

# Sharing IT resources and utility computing



An overview

*Hélène Coullon, Associate prof., IMT Atlantique, Inria, LS2N - [helene.coullon@imt-atlantique.fr](mailto:helene.coullon@imt-atlantique.fr)  
Jonathan Pastor, postdoc, IMT Atlantique, Inria, LS2N - [jonathan.pastor@imt-atlantique.fr](mailto:jonathan.pastor@imt-atlantique.fr)*

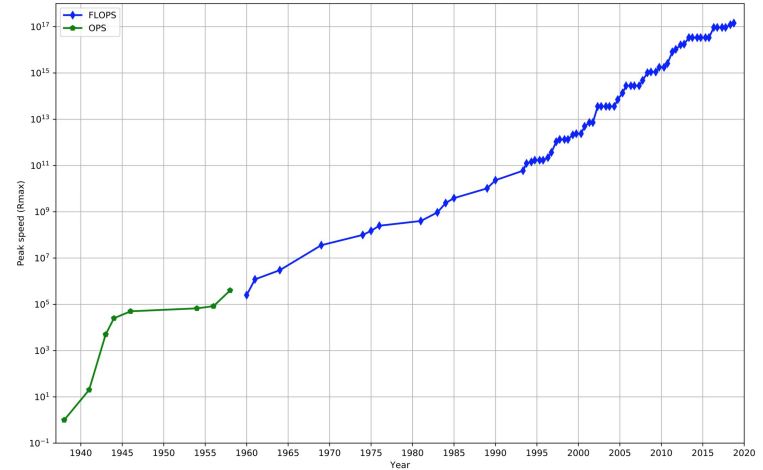
# The path to utility computing



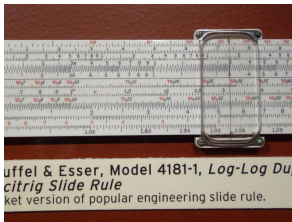
The history of IT resources

# A brief history of computers

*From logarithmic ruler to modern computers*

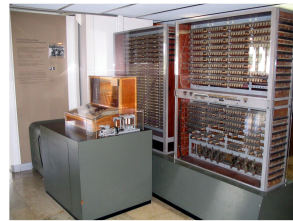


Top supercomputer speeds: **logscale** speed over 60 years

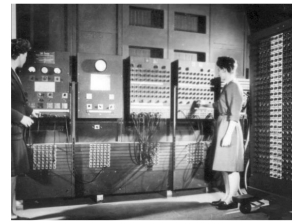


Buffel & Esser, Model 4181-1, Log-Log Duplex Slide Rule  
A pocket version of popular engineering slide rule.

Computational precursors



Mechanical computers

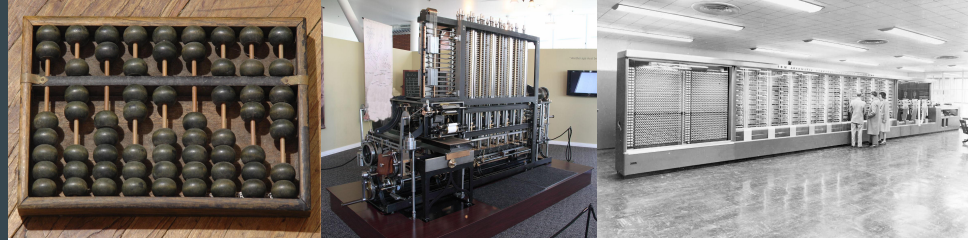


Electronic Computers



Modern computers  
(network)

# Pre-transistor computer



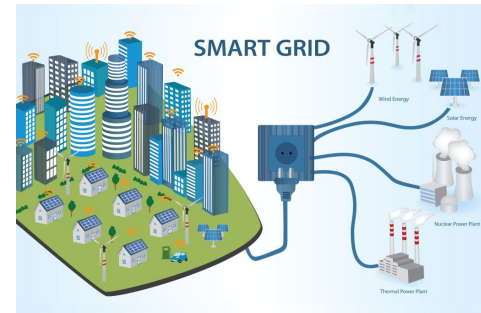
- Calculators (Abacuses, Babbage's Difference engine, ...)
  - Turing's computational model (1936)
  - Mechanical computers :
    - *Z serie (1941), Harvard MK-1 (1944)*
  - Electronic computers:
    - *Eniac (1946), first "Turing complete" computer*
  - Transistor discovered in 1947
-

# 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

- Large computers were used by local users
- **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://innovationnetwork.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



- Large 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



The history of Operating Systems

# What is a computer?

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

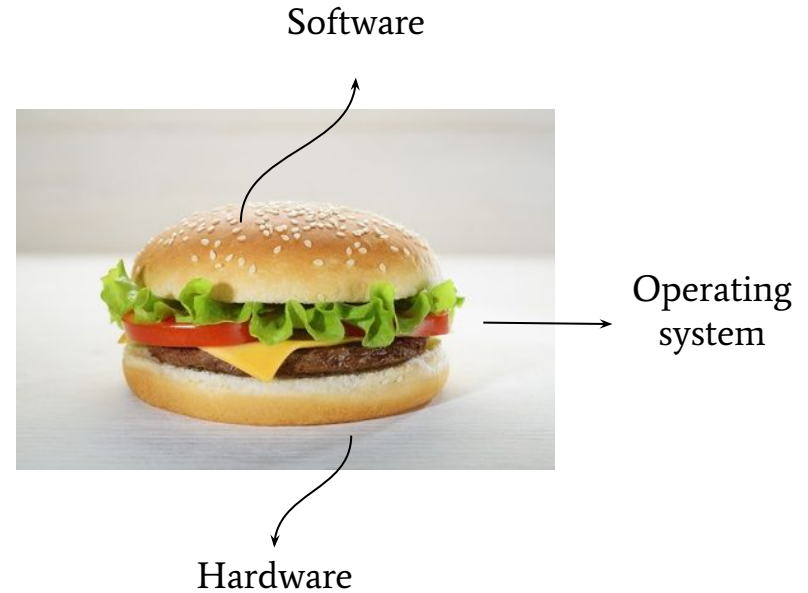
“Bare metal” usage in the 1950’s and 1960’s - *No hardware abstraction*

☐ *Still true in consoles and embedded systems*

---



# What is an operating system?



*Layer in between the hardware and software of a computer*

---

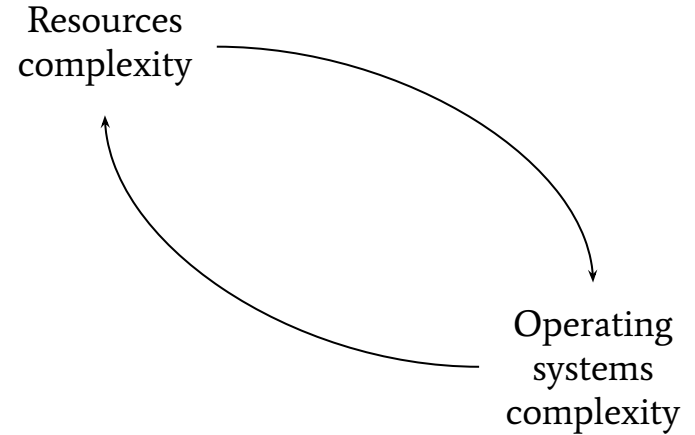
# What does an operating system do?

- 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

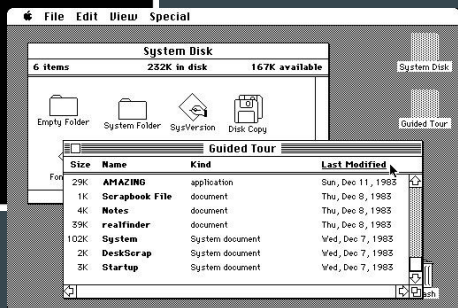
*Operating systems are mainly about  
IT resources and their sharing*



# From single- to multi-tasking OS

```
Enter today's date (m-d-y): 08-04-81
The IBM Personal Computer DOS
Version 1.00 (C)Copyright IBM Corp 1981
```

```
A>dir *.com
DIRIBIO COM      1920 07-23-81
DIRIBOS COM      6488 08-13-81
COMMAND COM     3231 08-04-81
FORMAT COM      2560 08-04-81
CHKDSK COM      1395 08-04-81
SYS COM          896 08-04-81
DISKCOPY COM    1216 08-04-81
DISKCOMP COM    1124 08-04-81
COMP COM        1620 08-04-81
DATE COM         252 08-04-81
TIME COM         250 08-04-81
MODE COM         860 08-04-81
EDLIN COM       2392 08-04-81
DEBUG COM       6049 08-04-81
BASIC COM       10880 08-04-81
BASICA COM      16256 08-04-81
A>_
```



- 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



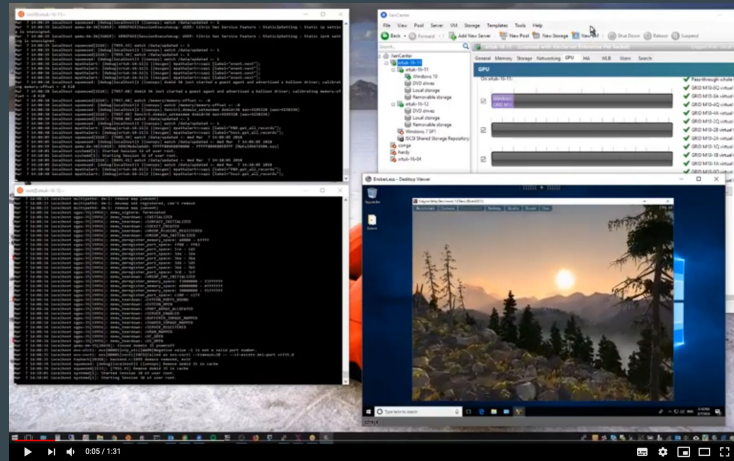
- Modular and Distributed OS
  - Different **modules** responsible for different parts of the OS
  - Academic initiatives
    - [1991 Dasgupta] [1997 Chow] [1998 Moller] [1999 Galli]
  - Micro-kernels (e.g. [Minix3](#) 2005, disaggregation [2018 Shan])
  - **Cloud OS** (e.g. [OpenStack](#) 2010)

# 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*

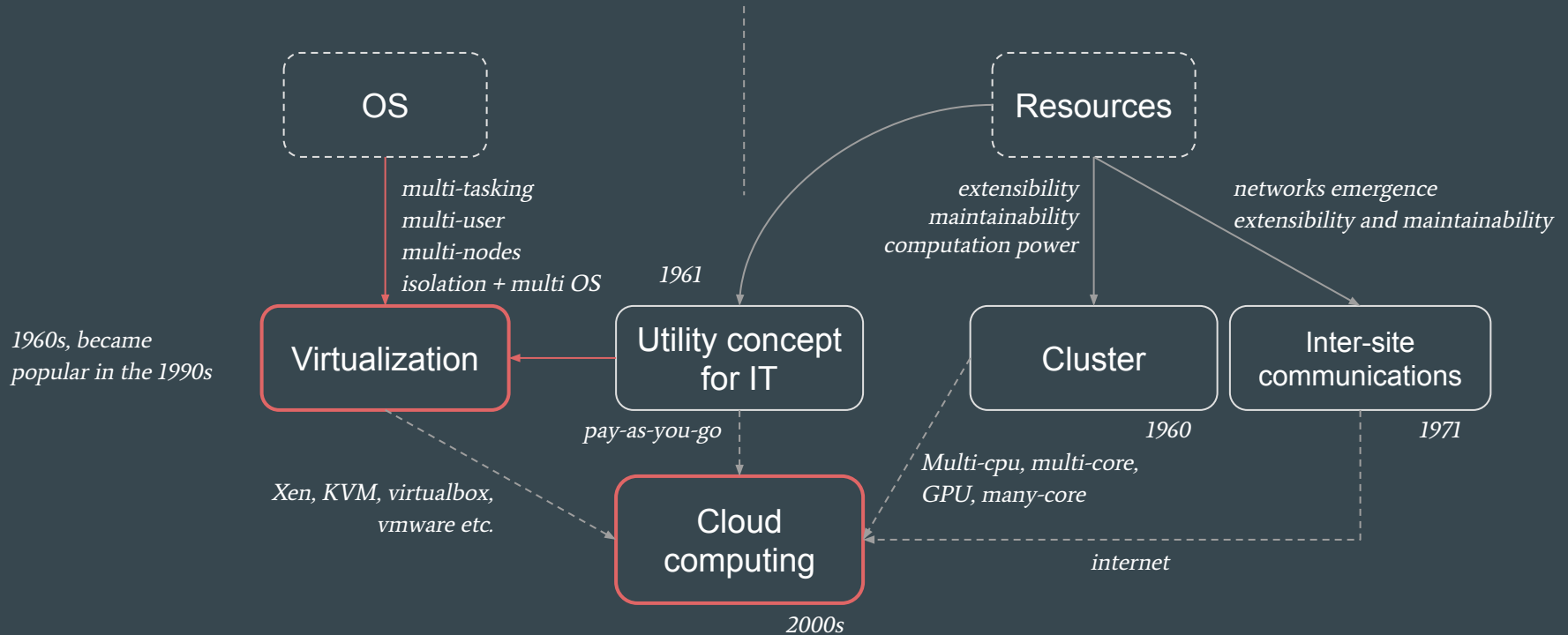


# Overview



*Hélène Coullon, Associate prof., IMT Atlantique, Inria - [helene.coullon@imt-atlantique.fr](mailto:helene.coullon@imt-atlantique.fr)*

# The path to the utility computing



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 Yiyang Zhang. OSDI 2018 bast paper.