SQLintersection

Session: Wednesday, 10:00am-11:00am

Introduction to Performance Troubleshooting Using Wait Statistics

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immerse yourself in sql server

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- **Instructor-led training (US, UK, Ireland, Australia), consulting (anything you need)**
- **Online training:** pluralsight hardcore developer training **http://pluralsight.com/**
- **Get our bi-weekly newsletter: http://www.sqlskills.com/Insider**

Reminder: Intersect with Speakers and Attendees

- **Tweet tips and tricks that you learn and follow tweets posted by your peers!**
  - □ Follow: #SQLintersection and/or #DEVintersection
- **Join us – Wednesday Evening – for SQLafterDark**
  - □ Doors open at 7:00 pm
  - □ Trivia game starts at 7:30 pm
    - *Winning team receives something fun!*
  - □ Raffle at the end of the night
    - *Lots of great items to win including a seat in a SQLskills Immersion Event!*
  - □ The first round of drinks is sponsored by SentryOne and SQLskills

Overview

- **Very common to see 'knee-jerk' performance tuning where someone jumps to a conclusion based on superficial analysis of performance data**
- **Interpreting wait statistics is not hard, but needs practice**

- **We're going to cover**
  - Introduction
  - Thread lifecycle
  - Waits and wait times
  - DMVs
  - Some common wait types

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Interpreting the Data

- **Don’t do ‘knee-jerk’ performance troubleshooting**
  - Work through the data to see what may be the root cause
  - You’ll end up spending less time overall
- **Proficiency in using wait statistics data comes from:**
  - Retrieving the data correctly
  - Understanding what common wait types mean
  - Recognizing patterns
  - Avoiding inappropriate Internet advice
  - Practice!
- **Better is to have a series of snapshots of wait statistics over time**

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What are Waits?

- **The term ‘wait’ means that a thread running on a processor cannot proceed because a resource it requires is unavailable**
  - It has to wait until the resource is available
- **The resource being waited for is tracked by SQL Server**
  - Each resource maps to a wait type
- **Example resources that may be unavailable:**
  - A lock (LCK_M_XX wait type)
  - A data file page in the buffer pool (PAGEIOLATCH_XX wait type)
  - Results from part of a parallel query (CXPACKET wait type)
  - A latch (LATCH_XX wait type)

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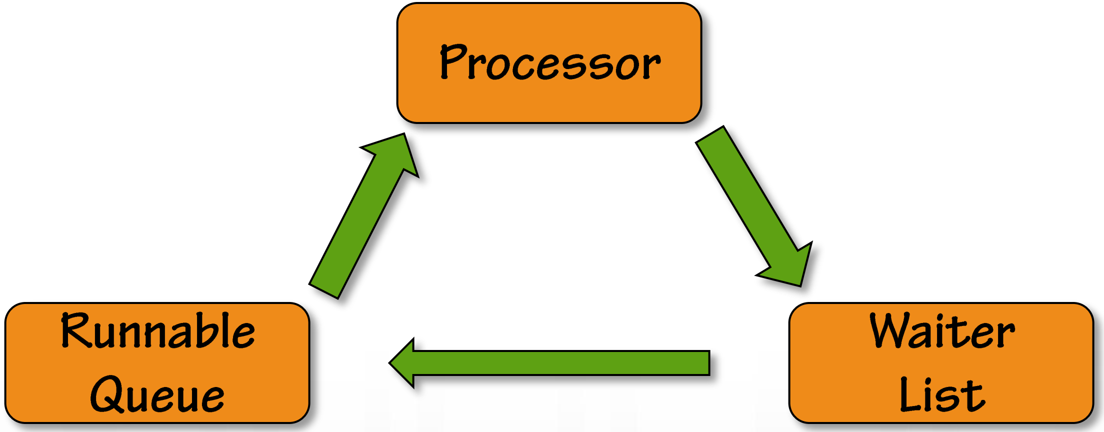
Thread Scheduling

- **SQL Server performs its own thread scheduling**
  - Called non-preemptive scheduling
  - More efficient for SQL Server than relying on Windows scheduling
  - Performed by the SQLOS layer of the Storage Engine
- **Each processor core (whether logical or physical) has a scheduler**
  - A scheduler is responsible for managing the execution of work by threads
  - Schedulers exist for user threads and for internal operations
  - Use the sys.dm_os_schedulers DMV to view schedulers
- **When SQL Server has to call out to the OS, it must switch the calling thread to preemptive mode so the OS can interrupt it if necessary**

Components of a Scheduler

- All schedulers are composed of three 'parts'



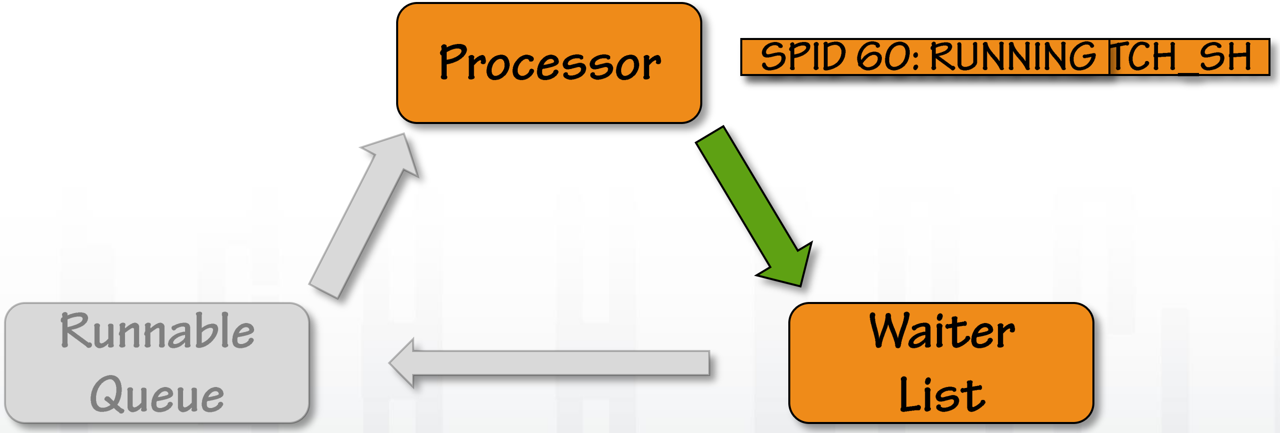
- Threads transition around these parts until their work is complete

Thread States

- **A thread can be in one of three states when being actively used as part of processing a query**
- **RUNNING**
  - The thread is currently executing on the processor
- **SUSPENDED**
  - The thread is currently on a Waiter List waiting for a resource
- **RUNNABLE**
  - The thread is currently on the Runnable Queue waiting to execute on the processor
- **Threads transition between these states until their work is complete**

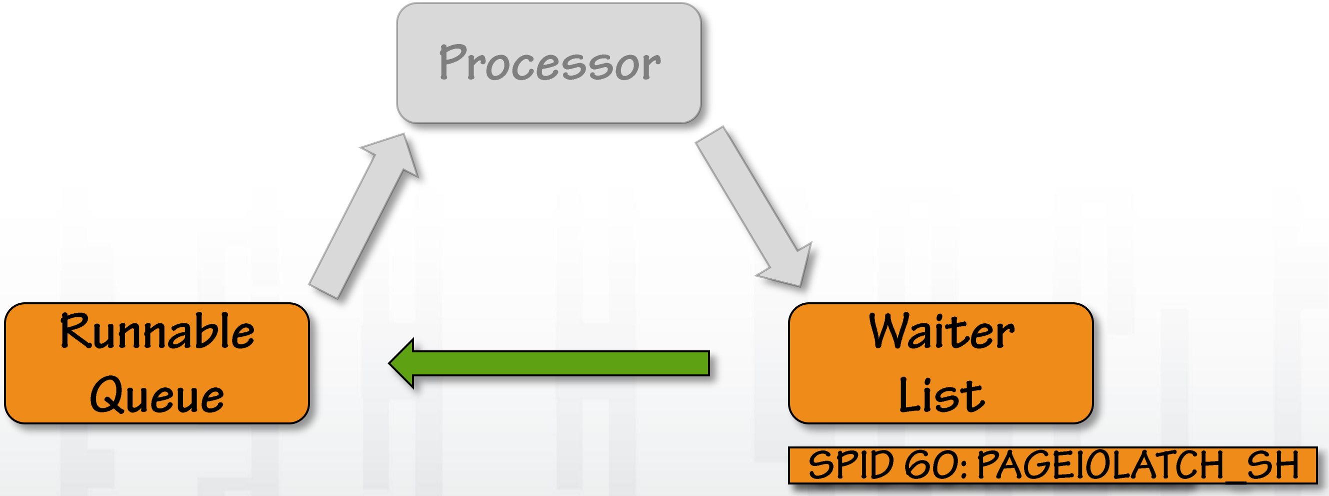
Transition: RUNNING to SUSPENDED

- **A thread continues executing on the processor until it must wait for a resource to become available**
  - The thread's state changes from RUNNING to SUSPENDED
  - The thread has been 'suspended' and moves to a Waiter List



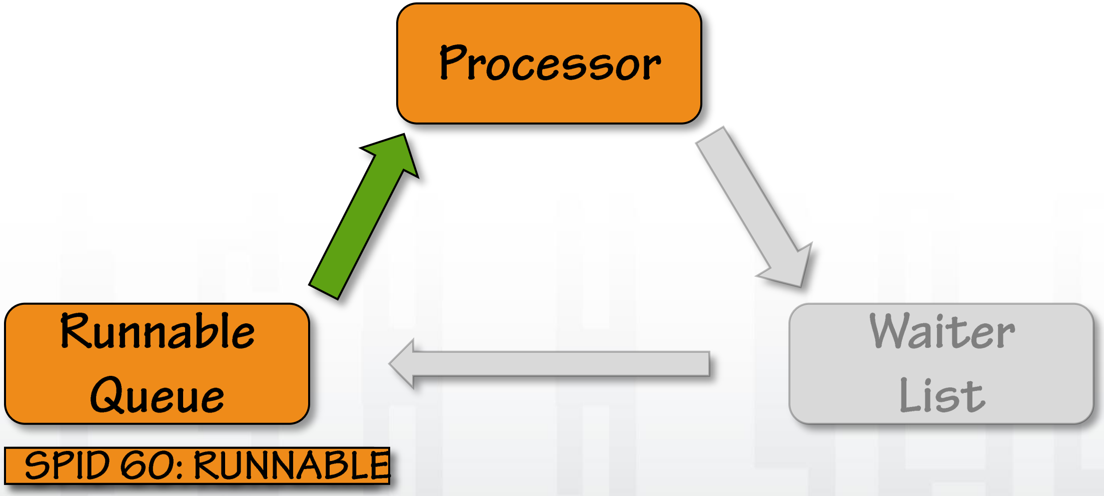
Transition: SUSPENDED to RUNNABLE

- **A thread continues to wait until it is told that the resource is available**
  - The thread's state changes from SUSPENDED to RUNNABLE
  - The thread moves to the Runnable Queue
  - This is called being 'signaled'

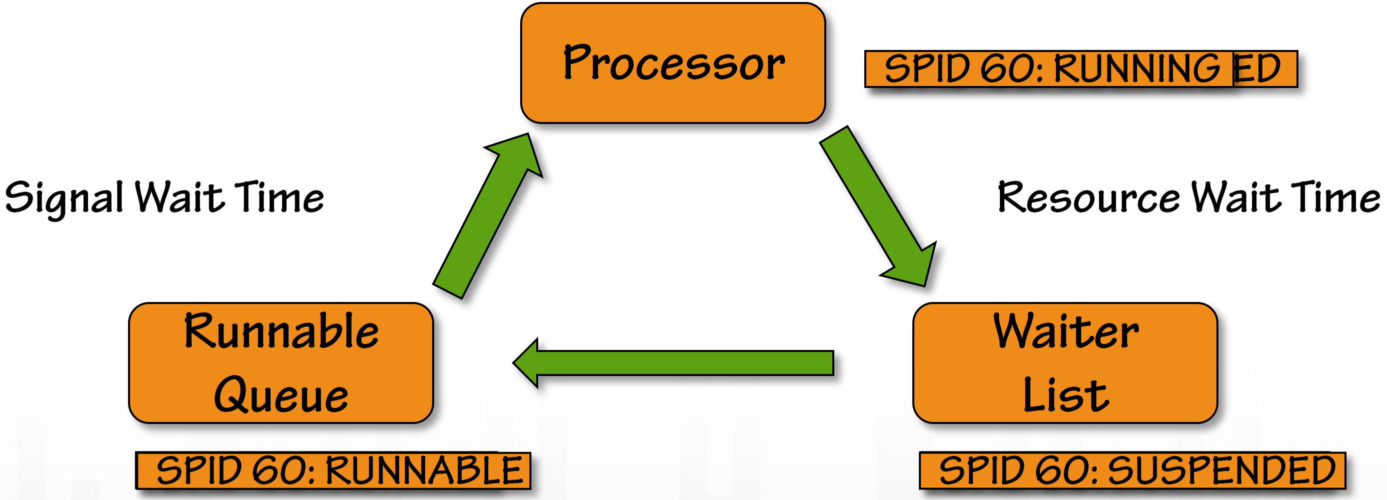


Transition: RUNNABLE to RUNNING

- **The thread waits on the Runnable Queue until it is picked as the next thread when the processor becomes available**
  - The thread’s state changes from RUNNABLE to RUNNING



Wait Times Definition



Wait Time = Resource Wait Time + Signal Wait Time

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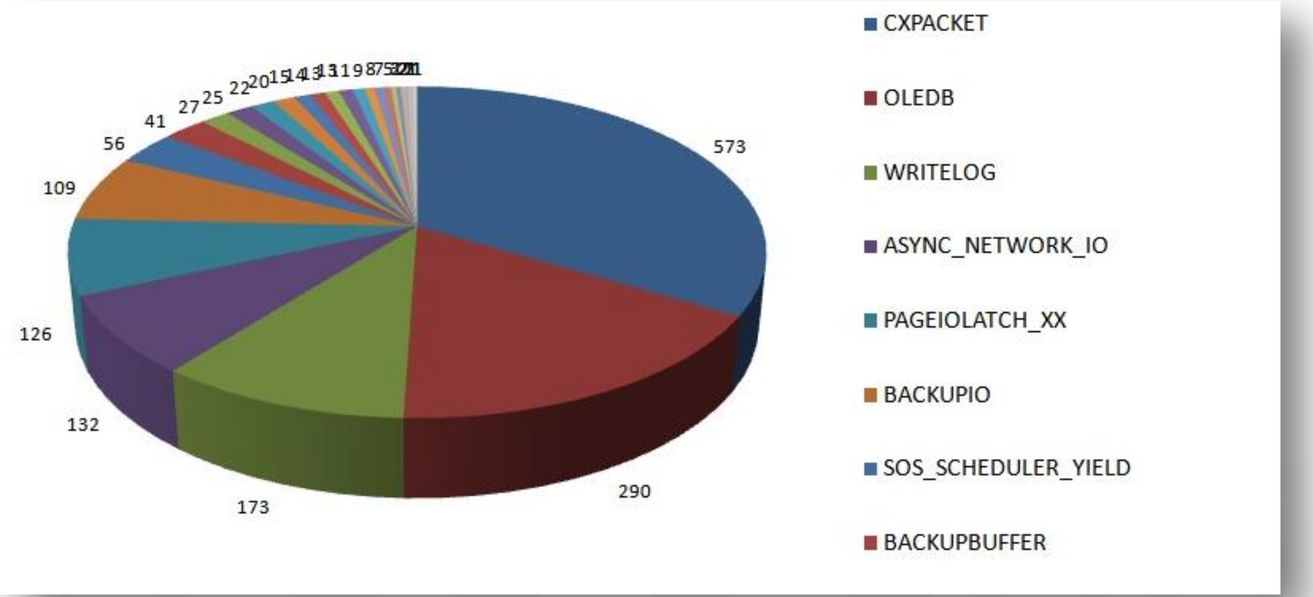
DMVs

- **sys.dm_os_waiting_tasks**
  - Shows all threads that are currently suspended
  - Think of it as the ‘what is happening right now?’ view of a server
    - Usually very first thing to run when approaching a ‘slow’ server
- **sys.dm_os_wait_stats**
  - Shows aggregated wait statistics for all wait types
    - Aggregated since the server started or the wait statistics were cleared
  - Think of this as the ‘what has happened in the past?’ view of a server
- **Need to filter out benign waits and background tasks**
- **Need to use script around each of these (see demos…)**

Top Wait Types

- **Survey results from 1700+ SQL Server instances across Internet**



Source: my blog at http://bit.ly/1n1m1IF

PAGEIOLATCH_XX Wait and Solutions

- **Waiting for a data file page to be read from disk into memory**
  - Common modes to see are SH and EX
- **Do not assume the I/O subsystem or I/O path is the problem**
- **Further analysis:**
  - Determine which tables/indexes are being read
  - Analyze I/O subsystem latencies with sys.dm_io_virtual_file_stats
    - Move the affected data files to faster I/O subsystem?
  - Correlate with CXPACKET waits, suggesting parallel scans
    - Create appropriate nonclustered indexes and/or update statistics
  - Examine query plans for parallel scans and implicit conversions
  - Investigate buffer pool memory pressure and Page Life Expectancy
    - If data volume has increased, consider increasing memory

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PAGELATCH_XX Wait and Solutions

- **Waiting for access to an in-memory data file page**
  - Common modes to see are SH and EX
- **Do not confuse these with PAGEIOLATCH_XX waits**
- **Does not mean add more memory or I/O capacity**
- **Further analysis:**
  - Determine the page(s) that the thread is waiting for access to
  - Classic tempdb contention?
    - Add more tempdb data files, enable trace flag 1118, reduce temp table usage
  - Analyze the table and index structures involved
    - Excessive page splits occurring in indexes
    - Insert-point hotspot in a clustered index with an ever-increasing key

LCK_M_XX Wait and Solutions

- **A thread is waiting for a lock that cannot be granted because another thread is holding an incompatible lock**
- **Do not assume that locking is the root cause**
- **Further analysis:**
  - Follow blocking chain to see what the lead blocking thread is waiting for
  - Use blocked process report to capture info on queries waiting for locks
    - Michael Swart's blog post (http://bit.ly/ki3bYI)
  - Lock escalation from a large update or table scan?
    - Consider a different indexes, snapshot isolation, a different isolation level, or locking hints
  - Something preventing a transaction from releasing its locks quickly?
    - E.g. synchronous DBM/AG, DTC, or log throughput problems

Demo

Insert hotspot and using the waits DMVs

WRITELOG Wait and Solutions

- **Waiting for a transaction log block buffer to flush to disk**
- **Do not assume that log file I/O system has a problem (can be the case)**
- **Do not create additional transaction log files**
- **Further analysis:**
  - Write queue limited to 31/32? Upgrade to 2012+
  - Move the log to a faster I/O subsystem
  - Increase size of transactions to prevent many tiny log block flushes
    - Or used delayed durability in 2014+
  - Reduce logging from unused nonclustered indexes, page splits
  - Potentially split the workload over multiple databases or servers
    - Consider In-memory OLTP in 2014+

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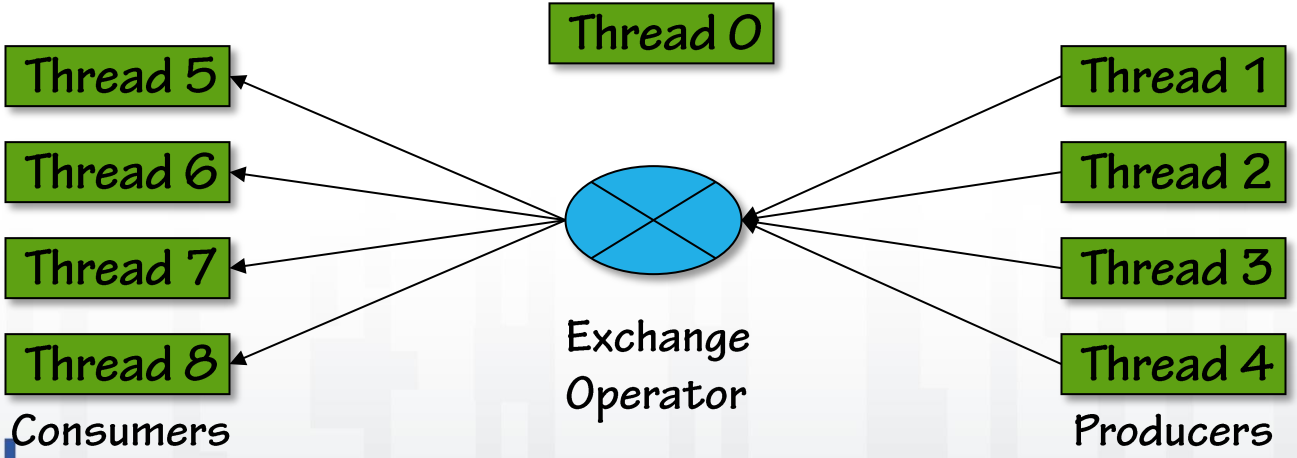
Demo

Slow transaction log

Parallel Threads Example

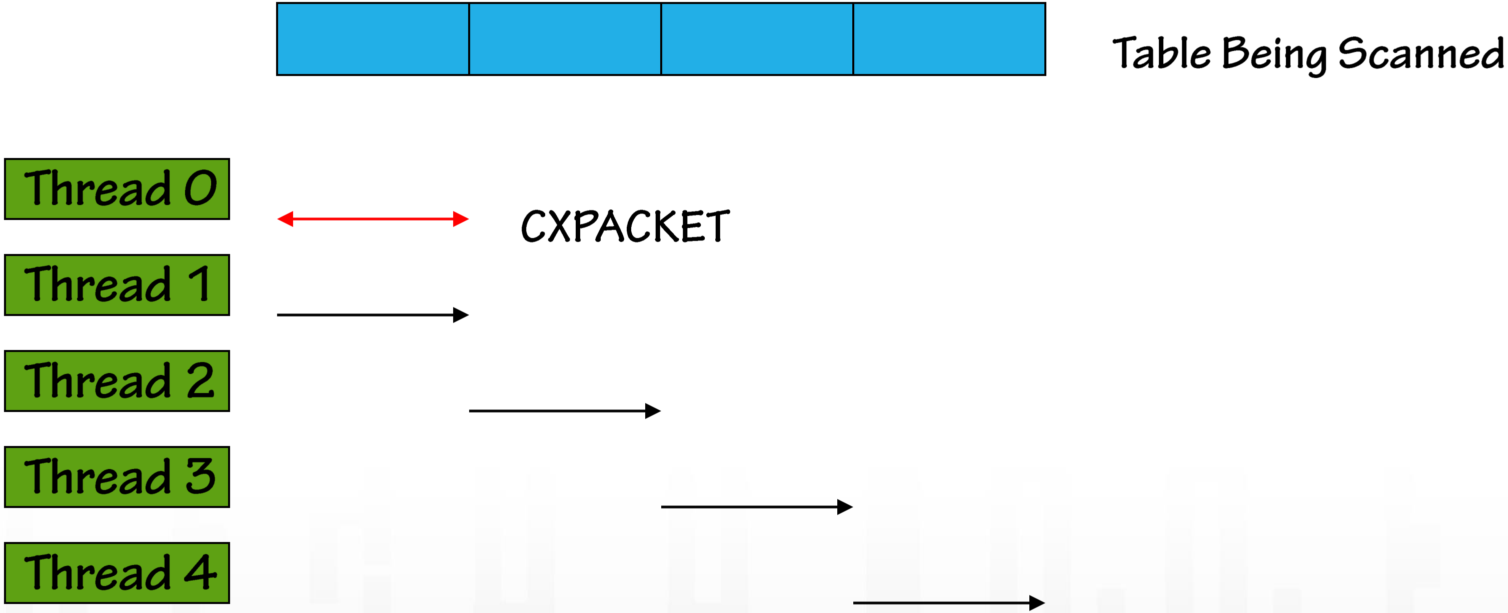
- **In a query plan, you may see the operator, for example**
- **This is a Repartition Streams operation**
  - Uses producer and consumer threads, plus a control thread
- **For a degree-of-parallelism = 4 operation, the threads would look like:**



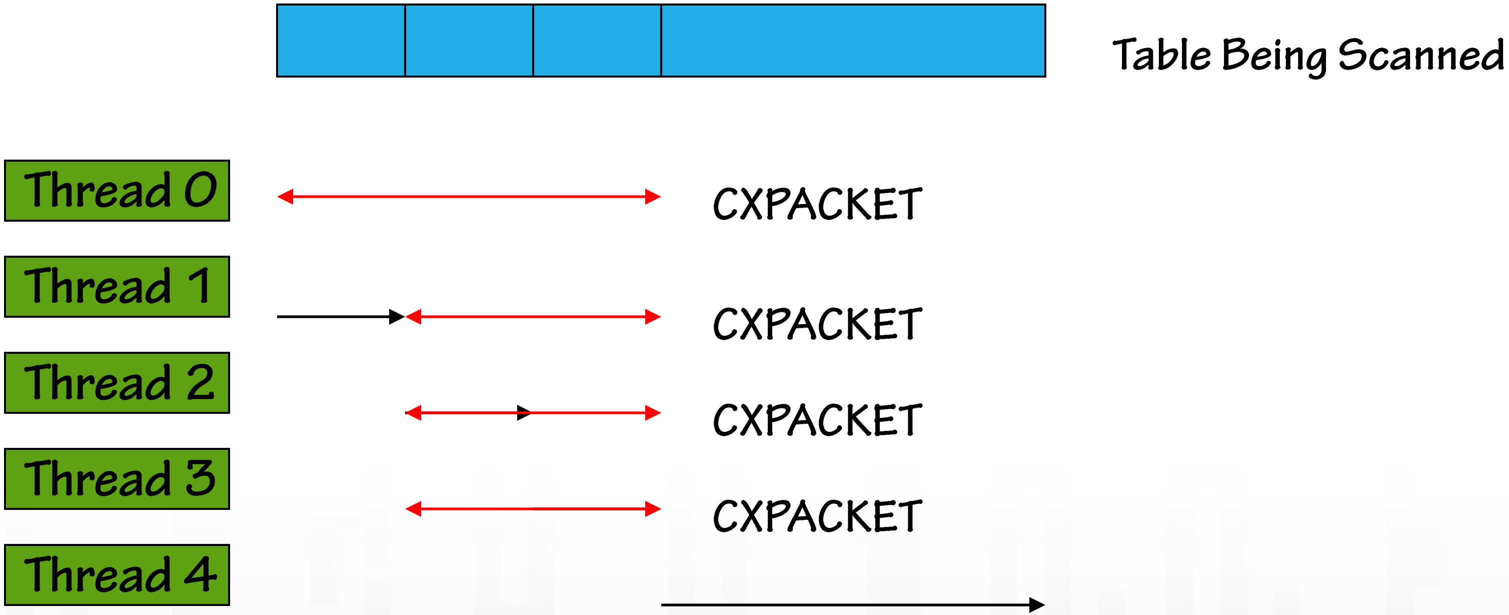
CXPACKET Wait Explanation

- **What does it mean:**
  - Parallel operations are taking place
  - Accumulating very fast implies skewed work distribution amongst threads or one of the workers is being blocked by something
- **Avoid knee-jerk response:**
  - Do not set server-wide MAXDOP to 1, disabling parallelism
- **Further analysis:**
  - Correlation with PAGEIOLATCH_SH waits? Implies large scans
  - Examine CXPACKET query plan to see if the query plans make sense
  - What is the wait type of the non-control parallel thread that is taking too long? (i.e. the thread that does not have CXPACKET as its wait type)

CXPACKET Wait Example (1)



CXPACKET Wait Example (2)



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CXPACKET Wait Solutions

- **Possible root-causes:**
  - Just parallelism occurring (e.g. http://bit.ly/1kPymkZ from CSS)
  - Table scans due to missing nonclustered indexes or incorrect query plan
  - Out-of-date statistics causing skewed work distribution
- **If there is actually a problem:**
  - Make sure statistics are up-to-date and appropriate indexes exist
  - Consider MAXDOP = physical cores per NUMA node, or 8 for non-NUMA
  - Consider MAXDOP for the instance, but beware of mixed workloads
  - Consider MAXDOP for the query or using Resource Governor for MAX_DOP
  - Consider setting 'cost threshold for parallelism' higher than query cost
    - Jon's blog post at http://bit.ly/1rTs9UX

Demo

Parallelism

ASYNC_NETWORK_IO Wait

- **What does it mean:**
  - SQL Server is waiting for a client to acknowledge receipt of sent data
- **Avoid knee-jerk response:**
  - Do not assume that the problem is network latency
- **Further analysis:**
  - Analyze client application code, client app server, network latencies
- **Possible root-causes and solutions:**
  - Usually poorly-coded application that is doing RBAR (Row-By-Agonizing-Row)
    - Very easy to show using a large query and SSMS on same machine as SQL Server
  - Could be from using MARS with large result sets
    - Otherwise look for network hardware issues, incorrect duplex settings, or TCP chimney offload problems (see http://bit.ly/aPzoAx)

Summary: Methodology

- **Gather information about exactly when the performance problem arose and the user-visible characteristics of the problem**
- **Gather information about what changed before the problem arose**
- **Examine the output from sys.dm_os_waiting_tasks**
  - What is happening on the server right now?
- **Examine the output from sys.dm_os_wait_stats**
  - What has happened in the past?
- **Look at the top 3-4 relevant waits**
- **Avoid temptation to knee-jerk and equate symptoms with root-cause**
- **Gather further information from relevant sources to pin-point problems**
  - DMVs, query plans, performance counters, code analysis

Resources

- **Comprehensive waits/latches library**
  - https://www.SQLskills.com/helps/waits
- **Whitepapers:**
  - SQL Server Performance Tuning Using Wait Statistics: A Beginners Guide
    - https://www.sqlskills.com/help/sql-server-performance-tuning-using-wait-statistics/
  - Diagnosing and Resolving Latch Contention on SQL Server
  - Diagnosing and Resolving Spinlock Contention on SQL Server
    - Gnarly links – see our whitepapers page at http://bit.ly/19j0cOd (zero then oh)
- **Blog post categories**
  - https://www.sqlskills.com/blogs/paul/category/wait-stats/ and /latches/ and /spinlocks/
- **Pluralsight:** SQL Server: Performance Tuning Using Wait Statistics

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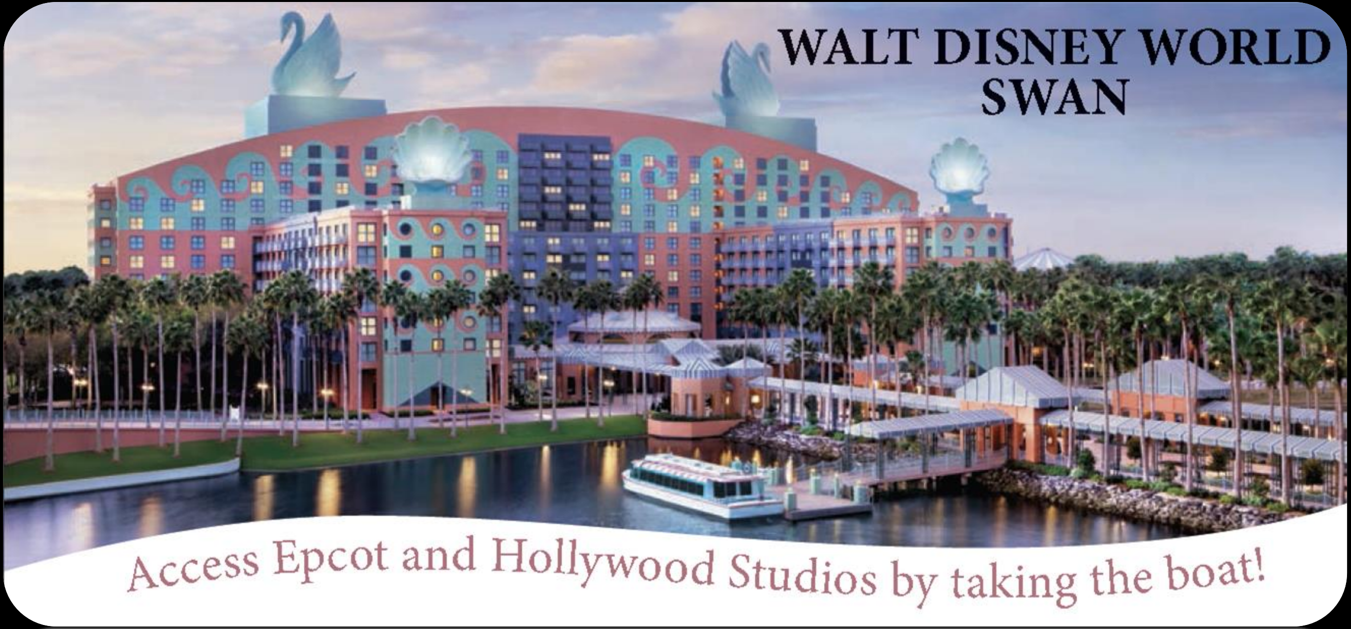

2018

Mar 25-28

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Leave the every day behind and enter a world of wonder and enchantment at the Walt Disney World® Resort. Located in the heart of the most magical place on earth, the Walt Disney World Swan and Dolphin Resort provides a truly extraordinary backdrop for our event! Beautiful tropical landscaping, tranquil waterways, and classic art and architecture work together to create a stunning landmark!