

System Software - Homework 5

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1 Explanation of Terms

- **Memory-mapped I/O:** A method of performing input/output (I/O) between the CPU and peripheral devices by assigning memory addresses to the I/O devices. The CPU can then interact with the devices by reading from or writing to these memory addresses, just as it would with regular memory.
- **DMA (Direct Memory Access):** DMA allows peripheral devices to transfer data directly to or from the main memory without constant CPU intervention. A DMA controller manages the data transfer, freeing up the CPU for other tasks.
- **Polling:** Polling is a technique where the CPU periodically checks the status of a peripheral device to see if it requires attention or has data to transfer.

2 Calculations

Clock frequency: $200 \text{ MHz} = 200 \times 10^6 \text{ cycles/second}$

2.1 1. Mouse

- Polling rate: 30/s
- Cycles per polling operation: 400
- Cycles spent on polling per second: $30 \times 400 = 12000$
- CPU utilization: $\frac{12000}{200 \times 10^6} \times 100\% = 0.006\%$

2.2 2. Floppy Disk Drive

- Data rate: $50 \text{ KB/s} = 50 \times 1024 \text{ Bytes/s}$
- Word size: 16 bits = 2 Bytes
- Data rate in words: $\frac{50 \times 1024}{2} = 25600 \text{ words/s}$
- Polling rate: 25600/s
- Cycles spent on polling per second: $25600 \times 400 = 10240000$
- CPU utilization: $\frac{10240000}{200 \times 10^6} \times 100\% = 5.12\%$

2.3 3. Hard Disk Drive

2.3.1 Polling

- Data rate: $2 \text{ MB/s} = 2 \times 1024 \times 1024 \text{ Bytes/s}$
- Word size: $32 \text{ bits} = 4 \text{ Bytes}$
- Data rate in words: $\frac{2 \times 1024 \times 1024}{4} = 524288 \text{ words/s}$
- Polling rate: $524288/\text{s}$
- Cycles spent on polling per second: $524288 \times 400 = 209715200$
- CPU utilization: $\frac{209715200}{200 \times 10^6} \times 100\% = 104.86\%$

2.3.2 DMA

- Data rate: $2 \text{ MB/s} = 2 \times 1024 \times 1024 \text{ Bytes/s}$
- Transfer size per DMA operation: $4 \text{ KB} = 4 \times 1024 \text{ Bytes}$
- DMA transfers per second: $\frac{2 \times 1024 \times 1024}{4 \times 1024} = 512$
- Cycles per DMA initialization: 4000
- Cycles per interrupt: 2000
- Total cycles per DMA transfer: $4000 + 2000 = 6000$
- Cycles spent on DMA per second: $512 \times 6000 = 3072000$
- CPU utilization: $\frac{3072000}{200 \times 10^6} \times 100\% = 1.536\%$

3 Summary of Results

Device	Method	CPU Utilization
Mouse	Polling	0.006%
Floppy Disk Drive	Polling	5.12%
Hard Disk Drive	Polling	104.86%
Hard Disk Drive	DMA	1.536%

Table 1: CPU Utilization of Different Devices