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Topic: Computer Architecture

Research Question: To what extent does varying the speeds of system RAM affect the speeds of a hard disk drive in a computer system in a computerized workplace?

Abstract

Overclocking has always been a means of gaining free performance at virtually no cost when done right, and benefits almost all aspects of a computer system. Almost all hardware can be overclocked but not everybody is willing to get within those settings especially in a workplace environment. In this case, it was never completely worth manipulating hardware to gain extra performance in a task such as video editing, especially in white collar jobs. This is why it was decided to investigate if overclocking would actually be worthwhile in terms of benefits to a workstation computer through examining RAM frequency overclocking. This kind of overclocking is not largely discussed especially in the case of its effect on other storage media, that is more than likely extremely important in workstation computer as this is what is constantly being relied upon to manipulate data. Through this, the following research question was arrived at: “To what extent does varying the speeds of system RAM affect the read/write speeds of a hard disk drive in a computer system based in a workplace atmosphere?”

Background information will be given on RAM frequencies and their functioning to give further understanding of the topic being addressed, after which the experiment and its conclusion and evaluation shall be presented.

Word Count: 210

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Introduction

RAM frequency is an area of computing that most are not as interested in or concerned about because of the assumption that the performance difference is barely noticeable by the user of the system and as such, is not favoured by many. More recently, in the case of DDR4 RAM, it has been brought to attention that it may actually be a good idea to look into overclocking of RAM, especially those who are computer enthusiasts. Overclocking is a process that usually results in an increase in performance for virtually no cost in comparison to buying more or faster RAM to increase the performance of a computer.

This is why such a research that studied the effects of RAM frequency on other hardware was necessary to expose the possible applications of this activity if it takes place in a workplace. We may be able to encounter some knowledge pertaining to how we can use RAM and manipulate it to get the most out of it.

This topic was also chosen because of an interest in computer architecture, disassembling and reassembling computers, as well looking at how different components affect the performance of the computer during operation. Thus, this research would allow an engagement in an interesting section of computer hardware while investigating a topic that is hugely underrated and unaddressed. An experiment would be conducted to allow a conclusion to be reached about whether the RAM frequency does have any effect on the hard drive speed of operation.

So as such, an experiment will be conducted under the context of the research question to allow this new knowledge to be created and supported, after which more details on RAM frequency and computer performance and multiple sectors will be touched upon

Background Information

What is RAM?

Computer RAM, standing for random access memory is a temporary storage device used for temporarily storing data that is in use by the computer when it is powered on. It is commonly said to be volatile memory because the data is erased from the RAM once the computer is shut down. It is much faster storage as compared to mass storage devices such as HDDs (Hard Disk Drives) and SSDs (Solid State Drives) which is why it is usually produced and bought in smaller quantities, between 4 and 16 GB depending on the use of the computer.

RAM also has a naming system which shows it generation and frequency such as 4GB DDR3 @1333MHz. The first part, 4GB, shows the capacity of RAM. Next, it shows the generation of DDR (Double Data Rate) of the RAM. DDR "lets the memory transfer data on both the rising and falling edges of the clock signal" meaning it would be twice as effective as RAM only transferring data one way (SDR) which was previously used (Murray). The higher the generation of RAM, the higher frequencies and timings were able to be achieved; the highest at the time of this essay is DDR4.

The RAM fits in between the CPU cache and the mass storage drives in terms of the storage hierarchy meaning when the cache is full, the RAM holds the information until there is CPU time created to perform the task or otherwise. If the RAM itself gets full, it offloads the extra data into the mass storage devices which is considerably slower than the RAM in terms of load times and speed and as such, it is important to have this type of memory in the system. In relation, the speed or frequency of the memory is also important in how effective the RAM performance is.

What is Frequency?

In RAM, the “frequency number shows how much data RAM can handle each second” (Ram Speed: Frequency and Timings). This is normally indicated on the RAM when it is bought and also works in tandem with timings of the RAM and affects the latency or how long it takes to handle the data, as one increases, the other decreases and vice-versa. In this case, the RAM timings and frequency helps in performing tasks but this is already known. Something to question is the interaction between the RAM and other storage devices because they all hold the data but not very much is known about their effect on each other to perform a task that all of them can help in such as hard drive activity.

Overclocking and Underclocking

Overclocking can be defined as the alteration of factory hardware settings in order to gain performance which is higher than that which was tested in the factory. Overclocking is mainly done in computer hardware such as central processing units (CPUs) and graphics cards or graphics processing units (GPUs) and this is done by manually increasing the operating upper limits of the hardware using either third party applications or the BIOS (basic input/output system). In this process, the operating frequencies and power delivered to the hardware are altered such that they run at higher frequencies and are delivered more power because of it. As a result, we see an increase in the speed at which they perform operations as it is now able to perform more operations per second which is what the measure of frequency is. Overclocking, however, could be very difficult for those who are not experienced. Setting an extremely aggressive overclock for a piece of hardware that clearly cannot handle it may end in permanent damage to that device. This could be as a result of insufficient power supply, inadequate cooling design or solution for the device, or simply the fact that the device

was not manufactured to operate at that level of overclocking. This is why some may fear the process of overclocking even if it delivers, essentially, free extra performance.

Underclocking is basically the opposite of overclocking. It is when the user manually sets the hardware to operate under the performance standard set by the factory. In this case, instead of increasing the frequency, power delivery, etc., we rather decrease the settings to below factory settings. Underclocking is mainly used for troubleshooting problems with hardware such that one can use the process of elimination by setting each piece of hardware to what is considered an even safer level of operation meaning that, in this range, the hardware should not malfunction.

Generally, RAM overclocking has been overlooked in that it does not make a significant difference in tasks such as gaming and video editing. However, the field of its effect on other storage media has been widely disregarded even though, in theory, having one operation finish faster should aid in another's ability to finish the task faster as well. This relates to this current research about how it the RAM frequency would affect a secondary storage device such as a hard drive.

Desktops in the Workplace

Generally, in white-collar jobs, the computers function with anywhere from 4GB to 16GB of RAM depending on the budget of the company and the performance needed for the computers. Dual-core or quad-core processors are also used because single-core processors are much too weak to perform day to day tasks in the present day. Also, a processor with 6 cores or more would not be cost effective as it would much too expensive for a computer that does not need that much power for its tasks. Normally we would also see anywhere from a 500GB hard drive to 1TB as most storage is ideally on a network (in a developed workplace). Discrete GPUs are also not needed in computers where the CPU has integrated graphics.

Experiment

Hypothesis

In this experiment, the hypothesis is that the results will show that an increase in frequency of the RAM stick would result also in an increase in operation speed. This would not be independent of the method of measuring speed whether it is read or burst speed and a trend line drawn in the graphs would indicate a positive gradient and thus a positive correlation. The reason is that of how virtual RAM works which is where the RAM is full or very busy and the data that is supposed to be held inside it is rather pushed into the hard drive. In this case, the faster the RAM is, the faster it would be able to execute tasks and allow what was held in the hard drive into the RAM and gives it more room to operate at a higher potential.

Software Used

The software being used for testing is HD Tach Benchmark software. This program shows the read speeds of the hard drive tested with a certain size of the file that is predetermined by the program. This program, in particular, will be used because of its simplicity and concision in displaying adequate and accurate results. Other software such as ATTO Disk Benchmark could have been used but had other features that were not necessary or essential in the experiment. As such, HD Tach was the most suitable application for the experiment.

Independent Variable

The independent variable, in this case, is the frequency of the 4GB and 8GB RAM stick used.

Dependent Variable

The dependent variable will be the read and write speeds of the hard drive once the frequencies of the RAM sticks have been altered.

Controlled Variables

This will basically be the entire system not including the RAM. (All components inside the desktop as well as room temperature)

Method

1. Prepare the system with known specifications and note the stock frequency of the RAM(out of the box frequency)
2. Load the HD Tach Software installation onto the system and install the program
3. Open HD Tach
4. Make sure “Quick Bench” is selected
5. Click “Run Test”
6. Once the benchmark has completed, note the “Burst Speed” as well as the “Average read” results shown in the UI
7. Repeat this test another 2 times with the same parts and note the burst speed and average read of both
8. Repeat steps 3-7 with varying RAM speeds by overclocking and underclocking the RAM to achieve at least 5 frequencies with 3 set of results for each. (Some RAM sticks may not overclock as far as others do because of their manufacturers keeping cost down)
9. Record these results in a suitable table

Explanation of Method

Firstly, HD Tach application software was used to collect the data by recording the results of burst speed and read speed after the program was run rather than manually obtaining the data

through copying files and observing by looking at the speed of the hard drive while it copies. The first reason for using software is consistency. Once we keep the method of observing changes as uniform as possible, it keeps the uncontrolled external variables to a minimum in terms of manipulating the results of the experiment thus increasing the reliability of the conclusion of the experiment.

Another reason is to make the experiment as simple as possible in regards to the steps to complete the experiment. Using a program, no steps would have to be taken to ensure the uniformity of data collection. If one were to monitor the hard drive's performance during one run of the experiment, further details are required such as the size of file used to conduct the experiment, how often the speed was recorded or when it was recorded, how long the file took to copy and others. Having one program eliminates the need for these further experimental details and adds simplicity to the experiment.

Secondly, the experiment is to be run 3 times for each frequency to increase the reliability of the data collected and the conclusion(s) drawn from it. Running the program only once would not result in any conclusive data because it does not show that whatever result was obtained will always be the case or be similar. Anything could happen the second time around, or even the third, which is why it is necessary to run the program several times for each tested frequency.

Lastly, two different capacities of RAM sticks were chosen because all RAM sticks have their own frequency "cap" or limit. These mostly depend on the manufacturer and how the sticks were engineered. Some allow increases to almost twice their base frequency because they were designed to allow more power into them to achieve higher frequencies. Whereas others only allow for the smallest alterations in frequency that does not give them any further increase in performance because they were made for people who do not necessarily

manipulate their hardware or are not overclockers. As a result, a stick was chosen that could attain frequencies ranging from 800 MHz to 1333MHz (4GB) and another that could attain frequencies from 800MHz to 1600MHz (8GB) which would allow one to examine a larger range of values for analysis.

It should also be noted that the RAM sticks could not necessarily be overclocked because of the nature of the sticks. The companies that manufacture these, in particular, were not designed to accept large amounts of power to enable higher than stick speed overclocking safely and the experiment was conducted using only underclocking as a method of altering RAM frequency.

Why Burst Speed and Average Read Speed?

The speeds of the hard drive are representative of the regular operating performance of the hard drive. More specifically, it focuses on the access speed of the hard drive in terms of how much the hard drive is able to load within a given a time frame which is usually in megabytes per second although higher speeds and lower speeds may be in gigabytes per second and kilobytes per second respectively and so on.

Average write was used because it would mirror the kind of real-world usage of constantly copying, loading and saving documents and data. The saving aspect would not be covered as with the average read speed but would rather be more related to the average write speed. However, the two are rather similar in their speeds most of the time in older generation hard disk drives (HDDs) normally used in workstation desktops meaning that obtaining one of the two should necessarily account for both situations. As such the experiment was conducted with a program (HD Tach) that showed this value in the tables below (Pages 15-17).

Next, the burst speed was also chosen to show the highest speeds attained by the hard drive during operation. The values, unlike read speeds, are very different to the read speeds meaning that it would be more significant if we observed changes in this factor.

Hardware Required for This Experiment

Processor: AMD A4-5300

RAM: 4GB DDR3 Kingston (1333MHz stock frequency)/8GB DDR3 Adata (1600MHz stock frequency)

Hard drive: Western Digital 5400RPM 500GB HDD

Power Supply: 650W EzCool

Motherboard: ASRock FM2A55M-HD+

Reason for choice of parts

This research is based on a workstation computer and how the RAM frequency will affect the hard drive's performance in terms of speed of operation. Based on this, desktop parts that one would normally find in a workstation grade computer were chosen in that the parts are not the most powerful but are still powerful enough to keep the computer running smoothly. The parts chosen were quite budget-friendly and represent what you would see in an everyday work computer. As a result, this system would provide accurate and representative data about the research topic of hard drive performance in a workstation computer where light works such as word processing, file management and possibly very light picture and video editing.

Results

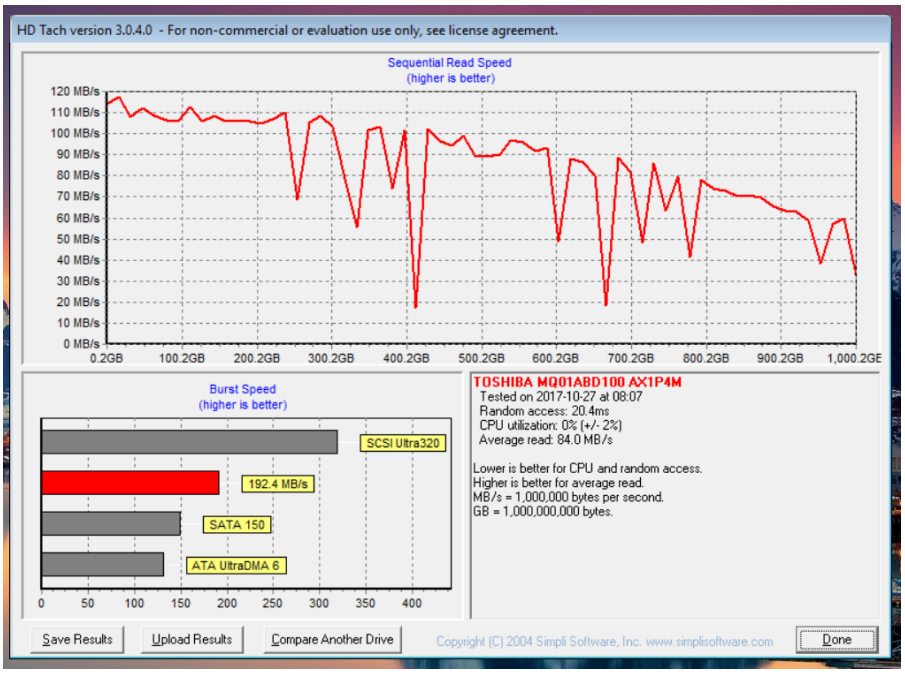


Fig. 1Screenshot of HD Tach

Quantitative Data

4GB of RAM

The graphs and tables below show the results obtained when the program, HD Tach, was run using the 4GB stick of RAM mentioned in the specification list (4GB DDR3 from Kingston). The burst speed and average read speed are recorded in the tables with respect to the frequency of the RAM and trend shown in the lines graphs further below.

Fig. 2

Frequency/MHz	Timings	Burst Speed/MBs^{-1}			Average Read/MBs^{-1}		
		1	2	3	1	2	3
800	6-6-6-15	226.2	224.0	213.5	102.4	102.3	103.5
1066	7-7-7-20	225.3	232.3	228.2	79.6	99	103.7
1333	9-9-9-24	221.6	227.6	229.0	92.5	101.4	104.2

Fig. 3

Frequency/MHz	Timings	Av. Burst Speed/ MBs^{-1}	Av. Average Read/ MBs^{-1}
800	6-6-6-15	221.2	102.7
1066	7-7-7-20	228.6	94.1
1333	9-9-9-24	226.1	99.4

Fig. 4

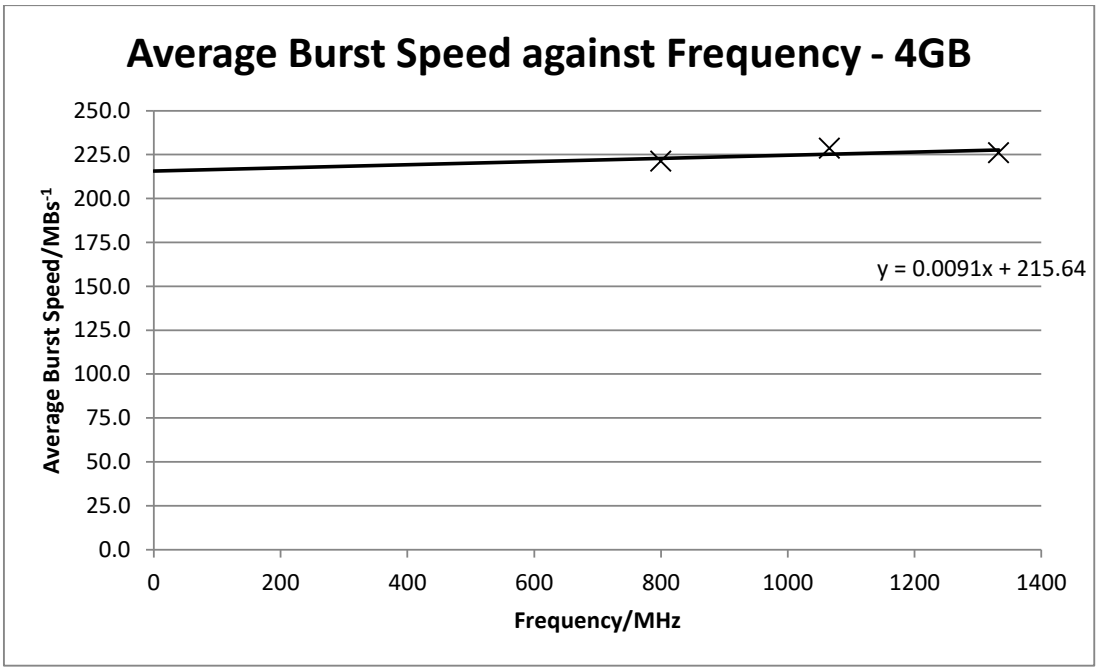
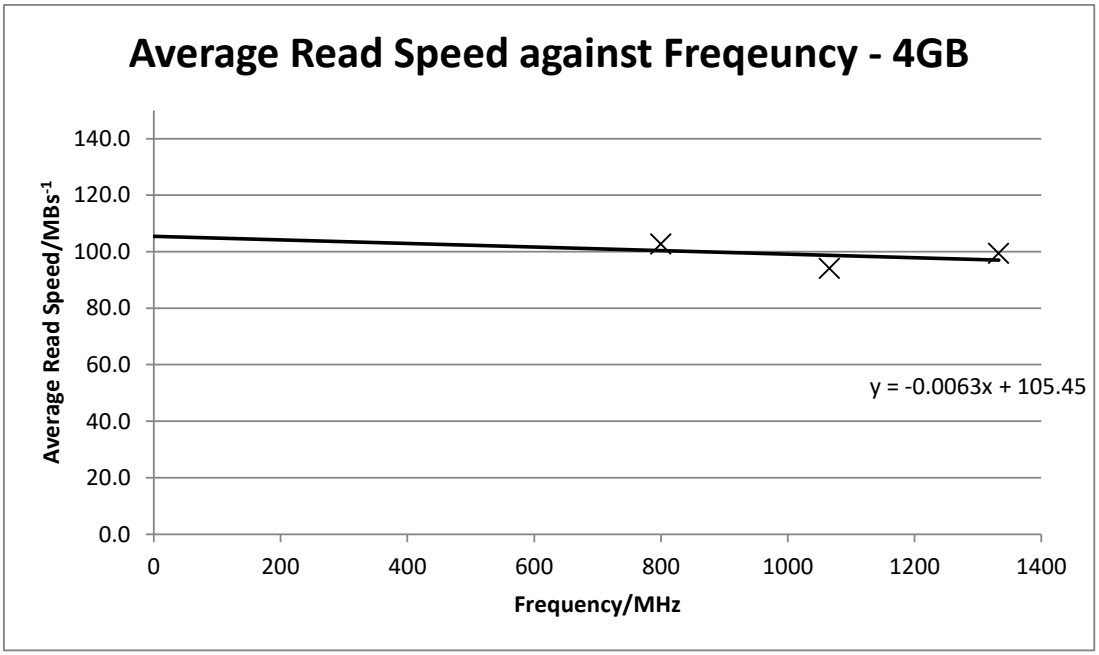


Fig. 5



8GB

The graphs and tables below show the results obtained when the program, HD Tach, was run using the 8GB stick of RAM mentioned in the specification list (8GB DDR3 Adata). The burst speed and average read speed are recorded in the tables with respect to the frequency of the RAM and trend shown in the lines graphs further below.

Fig. 6

Frequency/MHz	**Timings**	**Burst Speed/ MBs^{-1}**			**Average Read/ MBs^{-1}**		
		1	2	3	1	2	3
800	6-6-6-15	208.8	226.4	224.7	88.9	101.2	104.4
1066	7-7-7-19	213.5	221.4	224.2	81.5	100.7	103.4
1333	9-9-9-24	214.7	227.7	234.4	63.3	102.9	103.1
1600	11-11-11-28	233.3	198.9	226.4	84.8	102.3	105.1

Fig. 7

Frequency/MHz	Timings	Av. Burst Speed/ MBs^{-1}	Av. Average Read/ MBs^{-1}
800	6-6-6-15	220.0	98.2
1066	7-7-7-20	219.7	95.2
1333	9-9-9-24	225.6	89.8
1600	11-11-11-28	219.5	97.4

Fig. 8

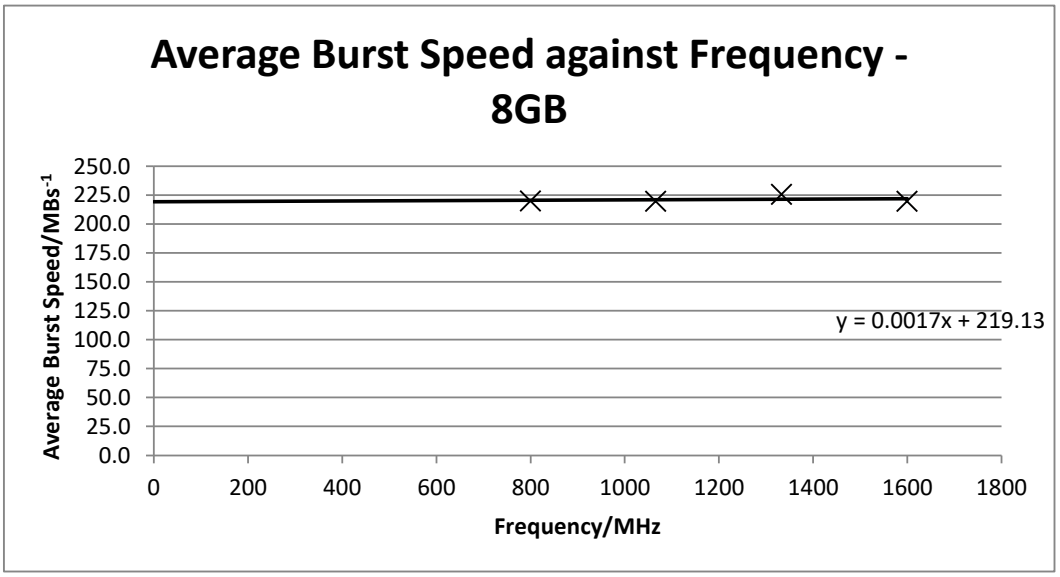
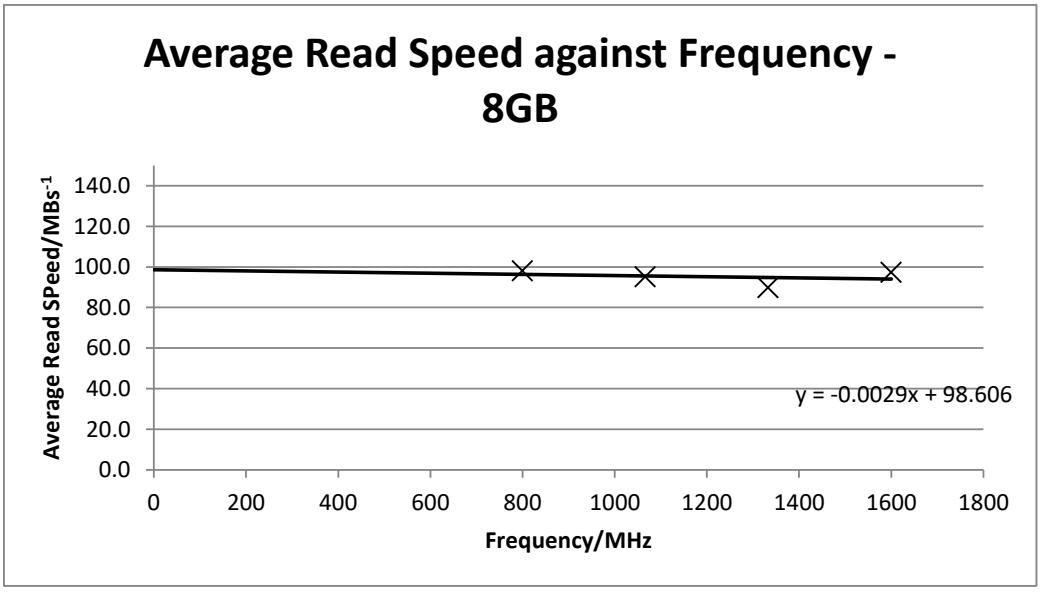


Fig. 9



Qualitative Data

- The graphical results of the variation of speed were unstable when the first run of each frequency was done. This could have been caused by the fact that the computer and all its components needed some time to warm up and reach the full operation potential.
- None of the RAM sticks were able to go past the 1600MHz boundary of operating frequency

Method of Graphical Analysis

Two graphs were plotted above for each stick of RAM showing the relationship between the burst speed and frequency and another with the average write speed and frequency. Each of these graphs had a trend line with their equations attached to them showing the relationship between the two variables in question allowing for easy reading, understanding, and analysis to obtain conclusions to the experiment.

Result Analysis

According to the data collected in the experiment, the trend lines produced on each of the graph showed a relatively small gradient or even, in some cases, a negative gradient such as the average read for the 8GB RAM stick. This meant that the relationship between both the independent variables and the dependent variable was very weak and had virtually no effect on the outcome of the experiment. This result is also shown in all experiments conducted evidently indicated by the graphs and their gradient values.

In figures 2, 3, 4 and 5, the variation in the average burst speed was very little relative to their overall speed. The largest difference in values did not exceed $10MBs^{-1}$ which is less than 5% of any value of average burst speed.

Furthermore, in the case of average read speed, a similar case was observed as the variation in results obtained at different RAM frequencies were similar and was most likely due to inconsistencies in the hard drive construction itself. Again we see less than a $10MBs^{-1}$ variation in values thus accounting for the near-zero gradient.

The graphs and tables showing the effect of RAM frequency on hard drive speed with 8GB of memory, figures 6, 7, 8 and 9, follow suit with the results of the other stick of memory; the variation in results did not exceed $10MBs^{-1}$ as the frequency increased.

In the end, the graphs for the 8GB stick and the 4GB stick were very similar in factors such as gradient and maximum variation of results showing how little the impact of having different RAM has on the hard drive's performance.

Conclusion and Evaluation of Results

The results showed that in the end, there is very little or no effect on the hard drive speed, irrespective of which value is being used to measure it when the frequency of the RAM stick is altered. Even though the results were conclusive, they were also quite limited and had no specific increment of data. This is mostly because of the nature of RAM sticks and how frequency works in RAM sticks with predetermined operating values and performance limits some of which are set by JEDEC (Main Memory: DDR4 & DDR5 SDRAM). As a result, very few results were actually obtained in regards to the independent variables but made sure to repeat the experiment multiple times to make the few results as accurate as possible. The results went against the hypothesis that an increase in frequency would result in an increase in hard drive speed thus providing a reason for overclocking in a workplace atmosphere.

Implications for Results

To explain the results, it is evident that even though both the hard and the RAM are active participants in data handling to some extent, their speeds remain irrespective of each other perhaps because they do not rely upon each other as much as was previously assumed. The relationship appears to be much less like a combination such as the hard drive RPM and the load times of applications or the capacity of RAM and the frame rate of a game application. Even though frequency does not impact very much in this area of performance, other hardware and software also benefit from higher speed RAM.

Higher speed RAM does favour software applications that are able to utilise their full potential such as in some specific games e.g. Rise of the Tomb Raider that a YouTube channel by the name of "Linus Tech Tips" talks about in great detail ("Does RAM speed REALLY matter?"). When they are able to take advantage of the faster speeds benefit in the form of faster loading times and higher and even more consistent frame rates within the game which makes overclocking RAM to as high as it will go worth the trouble, in the case of gamers who also happen to be computer enthusiasts. But this is relatively easy to achieve when the hardware has support for the kind of overclocking the RAM is capable of.

But this does not come cheap, free or easily mostly because of support issues or simply have no need for faster RAM especially on older or lower end platforms, applications or hardware. One example was shown in the video made by "Linus tech tips" which was concerning a benchmarking program by the name of "Cinebench R15" that examines rendering performance by the CPU ("Does RAM speed REALLY matter?"). In such cases, the results are rather similar to the experiment conducted where all the results were within a margin of error. Other cases include RAM specific to the graphics card or the GPU (Graphics Processing Unit) which is normally referred to as VRAM or Video RAM. The speed of this

kind of RAM is much more important in the case of running game software, video editing software and other processes that are graphically intensive as it is dedicated to that purpose and the computer is reliant on it to perform such tasks. The performance in terms of loading times, frame rates, processing times and other factors generally increases in programs with an increased speed if VRAM with the only problem being that VRAM properties are not usually easily accessible by the user. This is because the graphics card is like an extension of the motherboard in the sense that it has all the regular components of a full system; a processor, memory and even BIOS that were all designed by the manufacturer of the card. Similar to OEM (Original Equipment Manufacturer) systems, the parts are mostly sourced from within the company and the assembly is also done by the manufacturer that is actually a gain on the user's end because OEM systems or parts are usually much cheaper even though they have very limited customer support. The point, however, is that in the case of graphics cards, higher speeds would impact performance on tasks that it partakes in much more significantly but overclocking is not really an option, in this case, you must rather buy the increase in performance.

Conclusion

When we look at other factors that RAM frequency can have an effect on, employment with mainly word processing, presentations and spreadsheet management would not benefit to a large extent if time was taken to overclock each computer used in the office. Even the job of having to overclock can be very time-consuming and strenuous and may not be worth the increase if there was any. However, RAM frequency plays some pivotal roles in other aspects of computing and can provide reasonable increases in overall performance when it is manufactured to do such and is open to changes by users.

To conclude this research, overclocking in the work place in relation to increasing the hard drive speed via overclocking the frequency of installed RAM did not work and as such, workstations are better off keeping at stock operation settings also because there is generally better stability within the system.

Word Count: 3986

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