

# Operating Systems

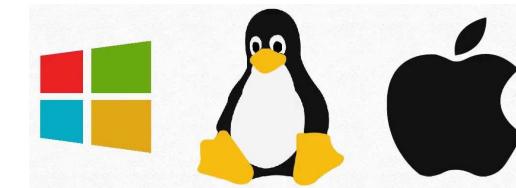
*Time:* Tues. 07:50–09:25

Fri. 14:00–15:35

*Place:* 3A313

Fall 2018

## Part o: Course Overview



## Today's agenda

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### □ Course overview

- ❖ What this course is about?
  - And what it is *not* about?
- ❖ My teaching/your learning strategies
  - Why you should (or *not*) take this course?
- ❖ Administrative aspects
  - How does this course *operate*?

### □ An adventure for thought

- ❖ What is “architecture?”

## OS ?

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Application

Virtual Machine Interface

Operating System

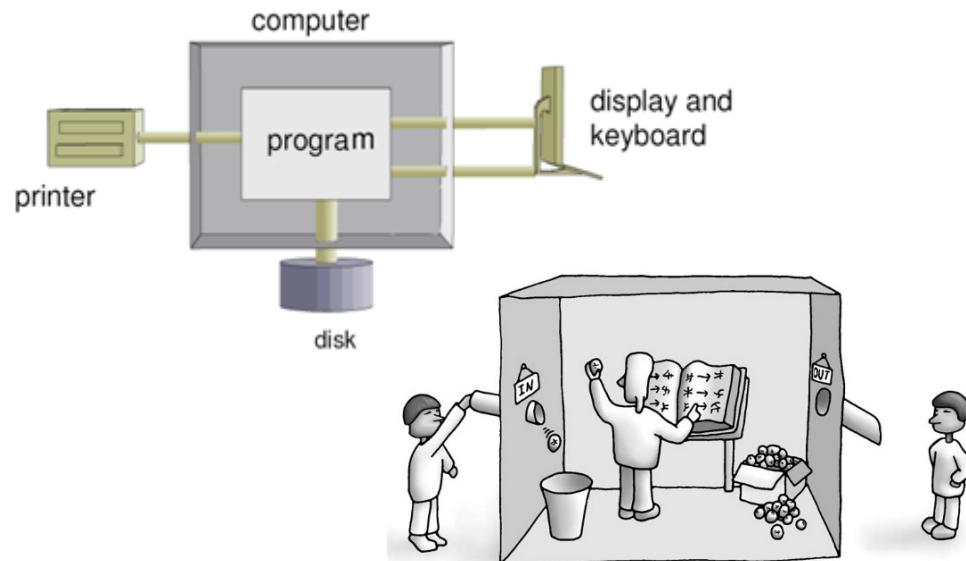
*Kernel*

Hardware

Physical Machine Interface



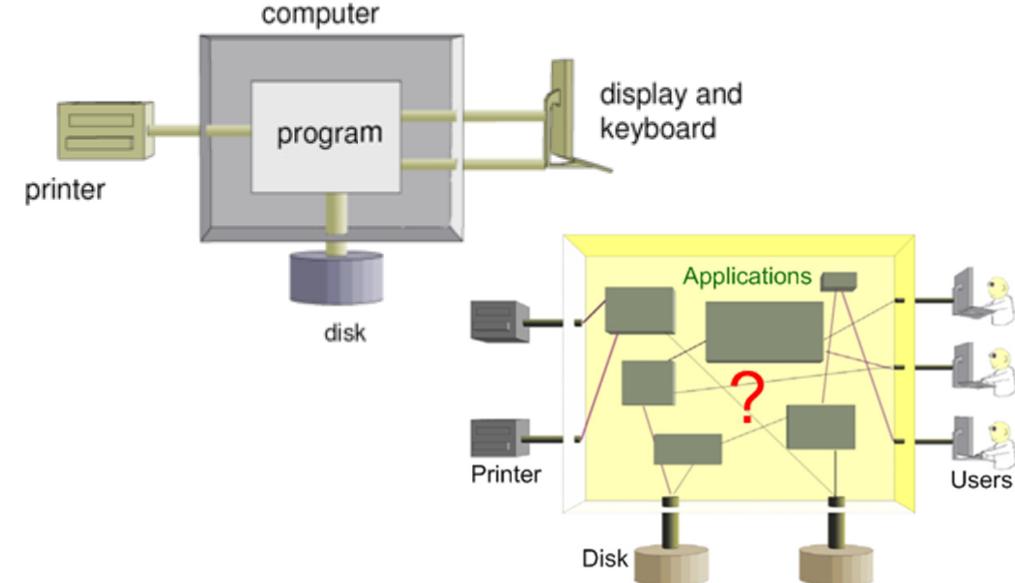
## Abstraction



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## Abstraction



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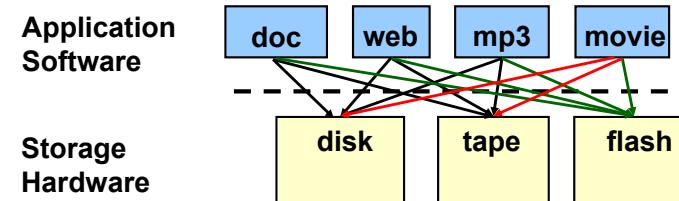
## Organizing computer functionalities

- ❑ Many kinds of computer devices and technologies
  - ❖ e.g., register, cache, memory, disk, tape, flash, etc.
- ❑ Many different applications
  - ❖ e.g., doc, email, web, mp3, movie, etc.
- ❑ Computer architecture
  - ❖ How should different pieces be organized?
  - ❖ How should different pieces interact?

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## A naïve architecture



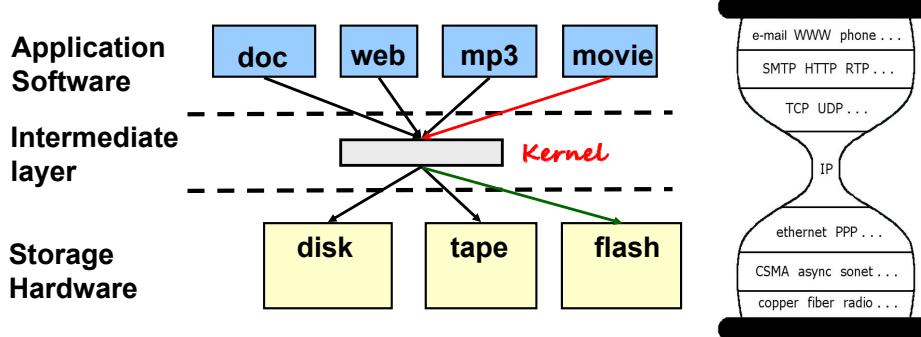
- ❑ new application has to interface to all existing storage media
  - ❖ adding new application requires  $O(m)$  work,  $m = \#$  of storage media
- ❑ new storage media requires all existing applications be modified
  - ❖ adding new media requires  $O(n)$  work,  $n = \#$  of applications
- ❑ total work in system  $O(mn)$  → eventually too much work to add apps/media
- ❑ application end points may not be on the same media!
  - ❖ i.e., a networking application, e.g., web, email, HTTP, etc.

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## Solution: indirection

- Solution: introduce an intermediate layer that provides a **single** abstraction for various storage technologies
  - ❖ O(1) work to add app/media
  - ❖ **Indirection** is an often used technique in computer science



## OS example 1

- Single user/single tasking



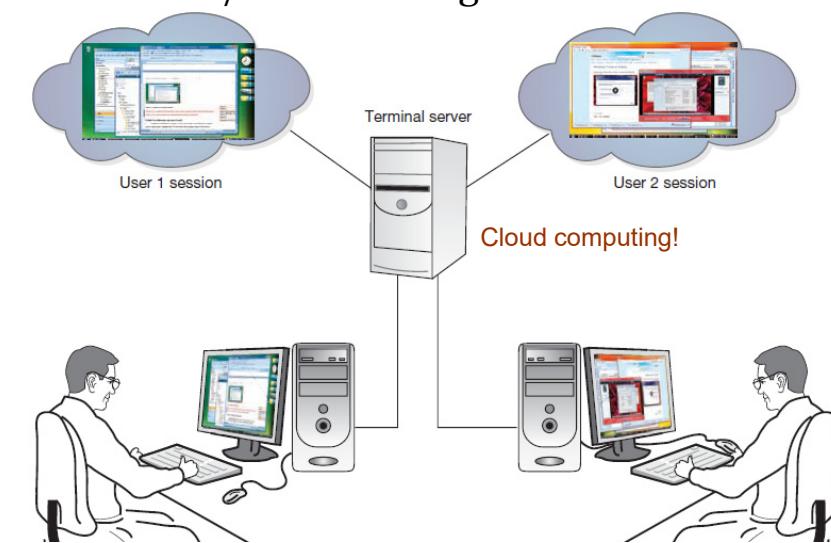
## OS example 2

- Single user/multi-tasking



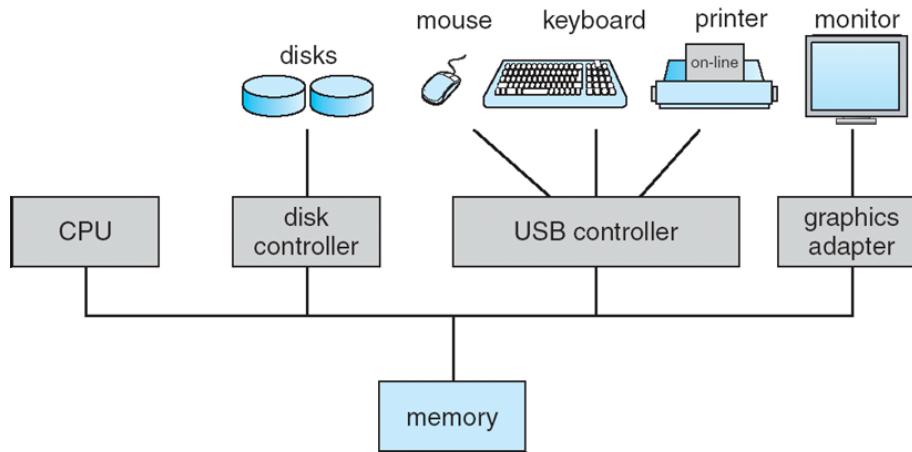
## OS example 3

- Multi-user/multi-tasking



# Computer hardware

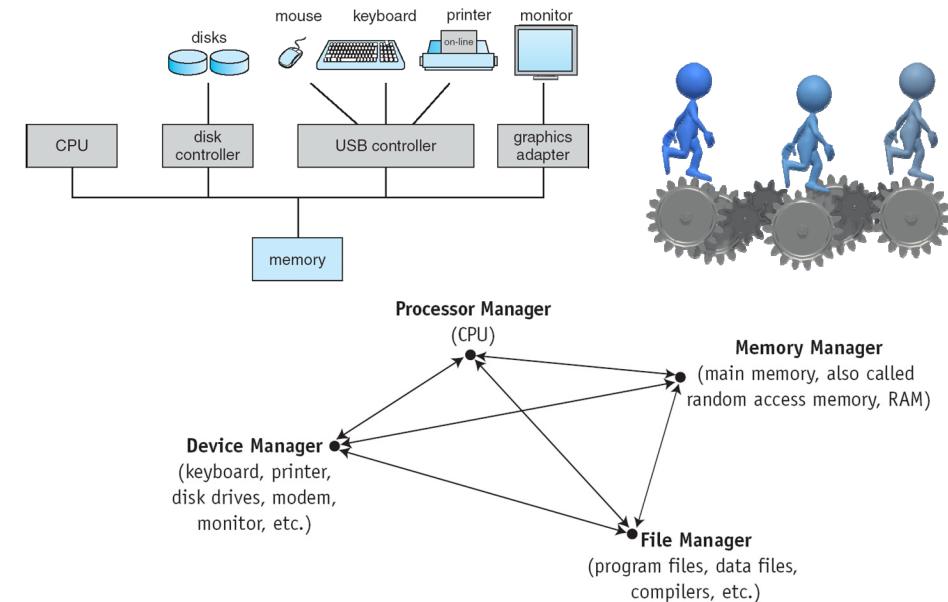
## □ Computer System



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# Hardware management



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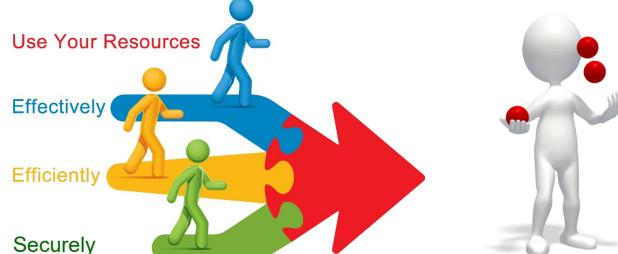
# OS's functionalities

## □ OS as a service provider

- ❖ Provide facilities/services that everyone needs

## □ OS as a governor

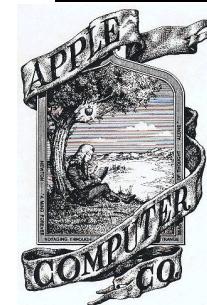
- ❖ Allocate resources efficiently and fairly
- ❖ Settle conflicting requests for resources
- ❖ Prevent errors and improper use of the computer



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# OS: the King of the IT world



- 1981
- Steve Jobs (Apple) vs. Bill Gates (Microsoft)
- The first Macintosh PC

MICROSOFT

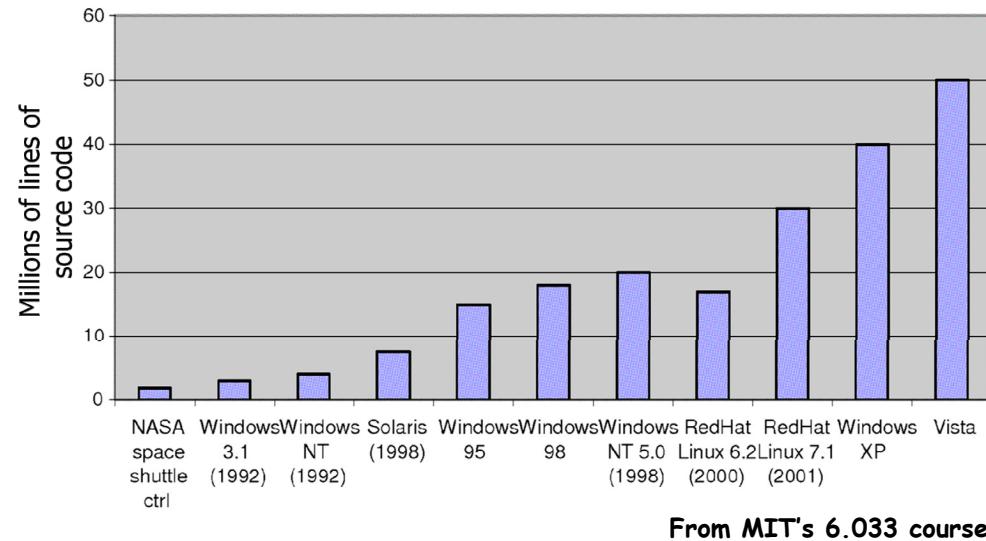


Microsoft

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## Increasing software complexity



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## This course is NOT about...

- ❑ How to use an operating system (e.g., DOS or Linux)?
- ❑ What is the future of mobile operating systems like Android, iOS, and Windows Phone?

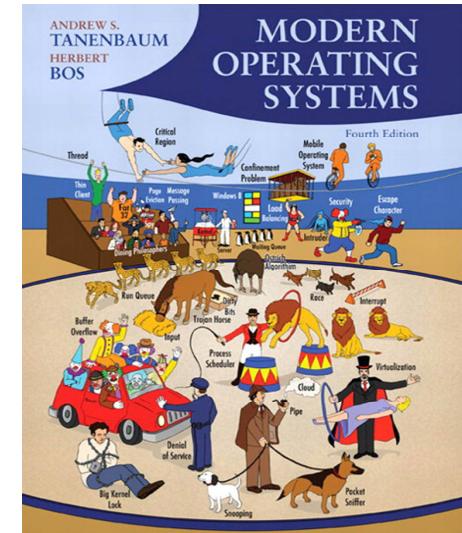
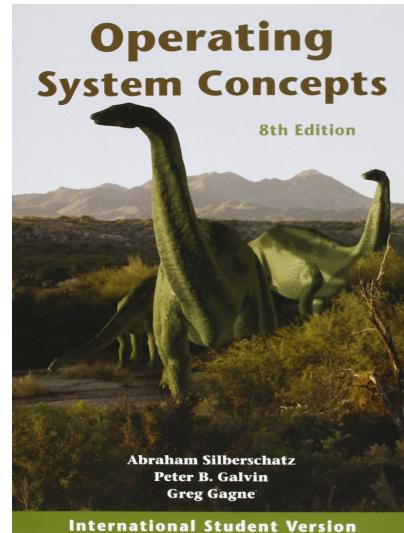


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## OSs look like...

- ❑ OSs: the most complicated software systems



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## So, what is the course about?

- ❑ Develop an understanding of OSs

- ❖ Obtaining the big picture: elements, principles and how they interact
- ❖ Reasoning the details behind the design decisions in all levels

- ❑ A theoretical CS course

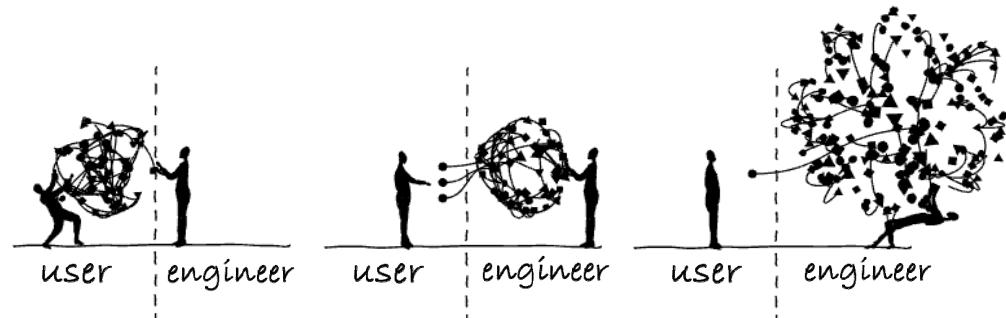
- ❖ What does this mean?



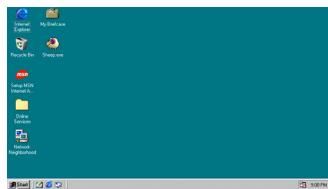
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## OS from an engineer's perspective



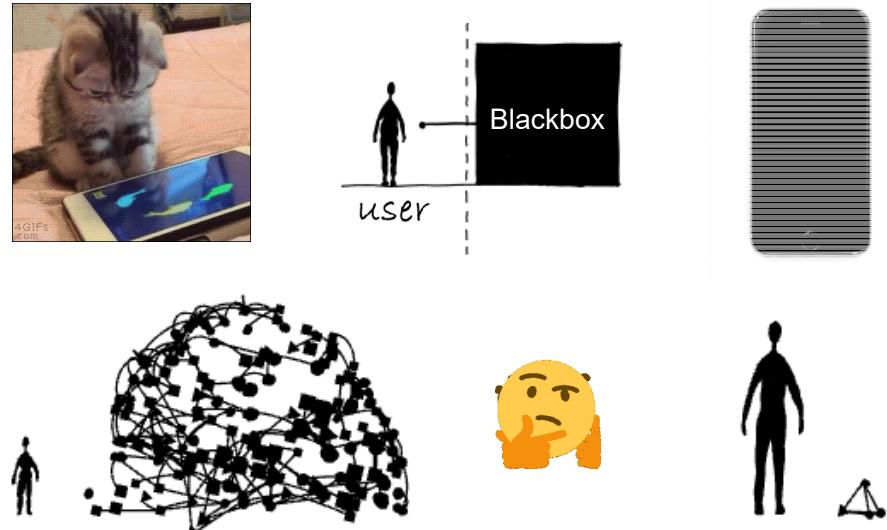
```
Starting disk defragmentation... It took 10 minutes to format the hard drives.  
It attempts to format all network drives.  
Bad command or file name  
C:\>dir to a bug, it only formats the C: drive and the network drives are fine.  
Bad command or file name  
C:\>netstat -an  
Bad command or file name  
C:\>netwerk  
INET 1000 - A Wells Shortboat.  
This program is public domain.  
Int 60h INT0F:020h E9 00 92 19 00 FC 03 01 00 29 00 00 22 00 3E  
Int 60h INT0F:020h E9 00 92 19 00 FC 03 01 00 29 00 00 22 00 3E  
Int 10h INT0F:1725 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 23 00  
Int 10h INT0F:1725 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 23 00  
Int 10h INT0F:075E E9 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 27 00  
Int 10h INT0F:075E E9 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 27 00  
Int 10h INT0F:075E E9 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 27 00  
Int 20h 0116:1696 CF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 06  
Int 27h 132C:300F 9C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 09
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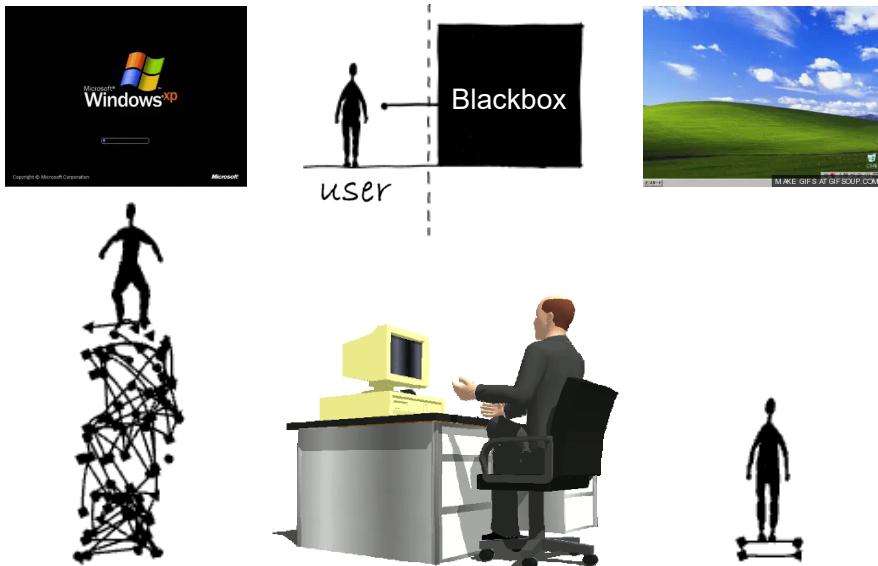
## OS from a user's perspective



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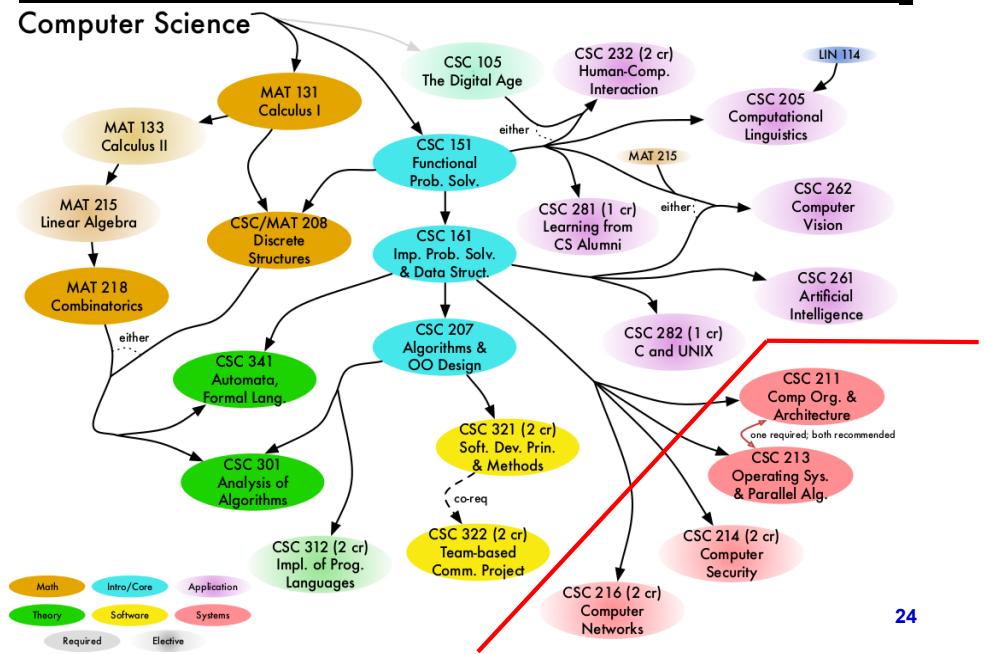
## OS from an advanced user's perspective



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## OS in CS curricula



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## Courses on systems

- ❑ Principles of Communications (EE)
- ❑ Computer Networks (EE, CS)
- ❑ Operating Systems (CS, EE)
- ❑ Computer Architecture (CS)
- ❑ System Thinking!



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## How to study OS ?

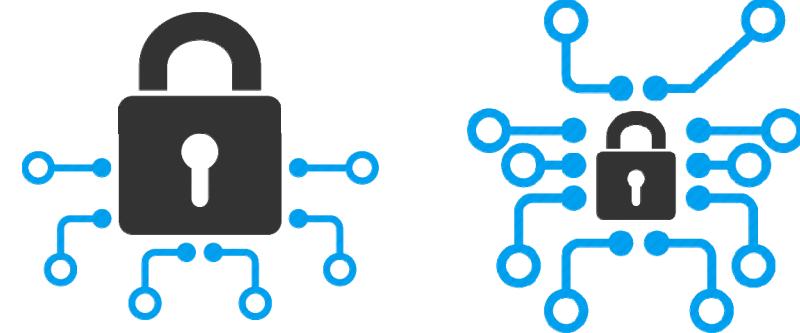


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## OS in cybersecurity curricula

- ❑ Crypto  $\Rightarrow$  Applied Crypto, Provable Security
- ❑ OS  $\Rightarrow$  System Security  $\Rightarrow$  APP Security



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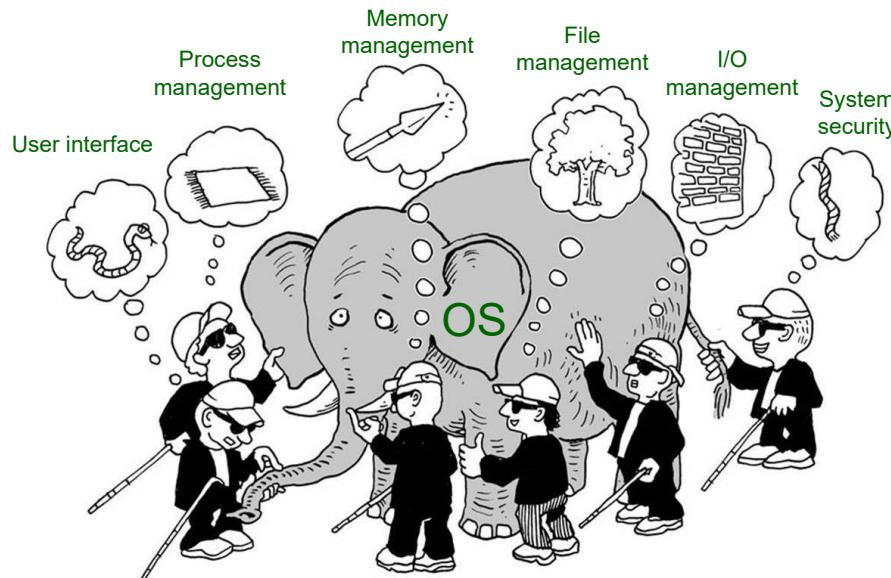
## Why OS is a difficult subject to study?

- ❑ Too many details
  - ❖ get in the way of understanding the concepts
  - ❖ lost the big picture
- ❑ Too many exceptions
  - ❖ apply to every rule
  - ❖ researchers love these exceptions
- ❑ Our knowledge of OSs is still evolving
- ❑ The OS is a “team effort” that involves many different players interacting with each other

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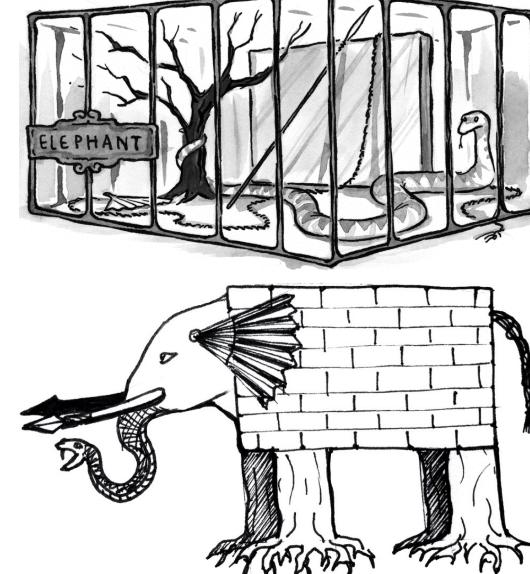
## Seeing the elephant



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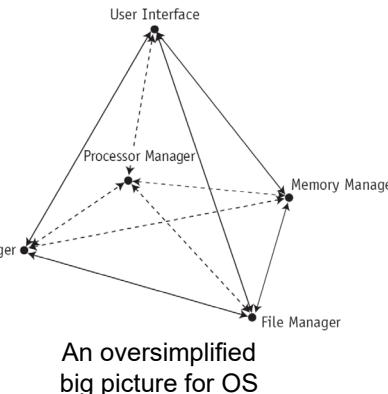
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## Get the big picture first!



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## Teaching philosophy

- 李尚志（中科大前数学系系主任）说：
  - ❖ 丁石孙教授讲的《交换代数》课给我留下特别深刻的印象。他讲课从来不一步一步讲证明的细节，而着重讲整体思路和想法，细节让我们自己课后去补充出来。他说：讲细节谁都听不懂、跟不上。如果你上来讲一个中学的平面几何证明题，你预先经过反复思考已经熟悉了，我预先没有思想准备，听的时候就肯定跟不上你的每一步。
  - ❖ 他这种讲课方式对我现在的讲课影响也很大。我发现，凡是科研搞得好、讲课也讲得好的老师，讲课风格可能各不相同，但一个共同点都是强调主体思路，分得清哪是主干哪是枝叶。因为他们搞科研的时候就是先大体上构思了总体框架、然后再添枝加叶加以实现和完善的。
- 课堂讲授的内容与教材里的内容是互补的，尽量不是重复的！因此，课后一定要阅读指定的材料。

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## Learn more, study less

- Scott Young分享了他在一年内通过观看在线教程的讲座自学完成MIT计算机科学本科课程全部4年33门课的经验



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## Learn more, study less

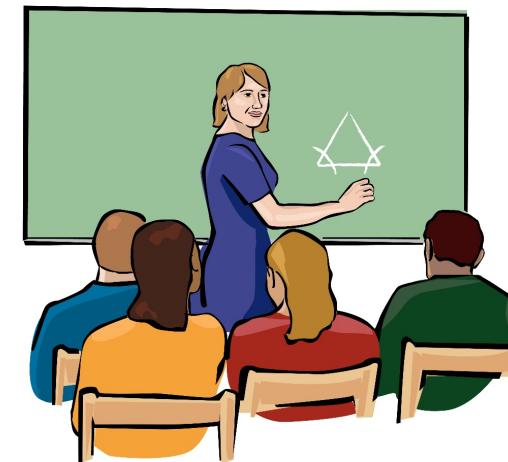
- Scott Young's TED Talk: How to get the finest education online?  
<http://tedxtalks.ted.com/video/TEDxEastsidePrep-Scott-Young-Ca>



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## Administrative info



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## Teaching staff

### □ Instructor: 张驰

- ❖ Email: [chizhang@ustc.edu.cn](mailto:chizhang@ustc.edu.cn)
- ❖ Office: 西区科技实验楼西楼9楼907
- ❖ Office hours: Tues. 9:35-11:30



### □ Instructor: 魏凌波

- ❖ Email: [lingbowei@ustc.edu.cn](mailto:lingbowei@ustc.edu.cn)
- ❖ Office: 西区科技实验楼西楼17楼1713
- ❖ Office hours: Tues. 9:35-11:30

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## Our TAs

### □ TA: 解岩凯

- ❖ Email: [ykxie@mail.ustc.edu.cn](mailto:ykxie@mail.ustc.edu.cn)
- ❖ Office: 西区科技实验楼西楼9楼910
- ❖ Office hours: Tues. 15:45-17:30
- ❖ Labs, projects



### □ TA: 周雪翎

- ❖ Email: [wxzxl@mail.ustc.edu.cn](mailto:wxzxl@mail.ustc.edu.cn)
- ❖ Office: 西区科技实验楼西楼9楼913
- ❖ Office hours: Tues. 15:45-17:30
- ❖ Homework, quizzes



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WeChat Group for OS-Fall-2018

请务必加入微信群

- ❖ 所有通知和讨论以微信群为准！
  - ❖ 请将自己在微信群中的昵称改为真实“姓名+学号”

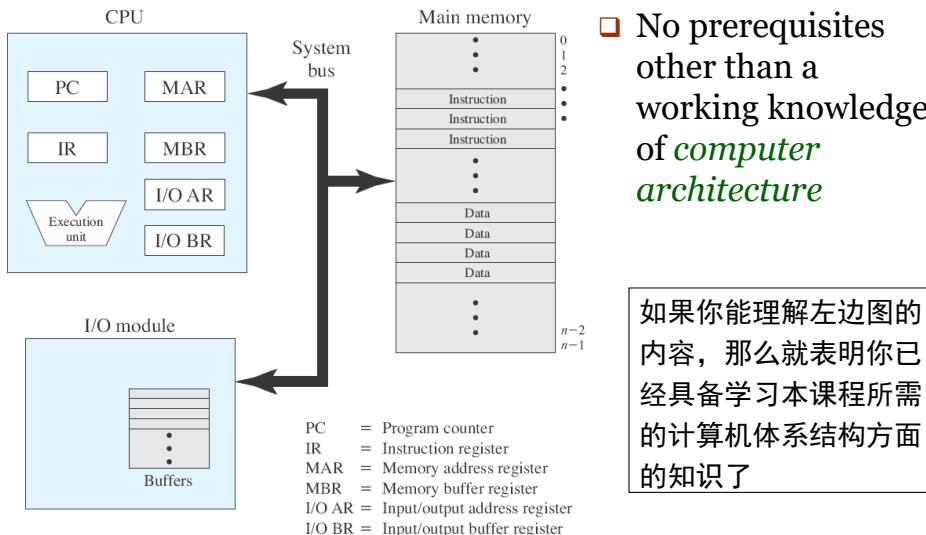


- 该二维码在9月10日前有效
- 若你想入群时二维码已经失效,请联系TA或者班上已经入群的同学获取新的二维码
- TA将在“十一”之后根据学号清理群中的成员

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## Prerequisites



如果你能理解左边图的内容，那么就表明你已经具备学习本课程所需的计算机体系结构方面的知识了

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## When/where/how to talk to me?

### Algorithm 1 (to be made distributive)

- 1: use WeChat Group OS-Fall-2018
  - 2: else talk to TAs
  - 3: else
    - email me at [chizhang@ustc.edu.cn](mailto:chizhang@ustc.edu.cn)
  - 4: else
    - use my office hours Tues. 9:35-11:30
    - 科技实验楼907
  - 5: else
    - sneak in whenever the door is opened
  - 6: goto 1

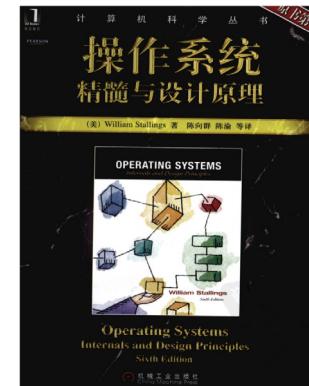
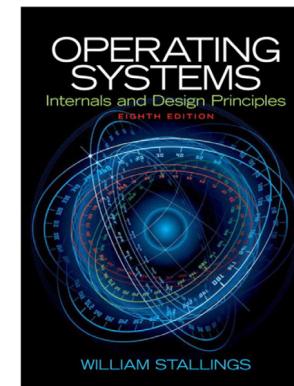
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## Course materials

□ Textbook:

- ❖ William Stallings, “*Operating Systems: Internals and Design Principles*”, 6th Edition 中译本《操作系统 精髓与设计原理》
  - ❖ Online supplements <http://williamstallings.com/OS/OS6e.html>
  - ❖ Question: need 7th or 8th edition? Answer: No



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## 关于教材的补充说明

#### □ 购买教材时

- ❖ Stallings的操作系统书第6, 7, 8三个版本的中英文均可
  - ❖ 就上课和考试范围而言，这三个版本无差别！
  - ❖ 为了方便学生，我们不硬性要求版本

### □ 布置作业和阅读范围时

- ❖ 为了便于统一，以英文第8版为准
  - ❖ 为此，我们提供了英文第8版的pdf，若有问题请联系TA

□ 请自己查核所用的版本与英文第8版的差别

- ❖ 基本上对于课堂教学的部分，上述3个版本无重大差别
  - ❖ 但我们还是鼓励同学直接阅读英文第8版，因为所有中文版本均存在或多或少的翻译错误

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# Course website

□ <https://yankaixie13.github.io/Operating-System-2018/>

- ❑ The course website is the official source for:

- ❖ lecture slides,
  - ❖ assignments,
  - ❖ labs,
  - ❖ supplemental material,
  - ❖ etc.

Please check the course website frequently!

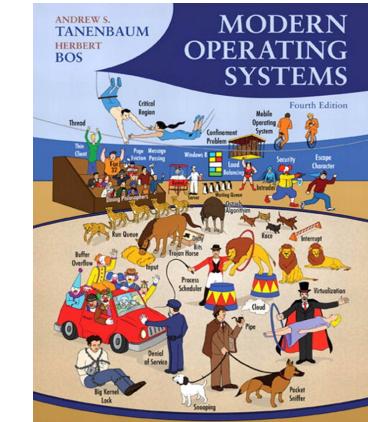
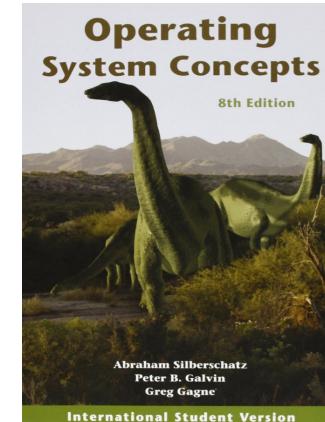
## □ Lecture slides

- ❖ **Do** cover all the material!
  - ❖ Please follow lecture slides for preparing your quizzes & exams

## Course materials

#### Other reference books & materials:

- ❖ Tanenbaum: Modern Operating 中译本《现代操作系统》
  - ❖ Silberschatz: Operating System Concepts 中译本《操作系统概念》
  - ❖ Other book chapters & papers: see course website



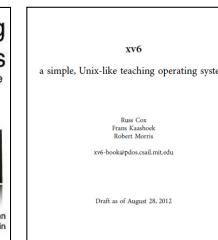
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## Suggested reading

#### Recommended further reading

- ❖ Operating Systems: Three Easy Pieces
    - <http://pages.cs.wisc.edu/~remzi/OSTEP/>
  - ❖ Operating Systems: Principles and Practice
    - <http://ospp.cs.washington.edu/>
  - ❖ Xv6, a simple Unix-like teaching operating system
    - <http://pdos.csail.mit.edu/6.828/2012/xv6.html>
  - ❖ 浪潮之巅, 吴军, 人民邮电出版社, 2013年7月第二版



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## Class schedule

- ❑ Part 1: OS Introduction (1 week)
- ❑ Part 2: Process Management (4.5 weeks)
- ❑ Part 3: Memory Management (2.5 weeks)
- ❑ Part 4: I/O Management (2 weeks)
- ❑ Part 5: File Management (1 week)
- ❑ Part 6: Distributed System (2 weeks)
- ❑ Course Review (1 week)

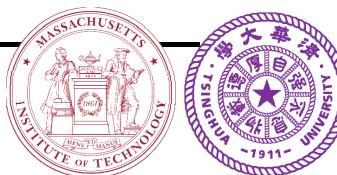
❑ 一共15周课时，预留1周的课时作为机动

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## Labs

- ❑ MIT-6.828: Operating Systems
- ❑ Vx6 System



A screenshot of a web browser showing the "6.828: Operating System Engineering" page. The top navigation bar includes links for Schedule, Class, Labs, xv6, References, and Piazza. The main content area is titled "6.828 lab tools guide" and provides information about the environment and useful commands.

### 6.828 lab tools guide

Familiarity with your environment is crucial for productive development and debugging. This page gives a brief overview of the JOS environment and useful GDB and QEMU commands. Don't take our word for it, though. Read the GDB and QEMU manuals. These are powerful tools that are worth knowing how to use.

Debugging tips: Kernel User environments  
Reference: JOS makefile JOS obj/ GDB QEMU

A screenshot of a web browser showing the "6.828: Operating System Engineering" page. The top navigation bar includes links for Schedule, Class, Labs, xv6, References, and Piazza. The main content area is titled "Xv6, a simple Unix-like teaching operating system" and provides an introduction to the system.

### Xv6, a simple Unix-like teaching operating system

#### Introduction

Xv6 is a teaching operating system developed in the summer of 2006 for MIT's operating systems course, 6.828: Operating System Engineering. We hope that xv6 will be useful in other courses too. This page collects resources to aid the use of xv6 in other courses, including a commentary on the source code itself.

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## Grading policy

- ❑ Homework assignments: 0%
  - ❑ Quizzes: 20%
  - ❑ Labs: 25%
  - ❑ Midterm exam: 25%
  - ❑ Final exam: 30%
- OR
- ❑ Quizzes: 20%
  - ❑ Labs: 25%
  - ❑ Project: 25%
  - ❑ Final exam: 30%
- ❑ I reserve the right to assign grades based on the overall performance
- ❑ 课堂不点名, quiz时间会提前通知



WeChat

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## Project (optional)

- ❑ Reading papers & 1 presentation  
❖ to be done in groups of size  $\leq 4$
- ❑ Distributed system analysis
- ❑ Trusted system design
- ❑ Blockchain design & analysis



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# Winter is coming!



This was no time for play.  
This was no time for fun.  
This was no time for games.  
There was work to be done.

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## How to do well?

- ❑ Participate: discuss, ask and answer questions
    - ❖ “the only stupid question is the question you don’t ask”
  - ❑ Give suggestions: I’ll take them seriously
  - ❑ Do the assigned readings and surf the web to read related things
  - ❑ Start early on homework assignments and labs
  - ❑ Make use of our TAs (and occasionally me too)

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## Work load

- Heavy ! Start early !!
  - Approx. 100 pages of (light) reading per week
  - Several homework assignments
  - $\geq 3$  OS labs
  - 1 project & presentation (optional)
    - ❖ to be done in groups of size  $\leq 4$
    - ❖ find your partners carefully
  - 3~4 quizzes (closed book)
  - Midterm & final exam (closed book, one A4 cheat sheet, and calculator)

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# An adventure for thought



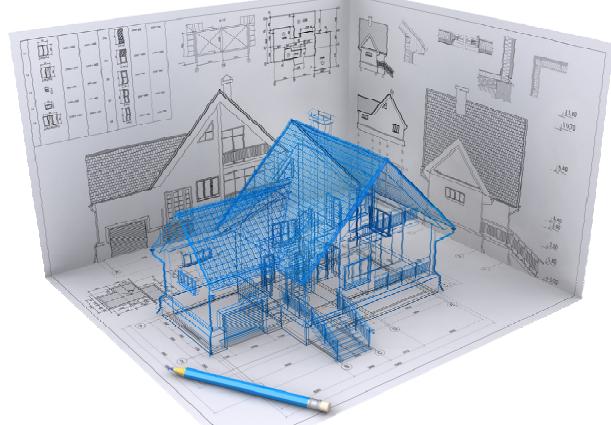
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## What is “architecture”?

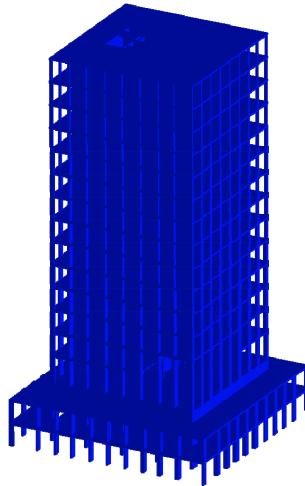
### □ Architecture = Systematic Design

- ❖ Structure of elements
- ❖ Interacting behaviors



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## A good example



何陋轩(上海松江方塔园)

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## 何陋之有?



冯纪忠先生与何陋轩

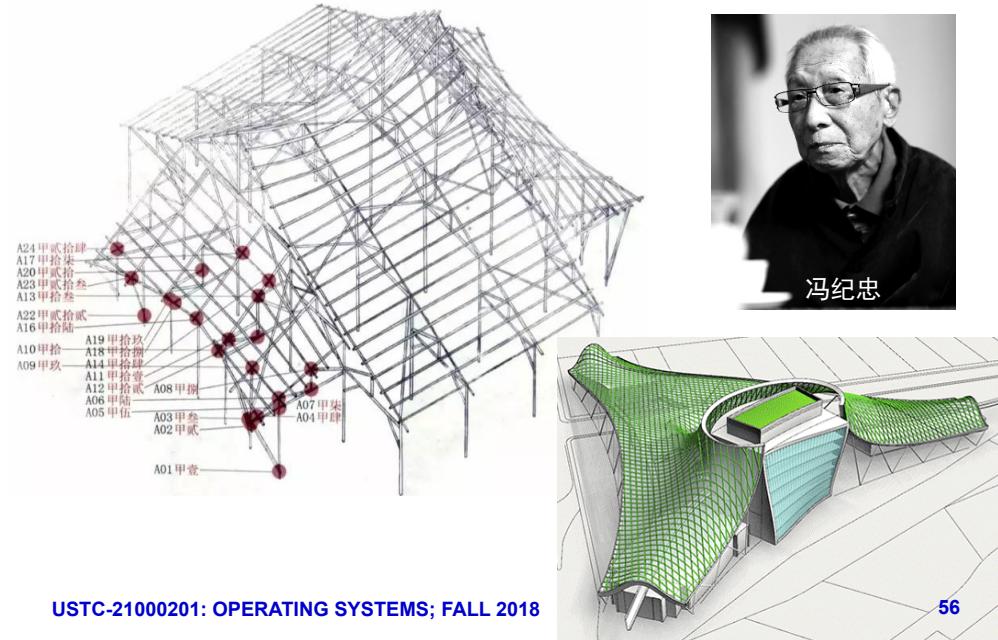
### □ 刘禹锡《陋室铭》

- ❖ 斯是陋室，惟吾德馨
- ❖ 谈笑有鸿儒，往来无白丁
- ❖ 南阳诸葛庐，西蜀子云亭
- ❖ 孔子云：君子居之，何陋之有？



1

## Substance triumphs over form



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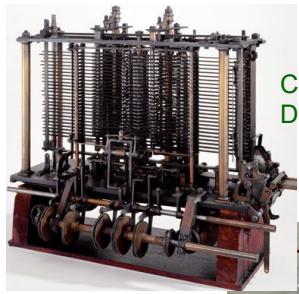


冯纪忠

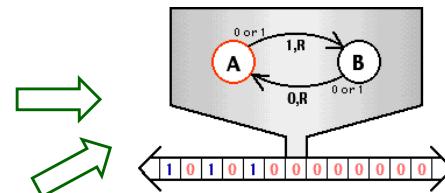
1

# What is CS?

- ❑ CS = the study of computers (1962)
  - ❑ CS = the study of abstract computing process (2010)



## Charles Babbage Difference Engine



Titan

# Supercomputer



## Turing Machine

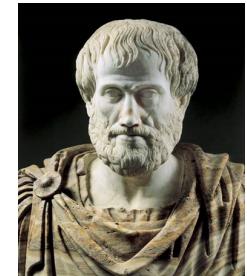
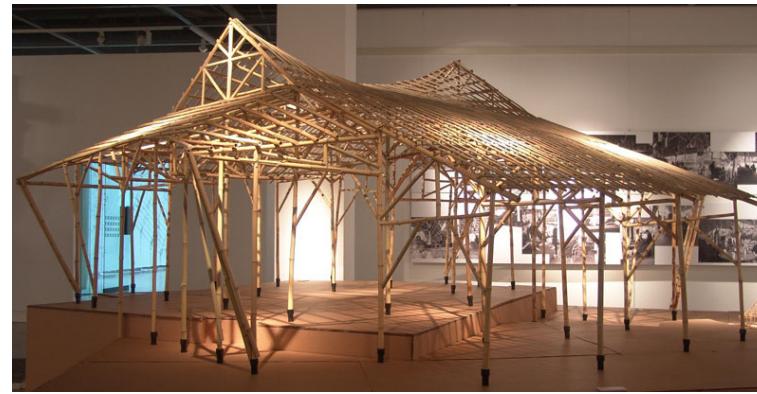
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2

Whole >  $\sum$  (parts)

- The whole is greater than the sum of its parts



Aristotle

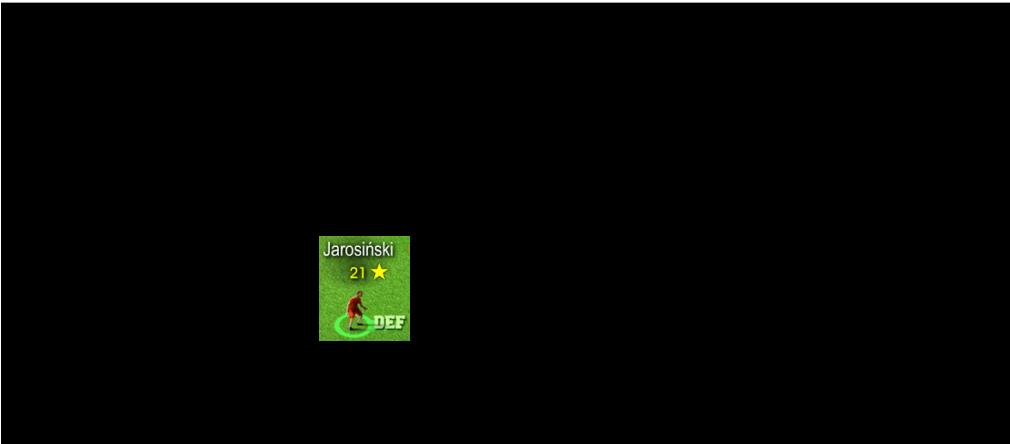


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Whole >  $\sum$  (parts)

- ❑ The whole is greater than the sum of its parts
  - ❑ A global view is important for understanding...



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# Windsor Guildhall



Sir Christopher Wren

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# 3

## Theory guides practice

- Theory guides practice; practice tests theory



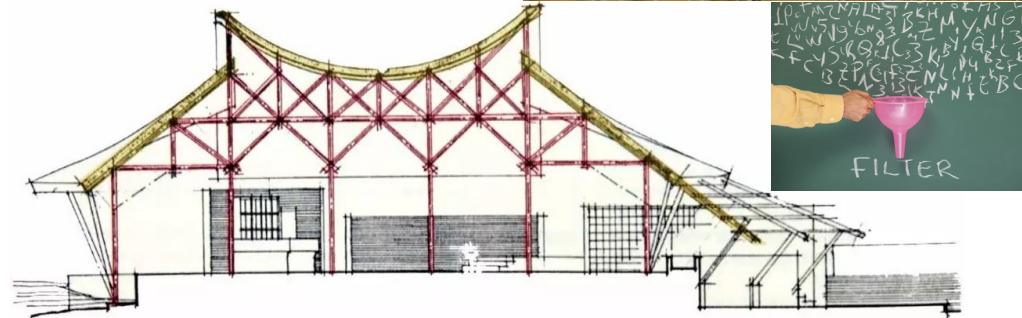
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# 4

## Less is more

LESS > MORE  
MORE

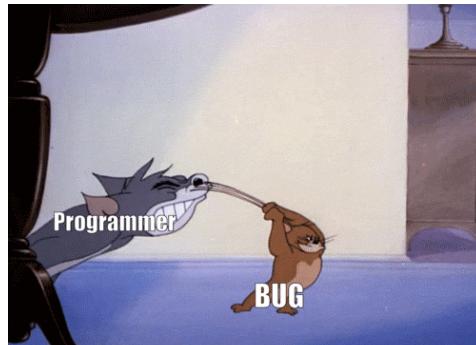


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# 4

## ...especially for system security



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## System level principles

- Substance triumphs over form
- The whole is greater than the sum of its parts
- Theory guides practice
- Less is more
- Welcome to the world of OSS!



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## After the class...

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### □ Reading:

- ❖ 教材第一章：硬件知识回顾 pp.7-45 (8<sup>th</sup> Edition)
- ❖ 教材第二章：操作系统概述 pp.46-104 (8<sup>th</sup> Edition)

### □ Watching:

- ❖ Hardware and Operating System Basic (11 short videos)

### □ Reminder:

- ❖ Finishing reading the textbook in 4 weeks!