Finding debugging clues in LE dumps

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Agenda

- CSI Training
- The Crime is committed
- Collecting the Clues
- Analyzing the Crime Scene
- Back in the Lab
- Forcing LE to Spill the Beans
- Sources of Additional Information
- Appendix
  - Programs
  - Really Cool Lab Equipment

Investigator training

Major clues to look for (ABENDs)

- U4038 A severe (unhandled) error occurred.
- U4039 A severe (unhandled) error occurred AND LE took a system dump.

- U4083 Save area back chain error
- U4087 Error during condition processing
- U4093 Error during initialization
- U4094 Error during termination

Major clues to look for (ABENDs)

- U4038/U4039
  - A severity 2 or greater condition has gone unhandled
  - Application will terminate (gracefully)
  - Clues will be gathered and collected if requested
    - TERMTHDACT controls amount and type of clues
    - CEEDUMP and/or DYNDUMP can be collected

Major clues to look for (ABENDs)

- U40xx
  - Application will terminate immediately
  - TERMTHDACT does NOT control what clues are gathered
  - No CEEDUMP is generated
  - DYNDUMP can be used (3rd suboption) to collect clues

Major clues to look for (messages)

- Message (and module) prefixes
  - CEE CEL (but may be reporting errors elsewhere)
  - IGZ COBOL
  - IBM PL/I
  - FOR Fortran (also AFH)
  - EDC C/C++

  See z/OS Language Environment Run-Time Messages

Some DNA mapping

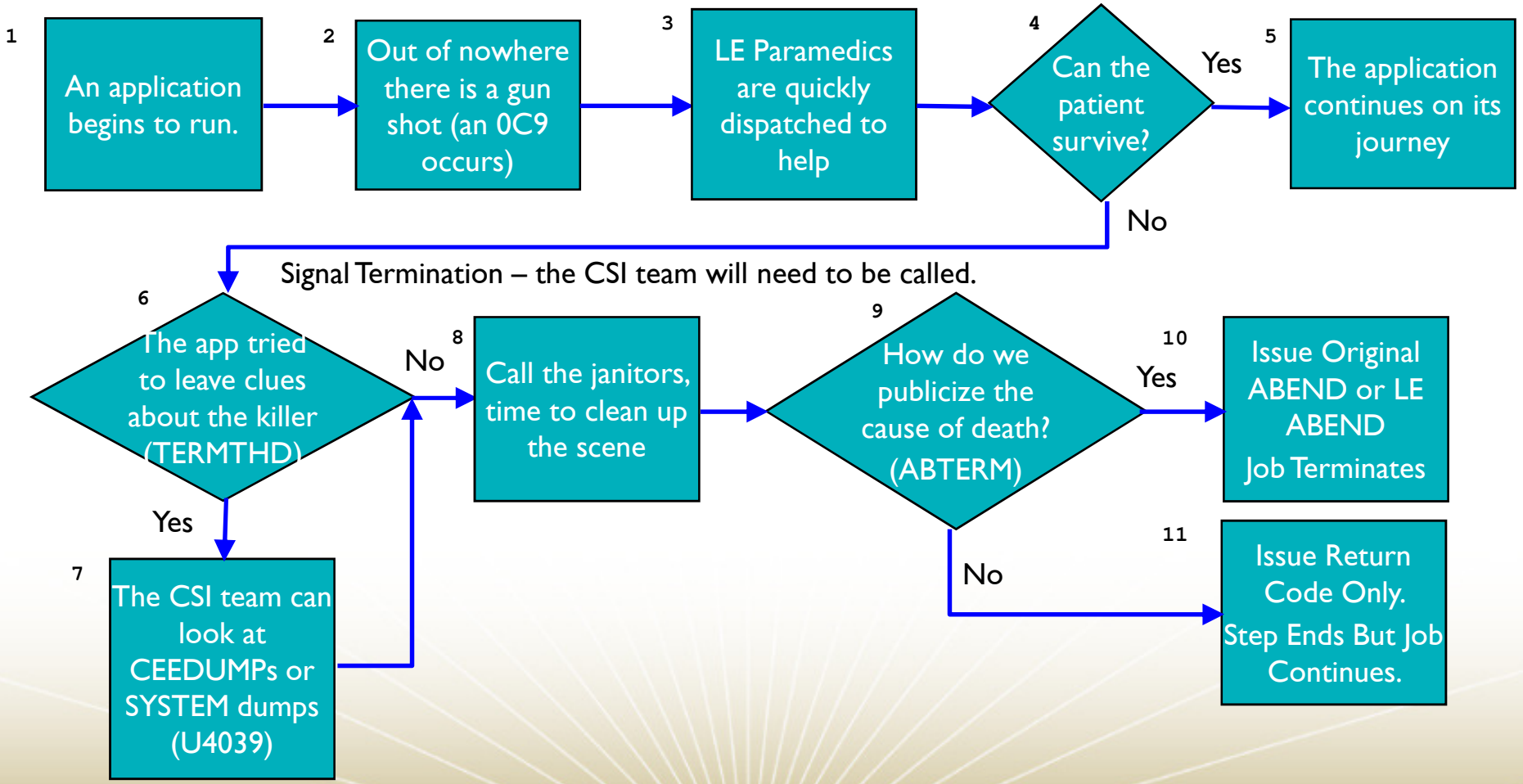
- Condition Token (Feedback Code)
  - Example: 00030C89 59C3C5C5 xxxxxxxx
    - 0003 | 0C89 | 59 | C3C5C5 | xxxxxxxx
      - 0003 Severity
        - 0000 Informational (I)
        - 0001 Warning (W)

        - 0002 Error (E)
        - 0003 Severe (S)
        - 0004 Critical (C)

Some DNA mapping

- Condition Token (Feedback Code)
  - Example: 00030C89 59C3C5C5 xxxxxxxx
    - 0003 | 0C89 | 59 | C3C5C5 | xxxxxxxx
      - 0003 Severity (**S**)
      - 0C89 Hex message number (**3209**)
      - 59 Flags (ignore)
      - C3C5C5 Hex (EBCDIC) facility ID (message prefix) (**CEE**)
      - xxxxxxxx Instance specific info (internal)
  - This token represents message CEE3209S

Timeline of a crime



The crime is committed

The criminal application is written

- A COBOL program (COBOLED1) calls
- A 2nd COBOL program (COBOLED2) which calls
- A C program (CPROG3)
- CPROG3 divides by zero!

See appendix for these programs

Collecting the clues

Major Sources of Evidence

- CEEDUMP
- LEDATA IPCS Verb Exit
- Other Language Environment-produced reports
  - Options Report
  - Storage Report
  - Heap Storage Diagnostics Report

Major Sources of Evidence

- Getting useful information
  - Use Language Environment run-time option TERMTHDACT() to request Language Environment take a dump
    - DUMP CEEDUMP with storage
    - TRACE CEEDUMP with traceback only
    - **UADUMP CEEDUMP, system dump via U4039**
    - UAONLY No CEEDUMP, system dump via U4039
    - UATRACE CEEDUMP (traceback) and system dump via U4039
    - *(UAIMM) System dump via original error (only for debug purposes), also TRAP(ON,NOSPIE)*

CEEDUMP (the picture)

- Formatted dump produced by Language Environment
  - Failure information, traceback, control blocks, heaps, run-time options report

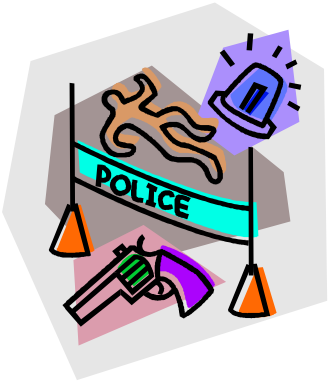
- Written to CEEDUMP data set:
  - CEEDUMP DD if allocated
  - Dynamically allocated if not available based on CEEDUMP run-time option
    - CEEDUMP(60,SYSOUT=*,FREE=END,SPIN=UNALLOC)
- CICS written to CESE Transient Data Queue
  - With TERMTHDACT(,CICSDDS) written as part of the CICS dump data set (CICS transaction dump)

CEEDUMP (the picture)

- Advantages
  - Immediately available and readable
  - Can provide a lot of information (with the right set of compile and run-time options)
- Disadvantages
  - Snapshot of the crime scene
    - May not contain all clues necessary to solve the crime

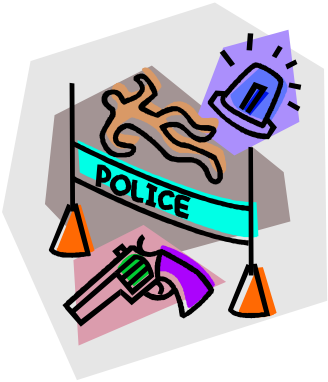
IPCS readable dump (the body)

- IPCS support to format and analyze data in a system dump
- Options to generate numerous reports
  - CEEDUMP information and more
- System dump generated:
  - For an unhandled condition of severity 2 or greater
    - TERMTHDACT(UADUMP/UATRACE/UAONLY)
      - with SYSMDUMP DD
      - DYNDUMP(hlq,DYNAMIC,TDUMP)
  - When CEE3ABD is called by the application
  - Using system mechanisms (SLIP, Console Dump)



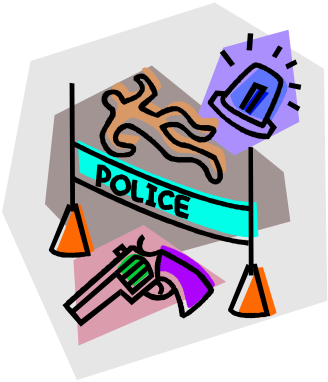
IPCS readable dump (the body)

- DYNDUMP run-time option
  - DYNDUMP(hlq,U4039-ABEND,U40xx-ABEND)
    - hlq
      - *USERID or *USERID.hlq
      - *TSOPREFIX or *TSOPRE
        - (also *TSOPREFIX.hlq or *TSOPRE.hlq)
      - Up to 26 characters of an MVS data set name



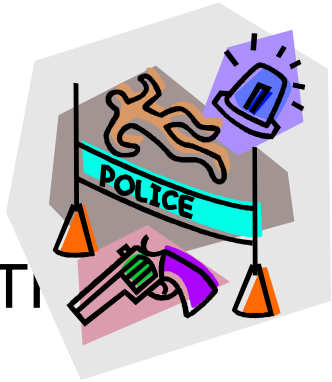
IPCS readable dump (the body)

- DYNDUMP run-time option
  - DYNDUMP(hlq,U4039-ABEND,U40xx-ABEND)
    - U4039-ABEND
      - NODYNAMIC (default)
        - DYNDUMP turned off for U4039 ABENDs
      - DYNAMIC
        - DYNDUMP active for U4039 ABENDs if no SYSMDUMP, SYSUDUMP or SYSABEND DD.
      - FORCE
        - DYNDUMP active for U4039 ABENDs even with above DDs allocated
      - BOTH
        - You want it all!!!



IPCS readable dump (the body)

- DYNDUMP run-time option
  - DYNDUMP(hlq,U4039-ABEND,U40xx-ABEND)
    - U4039-ABEND
      - TERMTHDACT MUST be set to UADUMP, UATI UAONLY to generate a U4039.
      - U4038 does not produce a dump!
      - Example: DYNDUMP(JMONTI,FORCE,TDUMP)



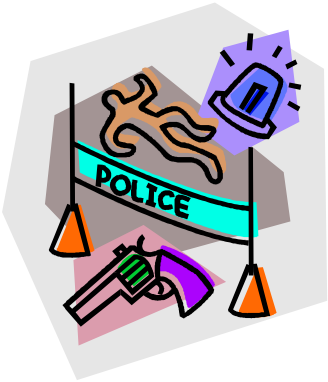

```
+CEE3798I ATTEMPTING TO TAKE A DUMP FOR ABEND U4039 TO DATA SET:
 JMONTI.D201.T1336225.JMONTI@B

IEA822I COMPLETE TRANSACTION DUMP WRITTEN TO
 JMONTI.D201.T1336225.JMONTI@B
+CEE3797I LANGUAGE ENVIRONMENT HAS DYNAMICALLY CREATED A DUMP.
```

IPCS readable dump (the body)

- DYNDUMP run-time option
  - DYNDUMP(hlq,U4039-ABEND,U40xx-ABEND)
    - U40xx-ABEND
      - TDUMP (Default)
        - DYNDUMP is active for all U40xx ABENDs (other than U4039) which request a dump.
      - NoTDUMP
        - DYNDUMP is not active for U40xx ABENDs

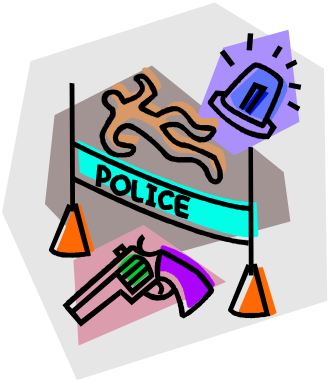
IPCS readable dump (the body)

- DYNDUMP run-time option
  - Not honored for CICS
  - Use CEMT to request system dumps in CICS
    - CEMT SET TRD(40xx) SYS ADD



IPCS readable dump (the body)

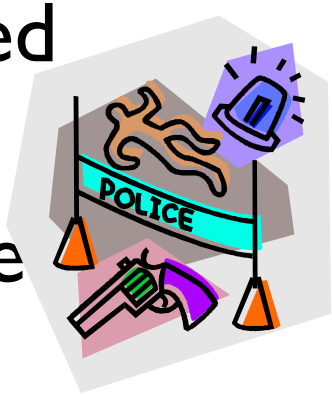
- Advantages
  - More complete picture of the crime scene
  - IPCS tools available for debugging
- Disadvantages
  - Additional skills required for analysis
  - Application programmers may not have access to system dumps and/or IPCS
  - Sometimes have to get your hands dirty (with bits and bytes)



False Leads!

Don’t be fooled!

- Don’t SLIP on Language Environment reissued ABEND (eg, 0C4)
  - Remember this is taking a picture after the crime scene has been cleaned up!



Analyzing the Crime Scene

Messages are the first clue

- Examine the Language Environment message file (usually SYSOUT)

CEE3209S The system detected a fixed-point divide exception (System Completion Code=0C9).
From compile unit POSIX.RTL.UT29.SRC(CPROG3) at entry point CPROG3 at statement 8 at compile unit offset +0000008C at entry offset +0000008C at address 219C60FC.

- Message tells us what the crime was and where it was committed!
  - A divide by zero occurred at offset x'8C' in CPROG3 (statement 8)!

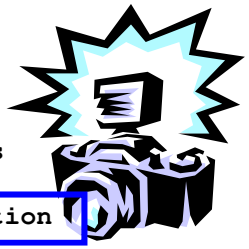
Getting a better picture

The header section of the CEEDUMP

```
CEE3DMP V1 R12.0: Condition processing resulted in the unhandled condition.      07/20/10 1:36:25 PM
ASID: 0180    Job ID: JOB15785    Job name: JMONTI@B    Step name: GO          UserID: JMONTI

CEE3845I CEEDUMP Processing started.
```

Getting a better picture

The traceback section of the CEEDUMP



```
Traceback:
  DSA   Entry      E  Offset   Statement   Load Mod          Program Unit          Service  Status
  1     CEEHDSP    +000041FA                CEEPLPKA          CEEHDSP               HLE7770  Call
  2     CPROG3     +0000008C  8             CPROG3            CPROG3                         Exception
  3     @@FECB
                   +00312B7C                                                               Call
  4     @@DB2C     +00000102                CEEEV003                                       Call
  5     IGZCFCC    +000002C0                IGZCPAC           IGZCFCC                      Call
  6     COBOLED2   +000004C0  28            COBOLSHR          COBOLED2                     Call
  7     COBOLED1   +0000037A  10            COBOLSHR          COBOLED1                     Call

  DSA   DSA Addr   E  Addr    PU Addr    PU Offset  Comp Date  Compile Attributes
  1     2199D768   217C8180   217C8180   +000041FA  20100319   CEL
  2     2199D6D8   219C6070   219C6070   +0000008C  20070212   C/C++
  3     2199D5E8   219BDE40   219BDE40   +00312B7C             LIBRARY
  4     2199D560   21C504F0   21C504F0   +00000102             LIBRARY
  5     2199D380   21922548   21922548   +000002C0  20100316   LIBRARY
  6     2199D1D8   21702220   21702220   +000004C0  20100720   COBOL
  7     2199D030   21700000   21700000   +0000037A  20100720   COBOL

Fully Qualified Names
DSA   Entry      Program Unit                                   Load Module

2     CPROG3     POSIX.RTL.UT29.SRC(CPROG3)                     CPROG3
```

Status
Why I left this entry point

Getting a better picture

The condition information section of the CEEDUMP

```
Condition Information for Active Routines
  Condition Information for POSIX.RTL.UT29.SRC(CPROG3) (DSA address 2199D6D8)
    CIB Address: 2199E060
    Current Condition:
      CEE0198S The termination of a thread was signaled due to an unhandled condition.
    Original Condition:
      CEE3209S The system detected a fixed-point divide exception (System Completion Code=0C9).
    Location:
      Program Unit: POSIX.RTL.UT29.SRC(CPROG3)
      Entry:        CPROG3  Statement: 8  Offset: +0000008C
    Machine State:
      ILC..... 0002    Interruption Code..... 0009
      PSW..... 078D2400 A19C60FE
      GPR0..... 00000000_00000000  GPR1..... 00000000_0000000A  GPR2..... 00000000_A1CD09BC
 GPR3..... 00000000_219C60B8
      GPR4..... 00000000_2199D2D8  GPR5..... 00000000_21F91A00  GPR6..... 00000000_21F92AC8
 GPR7..... 00000000_219BDE40
      GPR8..... 00000000_A19C63A8  GPR9..... 00000000_21F93368  GPR10.... 00000000_A19C6070
 GPR11.... 00000000_A19C60A0
      GPR12.... 00000000_21713B58  GPR13.... 00000000_2199D6D8  GPR14.... 00000000_00000000
 GPR15.... 00000000_00000006

  Storage dump near condition, beginning at location: 219C60EC
    +000000 219C60EC  D0848910 00011B01 41E00006 8EE00020  1DE0180F 5000D080 4400C1AC 47F03058
 |.di.................&....
```

Getting a better picture

The storage around regs section of the CEEDUMP

```
Storage around GPR15(21922548)
  -0020 21922528  F0F3F1F6 F2F0F4F4 F0F0F0F3 F0C3F0F0  00074040 4040
  +0000 21922548  47F0F028 00C3C5C5 000001E0 00000D78  47F0F001 0000
  +0020 21922568  00000000 0000D500 90ECD00C 18BF1841  58A09058 58C0
```

```
Local Variables:
        18 01 WS-VARS            AN-GR
        19   02 WS-COMP1          S9999 COMP        +00010
        20   02 WS-COMP2          S9999 COMP        +00000
        21   02 WS-COMP3          S9999 COMP        +00032
        22 01 DYN-NAME           X(8) DISP         'CPROG3   '
```

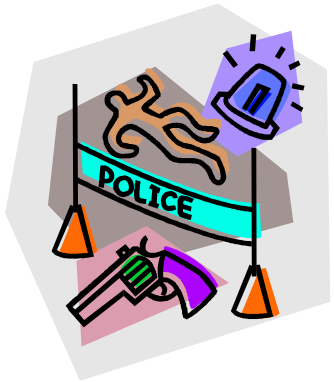
- To obtain Local Variables you must use the TEST compiler option

Even more clues!

- CEEDUMP also contains
  - Run-time options report
  - COBOL working storage
  - Language Environment control blocks
  - Heap storage
  - Language specific information
  - Any much more

- But it is only a picture of the crime

Examining the body

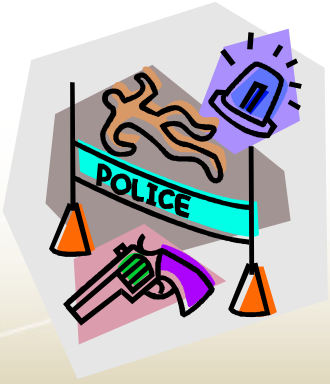


- IPCS Readable dumps
  - A bigger better picture of the crime
  - Use VERBX LE DATA
    - 'Summary' general info and run-time options
    - 'CEEDUMP' traceback similar to CEEDUMP
    - 'CM' Condition management
    - 'SM' Storage Management (Stacks/Heaps)
    - 'HEAP' Heap data
    - 'STACK' Stack data
    - 'NTHREAD' traceback for all threads
    - 'ALL' All the output

Examining the body

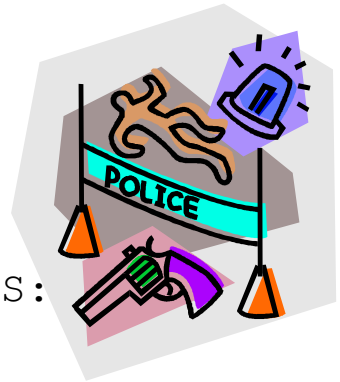
- IPVERBX LEDATA 'CEEDUMP'

```
Traceback:
 DSA      Entry      E  Offset  Statement   Load Mod            Program Unit     Service  Status

 1        CEEHSDMP   +000000DA              CEEPLPKA            CEEHSDMP         HLE7770  Call
 2        CEEHDSP    +00003EBA              CEEPLPKA            CEEHDSP          HLE7770  Call
 3        CPROG3     +0000008C              CPROG3                                        Exception
 4        @@FECB
                     +00312B7A                                                          Call
 5        @@DB2C     +00000102              CEEEV003                                      Call
 6        IGZCFCC    +000002C0              IGZCPAC             IGZCFCC                   Call
 7        COBOLED2   +000004C0              COBOLSHR            COBOLED2         .....%.  Call
 8        COBOLED1   +0000037A              COBOLSHR            COBOLED1         .....%.  Call

 DSA   DSA Addr   E  Addr    PU Addr    PU Offset  Comp Date  Compile Attributes
 1     219A0860   217D8038  217D8038   +000000DA  20100319   CEL
 2     2199D768   217C8180  217C8180   +00003EBA  20100319   CEL
 3     2199D6D8   219C6070  219C6070   +0000008C  20070212   C/C++
 4     2199D5E8   219BDE40  219BDE40   +00312B7A  ********   LIBRARY
 5     2199D560   21C504F0  21C504F0   +00000102  ********   LIBRARY
 6     2199D380   21922548  21922548   +000002C0  20100316   LIBRARY
 7     2199D1D8   21702220  21702220   +000004C0  20100720   COBOL
 8     2199D030   21700000  21700000   +0000037A  20100720   COBOL
```



Examining the body

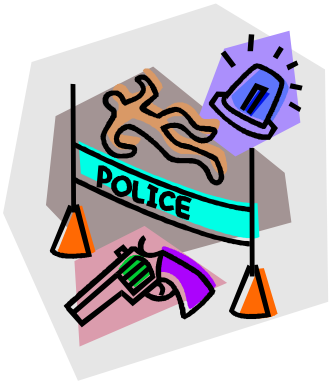
- IPVERBX LEDATA 'CM'




```
 CIBH:  2170F410
+000000  EYE:CIBH    BACK:00000000     FRWD:2199E570
+000010  PTR_CIB:2199E060         FLAG1:C5    ERROR_LOCATION_FLAGS:
+000018  HDLQ:00000000     STATE:00000000    PRM_DESC:00000000
+000024  PRM_PREFIX:00000000
+000028  PRM_LIST:2199E078 2199E140 2199E14C 2170FA5C
+000038  PARM_DESC:00000000       PARM_PREFIX:00000000
+000040  PARM_LIST:2199E13C 2199E060 2199E14C 2170FA5C   FUN:00000067
+000054  CIB_SIZ:010C      CIB_VER:0004      FLG_5:48    FLG_6:23
+00005A  FLG_7:04    FLG_8:00    FLG_1:00    FLG_2:00    FLG_3:00
+00005F  FLG_4:05    ABCD:940C9000     ABRC:00000009
+000068  OLD_COND_64:00030C89 59C3C5C5 (CEE3209S)
+000070  OLD_MIB:00000001         COND_64:00030C89 59C3C5C5 (CEE3209S)
+00007C  MIB:00000001      PL:219C6018       SV2:2199D6D8
+000088  SV1:2199D6D8      INT:219C60FC      MID:00000003
+000094  HDL_SF:21714600   HDL_EPT:A1918000         HDL_RST:00000000
+0000A0  RSM_SF:2199D6D8   RSM_POINT:219C60FE       RSM_MACHINE:2170F858
+0000B0  COND_DEFAULT:00000003   Q_DATA_TOKEN:2170F548   FDBK:00000000
+0000BC  ABNAME:........   BBRANCH_OFFSET:00000000
+000220  BBRANCH_STMTID:........      BBRANCH_STMTLEN:0000
```

Examining the body

- IPVERBX LEDATA 'CM'
  - PSW and Regs at time of condition




```
  Machine State
+000248  MCH_EYE:ZMCH
+000250  GPR00:00000000    GPR01:0000000A
+000258  GPR02:A1CD09BC    GPR03:219C60B8
+000260  GPR04:2199D2D8    GPR05:21F91A00
+000268  GPR06:21F92AC8    GPR07:219BDE40
+000270  GPR08:A19C63A8    GPR09:21F93368
+000278  GPR10:A19C6070    GPR11:A19C60A0
+000280  GPR12:21713B58    GPR13:2199D6D8
+000288  GPR14:00000000    GPR15:00000006
+000290  PSW:078D2400 A19C60FE
+000298  ILC:0002    IC1:00      IC2:09      PFT:00000000
```

Back in the lab

Who Took the Wild Branch…

The Clue: The Breaking Event Address

- Available on z/Architecture machines with PER-3 facility
- 64-bit CPU register that is updated with the address of any instruction that causes a break in sequential instruction execution
- BEA register contents saved when interrupt occurs
- BEA value saved in the SDWA and EPIE
- LE uses this value to identify possible wild branch location
  - LE may also attempt to use linkage register (i.e., R14)

Who Took the Wild Branch…

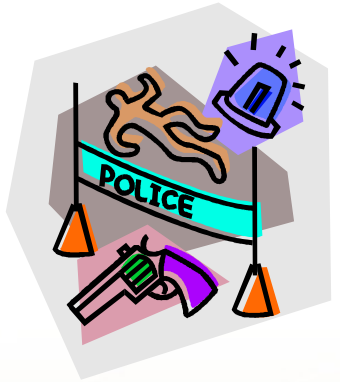
CEEDUMP Output

```
 :
Traceback:
    DSA    Entry        E  Offset   Statement   Load Mod  Program Unit   Service  Status
    1      CEEHDSP      +000040EC                CEEPLPKA  CEEHDSP        UK28165  Call
    2      OFFCLIFF     -20904128                CSICBBEA  OFFCLIFF                Exception
    3      LEAP         +0000031E  21            CSICBBEA  LEAP                    Call
    4      WILD         +0000031E  9             CSICBBEA  WILD                    Call
 :
Condition Information for Active Routines
    Condition Information for OFFCLIFF (DSA address 20998370)
      CIB Address: 20998E30
      Current Condition:
        CEE0198S The termination of a thread was signaled due to an unhandled condition.
      Original Condition:
        CEE3201S The system detected an operation exception (System Completion Code=0C1).
      Location:
        Program Unit: OFFCLIFF Entry: OFFCLIFF Statement:  Offset: -20904128
        Possible Bad Branch:  Statement: 35  Offset: +00000342
      Machine State:
        ILC..... 0002    Interruption Code..... 0001
        PSW..... 078D0000 80000002
        GPR0..... 209B8214  GPR1..... 00000000  GPR2..... 209B8190  GPR3..... 20904400
        GPR4..... 20904160  GPR5..... 20994100  GPR6..... 00000000  GPR7..... 00FD8640
        GPR8..... 209B8210  GPR9..... 20994C78  GPR10.... 20904250  GPR11.... 20904324
        GPR12.... 209139C0  GPR13.... 20998370  GPR14.... A090446C  GPR15.... 00000000
```

Who Took the Wild Branch…

LEDATA Output ('CM' or 'ALL')

```
  CIBH:   209102A8
+000000   EYE:CIBH     BACK:00000000      FRWD:20999340
  :
+000070   OLD_MIB:00000000          COND_64:00030C81 59C3C5C5 (CEE3201S)
  :
+0000BC   ABNAME:........    BBRANCH_OFFSET:00000342
+000220   BBRANCH_STMTID:35                BBRANCH_STMTLEN:0002
          Machine State
+000248   MCH_EYE:ZMCH
+000250   GPR00:209B8214     GPR01:00000000
+000258   GPR02:209B8190     GPR03:20904400
+000260   GPR04:20904160     GPR05:20994100
+000268   GPR06:00000000     GPR07:00FD8640
+000270   GPR08:209B8210     GPR09:20994C78
+000278   GPR10:20904250     GPR11:20904324
+000280   GPR12:209139C0     GPR13:20998370
+000288   GPR14:A090446C     GPR15:00000000
+000290   PSW:078D0000 80000002
  :
+0002EC   INT_SF:00000000    FLAGS:40     EXT:00000000      BEA:2090446A
```



Forcing LE to Spill the Beans

Coercing Evidence from C-RTL

perror(): Prints string with errno message to stderr

strerror(): Returns message string for a given errno value

Environment variables to tell these functions to provide more information

- _EDC_ERRNO_DIAG
- _EDC_ADD_ERRNO2

Coercing Evidence from C-RTL…

_EDC_ERRNO_DIAG = “x,y”

x

- 0: Do not generate additional diagnostic information (default)
- 1: Call ctrace() – writes a traceback to CEEDUMP
- 2: Call csnap() – writes a condensed dump to CEEDUMP
- 3: Call cdump() – writes a CEEDUMP; sends snap dump to CEESNAP

y

- List of errnos for which action “x” is to be taken, separated by commas
- If not specified, defaults to all errno values

Coercing Evidence from C-RTL…

_EDC_ADD_ERRNO2

- Tells perror() and strerror() whether to append errno2 information to their output
- For strerror(121):
  - _EDC_ADD_ERRNO2 = "0" or unset:
  - EDC5121I Invalid argument
  - With _EDC_ADD_ERRNO2 = "1":
  - EDC5121I Invalid argument. (errno2=0x0C0F8402)
- Default perror() behavior for z/OS V1.9 is to include errno2 value
- Interpret errno2 value using:
- BPXMTEXT TSO command (handles both USS and LE errno2 values)
- z/OS UNIX System Services Messages and Codes
- http://www.ibm.com/systems/z/os/zos/features/lang_environment/assist/r9errno2.html

Sources of Additional Information

- z/OS Language Environment Debugging Guide
- z/OS Language Environment Programming Reference
- z/OS MVS IPCS Commands
- z/OS UNIX System Services Messages and Codes
- Web site
  - http://www.ibm.com/systems/z/os/zos/features/lang_environment/

Appendix

Programs

Program COBOLED1

```
IDENTIFICATION DIVISION.
PROGRAM-ID. COBOLED1.

DATA DIVISION.
WORKING-STORAGE SECTION.
01 WS-VARS.
  05 WS-COMP1 PIC S9(4) COMP-4 VALUE 1234.
PROCEDURE DIVISION.
MAIN-PROG.
          CALL "COBOLED2".
          STOP RUN.
END PROGRAM COBOLED1.
```

Program COBOLED2

```
IDENTIFICATION DIVISION.
PROGRAM-ID. COBOLED2.

DATA DIVISION.
WORKING-STORAGE SECTION.
01 WS-VARS.
   05 WS-COMP1 PIC S9(4) COMP-4 VALUE ZEROES.
   05 WS-COMP2 PIC S9(4) COMP-4 VALUE ZEROES.
   05 WS-COMP3 PIC S9(4) COMP-4 VALUE ZEROES.
01 DYN-NAME PIC X(8).
PROCEDURE DIVISION.
MAIN-PROG.
          MOVE 32 TO WS-COMP3.
          MOVE 10 TO WS-COMP1.
          MOVE "CPROG3" TO DYN-NAME.
          CALL DYN-NAME.
          STOP RUN.
END PROGRAM COBOLED2.
```

Program CPROG3

```
#pragma linkage(CPROG3,COBOL)
#include <stdio.h>
void CPROG3()
{
    int i,j,k;
    /* Compiler needs to be coerced to */
    /* divide by zero.                 */
    j = 5;
    k = 10;
    i = 6 / (k - j*2);
    return;
 }
```

Program WILD

```
IDENTIFICATION DIVISION.
PROGRAM-ID. WILD.

DATA DIVISION.
WORKING-STORAGE SECTION.
LINKAGE SECTION.
PROCEDURE DIVISION.
MAIN-PROG.
    CALL "LEAP".
    GOBACK.
END PROGRAM "WILD".
```

Program LEAP

```
IDENTIFICATION DIVISION.
PROGRAM-ID. LEAP.

DATA DIVISION.
WORKING-STORAGE SECTION.
LINKAGE SECTION.
PROCEDURE DIVISION.
MAIN-PROG.
    CALL "OFFCLIFF".
    GOBACK.
END PROGRAM "LEAP".
```

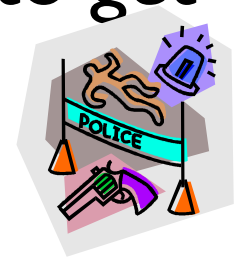
Program OFFCLIFF

```
IDENTIFICATION DIVISION.
PROGRAM-ID. OFFCLIFF.

DATA DIVISION.
WORKING-STORAGE SECTION.
01 FP USAGE IS PROCEDURE-POINTER.
01 OBVIOUS PIC X(4) VALUE "OBVS".
LINKAGE SECTION.
PROCEDURE DIVISION.
MAIN-PROG.
    SET FP TO NULL.
    CALL FP.
    DISPLAY "SURVIVED THE JUMP!"
    GOBACK.
END PROGRAM "OFFCLIFF".
```

Really cool lab equipment

Reconstructing a Vandalized Stack

The Crime: Stack control data is damaged, unable to get a complete Traceback




```
        :
Registers and PSW:
GPR0..... 84000000  GPR1..... 84000FF3  GPR2..... 00010078  GPR3..... 20EE0DF0
GPR4..... 20F21018  GPR5..... 20EE2530  GPR6..... 20EE149C  GPR7..... 20F016B0
GPR8..... 20EE22E8  GPR9..... 00000004  GPR10.... 20ED6378  GPR11.... 2181018C
GPR12.... 20EE5A20  GPR13.... 20EE13F0  GPR14.... A180FFA8  GPR15.... 00000004
PSW..... 078D1000 A180FFBA

Traceback:
  DSA    Entry     E  Offset  Statement  Load Mod    Program Unit Service  Status

  WARNING  An invalid DSA pointer was found on traceback while processing
                DSA: 20EE13F0 and CAA: 20EE5A20
        :
```

Reconstructing a Vandalized Stack…

The Clues:

- **CEECAADDSA, "Dummy DSA"** – First Stack Frame on the stack
- **Backchain Pointer** – Location in stack frame that points to previous stack frame, offset X'04'
- **Next Available Byte, "NAB"** – Location in stack frame where next stack frame is to be built, offset X'4C'

The Tool: IPCS **RUNCHAIN** command

- Processes a chain of control blocks
- Input: Starting address, "link" offset

Reconstructing a Vandalized Stack…

LEDATA Output

```
  :
CEECAA:   20EE5A20
+000000   FLAG0:00     LANGP:08     BOS:20F01018       EOS:20F21018
+000044   TORC:00000000       TOVF:80071660      ATTN:20EE0E38
     :
+0002CC   DMC:00000000       ABCODE:00000000    RSNCODE:00000000
+0002D8   ERR:20EE2DF0       GETSX:80070B20     DDSA:20EE63C0
+0002E4   SECTSIZ:00000000          PARTSUM:00000000
+0002EC   SSEXPNT:00000000          EDB:20EE4698       PCB:20EE41E8
  :
```

Reconstructing a Vandalized Stack...


```
ip runchain address(20ee63c0) display length(100) link(76) name(dsa)
  :
DSA005
LIST 20F01510. ASID(X'01CE') LENGTH(X'64') AREA
ASID(X'01CE') ADDRESS(20F01510.) KEY(88)
20F01510.                                           00104001 20F01370 00000000 A0ED44E0
20F01520. 20ED6250 20EFDF90 00000000 20F21230       20ED4478 20ED41F8 20EFD100 00000000
20F01540. 00FD8640 00058A80 20EFDE60 20ED42E8       20ED43A0 20EE5A20 00000004 20F016B0
20F01560. 20F01410 20ED1F18 20F01510 20EFDE60       20EFD100

DSA006
LIST 20F016B0. ASID(X'01CE') LENGTH(X'64') AREA
ASID(X'01CE') ADDRESS(20F016B0.) KEY(88)
20F016B0.                                           00104001 20F01510 20F018D0 A0ED8730
20F016C0. 80072020 A0ED85C0 20EFE048 00000000       20ED4478 20ED6288 20EFD100 00000000
20F016E0. 00FD8640 00058A80 000581BC 20ED42E8       20ED83C0 20EE5A20 00000004 20F01850
20F01700. 20F015B0 20ED3FA8 20F016B0 20EFE048       20EFD100

DSA007
LIST 20F01850. ASID(X'01CE') LENGTH(X'64') AREA
ASID(X'01CE') ADDRESS(20F01850.) KEY(88)
20F01850.                                           00002001 20F016D0 20F01A70 A18F2934
20F01860. A18E2588 00000000 00000000 00000095       00102001 20F01610 20F019F0 A198CE12
20F01880. 20ED61C8 00000001 20F21230 20EFDFD0       20ED6064 00000010 00000004 20ED41F8
20F018A0. 20F01750 20ED6038 20EFDE60 20ED62D4       20EFD100
  :
```

Reconstructing a Vandalized Stack…

LEDATA 'DSA(20F016B0) CEEDUMP' Output

```
Traceback:
  DSA    Entry    E  Offset Statement  Load Mod  Program Unit    Service  Status

  1      LOOK     +000024DE            CSICBLDP  LOOK            .....%.  Call
  2      FORTHE   +0000031E            CSICBLDP  FORTHE          .....%.  Call
  3      WEAPON   +0000031E            CSICBLDP  WEAPON          .....%.  Call
  4               +20ED03BE                                               Call
  WARNING  An invalid DSA pointer was found on traceback while processing
        DSA: BADBADBD and CAA: 20EE5A20

  DSA    DSA Addr    E  Addr     PU Addr     PU Offset  Comp Date  Compile
  1      20F016B0    20ED6250    20ED6250    +000024DE  20080128   COBOL
  2      20F01510    20ED41C0    20ED41C0    +0000031E  20080128   COBOL
  3      20F01370    20ED2130    20ED2130    +0000031E  20080128   COBOL
  4      20F011D0    00000000    00000000    +20ED03BE  ********
```

Reconstructing a Vandalized Stack...


```
ip runchain address(20ee63c0) display length(100) link(76) name(dsa)

DSA001
LIST 20EE63C0. ASID(X'01CE') LENGTH(X'64') AREA
ASID(X'01CE') ADDRESS(20EE63C0.) KEY(88)
20EE63C0. 00000000 0000D008 00000000 0006AB30  20ECE000 00000000 20EE47B8 00000000
20EE63E0 LENGTH(X'20')==>All bytes contain X'00'
20EE6400. 00000000 20EE5A20 00000000 20F01030  20F01030 00000000 00000000 00000000
20EE6420. 00000000

DSA002
LIST 20F01030. ASID(X'01CE') LENGTH(X'64') AREA
ASID(X'01CE') ADDRESS(20F01030.) KEY(88)
20F01030.                                      00104001 20EE63C0 20F014A8 A0ECE324
20F01040. 20ED00A0 20EFD578 00000000 20F21050  20ECE2BC 20ECE038 20EE47B8 00000000
20F01060. 00000000 00058A80 20EFD448 20ECE128  20ECE1E4 20EE5A20 00000000 20F011D0
20F01080. 00000000 00000000 20F01030 20EFD448  00000000

DSA003
LIST 20F011D0. ASID(X'01CE') LENGTH(X'64') AREA
ASID(X'01CE') ADDRESS(20F011D0.) KEY(88)
20F011D0.                                      00104001 BADBADBD 00000000 A0ED03C0
20F011E0. 20ED2130 20EFDBC0 00000000 20F210F0  20ED0358 20ED00D8 20EFD100 00000000
20F01200. 00FD8640 00058A80 20EFDA90 20ED01C8  20ED0280 20EE5A20 00000000 20F01370
20F01220. 00000000 00000000 20F011D0 20EFDA90  20EE47B8
        :
```

Reconstructing a Vandalized Stack…

LEDATA 'DSA(20F01030) CEEDUMP' Output

```
Traceback:
DSA  Entry      E  Offset Statement  Load Mod  Program Unit  Service  Status

  1    DUMPSTER  +00000322           CSICBLDP  DUMPSTER      .....%.  Call

  DSA   DSA Addr   E  Addr    PU Addr    PU Offset  Comp Date  Compile
  1     20F01030   20ECE000  20ECE000   +00000322  20080128   COBOL
```

Reconstructing a Vandalized Stack…

What about the corrupted stack frame?


```
ip runchain address(20ee63c0) display length(100) link(76) name(dsa)
  :
DSA002
LIST 20F01030. ASID(X'01CE') LENGTH(X'64') AREA
ASID(X'01CE') ADDRESS(20F01030.) KEY(88)
20F01030.                                          00104001 20EE63C0 20F014A8 A0ECE324
20F01040. 20ED00A0 20EFD578 00000000 20F21050      20ECE2BC 20ECE038 20EE47B8 00000000
20F01060. 00000000 00058A80 20EFD448 20ECE128      20ECE1E4 20EE5A20 00000000 20F011D0
20F01080. 00000000 00000000 20F01030 20EFD448      00000000

DSA003
LIST 20F011D0. ASID(X'01CE') LENGTH(X'64') AREA
ASID(X'01CE') ADDRESS(20F011D0.) KEY(88)
20F011D0.                                          00104001 BADBADBD 00000000 A0ED03C0
20F011E0. 20ED2130 20EFDBC0 00000000 20F210F0      20ED0358 20ED00D8 20EFD100 00000000
20F01200. 00FD8640 00058A80 20EFDA90 20ED01C8      20ED0280 20EE5A20 00000000 20F01370
20F01220. 00000000 00000000 20F011D0 20EFDA90      20EE47B8
  :
```

R15 slot of the previous stack frame provides yet another clue!

Reconstructing a Vandalized Stack…

IPCS Browse Panel


```
20ED00A0   47F0F028   00C3C5C5   000001A0   00000014   | .00..CEE........ |
20ED00B0   47F0F001   98CEAC00   20ED0156   00000000   | .00.q........... |
20ED00C0   00000000   00000000   90ECD00C   4110F038   | ..........}...0. |
20ED00D0   98EFF04C   07FF0000   20ED00A0   00000000   | q.0<............ |
20ED00E0   20ED1F18   20ED014E   20ED00A0   20ED02CE   | .......+........ |
20ED00F0   20ED83C0   20ED016A   00104001   00000008   | ..c{...... ..... |
20ED0100   C9D5E3C8   C5404040   F2F0F0F8   F0F1F2F8   | INTHE   20080128 |
20ED0110   F1F7F4F0   F3F5F0F3   F0F3F0F0   04740000   | 174035030300.... |
20ED0120   0000076C   A0C87CCC   20000000   10000000   | ...%.H@......... |
20ED0130   00000000   08000000   00800000   00000000   | ................ |
20ED0140   00000002   0000F000   40404040   0005C9D5   | ......0.    ..IN |
20ED0150   E3C8C540   40400500   000120ED   83100000   | THE   ......c... |
20ED0160   0000FFFF   FFB220ED   00A020ED   00D80000   | ............Q.. |
```

Reconstructing a Vandalized Stack…

Complications

- More substantial damage to the stack can make this task much more difficult
- NAB is only useful for current stack segment
  - Use "LEDATA 'STACK'" to identify additional stack segments
  - Use RUNCHAIN command on first stack frame in the segment (Starts at offset X'18' into stack segment)
    OR
  - Increase initial stack segment size with STACK run-time option so that NAB is always in current stack segment

Interpreting Raw Data

Manually mapping storage is tedious:

```
20F016B0   00104001   20F01510   20F018D0   A0ED8730   | .. ..0...0.}..g. |
20F016C0   80072020   A0ED85C0   20EFE048   00000000   | ......e{..\..... |
20F016D0   20ED4478   20ED6288   20EFD100   00000000   | .......h..J..... |
20F016E0   00FD8640   00058A80   000581BC   20ED42E8   | ..f ......a....Y |
20F016F0   20ED83C0   20EE5A20   00000004   20F01850   | ..c{..!......0.& |
20F01700   20F015B0   20ED3FA8   20F016B0   20EFE048   | .0.....y.0....\. |

+04 = backchain
+10 = Called routine
+4C = NAB
  . . .
```

There has to be a better way!

Interpreting Raw Data…

IPCS CBFORMAT Command

- Formats a control block
- Syntax: CBF(ORMAT) <cbaddr> STR(<cbname>)
  - <cbaddr> can be address or symbol
  - STR(UCTURE) support provided by various components
    - IPCS Commands, Appendix D for MVS control blocks
    - Language Environment Debugging Guide for LE control blocks
      - CEExxx for AMODE 24/31 (CEECAA, CEECIBH, CEEDSA, CEEEDB, CEEHANC, CEESTKH, etc.)
      - CELxxxx for AMODE 64 (CELCIBH, CELDSA, CELEDB, CELLAA, CELLCA, CELSANC, etc.)

Interpreting Raw Data...

CBF 20F016B0 str(ceedsa)

or

CBF DSA006 str(ceedsa)


```
 DSA:  20F016B0
+000000  FLAGS:0010  MEMD:4001   BKC:20F01510      FWC:20F018D0
+00000C  R14:A0ED8730      R15:80072020      R0:A0ED85C0
+000018  R1:20EFE048       R2:00000000       R3:20ED4478
+000024  R4:20ED6288       R5:20EFD100       R6:00000000
+000030  R7:00FD8640       R8:00058A80       R9:000581BC
+00003C  R10:20ED42E8      R11:20ED83C0      R12:20EE5A20
+000048  LWS:00000004      NAB:20F01850      PNAB:20F015B0
+000064  RENT:20ED41C0     CILC:20EFDE08     MODE:00058108
+000078  RMR:20ED8EB8
```

Interpreting Raw Data...

CBF can be combined with RUNCHAIN command:

ip runchain address(20f01030) link(76) name(dsa) exec((cbf x str(ceedsa)))


```
DSA001
LIST 20F01030. ASID(X'01CE') LENGTH(X'04') AREA
ASID(X'01CE') ADDRESS(20F01030.) KEY(88)
      DSA:  20F01030
   +000000  FLAGS:0010  MEMD:4001   BKC:20EE63C0      FWC:20F014A8
   +00000C  R14:A0ECE324      R15:20ED00A0      R0:20EFD578
   +000018  R1:00000000       R2:20F21050       R3:20ECE2BC
   +000024  R4:20ECE038       R5:20EE47B8       R6:00000000
   +000030  R7:00000000       R8:00058A80       R9:20EFD448
   +00003C  R10:20ECE128      R11:20ECE1E4      R12:20EE5A20
   +000048  LWS:00000000      NAB:20F011D0      PNAB:00000000
   +000064  RENT:00000000     CILC:00000000     MODE:00000000
   +000078  RMR:00000000

DSA002
LIST 20F011D0. ASID(X'01CE') LENGTH(X'04') AREA
ASID(X'01CE') ADDRESS(20F011D0.) KEY(88)
      DSA:  20F011D0
   +000000  FLAGS:0010  MEMD:4001   BKC:BADBADBD      FWC:00000000
   +00000C  R14:A0ED03C0      R15:20ED2130      R0:20EFDBC0
   +000018  R1:00000000       R2:20F210F0       R3:20ED0358
   +000024  R4:20ED00D8       R5:20EFD100       R6:00000000
   +000030  R7:00FD8640       R8:00058A80       R9:20EFDA90
   +00003C  R10:20ED01C8      R11:20ED0280      R12:20EE5A20
   +000048  LWS:00000000      NAB:20F01370      PNAB:00000000
   +000064  RENT:20ECE000     CILC:20EFD3F0     MODE:00058108
   +000078  RMR:20ED8EB8
```