Module 4

Memory usage

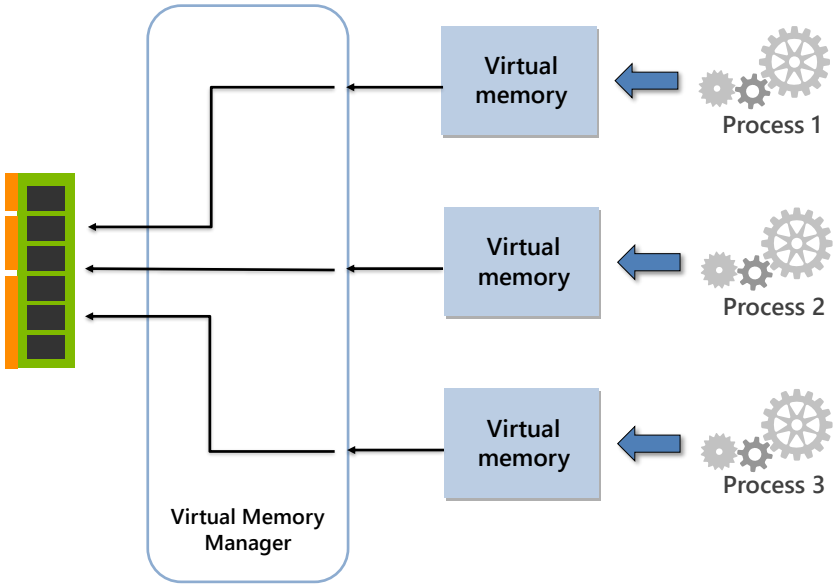
Module Overview

- Windows memory
- SQL Server memory
- In-Memory OLTP

Lesson: Windows memory

- Physical vs. virtual memory
- Virtual Address Space

Physical vs. Virtual Memory



Memory Management Architecture Guide
https://docs.microsoft.com/en-us/sql/relational-databases/memory-management-architecture-guide

Virtual Address Space, VAS

- VAS, abstraction layer between application and physical memory
- VAS size
  - 8 TB before Windows 2012
  - 128 TB Windows 2012 and later
  - Theoretical limit is 16 Exabyte, but OS sets limitation

Virtual address space
https://en.wikipedia.org/wiki/Virtual_address_space

Lesson: SQL Server memory

- SQL Server memory configuration
- SQL Server memory models
- SQL Server memory architecture

SQL Server memory configuration

- Min Server Memory:
  - Memory level that, once reached, will not be released
- Max Server Memory:
  - Maximum amount of memory that SQL Server will request
  - Various formulas exists, for how much to leave to OS in dedicated machine:
    - Leave 1 GB for every 4 GB memory until 16 GB. And 1 GB for every 8 GB after that.
    - Leave 4 GB or 10% of the memory in the machine, whichever is the largest.
- Signs of ”not enough memory”
  - Significant waits for
    - PAGEIOLATCH (reading data from disk)
    - RESOURCE_SEMAPHORE (memory grants for sorts, hash, …)
    - RESOURCE_SEMAPHORE_QUERY_COMPILE (producing execution plans)

Memory Management Architecture Guide
https://docs.microsoft.com/en-us/sql/relational-databases/memory-management-architecture-guide

sp_configure (Transact-SQL)
https://docs.microsoft.com/en-us/sql/relational-databases/system-stored-procedures/sp-configure-transact-sql

Server memory configuration options
https://docs.microsoft.com/en-us/sql/database-engine/configure-windows/server-memory-server-configuration-options

Does My SQL Server Need More Memory?
https://www.erikdarlingdata.com/sql-server/does-my-sql-server-need-more-memory/

Setting max server memory (includes link to Jonathan Kehayias’ blog post)
https://sqlblog.karaszi.com/setting-max-server-memory/

Memory Dangerously Low or Max Memory Too High
https://www.brentozar.com/blitz/max-memory/

SQL Server Memory Models

	Conventional	Locked	Large
OS Page Size	4 kB	4 kB	2 MB
Static/Dynamic	Dynamic	Dynamic	Static Memory is committed at startup Rarely used
Lock Pages In Memory (LPIM) for service account	Not set	Set	Required
Prerequisites			Enterprise Edition Trace Flag 834 Trace flag 874 if col-store ix are used

Demo Locked pages

SQL Server memory models
https://techcommunity.microsoft.com/t5/core-infrastructure-and-security/sql-server-memory-models-part-i/ba-p/370321

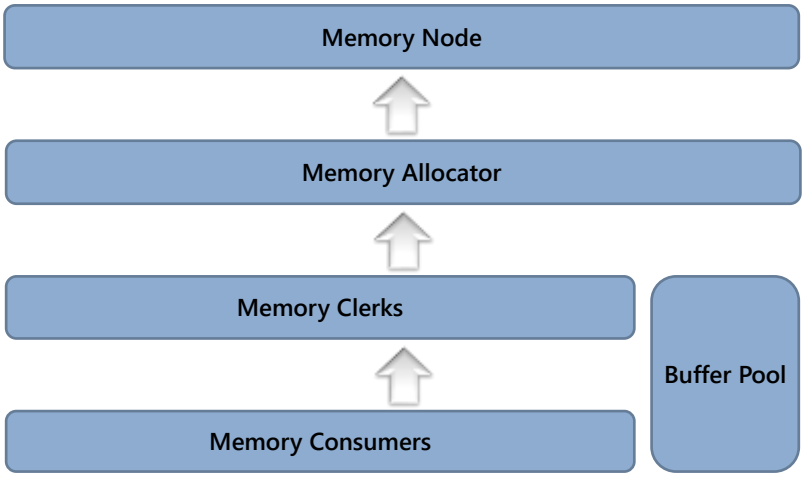
Enable the Lock Pages in Memory Option (Windows)
https://docs.microsoft.com/en-us/sql/database-engine/configure-windows/enable-the-lock-pages-in-memory-option-windows

Configuration: Lock Pages in Memory (LPIM)
https://www.brentozar.com/training/fundamentals-database-administration/lock-pages-memory-lpim-6m/

SQL Server and Large Pages Explained….
https://docs.microsoft.com/en-us/archive/blogs/psssql/sql-server-and-large-pages-explained

Memory video with Bob Ward (1 hour 17 minutes)
https://www.youtube.com/watch?v=CRAx73LiXTc

SQL Server Memory Architecture



Demo Memory clerks

Monitoring Memory Clerk and Buffer Pool Allocations in SQL Server
https://www.sqlshack.com/monitoring-memory-clerk-and-buffer-pool-allocations-in-sql-server/

sys.dm_os_memory_clerks (Transact-SQL)
https://docs.microsoft.com/en-us/sql/relational-databases/system-dynamic-management-views/sys-dm-os-memory-clerks-transact-sql

Memory grants

- Some operators in execution plan need explicit memory grants before the query starts executing
  - Sort
  - Hash
- SQL Server estimates how much memory will be needed
  - The operator will spill to disk in tempdb if it underestimated
  - You waste memory if it overestimated
- Wait stats when waiting for grant: RESOURCE_SEMAPHORE
- Query hints:
  - MAX_GRANT_PERCENT
  - MIN_GRANT_PERCENT

Understanding SQL server memory grant
https://techcommunity.microsoft.com/t5/sql-server-blog/understanding-sql-server-memory-grant/ba-p/383595

Memory Grants: The mysterious SQL Server memory consumer with Many Names
https://techcommunity.microsoft.com/t5/sql-server-support-blog/memory-grants-the-mysterious-sql-server-memory-consumer-with/ba-p/333994

Starting SQL: Query Memory Grants In SQL Server Execution Plans
https://www.erikdarlingdata.com/starting-sql-memory-grants-in-execution-plans/

SQL Server Community Tools: How To Use sp_WhoIsActive To Get Memory Grant Information
https://www.erikdarlingdata.com/sql-server-community-tools-how-to-use-sp_whoisactive-to-get-memory-grant-information/

Troubleshooting SQL Server With High Memory Grants using free monitoring tool
https://ajaydwivedi.com/performance-tuning/troubleshooting-sql-server-with-high-memory-grants/

Lesson: In-Memory OLTP

- What Is In-Memory OLTP?
- Memory-Optimized tables
- Natively Compiled stored procedures

What Is In-Memory OLTP?

- In-Memory OLTP tables:
- Transactional tables stored in-memory
- Access same as disk-based tables
- Fully transactional
- Durable
- Very low latency

In-Memory OLTP overview and usage scenarios
https://docs.microsoft.com/en-us/sql/relational-databases/in-memory-oltp/overview-and-usage-scenarios

Plan your adoption of In-Memory OLTP Features in SQL Server
https://docs.microsoft.com/en-us/sql/relational-databases/in-memory-oltp/plan-your-adoption-of-in-memory-oltp-features-in-sql-server

Transact-SQL Constructs Not Supported by In-Memory OLTP
https://docs.microsoft.com/en-us/sql/relational-databases/in-memory-oltp/transact-sql-constructs-not-supported-by-in-memory-oltp

Memory-Optimized tables

- Durable Memory-Optimized Tables:
  - ACID compliant
  - Persisted to disk
- Non-Durable Memory-Optimized Tables:
  - NOT ACID compliant
  - Not persisted to disk (server crash = data loss)
  - No disk IO

Table and Row Size in Memory-Optimized Tables
https://docs.microsoft.com/en-us/sql/relational-databases/in-memory-oltp/table-and-row-size-in-memory-optimized-tables

Natively Compiled Stored Procedures

- Compiled at create time
- Improved performance
- Support for atomic blocks and NOT NULL parameter constraints

Demo Memory optimized tables

Native Compilation Advisor
https://docs.microsoft.com/en-us/sql/relational-databases/in-memory-oltp/native-compilation-advisor

Supported Features for Natively Compiled T-SQL Modules
https://docs.microsoft.com/en-us/sql/relational-databases/in-memory-oltp/supported-features-for-natively-compiled-t-sql-modules

Creating Natively Compiled Stored Procedures
https://docs.microsoft.com/en-us/sql/relational-databases/in-memory-oltp/creating-natively-compiled-stored-procedures

Lab 4: Memory usage

- Ex 1: Set max server memory
- Ex 2: Work with query that has "memory issues"

Estimated Time: 30 minutes