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IBM System z – Hardware Workshop

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zHPF

High Performance FICON

Redbooks Workshops

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System z10

- *Features and Functions Part 2*
  - *zHPF*

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z10 High Performance FICON for System z (zHPF)

- **Improve FICON efficiency, scale, value and RAS**
  - As data density behind a CU and device increases
    - scale the I/O rates and bandwidth to grow with the data
  - Reduce elapsed times
    - improved I/O rates and bandwidth
  - Reduce the number of channels, switch ports, control unit ports and optical cables required to balance CPU MIPS with I/O capacity
  - Reduce time and skill it takes to resolve MIH and IFCC conditions
    - Improve First Failure Data Capture
- **Solution**
  - Leverage optimizations in Host/Bus Adapter (HBA) to improve I/O performance, especially for small block I/O
    - Significant improvements in I/O rates (2 to 3x) for small block transfers
  - I/O architecture changes
    - FICON protocol changes between channel and CU (industry standard)
    - New System z architecture to build new channel programs to be exploited by z/OS
    - New ECKD commands for improved efficiency
  - Additional channel and CU diagnostics for timeout conditions

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System z High Performance FICON (zHPF)

- FICON architecture for protocol simplification and efficiency designed to:
  - reduce the number of Information Units (IUs) processed
  - reduce FICON channel overhead and improve performance
- The maximum number of I/Os per second is designed to be improved up to 100%* for small data transfers that can exploit the zHPF protocol
- Requires control unit exploitation
  - IBM System Storage DS8000 – require LIC level 4.1 and FC7092
    - ✓ traditional and HyperPAV supported
  - OEM Support
- z10 FICON Express8, Express4 and Express2 features, CHPID type FC
  - Implemented in System z10 Licensed Internal Code
  - FC channel supports multiple CUs using both FICON and zHPF protocols at the same time
  - zHPF will not be used unless **all** the CHPIDs / CU ports for the device support the new protocol
  - Channel and CU inform each other of capabilities at initialization time
    - ✓ Process Login (PRLI) added to Link Initialization
- Supported by z/OS 1.8 and higher releases with PTF
  - Media manager driver supports data sets
    - ✓ DB2, VSAM, HFS, zFS, PDSE, and extended format sequential data sets

*Note: Some specific channel programs may not be converted to zHPF protocol

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zHPF vs FICON Architecture

- zHPF architecture moves significant function out of channel firmware
  - Emulex – (the processor chip used by the CU host adapter)
  - Control Unit
  - Software
- Basic transport uses *"FCP like"*
  - The concept of CCWs *"is gone"*
  - At the channel there is only *"ONE Command"*
  - CU commands and control data are encapsulated in one "FCP" command descriptor block
- After some initial setup by firmware, Emulex controls the entire operation
- Data can move only ONE direction in any given Start Subchannel
  - All Reads OR
  - All Writes

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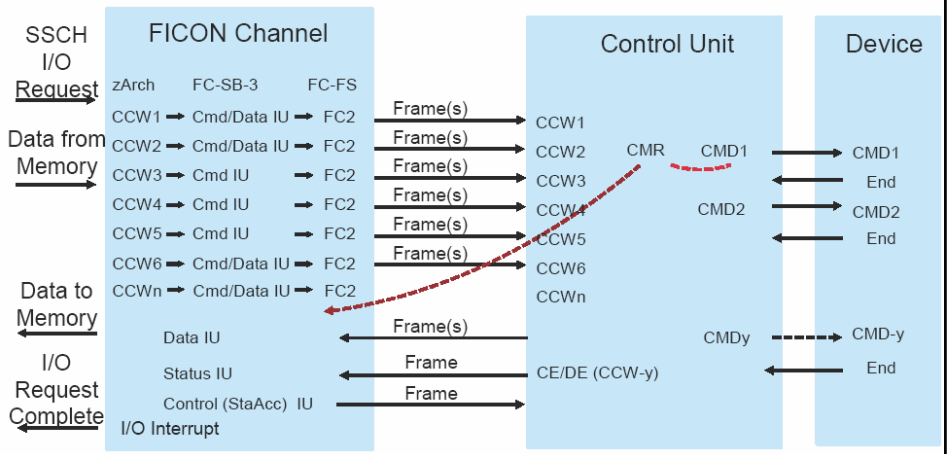
FICON – Command Mode



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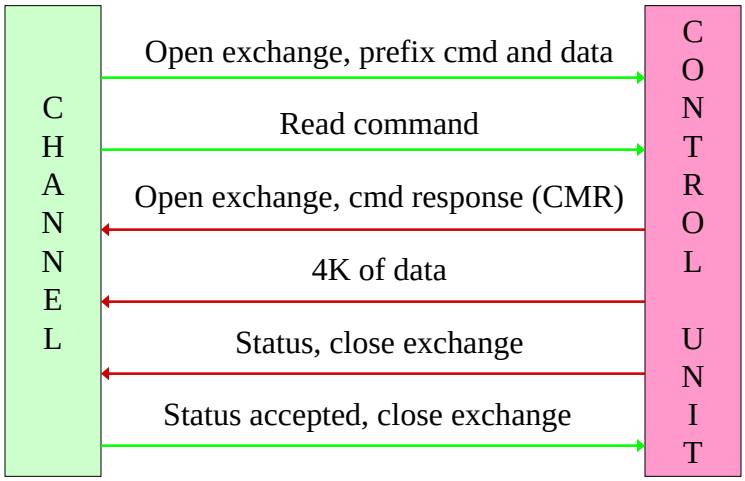
FC Link Protocol for FICON – (Command Mode)



Example of a 4K read I/O request

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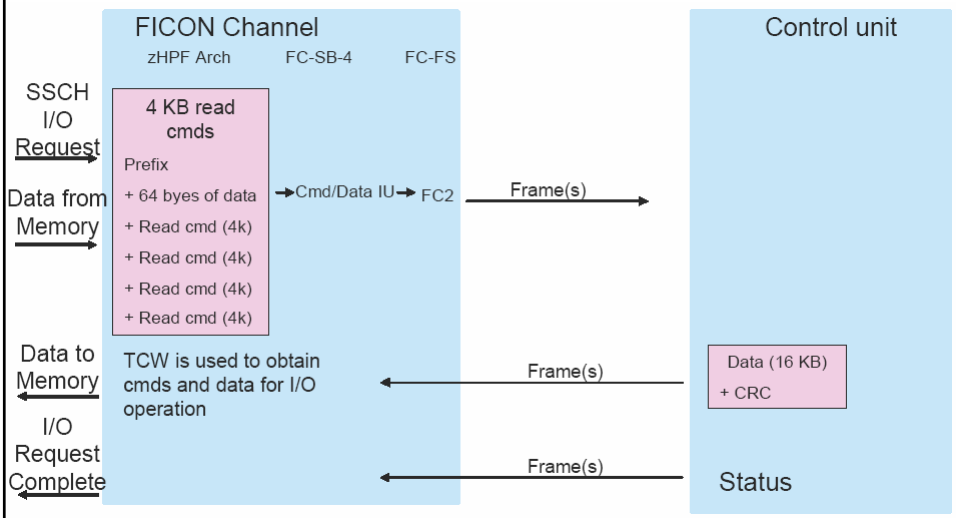
FICON – Transport Mode



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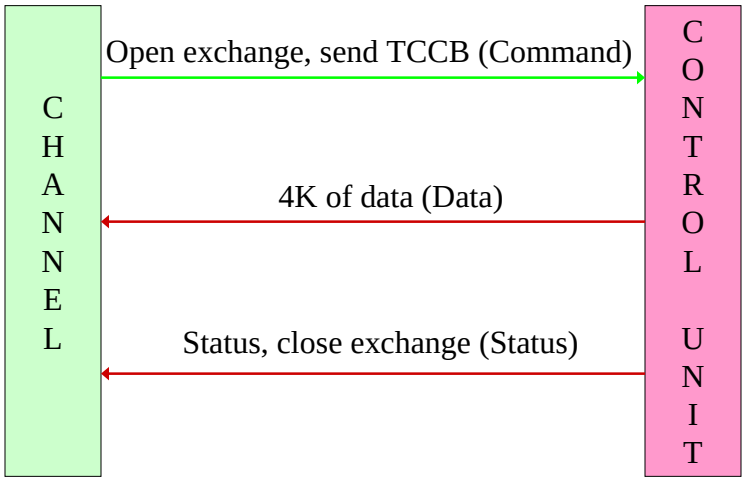
FC Link Protocol for FCP & zHPF – (Transport Mode)



Example of a 4K read I/O request

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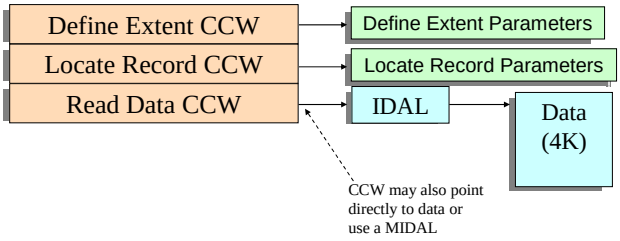
Today's Channel Program

- Each CCW contains
  - a command to be executed and either
  - points to control parameters (e.g., identifying where on DASD to read or write, search address)
  - or points to storage areas containing the data to be read or written
  - CCW may point directly to the storage areas, or
  - may use some form of indirect addressing (IDAL or MIDAL) to point to the storage areas.



- The device dependent STARTIO exit is called before the SSCH and may modify the channel program
  - it may add a reserve CCW to the channel program if the device needs to be reserved,
  - or it may collapse the define extent and locate record CCWs into a single prefix CCW

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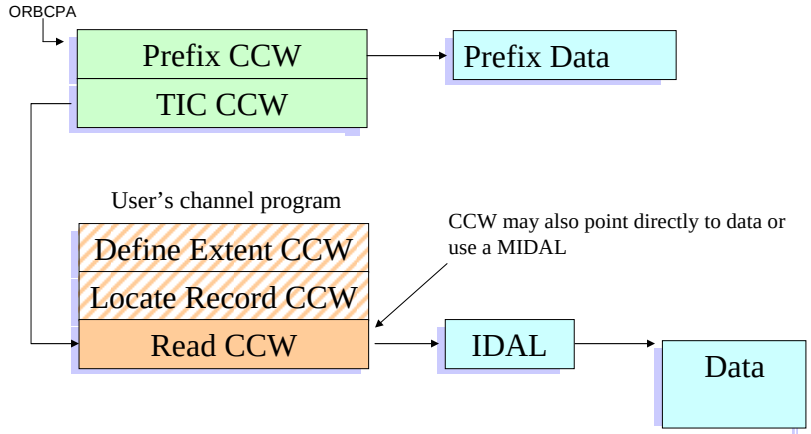
Today's Channel Program cont'd

- After the STARTIO exit completes
  - IOSB (IOSRST) points to the original start of the channel program (define extent CCW)
  - The ORB passed to SSCH points to the modified channel program(ORBCPA)



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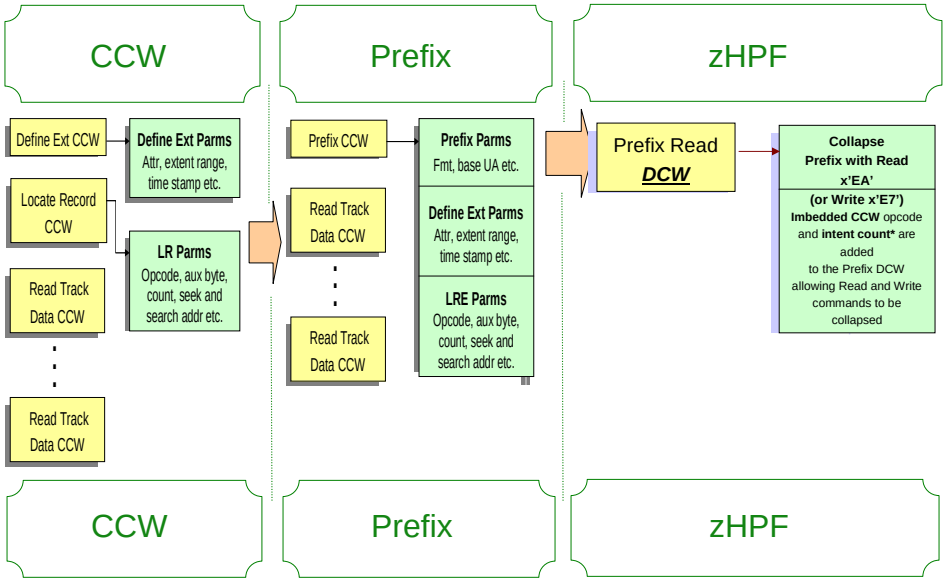

(*) The imbedded CCW opcode specifies the operation that normally would have been performed via a separate DCW, and the intent count specifies the number of operations to perform (1 to 255).

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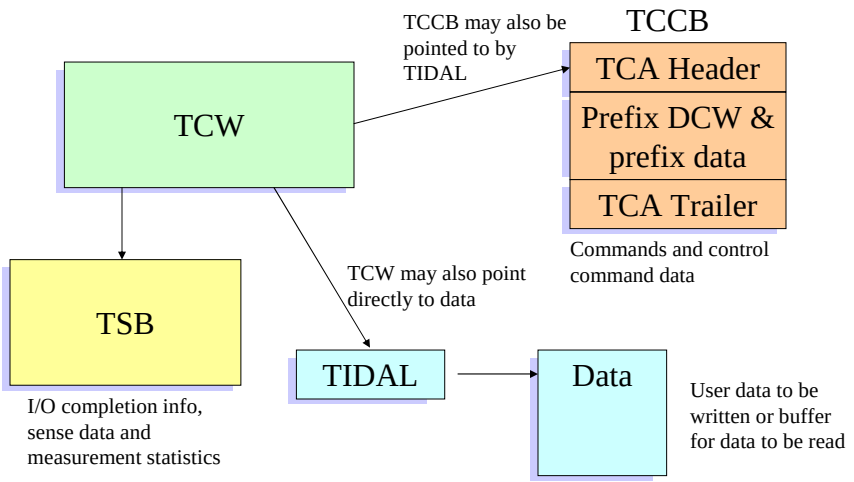
zHPF Channel Program



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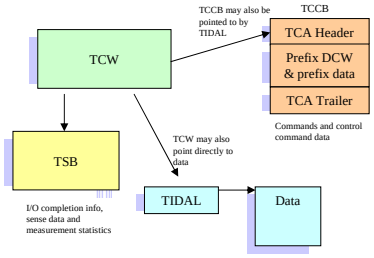
Transport Control Word (TCW)

Fmt	Flags	Rsvd	TCCB Len/R/W
TIDAL or data address for write (output)			
TIDAL or data address for read (input)			
TSB address			
TCCB address			
Output byte count	Input byte count		
Reserved	Reserved		
Reserved	Interrogate TCW address		

- Used only by the channel to drive the I/O operation
  - Fetch storage areas needed for I/O operation
  - Not sent to the control unit
- Contains pointers/lengths of:
  - Commands and control data - Transport Command Control Block (TCCB)
  - Data buffers* for data to be read or written
  - Ending status information – Transport Status Block (TSB)
  - Channel uses TCW to locate other parts of channel program

✓(*) **Data buffers** – The TCW points to the input and output buffers.
✓If the data buffers are scattered in storage, the TCW points to a Transport Indirect Address List (TIDAL)
✓Each TIDAW in the TIDAL points to a storage area.
✓A TIDAW is similar to a IDAW or MIDAW for a CCW channel program.
✓Currently an zHPF channel program can only read or write data, not both, so there is only one set of data buffers per channel program.



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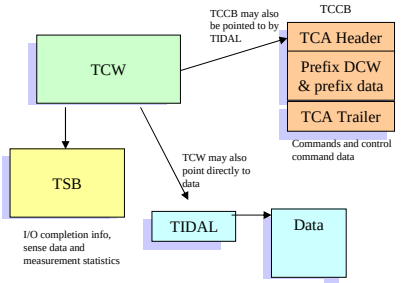
Transport Command Control Block (TCCB)

- Contains the commands to be executed **by the control unit**
  - Like SCSI Command Descriptor Block (CDB)
- Pointed to by the TCW
- Channel does not look at the TCCB contents – simply packages it and sends it to the CU
  - Allows FCP transport protocols to be used instead of FICON



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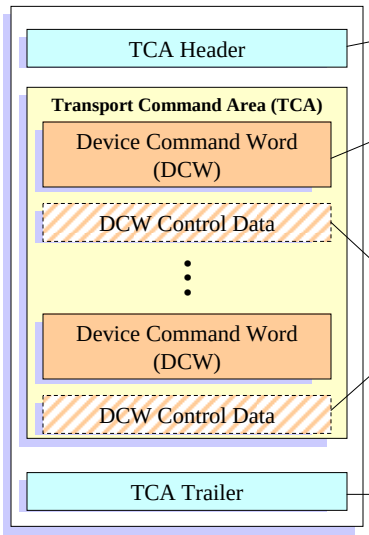
Transport Command Control Block (TCCB)



TCAH contains info about TCA and operations within (length, service action code)

DCW
- Command code, flags (chaining), control data length, and read/write data length
- Similar to CCW except no pointer to data being read or written
- Limited set of ECKD commands supported

DCW control data
- Optional, control parameters for DCW
- E.g., define extent or prefix parameters
- Follows DCW within TCA, not pointed to by DCW

TCAT contains reserved word plus count of bytes to be transferred

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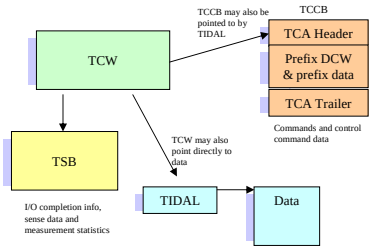
TSB – Transport Status Block

- Contains additional I/O completion status that is not presented in the IRB
  - 64 bytes in length
  - Stored by channel at I/O or interrogate completion time
  - It also contains response time statistics reported by the control unit
- I/O Status Format – TSB Format
  - Ending status for an I/O operation information not present in IRB
  - I/O measurement statistics used to update CMB/ECMB
  - Sense data for unit checks
- Device Detected Program Check – TSB Format
  - Errors detected by device that directs channel subsystem to present a program check
  - Describes reason for program check
- Interrogate Status – TSB Format
  - Status presented as a result of an interrogate request (MIH)
  - Describes state of I/O operation at time interrogate received



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I/O Status TSB

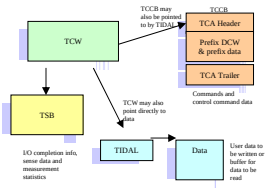
Up to 64 bytes

0	Size	Flags and Fmt	Last DCW offset
1	DCW residual byte count of last DCW		
2	Reserved		
3	Device time		
4	Defer time (Device disconnect time)		
5	Queue time		
6	Device busy time		
7	Device active only time		
8-15	Sense Data (0 to 8 words)		

Replaces residual count in IRB

I/O statistics used to update IRB and CMB/ECMB

No longer need to issue separate sense command



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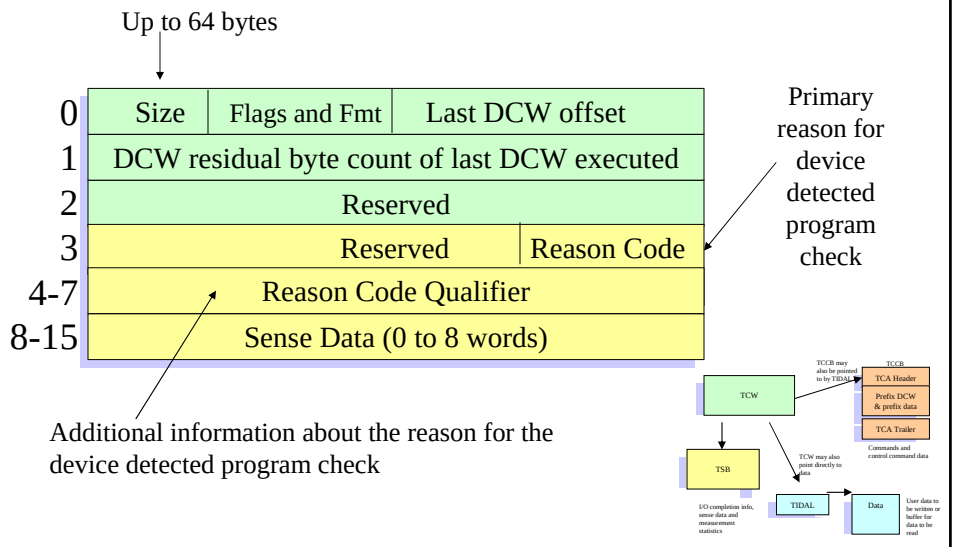
Device Detected Program Check TSB



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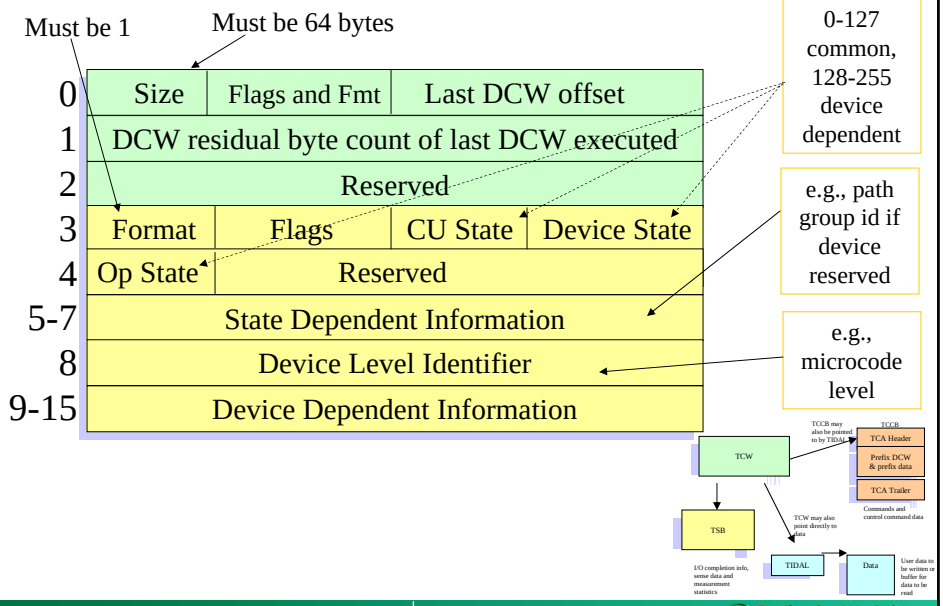
Interrogate TSB



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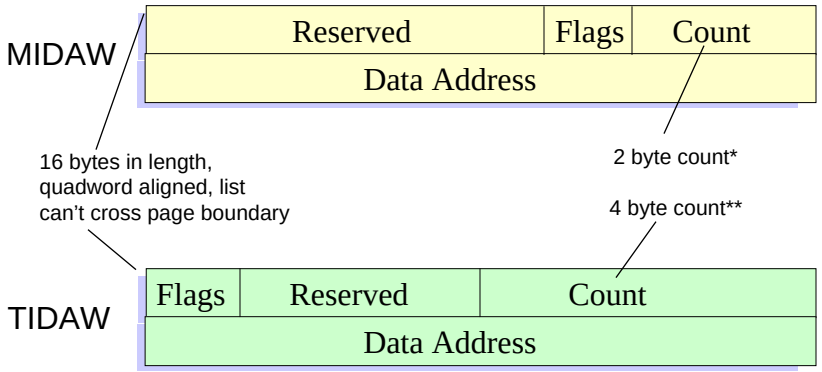
Transport Indirect Address Word (TIDAW)

- Used to indirectly address data and commands (TCCB)
  - TCCB TIDAL use is restricted to device support code



* 2 byte count = 64KB ** 4 byte count = 4 GB

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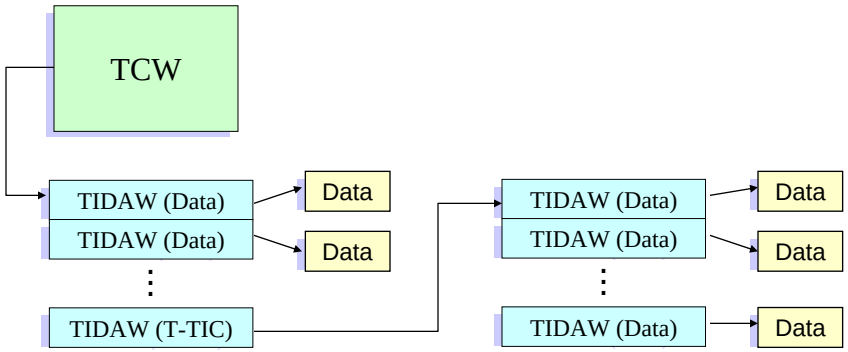
Chaining TIDALs Together

- Used when TIDAL exceeds size of page
- Last TIDAW in list has T-TIC flag on and pointer to next TIDAL



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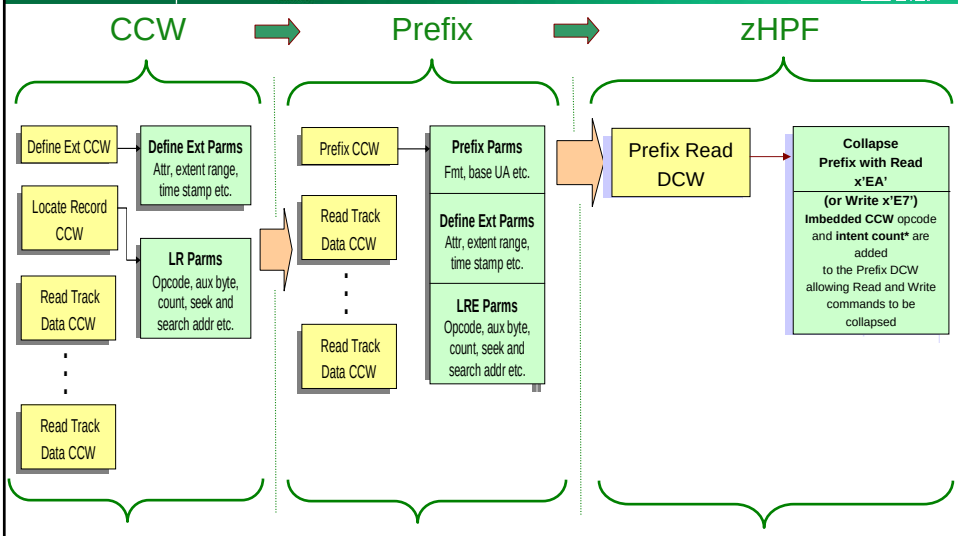

(*) The imbedded CCW opcode specifies the operation that normally would have been performed via a separate DCW, and the intent count specifies the number of operations to perform (1 to 255).

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zHPF Interactions and Dependencies

- Hardware Dependencies
  - Processor
    - z10 EC GA2 / z10 BC
    - FICON channel cards may be carried over to z10, but zHPF is supported only on FICON Express2 and higher cards
  - Control Unit
    - DS8000 - Microcode level 4.1 - LIC feature – FC7092
    - OEM support
  - No HCD, switches or configuration changes required

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Interactions and Dependencies

- Software Dependencies
  - Supported on z/OS 1.7*, 1.8*, and 1.9 and later
  - Support is enabled only when all H/W and S/W functions are present and zHPF feature/function is enabled
- Exploiters
  - Media manager is the current exploiter
    - DB2, VSAM, HFS, zFS, PDSE, and extended format sequential data sets
  - Media manager will retry zHPF I/O operations using CCW channel programs if zHPF I/O fails
  - No changes are needed to application programs to exploit zHPF once the function is enabled

*some z/OS releases require Lifecycle Extension contract

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Customer Control of zHPF

- New IECIOSxx and SETIOS commands to enable and disable zHPF
  - Default: Disabled (1.7 and up)

```
IECIOSxx: ZHPF=YES|NO
SETIOS ZHPF=YES|NO
```

- New display IOS command to display status

```
D IOS,ZHPF
IOS630I hh.mm.ss XXX DATA
HIGH PERFORMANCE FICON FACILITY IS
ENABLED|DISABLED
```


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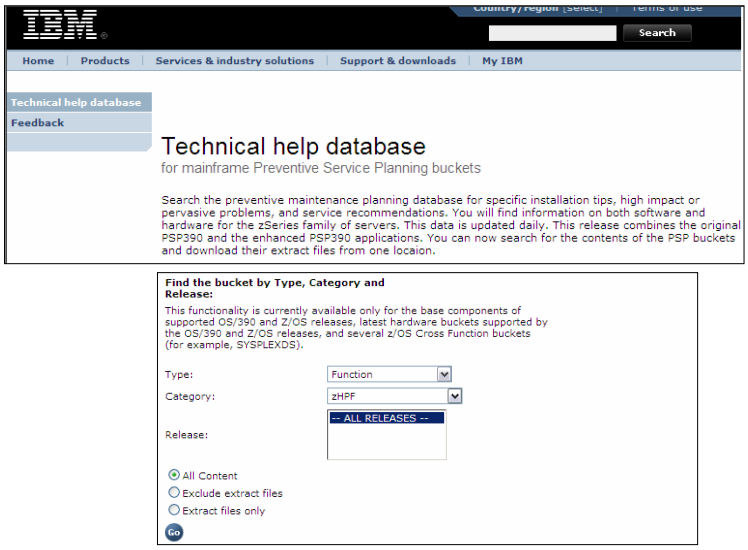
Determining if a Device Supports zHPF

```
D M=DEV(410)

IEE174I 11.00.11 DISPLAY M 258
DEVICE 0410   STATUS=ONLINE
CHP                  A0   A1   A2   A3
DEST LINK ADDRESS    A0   A1   A2   A3
PATH ONLINE          Y    Y    Y    Y
CHP PHYSICALLY ONLINE Y   Y    Y    Y
PATH OPERATIONAL     Y    Y    Y    Y
MANAGED              N    N    N    N
CU NUMBER            0400 0400 0400 0400
MAXIMUM MANAGED CHPID(S) ALLOWED:  0
DESTINATION CU LOGICAL ADDRESS = 04
SCP CU ND         = 002107.000.IBM.TC.02069A00FF04.00FF
SCP TOKEN NED     = 002107.000.IBM.TC.02069A00FF04.0400
SCP DEVICE NED    = 002107.000.IBM.TC.02069A00FF04.0410
FUNCTIONS ENABLED = MIDAW, ZHPF
```


Finding more info about zHPF

- *http://www14.software.ibm.com/webapp/set2/psp/srchBroker*



DataBase Search Results

- http://www14.software.ibm.com/webapp/set2/psp/srchBroker

```
/* Preventive Service Planning */
/* UPGRADE: FUNCTION, SUBSET: zHPF */
/* Updates also available at ftp site: */
/* ftp site  = ftp://ftp.software.ibm.com/s390/pspapartool/ */
/* ftp file  = FUNCTION_zHPF.txt  */
/* Last Extract: */
/*    Time = 18:25:31 */
/*    Date = 08/25/2009 */
APAR(AO04445) FMID(EER3500) FIX(UO00849) UPG(FUNCTION) SUB(zHPF).
APAR(AA18766) FMID(HBB7720) FIX(UA44235) UPG(FUNCTION) SUB(zHPF).
APAR(AA19156) FMID(HBB7720) FIX(UA44249) UPG(FUNCTION) SUB(zHPF).
APAR(AA19956) FMID(HBB7720) FIX(UA44245) UPG(FUNCTION) SUB(zHPF).
APAR(AA22918) FMID(HBB7720) FIX(UA44122) UPG(FUNCTION) SUB(zHPF).
APAR(AA18766) FMID(HBB7730) FIX(UA44236) UPG(FUNCTION) SUB(zHPF).
APAR(AA19156) FMID(HBB7730) FIX(UA44250) UPG(FUNCTION) SUB(zHPF).
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APAR(AA22918) FMID(HBB7730) FIX(UA44127) UPG(FUNCTION) SUB(zHPF).
APAR(AA27852) FMID(HBB7730) FIX(UA46183) UPG(FUNCTION) SUB(zHPF).
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APAR(AA19156) FMID(HBB7740) FIX(UA44251) UPG(FUNCTION) SUB(zHPF).
APAR(AA19956) FMID(HBB7740) FIX(UA44247) UPG(FUNCTION) SUB(zHPF).

APAR(AA21140) FMID(HRM7750) FIX(UA90470) UPG(FUNCTION) SUB(zHPF).
APAR(AA22918) FMID(JBB772S) FIX(UA44129) UPG(FUNCTION) SUB(zHPF).
APAR(AA21140) FMID(JRM773J) FIX(UA90475) UPG(FUNCTION) SUB(zHPF).
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APAR(AA21140) FMID(JRM775J) FIX(UA90471) UPG(FUNCTION) SUB(zHPF).
/* end of PSP extract file */
```

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FICON and zHPF Comparison

Function	FICON	zHPF
Devices supported	DASD, tape, CTC, printers etc.	DASD
Channels supported	All	FICON (2.0+)
I/O drivers supported	All	Media manager
Parallel Access Volumes (includes HyperPAV)	Supported	Supported
Channel Measurement Block statistics	Supported	Supported
Dynamic Pathing ▪ Alternate path reconnect ▪ Reserve allegiance	 ▪ Yes ▪ Yes	 ▪ No (no physical disconnect) ▪ Yes

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When is a Device Enabled for zHPF ?

A device is enabled for zHPF if all of the following are true:

1. The processor supports zHPF
2. All of the online channels support zHPF
   - CONFIG CHP(xx) and VARY PATH may affect zHPF status
   - Loss of path may also affect zHPF status
   - No message issued when zHPF status changes
3. The control unit supports zHPF
   - Indicated via Read Feature Codes
4. The device support code supports zHPF
   - UIM indicates this – Only DASD for now
5. zHPF has not been disabled by the customer
   - zHPF=YES specified in IECIOSxx or SETIOS command

✓ New UCB bit (UCBFCX) is set if device supports FCX

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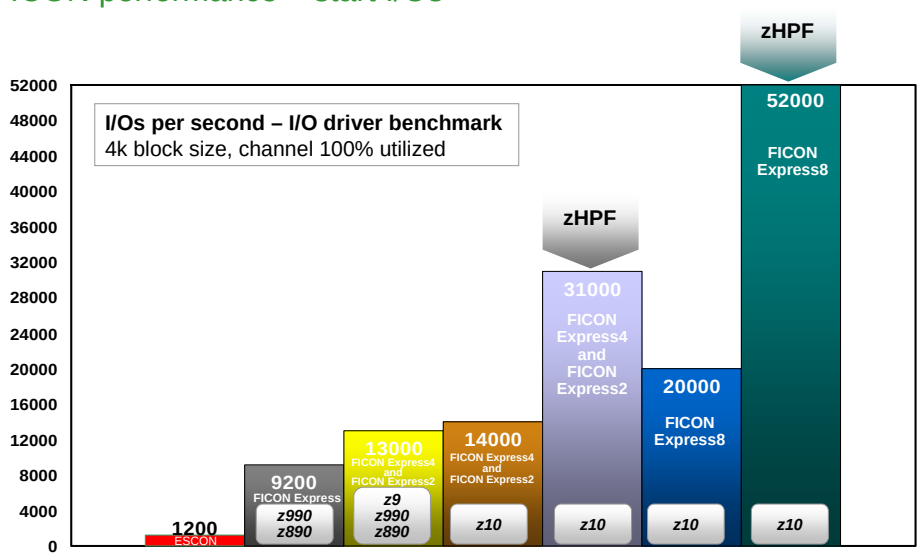
FICON performance – start I/Os



*This performance data was measured in a controlled environment running an I/O driver program under z/OS . The actual throughput or performance that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed.

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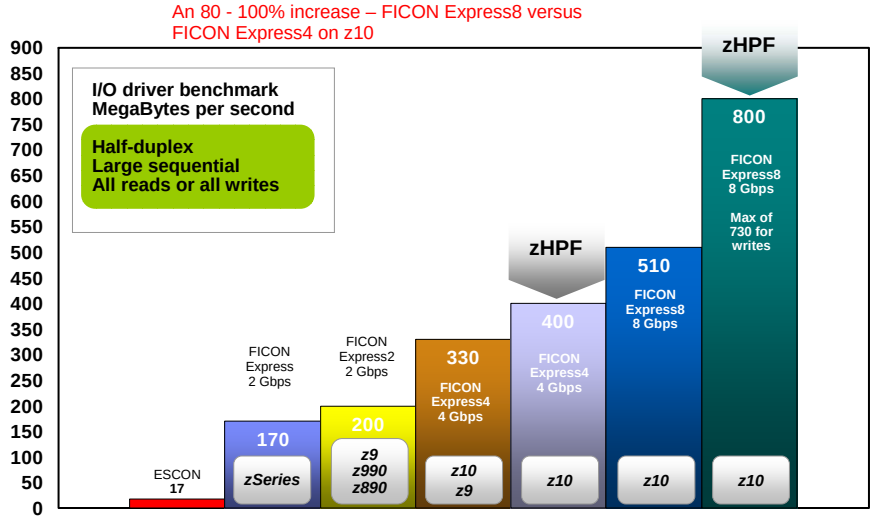
FICON performance – MBps troughput

An 80 - 100% increase – FICON Express8 versus FICON Express4 on z10



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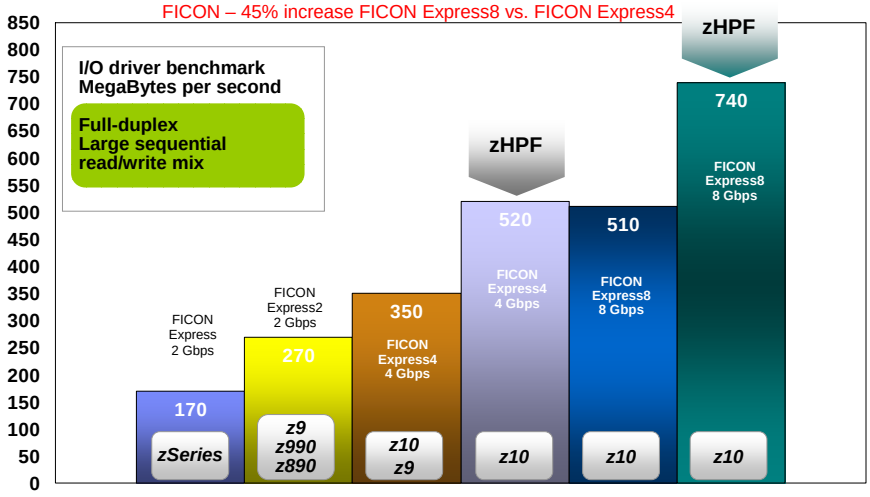
FICON performance – MBps troughput

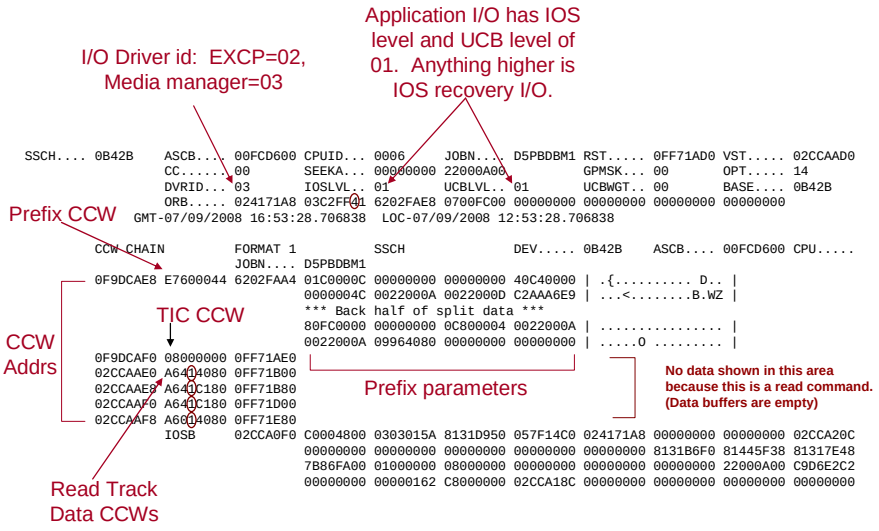
zHPF – 40% increase FICON Express8 vs. FICON Express4
FICON – 45% increase FICON Express8 vs. FICON Express4



*This performance data was measured in a controlled environment running an I/O driver program under z/OS . The actual throughput or performance that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed.

Non zHPF GTF CCW trace

- SSCH CCW trace



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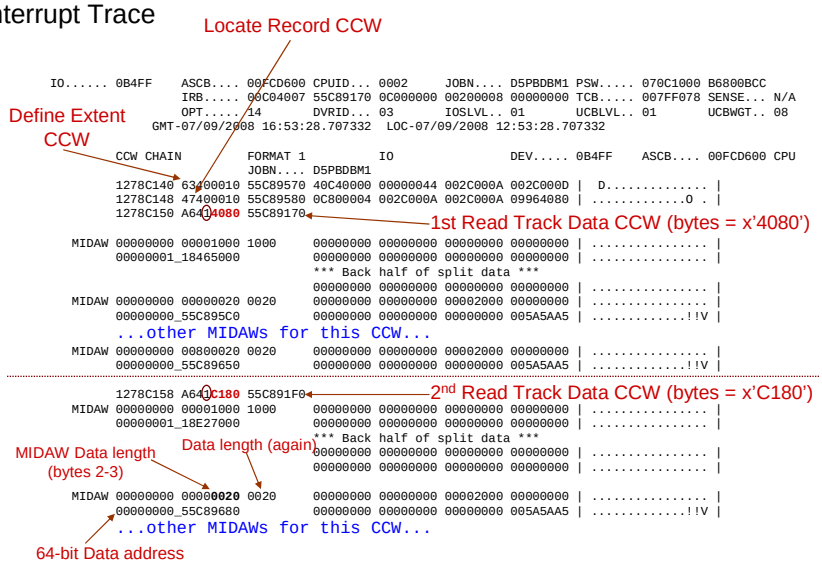
Non zHPF GTF CCW trace cont'd

- I/O Interrupt Trace



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zHPF GTF CCW trace (SSCH)

```
SSCH.... 0B449    ASCB.... 00FCD600 CPUID... 0006     JOBN.... D5PBDBM1 RST..... 7E28C680 VST..... 02CE6680
                  CC...... 00       SEEKA... 00000001 21000100          GPMSK... 00       OPT..... 14
                  DVRID... 03       IOSLVL.. 01       UCBLVL.. 01       UCBWGT.. 00       BASE.... 0B449
                  ORB..... 024184C8 0004FF01 6202FCC0 0700FC00 00000000 00000000 00000000 00000000
              GMT-07/09/2008 16:53:28.713689  LOC-07/09/2008 12:53:28.713689


  FORMAT 0          SSCH             TCW CHAIN         DEV..... 0B449    ASCB.... 00FCD600 CPU..... 0006
                    JOBN.... D5PBDBM1

  TCW at 0F9DCCC0 (6202FCC0)
    Format.......... 00                Flag1........... 06
    Flag2........... 00                Flag3........... 00
    TCCBL/R/W....... 4E
    Output Address... 00000000  00000000
    Input Address.... 00000000  7E28C6D0
    TSB Address..... 00000001  41373910
    TCCB Address.... 00000001  413739C0
    Output Count.... 00000000            Input Count..... 00001020
    Interrogate TCW.. 00000000

  TCCB TIDAW at 00000001_413739C0
    Flags... 00  Count... 00000058  Addr... 00000001  41373950

  TCA Header at 00000001_41373950
    Format.......... 7F        TCALen......... 54
    Serv Act Code... F901      Priority....... FC

  DCW at 00000001_41373960
    Command.. EA  Flags.. 00  CD Count.. 40  Count.. 00001020

  DCW Control Data at 00000001_41373968
    01C00000 00000000 00000000 40C01020 0000004E 01210001 01210001 C2AAA6E9 | .{.......... {.....+........B
    6D5D64B6 2000000C 00000000 0CE8A601 01210001 01210001 09001020 00000000 | _)...........Yw..............

  TCCB TIDAW at 00000001_413739D0
    Flags... 80  Count... 00000008  Addr... 00000000  7E28C778

  TCA Trailer at 00000000_7E28C778
    Transport Count... 00001024
```

Real and virtual addresses of TCW

Total input bytes for channel program (TCCB)

TCCB TIDAW for part of channel pgm modified by device code

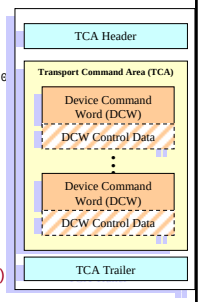
Prefix read

Control data (prefix parameter) length

Total data bytes transferred by prefix read

Prefix parameters

TCCB TIDAW for part of channel pgm not modified by device code



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zHPF GTF CCW trace (I/O interrupt)

```
IO...... 0B449    ASCB.... 00FCD600 CPUID... 0003     JOBN.... D5PBDBM1 PSW..... 071C6000 B6AEE826
                  IRB..... 00104007 6202FCC0 0C000100 00800000 00000000 TCB..... 007FF078 SENSE... N/A
                  OPT..... 14       DVRID... 03       IOSLVL.. 01       UCBLVL.. 01       UCBWGT.. 00
              GMT-07/09/2008 16:53:28.714713  LOC-07/09/2008 12:53:28.714713

  FORMAT 0          TCW CHAIN         IO                DEV..... 0B449    ASCB.... 00FCD600 CPU..... 0003
                    JOBN.... D5PBDBM1

  TCW at 02CE6680 (7E28C680)
    Format.......... 00                Flag1........... 04
    Flag2........... 00                Flag3........... 00
    TCCBL/R/W....... 4E
    Output Address... 00000000  00000000
    Input Address.... 00000000  7E28C6D0
    TSB Address..... 00000000  00000000
    TCCB Address.... 00000000  7E28C720
    Output Count.... 00000000            Input Count..... 00001020
    Interrogate TCW.. 00000000

  I/O Status TSB at 00000001_41373910
    Length.......... 20        Flags.......... D1
    DCW Offset...... 0000      Count.......... 00000000
    TotalDevTime.... 00000248  DeferTime...... 00000000
    CUQueueTime..... 00000000  DevBusyTime..... 00000000
    DevActOnlyTime.. 00000000
    Sense Data...... 00000000  00000000  00000000  00000000
                     00000000  00000000  00000000  00000000

  TCA Header at 00000000_7E28C720
    Format.......... 7F        TCALen......... 54
    Serv Act Code... F901      Priority....... 00

  DCW at 00000000_7E28C730
    Command.. EA  Flags.. 00  CD Count.. 40  Count.. 00001020

  DCW Control Data at 00000000_7E28C738
    01800000 00000000 00000000 40C01020 00000046 01210001 01210001 00000000 | ............ {............
    00000000 2000000C 00000000 0CE8A601 01210001 01210001 09001020 00000000 | ............Yw..........
```

Read/Write indicator – low order two bits (Read=B'10', Write=B'01')

Residual count – should be zero if successful completion

Size	Flags and Fmt	Last DCW offset
DCW residual byte count of last DCW executed		
Reserved		
Device time		
Defer time (Device disconnect time)		
Queue time		
Device busy time		
Device active only time		
Sense Data (0 to 8 words)		

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zHPF GTF CCW trace (I/O interrupt) cont'd

First input buffer TIDAW (4K buffer)

Amount of data formatted controlled by GTF CCW parameter

Second input buffer TIDAW (32 byte suffix)

```
Data TIDAW at 00000000_7E28C6D0
  Flags... 00  Count... 00001000  Addr... 00000001  52652000

Data at 00000001_52652000
  10000000 00000000 0000147C 00000000 00000000 002E4810 00570194 0DBC0000 | ..........@..............m..
  *** Back half of split data ***
  024A0222 01FF01E1 01C801B4 01A5015F 011E00E7 00BA0092 006F0051 003800D5 | .¢.......H...v.^...X...k.?....

Data TIDAW at 00000000_7E28C6E0
  Flags... 80  Count... 00000020  Addr... 00000000  7E28C798

Data at 00000000_7E28C798
  10000000 00000000 00141000 00000000 00000000 00000000 00000000 005A5AA5 | ..............................!

TCA Trailer at 00000000_7E28C778
  Transport Count... 00001024

IOSB at 02CCD0F0
  FLA..... C0        FLB..... 00        FLC..... 40        PROC..... 00        DVRID.... 03       ...
  ASID..... 015A     PGAD..... 8131D950 PKEY..... 05       COD..... 7F         OPT..... 14        ...
  UCB..... 02417CE8  CCWAD.... 00000000 DSTAT.... 00       SSTAT.... 00        CSWRC.... 0000     ...
  USE..... 02CCD020  IOPID.... 00000000 SCHC..... 0000     SNS..... 0000       IPIB..... 00000000 ...
  ERP..... 00000000  PCI..... 00000000 NRM..... 8131B6F0 ABN..... 81445F38  DIE..... 81317E48 ...
  VST..... 02CCD700  DSID..... 7B5D3C00 LEVEL.... 01       GPMSK.... 00        DCTI..... 0000     ...
  CKEY..... 00       MDB..... 00        MDM..... 00       CTC..... 00000000   SKM..... 00        ...
  SKCC..... 0011     SKH1..... 00       SKH2..... 03      SKR..... 00         XID..... IOSB      ...
  XFLG1.... 00       XFLG2.... 00       XSSXA.... 00000000 XIOBE.... 02CCD820  XRCOD.... 00       ...
  XASPR.... 015F     XFLG3.... C4       XIOD..... 02CCD18C XMSC..... 00000000  00000000           ...
  XRSVF.... 00000000 00000000

IOBE at 02CCD820
  ID..... IOBE       VERS..... 01       FLG1..... 00      FLG2..... 00        ERPM..... 00       ...
  IEDB..... 00000000 FLG3..... 00       SIOC..... 00      TIME..... 00        RESCOUNT. 00000000 ...
  DDPC_RC.. 00       DDPC_RCQ. 00
```

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System z10

Questions ?

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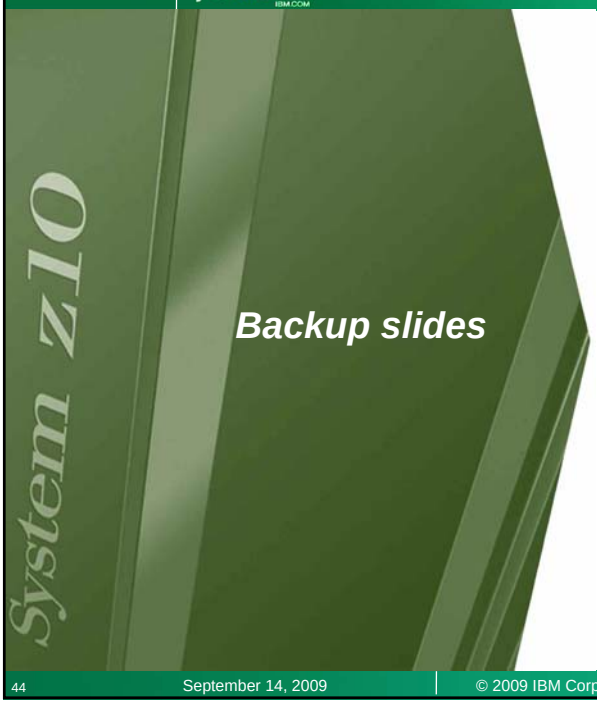

Backup slides

System z FICON Enhancements over time

- **FICON Link Incident Reporting**
  - Designed to allow an OS image (without operator intervention) to register for any link incident reports This improves the ability to capture data for link incident analysis
  - z/OS will display this information on consoles and will also save in the system log and in LOGREC
  - Introduced with the z9 EC and requires z/OS 1.7 or higher
- **FICON open exchanges increased from 32 to 64**
  - The number of open exchanges was increased from 32 to 64 to improve the FICON throughput and to align with the longer FICON paths
- **Channel Link Recovery Thresholding (Flapping Links)**
  - A channel subsystem function designed to threshold link failure events when repeated failures that are subsequently recovered do not disrupt customer's workload
  - Requires z/OS 1.4.1 plus PTFs or later
- **RNID (Remote Note IDentifier)**
  - Enables the CU node id's on the downstream side of switches to be displayed at the SE and at the operating systems console using the D M=DEV command
  - Requires z/OS 1.4.1 plus PTFs or later.
- **MIDAW (Modified InDirect Adress Word)**
  - The Modified Indirect Data Address Word (MIDAW) facility is a system architecture and software exploitation designed to improve FICON performance
  - Designed to reduce channel, director and control unit overhead by reducing the number of CCW's and frames that have to be processed

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Other z10 FICON/FCP Enhancements

- **CTC Logical Paths**
  - CTC now "remembers" logical path information
  - Saved locally in the channel when it changes
  - Restored after a CCC
  - Eliminates lost logical path headaches after a CCC
- **RMF enhancements**
  - Channel now provides information about the number of exchanges in use and the number of SSCHs that could not be executed due to an "out of resource" condition
- **Engine utilization changes**
  - Out of resource now shows up as engine busy
  - Helps make SAD more accurate with respect to RMF and SAP
- **Name Server registration**
  - FICON will register with the Switch "Name Server"
  - The FICON channel now provides the same information to the fabric as is commonly provided by open systems, registering with the "Name Server" in the attached FICON directors
    - Enables quick and efficient management of storage area network (SAN) and perform problem determination and analysis
  - Platform registration is a standard service defined in the Fibre Channel - Generic Services 3 (FC-GS-3) standard (INCITS (ANSI) T11.3 group)
    - It allows a platform (storage subsystem, host, etc.) to register information about itself with the fabric (directors)
    - Applicable to all FICON Express4, FICON Express2, and FICON Express features - CHPID type FC

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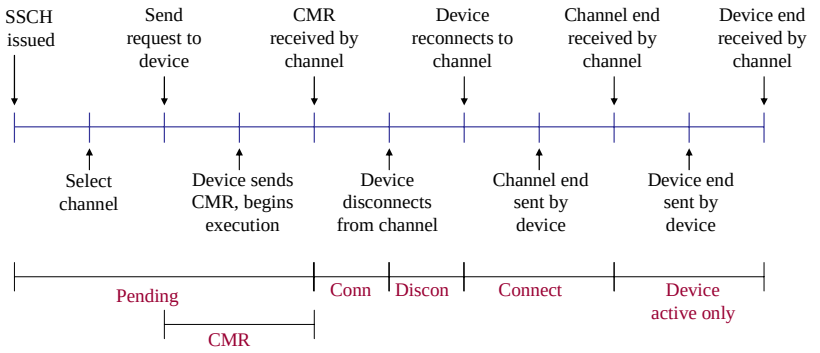
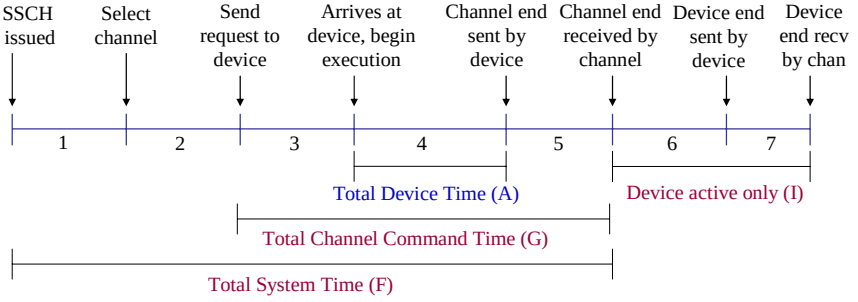
Channel Measurements



- All times shown above measured by channel
- Device may accumulate CU queuing and defer time during connect time
- CSS subtracts defer time from connect, adds to disconnect
- Operating system subtracts CU queuing time from connect, adds to pending
- Device busy (not shown) is also measured by channel when CU returns device busy to the initial selection sequence. It is part of pending time.

Channel Measurements cont'd



- CU will now collect 5 times: total device (A), CU defer (B), CU queuing (C), device busy (D), device active only (E). The last 4 times are a subset of the total device time.
- Connect = A – B – D – E (total device minus all CU times except CU queuing); time slot 4
- Pending = F – A (that portion of total system time that is not connect time); time slots 1, 2, 3, 5
- Disconnect = B (CU defer time)
- Device active only = E or I (time slots 6, 7)
- Device busy = D + what ever device busy was accumulated by the channel
- Initial command response = G – A (portion of channel time to traverse the link – both ways); time slots 3, 5