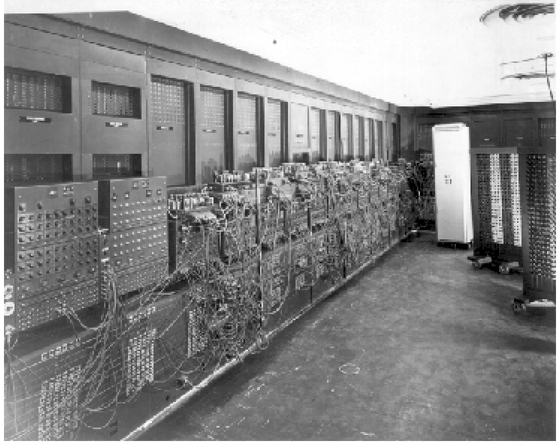
If the automobile had followed the same development cycle as the computer, a Rolls-Royce would today cost $100, get a million miles per gallon, and explode once a year, killing everyone inside.
-- Robert X. Cringely

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

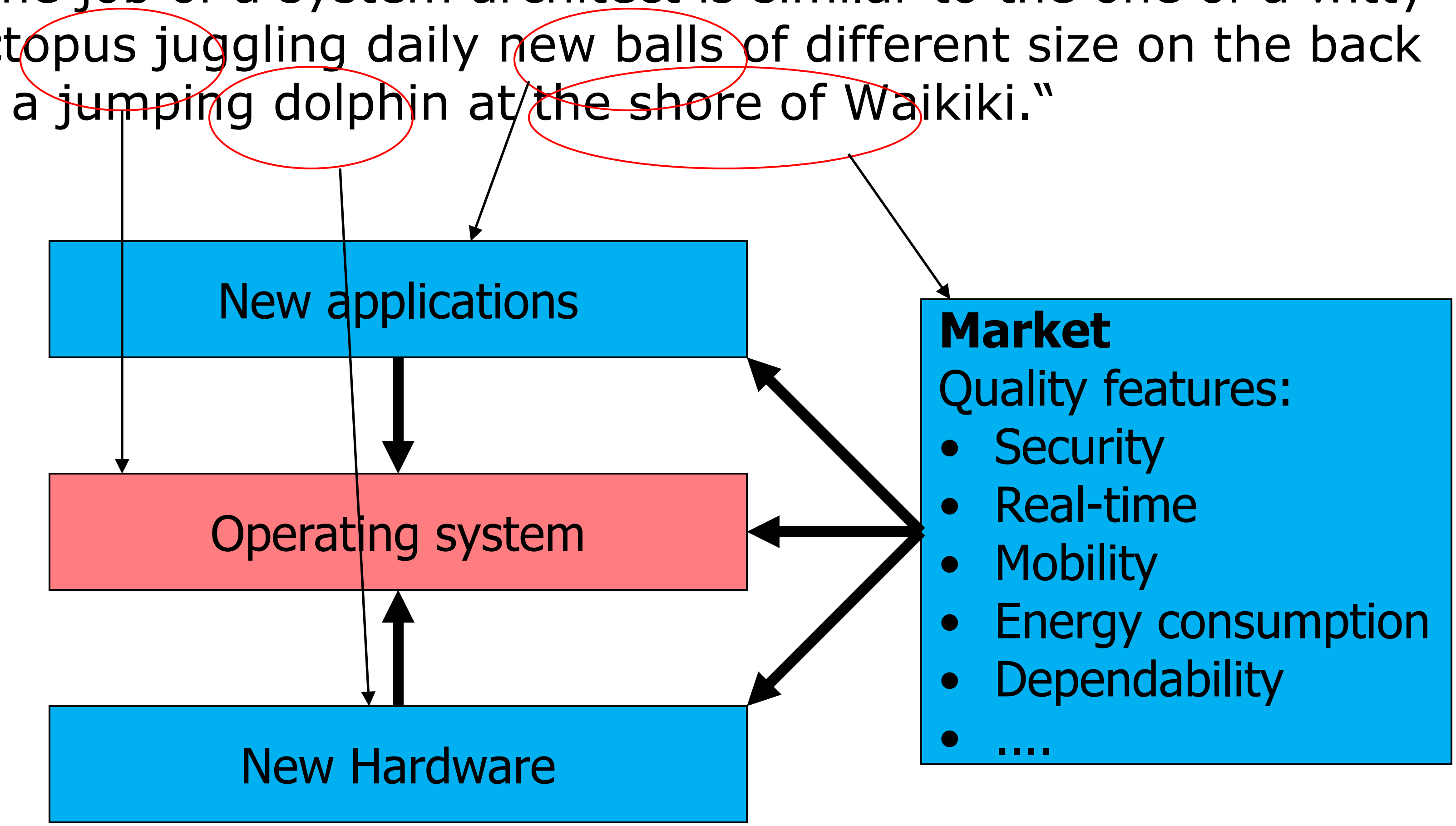
Tasks

- 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

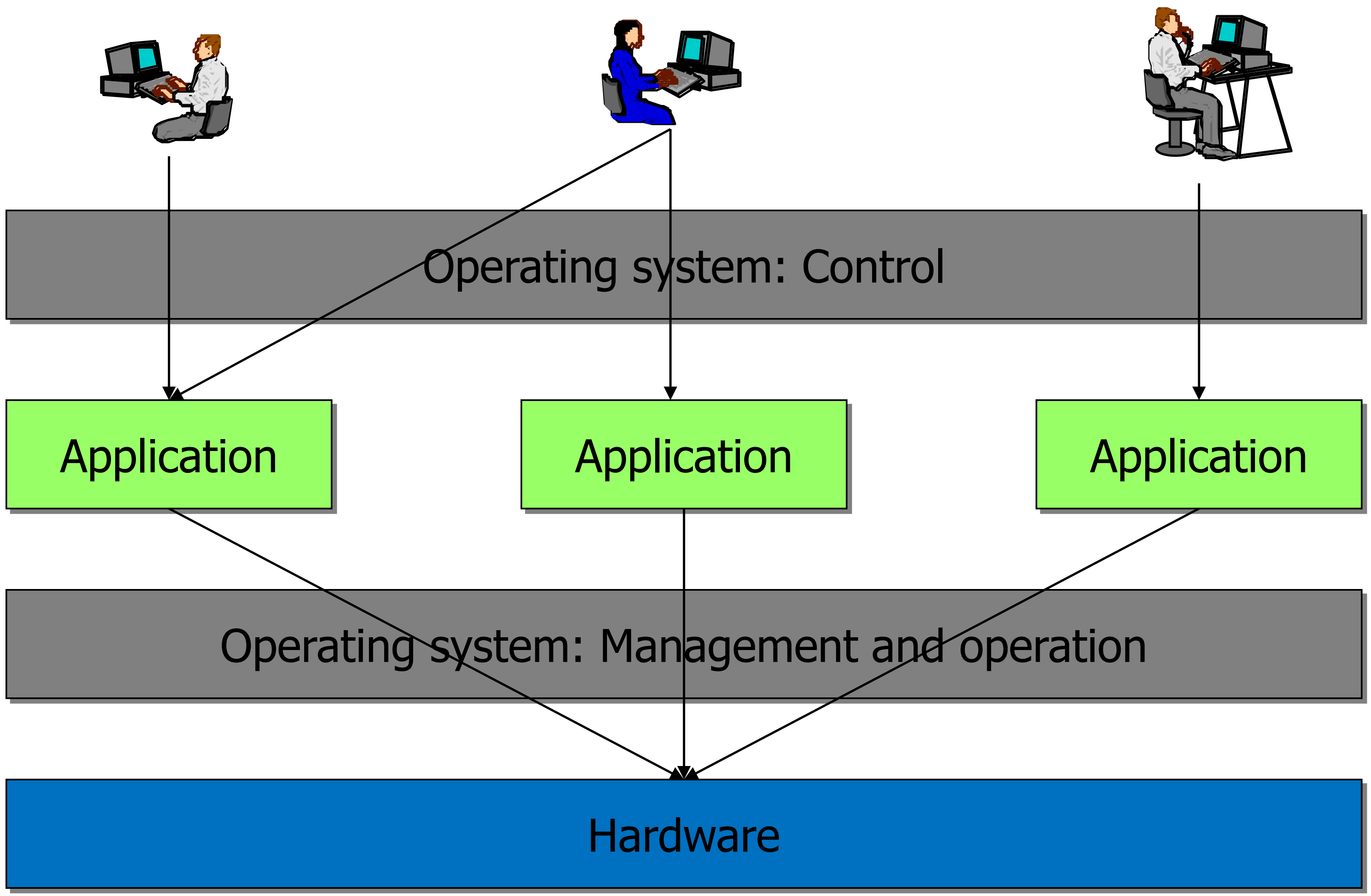
Operating system architecture

- 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."



Operating systems for general purpose computers



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
    - Material
    - Form
    - Strength
  - Doors
  - Windows

System architecture

- Example Electrical Engineering (ca. 120 years of experience)
  - Resistor
  - Coil
  - Capacitor
  - Diode
  - Tube
  - Transistor

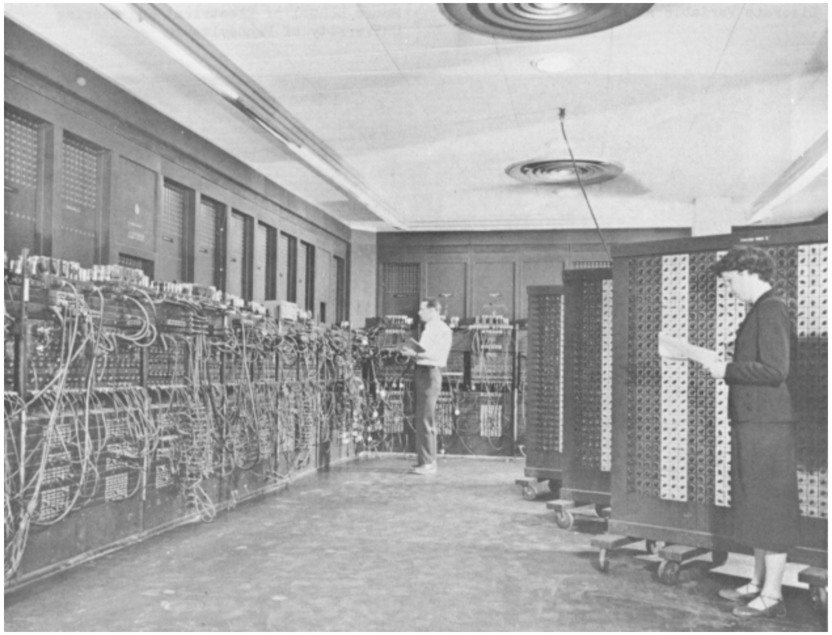
- **Example Operating systems (ca. 70 years of experience)**
  - Process
  - Signal
  - Address space
  - Channel
  - Interrupt
  - Driver
  - File

Channel:
- 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)

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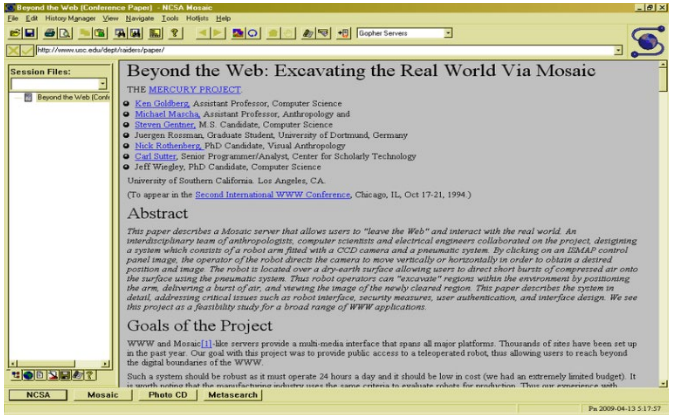
- Workstation computers and personal computers come up.
- Increased communication bandwidth: Ethernet, connected systems.
- For efficient implementation of communication software processes are needed.
- Processes are meanwhile complex entities: A process switch costs several thousand machine instructions. 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 super-computer (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

(Ubiquitous Computing, Pervasive Computing, Cloud Computing)

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- 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)

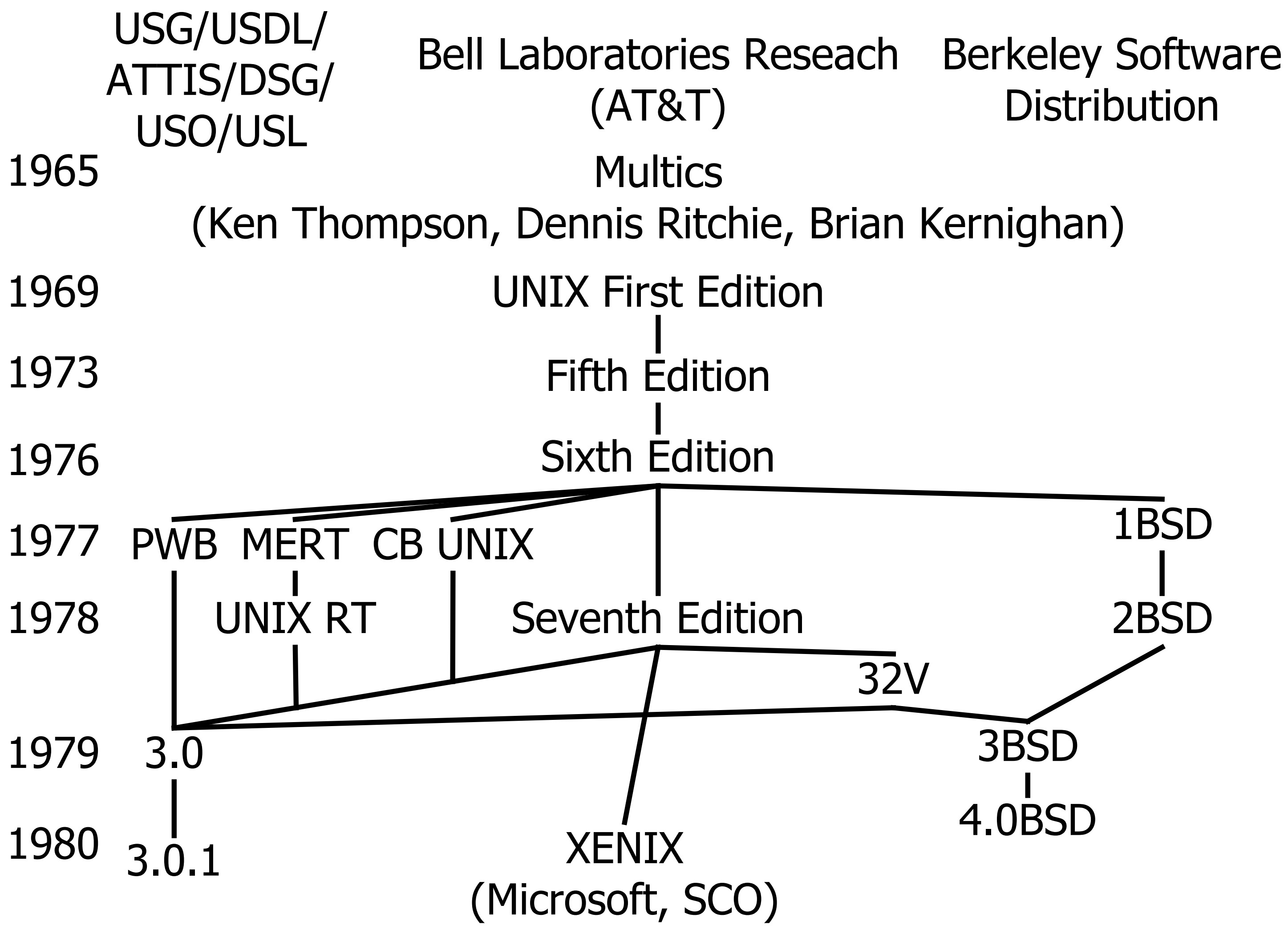
Further Reading

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

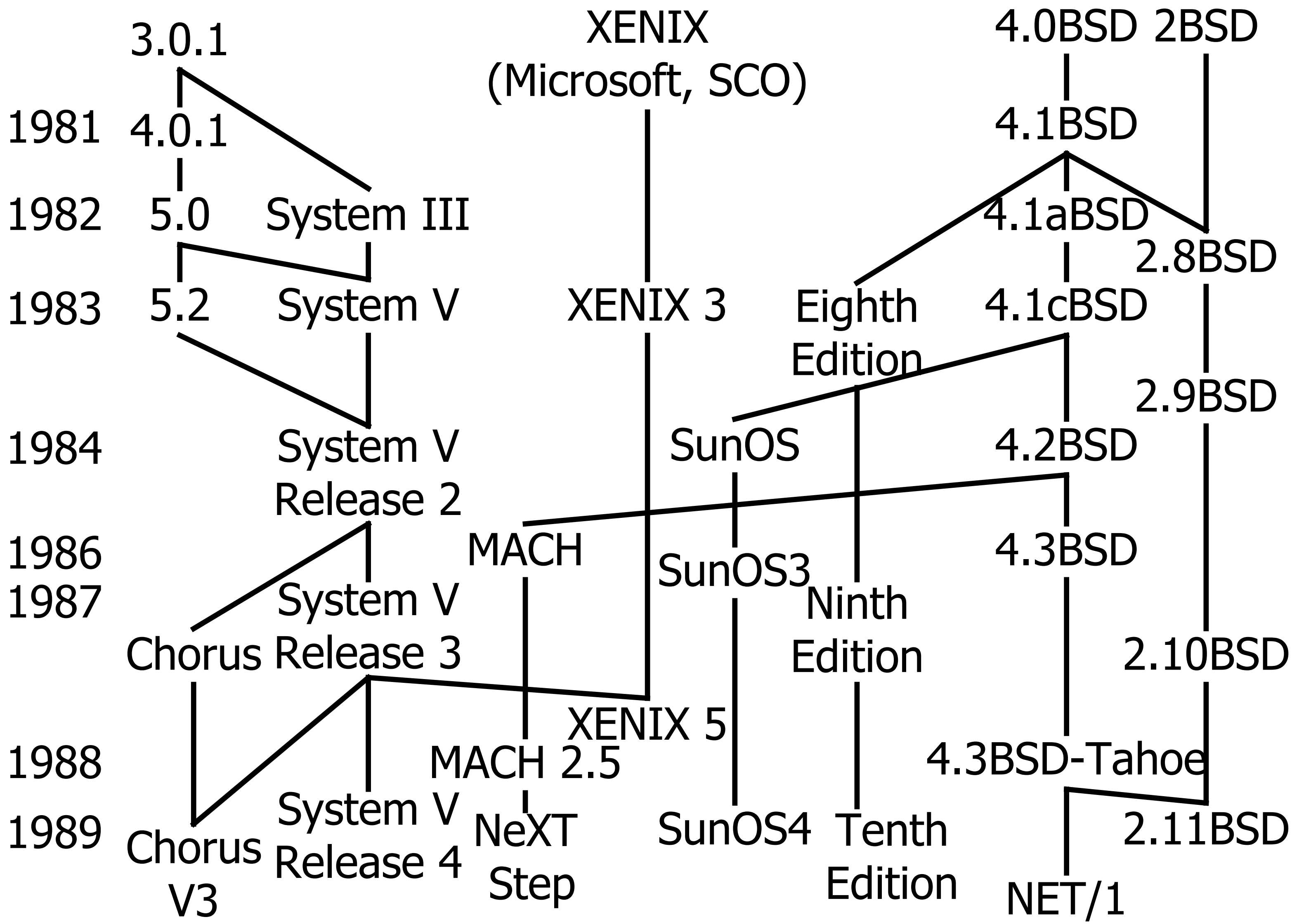
- The Virtual Museum of Computing
  http://vlmp.museophile.com/computing.html

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

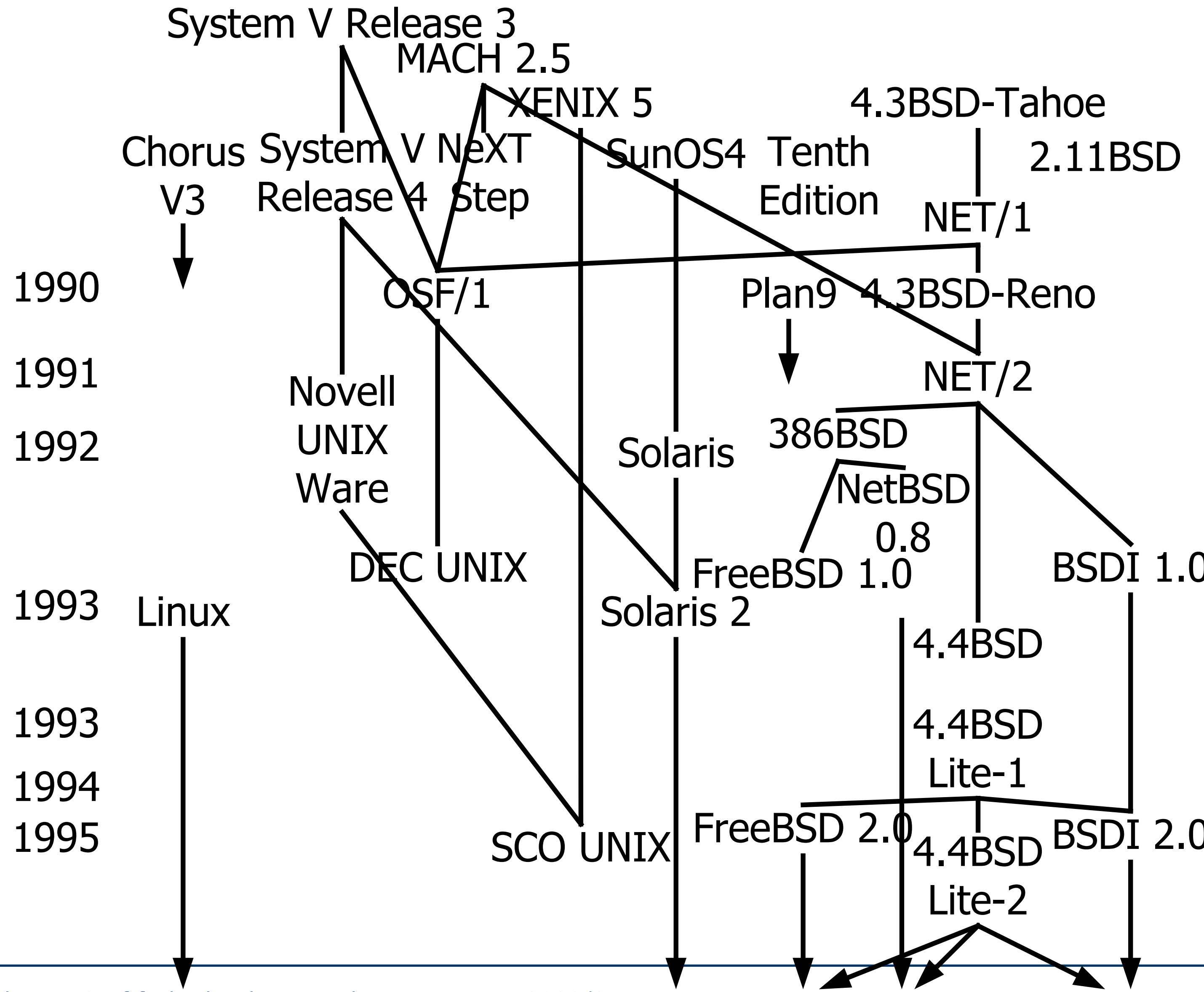
Example: UNIX



Example: UNIX



Example: UNIX



More information ;-)

- **Halt and Catch Fire**
  - https://de.wikipedia.org/wiki/Halt_and_Catch_Fire