Welcome to Linux world

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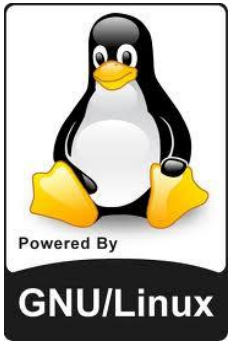


Course Perspective

- **Most Systems Courses are Builder-Centric**
  - Computer Architecture
    - Design pipelined processor in Verilog
  - Operating Systems
    - Implement sample portions of operating system
  - Compilers
    - Write compiler for simple language
  - Networking
    - Implement and simulate network protocols

Course Perspective (Cont.)

- **Our Course is Programmer-Centric**
  - Purpose is to show that by knowing more about the underlying system, one can be more effective as a programmer
  - Enable you to
    - Write programs that are more reliable and efficient
    - Incorporate features that require hooks into OS
      - E.g., concurrency, signal handlers
  - Cover material in this course that you won't see elsewhere
  - Not just a course for dedicated hackers
    - **We bring out the hidden hacker in everyone!**

Policies: Labs

- **Work groups**
  - You must work alone on all lab assignments
- **Handins**
  - Labs due at 11:59pm on Monday or Wednesday
  - Electronic handins using **Autolab** (no exceptions!)
- **Labs will use the Linux Servers**
  - `linux> ssh -p xx22 student-id@ics9.pku.edu.cn`
  - 8 servers
    - 1 gateway machine, 3~4 student machines (for student logins)
    - 1 head node (for Autolab server)
    - 1 grading machines (for autograding)
  - Each server:
    - 8 Intel Xeon E5-2650 (32 cores)
    - 32 GB DRAM
    - Ubuntu 16.04 amd64

Timeliness and version limit

- **Grace days**
  - **5 grace days for the semester**
  - **Limit of 2 grace days per lab used automatically**
  - Covers scheduling crunch, out-of-town trips, illnesses, minor setbacks
  - Save them until late in the term!
- **Lateness penalties**
  - Once grace day(s) used up, get penalized **10% per day**
  - No handins later than **3 days after due date**
- **Late Slack: 3600**
  - This is the number of seconds after a deadline that the server will still accept a submission and not count it as late.
- **Default Version Threshold: 16**
  - If a submission's version is greater than this threshold, it is penalized according to the version penalty.
- **Default Version Penalty: ~10% points**
  - The penalty applied to submissions with versions greater than the version threshold.

内容

- Linux入门
- Linux编程与工具
- Autolab简介

Linux入门

师傅领进门，修行在个人

Shell

- **Shell definition: interface between the user and the operating system**
  - fully programmable, interpreted
  - will read from standard input or file input; interacting with system vs. shell programming
- **Different shells (targeted toward different uses and applications)**
  - Bourne (sh) — original UNIX shell
  - Korn (ksh) — superset of Bourne
  - C (csh) — has a C-like syntax
  - Bash (bash) — bourne again shell, superset of Bourne
  - tcsh, zsh, ...
  - develop your own!
- **Environmental variables: HOME, USER, PS1**

Accessing your Linux account

- **SSH: Secure SHell**
- **Login process**
  - login name echo'ed
  - password not echo'ed
  - if you enter an invalid string for either, the system will not indicate which was invalid
- **Some system status commands:**
  - date, hostname, whoami (or logname), who, w, uptime (when was the system last rebooted), uname
  - the password are changed by execution of the passwd utility program
- **Logging out**
  - hit <ctrl-d> or enter exit

Change your password: `passwd`

SSH: Secure SHell

- **a common protocol for connecting to remote computers**
- **several free versions of SSH available**
  - My personal favorite is PuTTY
- **File transfer**
  - scp
  - sftp

Windows和Linux互传文件的问题:
权限和文本换行符

Kernel *meta*characters

- **Priority: shell does not receive command line until kernel has interpreted all kernel *meta*characters**
  - erase (^?): deletes previous character
  - kill (^U): deletes entire line
  - eof (^D): end of file
  - intr (^C): kills current foreground process
  - suspend (^Z)
  - stop (^S)
  - start (^Q)
  - and others
- **stty -a (displays them)**
  - get/set kernel *meta*characters
- **tset/reset**
  - terminal initialization

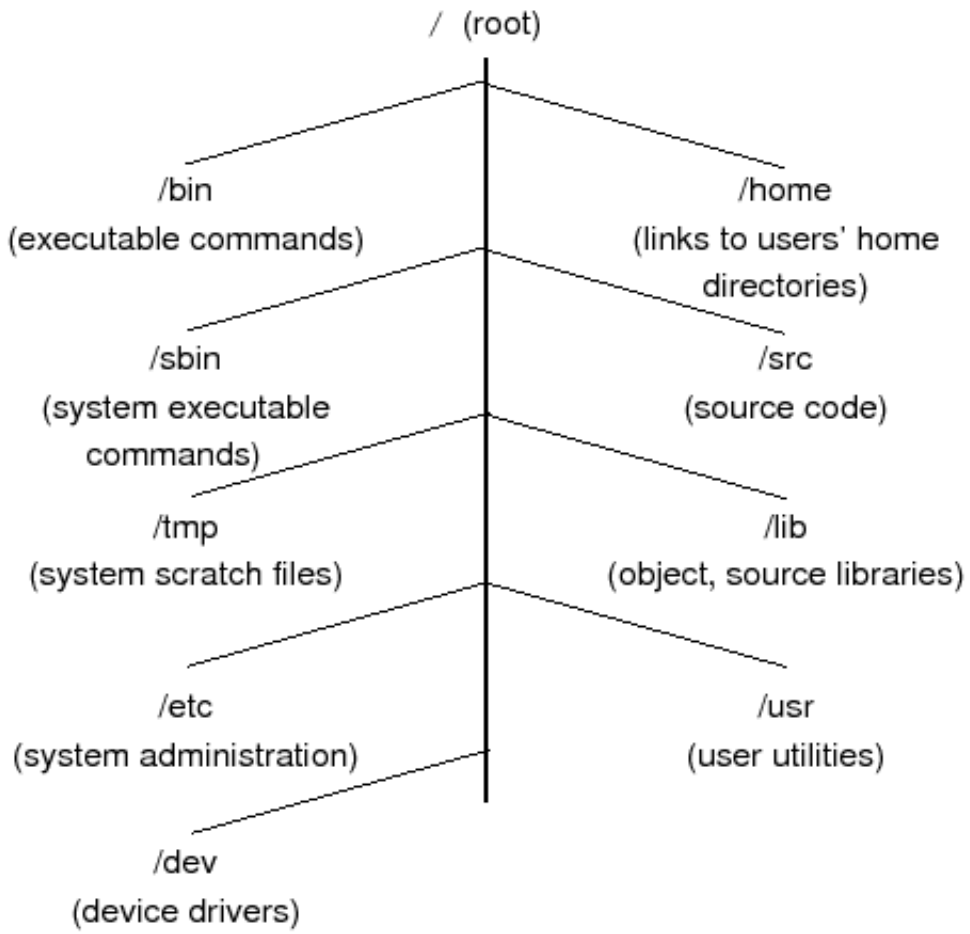
General syntax of UNIX commands

- **<command> [<*options*>] [<*argument(s)*>]**
- **examples:**
  - **$ ls**
  - **$ ls -l**
  - **$ ls -l myfile**
  - **$ ls -ld mydir**
  - **$ ls -F mydir**
  - **$ ls -al**
  - **$ ls -a -l (POSIX)**
  - **$ ls -l -d mydir**
- **command names (like filenames) are case sensitive**

Getting help on the UNIX system

- **For a help on a particular command, use man <command>**
  - man retrieves the manpage (manual page) for any command (and functions in C libraries)
  - e.g., man wc, man -s 3C printf, or man fgetc
  - man man (eerie self-referential command) (*eerie: weird, mysterious, supernatural*)
- **For all commands on a general topic, use apropos**
  - `apropos <keyword/topic>, e.g., apropos copy`
  - `apropos = man -k`
- **Examples:**
  - `whatis = man -f <title>`
  - `manpage can be searched with /<keyword/topic>`
  - `man printf (which section?)`
  - `use man -a printf (all)`
  - `man -s 2 fork`
  - `man -s 3 intro`

UNIX Filesystem



- Abstract: file
- highest level directory = root /
- working directory

Absolute vs. relative path

- **pathname: filename preceded by directories leading to the file**
  - absolute pathname: the complete pathname of a file starting with the root /
  - relative pathname: pathname which implicitly starts at the working directory
- **two special files in every directory**
  - . is a link to the current working directory
  - .. is a link to the directory containing the current working directory (i.e., its parent)

File manipulation and management

- **Navigating through directories: cd**
- **File manipulation and management**
  - pwd: print working directory
  - cp <src> <dest>: copy file(s)
  - rm <file(s)> (remove): erases file(s)
  - mkdir <dir(s)> (make directory): creates one or more directories
  - rmdir <dir(s)> (remove directory): deletes one or more directories
  - mv <src> <dest> (move): relocates the file(s) into the specified directory
  - more/less <file(s)> : display <file(s)>
  - head, tail: can specify number of lines with option
  - chmod <mode> <file(s)> : change file mode bits

Linux编程与工具

工欲善其事，必先利其器

Hello world!

- Edit hw.c
- Compile hw.c
- Run hw

```
#include <stdio.h>

int main()
{
  printf("Hello world!\n");
}
```

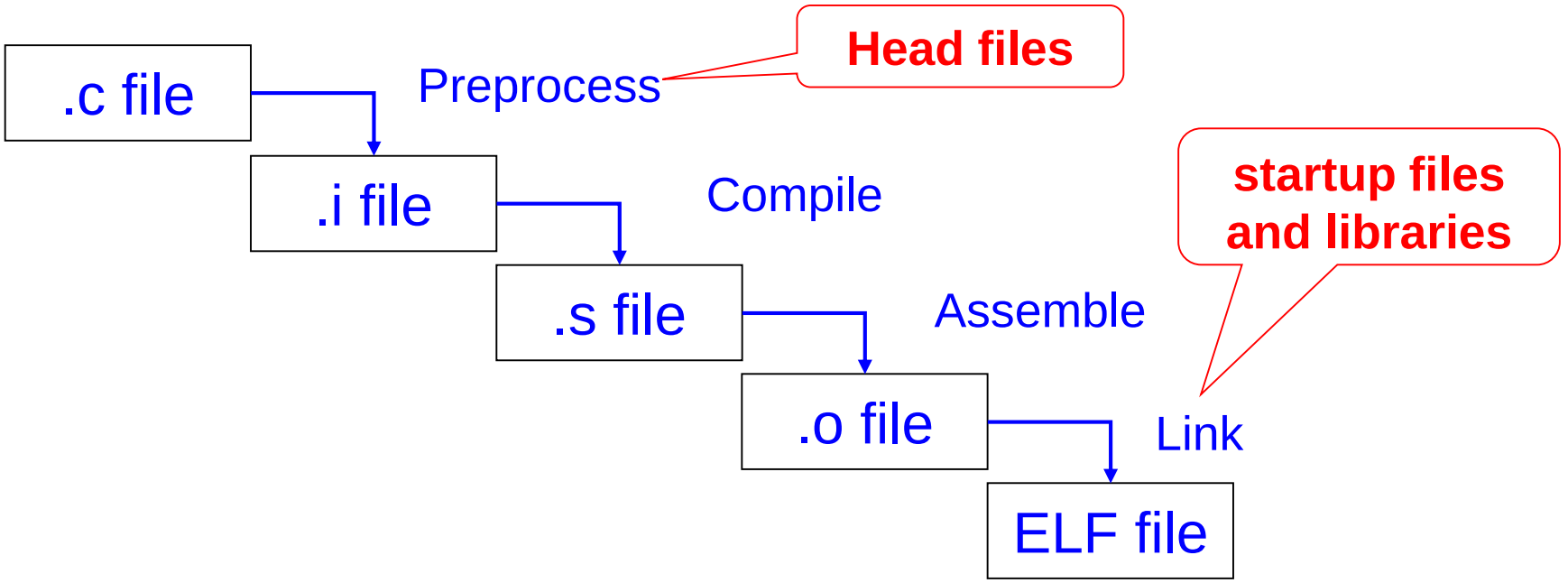
```
$ gcc -o hw hw.c
$
```

```
$ ./hw
Hello world!
$
```

Examine compilation details

```
$ gcc -o hw -save-temps hw.c
$ ll
total 52
drwxr-xr-x 2 guanxuetao guanxuetao  4096 Jul 25 13:52 ./
drwxr-xr-x 3 guanxuetao guanxuetao  4096 Jul 25 10:44 ../
-rwxr-xr-x 1 guanxuetao guanxuetao  7546 Jul 25 13:52 hw*
-rw-r--r-- 1 guanxuetao guanxuetao    63 Jul 25 10:45 hw.c
-rw-r--r-- 1 guanxuetao guanxuetao 21670 Jul 25 13:52 hw.i
-rw-r--r-- 1 guanxuetao guanxuetao   904 Jul 25 13:52 hw.o
-rw-r--r-- 1 guanxuetao guanxuetao   415 Jul 25 13:52 hw.s
$
```

Building flow



Examine the code

`ldd hw`

examine library dependency

`nm hw`

examine symbol name definitions

so many unfamiliar symbols

find "**`T main`**" near at the bottom

Brief anatomy of ELF

Executable and Linking Format

```
file hw
  readelf -a hw
  readelf -S hw
        strip hw
        ls -l
        readelf -S hw
        nm hw
        ldd hw
        ./hw ; echo $?
```

Discard symbols from object files

the vi editor

- **moded editor**
- **two modes**
  - type i to enter insert mode
  - hit <escape> to enter command mode
    - by default in command mode
    - use {h,j,k, l} keys to move {left, down, up, right}, resp., why?
    - u key undoes the previous operation
    - :w (file write)
    - :q (quit, no write)
    - :wq = <shift-ZZ> (file write and quit)
- **`$ vimtutor`**
- **quick reference card/guide**

GNU Tools

- **gcc**
  - GNU Project C and C++ Compiler
- **make**
  - GNU make utility to maintain group of programs
- **gdb**
  - The GNU debugger

GCC

- **gcc options**
  - -c Create symbolic link for each src file
  - -o filename Specify output file as file
  - -x language Expect input file to be written in language
  - -v Verbose mode
  - -S Compile source file into assembler code
  - -E Preprocess source file, do not compile
  - -O[level] Optimize level, 1, 2, 3, 0
  - -g Include debug information as user use gdb
- **Binutils**
  - objdump, strings, readelf, nm, …

Debugging with gdb

- **GDB -- the GNU debugger**
  - Invoked with “gdb [program]” or “gdb --args [program] [arg1] [arg2] ...”
  - To allow gdb access to information about your C source, compile with “gcc -g”
  - Allows you to step through your code, examine program state
- **Breakpoints – tell gdb to “Run until you get to this point”**
  - In gdb, type “break [argument]”
  - Function names
  - Line numbers (with -g)
  - Addresses – e.g. “break *0x00000e80“
- Running your program
  - start
    - Loads your program, but pauses before running any code
  - run
    - Loads your program and starts it executing
    - Runs until it terminates or hits a breakpoint

Debugging – Moving through code

- step/stepi
  - step: Proceed to the next line of code, passing into any function call
  - stepi: Proceed to the next instruction, passing into any function call
  - Without -g, step doesn't know where the next line is
  - Proceeds till program exits
- next
  - Only works with -g
  - Proceeds to the next line of code, running through any functions required to get there
- continue
  - Runs the program until it hits a breakpoint or terminates

Debugging – Examining your Program

- print
  - Takes an expression as its argument
  - With -g, can use variable names
  - Access registers with e.g. $eax
  - Can control formatting:
    - print/x for hex
    - print/t for binary
    - print/s for a null-terminated string
    - others – see “help print” for more information
- examine
  - Shows a memory location
  - Approximately, “examine x” = “print *x”

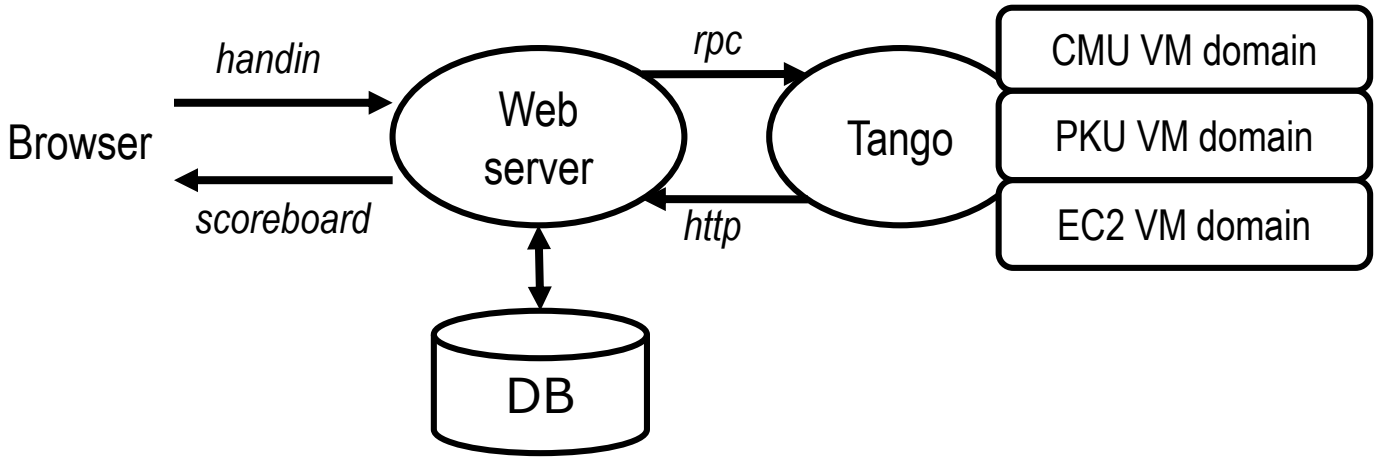
Autolab简介

Autolab Introduction

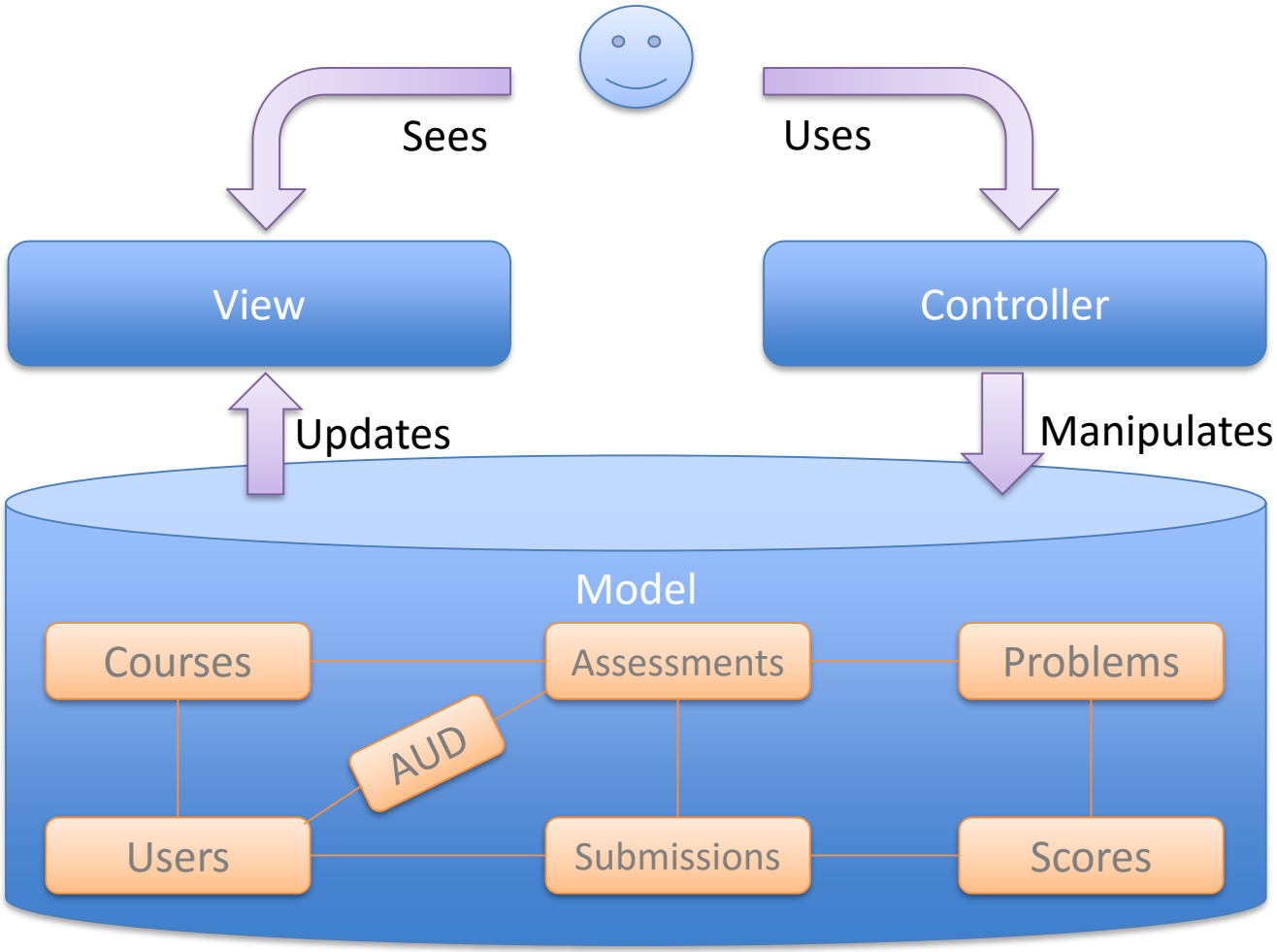
- **An online autograding service that allows instructors to offer programming assignments over the Internet.**
- **Two key ideas: autograding and scoreboards**
  - Autograding:
    - Programs evaluating the quality of other programs.
    - Student handins automatically autograded on secure VMs.
  - Scoreboard
    - Scores are posted in real-time on sorted class scoreboard.
    - Students anonymize themselves with nicknames.
      - "kill -9 ICS", "ICS makes me ANSI"!
- **With Autolab you can use your Web browser to:**
  - Download the lab materials
  - Handin your code for autograding by the Autolab server
  - View the class scoreboard
  - View the complete history of your code handins, autograded results, instructor's evaluations, and gradebook.
  - View the TA annotations of your code for Style points.

Autolab系统组成

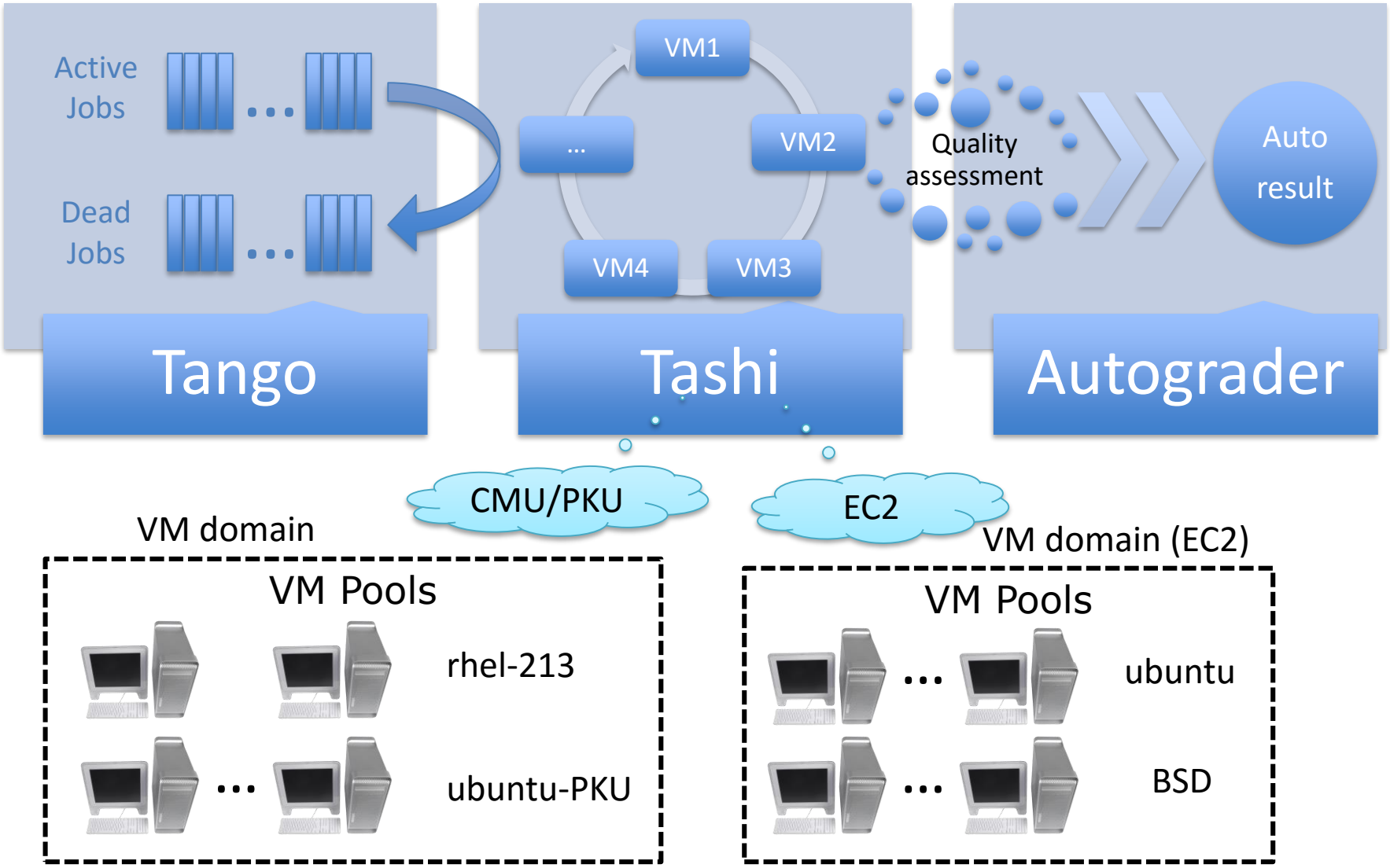
层次结构		基本功能
前端 Front-End	WebServer	用户交互、数据处理
	Database	数据管理、系统管理
后端 Back-End	Tango	任务管理、远程过程调用
	Tashi	集群管理器、节点管理器



前端（Front-End）


Sees
Uses
View
Controller
Updates
Manipulates
Model
Courses
Assessments
Problems
AUD
Users
Submissions
Scores

后端（Back-End）


Active Jobs
Dead Jobs
Tango
VM1
VM2
VM3
VM4
...
Tashi
Quality assessment
Auto result
Autograder
CMU/PKU
EC2
VM domain
VM Pools
rhel-213
ubuntu-PKU
VM domain (EC2)
VM Pools
ubuntu
BSD

Autolab: https://ics16.pku.edu.cn/

- **Account -> Change My Password**
- **Datalab -> View Writeup**
  - datalab.pdf
- **Datalab -> Download handout**
  - datalab-handout.tar
- **Datalab -> Handin your work**
  - bits.c
- **Due date and deadline**

八个实验

	名称	简要描述
L1	datalab	位级数据操作实验
L2	bomblab	拆解二进制炸弹实验
L3	attacklab	缓冲区溢出攻击实验
L4	archlab	处理器结构实验
L5	cachelab	性能优化实验
L6	tshlab	定制shell 程序实验
L7	malloclab	动态内存管理实验
L8	proxylab	Web 代理实验

Welcome and Enjoy!

人难免犯错误，但要真把事情搞砸，还需要一台电脑。

《墨菲定律》

Just do IT!