High Performance Ficon Demystified

Session 8759

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Agenda

What does zHPF Do For Me?

How Does zHPF Do It?

The Effect On Exchanges

Other Improvements
More Than 2X Ficon I/Os per Second

FICON performance on System z – start I/Os
Response Time Improves Too

zHPF vs FICON READ 4k bytes/io

Single FICON Express8 Channel: zHPF vs FICON
Read 4k bytes per IO
total IO response time vs channel IO/sec

response time (ms)

single channel io/sec

FEx8 zHPF
FEx8 FICON
How does zHPF do it?
How does zHPF do it?

- Significantly reduced Channel and CU overhead
How does zHPF do it?

- Significantly reduced Channel and CU overhead
- Takes advantage of hardware assists in Fibre Channel interface chips
- Rides on top of an existing standard protocol called….
F. C. P.
FCP ???

- Does zHPF convert my I/O to SCSI ???????
  NO!

- FCP is a generic method to transfer commands, data, and status

- FCP ≠ SCSI
  - It is true however, that SCSI is the single largest user of FCP
Why FCP?

• Many HBA vendors have optimized firmware and hardware to accelerate FCP I/O

• FCP protocol has less ‘Chit Chat’
### Read Comparison Summary (5 4K Reads)

<table>
<thead>
<tr>
<th></th>
<th>Channel to CU in Ficon Mode</th>
<th>CU to Channel in Ficon Mode</th>
<th>Total</th>
<th>Channel To CU in zHPF Mode</th>
<th>CU to Channel in zHPF Mode</th>
<th>Total</th>
<th>% Reduction in zHPF Mode¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchanges</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>Sequences</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>75</td>
</tr>
<tr>
<td>Frames</td>
<td>6</td>
<td>14</td>
<td>20</td>
<td>1</td>
<td>10</td>
<td>11</td>
<td>45</td>
</tr>
<tr>
<td>CRC Gen / Check</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>80</td>
</tr>
</tbody>
</table>

¹Except for exchanges, as the number of reads in a single I/O increase, the % reduction in Transport Mode increases
Let’s look under the hood
NO I/O Definition changes

- zHPF coexists with Ficon
- Channel is STILL type=FC
- NO IOCDS changes for zHPF capable control units
Initialization Changes

Switch

BLACK = Unchanged from Ficon

RED = Changed from Ficon

GREEN = NEW in zHPF

FLOGI

PLOGI (Fabric Ctrlr)

QSA

SCR

RNID

PLOGI (Mgmt Srvr)

RNID

PLOGI

LIRR

PRLI

NEW bit indicates support for PRLI

Exchanges zHPF capabilities

Accept

Responses not shown unless new/changed
Totally New I/O Structures

• CCWs no longer exist in zHPF (They live on happily in Ficon)
  • Replaced by Device Control Words (DCWs)

• IDAWs no longer exist in zHPF (They too are alive and well in Ficon)
  • Replaced by Transport Indirect Data Address Words (TIDAW)

• New structures added
  • Transport Control Word (TCW)
  • Transport Status Block (TSB)
  • Transport Command & Control Block (TCCB)
Command Mode Review
Command Mode Review

ORB

CCW
Command Mode Review

ORB -> CCW -> IDAW / MIDAW
Command Mode Review

ORB

CCW

IDAW / MIDAW

Data
Command Mode Review

ORB

CCW

IDAW / MIDAW

Data

Data

CCW

IDAW / MIDAW
Command Mode Review
Transport Mode
Transport Mode

ORB → TCW
Transport Mode

ORB -> TCW

Data -> TIDAW
Data -> TIDAW
Data -> TIDAW
Data -> TIDAW
Transport Mode

ORB → TCW

Data → TIDAW → TIDAW → TIDAW

Addressing & Control Information
- Device Command Word
- Device Command Word
- Device Command Word
- Device Command Word
- Device Command Word
- Checking Block
- Count

TCCB
Transport Command & Control Block
Transport Mode

- ORB
- TCW
- TSB (Transport Status Block)
- TIDAW
- Data
- Device Command Word
- Device Command Word
- Device Command Word
- Device Command Word
- Device Command Word
- Checking Block
- Count
- TCCB (Transport Command & Control Block)
Link View of 4 Reads in Command Mode

Prefix Cmd + 64 bytes
Read (4k)
Read (4k)
Read (4k)
Read (4k)

Cmd Resp
Data (4k) + CRC
Data (4k) + CRC
Data (4k) + CRC
Data (4k) + CRC
Status

Status Accept

<table>
<thead>
<tr>
<th></th>
<th>Channel to Control Unit</th>
<th>Control Unit to Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Commands</td>
<td>5</td>
<td>N/A</td>
</tr>
<tr>
<td>Exchanges</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sequences</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Frames</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>CRC Generate / Check</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>
Link View of 4 Reads in Transport (zHPF) Mode

Prefix + 64 bytes of prefix data +
Read (4k) + Read (4k) + Read (4k) +
Read (4k) → Data (16k) + CRC

Status

<table>
<thead>
<tr>
<th></th>
<th>Channel to Control Unit</th>
<th>Control Unit to Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Commands</td>
<td>5</td>
<td>N/A</td>
</tr>
<tr>
<td>Exchanges</td>
<td>1</td>
<td>1 (same one)</td>
</tr>
<tr>
<td>Sequences</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Frames</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>CRC Generate / Check</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Device Control Word (DCW)

<table>
<thead>
<tr>
<th>Command</th>
<th>Control Flags</th>
<th>Reserved</th>
<th>CD Count</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DCW Data Count
Device Control Word (DCW)

• Control Flags
  • CC (Chain Command)
    • Another command follows. If the command completes “normally” the next command is to be executed

• CD Count
  • Number of bytes that follow the DCW that contain Control Data for the DCW

• Data Count
  • Number of bytes of data to be transferred in the data phase for this DCW not including any Pad and CRC
ORB

<table>
<thead>
<tr>
<th>Word</th>
<th>Interruption Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Key: 0000000000</td>
</tr>
<tr>
<td>2</td>
<td>Channel-Program Address</td>
</tr>
<tr>
<td>3</td>
<td>CSS Priority</td>
</tr>
<tr>
<td>4</td>
<td>Reserved</td>
</tr>
<tr>
<td>5</td>
<td>Reserved</td>
</tr>
<tr>
<td>6</td>
<td>Reserved</td>
</tr>
<tr>
<td>7</td>
<td>Reserved</td>
</tr>
</tbody>
</table>

Specifies Transport (zHPF) Mode
TCW (Transport Control Word)

<table>
<thead>
<tr>
<th>Word</th>
<th>Flags</th>
<th>TCCBL</th>
<th>RW</th>
<th>Reserved</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>F</td>
<td>000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>Reserved</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Output-Data Address</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Input-Data Address</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Transport-Status-Block Address</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Transport-Command-Control Block Address</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Output Count</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Input Count</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td>Reserved</td>
</tr>
<tr>
<td>15</td>
<td>Interrogate-TCW Address</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Agenda

What does zHPF Do For Me?

How Does zHPF Do It?

The Effect On Exchanges

Other Improvements
How does zHPF affect EXCHANGES?

• Little’s Law states:
  • The number of “things” in a system can be determined by multiplying the average arrival rate of those “things” by the average time each “thing” stays in the system.
How does zHPF affect EXCHANGES?

• Little’s Law states:
  • The number of “things” in a system can be determined by multiplying the average arrival rate of those “things” by the average time each “thing” stays in the system.

• Applied to zHPF:
  • The average number of Exchanges active at any given time = Average I/O rate * Average response time

  • Example: 30000 Ficon I/Os / Second on a given channel with .3ms service time\(^1\) uses 9 Active Exchanges at any given time

\(^1\) The amount of time the I/O is active in the channel
How does zHPF affect EXCHANGES?

- The CU holds on to the Exchange even if the device:
  - Is reserved
  - Detects an Extent Conflict
  - Cache Miss
  - etc
- Drives requirement for higher number of possible open Exchanges

Example:
At 50,000 I/Os per Second, if 20% hit one of the above and if each of those conditions lasts for 10ms, then:

100 Exchanges are needed for Busies
20 Exchanges are needed for the rest
How does zHPF affect EXCHANGES?

- CU can dynamically adjust the number of open Exchanges any one channel can open to THAT CU

- Channel maintains a Exchange count and Exchange Limit for each PHYSICAL control unit
## New RMF Fields for zHPF

<table>
<thead>
<tr>
<th>CHANNEL PATH</th>
<th>UTILIZATION(%)</th>
<th>READ(MB/SEC)</th>
<th>WRITE(MB/SEC)</th>
<th>FICON OPERATIONS</th>
<th>ZHPF OPERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ID TYPE</td>
<td>G SHR</td>
<td>PART TOTAL</td>
<td>BUS</td>
<td>PART TOTAL</td>
</tr>
<tr>
<td></td>
<td>00 FC_S</td>
<td>5 Y</td>
<td>100.00</td>
<td>100.00</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>01 FC_S</td>
<td>5 Y</td>
<td>100.00</td>
<td>100.00</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>02 FC_S</td>
<td>4 Y</td>
<td>0.13</td>
<td>2.30</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>03 FC_S</td>
<td>4 Y</td>
<td>0.13</td>
<td>2.27</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>04 FC_S</td>
<td>5 Y</td>
<td>0.13</td>
<td>2.24</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>05 FC_S</td>
<td>5 Y</td>
<td>0.13</td>
<td>2.25</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>06 FC_S</td>
<td>4 Y</td>
<td>0.12</td>
<td>2.23</td>
<td>0.83</td>
</tr>
</tbody>
</table>
Where is zHPF exploited?

- All Supported Releases of z/OS
  - Media Manager Data Sets
    - DB2
    - VSAM
    - Extended Format Sequential Data Sets
  - PDSEs
  - Others
What Do I Need to Exploit zHPF?

- Z10 at Driver 76 or higher
  - Power On Reset is REQUIRED to activate zHPF
- z196
- Ficon Express-2 or above
- Control Unit that supports zHPF
  - Check with your vendor for appropriate code and/or hardware levels
- All supported releases of z/OS
  - zHPF mode has to be enabled (set ios command)
Agenda

- What does zHPF Do For Me?
- How Does zHPF Do It?
- The Effect On Exchanges
- Other Improvements
MIH

- Reduced False Missing Interrupt
  - Avoids “Go to the end of the line” penalty for MIH due to reserves
- HPF allows the OS to interrogate the state of an existing I/O operation
Transport Mode

ORB ➔ TCW ➔ Interrogate TCW

Data ➔ TIDAW ➔ TIDAW ➔ TIDAW ➔ TIDAW

Addressing & Control Information
- Device Command Word
- Device Command Word
- Device Command Word
- Device Command Word
- Device Command Word
- Device Command Word
- Checking Block
- Count

TSB (Transport Status Block)

TIDAW ➔ TCCB ➔ TSB

Data

TCCB
Transport Command & Control Block
Temporary Logout

- CU firmware updates can be “cleaner” with zHPF support

- zHPF introduces a “temporary logout” concept
  - CU tells channel that it is ‘going away’
I'm going to go away for 3 seconds

PRLO
Process Logout
Hmmm, I better stop sending him new work.

PRLO
Process Logout

I'm going to go away for 3 seconds.
Hmmm, I better stop sending him new work.

Ok, all existing work has completed. I'm ready.

I'm going to go away for 3 seconds.

PRLO Process Logout
I’m going to go away for 3 seconds

Hmmm, I better stop sending him new work

Ok, All existing work has completed. I’m ready

I’m going to go away for 3 seconds

3 Seconds later

PRLO Process Logout
Hmmm, I better stop sending him new work.

Ok, all existing work has completed. I'm ready.

Time's up. Let's get going.

I'm going to go away for 3 seconds.

3 Seconds later.

PRLI Process Login

PRLO Process Logout

PRLO Accept
• Any Additional Questions?
Thank You For Your Time And Attention

Feel free to e-mail me with any zHPF or Ficon questions