

HPC in Financial Services

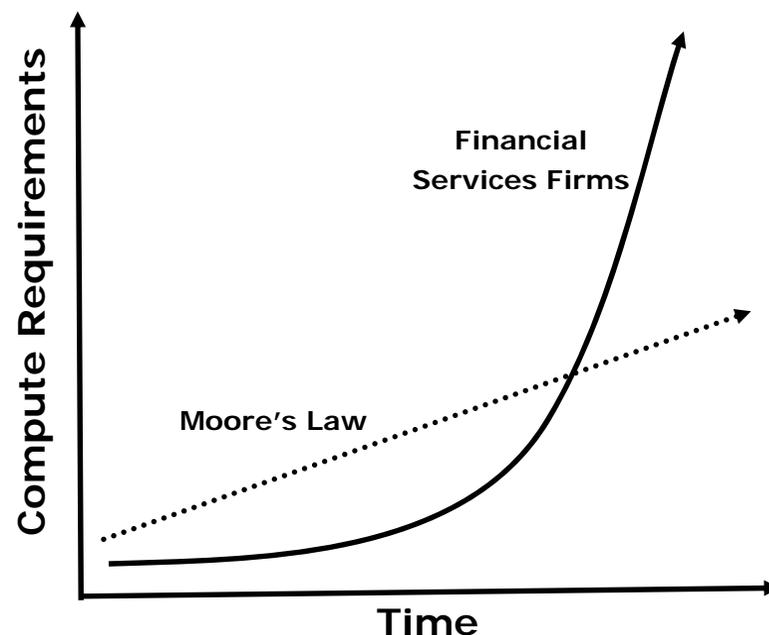
Michael Yoo



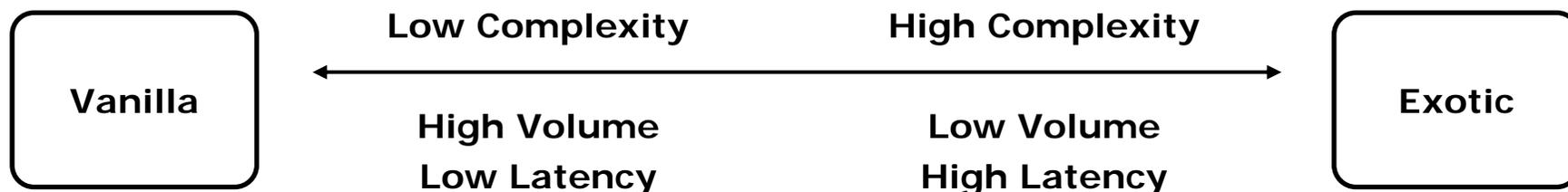
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Financial Services Compute Requirements

- ◆ The growth in compute requirements for Financial Services firms has been phenomenal in recent years
 - Obtaining the compute capacity to compete effectively is a new challenge now faced by investment banks
- ◆ There are three primary factors that have contributed to this:
 - Calculation Method, Volumes, and Complexity



- ◆ There are thousands of products that make up the Financial Services spectrum, and they vary widely in terms of compute requirements

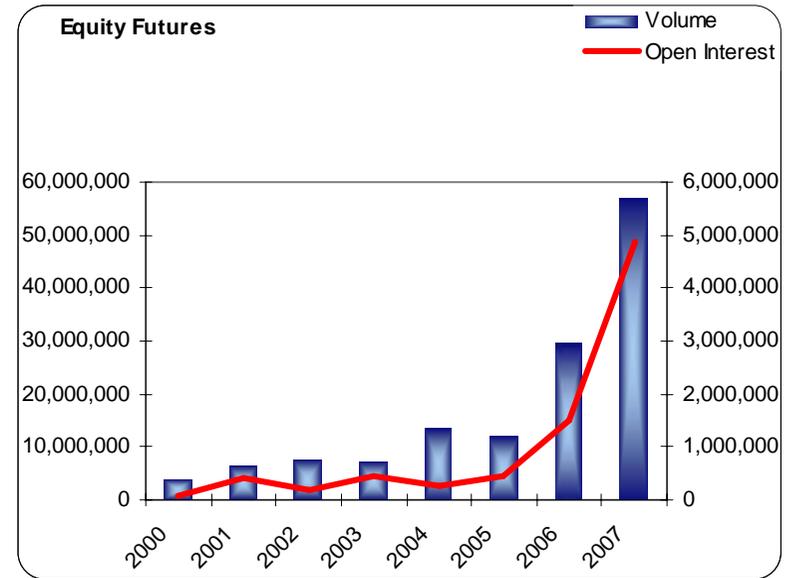


Monte Carlo Methods

- ◆ Two primary types of calculations are performed in the HPC area of our trading environment
 - Pricing of the instrument for quoting back to the market
 - Risk associated with the instrument for risk management or hedging
- ◆ Given the characteristics of these calculations, Monte Carlo methods are the only viable way to solve them
 - We use many optimized variants of Monte Carlo, but the calculation performance is still subject to the limits of this method
 - The key challenge we face is the relationship of accuracy to the number of paths (or runs): $\text{Accuracy} = \text{SQRT}(\#\text{Paths})$
- ◆ We always strive for greater accuracy, but there is a balancing act that needs to be managed
 - Greater accuracy equates to less risk which has a positive impact on our business
 - Greater accuracy equates to slower calculation times which has a negative impact on our business

Vanilla Product Volume

- ◆ For the products on the vanilla side of the spectrum, competition is based on volume and latency
 - Market volumes have been dramatically increasing due to implementations of algorithmic trading engines
 - Margins have been squeezed due to decimalization in the marketplace and an increasing amount of automated arbitrage trading

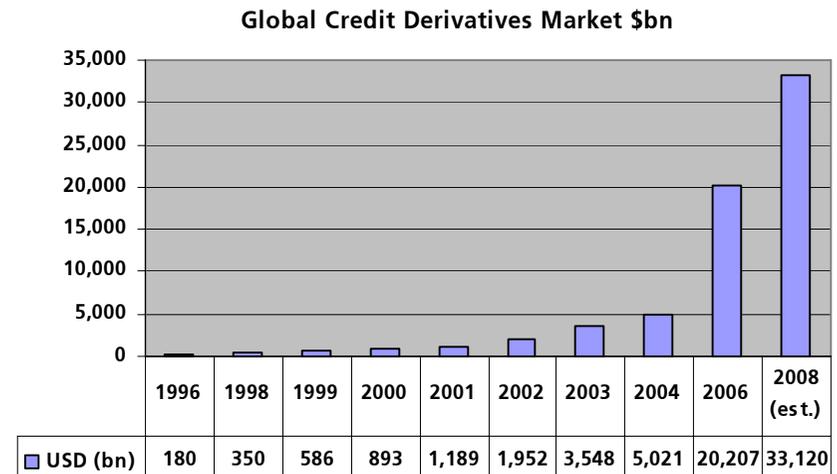


Source: Euronext Liffe Derivatives Market, 2000 to date

- ◆ The process consists of four main components
 - Receive the data from the markets, calculate the price, calculate the risk (hedge), and return the price to the market
- ◆ Target performance is typically in thousands of pricing and risk calculations per second with sub millisecond overall latency
 - Any improvements in our ability to price or risk calculate faster, or reduce latency, translate directly into revenue

Exotic Product Complexity

- ◆ The emergence of grid technology on Wall Street around 2000 acted as a catalyst for a new type of arms race to provide ever more complex products to the customer base
 - Grid technology and Monte Carlo methods were an ideal combination
- ◆ This has resulted in significant increases in both the complexity and the volumes of exotic products
 - Calculation capacity itself became a source of competitive advantage
 - Investment Banks continue to build out very large grids
 - Target volumes can be in tens of trades per day or less
- ◆ Customers continue to demand ever more complex products
 - There is a constant flow of new exotic products into the marketplace
- ◆ Last years exotics are this years commodities
 - Commoditization of exotic products has resulted in ever increasing volumes



Source: British Bankers Association

Key Requirements

- ◆ **Performance and Latency** – Continuous improvement is a must to survive, and significant improvements can result in competitive advantage
- ◆ **Accuracy** – Minimum levels must be met regardless of complexity, increased levels can have positive business benefits
- ◆ **Capacity** – The more the better, continuous increases required to maintain a position of leadership in the exotics marketplace
- ◆ **Resiliency** – The systems must continue to operate in the face of hardware failures, natural disasters, or other disruptive events
- ◆ **Time-to-Market** – New products are constantly being developed and need to be quickly implemented into production
- ◆ **Cost** – Do all of the above as cost-effective as possible
- ◆ The industry is at a crossroads
 - The complexity and volumes of products are both increasing exponentially
 - The calculation methods and technology scale linearly

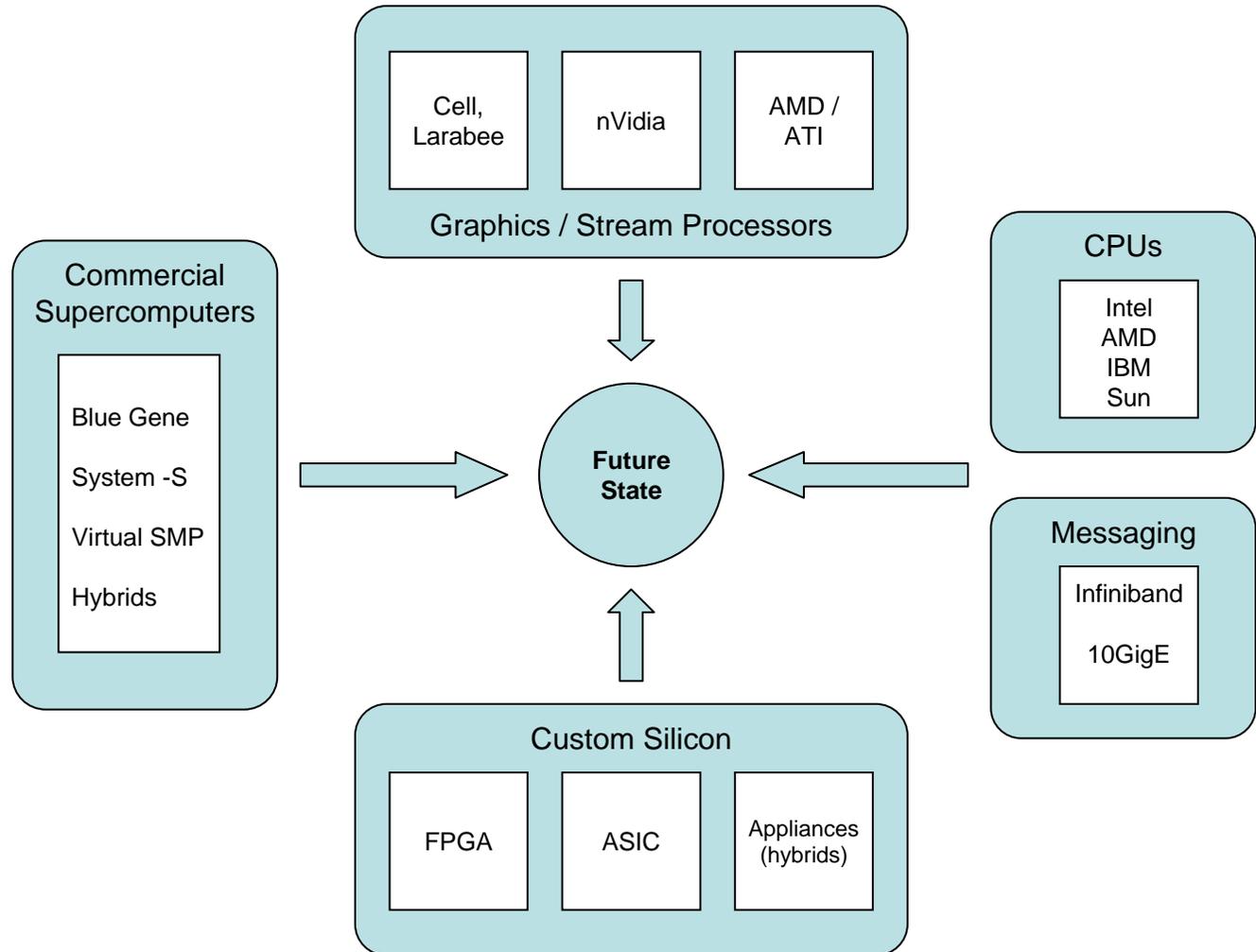
HPC Software Investigations

- ◆ Optimization of our existing software environment is a critical first step prior to implementation of any new hardware
- ◆ **Compilers** – Performance increases over general purpose compilers like GCC *Intel, The Portland Group*
- ◆ **Math Libraries** – Enable greater performance via use of x86 instruction extensions *MKL, ACML*
- ◆ **Parallel Programming** – When viable, parallelize code for multi-core *OpenMP, MPI, ASPEED*
- ◆ **Emerging Languages** – Several new languages hold promise for more efficient calculations *X10, Fortress, F#, Erlang, etc.*
- ◆ **XML** – Optimize software-based XML processing for market data *Intel*
- ◆ **Concurrent Caching** – Enable shared memory paradigm in our grid environments *Gigaspace, IBM Objectgrid*

HPC Hardware Investigations

- ◆ Hardware vendors have realized the challenges faced by the financial services industry and the opportunity it presents for the right solution

- ◆ The UBS HPC lab is used to test emerging hardware with production code
- ◆ Results are compared against optimized software solutions and ROI determined



HPC Challenges for Investment Banking

◆ **Separating product hype from reality**

- “An FPGA can perform one algorithm calculation per clock cycle no matter how complex the math is”
- “A GPU can price billions of options per second”
- “Our hardware can process 10 million messages per second”

◆ This requires piloting of the technology with actual code from our production environment

◆ **Code conversion costs**

- Our financial algorithms are extremely complex and have been built up over years
- Quantitative Analyst’s time is typically very expensive
- The costs associated with an error in the code can be enormous, so we have very long and complex test cycles

◆ This cost is usually the largest component of an emerging technology ROI, and often the least understood by the vendors

HPC Challenges for Investment Banking (cont.)

◆ **Integration with our existing environment**

- Our environment is very complex and all built on commodity hardware
 - Industry standard interfaces manage the flow of data between hardware components
 - Internal and external (vendor) support models are in place that meet our service level requirements
- ◆ For a non-commodity piece of hardware to be introduced into our environment, these interfaces and processes have to be developed

◆ **Resiliency Requirements**

- Our requirements are different from other industries. Unplanned outages can result in lost revenue or worse.
- Grid technology supports this requirement for exotics, as it has built in redundancy provided by the software's ability to handle node failures
- The majority of emerging technologies do not have mature or proven solutions for support of high availability or disaster recovery

HPC Challenges for Investment Banking (cont.)

◆ Numerical Precision

- Data flowing to and from the markets and our systems is single precision
 - However, the number of calculations that occur on a single piece of market data can be extensive making rounding an issue
 - Double precision is required in most calculations to ensure that rounding errors do not materially affect the outcome
- ◆ Several of the emerging technologies are based on single precision silicon so have to emulate double precision
- This can significantly change the performance figures

◆ Suitability

- As the technology becomes more specialized, the algorithm types that it is suitable for tends to become more limited
- We work closely with vendors to develop suitability models to ensure that time spent (vendor and UBS) is on the best algorithm candidates

Q & A

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