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Sharing IT resources and utility computing

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An overview

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The path to utility computing

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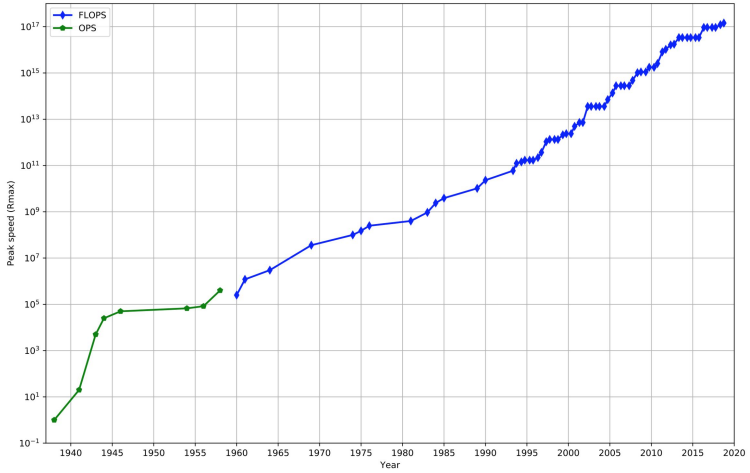
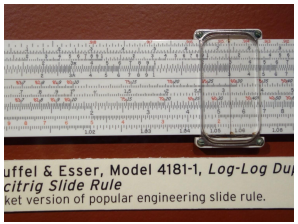
The history of IT resources

A brief history of computers

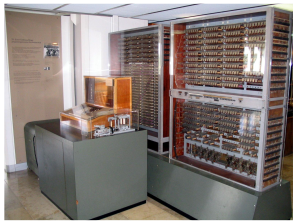
From logarithmic ruler to modern computers



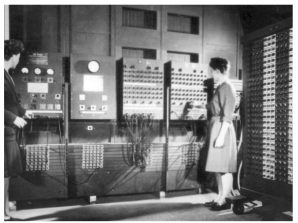
Top supercomputer speeds: **logscale** speed over 60 years



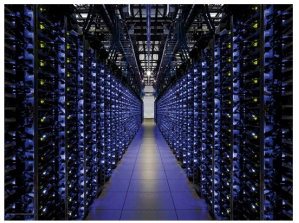
Computational precursors



Mechanical computers

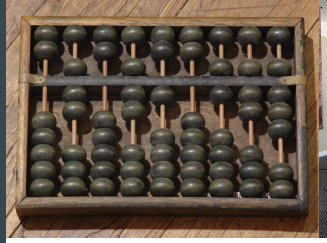
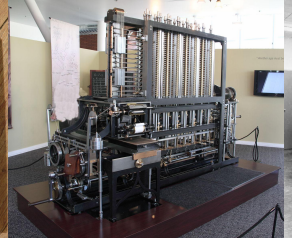


Electronic Computers



Modern computers (network)

Pre-transistor computer

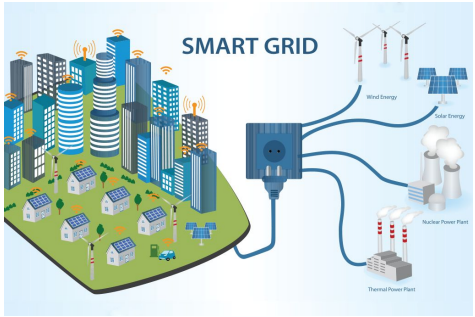

- Calculators (Abacuses, Babbage's Difference engine, ...)
- Turing's computational model (1936)
- Mechanical computers :
  - *Z serie (1941), Harvard MK-1 (1944)*
- Electronic computers:
  - *Eniac (1946)*, first "Turing complete" computer
- Transistor discovered in 1947

Toward networks of computers

If computers of the kind I have advocated become the computers of the future, then computing may someday be organized as a public utility just as the telephone system is a public utility... The ***computer utility*** *could become the basis of a new and important industry.*

– John McCarthy, 1961

- Computers used a “time sharing” model with local user using local computers
- **1958:** ARPA is founded in, ARPANET project starts in 1959
- **1961:** John McCarthy computing resources as an utility resource
- **1969:** Leonard Kleinrock : computer networks could led to an Utility Computing model, where computing resources could be consumed as requested
- **1971:** First inter-site communication between computers (ARPANET)



Credits: https://innovationatwork.ieee.org

Modern Systems of Computers

In pioneer days they used oxen for heavy pulling, and when one ox couldn't budge a log, they didn't try to grow a larger ox. We shouldn't be trying for bigger computers, but for more systems of computers.

Grace Hopper

- Time sharing Mainframes
  → Smaller computers (PDP-11)
- Emergence of networks
  → Computer clusters, Computer grids
- Emergence of desktop computers
  → Beowulf cluster, desktop grids
- Virtualization (1960s) become popular in 1990s
- Cloud Computing (2000's)

The path to utility computing

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The history of Operating Systems

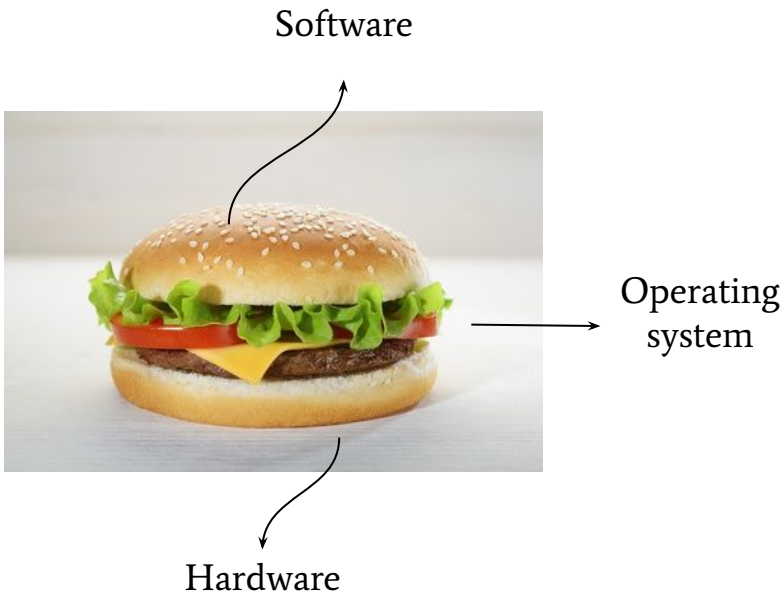
What is a computer?

- Hardware resources
  - CPU(s)
  - Memory
  - Network
  - Disk
- Software resources
  - Drivers
  - Applications
  - etc.

“Bare metal” usage in the 1950’s and 1960’s - *No hardware abstraction*

- *Still true in consoles and embedded systems*

What is an operating system?



Layer in between the hardware and software of a computer

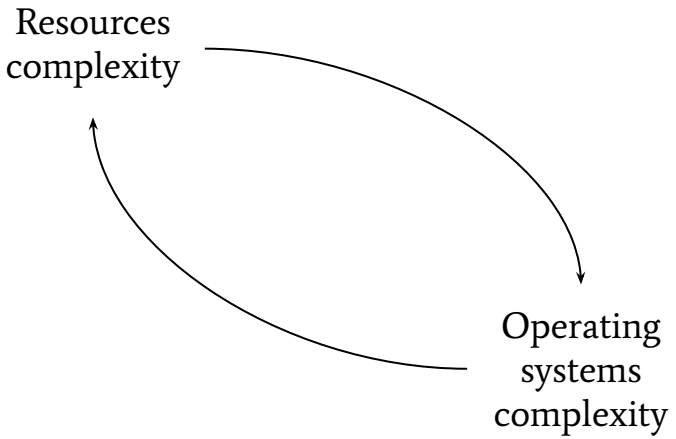
What does an operating system do?

- Hiding the complexity of hardware from the user
- Generic or specific to a given hardware
- Management of shared resources
- Scientific challenges of OSs:
  - Concurrency, parallelism
  - Task scheduling
  - Data management
  - I/O management
  - Security
  - Energy optimization
  - etc.

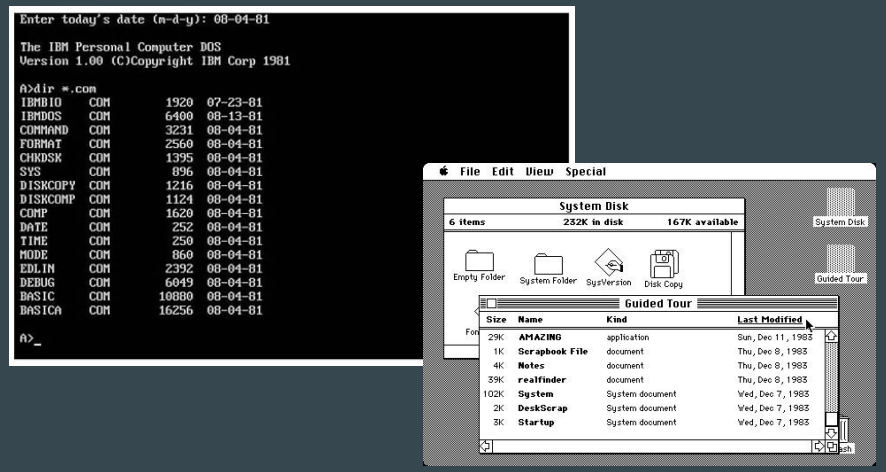
Operating systems & resources

A close linkage

Operating systems are mainly about IT resources and their sharing



From single- to multi-tasking OS

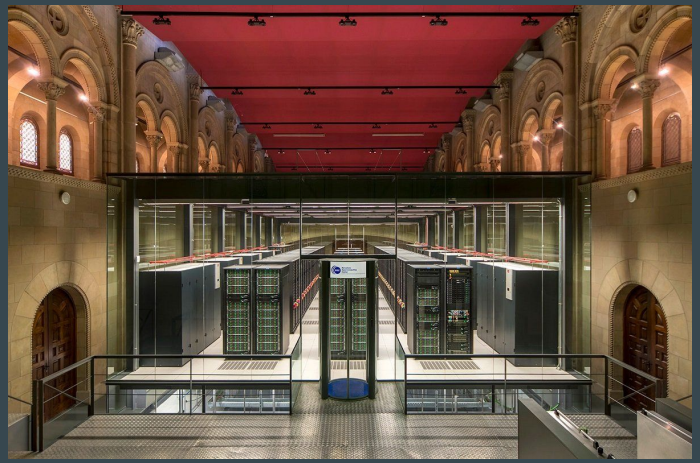


- Single-tasking OS
  - Apple Macintosh (*1980*)
  - MS-DOS (*1981*)
- Multi-tasking OS
  - ***Sharing resources between tasks***
  - All modern OSs (Windows, MacOS, Unix - 1970, Linux etc.)

Single- vs multi-user OS

- Single-user OS
  - One user at a time
  - Windows 95/NT, MS-DOS, Android
- Multi-user OS (servers)
  - ***Sharing resources between users***
  - Any OS with a ssh server
  - Unix (*1970*) and Linux (*1991*)
  - Windows servers (*1990*) and Windows 10
  - MacOS X Server 1 (*1999*) and recent MacOS
  - Cloud-specific OSs

Single- vs multi-node OS



Barcelona Supercomputing center

- Single-node OS
  - All PC OSs (Windows, MacOS, Linux)
- Multi-node OS
  - *Sharing resources of multiple nodes*
    - *Task/job migration*
  - Single System Image (SSI) [2001 Buyya] abstraction of the distributed aspects
  - Supercomputer OS - Microkernel on compute nodes + server entry point through batch scheduler (Slurm, OAR)
  - Cloud OS - Virtualization control on compute nodes + server entry point through user-friendly APIs
  - Directly related to modular and distributed OS

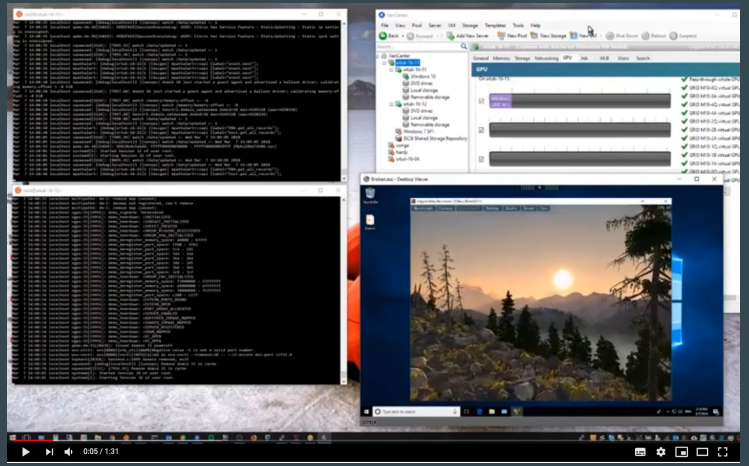
Distributed OS

- Modular and Distributed OS
  - Different **modules** responsible for different parts of the OS
  - Academic initiatives
    - [1991 Dasgupta] [1997 Chow] [1998 Moller] [1999 Galli]
  - Micro-kernels (e.g. Minix3 2005, disaggregation [2018 Shan])
  - Cloud OS (e.g. OpenStack 2010)

Operating systems & virtualization

Evolution of OSs has led to virtualization
Why?

- Easy Multi-OS management
- Easier Multi-user management
  - Strong isolation for security
  - Memory isolation
- Easier Multi-node and distributed management
  - Easy live migration of tasks/jobs
  - Simple API to request resources



Example of VM live migration

Overview

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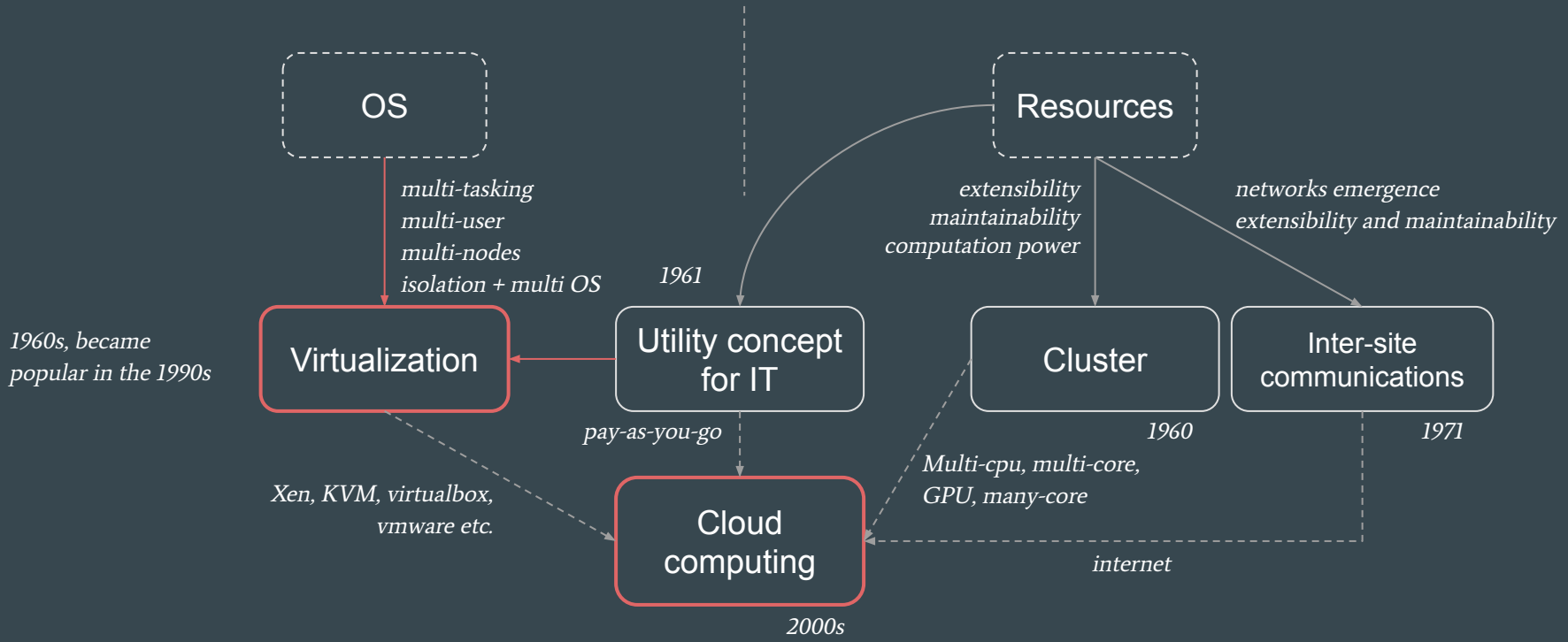

Next step
VIRTUALIZATION

Questions?

Some references

- [1991 Dasgupta] *The Clouds distributed operating system*. P. Dasgupta and R. J. LeBlanc and M. Ahamad and U. Ramachandran. Computer vol. 24, nov. 1991.
- [1997 Chow] *Distributed Operating Systems and Algorithms*. Chow Randy and Chow Yuen-Chien.
- [1998 Moller] *Distributed Operating Systems: Concepts And Design*. R. Moller. IEEE Concurrency vol. 6, apr. 1998.
- [1999 Galli] *Distributed Operating Systems*. Galli, Doreen L.
- [2001 Buyya] Single System Image
- [2018 Shan] *LegoOS: A Disseminated, Distributed OS for Hardware Resource Disaggregation*. Yizhou Shan and Yutong Huang and Yilun Chen and Yiying Zhang. OSDI 2018 bast paper.