TOSHIBA

White Paper

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Toshiba OptiFrame™ AI Firmware Control for AI Surveillance Storage

Surveillance | S300 AI

OptiFrame™ AI

Abstract

Video surveillance systems are no longer systems that only record and store video. Today, they work as always-on data platforms. They record camera videos without stopping, 24 hours a day, 365 days a year. At the same time, AI functions such as object detection, face recognition, and behavior analysis read past video data and analyze it.

In this environment, storage devices, especially hard disk drives (HDDs), must handle two very different types of work at the same time. The first is long and continuous sequential writing for video recording. The second is sudden and delay-sensitive random reading and writing for AI analysis and metadata access.

General-purpose PC or server firmware is not designed for this kind of mixed surveillance workload. When the load increases, recording delays or unstable cache behavior can occur. This can increase the risk of video frame loss.

This whitepaper introduces **OptiFrame™ AI**, a firmware control approach that adjusts HDD behavior to match mixed surveillance and AI workloads. The key idea is simple: prioritizing the "continuity of records" in our operations, while analysis should be processed as fast as possible within safe limits.

OptiFrame™ AI achieves this by identifying different types of I/O, and by carefully controlling cache usage and command order inside the drive. As a reference scale, this paper considers systems with up to 64 cameras and 32 AI analysis streams running at the same time.

1. Characteristics of Surveillance and AI Workloads

The most basic requirement of surveillance storage is uninterrupted recording. Cameras send video data at a fixed bit rate, so the storage system receives continuous sequential writing requests over long periods of time.

If delay or pause occurs during recording, video frames may be lost. For this reason, recording writes have strict delay limits and must be handled with the highest priority.

On the other hand, AI analysis reads recorded video and related data such as metadata. These reads often access many different locations on the disk. This results in random access rather than continuous access.

When random access occurs at the same time as continuous recording writes, HDD heads must move more often. This increases waiting time and makes reading and writing delay worse.

In systems where analysis results are used almost in real time, read delay directly affects detection delay. This means both recording and analysis performance are important.

As a result, surveillance systems must handle continuous sequential writes and sudden delay-sensitive random access at the same time. Queue depth becomes high, and 24/7 operation is required.

This workload is very different from typical desktop, server, or cloud storage workloads. Without special control, bottlenecks and unstable behavior are more likely to appear.

2. Problems That Appear as Systems Scale

As the number of cameras and AI analysis streams increases, storage behavior has a strong effect on system stability.

When recording writes and analysis reads run at the same time, HDD heads must move frequently. This can break up continuous writing and reduce effective throughput.

A common problem is competition for cache resources. If workloads are not separated, analysis traffic can push out the write buffer used for recording.

When this happens, the drive cannot absorb incoming video data smoothly, and the risk of frame loss increases.

Long-term heavy head movement also increases mechanical wear. Surveillance systems are often used for many years without stopping, so long-term stability and predictable behavior are very important.

From a system design point of view, the most critical requirement is clear: even if analysis load increases, recording always be protected.

For this reason, storage must actively manage conflicts between recording and analysis, instead of simply processing commands in order they arrive.

3. OptiFrame™ AI Firmware Control Concept

OptiFrame™ AI is a workload-aware firmware control framework designed for mixed surveillance and AI workloads.

Instead of treating all I/O requests in the same way, OptiFrame™ AI classifies them based on their role in the system. Handling rules are then changed depending on the type of workload.

The core ideas of OptiFrame™ AI are built on three points.

（1） **Workload classification:** Incoming I/O is identified as recording sequential writes, analysis-related reads and writes, or metadata operations.

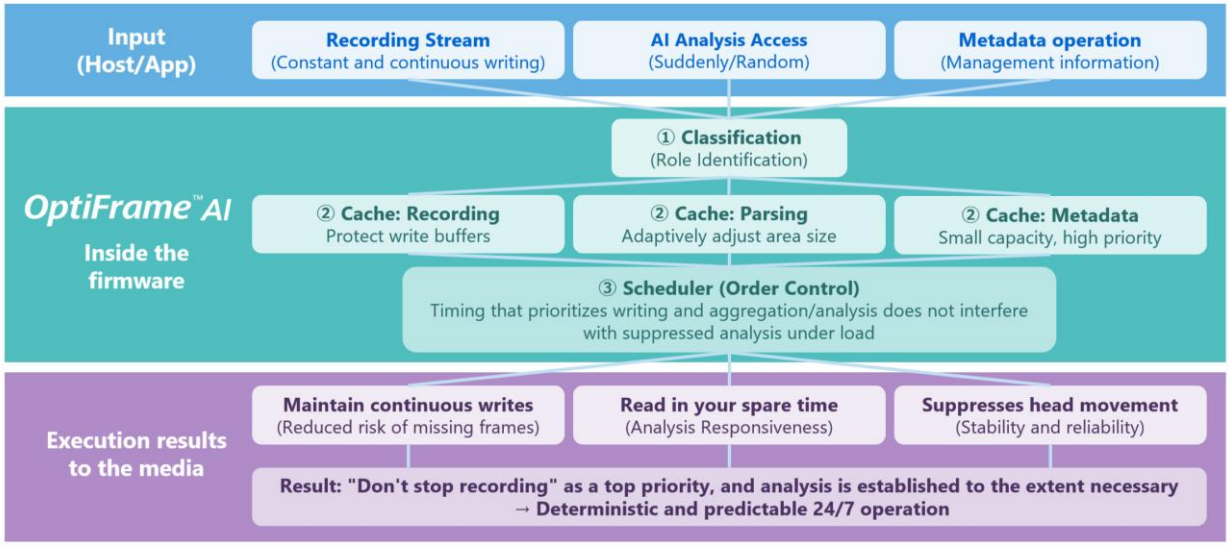
（2） **Cache control:** Recording write buffers are protected, while analysis cache space is provided as needed.

（3） **Command scheduling:** Recording writes are grouped and processed with the highest priority, while analysis requests are handled in a way that does not interfere with recording.

All of these controls operate inside the drive. No change is required on the host system or application side.

OptiFrame™ AI Role Identification I/O Control Flow：

① Classification → ② Cache → ③ Scheduler



4. Cache Control to Protect Recording

In mixed workloads, cache management has the largest effect on stability.

OptiFrame™ AI logically separates cache usage for recording and for analysis so that they do not interfere with each other.

First, a write-priority cache area is reserved for continuous recording writes. This area is protected so that random analysis access cannot easily replace it.

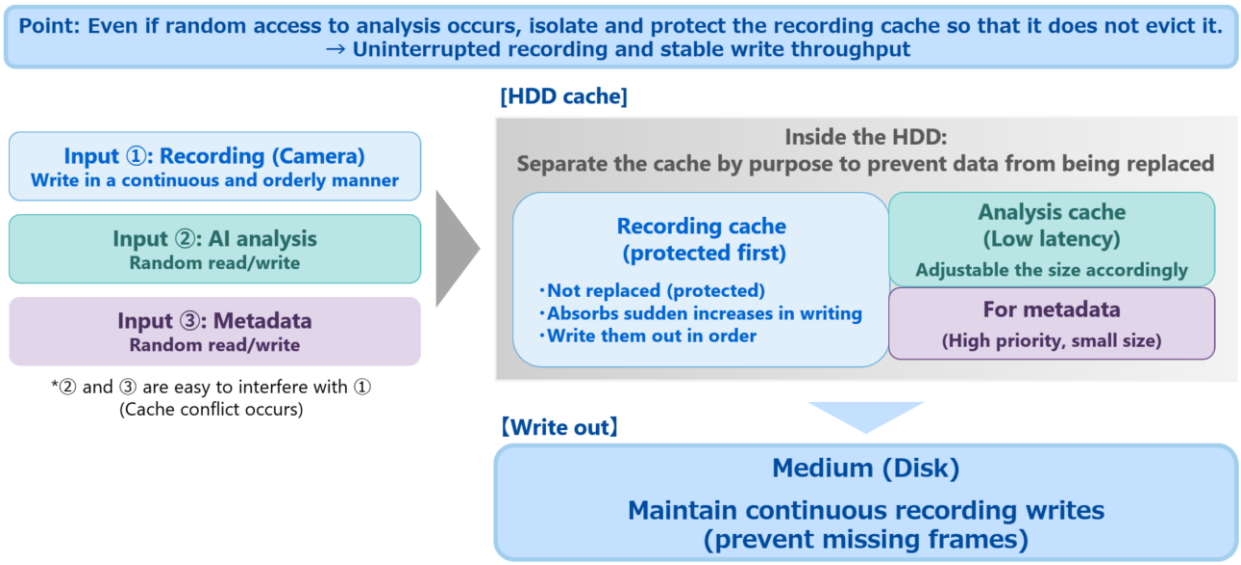
This allows incoming video frames to be accepted smoothly and written to disk at a steady rhythm. Keeping recording from becoming blocked is the highest priority.

Second, an adaptive cache area is prepared for analysis. When analysis reads or metadata updates increase, this area can grow. When analysis load decreases, it can shrink.

In addition, a small high-priority cache area is used for metadata. This reduces waiting time for control information and improves overall system response.

By preventing analysis access from pressing into the recording buffer, OptiFrame™ AI maintains stable recording throughput even under heavy analysis load.

Cache Control and Protection



5. Adaptive Command Scheduling

Cache control alone is not enough. The order in which I/O is executed also has a strong impact on performance and stability.

OptiFrame™ AI always gives top priority to recording sequential writes. These writes are grouped and processed in continuous order whenever possible.

This reduces head movement and helps keep recording writes smooth and uninterrupted.

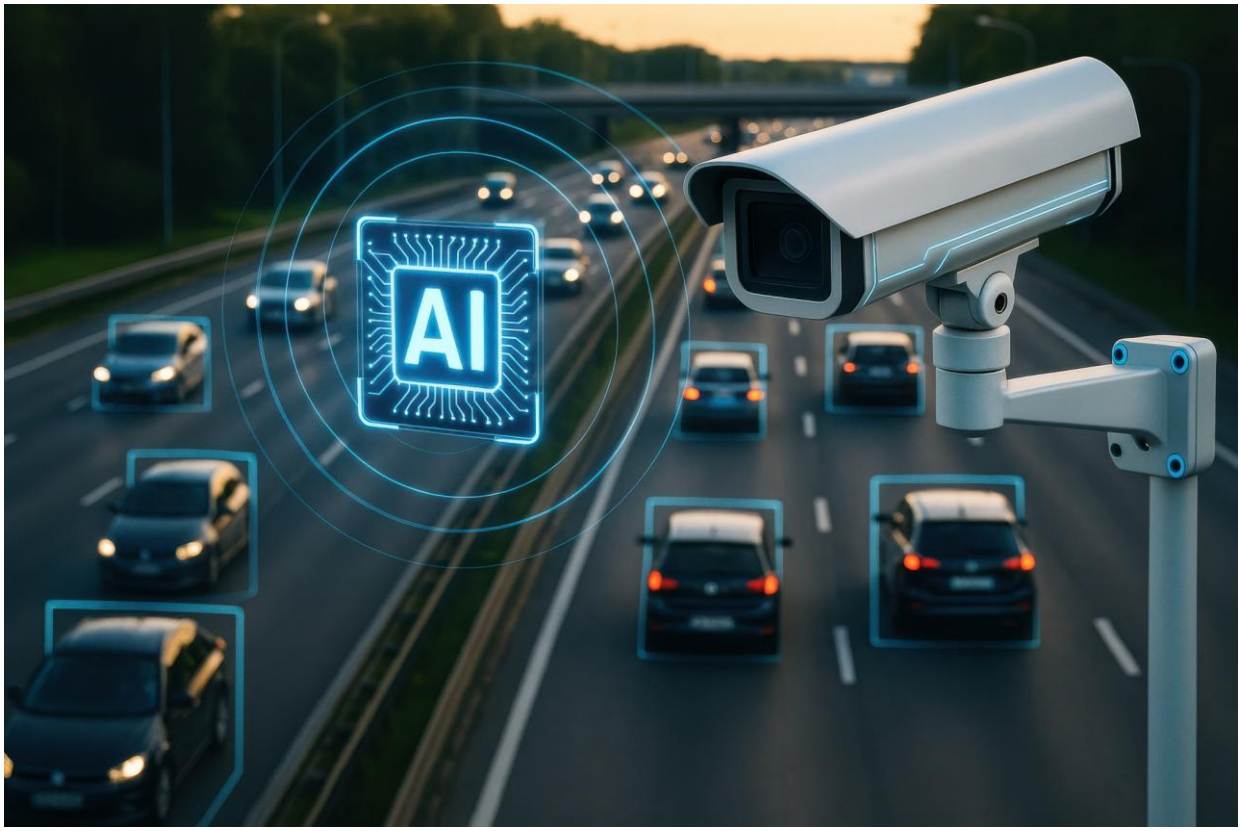
Analysis reads and supporting metadata access are processed at times that do not interfere with recording.

If system load increases and recording delay approaches unsafe levels, lower-priority requests are slowed down so that recording delay stays within a controlled range.

Surveillance systems change over time. Camera layouts, AI models, and retention policies are updated, and access patterns change.

OptiFrame™ AI continuously adjusts internal parameters such as cache size balance, scheduling limits, and request pacing.

This allows stable behavior to be maintained without fixed tuning for specific conditions.



6. Reliability and 24/7 Operation

Many surveillance systems are mission-critical and are expected to run continuously for years.

OptiFrame™ AI is designed to reduce unnecessary head movement and smooth write behavior, even under high yearly workloads.

By controlling cache flush timing and command order, the risk of long recovery times during peak load is reduced.

Stable access patterns also support better mechanical durability, making it easier for system designers to plan reliable long-term operation.

As a result, OptiFrame™ AI supports stable, predictable, and long-lasting surveillance storage behavior under continuous operation.

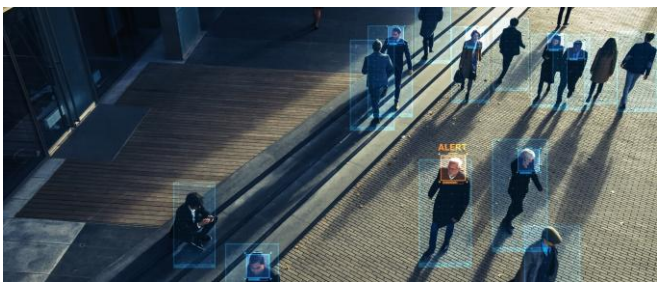
7. Conclusion

As camera counts increase and AI analysis becomes more advanced, storage is no longer just a component for capacity. It is a key factor that defines system quality.

In systems with up to 64 cameras and 32 concurrent AI streams, workload-aware control is required to protect recording while keeping analysis responsive.

OptiFrame™ AI performs I/O classification, cache protection, and adaptive scheduling inside the drive firmware.

This allows us to prioritize "continuity of records" in our operations, perform analyses within safe limits, and ensure the long-term reliability necessary for 24/7 operation.
For engineers and architects designing next-generation AI surveillance systems, OptiFrame™ AI provides a foundation to maintain stable recording behavior and predictable system operation, even as system size and analysis load continue to grow.



https://toshiba.semicon-storage.com/ap-en/storage.html

*The information in this book describes the design philosophy and technical features of the product and does not guarantee any specific performance or operation.