

1969



The American space agency, NASA, launched the first spacecraft to land on the moon, the Apollo 11.

1972



Computer Tomography/CT scans made it possible to directly reconstruct images of soft tissue on screen.

1975



Completely destroyed, the Cambodian town of Phnom Penh fell to the guerrilla army, the Khmer Rouge.

1978



Eleven people, Bill Gates among them (bottom row, first on the left), founded the software company Microsoft Corporation.

1978



Louise Joy Brown, the first baby to be conceived outside its mother's womb, was born in Oldham General Hospital in England.

## \_further breakthroughs

In 1969 the Apollo Guidance Computer steers Apollo 11 to the lunar surface.

In 1970 the U.S. Department of Defense establishes ARPANET with four initial nodes; Xerox Palo Alto Research Centre (PARC) opens its doors with the mission to create "the architecture of information"; the first compiler for the programming language Pascal, designed by Niklaus Wirth, becomes operational.

In 1971 the Electronic News publishes the first advertisement for a micro-processor, the Intel 4004.

In 1972 Smalltalk is deployed, the first object-oriented programming language with integrated user interface and documents, overlapping windows, and cut & paste editor.

In 1974 Tony Hoare publishes in the Communications of the ACM his paper on Monitors: "An Operating System Structuring Concept".

Dahl became Professor of Informatics at the University of Oslo in 1968.

Dahl's work was now mainly on structured programming. Together with Dijkstra and Hoare he published the book "Structured Programming". Dahl was building on his work on Simula I and Simula 67.

*"The only efficient way to deal with complicated systems is in a hierarchical fashion. The dynamic system is constructed and understood in terms of high level concepts, which are in turn constructed and understood in terms of lower level concepts, and so forth. This must be reflected in the structure of the program which defines the dynamic system; in some way or another the higher level concepts will correspond to program components. The construction of concepts suitable in a given situation is a creative process which often requires insights obtained at later stages of the system construction. Therefore, as programmers are painfully aware, any software project tends to be a complicated iterative process involving reconstruction and revision at each stage."*

Dijkstra left Eindhoven University of Technology in 1973 and joined the Burroughs Corporation as a Research Fellow in August 1973. In 1972 Dijkstra accepted the prestigious ACM Turing Award with a speech filled with observations on the evolution of programming as a discipline. His work during the seventies gave rise to many more concepts:

- **separation of concerns:** "...a characteristic for all intelligent thinking ...is, that one is willing to study in depth an aspect of one's subject matter in isolation for the sake of its own consistency, all the time knowing that one is occupying oneself only with one of the aspects. ...'the separation of concerns', which, even if not perfectly possible, is yet the only available technique for effective ordering of one's thoughts, that I know of."
- notion of **self-stabilizing systems:** a system is self-stabilizing if and only if, regardless of the initial state, the system is guaranteed to find itself in a legitimate state after a finite number of moves
- concept of **non-determinism** which allows one to model phenomena which are inherently non-deterministic (e.g. delays in communication)
- "**predicate transformers**", a tool for defining program semantics and starting point for his book "A Discipline of Programming" ('76)
- two useful abstractions (mutator and collector, conceived together with other authors) on the study of **garbage collection**
- "**tri-color marking**" that is a basis to incremental garbage collection
- an algorithm for **detecting termination in distributed systems**

Nygaard's work in the seventies is characterized by two main aspects: advancement of knowledge in object-orientation; and research for trade unions.

Nygaard and others decided to develop a successor for Simula, which would focus on system description rather than execution. This development process led to the language **Delta**. While at the Aarhus University (Visiting Professor 1973-1975) a project based on the Delta ideas was started and this resulted in the programming language **Beta**. In Beta classes, procedures, functions and types are replaced by a single abstraction mechanism called the pattern. A project led by Nygaard at the Norwegian Iron and Metal Worker's Union, was the first project about **participatory design**.



Ole Dahl, 1968



Ole Dahl, 1970



Ole Dahl, 1972



Edsger Dijkstra, 1972



Edsger Dijkstra, 1973