

TECH NOTE

Configuring vCPU for Microsoft SQL Server Standard Edition

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1. Executive Summary

This document discusses product licensing limitations in Microsoft SQL Server Standard edition and important points to consider when you deploy SQL Server Standard edition in a virtual environment.

SQL Server Standard edition can use a maximum of 4 virtual CPUs (vCPU) or 24 cores. In a virtual environment, SQL Server maps each vCPU to a socket in a physical server. Therefore, it's essential to configure VMs that yield the best possible performance within the licensing limitations.

In this document, we don't recommend any specific vCPU-to-core ratio; however, depending on the application's SQL profile, your environment might benefit more from one configuration than from another. Therefore, we strongly recommend that you perform benchmark testing with your application before you set a specific vCPU-to-core ratio for SQL Server Standard edition deployments.

Document Version History

Version Number	Published	Notes
1.0	February 2023	Original publication.

2. Licensing Limits by SQL Server Edition

The following table outlines the current compute capacity limits by SQL Server edition as detailed in the Microsoft article [Editions and supported features of SQL Server 2019](#). Refer to the Microsoft article [Compute capacity limits by edition of SQL Server](#) for more information on how capacity limits differ in physical and virtualized environments.

Table. Compute Capacity Limits per Single Instance by SQL Server Edition

SQL Server Edition	Maximum Compute Capacity per Single Instance (SQL Server Database Engine)
Enterprise	Operating system maximum
Developer	Operating system maximum
Standard	4 sockets or 24 cores (whichever is less)
Express	1 socket or 4 cores (whichever is less)

3. Nutanix vCPU Allocation Testing Environment

Nutanix tested vCPU allocation with the following software versions:

- SQL Server: Microsoft SQL Server 2019 RTM, 15.0.2000.5 (x64) Standard Edition (64-bit)
- Hypervisor: Nutanix AHV 5.20.3

Note: Although we tested with a specific version of Nutanix AHV, we expect other versions and other hypervisors to demonstrate similar behavior.

4. vCPU Allocation Configuration Options

Option 1: System with 2 vCPU and 24 Cores per vCPU

In the first test configuration, we create a virtual server with 2 vCPU and 24 cores per vCPU.

Compute Details

vCPU(s)

2

Number Of Cores Per vCPU

24

Figure 1: Option 1: Compute Details

We configure SQL Server CPU with automatic allocation.

Select a page

- General
- Memory
- Processors
- Security
- Connections
- Database Settings
- Advanced
- Permissions

Script Help

Enable processors

Automatically set processor affinity mask for all processors

Automatically set I/O affinity mask for all processors

Processor	Processor Affinity	I/O Affinity
NumaNode0	<input type="checkbox"/>	<input type="checkbox"/>
CPU0	<input type="checkbox"/>	<input type="checkbox"/>
CPU1	<input type="checkbox"/>	<input type="checkbox"/>
CPU2	<input type="checkbox"/>	<input type="checkbox"/>
CPU3	<input type="checkbox"/>	<input type="checkbox"/>
CPU4	<input type="checkbox"/>	<input type="checkbox"/>
CPU5	<input type="checkbox"/>	<input type="checkbox"/>
CPU6	<input type="checkbox"/>	<input type="checkbox"/>
CPU7	<input type="checkbox"/>	<input type="checkbox"/>
CPU8	<input type="checkbox"/>	<input type="checkbox"/>
CPU9	<input type="checkbox"/>	<input type="checkbox"/>
CPU10	<input type="checkbox"/>	<input type="checkbox"/>
CPU11	<input type="checkbox"/>	<input type="checkbox"/>
CPU12	<input type="checkbox"/>	<input type="checkbox"/>
CPU13	<input type="checkbox"/>	<input type="checkbox"/>
CPU14	<input type="checkbox"/>	<input type="checkbox"/>
CPU15	<input type="checkbox"/>	<input type="checkbox"/>
CPU16	<input type="checkbox"/>	<input type="checkbox"/>
CPU17	<input type="checkbox"/>	<input type="checkbox"/>
CPU18	<input type="checkbox"/>	<input type="checkbox"/>
CPU19	<input type="checkbox"/>	<input type="checkbox"/>
CPU20	<input type="checkbox"/>	<input type="checkbox"/>
CPU21	<input type="checkbox"/>	<input type="checkbox"/>
CPU22	<input type="checkbox"/>	<input type="checkbox"/>
CPU23	<input type="checkbox"/>	<input type="checkbox"/>
CPU24	<input type="checkbox"/>	<input type="checkbox"/>
CPU25	<input type="checkbox"/>	<input type="checkbox"/>
CPU26	<input type="checkbox"/>	<input type="checkbox"/>
CPU27	<input type="checkbox"/>	<input type="checkbox"/>
CPU28	<input type="checkbox"/>	<input type="checkbox"/>
CPU29	<input type="checkbox"/>	<input type="checkbox"/>
CPU30	<input type="checkbox"/>	<input type="checkbox"/>
CPU31	<input type="checkbox"/>	<input type="checkbox"/>
CPU32	<input type="checkbox"/>	<input type="checkbox"/>
CPU33	<input type="checkbox"/>	<input type="checkbox"/>
CPU34	<input type="checkbox"/>	<input type="checkbox"/>
CPU35	<input type="checkbox"/>	<input type="checkbox"/>
CPU36	<input type="checkbox"/>	<input type="checkbox"/>
CPU37	<input type="checkbox"/>	<input type="checkbox"/>
CPU38	<input type="checkbox"/>	<input type="checkbox"/>
CPU39	<input type="checkbox"/>	<input type="checkbox"/>
CPU40	<input type="checkbox"/>	<input type="checkbox"/>
CPU41	<input type="checkbox"/>	<input type="checkbox"/>
CPU42	<input type="checkbox"/>	<input type="checkbox"/>
CPU43	<input type="checkbox"/>	<input type="checkbox"/>
CPU44	<input type="checkbox"/>	<input type="checkbox"/>
CPU45	<input type="checkbox"/>	<input type="checkbox"/>
CPU46	<input type="checkbox"/>	<input type="checkbox"/>
CPU47	<input type="checkbox"/>	<input type="checkbox"/>

Threads

Connection

Server: WIN-9K3FS60AJ84

Figure 2: Option 1: CPU Automatic Allocation

The following screenshot shows the number of physical and logical CPUs that the SQL Server operating system (OS) detects.

	Number_of_PhysicalCPUs	Number_of_LogicalCPUs
1	2	48

Figure 3: Option 1: Physical and Logical CPUs Detected

Although 48 cores are available to the database server (assigned online CPU), SQL Server can only use 24 cores (visible online CPU).

	ASSIGNED ONLINE CPU #	VISIBLE ONLINE CPU #
1	48	24

Figure 4: Option 1: Allocated vs. Usable CPU

When we query the dynamic management view for `dm_osSchedulers`, we can verify that only 24 cores are available and scheduled in SQL Server. With the licensing restrictions, SQL Server doesn't use the remaining 24 cores.

The screenshot shows a SQL Server Management Studio (SSMS) interface. In the top pane, a T-SQL query is displayed:

```
select cpu_id, status from sys.dm_osSchedulers  
where status = 'VISIBLE ONLINE'
```

The bottom pane displays the results of the query in a tabular format. The results show 24 rows, each representing a scheduler with a visible online status. The columns are labeled 'cpu_id' and 'status'. The 'cpu_id' column contains values from 0 to 23, and the 'status' column is consistently 'VISIBLE ONLINE'.

	cpu_id	status
1	0	VISIBLE ONLINE
2	1	VISIBLE ONLINE
3	2	VISIBLE ONLINE
4	3	VISIBLE ONLINE
5	4	VISIBLE ONLINE
6	5	VISIBLE ONLINE
7	6	VISIBLE ONLINE
8	7	VISIBLE ONLINE
9	8	VISIBLE ONLINE
10	9	VISIBLE ONLINE
11	10	VISIBLE ONLINE
12	11	VISIBLE ONLINE
13	12	VISIBLE ONLINE
14	13	VISIBLE ONLINE
15	14	VISIBLE ONLINE
16	15	VISIBLE ONLINE
17	16	VISIBLE ONLINE
18	17	VISIBLE ONLINE
19	18	VISIBLE ONLINE
20	19	VISIBLE ONLINE
21	20	VISIBLE ONLINE
22	21	VISIBLE ONLINE
23	22	VISIBLE ONLINE
24	23	VISIBLE ONLINE

Figure 5: Option 1: Scheduler Query Results

Option 2: System with 8 vCPU and 1 Core per vCPU

In the second test configuration, we create a virtual server with 8 vCPU and 1 core per vCPU.

Compute Details

vCPU(s)

8

Number Of Cores Per vCPU

1

Figure 6: Option 2: Compute Details

We configure SQL Server CPU with automatic allocation.

The screenshot shows the 'Processor' configuration section. Under 'Enable processors', two checkboxes are checked: 'Automatically set processor affinity mask for all processors' and 'Automatically set I/O affinity mask for all processors'. A table lists processors from 'ALL' down to 'CPU7'. The 'Processor Affinity' column has a checkbox for 'ALL' and 'NumaNode0', while individual CPUs have checkboxes for each. The 'I/O Affinity' column has a checkbox for 'ALL' and 'NumaNode0', while individual CPUs have checkboxes for each.

Processor	Processor Affinity	I/O Affinity
ALL	<input type="checkbox"/>	<input type="checkbox"/>
NumaNode0	<input type="checkbox"/>	<input type="checkbox"/>
CPU0	<input type="checkbox"/>	<input type="checkbox"/>
CPU1	<input type="checkbox"/>	<input type="checkbox"/>
CPU2	<input type="checkbox"/>	<input type="checkbox"/>
CPU3	<input type="checkbox"/>	<input type="checkbox"/>
CPU4	<input type="checkbox"/>	<input type="checkbox"/>
CPU5	<input type="checkbox"/>	<input type="checkbox"/>
CPU6	<input type="checkbox"/>	<input type="checkbox"/>
CPU7	<input type="checkbox"/>	<input type="checkbox"/>

Threads

Figure 7: Option 2: CPU Automatic Allocation

Although the database server has 8 CPU allocated (assigned online), SQL Server can only use 4 CPU (visible online).

	ASSIGNED ONLINE CPU #	VISIBLE ONLINE CPU #
1	8	4

Figure 8: Option 2: Allocated vs. Usable Online CPU

When we query the dynamic management view for `dm_osSchedulers`, we can verify that only 4 vCPU are available and scheduled in SQL Server.

A screenshot of a SQL Management Studio window. The query pane contains the following T-SQL code:

```
select cpu_id, status from sys.dm_osSchedulers  
where status = 'VISIBLE ONLINE'
```

The results pane shows a table with two columns: 'cpu_id' and 'status'. The data is as follows:

cpu_id	status
0	VISIBLE ONLINE
1	VISIBLE ONLINE
2	VISIBLE ONLINE
3	VISIBLE ONLINE

Figure 9: Option 2: Scheduler Query Results

SQL Server Standard edition is only licensed to use up to 4 vCPU. Because SQL Server in a virtual environment (in this case, AHV) maps each vCPU to a socket in a physical server, SQL Server Standard edition considers 8 vCPU to be over-allocation.

Option 3: System with 4 vCPU and 6 Cores per vCPU

In the third test configuration, we create a virtual server with 4 vCPU and 6 cores per vCPU.

Compute Details

vCPU(s)

4

Number Of Cores Per vCPU

6

Figure 10: Option 3: Compute Details

We configure SQL Server CPU with automatic allocation.

The screenshot shows a SQL Management Studio interface. In the top pane, a query is written:

```
select cpu_id, status from sys.dm_osSchedulers  
where status = 'VISIBLE ONLINE'
```

The bottom pane displays the results of this query in a tabular format. The table has two columns: 'cpu_id' and 'status'. The 'cpu_id' column contains integers from 0 to 23, and the 'status' column contains the text 'VISIBLE ONLINE' repeated 24 times.

	cpu_id	status
1	0	VISIBLE ONLINE
2	1	VISIBLE ONLINE
3	2	VISIBLE ONLINE
4	3	VISIBLE ONLINE
5	4	VISIBLE ONLINE
6	5	VISIBLE ONLINE
7	6	VISIBLE ONLINE
8	7	VISIBLE ONLINE
9	8	VISIBLE ONLINE
10	9	VISIBLE ONLINE
11	10	VISIBLE ONLINE
12	11	VISIBLE ONLINE
13	12	VISIBLE ONLINE
14	13	VISIBLE ONLINE
15	14	VISIBLE ONLINE
16	15	VISIBLE ONLINE
17	16	VISIBLE ONLINE
18	17	VISIBLE ONLINE
19	18	VISIBLE ONLINE
20	19	VISIBLE ONLINE
21	20	VISIBLE ONLINE
22	21	VISIBLE ONLINE
23	22	VISIBLE ONLINE
24	23	VISIBLE ONLINE

Figure 11: Option 3: CPU Automatic Allocation

The following screenshot shows the number of physical and logical CPUs that the SQL Server OS detects.

A screenshot of the SQL Server Management Studio (SSMS) interface. The title bar says 'Configuring vCPU for Microsoft SQL Server Standard Edition'. The window has tabs for 'Results' and 'Messages', with 'Results' selected. The results grid contains one row with two columns: 'Number_of_PhysicalCPUs' and 'Number_of_LogicalCPUs'. The value '1' is in the first column and '4' is in the second column. The value '4' is highlighted with a dashed border.

	Number_of_PhysicalCPUs	Number_of_LogicalCPUs
1	4	24

Figure 12: Option 3: Physical and Logical CPUs Detected

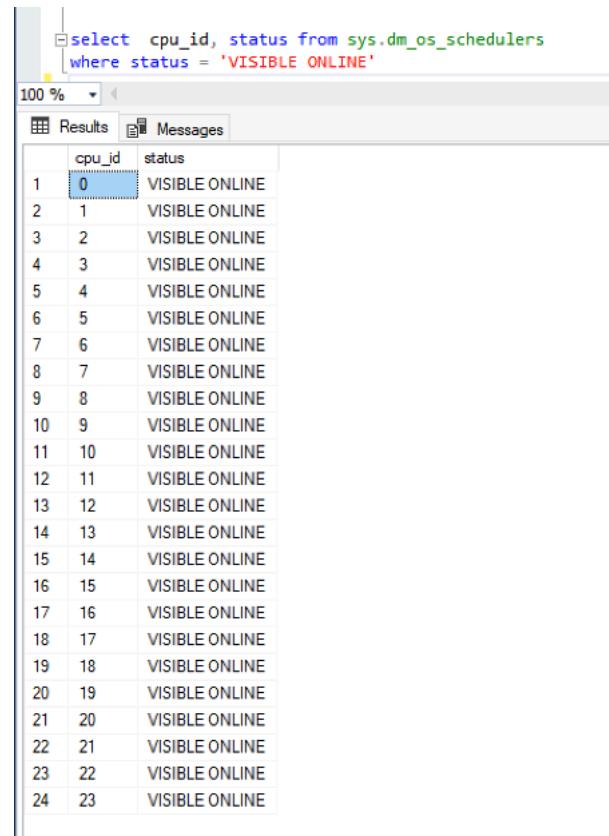
All allocated CPU resources (assigned online) are available and usable (visible online).

A screenshot of the SQL Server Management Studio (SSMS) interface. The title bar says 'Configuring vCPU for Microsoft SQL Server Standard Edition'. The window has tabs for 'Results' and 'Messages', with 'Results' selected. The results grid contains one row with two columns: 'ASSIGNED ONLINE CPU #' and 'VISIBLE ONLINE CPU #'. Both columns have the value '24'. The value '24' is highlighted with a dashed border.

	ASSIGNED ONLINE CPU #	VISIBLE ONLINE CPU #
1	24	24

Figure 13: Option 3: Allocated vs. Usable Online CPU

When we query the dynamic management view for `dm_osSchedulers`, we can verify that all 24 cores are available and scheduled in SQL Server. SQL Server Standard edition consumes the allocated CPU resources in this configuration option.



A screenshot of a SQL query results window. The query is:

```
select cpu_id, status from sys.dm_osSchedulers  
where status = 'VISIBLE ONLINE'
```

The results show 24 rows of data:

	cpu_id	status
1	0	VISIBLE ONLINE
2	1	VISIBLE ONLINE
3	2	VISIBLE ONLINE
4	3	VISIBLE ONLINE
5	4	VISIBLE ONLINE
6	5	VISIBLE ONLINE
7	6	VISIBLE ONLINE
8	7	VISIBLE ONLINE
9	8	VISIBLE ONLINE
10	9	VISIBLE ONLINE
11	10	VISIBLE ONLINE
12	11	VISIBLE ONLINE
13	12	VISIBLE ONLINE
14	13	VISIBLE ONLINE
15	14	VISIBLE ONLINE
16	15	VISIBLE ONLINE
17	16	VISIBLE ONLINE
18	17	VISIBLE ONLINE
19	18	VISIBLE ONLINE
20	19	VISIBLE ONLINE
21	20	VISIBLE ONLINE
22	21	VISIBLE ONLINE
23	22	VISIBLE ONLINE
24	23	VISIBLE ONLINE

Figure 14: Option 3: Scheduler Query Results

5. Conclusion

When deploying SQL Server Standard edition in a virtual environment, consider the optimal vCPU-to-core ratio. SQL Server maps vCPU to physical sockets.

The following combinations of vCPU and cores per vCPU yield the best compute capacity in compliance with SQL Server Standard edition licensing limitations for systems in a virtual environment.

Table. vCPU-to-Core Configurations

vCPU Count	Number of Cores per vCPU	Total Cores
1	24	24
2	12	24
3	8	24
4	6	24

Depending on the host system's CPU configuration and the application workload, you might find a specific vCPU-to-core configuration that yields better performance. We strongly recommend that you conduct appropriate load testing to determine the optimal vCPU-to-core ratio for your workload in your environment.

About Nutanix

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