

CSF2600505 Sistem Operasi CSGE602055 Operating Systems Minggu 00: Intro & Review



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Universitas Indonesia

<http://rms46.vlsm.org/2/207.html>

REV58 28-Aug-2017

Branch: master ▾ **os172 / OS172 /**

 **rms46**  **UI-FASILKOM-OS / os172**

..













 os00-172.pdf	pamulang1 OS172	20 minutes ago
 os01-172.pdf	pamulang1 UF-os172	44 minutes ago
 os02-172.pdf	pamulang1 UF-os172	44 minutes ago
 os03-172.pdf	pamulang1 UF-os172	44 minutes ago
 os04-172.pdf	pamulang1 UF-os172	44 minutes ago
 os05-172.pdf	pamulang1 UF-os172	44 minutes ago
 os06-172.pdf	pamulang1 UF-os172	44 minutes ago
 os07-172.pdf	pamulang1 UF-os172	44 minutes ago
 os08-172.pdf	pamulang1 UF-os172	44 minutes ago
 os09-172.pdf	pamulang1 UF-os172	44 minutes ago
 os10-172.pdf	pamulang1 UF-os172	44 minutes ago
 osXX-172.pdf	pamulang1 UF-os172	44 minutes ago

Figure: Alternatif: BADAK.cs.ui.ac.id:/extra/OS172/

Agenda

- 1 Start
- 2 Agenda
- 3 Pendahuluan
- 4 Goal
- 5 Assessment
- 6 Resources
- 7 Schedule
- 8 Self Service Lab
- 9 QR Code Memo
- 10 Tools
- 11 Lab Programing
- 12 Week 00: Introduction
- 13 Review
- 14 Managers Set
- 15 Potpourri
- 16 The End

- Bekerja di Universitas Indonesia: sejak 1984¹.
- Pengguna GNU/Linux: sejak 1994.
- VauLSMorg (vlsm.org): sejak 1996.
- Blog: `rahmatm.samik-ibrahim.vlsm.org/`
 - Blog: 2016/08/panggil-saya-rahmat.html
 - Blog: 2013/10/kumpulan-hal.html
 - Blog: 2011/08/ibu-ke-pasar-membeli-ayam.html
- Twitter: @rms46
- Facebook (page only): `facebook.com/RMS46F/`
- Kontak via WhatsApp group: +62-881-456-XXXX

¹MDCCXXXIV — Universitas Goettingen didirikan: 1734

TOP 10 REALITA

- 1 Nama saya **Rahmat**. Rahmat nama saya. Kalau bukan Rahmat, bukan nama saya!
- 2 Jangan datang lebih lambat dari pada Pengajar! Terdapat dua kesempatan untuk menyusul masuk kelas: T+15 menit dan setelah istirahat.
- 3 Jangan berisik/asyik sendiri dalam kelas dan jangan main "*games*" dan "*chat*" dengan "*gadget*" anda!
- 4 Jangan lupa mempersiapkan diri untuk berpartisipasi dalam kelas!
- 5 Jangan lupa membawa selembaar kertas (+QRC) untuk membuat memo kuliah!
- 6 Memo kuliah (+QRC) tersebut yang boleh dibawa saat UTS dan UAS.
- 7 Jangan curang!
- 8 Jangan meminjam peralatan selama kuis dan ujian!
- 9 Jangan menghubungi Pengajar untuk masalah Administratip!
- 10 Jangan menjadi "*Puss in Boot*"!

Jangan menjadi Puss In Boot

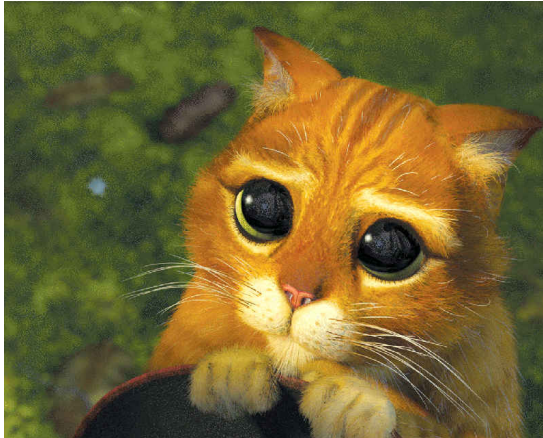


Figure: Ini Puss in Boot¹.

¹This is a fair use of a DreamWorks/Paramount Picture character.

Goal

Coverage

This is an introduction to a modern operating systems course. It will cover general overview, computer architecture review, operating system overview, software licenses, GNU/Linux CLI, versioning, scripting, C language overview, protection, security, gnupg, processes and threads, addressing and pointers, memory management, virtual memory, synchronization, mutual exclusion, deadlock, CPU scheduling algorithms, file systems.

Student-Centered

This course is student-centered where responsibility is in the hands of the students. Students are expected to be prepared for the class meeting.

GNU/Linux

Students will have a thorough understanding of how GNU/Linux provides services by using a Command Line Interface.

85 - ... = A	80 - 85 = A-	75 - 80 = B+	70 - 75 = B
65 - 70 = B-	60 - 65 = C+	55 - 60 = C	50 - 55 = D or C ¹
40 - 50 = D	30 - 40 = E	20 - 30 = E	00 - 20 = E

- **4 SKS:** Alokasikan 12 jam per minggu.
- **No Lab, No Assistant, Active Preparation/Participation Only.**
- UTS: 6 set problem @ 6 point (=36%).
- UAS: 5 set problem @ 6 point (=30%).
- Partisipasi Pra-UTS: 6 set @ 3 poin (=18%).
- Partisipasi Pasca-UTS: 5 set @ 3 point (=15%).
- Extra untuk nilai C keatas: 1 poin¹.
- C-2C untuk nilai C-: hingga 5 poin¹.

¹Syarat dan Ketentuan Berlaku

Resources

- Silakan memilih buku Sistem Operasi yang terbit dalam 10 tahun terakhir.
- OLD — (ARSIP)(017_BAHAN-AJAR-LAMA) Previous Slides.
- SUP — (ARSIP)(041_Suplemen) Supplement.
- OSCE2e — (ARSIP)(050_OSC-Silberschatz) OSCE2e
- UCB — (ARSIP)(070_KULIAH-INTERNASIONAL) UC Berkeley
- UDA — (ARSIP)(070_KULIAH-INTERNASIONAL) UDACITY
- ETC — (ARSIP)(075_ETC-Video) ETC
- DEMO — (GITHUB) <https://github.com/UI-FASILKOM-OS/demo>
- SLIDE — (SLIDE) <http://rms46.vlsm.org/2/207.html>
- SCELE: <https://scele.cs.ui.ac.id/course/view.php?id=124>
 - Enrollment key: "01111000"¹
- ARCHIVE (Arsip bahan pengajaran):
<https://scele.cs.ui.ac.id/course/view.php?id=126>
 - Enrollment key: "11100001"¹.

¹Sewaktu-waktu akan diganti!

Schedule part 1

- Week00 – Intro & Review (OSCE2e ch1/2)(UCB 01)(UDA P1L1/2) (OLD 00)
- Week01 – IPR, REGEX, & Scripting (ETC 000 001 002)(OLD 02-HKI 02-scripting) (Any Related Tutorial)
- Week02 – Protection, Security, Privacy, & C-language (OSCE2e ch13-4) (ETC 050-1 C001-8) (OLD 01) (Any C Language Tutorial)
- Week03 – BIOS, Loader, Systemd, & I/O (Any Related Tutorial) (ETC 300-324) (SUP WEEK03)
- Week04 – Addressing, Shared Lib, Pointer & I/O Programming (OLD 08 10)
- Week05 – Virtual Memory (OSCE2e ch7/8) (UCB 11 12 13) (UDA P3L2) (OLD 06)
- UTS 00 01 02 03 04 05

Schedule part 2

- Week06 – Concurrency: Processes & Threads (OSCE2e ch3/4) (UCB 02 03) (UDA P2L1/2/3) (OLD 03)
- Week07 – Synchronization (OSCE2e ch5) (UCB 7/8) (UDA P3L3/4) (OLD 04)
- Week08 – Scheduling & Network Sockets Programming (OSCE2e ch6) (UCB 9/10) (UDA P3L1) (OLD 05)
- Week09 – File System & Persistent Storage (OSCE2e ch9/10/11) (UCB 17A/18/19) (UDA P4L2 P4L2) (OLD 07 09) (SUP WEEK09)
- Week10 – Special Topic: Blockchain (TBA)
- UAS 06 07 08 09 10

Jadwal

Minggu 00: 27 Aug - 05 Sep 2017
Minggu 01: 06 Sep - 12 Sep 2017
Minggu 02: 13 Sep - 19 Sep 2017
Minggu 03: 24 Sep - 30 Sep 2017
Minggu 04: 01 Okt - 07 Okt 2017
Minggu 05: 08 Okt - 14 Okt 2017
Ming. UTS: 15 Okt - 24 Okt 2017

Minggu 06: 25 Okt - 31 Okt 2017
Minggu 07: 01 Nov - 07 Nov 2017
Minggu 08: 08 Nov - 14 Nov 2017
Minggu 09: 15 Nov - 21 Nov 2017
Minggu 10: 22 Nov - 28 Nov 2017
Cadangan : 29 Nov - 09 Des 2017
Ming. UAS: 10 Des - 23 Des 2017

● Informasi Pendaftaran

- Pengarahan Pendaftaran: 2 September 2017 jam 10:00
<https://scele.cs.ui.ac.id/mod/forum/discuss.php?d=5313>
- Tutorial: <http://bit.ly/Week00>

● Informasi Kuliah, Arsip Ujian, dan Demo

- badak.cs.ui.ac.id/extra/
- <https://github.com/UI-FASILKOM-OS/os172>
- <https://github.com/UI-FASILKOM-OS/demo>
- <https://rms46.vlsm.org/2/195.pdf> — [195.pdf - 205.pdf].

● BASH Account:

- Virtual Ubuntu: badak.cs.ui.ac.id (SSO)
- Ubuntu (BYOD)
- WSL: Windows 10 Subsystem for Linux
- Cygwin (Windows)

● QR Code Memo

- Mempersiapkan Memo Kuliah setiap awal minggu.
- Mengirim Memo ke os172@vlsm.org

QR Code Memo

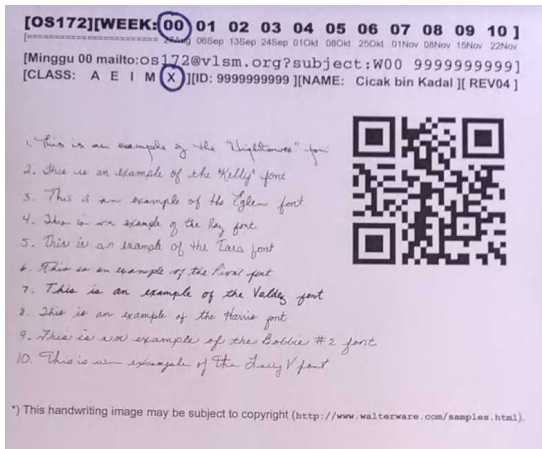


Figure: OS172 X 9999999999 Cicak bin Kadal

QR Code: OS172 CLASS ID NAME

```
# OS172: OS 2017 2nd term
# CLASS: A (reguler) E (Extention) I (International) M (Matriculation)
# ID:      Student ID (NPM)
# NAME:    NAME (SIAK)
```

```
$ qrencode "OS172 X 9999999999 Cicak bin Kadal" -s 20 -o
  OS172-A-9999999999.png
```

```
$ zbarimg OS172-A-9999999999.png
QR-Code:OS172 X 9999999999 Cicak bin Kadal
scanned 1 barcode symbols from 1 images in 0.11 seconds
```



Quick Response (QR) Code

- **Salinan Memo dengan QR Code**

- Silakan membawa kertas A4 ke ruang ujian¹.

- <mailto:os172@vlsm.org>

Minggu:	Subject:
Minggu 00 (Week00)	W00 KELAS NPM
Minggu 01 (Week01)	W01 KELAS NPM
⋮	⋮

Minggu 10 (Week10) W10 KELAS NPM

- Kelas: A (reguler), E (Extention), I (International), M (Matriculation).
- Contoh Subject Minggu 00: W00 A 1106123456
- Harap menghubungi SEKRE (Gedung B lantai 2) untuk segala masalah administratif, terutama absen, sakit, surat sakit, ujian susulan, dst.
- Harap merampungkan masalah administrasi ujian susulan dalam 6 hari kerja.

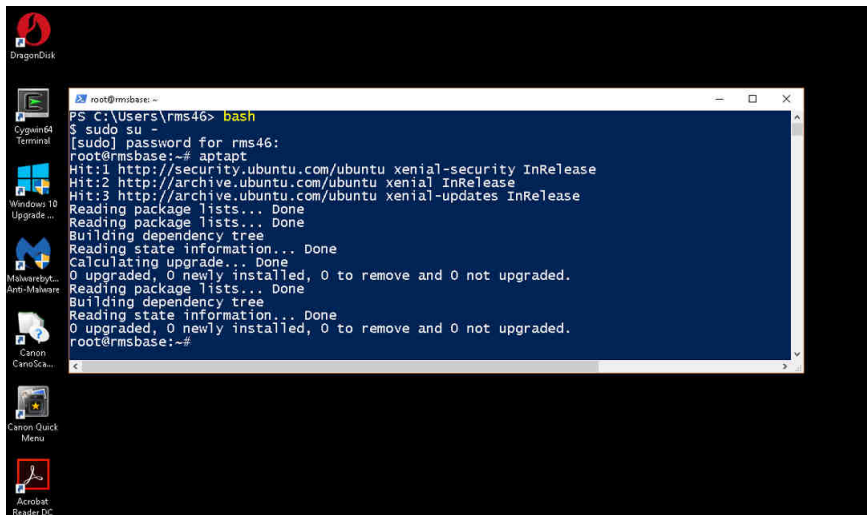
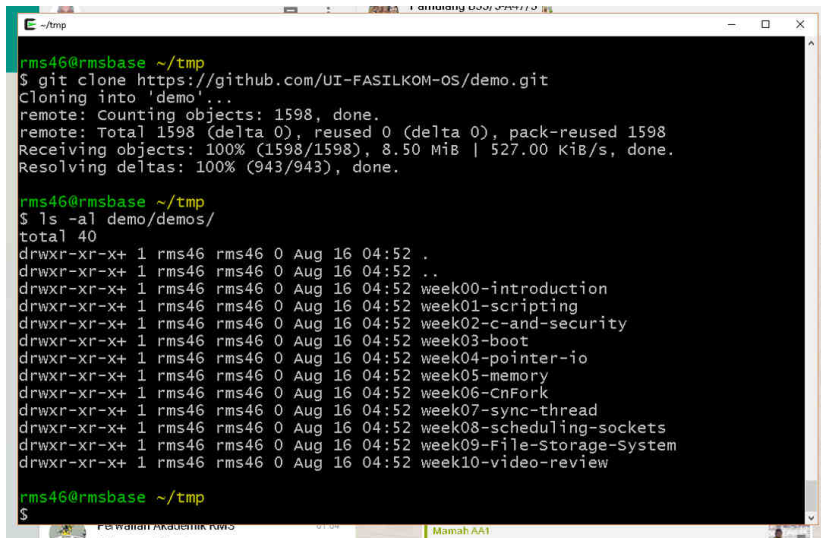


Figure: WSL: Windows Subsystem for Linux

```

$ cd demos/week00-introduction/
$ ls -al
total 4
drwxr-xr-x 0 rms46 rms46 4096 Aug 16 14:25 .
drwxr-xr-x 0 rms46 rms46 4096 Aug 16 14:25 ..
-rw-r--r-- 1 rms46 rms46 250 Aug 16 14:25 c-program-example.c
drwxr-xr-x 0 rms46 rms46 4096 Aug 16 14:25 directory
-rw-r--r-- 1 rms46 rms46 240 Aug 16 14:25 Makefile
$ ls -al directory/
total 0
drwxr-xr-x 0 rms46 rms46 4096 Aug 16 14:25 .
drwxr-xr-x 0 rms46 rms46 4096 Aug 16 14:25 ..
-rw-r--r-- 1 rms46 rms46 58 Aug 16 14:25 file1
-rw-r--r-- 1 rms46 rms46 58 Aug 16 14:25 file2
-rw-r--r-- 1 rms46 rms46 58 Aug 16 14:25 file3
-rw-r--r-- 1 rms46 rms46 58 Aug 16 14:25 file4
-rw-r--r-- 1 rms46 rms46 58 Aug 16 14:25 file5
$ make
gcc -o c-program-example c-program-example.c
$ ls -al
total 20
drwxr-xr-x 0 rms46 rms46 4096 Aug 16 15:21 .
drwxr-xr-x 0 rms46 rms46 4096 Aug 16 14:25 ..
-rwxrwxrwx 1 rms46 rms46 8616 Aug 16 15:21 c-program-example
-rw-r--r-- 1 rms46 rms46 250 Aug 16 14:25 c-program-example.c
drwxr-xr-x 0 rms46 rms46 4096 Aug 16 14:25 directory
-rw-r--r-- 1 rms46 rms46 240 Aug 16 14:25 Makefile
$ ./c-program-example
This is program #1
$
  
```

Figure: WSL: Windows Subsystem for Linux

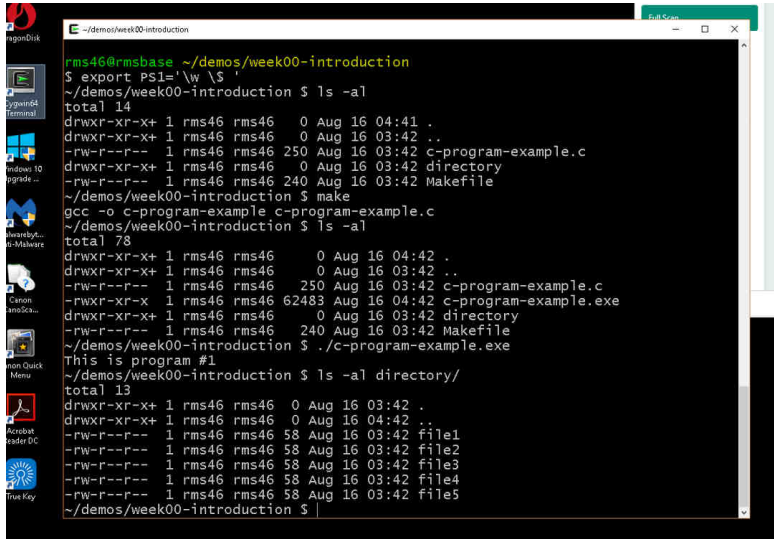


```
rms46@rmsbase ~/tmp
$ git clone https://github.com/UI-FASILKOM-OS/demo.git
Cloning into 'demo'...
remote: Counting objects: 1598, done.
remote: Total 1598 (delta 0), reused 0 (delta 0), pack-reused 1598
Receiving objects: 100% (1598/1598), 8.50 MiB | 527.00 KiB/s, done.
Resolving deltas: 100% (943/943), done.

rms46@rmsbase ~/tmp
$ ls -al demo/demos/
total 40
drwxr-xr-x+ 1 rms46 rms46 0 Aug 16 04:52 .
drwxr-xr-x+ 1 rms46 rms46 0 Aug 16 04:52 ..
drwxr-xr-x+ 1 rms46 rms46 0 Aug 16 04:52 week00-introduction
drwxr-xr-x+ 1 rms46 rms46 0 Aug 16 04:52 week01-scripting
drwxr-xr-x+ 1 rms46 rms46 0 Aug 16 04:52 week02-c-and-security
drwxr-xr-x+ 1 rms46 rms46 0 Aug 16 04:52 week03-boot
drwxr-xr-x+ 1 rms46 rms46 0 Aug 16 04:52 week04-pointer-io
drwxr-xr-x+ 1 rms46 rms46 0 Aug 16 04:52 week05-memory
drwxr-xr-x+ 1 rms46 rms46 0 Aug 16 04:52 week06-CnFork
drwxr-xr-x+ 1 rms46 rms46 0 Aug 16 04:52 week07-sync-thread
drwxr-xr-x+ 1 rms46 rms46 0 Aug 16 04:52 week08-scheduling-sockets
drwxr-xr-x+ 1 rms46 rms46 0 Aug 16 04:52 week09-File-Storage-System
drwxr-xr-x+ 1 rms46 rms46 0 Aug 16 04:52 week10-video-review

rms46@rmsbase ~/tmp
$
```

Figure: Cygwin



```
~/demos/week00-introduction
rms46@rmsbase ~/demos/week00-introduction
$ export PS1='\w \$ '
~/demos/week00-introduction $ ls -al
total 14
drwxr-xr-x+ 1 rms46 rms46  0 Aug 16 04:41 .
drwxr-xr-x+ 1 rms46 rms46  0 Aug 16 03:42 ..
-rw-r--r-- 1 rms46 rms46 250 Aug 16 03:42 c-program-example.c
drwxr-xr-x+ 1 rms46 rms46  0 Aug 16 03:42 directory
-rw-r--r-- 1 rms46 rms46 240 Aug 16 03:42 Makefile
~/demos/week00-introduction $ make
gcc -o c-program-example c-program-example.c
~/demos/week00-introduction $ ls -al
total 78
drwxr-xr-x+ 1 rms46 rms46  0 Aug 16 04:42 .
drwxr-xr-x+ 1 rms46 rms46  0 Aug 16 03:42 ..
-rw-r--r-- 1 rms46 rms46 250 Aug 16 03:42 c-program-example.c
-rwxr-xr-x 1 rms46 rms46 62483 Aug 16 04:42 c-program-example.exe
drwxr-xr-x+ 1 rms46 rms46  0 Aug 16 03:42 directory
-rw-r--r-- 1 rms46 rms46 240 Aug 16 03:42 Makefile
~/demos/week00-introduction $ ./c-program-example.exe
This is program #1
~/demos/week00-introduction $ ls -al directory/
total 13
drwxr-xr-x+ 1 rms46 rms46  0 Aug 16 03:42 .
drwxr-xr-x+ 1 rms46 rms46  0 Aug 16 04:42 ..
-rw-r--r-- 1 rms46 rms46 58 Aug 16 03:42 file1
-rw-r--r-- 1 rms46 rms46 58 Aug 16 03:42 file2
-rw-r--r-- 1 rms46 rms46 58 Aug 16 03:42 file3
-rw-r--r-- 1 rms46 rms46 58 Aug 16 03:42 file4
-rw-r--r-- 1 rms46 rms46 58 Aug 16 03:42 file5
~/demos/week00-introduction $
```

Figure: Cygwin

Github Demo

UI-FASILKOM-OS / demo

Unwatch 5 Star 0 Fork 1

<> Code Issues 0 Pull requests 0 Projects 0 Wiki Settings Insights

Branch: master demo / demos /

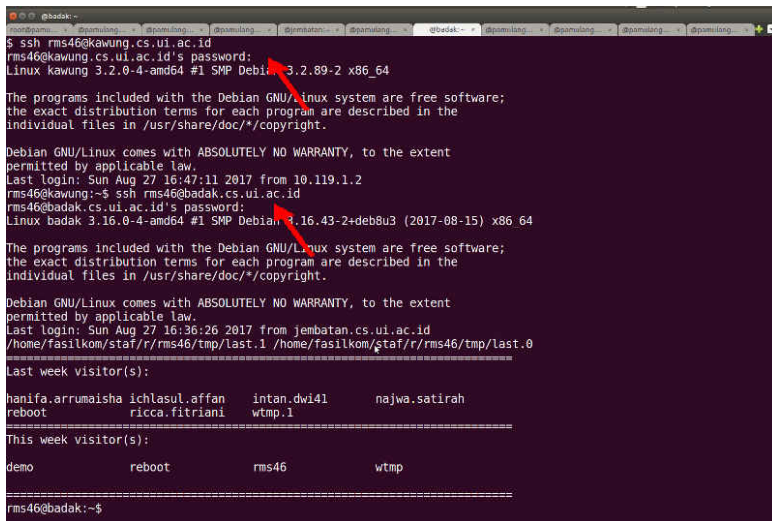
Create new file Upload files Find file History

rms46 edge135 week00-introduction Latest commit 456ae4a 19 hours ago

..		
week00-introduction	edge135 week00-introduction	19 hours ago
week01-scripting	pamulang1: UF-demo	5 months ago
week02-c-and-security	badak demo	6 months ago
week03-boot	badak week03-boot	6 months ago
week04-pointer-io	badak demo	6 months ago
week05-memory	pamulang1: UF-demo	5 months ago
week06-CnFork	rmsbase UF-demo	4 months ago
week07-sync-thread	badak demo	4 months ago
week08-scheduling-sockets	badak demo	10 months ago
week09-File-Storage-System	rmsbase UF-demo	4 months ago
week10-video-review	badak demo	4 months ago

Figure: <https://github.com/UI-FASILKOM-OS/demo>

Login: Kawung dan Badak



```
@badak:~  
$ ssh rms46@kawung.cs.ui.ac.id  
rms46@kawung.cs.ui.ac.id's password:  
Linux kawung 3.2.0-4-amd64 #1 SMP Debian 3.2.89-2 x86_64  
  
The programs included with the Debian GNU/Linux system are free software;  
the exact distribution terms for each program are described in the  
individual files in /usr/share/doc/*/copyright.  
  
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent  
permitted by applicable law.  
Last login: Sun Aug 27 16:47:11 2017 from 10.119.1.2  
rms46@kawung:~$ ssh rms46@badak.cs.ui.ac.id  
rms46@badak.cs.ui.ac.id's password:  
Linux badak 3.16.0-4-amd64 #1 SMP Debian 3.16.43-2+deb8u3 (2017-08-15) x86_64  
  
The programs included with the Debian GNU/Linux system are free software;  
the exact distribution terms for each program are described in the  
individual files in /usr/share/doc/*/copyright.  
  
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent  
permitted by applicable law.  
Last login: Sun Aug 27 16:36:26 2017 from jembatan.cs.ui.ac.id  
/home/fasilkom/staf/r/rms46/tmp/last.1 /home/fasilkom/staf/r/rms46/tmp/last.0  
=====
```

Last week visitor(s):			
hanifa.arrumaisha	ichlasul.affan	intan.dwi41	najwa.satirah
reboot	ricca.fitriani	wtmp.1	

```
=====
```

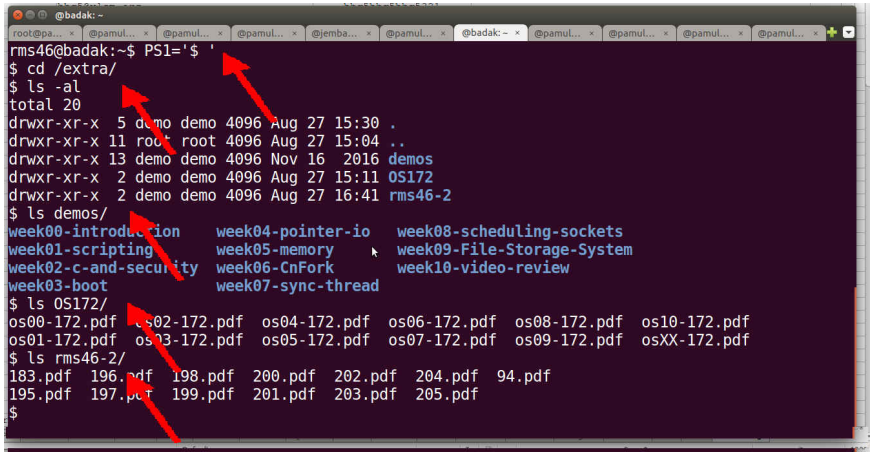
This week visitor(s):			
demo	reboot	rms46	wtmp

```
=====
```

rms46@badak:~\$

Figure: Login: Kawung dan Badak

Resources



```
@badak: ~
root@pa... x @pamul... x @pamul... x @pamul... x @jempa... x @pamul... x @badak: ~ x @pamul... x @pamul... x @pamul... x @pamul... x @pamul... x
rms46@badak:~$ PS1='$ '
$ cd /extra/
$ ls -al
total 20
drwxr-xr-x  5 demo demo 4096 Aug 27 15:30 .
drwxr-xr-x 11 root root 4096 Aug 27 15:04 ..
drwxr-xr-x 13 demo demo 4096 Nov 16 2016 demos
drwxr-xr-x  2 demo demo 4096 Aug 27 15:11 OS172
drwxr-xr-x  2 demo demo 4096 Aug 27 16:41 rms46-2
$ ls demos/
week00-introduction    week04-pointer-io    week08-scheduling-sockets
week01-scripting        week05-memory        week09-File-Storage-System
week02-c-and-security   week06-CnFork        week10-video-review
week03-boot            week07-sync-thread
$ ls OS172/
os00-172.pdf  os02-172.pdf  os04-172.pdf  os06-172.pdf  os08-172.pdf  os10-172.pdf
os01-172.pdf  os03-172.pdf  os05-172.pdf  os07-172.pdf  os09-172.pdf  osXX-172.pdf
$ ls rms46-2/
183.pdf  196.pdf  198.pdf  200.pdf  202.pdf  204.pdf  94.pdf
195.pdf  197.pdf  199.pdf  201.pdf  203.pdf  205.pdf
$
```

The image shows a terminal window with a dark background and white text. The window title is '@badak: ~'. The terminal shows a series of commands and their outputs. Red arrows are drawn on the image, pointing to specific files: 'OS172' in the first 'ls' output, 'week00-introduction' in the 'ls demos/' output, 'os02-172.pdf' in the 'ls OS172/' output, and '183.pdf' in the 'ls rms46-2/' output. The terminal output shows a directory structure with files and subdirectories, including 'demos', 'OS172', and 'rms46-2'.

Figure: Resources

Program Example

```
$ cat c-program-example.c
/* (c) 2016-2017 Rahmat M. Samik-Ibrhaim
 * REV01 Sun Aug 20 15:01:12 WIB 2017
 * START Fri Jan 01 00:00:00 WIB 2016
 * This is a free software.
 * To compile:
 * $ gcc -o c-program-example c-program-example.c
 * To execute:
 * $ ./c-program-example
 */
```

```
#include <stdio.h>
```

```
void main() {
    printf("This is program #1\n");
}
```


Makefile

```
$ cat Makefile
```

```
# (c) 2016-2017 Rahmat M. Samik-Ibrahim  
# REV01 Tue Aug 22 14:45:14 WIB 2017  
# START Fri Jan 01 00:00:00 WIB 2016  
# This is a free Makefile configuration.  
# Just run:  
# % make
```

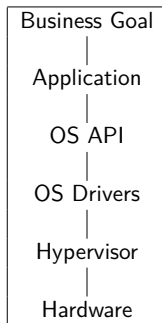
```
ALL:  c-program-example
```

```
c-program-example: c-program-example.c  
    gcc -o c-program-example c-program-example.c
```

```
clean:  
    rm -f c-program-example
```

Week 00: Introduction

- Reference: (OSCE2e ch1/2)(UCB 01)(UDA P1L1/2)(OLD 00)
- Operating System
 - Why take this OS class?
 - Definition: Resource Allocator & Control Program.
 - Managers: Process, Memory, Storage, ...
 - Layers
 - Interfaces



Computer Organization Review

- You should understand:
 - von Neumann Model.
 - Buses, Bridges, Transfer Rate, Clock.
 - Memory: DDR, DDR-2, ...
 - Cache.
 - Direct Memory Access (DMA).
 - Port & Memory Mapped I/O.
 - CPU: privilege/kernel/supervisor mode and user mode.
 - Hardware Limitation.
 - Priority: Read vs Write.
 - Interrupts: Polling & Vectored.
 - Multiprocessors: Symmetric vs. Asymmetric.
 - Multicore & Multithreading.
 - Clustered Systems.
 - Numbers: base 2, base 8, base 10, base 16.
 - Base 2: 110010101010_2
 - Base 8: $01234567_8 = 000\ 001\ 010\ 011\ 100\ 101\ 110\ 111_2$
 - Base 10: $012\ 345\ 679$
 - Base 16: $9AB\ CDEF_{16} = 1001\ 1010\ 1011\ 1100\ 1101\ 1110\ 1111_2$

Managers Set

- Process:
 - Creating/Deleting; Suspending/Resuming; Synchronization; Communication;
- Memory:
 - Tracking; Move In/Move Out; Allocating/Deallocating.
- Storage/File System:
 - Create/Delete; Open/Close; Read/Write.
- Mass Storage:
 - Scheduling; Allocating; Free Space.
- I/O:
 - Buffering; Caching; Spooling.
 - Interfacing (driving).
- Protecting & Scheduling:
 - Protecting.
 - Scheduling.

- Mobile/Distributed/Client-Server/Peer-to-Peer Computing.
- Real-Time Computing: Hard Real-Time vs. Soft Real-Time.
- Operating System Comparison: Android, *BSD, GNU/Linux, iOS, Mac OS, Windows.
- Operating System Services: UI (GUI, CLI); Program Executing; I/O Operations; File Systems Manipulation; Communication; Error Detection; Resource Allocation; Accounting; Protection & Security.
- System Calls: Process Control; File Management; Device Management; Information Maintenance; Communications; Protection.
- Application Programming Interface (API)
- Standard C Library.
- System Programs.
- Microkernel System Structure.
- Loadable Kernel Modules.

The End

- This is the end of the presentation.