Microsoft

SQL Server Configuration And Database Maintenance

Module 1

Learning Units covered in this Module

- Lesson 1: : Windows Server Configuration
- Lesson 2: SQL Server Configuration
- Lesson 3: Database Configuration
- Lesson 4: Database Maintenance

Lesson 1: Windows Server Configuration

Windows Server Configuration

Categories

- SQL Server Versions and Editions
- SQL Server Instances
- Security and Permissions
- Antivirus Exclusions
- Power Management
- Page File

SQL Server editions

Azure-enabled with continued performance and security innovation

Express
Free, entry-level database for small web and mobile apps

Feature highlights

- Up to 4 cores of CPU
- Up to 1410 MBs of memory
- Microsoft Purview Policies
- Azure AD authentication
- Built-in query intelligence: PSP Optimization, Optimized plan forcing
- Query store on by default for new databases
- Data Lake Virtualization
- Ledger
- Timeseries support

Standard
Full featured database for mid-tier applications and data marts

Feature highlights

- Up to 24 cores of CPU
- Up to 128 GBs of memory
- Azure Synapse Link for SQL
- Link feature for Azure SQL Managed Instance (basic availability groups)
- Buffer Pool Parallel Scan
- Backups to S3-compatible object storage

+ **Express features**

Enterprise
Mission-critical performance and intelligence for tier 1 databases

Feature highlights

- Unlimited cores of CPU
- Unlimited memory
- Azure Synapse Link for SQL (multi-threaded snapshot)
- Link feature for Azure SQL Managed Instance
- Built-in query intelligence: DOP feedback, CE Feedback, Memory Grant Feedback
- Contained Availability Group
- AVX 512 extension for batch mode

+ **Standard features**
+ **Express features**

Developer
Free to use with all the features of Enterprise Edition specifically for dev/test in non-production environments.
SQL Server 2025 includes a Developer Edition that only has Standard Edition features.

← Build once and deploy across any SQL Server edition without changing your app →

SQL Server continues to deliver unparalleled value

Business continuity through Azure

Seamless analytics over on-prem operational data

Visibility over your entire data estate

Most secure over the last 10 years[6]

Industry-leading performance and availability

2017 additions

- Support for Linux including Red Hat Enterprise Linux (RHEL), SUSE Linux Enterprise Server (SLES), and Ubuntu
- Support for Docker containers on Linux and Windows
- Python language support
- Support for graph data
- Automatic plan correction and adaptive query processing
- Cross platform availability groups

2019 additions

- Azure Machine Learning and Spark ML
- Support for Kubernetes deployment
- Free supported Java
- Native UTF-8 support
- In-Memory Database: Persistent Memory support
- Accelerated database recovery
- Free DR to Azure Always Encrypted with secure enclaves
- Data classification & auditing
- Vulnerability assessment

2022 additions

- Azure extension for SQL Server
- Link feature for Azure SQL Managed Instance
- Azure Synapse link for SQL
- Azure Purview policies
- SQL Server Ledger
- Large memory and concurrency scalability
- Data virtualization for any data lake
- Object storage backup and restore
- Query Store on by default with replica support
- Query Store hints
- Intelligent Query Processing NextGen
- JSON functions
- Modern T-SQL surface area
- Time series support
- Integrated acceleration & offloading

2025 additions

- Built-in AI Capabilities
- Vector Data Type and Search
- New Vector Functions
- Optimized Locking
- Reliable Failover Diagnostics
- Optional Parameter Plan Optimization
- Abort Query Hint
- Optimized sp_executesql procedure
- Accelerated Database Recovery and Resources Governor for TempDB
- Managed Identity Authentication
- Custom Password Policies on Linux
- Support for EKM with Azure Key Vault
- Support for CSV, Parquet, and Delta
- Support for JSON Data Types
- New T-SQL Aggregate Functions
- New RegEX Functions

Full list of SQL Server 2022 editions and supported features available on SQL Docs

SQL Server Instances

An instance of the Database Engine operates as a service that handles all application requests to work with the data in any of the databases managed by that instance.

Default Instance

- This instance has no name and is identified by the computer name alone. Only one default instance can be installed on a computer.
- The name of the services for the default instance will be MSSQLSERVER.

Named Instances

- Additional instances will have a unique name specified during installation.
- Multiple named instances can be installed on a single computer, and each is identified by the computer name and instance name.
- The name of the services will have a format of MSSQL$InstanceName

Windows Server Configuration

Security and Permissions

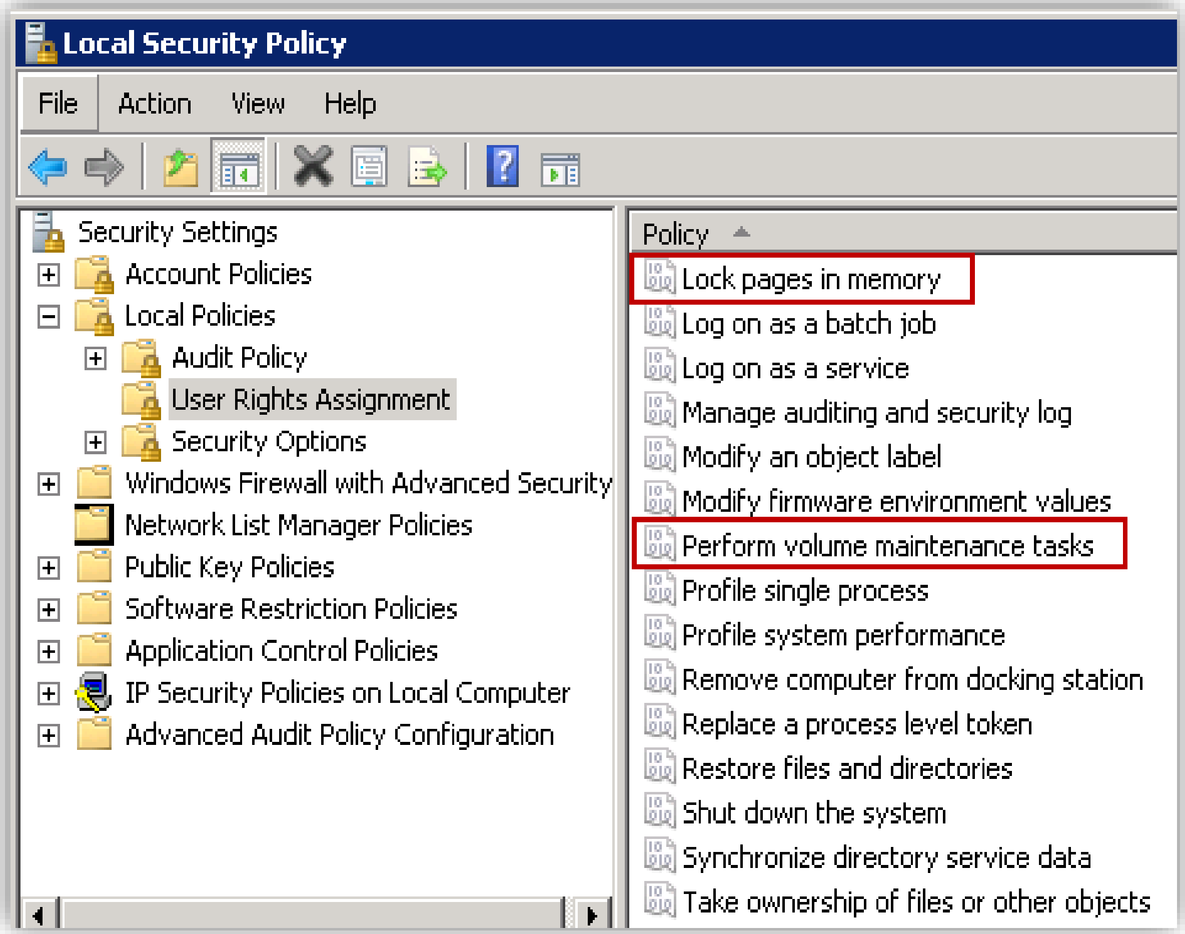
Required Permissions

- Log on as a Service
- Replace a process level token
- Bypass traverse checking
- Adjust memory quotas for a process

Optional Permissions

- Lock Pages In Memory
- Perform Volume Maintenance Tasks

Managed Service Accounts (MSA) and Group Managed Service Accounts (gMSA)



- Security Settings
  - Account Policies
  - Local Policies
    - Audit Policy
    - User Rights Assignment
    - Security Options
  - Windows Firewall with Advanced Security
  - Network List Manager Policies
  - Public Key Policies
  - Software Restriction Policies
  - Application Control Policies
  - IP Security Policies on Local Computer
  - Advanced Audit Policy Configuration

Policy

- Lock pages in memory
- Log on as a batch job
- Log on as a service
- Manage auditing and security log
- Modify an object label
- Modify firmware environment values
- Perform volume maintenance tasks
- Profile single process
- Profile system performance
- Remove computer from docking station
- Replace a process level token
- Restore files and directories
- Shut down the system
- Synchronize directory service data
- Take ownership of files or other objects

SQL Server Service Accounts

Partial List

- SQL Server Database Engine
- SQL Server Agent
- SQL Server Browser – Might be disabled
- SQL Server Full-text Filter Daemon Launcher
- SQL Server Launchpad – Optional
- SQL Server Integration Services – Optional
- SQL Server Analysis Services – Optional
- SQL Server Reporting Services - Optional

Types of SQL Server Service Accounts

Local or Domain User Account

Network Service Account

Virtual Service account (SQL 2012)

Managed Service account (SQL 2012)

Which one is “right”

- Consider the principle of least privilege
- Accounts should have the level of access required and nothing further.
- Accounts should be isolated (not used by any other service)

What is the best choice?

Largely dependent on your organizations needs, but there are recommended practices:

Non-administrative Local or Domain users

- Local users **cannot** access domain resources.
- Require regular service password management

Virtual accounts (SQL 2012+)

- Auto-managed, auto-provisioned
- Ideal for non-domain joined or isolated servers

Managed accounts (SQL 2012+)

- Auto-managed, manual provisioning
- Ideal for domain joined servers that must access domain resources or used linked servers

Virtual Accounts

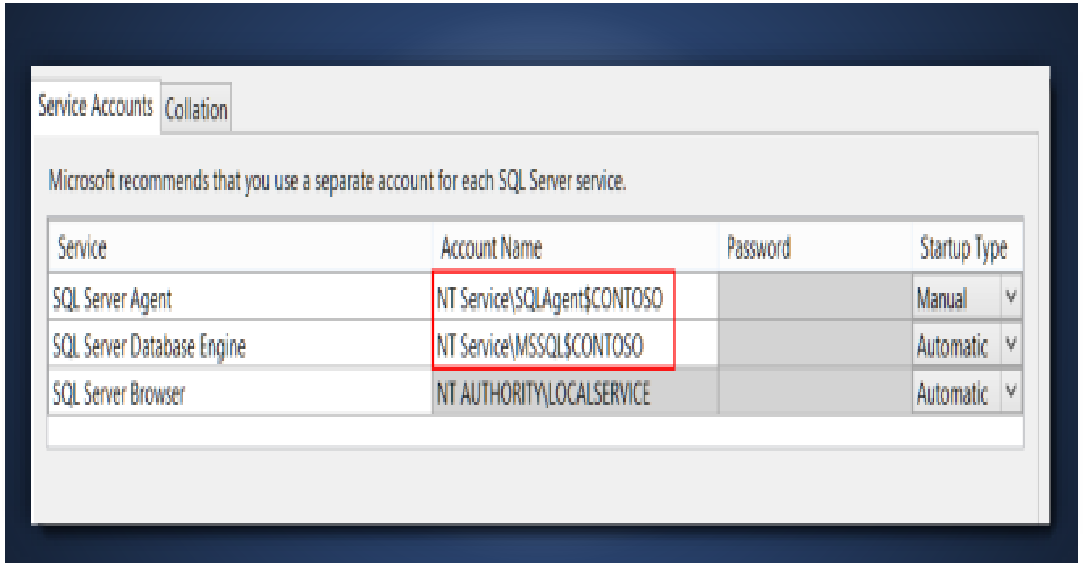
Managed local accounts

Automatically Provisioned and Managed

Default in SQL Server 2012 – specific during setup

Default instance of the Database Engine service:
NT SERVICE\MSSQLSERVER

Access network resources by using:
<domain_name>\<computer_name>$



Microsoft recommends that you use a separate account for each SQL Server service.

Service	Account Name	Password	Startup Type
SQL Server Agent	NT Service\SQLAgent$CONTOSO		Manual
SQL Server Database Engine	NT Service\MSSQL$CONTOSO		Automatic
SQL Server Browser	NT AUTHORITY\LOCALSERVICE		Automatic

Managed Service Accounts and gMSAs

Managed Service Accounts (MSAs)

- Limited to a single server
- Remove the need to manage a service account password
- Service Principal name (SPN) registration can be done automatically

Group Managed Service Accounts (gMSAs)

- Extend MSA functionality across multiple servers
- Supported in SQL Server 2014+
- Requires Windows Server 2012+ Active Directory Domain Controller
- Requires Windows Server 2012+

Service Account Best Practices

☑ Separate account for each SQL Server service for each server

☑ Use virtual service accounts, managed service accounts, or group managed service accounts

☑ Do not grant service accounts local administrator permissions

Windows Server Configuration

Antivirus Best Practices

- Antivirus Software adds security at the cost of CPU and IO overhead.
- Proper Antivirus scanning exclusions will help in mitigating the overheads and avoid problems in SQL Server.

Data Files

Log Files

Backup files

Trace files .trc and .xel

SQL Server executables

SSAS data directories

Windows Server Configuration

Power Management

OS Power Management impacts how the CPUs work

- Lower clock speeds
- Lower voltage
- Core-parking

Balanced versus High Performance

- For SQL Server workloads, High Performance is recommended

Can be set at the OS and at the BIOS/hardware level

Check periodically – Group Policy Objects (GPOs) may push down the change

Windows Server Configuration

Page File

Page file is an extension of physical memory for Windows OS to use when running low on memory.

Paging is controlled by Windows operating system; SQL Server has no direct control over Paging.

Warning messages in SQL error logs when SQL memory has been paged out.

- *A significant part of sql server process memory has been paged out. This may result in a performance degradation. Duration: 0 seconds. Working set (KB): 1086400, committed (KB): 2160928, memory utilization: 50%*

Increasing Page file size will not improve SQL Server performance.

- Performance will suffer if SQL Buffer Pool memory has been paged out.

Size of Page file.

- Not a consideration for SQL Server workloads or performance.
- Monitor Page File performance counters to determine a more appropriate page file size.

Windows Server Configuration

Windows Server Core

Windows OS without a desktop or GUI components

Only installs necessary server components

Benefits of Windows Server Core:

- Reduced servicing
- Reduced management
- Reduced attack surface area
- Less disk space required for the OS binaries

Questions?

Knowledge Check

What is the Page File size recommendation for SQL Server machines?

True/False: Only data files should be excluded from antivirus exclusion.

What to do when you see the "*A significant part of sql server process memory has been paged out*" messages in SQL Server error logs?

What type of service accounts can be used to have the password managed automatically by the domain controller?

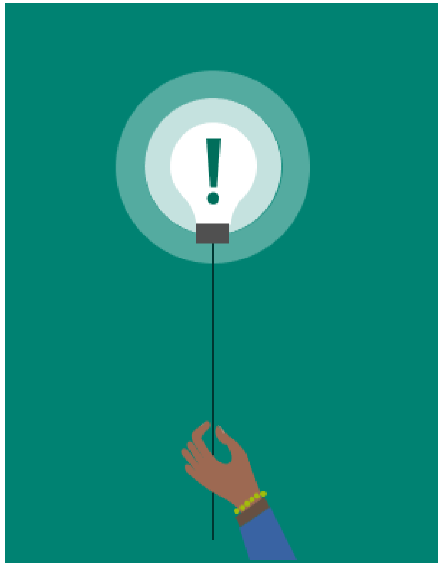
Which version of SQL Server introduced support for Group Managed Service Accounts for failover clusters?

Lesson 2: SQL Server Configuration

Objectives

After completing this learning, you will be able to:

- Explain various SQL Server configuration settings and best practices related to
  - Processor configuration.
  - Memory configuration.
  - Other important configuration settings.



SQL Server Configuration

Tools Used To Configure A SQL Server Instance

- SQL Server Management Studio
- SQL Server Configuration Manager
- sp_configure
- ALTER SERVER CONFIGURATION (transact-SQL)
- Registry

SQL Server Configuration

Processor Configuration Settings And Best Practices

Affinity Mask

- Assigns CPUs for SQL Server use
- Set via sp_configure or Alter Server Configuration
- Only required in specific scenarios

Max Degree of Parallelism (MAXDOP)

- Maximum number of processors that are used for the execution of a query in a parallel plan. This option determines the number of threads that are used for the query plan operators that perform the work in parallel.

Cost Threshold for Parallelism

- Queries with a cost that is higher than this value will use parallelism
- Only required when dealing with excessive parallelism

Max Worker Threads

- Number of threads SQL Server can allocate
- Recommended value is 0. SQL Server will dynamically set the Max based on CPUs and CPU architecture. (512 + (Processors -4) *16)

SQL Server Configuration

MAXDOP Setting and Best Practices

Best Practice Recommendations (documented in): KB 2806535

Server with single NUMA node	Less than or equal to 8 logical processors	Keep MAXDOP at or below # of logical processors
Server with single NUMA node	Greater than 8 logical processors	Keep MAXDOP at 8
Server with multiple NUMA nodes	Less than or equal to 16 logical processors per NUMA node	Keep MAXDOP at or below # of logical processors per NUMA node
Server with multiple NUMA nodes	Greater than 16 logical processors per NUMA node	Keep MAXDOP at half the number of logical processors per NUMA node with a MAX value of 16

SQL Server Configuration

Memory Settings and Best Practices

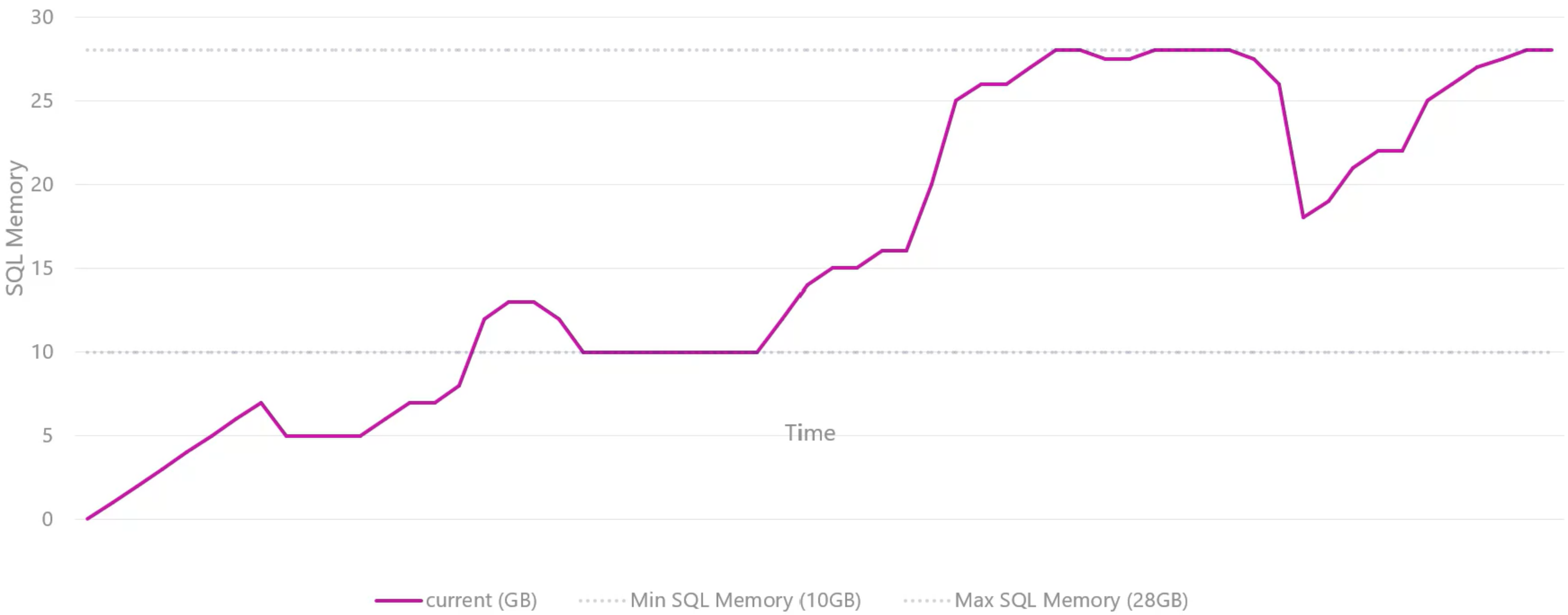
Min Server Memory and Max Server Memory

- Controls most of the memory allocated by SQL Server
- Can be left at default; however, most recommendations are to set to Max Server Memory to allow for memory to be available for all other services on the system
- Cluster Considerations
    - How many instances may run on one node at any given time?

Lock Pages in Memory

- Used to help ensure that SQL Server memory is not paged out

Dynamic Memory Management



SQL Server Configuration

Other important configuration settings

Backup Compression Default

- All backups taken on the SQL Server instance will be compressed.

Priority Boost

- Raises the priority of sqlservr.exe at the OS level.
- Leave at 0 unless directed by Microsoft Support.

Lightweight Pooling

- Enables Fiber mode. Leave to 0 unless directed by Microsoft Support.

Recovery Interval

- The maximum ideal time, in seconds, that SQL Server will spend during the recovery process for a given database after restart, crash or failover.

Optimize for ad-hoc workloads

- Avoid plan cache pollution with lots of Adhoc SQL statements.

SQL Server Configuration Manager

SQL Server Service and Network Configuration

Changing the Accounts Used by the Services

Change startup parameters (such as to add trace flags)

Enable Availability Groups and Filestream features

Manage Server & Client Network Protocols

- Enable/Disable specific network protocol: TCP/IP, Named Pipes or Shared Memory
- Change the order in which protocols are used
- Force protocol encryption
- Define and manage server aliases

SQL Server Configuration

ALTER SERVER CONFIGURATION

Processes affinity configuration and to replace the affinity mask sp_configure options.

Extends the usage to control diagnostic logging and failover clustering properties.

Extends the usage to control the Buffer Pool Extensions feature with this command.

Allows for the SOFT NUMA option to control Soft NUMA configuration.

Allows the MEMORY_OPTIMIZED option to enable or disable memory-optimized tempdb metadata and hybrid buffer pool.

Demonstration

ALTER SERVER CONFIGURATION command

Questions?

Knowledge Check

What is an easy way to find out which settings in sp_configure which can be changed without recycling SQL Service?

Which SQL Server tool can be used to enforce TCP/IP protocol encryption?

What is the recommended value for Priority Boost configuration option?

What is the recommend value for MAXDOP server configuration option for a server with single NUMA node and 12 logical processors?

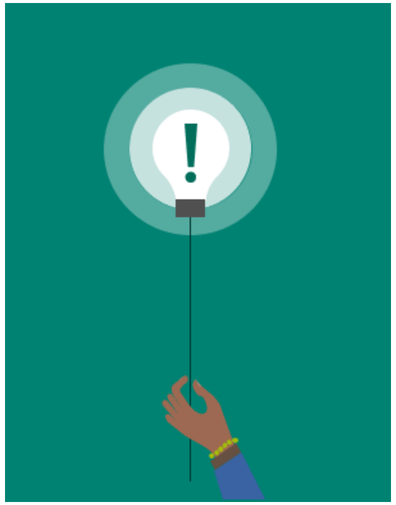
If you leave the Max_Worker_threads option to its default setting of 0, how many threads will SQL Server use?

Lesson 3: Database Configuration

Objectives

After completing this learning, you will be able to:

- Explain various configuration settings available at the database level.
- Describe the new DATABASE SCOPED CONFIGURATION command.



Database files and filegroups

Database files

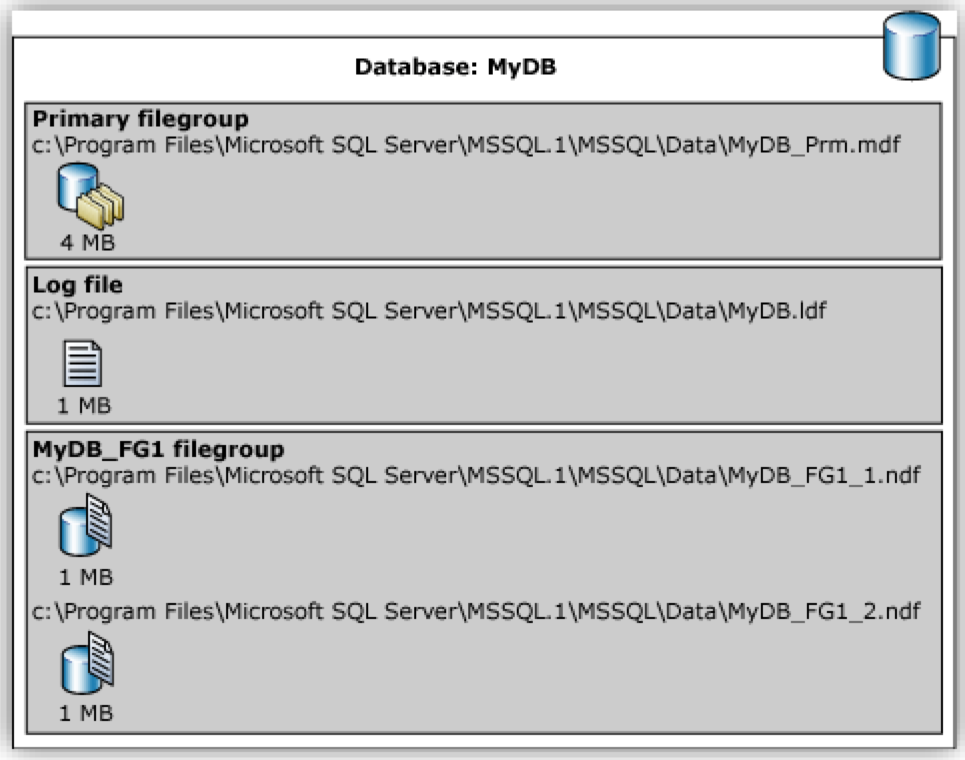
A database is composed by at least two operating system files:

Data files

- Contain database objects and data
- First data file is called primary data file. This file has a .mdf extension
- A database may have additional data files, known as secondary data files. They use .ndf extension
- Can be grouped together in filegroups for allocation and administration purposes

Log file

- Contain Log Records and entries are sequenced



Database: MyDB

Primary filegroup
c:\Program Files\Microsoft SQL Server\MSSQL.1\MSSQL\Data\MyDB_Prm.mdf
4 MB

Log file
c:\Program Files\Microsoft SQL Server\MSSQL.1\MSSQL\Data\MyDB.ldf
1 MB

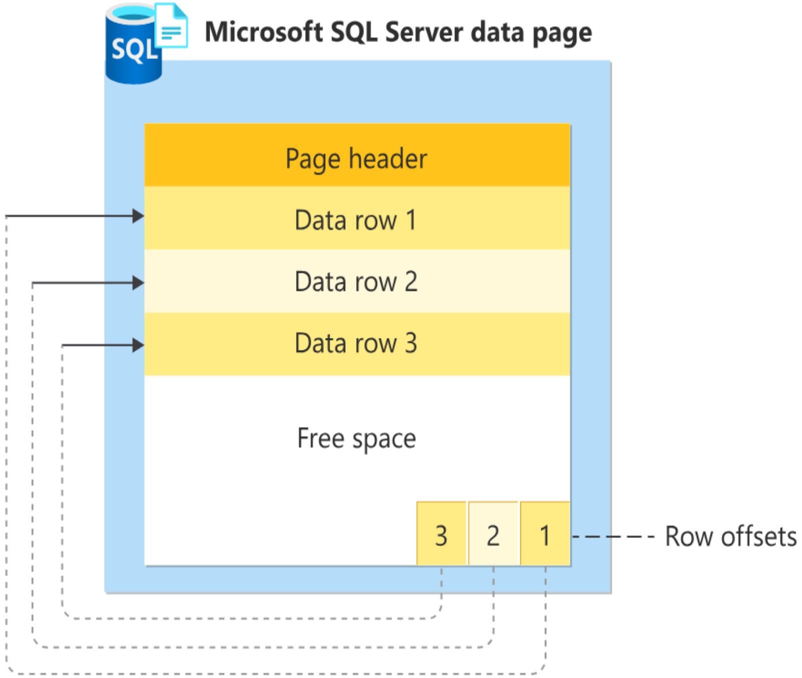
MyDB_FG1 filegroup
c:\Program Files\Microsoft SQL Server\MSSQL.1\MSSQL\Data\MyDB_FG1_1.ndf
1 MB
c:\Program Files\Microsoft SQL Server\MSSQL.1\MSSQL\Data\MyDB_FG1_2.ndf
1 MB

Pages and Extents architecture

A data page is the fundamental unit of data storage in SQL Server.

- The disk space allocated to a data file (.mdf or .ndf) is logically divided into pages.
- Each page is 8 KB in size
- Pages are numbered contiguously from 0 to n.
- Disk I/O operations are performed at the page level.

Extents are a collection of eight physically contiguous pages (64KB) and are used to efficiently manage the pages.



Database Configuration

Database Configuration Settings Categories

- General
- File/Filegroups
- Options
- Change Tracking
- Transaction Log Shipping
- Mirroring

Database Configuration

General Database Configuration Settings

Collation

- Governs how SQL Server sorts and compares data.

Recovery Model

- Governs how transactions are stored in the transaction log.

Compatibility Level

- Sets database functionality and behaviors to the SQL Server level specified.

Containment Type

- Determines if a database is partially contained.

Database Configuration

Database AUTO Configuration Settings

Auto Close

- Shuts down the database cleanly and frees resources after the last user exits

Auto Shrink

- Allows for the periodic shrinking of database files
- If turned on, this can cause an "accordion effect". Generally recommended to be turned off

Auto Create Statistics

- Determines whether a database automatically creates missing optimization statistics

Auto Create Incremental Statistics

- Update statistics for only a specific partition

Auto Update Statistics

- Automatic update of out-of-date statistics

Auto Update Statistics ASYNC

- Updates statistics asynchronously

Database Configuration

Database State Configuration Settings

Database State

- Online, Offline, Restoring, Recovery Pending, Suspect, and Emergency

Restricted Access

- Specifies which users may access the database (Multiple, Single, and Restricted)

Encryption Enabled

- Determines whether a database is enabled for encryption

Read Only

- Make the database read only

Database Configuration

Other Database Configuration Options

Parameterization

- Determines how parameterization of queries will be handled (SIMPLE versus FORCED)

Page Verify

- Defines the SQL Server mechanism of verifying page consistency when the page is written to disk and when it is read again from disk

Delayed Durability

- Accomplished using asynchronous log writes to disk

Target Recovery Time

- Enables Indirect Checkpoint

Database Configuration

DATABASE SCOPED CONFIGURATION

Implement some of the settings at the database level, which were earlier configurable only at the instance level. These are also customizable on Always On secondary replicas.

- CLEAR PROCEDURE_CACHE
- MAXDOP
- LEGACY_CARDINALITY_ESTIMATION
- PARAMETER_SNIFFING
- QUERY_OPTIMIZER_HOTFIXES
- IDENTITY_CACHE
- VERBOSE_TRUNCATION_WARNINGS
- LAST_QUERY_PLAN_STATS

```sql
SELECT * From sys.database_scoped_configurations;
```

Demonstration

ALTER DATABASE SCOPED CONFIGURATION command

SQL Server System Databases

master

- Records all the system-level information for an instance of SQL Server.
- Contains metadata about other databases, logins, and configuration settings.

model

- Serves as the template for all databases created on the SQL Server instance.
- Modifications made to the model database apply to new databases.

msdb

- Used by SQL Server Agent for scheduling alerts and jobs.
- Stores information related to maintenance plans, and other administrative tasks.

tempdb

- Workspace for holding temporary objects or intermediate result sets.
- Used for sorting, temporary tables, and other temporary storage needs.

“Hands-free” tempdb

Pre-SQL 2016

1 file = PFS, GAM, SGAM contention

Add multiple files

Trace flags 1117 and 1118

SQL Server 2016

SQL 2016 setup automatically adds multiple files

Trace flags not required by SQL Server 2016 as

Autogrow and uniform default for TempDB

SQL Server 2019

PFS concurrency

Now system table pages become hotspot

Tempdb metadata optimization ON

SGAM and GAM contention remain

SQL Server 2022

SGAM and GAM concurrency

Latch contention gone

Questions?

Knowledge Check

Which version of SQL Server first introduced the ALTER DATABASE CONFIGURATION SET MAXDOP option?

What is the recommended setting for the PAGE_VERIFY database option?

What are the recommended and default settings for the AUTO_CREATE_STATISTICS and AUTO_UPDATE_STATISTICS options?

True/False: SQL Server DBAs can change the database state value from Emergency to Online in the Database Properties in SSMS.

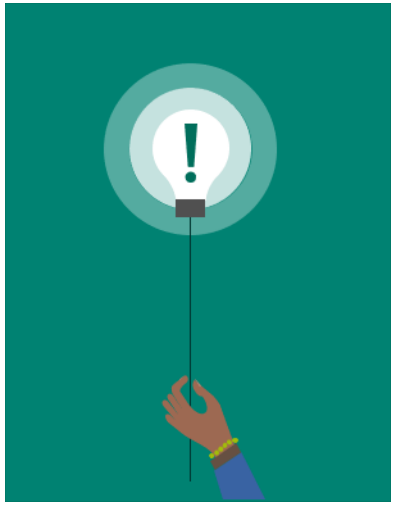
Which database option allows updating statistics for a specific partition?

Lesson 4: Database Maintenance

Objectives

After completing this learning, you will be able to:

- Explain various database maintenance activities such as index defragmentation, statistics maintenance, DBCC Checks.
- Explain the differences between index rebuild and index reorganize.
- Describe smart index maintenance.



Database Maintenance

Checklist

Data and Log File Management

Index Maintenance

- Reorganize and Rebuilding Indexes
- Online Index Maintenance

Statistics Maintenance

Integrity Checks

Smart Maintenance

- Maintenance Plans
- Custom solution

Database Maintenance

Database File Size Management

Monitor available space in data and log files

Adjust auto growth settings on data and log files

- Fixed Size Growth (Recommended)
- Percentage Growth
- Enable Instant File Initialization to reduce impact of autogrowth
- Defragment database file system if lots of autogrowth events have occurred

Monitor Virtual Log File (VLF) Fragmentation

- Monitor with the sys.dm_db_log_stats dynamic management view.

Shrinking database and log files

- Not recommended as a regular maintenance task
- Don’t forget to defragment indexes after shrinking database files

Clustered vs Nonclustered Indexes

An index is an on-disk structure associated with a table or view that speeds retrieval of rows.

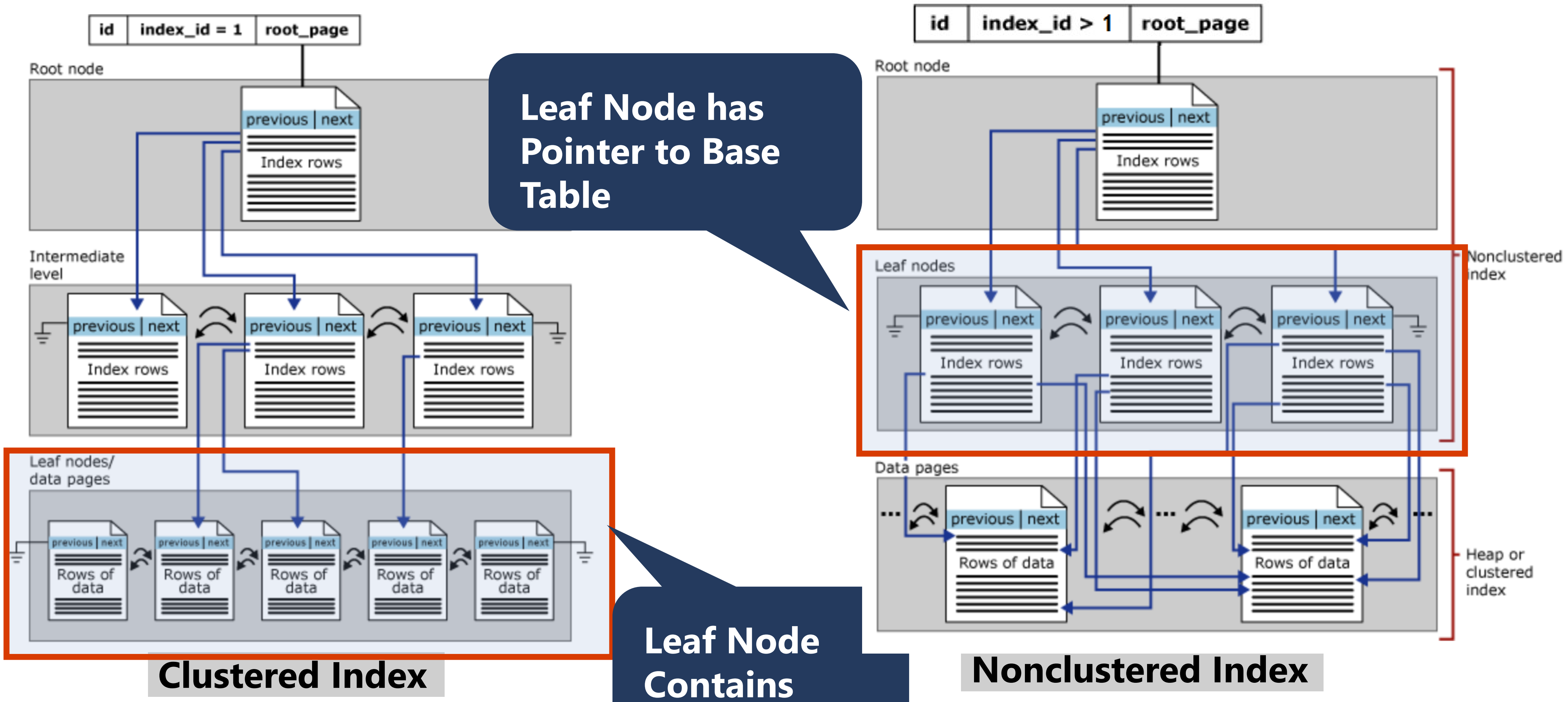
Clustered Indexes

- Defines the order in which data is physically stored in a table.
- Table data can be sorted in only one way.
- Leaf level has data rows stored with index.
- When a table has a clustered index, the object is called clustered table.
- Cluster key is added to nonclustered index (as the pointer), keep it as narrow as possible.

Non-clustered Indexes

- Separate structure from base table.
- Contains a pointer back to base table called:
  - Row ID (RID when base table is HEAP)
  - Key   (KEY when base table is Clustered)
- "Skinny" data structure as it contains a subset of base table only.
- To by-pass index key limits (1,700 bytes) ,non-key columns can be added to leaf level.
- As Leaf level contains fewer columns than base table, the non-clustered index uses fewer pages than the corresponding base table.

Comparing Clustered and Nonclustered indexes



Leaf Node has Pointer to Base Table

Leaf Node Contains Data Pages

Clustered Index

Nonclustered Index

Fragmentation

A fragmented table/Index is when some of its data pages point to pages that are not in sequence.

Logical fragmentation

- Occurs when leaf level pages are not physically corresponding to the logical order of the index:
  - Pages are not in the most efficient order for scanning purposes.
- Limits the efficiency of read-ahead scans, but not seeks.

Page density

- How full a page is when a rebuild/reorganization occurs.
- The fuller a page is, the more likely page splits occur when data is modified.
- The less full a page is, the more wasted space in the buffer pool when reading pages.

Database Maintenance

Index Fragmentation and Maintenance

Types of Index Fragmentation

- Internal Fragmentation
- Logical (aka External) Fragmentation

Monitor index fragmentation

- sys.dm_db_index_physical_stats data management function

Avoid Fragmentation

- Page Splits and Fill Factor

Address index fragmentation

- Index Reorganize versus Index Rebuild
- CREATE INDEX...WITH (DROP_EXISTING=ON)

Online Index Rebuild

Resumable Online Index Rebuild

Database Maintenance

Statistics Maintenance

Statistics Maintenance is important

- For good query plans and optimal performance

Two types of Statistics - Index Statistics and Column Statistics

Statistics sample size is important

Automatic Statistics Update

- 20% threshold to kick in automatic update of statistics
- Trace Flag 2371 (enabled by default)

Index Rebuild will update statistics associated with the index

Manual Statistics Update

- UPDATE STATISTICS command
- Sp_updatestats

Incremental Statistics

- Creates, stores and refreshes statistics on specific partitions thus reducing maintenance time

Demonstration

Viewing index fragmentation

Database Maintenance

Database Integrity Checks

Why database integrity checks are important

- Databases may be come corrupt for many reasons
- Recovery relies on proactive detection and mitigation

Commands to perform database integrity checks

- DBCC CHECKDB (most used)
- DBCC CHECKALLOC
- DBCC CHECKCATALOG
- DBCC CHECKTABLE

Repair Options

- REPAIR_FAST
- REPAIR_REBUILD
- REPAIR_ALLOW_DATA_LOSS

Database Maintenance

Smart Maintenance

Maintenance Plans

- Backup database and log files
- Check database integrity
- Reorganize index
- Update statistics
- Shrink database
- Rebuild index
- Maintenance cleanup

Index Maintenance

- Identifying and removing physical index fragmentation

LAB

Statistics Update

- Observing Automatic statistics update
- Updating Statistics by executing ALTER INDEX

LAB

Questions?

Knowledge Check

Which new dynamic management function was introduced in SQL Server 2017 to monitor VLF fragmentation?

What is the disadvantages of shrinking database and transaction log files?

Starting which version of SQL Server, trace flag 2371 (for changing auto statistics threshold) is enabled by default?

What commands can be used to update statistics manually on a specific object or an entire database?

What enhancements were made to DBCC CHECKDB in SQL Server 2016?

Which feature can be enabled to reduce the impact of large file size autogrowth?

Microsoft