Performance Evaluation Metrics: Can buffer size override the higher rotational speed of hard disk in terms of overall performance or throughput?

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Abstract: The aim of performance evaluation is to find out some performance metrics for systems under consideration or for prototypes to workout novel systematic and methodological basis for some portions of performance evaluation, discover methods to use speculative methods in conceiving and assessing performance models. In this paper measurement based performance evaluation techniques have been applied to two hard disks of same storage capacity but of different rotational speeds. Results have been studied, plotted and discussed. [Journal of American Science 2010;6(10):503-508]. (ISSN: 1545-1003).

Key-Words: - SUT (System under test), CUT (Component under test), Workload, Probe, Monitor, Agent

1 Introduction

In Design and Procurement the important benchmark is performance. The hardware design reflects the improvement in performance [8] Normal practice for the analyst, engineers and scientist is to get peak performance within the stipulated defined cost. The necessary knowledge of Performance analysis tricks and techniques is mandatory for a performance analyst [2]. A person that is realted to computer systems must be capable to define/state the requirements for a computer system and he must also be able to compare various options of computer systems for the purpose of meeting best specification. The hardware improvement [9] are not the criteria for performance measurement for this paper.
The techniques relating to this filed are applicable in many fields e.g in manufacturing plants, logistics, computers, etc **[**6]. This is mostly related with the procedural/methodological side the PE. The cases discusses in this technique are mostly related to computer networks and computer systems [5]. S. Sharma1 at el. calculated the effectiveness of current day contemporary simulation tools for modeling head-slap events by comparing computing and measuring head velocity histories [1].

2 Goals of Performance Evaluation

There are approximately three goals in the performance evaluation area [5]:

- Find out some performance metrics for SUT i-e the system under consideration.
- Carve novel investigative and systematic basis for some portions of performance evaluation, e.g. search for developments in queuing theory or analyzing the results of time series simulations and measurements [5].
- Thirdly for crafting and assessing performance models it necessary to search techniques either theoretical or practical.

3 A Systematic Performance Evaluation Methodology

In relation to approach the steps are, [4]

- Define goals and describe the system
- Itemize features and outcomes
- Chose metrics
- Enlist parameters
- Choose factors to study
- Choose assessment technique
- Choose workload
- Devise experiments
- Examine and explain data
- Depict results
- Repeat

4 Leading PE Techniques

To evaluate the performance of 1 or more systems, techniques of PE must be used. There are mainly three techniques of performance evaluation [5]:

4.1 Measurements

This technique is used when SUT is in prior existence and access to this is within the reasonable effort range.

4.2 Analytical Modeling
In this scenario the SUT normally have no prior existence or the system is very huge (Complicated, Unhandy, or unavailable). For this purpose a mathematical model or an analytical model can be used.

4.3 Simulation Modeling
It is just a copycat of SUT or a computer program that is just a copy of the actual system under test.

4.4 Measurements Based Performance Analysis
No mater you have a single computer of network of computers these techniques are equally applicable. The entities coming in the next heading are discussed conceptually.

4.5 SUT (System Under Test)
SUT is the system (network or a computer system) whose performance needs to be evaluated. In this study we are studying the performance two hard disks of 40GB capacity but of different RPM. One is 7200RPM and the other is of 5400RPM.

4.6 CUT(Component Under Test)
The Component Under Test may be part of a computer system or a computer network.

4.7 Workload
Work demanded by users from a system [4]. Workload specifies the series of requests the system must take care of. Various kinds of workloads exist.

4.8 Probe
The job of aprobe is to some metric values and append or attach some meta information and saves all in a buffer.

4.9 Monitor
Its job is to show user the interpreted and analyzed data that have been collected from agents. The protocol used for collecting data by the monitor is normally the query protocol.

4.10 Agent
The job of the agent is to provide the values residing in the buffer. Some time it may also do some processing job on the data.

5 Case Study

In this paper we have compared two hard disks of Maxtor Company, both are of same capacity i-e 40GB, but there is a speed difference in terms of RPM. One is 7200 RPM and the other is 5400 RPM. The aim is to evaluate the performance of the two hard disks through measurement based technique and tell which of the two is better and why? Figures 1 **(** [7] **&** [11] **)** are the two hard disks which would be studied for performance evaluation. Both these hard disks belong to same brand i-e Maxtor, but their model is different. The models are 2F040L0 (7200RPM) & 2F040L0 (5400RPM).

Fig. 1 Maxtor 2F040L0 (5400RPM) & Maxtor 6L040J2 (7200RPM)

5.1 Metrics
Quantitative measures to evaluate the performance of various components of a system are the metrics.
The following parameters have been measured.

- Burst Speed
- Sequential Read Speed
- CPU Utilization
- Random Access
- Transfer Rate Minimum
- Transfer Rate Maximum
- Transfer Rate Average
- Buffer size

These parameters are measured for both of the hard disks under identical conditions i-e same operating system (windows XP) and same hardware (Intel(R) Pentium(R) 4 CPU 1400MHz & 256MB RAM). For measurement of these parameters we used HD Tach 3.0.1.0 (shareware) & HD Tune (Freeware) softwares that are available as freeware or shareware from [3], the Benchmarking, system, information monitoring software archive. There are many benchmarking software monitors available in [3] but we have used only the following two.

5.2 Type of Benchmarks
J. K. Jones performed a comparative analysis of a variety of HDD performance software packages [10]. There are number of benchmarks softwares available from [3]. For example Active SMART 2.42, CHDDSPEED, Disk Bench, Disk Speed, DiskSpeed32, Drive!, Drive Speed Checker, FD Tach 0.9, HDDScan, HD_Speed, HD_Speed, HDD Speed 2.1, HD Tach 3.0.1.0, HD Tune, IDEdrive 2, Iometer, QDI Mark, Quick Bench, Victoria 3.52, etc.

5.3 HD Tach 3.0.1.0 (Shareware)
For flash devices, RAID arrays, ZIP drives, random access R/W storage devices HD Rach is a good low

level hardware benchmark. To avoid as many layers of software as likely and get as near to the physical performance of the device achievable, HD Tach utilizes custom device drivers and different low level Windows interfaces. This benchmark tool can measure CPU utilization, random access speed, interface burst speed, random access speed, sequential read speed and sequential write testing at different locations of the device. [3].

5.4 HD Tune (Freeware).

This hard disk utility has the capabilities to measure various important parameters such as temperature, buffer size, firmware version, SMART parameters from the hard disk., etc [3].

5.5 Results Presentation

The plotted results of measurements by the *HD Tune* for the 7200 rpm disk are shown in figure 3. Following are parameters measured by HD Tune for this model (6L040J2).

Transfer Rate Minimum : 21.8 MB/sec
Transfer Rate Maximum : 40.0 MB/sec
Transfer Rate Average : 34.1 MB/sec
Access Time : 12.6 ms
Burst Rate : 72.9 MB/sec
CPU Usage : 11.2%
Buffer size : 1819.5 KB

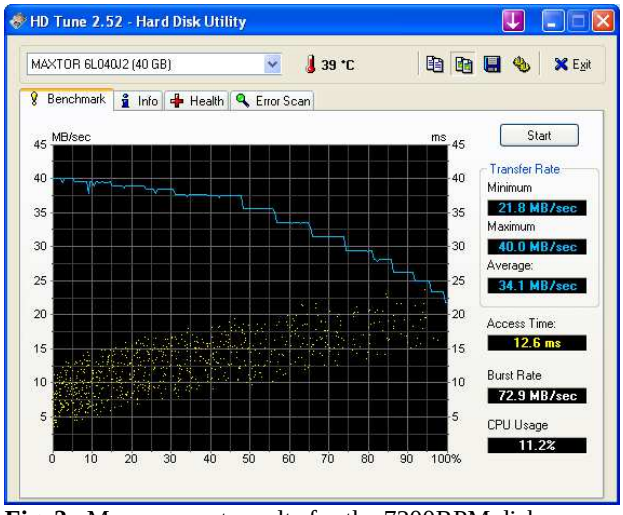

Fig. 2 Measurement results for the 7200RPM disk.

For the 5400 rpm disk the plotted results are shown in the figure 4. The parameters measured are as follows;

Transfer Rate Minimum : 27.0 MB/sec
Transfer Rate Maximum : 46.1 MB/sec
Transfer Rate Average : 39.8 MB/sec
Access Time : 21.5 ms
Burst Rate : 89.2 MB/sec
CPU Usage : 11.5%
Buffer size : 2048 KB

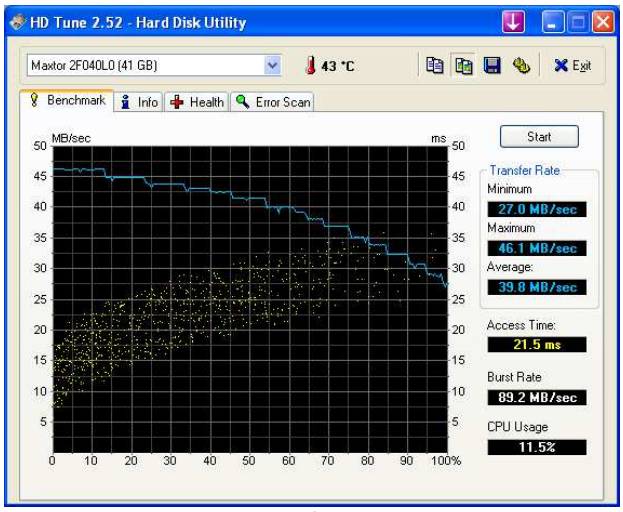

Fig. 3 Measurement results for the 5400RPM disk.

Now the results measured by the HD Tach benchmarking software for the 5400 rpm disk are shown in the figure 5. This benchmark measures the following parameters;

Random access : 22.7 ms
CPU utilization : 6%(+/- 2%)
Average read : 41.7 MB/s

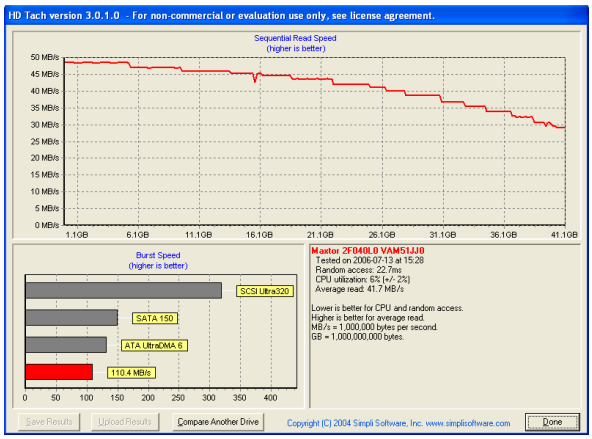

Fig. 4 Measurement results for the 5400RPM disk

For the 7200 rpm hard disk the results measured by the HD Tach are shown in the figure 6. The corresponding parameters measured are;

Random access : 12.0 ms
CPU utilization : 8%(+/- 2%)
Average read : 35.7 MB/s

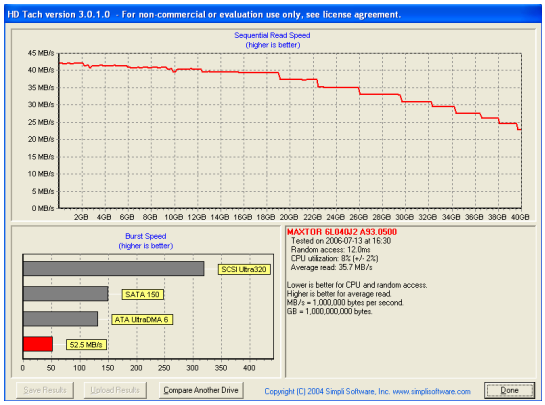

Fig. 5 Measurement results for the 7200RPM disk

Figure 7 shows the comparison of both the disks as graphed by the HD Tach benchmarking software. The Blue plot is the sequential read speed of the Maxtor 5400 rpm disk & the red plot is the sequential read speed for the Maxtor 7200 rpm disk.

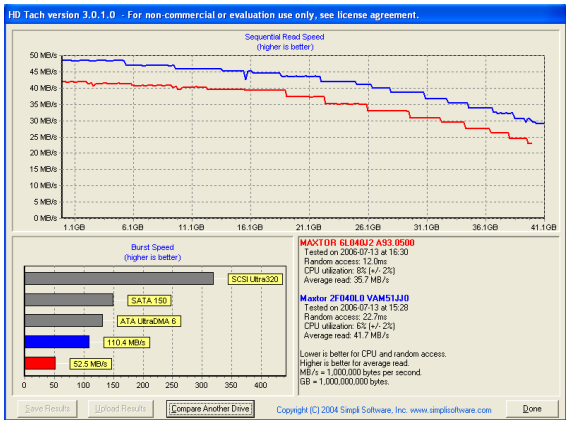

Fig. 6 comparison of results for the both disks

6 Results & Discussion

The results from both the benchmarks i-e HD Tune and HD Tach 3.0.1.0 clearly shows that the performance of the 5400 rpm hard disk is little bit superior to the 7200 rpm hard disk. The comparison of measured parameters is shown in the Table 1.

Table 1 Comparison of measured parameters.

Parameters	5400 RPM Disk	5400 RPM Disk
Transfer Rate Minimum	27.0 MB/sec	21.8 MB/sec
Transfer Rate Maximum	46.1 MB/sec	40.0 MB/sec
Transfer Rate Average	39.8 MB/sec	34.1 MB/sec
Access Time	21.5 ms	12.6 ms
Burst Rate	89.2 MB/sec	72.9 MB/sec
CPU Usage	11.50%	11.20%
Buffer size	2048 KB	1819.5 KB

From the table 1 it is clear that the overall transfer rate (in MB/sec) is higher for the hard disk having less RPM. Although the access time for the 5400 RPM disk is 8.9 ms higher than the access time of the 7200 RPM but it has slightly higher buffer size i-e 228.5 KB. This slight increase in the buffer size had a great impact on the overall throughput. This fact is also clear from the figure number 7.

6.1 Confidence Interval test

We shall use the Confidence Interval (CI) for small samples. For a confidence level of 100(1-α)% and sample size less than 30 values, confidence interval is given by [4];

$$(\bar{x} - t_{[1-\alpha/2;n-1]} s/\sqrt{n}, \bar{x} + t_{[1-\alpha/2;n-1]} s/\sqrt{n})$$

Where t [1-α/2; n-1] = (1-α/2)-quantile of a t-variate with n-1 degrees of freedom.

The table 2 shows the throughput or the transfer rate in MB/s for the 5400 rpm disk and the 7200 rpm disk.

Table 2: Transfer rates for the two disks

Percent of Disk	Transfer rate 5400 RPM (MB/s)	Transfer rate 7200 RPM (MB/s)
2.75%	48	42.5
15.25%	47	41
27.75%	46	40.5
40.25%	45.5	39.5
52.75%	44.1	37.5
65.25%	41	33
77.75%	37	31.1
90.25%	34.1	27.5
100.00%	29.5	23

The differences and the squared deviation of the values given in table 2 are shown in the table 3.

Table 3 Differences & squared deviation for values in table 2.

Percent of Disk	Differences	Squared Deviation
2.75%	5.5	0.622345679
15.25%	6	0.08345679
27.75%	5.5	0.622345679
40.25%	6	0.08345679
52.75%	6.6	0.096790123
65.25%	8	2.927901235
77.75%	5.9	0.151234568
90.25%	6.6	0.096790123

N = 9
Mean Value = $\mu = 6.28$
Sum of Squared Deviation = 4.73

$$\text{Standard Deviation} = \sqrt{\frac{\sum (x-\mu)^2}{N-1}}$$

$$= \sqrt{\frac{4.73}{9-1}}$$

$$= 0.768$$

Now at 90% Confidence Level the CI for the Mean is given by

$$90\ \%\ \text{CI} = \mu \pm t_{[1-\alpha/2,N-1]} \frac{s}{\sqrt{N}}$$

$$= 6.28 \pm t_{[1-0.1/2,9-1]} \frac{0.768}{\sqrt{9}}$$

$$= 6.28 \pm t_{[0.95,8]} \frac{0.768}{\sqrt{9}}$$

$$= 6.28 \pm (1.86) \frac{0.768}{\sqrt{9}}$$

$$= 6.28 \pm 0.476$$

Hence
90 % CI = [6.765, 5.813]

The Confidence Interval does not include zero therefore we can say with say with 90 % Confidence Level that the two hard disks are different in their performance. So we can say with 90 % confidence level that the 5400 rpm disk is better than 7200 rpm disk. The difference in the performance is due the larger buffer size.

7 Conclusion

We performed the measurement based performance analysis on the Quantum fire ball 5400 rpm and the Quantum fireball 7200 rpm disks. Two different benchmarking softwares were used to measure different parameters for the two hard disks. Both the benchmarking tools showed that the 5400 rpm disk has higher overall data transfer rate than the 7200 rpm hard disk. Then confidence interval test was applied to the data measured for both the hard disks. It was found that higher rotational speed may not necessarily give more throughput. In this analysis we discovered that a larger buffer size can give more throughput even with lesser rotational speed. Lesser rotational speed also has an added advantage that it has less vibration and data can be read more reliably. So higher rotational speed hard disk does not necessarily gives you more performance in terms of over all throughput or the data transfer rate. Some time higher rotational speed can lag in reliability in terms of read/write data to the hard disk.

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