Going to the wire:
The next generation financial risk management platform

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CME Group

CME Group is the world’s leading and most diverse derivatives marketplace – handling 3 billion contracts worth approximately $1 quadrillion annually, on average. We bring buyers and sellers together through our CME Globex electronic trading platform and our trading facilities in Chicago and New York.

Global Products

CME Group exchanges offer the widest range of global benchmark products across all major asset classes, including futures and options based on interest rates, equity indexes, foreign exchange, energy, agriculture commodities, metals, weather and real estate.

Clearing

CME Group operates CME Clearing, one of the world’s leading central counterparty clearing providers. We are the guarantor of every transaction that happens in our markets, providing unparalleled safety and soundness for our customers.

Electronic Trading

Through our CME Globex electronic trading platform, users worldwide are able to access the broadest array of the most liquid financial derivatives markets available anywhere. In addition, CME Globex offers speed of execution, transparency anonymity and market integrity. This makes up around 80% of all trades at CME.
Forging Partnerships to Expand Distribution, Build 24-Hour Liquidity, and Add New Customers

Partnerships include:
- Equity investments
- Trade matching services
- Joint product development
- Order routing linkages
- Product licensing
- Joint marketing
- European clearing services

- Developing capabilities globally
- Expanding upon global benchmark products
- Positioned well within key strategic closed markets

- Applied to FSA for CME Europe Ltd. – expected launch mid-2013
- Just renewed MOU with Shanghai Futures Exchange (SHFE)
- Bank of China, New York Branch becoming a CME Clearing settlement bank and collateral custodian, subject to regulatory approval
- Launched U.S. Dollar denominated IBovespa futures contract
Most Attractive, Valuable and Diverse Franchise in the Exchange Sector

Vertically integrated clearing, risk management expertise

Balanced portfolio of diverse, benchmark products

Industry-leading trading platform, flexible architecture

Combination of unique assets provides ability to retain competitive advantages and to be strongly positioned for longer-term growth

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CME Group Evolution

- First mover, strong vision, consistently reinventing as markets evolve
- Well positioned for future opportunities through successful strategic execution

1980s
- Innovation / Electronification / Demutualization...
- 0% electronic
- Chicago-based open outcry trading floor
- Mutual Offset System w/SGX
- Anticipating electronification

1990s
- 8% electronic
- Launch of CME Globex trading platform
- Product innovation – i.e. E-mini S&P 500 contract
- Less than 5 employees outside of U.S.

2000s
- 80% electronic
- Diversifying product and venue
- CME first U.S. exchange to go public
- CBOT demutualizes / goes public
- CME / CBOT merge
- CME Group acquires NYMEX
- CME Group partners w/BM&FBOVESPA

2010s
- Highest 88% electronic
- Averaging 6% privately negotiated/OTC
- OTC clearing capability growth / offering expansion beyond energy base
- Numerous global partnerships / building out global offices
- Diversify beyond futures transaction-related sources of revenue
  - CME Group / Dow Jones / McGraw Hill partner on index services business
  - Launch Co-Location Services

Average Daily Volume* (contracts in millions)
- 0.8M contracts
- 1.8M contracts
- 7.3M contracts
- 12.3M contracts
An Era of Convergence across Multiple Industries Enabled by Technology

* Devices + Mobility → Single Mobile Device

- Telephone, Video, Television, Movies, Music, Books, ...
- Internet → Digital Streaming Media

* Infrastructure, Software, ...
- Internet → Cloud Computing

<table>
<thead>
<tr>
<th>Component</th>
<th>+ Market Controls</th>
<th>Enhanced Pre-Trade Risk Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trading Order Entry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>+ Hardware</th>
<th>High Performance Computing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>+ Central Counterparty Clearing</th>
<th>Enhanced Post-Trade Risk Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>OTC and Portfolio Margining</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Next Generation Risk Management Enables the Future of Financial Industry Convergence

CME Group is uniquely positioned as a global leader in the derivatives marketplace to lead the next generation of risk management in support of enhanced market controls and the global mandates for central clearing.

- High-resolution mark to market processes
- Real-time, event-driven monitoring
- Complex computational modeling
- Risk management controls (Credit Controls)
- Increasing growth and frequency of financial market data
- Reduced total cost of ownership (TCO)
How To Handle The Growing Data Trend…
FPGA Dataflow Engines (DFEs) Enable the Next Generation of Financial Risk Management

Maxeler’s MaxCompiler facilitates the convergence of hardware and software without the traditional tradeoffs for Advanced Risk Management

<table>
<thead>
<tr>
<th>Area</th>
<th>Software</th>
<th>Hardware</th>
<th>MaxCompiler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenges</td>
<td>Interrupts Resource Starvation</td>
<td>Code complexity Skillset availability</td>
<td>Streaming</td>
</tr>
<tr>
<td>Architecture</td>
<td>Something</td>
<td>Block</td>
<td>Manager / Kernel Diagrams</td>
</tr>
<tr>
<td>Design</td>
<td>[Insert Your Best Practice]</td>
<td>RTL Diagrams w/ Flow Control</td>
<td>MaxJ/Java</td>
</tr>
<tr>
<td>Code Entry</td>
<td>Java</td>
<td>VHDL/Verilog</td>
<td>Kernel Tests</td>
</tr>
<tr>
<td>Unit Tests</td>
<td>JUnit</td>
<td>Simulation Test Vectors</td>
<td>Simulated DFE and MaxDebug</td>
</tr>
<tr>
<td>Design Debugging</td>
<td>Java Debug</td>
<td>Simulation Design Test</td>
<td>DFE + MaxDebug</td>
</tr>
<tr>
<td>Test / QA</td>
<td>Java</td>
<td>Hardware</td>
<td>Binary</td>
</tr>
</tbody>
</table>

- Allows existing software & support teams to program in hardware
- Supports agile, pure software SDLC
- Increases productivity and cost efficiency
The Multiscale Dataflow Computer

decoupling the data plane and control plane

Multiscale Dataflow Computing Platforms

- Risk Analytics Software Platform
- Seismic Imaging Software Platform
- Trading Transactions Software Platform
... 

Three Software Layers

MaxIDE
MaxCompiler
MatLab, Python, R, Excel, C/C++, Fortran

Linux based MaxelerOS: Realtime communication management

Controlflow Box: conventional CPUs

Fast Interconnect

Dataflow Box: Custom Intelligent Memory System
Software Layer for Programming Dataflow Boxes

- Multiscale hardware design, as simple as writing software
- MaxCompiler is a Dataflow Engine design library which is powered by Java
- It comes with a fully integrated Development Environment based on Eclipse called MaxIDE
- MaxSkins enable runtime integration with almost any language!
Computing with Multiscale Dataflow Engines (DFEs)

Multiscale Dataflow Computing enables the optimization of Compute intensive applications on the bit level, the architecture level, the memory system level, and the networking level, and the storage level.
Risk Analytics Platform

- Combine Trading and Risk in a unified platform
- Moving risk computations from local overnight to corporation global in real-time, moving traders from looking back to looking forward.

Wall Street Journal, Maxeler Makes Waves With Dataflow Design, American Finance Technology Award, New York, Dec 2011
Risk Analytics Platform Architecture

• Maxeler’s finance appliance accepts client input data and generates required risk management data at any and all requested levels of aggregation.
• Scenario analysis can be either permutative, combinatorial, ad-hoc or Monte Carlo.
• The finance appliance is fully scalable to client requirements.

Maxeler’s finance library provides accelerated analytics for valuation and risk management across all major asset classes.

Client generated risk management data is passed to client risk database for analysis.
Maxeler’s risk management system provides full functionality for users to specify and drive high-level business logic. Integration with existing client data, output and reporting is via a flexible interface layer.
DFE Programming Enables Real-Time Risk Management of Trading Strategies

Exchanges – CME, Eurex etc

TCP

FIX

UDP

FAST Decoding

Order-Book Building

Trading Strategy

Spot Market

Historical

Historical Markets

Market Scenarios

Bootstrap

Market Curves

Pricing Engine

Price Scenarios

Risk Analysis

Results Aggregation

Maxeler Finance Appliance functionality and information flow

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Maxeler Finance Appliance functionality and information flow
Financial Gateway Platform

- Maxeler provides Hardware, Software and Exchange/Trading interfaces, as well as financial data infrastructure
- Customers use MaxIDE and Java to write own risk management algorithms, security checks, credit checks that process at line rate
- Public customer: JP Morgan Equities Direct Market Access

- MaxCompiler enables unprecedented programmability of the dataplane.
- User Decision-Engine is fully programmable and executes in 3us
- All infrastructure (TCP/IP, feed-handlers, performance etc.) is managed by Maxeler, allowing the customer to focus on their business.
MaxCompiler

- Dataflow kernels using MaxCompiler powered by java

MaxJava Code

```
Output[“TTL”] <=
    Input[“TTL”] - 1;
```

Corresponding Dataflow graph
Dataflow Description

FrameData<SimpleInput> inputFrame =
  io.frameInput("input",
  simpleInputType, simpleLinkType);

DFEVar index = inputFrame["index"];  
DFEStruct routingData =
  mem.romMapped("routingTable",
    index, routingInfoType);

DFEVar outputPort =
  routingData.get("outputPort");
io.frameOutput("outA",
    outputPort === 'A') <==
  inputFrame;
io.frameOutput("outB",
    outputPort === 'B') <==
  inputFrame;
User defined I/O routing

DFELink cpuFrame =
addFramedStreamFromCPU("cpuFrame");

UDPStream sfp1 = addUDPStream("udp",
NetworkConnection.SFP1);

sfp1.getTransmitStream() <= cpuFrame;

EthernetStream sniff =
addEthernetStream("sniff",
NetworkConnection.SFP2);

addFramedStreamToCPU("sfp2") <=
sniff.getReceiveStream();
Mix and Match
From Graphs to Hardware

1. Design your kernels with MaxCompile
   - .maxj Files

2. Compile Using MaxCompile
   - MaxJava Compiler

3. A Java Executable is Generated
   - DFE Generator Executable

4. Running the Executable first Generates HDL
   - HDL Files

5. Then, It calls the Vendor tools
   - Vendor Tools

6. Final output is generated
   - .max File

* Fully Automated
From .max to Application

1. .max file generated previously

2. Convert it to a .o file

3. Compile application code

4. Link with MaxelerOS Libraries and .o File

5. Linker produces the final output

Executable Application

Standard Compiler (gcc)

Maxfile Compile

.o File

.c Application Source Files

MaxelerOS Libraries
Simulation

- Switching between the two flows is trivial

Target a Simulation model of the Hardware
- Cycle accurate model of Hardware
- Total Visibility
- Builds in a few minutes
- 1000x faster than other simulations
- Does not require hardware
- No Code changes compared to hardware
- Software engineering methodologies

Hardware Flow
- Incredibly Fast
- Just Works

Target Physical Hardware

File

- .max
- .maxj Files
Predictable and Consistent Processing

Measurement Details:
- Dual passive-optical fiber taps, 50/50 – 50um
- Timestamping card on RX and TX fibers
- 50B payload in standard TCP/IP packets
- Timestamps measured after last bit of frame received
- TCP, IP and Ethernet checksums calculated and checked
- Measurements valid up to line rate
Maxeler Hardware Solutions

**MPC C Series**
- CPUs plus DFEs
- Intel Xeon CPU cores and up to 6 DFEs with 288GB of RAM

**MPC X Series**
- DFEs shared over Infiniband
- Up to 8 DFEs with 768GB of RAM and dynamic allocation of DFEs to CPU servers

**MPC N Series**
- Low latency connectivity
- Intel Xeon CPUs and 1-2 DFEs with up to six 10Gbit Ethernet connections

**MaxWorkstation**
- Desktop development systems

**MaxCloud**
- On-demand scalable accelerated compute resource, hosted in London