

C2110 *UNIX and Programming*

2nd lesson

Linux as a multi-user system

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Linux vs UNIX

In informatics, **UNIX** is a trademark of operating system created by Bell Labs of US company AT&T in 1969. The trademark is currently owned by The Open Group consortium, and can be used only by systems that are certified according to the Single UNIX Specification.

Various systems exist, that **are to the varying degree compatible with Unix**, but cannot or do not want to pay license fees. Because of that, they often use names that link to the name UNIX (for example, Xenix, MINIX, **Linux**), but they can be named differently (for example, BSD, variants OpenBSD, NetBSD, but also **Mac OS X**, etc.). They are collectively known as the Unix-like Systems.

GNU/Linux or just **Linux** is term used for an operating system based on **Linux kernel**. The first version of the kernel was programmed by Linus Torvalds in 1991, who is still actively involved in its further development.

Adapted from:

<https://cs.wikipedia.org/wiki/Unix>

<https://cs.wikipedia.org/wiki/Linux>

https://cs.wikipedia.org/wiki/Linux_%28j%C3%A1dro%29

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➤ Revision

- terminals, command line

➤ Commands

- manual pages

➤ Remote log in

- ssh, transmission security (encryption), nested logging in,
- running GUI applications, password-less login (Kerberos)

➤ Virtualization

- what is virtualization, typical use, overview of hypervisors, MS Windows in VirtualBox, Putty, installing Ubuntu OS

Revision

- **terminals**
- **command line**

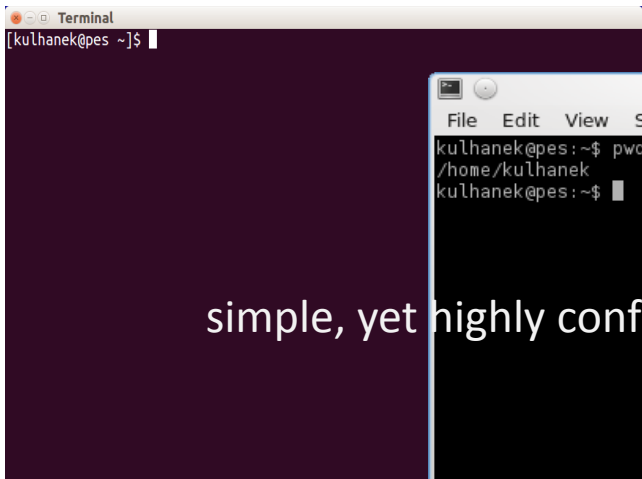
Terminals

Command line is accessible directly from the text terminals. In a graphical environment, X11 must be run in the appropriate application emulating the text terminal:

- **gnome-terminal (Terminal)**
- **konsole**
- **xterm**

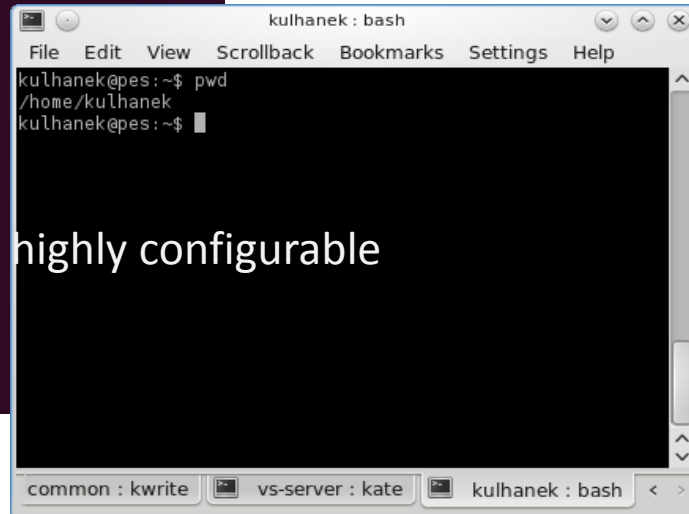
Default directory is: **/home/username**

gnome-terminal

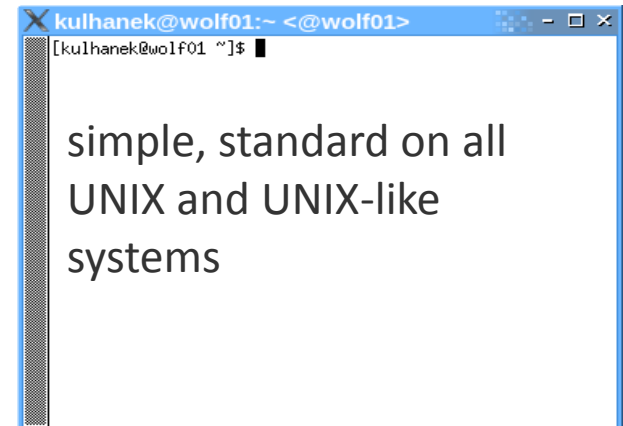


simple, yet highly configurable

konsole



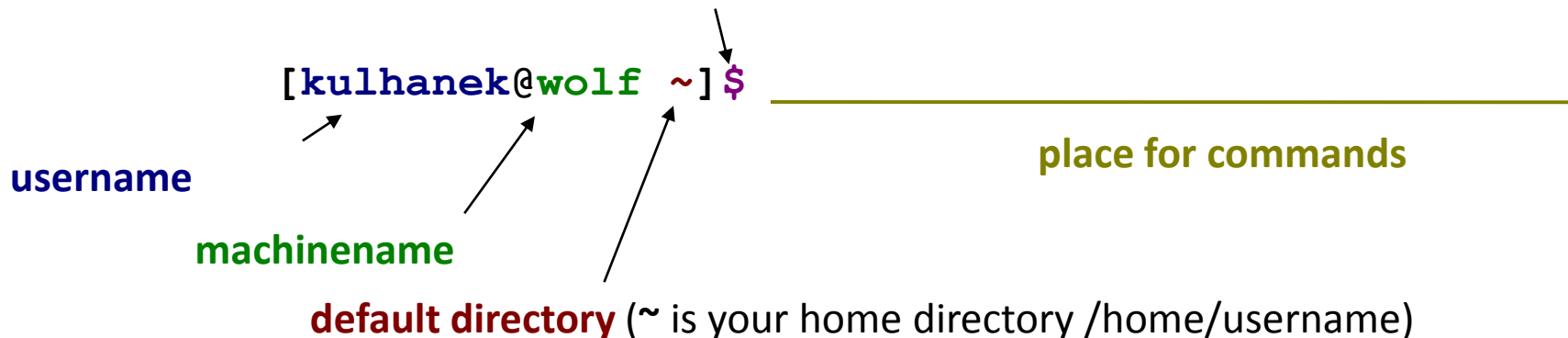
xterm



simple, standard on all
UNIX and UNIX-like
systems

Command Line

Prompt - user type / calls (\$ normal user, # super user, other possibilities %, >)



Command is executed by hitting **Enter**.

History: It is possible to scroll through the list of previously used commands by using the up and down arrow keys. The command from history can be reused or modified before use. History is also accessible by command **history**.

Notation:

```
$ ls -l  
$ ssh wolf01.wolf.inet ls -l  
# apt-get install firefox
```

Means new line. Characters \$ and # are not typed to command line

Commands

- manual pages

Command Help

Manual pages (what to do if you get lost):

man

command displays the manual page

```
$ man [section_number] topic
```

↑
name of command, function, topic, chapter etc.

Available sections:

- *Section 1* user commands
- *Section 2* system calls
- *Section 3* library functions
- *Section 4* special files
- *Section 5* *file formats*
- *Section 6* games
- *Section 7* conventions and miscellany
- *Section 8* administration and privileged commands
- *Section L* math library functions
- *Section N* tcl functions

Section number should be quoted in subjects with the same name assigned to different sections.

```
$ man 1 printf
```

Manual page of command printf

```
$ man 3 printf
```

Manual page of print() function in C language

Help, Looking for Commands

Navigation in the manual:

- shifting the text line by line (up and down arrow keys or **j** and **k**)
- shifting the text by page (**PgDn** and **PgUp** keys or **f** and **b**)
- searching (**/search_text**, **n** key for further search)
- closing the manual (key **q**)

On-line manual pages in HTML format:

<http://linux.die.net/man/>

Useful commands:

whatis	displays a short description of a command (from the man page)
apropos	searches for commands containing specified word in the manual pages
info	views info pages of a command (similar to man pages)

Command Syntax

\$ **command** [options] [--] [arguments]

short options

-a
-as or -a -s
-f test.txt

long options

--file test.txt

arguments
main data or information given to the command
must be given in a specific order

Options expand/change behavior of the command and can be given in any order

end of options entering, has to be used only in very specific cases, is not used regularly.

[] marks **optional** arguments or options

<> marks **mandatory** options or arguments, can be stated without brackets

Commands

man	manual pages of commands
whatis	displays a short description of a command (from the manual page)
apropos	searches for commands containing specified word in the manual page
info	displays info pages of a command (similar to man pages)
whoami	prints the name of the logged user
hostname	prints the name of the machine on which you are logged in
id	prints identification data of the logged user and user's groups
w	prints users logged on the machine and their actions
who	prints users logged on the machine
ps	displays running processes
top	monitors running processes
ssh	command for secure login to the remote machine

Exercise I

1. What is the full name of your computer? (command **hostname** and an option according to the manual pages)
2. Display your user name by **whoami** command.
3. What is your identification number (**UID**)?
4. Find out who is logged to your work station by using commands **w** and **who**.
5. What is the difference between commands **w** and **who** according to the manual pages?
6. Find manual pages from section 1, that contain key word **directory** or **directories**. Which command is used to make directories?
7. Monitor running processes by **top** command (press **q** to quit the program)

Remote Login

- ssh
- encryption
- nested login
- remote running of graphical applications
- password-less login (Kerberos)

Remote Login

Several options for remote login (rsh, XDMCP, etc.) exist, but the most used and **safest** is the Secure shell (**ssh**)

[] - can be skipped

Syntax:

```
$ ssh [user@]hostname [command]
```

user name;
if not stated, ssh uses name of
the logged user

machine name

command we want to execute, if
command is not stated, command
line is opened up in interactive
mode

Examples:

```
$ ssh wolf.ncbr.muni.cz
```

```
$ ssh wolf01 who
```

Logout:

Remote interactive logins (sessions) are terminated by **exit**.

First Remote Login

```
[kulhanek@wolf01 ~]$ ssh wolf02
```

The authenticity of host 'wolf02 (10.251.28.102)' can't be established.

ECDSA key fingerprint is **1f:9d:f3:d3:1d:24:28:12:56:30:99:ef:2d:68:d2:cf**.

Are you sure you want to continue connecting (yes/no)? **yes**

Warning: Permanently added 'wolf02,10.251.28.102' (ECDSA) to the list of known hosts.

```
[kulhanek@wolf02 ~]$
```

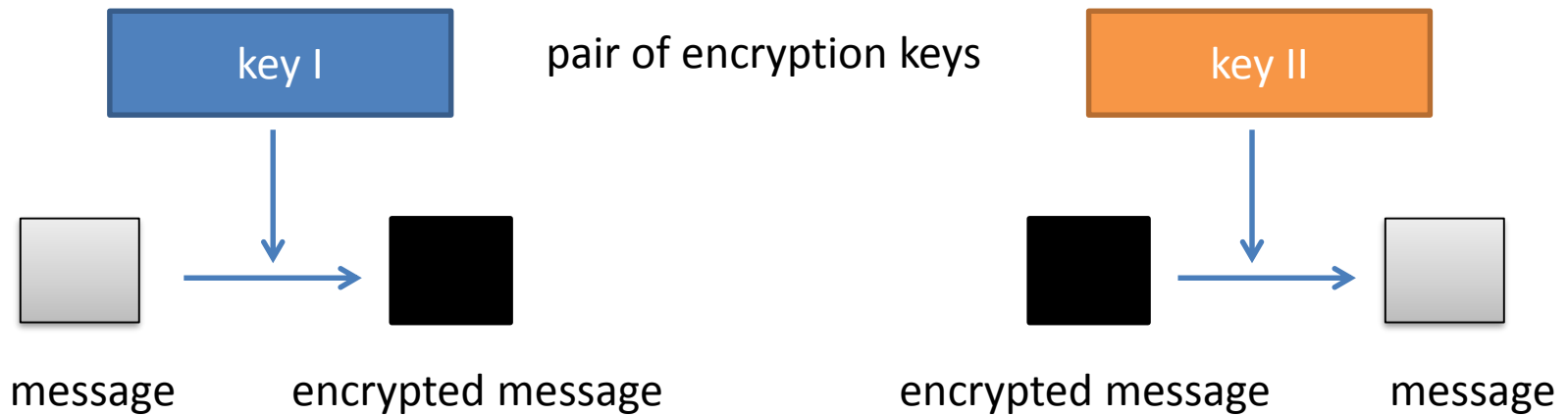
When you login to a machine for the first time, it is required to confirm the authenticity of the machine. Fingerprint can be accepted without verification only in secure networks.

In non-secure environment, it is appropriate to certify the fingerprint of machine by an independent way (e.g., by sending fingerprints via mail by the administrator of the remote machine).

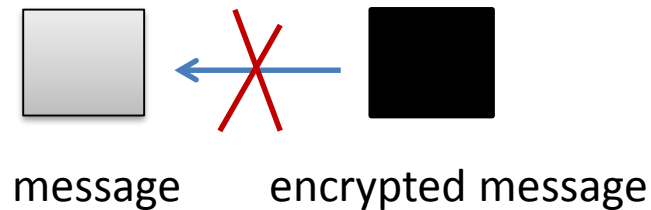
Note:

WOLF cluster is a safe network and the confirmation is not required between its computers

Asymmetric Encryption



Decrypting of the message by the key for encrypting **is not feasible**.



Asymmetric Encryption, Usage I

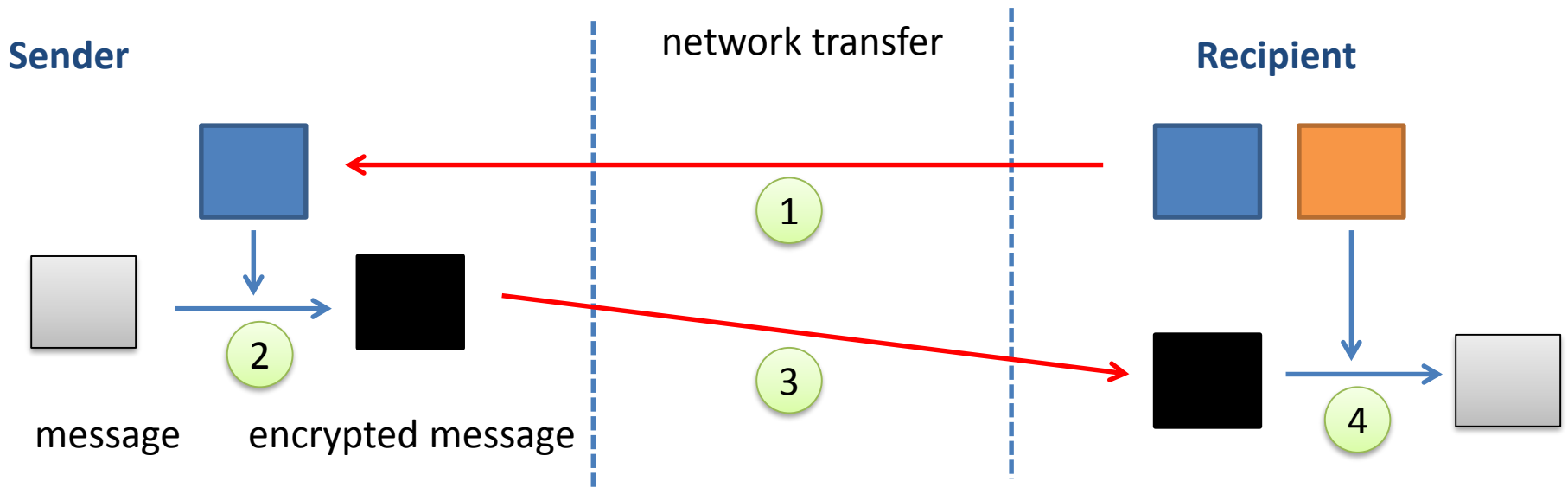
public key

private key

pair of encrypting keys

Transfer of encrypted data:

1. obtaining the public key of the recipient
2. encrypting the message of sender by public key of recipient
3. sending encrypted messages through an insecure network
4. recipient decrypts the message with his private key



Anybody who steals the recipient's private key, can decrypt transmitted data!

Asymmetric Encryption, Usage II

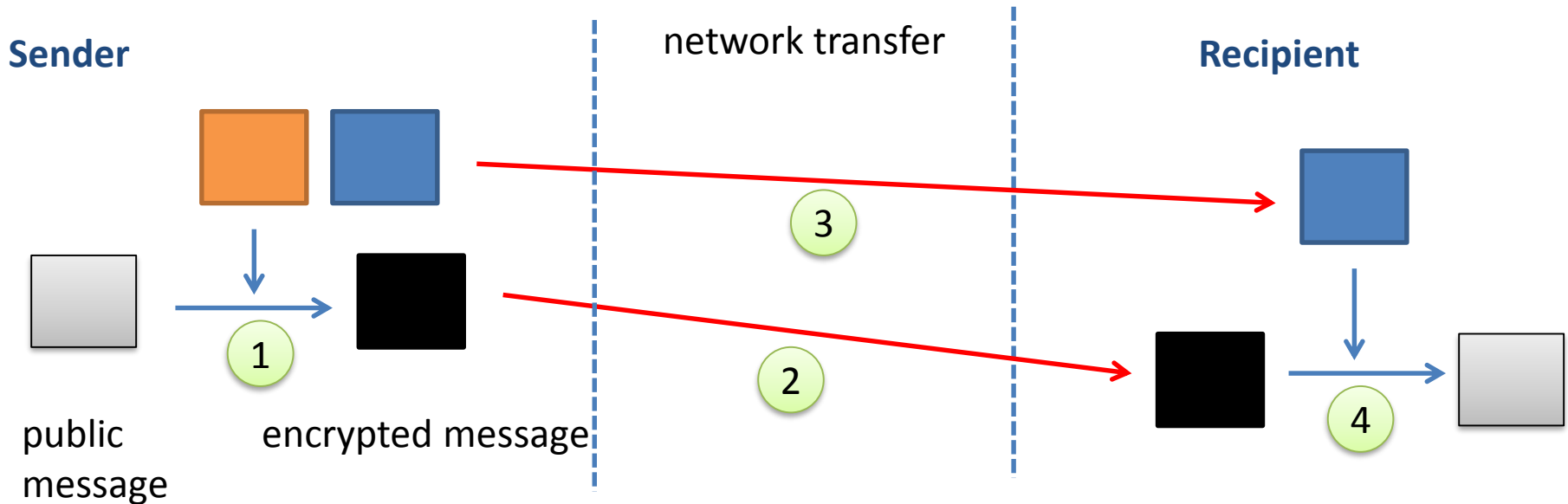
public key

private key

pair of encrypting keys

Validation of the sender of public message

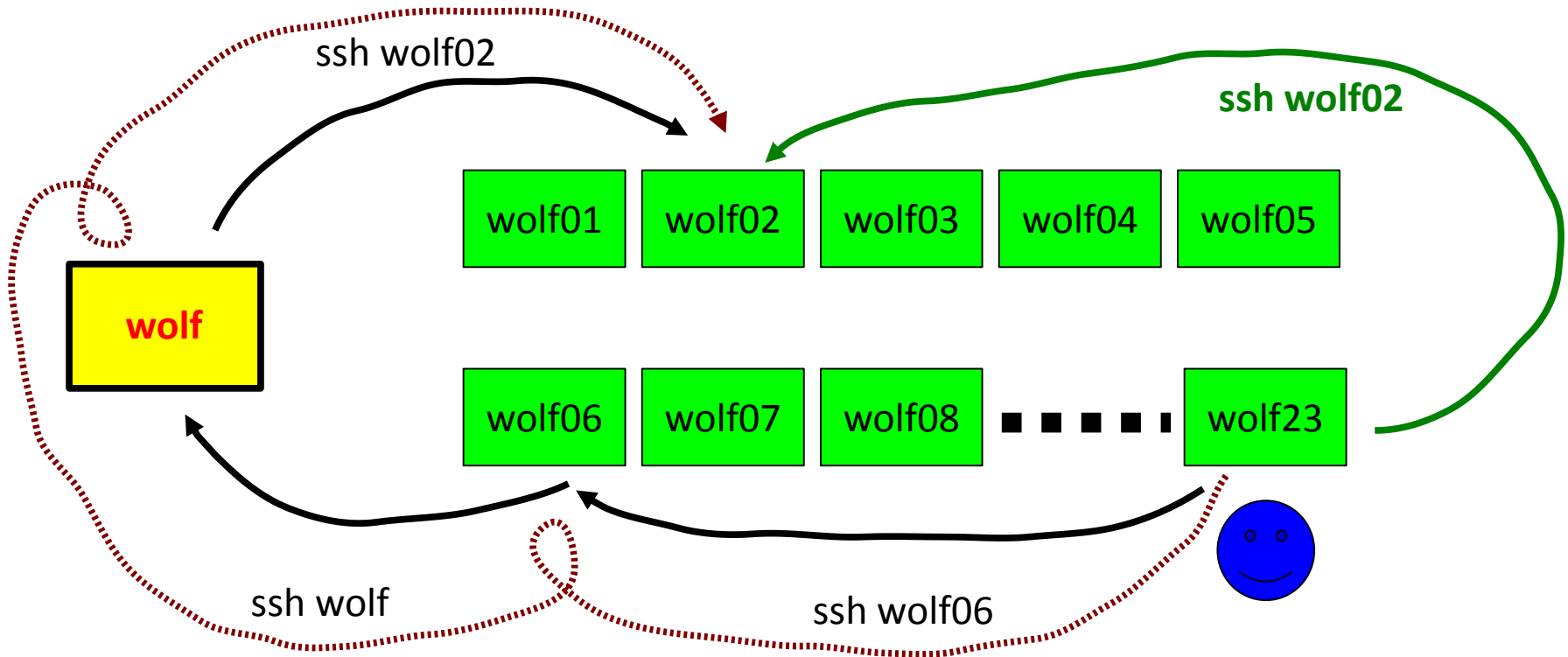
1. encrypting data by private key of the sender
2. recipient obtains encrypted data and the public key of sender
3. recipient decrypts the data by sender's public key



Anybody who steals sender's private key, can impersonate him!

Remote Login

ssh can perform **nested remote login**.



Each level of remote login **increases overhead**, therefore, if possible, use the most **direct path to log in**

Nested remote login must be used to access the computers in private networks. (details in supercomputing C2115).

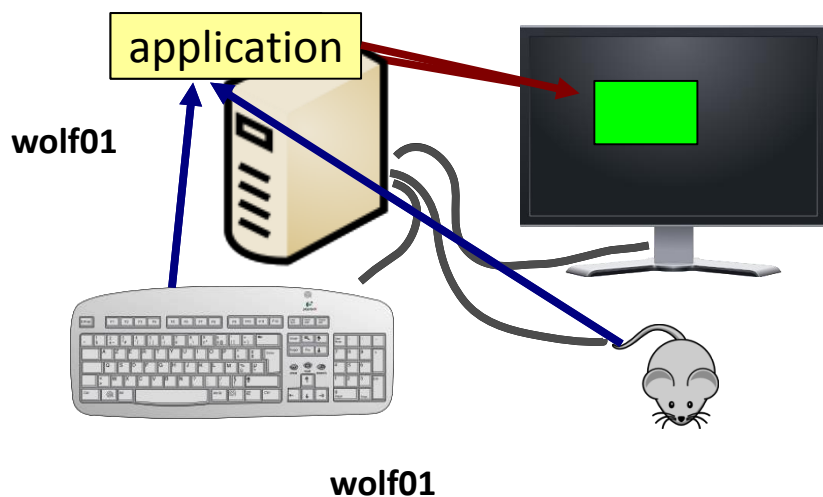
Exercise II

1. Log in to the remote node **wolf01.ncbr.muni.cz**
2. Verify that this is indeed a node wolf01 (**hostname** command). Using commands **w** and **who** find out who is the node logged in.
3. Log off from node **wolf01.ncbr.muni.cz**
4. Find out who is logged onto the node **wolf01.ncbr.muni.cz** without using the interactive session.

Remote GUI Applications

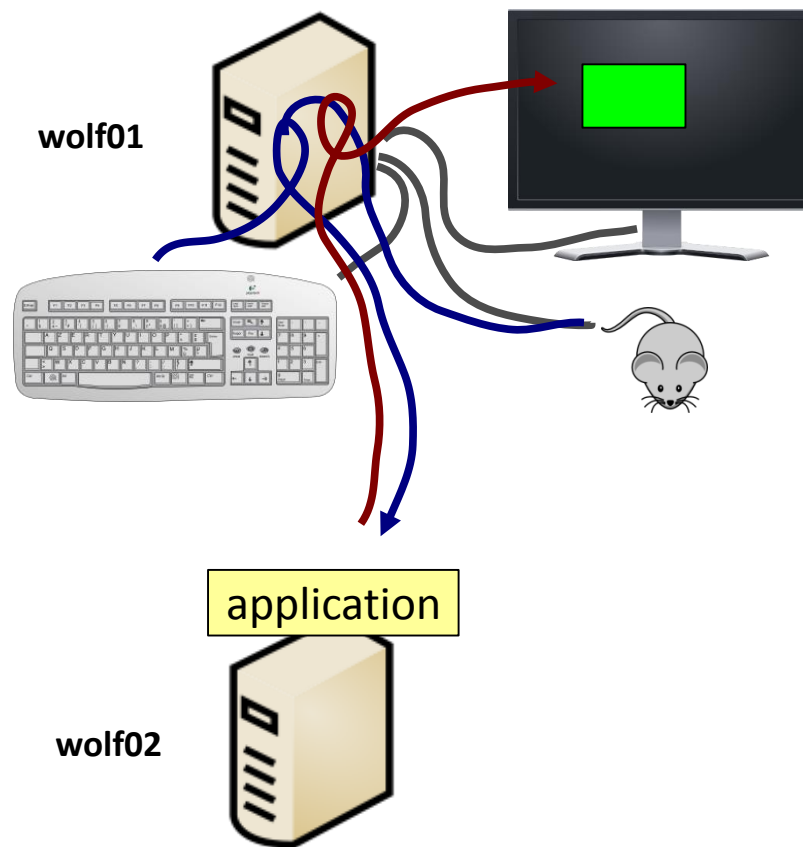
Graphical User Interface (GUI) can be run directly in the X11 environment (graphical terminal) or by exporting display from the remote desktop environment with X11.

Direct usage

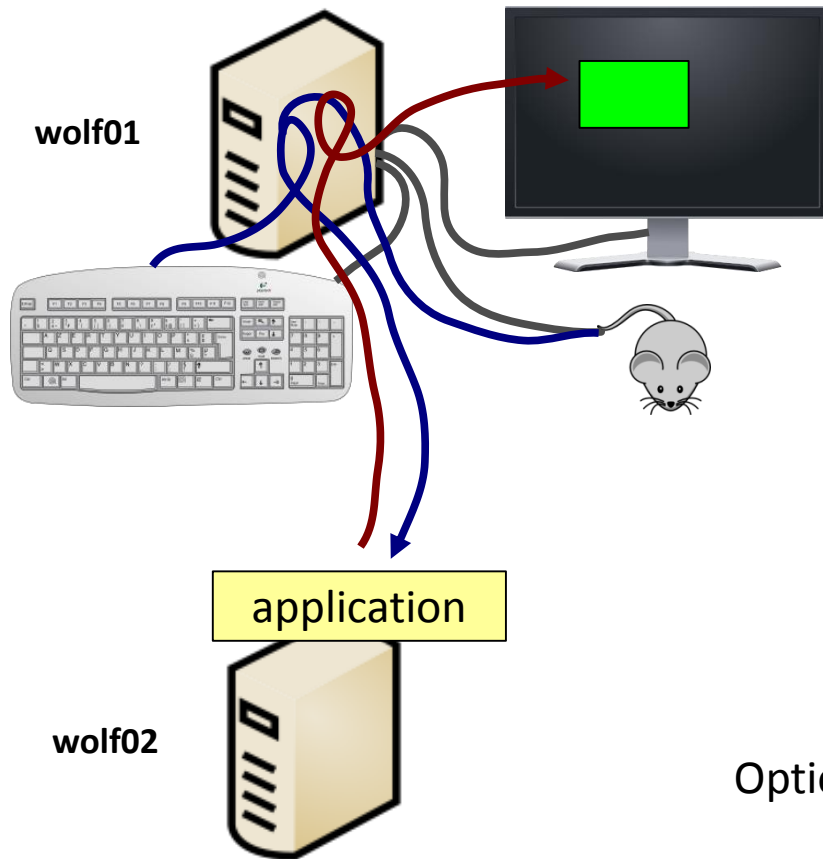


GUI = Graphical User Interface

Display export



Display Export



ssh command sets all requirements for display export automatically when using option -X (large X).

```
[wolf01] $ ssh -X wolf02  
[wolf02] $ ./my_application
```

Option -x (lowercase x) forbid the export

Option -X is enabled by default on the WOLF cluster.

Display export can also be done manually, however, it is necessary to set the **DISPLAY** variable correctly and execute commands xhost and xauth

Display Export - Recommendations

- Display export requires high quality of network connectivity with low latency and high transfer speed
- Requirements for the transfer speed and compatibility of the graphical interfaces of the local and remote computer rise in the case of applications displaying 3D graphics (OpenGL).
- It is recommended to avoid display export (by e.g., moving the data to the local computer and displaying them by application run locally). It is more suitable to use **VNC (Virtual Network Computing)** when display export is necessary.



Notes to VNC:

- WOLF cluster has forbidden ports 5900 and higher (firewall), which are by default used by VNC protocol. Therefore, VNC client must be connected to the VNC server through the appropriate port by an ssh tunnel.
- All requirements are automatically set by module tigervnc on machines with available Infinity environment.

\$ module help tigervnc

Exercise III

1. Log in to your colleague's workstation.
2. Run on his machine program **nemesis** (module nemesis)
3. Verify in the list of running programs (**ps -e**), that the application really runs on the remote machine.
4. Verify that your workstation is running nemesis (**ps -u username**) started by your colleague.
5. What do the options **e** and **u** of ps command do?

Work in pairs, use multiple terminals

Kerberos

https://cs.wikipedia.org/wiki/Kerberos_%28protokol%29

Why do I do not need to retype my password?

More detailed information in the C2115 course.

Kerberos

WOLF cluster uses **Kerberos** system to authenticate the user's identity. After primary verification (username/password), the user obtains a ticket from **META** realm. While the ticket is valid, it authenticates the user to use services of the cluster and to log in on machines of the same realm without further typing of password.

Kerberos is a network authentication protocol, that allows anyone to securely prove their identity to someone else in non secure network. Kerberos prevents listening to or repeating of such communication and ensures data integrity. It was created primarily for client-server model and provides mutual authentication - both client and server identify their counterparts. Kerberos is based on symmetric cryptography, and therefore needs a trustworthy third party. Optionally, you may use asymmetric encryption in some parts of authentication process.

Kerberos has strict **requirements for time synchronization of clients and servers**. Tickets have given lifetime and if the client time is not synchronized with the server time, authentication fails. Standard setting by MIT requires that these times do not differ by more than **5 minutes**. In practice, NTP (**Network Time Protocol**) is used to synchronize time.

wikipedia.org

Commands

- kinit** creates new Kerberos ticket
- klist** prints existing Kerberos tickets
- kdestroy** deletes existing Kerberos tickets

META realm



```
[kulhanek@pes ~]$ kinit
Password for kulhanek@META:
[kulhanek@pes ~]$ klist
Ticket cache: FILE:/tmp/krb5cc_1001
Default principal: kulhanek@META
```

Valid starting	Expires	Service principal
01/30/2016 23:28:30	01/31/2016 23:28:24	krbtgt/META@META

```
[kulhanek@pes ~]$ kdestroy
[kulhanek@pes ~]$ klist
klist: No credentials cache found (ticket cache
FILE:/tmp/krb5cc_1001)
[kulhanek@pes ~]$
```

Ticket Expiration

When ticket expires, further access to services that require it will be denied. It can lead to errors with access denying. **Some errors are might not be clear and finding the cause of the error may not be straight forward.** Typically, this situation occurs in the sessions, that are opened longer than the validity of Kerberos ticket, and it is related mainly to software activated with the command module or physically located on the AFS file system (almost all the software in MetaCentrum and WOLF cluster).

If something starts to behave strangely (not working software modules), verify that you have valid Kerberos tickets (klist) and eventually re-create them (kinit).

Exercise III

1. Verify the status of Kerberos ticket. When do they expire?
2. Log in to the neighboring computer using **ssh**. Is password required?
3. Try it again, but first remove the Kerberos tickets using command **kdestroy**.
4. Try it again, but first restore tickets using command **kinit**.

Virtualization

- **what is virtualization**
- **typical use**
- **overview of hypervisors**
- **MS Windows in VirtualBox**
- **installing Ubuntu OS**

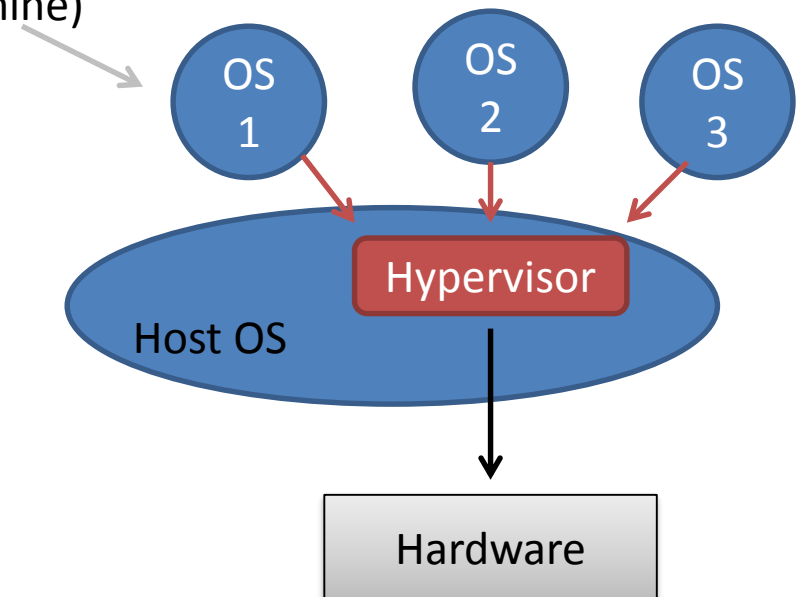
Virtualization - Hypervisor

Virtualization are procedures and techniques that allow to use the available resources in different ways than they physically exist. You can virtualize at **different levels**, from whole computer (called **virtual machine**) to the individual hardware components (e.g., virtual processor, virtual memory) or software-only environment (OS virtualization)

Source: www.wikipedia.org

Hypervisor – manager of virtual machines

Guest OS (in virtual machine)



Advantages of Virtualization

- Single physical machines can run **multiple virtual machines** (each can have different OS).
- Performance of the physical hardware is better utilized (lower operating costs).
- Easier backup. State of virtual machines can be recorded in a so-called **snapshots**, from which it is possible to **restore** virtual machine.
- **Teleportation**. Virtual machines can be transferred between two physical machines with minimal time of virtual machine shutdown. Useful when replacing the defective hardware or upgrade.
- **Easier testing of OS.**

List of Tools for Virtualization

VirtualBox

www.virtualbox.org

Supported host OS: MS Windows, Mac OS X, Linux

License: freeware + proprietary extensions for non commercial use

KVM

part of the host kernel

Supported host OS: Linux

Supports programs: virt-manager , qemu

License: freeware

VMWare

<http://www.vmware.com/>

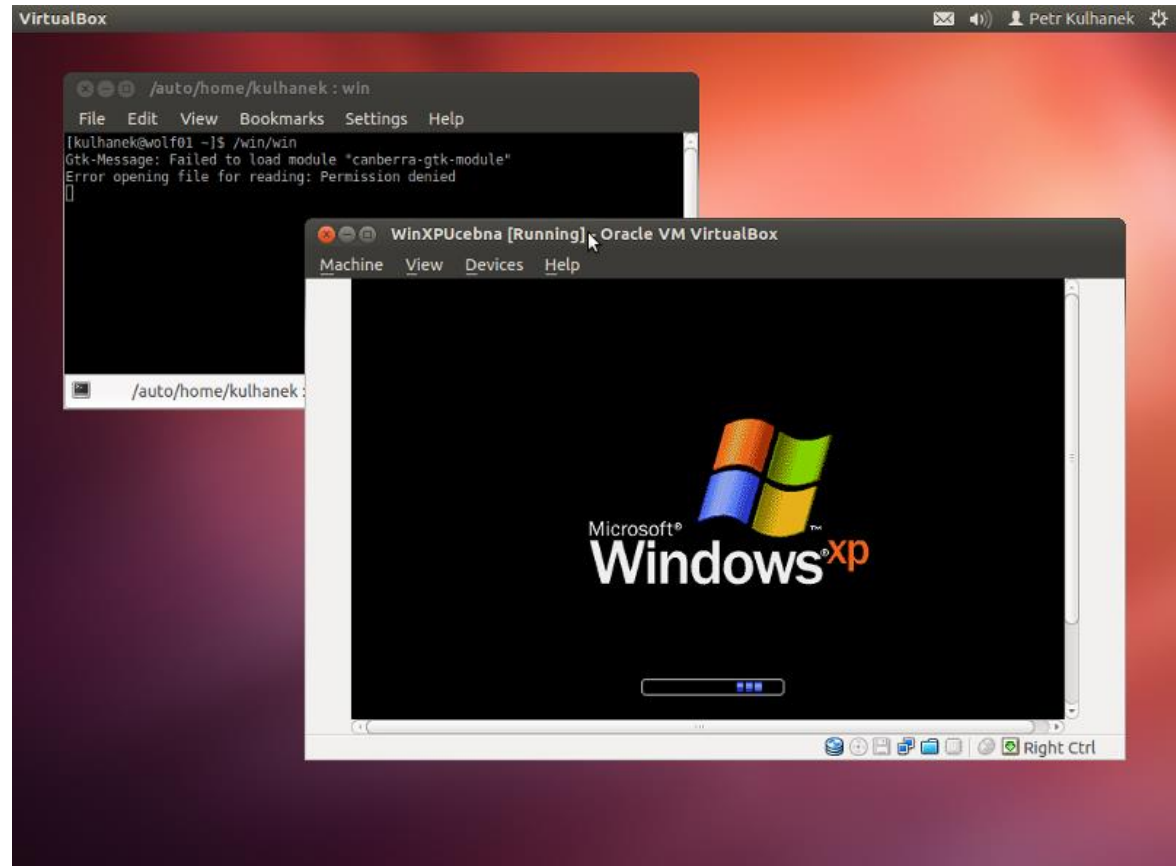
Supported host OS: MS Windows, Linux

License: commercial

MS Windows in WOLF cluster

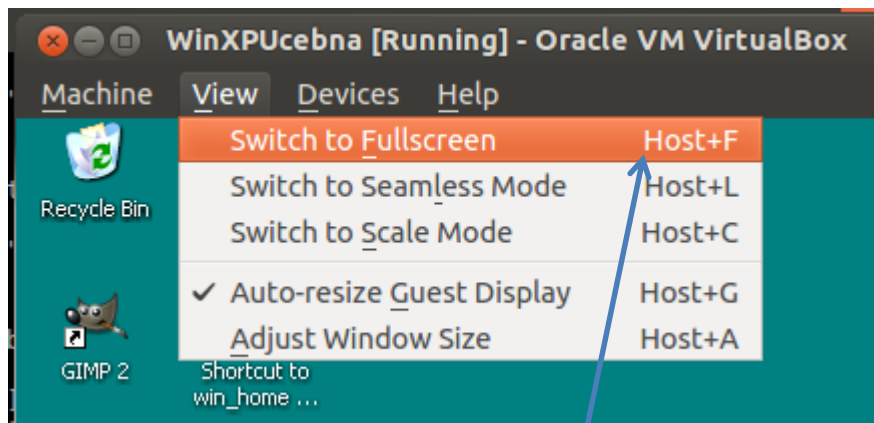
Launched MS Windows XP in a virtual machine (VirtualBox hypervisor)

```
$ /win/win7uc/start
```



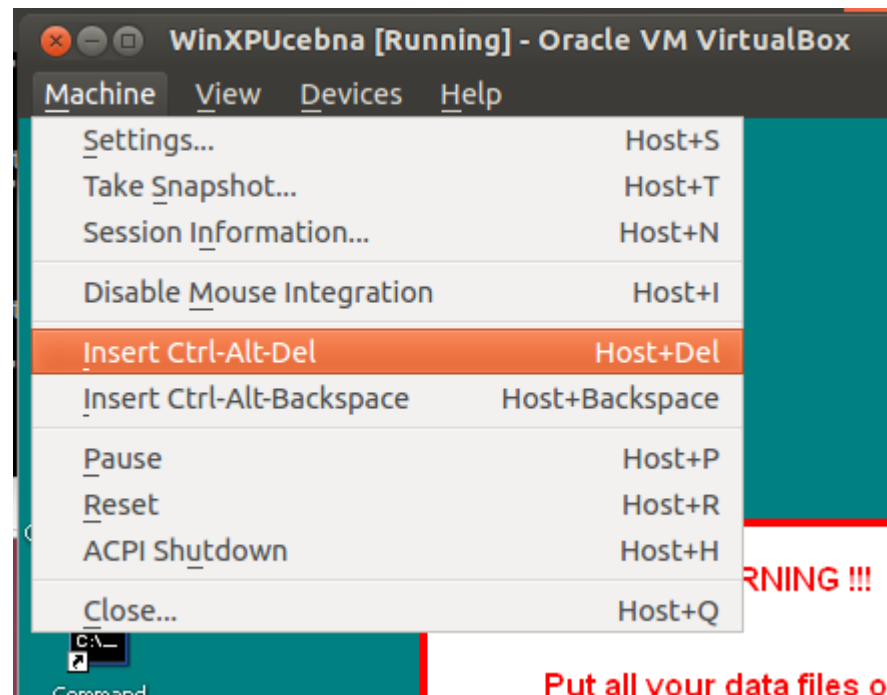
Control of Virtual Machine

Switching to/from Fullscreen



Host = (right key Ctrl)
(MS Windows and Linux)

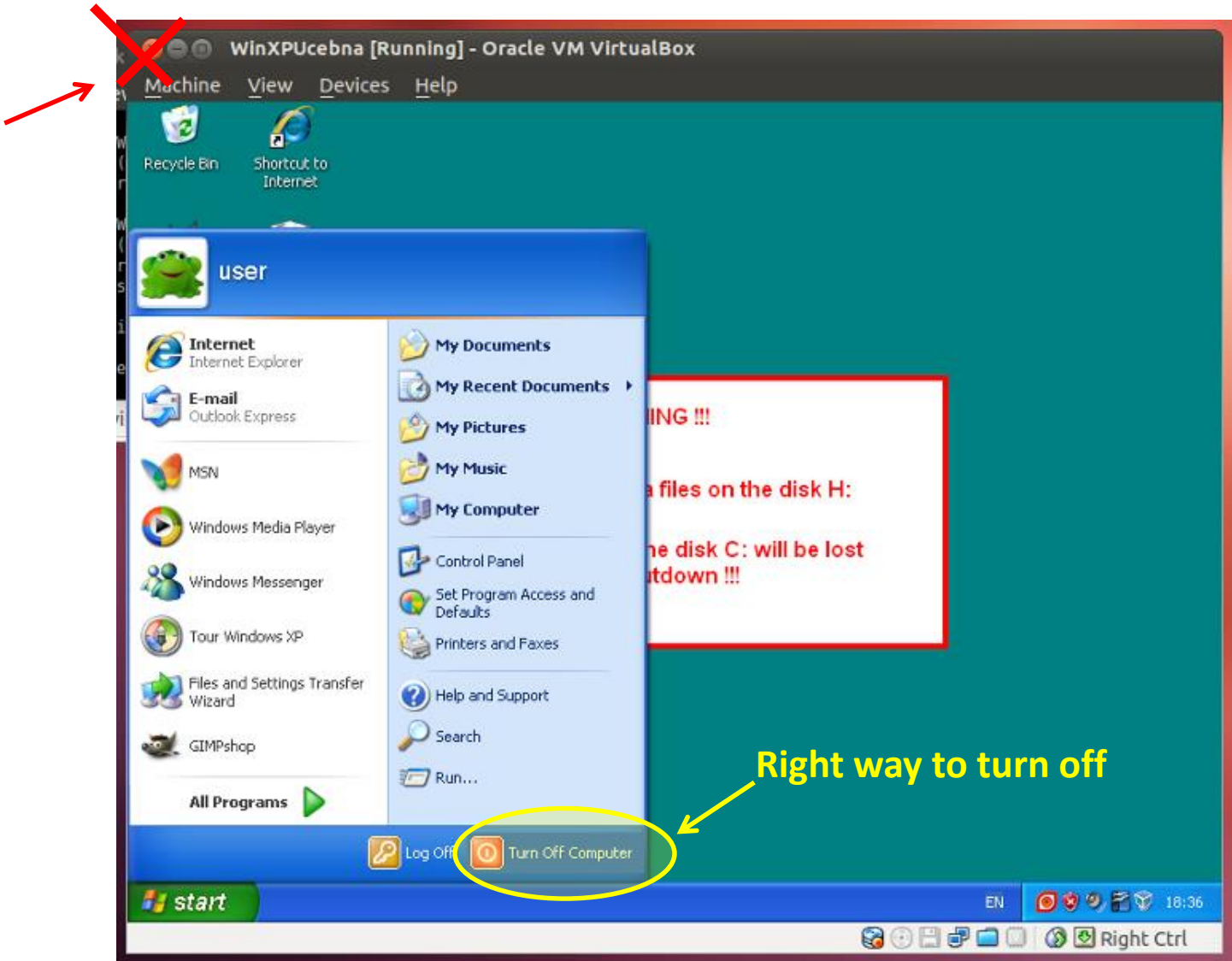
Pressing keys Ctrl+Alt+Del



WARNING !!! Put all your data files on

Turning Off the Virtual Machine

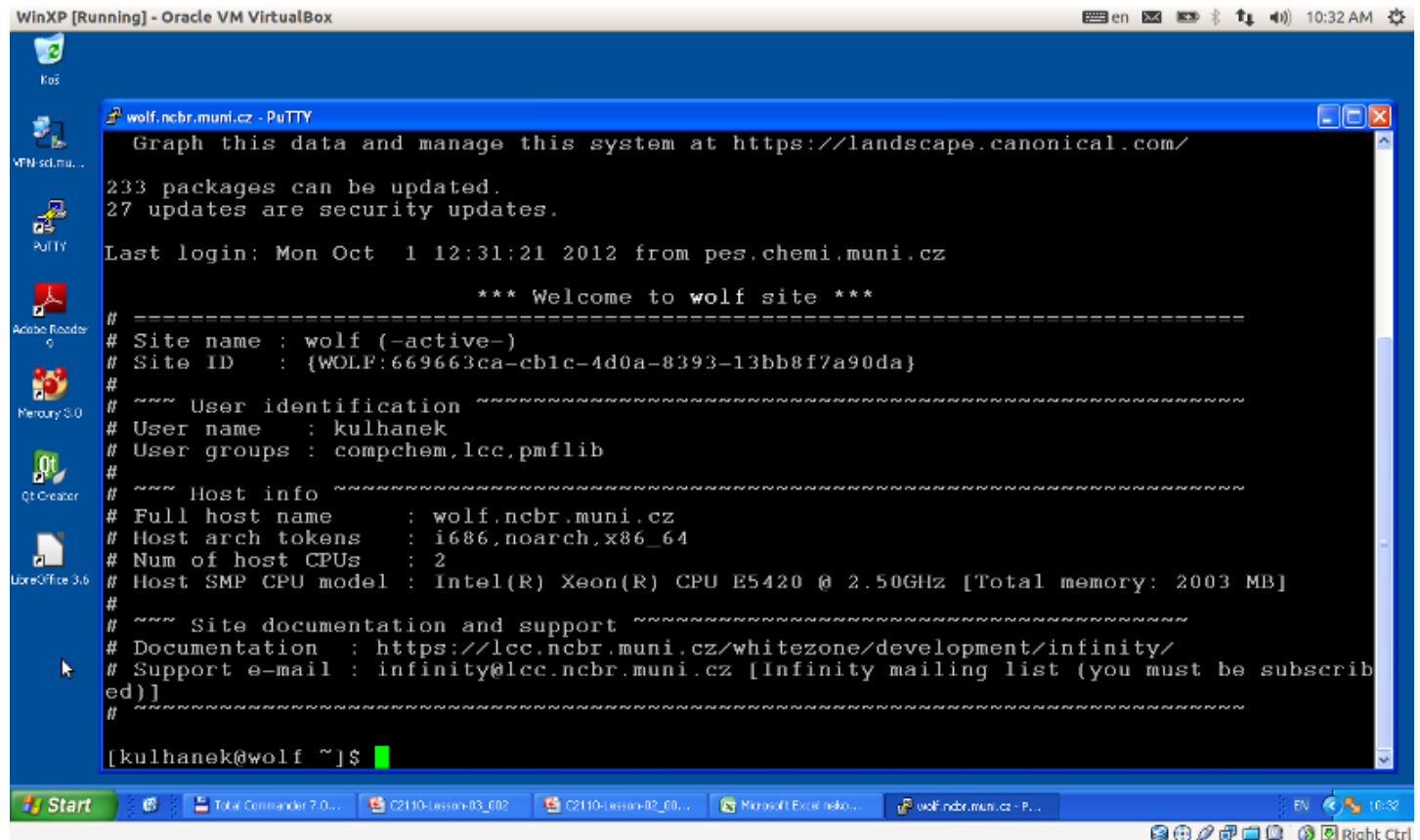
Wrong way of turn off



Right way to turn off

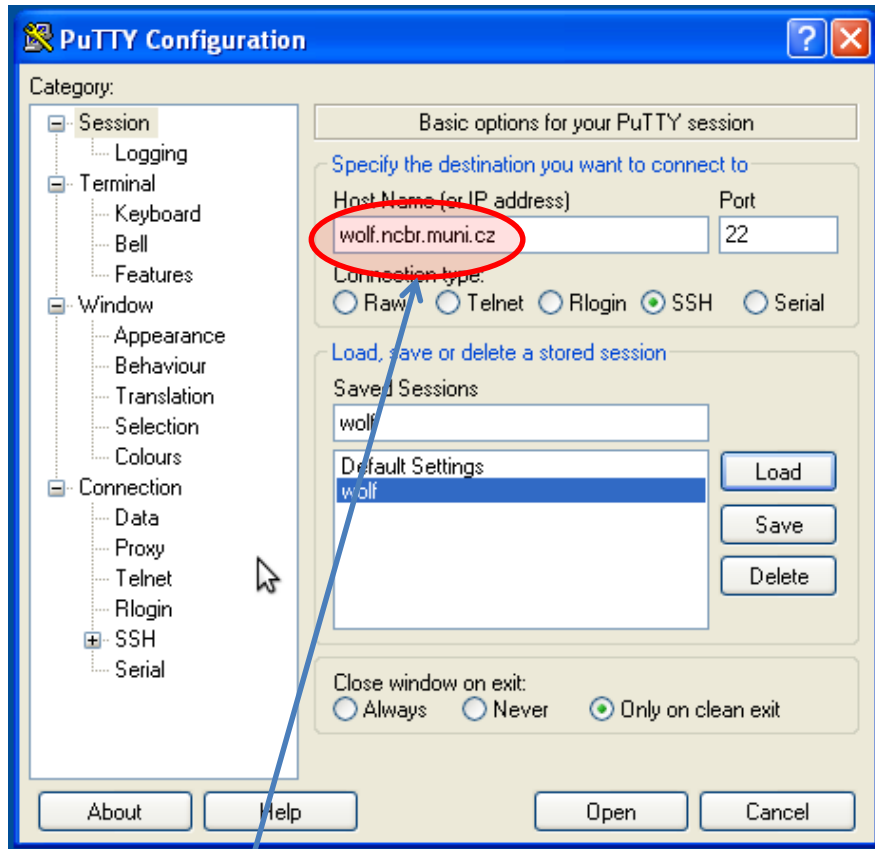
Putty

Putty <http://www.chiark.greenend.org.uk/~sgtatham/putty/>
Implementation of SSH (Secure Shell) for Windows, which allows remote log in to computers that support this type of protocol (mostly Unix).



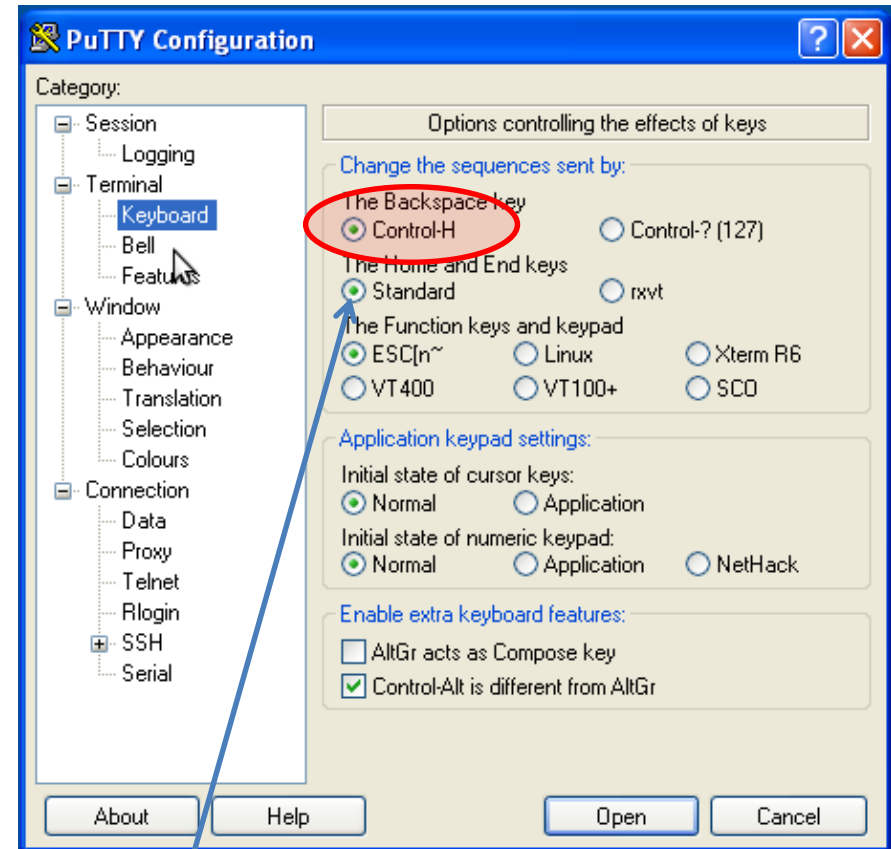
```
WinXP [Running] - Oracle VM VirtualBox
en 10:32 AM
wolf.ncbr.muni.cz - PuTTY
Graph this data and manage this system at https://landscape.canonical.com/
233 packages can be updated.
27 updates are security updates.
Last login: Mon Oct  1 12:31:21 2012 from pes.chemi.muni.cz
*** Welcome to wolf site ***
# -----
# Site name : wolf (-active-)
# Site ID   : {WOLF:669663ca-cb1c-4d0a-8393-13bb8f7a90da}
#
# ~~~ User identification ~~~
# User name   : kulhanek
# User groups : compchem,lcc,pmflib
#
# ~~~ Host info ~~~
# Full host name   : wolf.ncbr.muni.cz
# Host arch tokens : i686,noarch,x86_64
# Num of host CPUs : 2
# Host SMP CPU model : Intel(R) Xeon(R) CPU E5420 @ 2.50GHz [Total memory: 2003 MB]
#
# ~~~ Site documentation and support ~~~
# Documentation : https://lcc.ncbr.muni.cz/whitezone/development/infinity/
# Support e-mail : infinity@lcc.ncbr.muni.cz [Infinity mailing list (you must be subscribed)]
#
[kulhanek@wolf ~]$
```

Putty – settings



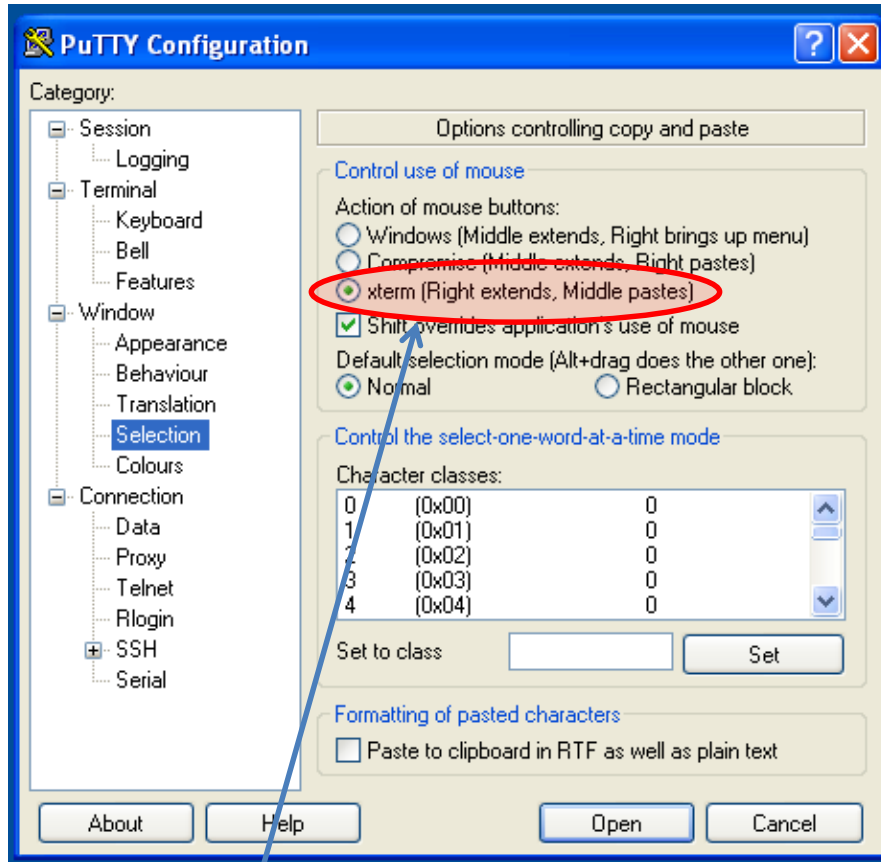
Address of remote machine

wolf.ncbr.muni.cz

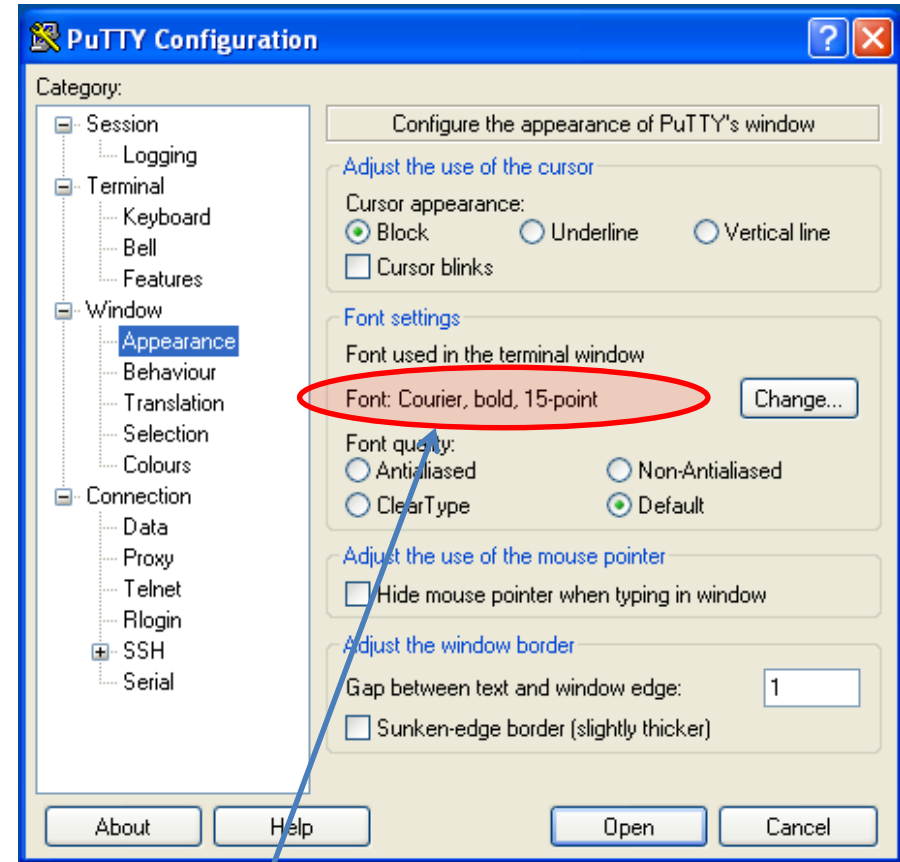


For proper function of the backspace key.

Putty – settings II



mouse selection compatible with Unix terminal



non-proportional font (all characters have the same width)

Exercise V

1. Start virtual machine with MS Windows 7 (`/win/win7uc/start`).
2. In the virtual machine, open **Internet Explorer** and in Wikipedia (English) find keyword Hypervisor.
3. Monitor run of the hypervisor on the host machine by using **top** (termination by pressing key q) .
4. Pause and resume running of the virtual machine.
5. Open **Putty** in MS Windows.
6. Make settings according to previous pages and log in to the frontend of cluster WOLF (**wolf.ncbr.muni.cz**)
7. Print users logged to frontend, both in the Putty terminal and your host machine. Compare them.
8. launch nemesis (module nemesis) in Putty terminal. Explain the behavior.
9. Terminate Putty by command **exit**.
10. Turn off your virtual machine.

Conclusion

Conclusions

- Linux is a **multi-user operational system**, which allows parallel work of more users, who can be **logged locally or remotely**.
- Linux has native support of **remote launching of applications** with graphical output (GUI).
- Linux has **support for running virtual machines**, thus it can run instances of MS Windows OS.
- **System is very well documented** (commands, etc.)

Homeworks

- **Installation of Ubuntu 16.04 LTS**



Instalation Ubuntu 16.04 LTS

- Install VirtualBox (<http://www.virtualbox.org>).
- Download installation image for OS Ubuntu in iso format
<http://www.ubuntu.com/>
Ubuntu 16.04 LTS (Ubuntu Desktop)
- Create virtual machine in VirtualBox manager
chose OS Linux and Ubuntu version
keep rest of the setting default
- First launch of virtual machine
when first starting virtual machine, you will be asked to insert installation medium, insert medium to the virtual machine in form of iso (right icon and select the downloaded image)
- Installation of system
when installation starts, continue according to the instructions of the installation wizard.



Homework.