Tales from the sweet shop

VSI OpenVMS 8.4-1H1 and hp i4 @ Deutsche Boerse

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Agenda

• Group Deutsche Boerse

• Targets

• System Setup and Changes for 8.4-1H1

• Performance Observations

• Conclusion
Group Deutsche Boerse
## Historical overview 1585–2014

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1585</td>
<td>Beginning of organised exchange trading in Frankfurt/Main</td>
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<tr>
<td>1992</td>
<td>Deutsche Börse AG is established</td>
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<tr>
<td>1993</td>
<td>Deutsche Börse AG begins to operate Frankfurter Wertpapierbörse (FWB®, the Frankfurt Stock Exchange)</td>
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<tr>
<td>1997</td>
<td>Launch of the electronic Xetra® trading platform</td>
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<tr>
<td>1998</td>
<td>The Eurex derivatives exchange is established on the basis of a merger of DTB Deutsche Terminbörse and Swiss Soffex</td>
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<tr>
<td>2001</td>
<td>IPO of Deutsche Börse AG</td>
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<tr>
<td>2002</td>
<td>Full integration of Clearstream International; Deutsche Börse AG shares included in the DAX® index</td>
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<tr>
<td>2007</td>
<td>Founding of an exchange for structured products: Börse Frankfurt Zertifikate AG; Eurex acquires the US options exchange International Securities Exchange Holdings, Inc. (ISE)</td>
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<tr>
<td>2011</td>
<td>Migration of the floor trading to Xetra® technology</td>
</tr>
<tr>
<td>2012</td>
<td>Full acquisition of the Eurex derivatives exchange</td>
</tr>
<tr>
<td>2013</td>
<td>Launch of 7 Market Technology family</td>
</tr>
<tr>
<td>2014</td>
<td>Increase of the interest held in the European Energy Exchange (EEX);</td>
</tr>
</tbody>
</table>
Deutsche Börse Group: exchange organisation and provider of financial services infrastructure with comprehensive product range

<table>
<thead>
<tr>
<th>Cash / Derivatives market</th>
<th>Clearing</th>
<th>Post-trading</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Listing</td>
<td>▪ Verification of trade-related information</td>
<td>▪ Delivery of securities</td>
</tr>
<tr>
<td>▪ Connectivity to international trading participants</td>
<td>▪ Central counterparty</td>
<td>▪ (in exchange for payment)</td>
</tr>
<tr>
<td>▪ Operation of open electronic order books</td>
<td>▪ Risk management</td>
<td>▪ Financing services</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Collateral management</td>
</tr>
</tbody>
</table>

- Trading
- Clearing
- Settlement
- Custody

Market data and technology-based services
Data feeds, market data, news services, reference data, reporting services, indices, external IT services, connectivity services, trading infrastructure

Information technology
Internal IT services, software development

www.eurexchange.com
Easy and efficient access:
Xetra® – international participant network

211 participants:
- 105 participants in Germany
- 106 participants in other countries

Source: www.xetra.com > Trading > Trading participants, as at 30 June 2015
Exchanges and trading venues all over the world use Deutsche Börse Group technology.

1) Worldwide, more than 30 markets are currently operated using Deutsche Börse Group technology.
Deutsche Börse IT provides powerful applications that successfully support the Groups Services along the process chain.
2

Targets
Targets

What are the (non-functional) goals of an exchange trading system?

- **100% Availability**
  - ... during trading hours (i.e. there is still a time window for maintenance)

- Quick recovery of the system in case of medium/large disaster

- Fair and level playing field for all market participants

- Predictable system behaviour for market participants (esp. in case of problems)

- Elastic reaction to quickly increasing load (ms time scale)

- Low latency for order/quote transactions (magnitude $10^2$ us)
Targets

Which distribution is preferred by customers?
3

System setup
Simplified schematic Data flow

TCP

GW
GW
GW
GW
GW

UDP

Host

Router

Matching

Matching

Matching

Market Data

Mailbox

Mailbox

Stream A

Stream B

www.eurexchange.com
Required SW changes

• Started conformance testing with field test version of 8.4-1H1

• This identified itself as “E8.4-1H1”

• “Serious problems” with the following DCL construct

  $ IF F$GETSYI("VERSION") .LTS. "V5.5"

• Solution: Remove code path keeping compatibility to VAX/VMS 5.4 and earlier
• No further code changes and/or recompiles required
Performance Observations
Performance observation - “Free” orders

- Expectation: CPU frequency scaling: i4/i2 = 2.53 GHz/1.73 GHz $\rightarrow$ 46%
- Observation:
  - Optimized products: 150 us / 225 us $\rightarrow$ 33%
  - Standard products: 275 us / 400 us $\rightarrow$ 31%
  - Standard products + Broadcast 275 us / 550 us $\rightarrow$ 50%

![Average non-queued Order Host processing time graph]
Performance observation - “Busy” products

- ETF products: Lots of price updates (driven by index(future))
- Data shown here does include queuing effects
- Observation: 575 us / 1250 us → 54%

![Average Host RTT Xetra ETF orders graph](chart.png)
Performance observation - Outliers

- Outliers are a problem for market participants
- Measurement of extremely long order transactions for stocks in the DAX index
- Percentage decreased by more than a factor of two with the move to i4
# Process Layout

### BL870c i4

<table>
<thead>
<tr>
<th>Socket 0</th>
<th>CPU</th>
<th>0</th>
<th>NETACP DECW</th>
<th>1</th>
<th>ME1_R</th>
<th>2</th>
<th>FP:EW,PE</th>
<th>3</th>
<th>FP:BG</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>FP:FG</th>
<th>7</th>
<th>FP:PK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socket 1</td>
<td>CPU</td>
<td>0</td>
<td>FP: PK</td>
<td>1</td>
<td>FP:EW</td>
<td>2</td>
<td>FP:EW</td>
<td>3</td>
<td>FP:EW</td>
<td>4</td>
<td>FP:EW Router</td>
<td>5</td>
<td>FP:EW MD</td>
<td>6</td>
<td>FP:EW</td>
</tr>
<tr>
<td>Socket 2</td>
<td>CPU</td>
<td>0</td>
<td>FP:EW</td>
<td>1</td>
<td>FP:EW</td>
<td>2</td>
<td>FP:EW</td>
<td>3</td>
<td>FP:EW</td>
<td>4</td>
<td>FP:EW</td>
<td>5</td>
<td>FP:EW</td>
<td>6</td>
<td>FP:EW</td>
</tr>
<tr>
<td>Socket 3</td>
<td>CPU</td>
<td>0</td>
<td>ME2_R</td>
<td>1</td>
<td>ME2_P</td>
<td>2</td>
<td>ME3_R</td>
<td>3</td>
<td>ME3_P</td>
<td>4</td>
<td>ME4_R</td>
<td>5</td>
<td>ME4_P</td>
<td>6</td>
<td>ME5_R</td>
</tr>
</tbody>
</table>
Performance observation – IP Congestion

- Attempt to load servers with more optimized products
- Inbound path (TCP) somewhat affected, but still ok
- Outbound path (2 x UDP) considerably degraded, back to i2 level
- Looking forward to 8.4-2 and VSI TCP/IP!
5

Conclusion
Conclusion

• The move to Poulson/i4 was very smooth from a SW point of view
• Overall performance gain as one would expect from a simple scaling of CPU frequencies, about 30-40% just by HW upgrade
• For our application
  - extremely bursty transaction rate
  - lots of IP network IO (both TCP and UDP)

  Room for improvement, to utilize full number of cores

• Boot Camp: VSI is working on this, looking forward to 2016