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BRIEF

TCO Ramifications of SSD Write Endurance

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Overview

Because Flash memory has a limited write life, solid state drives (SSDs) use a variety of techniques to extend write endurance. Typically, SSDs are over-provisioned with a reserve of Flash memory to extend total write life. However, this additional memory drives up the price of the SSD. This could prompt users to purchase the least expensive drive with low write endurance and just replace it when it wears out, thinking that it will be cheaper in the long run. They assume that if the cost of SSDs decreases over time, the incremental cost of replacing drives at a later date will be lower than the cost of purchasing more expensive drives with higher write endurance up front. This paper explains when it is most economical to purchase one drive versus another.

SSD Endurance Definitions

SSD write endurance is specified in total bytes written (TBW); data on the drive can be continuously deleted and rewritten up to the TBW limit. For example, Micron's 480GB M500DC SSD has a 1.9PB TBW limit.

SSD endurance can also be defined based on drive writes (or fills) per day (DWPD).

$$\text{DWPD} = \frac{\text{TBW [TB]}}{\text{Capacity [TB]} \times 365 \text{ days} \times \text{warranty}}$$

Assuming that enterprise drives typically have a five-year warranty, and using the above formula, the DWPD for the 480GB M500DC would be approximately two fills per day.

Monitoring Write Lifetime Used

Many manufacturers enable their SSD to be examined using self-monitoring, analysis, and reporting technology (SMART) attributes. For example, the "% Lifetime Used" attribute provides feedback on the write wear that Micron's M500DC drive has experienced over its lifetime.

Challenges of Forecasting Write Endurance Requirements

It can be challenging to estimate the frequency of write transactions that an application requires. While storage access statistics can be examined using monitoring tools such as IOSTAT and Perfmon, it can be difficult to determine the long-term write endurance requirement of an application. Operating in a virtualized environment can further compound this task because application load balancing changes the environment's storage characteristics. For example, vSphere's dynamic resource scheduler (DRS) runs every five minutes by default, enabling application migrations to occur at various times a day in most environments. As a result, write rates constantly change depending on the activity of the applications on that physical server. Micron recommends taking a conservative approach and overestimating the write endurance needed from an SSD.

SSD Replacement

Figure 1 shows the accumulative number of drives needed to support an environment with different write requirements. It assumes that an SSD supporting one-half drive fill per day was installed at the beginning of year 1. If the application only fills half of the drive every day, the SSD will last five years; however, if the application's average write rate exceeds one-half drive fill per day, the SSD will need to be replaced at least once—well before the five-year mark. For example, under a constant write load of two drive fills per day, the SSD will need to be replaced three times in five years.

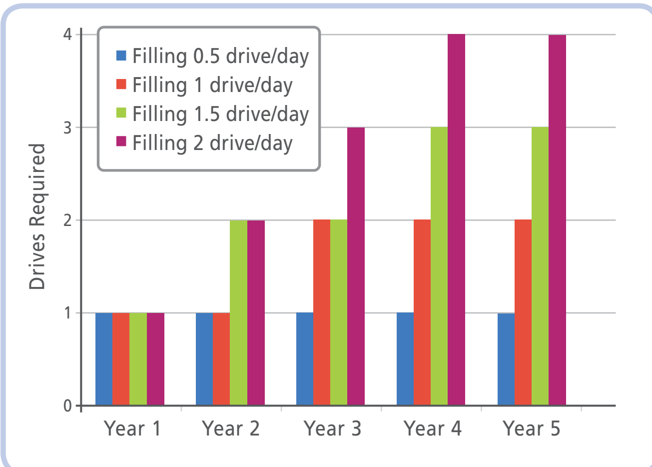

FIGURE 1: Number of drives required for different fill rates using a one-half-fill-per-day drive

Total Investment in SSDs

Using industry estimates of the declining cost per gigabyte for SSDs, Figure 2 compares the total investment cost of an SSD that supports one-half drive fill per day versus one that supports two drive fills per day over several years. Based on an application with a write load of two fills per day, it will cost $2040 to purchase and replace four SSDs that support one-half drive fill per day between year 1 and year 5 versus purchasing just one $1010 SSD that can support two fills per day for five years—a savings of more than 50%. In fact, the only time it would be economical to purchase a lower-endurance SSD is when it is certain that the write rate will never exceed one-half drive fill per day.

Conclusion

While some initial cost savings can be realized when purchasing the least expensive SSD with low write endurance, the total cost of ownership (TCO) significantly increases if the drive needs to be replaced even once within a five-year period. Additionally, purchasing the cheaper, lower-endurance SSD may require data being moved to the replacement SSD, potentially adding OPEX costs that also affect TCO. Consequently, to obtain the best TCO, be conservative when estimating fill rate requirements and minimize the need to replace drives by purchasing the highest-endurance SSD possible.

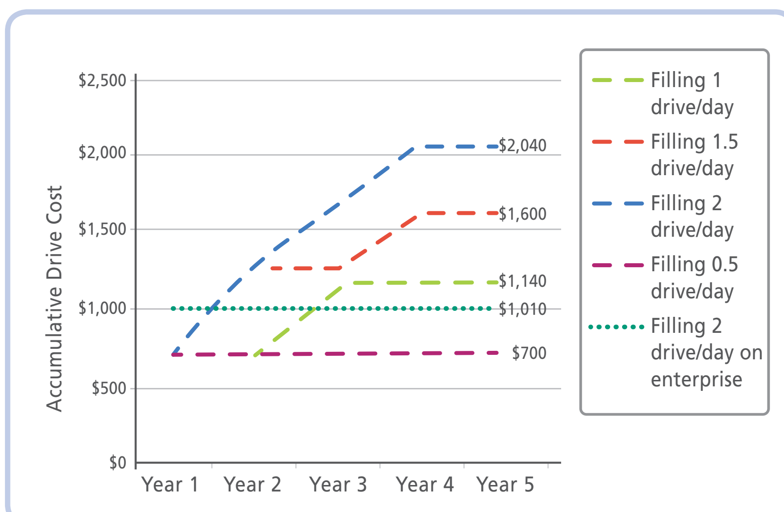

FIGURE 2: TCO of purchasing a lower-endurance SSD and replacing it as needed vs. purchasing a high-endurance SSD