Instrumentation of Multics

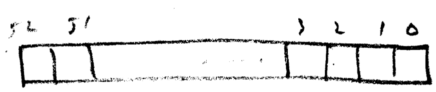
(Based on a paper given in Princeton in October)

[illegible] 7:55 [illegible] MAC

1. Purpose of Instrumentation for Multics
   - a. To improve system performance
   - b. To understand ~~how~~ why the system works.

(Results: a. have monitored and frequently guided in correct [illegible] changes to give factor of 6 in system performance. Currently are following the "best" for goal 2.
b. Beginning to develop some simple models.)

2. Strategy of Instrumentation used in Multics
   - a. Simple, few, but effective, hardware attachments
   - ~~b. Extensive use of [illegible] hardware in operating system itself~~
   - b. Permanent, integral software instrumentation

3. Hardware tools
   - a. Calendar clock, 1 μsec 

   - b. CPU Memory cycle timer (not used yet)
   - c. Self-driving I/O channel for PDP-8/338 Display

4. ~~Software tools~~ types of software tools

counters

clock readers

integrators

ring buffers

5. Examples of software tools

- counter in standard ~~entry~~ subroutine entry sequence
- missing-page trace in a ring buffer — reading message
- ~~page fault distribution~~ missing-page handler run time distribution
- average ~~page length~~ [illegible] lengths integrator
- segment usage distribution meter

a. can use to count interrupt classes

b. discover long tails

c. discovered extra wakeups in ... strategy

d. visible core management excess

6. Script-driven testing

Purpose: to find out how significant a change was

Technique: PDP-8 dials up Multics, sends commands

Script: Type in & debug a small FORTRAN program

7. Summary

Emphasis on internal, integrated, permanent meeting facilities.

Emphasis on understanding why system behaves that way

Emphasis on controlled experiments.

Purpose of Instrumentation for Multics

- Find ways to improve performance

- Understand why the system works

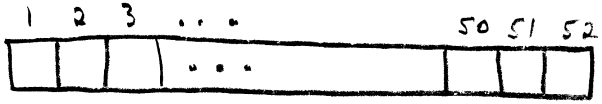
STRATEGY OF MULTICS INSTRUMENTATION

- SIMPLE, FEW, EFFECTIVE HARDWARE HELPS

- PERMANENT, INTEGRAL SOFTWARE METERS

HARDWARE TOOLS

- 1 μsec CALENDER CLOCK:



- CPU MEMORY CYCLE COUNTER

- SELF-DRIVING I/O CHANNEL TO PDP-8/338 DISPLAY

Types of Software Tools

- Counters
- Clock readers
- Integrators
- Ring buffers

EXAMPLES OF SOFTWARE TOOLS

- COUNTER IN STANDARD SUBROUTINE ENTRY CODE
- "READY" MESSAGE FOLLOWING EACH COMMAND
- CLOCK READ LOOP TO WATCH FOR INTERRUPTS
- CPU QUEUE-LENGTH RECENT AVERAGE INTEGRATOR

$$(I = \alpha I + N)$$

- MISSING-PAGE TRACE

SCRIPT-DRIVEN TESTING

PURPOSE: CONTROLLED MEASUREMENT OF A CHANGE AFFECTING PERFORMANCE

TECHNIQUE: PDP-8 DIALS UP MULTICS, SENDS COMMANDS WITH PAUSES BETWEEN

SCRIPT: TYPE IN AND DEBUG A SMALL FORTRAN PROGRAM.

MULTICS INSTRUMENTATION EMPHASIS

- INTERNAL, INTEGRATED, PERMANENT METERS

- UNDERSTANDING WHY SYSTEM BEHAVES AS IT DOES

- CONTROLLED EXPERIMENTS