Session 9727

z/OS Debugging: a review of System Trace

MVS Core Technologies Project – August 9th 2011

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Agenda

- What is the System Trace Table?
- How do you format it in a dump?
- How do you read the system trace entries?
- Recent enhancements
What is the MVS System Trace Table?

- Consists of trace buffers (one per CPU) residing in the Trace Address Space (ASID 4)
- System trace entries are inserted continuously into the trace buffers
- Contains detailed system activity
- Default size of 1 Meg per CPU
- Entries from trace buffers are merged when viewed using IPCS
Why look at the System Trace?

- It contains the sequence of system events leading up to the problem
- It contains historical information that can be very useful for debugging
- It helps you to identify the source of the problem or confirm a failing scenario
How are system trace entries generated?

- By hardware, when certain instructions are issued:
  - Cross Memory instructions such as PC, PT, PR and SSAR
  - A branch is taken via a Branch and Link instruction such as BALR, BASR, BASSM, BAKR… (if Branch Tracing is active)
  - Instructions causing switch of AMODE between 24/31 and 64 such as SAM (if Mode Tracing is active)

- By the operating system, when the TRACE/TRACG instruction is issued by system component modules
How can the System Trace options be changed?

- Via the TRACE operator command:
  - Stop or start system trace
  - Turn on Branch Tracing or Mode Tracing (or both)
  - Change the size of the trace table

- Note: System Trace is started during IPL with Branch and Mode Tracing off
How do I find the System Trace Table when debugging?

- The System Trace Table is dumped in SYSMDUMPs, SVC and Standalone dumps

- Use the IPCS subcommand SYSTRACE to format the System Trace Table in a dump

- SYSTRACE is documented in:
  - z/OS MVS IPCS Commands
Frequently used SYSTRACE parameters

- **Current**
  - Select entries of current address space (this is the default)

- **All**
  - Select all entries

- **ASID(x,y....)**
  - Select entries of specific address space(s) by ASID

- **Jobname(name1,name2.....)**
  - Select entries of specific address space(s) by jobname

- **TCB(tcb_address)**
  - Select entries of a TCB in an address space
More SYSTRACE parameters...

- **CPU**
  - Select entries of a specific CPU

- **Time(z)**
  - \( z = \) hex, local or GMT (default is hex)

- **Exclude(x)**
  - \( x = \) BR or MODE or BR,MODE
  - Exclude branch or mode trace entries, or both
Examples of using SYSTRACE

- SYSTRACE TIME(LOCAL)  select entries of current address space
- SYSTRACE ALL TIME(LOCAL)  select all entries
- SYSTRACE ASID(X'5C') TIME(LOCAL)  select entries of ASID 5C
- SYSTRACE ALL EX(BR,MODE) TIME(LOCAL)  select all entries and exclude BR and Mode entries
- SYSTRACE ASID (X’1F’) TCB(X’9D2380’) TIME(LOCAL)  select entries of TCB 9D2380 in ASID 1F
Reading the System Trace

Entries are presented chronologically and intermixed
- Oldest entry at the top
- Newest entry at the bottom
## Reading the System Trace: *who did it?*

### IPCS OUTPUT STREAM

Command ===>

****************************************************************************** TOP OF DATA **************************************************************************

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### Notes:

- **PR (processor id)**
- **ASID**
- **WU-ADDR** *(TCB mode: TCB address / SRB mode: WEB address or zero)*
- **PSW**
Reading the System Trace: *what was done?*

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</tbody>
</table>
```

- **IDENT** - trace table entry identifier
- **CD/D** – a number describing the entry
- **SVC descriptors**
## Reading the System Trace: *how was it done?*

![IPCS Output Stream Table](image)

- **UNIQUE** – up to 6 unique fields containing information related to the entry.
Reading the System Trace: **under what conditions?**

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</table>

- **PSACLHS** / **PSACLHSE** / **PSALCAL** – local lock information
- **PASD** / **SASD** - Primary and Secondary ASID
- **TIME** – timestamp

Note: the rightmost column is CP (not shown above). It is the physical CPU number which is usually not useful for common debugging purposes
Common System Trace entries

- **Dispatch**
  - DSP (TCB dispatch)
  - SRB (SRB dispatch)
  - SSRB (Suspended SRB dispatch)
  - WAIT (no-work wait dispatch)

- **Interrupts**
  - SVC, SVCR, SVCE (SVC issuance, SVC completion, SVC error)
  - I/O
  - CLKC, EMS, EXT, CALL, SS (external interrupts such as clock comparator, emergency signal, general external, external call and service signal)
  - PGM (program check)
  - MCH (machine check)
  - RST (restart interrupt)

See z/OS MVS Diagnosis: Tools and Service Aids manual, chapter on System Trace for detailed description of system trace entries
Common System Trace entries...

- **I/O operations**
  - SSCH (start subchannel)
  - MSCH (modify subchannel)
  - HSCH (halt subchannel)
  - RSCH (resume subchannel)

- **Cross Memory instructions**
  - PC (program call)
  - PT (program transfer)
  - PR (program return)
  - SSAR (set secondary address space number)

- **Recovery**
  - RCVY (recovery termination manager processing)
  - ACR (alternate CPU recovery)
Common System Trace entries...

- **Other entries**
  - SSRV (system service entered through branch entry or PC)
  - SUSP (suspended for a lock)
  - BR (branch trace entry)
  - MODE (mode trace entry)
  - BSG (branch to subspace group)
Example: DSP - TCB Dispatch

- **WU ADDR = TCB address**
- **UNIQUE-2 = R0**
- **UNIQUE-3 = R1**
- **TCB continues to run until a new unit of work is dispatched on the same CPU**
## Example: SVC/SVCR/SVCE

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- SVC entry indicates an SVC issued by a TCB
- SVCR entry indicates completion of SVC
- SVCE entry indicates an error condition
- UNIQUE-1 = R15  UNIQUE-2 = R0  UNIQUE-3 = R1
- See SVC description after the UNIQUE fields
- See z/OS MVS Diagnosis: Reference for SVC summary and registers usage
Example: SRB/SSRB

- SRB entry indicates initial SRB dispatch
- SSRB entry indicates suspended SRB re-dispatch
- WU-ADDR has WEB (Work Element Block) address
- UNIQUE-2 = R0  UNIQUE-3 = R1
- While SRB/SSRB is running, WU-ADDR will contain zero or associated TCB address (PurgeDeq TCB)
Example: Program Check

<table>
<thead>
<tr>
<th>PR</th>
<th>ASID</th>
<th>WU-ADDR-</th>
<th>IDENT</th>
<th>CD/D</th>
<th>PSW-</th>
<th>ADDRESS-</th>
<th>UNIQUE-1</th>
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- A program interrupt can be resolvable
- A PGM entry indicates an error condition only if it is followed by RCVY
- RCVY entry indicates RTM (Recovery Termination Manager) in control
- UNIQUE-1 of PGM entry contains instruction length and interrupt code
Example: ABEND

For ABEND (SVC D), R0 contains ABEND code (UNIQUE-3)

Trace entry is SVCE because SVC was issued in an invalid environment

Note RCVY entry following the SVCE D
**Example: Loop**

- A simple loop is indicated by trace entries with similar PSW addresses.
- A complicated loop consists of groups of entries repeating and may not be obvious.
Branch Tracing: is it useful?

- Branch Tracing traces target address of instructions such as BALR, BASR, BASSM, BAKR when they cause branching during their execution.
- The return address is not traced.
- Helpful when investigating module flow but does not give a complete picture.

<table>
<thead>
<tr>
<th>PR</th>
<th>ASID</th>
<th>WU-ADDR</th>
<th>IDENT</th>
<th>CD/D</th>
<th>PSW</th>
<th>ADDRESS</th>
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</table>
Missing System Trace Table: why?

- Using the wrong level of IPCS (compared to level of system where dump was taken)
- ASID(4) is not dumped due to TRT not requested in SDATA of SVC Dump
- A major MVS control block is overlaid and IPCS cannot get to the system trace table
SYSTRACE enhancements

- **z/OS R12**
  - New parameter SORTCPU provides output with trace entries sorted by CPU (instead of by time)

- **z/OS R13**
  - New parameters CPUMASK and CPUTYPE allow selection of CPU by bit mask or type (instead of by number)

- See [z/OS MVS IPCS Commands](#) for details
Reference Information

- Manuals
  - z/OS MVS IPCS Commands
  - z/OS MVS IPCS Customization
  - z/OS MVS IPCS User’s Guide
  - z/OS MVS Diagnosis: Reference
  - z/OS MVS Diagnosis: Tools and Service Aids
  - z/OS MVS System Codes