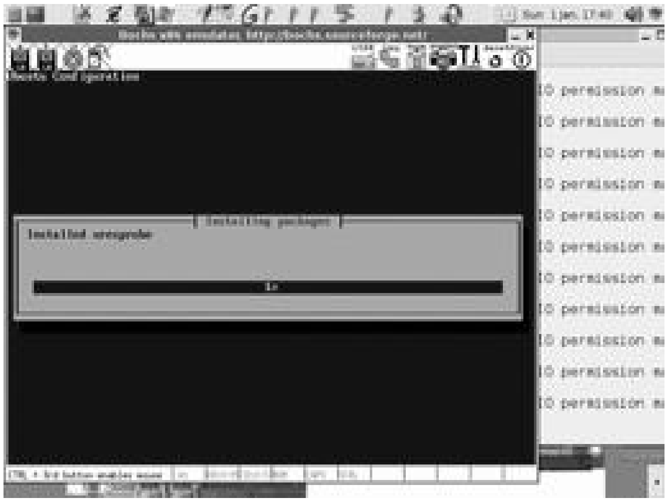


[!!] Finish the installation

First stage of installation complete

The first stage of the installation process is complete. Your computer will now reboot and install more packages. Make sure to remove the installation media (CD-ROM, floppies), so that your system boots from the disk to which Ubuntu was installed.

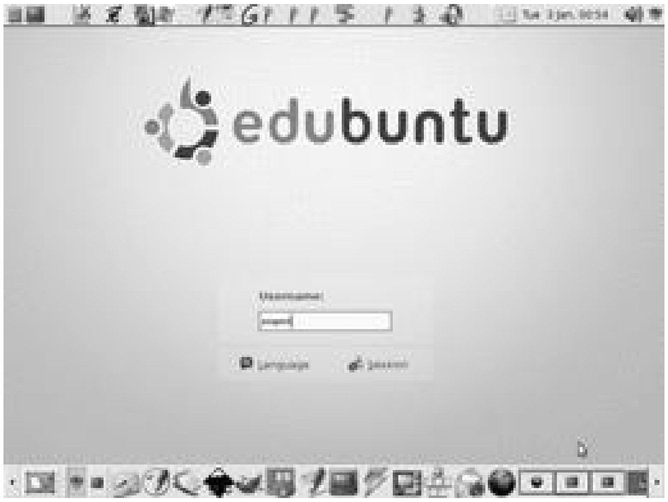
Step 21: Installing packages



Installing packages

Installed xresprobe

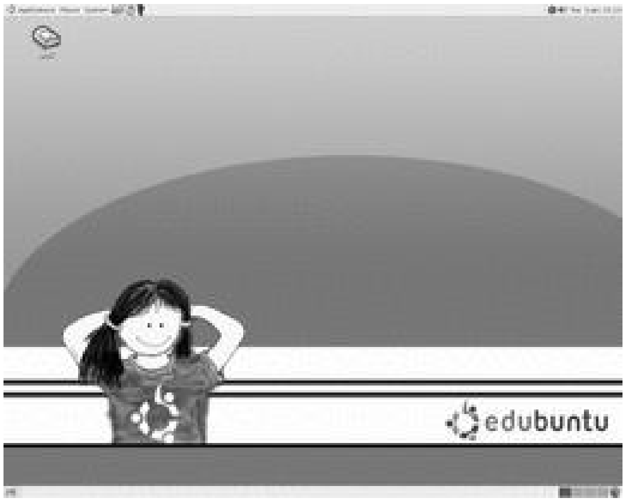
Step 22: Login (on server)



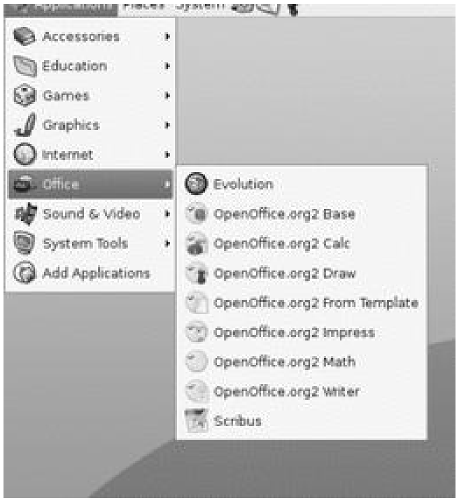
Username:

pogson

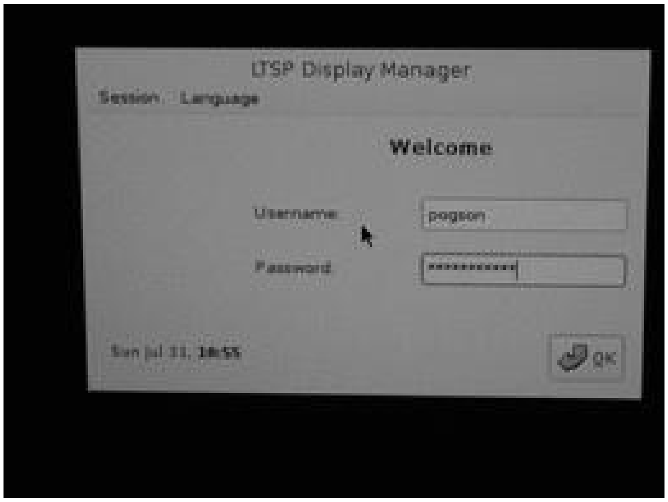
Step 23: The Edubuntu desktop



Step 24: Menus



Step 25: Login (on client)



LTSP Display Manager

Welcome

Username: pogson

Password: ************

Sun Jul 31, 10:55