CICS and Threadsafe

Conversion Techniques for CICS Applications

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Objectives

- History of Multithreading
- The Open Transaction Environment
- Determining if a program is Threadsafe
- Making programs Threadsafe
- Exploiting the OTE
- OTE Performance Considerations
- Recommendations

History of Multithreading

- CICS as a Single TCB
  - Most efficient on a uni-processor
  - “Quasi-Reentrancy”
  - Issues:
    - Runaway tasks
    - OS Waits = Region Wait
    - Many restricted OS and COBOL Commands
    - Limited by speed of one processor

History of Multithreading

- CICS Exploiting Multiple Processors
  - Multiple TCBs
  - Primary TCB is “QR”, Quasi-Reentrant
  - Additional TCBs for:
    - VSAM
    - DB2
    - Program Loader
    - etc.

History of Multithreading

- CICS and DB2
  - Separate TCB (‘thread’) for each DB2 Request
  - Task is switched to DB2 TCB for DB2 work, DB2 system code runs on DB2 TCB
  - Significant workload shifted to DB2 TCBs, but measurable overhead from TCB switching

Open Transaction Environment

- Transaction runs under own TCB
- Introduced in TS 1.3 for Java
- DB2 Support added for TS 2.2
- Supports full OS function
- Allows true Multitasking in CICS
- Pseudo-reentrancy no longer **allowed**

OTE and DB2

Without Threadsafe

QR TCB		Open TCB
Task Starts		
EXEC CICS		
EXEC SQL	→	DB2 Code executes
Application Code	←	DB2 Code completes
EXEC SQL	→	DB2 Code executes
	←	DB2 Code completes

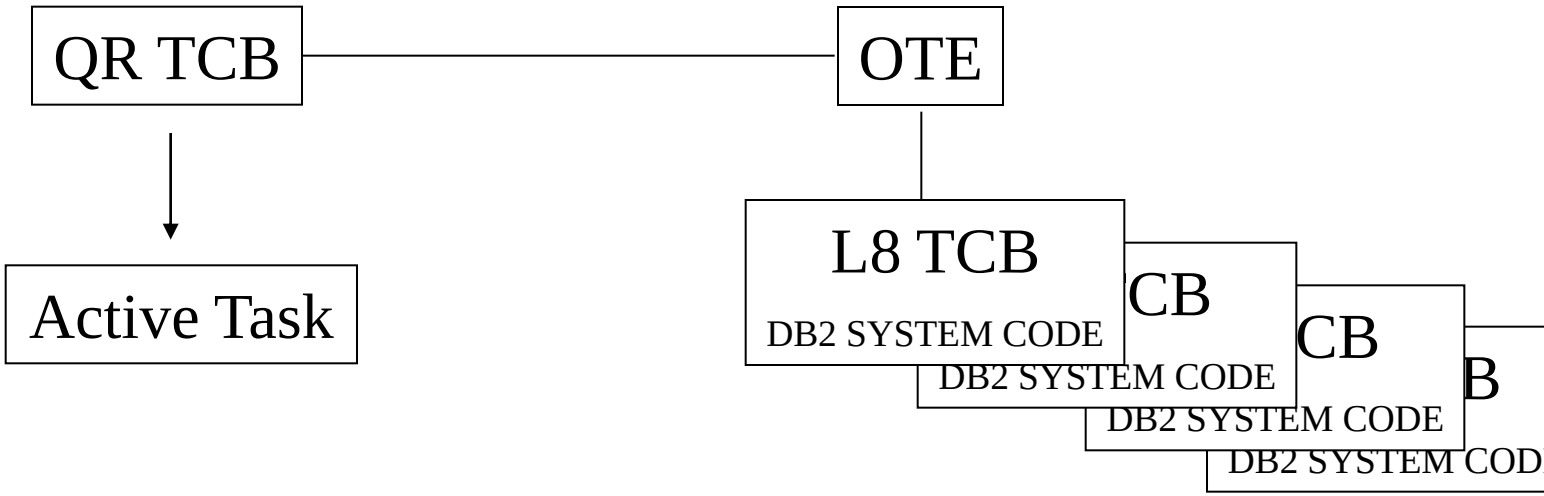
OTE and DB2

With Threadsafe

QR TCB		Open TCB
Task Starts		
EXEC CICS		
EXEC SQL	→	DB2 Code executes
		Application Code
		DB2 Code executes
Task Termination	←	Task completes

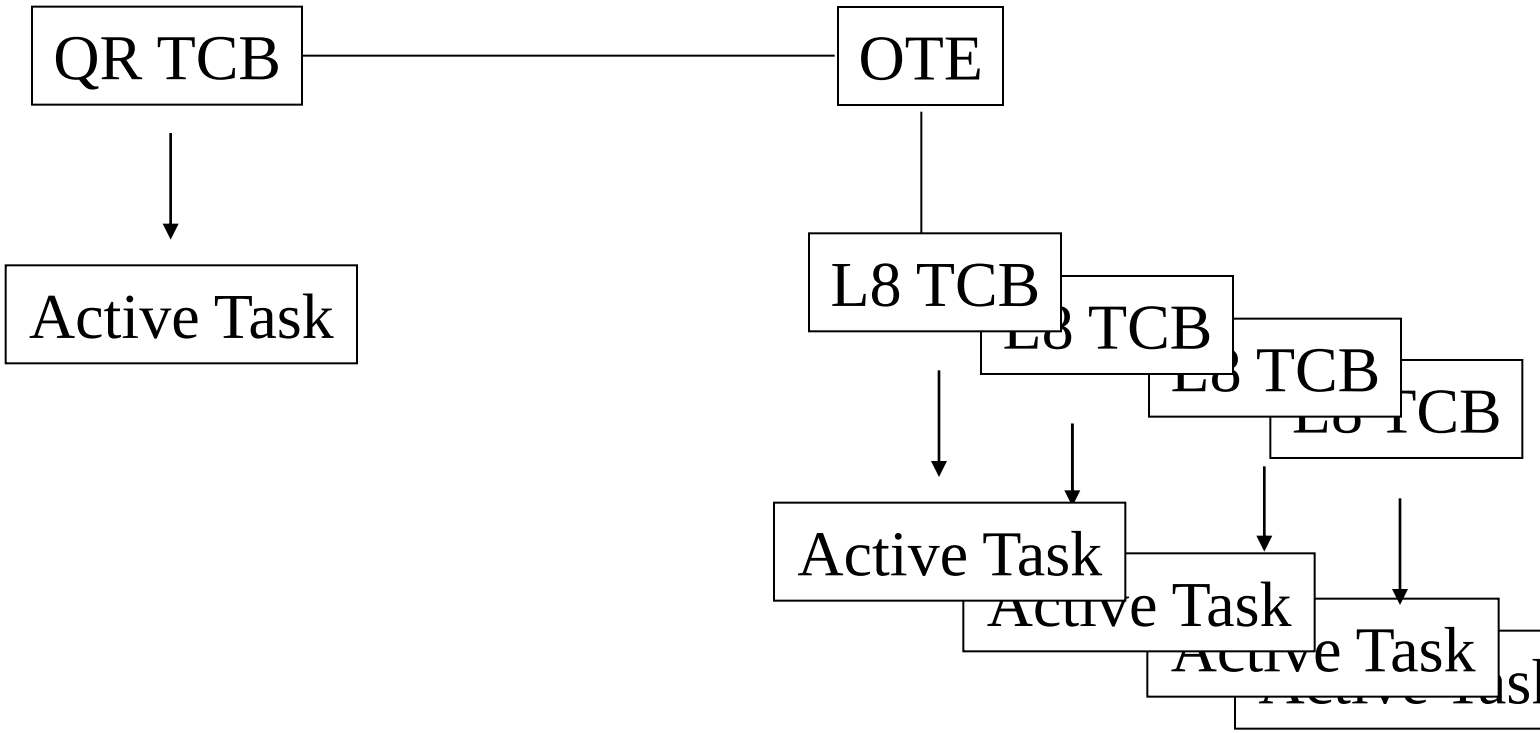
CICS and OTE

Without Threadsafe

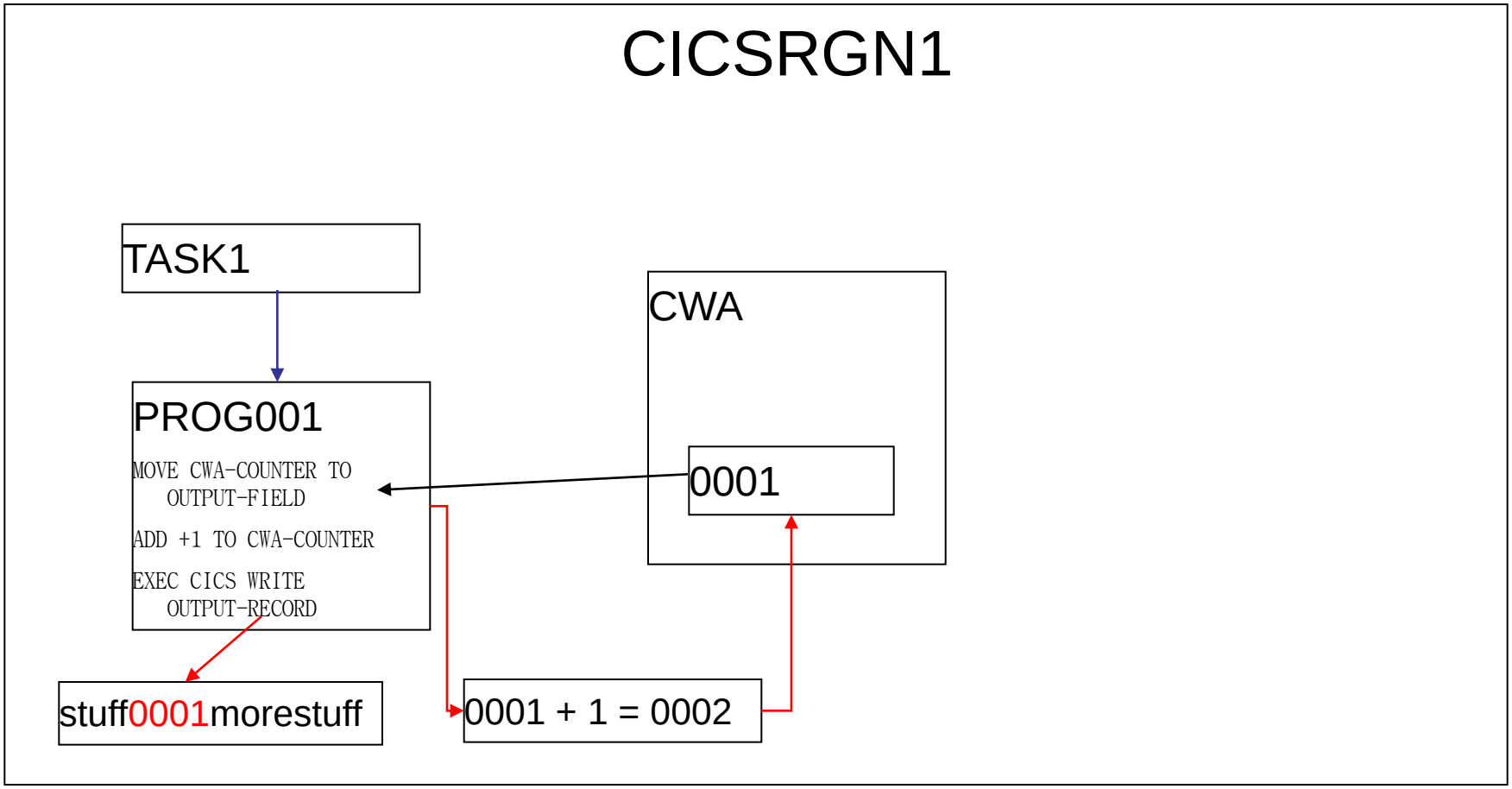


CICS and OTE

With Threadsafe



So, What's the Problem



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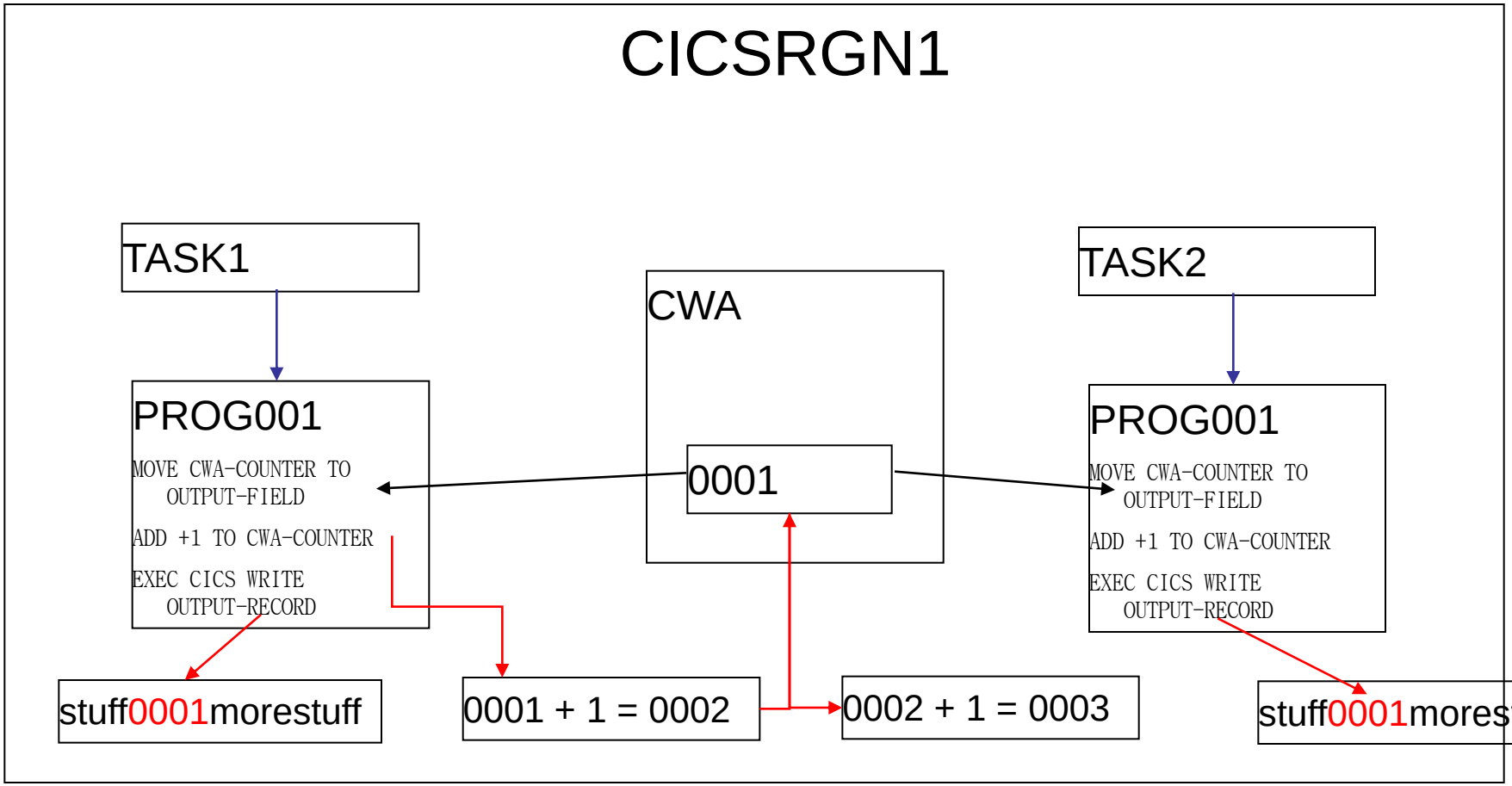


Definitions

Define “threadsafe”

1. “A threadsafe **program** is one that does not modify any area of storage that can be modified by any other program at the same time, and does not depend on any area of shared storage remaining consistent between machine instructions.”

Controlling Threadsafe

- At the program level:
  New parameter on Program Definition
  - CONCURRENCY=QUASIRENT
    Not Threadsafe
  - CONCURRENCY=THREADSAFE
  - CONCURRENCY=REQUIRED
- At the region level, new SIT parm:
  FORCEQR=YES/NO
  - FORCEQR=YES All programs run non-Threadsafe
  - FORCEQR=NO Programs follow CONCURRENCY parm on program definition

Identifying Threadsafe Programs

- No automated method of identification
- IBM Tool can help
- Rules of thumb:
  - COBOL and PL/1 must be LE
  - All programs must be re-entrant
  - Aps with no affinities are more likely to be threadsafe

Identifying Threadsafe Programs

Ensure programs are re-entrant:

- COBOL:
  - Compile with RENT
  - Link with RENT
- Assembler:
  - Code review, possible coding changes required
  - Assemble/Link with Rent
- CICS:
  - RENTPGM=PROTECT
  - Adjust RDSA/ERDSA sizes
  - Non-reentrant activity will generate DFHSR0622 followed by S0C4/ASRA
  - Possible conflicts with debuggers

Identifying Threadsafe Programs

No automated method of identification

CONCURRENCY

parm is a

promise

by you, not an order to CICS

Definitions

Define “threadsafe”

1. “A threadsafe **program** is one that does not modify any area of storage that can be modified by any other program at the same time, and does not depend on any area of shared storage remaining consistent between machine instructions.”
2. “A program **defined** as CONCURRENCY=THREADSAFE is one that will be **allowed** to run on an open TCB.”

Identifying Threadsafe Programs

Continued...

There is a tool available to help start…..

- Utility DFHEISUP will scan for CICS commands commonly used in non-threadsafe applications
- Use command table DFHEIDTH

Identifying Threadsafe Programs

Continued...

There is a tool available to help start…..

- Identifies programs that issue:
  - ADDRESS CWA
  - EXTRACT EXIT
  - GETMAIN SHARED
- Consider adding:
  - LOAD PROGRAM () HOLD

Identifying Threadsafe Programs

Continued...

```
CICS LOAD MODULE SCANNER UTILITY
    SCAN PERFORMED ON Mon Oct 20 08:01:46 2003 USING TABLE
    DFHEIDTH
    SUMMARY LISTING OF CICS.NOT.TSAFE.LOADLIB
    ==================================
    Module Name   Commands Found    Language
    ASMPGM1                  1          Assembler
    COBPGM1                   1          Cobol

LOAD LIBRARY STATISTICS
    ======================
    Total modules in library = 63
    Total modules Scanned = 63
    Total CICS modules/tables not scanned = 0
    Total modules possibly containing requested commands = 2
```

Identifying Threadsafe Programs

Continued...

Programmer must:

- Review each program reported
- Determine if any non-threadsafe activity
- Review all calls/LINKs/XCTLs out of program to see if addressability to area is passed
  - If yes, review called programs to determine if any non-threadsafe activity

Identifying Threadsafe Programs

Continued...

Identify non-threadsafe activity:

```
IF CWA-HR-AP-AVAILABLE = ‘YES’

MOVE CWA-FILE-NAME TO WS-DD-OUT

ADD +1 TO CWA-REC-CNTR

IF CWA-USE-FLD >= WS-GOOD-FIELD
```

Making Programs Threadsafe

After identifying non-Threadsafe code you have two choices:

1) Alter the code to serialize the shared storage access
   A) Use CICS to automatically ensure serialization
   B) Manually ensure serialization
2) Do nothing

Making Programs Threadsafe

continued...

If shared storage use is limited to few programs:

- Leave non-threadsafe programs QUASIRENT
- CICS will switch to QR on LINK or XCTL (But…**not for CALL!**)
- Access to shared storage is automatically serialized

Making Programs Threadsafe

continued...

Our CWA Issue Resolved by Marking Program QUASIRENT

OTE TCB #1	OTE TCB #2
Switch to QR TCB	Switch to QR TCB
MOVE CWA-REC-COUNT TO KEY-UNIQUE-PORTION ADD +1 TO CWA-REC-COUNT EXEC CICS WRITE IMPORTANT-FILE RIDFLD(KEY-COMPLETE)	Wait for QR TCB to become available
	MOVE CWA-REC-COUNT TO KEY-UNIQUE-PORTION

Making Programs Threadsafe

continued...

Advantages:

- No coding changes, so quick implementation

Disadvantages:

- Additional TCB switching overhead
- Maintenance issues
- All programs that access these areas **must** also remain QUASIRENT

Making Programs Threadsafe

continued...

What is this data used for?

- Is this data still used/required?
- Does it matter if the data is inaccurate?
- Must I lock the data for both read and update, or just for update?
  - Assume OPS tran to display CWA-REC-COUNT:
    - Value is potentially incorrect prior to its display
    - Need only be approximate
    - Leave program unchanged

Making Programs Threadsafe

continued...

To serialize access to shared storage:

- “Wrap” access in CICS ENQ/DEQ
- For Assembler, use CS/CDS
- Move data to a threadsafe but serialized facility:
  - CICS Maintained Data Table
  - DB2 table
  - Coupling Facility

Making Programs Threadsafe

continued...

Serialization techniques to avoid:

- OS ENQ
  Difficult to ensure that program is on L8 at time of ENQ
- TCLASS
  Performance issues from bottlenecks

The Assembler Compare & Swap Command

The Compare and Swap works on a fullword value. Since the storage area is only locked during execution of the CS, it can be changed while the program is preparing its update. To handle this situation, the CS takes three operands:

What the value was when I first accessed it
What I want the new value to become
The storage area in question

When the CS executes, it first locks the storage area. Then, it compares the actual value in the storage area to the value you say it should be. If these values match, then the data in the storage area is replaced with the value you asked for, and the condition code is zero.

If the values don't match, it means that some other task has updated the area after you retrieved its value. The data in the storage area is not replaced, and the condition code is set to non-zero.

In this example, we are attempting to increment a counter by one. If the CS fails, we simply acquire the new current value and try again.

The Assembler Compare & Swap Command

```
GETCOUNT DS  0H
     L R15,CWA_REC_COUNT  pick up the rec number
     LA R0,1(,R15)        increment the use count
     CS R15,R0,CWA_REC_COUNT  save the new count
     BNE GETCOUNT         data altered, try again
     ST R15,KEY_UNIQUE_PORTION build key
```

Making Programs Threadsafe

continued...

CS Issues:

- Limited to 4 or 8 bytes max (16 for 64 bit!)
- Requires Assembler experience or called routine
- Potential for a spin loop.

Making Programs Threadsafe

continued...

Our CWA Issue Resolved by Using ENQ/DEQ

OTE TCB #1

```
EXEC CICS ENQ RESOURCE()
MOVE CWA-REC-COUNT TO
          KEY-UNIQUE-PORTION
ADD +1 TO CWA-REC-COUNT
EXEC CICS DEQ RESOURCE()
 EXEC CICS WRITE IMPORTANT-FILE
          RIDFLD(KEY-COMPLETE)
```

OTE TCB #2

```
EXEC CICS ENQ RESOURCE()
                .
                .
                .
MOVE CWA-REC-COUNT TO
          KEY-UNIQUE-PORTION
```

Making Programs Threadsafe

continued...

ENQ Issues:

- CPU Cost
- Potential bottleneck
  - Limit ENQ duration by issuing DEQ as soon as possible
  - Ensure no possibility of deadly embrace

Making Programs Threadsafe

continued...

Our CWA Issue Resolved by Using Named Counter

OTE TCB #1

```
EXEC CICS GET COUNTER()
MOVE COUNTER-VALUE TO
        KEY-UNIQUE-PORTION
EXEC CICS WRITE IMPORTANT-FILE
        RIDFLD(KEY-COMPLETE)
```

OTE TCB #2

```
EXEC CICS GET COUNTER()
MOVE COUNTER-VALUE TO
        KEY-UNIQUE-PORTION
EXEC CICS WRITE IMPORTANT-FILE
        RIDFLD(KEY-COMPLETE)
```

Making Programs Threadsafe

continued...

Named Counter Issues:

- Requires coupling facility
- GET is not a threadsafe command until CICS 4.2

Making Programs Threadsafe

continued...

Regardless of which method, remember:

All programs that access the same shared storage area in the same CICS region **must** be converted before **any** of these programs are marked as Threadsafe!

Diagnosing Threadsafe Problems

No way to prove threadsafe!

- Threadsafe problems most likely to occur during peak time.
- Stress testing more likely to bring out threadsafe problems.
- Best way to ensure success is strong application knowledge.
- Be thorough in your review.

Diagnosing Threadsafe Problems

How to tell when Testing is Complete?

- Errors based on probability
- Difficult to force simultaneous execution of code path
- Use stress testing
  - Set MAXTASK high
  - Set DSALIMITs high
  - Set SYSDUMPING on!
  - Use driver program to issue large number of STARTs

Diagnosing Threadsafe Problems

Unpredictable Results Means Just That!

- Difficult to identify
- “Impossible” behavior likely to be threadsafe issue
- Use CICS auxtrace
- Use homegrown application trace
- CICS system dump

Diagnosing Threadsafe Problems

Paired MVS macros that need same TCB

- Macros such as ENQ and DEQ must run on same TCB
- Intervening user code can force TCB switch
- Second macro in pair fails
- Macros include:
  - ENQ/DEQ
  - ATTACH/DETACH

Diagnosing Threadsafe Problems

A Statically Called Assembler Program Isn't Threadsafe

COBPGM

CALL 'ASMPGM1'
USING PARM-LIST.

```
ASMPGM1 CSECT
        LA   R13,SAVEAREA
        STM  R14,R12,12(R13)
             .
             .
        LM   R14,R12,12(R13)
        BR   R14
             .
             .
SAVEAREA DS   18F
```

Diagnosing Threadsafe Problems

All Called Routines Run on TCB of the Caller

- Because ASMPGM1 issues no CICS commands, the code runs normally in a non-threadsafe environment
- CICS is not notified for calls
- Simultaneous access to SAVEAREA results in overlay
- Probable S0C4
- Identifiable in test via RENTPGM=PROTECT

Diagnosing Threadsafe Problems

All Called Routines Run on TCB of the Caller

Possible solutions:

1. Convert ASMPGM1 to Command Level
2. Alter COBPGM to pass address of RSA
3. Leave COBPGM non-Threadsafe

Definitions

Define “threadsafe”

1. “A threadsafe **program** is one that does not modify any area of storage that can be modified by any other program at the same time, and does not depend on any area of shared storage remaining consistent between machine instructions.”
2. “A program **defined** as CONCURRENCY=THREADSAFE is one that will be allowed to run on an open TCB.”
3. “A threadsafe CICS **command** is one that is **allowed** to run under an open TCB. A non-threadsafe command is one that is **not allowed** to run under an open TCB”

Non-Threadsafe CICS Commands

- Many commands not Threadsafe
- Use of non-Threadsafe commands *is **fully** supported* by CICS
- CICS detects non-threadsafe command and switches task to QR TCB
- Task's TCB status following command depends on API definition
- Potential performance issue for API=OPENAPI

Non-Threadsafe CICS Commands

A list of the commands that are threadsafe can be found in the *CICS Application Programming Reference Manual*, under **CICS threadsafe commands in the API.**

A list of the threadsafe SPI commands can be found in the *CICS System Programming Reference Manual*, in Appendix D, **Threadsafe SPI commands**

Non-Threadsafe CICS Exits

- Significant area of concern
- Task switched to QR for duration of exit, then back to Open TCB
- Infrequently referenced exits less of a problem
- Frequently referenced exits (eg., XEIIN) are a major performance problem
- XRMIIN/OUT and Dynamic Plan Selection most worrisome
- Worst case: significant (20%++?) increase in CPU utilization.
- Can cause CPU impact even if FORCEQR=YES

Non-Threadsafe CICS Exits

- Use DFH0STAT to identify exits in use
  - Select DB2, User Exit and Global User Exit options
  - Identifies all active exits by program name, CONCURRENCY option, exit point, and GWA usage
  - Shows Dynamic Plan exits
- Identify vendor exits and contact vendor
  - Do not mark threadsafe without vendor OK
  - Do not convert with heavily used QUASIRENT exits
- Review homegrown exit code to ensure threadsafe

Using IBM Utility DFH$MOLS

- IBM supplied utility to analyze SMF 110 records
- Provides detailed report
  - One page / task
  - Storage utilization
  - CPU utilization
    - By TCB type
  - Response time
- Can use pre-generated MCT A$
- Activate monitoring with CEMT
  - SET MON ON PER
- Flush buffers with CEMT
  - SET MON ON NOP

Using IBM Utility DFH$MOLS

Use IFASMFDP to extract the 110 records

INDDx points to your SMF datasets. You can use either active datasets or archives

```
//*******************************************************************
//*  Step 1: Unload data from the SMF data sets
//*******************************************************************
//SMFDUMP  EXEC PGM=IFASMFDP
//INDD1     DD DSN=SYS1.D002.MAN11,DISP=SHR,AMP=('BUFSP=65536')
//INDD2     DD DSN=SYS1.D002.MAN12,DISP=SHR
//INDD3     DD DSN=SYS1.D002.MAN13,DISP=SHR
//OUTDD1    DD DSN=?????.SMF.DATA1,DISP=(NEW,CATLG),
//             SPACE=(CYL,(50,10)),UNIT=SYSDA
//SYSPRINT  DD SYSOUT=A
//SYSIN     DD *
        INDD(INDD1,OPTIONS(DUMP))
        INDD(INDD2,OPTIONS(DUMP))
        INDD(INDD3,OPTIONS(DUMP))
        OUTDD(OUTDD1,TYPE(110(1)))
```

OUTDD1 points to the output dataset that holds the extracted 110 records

Use an INDD control statement to describe each SMF file used as input.

The OUTDD control statement describes your output file and the record types to be extracted. We're using 110 subtype 1 records

Using IBM Utility DFH$MOLS

Use DFH$MOLS to format the extracted records

INPUT DD points to OUTDD dataset from previous step.

The report is written to SYSPRINT

Use the SELECT TRANID cards to limit your report.

Use the DATE START card to limit your report

```
//PRNT     EXEC PGM=DFH$MOLS
//STEPLIB  DD DSN=SYS2.CICSTS41.CICS.SDFHLOAD,DISP=SHR
//INPUT    DD DSN=?????.SMF.DATA1,DISP=OLD
//SORTWK01 DD SPACE=(CYL,(5,1)),UNIT=SYSDA
//SORTWK02 DD SPACE=(CYL,(5,1)),UNIT=SYSDA
//SORTWK03 DD SPACE=(CYL,(5,1)),UNIT=SYSDA
//SORTWK04 DD SPACE=(CYL,(5,1)),UNIT=SYSDA
//SORTWK05 DD SPACE=(CYL,(5,1)),UNIT=SYSDA
//SORTDIAG DD SYSOUT=A
//SYSOUT   DD SYSOUT=A
//SYSPRINT DD SYSOUT=A
//SYSABEND DD SYSOUT=A
//SYSUDUMP DD SYSOUT=A
//SYSIN    DD *
SELECT TRANID=trn1,trn2
DATE START=03/23/2011
/*
```

Using IBM Utility DFH$MOLS

```
----------FIELD-NAME-----------------------UNINTERPRETED-------------------------------INTERPRETED--------------
          DFHTASK C001      TRAN             C5E2C3F1                                      ESC1
          DFHTERM C002      TERM             C3D7F8F4                                      CP84
          DFHCICS C089      USERID           C3C9C3E2 C4F2F2F4                             CICSD224
          DFHTASK C004      TTYPE            E3D60000                                      TO
          DFHCICS T005      START            BED82B7ADC91D761                    2011/05/23 10:53:46.968349
          DFHCICS T006      STOP             BED82B7ADD3A7B40                    2011/05/23 10:53:46.971047
          DFHTASK P031      TRANNUM          0000513C                                    513
          DFHTASK A109      TRANPRI          00000001                                      1
             ...
          DFHTERM C111      LUNAME           E2F0F1E3 C3D7F8F4                             S01TCP84
          DFHPROG C071      PGMNAME          C5E2D7E4 E2C5C3F1                             ESPUSEC1
          DFHTASK C097      NETUOWPX         C2C8C4D5 C5E34BE2 F0F1E3C3 D7F8F400 00000000  BHDNET.S01TCP84
          DFHTASK C098      NETUOWSX         D82B7ADC9D100001
          DFHCICS A131      PERRECNT         00000001                                      1
          DFHTASK T132      RMUOWID          BED82B7ADC9D1021                    2011/05/23 10:53:46.968529
          DFHCICS C167      SRVCLSNM         C3C9C3E2 40404040                             CICS
             ...
          DFHTASK C163      FCTYNAME         C3D7F8F4                                      CP84
          DFHTASK A164      TRANFLAG         4000800002000000
          DFHTERM A165      TERMINFO         01000191
             ...
          DFHTASK C082      TRNGRPID         180FC2C8C4D5C5E3...
          DFHTERM C197      NETID            C2C8C4D5 C5E34040                             BHDNET
          DFHTERM C198      RLUNAME          E2F0F1E3 C3D7F8F4                             S01TCP84
```

Non-Threadsafe CICS Exits

DFH$MOLS report of non-threadsafe program:

DB2REQCT		14879
USRCPUT	00:00:01.11961	29763
SUSPTIME	00:00:01.79190	29763
DISPWTT	00:00:01.69950	29762
QRDISPT	00:00:00.37627	14882
QRCPUT	00:00:00.01568	14882
KY8DISPT	00:00:03.67361	14880
KY8CPUT	00:00:01.10212	14880
L8CPUT	00:00:01.10212	14880
RMITIME	00:00:03.37489	14880

Non-Threadsafe CICS Exits

DFH$MOLS report of non-threadsafe EXIT:

DB2REQCT		14879
USRCPUT	00:00:01.15467	59519
SUSPTIME	00:00:02.71036	59519
DISPWTT	00:00:02.41534	59518
QRDISPT	00:00:00.63364	29760
QRCPUT	00:00:00.01456	29760
KY8DISPT	00:00:03.35622	29759
KY8CPUT	00:00:01.14011	29759
L8CPUT	00:00:01.14011	29759
RMITIME	00:00:02.92852	14880

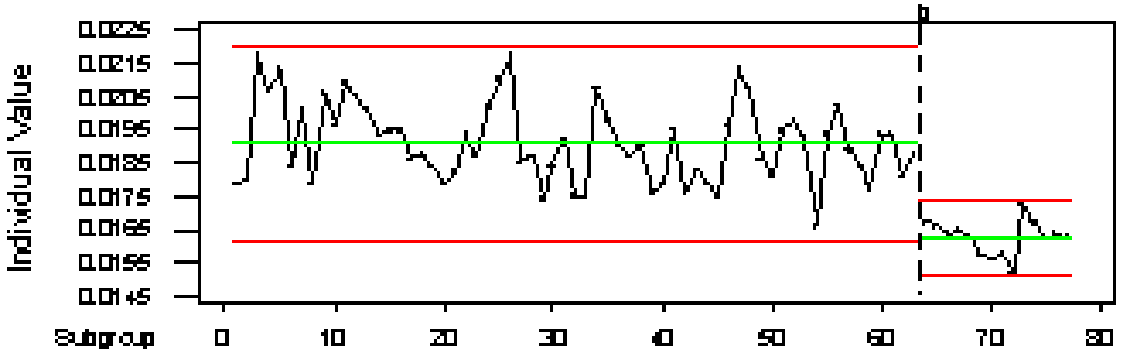
Identifying Candidates for Threadsafe CPU Savings

CPU reduction with DB2 and Threadsafe is achieved by reducing the number of TCB switches

QR TCB		Open TCB
Task Starts		
EXEC CICS		
EXEC SQL		DB2 Code executes
		Application Code
		DB2 Code executes
Task Termination		Task completes

Identifying Candidates for Threadsafe CPU Savings

Example from GE Convert to Threadsafe:



An 8% CPU reduction

Identifying Candidates for Threadsafe

Reduce the **total** number of TCB switches:

- Heavily utilized programs with large number of SQL
- Heavily utilized programs with small number of SQL
- Lightly utilized programs with large number of SQL

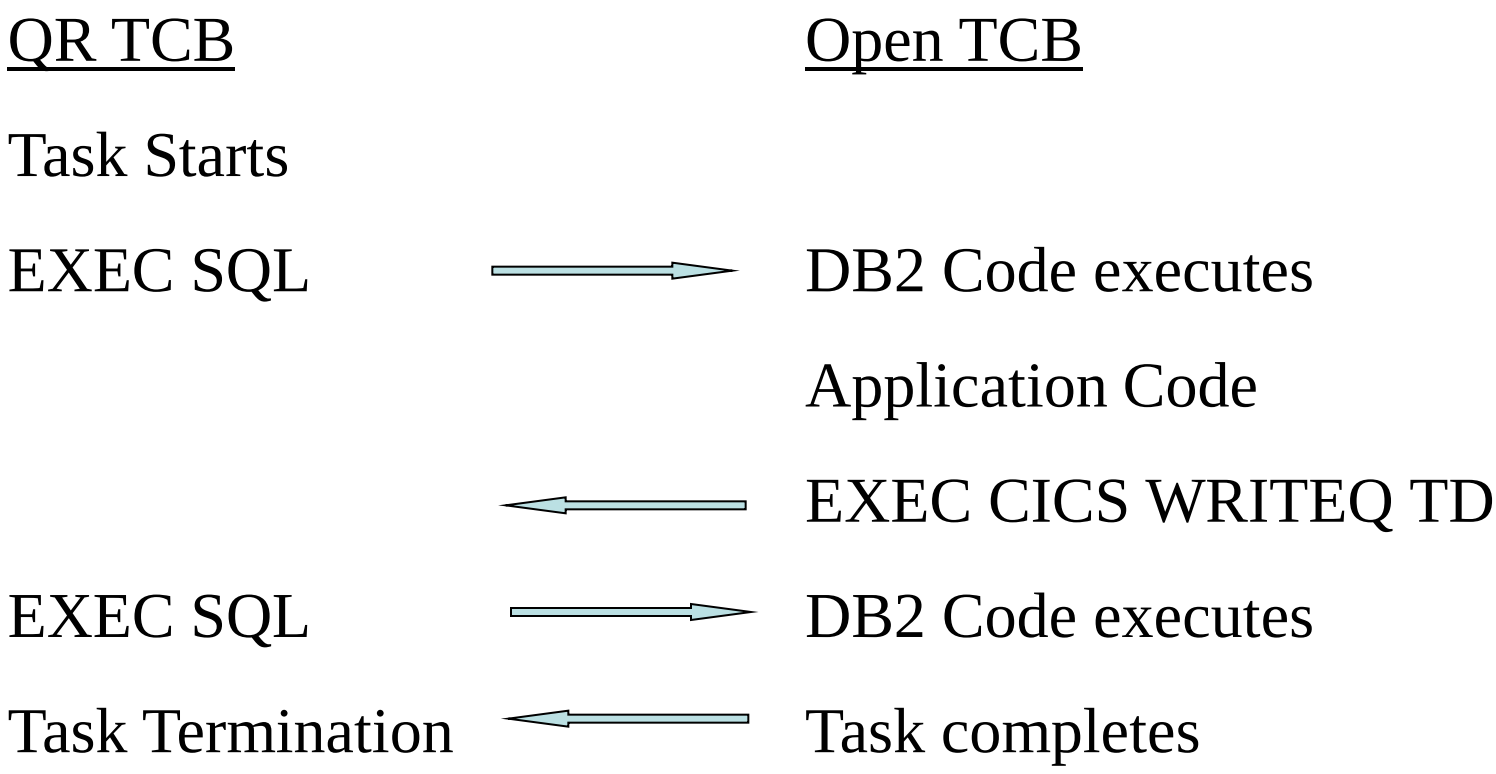
Identifying Candidates for Threadsafe

Maximum potential CPU savings is a function of Program use and SQL count:

Potential = Program Use X (SQL count – 1)

Identifying Candidates for Threadsafe

Any additional TCB switches supporting non-Threadsafe activity will **reduce the potential savings**



Identifying Candidates for Threadsafe

CPU savings is produced every time an SQL statement is issued when the task is already on the L8 TCB.

CPU savings is maximized when most SQL statements are issued while on the L8 TCB

Tools to identify **actual** savings vs. **potential** savings:

- SMF Statistics
- CICS Auxiliary Trace

Can be run in test regions prior to Threadsafe conversion

Identifying Candidates for Threadsafe

DFH$MOLS reports on the number of SQL calls per task:

DB2REQCT	00004E20		20000
USRDISPT	001A1C7200009C45	00:00:27.37948	40005
USRCPUT	0004978400009C45	00:00:04.81491	40005
SUSPTIME	0004003300009C45	00:00:04.19512	40005
DISPWTT	0004763500009C44	00:00:04.67848	40004
QRDISPT	0003E7D800004E23	00:00:04.09536	20003
QRCPUT	000089EB00004E23	00:00:00.56491	20003
MSDISPT	000010D800000001	00:00:00.06899	1
MSCPUT	0000006500000001	00:00:00.00161	1
RODISPT	000010D800000001	00:00:00.06899	1
ROCPUT	0000006500000001	00:00:00.00161	1
KY8DISPT	001623C200004E21	00:00:23.21513	20001
KY8CPUT	00040D3400004E21	00:00:04.24838	20001
L8CPUT	00040D3400004E21	00:00:04.24838	20001
QRMODDLY	0002801300004E22	00:00:02.62174	20002

Identifying Candidates for Threadsafe

DFH$MOLS on the same task running Threadsafe in test

DB2REQCT	00004E20		20000
USRDISPT	001001E600009C43	00:00:16.78499	40003
USRCPUT	0004D0E500009C43	00:00:05.04993	40003
SUSPTIME	000253B600009C43	00:00:02.44003	40003
DISPWTT	00023D4400009C42	00:00:02.34809	40002
QRDISPT	000366E800004E22	00:00:03.56723	20002
QRCPUT	0000F7A500004E22	00:00:01.01435	20002
KY8DISPT	000C9AFE00004E21	00:00:13.21776	20001
KY8CPUT	0003D94000004E21	00:00:04.03558	20001
L8CPUT	0003D94000004E21	00:00:04.03558	20001
QRMODDLY	000151C100004E21	00:00:01.38344	20001
DSCHMDLY	000253B400009C42	00:00:02.44000	40002

Identifying Candidates for Threadsafe

SMF Statistics

Look at ratio of (Mode Switches / 2) **:** SQL Calls

- High ratio indicates many non-threadsafe commands
- Low ratio shows maximizing savings
- Ratio > 1 indicates non-threadsafe exits

Identifying Candidates for Threadsafe

The ratio for this task is (40,003/2) : 20,000, or 1:1.

While the **potential** CPU savings for marking this program as Threadsafe is large (40,000 mode switches) the **actual** CPU savings is **zero.**

We use CICS Aux Trace to find out why.

Identifying Candidates for Threadsafe

Identifying the non-Threadsafe Commands Using DFHEISUP.

Filter DFHEIDNT contains a list of all commands that are not threadsafe for your release of CICS.

Identifying the non-Threadsafe Commands Using Auxtrace

L8000 DS 0002 DSAT ENTRY CHANGE_MODE QR

Will follow the “entry” trace for non-Threadsafe CICS commands

Use trace parms:

SHORT,TRANID=xxxx,TYPETR=(DS0002-0003,AP00E1,AP2520-2521)

(NOTE: Change mode trace entries require DS trace level 2)

Identifying Candidates for Threadsafe

```
00155 QR    DS 0003 DSAT  EXIT  CHANGE_MODE/OK OLD_MODENAME(QR)              RET-95A61B2E
00155 L800H DS 0003 DSAT  EXIT  CHANGE_MODE/OK                              RET-80096D00
00155 L800H AP 2521 ERM   EXIT  COBOL-APPLICATION-CALL-TO-TRUE(DSNCSQL )    RET-96E443A0
00155 L800H AP 2520 ERM   ENTRY COBOL-APPLICATION-CALL-TO-TRUE(DSNCSQL )    RET-96E444AA
00155 L800H AP 2521 ERM   EXIT  COBOL-APPLICATION-CALL-TO-TRUE(DSNCSQL )    RET-96E444AA
00155 L800H AP 00E1 EIP   ENTRY WRITEQ-TD                                   REQ(0004) FIELD-A(16
                                                                                  RET-80033ADC
00155 QR    DS 0003 DSAT  EXIT  CHANGE_MODE/OK OLD_MODE()                   RET-800832B6
00155 QR    AP 00E1 EIP   EXIT  WRITEQ-TD OK                                REQ(00F4) FIELD-A(00
                                                                                  RET-80033ADC
00155 QR    AP 00E1 EIP   ENTRY WRITEQ-TD                                   REQ(0004) FIELD-A(16
                                                                                  RET-80033ADC
00155 QR    AP 00E1 EIP   EXIT  WRITEQ-TD OK                                REQ(00F4) FIELD-A(00
                                                                                  RET-80033ADC
00155 QR    AP 2520 ERM   ENTRY COBOL-APPLICATION-CALL-TO-TRUE(DSNCSQL )    RET-96E443A0
00155 QR    DS 0002 DSAT  ENTRY CHANGE_MODE MODENAME_TOKEN(0000000D)        RET-80096D00
00155 L800H DS 0003 DSAT  EXIT  CHANGE_MODE/OK                              RET-80096D00
```

Maximizing CPU Savings

CPU savings is maximized when no non-Threadsafe commands are issued between the first SQL command and the last

```
EXEC SQL OPEN CURSOR
PERFORM UNTIL ...
    EXEC SQL FETCH….
    EXEC CICS WRITEQ TD
END-PERFORM
```

Maximizing CPU Savings

Once the command has been identified…..

- Replace it

  Replace Transient Data with CICS TempStor?
- Relocate it

  Move the command outside of the SQL loop?

Maximizing CPU Savings

Replace Transient Data with CICS Temporary Storage:

```
EXEC SQL OPEN CURSOR
PERFORM UNTIL ...
    EXEC SQL FETCH….
    EXEC CICS WRITEQ TS
END-PERFORM
```

Maximizing CPU Savings

DFH$MOLS of modified program running Threadsafe in test

EXEC CICS WRITEQ TD replaced with WRITEQ TS

DB2REQCT	00004E20		20000
USRDISPT	00066339000001E3	00:00:06.69787	483
USRCPUT	0003A4D3000001E3	00:00:03.82084	483
SUSPTIME	00002570000001E3	00:00:00.15334	483
DISPWTT	000003CE000001E2	00:00:00.01558	482
QRDISPT	0000065400000141	00:00:00.02592	321
QRCPUT	000002B100000141	00:00:00.01102	321
KY8DISPT	000659D3000000A1	00:00:06.65937	161
KY8CPUT	0003A1F7000000A1	00:00:03.80913	161
L8CPUT	0003A1F7000000A1	00:00:03.80913	161
QRMODDLY	0000032D00000140	00:00:00.01300	320
DSCHMDLY	0000033C00000144	00:00:00.01324	324

A ratio of .01

Maximizing CPU Savings

QR TCB		Open TCB
Task Starts		
FETCH	→	DB2 Code executes
		WRITEQ TS
		FETCH
		WRITEQ TS

Maximizing CPU Savings

Relocate Transient Data Writes:

```
EXEC SQL OPEN CURSOR
PERFORM UNTIL ...
     PERFORM VARYING…
             EXEC SQL FETCH….
             MOVE RESULTS TO WS-RESULTS()
     END-PERFORM
     PERFORM VARYING…
             EXEC CICS WRITEQ TD FROM(WS-RESULTS())
      END-PERFORM
END-PERFORM
```

Maximizing CPU Savings

DFH$MOLS of modified program running Threadsafe in test

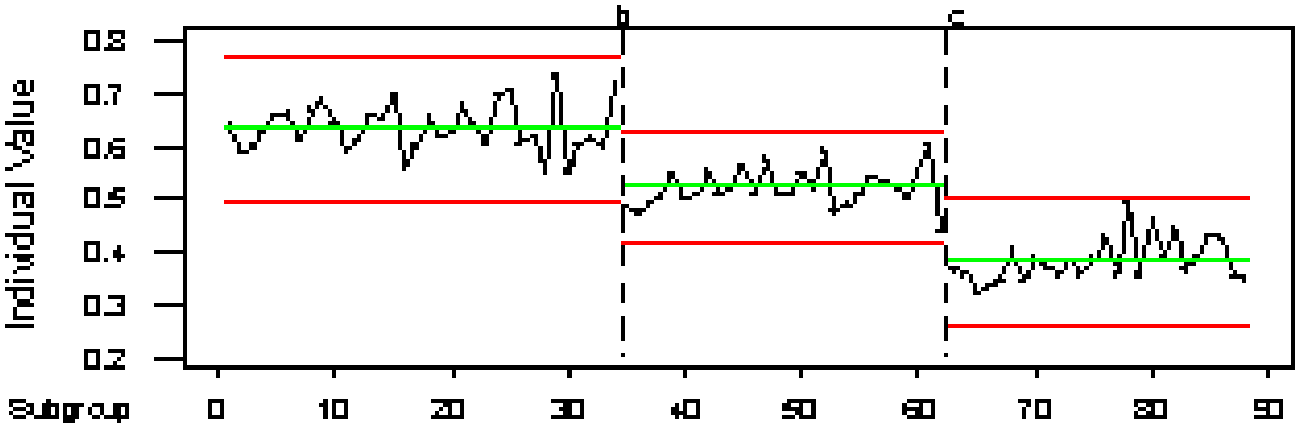
Results of 10 SQL FETCH placed in Working Storage, then issue 10 EXEC CICS WRITEQ TD at once

DB2REQCT	00004E20		20000
USRDISPT	00066339000001E3	00:00:06.69787	2612
USRCPUT	0003A4D3000001E3	00:00:03.82084	2612
SUSPTIME	00002570000001E3	00:00:00.15334	2612
DISPWTT	000003CE000001E2	00:00:00.01558	2611
QRDISPT	0000065400000141	00:00:00.02592	1052
QRCPUT	000002B100000141	00:00:00.01102	1052
KY8DISPT	000659D3000000A1	00:00:06.65937	526
KY8CPUT	0003A1F7000000A1	00:00:03.80913	526
L8CPUT	0003A1F7000000A1	00:00:03.80913	526
QRMODDLY	0000032D00000140	00:00:00.01300	1050
DSCHMDLY	0000033C00000144	00:00:00.01324	1055

A ratio of .06

Maximizing CPU Savings

Example from GE Convert to Threadsafe followed by program modification to minimize TCB switching



Initial threadsafe conversion yielded 12% savings; second phase yields additional 20% for a total 36% reduction in CPU

Exploiting The OTE Without DB2

Three methods of executing on OTE TCB.

For CICS 2.2 and above, write a “dummy” TRUE:

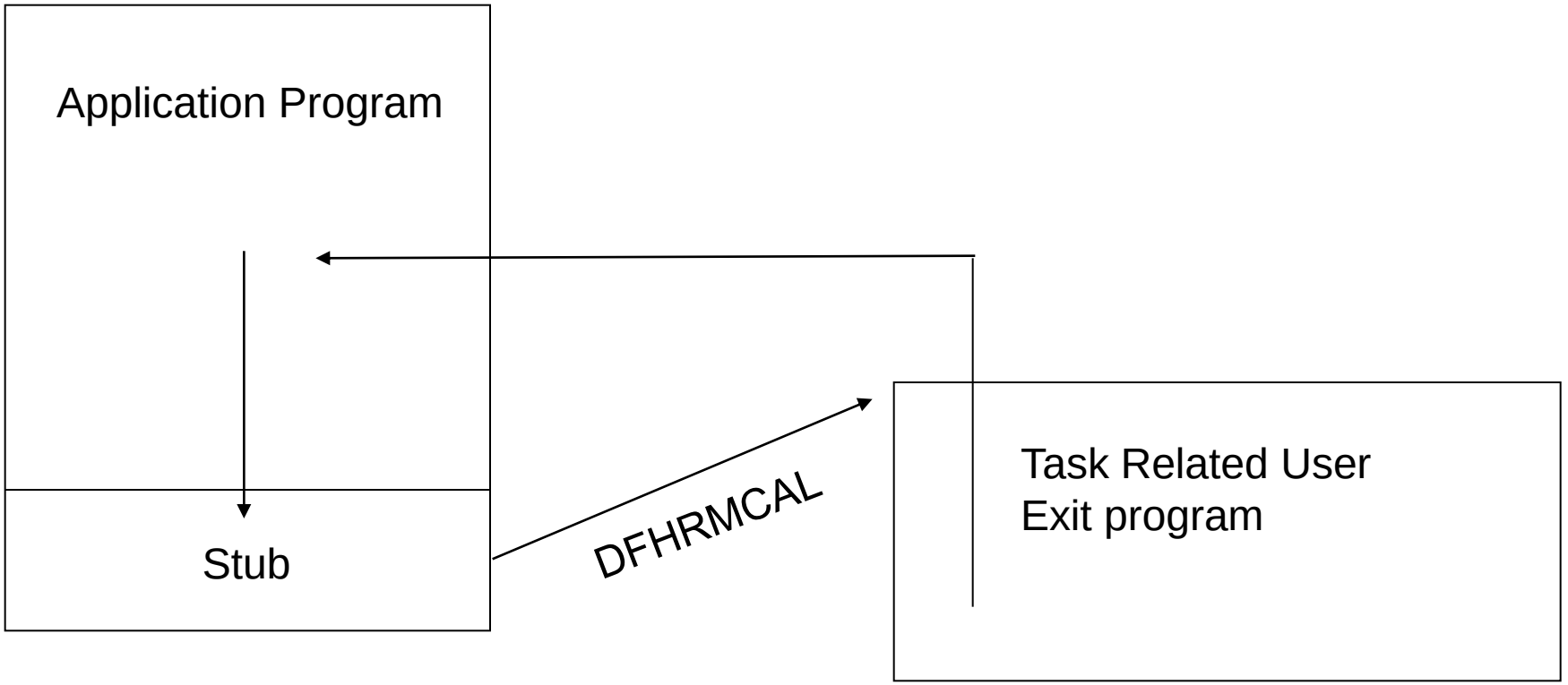
- Include OPENAPI on the ENABLE command
- The TRUE program **must** be defined as Threadsafe
- See the CICS Customization Guide section on Task Related User Exits

Exploiting The OTE Without DB2

Functions like DB2 call:

- When task calls OPENAPI true, spun to L8 TCB
- If user program THREADSAFE, task remains on L8 until forced off
- L8 TCB owned until task termination
- No supported method to tell if task is on L8 or QR
- **Review restrictions defined in Customization Guide!**

Exploiting The OTE Without DB2



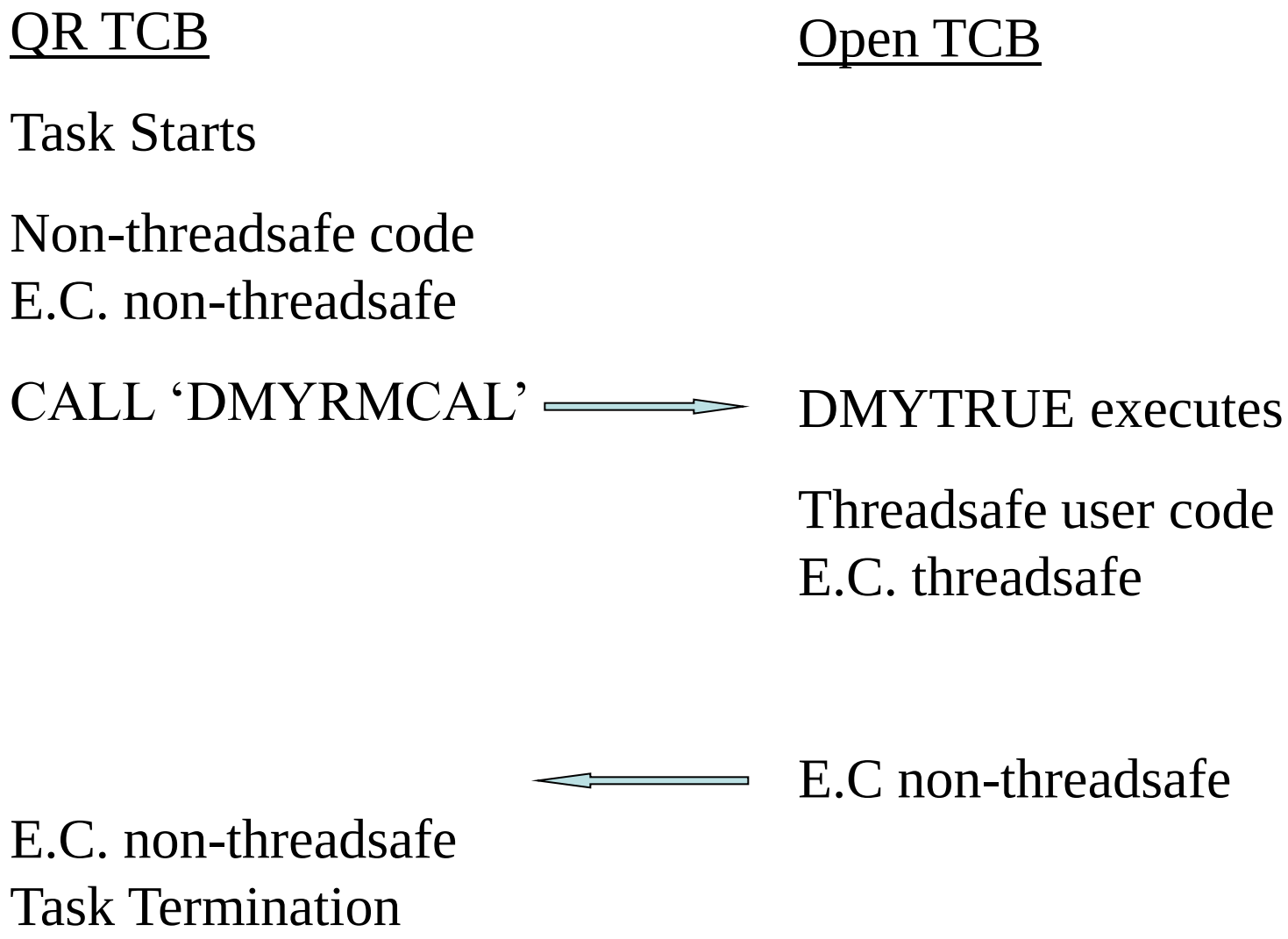
Exploiting The OTE Without DB2

```
DMYRMCAL TITLE ' - Sample Dummy stub for TRUE for OPENAPI Processing.
**-------------------------------------------------------------*
** Name    : DMYRMCAL                                          *
** Purpose : Provide a means to programmatically force a task to *
**           be spun to an L8 TCB.                              *
**           This is the callable stub that invokes the dummy   *
**           TRUE. This stub must be linked into any program    *
**           wishing to use the TCB spin TRUE. It is called via *
**           standard call syntax:                              *
**                CALL DMYRMCAL                                 *
**           As no actual work is performed by the TRUE, no parms*
**           are used on the call statement.                    *
**                                                              *
**-------------------------------------------------------------*
**
**
** ------------------------------ Module entry point.
DMYRMCAL CSECT ,                  Define the module environment
DMYRMCAL AMODE 31
DMYRMCAL RMODE 31
         DFHRMCAL TO=DMYTRUE      Call the TRUE
         LTORG ,
         END   DMYRMCAL
```

Exploiting The OTE Without DB2

```
DMYTRUE TITLE ' - Sample Dummy TRUE for OPENAPI Processing.'
**-------------------------------------------------------------*
** Name    : DMYTRUE                                           *
** Purpose : Provide a means to programmatically force a task to *
**           be spun to an L8 TCB.                             *
** Returns : Rc in R15 == 0                                    *
**                                                             *
**-------------------------------------------------------------*
         DFHUEXIT TYPE=RM         Parmlist  is passed in R1
**
**
** ----------------------------- Module entry point.
DMYTRUE CSECT ,                   Define the module environment
DMYTRUE AMODE 31
DMYTRUE RMODE 31
         SR    15,15
         BR    14                Return to caller
         LTORG ,
         END   DMYTRUE
```

Exploiting The OTE Without DB2



Exploiting The OTE Without DB2

Returning The Task to QR TCB

- Clone DMYTRUE/DMYRMCAL
- Define DMxTRUE as CONCURRENCY=QUASIRENT
- Enable the new exit as QUASIRENT

Exploiting The OTE Without DB2

QR TCB		Open TCB
Task Starts		
Non-threadsafe code E.C. non-threadsafe		
CALL ‘DMYRMCAL’	⟶	DMYTRUE executes
		Threadsafe user code E.C. threadsafe
Non-threadsafe code	⟵	CALL ‘DMxRMCAL’
Task Termination		

Exploiting The OTE Without DB2
OPENAPI

For CICS 3.1 and higher, modify the PROGRAM definition on the application program to API=OPENAPI

- The program **must** be Threadsafe
- **All** application code runs in the OTE environment
- **All** application code runs on the same TCB instance on which the program was initialized.

Exploiting The OTE Without DB2

Forces program to run on L8/9 TCB:

- Program is initialized on L8 TCB if CICS key
- Program is initialized on L9 TCB if USER key
- If program issues non-threadsafe command, task is spun to QR
- Once command has completed, task is spun to L8/9
- Use INQUIRE_CURRENT_PROGRAM and INQUIRE_PROGRAM to identify

Exploiting The OTE Without DB2

QR TCB		Open TCB
		Task Starts
		E.C. threadsafe E.C. threadsafe
Command Starts	⟵	E.C. non-threadsafe
Command Completes	⟶	
		Task Termination

Exploiting The OTE Without DB2

There are performance issues for USER key OPENAPI programs that also access OPENAPI TRUEs (includes DB2)

- USER key Program is initialized on L9 TCB
- OPENAPI TRUE is initialized on L8 TCB
- When L9 program issues DFHRMCAL to OPENAPI TRUE:
  - Task is spun to L8 TCB for duration of TRUE
  - Task is returned to L9 following completion of TRUE
- L8 TCB instance held until task termination

Exploiting The OTE Without DB2

There are performance issues for USER key OPENAPI programs that also access OPENAPI TRUEs (includes DB2)

- Review MAXOPENTCB for possible increase
- Review TCBLIMIT for possible increase
- Open TCB “stealing” performance issues
- Potential TCB deadly embrace

Exploiting The OTE Without DB2 CONCURRENCY(REQUIRED)

For CICS 4.2, modify the PROGRAM definition on the application program to API(CICSAPI) and CONCURRENCY(REQUIRED)

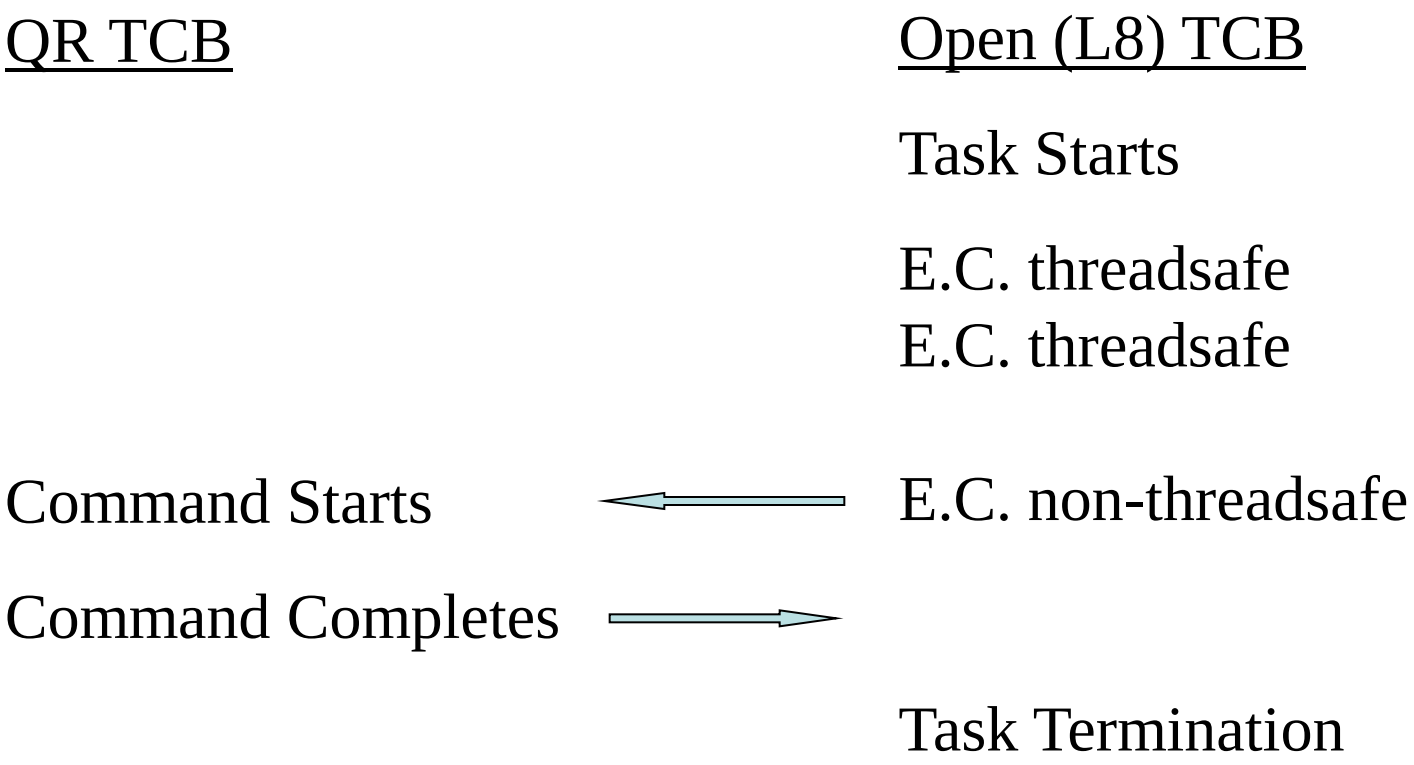
- The program **must** be Threadsafe
- **All** application code runs in the OTE environment
- **All** application code runs on the same TCB instance on which the program was initialized.
- **All** application code runs on an L8 TCB

Exploiting The OTE Without DB2

Forces program to run on L8 TCB:

- Program is initialized on L8 TCB
- If program issues non-threadsafe command, task is spun to QR
- Once command has completed, task is spun to L8
- Use INQUIRE_CURRENT_PROGRAM and INQUIRE_PROGRAM to identify

Exploiting The OTE Without DB2 CONCURRENCY(REQUIRED)



Exploiting The OTE Without DB2 CONCURRENCY(REQUIRED)

There are no additional performance issues for USER key CONCURRENCY(REQUIRED) programs that also access OPENAPI TRUEs (includes DB2)

- USER key Program is initialized on L8 TCB
- OPENAPI TRUE is initialized on L8 TCB
- Only one L8 TCB is acquired by the task
  - L8 is shared by user program and all OPENAPI TRUEs
- L8 TCB instance held until task termination

Exploiting The OTE Without DB2

Via Dummy TRUE

Advantages:

- Control application environment programmatically
- CPU savings if large number of non-threadsafe commands
- CPU savings when accessing DB2 in USER key
- Non-threadsafe application code may continue to run on QR TCB

Exploiting The OTE Without DB2

Via Dummy TRUE

Disadvantages:

- Requires changes to application code
- Requires process to enable TRUE
- If any non-threadsafe commands, must call TRUE prior to any OTE activity
- Cannot determine environment programmatically

Exploiting The OTE Without DB2

Via OPENAPI Parm

Advantages:

- No coding changes required
- All application code **guaranteed** to run in OTE
- No requirement to enable TRUE
- Can determine environment programmatically
- All user code on same TCB – no issues with “paired” z/OS macros

Exploiting The OTE Without DB2

Via OPENAPI Parm

Disadvantages:

- CPU overhead when accessing DB2 in USER key
- CPU overhead when issuing non-threadsafe EXEC CICS commands
- **All** application logic **must** be threadsafe
- Can increase the number of open TCBs required.
- Overhead if TCB stolen to switch key

Exploiting The OTE Without DB2

Via CONCURRENCY(REQUIRED) Parm

Advantages:

- No coding changes required
- All application code **guaranteed** to run in OTE
- No requirement to enable TRUE
- Can determine environment programmatically
- All user code on same TCB – no issues with “paired” z/OS macros
- Avoid User key issues found with OPENAPI

Exploiting The OTE Without DB2

Via CONCURRENCY(REQUIRED) Parm

Disadvantages:

- CPU overhead when issuing non-threadsafe EXEC CICS commands
- **All** application logic **must** be threadsafe

Exploiting The OTE Without DB2

One restriction in programs running in the OTE:

- **Do not attempt to initialize batch LE environment under CICS OPENAPI.**

Why Bother?

Run tasks on an open TCB to:

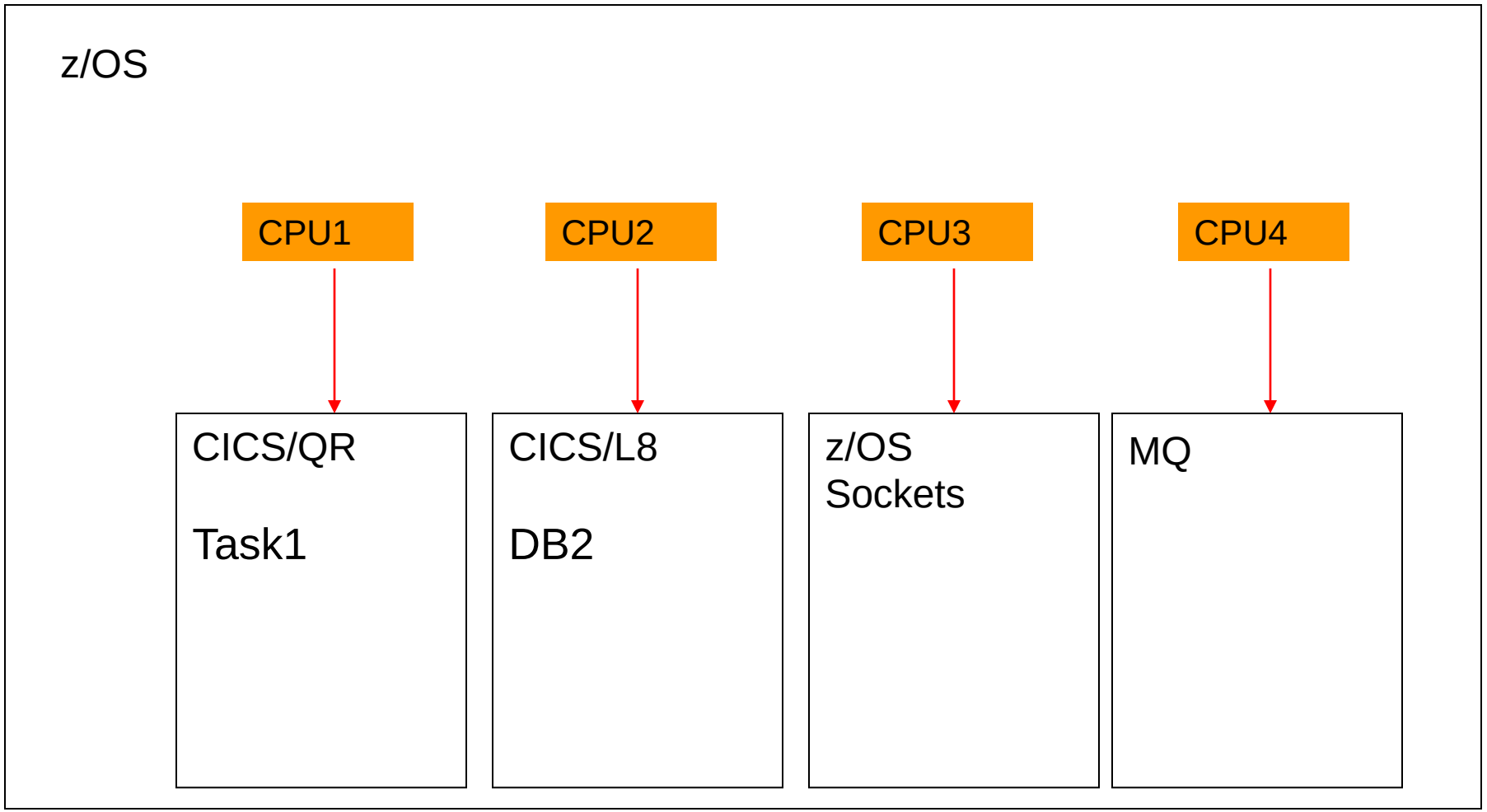
- Reduce QR CPU constraint by moving tasks to other processors
- Use z/OS functionality forbidden on QR TCB
  - Activity generating z/OS waits
    - I/O
    - ENQ/DEQ
- Segregate troublesome transactions

Implications of New TCB Types

- Multiple TCB types
- Application code running in OTE
  - Application programs fighting for CPU
  - Poor coding only affects program user, not region
  - Resource hogs build up
- CICS system code running in multiple TCBs
- IBM converting sub-products to use OTE
  - MQ
  - Sockets
  - XML parser

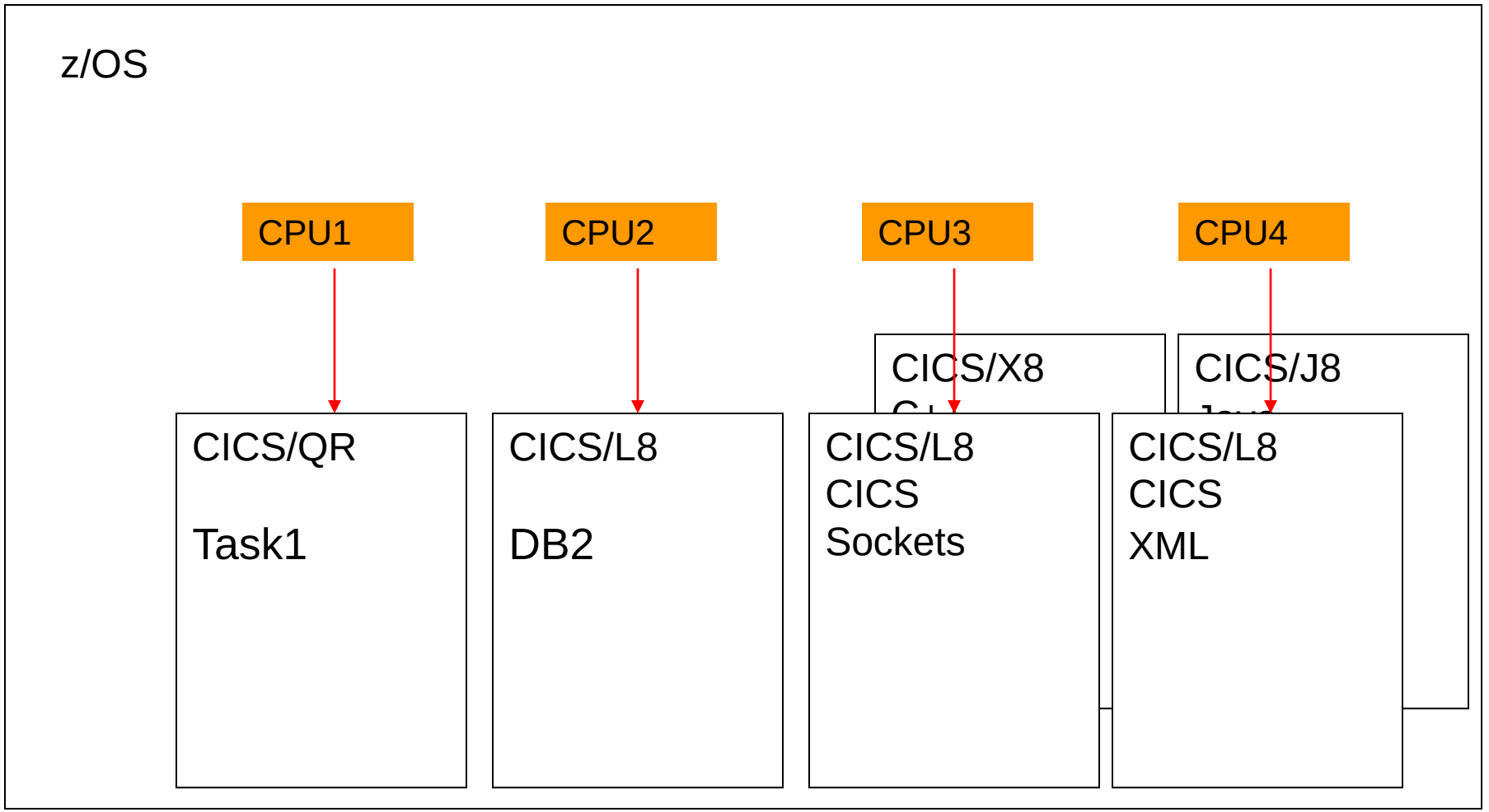
Multiple TCB Structure

Classic CICS



Multiple TCB Structure

Modern CICS



Reducing QR CPU Constraint

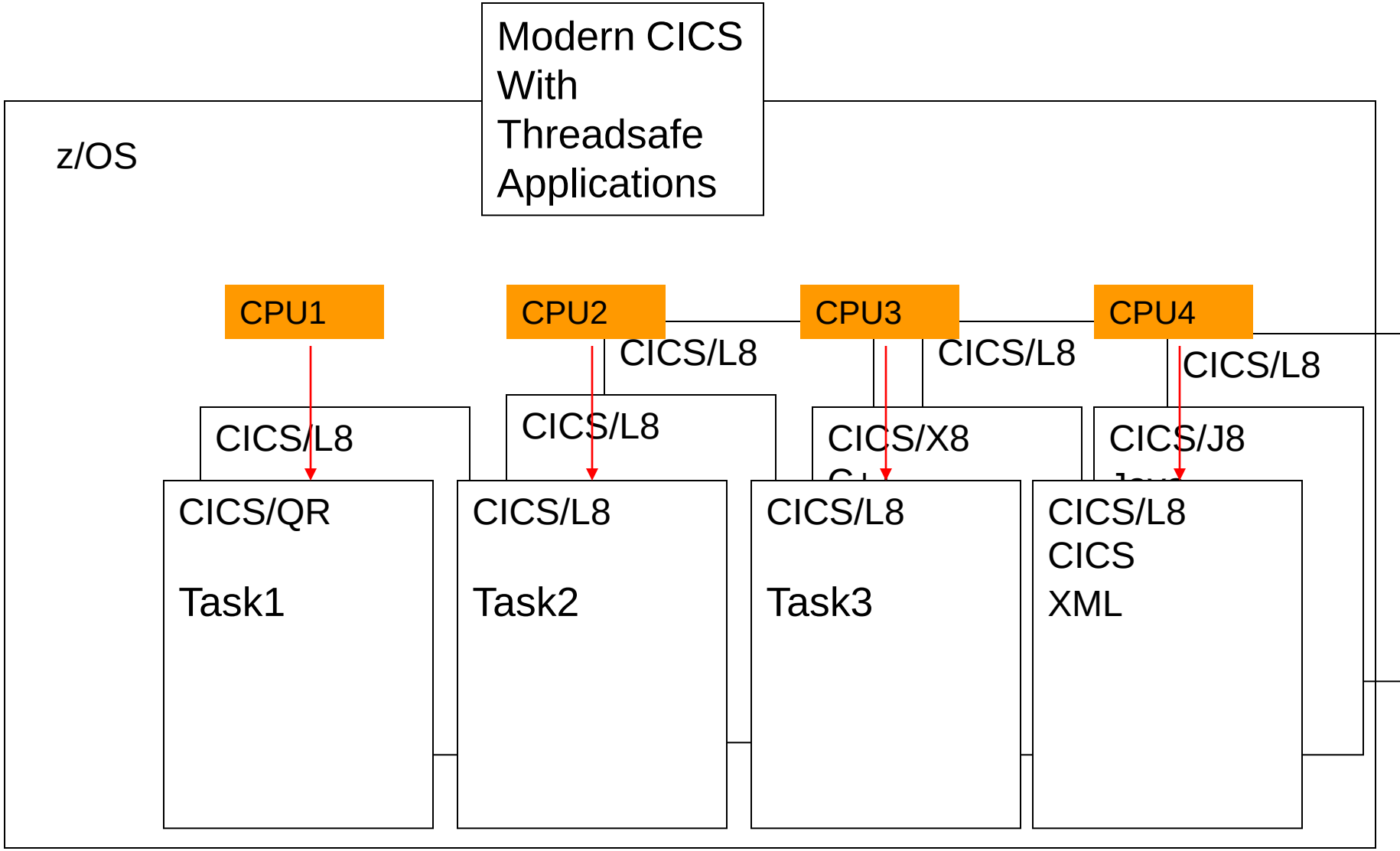
Warning: Consider LPAR CPU Implications when converting a QR constrained region to exploit open TCBs:

- Reduce QR constraint by moving tasks to other processors
- In MP environment, total CPU will increase until:

  1. CICS CPU requirements satisfied
  2. Box CPU capacity met

- Can negatively impact z/OS workload CICS depends on

Multiple TCB Structure



Using Forbidden Functionality

Use almost any z/OS function:

- Communicate with operator via WTOR
- Make use of flexibility of STORAGE OBTAIN/RELEASE
- Issue I/O without CICS file control
- Use z/OS ENQ/DEQ to synchronize with batch jobs
- …….

Using Forbidden Functionality

Transaction initiated communication with operator via WTOR:

- OTE TCB waits, not entire region
- Synchronous waits on external events/requests
- CICS command input from master console
- Enable use of standard auto operation facility

Disadvantages:

- Task shows as “running”
- No way to track WTOR back to task

Using Forbidden Functionality

Use of z/OS STORAGE OBTAIN/RELEASE

- Powerful options not available from EXEC CICS GETMAIN
- Storage acquired outside of CICS subpools
- More efficient than CICS GETMAIN

Disadvantages:

- Storage invisible to CICS monitor
- No automatic cleanup at task termination
- Storage not displayed in dump, trace, etc.
- Problems with OS GETMAIN and USER key OPENAPI tasks

Using Forbidden Functionality

Error on STORAGE OBTAIN causes ASRB, not region failure:

DFHAP0001 CICSD225 An abend (code 878/AKEB) has occurred at offset X'FFFFFFFF' in module TEST.

```
00057 L9002 AP 00E1 EIP   EXIT  LOAD
00057 L9002 AP 1942 APLI  *EXC* Abend
00057 L9002 AP 0791 SRP   *EXC* MVS_ABEND
00057 L9002 DS 0010 DSBR  ENTRY INQUIRE_TASK
00057 L9002 DS 0011 DSBR  EXIT  INQUIRE_TASK/OK
00057 QR    PG 0500 PGIS  ENTRY INQUIRE_CURRENT_PROGRAM
00057 QR    PG 0501 PGIS  EXIT  INQUIRE_CURRENT_PROGRAM
00057 QR    AP 0782 SRP   *EXC* ABEND_ASRB
```

TCB is marked as unusable:

```
DSTCB QR    KE 0502 KEDS  ENTRY DETACH_TERMINATED_OWN_TCBS
DSTCB QR    KE 0503 KEDS  EXIT  DETACH_TERMINATED_OWN_TCBS/OK
```

Using Forbidden Functionality

Issue I/O without CICS file control:

- Bypass CICS file control
- “Batch” transactions segregated from normal processing

Disadvantages:

- Cannot issue OPEN/CLOSE in COBOL program
- No backout or forward recovery
- Activity not in dump, trace, etc.

Using Forbidden Functionality

Reminder: the OTE only supports CICS LE service routines:

- COBOL display becomes a WRITEQ TD (not threadsafe!)
- COBOL dynamic call modified for CICS
- OPEN/CLOSE unavailable
- Storage obtained via EXEC CICS GETMAIN

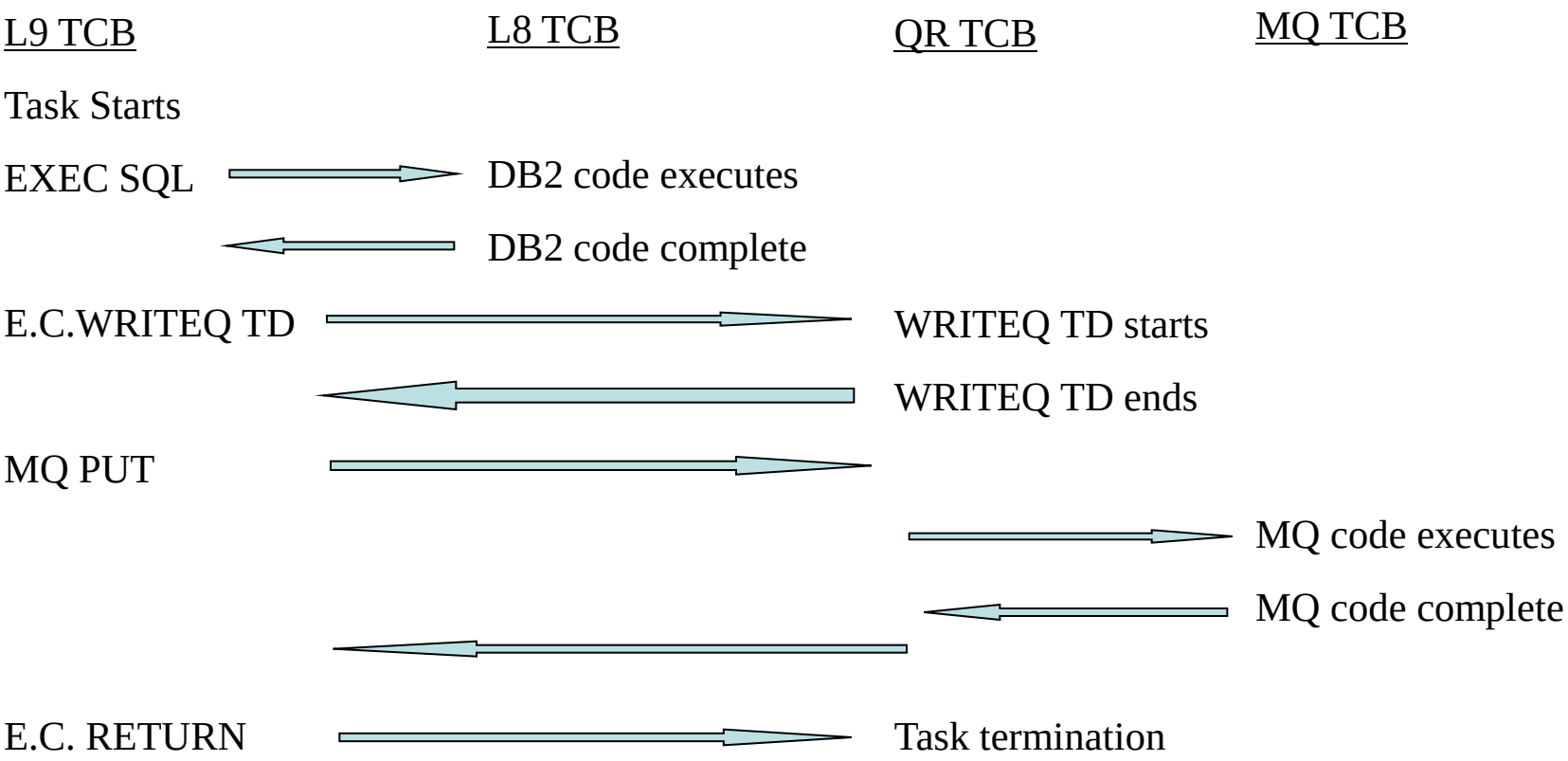
Segregating Transactions

OTE provides some insulation from difficult transactions

- CPU intensive tasks don’t own QR TCB
- QR available for CEMT, etc.

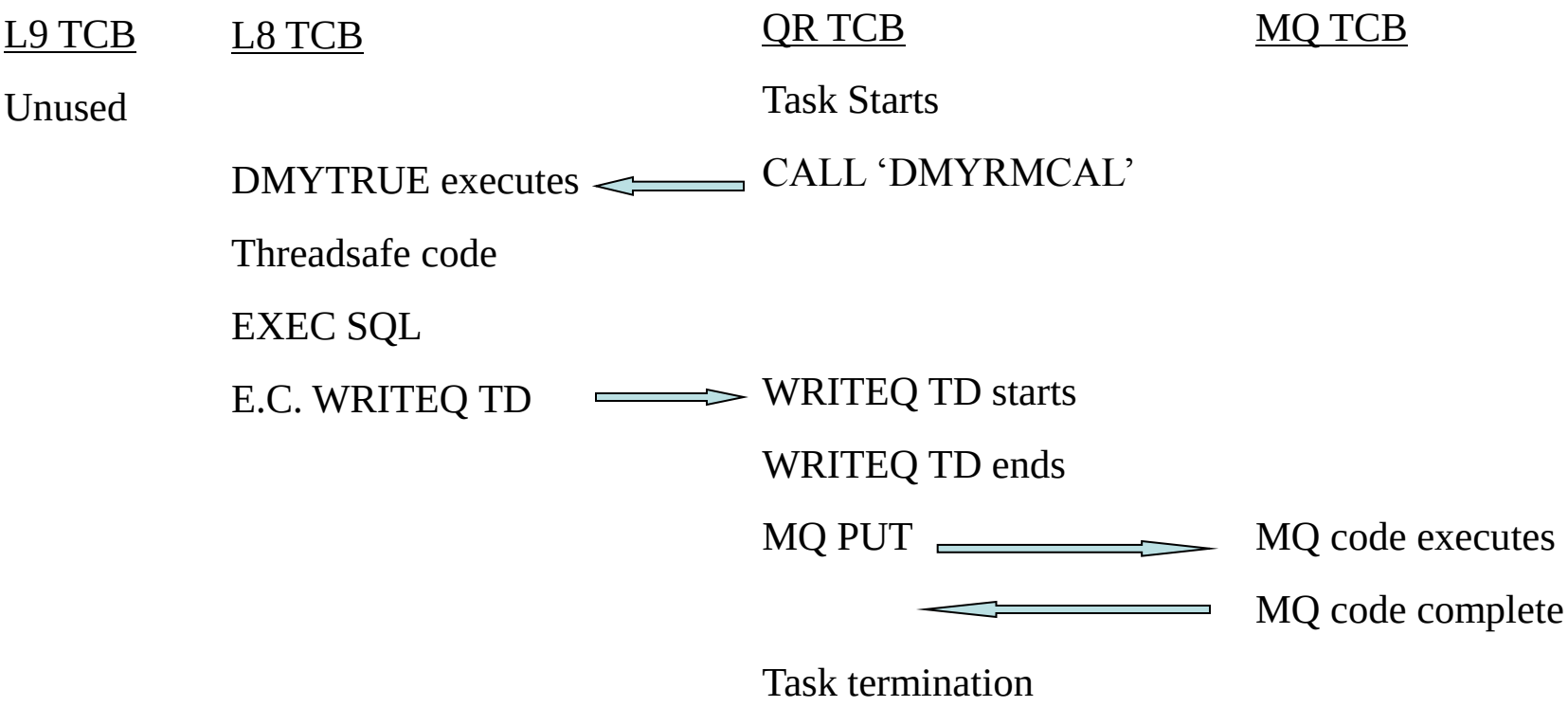
OTE and TRUEs – Scenarios for OPENAPI Program

MQ Series With OPENAPI program in USER key



OTE and TRUEs – Scenarios for OPENAPI TRUE

MQ Series With Program in USER key and Dummy TRUE



Minimize OTE Overhead: Dummy TRUE

CPU overhead is minimized when no non-Threadsafe commands are issued between the DMYRMCAL and the end of OTE user code

```
PERFORM UNTIL ...
    CALL ‘DMYRMCAL’
    [ote user code]
    EXEC CICS WRITEQ TD
END-PERFORM
```

Minimize OTE Overhead: Dummy TRUE

QR TCB		Open TCB
Task Starts		
CALL ‘DMYRMCAL’	→	OTE user code
	←	WRITEQ TD
CALL ‘DMYRMCAL’	→	OTE user code
	←	WRITEQ TD

Minimize OTE Overhead: OPENAPI Program

CPU overhead is minimized when:

1. No non-Threadsafe commands are issued by the program

2. If USER key, no DB2 or OPENAPI TRUE calls issued by the program

Minimize OTE Overhead: OPENAPI Program
Relocation Ineffective for OPENAPI!

QR TCB

Open TCB

Task Starts
OTE user code

WRITEQ TS

Inner Loop


WRITEQ TD


WRITEQ TD


WRITEQ TD

Outer Loop

Minimize OTE Overhead: REQUIRED Program

CPU overhead is minimized when:

1. No non-Threadsafe commands are issued by the program

Minimize OTE Overhead: REQUIRED Program
Relocation Ineffective for REQUIRED!

QR TCB

Open TCB

Task Starts
OTE user code

WRITEQ TS

Inner Loop


WRITEQ TD


WRITEQ TD


WRITEQ TD

Outer Loop

Reducing CPU Overhead

Note:

Prior to CICS 4.2, IRC is not threadsafe. This means that Threadsafe commands that are function shipped will be treated as if they are non-threadsafe.

CICS 4.2 IPIC connections support threadsafe mirror transactions

Ensuring Threadsafe Coding When Creating New Programs

Design is critical

- Ensure threadsafe coding standards are met
- Minimize number of TCB switches

Ensure Threadsafe Coding Standards

- Eliminate updates to shared storage areas:
  - CWA
  - GWA
  - GETMAIN(SHARED)
  - OS GETMAIN
  - LOAD HOLD
- Require use of RENT on link-edit step
- Use RENTPGM=PROTECT in CICS

Ensuring Threadsafe Coding When Creating New Programs

Minimize number of TCB switches

- Maximum performance
- Use only Threadsafe commands
- Design program flow to cluster OTE usage
- Issue non-Threadsafe commands before or after OTE activity complete

Threadsafe File Control

Threadsafe VSAM RLS available with CICS 3.2

Threadsafe **local** VSAM shipped in CICS 3.2 as disabled

New SIT parm:

FCQRONLY=[YES | NO]

- FCQRONLY=YES forces all file control to run on QR TCB
- FCQRONLY=NO allows threadsafe file control requests to run on L8/L9 TCB

Remote VSAM on non-IPIC connections remains non-threadsafe

Threadsafe File Control

Enable local VSAM threadsafe in CICS 3.2 with PTF UK37688

VSAM APARs OA20352 and OA24071 are required

NOTE: UK37688 changes the default on FCQRONLY from NO to YES. If you are running VSAM RLS threadsafe, and take the default on FCQRONLY, applying UK376688 will disable RLS threadsafe.

Futures

“It is the intention of IBM for future releases of CICS Transaction Server for z/OS to continue to enhance OTE support to enable the ongoing migration of CICS and application code from the QR to open TCBs.”

Threadsafe considerations for CICS

Futures

- IBM committed to making more commands threadsafe
- IBM Announces additional threadsafe commands in every release since TS 2.2
- CICS 3.2 introduces threadsafe file control (local) Note, CICS TS 3.2 was shipped with threadsafe VSAM disabled. Apply PK45354 to activate it
- CICS 4.2 introduced threadsafe DBCTL for DLI
- Conversion to OPENAPI TRUEs for CICS Sockets, MQ
- Internal use of OPENAPI for CPU intensive processes

Recommendations

- Consider Threadsafe implications now.
- Heavy CPU users exploit multiprocessors
- Don’t forget purchased packages
- Beware of COBOL calls (dynamic or static)

Recommendations

- Convert XRMIIN/OUT and Dynamic Plan Selection exits **before** migrating to a threadsafe capable CICS release
- Convert all frequently used exit programs to threadsafe before converting programs
- Verify that required maintenance is on CICS and vendor products before converting programs to threadsafe
- Review IBM Redbook “Threadsafe Considerations for CICS”