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Research paper

Dependence of Reallocated Sectors Count on HDD Power-on Time

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Abstract

The problem of SMART-data ambiguity in different models of hard disk drives of the same manufacturers is considered. This circumstance creates obstacles for the use of SMART technology when assessing and predicting the reliability of storage devices. The scientific task of the work is to study the dependence of the hard disk failure probability on the reliability parameters values for each individual storage device of any model of any manufacturer. In the course of the study, two interrelated parameters were analyzed: "5 Reallocated sectors count" and "9 Power-on hours" (the number of hours spent in the on state). As a result of the analysis, two types of dependences were revealed: drooping and dome shaped. The first means the maximum failure frequency of information storage devices immediately after commissioning, the second - after a certain period of time, actually coinciding with the warranty period for the products (two years). With the help of clustering in plane according to the coordinates of the number of reallocated sectors and the time of operation, two different reasons for the failure of the drives were discovered: due to deterioration of the disk surface and due to errors in the positioning of the read / write heads. Based on the variety of types of causes and consequences of equipment failure, the task of individual assessment of an individual data storage device reliability is proposed to be solved using several parameters simultaneously.

Keywords: *information, information storage device, hard drive, reliability, reallocated sector, operating time.*

1. Introduction

To ensure the data security, provided that the information system effectiveness of an organization is maintained, it is necessary to copy information from the unreliable drive to a new and reliable one in a timely and complete manner. To this end, SMART technology (self-monitoring, analysis and reporting technology) [1] is usually used for internal assessment of the computer hard disk state, and also as a mechanism for predicting its possible failure. However, the meaning and value of the same parameters do not always coincide in different models of hard disk drives, even for the same producers; some parameters have only zero values, and some are completely absent. The scientific task of the study is to determine the dependence of the hard disk failure probability on the reliability parameters values of each individual information storage device of any model of any manufacturer in the specified ambiguity conditions.

In the course of the study, two interrelated parameters were analyzed: "5 Reallocated sectors count" and "9 Power-on hours" (the number of hours spent in the on state). The time axis was divided into intervals with a step of 1000 hours. The number of drives that have worked during a total number of hours corresponding to a certain interval until their failure was calculated.

Two types of the dependence have been identified: drooping and dome-shaped. The first means the maximum frequency of the failure of the information storage devices immediately after their commissioning, and the second - after a certain period of time, actually coinciding with the warranty period for the products (two years). With the help of clustering in the plane according to the coordinates corresponding to the number of reallocated sectors and the time of operation, two different reasons for the failure of the drives were discovered: due to deterioration of the disk surface and due to errors in the positioning of the read / write heads. Based on the variety of types of causes and consequences of equipment failure, it is proposed to solve the task on individual assessment of the individual data storage device reliability using several parameters simultaneously.

2. Methods

SMART data from the website of the company Backblaze [2, 3] were analyzed to study the dependence of failure probability for hard magnetic disks drives on the time of operation. We examined 45 SMART parameters for 92530 drives of 93 models of 6 HGST trademarks (Hitachi Global Storage Technologies), Hitachi (later HGST), Samsung, ST (Seagate), Toshiba, WDC (Western Digital) for the period from 10 April, 2013 to 31 December, 2016 [4]. It was found that 79.58% of the drives continued to function normally at the end of the period under study, 14.74% were withdrawn prematurely, and 5.68% failed.

In total, information on the meaning of more than 80 SMART parameters is available, but most of them are not used by manufacturers. Therefore, Backblaze specialists recorded only 40 of them in 2013-2014, and starting from 2015 - 45 of them with numbers of 1-5, 7-13, 15, 22, 183, 184, 187-201, 220, 222-226, 240 -242, 250-252, 254, 255 (in 2015 they added 22, 220, 222, 224, 226). Among these, the parameter "5 Reallocated sectors count" is the best for diagnosing and evaluating the status of data storage devices of any manufacturers. Evidence of the priority of the reallocated sectors' number in evaluating the state of a hard

disk is presented in [5], where the results of a study of 100,000 drives in servers around the world, carried out by Google, are presented.

We studied the dependence of the number of reallocated sectors on the parameter "9 Power-on hours", i.e. the operating time of hard magnetic disks. This parameter is one of those five parameters identified as a result of the research, which are always available for all brands, models and numbers of storage devices of all manufacturers. The remaining four are "1 Raw read error rate", "5 Reallocated sectors count", 194 "Hard disk assembly temperature", and "197 Current pending sector count".

3. Results and Discussion

A common reliability indicator for the data storage devices according to the specification is MTBF (Mean time between failures). Its measurement unit is one hour. When considering the distribution of the number of failed drives relating to the operation time, it is found that there are at least two types of dependencies: the first is a drooping with a long tail (Figures 1, 2), and the second is a dome shaped one (Figures 3, 4) [6].

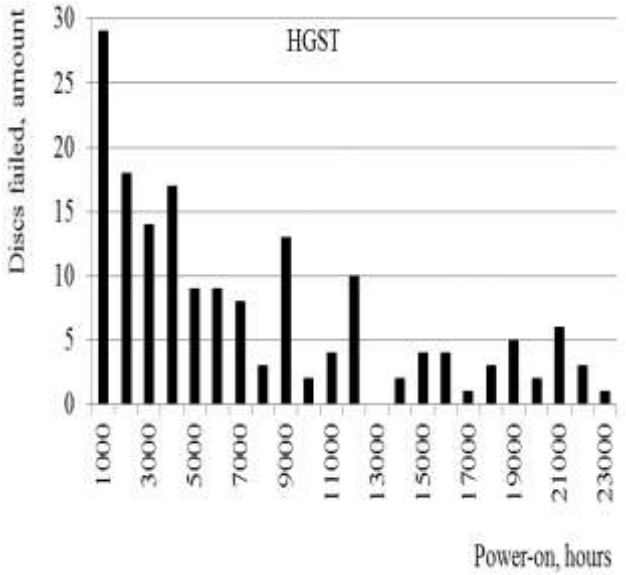

Figure 1:. Distribution of 167 failed ones from all 17497 HGST drives depending on the time of operation

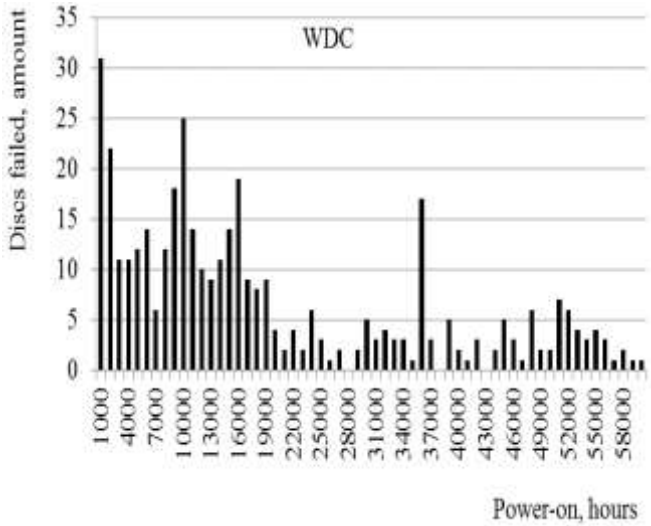

Figure 2:. Distribution of 404 failed ones from a total of 3,976 WDC disks depending on the time of operation

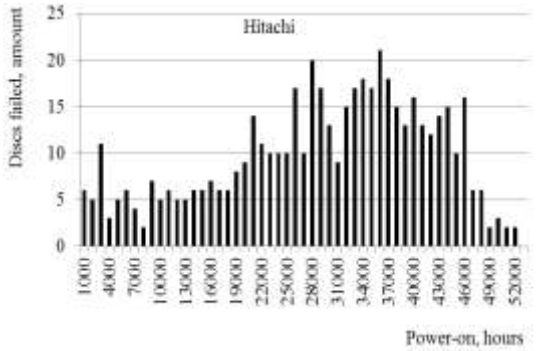

Figure 3:. Distribution of 510 failed ones from all 13246 Hitachi disks depending on the time of operation

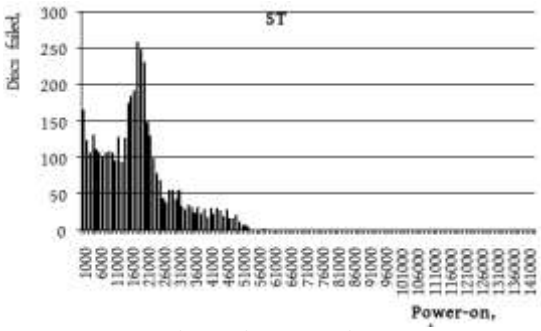

Figure 4:. Distribution of 4158 failed ones from all 57438 ST disks depending on the time of operation

Due to small volume of statistics (1 failure after 5,839 hours out of a total of 18 Samsung drives, 12 failures after working from 634 to 26,237 hours from a total of 355 Toshiba drives), the results for these brands are not shown graphically.

Dome-shaped type of dependence usually indicates that the equipment is working until some moment, then it goes out of order. It is noteworthy that the tops of the domes of Hitachi and ST dependencies are after 17520 hours, i.e. just after a two-year warranty period.

If the dome is narrow as in figure 4, then it is possible to more accurately predict the period of efficiency, if it is wide as in Figure 3, then this period is determined less accurately. If the type of dependence is drooping like in Figures 1 and 2, then failures begin to occur from their first day of operation. In fact, the drooping component is also in Figures 3 and 4, what indicates the possibility of failure at any time.

The Backblaze specialists who decomposed the observed general picture into components, explain it in the following manner [7]. Defects of hard disks come from 3 factors:

1) Factory defects, leading to "infant mortality";

2) Random failures which are distributed relatively uniformly in time;

3) Failure after long use.

In total, due to the large number of HitLabs and ST storage devices in Backblaze, during the first 18 months the failure rate fluctuates around 5%, then it falls for a while, and then it increased significantly with a maximum after the 2-year mark. Therefore, the general picture does not show that there is a lot of "infant mortality", but it seems that 2 years is the point where the disks start to wear out.

To detect any hidden structures inside the data, we can apply the cluster analysis method. To do this, let's imagine the distribution of the failed drives in the plane along to the coordinates which are the number of reallocated sectors and the operating time for the two most numerous failures from the used trademarks Hitachi and ST (Figures 5, 6).

The main accumulation of the points in Figure 5 as to the number of reallocated sectors is observed near zero and the small accumulation is near 2000 pieces, and by the time of operation it is located about 36,000 hours. At more detailed consideration, groups of points are clearly visible through each unit of measurement of the reallocated sectors.

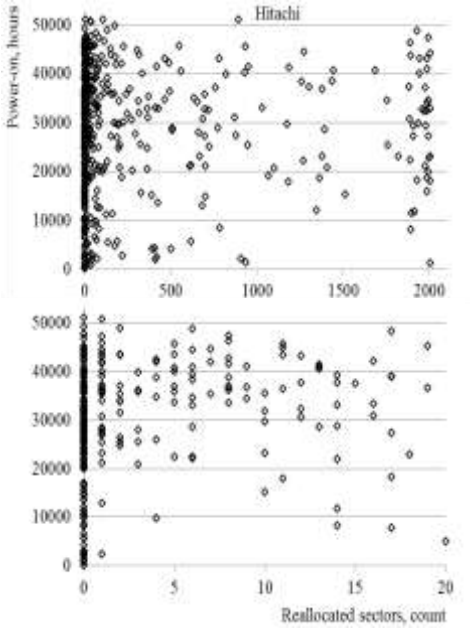

Figure 5:. Distribution of failed Hitachi information storage devices by the number of sectors reallocated and the time of operation

In Figure 6, the main accumulation is also observed near zero and there are small ones near in the amount of 2600 and 4000 pieces, and by the time of operation - about 18,000 and 40,000 hours. At more detailed consideration, groups of points are clearly visible after every 8 pieces of the reallocated sectors. This may be due to the fact that reallocation occurs more often not in sectors, but in whole tracks. In other words, failures are mainly due not to the deterioration of the surface quality of the discs, but to the mechanics of the drive of the read / write heads. Earlier a similar result was obtained for the drives of the most numerous model ST4000DM000 separately according to data only in 2015 [8].

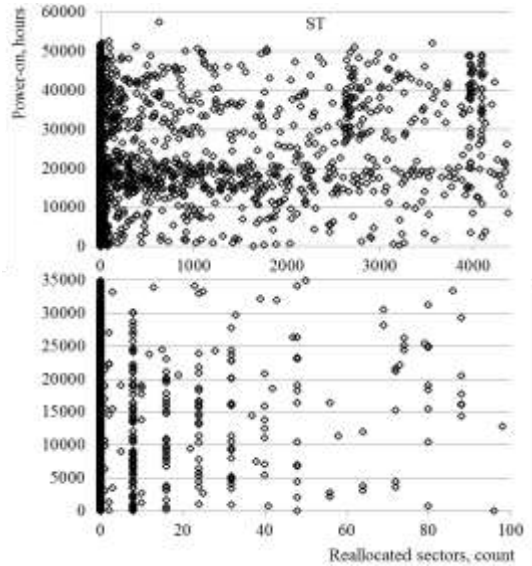

Figure 6:. Distribution of failed ST information storage devices by the number of reallocated sectors and operating time

Thus, cluster analysis showed that most of the drives fail at zero value of the number of reallocated sectors, and also revealed two types of reasons for the deterioration of the reliability of storage devices at non-zero values - due to deterioration of the surface quality of disks and the failure of the drive recording / reading mechanics.

Hence, the necessity of using not only one but several parameters for analysis follows. If even one of them shows that everything is in order, others may indicate a danger of equipment failure, because the causes and consequences of damage in the storage devices turned out to be different. For example, a large number of failures due to the reallocation of sectors at once in whole tracks (multiples of 8) for ST disks is completely consistent with the fact that the number of failed drives in which the parameter "7 Seek error rate" has nonzero value is on the second place (3365 pcs.) after the failed drives with non-zero parameter "1 Raw read error rate" (4146 pcs.).

4. Summary

As a result, according to the results of the study, it was found that the dependence of the number of reallocated sectors on the time of operation of hard disks has two types: drooping and dome shaped. The first type means that disk failures occur immediately after the start of their use, the so-called "infant mortality". The second type is associated with depreciation and occurs mainly after the expiry of the two-year warranty period.

Cluster analysis made it possible to identify two variants of accumulation of the reallocated sectors number: one by one and by whole tracks of 8 pcs. The first option is due to the deterioration of the disk surface quality, and the second is due to errors in the positioning of the read / write heads.

The scientific novelty of the results obtained is that it is possible to develop on their basis a system of criteria for the risk of drive failures, which is justified by the fact that a significant number of sectors are detected as a result of cluster analysis of the whole paths.

5. Conclusion

Analogous studies with the same data for disparate groups of disks were carried out in [9], where a search was carried out for universal predictors of disk failures that could be applied to disks of all brands and models. The main problem was also a significant number of SMART-parameters, which were absent for the specified data set as to most brands and models of disks. As a result, the authors were forced to discard parameters that were absent in at least 90% of the disks, after which 21 parameters remained.

In [10-14], SMART parameters of the specified data set were used to determine the intensity and prediction of disk drive failures.

Therefore, the question on assessment of the information storage device reliability based on SMART parameter values is really important for ensuring data security in any organization. Based on the variety of types of causes and consequences of equipment failure, the individual assessment task for reliability of individual data storage devices is proposed to be solved using several parameters simultaneously.

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