THE

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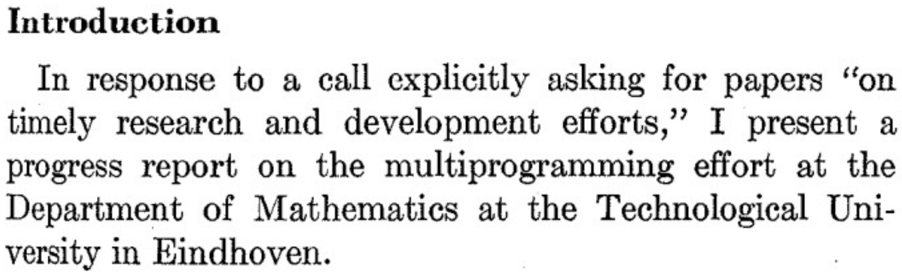
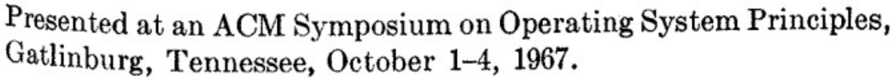


Introduction

In response to a call explicitly asking for papers "on timely research and development efforts," I present a progress report on the multiprogramming effort at the Department of Mathematics at the Technological University in Eindhoven.



Presented at an ACM Symposium on Operating System Principles, Gatlinburg, Tennessee, October 1–4, 1967.

Goal of this system

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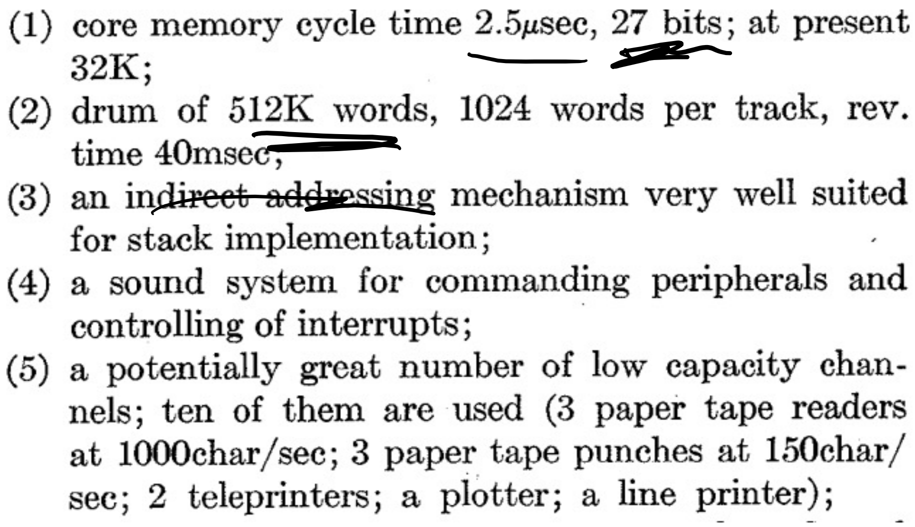
- “The primary goal of the system is to process smoothly **a continuous flow of** user programs as a service to the University”

The hardware



(1) core memory cycle time 2.5μsec, 27 bits; at present 32K;

(2) drum of 512K words, 1024 words per track, rev. time 40msec;

(3) an indirect addressing mechanism very well suited for stack implementation;

(4) a sound system for commanding peripherals and controlling of interrupts;

(5) a potentially great number of low capacity channels; ten of them are used (3 paper tape readers at 1000char/sec; 3 paper tape punches at 150char/sec; 2 teleprinters; a plotter; a line printer);

Outline

- Major design decisions
  - CPU management
    - Multi-programming
    - Processes
    - Synchronization
  - Memory management
    - Virtual memory
- Overall OS architecture
  - Monolithic kernel design

Multi-programming

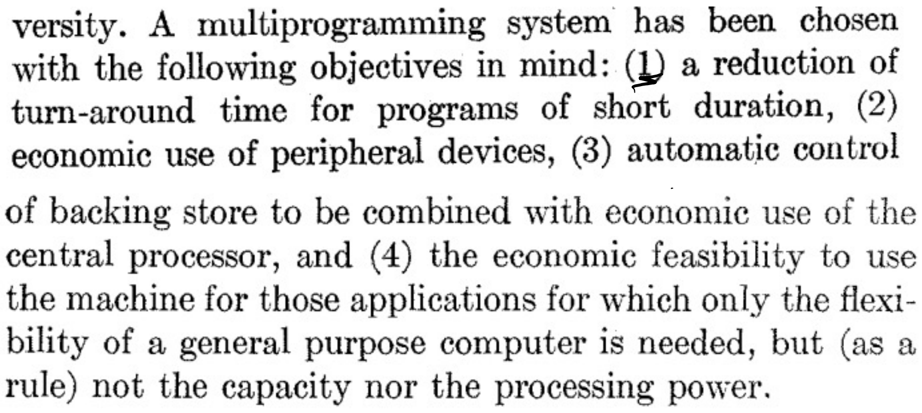
- What does this mean?
  - Multiple programs running at *the same time*

Multi-programming

- What is its benefit over uni-programming?
    - Throughput!!!

Multi-programming

- What is its benefit?



versity. A multiprogramming system has been chosen with the following objectives in mind: (1) a reduction of turn-around time for programs of short duration, (2) economic use of peripheral devices, (3) automatic control of backing store to be combined with economic use of the central processor, and (4) the economic feasibility to use the machine for those applications for which only the flexibility of a general purpose computer is needed, but (as a rule) not the capacity nor the processing power.

Multi-programming

- What is its benefit?
  - Reduce <u>turn-around time</u>
  - Better utility of peripheral devices
  - Better utility of storage
  - Better accommodate for low-demand tasks

Multi-programming

- What is its benefit?
    - Reduce turn-around time
    - Better utility of peripheral devices
    - Better utility of storage
    - Better accommodate for low-demand tasks
- Does it have problems?
    - Switching among applications (processes) takes time

Memory management

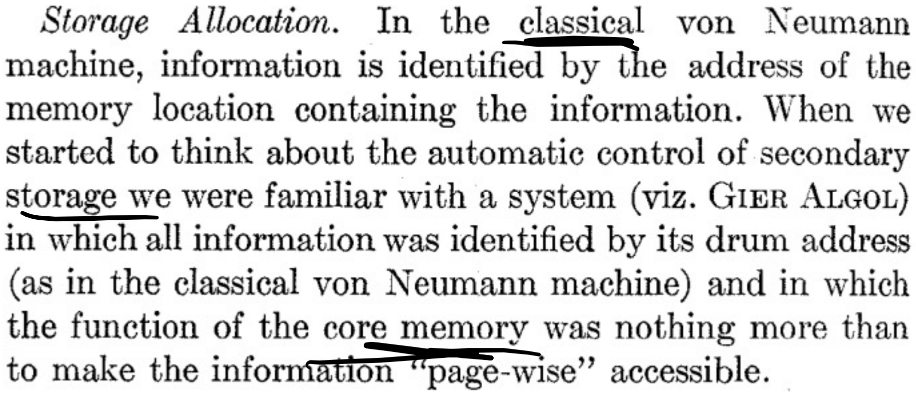
- What is the difference between physical address and virtual address?

- char* x = malloc (10)
  *x =‘a’;

- printf(“Address of variable G is %d\n”, &G)

Memory management

- OLD days

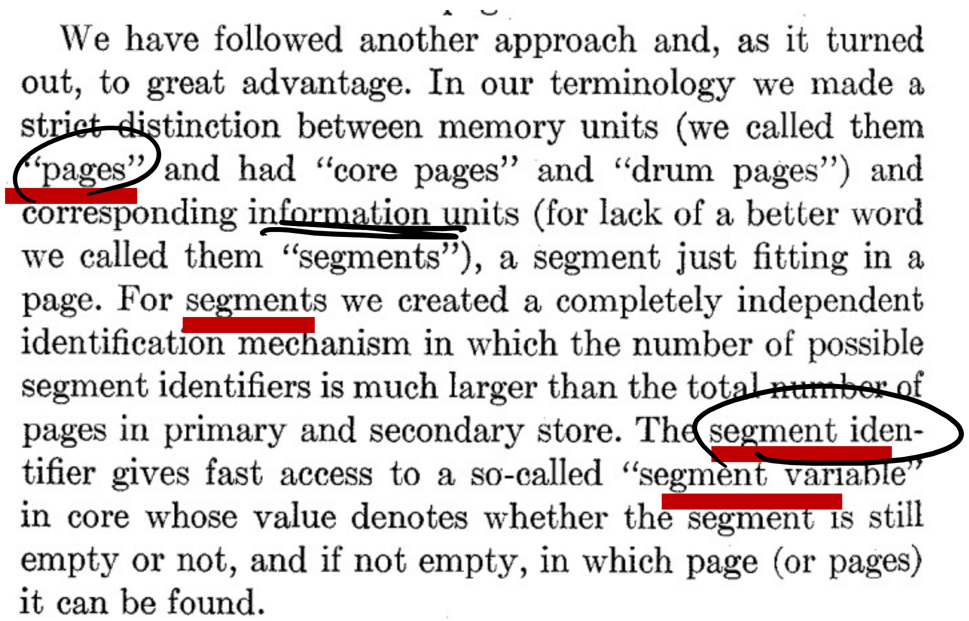


Storage Allocation. In the classical von Neumann machine, information is identified by the address of the memory location containing the information. When we started to think about the automatic control of secondary storage we were familiar with a system (viz. Gier Algol) in which all information was identified by its drum address (as in the classical von Neumann machine) and in which the function of the core memory was nothing more than to make the information "page-wise" accessible.

Memory management

- THE

What is this?



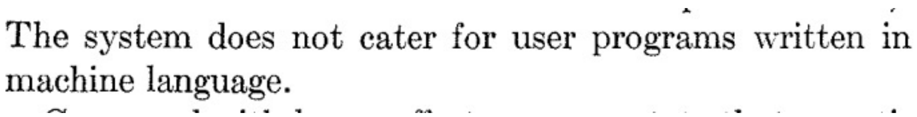
We have followed another approach and, as it turned out, to great advantage. In our terminology we made a strict distinction between memory units (we called them "pages" and had "core pages" and "drum pages") and corresponding information units (for lack of a better word we called them "segments"), a segment just fitting in a page. For segments we created a completely independent identification mechanism in which the number of possible segment identifiers is much larger than the total number of pages in primary and secondary store. The segment identifier gives fast access to a so-called "segment variable" in core whose value denotes whether the segment is still empty or not, and if not empty, in which page (or pages) it can be found.

What is the benefit of virtual memory?

What is the benefit of virtual memory?

- No need to write back to the same disk location
- A program has no need to occupy consecutive drum pages
- Making programming much easier

How is this achieved in THE?



The system does not cater for user programs written in machine language.

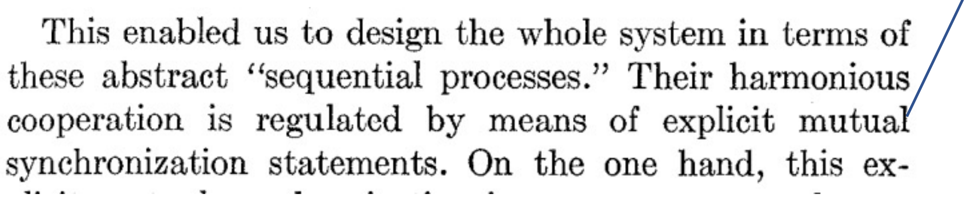
Processes

- What is the modern definition of “process”?
    - Running program

- What is the difference between processes in THE and Nucleus?
    - THE: no dynamic process creation; batching OS
    - Nucleus: start

- How does THE perform CPU scheduling?

Processes & Synchronization



This enabled us to design the whole system in terms of these abstract "sequential processes." Their harmonious cooperation is regulated by means of explicit mutual synchronization statements. On the one hand, this ex-

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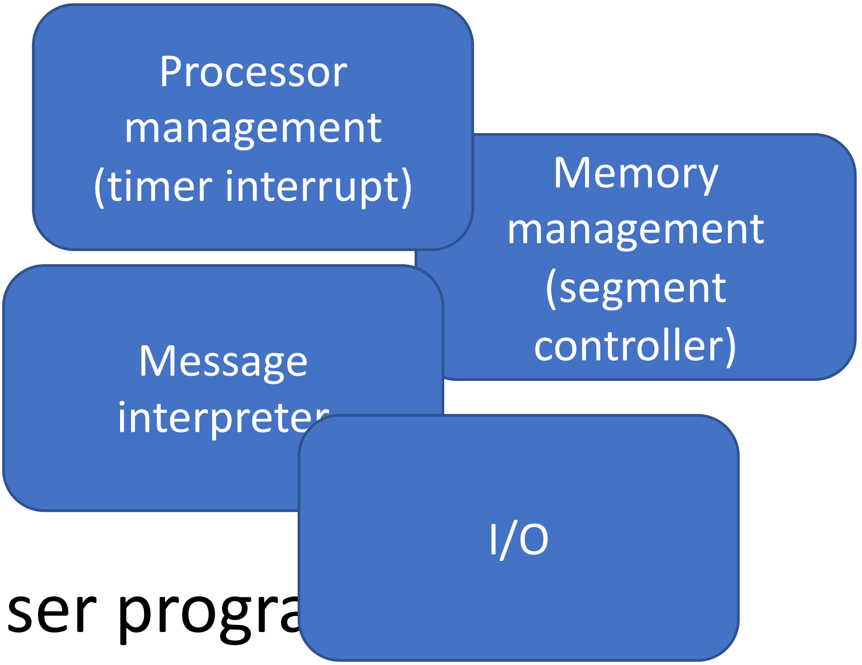
Is there a file system?

OS organization: monolithic kernel!!

- Level 0:
- Level 1:
- Level 2:
- Level 3:
- Level 4: user progra



Processor management (timer interrupt)

Memory management (segment controller)

Message interpreter

I/O

Why levels?

- What exactly are these levels
- Why levels?