zHISR: Improving Application Performance using Hardware Instrumentation

Ed Jaffe
Phoenix Software International

10 March 2014
Session Number 15379
What is zHISR?

zHISR is an interactive application execution profiler that allows developers, performance analysts and others to easily interface with System z Hardware Instrumentation to perform near-zero overhead, high-resolution hot spot analysis of programs running under z/OS.
Software Timer-based Sampling Technologies

• Most commercial application profilers use software timer-based sampling to obtain the data upon which to perform the analysis.
  • STIMER(M), TIMER DIE (Disabled Interrupt Exit), etc.

• The timer routines themselves are dispatched by z/OS. Therefore, they become part of the application execution path as seen by the system and its accounting routines.

• Sampling this way can be expensive in terms of CPU consumption and is one reason that the use of application profilers is often strictly controlled.
STIMER-Based Sampling

- Normal condition of task-based execution:
  - Program executes under a Program Request Block (PRB)
STIMER-Based Sampling

• When timer interrupt occurs, the operating system:
  • Schedules an SRB into the target address space
  • The SRB schedules an IRB to run the timer exit
  • The timer exit collects the PSW from the PRB

TCB

PRB

IRB

Applicatio<onation Program Old PSW

Profiler’s Timer Exit
Timer DIE-Based Sampling

- The operating system provides authorized programs with the Timer DIE (Disabled Interrupt Exit) function.
- The Timer DIE gets control directly from the SLIH when the timer interrupt is handled. This can occur in any address space and within any unit of work (task or SRB) in the system.
- The DIE executes disabled (must not create a page fault) and cannot obtain locks or reference private area storage.
- The DIE can schedule (or resume) an SRB to do whatever collection is necessary.
Timer DIE-Based Sampling

Timer Interrupt

FLIH

SLIH

DIE

Dispatch

SRB

Collect PSWs

Issue IEAMSCHD (SCHEDULE) or RESUME SRB
Most Obvious Disadvantages of Software Timer-based Sampling

- z/OS timer services are efficient, but they are not designed for sampling. Significant CPU is consumed.
- Dispatch latency is unpredictable.
- Timer resolution higher than 100 samples per second adds significant complexity and even higher CPU consumption.
- Sampling code must make an educated “guess” at what the dispatcher would have run, if the sampling code was not there, and record those assumed PSWs.
- SRB routines (especially non-preemptible SRBs) are difficult to sample.
- Cycles Per Instruction (CPI) information is not available.
System z Hardware Instrumentation

- Hardware Instrumentation is a mainframe hardware facility that was introduced long before System z, but was accessible only to IBM internal tooling through activation of a special diagnostic mode on the machine.
- The facility was first externalized to customers with the z10 family of processors (z10EC and z10BC).
- Sampling using Hardware Instrumentation is almost “free.” There is no appreciable overhead.
- The default sampling frequency is 800,000 samples per minute. That’s 13,333 samples per second – PER CPU!
- Cycles Per Instruction (CPI) information is available if you know how to calculate it.
System z Hardware Instrumentation

- The first operating system release to support Hardware Instrumentation was z/OS 1.9. For five releases, the IBM Hardware Instrumentation Services (HIS) address space performed all data collection and mapping activities.
  - Functionality extremely limited: only one data collection per system at a time, jobs to be mapped had to be running and execute for the entire duration, no recording of fetch/unfetch activities – mapping was a “snap shot” at the end.
- In z/OS 2.1, the capabilities of HIS were greatly expanded to allow authorized applications to become profilers.
- zHISR leverages these new HIS capabilities as well as other operating system functions to create an easy to use, near-zero overhead application profiler.
Cycles Per Instruction

• If you have an increase in CPU cost in a module, it's often useful to know if the module or a loop in the module is executed more frequently (higher path length) or if the average instruction cost has gone up (higher CPI).

• Years ago, when instructions executed one at a time on a CPU, a signal called Instruction First Cycle (IFC) was turned on for the first cycle of an instruction.

• IFC allowed us to estimate the average Cycles Per Instruction (CPI) in a module.

\[ CPI_{in\text{Module}} = \frac{Samples_{in\text{Module}}}{IFCsamples_{in\text{Module}}} \]
Cycles Per Instruction

- Samples provide an indication of CPU cost in a module or section of code. IFC samples provided an indication of frequency of various paths in the code. Regardless of how long the instruction took to execute, the IFC signal was only on for one cycle, providing instruction frequency, not instruction execution time.

- Today, things are not so simple. Groups of instructions execute at the same time (superscalar) and OOO, but we still want the useful information from the old IFC signal.

- The Unique Instruction counts captured by Hardware Instrumentation are used by zHISR to calculate CPI for each execution analysis unit. The result is presented in terms of a ratio relative to the owning section or module.
zHISR Data Collection Flow

- **Hardware Instrumentation**
  - CP0, CP1, CP2, ..., CPn
  - SDB, SDB, SDB, ..., SDB

- **HIS Profiler Exit Driver**

- **zHISR Server**
  - Fixed memory blocks on z/OS populated with sample data
  - SDB full condition generates interrupt
  - zHISR quickly copies SDBs to its private area and schedules high-speed write to disk files

System z Hardware
zHISR HIS Profiler Registration

• The first data collection registers zHISR’s HIS Profiler.
• Additional data collections do not register additional HIS Profilers. Only one is ever registered.
• When no more data collections are running, zHISR’s HIS Profiler is deregistered.
• This approach ensures the “performance” path, i.e., when copying the populated SDBs to zHISR’s private area in response to the full-SDB interrupt, is as short as possible.
• The private area SDB copies are simultaneously written to disk, for each running data collection that needs them, and then made available for future copy/write operations.
zHISR HIS Profiler Registration

USER1 START

USER2 START

USER2 END

USER1 END

zHISR Server

REGISTER

SDB Handling

DEREGISTER

HIS

Advancing Time

Complete your session evaluations online at www.SHARE.org/Anaheim-Eval
zHISR Fetch/Unfetch Monitoring

- Native HIS maps modules only at data collection end time.
- In many applications, modules are fetched and unfetched throughout execution. A newly-loaded module can occupy the address range previously occupied by another module.
- In some applications (e.g., CICS) “directed load” techniques are used. No CDE is created.
- zHISR monitors module fetch/unfetch activity, including “directed” loads. The HIS module mapping format has been compatibly extended to record necessary timings.
- At analysis time, a time-oriented module matrix is created and used to ensure samples are attributed to the proper module instance.
zHISR Fetch/Unfetch Monitoring
Which Jobs are Monitored and Mapped?

• All jobs are always monitored when a collection is running.
  • That’s just how Hardware Instrumentation works! 😊

• Already-running jobs for which module mapping is desired can be identified by an ASID list and/or job name mask list.
  • A list of job names owned by a given userid can be generated for you on request.

• The **Auto Start Id** and **Match Limit** parameters allow collections to be deferred until a named job actually starts.
  • Parameters similar to SLIP ID= and MATCHLIM= keywords.
  • Makes it possible to monitor/map short-running batch jobs.

• A program can invoke the zHISR API to start/stop/pause its own data collection to target only a subset of its code.
zHISR Server Characteristics

- Service access via space-switching PC routine interface.
- Server fully supports ASN/LX reuse (REUSASID=YES).
- Command interface allows full start/stop/modify control of data collections from MCS console.
  - End-user data collection management is via EMCS console.
- Data collections are fully multi-tasked to minimize latency.
- Files can be written to zFS using z/OS UNIX file system interfaces or to classic, multivolume MVS data sets using Phoenix Software International’s proprietary STARTIO driver, which performs like NO OTHER.
- STARTIO driver fully supports advanced channel program technologies including ZHPF. Same driver used for (E)JES!
Files Created by zHISR

• zHISR creates sample and map files, no counters.
• Sample data format is identical to z/OS 2.1 HIS.
• Map data format is upward compatible to z/OS 2.1 HIS.
  • A format which is *totally incompatible* with earlier releases of z/OS HIS. :-/
• This means existing customer code that processes z/OS 2.1 HIS sample and map files can process zHISR sample and map files, unless the code is sensitive to record length or other things to which it should not be sensitive.
Starting a zHISR Data Collection

11/06/2013  zHISR: Manage H.I.S. Event Data Collection  16:23:09

System MVSAO  Proc ZHISR  Title Sample Collection

Duration 10.0  Space 0  MapUser GILBERT  MapOnly N

MapAsid  

MapJob C3CONDOR  

Path disk

AutoStart_Id  Match_Limit 000001

1=Help 2=View 3=End 4=Start 5=HisInfo 7=Status 8=Jobs 9=Schedule 11=Clear
Starting a zHISR Data Collection Run

11/06/2013  16:23:19  zHISR: System Log / Start

F ZHISR,START CLIENT=YES,
F ZHISR,CONT DURATION=10.0,
F ZHISR,CONT PATH=DISK,
F ZHISR,CONT MAPJOB=(C3CONDOR),
F ZHISR,CONT TITLE='Sample Collection'
ZHS059I: SPACE= is required with PATH=DISK, set to 15620
Displaying zHISR Data Collection Status

11/06/2013  zHISR: System Log / Status  16:24:03

F ZHISR,STATUS CLIENT=YES

ZHS004I: zHISR Server (V02R0.0037.253) is ONLINE
Connections in progress: 0  Client requests: 428
Collections in progress: 1  Collections taken: 3
Samples written: 0.31K  Samples lost: 0
Server CPU time: 00:00:00.910  Server zIIP time: 00:00:00.391
Client CPU time: 00:00:00.060  Client Delay time: 00:00:00.583
Client delay HWM: 0  Repository HWM: 0
CPU count: 4  Buffers per CPU: 14

<table>
<thead>
<tr>
<th>Item</th>
<th>User_Id</th>
<th>Job/ASID</th>
<th>Time</th>
<th>Space</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>_</td>
<td>GILBERT</td>
<td>C3CONDOR</td>
<td>000918</td>
<td>60.59M</td>
<td>Sample Collection</td>
</tr>
</tbody>
</table>

F ZHISR,STATUS ID=ALL,CLIENT= YES
ZHS074I: No AutoStart Id's match selection criteria

0001 of 0001  1=Help  2=Refresh  3=End  7=Bwd  8=Fwd  P=Stop  K=Halt  XXXX FB in Anaheim

Complete your session evaluations online at www.SHARE.org/Anaheim-Eval
Stopping a zHISR Data Collection Run

11/06/2013  zHISR: System Log / Status  16:24:03

F ZHISR,STATUS CLIENT=YES

ZHS004I: zHISR Server (V02R0.0037.253) is ONLINE
Connections in progress: 0  Client requests: 428
Collections in progress: 1  Collections taken: 3
Samples written: 0.31K  Samples lost: 0
Server CPU time: 00:00:00.910  Server zIIP time: 00:00:00.391
Client CPU time: 00:00:00.000  Client Delay time: 00:00:00.583
Client delay HWM: 0  Repository HWM: 0
CPU count: 4  Buffers per CPU: 14

<table>
<thead>
<tr>
<th>Item</th>
<th>User_Id</th>
<th>Job/ASID</th>
<th>Time</th>
<th>Space</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>GILBERT</td>
<td>C3CONDOR</td>
<td>000918</td>
<td>60.59M</td>
<td>Sample Collection</td>
</tr>
</tbody>
</table>

F ZHISR,STATUS ID=ALL,CLIENT=YES
ZHS074I: No AutoStart Id's match selection criteria
Stopping a zHISR Data Collection Run

11/06/2013  zHISR: System Log / Stop  16:24:30

F ZHISR,STOP 0001,CLIENT=YES
ZHS015I: STOP command has been serviced
zHISR Data Collection Analysis Wizard

Navigate File Tree

Select Files, Time Range, Unit Size*

PASN Chooser

Fast-path Range, Module, Section Chooser

Module Chooser

Section Chooser

Boundary Chooser

Interactive Analysis Reports

Optional

* Unit size can be any power of two, 8 thru 4K. Default is 64 bytes.
Select File, Choose Analysis Unit Size

11/19/2013 zHISR: Collection Dataset Catalog Display 14:41:02
A(n)=Analyze B(L|A)=Browse RM=Remove S=Sltct Cursor=Sltct
Directory disk john1

<table>
<thead>
<tr>
<th>Type</th>
<th>Permission</th>
<th>MgmtClas</th>
<th>Volume</th>
<th>FileName</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV1</td>
<td>JOHN1.D131019.T1627318.C00000.HISMAP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV0</td>
<td>JOHN1.D131019.T1627318.C00000.HISSMP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV1</td>
<td>JOHN1.D131019.T1627318.C00002.HISSMP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV1</td>
<td>JOHN1.D131019.T1627318.C00003.HISSMP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV0</td>
<td>JOHN1.D131019.T1856090.C00000.HISMAP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV1</td>
<td>JOHN1.D131019.T1856090.C00000.HISSMP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV0</td>
<td>JOHN1.D131019.T1856090.C00002.HISSMP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV1</td>
<td>JOHN1.D131019.T1856090.C00003.HISSMP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV1</td>
<td>JOHN1.D131019.T2017175.C00000.HISMAP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV1</td>
<td>JOHN1.D131019.T2017175.C00000.HISSMP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV0</td>
<td>JOHN1.D131019.T2017175.C00002.HISSMP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV1</td>
<td>JOHN1.D131019.T2017175.C00003.HISSMP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV1</td>
<td>JOHN1.D131019.T2025020.C00000.HISMAP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV1</td>
<td>JOHN1.D131019.T2025020.C00000.HISSMP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV0</td>
<td>JOHN1.D131019.T2025020.C00002.HISSMP</td>
</tr>
<tr>
<td></td>
<td>zr--r--r--</td>
<td>STANDARD</td>
<td>MVSNV1</td>
<td>JOHN1.D131019.T2025020.C00003.HISSMP</td>
</tr>
</tbody>
</table>

0001 of 0003 1=Help 2=Refresh 3=End 4=Return 7=Bwd 8=Fwd
Specify Time Period and Included CPUs

11/19/2013  zHISR: H.I.S. Sample Data CPU Selection  14:42:30
CPU Report   JOHN1.D131019.T1627318.C00000  Sort: Cpu#

Move the cursor to a line to be excluded or included in the analysis and press Enter. Alter the range data to change the time period that is to be analyzed. Once you have completed your selections press PF5.


<table>
<thead>
<tr>
<th>CPU Address</th>
<th>Value</th>
<th>Start Time</th>
<th>End Time</th>
</tr>
</thead>
</table>
Primary ASN Chooser

<table>
<thead>
<tr>
<th>Primary ASN</th>
<th>Percentage</th>
<th>ASID</th>
<th>Percentage</th>
<th>ASID</th>
</tr>
</thead>
<tbody>
<tr>
<td>C3CONDOR</td>
<td>35.352%</td>
<td>003A</td>
<td>15.336%</td>
<td>0055</td>
</tr>
<tr>
<td>002B</td>
<td>6.606%</td>
<td>002B</td>
<td>5.906%</td>
<td>0006</td>
</tr>
<tr>
<td>0002</td>
<td>2.801%</td>
<td>0002</td>
<td>2.218%</td>
<td>0037-ZHISR</td>
</tr>
<tr>
<td>0003</td>
<td>2.065%</td>
<td>0003</td>
<td>1.891%</td>
<td>0021</td>
</tr>
<tr>
<td>002C</td>
<td>1.611%</td>
<td>002C</td>
<td>1.190%</td>
<td>0025</td>
</tr>
<tr>
<td>005D</td>
<td>0.792%</td>
<td>005D</td>
<td>0.689%</td>
<td>0047</td>
</tr>
<tr>
<td>000A</td>
<td>0.292%</td>
<td>000A</td>
<td>0.198%</td>
<td>0010</td>
</tr>
<tr>
<td>0023-HIS</td>
<td>0.175%</td>
<td>0023</td>
<td>0.163%</td>
<td>0018</td>
</tr>
<tr>
<td>003D</td>
<td>0.163%</td>
<td>003D</td>
<td>0.140%</td>
<td>0013</td>
</tr>
<tr>
<td>0008</td>
<td>0.093%</td>
<td>0008</td>
<td>0.093%</td>
<td>0049</td>
</tr>
<tr>
<td>002A</td>
<td>0.035%</td>
<td>002A</td>
<td>0.035%</td>
<td>0019</td>
</tr>
<tr>
<td>003B</td>
<td>0.023%</td>
<td>003B</td>
<td>0.023%</td>
<td>0059</td>
</tr>
<tr>
<td>0026</td>
<td>0.012%</td>
<td>0026</td>
<td>0.012%</td>
<td>0032</td>
</tr>
</tbody>
</table>

Move the cursor to the ASID of the address space to be included in the analysis and press Enter. Only one ASID may be selected. Once you have completed your selection press PF5.

Proceed directly to Fast-path Range, Module, Section Chooser.

0001 of 0001 1=Help 2=Anal 3=End 5=Next 7=Bwd 8=Fwd 9=Sort ASID
Module Chooser

Move the cursor to a module to be excluded or included in the analysis and press Enter. Continue this process as often as needed. Once you have completed your selections press PF5.

003A-FMBCREXX 00000000_0CD67000 00020900 C3CONDOR 13292.2327323 -
003A-FMBLIOCS 00000000_0CA8E000 00005000 C3CONDOR 13292.2327323 -
003A-FMBLOGIC 00000000_0CADD800 00033000 C3CONDOR 13292.2327323 -
003A-FMBLOGIC 00000000_0CFB0000 000D0000 C3CONDOR 13292.2327323 -
003A-FMBCCI2 00000000_0CF23000 00004000 C3CONDOR 13292.2327323 -
003A-FMBCDMA2 00000000_0CF2D800 00010000 C3CONDOR 13292.2327323 -
003A-FMBCENVC 00000000_0CF80000 0000C8C8 C3CONDOR 13292.2327323 -
003A-FMBCENU 00000000_0CFD8000 00058000 C3CONDOR 13292.2327323 -
003A-FMBCLIC 00000000_0CF14000 0000000A C3CONDOR 13292.2327323 -
003A-FMBCMML 00000000_0CF1D000 00006000 C3CONDOR 13292.2327323 -
003A-FMBCMS 00000000_0CF27000 000
003A-FMBCOL 00000000_0CF54000 000
003A-FMBCOPTS 00000000_0CF13000 000
003A-FMBCRMGR 00000000_0CF12000 000
003A-FMBCSSE 00000000_0CF17000 000

Provide a selection mask: *  
To select all privates, Type *PVT.  
3=End 4=Include 5=Exclude

0001 of 0101 1=Help 2=Mask 3=End 5=Next 7=Bwd 8=Fwd 9=Sort_Address  XXXX FB :
Move the cursor to a Csect to be excluded or included in the analysis and press Enter. Continue this process as often as needed. Once you have completed your selections press PF5.

- 003A-@@KJUMP 00000000_0CD69968 000000A0 13292.2327323 -
- 003A-@@TRT 00000000_0CD6B330 00000100 13292.2327323 -
- 003A-@@XTOVFN 00000000_0CD6BF00 00000220 13292.2327323 -
- 003A-ACCESS 00000000_0CD5C000 00000473 13292.2327323 -
- 003A-ALLOC 00000000_0C755000 0000120A 13292.2327323 -
- 003A-ALTER 00000000_0C757000 00000A4A 13292.2327323 -
- 003A-ATTRIB 00000000_0C74F000 00001500 13292.2327323 -
- 003A-BPXWESTA 00000000_0CD6C1A0 0000008C 13292.2327323 -
- 003A-BPXWREXX 00000000_0CD6C230 0001B27E 13292.2327323 -
- 003A-BPXWRFM 00000000_0CD87658 000000AE 13292.2327323 -
- 003A-BPXWRFMS 00000000_0CD87708 000000BC 13292.2327323 -
- 003A-BPXWRGM 00000000_0CD875A0 000000B4 13292.2327323 -
- 003A-BPXWRTLM 00000000_0CD877C8 000000FC 13292.2327323 -
- 003A-BPXWRT2E 00000000_0CD878C8 000000E4 13292.2327323 -
- 003A-BPXWRXST 00000000_0CD87400 00000044 13292.2327323 -
Virtual Storage Boundary Chooser

Move the cursor to a boundary to be excluded or included in the analysis and press Enter. Continue this process as often as needed. Once you have completed your selections press PF5.

- CSA 00000000_00000000 00000000_00D2FF
- DONUC 00000000_7FD7C000 00000000_7FD7FFFF
- ECSA 00000000_076BA000 00000000_0CFFFFFF
- EFLPA 00000000_076A9000 00000000_076ABFFF
- EMLPA 00000000_076AC000 00000000_076B9FFF
- EPLPA 00000000_03C0B000 00000000_076A8FFF
- EPRV 00000000_0C700000 00000000_7FFFFFFF
- ERON 00000000_01000000 00000000_01B35FFF
- ERWN 00000000_01B36000 00000000_01B98FFF
- ESQA 00000000_01B99000 00000000_03C0AFFF
- HCSA 000001EF_00000000 000001FF_FFFFFF
- PLPA 00000000_00D26000 00000000_00F07FFF
- PRIVATE 00000000_00000000 00000000_00AFFFFF
- RON 00000000_00FE1000 00000000_00FFFFFF
- RNNUC 00000000_00FD5000 00000000_00FE0387

0001 of 0002  1=Help  2=Mask  3=End  5=Next  7=Bwd  8=Fwd  9=Sort_Address  XXXX FX: in Anaheim
Fast-path Range, Module, Section Chooser

All available modules, csect and boundaries have been selected

Up to ten modules, Csects or address ranges may be entered into this screen. To specify a module or Csect, enter its name in the left field while setting the right field to blanks. Press PF2 to display a usage report that includes all the data that you have selected for address space 003A.

Wait state: N  Include Wait dispatched, Y or N

Address range: ____________________ to ____________________
____________________ to _________________
____________________ to _________________
____________________ to _________________
____________________ to _________________
____________________ to _________________
____________________ to _________________
Press <F9> to include all virtual storage ranges. Useful when nothing else has been selected previously.

Press <F2> to Create Interactive Analysis Reports

1=Help 2=Run 3=End 4=Return 7=Counter 8=Info 9=Select All 10=Memory 11=Clear
Interactive Analysis Report Navigation

• The Full Analysis shows all execution analysis units with the most frequently-executed at the top of the display.
  • Control section, module and boundary are displayed for every execution analysis unit.
  • Change sort order as desired using cursor-based selection.
• Use cursor-based selection to drill down to the Spot Analysis, where all execution analysis units for a given control section, module or virtual storage boundary are shown.
• From there, you can display control section source code with execution analysis unit highlighted – if ADATA or COBOL SYSDEBUG information is available.
### Full Analysis

**Run Summary**

<table>
<thead>
<tr>
<th>PSW_Address</th>
<th>Tot_Pct</th>
<th>Sel_Pct</th>
<th>Csect</th>
<th>Module</th>
<th>Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000000_01864C40</td>
<td>2.451%</td>
<td>6.933%</td>
<td>IAXFP</td>
<td>-</td>
<td>ERON</td>
</tr>
<tr>
<td>00000000_0CF321C0</td>
<td>1.190%</td>
<td>3.367%</td>
<td>FMBCD012</td>
<td>FMBCD012</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_01864C80</td>
<td>1.155%</td>
<td>3.268%</td>
<td>IAXFP</td>
<td>-</td>
<td>ERON</td>
</tr>
<tr>
<td>00000000_0CF320C0</td>
<td>1.120%</td>
<td>3.169%</td>
<td>FMBCD012</td>
<td>FMBCD012</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_00050080</td>
<td>0.969%</td>
<td>2.740%</td>
<td>ERBSMFI</td>
<td>ERBSMFI</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_0CF7700</td>
<td>0.700%</td>
<td>1.981%</td>
<td>-</td>
<td>-</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_015CD00</td>
<td>0.654%</td>
<td>1.849%</td>
<td>GAAUX</td>
<td>-</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_0CF31700</td>
<td>0.514%</td>
<td>1.453%</td>
<td>IGVCP</td>
<td>-</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_0CF33000</td>
<td>0.479%</td>
<td>1.354%</td>
<td>FMBCS</td>
<td>-</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_00D52000</td>
<td>0.444%</td>
<td>1.255%</td>
<td>FMBCD012</td>
<td>FMBCD012</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_0CF33200</td>
<td>0.444%</td>
<td>1.255%</td>
<td>FMBCD012</td>
<td>FMBCD012</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_00D52000</td>
<td>0.397%</td>
<td>1.122%</td>
<td>ERBSMFI</td>
<td>ERBSMFI</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_0CB280C0</td>
<td>0.385%</td>
<td>1.083%</td>
<td>GAAUX</td>
<td>-</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_0CF327C0</td>
<td>0.385%</td>
<td>1.083%</td>
<td>FMBCD012</td>
<td>FMBCD012</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_0D15D200</td>
<td>0.303%</td>
<td>0.857%</td>
<td>MBCCSUBS</td>
<td>-</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_7FD7C3C0</td>
<td>0.292%</td>
<td>0.825%</td>
<td>-</td>
<td>-</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_011BC500</td>
<td>0.268%</td>
<td>0.759%</td>
<td>IEAVETRC</td>
<td>-</td>
<td>ERON</td>
</tr>
</tbody>
</table>

*Point and <F6> for Location Pop-Up*

*Click for Spot Analysis of Section, Module or Boundary.*

*Press <F9> to rotate through available sorts.*

---

Complete your session evaluations online at [www.SHARE.org/Antwerp-Eval](https://www.SHARE.org/Antwerp-Eval)
# Full Analysis with Location Pop-up

<table>
<thead>
<tr>
<th>PSW_Address</th>
<th>Tot_Pct</th>
<th>Sel_Pct</th>
<th>Csect</th>
<th>Module</th>
<th>Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000000_01864C40</td>
<td>2.451%</td>
<td>6.933%</td>
<td>IAXFP</td>
<td>-</td>
<td>ERON</td>
</tr>
<tr>
<td>00000000_0CF321C0</td>
<td>1.190%</td>
<td>3.367%</td>
<td>FMBCDA2</td>
<td>FMBCDA2</td>
<td>EPRV</td>
</tr>
</tbody>
</table>

- **01 of 01** Module: FMBCDA2

Start 00000000_0CF2D000 End 00000000_0CF3CFFF Length 00010000
CPI ratio: MOD FMBCDA2 21.2927 Csect FMBCDA2 21.2927

VolSer MVSNV0 DSN PHOENIX.TESTLOADLIB

Press <F6> repeatedly to step through Location Pop-Ups
## Spot Analysis for Control Section

### Data Table

<table>
<thead>
<tr>
<th>Psw_Address</th>
<th>Offset</th>
<th>Tot_Pct</th>
<th>Sel_Pct</th>
<th>Csect</th>
<th>Module</th>
<th>Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000000_OCF321C0</td>
<td>000051C0</td>
<td>1.190%</td>
<td>3.367%</td>
<td>FMBCD4A2</td>
<td>FMBCD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF320C0</td>
<td>000050C0</td>
<td>1.120%</td>
<td>3.169%</td>
<td>FMBSD4A2</td>
<td>FMBSD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF31700</td>
<td>00004700</td>
<td>0.444%</td>
<td>1.255%</td>
<td>FMBSD4A2</td>
<td>FMBSD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF33000</td>
<td>00006000</td>
<td>0.444%</td>
<td>1.255%</td>
<td>FMBSD4A2</td>
<td>FMBSD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF327C0</td>
<td>000057C0</td>
<td>0.385%</td>
<td>1.889%</td>
<td>FMBCD4A2</td>
<td>FMBCD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF333C0</td>
<td>000063C0</td>
<td>0.187%</td>
<td>0.528%</td>
<td>FMBCD4A2</td>
<td>FMBCD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF32080</td>
<td>00005800</td>
<td>0.163%</td>
<td>0.462%</td>
<td>FMBCD4A2</td>
<td>FMBCD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF31200</td>
<td>00004200</td>
<td>0.128%</td>
<td>0.363%</td>
<td>FMBCD4A2</td>
<td>FMBCD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF32700</td>
<td>00005700</td>
<td>0.117%</td>
<td>0.330%</td>
<td>FMBCD4A2</td>
<td>FMBCD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF30D80</td>
<td>00003D80</td>
<td>0.105%</td>
<td>0.297%</td>
<td>FMBCD4A2</td>
<td>FMBCD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF32E80</td>
<td>00005E80</td>
<td>0.105%</td>
<td>0.297%</td>
<td>FMBCD4A2</td>
<td>FMBCD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF32D80</td>
<td>00005D80</td>
<td>0.093%</td>
<td>0.264%</td>
<td>FMBCD4A2</td>
<td>FMBCD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF31400</td>
<td>00004400</td>
<td>0.082%</td>
<td>0.231%</td>
<td>FMBCD4A2</td>
<td>FMBCD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF36240</td>
<td>00009240</td>
<td>0.082%</td>
<td>0.231%</td>
<td>FMBCD4A2</td>
<td>FMBCD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF36600</td>
<td>00009600</td>
<td>0.082%</td>
<td>0.231%</td>
<td>FMBCD4A2</td>
<td>FMBCD4A2</td>
<td>EPRV</td>
</tr>
<tr>
<td>00000000_OCF31900</td>
<td>00004900</td>
<td>0.058%</td>
<td>0.165%</td>
<td>FMBCD4A2</td>
<td>FMBCD4A2</td>
<td>EPRV</td>
</tr>
</tbody>
</table>

### Notes
- Click here to show source code via ADATA

---

Complete your session evaluations online at [www.SHARE.org/Anaheim-Eval](http://www.SHARE.org/Anaheim-Eval)
Define the SYSADATA and SYSDEBUG dataset name(s) using the catalog mask and the PF5 and PF6 key functions. Correct the target member name if necessary and if using SYSDEBUG, provide the program name. After all required fields have been provided press the PF2 key to view the associated data.

Catalog Search mask  **.ADATA
Target member name  FM6CDA2

Target program name  
(Only if SYSDEBUG)  
(Case sensitive)  

Report page limit  1000

Instruction address  00000000_0CF30A80

Instruction offset  00003A80

1=Help  2=Adata  3=End  5=Dataset(s)  6=Catalog,Search  11=Clear
## Scrollable ADATA with Highlighted Code from Execution Analysis Unit

<table>
<thead>
<tr>
<th>Address</th>
<th>Code</th>
<th>Instruction</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>003A7C</td>
<td>41E0 E0C0</td>
<td>000C0 29599+</td>
<td>LA R14,ESTKESIZ(,R14)</td>
</tr>
<tr>
<td>003A80</td>
<td>E3E0 A010 0024 00000 00000</td>
<td>29600+</td>
<td>STG R14,ESTKCUR</td>
</tr>
<tr>
<td>003A86</td>
<td>D207 E000 A028 00000 00018</td>
<td>29601+</td>
<td>MVC 0(8,R14),ESTKWORK</td>
</tr>
<tr>
<td>003A8C</td>
<td>E6FD E008 0024 00000 00008</td>
<td>29607+</td>
<td>STMG 15,13,8(R14)</td>
</tr>
<tr>
<td>003A92</td>
<td>E3E0 A028 0004 00000 00018</td>
<td>29610+</td>
<td>LG R14,ESTKWORK</td>
</tr>
<tr>
<td>003A80</td>
<td>B904 0041 00000</td>
<td>29612</td>
<td>LGR R4,R1</td>
</tr>
<tr>
<td>003A9C</td>
<td>D703 4137 4137 00137 00137</td>
<td>29613</td>
<td>XC DASECPUP,DASECPUP</td>
</tr>
<tr>
<td>003A9C</td>
<td>D703 413B 413B 0013B 0013B</td>
<td>29614</td>
<td>XC DASEACPP,DASEACPP</td>
</tr>
<tr>
<td>003A9A</td>
<td>D703 413F 413F 0013F 0013F</td>
<td>29615</td>
<td>XC DASEZAPP,DASEZAPP</td>
</tr>
<tr>
<td>003AAE</td>
<td>D703 4147 4147 00147 00147</td>
<td>29616</td>
<td>XC DASEGCPP,DASEGCPP</td>
</tr>
<tr>
<td>003AB4</td>
<td>D703 414B 414B 0014B 0014B</td>
<td>29617</td>
<td>XC DASEUCPP,DASEUCPP</td>
</tr>
<tr>
<td>003ABA</td>
<td>D703 414F 414F 0014F 0014F</td>
<td>29618</td>
<td>XC DASEVACP,DASEVACP</td>
</tr>
<tr>
<td>003AC0</td>
<td>D703 4153 4153 00153 00153</td>
<td>29619</td>
<td>XC DASEPAGR,DASEPAGR</td>
</tr>
<tr>
<td>003AC6</td>
<td>D703 4157 4157 00157 00157</td>
<td>29620</td>
<td>XC DASESIOR,DASESIOR</td>
</tr>
<tr>
<td>003ACC</td>
<td>E370 A0C0 0017 00000 000C0</td>
<td>29621</td>
<td>LLGT R7,EMRACTRD</td>
</tr>
<tr>
<td>003AD2</td>
<td>B902 0077 00000</td>
<td>29622</td>
<td>LTGR R7,R7</td>
</tr>
<tr>
<td>003AD6</td>
<td>A784 0024 03B1E 29623</td>
<td>JZ DARATE1A</td>
<td></td>
</tr>
<tr>
<td>003ADA</td>
<td>E310 4027 0090 00000 00027</td>
<td>29624</td>
<td>LLGC R1,DASESYID</td>
</tr>
<tr>
<td>003AE0</td>
<td>A71B FFFF FFFF FFFF</td>
<td>29625</td>
<td>AGHI R1,-1</td>
</tr>
</tbody>
</table>
Print, Save or Export Results

- The Full Analysis, Spot Analysis and ADATA source code reports can be printed or saved. These reports are text versions of the 3270-based reports – all rows shown.
- Exporting the Full Analysis or Spot Analysis report to a CSV (comma-separated values) file allows you to easily import the data into your favorite spreadsheet or charting utility.
To print the current report provide a valid SYSOUT class and press the PF4 key. To save the current report supply the name of a PDS or PDSE dataset that you are authorized to update and the member name that is to contain the report and press the PF5 key. To export the current report as a CSV file specify the output path name and press the PF7 key.

Sysout Class

Output Dataset Name ____________________________
Output Member Name _______

Output Path Name ____________________________
Character encoding ASCII

1=Help 3=End 4=Print 5=Save 7=Export 11=Clear
Import CSV File into Your Spreadsheet

<table>
<thead>
<tr>
<th>PSW_Address</th>
<th>Tot_Pct</th>
<th>Sel_Pct</th>
<th>Csect</th>
<th>Module</th>
<th>Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000000_01864C40</td>
<td>2.45%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0CF3321C</td>
<td>1.19%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_01864C80</td>
<td>1.16%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0CF3320C</td>
<td>1.12%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_000S080</td>
<td>0.97%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0CD7700</td>
<td>0.70%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0CB27D40</td>
<td>0.65%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_00F8E80</td>
<td>0.51%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0D15C300</td>
<td>0.48%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0CF33170</td>
<td>0.44%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0CF33000</td>
<td>0.44%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0CE052D0</td>
<td>0.40%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0CF27C30</td>
<td>0.39%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0D15D20</td>
<td>0.30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0D77C300</td>
<td>0.29%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_01185380</td>
<td>0.27%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_017524C0</td>
<td>0.26%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0D1A4C90</td>
<td>0.23%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_01215860</td>
<td>0.19%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_013258B0</td>
<td>0.19%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0CF333CC</td>
<td>0.19%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0CF33D80</td>
<td>0.19%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0B19C0C0</td>
<td>0.16%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0CE329D0</td>
<td>0.16%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0CA77C0</td>
<td>0.15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0D1A4500</td>
<td>0.15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0D77C480</td>
<td>0.15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0A29A00</td>
<td>0.14%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0B19C6C0</td>
<td>0.14%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000_0CF33D40</td>
<td>0.14%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Csect**
  - 6.93%
  - 3.37%
  - 3.27%
  - 3.17%
  - 2.74%

- **Module**
  - IAXFP
  - FMBCDA2
  - IAXFP
  - FMBCDA2
  - ERBSMF1
Questions?