Operating Systems
Linux Installation

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The course ”Virtual Machine”

NO NEED TO DO THIS IN THE LAB TODAY.
THE SYSADMIN DID IT FOR US!

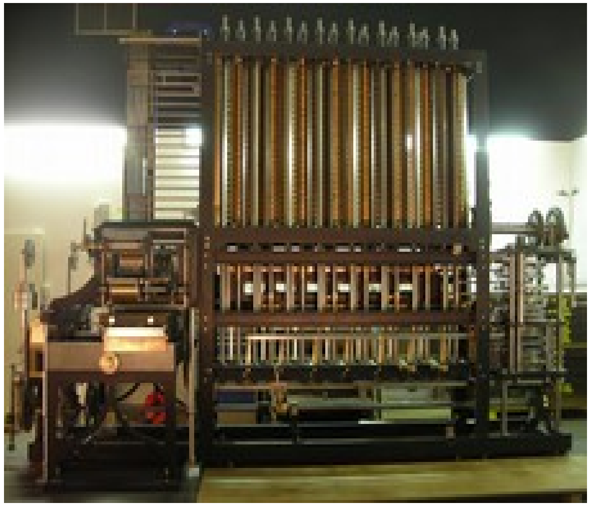
- A *virtual machine* is a *software emulation* of an *hardware machine*.
- Download it at http://www.hep.lu.se/courses/MNXB01/
- **OBS!**: right click, save link as... and save it in **`C:\VirtualBox\`**
  OR IT WILL NOT WORK!
  - Reason: there is not enough free space in your personal folder. A virtual machine has big files. Why?

Outline

- Part A: Theory and practice of computers and operating systems
  - What is a computer?
    - A computer as a finite state machine
    - Brief history and architecture overview
  - Introduction to virtualization
    - Installing the course virtual machine
    - Basic Lubuntu use
    - Creating a virtual machine with VirtualBox
  - Operating Systems
    - Why do we need it?
    - Examples of operating systems
    - Linux and distributions
- Part B: Installing GNU/Linux in a Virtual Machine

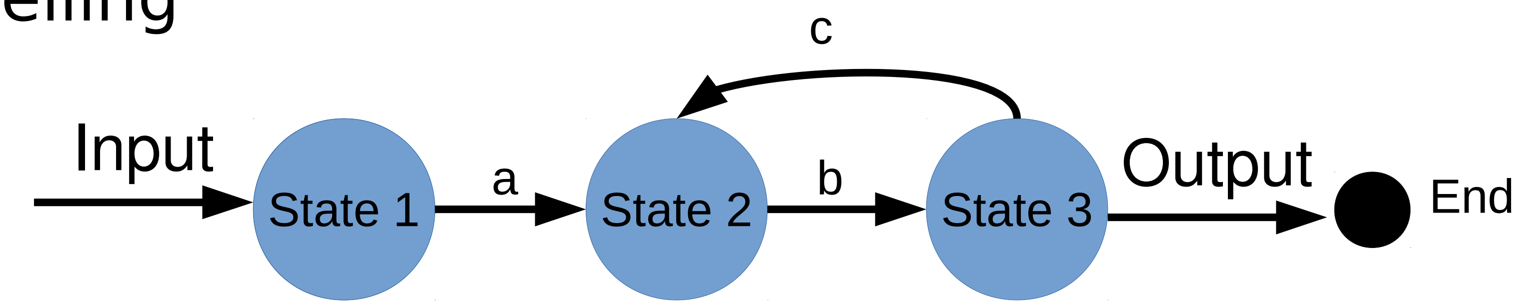
What is a computer?

- A **programmable machine** that can store, retrieve and process **information**.
- **Information** can be, for example
  - Data
  - Simple and complex operations
- Most of modern computers are based on electronic circuits. Whatever we **program** these circuits to do for our needs is usually called **information processing.**



Finite State Machine

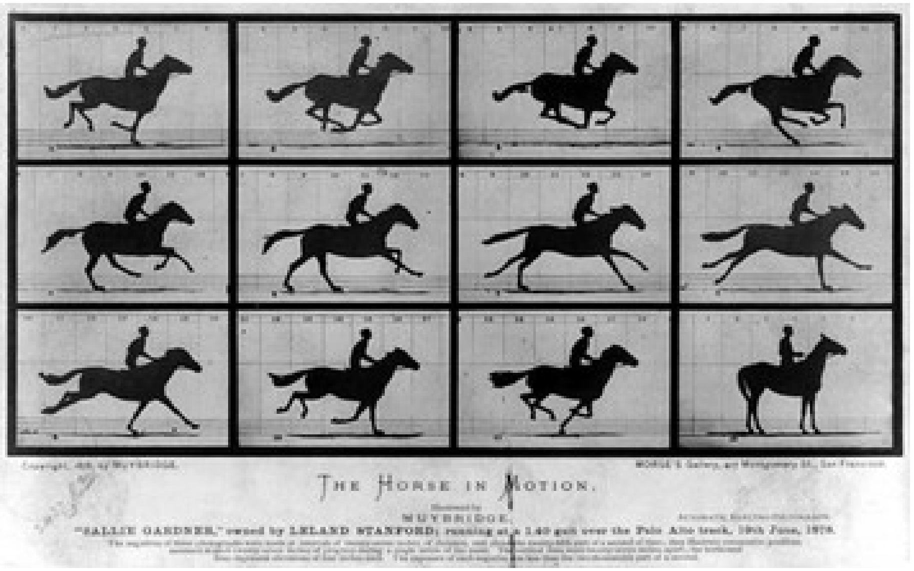
- A mathematical object that represents a sequence of events and their possible outcomes
- You can use this model for:
  - Evolution of a closed system
  - Card games
  - Movies cutting
  - Storytelling
  - Music



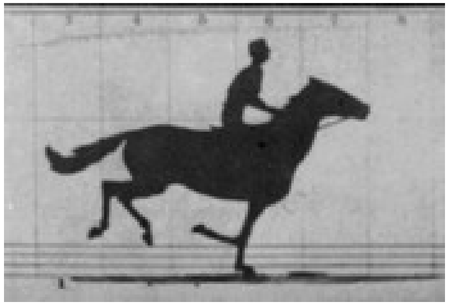
Finite state automaton

Finite state machines

- A modern computer is modeled by a finite state machine.
  - A “state” is the contents of “memories” of the machine
  - If we could stop time, the computer would stay in a defined state
- A state can be restored by restoring the machine's ”memories”
  - Examples: hibernation, **virtualization (some about it later)**



States



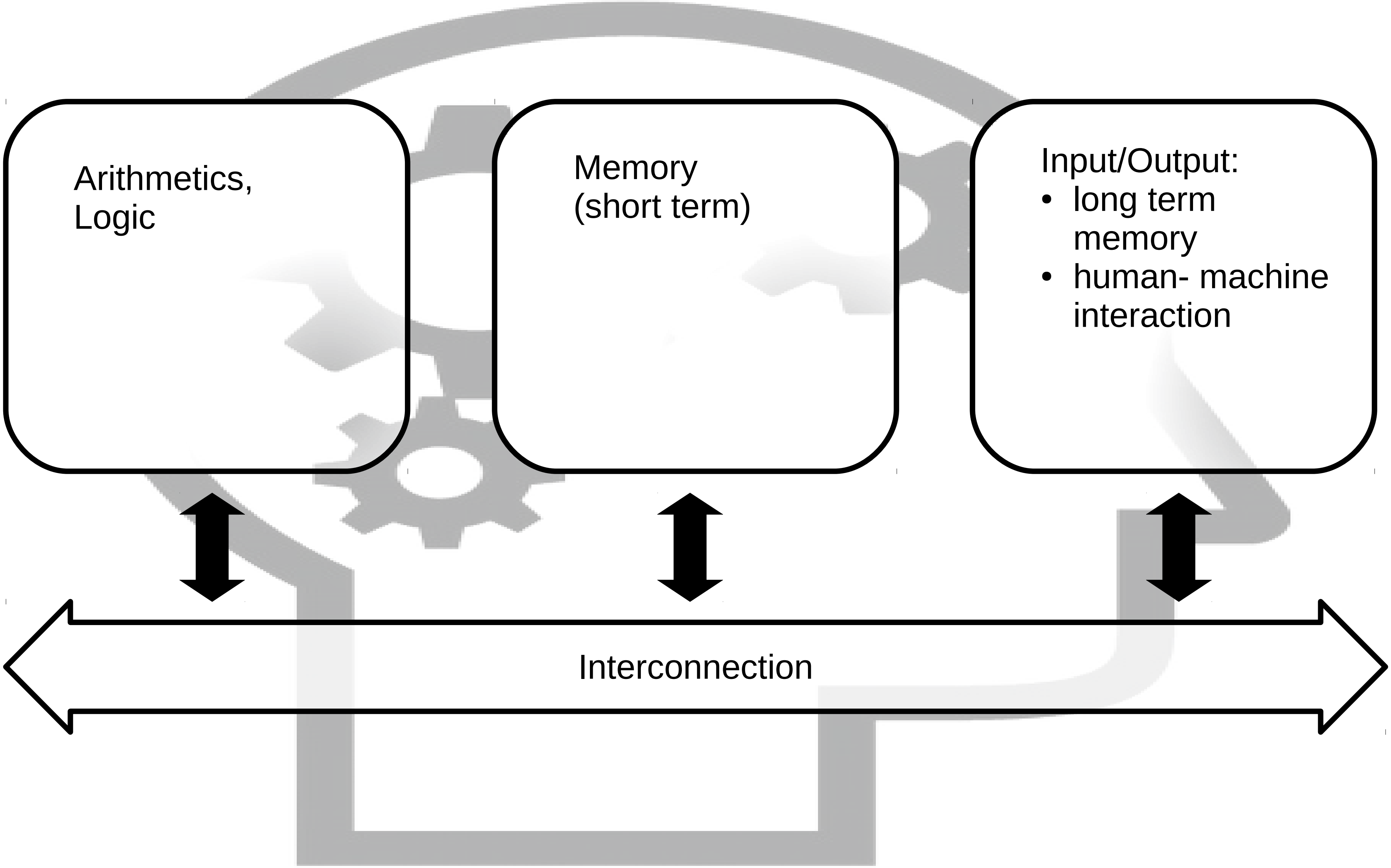
States during execution
(only visible in libreoffice)

VERY Brief history of computing

- 1945 Von Neumann's paper[1] defines the modern computer architecture
- 1960-70 Various researchers start improving the communication between components
- 2017: We still use the same basic approach, with lots of improvements, and increased complexity.

[1] First Draft of a Report on the EDVAC, John von Neumann, Contract No. W-670-ORD-4926, June 30, 1945

Von Neumann-based modern architecture



Arithmetics,
Logic

Memory
(short term)

Input/Output:

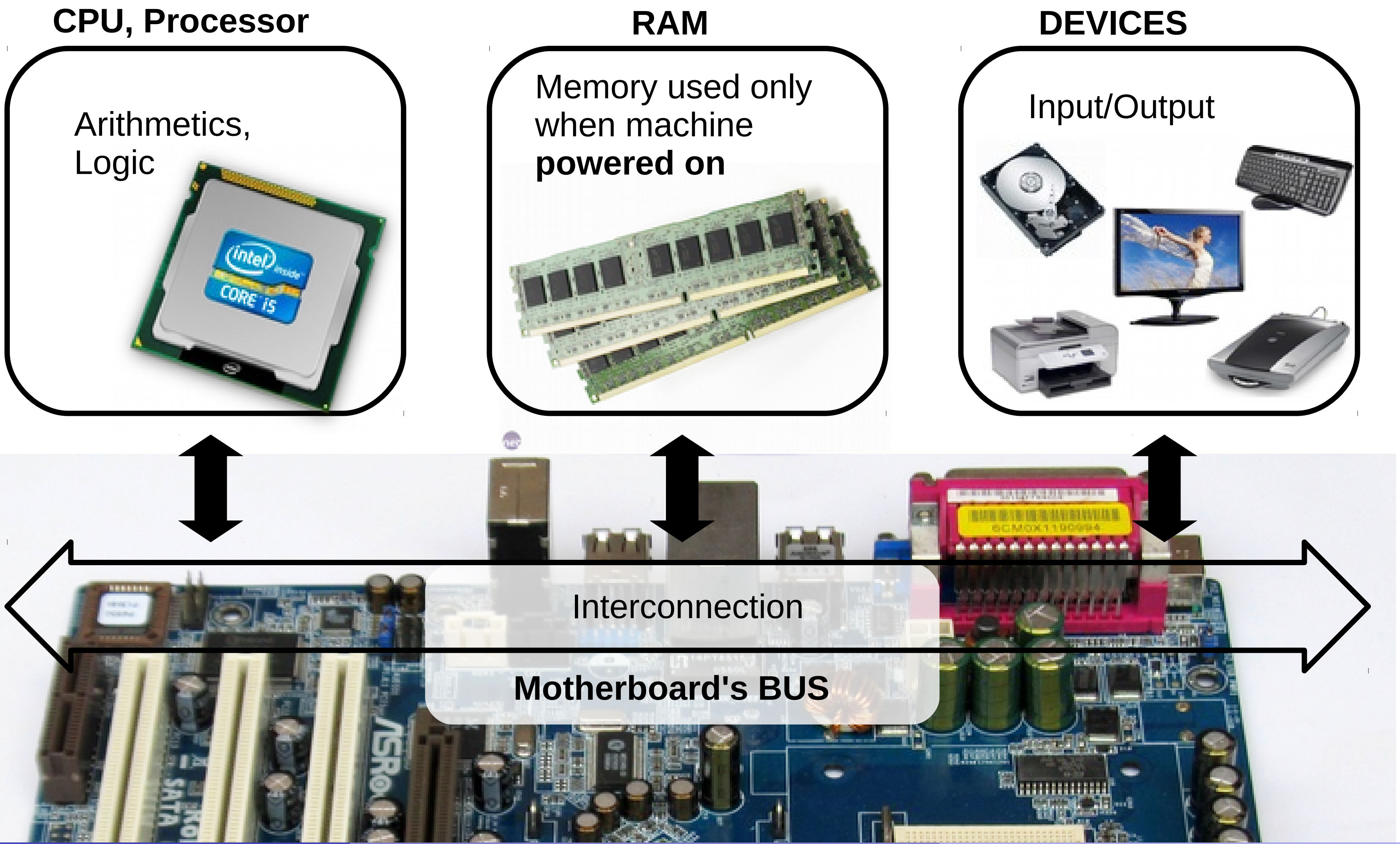
- long term memory
- human- machine interaction

Interconnection

Von Neumann-based modern architecture

- Arithmetics and Logic: Brain ability to process numbers and operations
- Memory:
  - Short term: used in quick operations
  - Long term: memories
- Interconnection: neurons, the spine or the nervous system
- Interaction with external world: the senses, like sight, smell, taste, touch, ...

Hardware: electronic components of a computer



CPU, Processor

Arithmetics, Logic

RAM

Memory used only when machine **powered on**

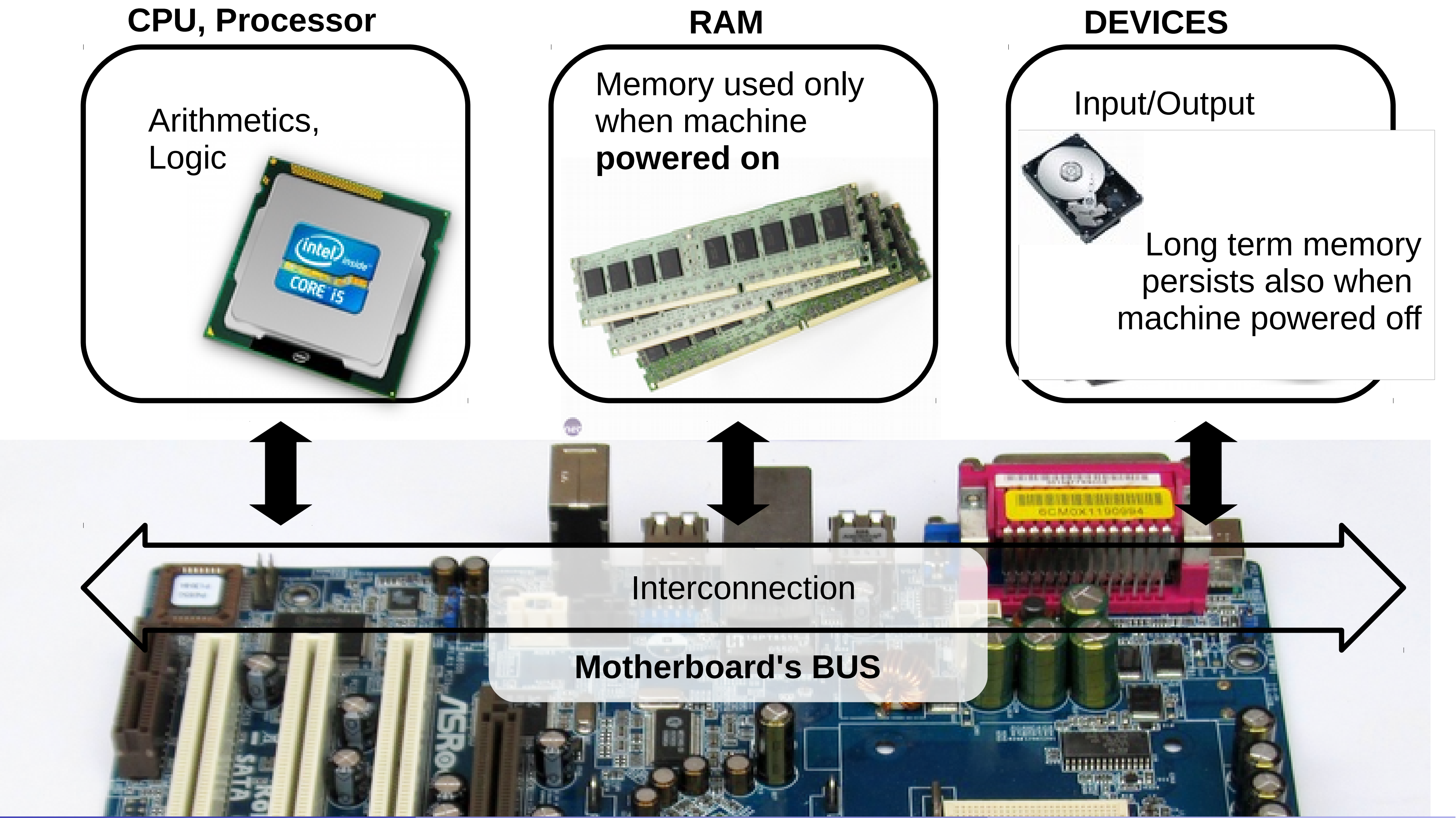
DEVICES

Input/Output

Interconnection

Motherboard's BUS

Hardware: electronic components of a computer



CPU, Processor

Arithmetics, Logic

RAM

Memory used only when machine **powered on**

DEVICES

Input/Output

Long term memory persists also when machine powered off

Interconnection

Motherboard's BUS

Hardware: electronic components of a computer

- Arithmetics and Logic: CPU (Central Processing Unit)
- Memory:
  - Short term storage: RAM (Random Access Memory) only works when powered
  - Long term storage: magnetic discs / USB dongles / cloud storage . Works also when not directly powered.
- Interconnection: BUS(PCIE,SATA,USB)
- Interaction with external world: devices like Network cards, Screen, Keyboard, Touch screen...

Software

- Anything that is designed to **run** or **execute** in a computer , that is, the information that is processed by the hardware.
- Can be of different kinds:
    - **System software**: used to interact directly with the hardware, usually as an *interface* between the hardware and other kind of software.
      Examples: device drivers, operating systems, firmware...

    - **User software:** something with which a user interacts directly to perform a task. Also called **Programs** or **Applications** (shortened: **Apps**). It is usually run inside an operating system.

    - **Development software**: software that is used to develop and create other software.
      Examples: SDK (Software Development Kit), libraries, compilers...

Hardware-Software equivalence

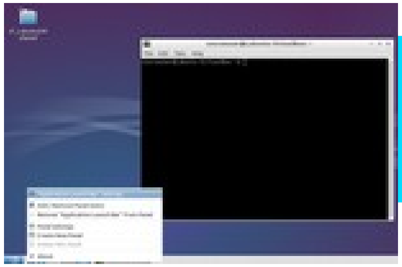
- Everything that can be modelled via software can be created in hardware and vice-versa
- This poses the foundation for machine **simulation** and **emulation**
    - **Simulation**: software that behaves exactly like some piece of hardware, internally and externally. For prototyopes and testing
    - **Emulation**: write software that whose external behaviour is like a piece of hardware. The internals can differ. It ”pretends” to be some hardware.

”Booting” a computer (simplified)

- Booting: **starting** a computer. It usually happens when one turns the machine power button on.
- During the *boot process* the computer executes these steps, in order:

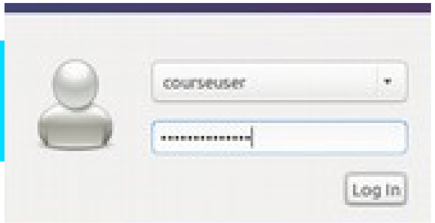
1. Gives power to all the hardware and runs hardware checks

2. Chooses a *device* where the *Operating System* is *installed* and *boots* (starts) the operating system from that device



3. Loads the operating system *user interface software*, for example a graphical environment or a terminal.

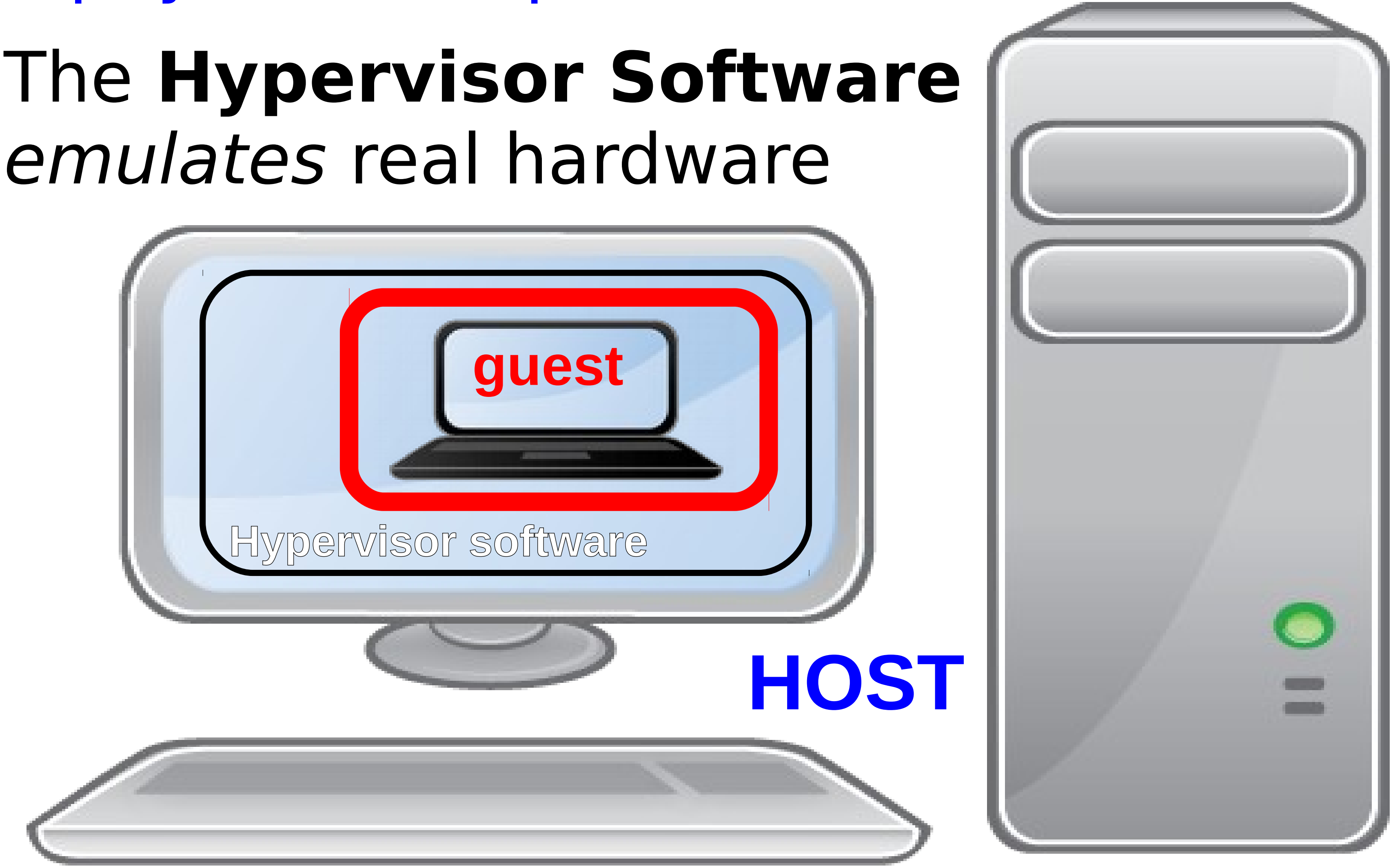
4. Presents a *login prompt* to the user



courseuser

Virtualization

- Running a virtual computer (guest) inside a physical computer (host)
- The **Hypervisor Software** *emulates* real hardware



Virtualization

- Running a computer (guest) inside a computer (host)
- The guest machine is usually called Virtual Machine.
- The Host machine manages the guest machine using something called Hypervisor
- The host offers software simulated or emulated hardware, plus it can offer **real** hardware to the guest machine
- The guest machine sees all the software simulated/emulated/virtualized hardware as it was real hardware, but it can also be aware that it is virtualized to boost performance

Ex. A1: Install the course custom VM

For better user experience, the teacher set up a fine-tuned machine for the course, that contains all we will need.

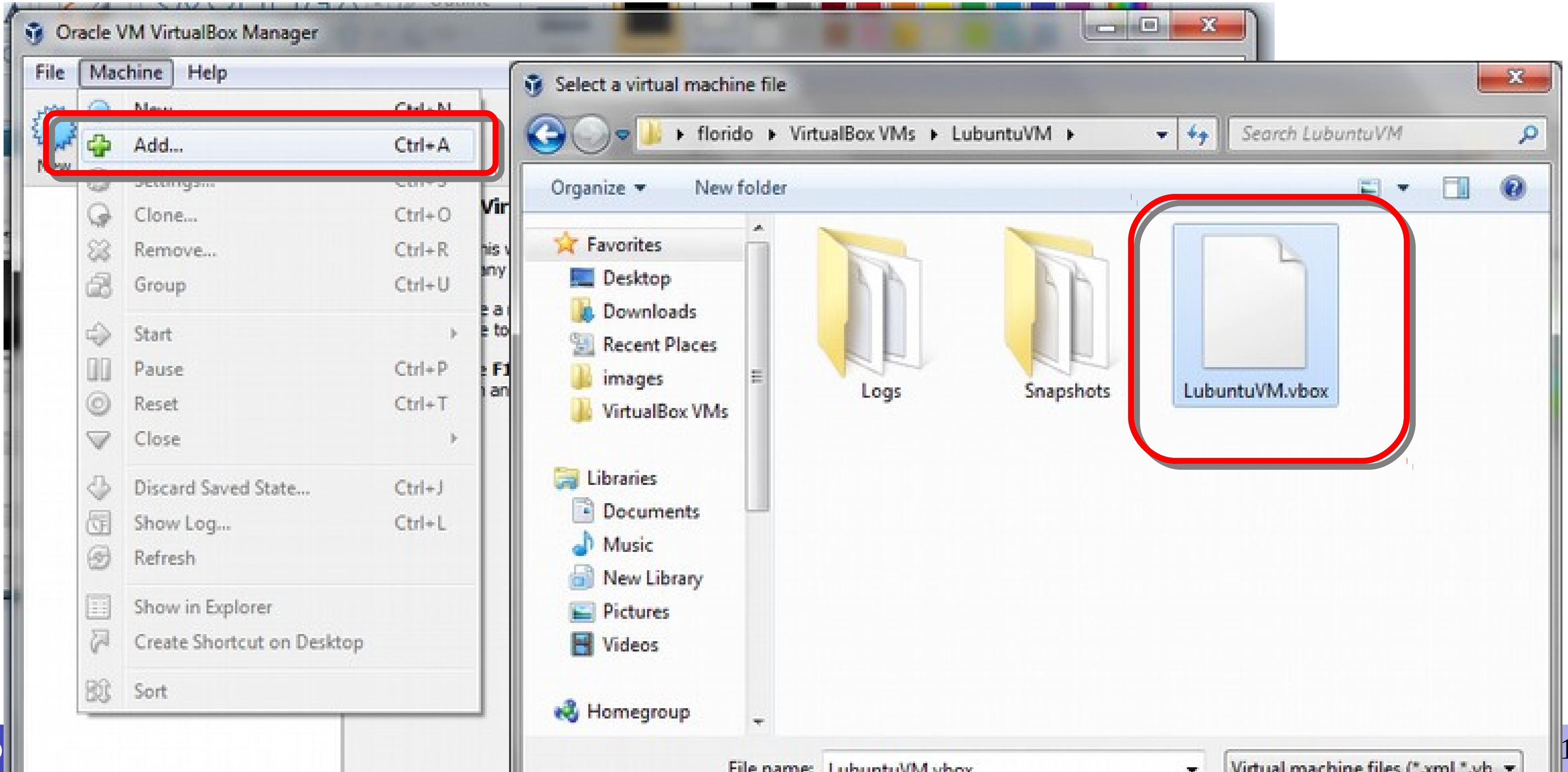
1.1. Download it from/copy link (we already did this):
 http://www.hep.lu.se/staff/paganelli/fileshare/LubuntuVM.zip
to `C:\VirtualBox\`

1.2. Extract it into (right click, extract to...):
`C:\VirtualBox\LubuntuVM\`

1.3. Open VirtualBox:

Ex. A1: Install the course custom VM

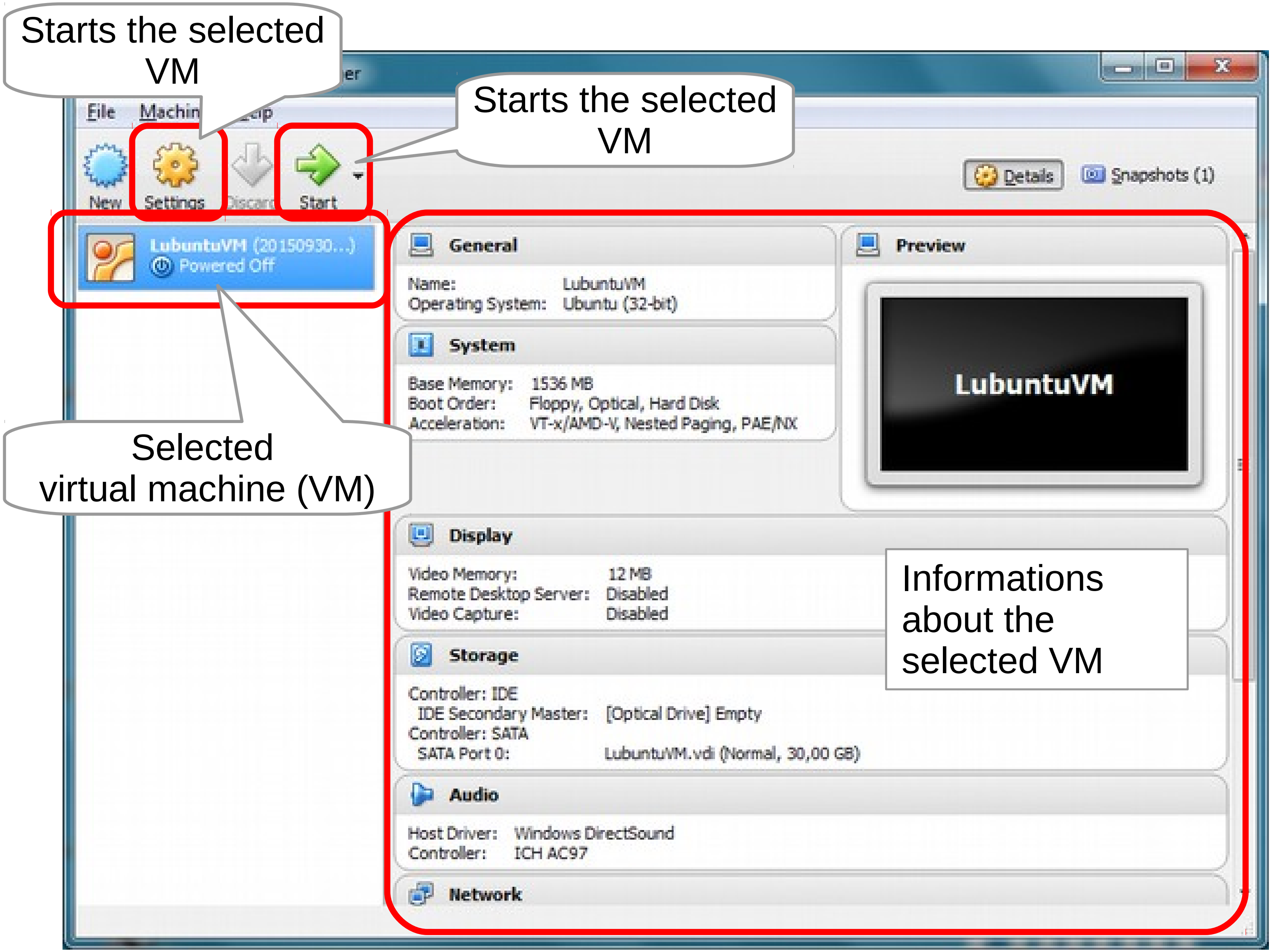
3. Open the machine with VirtualBox:
   Machine → Add...
   and select
`C:\VirtualBox\LubuntuVM\LubuntuVM.vbox`
   (the blue icon)



File name: LubuntuVM.vbox

Virtual machine files (*.xml *.vb

VirtualBox interface explained



Starts the selected VM

Starts the selected VM

Selected virtual machine (VM)

Informations about the selected VM

General

Name: LubuntuVM
Operating System: Ubuntu (32-bit)

System

Base Memory: 1536 MB
Boot Order: Floppy, Optical, Hard Disk
Acceleration: VT-x/AMD-V, Nested Paging, PAE/NX

Display

Video Memory: 12 MB
Remote Desktop Server: Disabled
Video Capture: Disabled

Storage

Controller: IDE
IDE Secondary Master: [Optical Drive] Empty
Controller: SATA
SATA Port 0: LubuntuVM.vdi (Normal, 30,00 GB)

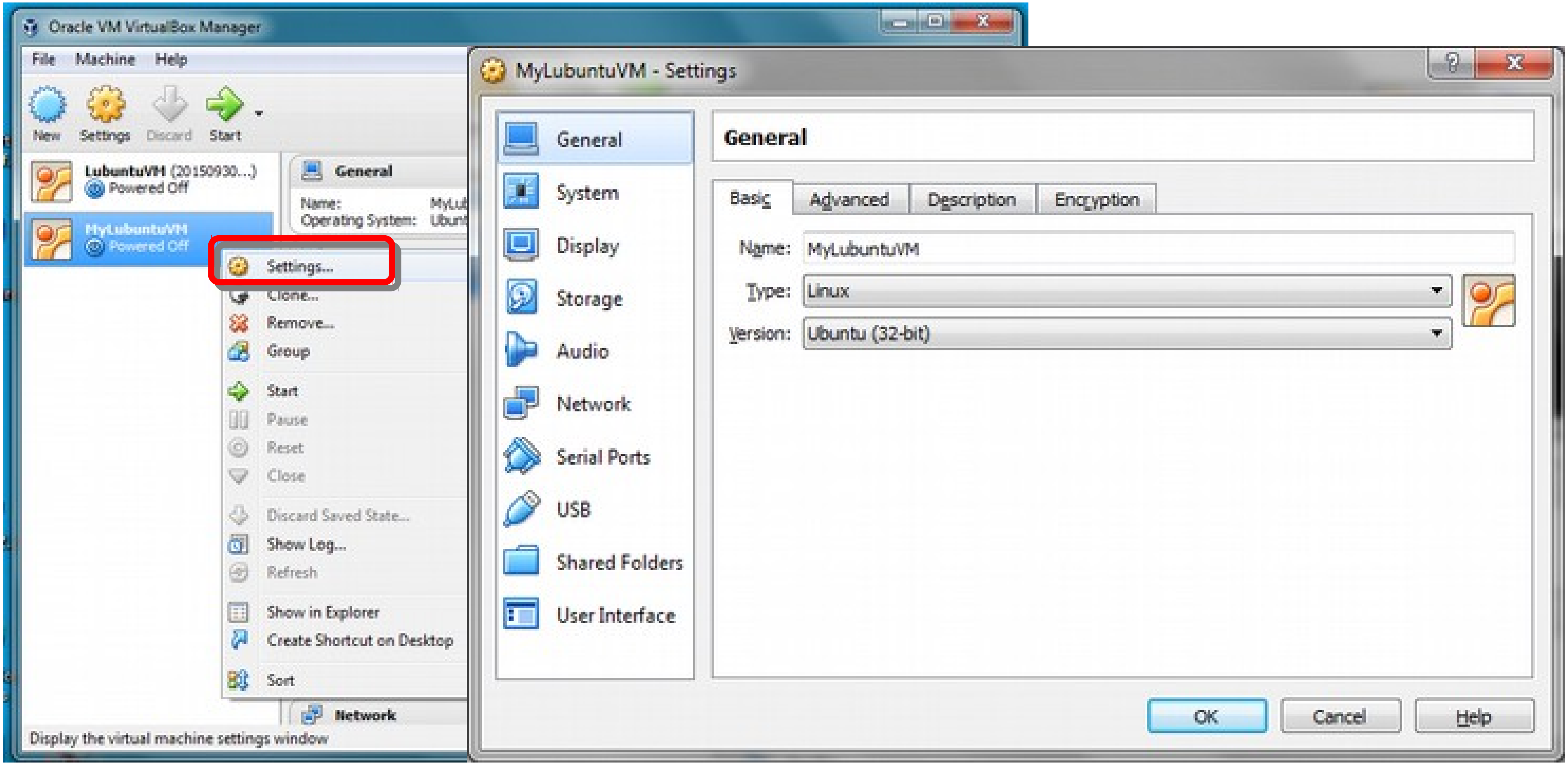
Audio

Host Driver: Windows DirectSound
Controller: ICH AC97

Network

Ex A1.2: Review the virtual machine virtual hardware

- Right-click on the machine LubuntuVM and select ”Settings...”
- Browse around the hardware options. Any comments?

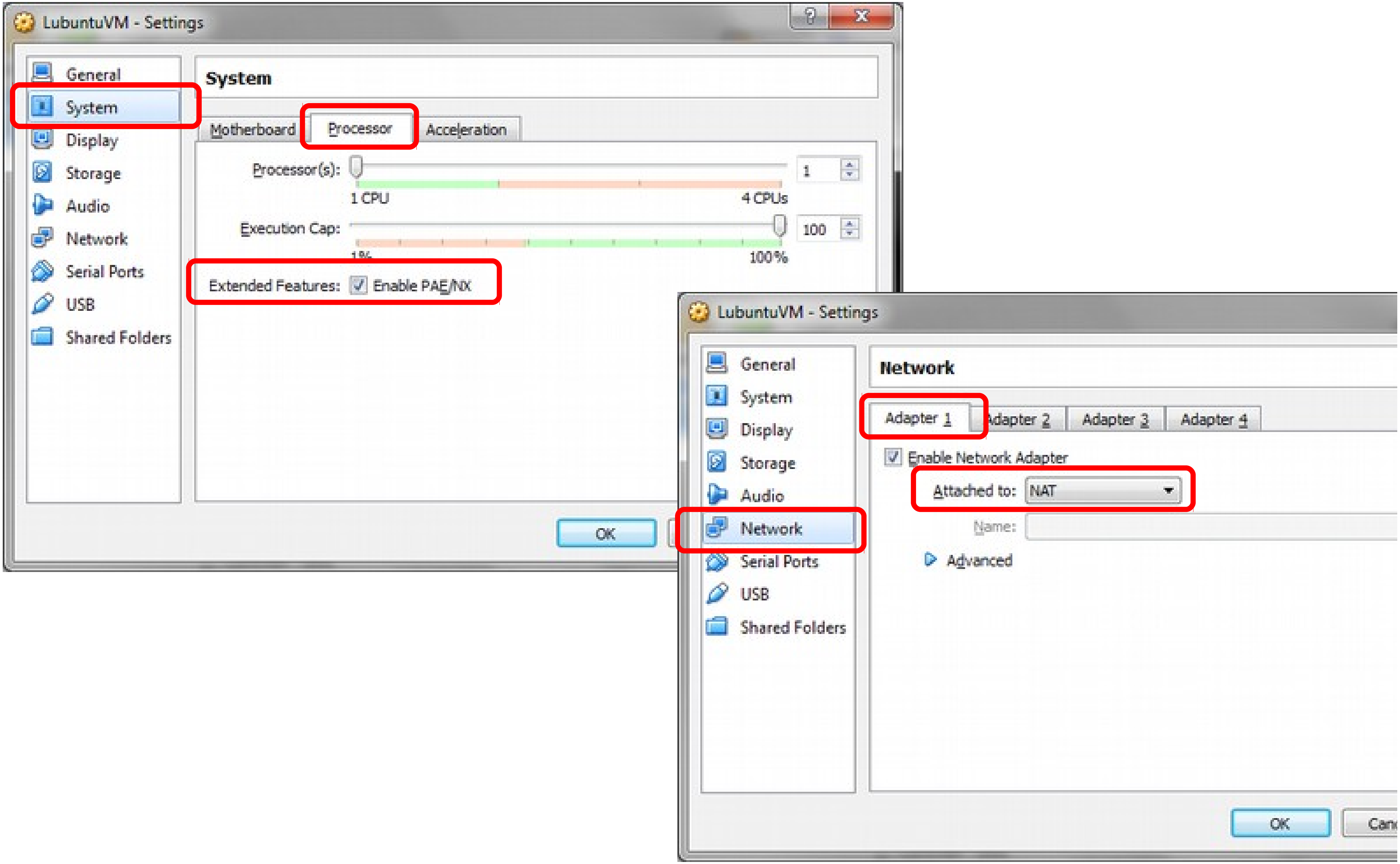


Name: MyLubuntuVM

Type: Linux

Version: Ubuntu (32-bit)

Enable PAE and NAT



System

Processor(s): 1

Execution Cap: 100

Extended Features: ☑ Enable PAE/NX

Network

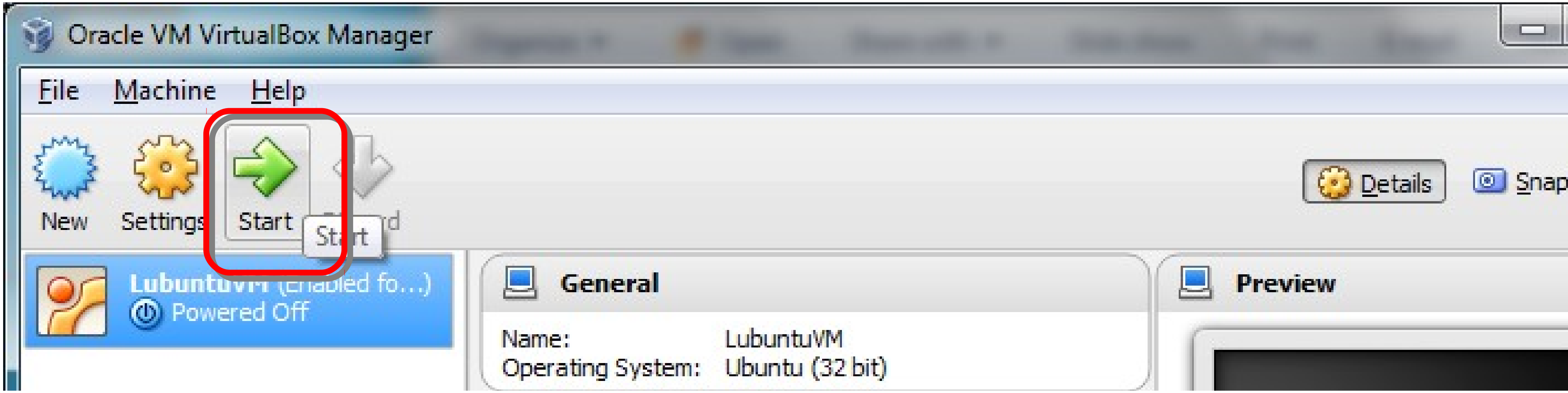
☑ Enable Network Adapter

Attached to: NAT

Name:

Ex. A3: Start the machine

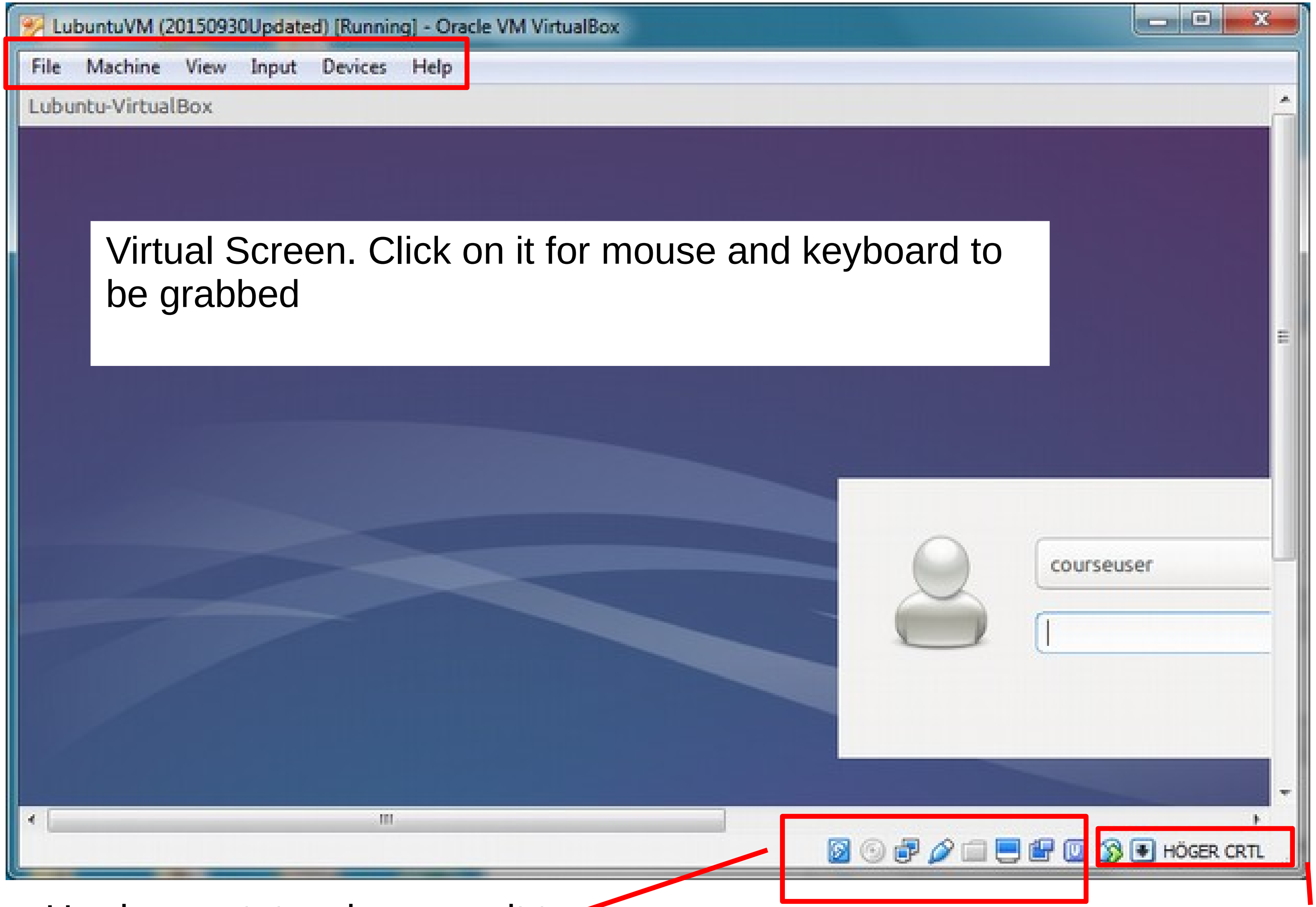
- Click on the Start arrow.



Name: LubuntuVM
Operating System: Ubuntu (32 bit)

VirtualBox interface explained 2

Machine menu.
Try to go Fullscreen
Using the View menu!
Shortcut:
RightCtrl + F



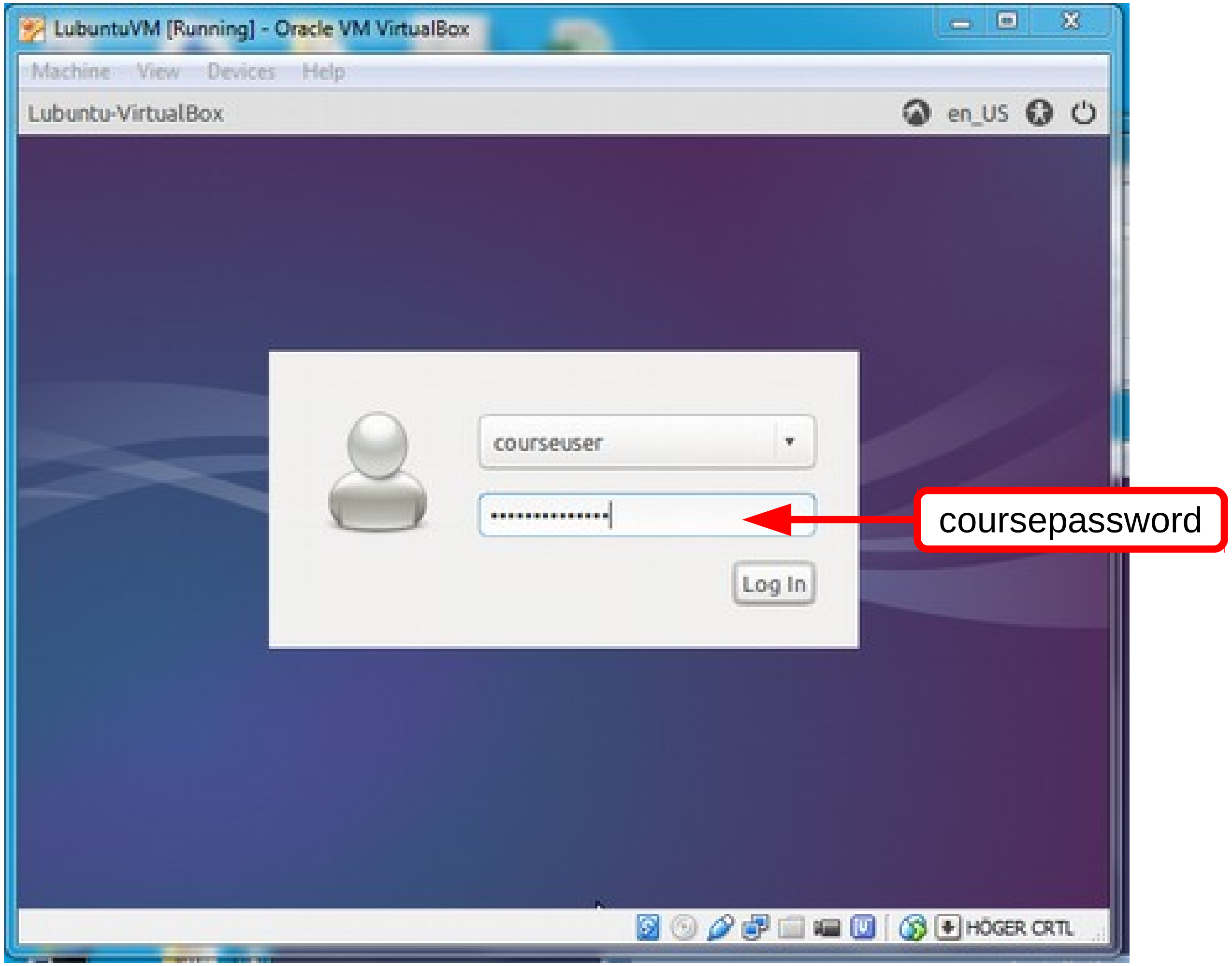
Virtual Screen. Click on it for mouse and keyboard to be grabbed

Hardware status, hover on it to see description

Keyboard and mouse status.
Use right control to ungrab

Ex. A4: First steps in lubuntu usage

Login using the user name courseuser and password coursepassword



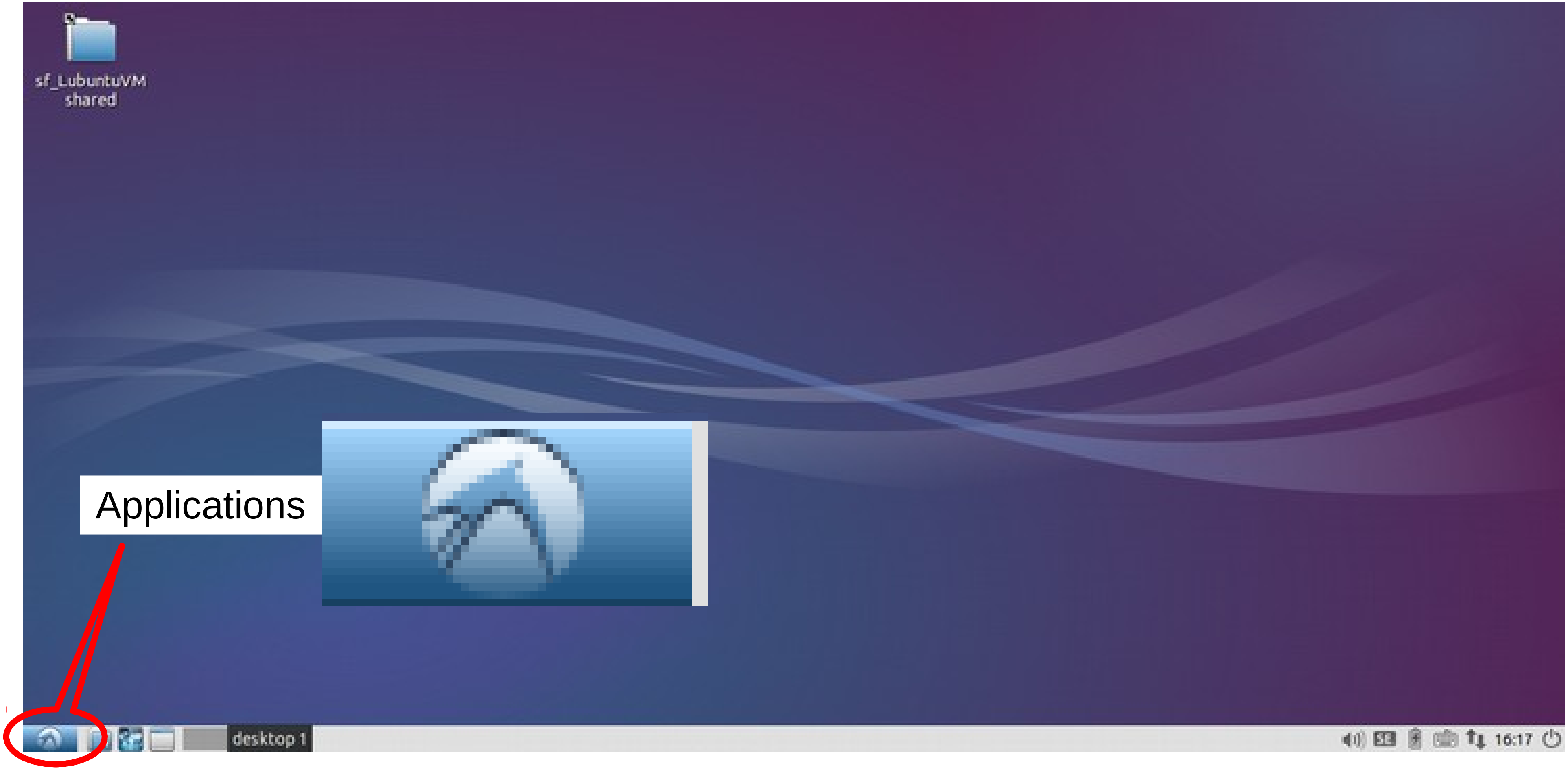
LubuntuVM [Running] - Oracle VM VirtualBox

Lubuntu-VirtualBox

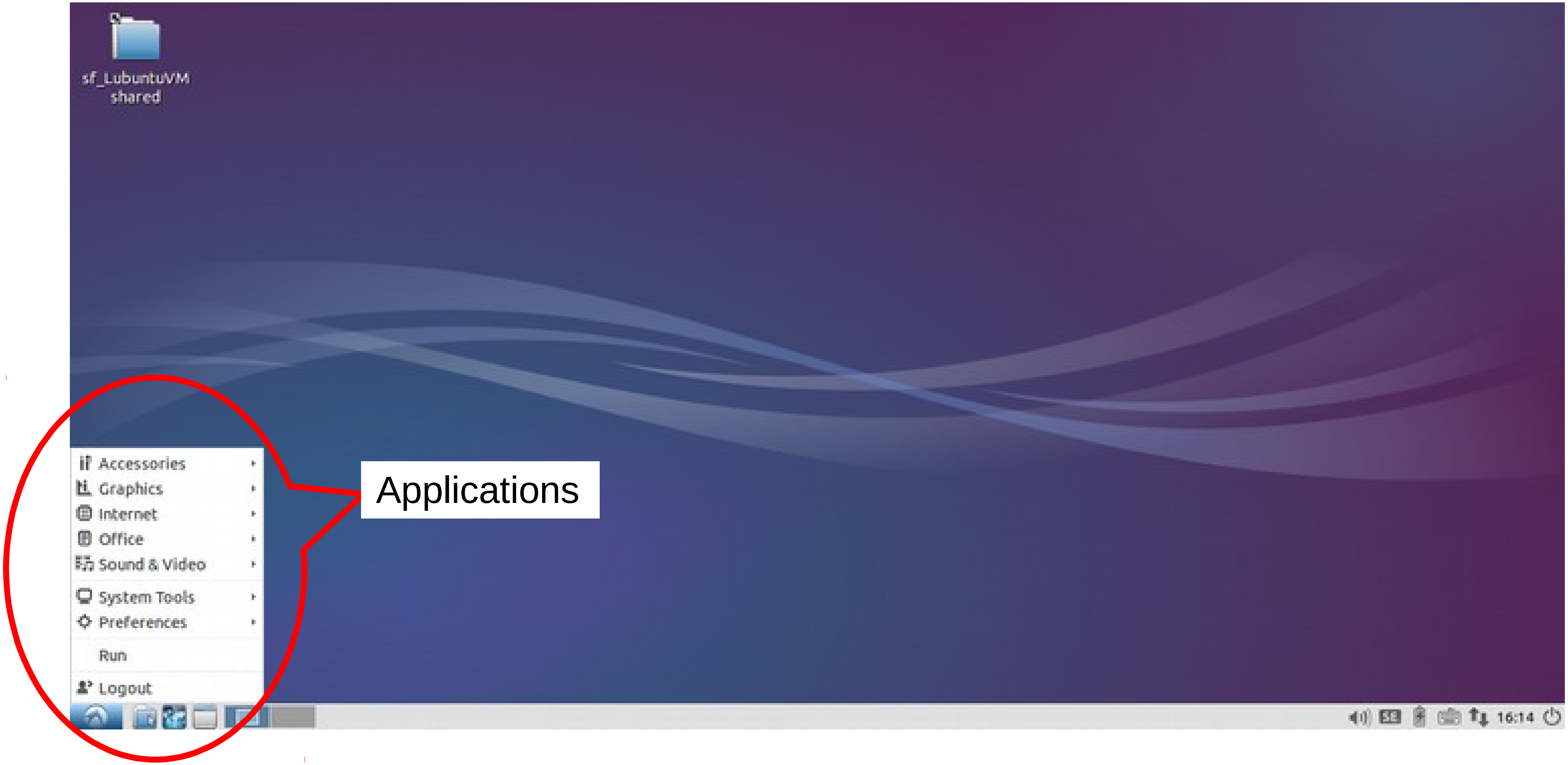
courseuser

coursepassword

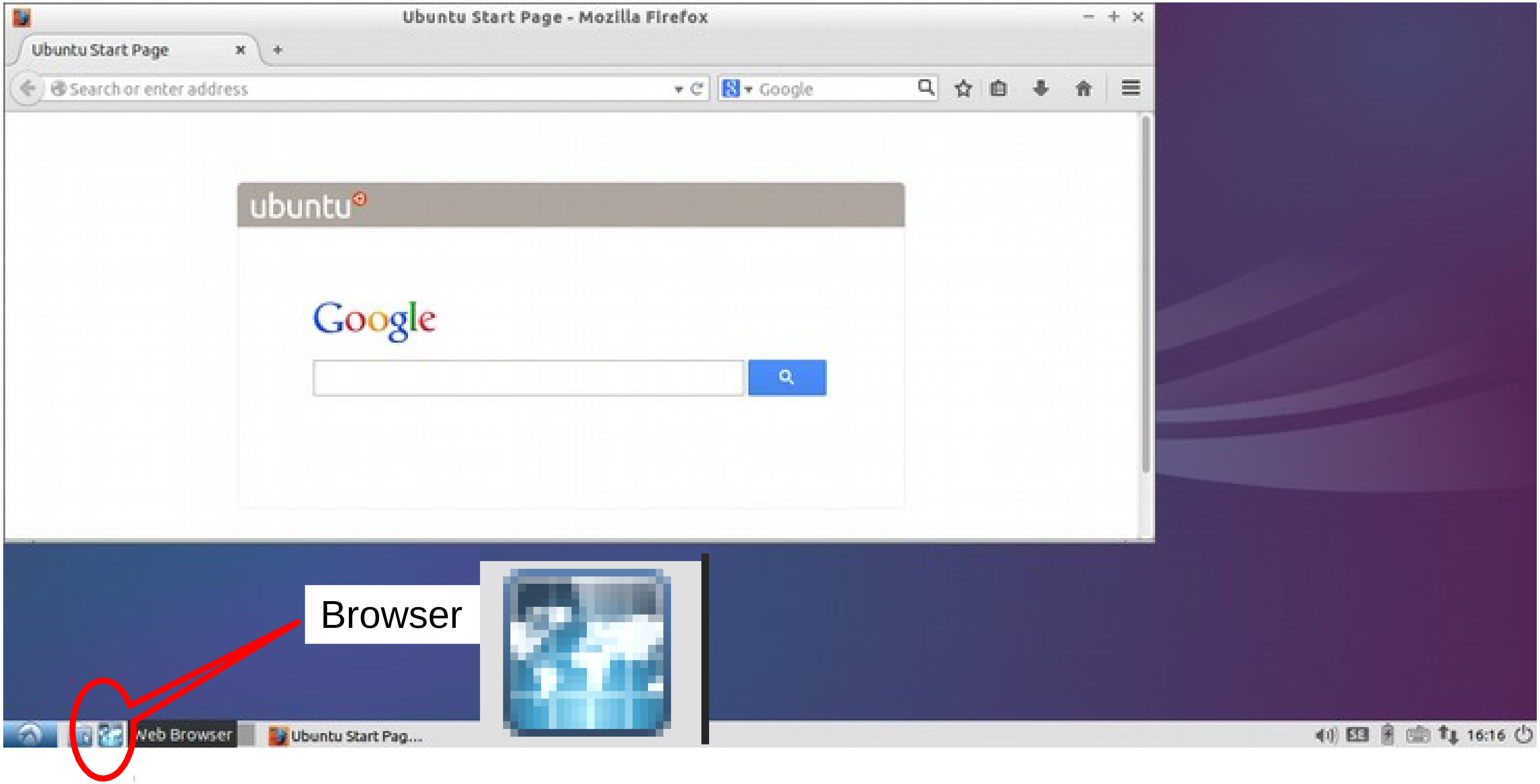
Ex. A4.1: Moving around the desktop



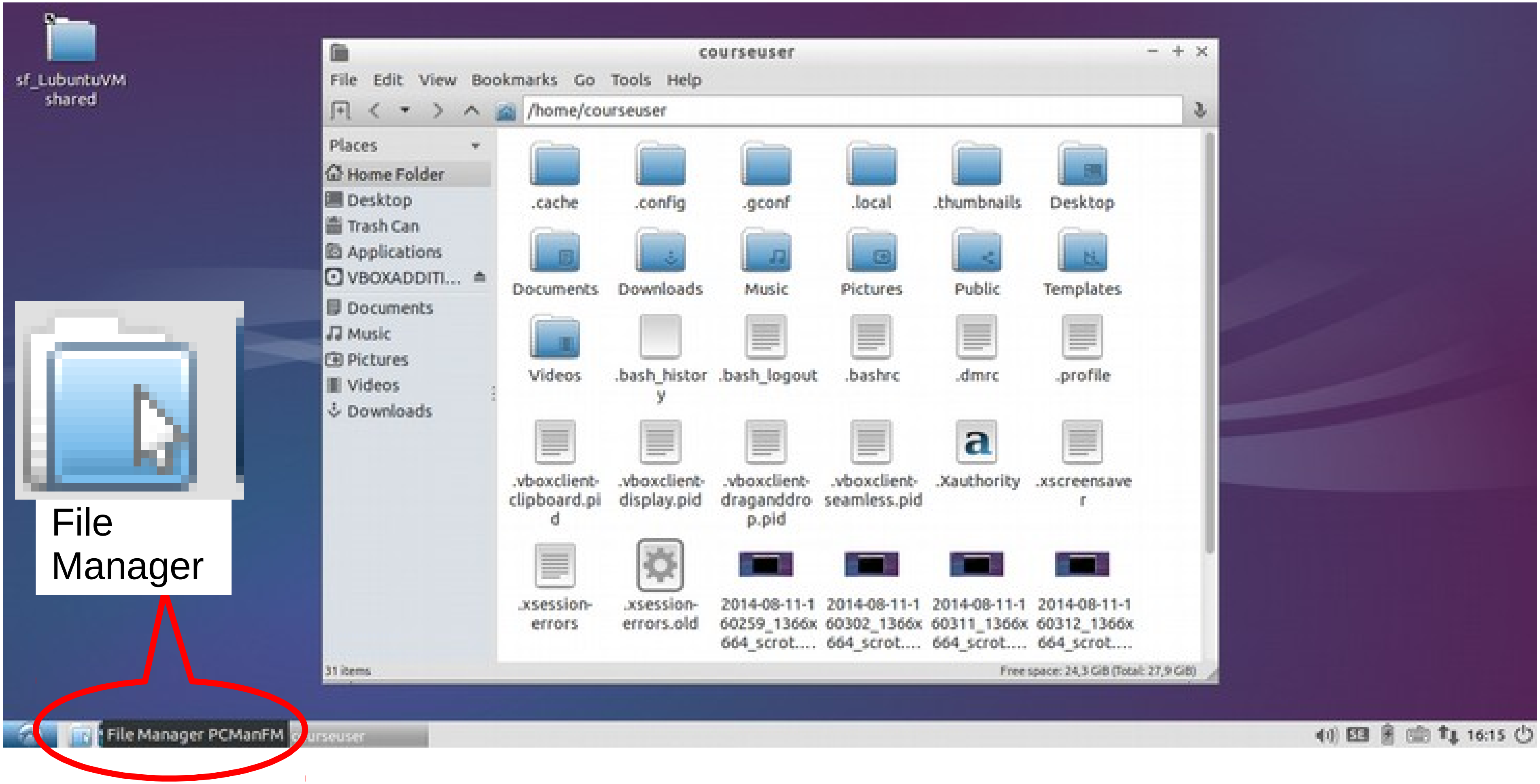
Ex. A4.1: Moving around the desktop



Ex. A4.1: Moving around the desktop



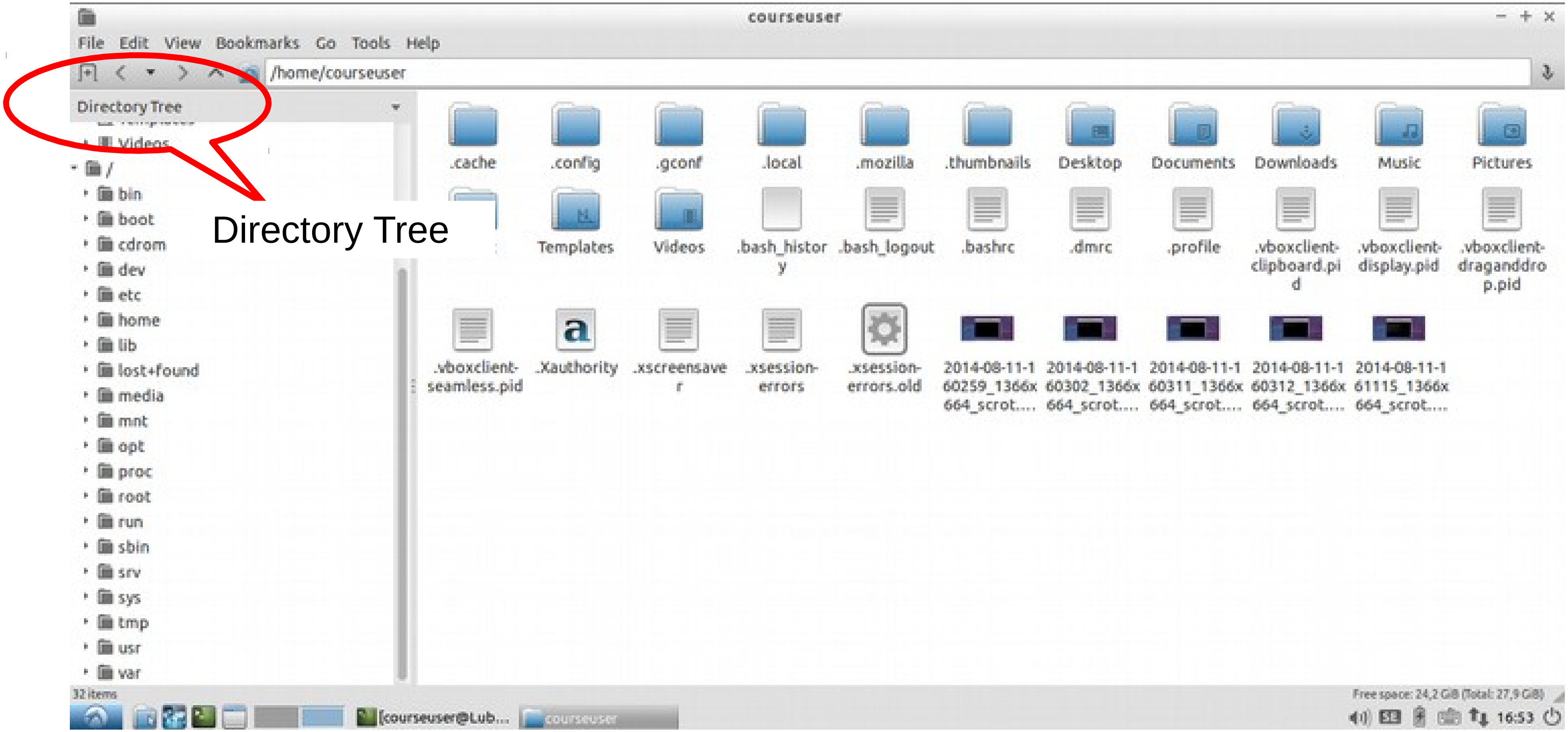
Ex. A4.1: Moving around the desktop



/home/courseuser

Ex. A4.2: Moving around the desktop

Organization of files in Linux



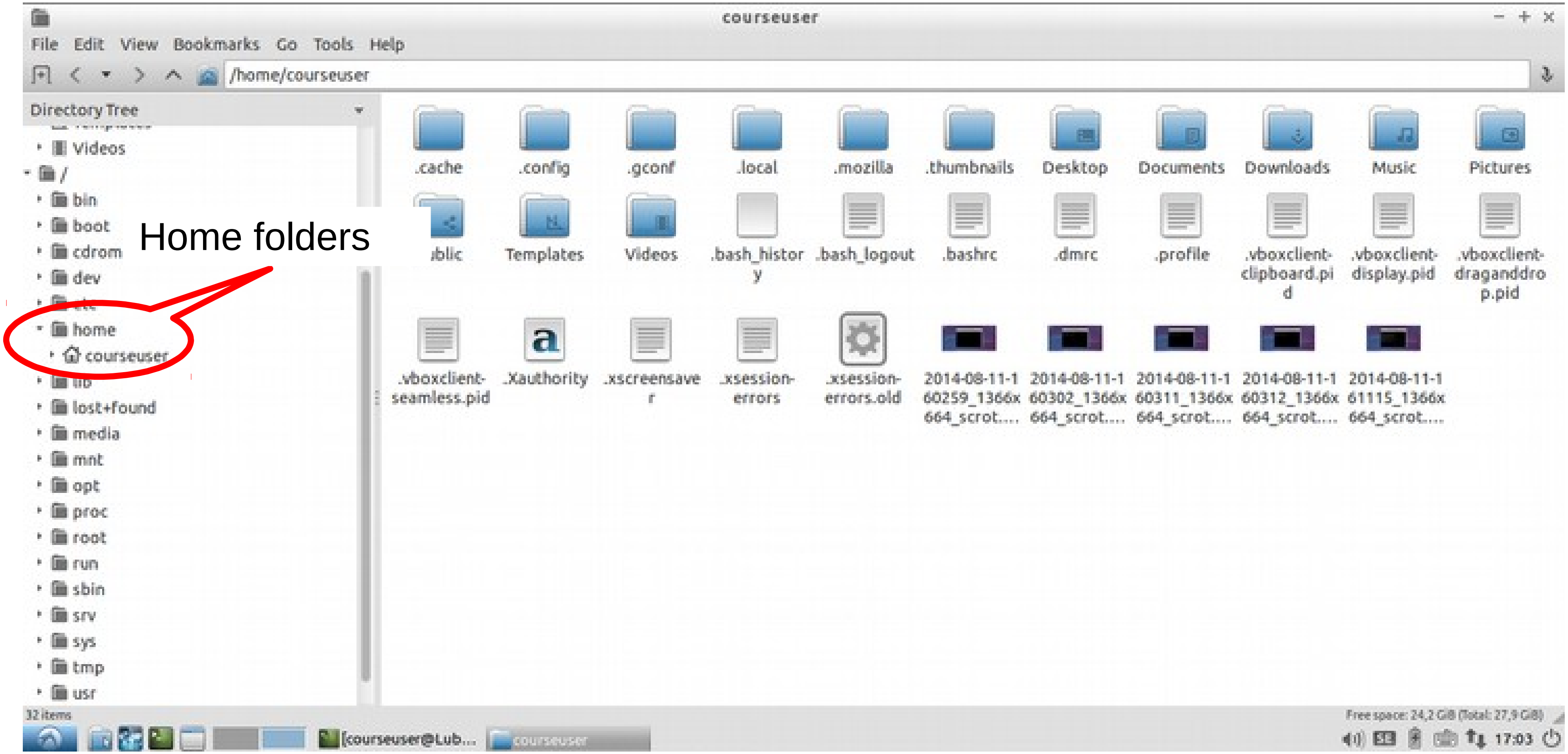
Directory Tree

the filesystem ”root”: /

Home directory: /home/courseuser

Ex. A4.2: Moving around the desktop

Organization of files in Linux

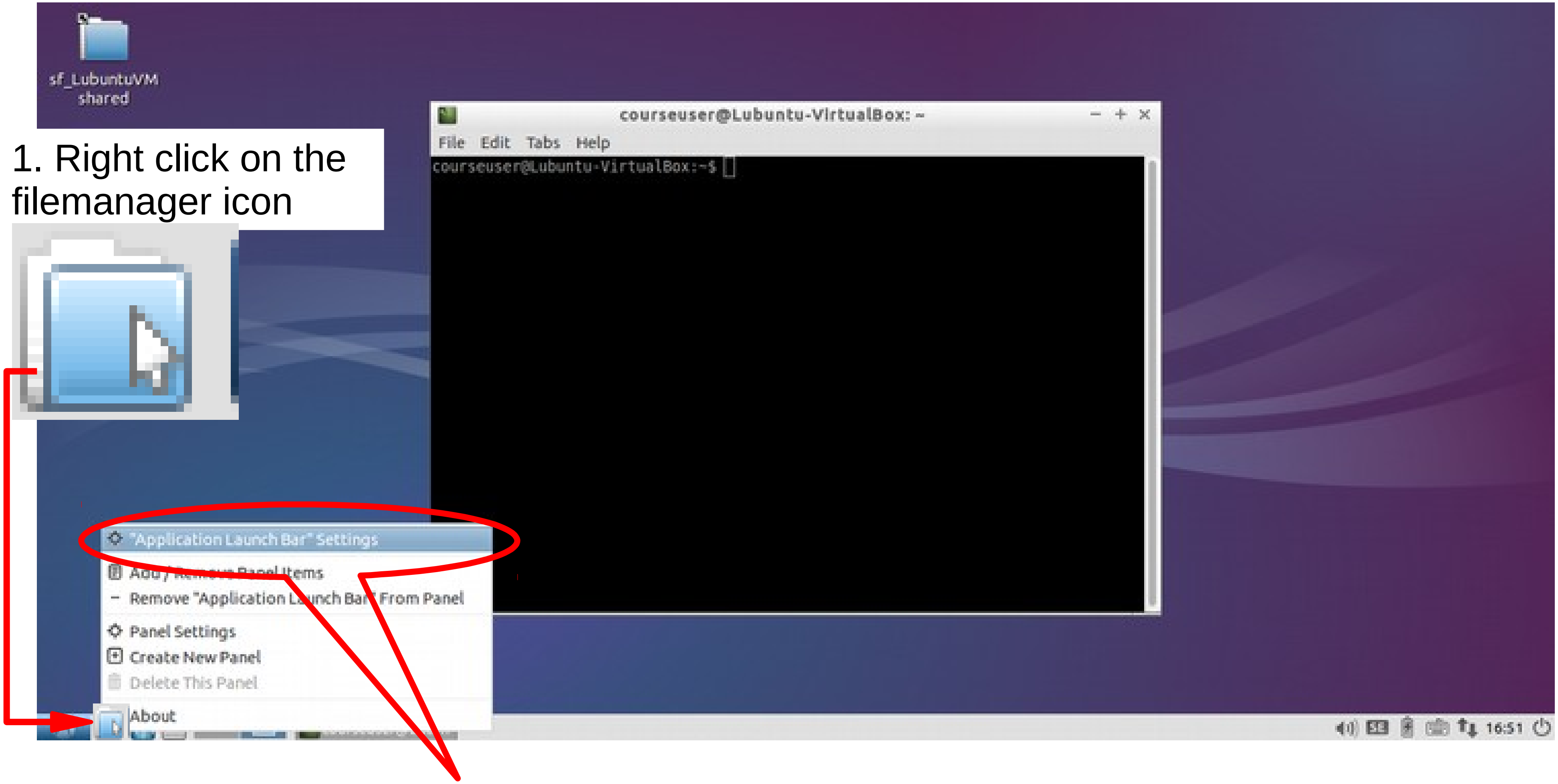


Home folders

the filesystem ”root”: /
Home directory: /home/courseuser

Ex. A4.3: Customizing the desktop

Customization of the desktop: application shortcuts



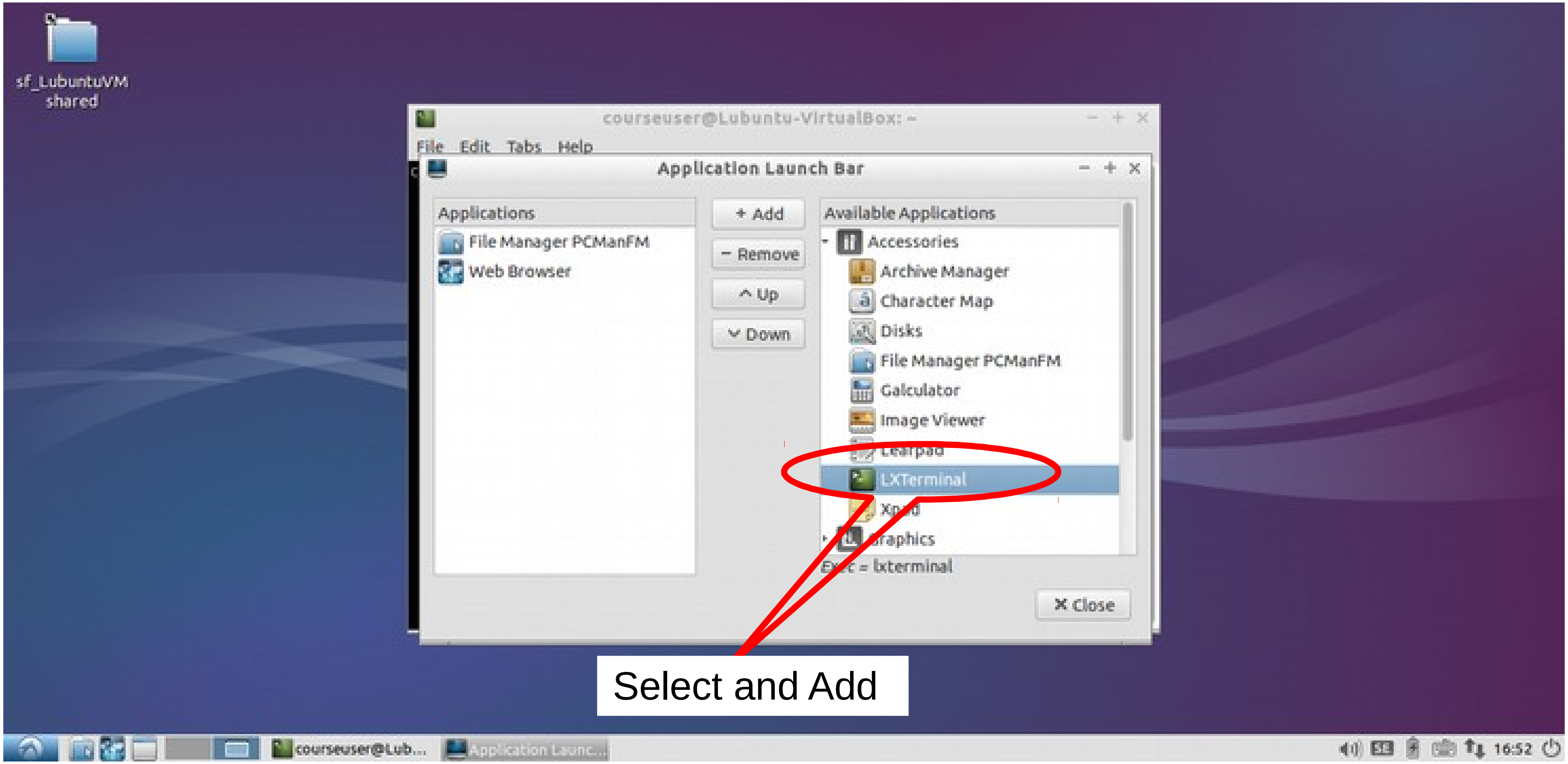
1. Right click on the filemanager icon

```
courseuser@Lubuntu-VirtualBox:~$ 
```

2. Click on ”Application Launch Bar” settings

Ex. A4.3: Customizing the desktop

Customization of the desktop: application shortcuts

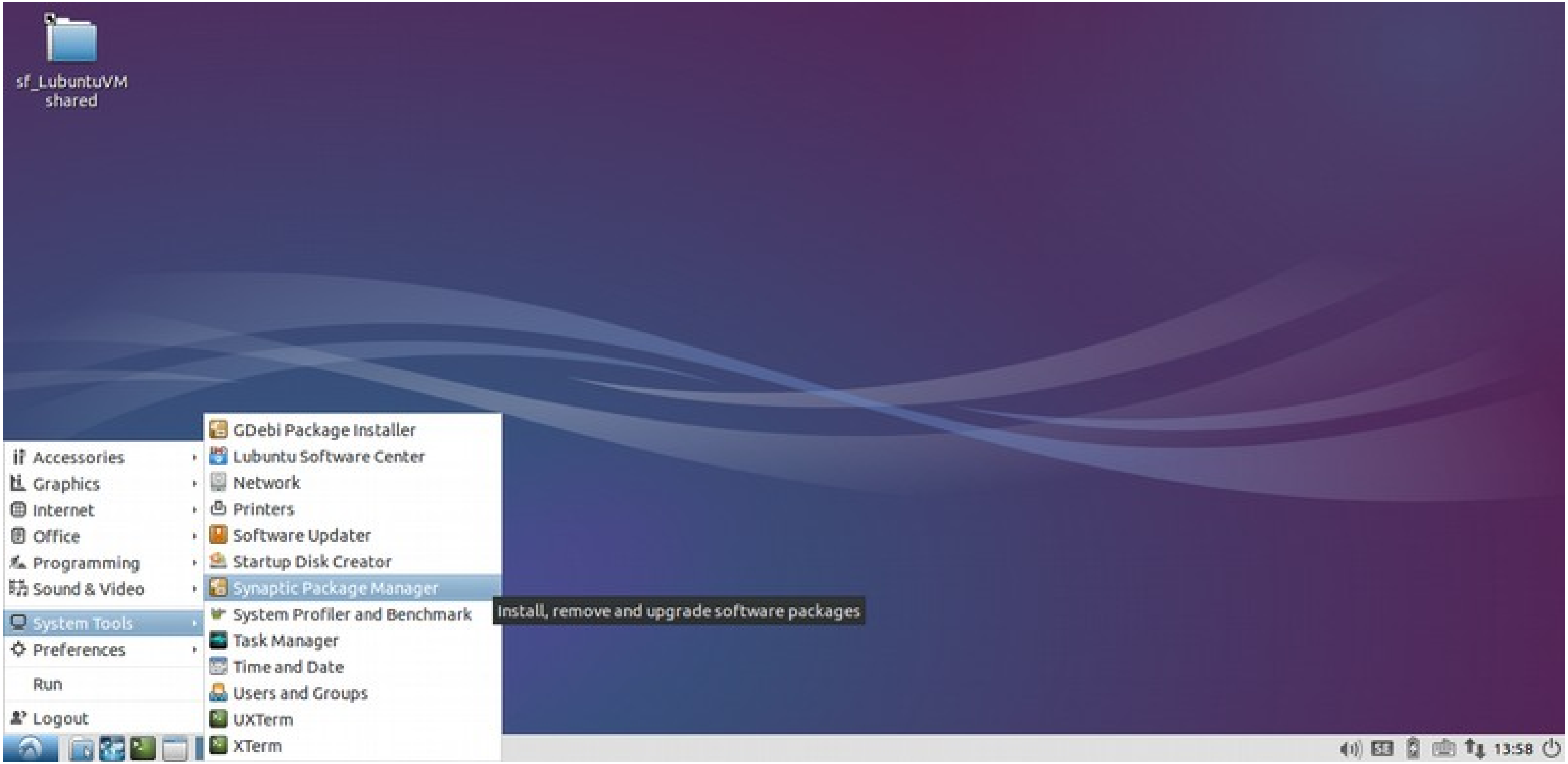


Select and Add

Add LXTerminal to Launchbar

Ex. A5.1: Installing software from repositories

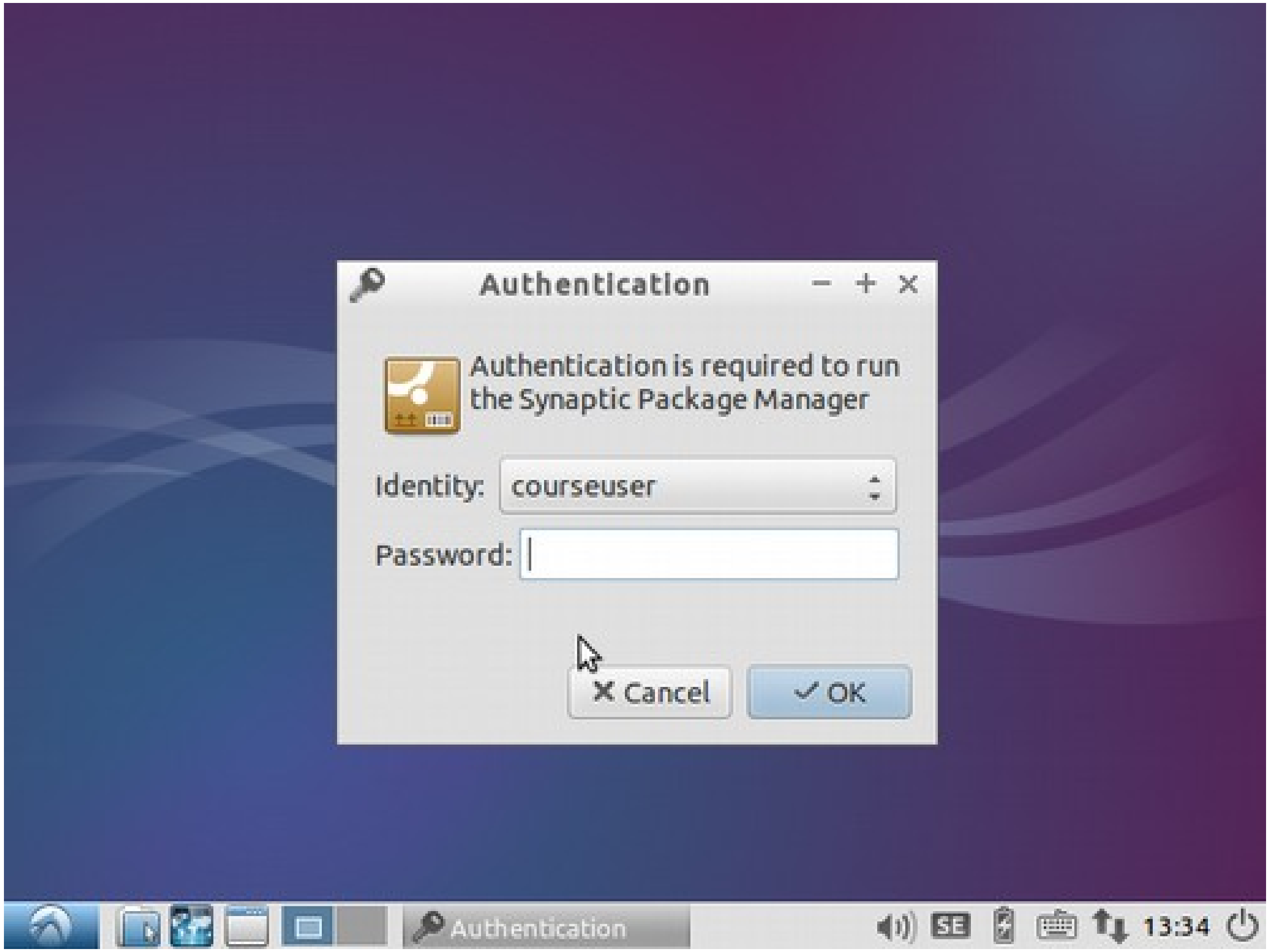
- Scientist: Synaptic, search for libraries, packages



Install, remove and upgrade software packages

Ex. A5.1: Installing software from repositories

- Adding software requires superuser privileges



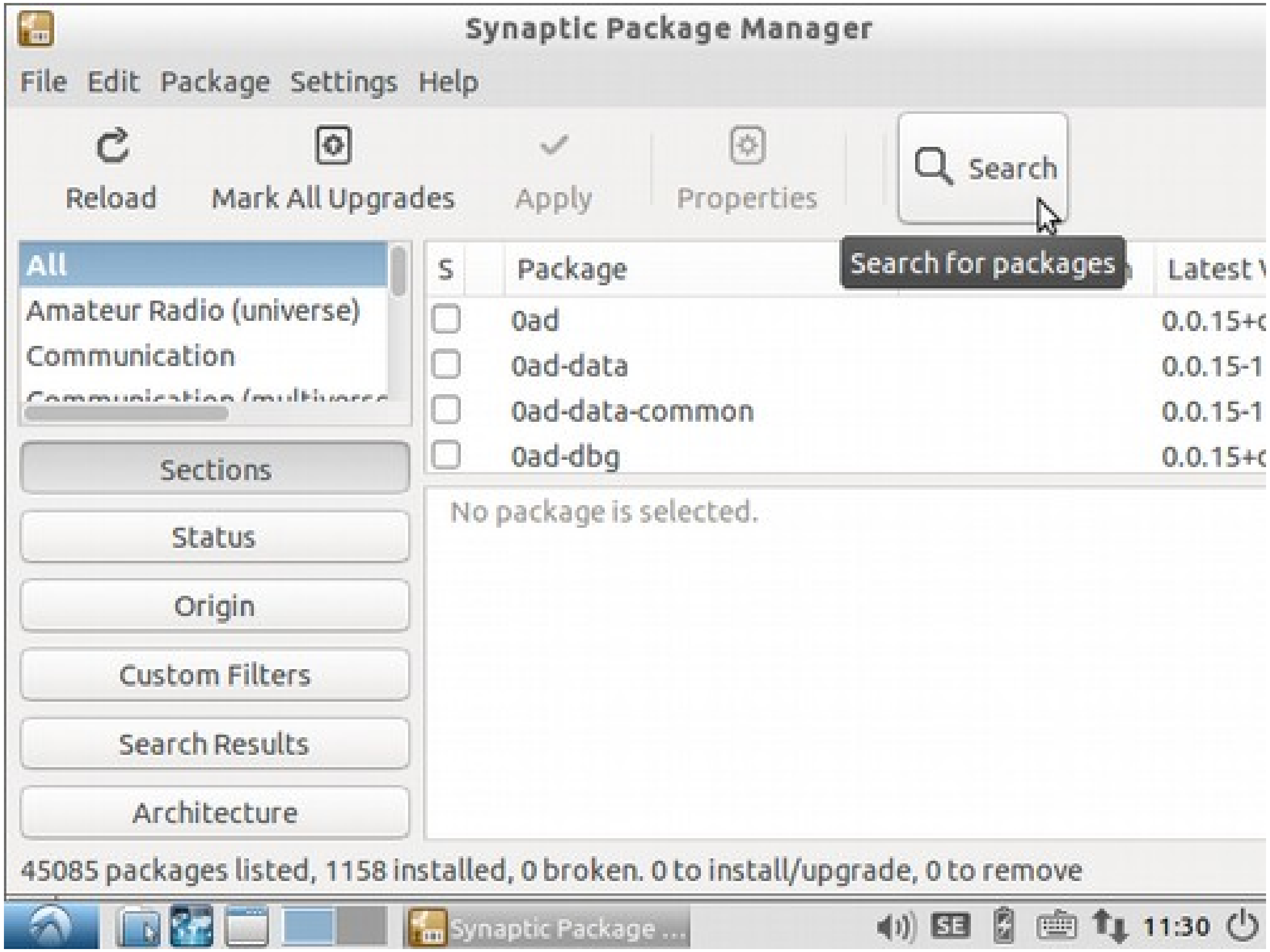
Authentication

Authentication is required to run the Synaptic Package Manager

Identity: courseuser

Password:

Ex. A5.2: Installing software from repositories

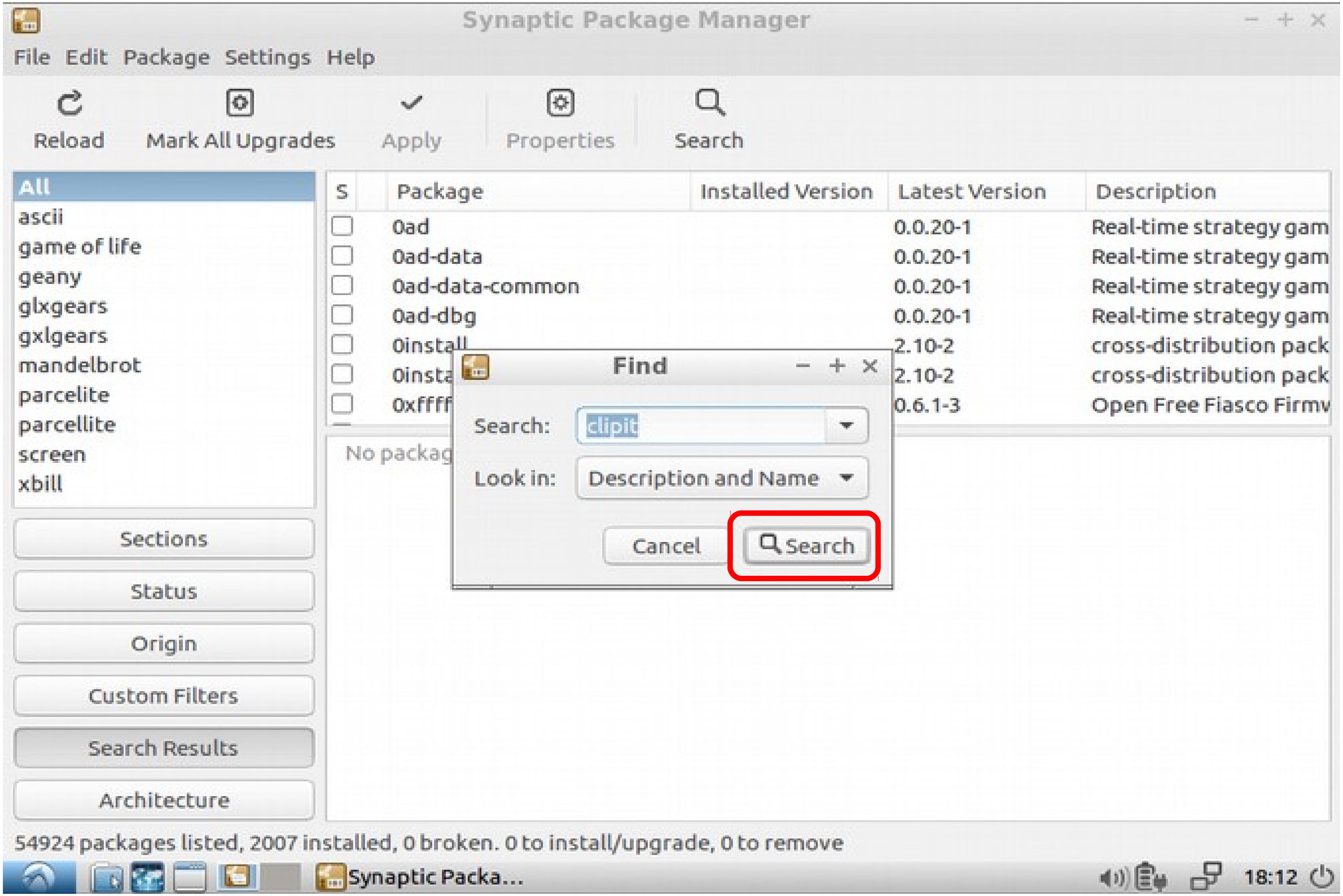


S	Package	Latest V
□	0ad	0.0.15+c
□	0ad-data	0.0.15-1
□	0ad-data-common	0.0.15-1
□	0ad-dbg	0.0.15+c

No package is selected.

45085 packages listed, 1158 installed, 0 broken. 0 to install/upgrade, 0 to remove

Ex. A5.2: Installing software from repositories



S	Package	Installed Version	Latest Version	Description
□	0ad		0.0.20-1	Real-time strategy gam
□	0ad-data		0.0.20-1	Real-time strategy gam
□	0ad-data-common		0.0.20-1	Real-time strategy gam
□	0ad-dbg		0.0.20-1	Real-time strategy gam
□	0install		2.10-2	cross-distribution pack
□	0insta		2.10-2	cross-distribution pack
□	0xffff		0.6.1-3	Open Free Fiasco Firmv

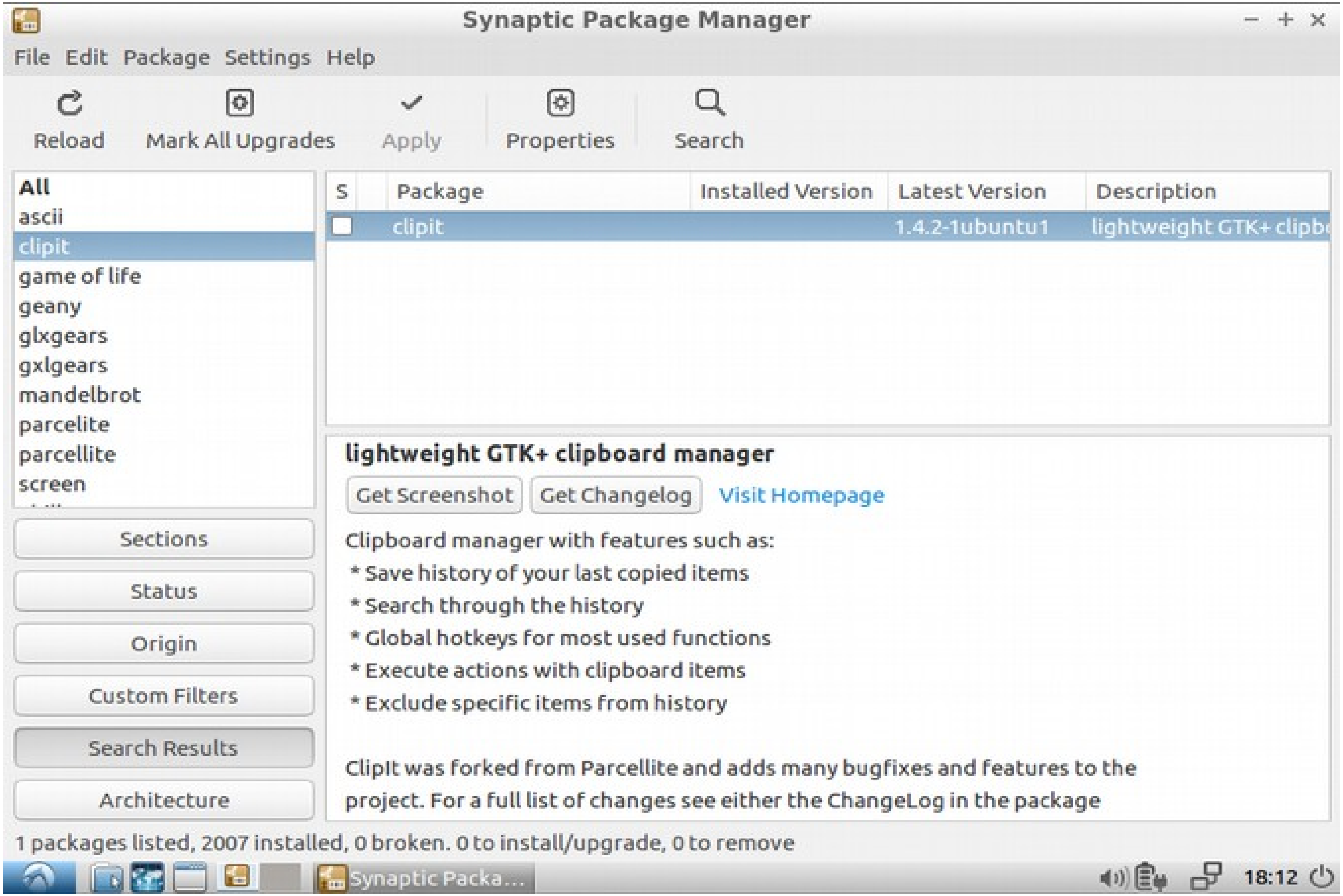
No packag

Search: clipit

Look in: Description and Name

54924 packages listed, 2007 installed, 0 broken. 0 to install/upgrade, 0 to remove

Ex. A5.2: Installing software from repositories



S	Package	Installed Version	Latest Version	Description
□	clipit		1.4.2-1ubuntu1	lightweight GTK+ clipb

lightweight GTK+ clipboard manager

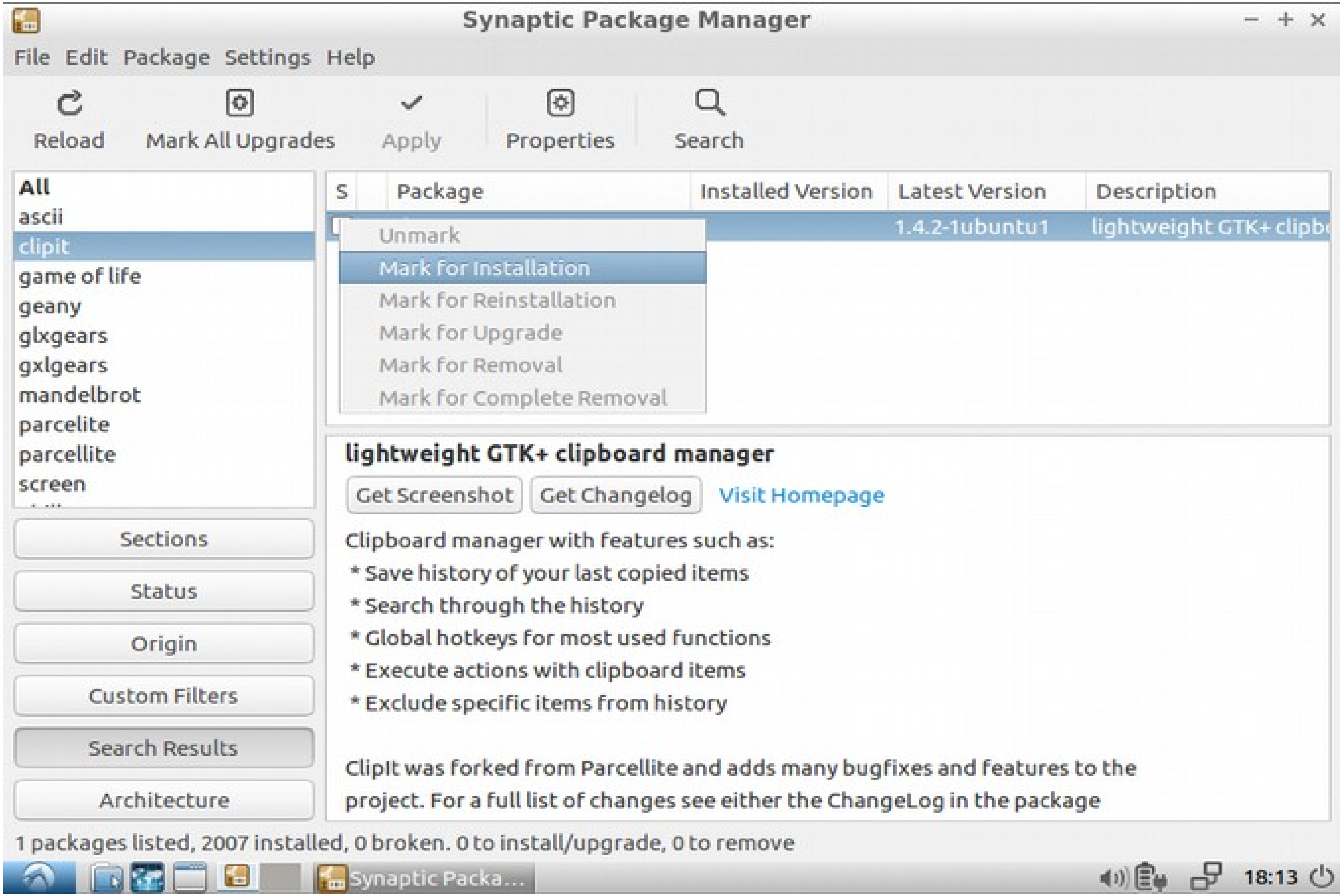
Clipboard manager with features such as:

* Save history of your last copied items
* Search through the history
* Global hotkeys for most used functions
* Execute actions with clipboard items
* Exclude specific items from history

ClipIt was forked from Parcellite and adds many bugfixes and features to the project. For a full list of changes see either the ChangeLog in the package

1 packages listed, 2007 installed, 0 broken. 0 to install/upgrade, 0 to remove

Ex. A5.2: Installing software from repositories



lightweight GTK+ clipboard manager

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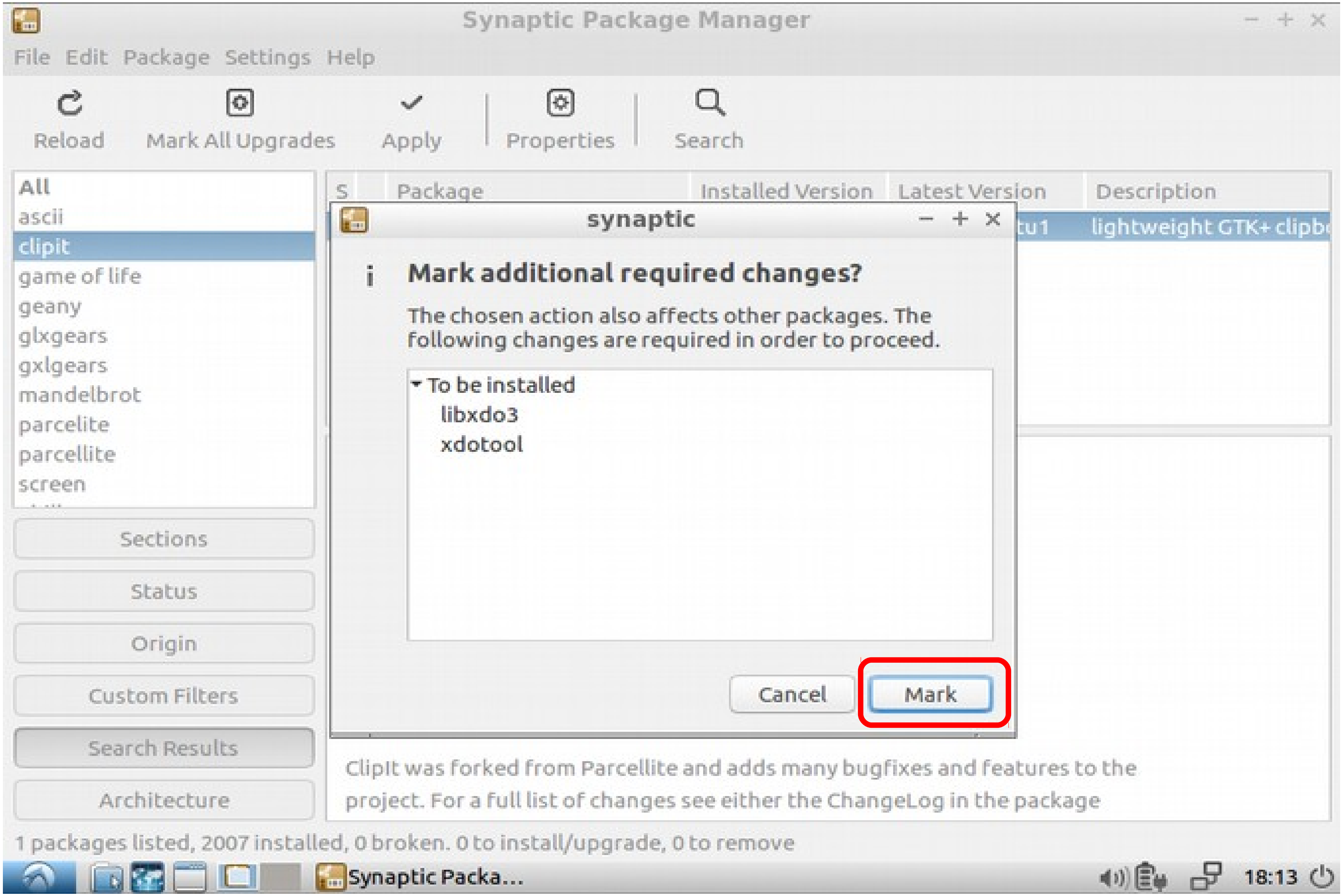
Ex. A5.2: Installing software from repositories



Mark additional required changes?

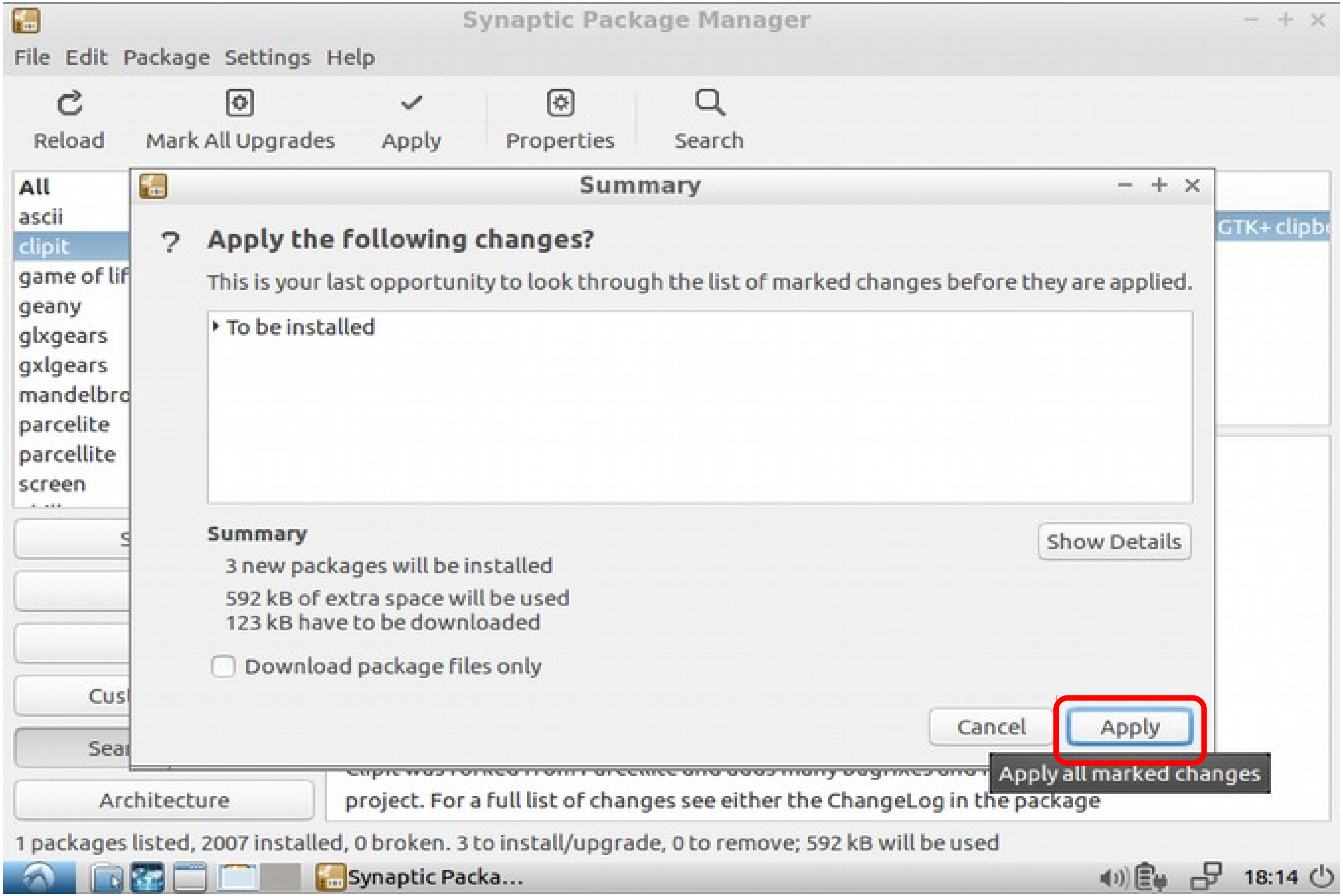
The chosen action also affects other packages. The following changes are required in order to proceed.

- To be installed
  - libxdo3
  - xdotool

ClipIt was forked from Parcellite and adds many bugfixes and features to the project. For a full list of changes see either the ChangeLog in the package

1 packages listed, 2007 installed, 0 broken. 0 to install/upgrade, 0 to remove

Ex. A5.2: Installing software from repositories



? **Apply the following changes?**

This is your last opportunity to look through the list of marked changes before they are applied.

- To be installed

Summary

3 new packages will be installed

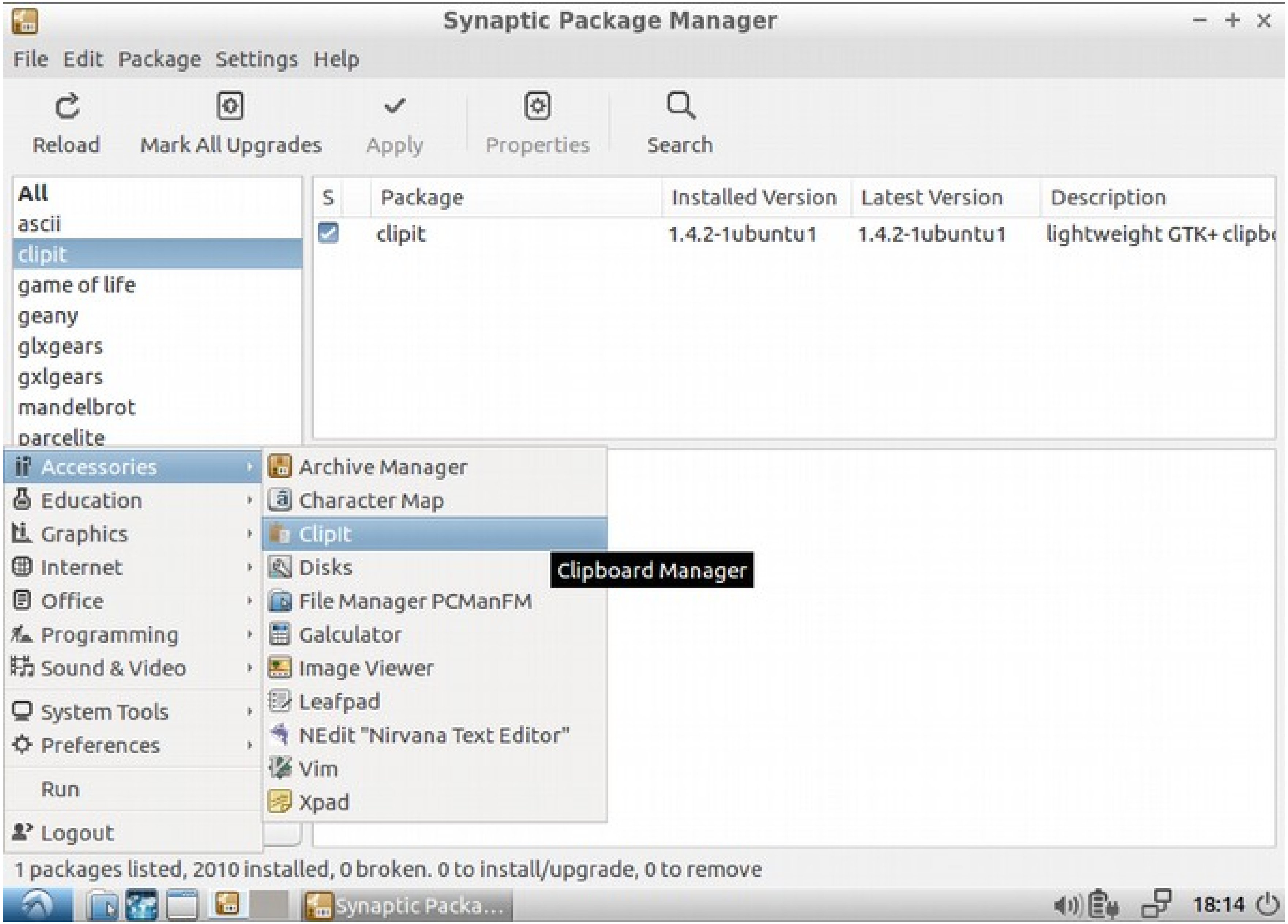
592 kB of extra space will be used
123 kB have to be downloaded

□ Download package files only

project. For a full list of changes see either the ChangeLog in the package

1 packages listed, 2007 installed, 0 broken. 3 to install/upgrade, 0 to remove; 592 kB will be used

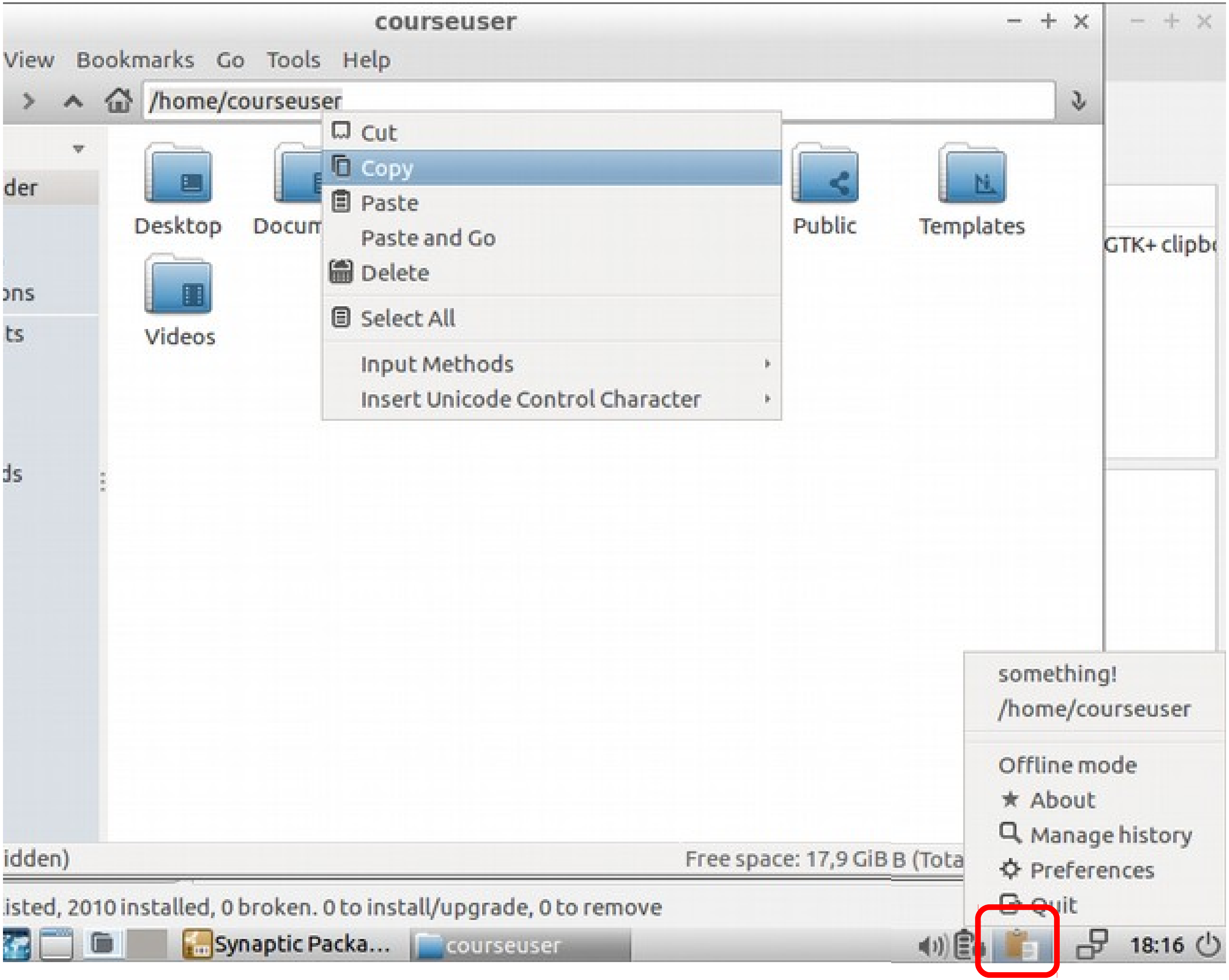
Using clipit



S	Package	Installed Version	Latest Version	Description
☑	clipit	1.4.2-1ubuntu1	1.4.2-1ubuntu1	lightweight GTK+ clipb

1 packages listed, 2010 installed, 0 broken. 0 to install/upgrade, 0 to remove

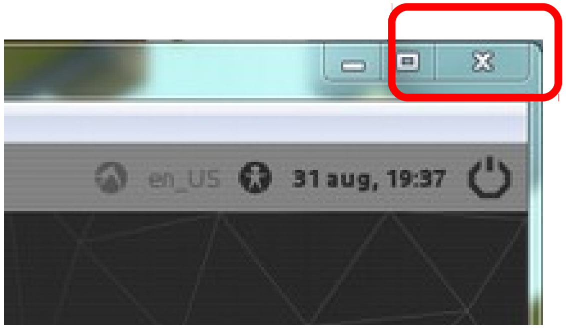
Using clipit



isted, 2010 installed, 0 broken. 0 to install/upgrade, 0 to remove

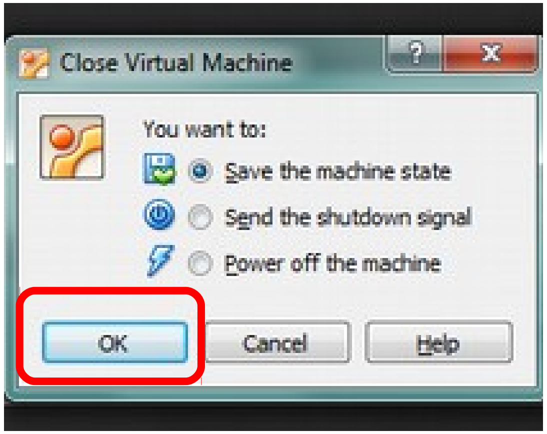
Ex. A6: Freezing the machine state thanks to virtualization

- Have no time to finish the assignments? No problem! You can freeze time by using the property that a Von Neumann Machine is a finite state machine.
- Close the machine window



Ex. A6: Freezing the machine state thanks to virtualization

- On the dialog that appears, click on *"Save the machine state"*



Close Virtual Machine

You want to:

● Save the machine state

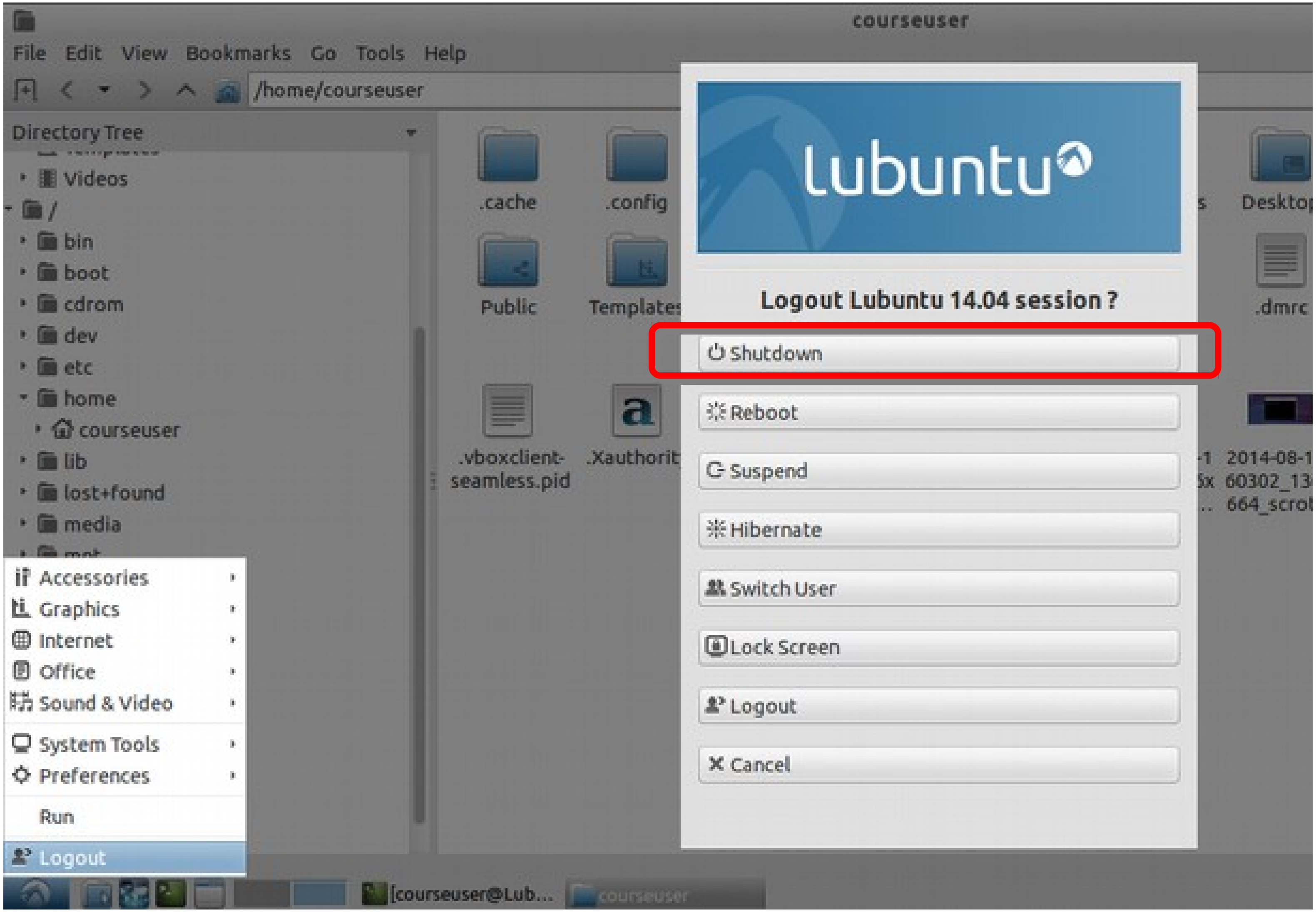
○ Send the shutdown signal

○ Power off the machine

- The machine is now hibernated. All your work is saved as you could stop time.
  - All the RAM content is saved to disk.
- Start the machine again. What happens?
  - All the RAM is reloaded into memory and the machine is in the same state as when we closed it.

Ex. A7: Logout dialog: Shutdown

A6.1 Poweroff the machine.



Logout Lubuntu 14.04 session ?

Part B: Installing GNU/Linux in a Virtual Machine

Prerequisites

- Your machine needs to have at least 4GB of RAM.
  8GB RAM is recommended.
- You need at least 40GB of free harddisk space.
- On Apple computers you need to enable the mouse right click, see https://support.apple.com/kb/PH18768?locale=en_US
- This step is not required in the lab. VirtualBox is already installed:
  Install Oracle VirtualBox for your operating system.
  Download it from
  http://www.virtualbox.org
  - If you already have GNU/Linux installed, the open source version of VirtualBox can be found in the distribution's repositories.

Ex. B1: Create a virtual machine

Goal: create a virtual machine to run Lubuntu Linux.

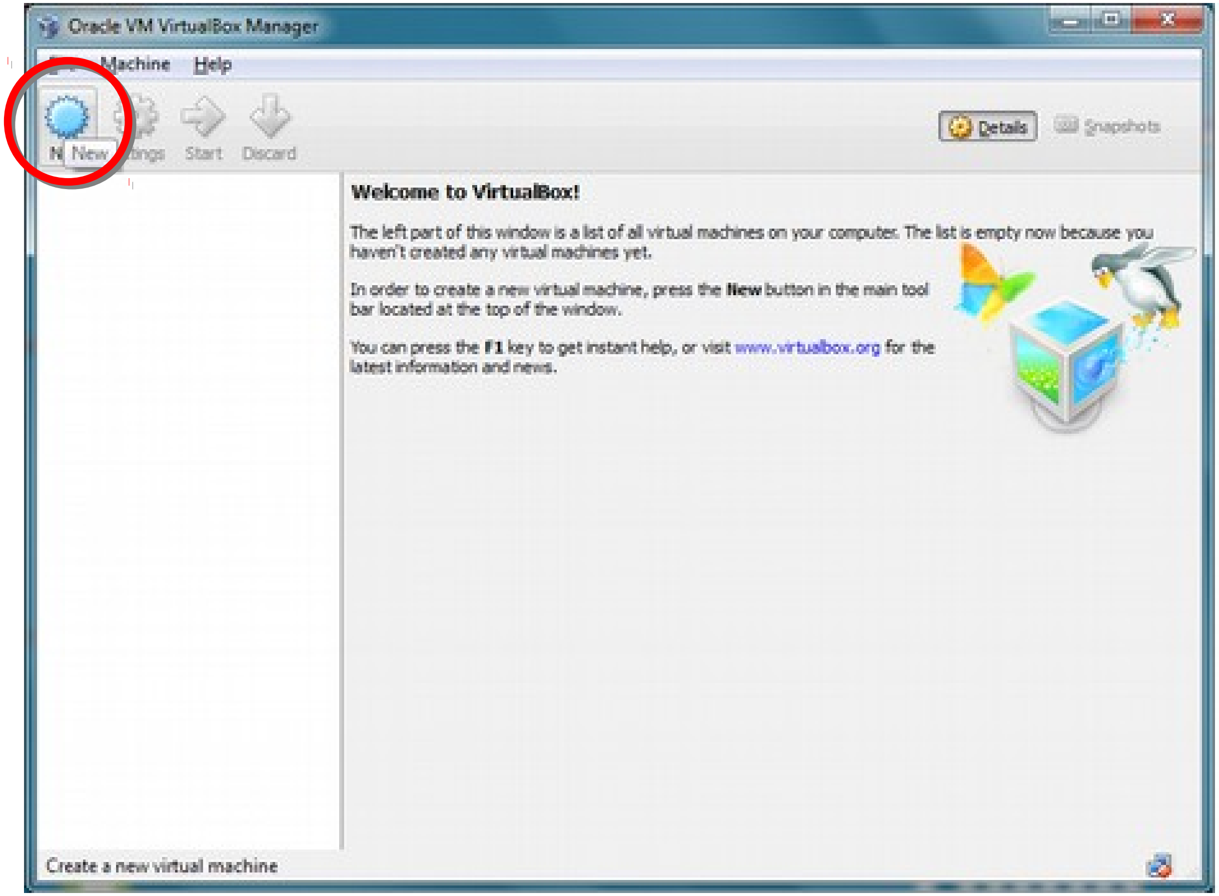
Use the following information:

VM Name	MyLubuntuVM
Operating System Type	Linux
Version	Ubuntu (32 bit)
memory (RAM)	1536 MB (that is, 1,5 Gigabytes)

The slides that follow will guide you through the process.
A more general and detailed tutorial can be found on VirtualBox offcial documentation:
https://www.virtualbox.org/manual/ch01.html#gui-createvm

Ex. B1: Create a virtual machine

B1.1.Open virtualbox . Click on ”New”



Welcome to VirtualBox!

The left part of this window is a list of all virtual machines on your computer. The list is empty now because you haven't created any virtual machines yet.

In order to create a new virtual machine, press the **New** button in the main tool bar located at the top of the window.

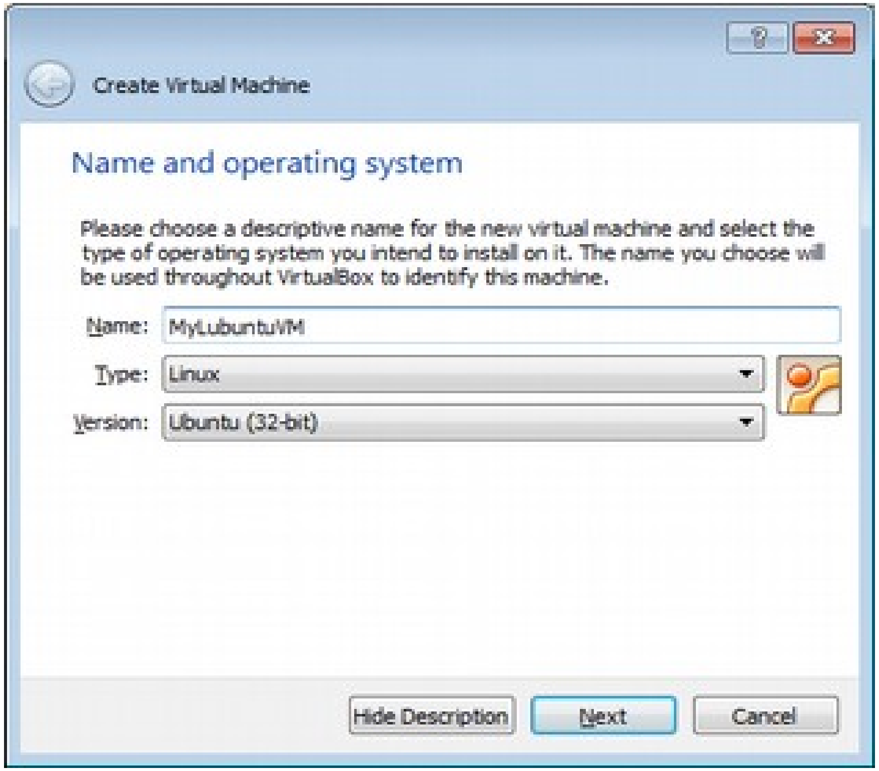
You can press the **F1** key to get instant help, or visit www.virtualbox.org for the latest information and news.

Create a new virtual machine

Note: following these slides will give you a good introduction. A more general and detailed tutorial can be found on VirtualBox offcial documentation: https://www.virtualbox.org/manual/ch01.html#gui-createvm

Ex. B1: Create a virtual machine

B1.2 Insert the following information when asked:



Create Virtual Machine

Name and operating system

Please choose a descriptive name for the new virtual machine and select the type of operating system you intend to install on it. The name you choose will be used throughout VirtualBox to identify this machine.

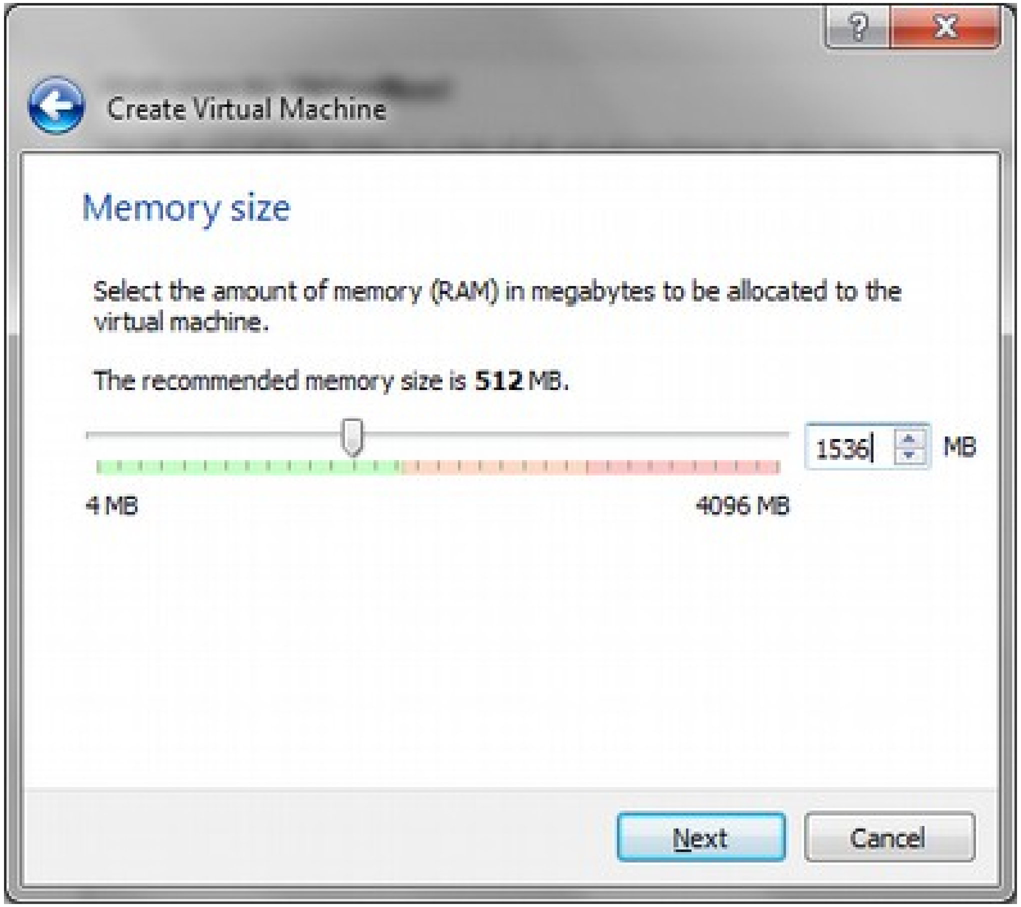
Name: MyLubuntuVM

Type: Linux

Version: Ubuntu (32-bit)

Ex. B1: Create a virtual machine

B1.3 Set memory size.
Suggested: 1536 MB
(1.5GB as a multiple of 8)



Create Virtual Machine

Memory size

Select the amount of memory (RAM) in megabytes to be allocated to the virtual machine.

The recommended memory size is **512** MB.

1536 MB

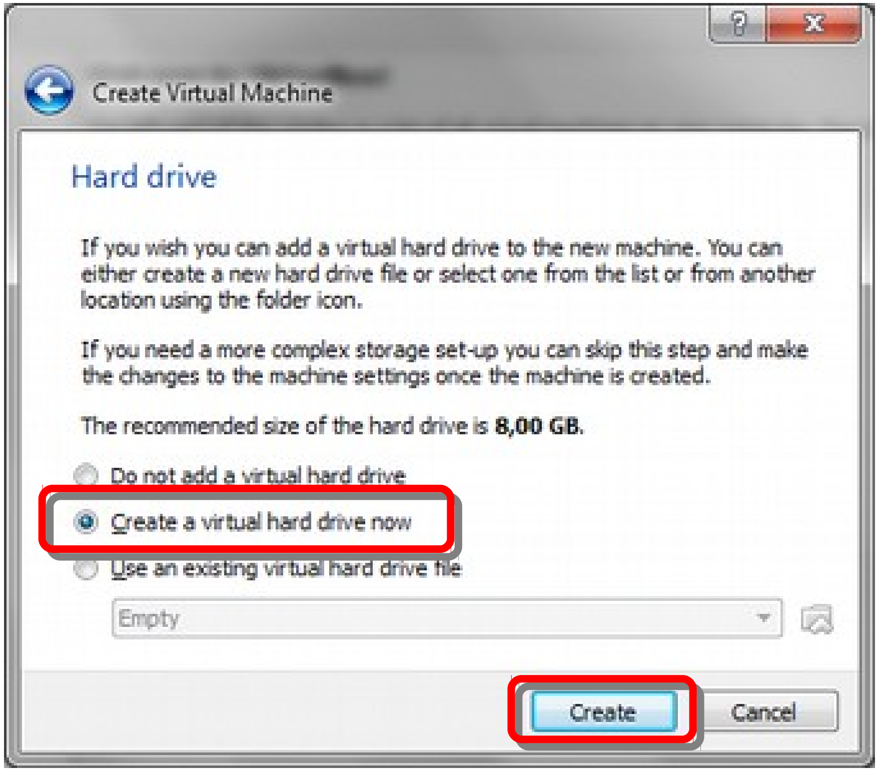
Ex. B1: Create a virtual machine creating a virtual disk

- Create a **new virtual harddisk** for the machine (step 4 in https://www.virtualbox.org/manual/ch01.html#gui-createvm)
- When asked, choose
  ”Create a virtual hard drive now” and click ”Create”
- Use the following parameters:

Disk Type	VDI (VirtualBox Disk Image)
Storage on physical hard drive	Dynamically allocated
Name	MyLubuntuLinux
Size	30,00 GB

Ex. B1: Create a virtual machine creating a virtual disk

B1.4 Create a **new virtual harddisk** for the machine, click create as shown in the picture.



Create Virtual Machine

Hard drive

If you wish you can add a virtual hard drive to the new machine. You can either create a new hard drive file or select one from the list or from another location using the folder icon.

If you need a more complex storage set-up you can skip this step and make the changes to the machine settings once the machine is created.

The recommended size of the hard drive is **8,00 GB**.

○ Do not add a virtual hard drive

● Create a virtual hard drive now

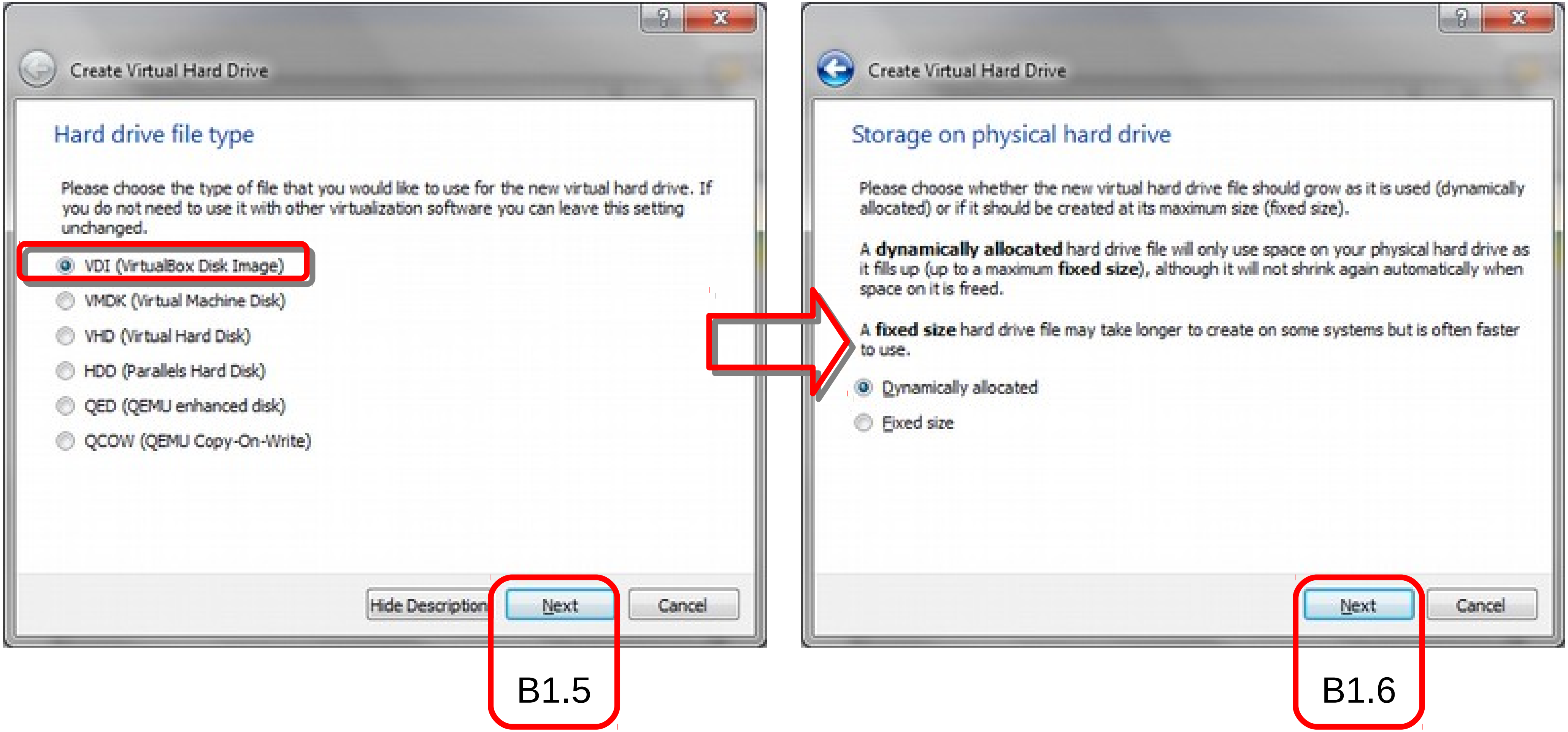
○ Use an existing virtual hard drive file

Empty

Ex. B1: Create a virtual machine creating a virtual disk

B1.5. Select VDI as disk type

B1.6. Choose ”Dynamically allocated” (saves disk space)



Create Virtual Hard Drive

Hard drive file type

Please choose the type of file that you would like to use for the new virtual hard drive. If you do not need to use it with other virtualization software you can leave this setting unchanged.

● VDI (VirtualBox Disk Image)
○ VMDK (Virtual Machine Disk)
○ VHD (Virtual Hard Disk)
○ HDD (Parallels Hard Disk)
○ QED (QEMU enhanced disk)
○ QCOW (QEMU Copy-On-Write)

Create Virtual Hard Drive

Storage on physical hard drive

Please choose whether the new virtual hard drive file should grow as it is used (dynamically allocated) or if it should be created at its maximum size (fixed size).

A **dynamically allocated** hard drive file will only use space on your physical hard drive as it fills up (up to a maximum **fixed size**), although it will not shrink again automatically when space on it is freed.

A **fixed size** hard drive file may take longer to create on some systems but is often faster to use.

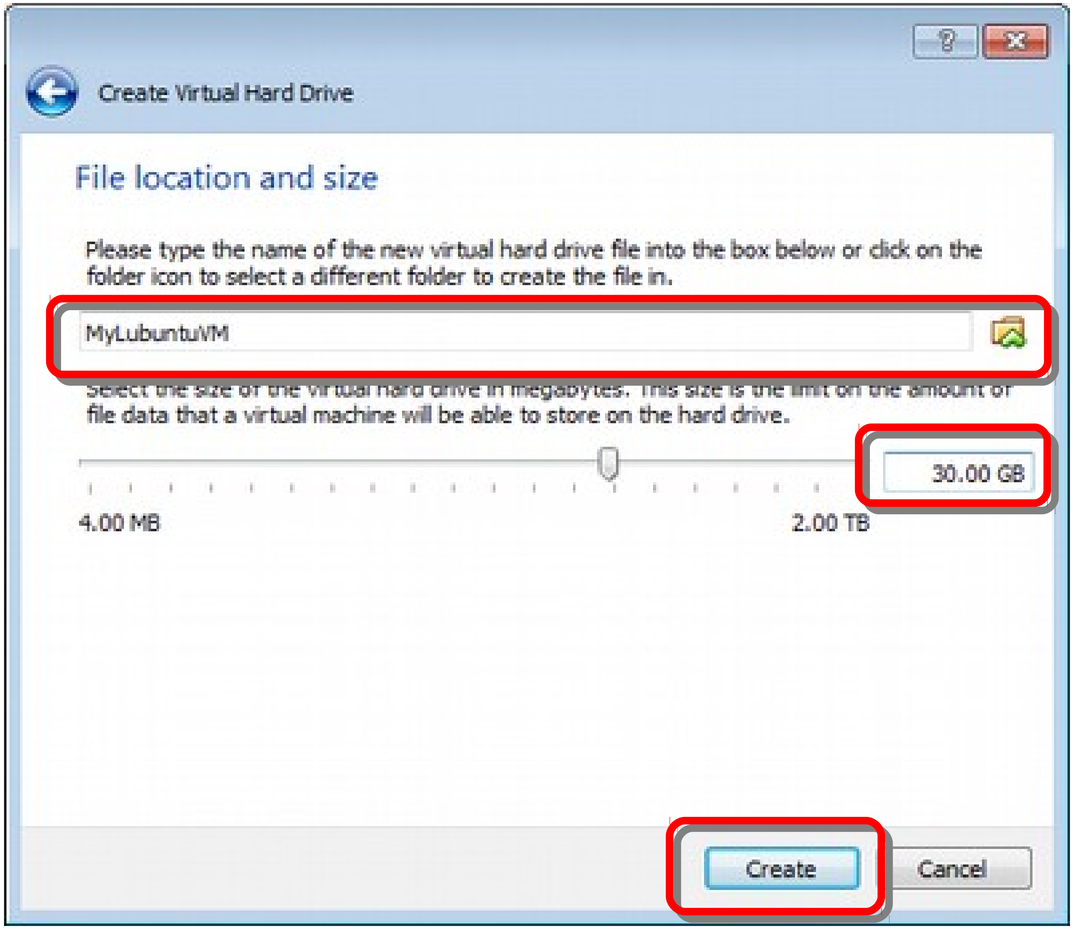
● Dynamically allocated
○ Fixed size

Ex. B1: Create a virtual machine creating a virtual disk

B1.7. Change the harddisk path to be:

```
C:\VirtualBox\MyLubuntuVM\MyLubuntuVM.vdi
```

6.8. Set the disk size as shown in the picture and create the disk:



Create Virtual Hard Drive

File location and size

Please type the name of the new virtual hard drive file into the box below or click on the folder icon to select a different folder to create the file in.

MyLubuntuVM

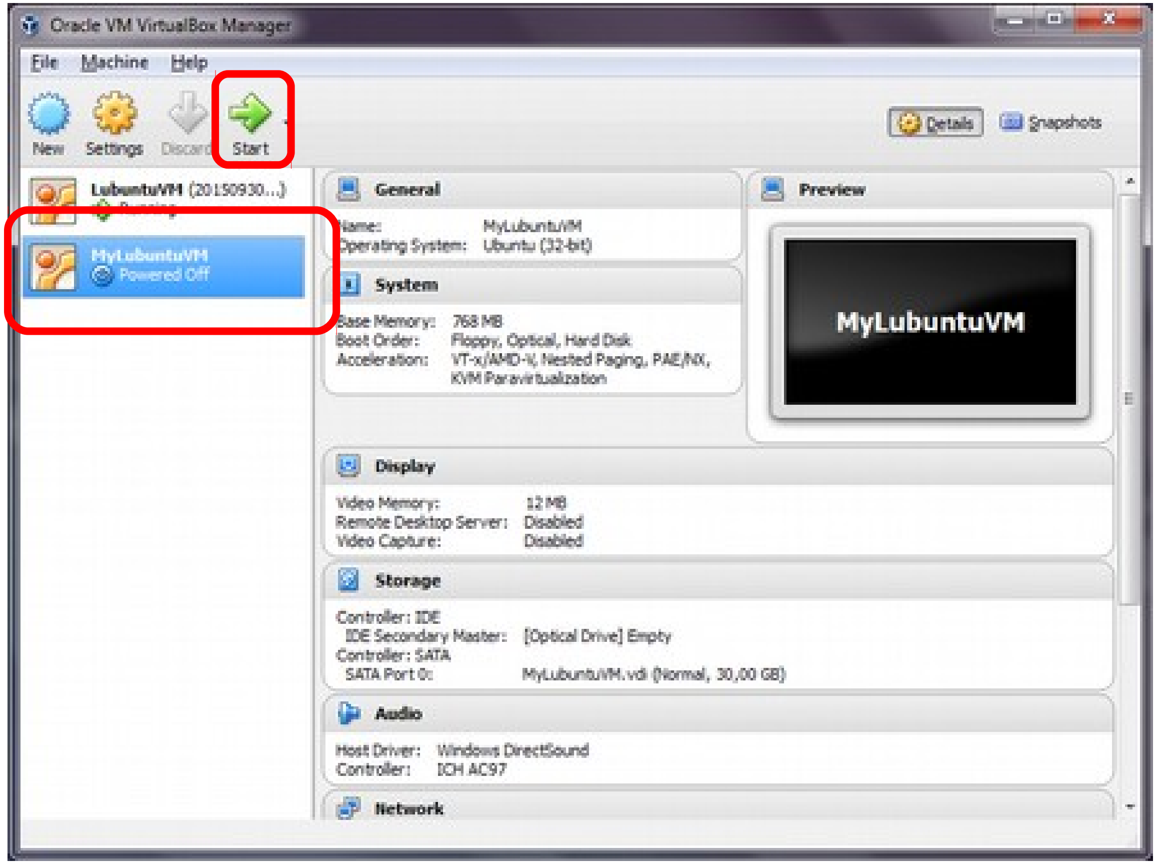
Select the size of the virtual hard drive in megabytes. This size is the limit on the amount of file data that a virtual machine will be able to store on the hard drive.

30.00 GB

Ex. B1: Create a virtual machine - start it!

B1.9. Select and Start the virtual machine. What happens? Discuss with the teacher.

(Hint: check slide 15)



General

Name: MyLubuntuVM
Operating System: Ubuntu (32-bit)

System

Base Memory: 768 MB
Boot Order: Floppy, Optical, Hard Disk
Acceleration: VT-x/AMD-V, Nested Paging, PAE/NX, KVM Paravirtualization

Display

Video Memory: 12 MB
Remote Desktop Server: Disabled
Video Capture: Disabled

Storage

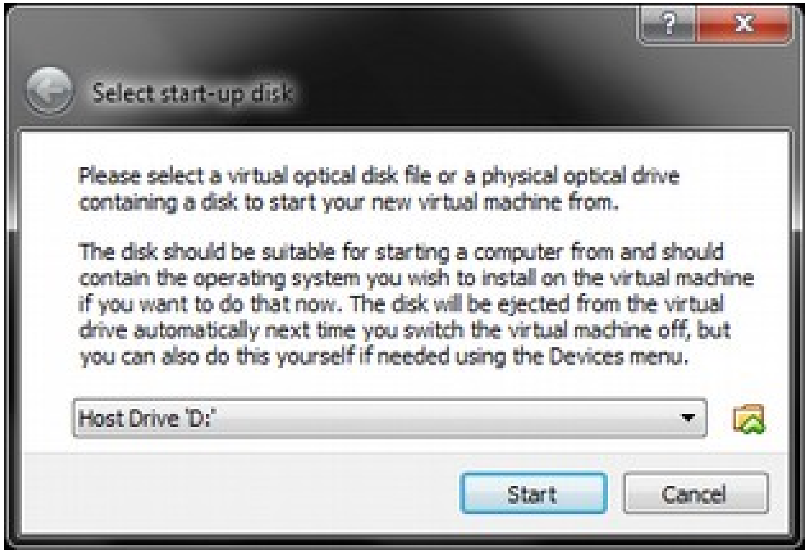
Controller: IDE
IDE Secondary Master: [Optical Drive] Empty
Controller: SATA
SATA Port 0: MyLubuntuVM.vdi (Normal, 30,00 GB)

Audio

Host Driver: Windows DirectSound
Controller: ICH AC97

Network

Ex. B1: Create a virtual machine - Missing boot device

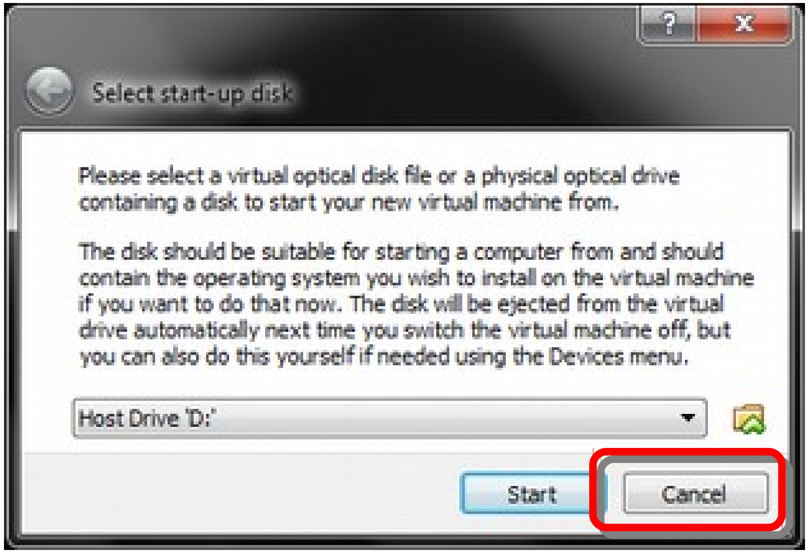


Please select a virtual optical disk file or a physical optical drive containing a disk to start your new virtual machine from.

The disk should be suitable for starting a computer from and should contain the operating system you wish to install on the virtual machine if you want to do that now. The disk will be ejected from the virtual drive automatically next time you switch the virtual machine off, but you can also do this yourself if needed using the Devices menu.

Host Drive 'D:'

Ex. B1: Create a virtual machine - Missing boot device

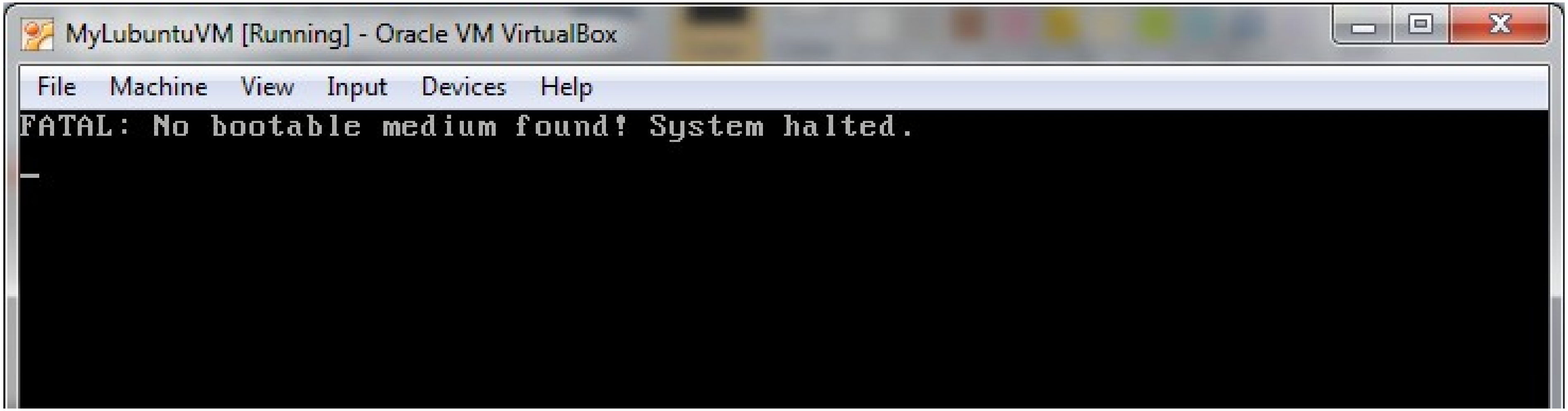


Select start-up disk

Please select a virtual optical disk file or a physical optical drive containing a disk to start your new virtual machine from.

The disk should be suitable for starting a computer from and should contain the operating system you wish to install on the virtual machine if you want to do that now. The disk will be ejected from the virtual drive automatically next time you switch the virtual machine off, but you can also do this yourself if needed using the Devices menu.

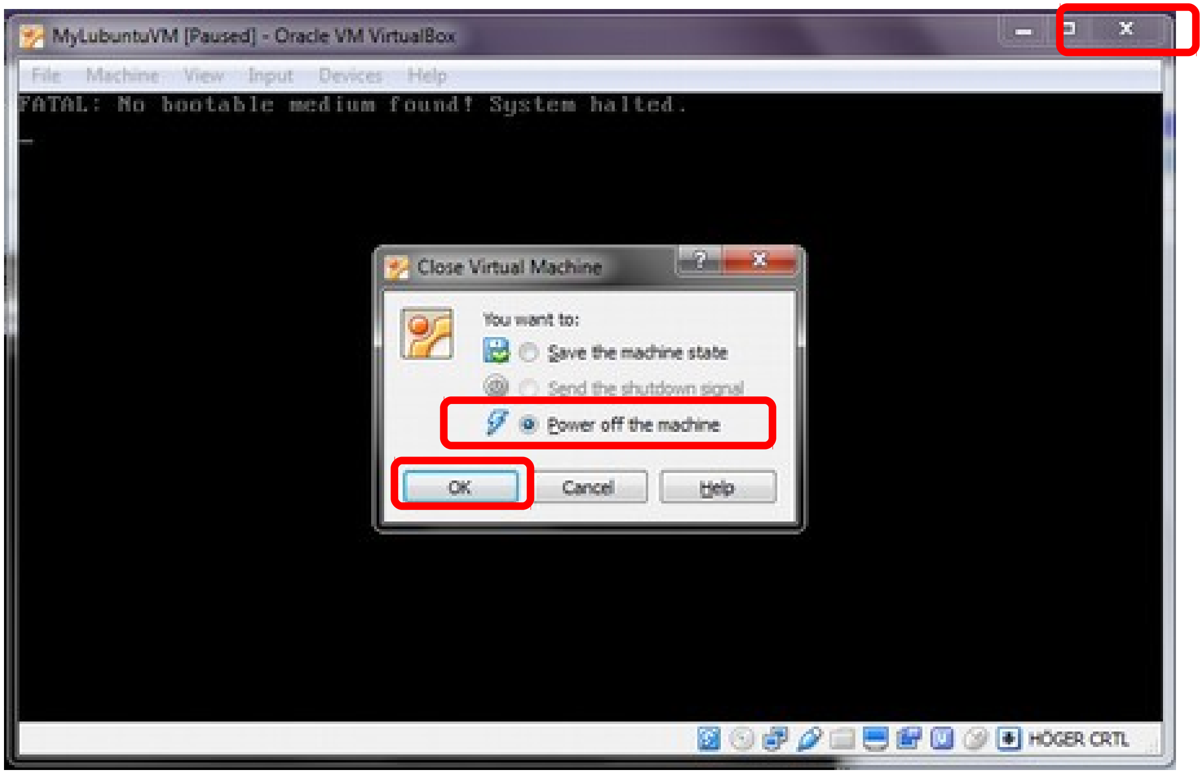
Host Drive 'D:'



```
FATAL: No bootable medium found! System halted.
_
```

Ex. B1: Create a virtual machine - stop it!

B1.10. Close the virtual machine by clicking the close window (X) button. Choose *power off the machine* and then OK when asked.



MyLubuntuVM [Paused] - Oracle VM VirtualBox
File Machine View Input Devices Help

```
FATAL: No bootable medium found! System halted.
_
```

Close Virtual Machine

You want to:

○ Save the machine state

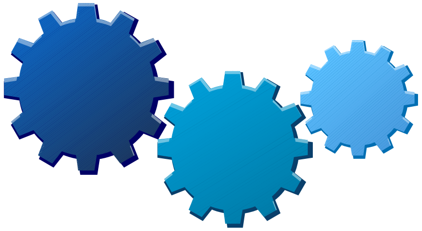
○ Send the shutdown signal

● Power off the machine

OK
Cancel
Help
HÖGER CRTL

OBS! : Only use this method if the machine has no operating system installed. This method may cause errors on the virtual machine disk.

The operating system



- Is a **collection of programs** running in your computer all the time it is turned on.
- **Orchestrates** the interaction between all components of a computer.
- Usually allows the machine to run **multiple programs** at the same time (multitasking).
- It is usually **installed** on a **long-term storage memory** , typically an HardDisk or a ROM (for example in mobile phones), but can be on a CD, a USB pen...
- The kind of operating system we will see in this course is generally meant to bring the machine “closer” to the **user** – not only allows the machine to **operate**, but also the user **to operate** the machine.

Examples of operating systems

- Microsoft Windows
- Mac OS X
- UNIX
- GNU/Linux
- Android
- Symbian
- ...

Basics of operating systems

- **Kernel**: a program more important than the others. It's a **software** that is the **core** of an operating system.
- **Drivers** or **Modules**: set of programs that allow the kernel to interact directly with the **hardware**
- **User interfaces**: set of programs allowing the users to communicate with the computer and use **software**.

GNU/Linux or Linux

- One of the **full community based** accessible operating system, based on UNIX (proprietary)
- GNU (GNU's not Unix!) project: community that wrote many of the **drivers, basic tools and user interfaces**.
  Founder Richard Stallman (father of Free Software)
- Linux: the operating system whose **kernel** was developed by Linus Torvalds

<<-- Tux the penguin,
the GNU/Linux mascotte

Linux, why we're using it

- Popular **free (as in free beer)** alternative to many proprietary operating systems
- **Free access** (as **free software**) to source code: anybody has **right to**
  - **Run the programs**
  - **Read and modify the programs**
  - **Redistribute modifications to friends**
  - **Propose changes to the community for everybody to benefit**
- Components developed by many universities (e.g. MIT) on a free-for-all knowledge basis
- Accessible libraries to build software upon
  - most of scientific software is written on it
- After 20 years, it still ”scales” better than others on cheap hardware – used for intensive computation
  - Many universities install it on workstations, clusters, servers...
- Huge community based effort to keep it up to date and to keep it accessible for everybody

What is a Linux **Distribution**
What are **Software repositories**

- A **selection of software** that runs on top of a GNU/Linux operating system. This includes:
  - Installation tools (to install the operating system in a computer)
  - Software installation programs (to add new software to a computer)
  - **Configuration** and **management** software
  - Graphical interfaces
  - Office programs alternatives
  - Development tools
  - Communication software
  - Scientific software
  - Videogames
  - ....
- Bound to a place on the internet where such software is available, often called **software packages repository** or in short **repository**.

✓

Popular Linux distributions

- **Debian**, community based
  - **Ubuntu**, **Kubuntu**, **Lubuntu** based on Debian, commercially maintained by Canonical
    - Derivatives: Linux Mint ...
- **Arch** Linux: community based
- **RedHat**: first commercial open source Linux
    - Derivatives: Mandrake Linux, ...
  - **CentOS**, community based
  - **Scientific Linux**, developed at CERN
- **Novell SuSE**: commercial Linux
  - **OpenSuSE**: community based SuSE

- Lots more: http://distrowatch.com/

Lubuntu: the one we will use

- Best user community effort backed up by the Canonical company, although with lots of criticism by other communities
- Probably the easiest for you to try at home
- L stands for *lightweight*, that means that we doesn't require a computer with very powerful hardware.

Linux installation: basic concepts

- The operating system usually comes in a **DVD** image, that one can put on a DVD or on a USB pen. The image contains also an **installer software**.

- The operating system is usually **installed on a hard disk**.

- Popular operating systems like Windows and OSX **do not like to share the hard disk** with other systems: this poses installation problems.
  - The Linux community has found many solutions to this limitation, in order for Linux to be installed together with other systems.

Linux installation: three strategies

Requires to be administrator

1. Linux as the *only* operating system

3. Dual boot with GRUB2: two systems installed, but only *one* runs at every restart

Admininstrator must install Virtualization software

2. Virtual Machine: operating systems running *at the same time*

Hypervisor software
HOST

Linux installation: three strategies

1 **Single operating system:** Linux deletes everything on the disk and it becomes the one and only operating system for that computer

- Costraint: user must own the computer (administrator)

2 **Virtual Machine**: Run Linux in a virtual machine where it is the one and only system. The virtual machine is run on an hypervisor that is running in the existing OS.

- Constraint: User must be able to **install software**, i.e. VirtualBox hypervisor

3 **Dual boot:** Linux shares the disk with other operating systems. Requires an alternative boot loader (e.g. GRUB2), a small program that is loaded **BEFORE** any other installed system. This program must be installed at the beginning of the disk.

- Constraint: user must own the computer (administrator)

Today's tutorial continued

- Download of Lubuntu Linux
- Installation of Lubuntu Linux
- Installing software from repositories
- Reboot
- Software update
- Customizing the work environment
- Repositories and other installation methods

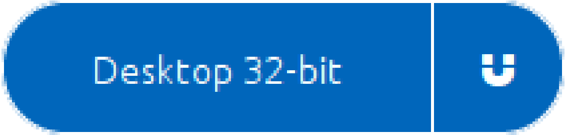
Download Lubuntu LTS*

OBS: Since the network might be too slow in the lab, ask the teacher for a USB stick containing the installation CD-ROM ISO image.

a) Go to
http://lubuntu.me/downloads

b) Look for ”**Version 16.04.3 LTS**”

c) Right-click on the link ”**Desktop 32bit**”



d) choose ”save link as...”

e) Select a folder where there is enough space, like `C:\VirtualBox\`

f) Remember the above folder! We will use it in the next step.

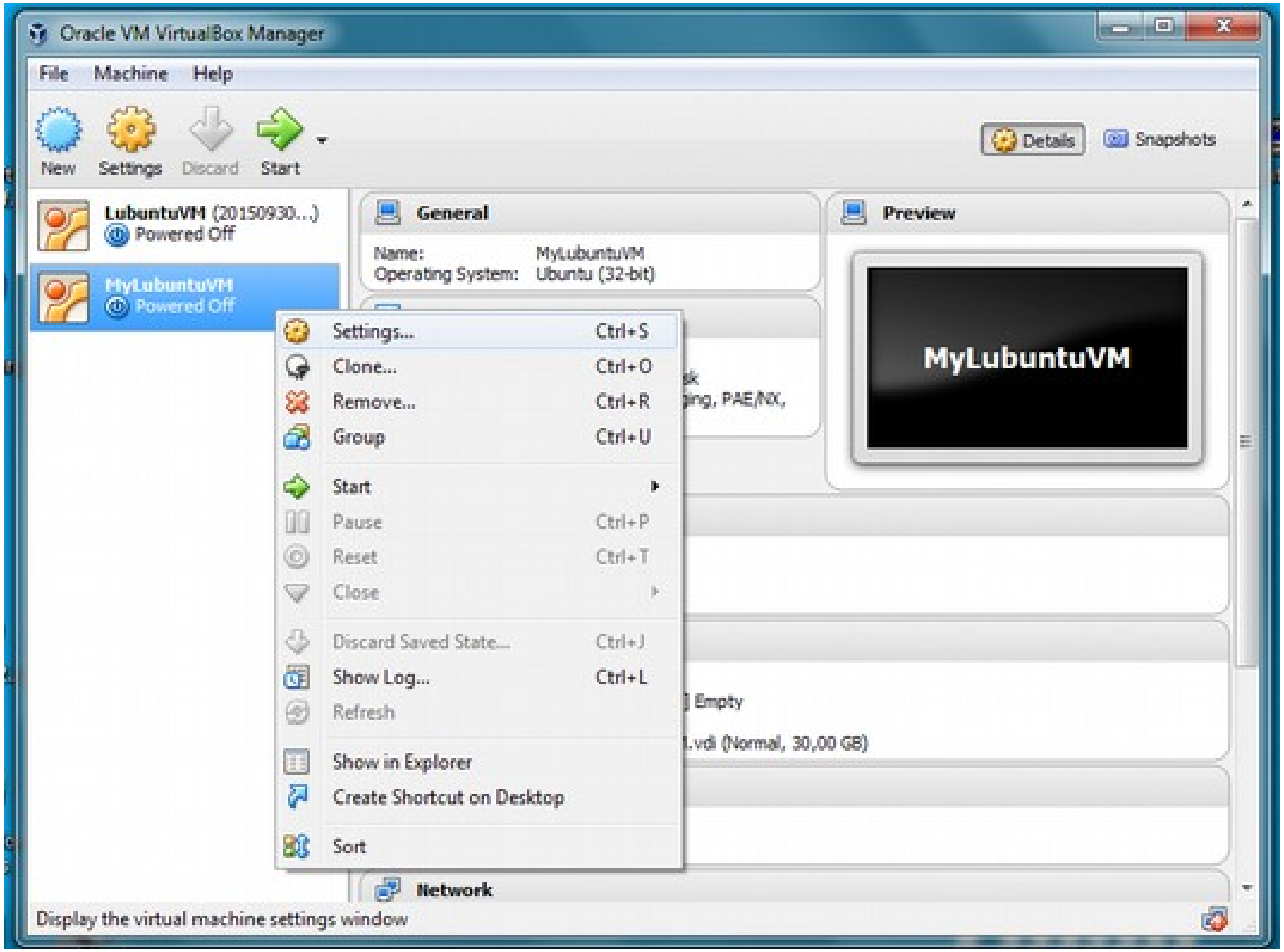
Direct link:

http://cdimage.ubuntu.com/lubuntu/releases/16.04/release/lubuntu-16.04.3-desktop-i386.iso

* LTS stands for Long Term Support. Means the system is ensured to be stable (no crash/malfunction) while using it, and software updates are provided for some Long Time.

Ex. B2: Install Lubuntu in MyLubuntuVM

Select the virtual machine and open settings.

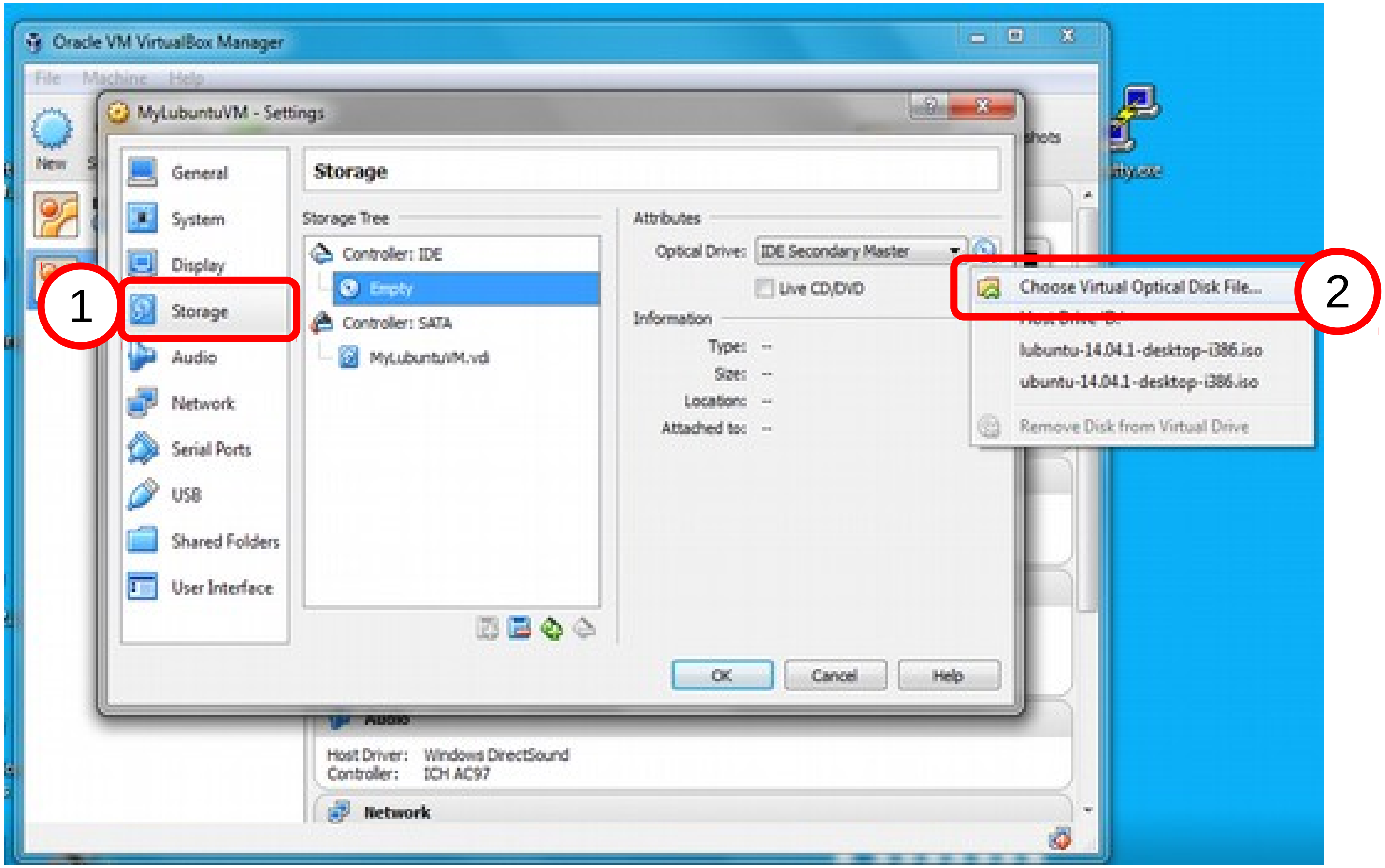


Name: MyLubuntuVM
Operating System: Ubuntu (32-bit)

Display the virtual machine settings window

Ex. B2: Install Lubuntu in MyLubuntuVM

B2.1 Add the ISO file just downloaded to MyLubuntuVM



Optical Drive: IDE Secondary Master

□ Live CD/DVD

Type: --

Size: --

Location: --

Attached to: --

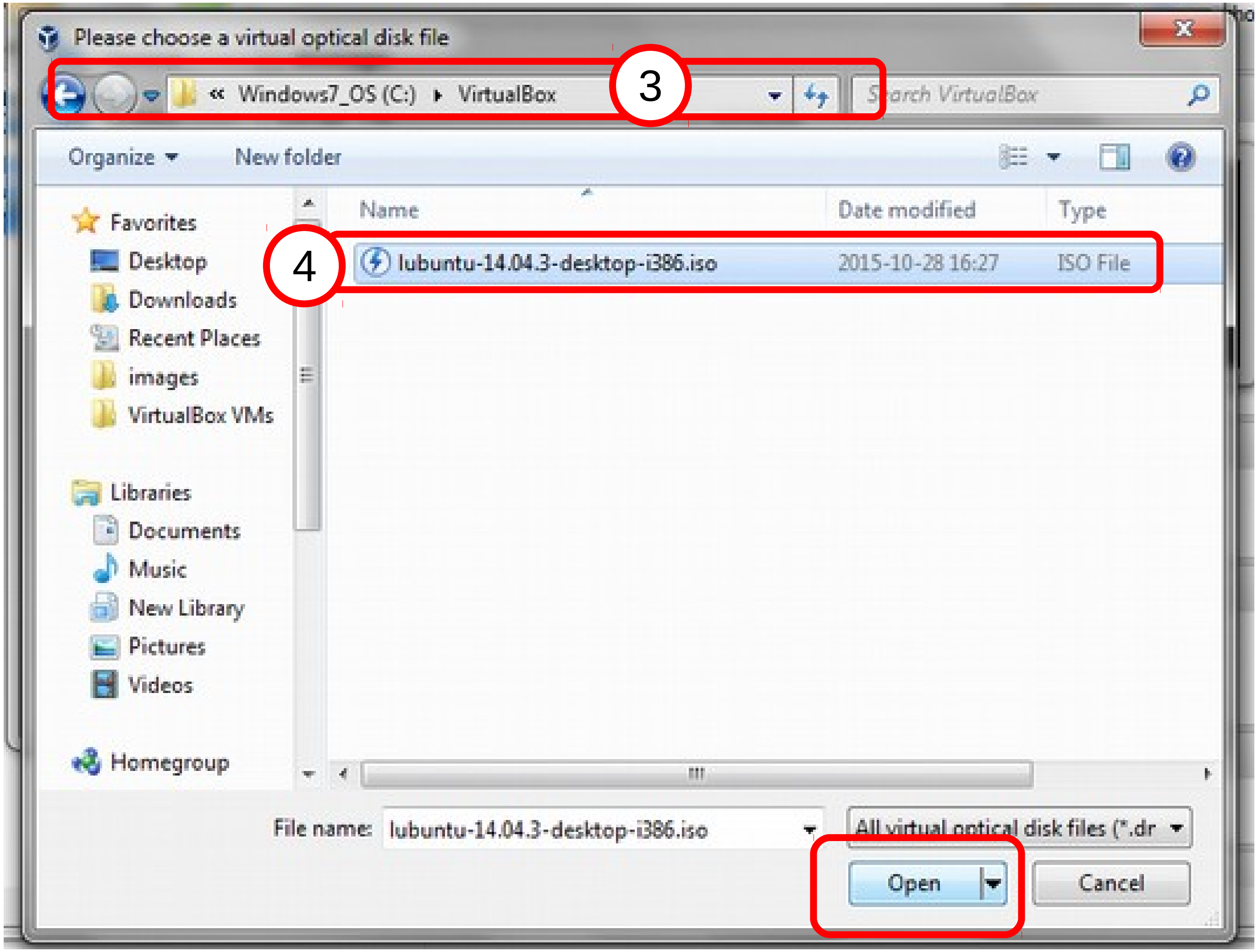
Host Driver: Windows DirectSound

Controller: ICH AC97

Ex. B2: Install Lubuntu in MyLubuntuVM

B2.2 Go to the folder where you saved the file (3) at slide 58 and select the ISO file downloaded (4)

(filename might be different from the picture)



Please choose a virtual optical disk file

« Windows7_OS (C:) ▸ VirtualBox

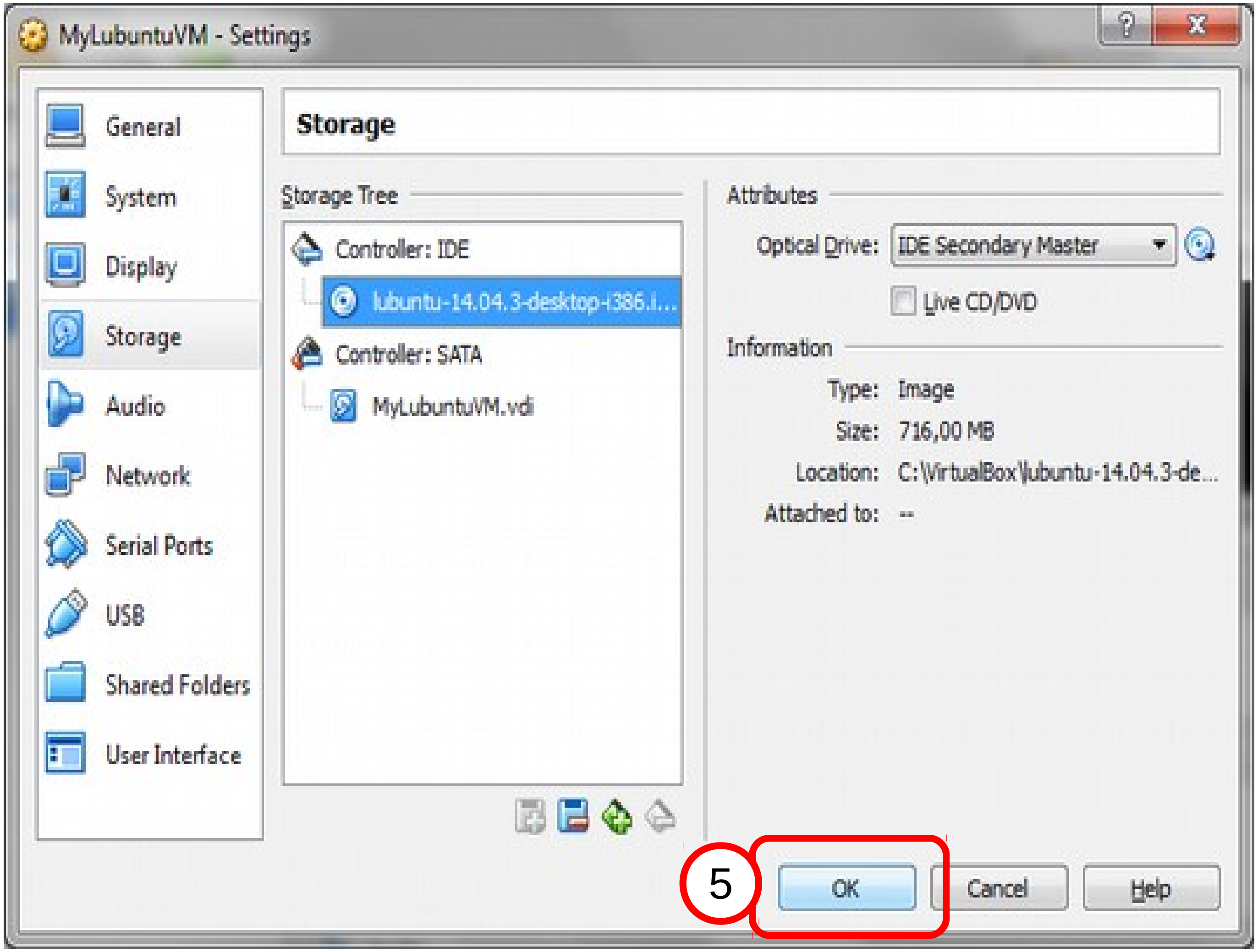
Name	Date modified	Type
lubuntu-14.04.3-desktop-i386.iso	2015-10-28 16:27	ISO File

File name: lubuntu-14.04.3-desktop-i386.iso

All virtual optical disk files (*.dr

Ex. B2: Install Lubuntu in MyLubuntuVM

B2.3 Accept the configuration changes (5)



Optical Drive: IDE Secondary Master

□ Live CD/DVD

Type: Image

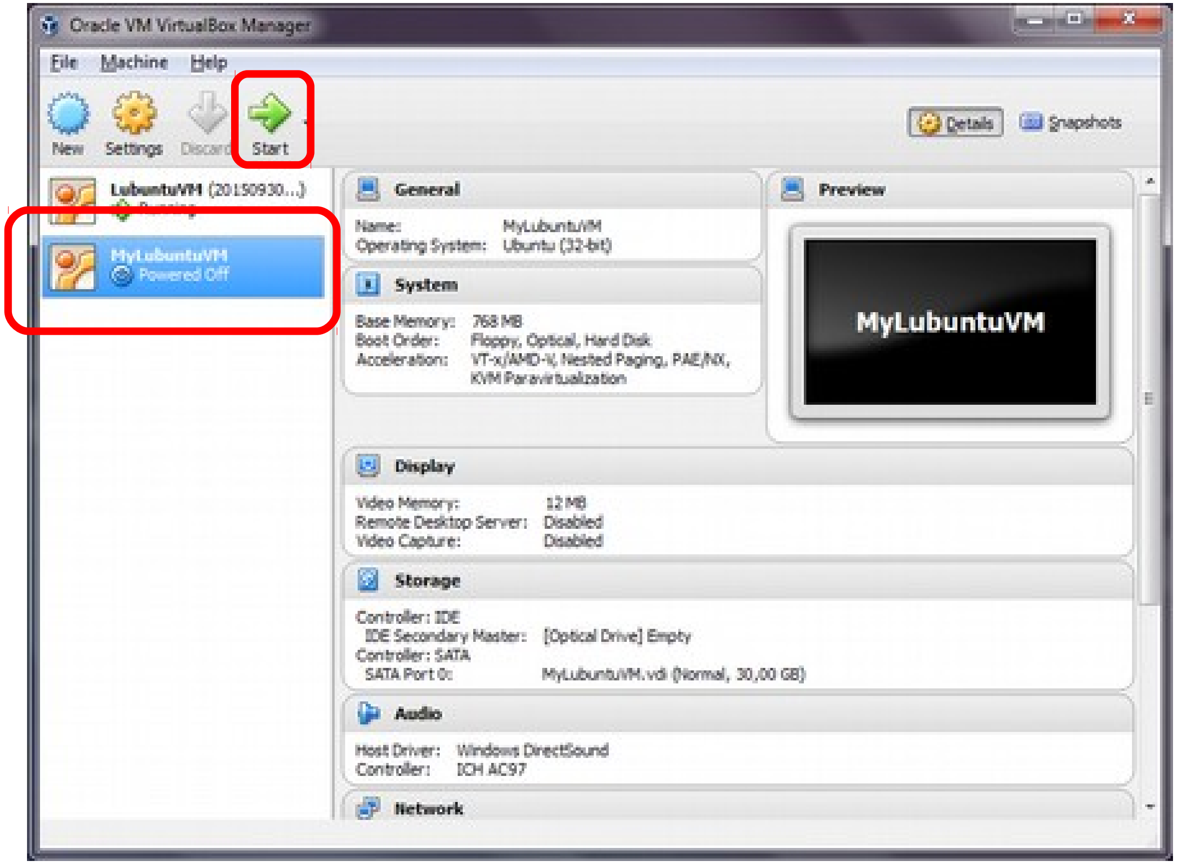
Size: 716,00 MB

Location: C:\VirtualBox\lubuntu-14.04.3-de...

Attached to: --

Ex. B2: Install Lubuntu in MyLubuntuVM - start it!

B2.3 Select and Start the virtual machine.



General
Name: MyLubuntuVM
Operating System: Ubuntu (32-bit)

System
Base Memory: 768 MB
Boot Order: Floppy, Optical, Hard Disk
Acceleration: VT-x/AMD-V, Nested Paging, PAE/NX, KVM Paravirtualization

Display
Video Memory: 12 MB
Remote Desktop Server: Disabled
Video Capture: Disabled

Storage
Controller: IDE
IDE Secondary Master: [Optical Drive] Empty
Controller: SATA
SATA Port 0: MyLubuntuVM.vdi (Normal, 30,00 GB)

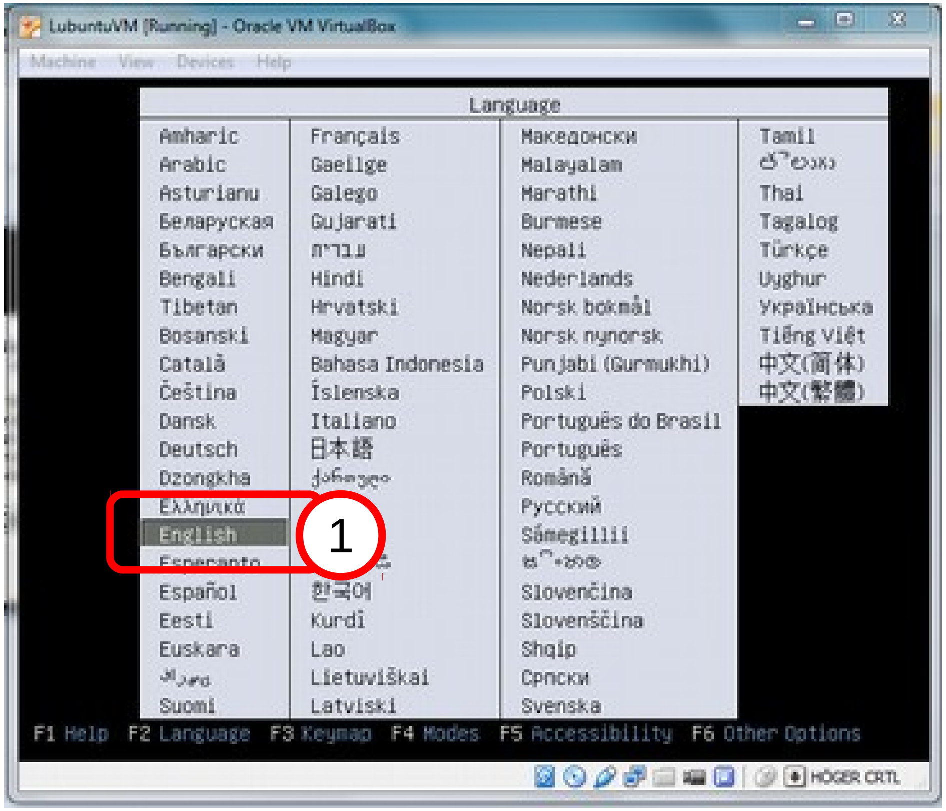
Audio
Host Driver: Windows DirectSound
Controller: ICH AC97

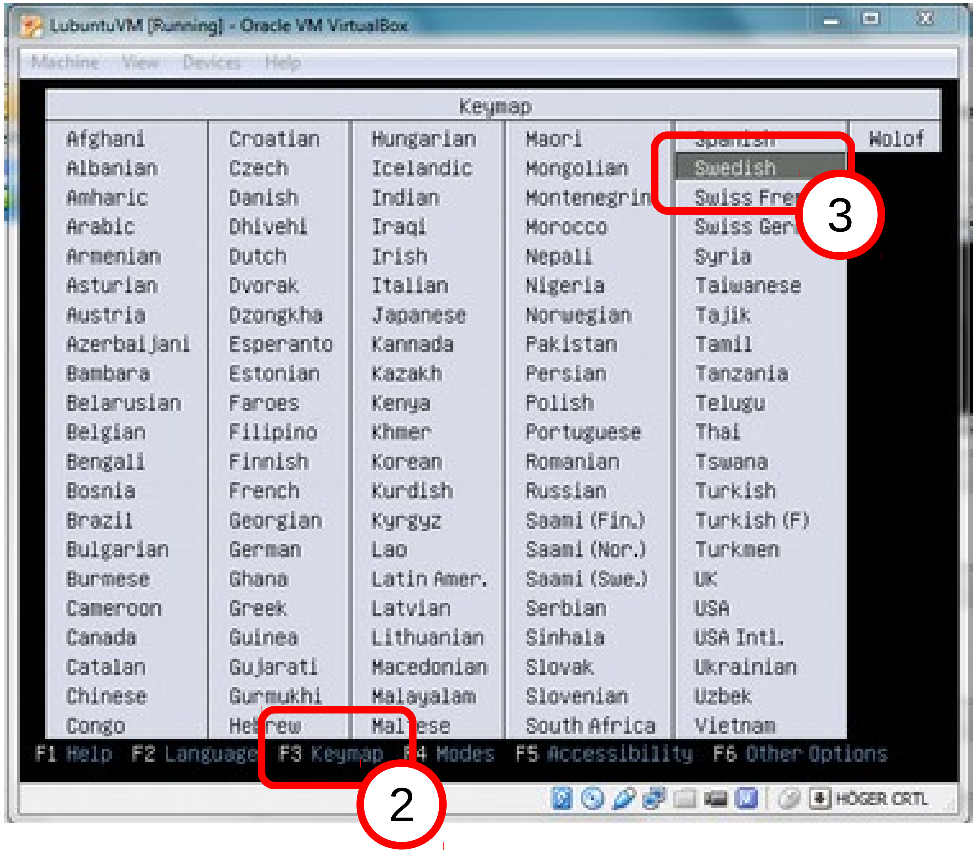
Network

Ex. B2: Install Lubuntu in MyLubuntuVM

B2.4 Select English as installation language, press F3 and change keyboard to Swedish*.

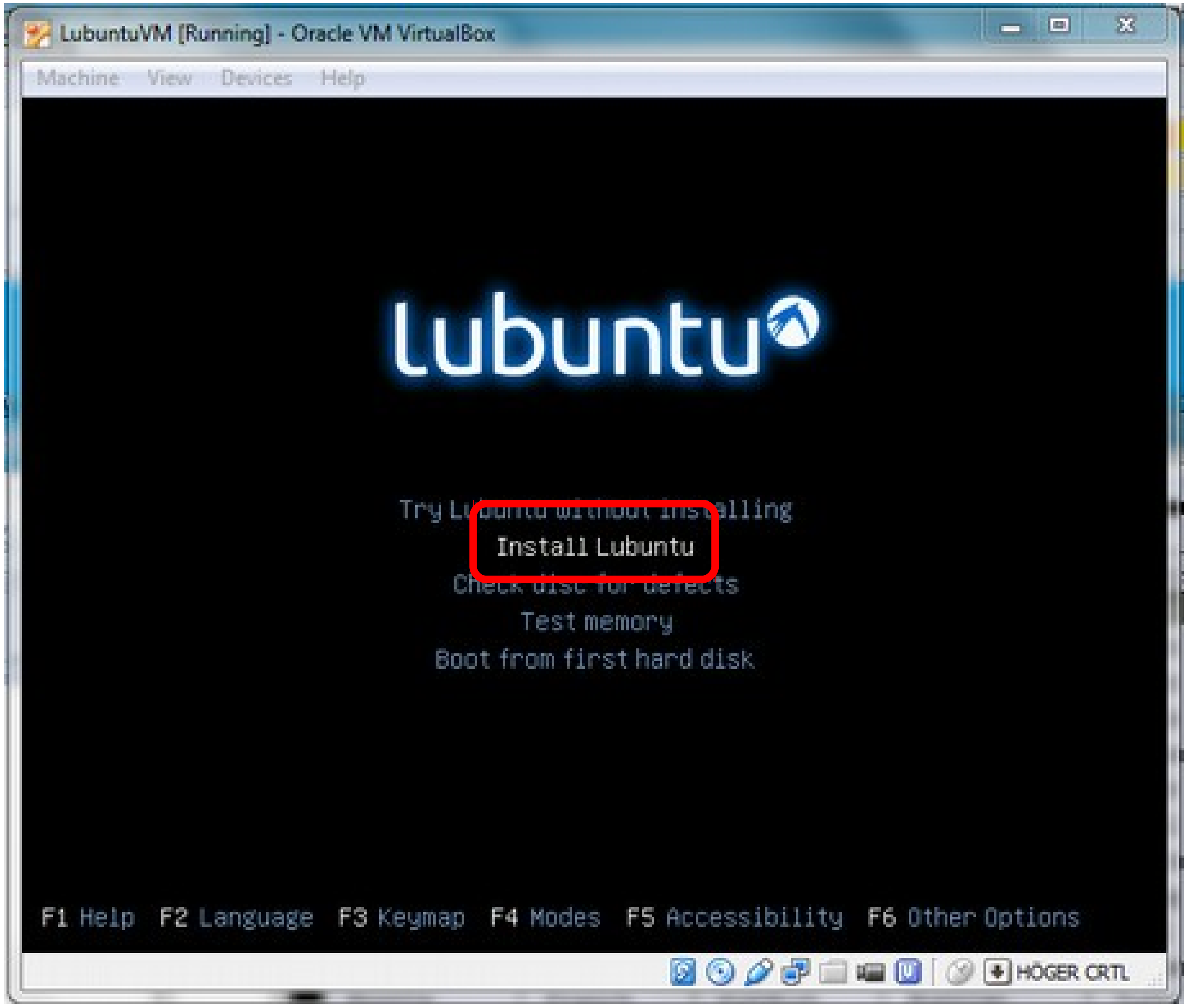
* if you're using your own laptop and has a keyboard in some other language, choose that language!





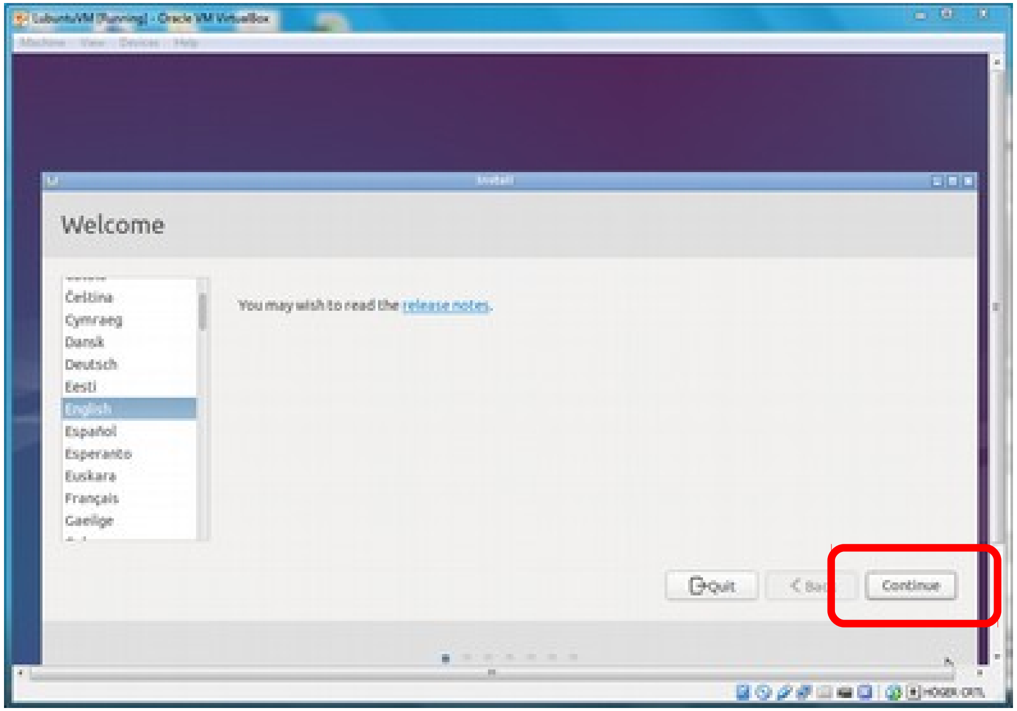
Ex. B2: Install Lubuntu in MyLubuntuVM

B2.5 Select *Install Lubuntu* and press enter.



Ex. B2: Install Lubuntu in MyLubuntuVM

B2.6 Click on continue twice

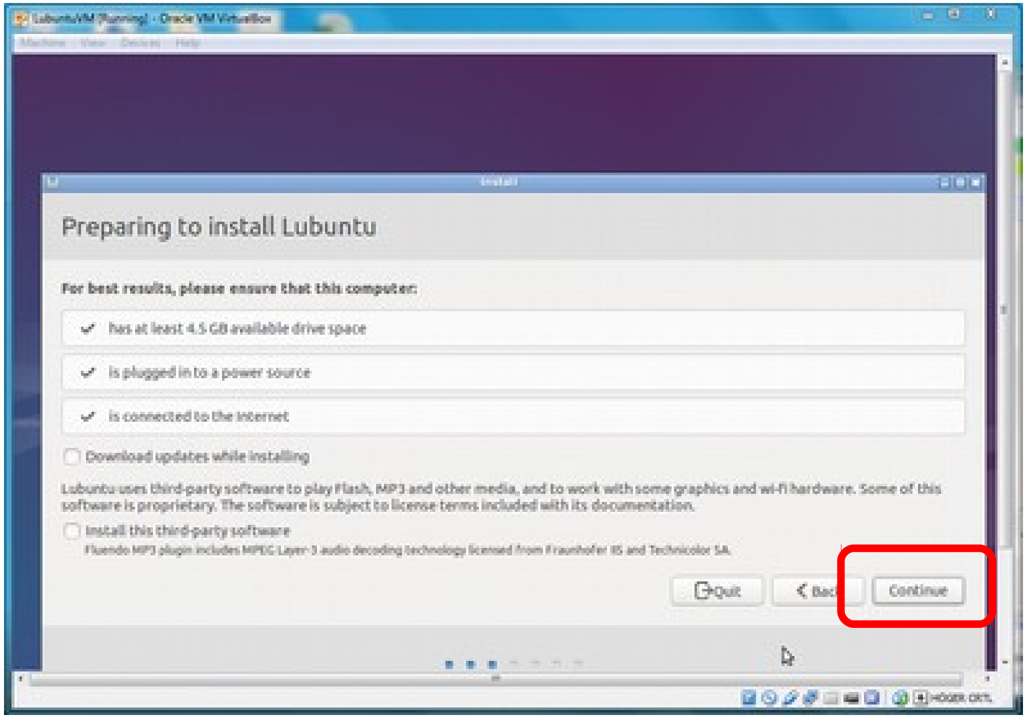


LubuntuVM [Running] - Oracle VM VirtualBox
Machine View Devices Help
Install
Quit
Back
Continue

Welcome

Čeština
Cymraeg
Dansk
Deutsch
Eesti
English
Español
Esperanto
Euskara
Français
Gaeilge

You may wish to read the release notes.



LubuntuVM [Running] - Oracle VM VirtualBox
Machine View Devices Help
Install
Quit
Back
Continue

Preparing to install Lubuntu

For best results, please ensure that this computer:

- ✓ has at least 4.5 GB available drive space
- ✓ is plugged in to a power source
- ✓ is connected to the Internet

□ Download updates while installing

Lubuntu uses third-party software to play Flash, MP3 and other media, and to work with some graphics and wi-fi hardware. Some of this software is proprietary. The software is subject to license terms included with its documentation.

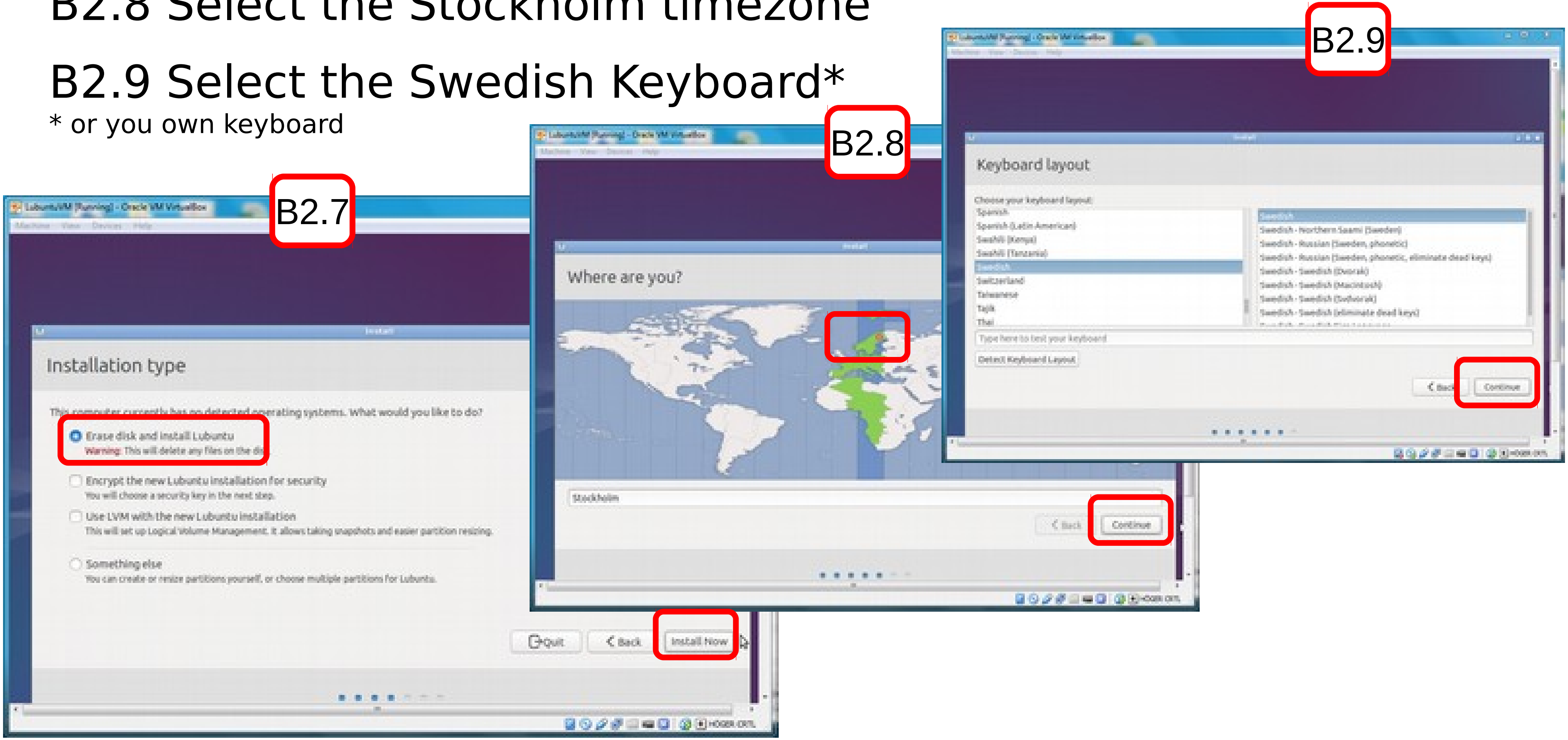
□ Install this third-party software
Fluendo MP3 plugin includes MPEG Layer-3 audio decoding technology licensed from Fraunhofer IIS and Technicolor SA.

Ex. B2: Install Lubuntu in MyLubuntuVM

B2.7 Choose installation type ”*Erase disk and install ubuntu*” and click ”Install Now”.
Click ”continue” on the ”*Write changes to disk?*” dialog.

B2.8 Select the Stockholm timezone

B2.9 Select the Swedish Keyboard*
* or you own keyboard



B2.7
B2.8
B2.9
LubuntuVM [Running] - Oracle VM VirtualBox
Machine View Devices Help
Install

Installation type

This computer currently has no detected operating systems. What would you like to do?

● Erase disk and install Lubuntu
Warning: This will delete any files on the di

□ Encrypt the new Lubuntu installation for security
You will choose a security key in the next step.

□ Use LVM with the new Lubuntu installation
This will set up Logical Volume Management. It allows taking snapshots and easier partition resizing.

○ Something else
You can create or resize partitions yourself, or choose multiple partitions for Lubuntu.

Where are you?

Stockholm

Keyboard layout

Choose your keyboard layout:

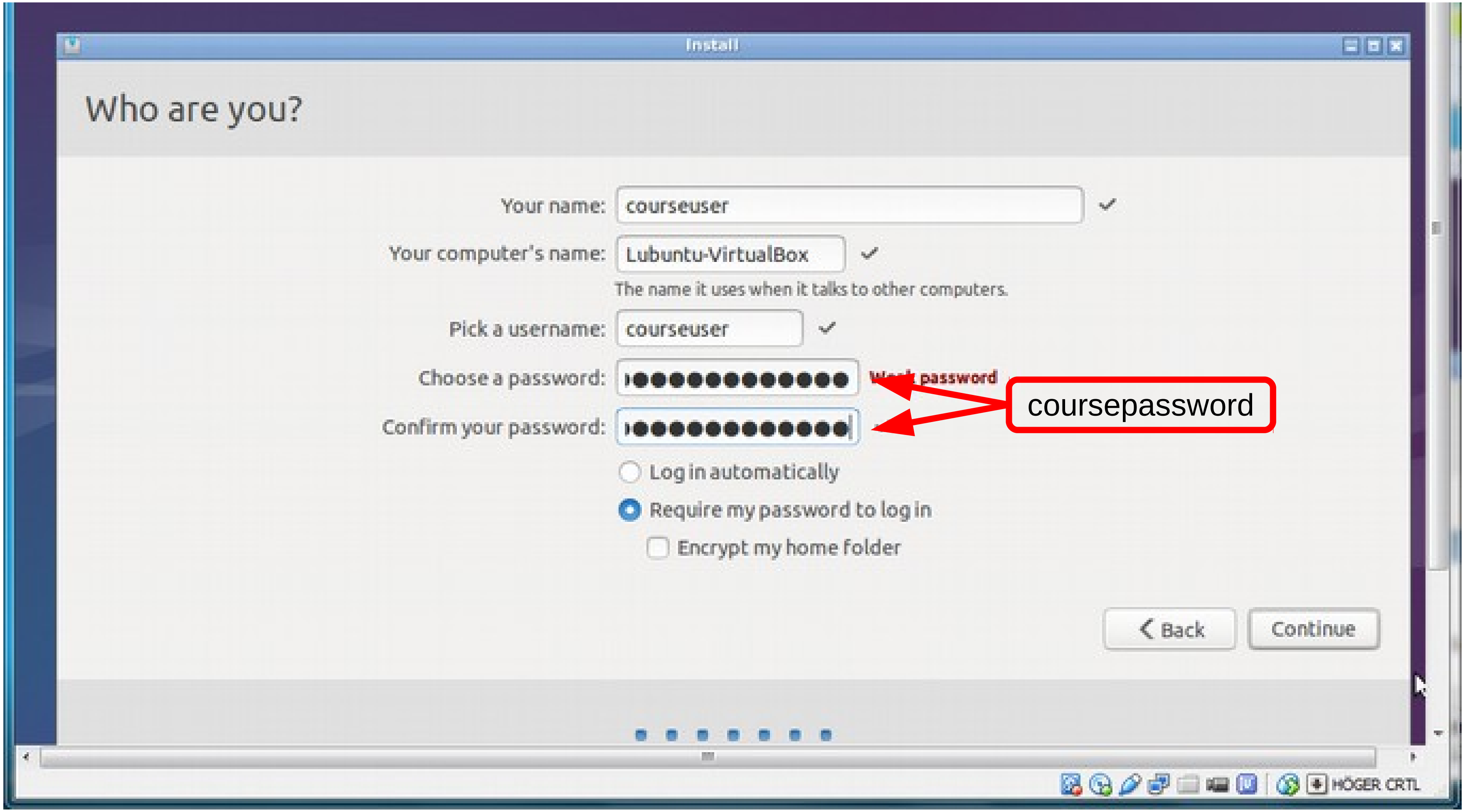
Spanish
Spanish (Latin American)
Swahili (Kenya)
Swahili (Tanzania)
Swedish
Switzerland
Taiwanese
Tajik
Thai

Swedish
Swedish - Northern Saami (Sweden)
Swedish - Russian (Sweden, phonetic)
Swedish - Russian (Sweden, phonetic, eliminate dead keys)
Swedish - Swedish (Dvorak)
Swedish - Swedish (Macintosh)
Swedish - Swedish (Svdvorak)
Swedish - Swedish (eliminate dead keys)

Type here to test your keyboard

Ex. B2: Install Lubuntu in MyLubuntuVM

B2.10 Insert computer name and username/password as in the picture:



Who are you?

Your name: courseuser ✓

Your computer's name: Lubuntu-VirtualBox ✓

The name it uses when it talks to other computers.

Pick a username: courseuser ✓

Choose a password: ●●●●●●●●●●●●● Weak password

Confirm your password: ●●●●●●●●●●●●●

○ Log in automatically

● Require my password to log in

□ Encrypt my home folder

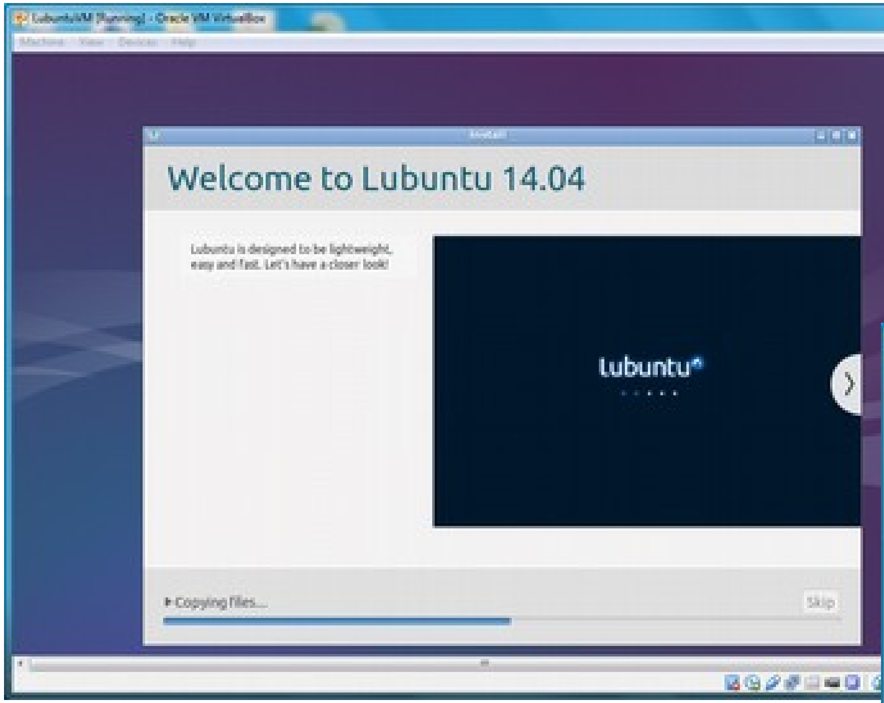
coursepassword

Disclaimer

- **NEVER use such a simple password such as *coursepassword* in a machine you install.**
- Read this recommendation for good passwords: http://www.hep.lu.se/staff/paganelli/doku.php/variousnotes#passwords
- Read this about how easy is to crack(discover) weak linux passwords: https://null-byte.wonderhowto.com/how-to/hack-like-pro-crack-user-passwords-linux-system-0147164/
  - Fun: you can try the above at home and watch it cracking courseuser's password.

Ex. B2: Install Lubuntu in MyLubuntuVM

B2.11 Let's wait for installation to complete!

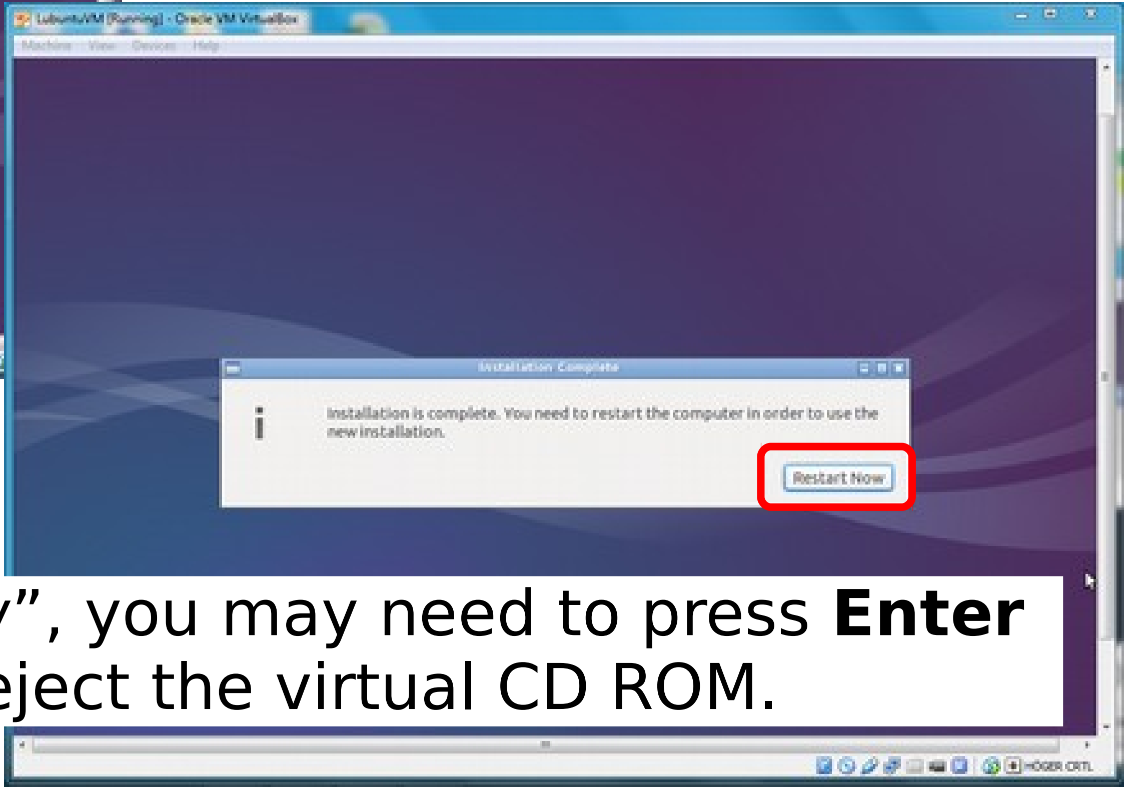


LubuntuVM [Running] - Oracle VM VirtualBox
Machine View Devices Help
Install

Welcome to Lubuntu 14.04

Lubuntu is designed to be lightweight, easy and fast. Let's have a closer look!

▸ Copying files...



LubuntuVM [Running] - Oracle VM VirtualBox
Machine View Devices Help
Installation Complete

Installation is complete. You need to restart the computer in order to use the new installation.

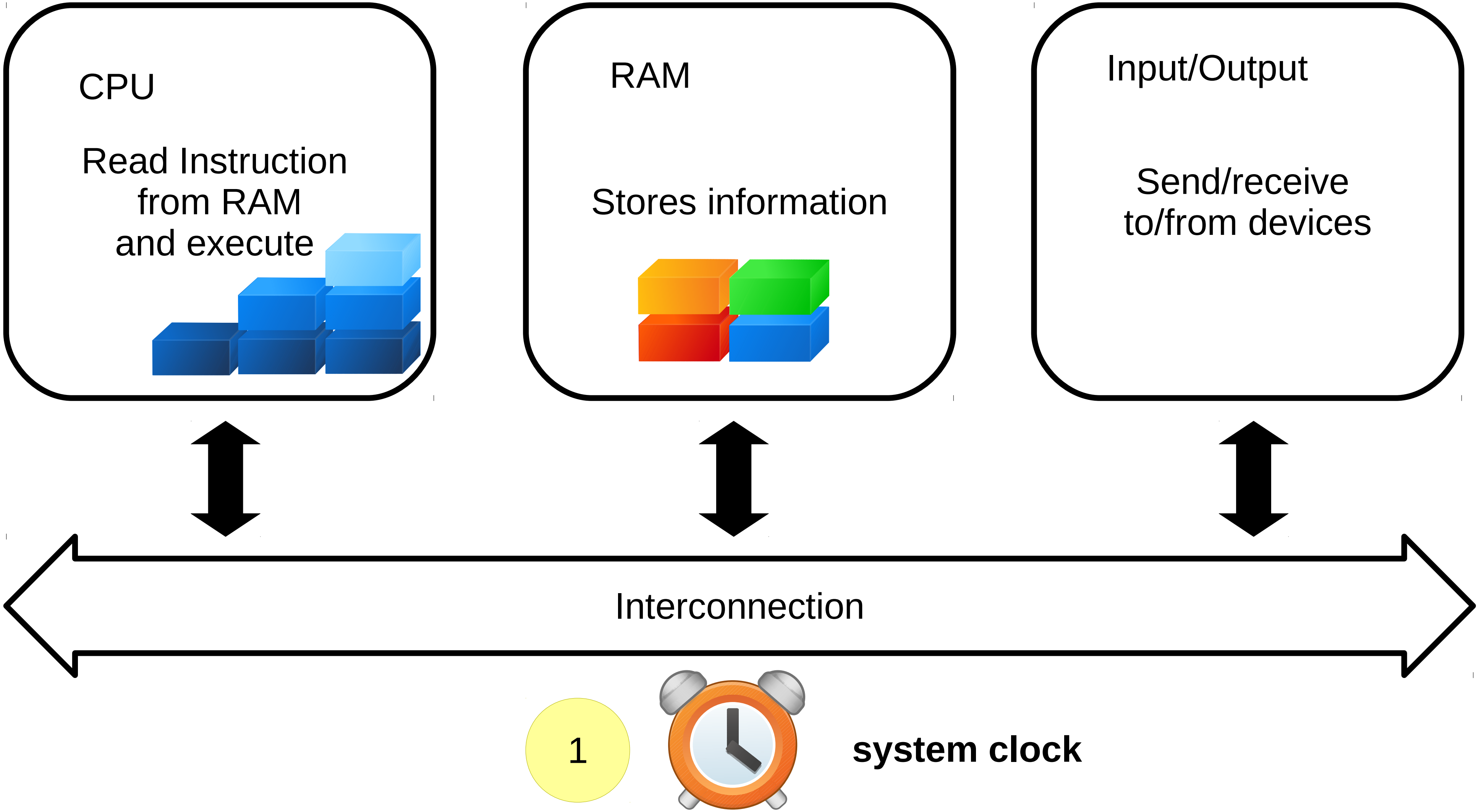
After clicking "*Restart Now*", you may need to press **Enter** to tell the installer it can eject the virtual CD ROM.

Ex. B2 summary: Install Lubuntu in MyLubuntuVM

- Start the virtual machine with the Start button with the arrow.
- At the lubuntu prompt:
  - Choose ”English”
  - Press F3. Select the Swedish keyboard.
  - Select ”Install lubuntu”
- Follow the on-screen instructions. When prompted, insert the informations/choices in the following table:

Installation dialog	Click continue button twice
Installation type dialog	Select ”Erase disk and install ubuntu” and click continue
User name	courseuser
Computer name	Lubuntu-VirtualBox
User name	courseuser
password	coursepassword (insert twice)

How does it work?
The computing cycle



CPU

Read Instruction from RAM and execute

RAM

Stores information

Input/Output

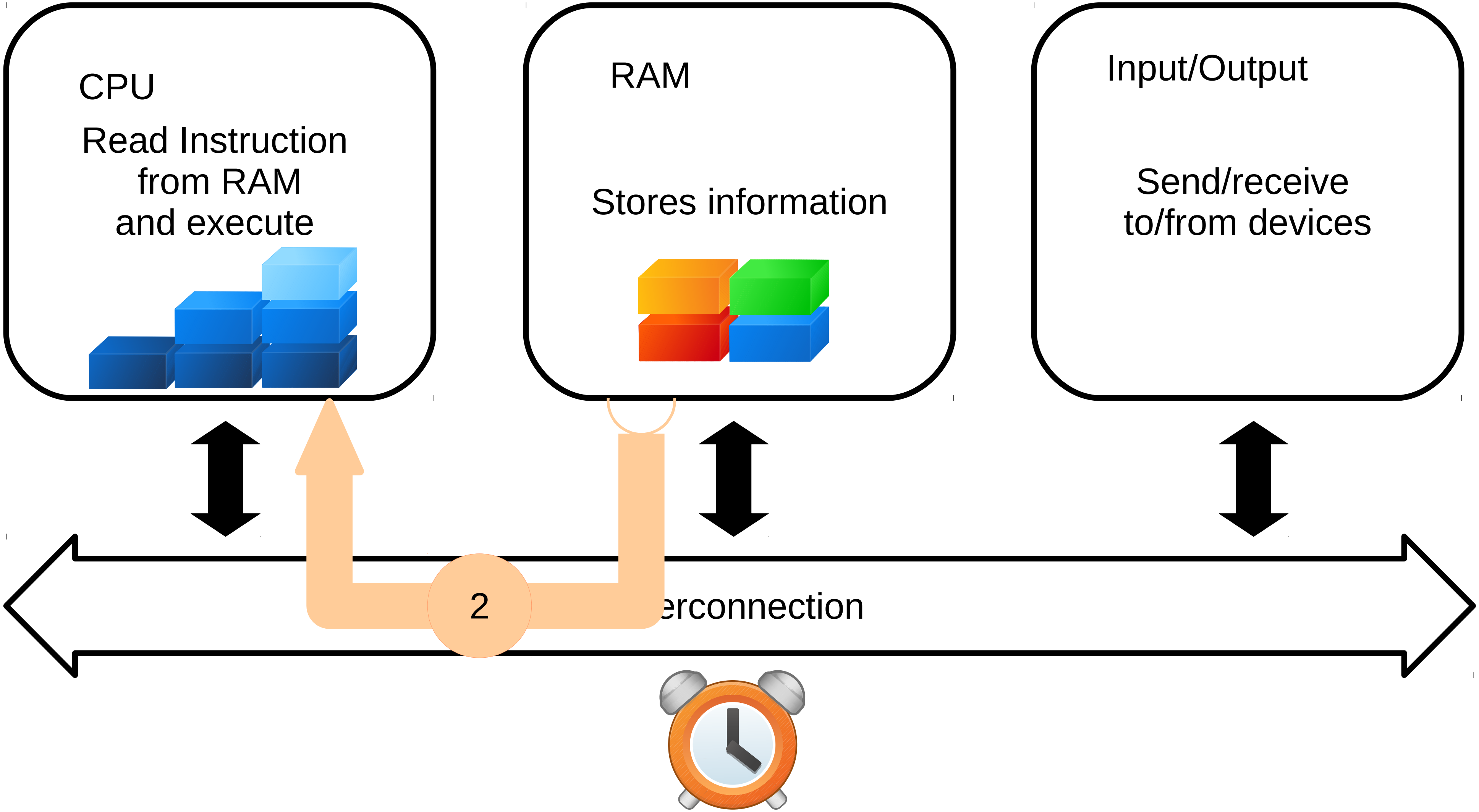
Send/receive to/from devices

Interconnection

1

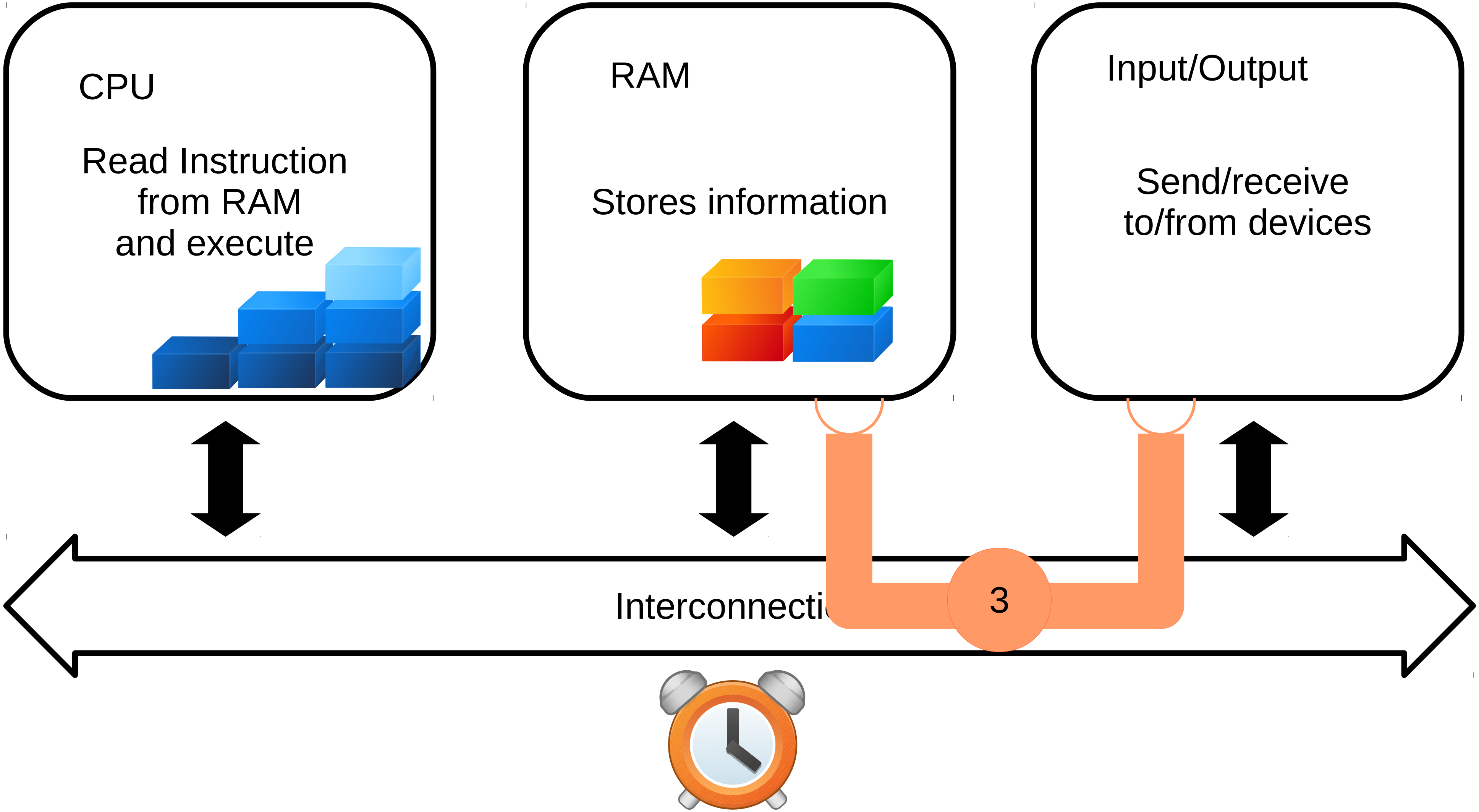
system clock

How does it work?
The computing cycle

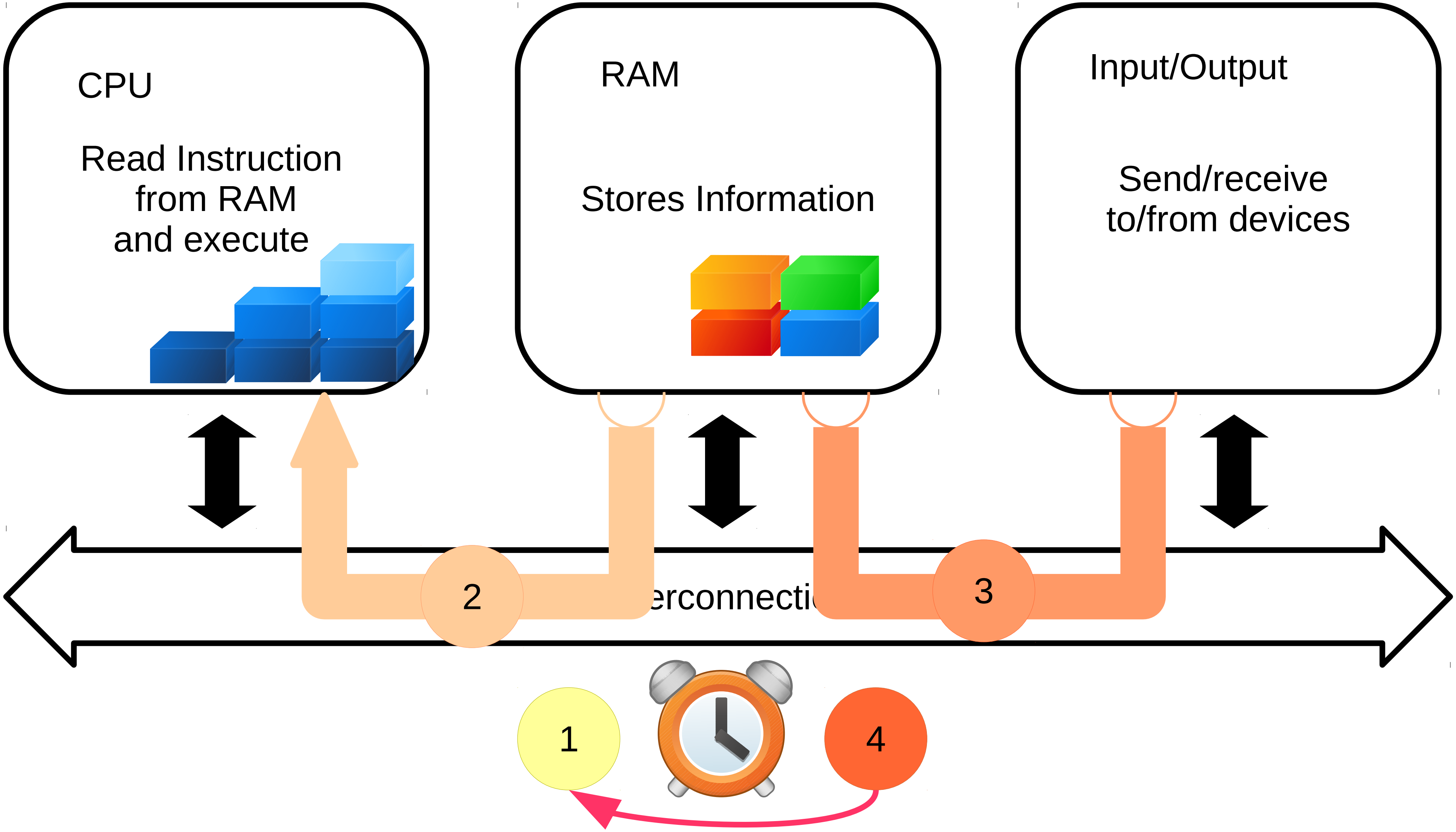


CPU
Read Instruction from RAM and execute
RAM
Stores information
Input/Output
Send/receive to/from devices
2
erconnection

How does it work?
The computing cycle



How does it work?
The computing cycle



How does it work?
The computing cycle

The execution cycle and the clock

1) clock ticks
2) CPU reads content of RAM(instructions) into registries and executes
3) Execution might dispatch information over the bus
4) Wait for next clock cycle

The execution is **always serial**, but gives us a feeling of parallel tasks because of speed.

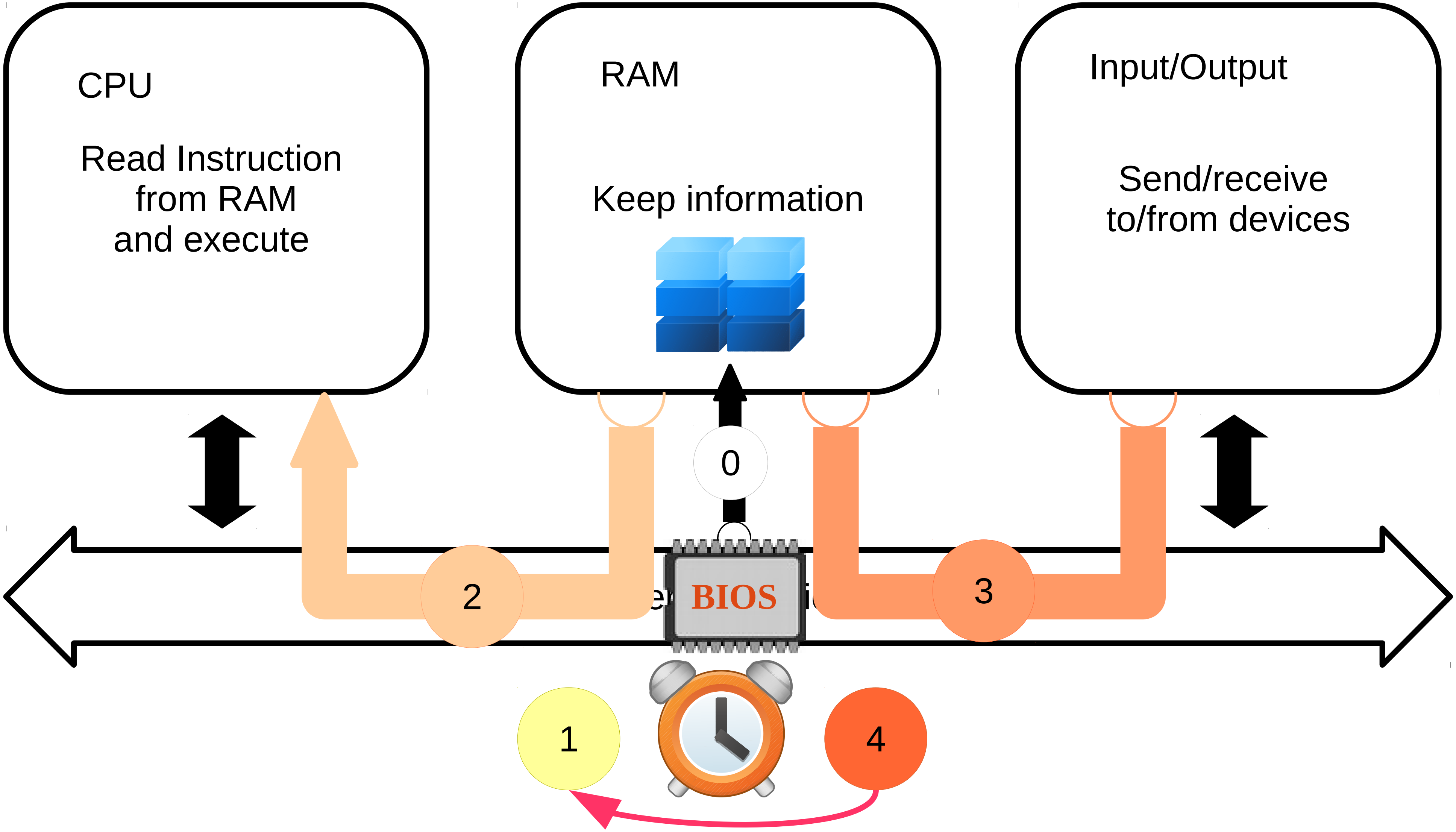
It might require more than one clock cycle to execute an instruction.

But... How does it start?

- When a computer is turned on, the first thing it does is to **boot**
- **Boot**, or the bootstrap sequence, is a set of operations done in order to start the the computing cycle as described before.
- A small program is copied into the RAM as soon as the computer starts, and this is executed by the machine.
- This program is usually stored in a long term memory chip and is called **BIOS**

But... how does it start?!?

BIOS: Basic Input/Output System
to bootstrap the computer



CPU

Read Instruction from RAM and execute

RAM

Keep information

Input/Output

Send/receive to/from devices

But... how does it start?!?

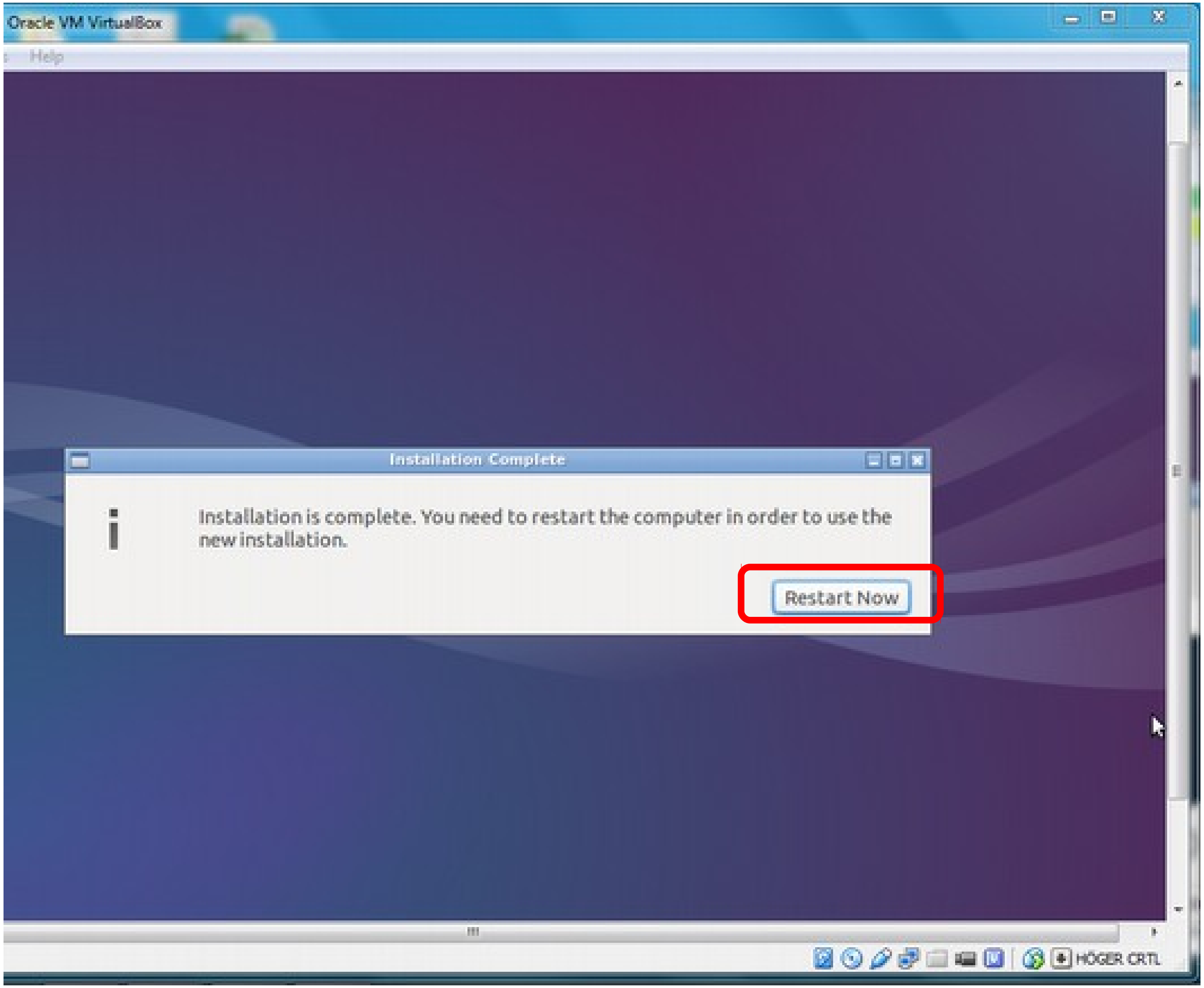
BIOS: Basic Input/Output System
to bootstrap the computer

0. The BIOS loads a small program (a set of intructions and the data needed) into the RAM.
When the clock starts, the CPU will start executing as explained.

Ex. B2: Install Lubuntu in MyLubuntuVM

B2.12 If installation completed, Restart Now!

If the system looks stuck, press *Enter*: the installer is asking if you want to eject the (virtual) CD-ROM, but sometimes it is not possible to see such message! The system cannot detect that this is a virtual machine.



Installation is complete. You need to restart the computer in order to use the new installation.

Typical issues

- Screen is messed up.
  Solution: Enable 3D acceleration in the VM settings.

CLI installation methods

- **CLI** (Command Line Interface)

  You'll see a short example tomorrow. But here's a list of common commands:

  - Search for a package:
    ```
    apt-cache search <something>
    ```
  - Install a package:
    ```
    sudo apt-get install <packagename>
    ```
  - Remove a package:
    ```
    sudo apt-get remove <packagename>
    ```
  - Update package list:
    ```
    sudo apt-get update
    ```
  - Software update:
    ```
    sudo apt-get upgrade
    ```

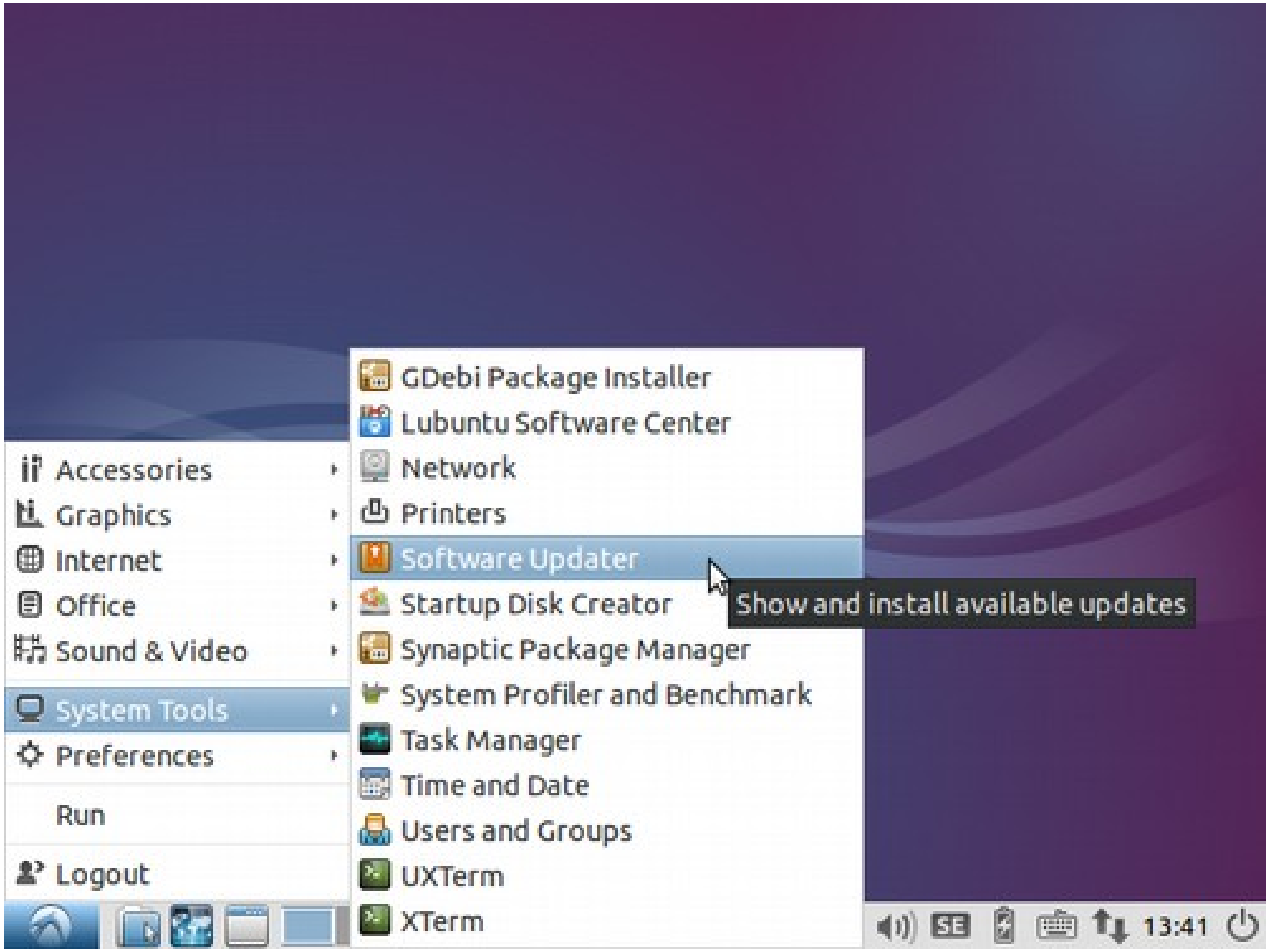
Ex. B3: Installing the virtual machine graphical environment

- Did you notice how small is the screen? This is because **video drivers** for the **virtual video card** are missing.
- Lubuntu is aware it is running in a virtual machine, but needs to know **how to access the virtual hardware**.
- We will install the so-called **guest additions**
- There is a problem: these are not compatible with Lubuntu graphical stack. We will have to uninstall the existing graphical stack.
- We will use the command line.

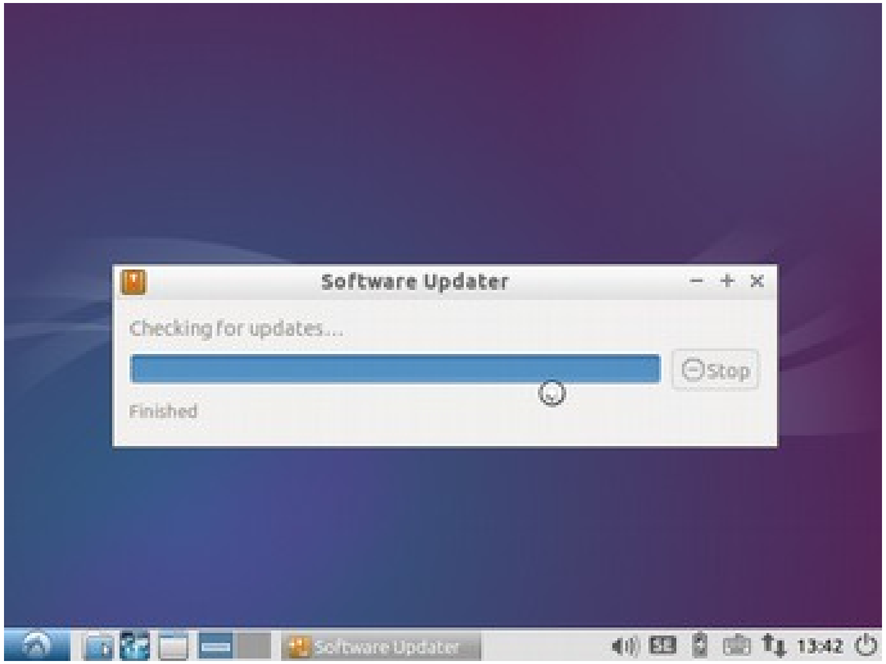
Ex. B3: Installing the virtual machine graphical environment

- Switch to a text terminal by pressing Right Ctrl + F1
  (in a real machine is Ctrl + Alt + F1)
- Login with username *courseuser* and password *coursepassword*
- Run the following commands to achieve the mentioned effect:
  - Replace the existing graphical stack with the generic software stack:
    ```
    sudo apt-get install xserver-xorg
    ```
  - Install Virtualbox open source drivers. This will compile the drivers for you for every version of the kernel that is installed.
    ```
    sudo apt-get install virtualbox-guest-utils virtualbox-guest-x11 virtualbox-guest-dkms
    ```
  - Reboot the machine via command line
    ```
    sudo reboot
    ```
  - After reboot, test that the machine screen resizes every time you resize the machine window.

Ex. B3: Software update



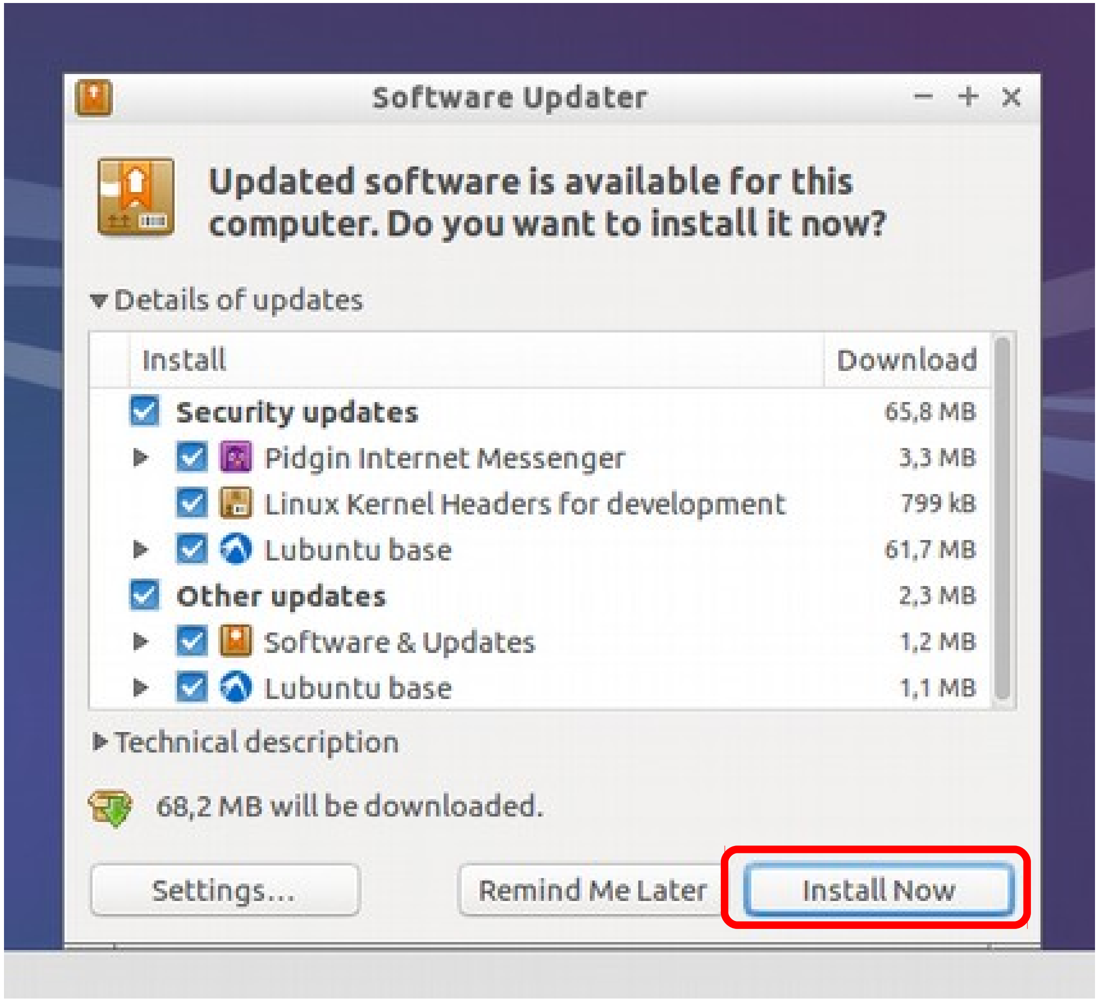
Ex B3: Software update



Software Updater

Checking for updates...

Finished



Software Updater

Updated software is available for this computer. Do you want to install it now?

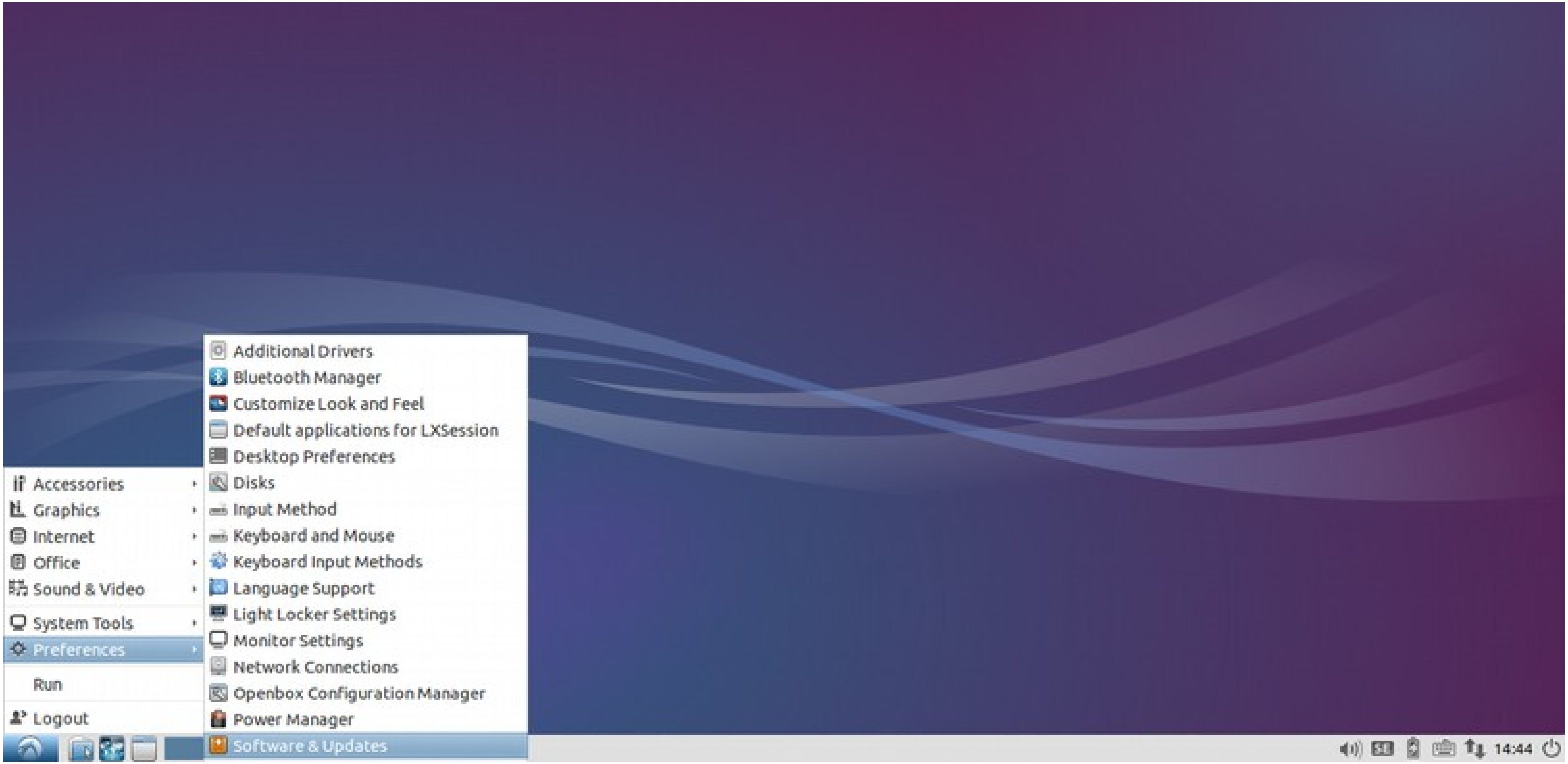
▾ Details of updates

Install	Download
☑ **Security updates**	65,8 MB
▸ ☑ Pidgin Internet Messenger	3,3 MB
☑ Linux Kernel Headers for development	799 kB
▸ ☑ Lubuntu base	61,7 MB
☑ **Other updates**	2,3 MB
▸ ☑ Software & Updates	1,2 MB
▸ ☑ Lubuntu base	1,1 MB

▸ Technical description

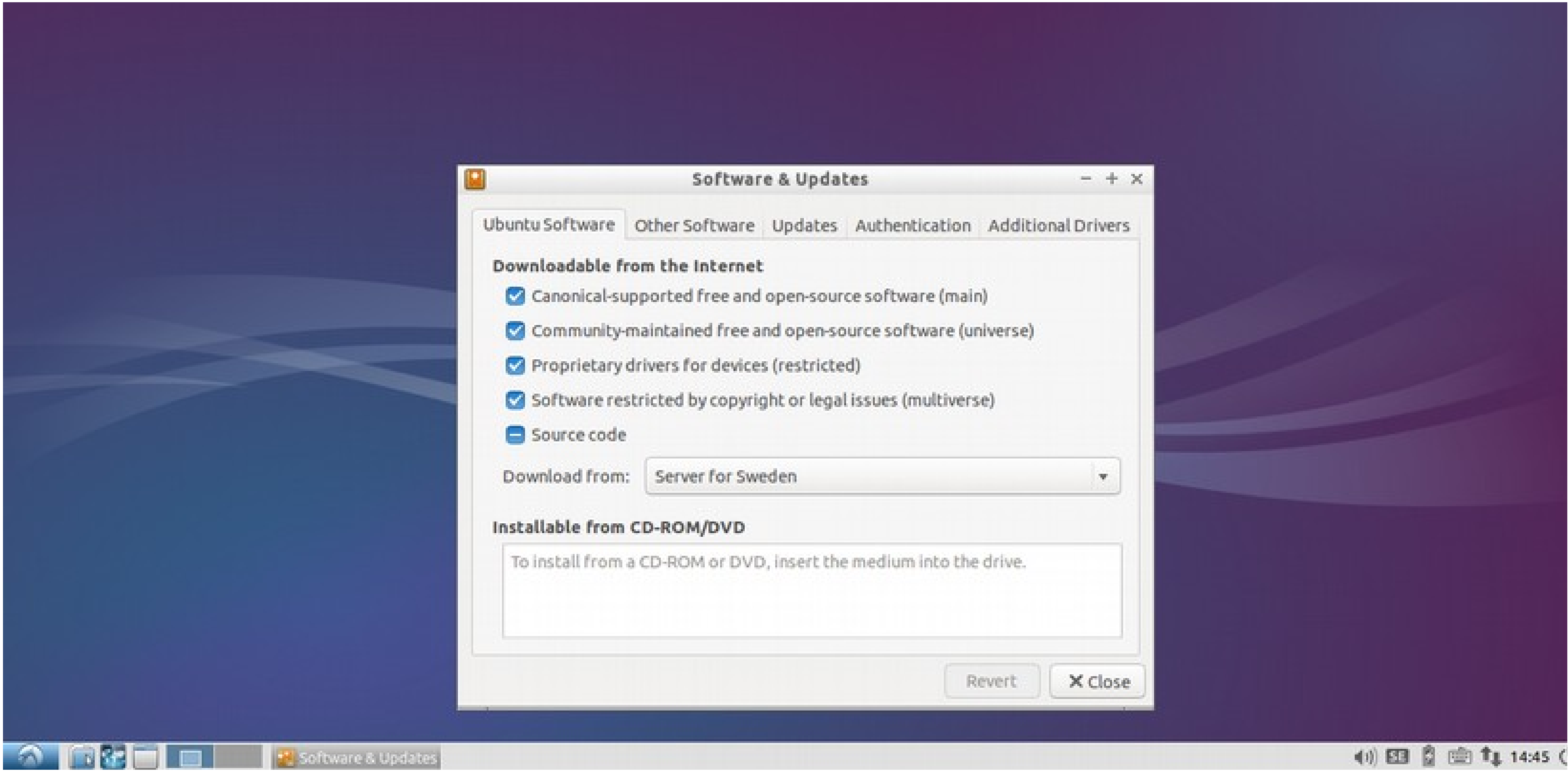
68,2 MB will be downloaded.

Ex. B4: Software Repositories



What were repositories? Click here for the slide about repositories

Ex. B4: Software Repositories



Downloadable from the Internet

☑ Canonical-supported free and open-source software (main)

☑ Community-maintained free and open-source software (universe)

☑ Proprietary drivers for devices (restricted)

☑ Software restricted by copyright or legal issues (multiverse)

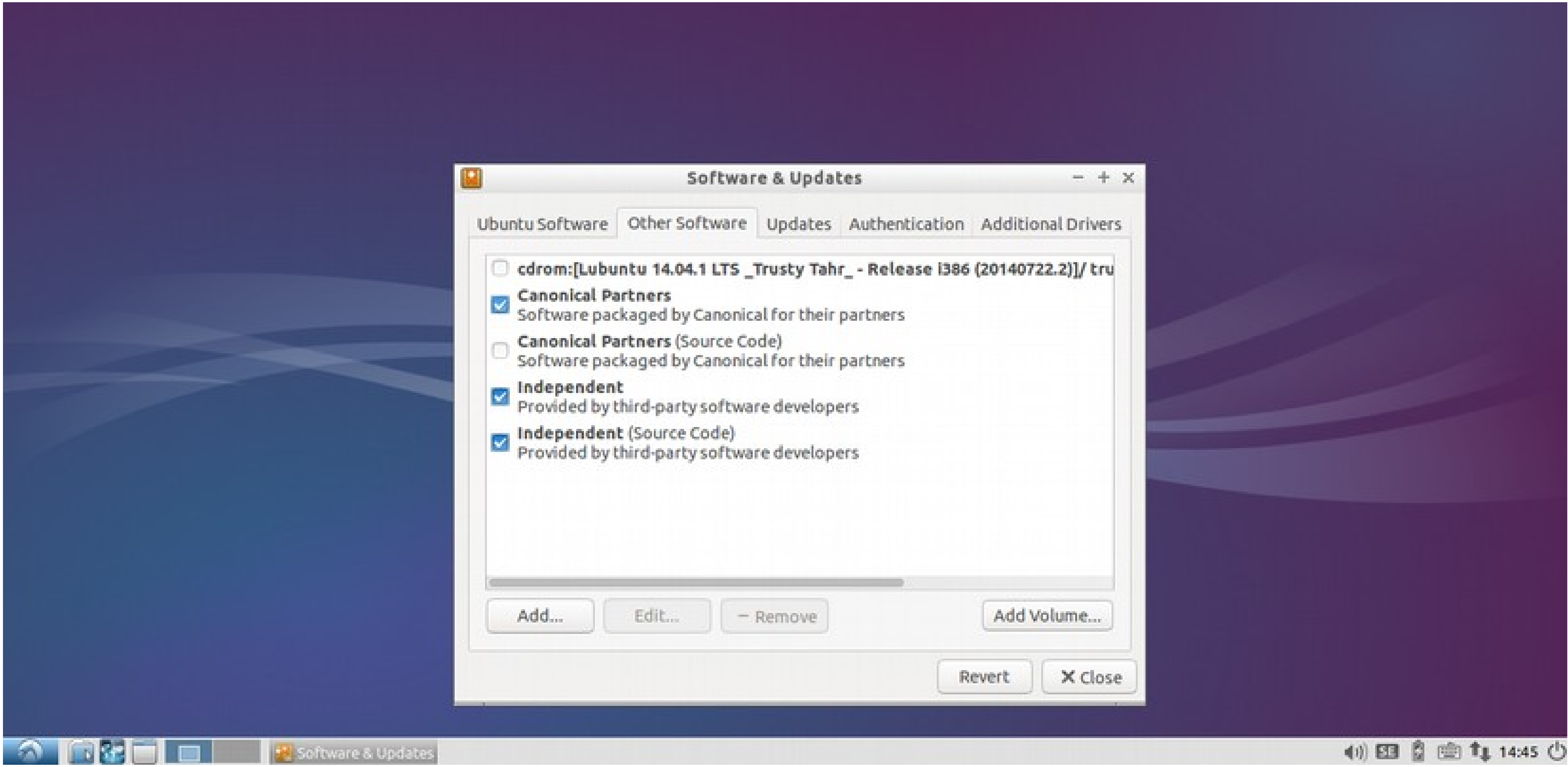
⊟ Source code

Download from: Server for Sweden

Installable from CD-ROM/DVD

To install from a CD-ROM or DVD, insert the medium into the drive.

Ex. B4: Software Repositories



Software & Updates

□ cdrom:[Lubuntu 14.04.1 LTS _Trusty Tahr_ - Release i386 (20140722.2)]/ tru

☑ **Canonical Partners**
Software packaged by Canonical for their partners

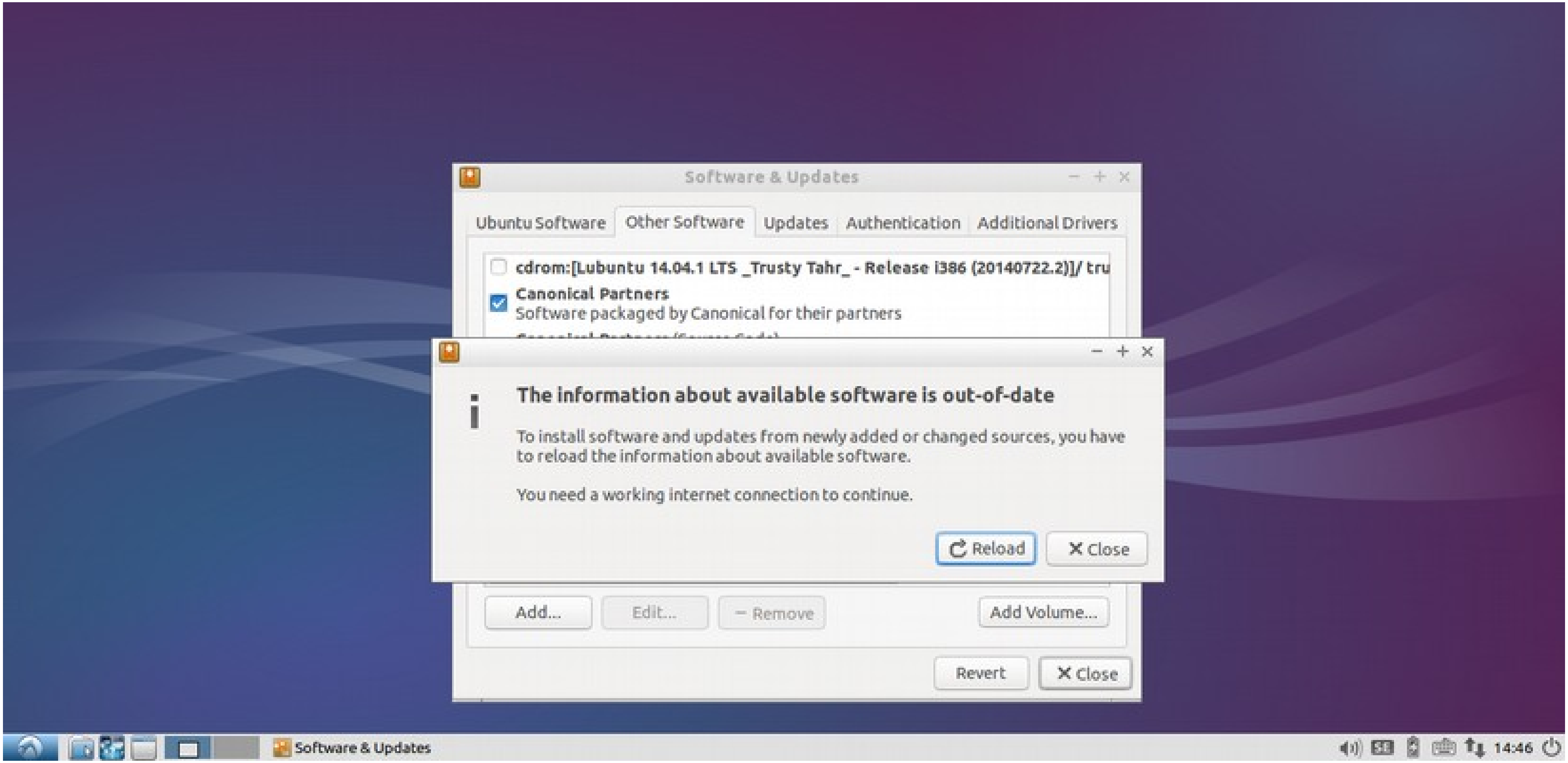
□ **Canonical Partners** (Source Code)
Software packaged by Canonical for their partners

☑ **Independent**
Provided by third-party software developers

☑ **Independent** (Source Code)
Provided by third-party software developers

Tick ”Canonical Partners”. You might need to enter the password.

Ex. B4: Software Repositories



□ cdrom:[Lubuntu 14.04.1 LTS _Trusty Tahr_ - Release i386 (20140722.2)]/ tru

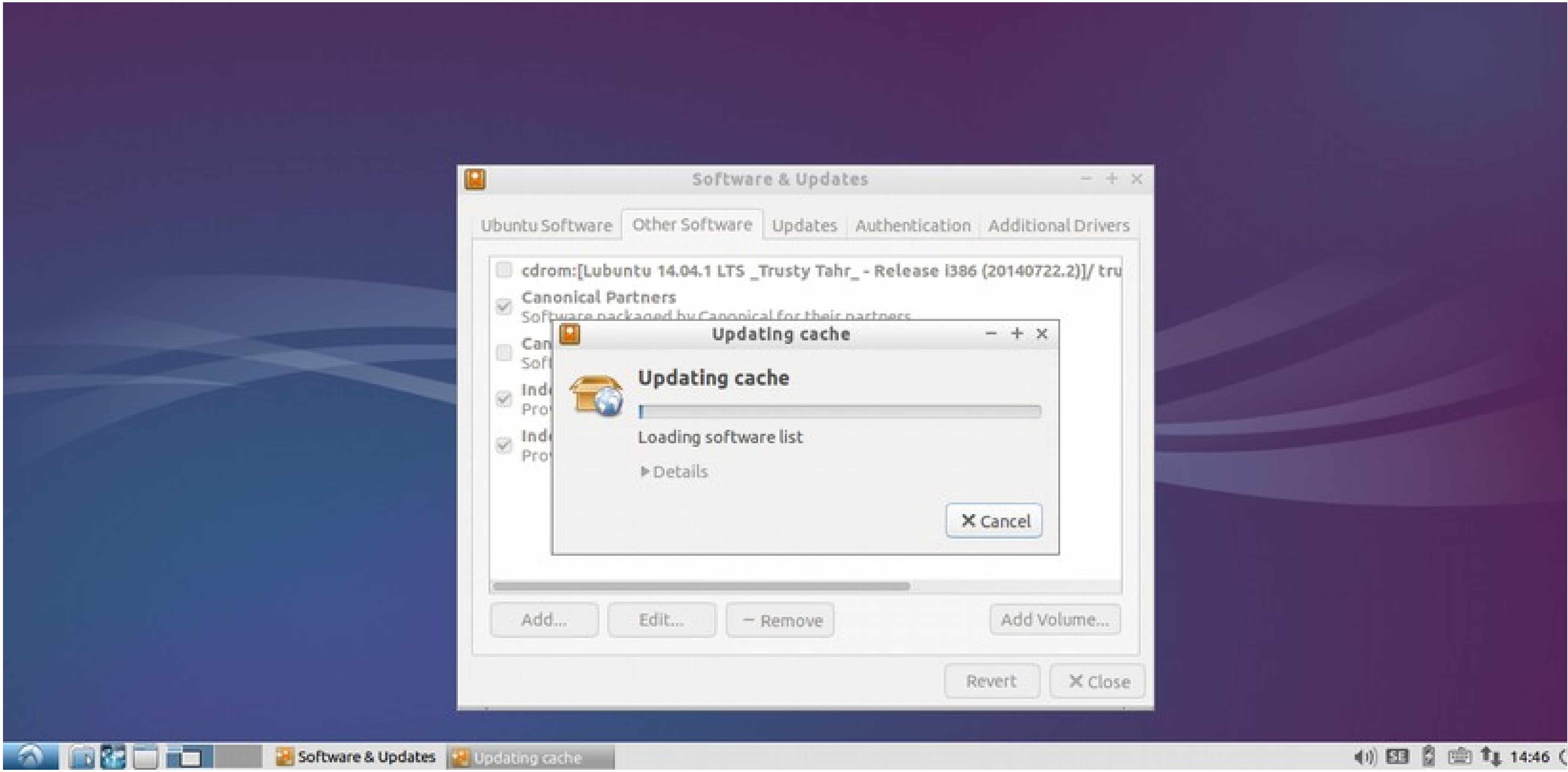
☑ Canonical Partners
Software packaged by Canonical for their partners

The information about available software is out-of-date

To install software and updates from newly added or changed sources, you have to reload the information about available software.

You need a working internet connection to continue.

Ex. B4: Software Repositories



Software & Updates

☐ cdrom:[Lubuntu 14.04.1 LTS _Trusty Tahr_ - Release i386 (20140722.2)]/ tru

☑ Canonical Partners
Software packaged by Canonical for their partners

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Soft

☑ Ind
Pro

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Pro

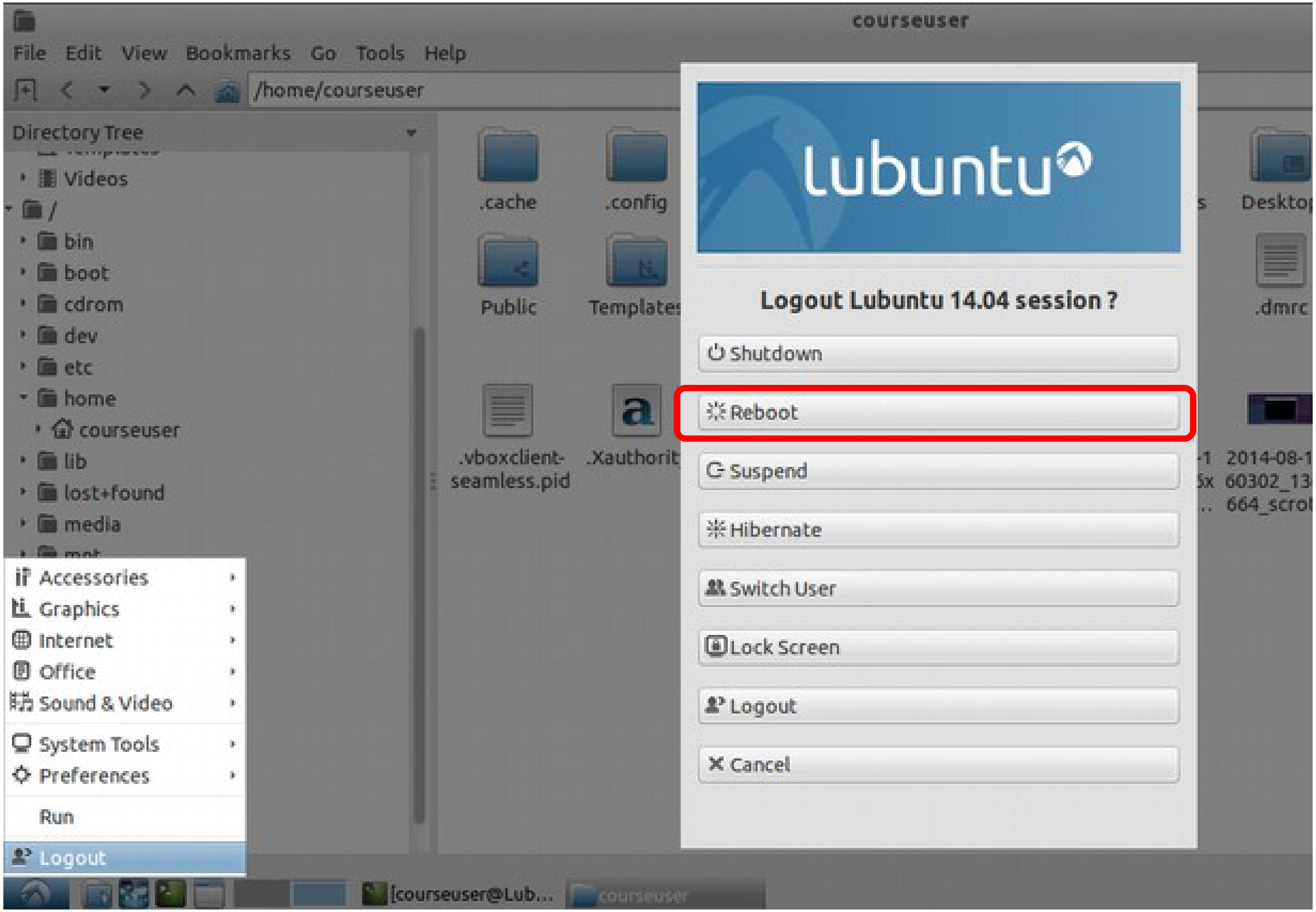
Updating cache

Updating cache

Loading software list

Ex. B5: Logout dialog: Reboot

B5.1 Reboot the machine.



Logout Lubuntu 14.04 session ?

Advanced installation methods

- **Compile** and **install** your own software.
- **Compile:** You will see this during the course.
- **Install:** copy files somewhere
- It **does not require administrative privileges**, so you can do everywhere!

Homework

New to GNU/Linux? Install you own linux!
Read about the different installation strategies
(slides 67-68, 117-118).

Install your own GNU/Linux. You can either use virtualbox or a physical machine but **make sure you read the dangers of the different installation strategies or you risk of breaking your computer!**

1. Use the machine name *`distributionname-yourname`* where
    1. *`distributionname`* is the Linux distribution you have installed
    2. *`yourname`* is your first name.
2. Open a terminal, make the terminal window big and type the following commands:
    1. `uname -a` (and press enter)
    2. `id` (and press enter)
    3. `pwd` (and press enter)
3. Take a screenshot of the whole screen including your windows/linux/macos desktop that runs virtualbox
4. Post the screenshot as your assigment result and describe in few words what you did.

Homework – Alternative for those who already have linux installed

Already have GNU/Linux? Make your Linux MNXB01-ready!

If you already know how to install linux or you cannot use a virtual machine (for example because your laptop doesn't meet the Hardware Requirements) make your machine MNXB01-ready.

1) Install the following software:

```
build-essential geany geany-plugins git gitg htop kile nedit openssl root-system
screen subversion texlive texlive-base texlive-full tig wget meld vim
```

   build-essential is a collection of developer tools, in other distributions the software needed is called in a different way. It includes:

```
libc6-dev libc-dev gcc  g++  make dpkg-dev
```

2) Install the grid software:
   1) add nordugrid repositories for your distro from http://download.nordugrid.org/repos-15.03.html
   2) Install:

```
nordugrid-arc-client nordugrid-arc-doc ca-policy-igtf* ca-incommon-igtf-server-ca
```

3) When done, send a text file containing the installed packages in your machine. How this is done depends on the distribution you installed, for lubuntu is

```
dpkg -l > packagelist.txt
```

4) Send the output of the commands

```
uname -a
id
pwd
```

Linux installation: three strategies

1. **Single operating system:** Linux deletes everything on the disk and it becomes the one and only operating system for that computer
   - Difficulty: easy
   - Costraint: user must own the computer (administrator)
   - Pros:
     - Performance: Linux can take all the resources available on the machine
   - Cons:
     - The machine can only run Linux programs.

Method 1 prerequisites

1.1. Make sure you are using an hard disk that you can **completely wipe**. **No data but Lubuntu will be left on the disk after installation!! You will lose everything!**

1.2. Download the Lubuntu ISO as seen in the tutorial.

1.3. Burn the ISO on a CD/DVD or on a USB stick. There are several ways to do this, search Ubuntu mainpage or the internet to find how. Start here:
http://www.ubuntu.com/download/desktop/install-ubuntu-desktop

1.4. Boot the machine from the ISO. Usually it is enough to insert the burned CD or the USB pen and start the machine.

1.4. Install Linux as we've seen in the course. Remember, **everything on the hard disk will be removed**!!

Linux installation: three strategies

2 **Virtual Machine**: Run Linux in a virtual machine where it is the one and only system. The virtual machine is run on an hypervisor that is running in the existing OS.

- Difficulty: Medium
- Constraint: User must be able to install software, i.e. VirtualBox hypervisor

- Pros:
  - The machine can run program s for the existing OS **and** linux, **at the same time**
- Cons:
  - No need to touch the existing OS boot: all is taken care by the Virtualization Hypervisor
  - Performance loss due to virtualized hardware.

Method 2 prerequisite: Download and install Virtualbox

https://www.virtualbox.org/wiki/Downloads

- 1.1. Download *VirtualBox <some version> for Windows hosts*
- 1.2. double click on the Virtualbox file just downloaded and follow the installation procedure on screen.
- 1.3. install linux as seen during the tutorial.

Linux installation: three strategies

3 **Dual boot:** Linux shares the disk with other operating systems.
Requires an alternative boot loader (e.g. GRUB2), a small program that is loaded **BEFORE** any other installed system.
This program must be installed at the beginning of the disk.

- Difficulty: Hard
- Constraint: user must own the computer (administrator)
- Pros:
  - Performance: Linux can take all the resources available on the machine
  - The machine can run programs for windows and linux, at the cost of a reboot
- Cons:
  - Rewriting the initial part of the disk usually prevents windows to boot properly. One needs to be very aware of what he is doing.
  - Only one operating system can control the machine at time: requires reboot to switch from one operating system to the other.

Method 3 prerequisites

DISCLAIMER: USE THIS METHOD ONLY IF YOU UNDERSTAND WHAT YOU'RE DOING. YOU RISK DESTROYING YOUR EXISTING DATA.

1.1. Download the Lubuntu ISO as seen in the tutorial.

1.2. Burn the ISO on a CD/DVD or on a USB stick. There are several ways to do this, search Ubuntu mainpage or the internet to find how. Start here:
http://www.ubuntu.com/download/desktop/install-ubuntu-desktop

1.3. Make space on the harddisk to fit linux. You usally need at least 40GB. To do that on windows, read about it here:
http://technet.microsoft.com/en-us/magazine/gg309169.aspx

1.4. Decide how to install linux: using GRUB, using Windows bootloader... and follow the procedures. More information here:
https://help.ubuntu.com/community/WindowsDualBoot

1.4.a **Legacy BIOS**: For Windows up to Windows 7, I suggest to use windows boot loader and a tool called EasyBCD. A guide here:
http://askubuntu.com/questions/325402/booting-win7-12-04-what-do-i-need-for-easybcd

1.4.b **UEFI BIOS**: If you have Windows 8 or 10, those support a new booting method called UEFI. This is a very annoying technology and setup is more complicated.

Read this: https://help.ubuntu.com/community/UEFIBooting

Follow the instructions here:http://www.everydaylinuxuser.com/2015/11/how-to-install-ubuntu-linux-alongside.html

1.5. Install linux as described in the course, but targetting the correct partition/disk you made space for on the disk. **Do not choose ”erase entire disk” when prompted.**

Linux installation: Recommendations

During this course we will use **method 2 (Virtual Machine)**, as it is supposed to work on every platform.

Methods 1 and 3 are only recommended to those who want to learn about the boot process or plan to use Linux for intense computation, or simply to switch to Linux as their main operating system (It's fun! :D).

Exercise: Install the geany editor

- Use synaptic
- Find the geany text editor and install it.
- Test that it works by finding it in the applications menu.
- Remove the geany package (hint: search for it in synaptic and untick the checkbox!)
- Test that is removed: the icon should not be anymore in the menu.
- What happen if you remove it while you're using it? Discuss with the teacher.

References

- Lubuntu installation official documentation
  https://help.ubuntu.com/community/Lubuntu/InstallingLubuntu
- Lubuntu official documentation / How Tos
  https://help.ubuntu.com/community/Lubuntu/Documentation
- Virtualbox
  https://www.virtualbox.org/
- Lubuntu Desktop
- GNU, https://www.gnu.org/home.en.html
- The Linux kernel organization
  https://www.kernel.org/category/about.html
- The Sociotechnical Boundaries of Hardware and Software: A Humpty Dumpty History, Brent K. Jesiek,
  http://bst.sagepub.com/content/26/6/497

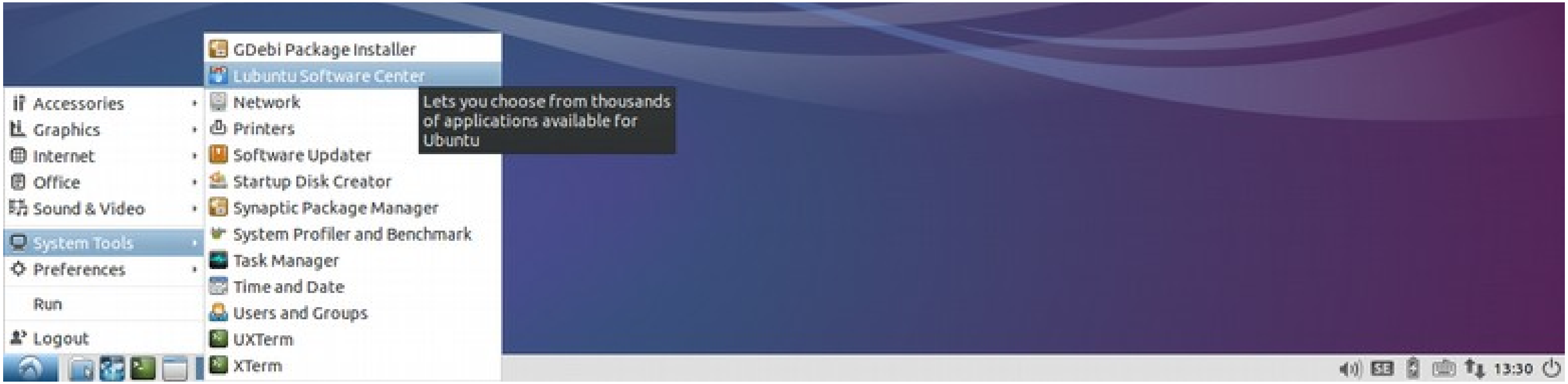
Pictures references (not complete)

- https://openclipart.org/
- http://members.peak.org/~jeremy/superlative/pix/babbageMachine.jpg
- http://en.wikipedia.org/wiki/Eadweard_Muybridge
- http://commons.wikimedia.org/wiki/File:ASRock_P4i65G_motherboard_view.jpg
- http://elaanisvital.com/final_png/icon_-35.png
-

Backup slides

Ex. 13: Other installation methods

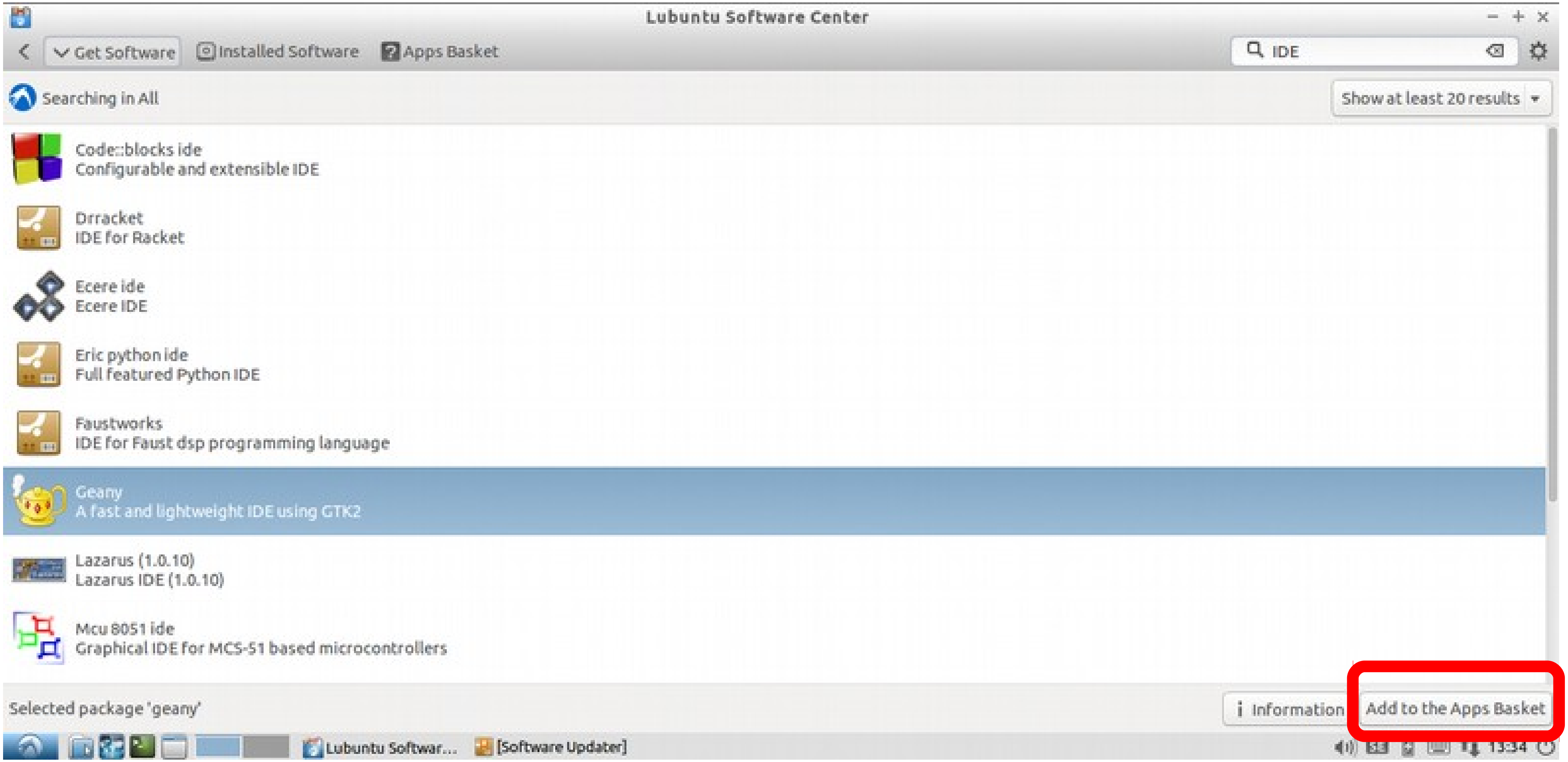
- Normal user: Lubuntu Software Center



Lets you choose from thousands of applications available for Ubuntu

Ex. 13: Other installation methods

- Installing Geany editor



Code::blocks ide
Configurable and extensible IDE

Drracket
IDE for Racket

Ecere ide
Ecere IDE

Eric python ide
Full featured Python IDE

Faustworks
IDE for Faust dsp programming language

Geany
A fast and lightweight IDE using GTK2

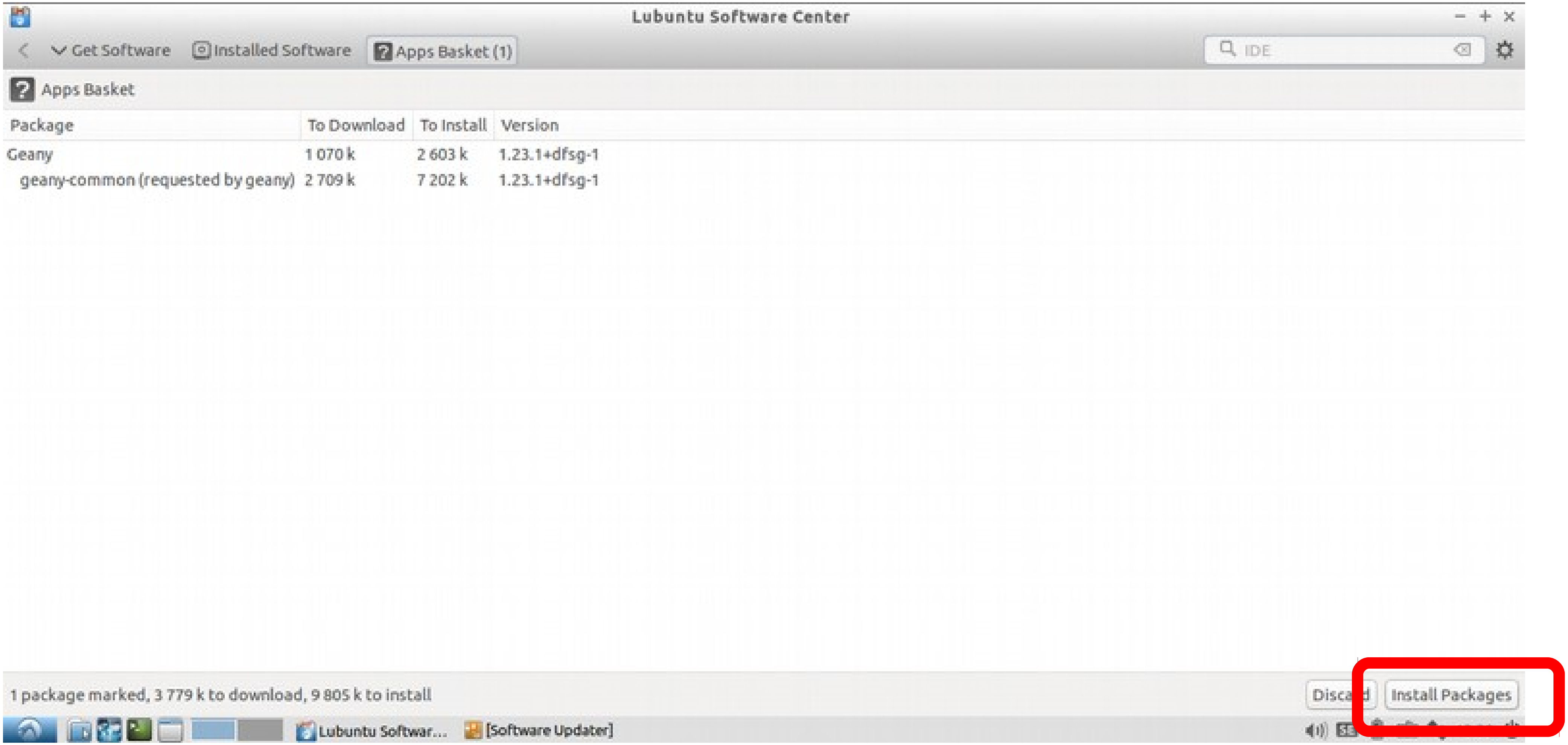
Lazarus (1.0.10)
Lazarus IDE (1.0.10)

Mcu 8051 ide
Graphical IDE for MCS-51 based microcontrollers

Selected package 'geany'

Ex. 13: Other installation methods

- Installing Geany editor

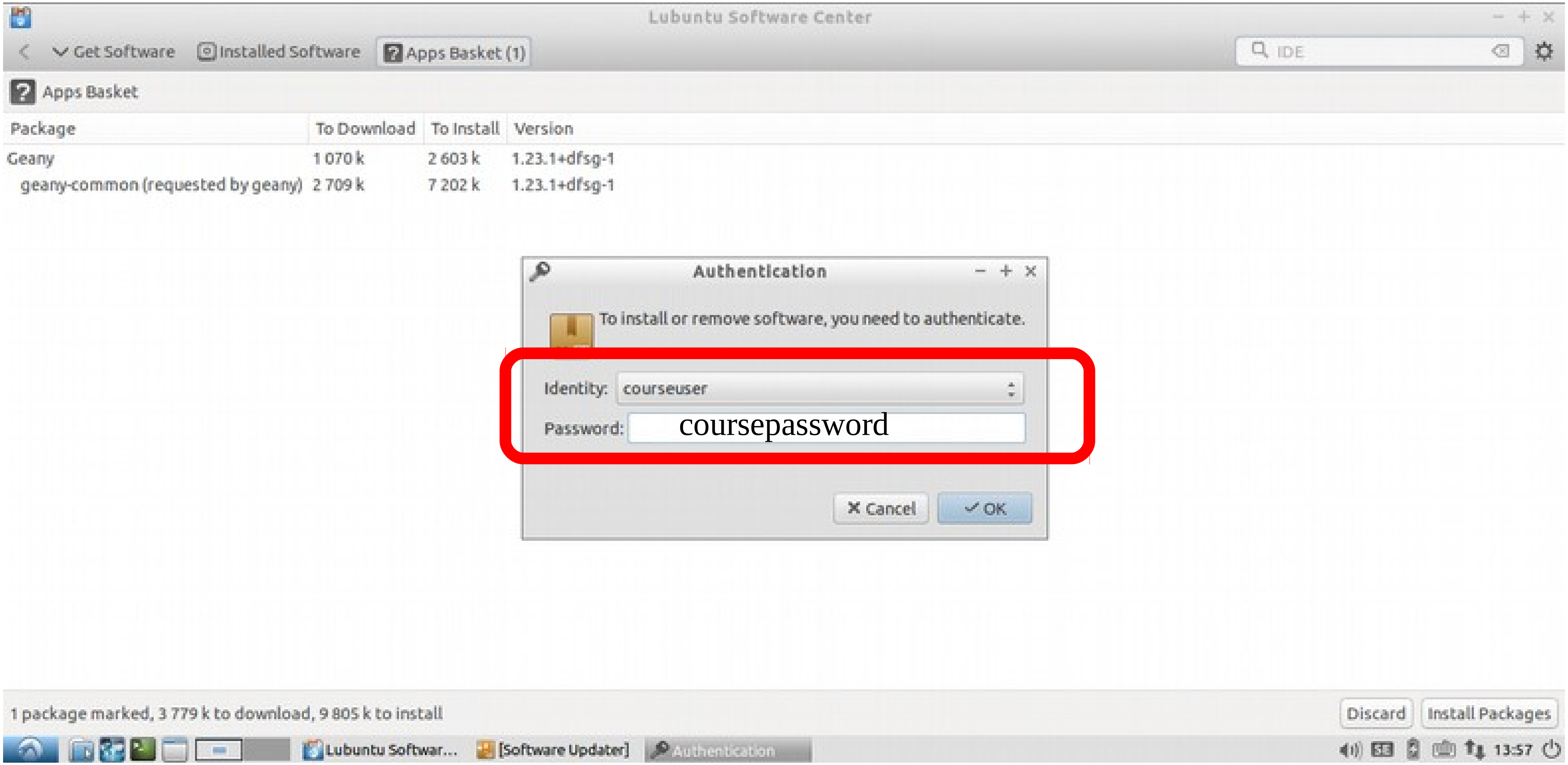


Package	To Download	To Install	Version
Geany	1 070 k	2 603 k	1.23.1+dfsg-1
geany-common (requested by geany)	2 709 k	7 202 k	1.23.1+dfsg-1

1 package marked, 3 779 k to download, 9 805 k to install

Ex. 13: Other installation methods

- Installing Geany editor



Package	To Download	To Install	Version
Geany	1 070 k	2 603 k	1.23.1+dfsg-1
geany-common (requested by geany)	2 709 k	7 202 k	1.23.1+dfsg-1

To install or remove software, you need to authenticate.

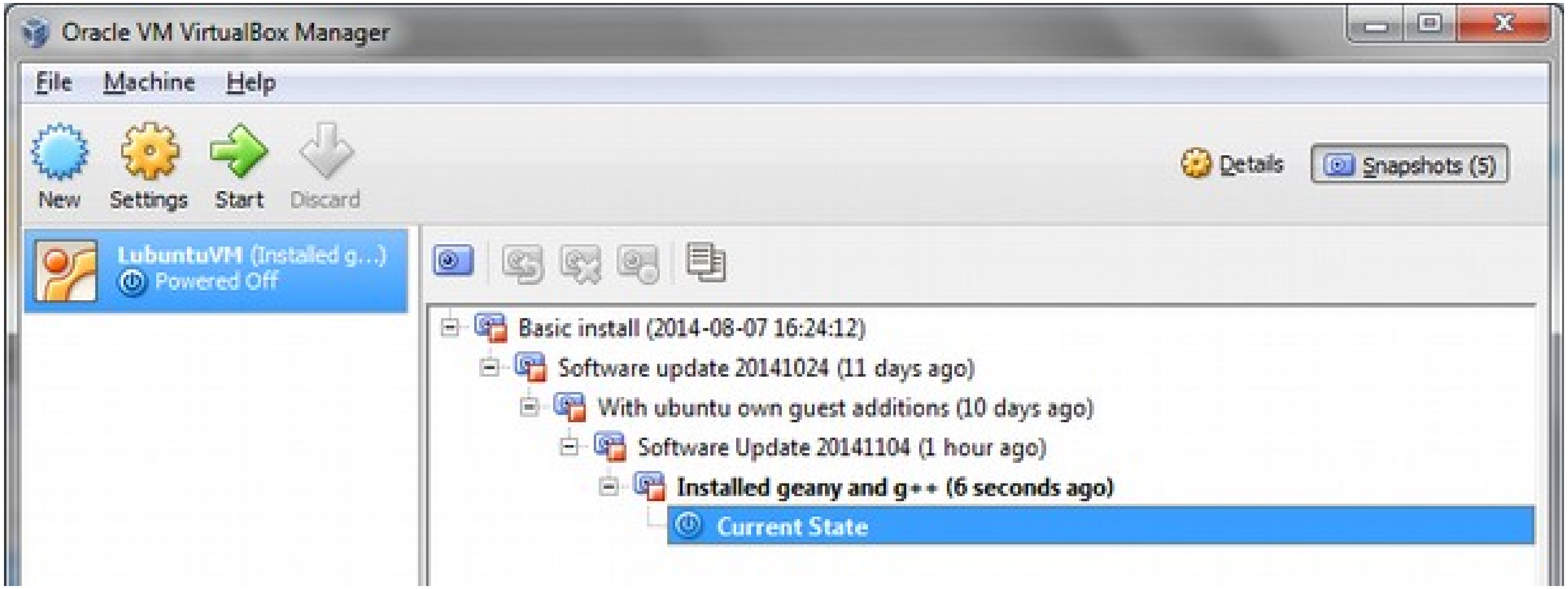
Identity: courseuser

Password: coursepassword

1 package marked, 3 779 k to download, 9 805 k to install

Snapshots in the custom VM

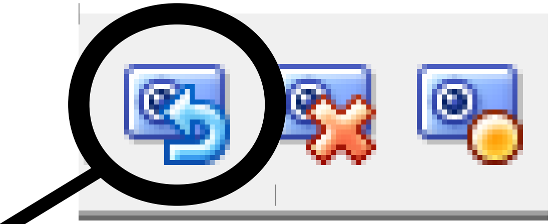
- A **snapshot** is the state of the virtual machine in a defined point in time. (See slide about states)
- Snapshots can be created, activated, or deleted by using the higlighted button
- Once a snapshot is set as starting point, the machine execution will start from that point.
- Try to save the current state by pressing the create snapshot button!
- For various technical reasons, the best is to snapshot when the VM is shutdown.

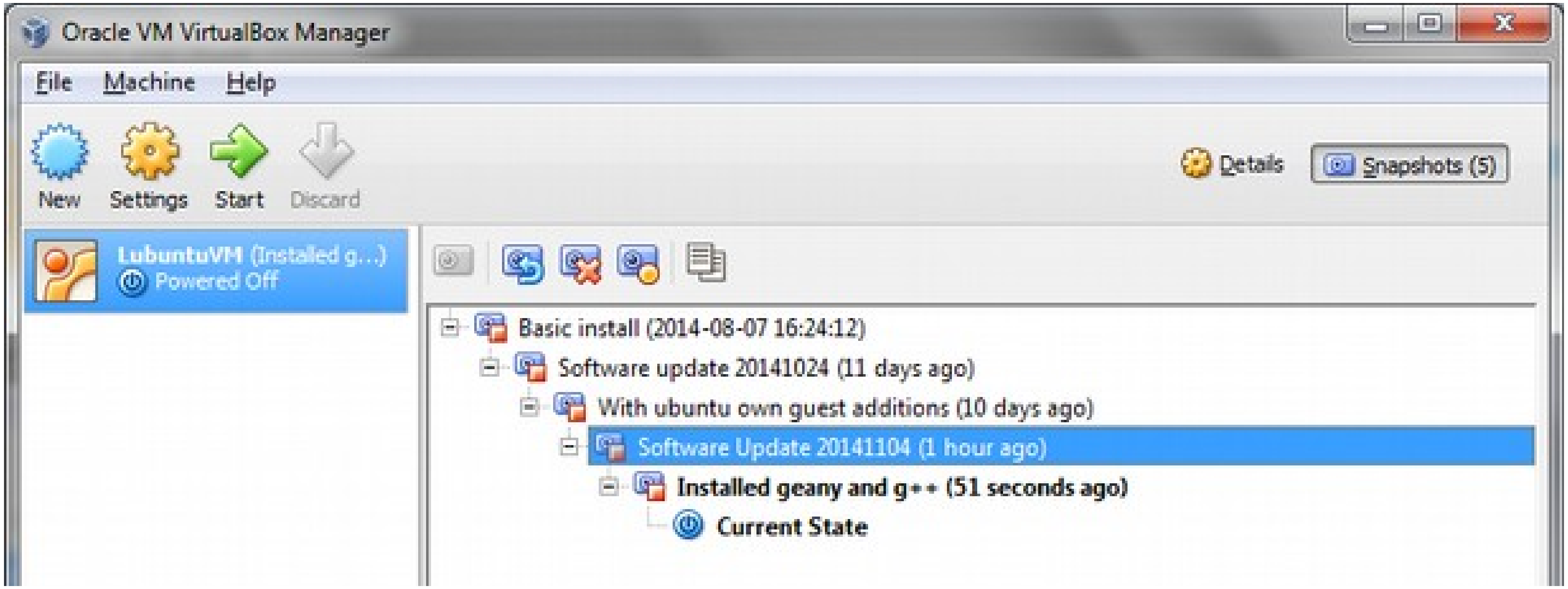


Basic install (2014-08-07 16:24:12)
Software update 20141024 (11 days ago)
With ubuntu own guest additions (10 days ago)
Software Update 20141104 (1 hour ago)
Installed geany and g++ (6 seconds ago)
Current State

Snapshots in the custom VM

- Using the buttons, one can move the machine back and forth in time.
- Let's try to restore a state!
  - Select a snapshot
  - Press the restore snapshot button





- Basic install (2014-08-07 16:24:12)
  - Software update 20141024 (11 days ago)
    - With ubuntu own guest additions (10 days ago)
      - Software Update 20141104 (1 hour ago)
        - Installed geany and g++ (51 seconds ago)
          - Current State