IBM AIX Dynamic System Optimizer
Version 1.1

IBM AIX Dynamic System Optimizer

IBM

Note

Before using this information and the product it supports, read the information in "Notices" on page 11.

Contents

About this document

This document provides system administrators with information about how to install, configure, and use the IBM AIX Dynamic System Optimizer.

Highlighting

The following highlighting conventions are used in this document:

Bold	Identifies commands, subroutines, keywords, files, structures, directories, and other items whose names are predefined by the system. Bold highlighting also identifies graphical objects such as buttons, labels, and icons that you select.
Italics	Identifies parameters whose actual names or values you supply.
Monospace	Identifies examples of specific data values, examples of text similar to what you might see displayed, examples of portions of program code similar to what you might write as a programmer, messages from the system, or information text that you must type.

Case-sensitivity in AIX

Everything in the AIX® operating system is case sensitive, which means that it distinguishes between uppercase and lowercase letters. For example, you can use the **ls** command to list files. If you type LS, the system responds that the command is not found. Likewise, FILEA, FiLea, and filea are three distinct file names, even if they reside in the same directory. To avoid causing undesirable actions to be performed, always ensure that you use the correct case.

ISO 9000

ISO 9000 registered quality systems were used in the development and manufacturing of this product.

IBM AIX Dynamic System Optimizer

The IBM® AIX Dynamic System Optimizer (DSO) extends the features provided by the Active System Optimizer (ASO) to automatically adjust some system settings to maximize the efficiency of your system. This automates the difficult job of manually tuning those system settings to optimize eligible workloads. The additional features provided by DSO are large page optimization and data stream prefetch optimization.

In AIX Version 7.2.0, or later, both the Active System Optimizer (ASO) and the Dynamic System Optimizer (DSO) are included with the AIX operating system. DSO extends the function of ASO with additional optimization capabilities.

Starting with IBM AIX 7.2 with Technology Level 3, or later, ASO and DSO are supported on systems that are based on POWER9™ processors.

What's new in IBM AIX Dynamic System Optimizer

Read about new or significantly changed information for the AIX Dynamic System Optimizer topic collection.

How to see what's new or changed

To help you see where technical changes have been made, the information center uses:

- The ⟩I image to mark where new or changed information begins.
- The I⟨ image to mark where new or changed information ends.

November 2020

The following information is a summary of the updates made to this topic collection:

- Updated the information about the cache affinity in the Cache and memory affinity optimizations topic. Also, updated the information about multithreaded or multiprocess for a workload in the Workload requirements topic.

September 2018

The following topics were updated with information about POWER9 processors:

- "IBM AIX Dynamic System Optimizer" on page 1
- "Planning for the IBM AIX Dynamic System Optimizer" on page 5

IBM AIX Dynamic System Optimizer concepts

The AIX Dynamic System Optimizer is a framework that automatically adjusts the system settings to achieve the most efficient use of the systems by using different optimizations.

Active System Optimizer within IBM AIX Dynamic System Optimizer

The Active System Optimizer (ASO) daemon is a user-level daemon that is available with the AIX operating system and runs the installed optimizations.

The ASO daemon is started at boot time, but is inactive by default. It can be activated using the **asoo** command.

When the ASO daemon is activated, it monitors and analyzes the workloads on the system to determine whether it can make changes to improve the performance of the system. If the daemon detects that changes might improve performance, the changes are made automatically. The ASO monitors the changes to determine whether the change produced the required results. If the change does not result in the improvements that were expected by the ASO, it reverses the change.

The ASO requires minimal resource for its own operation because it monitors its own use and keeps its use within internally established limits. The ASO also hibernates when it recognizes situations when constant monitoring causes resource problems, activating itself occasionally to test whether conditions are more favorable for optimization.

Note: ASO is supported only on systems that are based on POWER7®, or later processors that are running in native mode.

AIX Dynamic System Optimizer optimizations

DSO extends the function of the ASO with additional optimization capabilities.

Cache and memory affinity optimizations

The cache and memory affinity optimizations are functions of the AIX Dynamic System Optimizer that change the settings by minimizing the amount of data that crosses the affinity domains.

The IBM Power Systems server divides its processor and memory units into symmetric multiprocessing (SMP) *affinity domains*. Affinity domain refers to a group of processing units which have similar memory and cache access times. A processor socket is an example of an affinity domain. System performance is close to optimal when the amount of data crossing between the domains is minimized.

Cache affinity

Active System Optimizer (ASO) analyzes the cache access patterns based on information from the kernel and Performance Monitoring Unit (PMU) to identify potential improvements in cache affinity by moving threads of workloads closer together. When this benefit is predicted, ASO uses algorithms to estimate the optimal size of the affinity domain for the workload and uses kernel services to restrict the workload to that domain. The closer cache locations result in improved performance as compared to cache locations that are farther away. In AIX version 7.2.5 and later, multi-threaded single-process workloads and multi-process single-threaded workloads are considered for the cache affinity optimization.

Memory affinity

After a workload is identified and optimized for cache affinity, ASO monitors the memory access patterns of the process-private memory of the workload. If the conditions of the workload might benefit from moving process-private memory closer to the current affinity domain, hot pages are identified and migrated closer to the current affinity domain using software tools. Hot pages are frequently accessed memory allocations. Single-threaded processes are not considered for this optimization because their kernel already adjusts the affinity of the process-private data when the thread is moved to a new affinity domain. Only workloads that fit within a single *scheduler resource affinity domain(SRAD)* are considered.

Large page optimization

Large page optimization is a feature of IBM AIX Dynamic System Optimizer that automatically changes the page size to a larger 16 MB page size when it predicts improved performance.

Large page optimization transparently upgrades 4 KB and 64 KB page sizes to a 16 MB page size. This larger page size can benefit workloads that use large chunks of data because it reduces the number of errors caused by the translation lookaside buffer (TLB). When this optimization is installed, is activated, and determines that there might be a benefit, ASO automatically promotes heavily used regions of memory to 16 MB pages. This optimization potentially improves the performance of workloads that use those regions because it reduces the number of TLB misses.

Note: Only System V shared memory is eligible for large page optimization.

Data stream prefetch optimization

The data stream prefetch optimization is available only in POWER7 processors. The data stream prefetch optimization is a feature of the IBMAIX Dynamic System Optimizer that modifies the Data Stream Control Register (DSCR), when required, to improve the performance of an application.

A system that is based on the IBM Power Architecture® implementation includes a special purpose register named the DSCR. The DSCR controls the enablement, depth, and settings for hardware data stream prefetching. This setting is correct when the DSCR maximizes the amount of information that it is able to access in the shortest amount of time. The prefetch optimization accomplishes this performance by loading some data that is frequently accessed before that data is required, based on established patterns.

This optimization often benefits systems that have large memory footprints and high processor utilization with high context switch rates. When enabled, the Active System Optimizer collects information from the AIX kernel and Performance Monitoring Unit (PMU) to dynamically determine the optimal setting for this register for a specific application.

Workload requirements

Not all workloads are considered for optimization. The workload must meet certain requirements to benefit from the optimization.

General requirements

All thresholds are set internally by ASO and cannot be changed. For any workload to be considered for optimization, it must meet the following requirements:

Minimum age
Workloads must be a certain age to be considered for a cache affinity optimization or a memory affinity optimization. The age requirement ensures that there is enough history to use as a basis to determine whether a change to the settings is required.

Priority order
The ASO daemon runs with a fixed scheduler priority. If the scheduler priority of a workload, or any of its threads, is higher than the scheduler priority of the ASO daemon, the workload is not optimized.

Minimum processor utilization
Workloads that have processor utilization lesser than the minimum level required to qualify for optimization are not changed.

Specific optimization requirements

AIX Dynamic System Optimizer also has requirements that do not apply to all of the optimizations.

Cache affinity optimization and memory affinity optimization
ASO is designed to improve performance of workloads that have a long-term existence, are multithreaded, and have stable processor utilization. The minimum time that a workload must exist varies according to the type of optimization. The performance gain is higher for workloads that have a high amount of communication between the threads in the workload.

Multithreaded or Multiprocess
Workloads must contain multithreaded processes or multiple single-threaded processes that are using the same shared memory.

Free of Workload Manager (WLM) tiers and minimum limits classifications
Workloads that are classified with tiers or have minimum limits set by the Workload Manager are not optimized. If the processor capacity of the system is fully used, ASO does not optimize processes that belong to classes with specific shares.

Note: Workload Partition (WPAR) workloads (which implicitly use WLM) can be optimized by ASO if minimum processor limits are not specified.

User-specified placement
When you explicitly set the location of workloads by using attachments like bindprocessor, resource set (RSET) (Real, Partition, or Exclusive RSETs), and Scheduler Resource Affinity Domain (SRAD), those workloads are not eligible for ASO optimization. Although ASO does not affect these workloads, the AIX operating system continues to enforce the resource constraints as normal. Any attempts to place such a restriction on a workload that is being optimized by ASO causes ASO to undo its optimization, and ASO allows your restriction to take priority.

Large page optimization
The ideal workload is one that uses large System V memory regions. Examples of these workloads are a database with a large shared memory region or Java™ programs that use a large heap. Workloads can be either multithreaded or a group of single threaded processes that are attached to the same shared memory region.

Fully populated segments
Only 4 KB and 64 KB regions within a shared memory segment that are fully populated are considered for an upgrade to the 16 MB page size.

Memory footprint minimum
The memory footprint of the workload must be greater than the minimum value, measured in gigabytes.

Data stream prefetch optimization
Workloads with large memory footprints, high processor utilization, and high-context switch rates are often candidates for this optimization. Workloads must use System V shared memory to be considered for the data stream prefetch optimization. Workloads are either multi-threaded or a group of single-threaded processes. This optimization is disabled if the Data Stream Control Register (DCSR) is set manually at the system level by using the **dscrctl** command.

Memory footprint minimum
The memory footprint of the workload must be greater than the minimum value, measured in gigabytes.

Environment variables

The ASO_ENABLED and ASO_OPTIONS environment variables provide some customization of the AIX System Optimizer (ASO) daemon when using the IBM AIX Dynamic System Optimizer

ASO_ENABLED

The ASO_ENABLED environment variable alters the default behavior of the ASO when it evaluates a workload for optimization.

The following values are valid for the ASO_ENABLED environment variable:

Always
ASO skips some of the primary eligibility checks, such as the age of the workload and the minimum processor utilization, to view more information about a workload without those restrictions.

Never
ASO excludes this workload from any optimization under all circumstances.

Unsupported value
ASO optimizes the workload normally.

ASO_OPTIONS

The ASO_OPTIONS environment variable individually enables or disables the cache affinity optimization and the memory affinity optimization.

The values for this environment variable are shown in the following table:

Option	Values	Results
ALL	ON, OFF	Enables or disables all of the ASO optimizations.
CACHE_AFFINITY	ON, OFF	Enables or disables the cache affinity optimization.
MEMORY_AFFINITY	ON, OFF	Enables or disables the memory affinity optimization. **Note:** The cache affinity optimization must be applied for the memory affinity optimization to be applied.
LARGE_PAGE	ON, OFF	Enables or disables the large page optimization.
MEMORY_PREFETCH	ON, OFF	Enables or disables the data stream prefetch optimization.
unset		All optimizations are enabled.
any other values		Undefined.

Planning for the IBM AIX Dynamic System Optimizer

There are following considerations when you are planning to use the AIX Dynamic System Optimizer.

- The Active System optimizer (ASO) daemon is started at boot time, but it is inactive by default. It can be activated by using the **asoo** command.
- The ASO daemon is supported on the following versions of the AIX operating system and POWER® processors:

AIX version	POWER processor
AIX 7.2, or later	POWER7
AIX 7.2 Service Pack 2, or later	POWER8®
AIX 7.2 with Technology Level 3, or later	POWER9

- Running ASO in a dedicated processor environment requires that Virtual Processor Management (core folding) is disabled, which is the default setting. Enabling Power® Management on the Hardware Management Console (HMC) enables Virtual Processor Management to be started in a dedicated environment and disables ASO.
- Enabling Active Memory Sharing disables all the optimizations except data stream prefetch optimization.
- When processor resources are capped in a shared processor LPAR (SPLPAR) environment, the system entitlement must be a minimum of two cores. The entitlement for each virtual processor must be high enough to ensure that ASO can optimize the workload.
- For large page optimization, the system must have a minimum of 16 GB of system memory.

Installing the IBM AIX Dynamic System Optimizer

In AIX 7.2.0, or later, both the Active System Optimizer (ASO) and theAIX Dynamic System Optimizer are automatically installed with the AIX operating system.

The existing AIX Dynamic System Optimizer framework that is installed with the AIX operating system automatically starts the data stream prefetch and large page optimizations. You do not need to restart the AIX operating system or the ASO daemon to enable the additional optimization capabilities

Understanding the IBM AIX Dynamic System Optimizer log files

Information about the functioning of the AIX Dynamic System Optimizer is maintained in log files.

The log files are controlled by **syslogd**. The syslog configuration file, /etc/syslog.conf, provides the following information by default:

```
# ASO log configuration
aso.notice /var/log/aso/aso.log rotate size 1m files 8 compress
aso.info /var/log.aso/aso_process.log rotate size 1m files 8 compress
aso,debug /var/log/aso/aso_debug.log rotate size 32m files 8 compress
```

The following log files are used by AIX Dynamic System Optimizer:

/var/log/aso/aso.log
> This log contains the major ASO events, including when it is enabled and disabled, or when it hibernates. An example of an entry in this log that results from insufficient processor entitlement on shared processor LPAR (SPLPAR) follows:

```
Oct 20 02:15:04 p7e04 aso:notice aso[13238402]: [HIB] Current
number of system virtual cpus too low (1 cpus)
Oct 20 02:15:04 p7e04 aso:notice aso[13238402]: [HIB] Increase
system virtual cpus to at least 3 cpus to run ASO. Hibernating.
```

> The following list describes the most commonly used information in this entry:

> **Oct 20 02:15:04**
>> The timestamp of when the workload was analyzed.

> **p7e04**
>> The system where the ASO is installed.

> **aso:notice**
>> The type of message.

> **aso[13238402]**
>> The process ID of the ASO daemon.

> **Current number of system virtual CPUs too low**
>> The message content.

/var/log/aso/aso_process.log
> This log contains the data in the aso.log and an additional audit trail of workloads that were considered for optimization. For those workloads that were considered for optimization, it logs the actions that were taken or the reasons that no actions were taken. An example of an entry in the log follows:

```
Oct 21 05:52:47 localhost aso:info aso[5963954]: [SC] [5243360]
Considering for optimisation (cmd='circularBufferBenchmark',
utilisation=1.14,pref=0; attaching StabilityMonitorBasic)
```

> The following list describes the items in the log entry:

> **Oct 21 05:52:47**
>> The timestamp of when the workload was analyzed.

> **localhost**
>> The system where the ASO is installed.

> **aso:info**
>> The type of message.

aso[5963954]
> The process ID of the ASO daemon.

The remaining information in the message is the content of the message.

/var/log/aso/aso_debug.log
> This log contains the data when the debug mode is activated by entering the following command:

```
asoo -o debug_level=N
```

where N is a debug level within the range of **-1** through **9**. The default value is **-1**, which indicates that the debugging feature is off.

Scenario: Running the IBM AIX Dynamic System Optimizer

This scenario provides a practical example of how and when you can use the AIX Dynamic System Optimizer.

You are running a POWER7 processor-based system with the IBM AIX 6.1 with Technology Level 8 operating system. You installed the AIX Dynamic System Optimizer package on the system because you recently changed the system. You want to ensure that the current system settings are optimized.

The ASO daemon is running, but it is in hibernate mode. You enable the ASO daemon by entering the following command on the AIX command line:

```
asoo -o aso_active=1
```

Now that the ASO daemon is running, you check the aso.log file to verify that the daemon is running. You see the following message:

```
Jun 21 02:05:41 p7machine aso:notice aso[3604612]: ASO enabled by tunable
```

If the setting for the **asoo_active** parameter is already set to 1 when you attempt to start ASO, no new message is logged.

After a few weeks, you are interested in seeing whether the AIX Dynamic System Optimizer discovered any workloads that benefitted from the optimization. You know that the log provides information about whether the optimizations were applied, so you look at the aso_process.log file to determine whether any changes occurred to the system.

You cannot quickly find an entry that contains any information that is related to workload1. You use a grep tool to find workload1 in the log file.

The ID for the workload is in braces before the workload name. You search for the ID that was related to workload1 throughout the log file and determine what actions were taken on that workload.

You realize that workload1 was identified as a possible candidate for optimization, and AIX Dynamic System Optimizer automatically started the optimization.

Troubleshooting the IBM AIX Dynamic System Optimizer

Some problems might require troubleshooting when you are using AIX Dynamic System Optimizer.

Problem: You migrated to a new system and the ASO daemon was activated, but it is not doing anything.
> **Reason:** The ASO daemon is only supported on systems that are running with POWER7 or newer processors in native mode. If you migrate from a system that is based on POWER7 or a newer processor to a system that is running with a processor that is not supported, the ASO daemon continues to hibernate even if ASO is activated with the **asoo** command. The ASO log file (`/var/log/aso/aso.log`) contains a message that indicates the processor version is not supported. When the ASO daemon is in hibernation mode, it is sleeping and does not use any CPU

resources. If you migrate back to a system that is running with POWER7 processors in native mode, the ASO daemon is activated automatically.

Resolution: No action is required.

Problem: The ASO daemon process was activated, but it is not doing anything.

Reason: The ASO daemon is started by the srcmstr daemon at boot time. It remains in hibernation mode until the `aso_active` tunable command is set to `1` by using the **asoo** command.

Resolution: This situation is normal.

If the ASO daemon needs to be activated, run the following command:

```
asoo -o aso_active=1
```

Problem: The ASO daemon process is running in an unsupported environment.

Reason: When ASO determines that the system has an unsupported configuration at startup, the ASO daemon goes into hibernation mode. This automatic hibernation allows the daemon to be activated automatically when the LPAR is migrated to a supported environment.

Resolution: This situation is normal.

If the ASO daemon needs to be activated, run the following command:

```
asoo -o aso_active=1
```

Problem: The ASO daemon is not optimizing certain workloads.

Reason: Each optimization has a list of selection criteria that a workload must satisfy to be considered for optimization.

Resolution: See "Workload requirements" on page 3 to ensure that the workloads meet the minimum requirements.

Problem: The log file shows lesser utilization than what is shown by other tools.

Reason: The processor utilization that is shown by the log files is only for the workloads that satisfy the eligibility criteria for at least one type of optimization.

Resolution: This situation is normal.

If the ASO daemon needs to be activated, run the following command:

```
asoo -o aso_active=1
```

Problem: The memory page size of the workload was promoted by ASO, but it was restored to the original size.

Reason: The kernel reverses actions that are taken by ASO if the changes made by ASO hamper the stability of the system. Using the MPSS optimization as an example, an imbalance of memory pools can cause the kernel to reduce the memory page size of pages that were previously increased by ASO.

Resolution: This situation is normal.

If the ASO daemon needs to be activated, run the following command:

```
asoo -o aso_active=1
```

Problem: The ASO daemon is active but are not logging new information in the log files.

Reason: The syslogd daemon is not running. The syslogd daemon must be running to format the messages that are created by the ASO daemon. The resulting log messages are written to the files specified in the `/etc/syslogd.conf` file.

Resolution: Start the syslogd daemon by entering the following command:

```
startsrc -s syslogd
```

Problem: After ASO log files were deleted or moved to a backup location, no information is being logged in the newly created log files

Reason: Any change to the log files or to the `/etc/syslog.conf` file requires a restart of the syslog daemon.

Resolution: Restart the syslog daemon by entering the following commands:

```
stopsrc -s syslogd
startsrc -s syslogd
```

Related information

ASO command
ASOO command
stopsrc command
startsrc command

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