МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ

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**Data processing algorithms on external storages**

(Labs)

Lab 3

Memory Hieararchies

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# Introduction

When a data set is too large to fit in internal memory, it is typically stored in external memory (EM) on one or more magnetic disks. EM algorithms explicitly control data placement and transfer, and thus it is important for algorithm designers to have a simple but reasonably

accurate model of the memory system’s characteristics.

A magnetic disk consists of one or more platters rotating at constant speed, with one read/write head per platter surface, as shown in Figure 1. The surfaces of the platters are covered with a magnetizable material capable of storing data in nonvolatile fashion. The read/write heads are held by arms that move in unison. When the arms are stationary, each read/write head traces out a concentric circle on its platter called a track. The vertically aligned tracks that correspond to a given arm position are called a cylinder. For engineering reasons, data to and from a given disk are typically transmitted using only one read/write head (i.e., only one track) at a time.

Disks use a buffer for caching and staging data for I/O transfer to and from internal memory. To store or retrieve a data item at a certain address on disk, the read/write heads must mechanically seek to the correct cylinder and then wait for the desired data to pass by on a particular track. The seek time to move from one random cylinder to another is often on the order of 3 to 10 milliseconds, and the average rotational latency, which is the time for half a revolution, has the same order of magnitude. Seek time can be avoided if the next access is on the current cylinder. The latency for accessing data, which is primarily a combination of seek time and rotational latency, is typically on the order of several milliseconds. In contrast, it can take less than one nanosecond to access CPU registers and cache memory — more than one million times faster than disk access!

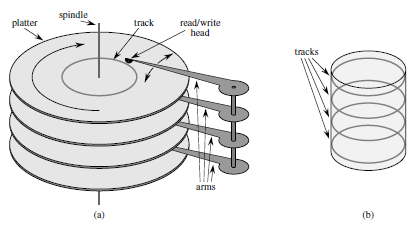


Figure 1

We can capture the main properties of magnetic disks and multiple disk systems by the commonly used parallel disk model (PDM) introduced by Vitter and Shriver [1]. The two key mechanisms for efficient algorithm design in PDM are locality of reference (which takes advantage of block transfer) and parallel disk access (which takes advantage of multiple disks).

In a single I/O, each of the D disks can simultaneously transfer a block of B contiguous data items. PDM uses the following main parameters:

N = problem size (in units of data items);

M = internal memory size (in units of data items);

B = block transfer size (in units of data items);

D = number of independent disk drives;

P = number of CPUs,

where M < N and 1 ≤ DB ≤ M/2. The N data items are assumed to be of fixed length. The *i*th block on each disk, for *i* ≥ 0, consists of locations *i*B, *i*B + 1, . . ., (*i* + 1) B − 1.

# 2. Exercise

In this lab, you need to measure the speed of your disk and RAM caches. Your solution should consist of two parts:

1. program code that performs the necessary measurements;
2. the report, which will be described measurements.

**The program**

Your program should accept input (as command-line argument) the type of measurement that you want to produce. The program should print the result of the measurement and its inaccuracy where applicable.

You want to implement the following checks:

1. Measurement of the speed of the serial read data from disk (the output should be in MB/s).

2. The measurement time to seek of your drive (it should display time in milliseconds, in the case of SSD can be in microseconds).

3. The measurement of time of random access memory (time should be displayed in nanoseconds).

4. The measurement of time of the cache/sequential access to the memory (the display time in nanoseconds, or as speed in MB/s).

You should measure for different block sizes, to which will be access and show how the resulting values depend on the size of the block.

**Report**

The report must include the following:

1. Brief characteristics of your hardware:

• Volume and model RAM;

• Hard drive type, and the characteristics listed in the specifications.

2. A description of how to compile your program and how it measures these required values.

3. The obtained values of the measurements on your hardware.

4. If the values differ from the expected for your hardware (dozens of times), the rationale for why it happened.

# Bibliography

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2. Kleinbeg J., Tardos E, Algorithm Design. Cornell Univesity
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