GRS

Its Scalability, Performance and CPU Utilization

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GRS Development

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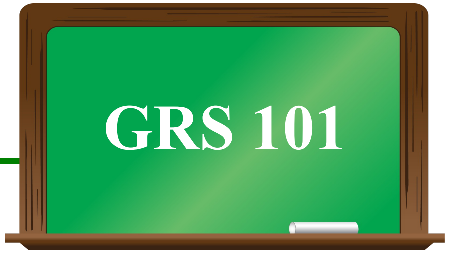
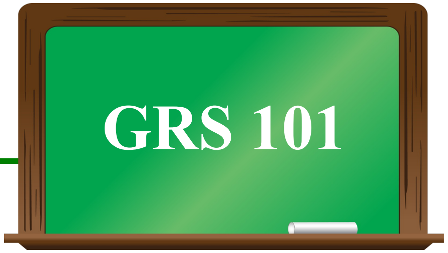
Quick Review

What does GRS do?



- Global Resource Serialization provides:
  - ENQ/DEQ services
    - Abstract, granular resources
    - Scope of step, system, or systems
  - Latch callable services
    - Only scope of system
    - Only available to authorized requesters
    - Fast!

Continued Review



What else does GRS do?

- ENQ/DEQ supporting functionality includes:
  - Corresponding Query service
  - GRSCNFxx & GRSRNLxx parmlib members
  - Display and SetGRS system commands
  - Many CSVDYNEX exits
  - ENF 51 signals for configuration & contention
  - "EQDQ" Monitor

Ring, Star, or None?

Modes for handling global resources

- None mode
  - Single-system GRS Complex
- Ring mode
  - Utilizes base sysplex communication
- Star mode
  - Utilizes parallel sysplex / coupling facility
  - Better scalability and performance

Continued Review

GRS 101

What else does GRS do?

- Latch Callable Services include:
  - Latch Create (ISGLCRT)
  - Latch Obtain (ISGLOBT)
  - Latch Release (ISGLREL)
  - Latch Purge (ISGLPRG)
  - Latch Purge by Space (ISGLPBA)
  - Latch Identity (ISGLID)
- Display and SetGRS system commands apply too

Review Complete

After glossing over a few details

The presentation now continues with a true story...

GRS Constraint Story

One day, a very large system image ran out of ENQs...

- Background:
  - DB2 supports tens of thousands of datasets
  - GRS handles multiple ENQs per dataset open
- Plot:
  - Customer had several large DB2 ramp-ups
  - GRS' virtual memory for ENQs was exhausted
- Conclusion:
  - The system waitstated!

Short-Term Fix

The service stream solution

- GRS maintains a set amount of storage for ENQs
  - This is a large pool of 31-bit private blocks
  - Amount set at IPL-time to aid performance
  - Balanced against other needs of GRS-private
- The pool of storage was increased dramatically
  - DB2 ramp-ups were alleviated
  - However 31-bit virtual has its limits!

GRS Direction

Enhancements can't always be measured in a single release

- This customer scenario significantly shaped GRS
  - Reprioritized many items over many releases
  - Renewed emphasis on scalability **(S)**
  - Coupled with emphasis on performance **(P)**
- Subsequent pages show this progression
  - Not all GRS items are listed
  - Miscellaneous but related items denoted **(*)**

GRS Timeline

A set of stories with happy endings

- z/OS R6
  - ISGENQ & ISGQUERY **(S)**
  - CMSEQDQ relief **(P)**
  - CMSLATCH relief **(P)**
- z/OS R7
  - GRS Health Checks **(*)**

GRS Timeline

The progression of stories continues

- z/OS R8
  - VSCR part 1 **(S)**
  - ENQMAX **(*)**
  - Dynamic CNS **(P)**
- z/OS R9
  - VSCR part 2 **(S)**
  - Latch performance **(P)**

GRS Timeline

Progression of stories continues

- z/OS R10
  - GRS "hot spots" (P)
  - IPCS ENQ Filtering (*)
  - CMSEQDQ relief 2 (P)
  - Monitor enhancement (P)
- z/OS R11
  - VSCR part 3 (S)
  - ISV API Extension (*)

GRS Timeline

External "end" of the progression

- z/OS R12
  - Fast GRSQ **(P)**
  - GRS Ctrace improvements **(S)**

Rather than review these items chronologically,

We will review these categorically…

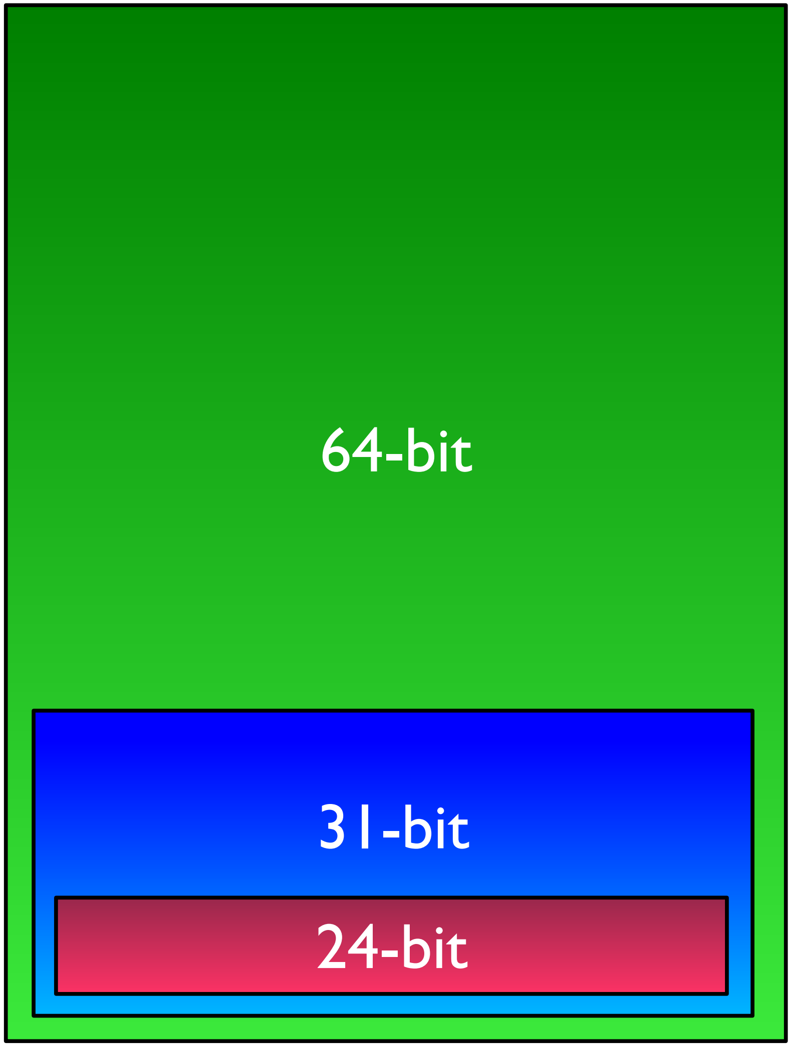
Virtual Storage Constraint

Virtually the biggest scalability issue

- zSeries provided 64-bit addressability
  - Storage Management provided services
    - GRS needed to use them
      - Several challenges to any z/OS component
      - Some challenges specific to GRS

Mapping the Space

Although it's problematic mapping 16E with 16M to scale



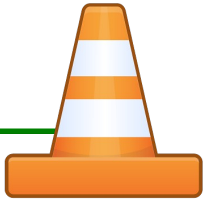
16 Exabytes ...over 8 billion times the size!

2 Gigabytes “The Bar” ...128 times the size!

16 Megabytes “The Line”

0

VSCR Challenges



It's not as easy as changing the Amode

- Control blocks contain addresses
  - 64-bit address is twice the size of 31-bit
    - Changes offset of every subsequent field
    - Lots of incompatibility and recompilation
- Linkage conventions save General Registers
  - Those registers doubled in size
  - Linkage stack can alleviate the complexity
    - Although with poor performance

GRS VSCR Challenges

Nitty gritty details

- We needed to support 64-bit parameter lists
  - In support of ENQ *users*' VSCR
  - ENQ/DEQ/GQSCAN parms “maxed out”
    - Problematic to expand compatibly
- ENQ SVC code-path separate from PC
  - Linkage=System path was considerably slower
  - Had its own recovery model as well

ISV VSCR Challenges

Internal changes can still create incompatibility

- Alternate serialization product not using “PI”
  - Accessing GRS blocks moving above the bar
  - Told IBM that they would be broken
    - New APIs would need to be created
    - Coordination required for GA

Phases of VSC Relief

Starting with services

- ISGENQ & ISGQUERY delivered in z/OS R6
  - 64-bit, expandable parameter lists
  - New function could make VSCR “no worse”
  - New GRS control blocks went above the bar
  - Coincided with z/OS architectural level-set
- 64-bit versions of Latch services delivered as well

Phases of VSC Relief

Moving Star blocks

- True VSCR began in z/OS R8
  - Star-mode specific blocks did not affect ISVs
  - Infrastructure laid out for above-the-bar work
- ENQ dual-pathing still existed, SVC vs. PC
  - Incompatible recovery models persisted too

Phases of VSC Relief

2

Moving nearly everything else

- Bulk of VSCR delivered in z/OS R9
  - Remaining ENQ-related blocks moved up
  - ENQ paths converged
  - Recovery models converged
  - New interfaces for alternate serialization
    - CSVDYNEX exits to intercept ENQs
    - ISGADMIN service to manipulate queues

ISV Segue

What exactly did they get?

- CSVDYNEX exits:
  - ISGNQXITPREBATCH
  - ISGNQXITBATCHCND
  - ISGENDOFLQCB
  - ISGNQXITQUEUED1
- ISGADMIN REQUEST=MOVEWAITER

These are official externals. But don't use them.

ISV Segue Continued

Alternate serialization support needed more work

- APIs delivered in z/OS R9 aided ISV serialization
- They didn't address breakage in ISV monitoring
  - More APIs delivered in z/OS R11 for this
    - ISGNQXITQUEUED2 for global results
    - Global resource token externalized
    - ISGCNFXITxxx got more contention data
      - These exits originally for skipping ENF 51

Phases of VSC Relief

Follow-up on Qscan

- VSCR follow-up delivered in z/OS R11
    - GQScan/ISGQUERY code used a dataspace
    - Constraint had never been seen in the field
    - Blocks moved above the bar

Service Segue

A GRS CTRACE dilemma

Q: What's more frustrating than debugging a GRS issue with insufficient CTRACE options?

Service Segue

A GRS CTRACE dilemma

Q: What's more frustrating than debugging a GRS issue with insufficient CTRACE options?

A: Debugging a GRS problem with sufficient CTRACE options, but having that information wrap off the buffer!

This too, was a VSCR item of sorts...

Phases of VSC Relief

Enhancing GRS CTRACE

- Another VSCR follow-up delivered in z/OS R12
  - GRS CTRACE blocks moved above the bar
  - New maximum buffer size: 2047M
    - Coincided with new CTRACE maximum
  - New default size: 16M (the old maximum)
- New CTRACE FLOWA also added
  - CTRACE data for latches

Understanding ENQMAX

An earlier DB2 ramp-up story

- Background:
  - GRS limits an address space to 250,000 ENQs
    - Safeguards against excessive ENQing
- Plot:
  - Customer had a large DB2 ramp-up
  - GRS still had plenty of virtual storage
- Conclusion:
  - Customer given GVT zap to avoid ABEND538

Clarifying ENQMAXA/U

Authorized & unauthorized maximums

- ENQMAX support provided in z/OS R8
  - Real externals for adjusting ENQ maximums
  - GRSCNFxx and SETGRS support
    - ENQMAXA for authorized requesters
    - ENQMAXU for unauthorized requesters
- Ironically, these externals were an afterthought
  - Cleaned up the GVT zap hack
  - So what was the “main” solution to the issue?

ISGADMIN SETENQMAX

Space-specific maximums

- Solution: space-specific maximum for DB2
  - ISGADMIN REQUEST=SETENQMAX
  - System-wide maximums maintained
    - Safeguard intact for other address spaces
- Problem: DB2's ISGADMIN usage was delayed
  - ENQMAXA became the interim solution
  - Confused as a GRS scalability problem

It's not just Scalability

There were performance challenges too

- Considerable investment into GRS performance
  - More CPU utilization can affect TCO
  - Certain performance issues affect scalability
- Several types of performance factors considered...

Performance Factor #1

Length of the path in front of you

- Pathlength
  - New functionality takes more lines of code
    - Simplified view of instruction speed
    - Simplified view of instruction sequencing
    - Reduction of pathlength still significant

“Fast Paths”

Streamlined ENQ paths

- Authorized requesters are trusted
  - Less parameter checking
  - Parmlists not copied in caller's key
- Fastpath added for ISGENQ in z/OS R9
  - Some other qualifications:
    - Singleton request
    - Local scope
    - No OwningTtoken specified

“Hot Spots”

Miscellaneous updates

- z/OS R10 delivered several performance updates
  - Latch
  - ENQ/ISGENQ
  - GQScan/ISGQUERY
- Examples
  - Expanded hash table sizes
  - Shortened Qscan pathlength in some areas
  - Stopped clearing dynamic areas

"Hot Queues"

Readily available ENQ blocks

- ENQ blocks pre-allocated in separate pools
  - Various internal control blocks used for ENQ
  - Significantly reduced pathlength to obtain
  - Applicable to any ENQ request
  - Usage expanded usage as blocks moved above the bar
    - Began in z/OS R6
    - Expanded in z/OS R8 and again in z/OS R9

Slow GRSQ

Faster mainline meant slower dumps

- GRSQ is an optional keyword for SVC Dumps
  - Provides additional GRS diagnostics
- GRSQ already a topic of dump times in the past
  - Its internally-driven GQScan took too long
    - GRSQ(CONTENTION) in GRSCNFxx
    - GQScan driven after system dispatchable
- However “hot queues” created a new problem...

Fast GRSQ

Hot queue compression compromise

- Spikes of ENQ activity drove hot queue usage
  - e.g. DB2 ramp-up
  - Transient cells were subsequently paged out
  - SVC Dumps with GRSQ hit page-in delays
- Fast GRSQ delivered in z/OS R12
  - RSM enhanced for paged-out dumping
  - GRS used improved SDump interface
  - Hot queues compressed to alleviate paging

Disabling Performance?

Hot queue disablement

- "Fast GRSQ" item also added some disablement
- GRS now listens for ENF signals from RSM
  - Hot queues disabled for Real & Aux shortage
  - Message ISG376I issued when this occurs
  - Queues re-enabled when shortage relieved
  - Originally ISG376I issued for compression too
    - Caused many PMRs against this self-tuning
    - Message removed per customer request

GRS IPCS Filtering

It's not just about taking the dump

- Scalability to GRS means many more ENQs
  - It's not just about the speed to take the dump
  - It's also about the user interface for diagnosis
- In z/OS R10 we introduced GRS IPCS Filtering
  - Applicable to both GRSTRACE & GRSDATA

Q: What's the difference between the two?

GRSTRACE & GRSDATA

Fraternal diagnostic twins

Q: What's the difference between the two?

A: Both provide information on ENQ requests, but...

- GRSTRACE is from in-storage control blocks
  - Star global data only from local requests
- GRSDATA is from the GQScan
  - Star typically has GRSQ(CONTENTION)

GRS IPCS Filtering

What does it filter?

- Filtering includes:
  - SYSNAME
  - JOBNAME
  - ASID
  - TCB
  - CONTENTION
  - QNAME
  - RNAME
  - SCOPE
  - RESERVE
  - START TIME
  - STOP TIME

All of the selected filters, if chosen, must be true

GRS IPCS Data

What interesting data was added?

- Event TODs showing ENQ history
  - Request
  - Contention
  - Ownership
- Alteration flags
  - RNLs
  - Exits
  - Alternate Serialization

Performance Factor #2

When multiple paths converge

- Bottlenecks
  - Shared resource or service slows activity
  - Limits amount of concurrent work
    - Independent of pathlength
    - Adversely affects overall throughput
    - Typically worsens with more concurrency
      - Therefore a scalability issue as well

CMSEQDQ Constraint Relief

Limiting the footprint

- CMSEQDQ is a suspend lock used for ENQs
  - Most Step ENQs skip it as of z/OS R6
  - RNL processing skips it as of z/OS R10
  - Star-mode globals usage reduced in z/OS R10
- Serialization still intact
  - Alternate, more granular mechanisms used

CMSLATCH Constraint Relief

Limiting this footprint too

- CMSLATCH is a suspend lock used for Latches
  - Alternative “fast locks” developed in z/OS R6
  - Four locks per latch set
  - CMSLATCH usage now minimal

Multi-header Cpool

CPU-specific cells

- Latches provide high-performance serialization
- CPU-specific memory provided an opportunity
  - Multi-header Cpool usage began in z/OS R9
  - Used further in z/OS R10, part of "Hot Spots"
    - Cells are chained by specific processors
    - Used for various blocks and dynamic areas
    - Implicit benefit to all latch users

Performance Factor #3

A matter of priority

- Priority problems
  - Units of work can be “starved out”
  - “Server priority” lower than “Client priority”
  - Problems can exist at various levels, e.g.
    - System weight
    - Priority of an address space and its tasks
  - Essentially a special-case bottleneck
    - Insufficient processor time

Dynamic CNS

Understanding what it is to understand the problem

Q: What is the CNS?

CNS Explained

What it is

Q: What is the CNS?

A: The Contention Notification System

- Star system for global contention signals
- Generates GQScan each time for the data
- Broadcasts the ENF 51 signal

Why is this part of a performance discussion?

ENF 51

Informative data, but a lot of data

- GRS is the largest producer of ENF signals by far
  - ENF 51 signals are input to RMF reports
- Global GQScans drive GRS CPU and signalling
- Low-weighted systems can encounter difficulty
  - CNS task will fail if it can't handle the load
  - Sympathy sickness is also possible

Dynamic CNS

Important tuning tip

- SetGRS supports dynamic CNS in z/OS R8
- This is still a common problem reported by L2
  - Installations need to choose wisely!
    - May not be “apples to apples” across CECs
    - Don't choose the lowest weighted LPAR!

EQDQ Monitor

An informative tool, albeit with overhead

- EQDQ Monitor tracks ENQ requests
  - Not limited to contention events
  - Lots of data for Scope=System and Systems
    - Does not include Scope=Step
  - Various filters provided
- Input fed from ISGNQXITBATCH exit
  - Adds overhead to ENQ mainline
  - But there was a worse problem...

ENQ & Monitor Priorities

Priority mismatch

- Priority of the GRS address space is very high
- Priority of the Monitor's space was very low
  - GRS PCs into the space for each ENQ request
  - Local lock priority is that of the primary space
    - Not the priority of the unit of work's home
    - The EQDQ Monitor slowed ENQs further
    - So installations turned the Monitor off

EQDQ Monitor Update

Problem not solved, but much improved

- EQDQ Monitor updated in z/OS R10
  - Priority of its address space much higher
    - Pathlength overhead still remains
    - Overall throughput much better
  - New NCRESERVE filter added
    - Shows unconverted Reserve requests
    - Useful for GDPS migrations
    - Useful for GRS best practices

GRS Health Checks

Formalized best practices

- GRS Health Checks began in z/OS R7
- More added in z/OS R8
  - GRS Star mode
  - Synchres(Yes) for Reserves
  - RNLs converting all Reserves
  - No RNL exclusions preventing conversion
  - GRSQ set to Contention
  - Higher-performance exit usage

GRS CPU Utilization

How your CPU is spent

- There are three main tasks in GRS
  - Global ENQ processor
    - Global ENQs, Ring and Star versions
  - Qscan task
    - Handles GQScan/ISGQUERY requests
  - Contention Notification task
    - Each system has one for local contention
    - The CNS also handles the global contention

GRS Tuning Checklist

Making the most efficient use of the CPU

- Ensure the parallel sysplex is properly tuned
  - Qscans heavily dependent on XCF Signalling
  - Minimize false contention to ISGLOCK in CF
- Consider EQDQ Monitor usage
- Convert all Reserves to global ENQs
- Ensure the CNS is on a high-weighted system
- Limit global Qscan activity where possible

GRS Troubleshooting

White paper from GRS Level 2

- GRS Level 2 recently published this
  - Further detail on GRS CPU consumption
  - Best practices and case studies

http://www-03.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/WP101725

Summary

Advances in Serialization

- Significant enhancements made to GRS in areas of:
  - Scalability
  - Performance
- With a handful of best practices...
  - Maximize efficiency of GRS' CPU utilization