An Introduction to the SSSI WIOCP I/O Metrics

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Table of Contents

List of Tables

List of Figures

Abstract

Empirical file and disk I/O operation performance metrics can be invaluable with regard to substantiating theories and assessing claims about disk I/O performance. This is especially so when these metrics reflect the actual file and disk I/O operation activity performed by individual applications and workloads during normal usage. Moreover, such empirical I/O metrics can be instrumental in uncovering and understanding performance bottlenecks, determining more precise I/O performance requirements, better matching disk storage purchases to the particular workload usage and needs, and designing as well as optimizing various disk storage solutions.

This white paper briefly describes how the SNIA SSSI "Workload I/O Capture Program (WIOCP)" collects these empirical I/O operation performance metrics in a simple and easy manner with little time or effort required by the SSSI WIOCP participants. In addition, this white paper provides numerous examples of how the collected SSSI WIOCP I/O metrics can provide insights into the particular ways that applications actually perform and experience I/O operation activity in real-life use. These examples are based upon SSSI WIOCP I/O metrics that have been collected and made available for free download from the SNIA I/O Traces, Tools, and Analysis (IOTTA) Repository.

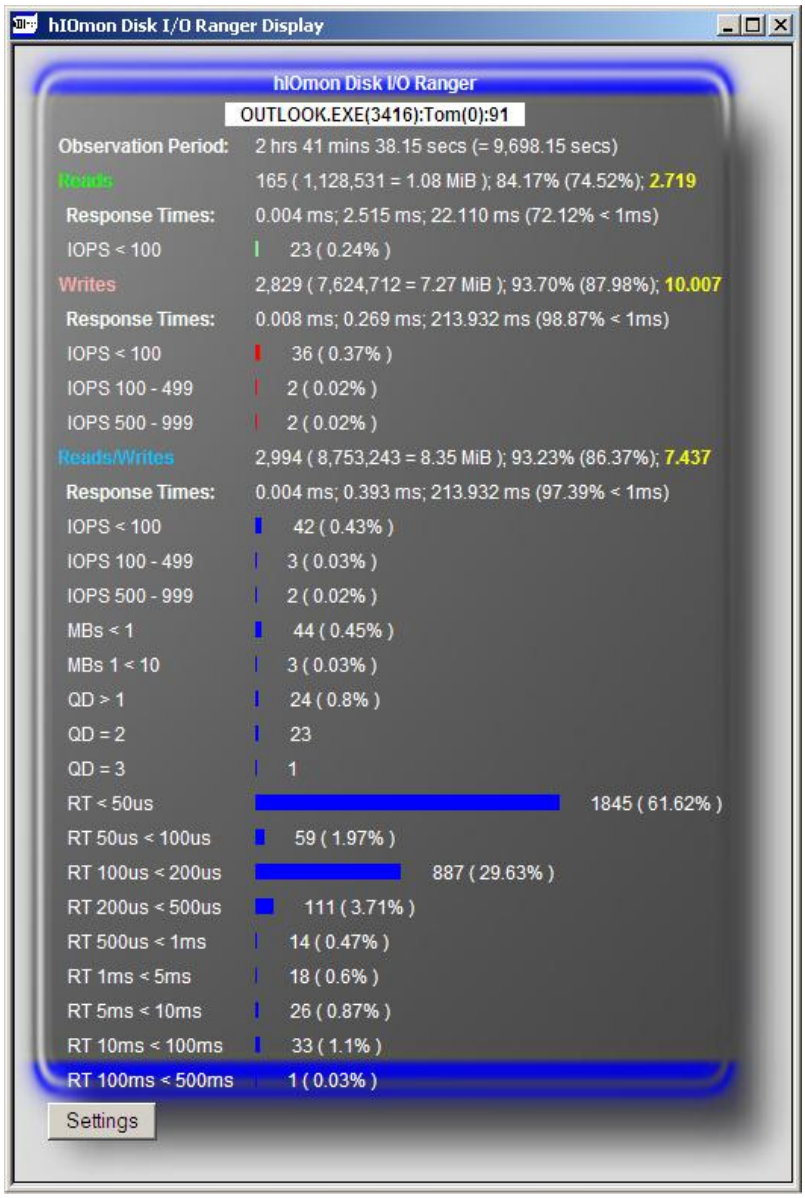
Who Can Benefit

- SNIA Technical Work Groups
- Users of the SSSI Performance Test Specification
- SSS Vendors
- Storage Industry Analysts
- Industry and Academic Researchers
- SSS Benchmark Testing Reviewers
- SSSI WIOCP Software Tool Users

1. Introduction

The WIOCP is a project undertaken by the SNIA SSSI to collect ***current*** I/O operation performance metrics. These metrics reflect the actual I/O operation activity performed during normal, everyday application and workload usage spanning both consumer/client and enterprise systems.

Figure 1 – hIOmon Disk I/O Ranger Display



The empirical I/O operation performance metrics collected by the WIOCP go far beyond basic I/O operation counts and data transferred amounts. As shown in Figure 1, these metrics include ranges of I/O operations per second (IOPS), megabytes-per-second data transfer rates (MB/s), queue depths, and response times (latency).

Both random and sequential access, TRIM command, idle time, and other metrics are also captured. Moreover, the SSSI WIOCP I/O metrics are collected separately for each individual device and process whose I/O operations are monitored.

The procedure used to collect the SSSI WIOCP I/O metrics is quick and simple. A customized version of a commercially available I/O operation monitoring software tool runs unobtrusively in the background for a seven-day collection period with negligible impact upon system performance – and with **no** collection of individual I/O operation trace data (only automatically-aggregated summary I/O operation metrics are

collected). Special emphasis has been placed upon ease-of-use and privacy (with **no** Personally Identifiable Information being collected).

Overall, the breadth and depth of the SSSI WIOCP I/O metrics enable valuable insights into actual device I/O usage, application and workload I/O characteristics, and key performance metrics to be considered.

In particular, users of the WIOCP metrics can see firsthand how I/O operation activity is performed in real-life everyday usage within a variety of modern-day systems.

Moreover, these observations are based upon a large, robust set of empirical I/O operation performance metrics that are directly made available within a concise summary format.

The SSSI WIOCP participants themselves can especially benefit by obtaining a precise empirical picture of what their particular application and disk I/O profiles actually look like during their normal system usage and within their own specific system environment. This can enable them to uncover and better understand performance bottlenecks, accurately tune and enhance I/O performance, determine more precise I/O performance requirements, and better match disk storage purchases to their particular workload usage and needs.

I/O Metrics that You Can Use:

- Summary I/O metrics that can be easily and quickly viewed, analyzed, and utilized
  - ✓ No need to spend time/effort dealing with huge volumes of I/O operation trace data
- Empirical data that can help substantiate presumed application and device I/O behaviors
  - ✓ Verify whether these presumptions match what is observed in actual practice
- Empirical evidence to help assess I/O performance claims
  - ✓ See firsthand how particular system and application usage measures up in real-life

2. How the I/O Metrics Are Collected

The SSSI WIOCP utilizes a free, customized version of a commercial, enterprise-class software utility (hIOmon™ Disk I/O Ranger). This tool enables an easy and quick way of collecting I/O operation

performance metrics in a safe, secure, and reliable manner for both Solid State Storage (SSS) and hard disk drives.

Key Features of the I/O Operation Monitoring Tool:

- **No** individual I/O operation trace data, file names, or binary data are collected
- **No** Personally Identifiable Information is collected
- **No** application, file, file system, device, or operating system code changes are required

Only summary (i.e. automatically-aggregated) I/O operation performance metrics (based upon the individually observed I/O operations) are collected and periodically written to standard Comma-Separated-Values (CSV) export files, which can be imported into an Excel spreadsheet and other tools.

Collection Steps

The specific steps required to collect the SSSI WIOCP I/O metrics are easy to perform. They can be done with a very minimal amount of time and effort on the part of the SSSI WIOCP participant. Please note that participation in the SSSI WIOCP entails the participant's acceptance that the collected WIOCP metrics be contributed to the SNIA IOTTA Repository.

Figure 2 – SSSI WIOCP I/O Metrics Collection Steps

SSSI WIOCP I/O Metric Collection Steps:

1) **Download** the special SSSI WIOCP hIOmon software package
2) **Install/configure** the SSSI WIOCP hIOmon software (this installation and configuration step uses the standard system installer and can be completed within a few minutes)
3) **Generate** the System Information Report text file, which provides basic information about the computer platform used (an included script file is used to generate this report)

After the 7-day collection period ends:

1) **Send** via e-mail the CSV export files along with the System Information Report to the SSSI WIOCP Project Coordinator
2) **Uninstall** the hIOmon software using the standard system Software Uninstall option

The download link for the special SSSI WIOCP hIOmon software package is provided at the following URL: http://www.hyperIO.com/hIOmon/hIOmonSSSIworkloadIOcaptureprogram.htm

Export Files

Only summary I/O operation performance metrics are collected, which greatly reduces the overall amount of I/O operation metrics exported. This makes it easy to e-mail the export files to the SSSI.

Figure 3 – Key Features of the SSSI WIOCP Export Files

Key Features of the SSSI WIOCP Export Files:

- Contain summary I/O operation performance metrics collected upon **cumulative** basis.
- Metrics automatically written to the small CSV files at ten minute intervals.
- "SSSIioProfileSummaryDevices" file containing metrics for the devices monitored; a separate row (representing a successive 10-minute period) is written for each monitored Logical Disk along with a separate row for the associated OS physical volume and a separate row for the associated OS physical device.
- "SSSIioProfileSummaryDTSdevices" file containing "data transfer size (DTS)" summary metrics for each OS physical device monitored; a separate row (representing a successive 10-minute period) is written for each individual data transfer size associated with the device. Please note that the WIOCP software is configured to collect DTS summary metrics for a limited set of data transfer sizes. This set includes all data transfer sizes specified within the SNIA SSSI Performance Test Specification (PTS).
- "SSSIioProfileSummaryProcesses" file containing metrics for the application and system processes monitored, that is, for each process that issued file I/O operations which were observed by the hIOmon I/O Monitor software component. A separate row representing a successive 10-minute period is written for each individual process instance.

A comprehensive set of summary I/O operation performance metrics is exported by the SSSI WIOCP. See the SSSI WIOCP "Types of I/O Metrics Exported" web page at the following URL:

http://www.hyperIO.com/hIOmon/WIOCP/SSSI/hIOmonSSSI-WIOCP-CollectedMetricsDefinition.htm

SNIA IOTTA Repository

A SSSI WIOCP Metrics package is made available for free public download from the SNIA IO Traces, Tools, and Analysis (IOTTA) Repository.

This download package includes the SSSI WIOCP export files and the accompanying "System Information Report" file received from the SSSI WIOCP participant. Several additional CSV files are also included within this package; these auxiliary files (e.g. the Daily and Totals files) enable a quick overview of the overall I/O operation activity and a top-down approach to analysis.

Figure 4 – SSSI WIOCP Metrics Download Package Contents

SSSI WIOCP Metrics Download Package Contents

- The separate Device and Process CSV export files collected by the WIOCP participant
- The associated System Information Report text file (providing basic information about the computer platform used during the collection of the WIOCP metrics)
- Several auxiliary CSV files, such as:
  - ✓ A Daily CSV file (separately for devices and processes) containing the summary I/O metrics that have been coalesced (aggregated) upon a daily basis
  - ✓ A Totals CSV file (separately for devices and processes) containing the summary I/O metrics that have been coalesced upon the overall 7-day collection period basis
  - ✓ A Processes Top Tens CSV file that contains the "Top Ten" processes for a selected subset of the summary I/O operation performance metrics based upon the overall 7-day collection period
- A ReadMe file providing general information about the download package contents

The SSSI WIOCP Metrics download packages are provided in a zipped-file (compressed) format that are small in size, which enables quick and easy download. The overall small size together with the CSV file format and the separate coalesced auxiliary files (e.g., the Daily and Totals files) enable quick and easy viewing (and moreover, review and analysis) of the SSSI WIOCP metrics contained within the SSSI WIOCP Metrics download packages.

SNIA IOTTA Repository: http://iotta.snia.org/

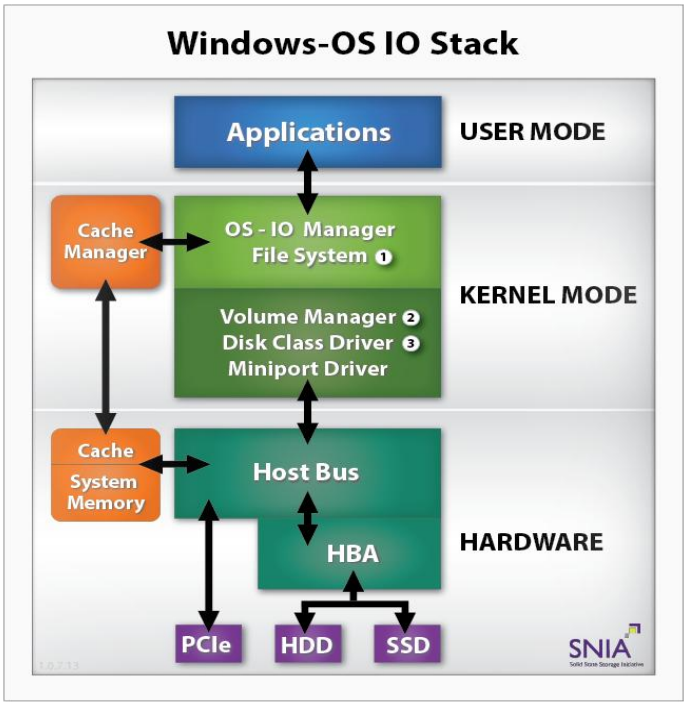
3. The I/O Software/Hardware Stack

I/O operation activity issued by applications is notably subject to the various software components incorporated within the I/O Software/Hardware Stack. In particular, the performance of this I/O operation activity is highly dependent upon how (and moreover, the extent to which) the I/O operations traverse through these I/O stack software components.

One key benefit of the SSSI WIOCP is the collection of empirical I/O operation performance metrics that help clearly highlight and substantiate how I/O activity is actually realized within the I/O software stack.

What the I/O Software/Hardware Stack Looks Like

Figure 5 – The I/O Software/Hardware Stack



As illustrated by the Figure 5 graphic, the I/O Software/Hardware Stack exhibits a layered-stack architecture – with the upper layers related to file systems – and with various device driver components underneath – and finally the actual physical storage devices at the bottom of the stack.

It is important to note that I/O operations issued by applications do not necessarily travel the full extent of the I/O stack. In fact, many file I/O operations performed by applications are often satisfied entirely using the system file cache and thus avoid actually traveling further down to the storage device itself.

A deeper discussion of the I/O stack can be found within the SNIA webinar entitled *How Your Data Gets to Your SSD – Exploring the Software/Hardware Stack* at this URL: https://www.brighttalk.com/webcast/663/41701.

The SSSI WIOCP and the I/O Software Stack

The I/O operation monitoring software used by the WIOCP is configured to *concurrently* monitor I/O operations at **three** distinct levels within the I/O software stack (as numbered within the Figure 5 graphic above):

1) File System / Logical Disk level (i.e. the file I/O operations issued by the applications)
2) Operating system physical volume level
3) Operating system physical device level

Moreover, a separate set of summary I/O operation performance metrics is collected at each of these levels for each logical disk requested to be monitored by the WIOCP software (i.e. in accordance with the user-specified configuration of the WIOCP software when it is installed).

What the SSSI WIOCP 'I/O Software Stack Metrics' Can Reveal

As discussed in the prior chapter, each SSSI WIOCP Metrics download package from the IOTTA Repository contains several auxiliary CSV files, which reflect summary I/O operation performance metrics that have been further coalesced (e.g. aggregated upon a daily basis or upon an overall total collection period basis for the individual devices or processes).

For example, the SNIA-SSSI-WIOCP-01-PC-4804467 download package[1] includes the SSSIioProfileSummaryDevices_Totals_MetricsByRow file. This file contains the summary I/O operation performance metrics coalesced upon an overall total basis (i.e. for the entire collection period, which in this case was the full seven-day period). Each row represents a different summary I/O operation performance metric and the columns reflect a different device or associated physical volume/device.

Table 1 that follows is an excerpt from this file; please note that all of the following data transfer amounts are in bytes.

[1] Please note that all SSSI WIOCP I/O metric excerpts shown within this white paper are from the "**SNIA-SSSI-WIOCP-01-PC-4804467**" download package, which can be downloaded from the SNIA IOTTA Repository (http://iotta.snia.org/).

Table 1 – I/O Metrics from Three Different Levels within the I/O Software Stack

Name	C:	\Device\HarddiskVolume2:	\Device\Harddisk0\DR0:
Read IOP Count	33 275 759	11 759 656	11 759 816
Read Data Xfer	773 153 218 377	449 063 986 176	449 064 162 304
Read Max I/O Queue Len	16	34	34
Write IOP Count	7 833 749	891 654	892 180
Write Data Xfer	39 523 059 603	23 033 721 856	23 035 724 800
Write Max I/O Queue Len	99	55	55

It is important to note that the amount of I/O operation activity observed at the C: Logical Disk (i.e. the application/file level and which reflects the combined total of all file I/O operations for all monitored files residing upon the C: Logical Disk) is quite different than that observed further down the I/O software stack at the associated OS physical volume level (\Device\HarddiskVolume2) and at the corresponding OS physical device level (\Device\Harddisk0\DR0). This is principally the result of file I/O operation activity usage of the system file cache as previously mentioned above.

- Not every Application I/O operation results in a Device I/O operation
- As a result, Application I/O counts do **NOT** always equal the Device I/O counts

As can be seen from the WIOCP metrics, I/O operation performance metrics can be dissimilar amongst the three different levels within the I/O software stack. When referencing I/O operation performance metrics, it is therefore important to note at what level within the I/O software stack were the I/O metrics captured/collected.

Key Question When Considering I/O Metrics:

To which particular I/O Stack Level do the reported I/O Metrics pertain?

Physical Device Extended I/O Metrics

The WIOCP metrics include a set of Physical Device Extended Metrics. These are I/O metrics collected by the WIOCP I/O operation monitoring component at the either the OS physical volume level or the OS physical device level and which are associated by the I/O operation monitoring component with their related file I/O operations.

WIOCP Physical Device Extended I/O Metrics further demonstrate:

- Impact that the traversal of the I/O stack can have upon I/O operation performance
- The specific extent to which such traversal actually occurs for a specific application's file I/O operation activity

The Physical Device Extended Metrics essentially reflect those OS physical volume and device I/O operations that were performed so as to directly satisfy file I/O operations, which were also monitored by the WIOCP I/O operation monitoring component. That is, they basically reflect physical volume or physical device I/O operations that were required to complete current file I/O operations for those files that were also being monitored.

The WIOCP includes this set of Physical Device Extended Metrics upon an individual process basis. Table 2 below is an excerpt from the SSSIioProfileSummaryProcesses_Totals export file (included within the SNIA-SSSI-WIOCP-01-PC-4804467 download package). The table provides two examples of processes that incurred physical volume/device I/O operations associated with their file I/O operations.

Table 2 – Physical Device Extended I/O Metrics for Processes

Name	GuardAgent.exe(1744)	WINWORD.EXE(4960)
Read IOP Count	1	430
Read Min Time	0.729	0.002
Read Max Time	0.729	0.934
Read Data Xfer	32 768	1 886 637
Read Min Xfer Size	32 768	2
Read Max Xfer Size	32 768	32 768
PhyDev Read IOP Count	2	182
PhyDev Read Min Time	0.590	0.038
PhyDev Read Max Time	0.605	0.818
PhyDev Read Data Xfer	65 536	3 209 216
PhyDev Read Min Xfer Size	32 768	512
PhyDev Read Max Xfer Size	32 768	32 768

The GuardAgent process was observed to have issued only a single read file I/O operation, which resulted in two physical I/O operations (one at the physical volume level and the other at the physical device level within the I/O software stack). This single read file I/O operation transferred 32 768 bytes of data (with a total of 65 536 bytes shown for the physical device data transfer amount as a result of the 32 768 bytes associated with the physical volume read I/O operation and 32 768 bytes associated with the physical device read I/O operation). Also note the differences in the minimum response times (all in milliseconds) as a result of traversing the I/O software stack.

The WINWORD.EXE process (the Microsoft® Word application) was observed to have performed 430 read file I/O operations, which resulted in 182 physical I/O operations (91 at the physical volume level and the corresponding 91 at the physical device level within the I/O software stack). The read file I/O operations transferred 1 866 637 bytes of data (with a minimum data transfer size of 2 bytes observed). The 182 physical read I/O operations transferred a combined total of 3 209 216 bytes (one-half of which is about 85% of the total data transferred by the file I/O operations).

Overall, the I/O operation activity generated by applications as directly observed can be markedly different from the I/O operation activity seen at other levels within the I/O software stack. This phenomenon applies not only to what applications actually experience during normal, everyday usage, but it also has implications that can impact other important areas, such as those noted below:

Additional areas impacted by the I/O Software/Hardware Stack:

- Storage performance **benchmark testing**, for example:
  - ✓ Which specific levels within the I/O stack are actually being tested?
  - ✓ How do the test results correspond to what applications in fact perceive?
- Various **caching strategies and implementations**, for instance:
  - ✓ Which particular caching algorithms to employ?
  - ✓ Where to cache within the I/O stack?
- Storage I/O performance **bottlenecks** within the I/O stack, for instance:
  - ✓ Specifically, where are they located within the I/O stack?
  - ✓ How might they best be addressed?

The collection of empirical I/O operation performance metrics by the WIOCP can clearly highlight and substantiate how I/O operation activity is actually accomplished and experienced within the I/O software stack. Moreover, these I/O metrics can be useful when investigating, substantiating, etc., areas such as those noted above that can be impacted by the I/O software/hardware stack.

4. IOPS and Discrete Ranges of IOPS

I/O operations per second (IOPS) is a fundamental storage I/O operation performance metric. Given such significance, it is important to understand and appreciate how reported IOPS metric values are precisely calculated. The WIOCP goes beyond simple average IOPS and one-off maximum IOPS metrics to provide empirically-collected I/O operation performance metrics that reflect the real life I/O operation activity observed during normal, everyday application and workload usage.

The WIOCP metrics include the maximum IOPS observed upon a *periodic basis*. In addition, a set of summarized I/O operation performance metrics that are specifically focused upon the particular *ranges* of IOPS observed are also collected by the WIOCP. Both of these more discriminating IOPS metrics are described in greater detail below.

Maximum IOPS

The WIOCP metrics include the cumulative number of I/O operations observed (separately for read I/O operations and write I/O operations) along with the associated overall time duration during which I/O operations were monitored. Consequently, the *average* IOPS metric (sometimes also referred to as the average IOPS rate) can be calculated simply by dividing the I/O operation count by the associated overall time duration.

In addition, the WIOCP is configured to capture the maximum number of I/O operations actually observed during one second (for reads and for writes separately). As with the other WIOCP metrics, this maximum IOPS metric is collected upon an individual monitored device basis (at the three distinct levels within the I/O software stack) as well as upon an individual application and system process basis.

The excerpt from "Table 1 – I/O Metrics from Three Different Levels within the I/O Software Stack" has been extended below to also include the respective Maximum IOPS metric values (again upon an overall total basis; that is, for the entire seven-day collection period):

Table 3 – Maximum IOPS at the Three Levels within the I/O Software Stack

Name	C:	\Device\HarddiskVolume2:	\Device\Harddisk0\DR0:
Read IOP Count	33 275 759	11 759 656	11 759 816
Read Max IOPS	72 973	10 195	10 195
Read Data Xfer	773 153 218 377	449 063 986 176	449 064 162 304
Read Max Queue Len	16	34	34
Write IOP Count	7 833 749	891 654	892 180
Write Max IOPS	45 010	11 473	11 473
Write Data Xfer	39 523 059 603	23 033 721 856	23 035 724 800
Write Max Queue Len	99	55	55

As highlighted within the table above, the maximum IOPS observed at the C: Logical Disk (i.e. the application/file level for the combined total of all monitored file I/O operation activity) is quite different than that observed further down the I/O software stack at the associated OS physical volume level (\Device\HarddiskVolume2) and at the corresponding OS physical device level (\Device\Harddisk0\DR0). Again, this is principally due to file I/O operation activity usage of the system file cache.

Maximum IOPS upon a Periodic Basis

The WIOCP is additionally configured to write/save the collected summary I/O operation performance metrics to the CSV export files upon the collection period basis. Certain summary I/O metrics (such as the maximum IOPS metrics) are collected upon a per-period basis of ten minutes. As a result, the value of the maximum IOPS metric for a given period reflects the maximum IOPS observed during that specific ten-minute period.

Table 4 below is an excerpt from the SSSIioProfileSummaryDevices export file (SNIA-SSSI-WIOCP-01-PC-4804467 download package). This excerpt illustrates the periodic offload of the cumulative summary I/O metrics to the export file, with the read and write maximum IOPS values reflecting the maximum observed during the respective period (whose precise time duration in seconds is shown within the Duration column, with the Hour and Minute columns representing a portion of the date/timestamp when the I/O metrics were prepared for offload to the export file):

Table 4 – Maximum IOPS upon a Periodic Basis

Name	Hour	Minute	Duration	Read IOP Count	Read Max IOPS	Write IOP Count	Write Max IOPS
C:	10	32	600.001	10 939	3 036	5 179	1 350
\Device\HarddiskVolume2	10	32	600.001	3 367	668	3 673	1 351
\Device\Harddisk0\DR0	10	32	600.001	3 367	668	3 700	1 351
C:	10	42	601.238	965 952	42 662	1 264 085	45 010
\Device\HarddiskVolume2	10	42	602.172	19 801	1 731	25 519	1 551
\Device\Harddisk0\DR0	10	42	602.172	19 801	1 731	25 546	1 551
C:	10	52	600.556	967 955	1 106	1 265 275	104
\Device\HarddiskVolume2	10	52	601.999	20 228	347	26 342	109
\Device\Harddisk0\DR0	10	52	601.999	20 228	347	26 369	109
C:	11	2	600.376	970 625	455	1 269 273	325
\Device\HarddiskVolume2	11	2	600.999	20 567	268	28 049	110
\Device\Harddisk0\DR0	11	2	600.999	20 567	268	28 076	110
C:	11	12	600.179	985 744	1 070	1 275 647	818
\Device\HarddiskVolume2	11	12	600.998	20 810	99	29 611	118
\Device\Harddisk0\DR0	11	12	600.998	20 810	99	29 638	118
C:	11	22	601.121	993 120	510	1 276 924	103
\Device\HarddiskVolume2	11	22	600.002	21 006	78	30 506	108
\Device\Harddisk0\DR0	11	22	600.002	21 006	78	30 533	108

The highlighted entries within the table above plainly show the magnitude of difference in observed maximum IOPS amongst the six 10-minute periods within the hour between 10:22 and 11:22. There is

also a notable difference in maximum IOPS between the logical disk (C:, which reflects the aggregated observed file I/O operation activity) and the underlying physical volume and physical device; this, again, reinforces the value of collecting empirical I/O metrics at distinct levels within the I/O software stack.

Maximum IOPS for Individual Processes

The WIOCP collects the maximum IOPS metrics both upon an individual application and system process basis as well as upon an individual monitored device basis (as shown above).

Table 5 below is an excerpt from the SSSIioProfileSummaryProcesses export file (SNIA-SSSI-WIOCP-01-PC-4804467 download package). This excerpt illustrates the maximum IOPS metric values that were captured upon an individual process basis. Please note that for brevity's sake, a number of processes have been excluded from the excerpt below.

Table 5 – Maximum IOPS for Individual Processes

Process Name	Hour	Minute	Duration	Read IOP Count	Read Max IOPS	Write IOP Count	Write Max IOPS
msiexec.exe(2240)	10	44	600.152	165	157	976	299
installer.exe(1900)	10	44	600.466	576	471	145	145
msiexec.exe(4004)	10	44	604.950	9 820	3 262	25 887	14 779
msiexec.exe(932)	10	44	601.030	9	3	113	27
msiexec.exe(4668)	10	44	604.777	1	1	8	6
netsession_win.exe(1172)	10	44	600.337	631 661	4 915	942 611	7 161
SetupDWGTrueView2013_64bit.exe(5748)	10	46	603.636	94 113	4 971	26 256	2 114
setup.exe(5892)	10	46	600.029	355	237	543	531
TrustedInstaller.exe(5976)	10	46	604.040	1 082	474	3 164	1 598
makecab.exe(6000)	10	46	604.003	4 738	1 396	6 771	2 172
setup.exe(5944)	10	46	604.373	1 707	1 028	3 191	925
msiexec.exe(6128)	10	46	604.905	41	39	4	4
vcredist_x86.exe(944)	10	46	601.997	867	436	193	190
install.exe(5420)	10	47	601.377	59	58	879	459
install.exe(2540)	10	47	604.452	59	59	887	460
vcredist_x64.exe(5152)	10	47	602.786	1 079	540	245	240
Setup.exe(3792)	10	47	603.084	1 004	993	1 425	494
msiexec.exe(1812)	10	47	600.630	0	0	34	34
vcredist_x64.exe(5424)	10	47	604.838	1 225	615	306	301
DXSETUP.exe(5484)	10	47	603.587	27 075	3 071	5 573	977
infinst.exe(376)	10	47	601.271	16	16	70	67

msiexec.exe(4044)	10	47	601.225	35 012	3 244	20 4459	34 808
mscorsvw.exe(2660)	10	48	601.618	355	320	437	435
mscorsvw.exe(5148)	10	48	601.929	248	246	0	0
mscorsvw.exe(2712)	10	48	600.153	168	166	0	0
mscorsvw.exe(1756)	10	48	602.174	179	177	0	0
mscorsvw.exe(5396)	10	48	604.993	244	204	492	490
mscorsvw.exe(5224)	10	48	602.031	166	141	2 524	2 522
mscorsvw.exe(5652)	10	48	602.976	189	187	0	0
mscorsvw.exe(1900)	10	48	602.691	306	194	1 241	1 239
mscorsvw.exe(4584)	10	48	604.401	261	231	317	315
mscorsvw.exe(2844)	10	48	601.778	194	183	615	613
mscorsvw.exe(5272)	10	48	601.989	170	168	0	0
mscorsvw.exe(5876)	10	48	604.182	146	131	1 075	1 073
mscorsvw.exe(5708)	10	48	604.274	153	151	0	0
services.exe(604)	10	48	600.541	5	0	158	24
wmpnetwk.exe(3268)	10	49	603.182	1	1	0	0
AcDeltree.exe(6132)	10	49	602.766	4	4	13	13
dwgviewr.exe(2376)	10	49	602.618	102 609	37 547	2 250	2 197
dllhost.exe(5240)	10	49	604.846	2	2	0	0

The highlighted entries within the table above represent those particular processes that likely contributed to the highest maximum IOPS for the C: Logical Disk as shown within the prior Device Maximum IOPS Per Period table above (Table 4).

By collecting I/O operation performance metrics for both devices and processes, the WIOCP enables correlation between specific device I/O operation activity and file I/O operation activity performed by application and system processes.

Discrete IOPS Ranges

Beyond collecting maximum IOPS metrics for both individual devices and processes (moreover, upon a separate periodic basis), the I/O operation monitoring software used by the WIOCP also collects summarized I/O operation performance metrics that are specifically focused upon particular *ranges* of IOPS.

The WIOCP provides by default a defined, specific set of IOPS ranges. The first IOPS Range is an IOPS of between one and 99 I/O operations inclusive, the second IOPS Range is an IOPS of between 100 and 499 I/O operations inclusive, the third IOPS Range is an IOPS of between 500 and 999 I/O operations inclusive, and so on.

A separate summary I/O operation performance metric counter is maintained for each of these discrete IOPS Ranges. The respective counter is incremented each time that the corresponding number of successfully-performed I/O operations within the range is observed during the one-second interval. For instance, if 129 read I/O operations are observed during the one-second interval, then the Second IOPS Range Count metric for read I/O operations would be incremented by one.

Please note that these IOPS Range Count I/O metrics are collected for read and write I/O operations separately and combined. Moreover, they are collected upon an individual process basis as well as individual device basis.

Table 6 below is an excerpt from the SSSIioProfileSummaryDevices_Totals_MetricsByRow file (SNIA-SSSI-WIOCP-01-PC-4804467 download package). This excerpt shows the overall total IOPS Range Counts collected for read I/O operations for the seven-day collection period.

Table 6 – Read IOPS Ranges at the Three Levels within the I/O Software Stack

Name	C:	\Device\HarddiskVolume2	\Device\Harddisk0\DR0	Range Count Description
Duration	293 504	293 518	293 518	
ReadIOPSCountRange1	173 970	33 383	33 383	IOPS 1 – 99
ReadIOPSCountRange2	4 335	3 227	3 224	100 – 499
ReadIOPSCountRange3	1 461	1 125	1 126	500 – 999
ReadIOPSCountRange4	853	1 378	1 378	1000 – 1999
ReadIOPSCountRange5	1 901	2 529	2 529	2000 – 4999
ReadIOPSCountRange6	2 768	38	38	5000 – 9999
ReadIOPSCountRange7	12	2	2	10000 – 19999
ReadIOPSCountRange8	12	0	0	20000 – 39999
ReadIOPSCountRange9	15	0	0	40000 and >

The Duration row in the table above reflects the number of seconds within the seven-day collection period during which the computer was in a powered, running state with I/O operation monitoring active for the respective device.

The values within the remaining rows reflect the number of seconds within which the number of read I/O operations observed were within the respective IOPS range (for example, there was 173 970 seconds within which between one and 99 successfully-performed file read I/O operations were observed for the C: drive). Similarly, there were only two seconds (amongst the 293 518 seconds during which I/O operation monitoring was active for the physical device DR0) where between 10 000 and 19 999 read I/O operations were observed for the physical device.

Figure 6 – Read IOPS Ranges during an Overall 7-day Collection Period

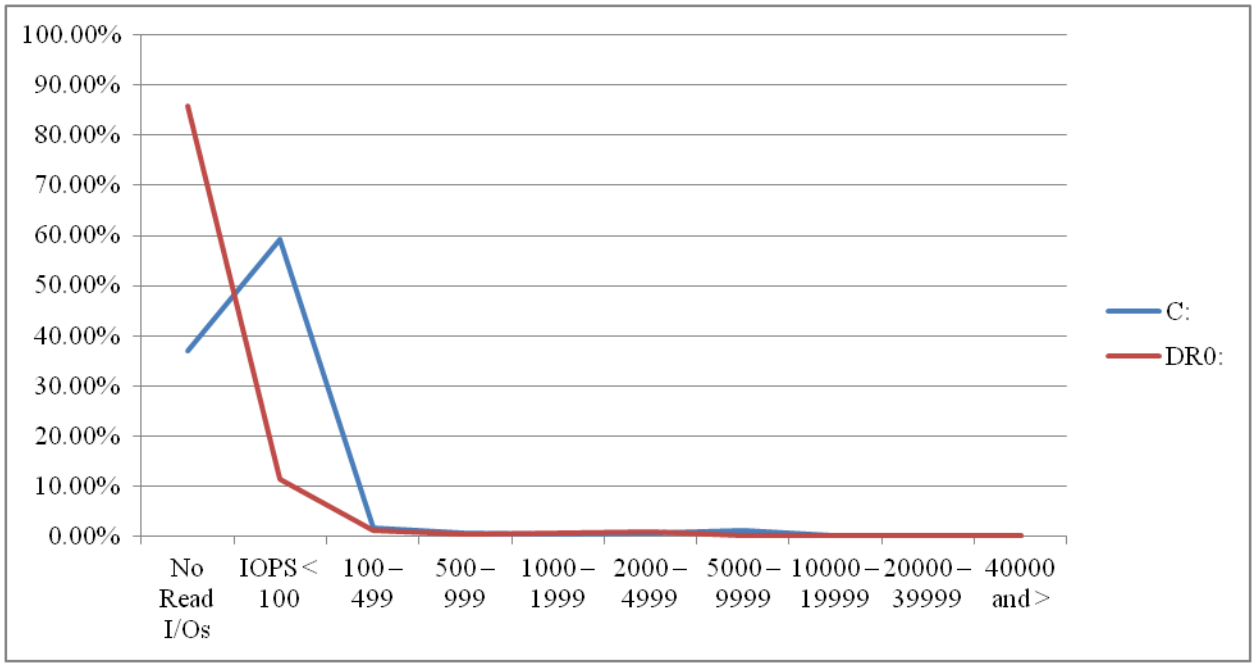


Figure 6 above shows the percentage of the overall 7-day collection period during which the respective read IOPS Range was observed. This percentage is calculated by simply dividing the respective IOPS Range Count metric value by the Duration value both from the table above (e.g. for the C: First IOPS Range Count, divide 173 970 by 293 504, which is 59.27%).

The IOPS Range Count I/O metrics that are collected by the WIOCP are also saved to the CSV export files upon the periodic ten-minute basis, as illustrated by the excerpt below from the SSSIioProfileSummaryDevices export file (SNIA-SSSI-WIOCP-01-PC-4804467 download package) for the observed read I/O operations.

Table 7 – Read IOPS Ranges upon a Periodic Basis

Name	Hour	Minute	IOPS 1 - 99	IOPS 100 - 499	IOPS 500 – 999	IOPS 1000 - 1999	IOPS 2000 - 4999	IOPS 5000 - 9999	IOPS 10000 - 19999	IOPS 20000 - 39999	IOPS 40000 and >
C:	10	32	302	13	1	1	1	0	0	0	0
Volume2:	10	32	44	6	2	0	0	0	0	0	0
DR0:	10	32	44	6	2	0	0	0	0	0	0
C:	10	42	527	63	32	32	93	0	1	1	1
Volume2:	10	42	187	48	6	1	0	0	0	0	0
DR0:	10	42	187	48	6	1	0	0	0	0	0
C:	10	52	826	64	32	33	93	0	1	1	1
Volume2:	10	52	190	49	6	1	0	0	0	0	0
DR0:	10	52	190	49	6	1	0	0	0	0	0
C:	11	2	1 137	68	32	33	93	0	1	1	1
Volume2:	11	2	206	50	6	1	0	0	0	0	0
DR0:	11	2	206	50	6	1	0	0	0	0	0
C:	11	12	1 445	78	37	34	93	0	1	1	1
Volume2:	11	12	225	50	6	1	0	0	0	0	0
DR0:	11	12	225	50	6	1	0	0	0	0	0
C:	11	22	1 786	86	38	34	93	0	1	1	1
Volume2:	11	22	237	50	6	1	0	0	0	0	0
DR0:	11	22	237	50	6	1	0	0	0	0	0

The IOPS Range Count I/O metrics are collected upon a cumulative basis. The blue cells within the table above highlight those read IOPS Range counts for the Logical Disk C: (i.e. the total combined file read I/O operations) that have a value greater than that from a prior period. For instance, there were 225 occurrences of "read IOPS of between 1 and 99" observed during the 10-minute period ending at 10:42; consequently, a "read IOPS of between 1 and 99" was observed 37% percent of the time during this 10-minute period (i.e., 225 seconds / 601 seconds, where the precision duration of this 10-minute period can be found in Table 4). Cells are similarly highlighted in orange for the physical device DR0 (\Device\Harddisk0\DR0).

As previously mentioned, the IOPS Range Count I/O metrics are collected upon an individual process basis as well as individual device basis.

Table 8 below is an excerpt from the SSSIioProfileSummaryProcesses_Totals export file (SNIA-SSSI-WIOCP-01-PC-4804467 download package) that illustrates the observed Read IOPS Range Count I/O metrics for the "Crysis2" application process.

Table 8 shows that there were ten different instances of the "Crysis2" process observed (i.e., the "Crysis 2" video game application was run ten different times during the overall 7-day collection period). The Duration column reflects the total number of seconds during which the corresponding Read IOPS Range Count I/O metrics were collected. The Read IOPS Range Count I/O metrics for each process instance reflect the cumulative total for the respective process instance.

Table 8 – Read IOPS Ranges for an Individual Process

Name	Duration	IOPS 1 - 99	IOPS 100 - 499	IOPS 500 – 999	IOPS 1000 - 1999	IOPS 2000 - 4999	IOPS 5000 - 9999	IOPS 10000 - 19999	IOPS 20000 - 39999	IOPS 40000 and >
Crysis2.exe(140)	3 605	2 859	86	27	7	5	1	0	1	1
Crysis2.exe(2612)	5 404	4 279	79	28	10	4	0	0	0	1
Crysis2.exe(3596)	3 604	2 896	58	22	4	3	1	0	0	2
Crysis2.exe(3780)	13 779	10 168	166	50	16	7	0	0	0	1
Crysis2.exe(3888)	4 202	3 105	47	12	4	2	0	0	0	2
Crysis2.exe(5040)	6 601	5 220	98	39	21	6	1	0	1	1
Crysis2.exe(5060)	602	176	4	2	0	0	0	0	0	1
Crysis2.exe(5248)	1 201	595	23	11	6	1	0	1	1	1
Crysis2.exe(5376)	3 002	2 164	49	20	7	3	0	0	1	1
Crysis2.exe(7660)	4 071	2 877	52	17	5	2	0	0	0	1

Within all runs of the Crysis2 game application, the majority of the file read I/O operations were performed within an IOPS range of between one and 99 read I/O operations per second (orange cells). Nevertheless, this same application also consistently reached a read IOPS of 40 000 or greater during each execution (blue cells) and moreover represented 12 out of the 15 such occurrences associated with the Logical Disk C: (see Table 6 above containing Read IOPS Range Count I/O metrics for the individual devices). Overall, the IOPS Range Count I/O metrics provide a more granular picture of how dimensional a specific application (such as Crysis2) performs in terms of actual I/O operation rates.

Along these same lines, a quick look at the SSSIioProfileSummaryProcesses_TopTens export file (which is also included within the SNIA-SSSI-WIOCP-01-PC-4804467 download package) shows the Crysis2 process at the top of the observed Top Ten Read Maximum I/O Operations Per Second processes with 71 366 read file I/O operations per second observed.

The SSSI WIOCP IOPS Metrics

- Go far beyond simple average IOPS and one-off maximum IOPS metrics by including:
  - ✓ Maximum IOPS upon a periodic basis
  - ✓ Discrete IOPS Ranges
- These extended IOPS metrics are collected:
  - ✓ Upon an individual device basis at three different levels within the I/O software stack
  - ✓ Also upon an individual application and system process basis
- Provide greater granularity as to the extent and manner of the I/O operation activity actually performed
- Enable a much richer understanding of specific application and device I/O operation activity
  - ✓ Especially as it pertains to normal, everyday usage

5. Response Times, MB/s, and Other I/O Metrics

The prior chapter focused upon the various IOPS-related I/O metrics that are collected and exported by the WIOCP. This chapter briefly illustrates several additional major I/O metric types available with the WIOCP (a full discussion of the many other I/O metric types collected and exported by the WIOCP is beyond the scope of this white paper).

Response Times (Latency) and Ranges of Response Times

In general, response time (also referred to as latency) reflects the amount of time taken for an I/O operation to complete, that is, the amount of time between when the I/O operation was issued (started) and when the I/O operation is considered completed (e.g. when the application receives an indication that the data transfer associated with the I/O operation has finished).

From an application perspective, the I/O operation response time can be seen as the amount of time **waiting** for the I/O operation to complete. Consequently, a faster response time (i.e. a shorter time duration) benefits the application.

The collected WIOCP I/O metrics include (separately for read and write I/O operations) the minimum and maximum response times observed along with the accumulated response time (i.e. the combined total for the I/O operations).

Table 9 below is an excerpt from the SSSIioProfileSummaryDevices_Totals_MetricsByRow file (SNIA-SSSI-WIOCP-01-PC-4804467 download package). This excerpt illustrates these metrics (along with the calculated average response time, which is derived by dividing the aggregated response time total by the respective total number of I/O operations) upon an overall basis, that is, for the entire seven-day collection period. Please note that the response time values within the table below are all in terms of **milliseconds** for convenience:

Table 9 – Response Times at the Three Levels within the I/O Software Stack

Name	C:	\Device\HarddiskVolume2:	\Device\Harddisk0\DR0:
Read IOP Count	33 275 759	11 759 656	11 759 816
Read Min Time	0.0015	0.0236	0.019
Read Max Time	996.9979	996.9664	996.9605
Read Average Time	0.0895	0.1959	0.1538
Write IOP Count	7 833 749	891 654	892 180
Write Min Time	0.0023	0.0239	0.0187
Write Max Time	999.6054	499.944	499.9361
Write Average Time	0.0501	0.3522	0.2397

Both the minimum and maximum response time values are also collected and exported upon a periodic basis (that is, upon a per-period basis so that the values of the minimum and maximum response time metrics reflect the respective response times observed during the specific period). This applies to the process response time I/O metrics as well as those for devices.

In addition, the WIOCP provides by default a defined, specific set of Response Time range metrics similar to the IOP Ranges discussed within the prior chapter. Each Response Time Range Count metric reflects the total number of times that the I/O operation monitoring component observed a successful I/O operation whose response time (i.e. the time duration between the observed start of an I/O operation and the observed completion of the I/O operation, which includes both the service time and the queue time) was within the corresponding range.Table 10 that follows is an excerpt from the SSSIioProfileSummaryDevices_Totals_MetricsByRow file (SNIA-SSSI-WIOCP-01-PC-4804467 download package). This excerpt shows the overall total Response Time Range Counts collected for successfully-performed read I/O operations for the seven-day collection period (where "RT" indicates observed response time and "us" represent microseconds).

Table 10 – Read Response Time Ranges

Name	C:	\Device\HarddiskVolume2	\Device\Harddisk0\DR0	Range Count Description
ReadRTCountRange1	16 065 118	101 367	558 369	RT < 50 us
ReadRTCountRange2	3 739 483	6 000 451	6 306 262	50 < 100 us
ReadRTCountRange3	8 037 569	3 363 738	3 067 150	100 < 200 us
ReadRTCountRange4	3 890 366	1 666 251	1 633 078	200 < 500 us
ReadRTCountRange5	180 188	471 506	175 935	500 < 1 ms
ReadRTCountRange6	30 576	152 107	15 042	1 < 5 ms
ReadRTCountRange7	916	713	529	5 < 10 ms
ReadRTCountRange8	2 754	3 078	3 020	10 < 100 ms
ReadRTCountRange9	495	413	402	100 < 500 ms
ReadRTCountRange10	39	32	29	500 ms and >

The table above illustrates once again the impact of file I/O operation activity usage of the system file cache.Table 11 below shows the individual Response Time Range Count values as a percentage of the total successfully-performed Read I/O operations; for instance, 25.1587 % of the successfully-performed file read I/O operations (i.e. the C: column) were observed to have a response time of 100 microseconds or greater, but less than 200 microseconds.

Table 11 – Read Response Time Range Percentages

Response Time Range	C: % of Total	C Run Total %	Volume2 % of Total	Volume2 Run Total %	DR0 % of Total	DR0 Run Total %
RT < 50 us	50.2860%	50.2860%	0.8620%	0.8620%	4.7481%	4.7481%
50 < 100 us	11.7051%	61.9911%	51.0257%	51.8877%	53.6255%	58.3736%
100 < 200 us	25.1587%	87.1498%	28.6041%	80.4918%	26.0816%	84.4552%
200 < 500 us	12.1774%	99.3271%	14.1692%	94.6610%	13.8869%	98.3422%
500 < 1 ms	0.5640%	99.8911%	4.0095%	98.6705%	1.4961%	99.8382%
1 < 5 ms	0.0957%	99.9868%	1.2935%	99.9640%	0.1279%	99.9662%
5 < 10 ms	0.0029%	99.9868%	0.0061%	99.9700%	0.0045%	99.9707%
10 < 100 ms	0.0086%	99.9897%	0.0262%	99.9962%	0.0257%	99.9963%
100 < 500 ms	0.0015%	99.9999%	0.0035%	99.9997%	0.0034%	99.9998%
500 ms and >	0.0001%	100%	0.0003%	100%	0.0002%	100%

The table above also shows the running sum (running total) percentages. For DR0, 98.3422 % of the read I/O operations were observed to have a response time of less than 500 microseconds (orange highlight) and 99.8382 % of the read I/O operations had an observed response time of less than one millisecond (yellow highlight). The highlighted blue cells show the percentage of read I/O operations that were observed with a response time of less than 50 microseconds.

Data Transfer Rates (MB/s) and Ranges of MB/s

The collected WIOCP metrics include (separately for read and write I/O operations) the maximum amount of data transferred within one second. It is important to note that this metric value reflects the **actual** amount of data transferred within the one second rather than a calculated average rate (i.e. where the amount of data transferred is simply divided by some overall amount of time).

Table 12 below is an excerpt from the SSSIioProfileSummaryDevices_Totals_MetricsByRow file (SNIA-SSSI-WIOCP-01-PC-4804467 download package). This excerpt illustrates this maximum data transfer rate metric with the data transfer amounts in bytes:

Table 12 – Maximum MB/s at the Three Levels within the I/O Software Stack

Name	C:	\Device\HarddiskVolume2:	\Device\Harddisk0\DR0:
Read IOP Count	33 275 759	11 759 656	11 759 816
Read Data Xfer	773 153 218 377	449 063 986 176	449 064 162 304
Read Data Xfer Rate Max	475 543 793	237 845 504	237 845 504
Write IOP Count	7 833 749	891 654	892 180
Write Data Xfer	39 523 059 603	23 033 721 856	23 035 724 800
Write Data Xfer Rate Max	174 164 811	87 864 320	87 864 320

The maximum data transfer rate metric is also collected and exported upon a periodic basis. This applies to both devices and processes. The WIOCP provides by default a defined, specific set of MB/s range metrics similar to the IOP Ranges and Response Time Ranges previously mentioned.

Table 13 below is an excerpt from the SSSIioProfileSummaryDevices_Totals_MetricsByRow file (SNIA-SSSI-WIOCP-01-PC-4804467 download package). This excerpt shows the overall total MBs Range Counts collected for read I/O operations for the overall seven-day collection period.

Table 13 – Read MB/s Ranges

Name	C:	\Device\HarddiskVolume2	\Device\Harddisk0\DR0	Range Count Description
ReadMBSCountRange1	172 273	32 280	32 277	MBS < 1
ReadMBSCountRange2	6 643	3 633	3 633	1 < 10
ReadMBSCountRange3	762	729	730	10 < 20
ReadMBSCountRange4	1 024	1 452	1 452	20 < 50
ReadMBSCountRange5	1 056	1 349	1 349	50 < 100
ReadMBSCountRange6	2 475	2 235	2 235	100 < 200
ReadMBSCountRange7	1 094	4	4	200 < 500
ReadMBSCountRange8	0	0	0	500 < 1000
ReadMBSCountRange9	0	0	0	1000 and >

Within Table 13 above, the value of each MBs Range Count reflects the total number of times that the I/O monitoring component observed an actual megabytes-per-second (MBS) transfer amount within the corresponding range for read I/O operations that were successfully performed (where the MBS transfer amount is the actual number of bytes transferred within the one second).

Queue Depths and Queue Depth Ranges

The various Queue Depth (QD) I/O metrics collected and exported by the WIOCP reflect the number of I/O operations that were observed to be concurrently outstanding (had not yet completed and includes requests in service). These Queue Depth (also called Queue Length) I/O metrics are available for read and write I/O operations separately and combined.

The collected WIOCP metrics include the average and maximum QD values observed upon a periodic basis (that is, upon a per-period basis so that the values pertain to those observed during the specific period). This applies to both the device and the process I/O metrics.

In addition, the I/O operation monitoring software provides by default a defined, specific set of Queue Depth range metrics similar to the various other Range Count I/O metrics already described.

Table 14 is an excerpt from the SSSIioProfileSummaryDevices_Totals_MetricsByRow file (SNIA-SSSI-WIOCP-01-PC-4804467 download package). This excerpt shows the overall total QD Range Counts collected for read I/O operations for the overall seven-day collection period. Each QD Range Count reflects the total number of times that the I/O monitoring component observed an actual Queue Depth/Length within the corresponding range.

Table 14 – Read Queue Depth Ranges at the Three Levels within the I/O Software Stack

Name	C:	Volume2:	DR0:	Range Count Description
Read IOP Count	33 275 759	11 759 656	11 759 816	
ReadQueueLenCountMultiple	5 215 625	289 580	286 422	QD > 1
ReadQueueLenCountRange1	4 946 411	216 683	215 943	QD = 2
ReadQueueLenCountRange2	204 763	49 106	47 823	3
ReadQueueLenCountRange3	42 080	14 311	13 677	4
ReadQueueLenCountRange4	21 054	8 142	7 674	5 – 7
ReadQueueLenCountRange5	1 306	892	859	8 – 15
ReadQueueLenCountRange6	11	401	401	16 – 31
ReadQueueLenCountRange7	0	45	45	32 – 63
ReadQueueLenCountRange8	0	0	0	64 and >

Random and Sequential Access I/O Metrics

I/O operations that perform random accesses to different data locations can incur a notable performance penalty due to, as examples, required mechanical movement (as with hard disk drives) and caching limitations and misses. In general, an I/O operation is considered to be a random access when the data transferred at its starting address is not contiguous to the address of the last data transferred by the preceding I/O operation.

The collected WIOCP metrics include several I/O operation performance metrics related to random and sequential I/O operation activity. These I/O metrics include the number of I/O operations that represent a random or sequential access (separately for read and write I/O operations as well as regardless of read or write). The accumulated total (in bytes) of data transferred by random I/O operations (and separately for sequential I/O operations) is additionally collected (also separately for read and write I/O operations as well as regardless of read or write).

Table 15 below is an excerpt from the SSSIioProfileSummaryDevices_Totals_MetricsByRow file (SNIA-SSSI-WIOCP-01-PC-4804467 download package). This excerpt illustrates several of these random and sequential I/O metrics collected overall for the seven-day collection period:

Table 15 – Random/Sequential Access Counts at Three Levels in the I/O Software Stack

Name	C:	\Device\HarddiskVolume2	\Device\Harddisk0\DR0
Read IOP Count	33 275 759	11 759 656	11 759 816
Read Random Access IOP Count	10 772 294	1 153 682	1 153 842
Read Random IOP %	34.16 %	9.81 %	9.81 %
Read Random Data Xfer	361 642 786 178	30 211 759 616	30 211 952 128
Read Random Xfer %	47.08 %	6.73 %	6.72 %
Write IOP Count	7 833 749	891 654	892 180
Write Random Access IOP Count	1 232 766	680 777	681 211
Write Random IOP %	20.06 %	76.35 %	76.36 %
Write Random Data Xfer	14 671 316 693	16 397 029 376	16 399 707 136
Write Random Xfer %	38.56 %	71.19 %	71.20 %

The WIOCP random and sequential I/O metrics are collected and exported upon both an individual device and individual process basis.

Overall, the collection and export of WIOCP metrics related to response times, data transfer rates, queue depths (queue lengths), and random and sequential access can provide a more complete picture

of specific application and device I/O operation activity. This results in a much more comprehensive understanding of such I/O operation activity.

Moreover, these particular I/O metrics can be interrelated (e.g. high response times due to excessive queue depths). Consequently, the ability to collect such metrics can be a key requirement in order to better understand the dynamics associated with various I/O performance problems and concerns.

6. Conclusion

The SSSI WIOCP project provides a significant opportunity to easily and quickly collect current I/O operation performance metrics that reflect the actual I/O operation activity performed during normal, everyday application and workload usage for a broad spectrum of users and computer systems.

The WIOCP can provide a comprehensive picture of what I/O operation activity actually looks like upon modern computer systems from both the device and the process perspective. It enables the user to empirically gather a large, robust set of I/O operation performance metric types in an automatically aggregated manner.

The WIOCP also provides the concurrent collection of I/O operation metrics at three distinct levels within the I/O software stack, thus allowing comparative analysis of I/O operation activity.

In addition, the ability to easily obtain the I/O metrics collected by the WIOCP by means of free downloads from the SNIA IOTTA Repository provides ready access to a wide audience of diverse parties. Various theories can be better substantiated based upon empirically collected I/O metrics that are readily available for review. New and perhaps surprising insights can be gleaned from the analysis of the WIOCP metrics, and I/O performance claims can be assessed in terms of I/O metrics that actually reflect one's own particular environment.

The concern might arise as to "how representative" are the WIOCP metrics. To the individual SSSI WIOCP participant, their collected I/O metrics are, of course, an accurate reflection of their specific usage.

Nonetheless, a larger and broader number of SSSI WIOCP download packages within the IOTTA Repository is certainly welcome and could help establish a better sense as to what appears to be more "representative." With this in mind, the SSSI strongly encourages additional participation in the SSSI WIOCP project.

Get involved – download the SSSI WIOCP software package, collect your WIOCP metrics, and send the resulting WIOCP metric export files to the SSSI!

Your active participation in the SSSI WIOCP project will benefit various SNIA efforts as well as other interested parties – and, moreover provide you with a detailed empirical picture of what your real world application I/O profiles and device I/O activity actually look like!

For more SSSI WIOCP information and to participate:
http://snia.org/forums/sssi/wiocp

About the SNIA

The Storage Networking Industry Association (SNIA) is a not-for-profit global organization, made up of some 400 member companies and 7,000 individuals spanning virtually the entire storage industry. SNIA's mission is to lead the storage industry worldwide in developing and promoting standards, technologies, and educational services to empower organizations in the management of information. To this end, the SNIA is uniquely committed to delivering standards, education, and services that will propel open storage networking solutions into the broader market. For additional information, visit the SNIA web site at www.snia.org.

About the Solid State Storage Initiative

The SNIA Solid State Storage Initiative (SSSI) fosters the growth and success of the market for solid state storage in both enterprise and client environments. Members of the SSSI work together to promote the development of technical standards and tools, educate IT communities about solid state storage, perform market outreach that highlights the virtues of solid state storage, and collaborate with other industry associations on solid state storage technical work.

SSSI member companies come from a wide variety of segments in the SSS industry:
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