Western Digital

Innovation in Smart Video Storage; How WD Purple™ Intelligently Manages Video Data

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Abstract

This paper discusses an intelligent approach to storing video surveillance data on Hard Disk Drives (HDDs), utilizing on-drive Artificial Intelligence (AI) and Machine Learning (ML) technologies.

In today's video surveillance environment, high-definition cameras with video analytic capabilities send multiple streams of video data to network recorders and drives, causing new storage complexities.

Utilizing on-drive intelligence, new generation WD Purple™ Smart Video HDDs(1) are able to recognize incoming video stream characteristics and data types, coalesce data together in cache and place data in specific track locations on disk, for optimal performance.

With this innovation, the workload capability of these new drives can be vastly improved without resorting to other performance enhancing enablers such as higher RPM. As a result, average Power Efficiency (PE) can be improved and thermal output reduced, making the new WD Purple™ Smart Video HDDs more efficient than the prior generation of video storage technology.

Higher Resolution, Multi-stream Cameras, and AI Increase Demands on HDDs

The video surveillance market is growing rapidly, driven by new uses for video that expand beyond traditional monitoring. Rich video data provides details that can be analyzed and formed into actionable information. Video analytics are now used daily to enhance and improve security, safety, transportation, manufacturing, business intelligence, smart city operation and more.

As camera resolutions increase from HD (720p) to 4k (2160p) and beyond, the greater detail not only delivers a larger picture, but it allows analytics systems to "see" and process more information. The expansion in video data leads to greater insights and ultimately, to more timely decision making. Moving from Full HD (1080p) resolution to Ultra HD / 4k (2160p) roughly doubles the size of the video stream, increasing bit rates and requiring more storage for video data.

In addition to transmitting a main video stream, modern network cameras also output auxiliary video streams, picture streams, and video metadata information. These additional streams enhance both the usability of the security solution as well as the effectiveness of AI, and add workload and capacity requirements to the recorder's storage subsystem.

Main video, auxiliary video, picture streams, and video metadata all have different data characteristics, including structure, size and frequency of transmitted data for the Hard Disk Drive (HDD) to process and store.

AI-based solutions may also implement an image reference database for pattern matching.

Metadata information ties these images to video segments for security functions such as video verification. For example, when an employee swipes their access control card against a card reader, an intelligent security system may grab a high-resolution image of the employee taken from a camera at the entry point and in near real-time, comparing the frame image against the employee's ID photo for verification.

All of these factors – higher resolution, multiple streams, AI metadata, longer retention times, and more – drive increased workload demand in network recorders and create challenges for HDD storage.

Hundreds of DVR and NVR Models with Varying Capabilities Create Challenges for Hard Disk Drives

Western Digital has analyzed hundreds of DVRs and NVRs from dozens of manufacturers and found that different manufacturers and suppliers write data to storage devices using different methods. Recorder file systems do not necessarily write video data in sequential fashion, and streams and metadata are not necessarily written to contiguous disk space.

Recorder manufacturers also employ different video analytic implementations, which have an impact on data movement and storage. Some implementations require frequent metadata capture, analysis, and storage; others are dependent on the individual analytic data requirements and data sizing needs may vary widely.

These challenges cause more inefficient drive activity and may lead to non-optimal data placement, which together can impact performance and reliability. Knowing how a system manages storage helps to maximize the drive's utilization, and ultimately helps the drive's ability to manage requested data operations.

Additional analysis of DVRs and NVRs revealed something surprising: Even though video streams are sequential in nature, in a typical DVR or NVR, the HDD encounters a workload that looks very random in nature. This is because multiple sequential video stream writes are mixed with metadata and AI database writes, and so in aggregate, the overall workload appears more random in nature. Western Digital engineers observed that the main contributor to successful HDD operation in surveillance recorders is seek efficiency, not data throughput. Drives that can reduce or optimize seeks despite the myriad of data operations would be better tuned for DVR and NVR workloads.

An Intelligent Approach to Video Surveillance Storage

Western Digital engineers concluded that intelligent data management technologies – such as drive self-configuration, improved stream and data input/output (I/O) management, and smart data placement policies – improve the drive's overall performance and reliability.

By detecting the host environment and self-configuring into the appropriate operating state, the HDD can set up to be more predictive of incoming workloads. Drive-implemented

machine learning can improve self-configuration effectiveness over time, making this approach truly smart.

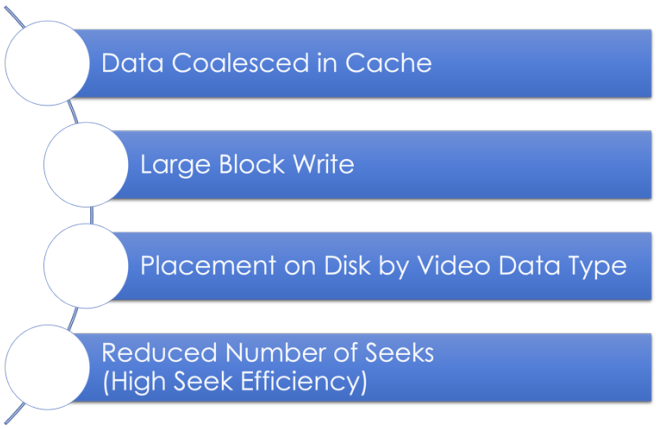
In addition, detecting the types of incoming video data allows the HDD to coalesce data in a more optimized manner, reducing unnecessary seeks. An example of one type of video data is a continuously incoming video stream with the same camera parameters. Another is embedded video analytics metadata that are highly structured and consistent.

By placing video streams and embedded video analytic metadata on different areas of the disk, background drive tasks can be managed in such a way as to reduce performance impact yet still maintain data integrity.

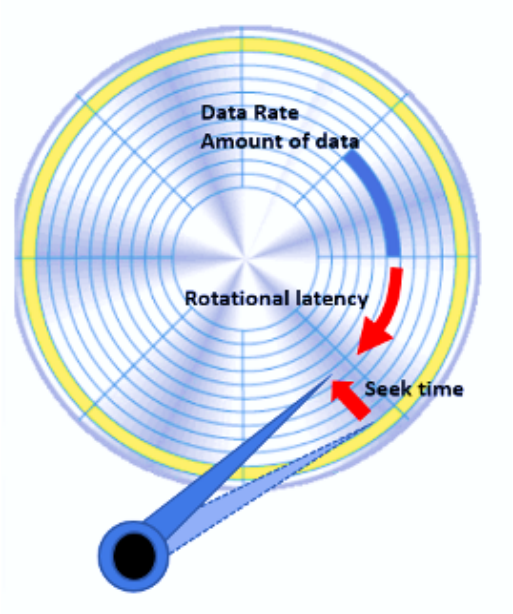
Data Detection, Caching and Placement Reduces Seek Times

Intelligent data placement helps to reduce seek times for video data writes. Seek times are reduced as the actuator has shorter travel distances to put the head assembly in the right track position. Reading and writing contiguous data to and from close proximity track locations can help to reduce seek times, especially for predictable video surveillance workloads.

On drive Machine Learning (ML) helps to detect data types, such as video metadata, video streaming data and host OS file system data. Data blocks may be coalesced in cache; this, in turn, improves data placement, enhances seek efficiency, and minimizes internal workload. Better data placement by distinguishing data types on smart video drives to process surveillance workloads.



Reducing seek time is the key to managing consistently incoming and outgoing video streams and video data.

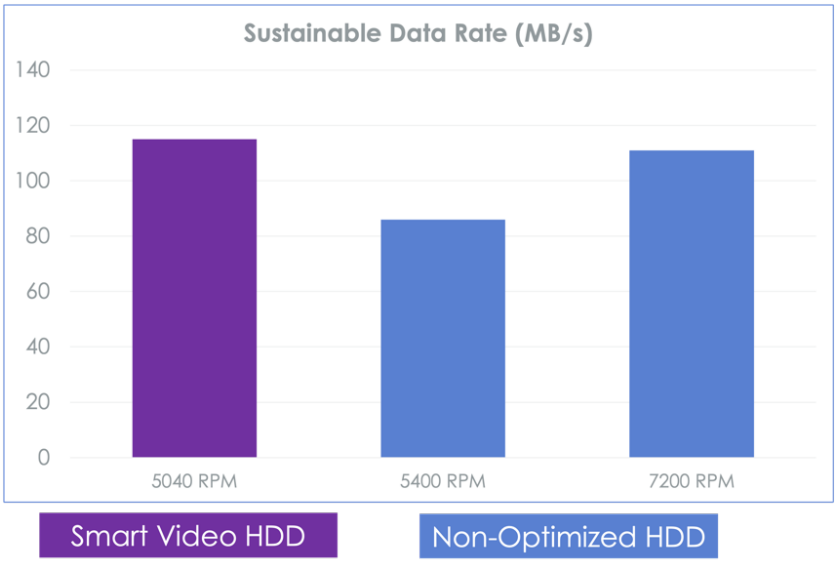


Smart Video HDDs May Be Faster for Surveillance Workloads

Internal WD lab computer simulations show that Smart Video drives utilizing ML, operating at low RPM speeds may perform equally well, if not better than standard HDDs, untuned for video workloads, operating at higher RPM speeds.

In a simulation with a typical video surveillance workload[(2)], a standard 7200 RPM HDD performed with a Sustainable Data Rate of 111 MB/s. A Smart Video HDD, operating at a power-efficient speed of 5040 RPM, matched and exceeded performance with a rate of 115 MB/s.

Another simulated direct comparison to a standard 5400 RPM HDD yielded a larger gap in favor of the slower 5040 RPM speed HDD when using the same typical video surveillance workload.



Combining Workload Capability and Power Efficiency

HDDs operating at slower RPM speeds are generally more power efficient.
By using innovation to improve data management and by keeping RPM low, the new generation of WD Purple Smart Video HDDs[1] can help provide both operating cost benefits and performance needed to handle the challenging workloads of new mainstream recorders. As a result, our newest drives are more power efficient than previous generation higher RPM drives, using up to 25.8%[(2)] fewer watts per drive, in average operating conditions.

More power efficient hard drives are welcome news for recorder manufacturers and suppliers whose NVRs may have constrained power budgets and face thermal limitations with limited airflow. For end-user customers, more efficient drives may result in lower system operating costs.

New Generation WD Purple™ HDDs

Western Digital's latest line of WD Purple™ HDDs (WD22PURZ, WD42PURZ, and WD63PURZ) implement breakthrough 2TB per platter CMR technology and deliver substantial improvement in power efficiency compared with previous models.

Western Digital AllFrame™ technology has been enhanced with new cache policies for stream detection and data placement. AllFrame™ enables WD Purple™ HDDs to be compatible with today's modern multi-stream recorders that incorporate basic AI functionality, while still providing stellar power efficiency.

New generation WD Purple™ HDDs can handle up to 32 primary HD video streams, 32 auxiliary streams, 32 picture streams, and 16 read streams[(3)], simultaneously.

Western Digital's investment in smart video optimized storage innovation ensures that we continue to deliver trust, reliability, and capability in our WD Purple™ family of storage devices.

Conclusion

Video data streams increasingly include both video and embedded video analytic data. Rapid adoption of higher resolution network cameras coupled with AI metadata places growing demands on network recorders and hard disk drives.

Detection of video data type, caching, and placement of data types on HDDs is a smarter approach for handling video surveillance workloads. The key to smart video data movement is to reduce head seeks. Intelligent data recognition, caching and selective disk track placement helps to write incoming video data streams.

A by-product of this work smarter, not harder approach, is that drives become more efficient and may require less operating power, decreasing thermal output per HDD(4).

WD Purple™ Smart Video HDDs(1) utilize technology innovation to intelligently manage video data, ideal for today's demanding surveillance environment.

References:

(1) Includes the following WD Purple™ models:
WDPURZ22
WDPURZ42
WDPURZ63
WDEJRX22
WDEJRX42
WDEJRX63

(2) "Typical" video surveillance workload includes a balance of network cameras at varying resolutions, frame rates, and video codes, along with auxiliary streams, and metadata.

(3) Single stream per camera @ 3.2Mbps (1080p, H.265, 25 fps). Results may vary depending on camera resolution, file format, frames per second, software, system settings, video quality, and other factors.

(4) Power Efficiency calculations are based on comparison of previous generation versus latest generation WD Purple HDD models.