If the automobile had followed the same development cycle as the computer, a Rolls-Royce would today cost $100, get a million miles per gallon, and explode once a year, killing everyone inside.

-- Robert X. Cringely

Chapter 1

Historical Background
1.1 Functions and Coarse Structure

Operating system (Definition according DIN 44300)

“The programs of a digital computing system which lay - together with the basic properties of the computing system - the foundation for the possible modes of operation and especially control and monitor the execution of programs."

Main Tasks

• Provision of virtual machine
  • as an abstraction of the computer system
• Resource Management
Tasks

• Adaption of machine structure to user requirements
• Laying the foundation for a controlled concurrency of activities
• Management of data and programs
• Efficient usage of resources
• Support in case of faults and failures
Operating system architecture

- Quotation:
  "The job of a system architect is similar to the one of a witty octopus juggling daily new balls of different size on the back of a jumping dolphin at the shore of Waikiki."

New applications

Operating system

New Hardware

Market
Quality features:
- Security
- Real-time
- Mobility
- Energy consumption
- Dependability
- ....
Operating systems for general purpose computers

Operating system: Control

Application

Operating system: Management and operation

Application

Hardware

Barry Linnert, linnert@inf.fu-berlin.de, Betriebssysteme WS 2019/20
System architecture

- Complex systems (in all areas) are composed of single components of different types.
- Successful design of a complex system requires the knowledge of different variants of the components and their interplay.

Example: Buildings (20 000 years of experience)

- Walls
- Columns
- Ceilings
- Roofs
- Stairs
- Doors
- Windows

Material
Form
Strength
System architecture

- Example Electrical Engineering (ca. 100 years of experience)
  - Resistor
  - Coil
  - Capacitor
  - Diode
  - Tube
  - Transistor

- Example Operating systems (ca. 50 years of experience)
  - Process
  - Signal
  - Address space
  - Channel
  - Interrupt
  - Driver
  - File
  - Capacity
  - Synchronization
  - Type of message transfer
1.2 Historical Sketch

The Fifties (Early stages)

- *One* program is being executed by *one* processor.
  - Batch operation
- The Operating system functionality is limited to
  - support of input/output,
  - transformation of number and character representation.
The Sixties (Virtualization)

- The ratio between CPU- and I/O-speed becomes large.
- OS support the interleaving execution of several independent programs (Multiprogramming).
- Real parallelism due to the advent of I/O-processors.
- The notion of a process as a virtual processor is born.
- Also the memory is „virtualized“ (virtual memory).
- The process also becomes an internal mean of structurization for OS.
- Interactive operation by more than one user (Timesharing).
- Prototypes or predecessors of today’s mainframe OS are developed (OS/360, CTSS/Multics, CP67, VMOS/BS2000).
The Seventies (Software Engineering)

- The beginning of the software crisis: OS become large, complex and error prone.
- Unix is built according to the principle "simple is beautiful" based on simple hardware (PDP-11).
- The quest for structured system design, maintainability, reliability, protection and security comes up.
- Employment of high level programming languages to implement OS.
- Process becomes a protection domain (context) with a private protected address space and access control (rights, capabilities).
- Quest for support of modular programming abstract data types and object orientation.
- Application of these principles to the operating system itself.
The Eighties (Distributed Systems)

- Workstation computers and personal computers come up.
- Increased communication bandwidth: Ethernet, connected systems.
- For efficient implementation of communication software processes are needed.
- Processes are meanwhile complex entities: A process switch costs several thousand machine instructions. Therefore, address space and process are separated allowing for several processes sharing an address space (*lightweight process, thread*).
- Concepts for parallelism are integrated into program languages.
- Distributed (parallel) computing on networks of workstation computers.
- Workstations provide an ideal means for dissemination of UNIX and UNIX becomes sort of a “standard”.
- Necessity for integration generates pressure for standardization (OSI, TCP/IP, NFS, POSIX, OSF, X/OPEN, OMG, ODP).
- OS overcome node boundaries: From communicating computers to distributed systems.
The Nineties

(Highly Parallel Systems, PCs, Embedded Systems, Internet & Web)

- Due to high production numbers, microprocessors become cheap.
- Connecting thousands of microprocessors achieves (theoretically) higher performance at a lower price compared to supercomputer (e.g. Cray).
- New OS-Functionality needed to support parallel processing.
- PCs and GUIs for OSs become mainstream (Windows 3, Linux).
- Multimedia-applications require support for audio- and video data (real-time capabilities).
- Software in *embedded systems* needs OS-support (e.g. Consumer Electronics).
- Birth and rise of the Web leading to distributed systems in heterogeneous environments (e.g. Corba, Web services).
The 2000s and Today

- Computing technology moves into the everyday while becoming increasingly small and invisible.
- OS support for ubiquitous and pervasive computing and intelligent devices (cf. Internet of things)
- OS platforms for mobile phones with multi-touch user interfaces (e.g. iOS and Android OS)
- Thin clients running web-applications within a browser (e.g. Chrome OS)
- Emulation of other OS-interfaces (i.e. several “OS worlds” on the same computer).
- Converged infrastructures, shared services and the renaissance of virtualization are enabling factors for Cloud computing.
Current topics

- Safety and security
- Robustness and dependability
- Virtualization
- Optimization for multi- and many-core processors (scheduling, locking)
- Energy consumption (mobile devices, data centers)
- User interface
- Database support for file systems
- Cluster-, Grid-, and Cloud-Computing
- Small OS (e.g. for sensor networks)
Further Reading

- Hansen, P.B.: Classic Operating Systems
  Springer, New York, 2001

- The Virtual Museum of Computing
  http://vlmp.museophile.com/computing.html

- ACM Special Interest Group on Operating systems:
  http://www.sigops.org
Example: UNIX

USG/USDL/ATTIS/DSG/USO/USL

Bell Laboratories Research (AT&T)

Multics
(Ken Thompson, Dennis Ritchie, Brian Kernighan)

1965

Berkeley Software Distribution

1969

UNIX First Edition

1973

Fifth Edition

1976

Sixth Edition

1977

PWB MERT CB UNIX

1978

UNIX RT Seventh Edition

1979

3.0

1980

3.0.1

XENIX
(Microsoft, SCO)

Barry Linnert, linnert@inf.fu-berlin.de, Betriebssysteme WS 2019/20
Example: UNIX

- System V Release 3
- MACH 2.5
- XENIX 5
- SunOS4 Tenth Edition
- Plan9 4.3BSD-Reno
- 386BSD
- NetBSD 0.8
- FreeBSD 1.0
- Solaris 2
- FreeBSD 2.0
- FreeBSD Lite-1
- FreeBSD Lite-2
- 4.4BSD
- BSDI 1.0
- BSDI 2.0
- 4.4BSD-Lite-1
- 4.4BSD-Lite-2
- NET/1
- NET/2
- 2.11BSD
- 0.8
- 4.3BSD-Tahoe
- 4.3BSD-Reno
- Plan9
- 4.3BSD
- System V Release 4 Step
- OSF/1
- Novell UNIXWare
- DEC UNIX
- SCO UNIX
- Linux
- 1990
- 1991
- 1992
- 1993
- 1994
- 1995
- Barry Linnert, linnert@inf.fu-berlin.de, Betriebssysteme WS 2019/20
• **Halt and Catch Fire**