The IBM Hardware Acceleration Lab and the InfoSphere® Data Replication for VSAM for z/OS® development teams used a CICS® VSAM record-level sharing workload to measure and improve the performance of InfoSphere Data Replication for VSAM for z/OS 11.1. These improvements were shipped in version 11.3. This tutorial outlines the improvements and the resulting measured performance benefits.
Introduction
The IBM Hardware Acceleration Lab System z® team and the InfoSphere Data Replication for VSAM for z/OS (IIDR) development teams used the CICS development performance team's Data Systems Warehouse (DSW) VSAM record-level sharing (RLS) workload to measure and improve the performance of IIDR for VSAM. The efforts resulted in significant performance improvements being shipped in IIDR for VSAM 11.3. These include significant reductions in IIDR CPU time and elapsed time, as well as improvements in the DSW workload's throughput and response time. This tutorial describes the workload used, significant changes, and resulting benefits.

VSAM replication overview
IIDR for VSAM can be used to produce synchronized replicas of VSAM datasets in near real-time between typically geographically dispersed CICS regions. Figure 1 shows the basics of the replication flow. Logically related VSAM datasets that need to synchronize as a group and are updated under the same unit of recovery (UOR) are defined by the user via replication subscriptions. The Classic Data Architect (CDA) tool can be used to assist with this process. The workload flow starts on the left with end-user requests that result in source CICS transactions updating VSAM datasets under a CICS transaction or unit of recovery (UOR). For each transaction, CICS writes replication log records to z/OS system logger-managed replication logs. IIDR for VSAM capture processing reads the replication log and sends captured replication data to the target server. The target IIDR server sends transactions to a CICS region, where an IIDR transaction replicates file control requests, resulting in the target VSAM datasets being updated with identical synchronized data. Note that other CICS log streams used for transaction roll back, etc. are not illustrated.

Figure 1. IIDR VSAM replication for z/OS flow/overview

DSW workload overview
The IBM-created CICS OLTP VSAM data store DSW was used to drive replication. DSW is a Teleprocessing Network Simulator (TPNS)-driven set of 34 COBOL transaction types that execute in a CICS CPSM-managed complex consisting of TORs, AORs, and, in our case, 10 sets...
(databases) of 32 VSAM KSDS files shared among the CICS source AORs via VSAM RLS. DSW, along with other workloads, is used by the CICS development team to do performance testing. As such, it is known to scale and proved to be a good workload for VSAM replication testing.

**Figure 2. DSW workload flow with IIDR VSAM replication for z/OS**

![Diagram of DSW workload flow with IIDR VSAM replication for z/OS](image)

The above figure illustrates the DSW workload flow. A separate zEnterprise® machine (CEC A) was used for the TPNS terminal simulation, which flowed transaction requests to CICS CPSM on z/OS LPAR LP05 system P9B on the zEnterprise EC12 machine. VSAM changes were replicated to VSAM datasets on z/OS LPAR LP09 system P9C on the same EC12.

Both the z/OS systems were in the same Sysplex, on the same EC12. This made testing more convenient, but typically, the source and target would be geographically separated by some distance, which could introduce additional network delays. To prevent any atypical VSAM interaction between the source and target systems, which would not occur when otherwise geographically dispersed, the source VSAM datasets were only updated through RLS, and the target VSAM datasets were only updated by each owning CICS region (non-RLS). A separate integrated coupling facility (ICF) was also used on the EC12 for XCF signaling and the RLS structures, but it was not included in the figure.

**Measurement approach**

**Table 1. Hardware and software configuration**

<table>
<thead>
<tr>
<th>CP, IIDR servers, and CICS region configuration</th>
<th>P9B CPs</th>
<th>CPU P9B %</th>
<th>P9B zIIPs</th>
<th>IIDR</th>
<th>P9B AORs</th>
<th>P9B TORs</th>
<th>IIDR Source Servers</th>
<th>P9C CPs</th>
<th>CPU P9C %</th>
<th>Required P9C CPs</th>
<th>Measurement ID</th>
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</table>
The above table outlines the CP, IIDR servers, and CICS region configuration on the source (P9B system) and target (P9C system) sides.

Why these configurations were used:

- Each test used 10 subscriptions, each with a set of VSAM datasets as described.
- To measure how the workload scaled under different demands, 8, 16, and 32 dedicated CP source server LPAR configurations running at approximately 90-percent utilization were measured and compared.
- As the primary focus was on the capture side, the apply-side configuration was simplified to reduce the testing effort as follows:
  - The number of CPs per source system size were altered to ensure acceptable latency, but were not adjusted to what was only required to be at 90-percent utilized. The number of required apply-side CPs as illustrated by column "Required P9C CPs" were extrapolated by using the CP percentage of the actual number of CPs. The numbers increase for IIDR 11.3 because more work is being done, not because of an inefficiency with the release.
  - The number of IIDR target servers was kept constant at 10 and was not adjusted to the minimum required.
  - There was always one AOR per subscription and they were not adjusted to the minimum required.
  - To measure how much of the IIDR log reading activity could be offloaded to a System z Integrated Information Processor (zIIP), one additional zIIP was added to the larger 32-CP environment and compared to the non-zIIP 32-CP measurement at the same transaction rate.
  - To measure the cost of doing replication with both releases, an additional 8, 16, and 32-CP set of measurements with full UNDO logging were compared to the corresponding replication measurements.

Varying the TPNS Terminal User Think Interval between transaction requests was used as a means to tune the CPU utilization of the source server LPAR for each measurement to as close to 90 percent as possible. The number of P9B CICS AORs and TORs were kept proportional to the number of CPs. This allowed 90-percent utilization while providing acceptable CICS throughput and response times. It is possible that reducing or increasing the number of regions could provide similar results.

As a one second end-to-end (END2END) replication elapse time is considered to be acceptable by most customers, only measurements where the END2END elapsed time was one second or
less were considered acceptable. Additional IIDR source servers were added as needed in order to meet the 1-second requirement. Note that the 10 P9C target servers were more than adequate and the number was not tuned to simplify the testing.

**Data collection and performance metrics**

RMF™ was used to gather the following three critical metrics for comparison:

- Transaction rate and response time. The transaction rate is the average number of transactions per second, and the response time is the average time in milliseconds that a transaction takes to complete. The WLM policy was updated by modifying the CICS subsystem classification rules to classify the DSW CICS transactions in a unique WLM Service and Report Classes.
- CPU service-time usage per address space was reported by RMF by putting the CICS regions' and IIDR servers' job names in a unique WLM report class in the JES subtype.

Replication monitoring data provided by CDA was used to determine:

- Elapsed times
- Megabytes transferred per second
- Units of recovery processed per second

To find code areas of high CPU usage, an IBM internal version of the z/OS Hardware Instrumentation Services (HIS) was used to gather system Z CPU measurement facility sample data.

**Software versions**

z/OS V2R1, CICS 5.1, and InfoSphere Data Replication for VSAM for z/OS (VSAM 11.1 and 11.3) were used.

**Hardware configuration**

All tests were done using a source and target replication system on unique LPARs of an IBM zEnterprise EC12 processor with varying numbers of dedicated CPs and zIIPs.

All VSAM datasets under test were on high-performance 2107-951 DS8800 DASD, with tuned channel paths and logical control units.

**IIDR 11.3 product performance improvements**

The result of the team's analysis of IIDR 11.1 performance resulted in prototyping and measuring code changes resulting in the following IIDR 11.3 product improvements:

1. Source-server subscription capture caches were moved from a high-performance space (hiperspace) to above-the-bar (64-bit) storage. This eliminated the need for hiperspace services to move 4K blocks between the hiperspace and the source server's 31-bit virtual storage. This change was the major contributing factor to the improvements.
2. Search and storage movement algorithms were improved after the capture cache change to use above-the-bar storage (see No. 1 above). It was possible to limit data movements to the bytes used, rather than requiring complete page movements and algorithms using MVC loops became more efficient than MVPG or MVCL instructions.

3. The internal capture cache buffers were increased from 4 to 16.

4. The VSAM zIIP-eligible log reading SRB was changed to a dependent enclave SRB from an independent enclave SRB to ensure that it is run with the same WLM classification as the IIDR source server, as well as to provide proper zIIP services times in RMF.

**Note:** The improvements above numbered 1, 2, and 3 affect the following products: Data Replication for VSAM, Data Replication for IMS, Classic CDC for VSAM, and Classic CDC for IMS. Item No. 4 only affects Data Replication for VSAM and Classic CDC for VSAM.

### Result comparisons and highlights

#### Table 2. Result highlights

<table>
<thead>
<tr>
<th>DSW improvement</th>
<th>CPUs P9B</th>
<th>zIIPs</th>
<th>IIDR</th>
<th>ETR P9B</th>
<th>ETR Delta%</th>
<th>P9B ITR</th>
<th>ITR Delta %</th>
<th>P9B Tx Resp time</th>
<th>P9B IIDR Service time</th>
<th>P9B IIDR Service Time/Tx</th>
<th>P9B IIDR Service Time/Tx Delta %</th>
<th>Measurement ID</th>
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The measurement results shown in the above table illustrate significant benefits to the DSW when running with IIDR 11.3. Outlined by the Delta columns, there are considerable improvements in External Throughput Ratio (ETR=Transactions/Second) and Internal Throughput Ratio (ITR = Transactions/CPU time), and even though the transactions rates were much higher as outlined by the ETR Delta% column, there was still a minor improvement in the CICS transaction response times. The benefit is clearly coming from the dramatic reduction in IIDR capture service times per transaction as outlined in the P9B IIDR Service Time/Tx Delta % column.

The dramatic reduction in service times will also reduce software licenses fees and the total cost of replication. These can be further reduced by offloading the VSAM log reading to a zIIP engine. See "IIDR VSAM Log Reader Offloading to zIIP" for more information about zIIP offloading.

The ITR was computed by dividing the ETR by the CPU percentage, then multiplying by 100. It measures transaction rates per second of CPU resource efficiency. A higher ITR is achieved for
less CPU and a lower ITR for more CPU given the same transaction rate. The CPU percentage includes CPU used by the entire system, including the IIDR replication processing.

Table 3. Result highlights

<table>
<thead>
<tr>
<th>Replication improvement</th>
<th>CPs P9B</th>
<th>zIIPs</th>
<th>IIDR</th>
<th>END2END Latency; ms</th>
<th>END2END Latency Delta%</th>
<th>IIDR MB/s</th>
<th>IIDR MB/s Delta %</th>
<th>IIDR Rows/s</th>
<th>IIDR Rows/s Delta %</th>
<th>IIDR UOR/s</th>
<th>IIDR UOR/s Delta %</th>
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The measurement results shown in the table contained in Table 3 illustrate significant improvements in replication performance when running with IIDR 11.3. Although IIDR is using much less CPU, as outlined in Table 2, there is a significant reduction in END2END Latency (END2END Latency Delta%) and increases in megabytes per second (IIDR MB/s Delta%), rows per second (IIDR Rows/s Delta%), and units of recovery per second (IIDR UOR/s Delta%).

Table 4. The cost of replication

<table>
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<tr>
<th>DSW workload</th>
<th>CPs P9B</th>
<th>IIDR</th>
<th>ETR P9B</th>
<th>ETR Delta% from Non-replication</th>
<th>P9B ITR</th>
<th>ITR Delta% from Non-Repliation</th>
<th>P9B Tx Resp time</th>
<th>Measurement ID</th>
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To determine the impact replication has on the DSW workload, we also did non-replicating measurements that continued to use CICS UNDO logs and compared them to their full replication equivalents. The measurements are illustrated in the above table by the last 3 rows. The zIIP measurement was not included as the ETR was kept stable by design.
The measurement data in the above table clearly illustrates that replication is not without a cost. The negative values show that there is a significant cost to ETR and ITR when replicating. However, that cost is significantly reduced when running IIDR 11.3.

**IIDR VSAM log reader offloading to zIIP**

Both IIDR 11.1 and 11.3 provide the ability to offload the VSAM log-reading processing to a zIIP processor. This is advantageous because zIIP processor CPU service is not charged toward software fees. To be eligible to execute on a zIIP processor, the z/OS unit of work must be an enclave SRB. 11.3 introduced a change to run the log reader as a dependent SRB. See "IIDR 11.3 Product Performance Improvements" for details. This change was not expected to have any performance benefit in our environment. However, we wanted to measure how much could be offloaded as it lowers the total cost of ownership. We used the largest 32 CP environment and left the number of general processors (GPUs) at 32 adding one zIIP processor and kept the TPNS ITR the same as the none zIIP 32-CP measurement to minimize changes to the workload's ETR. Using tables 2 and 3 above, the comparison of run identifiers z4339PB2 and z4346PB1 is summarized as follows:

1. 4.6% (0.016-0.0153/0.016*100) of IIDR 11.3's service time per transaction could be offloaded to the zIIP.
2. The workload demand was as identical as could be expected:
   a. The ETRs are nearly identical.
   b. The units of recovery per second were nearly identical.
3. The END2END latency decreased by 4.4 percent as IIDR has the zIIP to itself. Note that the zIIP utilization was only 0.151 percent and not contained in the tables contained in the figures.

**Tuning considerations**

Tuning any workload is key to good results. A fair amount of time was spent ensuring that there were no delays that could be tuned away in CICS, system logger log streams, CP/SM, VSAM RLS, etc. The most benefit was achieved by ensuring that the system logger-managed log streams were properly tuned. CF log streams were used for better performance. The RMF XCF Activity Report and the non RMF System Logger Activity Report (IXGRPT1) were used to tune the log streams' performance. The IBM Internal Technical Support Organization (ITSO) Redbooks® publication titled "Performance Considerations and Measurement for CICS and System Logger" provides in-depth details on how to do this.

**Conclusion**

There are considerable performance improvements in InfoSphere Data Replication for VSAM for z/OS 11.3, which cannot be overlooked. These performance improvements will help reduce the total cost of VSAM replication and will help reduce replication elapse times, which in turn will help to meet lower recovery point objectives.

It should also be noted that some of the changes are relevant to IIDR for IMS as well and should provide some benefit in those deployments. As discussed, some of these benefits are also available to Classic CDC products due to the use of common components.
Readers should be aware that the benefit to any given workload will vary due to many factors that are unique to the workload such as the UOR sizes, throughput arrival patterns and rates, etc.
Resources

- Check out the InfoSphere Data Replication for VSAM for z/OS 11.3 documentation.
- Read the ITSO Redbooks publication titled "Performance Considerations and Measurement for CICS and System Logger."
- Read the ITSO Redbooks publication titled "IBM CICS Performance Series: CICS and VSAM RLS."
- The Information Management area on developerWorks provides resources for architects, developers, and engineers.
- Stay current with developer technical events and webcasts focused on a variety of IBM products and IT industry topics.
- Follow developerWorks on Twitter.
- Watch developerWorks demos ranging from product installation and setup demos for beginners, to advanced functionality for experienced developers.
- Get involved in the developerWorks Community. Connect with other developerWorks users while you explore developer-driven blogs, forums, groups, and wikis.
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