TUNING GUIDE
AMD EPYC 8004

Microsoft® Windows® Server

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Jul, 2023	0.1	Initial NDA release
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Audience

The tuning guide is intended for a technical audience with a background of configuring Microsoft® Windows® servers.

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Chapter 1 Introduction

This tuning guide describes various parameters that can optimize performance of servers powered by AMD EPYC™ 8004 Series Processors that are running Microsoft® Windows® Server Operating Systems.

The default OEM hardware and BIOS configurations normally provide the best performance across all operating systems and for general workloads; however, additional tuning can improve performance of specific workloads.

This tuning guide discusses the following topics:

- Supported OS versions
- System configuration best practices
- BIOS settings that may impact performance
- OS information and commands that relate to optimization
- Information on further resources to assist with performance and analysis

1.1 AMD EPYC 8004 Processor Specifications

Please see the *AMD EPYC™ 8004 Series Architecture Overview* (available from AMD EPYC Tuning Guides) for general AMD EPYC 8004 processor specifications.

1.2 Operating Systems

AMD recommends using the latest available Operating System version. Please see AMD EPYC™ Processors Minimum Operating System (OS) Versions for detailed OS version information.

4th Gen AMD EPYC processors support the following version of Microsoft Windows Server:

- **Windows Server 2022:** Released in September of 2021. This is the most current Windows Server recommended release.
- **Windows Server 2019**

Windows Server 2022 is the current Long Term Servicing Channel (LTSC) Windows Server release. Microsoft may release monthly Windows Cumulative Updates, but full official LTSC Windows Server releases occur only every 3-4 years. AMD's Windows Server support is based upon these LTSC releases i.e., Windows Server 2022, Windows Server 2019, etc. Please see Windows Server Servicing Channels* for more information.

You can obtain the latest Windows Server versions from any one of the following links:

- Evaluation Channels:
  - Windows Server 2019 Evaluation*
  - Windows Server 2022 Evaluation*
- Visual Studio subscription (formerly MSDN or Microsoft Developer Network)*.
- Microsoft Partner Network (MPN)*.
- Volume Licensing Service Center (VLSC), if you have valid Software Assurance*

Note: You should install Windows Cumulative Updates as Microsoft releases them.

AMD EPYC 8004 Series Processors require using the latest Windows Server Full Media Refresh releases from respective licensing channels. For more details, latest requirements, and latest known issues and limitations of Windows operating system running on AMD EPYC 8004 based systems, please see the Windows Server support and installation instructions for the AMD EPYC 8004 Series server processors*.

If you use the Windows Preinstallation Environment (WinPE) to deploy AMD EPYC 8004-based servers (such as for applying Windows Server images and applications from a network share, provisioning the system [e.g., its hard drive], adding a custom shell or GUI to automate deployment, etc.) then you will need an updated WinPE image that includes the latest support for AMD EPYC 8004 Series Processors.

AMD recommends using the Windows Server 2022 WinPE image and customizing it by adding the latest Windows Server 2022 Cumulative Update package available from the Microsoft Update Catalog*. You can search the official Microsoft Web site for specific information about WinPE and how to update an image, such as Create Bootable Windows PE Media*, but the high-level steps are:

1. Download* and install the Assessment and Deployment Kit (ADK) & the “WinPE add-on for the ADK” for Windows Server 2022.
2. Download the latest Windows Server 2022 Cumulative Update package and all prerequisite packages, if any, as required by the Cumulative Update package (See details in its release page) from the Microsoft Windows Server 2022 update site*.
3. Add the prerequisite packages followed by the Cumulative Update package to the Windows Server 2022 WinPE image. For details, see Add or Remove Packages Offline using DISM*.

Chapter 2

System Configuration Best Practices

2.1 Processors

AMD provides a variety of EPYC 8004 Series Processors to support a full range of workloads and environments. Processors with higher core counts will provide more computational resources. Processors that run at higher frequencies also will increase performance. Processors with access to larger L3 Cache may also show increased performance. Systems configured with 8004 EPYC processors may also provide greater computing power. Please see AMD EPYC™ 8004 Series Processors: A New Standard for the Modern Datacenter for more details on available 4th Gen AMD EPYC Orderable Part Numbers (OPNs) and models.

2.2 Memory

AMD EPYC 8004 Series Processors support up to 3 TB of 4800 MT/sec RAM per processor. In general, it is important to have enough memory for corresponding workloads in order to avoid degraded performance caused by excessive paging.

AMD recommends populating all six memory channels per CPU socket with an equal number of equal-capacity DIMMs. If your system provides 2 DIMM slots per channel, then populate each channel with at least a single DIMM before populating the second DIMM slot on a given channel.

Please see the latest version of Memory Population Guidelines for AMD Family 19h Models A0h–AFh Socket SP6 Processors for additional memory population guidelines (login required).

2.3 I/O

I/O intensive workloads may perform better if they execute on the cores and memory that correspond to the same quadrant or NUMA node as the PCIe device's I/O hub.

You can obtain more detailed device by locating the device within Windows Device Manager, right-clicking it, and then selecting **Properties** to display the device **Properties** page. Select the **Details** tab and then click **Property Field** to display a list of device-specific settings and their corresponding values.

3rd Gen and prior AMD EPYC processors included the **Preferred I/O** and **Relaxed Ordering** settings that helped optimize network and disk I/O performance. 4th Gen AMD EPYC processors (8xx4 models) include architectural enhancements that deliver optimal network and disk I/O performance by default without the need for either of these features.

2.3.1 Storage

Systems powered by AMD EPYC processors support a variety of high-performance devices. For example, NVMe SSDs provide both power savings and performance advantages for I/O queues, interrupt processing, etc. compared to older storage technologies. Always provide enough appropriately distributed disks to avoid bottlenecks. Placing the paging file on its own disk will avoid contention from other processes attempting to access a shared disk.

2.3.2 Network Interface Cards (NICs)

Place network intensive workloads on the cores of the socket which the NIC also connects to. Many modern day NICs support Receive Side Scaling (RSS), which can distribute network workloads across multiple logical processors. This support allows you to determine the nearest processor-PCIe slot distance:

1. Start Windows PowerShell*.
2. Execute the `Get-NetAdapterHardwareInfo` cmdlet to obtain the connection name for each NIC.

```
PS C:\Users\Administrator> Get-NetAdapterHardwareInfo

Name                          Segment Bus Device Function Slot NumaNode PcieLinkSpeed PcieLinkWidth Version
----                          ------- --- ------ -------- ---- -------- ------------- ------------- -------
Ethernet 2                          0  33      0        0  238        9      8.0 GT/s             8 1.1
Ethernet                            0  33      0        1  238        9      8.0 GT/s             8 1.1
```

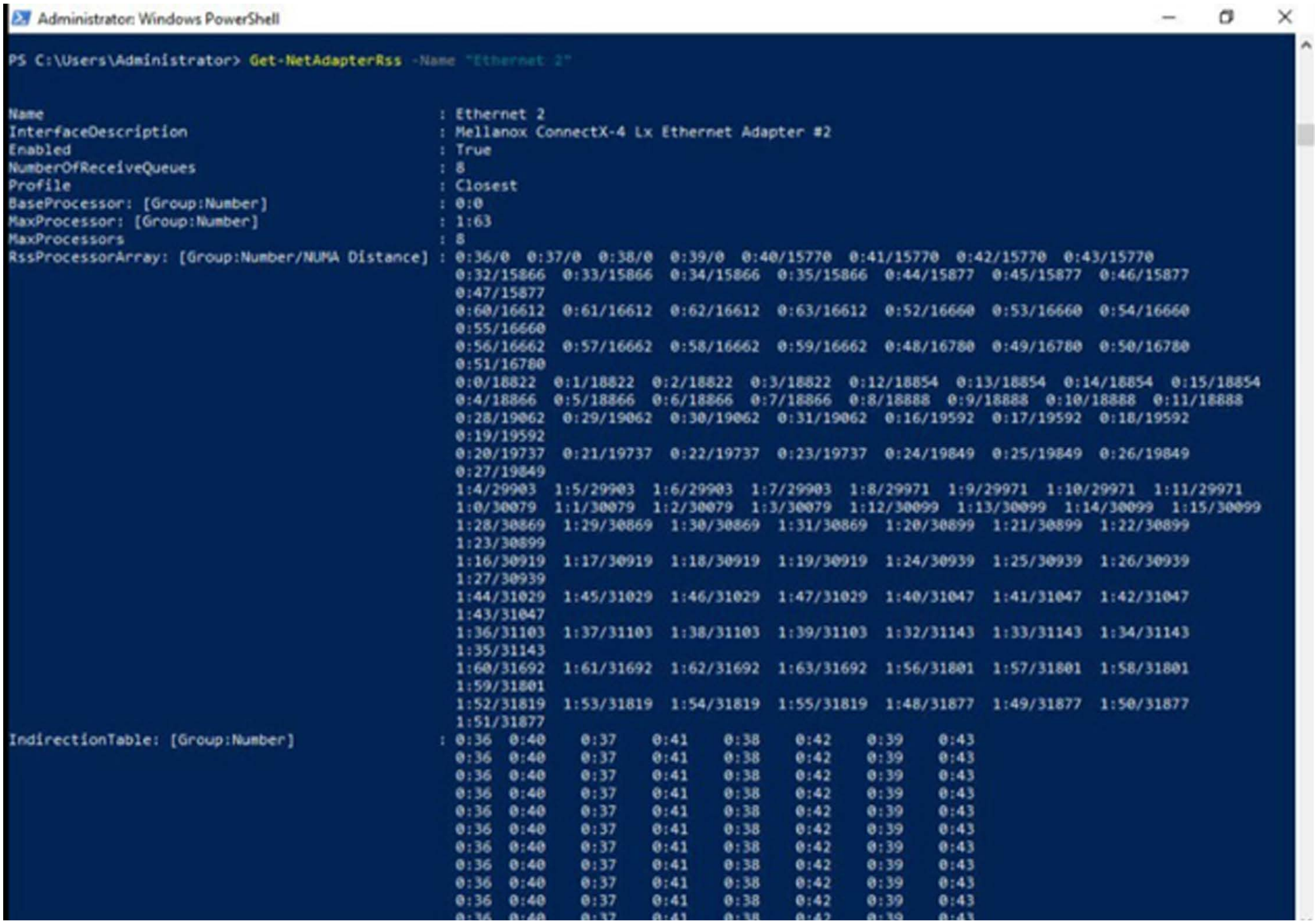
3. Execute the `Get-NetAdapterRss -Name <Connection Name>` cmdlet to get the `RssProcessorArray` elements that each show the distance between the processor cores and the PCIe slot where the NIC is currently plugged in.

AMD recommends placing workloads on the cores with the nearest distance, with 0 being optimal because those processor cores belong to the NUMA node that is closes to the NIC.

`RssProcessorArray` returns information formatted as `A : B / C` where

- A = Processor Group
- B = Logical Processor ID within this group/node
- C = Distance between the PCIe slot the NIC is plugged in to and the Logical Processor

AMD recommends using cores with the nearest distance (ideally C = 0, which implies that the processor cores are within the closest NUMA node to the NIC). Please see the latest version of Windows® Network Tuning Guide for AMD EPYC™ 8004 Series Processors for additional NIC tuning information.



```
Administrator: Windows PowerShell
PS C:\Users\Administrator> Get-NetAdapterRss -Name "Ethernet 2"

Name                                       : Ethernet 2
InterfaceDescription                       : Mellanox ConnectX-4 Lx Ethernet Adapter #2
Enabled                                    : True
NumberOfReceiveQueues                      : 8
Profile                                    : Closest
BaseProcessor: [Group:Number]              : 0:0
MaxProcessor: [Group:Number]               : 1:63
MaxProcessors                              : 8
RssProcessorArray: [Group:Number/NUMA Distance] : 0:36/0  0:37/0  0:38/0  0:39/0  0:40/15770  0:41/15770  0:42/15770  0:43/15770
                                             0:32/15866  0:33/15866  0:34/15866  0:35/15866  0:44/15877  0:45/15877  0:46/15877
                                             0:47/15877
                                             0:60/16612  0:61/16612  0:62/16612  0:63/16612  0:52/16660  0:53/16660  0:54/16660
                                             0:55/16660
                                             0:56/16662  0:57/16662  0:58/16662  0:59/16662  0:48/16780  0:49/16780  0:50/16780
                                             0:51/16780
                                             0:0/18822  0:1/18822  0:2/18822  0:3/18822  0:12/18854  0:13/18854  0:14/18854  0:15/18854
                                             0:4/18866  0:5/18866  0:6/18866  0:7/18866  0:8/18888  0:9/18888  0:10/18888  0:11/18888
                                             0:28/19062  0:29/19062  0:30/19062  0:31/19062  0:16/19592  0:17/19592  0:18/19592
                                             0:19/19592
                                             0:20/19737  0:21/19737  0:22/19737  0:23/19737  0:24/19849  0:25/19849  0:26/19849
                                             0:27/19849
                                             1:4/29903  1:5/29903  1:6/29903  1:7/29903  1:8/29971  1:9/29971  1:10/29971  1:11/29971
                                             1:0/30079  1:1/30079  1:2/30079  1:3/30079  1:12/30099  1:13/30099  1:14/30099  1:15/30099
                                             1:28/30869  1:29/30869  1:30/30869  1:31/30869  1:20/30899  1:21/30899  1:22/30899
                                             1:23/30899
                                             1:16/30919  1:17/30919  1:18/30919  1:19/30919  1:24/30939  1:25/30939  1:26/30939
                                             1:27/30939
                                             1:44/31029  1:45/31029  1:46/31029  1:47/31029  1:40/31047  1:41/31047  1:42/31047
                                             1:43/31047
                                             1:36/31103  1:37/31103  1:38/31103  1:39/31103  1:32/31143  1:33/31143  1:34/31143
                                             1:35/31143
                                             1:60/31692  1:61/31692  1:62/31692  1:63/31692  1:56/31801  1:57/31801  1:58/31801
                                             1:59/31801
                                             1:52/31819  1:53/31819  1:54/31819  1:55/31819  1:48/31877  1:49/31877  1:50/31877
                                             1:51/31877
IndirectionTable: [Group:Number]           : 0:36  0:40    0:37    0:41    0:38    0:42    0:39    0:43
                                             0:36  0:40    0:37    0:41    0:38    0:42    0:39    0:43
                                             0:36  0:40    0:37    0:41    0:38    0:42    0:39    0:43
                                             0:36  0:40    0:37    0:41    0:38    0:42    0:39    0:43
                                             0:36  0:40    0:37    0:41    0:38    0:42    0:39    0:43
                                             0:36  0:40    0:37    0:41    0:38    0:42    0:39    0:43
                                             0:36  0:40    0:37    0:41    0:38    0:42    0:39    0:43
                                             0:36  0:40    0:37    0:41    0:38    0:42    0:39    0:43
                                             0:36  0:40    0:37    0:41    0:38    0:42    0:39    0:43
                                             0:36  0:40    0:37    0:41    0:38    0:42    0:39    0:43
```

Figure 2-1: Sample Get -NetAdapterRss output

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Chapter 3

BIOS Settings Best Practices

Various BIOS settings can impact Windows Server performance. Default OEM BIOS settings provide general high performance for their servers, but specific workloads and contexts benefit from additional tuning. See the *BIOS & Workload Tuning Guide for AMD EPYC™ 8004 Series Processors* (available from AMD EPYC Tuning Guides) for additional tuning guidelines.

If present, the following BIOS settings can impact both performance and other factors, such as power consumption.

3.1 IOD Settings

- **xGMI Link Max Speed:** Increasing speed between SoC communication links (which increases power to SoC which may have the unintended consequence of preventing core frequency boost).
- **xGMI Link Width:** Widening the communication link between sockets.
- **SoC P-state:** Forcing the Data Fabric power state to highest performing state.
- **Data Fabric C-states:** Preventing the I/O Die from going into low power state.

3.2 NUMA Settings

- **LLC as NUMA:** Use the ACPI SRAT table to define the NUMA domain based on CCX boundary, so number of NUMA domains is equal to the number of Last Level Caches or CCXs. Users who desire smaller NUMA Nodes, or to work around potential OS limitations of representing multiple CCXs within the same NUMA Node, may consider enabling LLC as NUMA.
- **NUMA Nodes per Socket (NPS):** This setting also relates to memory interleaving of the memory channels per socket. For example, NPS1 implies a single NUMA domain with all cores within the 8004 processor (socket) and all the corresponding memory in one NUMA domain. Memory is interleaved across the socket's six memory channels. All PCIe devices on the socket belong to this single NUMA domain. NPS2 i.e., 2 nodes per socket, interleaves memory across three channels. NPSx setting may be set independently of the **LLC as NUMA Domain** BIOS setting. With Hyper-V and 1P-64c\SMT enable part, NPSx = 2 or 4 should be used if **LLC as NUMA Domain** is not enabled. AMD suggests NPS1 or NPS2 for most workloads.

  Setting **LLC as NUMA** to **Enabled** yields NUMA nodes equal to the number of CCXs or L3 caches in the system, such as 8 NUMA nodes on a 1P 64-core EPYC 8004 -based server. Concurrently, you can also use the **NUMA Nodes per Socket** (NPSx) setting to define the memory interleave. However, disabling **LLC as NUMA** means that **NUMA Nodes per Socket** (NPSx) will both provide the memory interleave info and dictate the number of NUMA nodes.

Some NUMA settings may not be available for all AMD EPYC 8004 Series Processor models. For more details, please see the latest version of Socket SP5/SP6 Platform NUMA Topology for AMD Family 19h Models 10h–1Fh and Models A0h–AFh (login required).

3.3 Memory Settings

Memory Clock Speed: The memory and I/O Die each have a corresponding clock. You can obtain lower latencies by adjusting memory speeds to couple with the fabric clock. The fabric clock (FCLK) can now run up to 2400Mhz and thus be coupled with DDR5-4800 Memory DIMMs, also running at 2400MHz (MEMCLK), to further improve memory latency.

3.4 Power Settings

- **Power Determinism:** May increase power to die, to maximize core performance. See the latest version of Power/ Performance Determinism for additional information.
- **CPPC:** Collaborative Processor Performance Control allows OS control over processor boost, as described in "Collaborative Processor Performance Control (CPPC)" on page 8.

3.5 Core Setting

SMT: Allowing for 2 execution threads per core. Turning on SMT will provide further gains. However, because there are resources within the core that are shared 2x performance is usually not expected.

3.6 Collaborative Processor Performance Control (CPPC)

Collaborative Processor Performance Control (CPPC) is defined in the Advanced Configuration and Power Interface (ACPI) specification and provides a mechanism for the OS to potentially request varying performance levels from processors. CPPC replaces traditional discrete frequency P-state requests.

Windows Server provides three power plans:

- Balanced (default).
- High Performance
- Power Saver

The default Windows Server power plan is **Balanced**. To obtain best performance, you can change the power plan to **High Performance**. Each of the three power plans has a separate GUID, for High Performance it is: `8c5e7fda-e8bf-4a96-9a85-a6e23a8c635c`.

For **High Performance** Mode with CPPC, use the Windows `Powercfg,exe` tool using a Window Command window running as Administrator:

- To show the current Power plan/scheme type: `Powercfg /L`
- To change to **High Performance**: `Powercfg /s 8c5e7fda-e8bf-4a96-9a85-a6e23a8c635c`
- To make the power scheme active: `Powercfg /setactive scheme_current`

Additionally, CPPC supports an autonomous mode, which AMD recommends, where AMD's System Management Unit (SMU) hardware promptly selects processor performance levels best suited to the current workload and power limits.

```
Powercfg /setacvalueindex scheme_current sub_processor PERFAUTONOMOUS 1
Powercfg /setacvalueindex scheme_current sub_processor PERFEPP 0
Powercfg /setacvalueindex scheme_current sub_processor PERFBOOSTMODE 4
Powercfg /setactive scheme_current
```

3.7 NUMA

Using the **NUMA Nodes Per Socket** (NPSx) and **LLC as NUMA** BIOS settings mentioned prior (NUMA related BIOS settings), you can abstract the AMD EPYC 8004 processor into a variety of NUMA configurations. In Windows, systems with fewer than 64 logical processors always have a single Processor Group. Windows will try and assign processors that are closest to each other into the same Processor Group.

There may potentially be multiple NUMA Nodes within that Processor Group. The Windows scheduler sees each processor group as a single entity. The maximum size of a Windows Processor Group is currently 64 logical processors.

Prior to Windows Server 2022, the OS scheduler only assigns application threads of a process to a single processor group. Regardless of NPS settings, applications must be multi-group aware to take advantage of all the processors. Otherwise, their affinity will be to a single processor group. Starting with Windows Server 2022, applications are no longer constrained by default to a single processor group. The OS scheduler assigns thread across all processor groups by default without requiring applications to be multi-group aware. Please see Processor Groups* for more information about Processor Groups in Windows.

Windows historically supports a maximum of 64 logical processors per NUMA Node. When there were more than 64 logical processors, Windows would internally split the node into multiple soft NUMA nodes. Furthermore, all that node's memory is associated with the first soft NUMA node. Starting with Windows Server 2022 Microsoft introduced: `KeQueryNodeActiveAffinity2` API, which allows a NUMA node to span across more than a single processor group

Note: In Windows Server 2019, Task Manager displays soft NUMA nodes internally created by the OS. If there are more than 64 logical processors per NUMA node, then the number of NUMA nodes shown in Task Manager will not match the actual number of NUMA nodes configured in the system. Windows Server 2022 fixes this Task Manager limitation.

Please see NUMA Architecture* for more information about NUMA in Windows.

Be aware of BIOS settings which allow for more than 64 logical processors *per node. For example, a 1 socket, 64-core AMD EPYC 8004-based system with SMT enabled and with NPSx equal to 1, would have 128 threads per NUMA Node. Settings which result in >64 threads per NUMA node are not supported by Windows Server 2019. Users who desire smaller NUMA Nodes, or wish to work around potential OS limitations of representing multiple CCXs within the same NUMA Node, may consider enabling **LLC as NUMA**.*

Please see the *NUMA Topology* section of the *AMD EPYC™ 8004 Series Architecture Overview* here for additional information.

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Chapter 4 Windows Tunings and Tools

This chapter provides settings and links to tools that may help you analyze and optimize Windows Server performance on systems powered by AMD EPYC 8004 Series Processors.

4.1 OS updates

Microsoft regularly releases OS security and functionality patches. AMD recommends running Windows Update and installing the latest OS patches.

4.2 Processor Affinity

You can set processor affinity in Windows using either:

- Task Manager
- Windows PowerShell

4.2.1 Task Manager

To set Windows processor affinity using Task Manager running as Administrator:

1. Select the app you want to affinitize.
2. Right-click the desired app, and then select **Details** to show the app processes
3. Right-click the desired process, and then select **Set Affinity**.

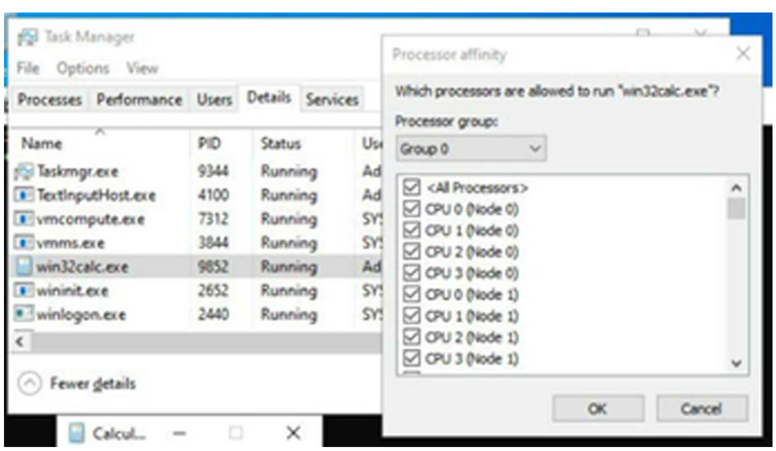

Figure 4-1: Setting affinity using Windows Task Manager

4.2.1.1 PowerShell

To set Windows processor affinity using PowerShell:

1. Open PowerShell.
2. Obtain affinity by entering `Get-Process appname | Select-Object ProcessorAffinity`.
3. Set affinity by entering `$Process = Get-Process app; $Process.ProcessorAffinity=mask- value`.

For example, running `get-process` shows all currently-running processes:

```
PS C:\> Get-Process wincalc32 | Select-Object ProcessorAffinity
```

`ProcessorAffinity` will return a bitmask representing the processors that the threads in the associated process can run on. So, to run a process on first CCX (assuming SMT is off):

```
PS C:\> $Process = Get-Process win32calc; $Process.ProcessorAffinity=15
PS C:\> Get-Process win32calc | Select-Object ProcessorAffinity
```

Calculator will now only run on the first 4 logical processors.

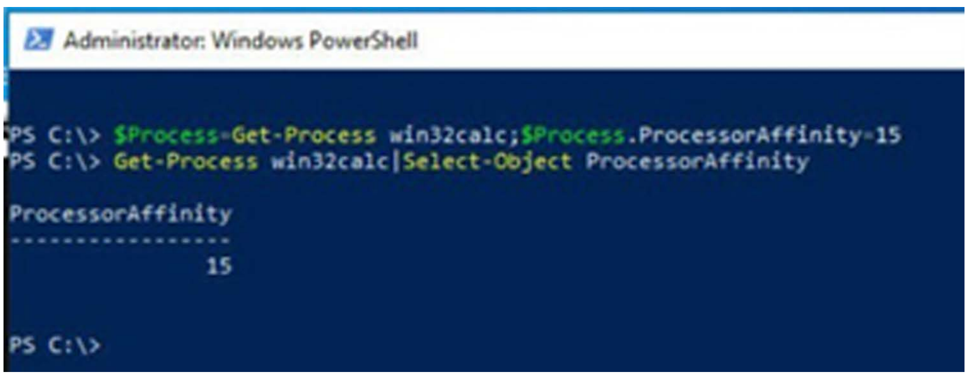

Figure 4-2: Sample Calculator output

4.3 Managing Microsoft Hyper V

Hyper-V is a Type-1/bare-metal hypervisor that runs directly on the underlying hardware. It is used for virtualization in Windows Client, Windows Server, and Azure.

Hyper-V provides isolated guest operating system environments running on a single server platform. Each isolated partition receives its own resources. Hyper-V has a parent (or management) Root Partition, which is a virtual machine partition with unique access and increased privileges. This root partition creates the requested isolated child partitions. AMD recommends not running other applications on the Root Partition.

Enabling Hyper-V on AMD EPYC 8004-based servers requires the following:

- **Windows Server 2022:** If the OS build is prior to 20348.859, then install the latest Windows Cumulative Update before enabling Hyper-V.
- **Windows Server 2019:** If the OS build is prior to 17763.3532, then install the latest Windows Cumulative Update before enabling Hyper-V.

Use the following cmdlet to enable Hyper-V on Windows Server via PowerShell:

```
Install-WindowsFeature -Name Hyper-V -IncludeManagementTools -Restart
```

Hyper-V Minimum Root configuration (Miniroot)* allows you to specify the maximum number of logical processors available to the root partition. Set the root partition number of logical processors to N by opening an elevated Command Prompt window, executing the following `bcdedit` command, and then rebooting for the command to take effect:

```
C:\ > bcdedit /set hypervisorrootproc N
```

Please see:

- Hyper-V Host CPU Resource Management* for an overview of Hyper-V Miniroot.
- Windows Server 2019 Hyper-V host behavior running in the Minroot configuration* for behaviors and known issues specific to Windows Server 2019 Hyper-V Miniroot.

`Cpugroups.exe` is a tool from the Hyper-V Team that allows you to allocate processing resources at a much more granular level. See Virtual Machine Resource Controls* for information about Microsoft VM CPU tools.

Hyper-V Integration Services* provide enlightened guest OS drivers for Hyper-V and will improve performance of the guest OS while it is running on Hyper-V.

For Hyper-V scalability and capacity planning, please consult the current maximum configuration limits supported by Hyper-V.Details are available at Plan for Hyper-V scalability in Windows Server*. Microsoft continues to update these limits in response to business needs. Please continue to consult this article on an ongoing basis.

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Chapter 5 Performance Monitoring Tools

5.1 Microsoft Windows Tools and Resources

Windows includes the following resources:

- **Windows Resource Monitor:** Monitors CPU, memory, disk, and network usage in real time.
- **Windows Performance Monitor:** View OS\Hyper-V performance counters in either real time or saved from the Performance recorder. This feature is part of Windows Admin Center and can thus track multiple servers.

Microsoft also provides various kits, such as:

- **Windows Assessment and Deployment Kit (ADK):** Includes a variety of useful performance tools, such as:
- **Windows Performance Recorder (WPR) / xPerf:** Recording utility based on Event Tracing for Windows (ETW).
- **Windows Performance Analyzer:** Creates graphs and data tables of recorded events.
- **Windows Software Development Kit (SDK):** Includes the powerful Windows Kernel Debugger (WinDbg) that can investigate OS functionality and view data structures.

Please also see the following Microsoft documents for additional information:

- Windows NUMA Support and APIs*
- Powercfg configuration options*

5.2 AMD Tools and Resources

- uProf for Windows: Profiling tool that can monitor system metrics and performance counters.

Other AMD EPYC resources are available from:

- https://developer.amd.com/resources/epyc-resources/
- www.amd.com/epyc-tech-docs
- www.amd.com/epyc-tuning-guides

5.3 Other Documents

ACPI Specification v6.5*

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Chapter 6

Processor Identification

Figure 6-1 shows the processor naming convention for AMD EPYC 8004 Series Processors and how to use this convention to identify particular processors models:

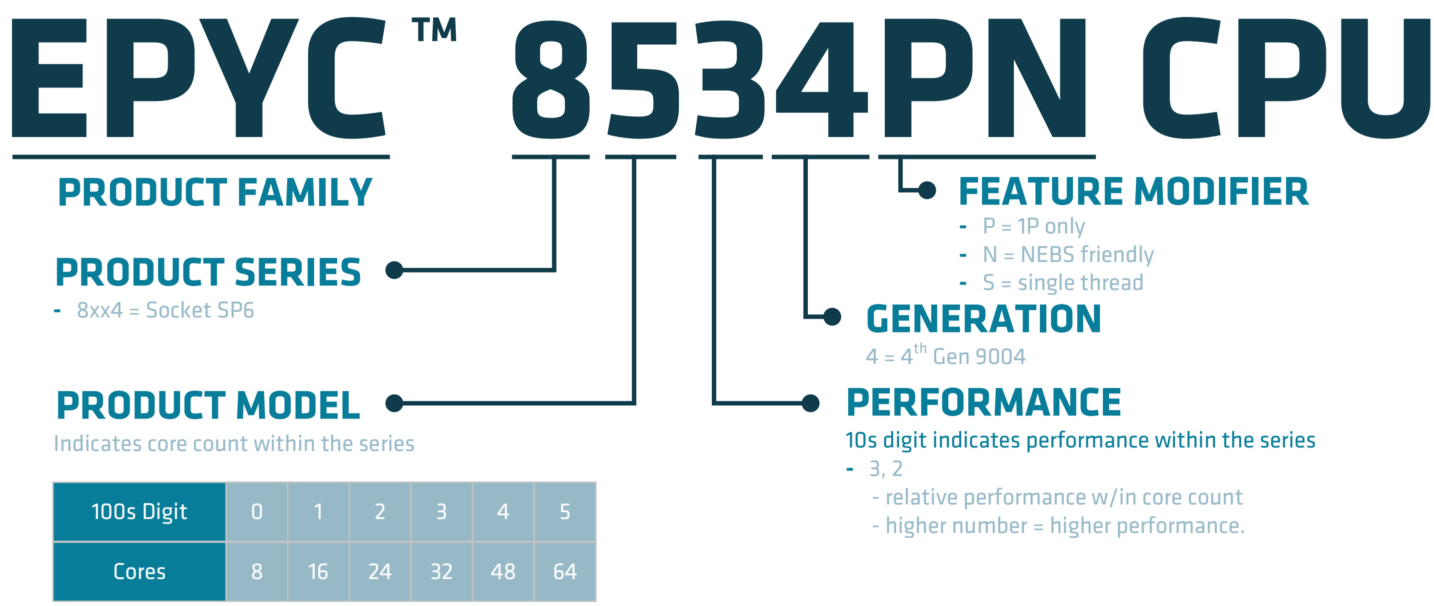

Figure 6-1: AMD EPYC SoC naming convention

6.1 CPUID Instruction

Software uses the `CPUID` instruction (`Fn0000_0001_EAX`) to identify the processor and will return the following values:

- **Family:** 19h identifies the "Zen 4" architecture
- **Model:** Varies with product. For example, EPYC Model 10h corresponds to an "A" part "Zen 4" CPU.
  - **8xx4:** Models A0h–AFh
- **Stepping:** May be used to further identify minor design changes

For example, `CPUID` values for Family, Model, and Stepping (decimal) of 25, 17, 1 correspond to a "B1" part "Zen 4" CPU.

6.2 New Software-Visible Features

AMD EPYC 8004 Series Processors introduce several new features that enhance performance, ISA updates, provide additional security features, and improve system reliability and availability. Some of the new features include:

- 5-level Paging
- AVX-512 instructions on a 256-bit datapath, including BFLOAT16 and VNNI support.
- Fast Short Rep STOSB and Rep CMPSB

Not all operating systems or hypervisors support all features. Please refer to your OS or hypervisor documentation for specific releases to identify support for these features.

Please also see the latest version of the *AMD64 Architecture Programmer's Manuals* or *Processor Programming Reference (PPR) for AMD Family 19h*.

6.2.1 AVX-512

AVX-512 is a set of individual instructions supporting 512-bit register-width data (i.e., single instruction, multiple data [SIMD]) operations. AMD EPYC 8004 Series Processors implement AVX 512 by "double-pumping" 256-bit-wide registers. AMD's AVX-512 design uses the same 256-bit data path that exists throughout the Zen4 core and enables the two parts to execute on sequential clock cycles. This means that running AVX-512 instructions on AMD EPYC 8004 Series will cause neither drops on effective frequencies nor increased power consumption. On the contrary, many workloads run more energy-efficiently on AVX-512 than on AVX-256P.

Other AVX-512 support includes:

- Vectorized Neural Network Instruction (VNNI) instructions that are used in deep learning models and accelerate neural network inferences by providing hardware support for convolution operations.
- Brain Floating Point 16-bit (BFLOAT16) numeric format. This format is used in Machine Learning applications that require high performance but must also conserve memory and bandwidth. BFLOAT16 support doubles the number of SIMD operands over 32-bit single precision FP, allowing twice the amount of data to be processed using the same memory bandwidth. BFLOAT16 values mantissa dynamic range at the expense of one radix point.