Ultimate Control

Maxeler RiskAnalytics

MAXELER Technologies
MAXIMUM PERFORMANCE COMPUTING

Risk Analytics

Financial markets are rapidly evolving. Data volume and velocity are growing exponentially. To keep ahead of the competition financial institutions need computation platforms that deliver best performance across a wide range of application types driven by diverse markets.

Only Maxeler Technologies can deliver maximum performance computing spanning the full range from high throughput RiskAnalytics to low latency trading algorithms, all in the same technology platform.

The Maxeler RiskAnalytics platform is built from the ground up around the concept of dataflow. By streaming data through our award winning Dataflow Engines we can deliver unparalleled compute performance resulting in unparalleled portfolio transparency.

This brochure outlines Maxeler's RiskAnalytics platform and describes how it can radically transform your business

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RiskAnalytics at hardware speeds,
imagine the possibilities.

Compute Book Risk in Real Time

Maxeler RiskAnalytics is a hardware accelerated financial risk management platform, giving you the ability to reduce the computation of book risk, including complex exotics, from hours to minutes. We've made this possible by accelerating core analytic algorithms in hardware using our award winning Dataflow Engine technology, and integrating the result into a full featured risk platform.

The computation of VaR using conventional technology is often slow, inaccurate and unstable. This is especially so for full reval VaR where the entire book value needs to be computed over many thousands of market scenarios. 5f there are insufficient scenarios in the tail, VaR becomes strongly dependent on a few scenarios, rather than the whole tail.The result is uncertainty in attribution and explain as well as difficulty in optimising positions against VaR.

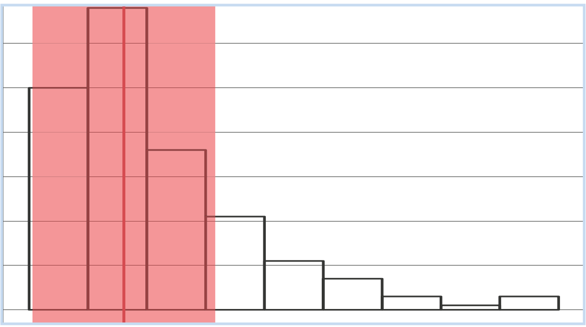


Fig. 1 VaR with 10,000 scenarios

By massively increasing the number of feasible scenarios, Maxeler RiskAnalytics gives you the ability to see your VaR in new ways. Get higher resolution in the tail for greater precision, significantly improve stability for allocation and attribution, or see immediately the impact of market and portfolio changes. New approaches to VaR become feasible:

- pre-horizon cashflow generation and dynamic portfolio hedging
- sensitivity metrics for enhanced explain
- stable and efficient portfolio optimization

With full reval VaR, combined with in model dynamic hedging, tail risk metrics behave consistently with portfolio risk and PnL. In summary, VaR is faster, more accurate and more comprehensive.

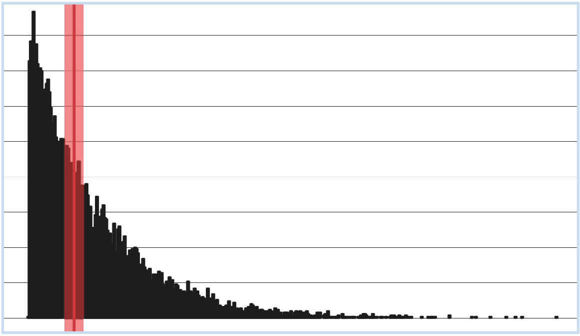


Fig. 2 VaR with 500,000 scenarios

The charts illustrate the impact on VaR accuracy of a 50x increase in the number of Monte Carlo scenarios from 10,000 (Fig. 1) to 500,000 scenarios (Fig. 2). Confidence intervals for VaR (red band) significantly decrease, while granularity in the tail, and hence VaR stability, increases.

RiskAnalytics Platform

The RiskAnalytics platform consists of all the components needed for streamlined front-to-back portfolio risk management, including:

- front end trade booking, portfolio management, model and risk metric selection
- application layer in software allowing for quick and flexible functional reconfiguration
- adaptive load balancing
- database integration

Designed by quants with over 20 years top-tier investment banking experience leading front office quant teams, the Maxeler RiskAnalytics platform is truly a step change in risk management capability, bringing you a level of portfolio transparency previously infeasible, whatever your portfolio.

Dataflow computing,
data choreography in action.

What is dataflow computing?

Frequency scaling of silicon came to an end about a decade ago, while transistor density continues to increase. In response, implementations turned to some form of parallel processing to improve computational performance.

The obvious form of parallel processor is simply a replication of multiple processors starting with a single silicon die (multi-core) and extended to racks and racks of interconnected processor+memory server units. Unfortunately, the more processors used to access common memory data the more likely contention develops to limit overall speed.

Maxeler Technologies has developed an alternative paradigm to parallel computing: Multiscale Dataflow Computing. This approach, popularised in the 1980s, considers an application as a dataflow graph of executable actions whereby data flows through a sea of arithmetic units.There are no time consuming load or store instructions among the operational nodes. However, creating a generalised interconnection among arithmetic units proved to be a significant limitation to dataflow realisations given the technology available at the time.

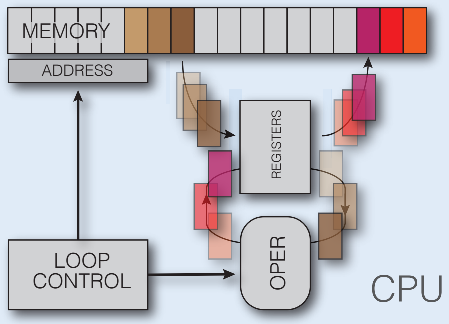
Why Dataflow Today?

Over recent years the extraordinary improvement in transistor array density has opened up new possibilities. The Maxeler dataflow implementations are a generalization of earlier work employing static, synchronous dataflow with an emphasis on data streaming. Indeed, "multiscale" dataflow incorporates vector and array processing to offer a multifaceted compute platform.

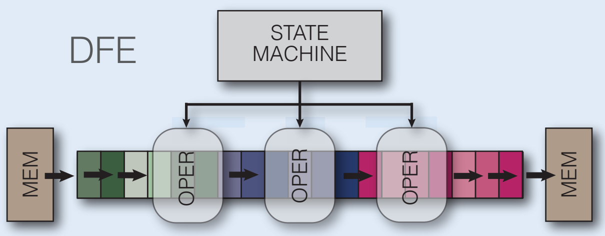
Maxeler dataflow engines are currently used by clients across diverse industry backgrounds, including financial risk, high frequency trading, oil and gas exploration, bio informatics and big data.

Dataflow versus Control flow

In a software application, a program's source code is transformed into a list of instructions for a particular processor. Instructions move through the processor which reads or writes data to and from memory. The programming model is inherently sequential and performance depends heavily on the latency of memory access.



In a Dataflow Engine (DFE), data streams from memory into the processing chip where data is forwarded directly from one arithmetic unit (dataflow core) to another until a chain of processing is complete. In a DFE processing pipeline every dataflow core computes simultaneously on neighbouring data items in a stream.



Unlike control flow cores, where operations are computed at different points in time on the same computational units (computing in time), a dataflow computation is laid out spatially on the chip (computing in space). Once a dataflow program has processed its stream of data, the dataflow engine can be reconfigured for a new application in less than a second.

Integrated Risk Management Platform,
powered by Dataflow Engines.

Massive Parallelism

All core RiskAnalytics components have been implemented on Dataflow Engines. Each Dataflow Engine (DFE) implementation consists of multiple parallel computational pipelines. Each pipeline itself consists of many thousands of computational stages. Data is continuously streamed in filling the pipeline from top to bottom, with each stage operating on the data as it flows through. In this way many tens of thousands of computations are performed each clock cycle and massive parallelism is achieved.

Swap Pricing Example

The RiskAnalytics platform has been designed in a modular fashion to maximise flexibility of configuration and performance. Each module realises a core analytics component, such as curve bootstrapping or Monte Carlo path generation. For maximum flexibility each module is available both as a CPU library and as a DFE. The diagram below illustrates a typical module configuration for pricing interest rate swaps, with each stage representing either a CPU library or a DFE.

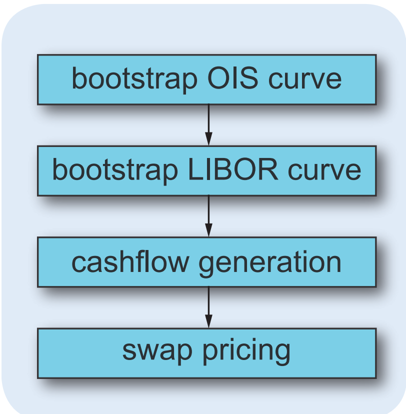


Fig. 3 Swap pricing pipeline

Modular design allows the Maxeler OS to dynamically load balance between CPUs and DFEs to target heavy compute load to DFEs, leaving CPUs to support application logic and lighter compute loads. DFE functionality can be switched in real time by the Maxeler OS.

The table below illustrates two possible module configurations dependent on the relative cost of each stage:

COMPUTE	OIS	LIBOR	cashflow	pricing
many curves few swaps	DFE	DFE	CPU	CPU
few curves many swaps	CPU	CPU	DFE	DFE

The Maxeler OS can programatically allocate resources to optimise performance.

VaR Computation Example

Finally, we give a more comprehensive example based on the computation of VaR. In this example we have additional modules including Monte Carlo, Scenario Bumping and Risk Analysis.

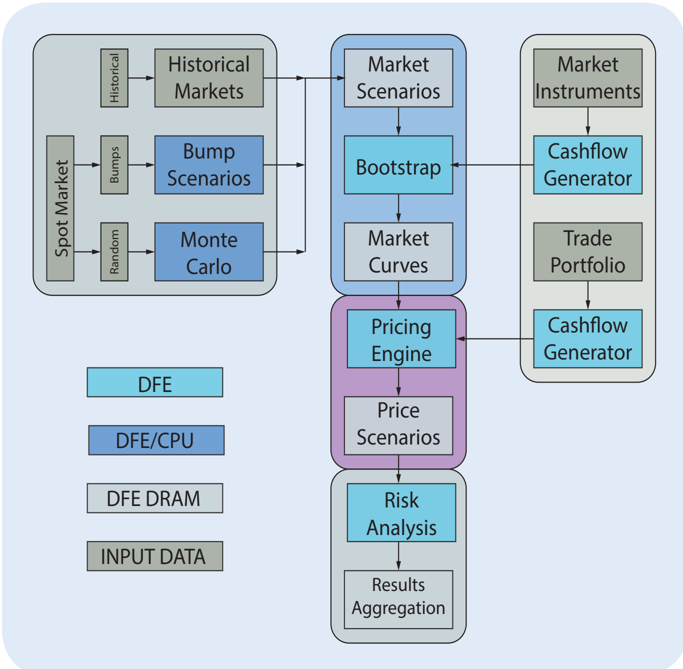


Fig. 4 VaR Engine Architecture

The modular architecture allows core functionality to be swapped programatically in and out, while maintaining a balanced computational load. Large DRAM memory next to each DFE further extends the load balancing capability, while allowing more complex models such as LMM to be easily supported.

Maxeler finance library,
product and model coverage.

Interest Rate Products
- money market instruments
- Govt and Corp bonds
- callable/putable bonds
- options on bonds
- forward rate notes
- vanilla swaps
- OIS swaps
- amortizing swaps
- basis swaps
- credit contingent swaps
- capped/floored swaps
- European swaptions
- Bermudan swaptions
- vanilla caps/floors
- digital caps/floors

Commodity Products
- forwards and futures
- european options on futures
- american options on futures
- digital and barrier options
- options on baskets

Credit Products
- credit default swaps
- recovery swaps and locks
- credit linked notes
- options on credit linked notes
- index default swaps
- options on index default swaps
- index CDOs
- bespoke CDOs

Equity Products
- asian options
- barriers, binaries and digitals
- options on baskets

FX Products
- asian options
- barriers
- forward start
- basket

Calibration
- OIS curve boostrap
- LIBOR curve boostrap
- hazard curve bootstrap
- yield curve bootstrap
- implied volatility surface
- implied correlation surface
- implied correlation mapping

Models
- Black-Scholes option
- Black futures option
- Gaussian copula for CDOs
- affine multivariate basket model
- displaced Libor Market Model
- Ritchken-Sankara spot model
- local volatility skew
- stochastic volatility
- bivariate Credit-FX with jumps
- top down / bottom up point processes
- finite difference 3-factor PDE solver
- generic Monte Carlo simulation engine

Core Utility Libraries
- date conventions and holidays
- solvers and root finders
- linear algebra
- probability distribution and sampling
- statistical and time series analysis
- function approximation and interpolation
- sparse matrix library

Client APIs
- Java
- Matlab
- R
- Excel
- Python

Application case studies in extreme performance.

Real Time Swap Portfolio Risk

The secret to extreme speed in pricing interest rate swaps lies in the efficient implementation of the date convention and holiday calendar library. This is simply because computing swap schedules is the most time consuming component of any swap pricing.

Maxeler has implemented all standard date conventions and date offset functionality directly within the DFE resulting in massive acceleration for swap pricing. For example, a portfolio of swaps with average maturity 30 years and quarterly tenors can be priced with sustained performance of ***32 million swaps per second*** on a single Maxeler 1U node.

Utilising on DFE OIS and LIBOR curve bootstrapping, real time swap portfolio pricing and risk management is effortlessly supported.

Exotic Interest Rate Pricing

But what if you need to price more exotic products, such as Bermudan swaptions? The industry standard model, LMM, employs a high-dimensional Monte Carlo model with complex dynamics and large state space. Pricing involves a multi-stage algorithm with forward and backward cross-sectional (Longstaff-Schwartz) computations across the full path space. Here the challenge is to manage large path data sets, typically several GBs, across multiple stages.

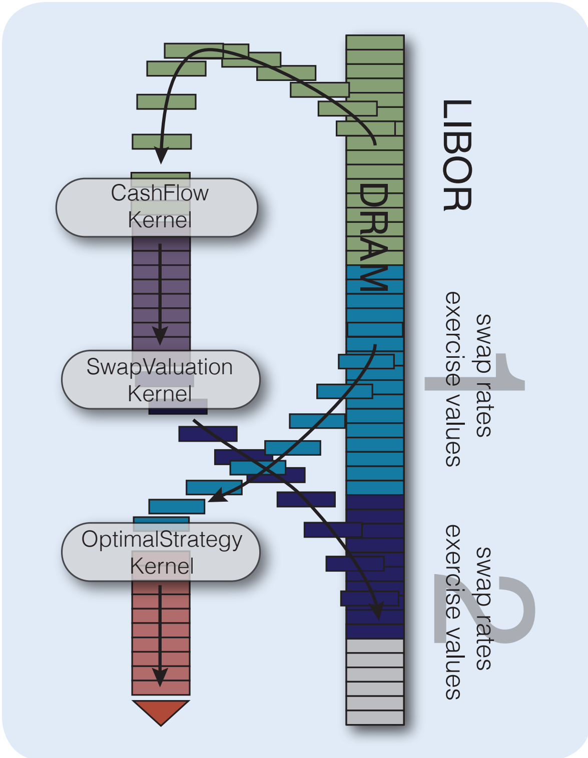


Fig. 5 Bermudan swaptions in LMM

Figure 5 above illustrates the RiskAnalytics DFE implementation, including cashflow generation and Longstaff-Schwartz backward regression,

By closely coordinating between multiple DFE stages and DRAM memory, ***6,700 quarterly 30y Bermudan swaptions per second*** can be priced on a Maxeler 1U node.

The table below compares instruments priced per second for a range of instrument types.

Instrument	CPU 1U-Node	Max 1U-Node	Comparison
European Swaptions	848,000	35,544,000	42x
American Options	38,400,000	720,000,000	19x
European Options	32,000,000	7,080,000,000	221x
Bermudan Swaptions	296	6,666	23x
Vanilla Swaps	176,000	32,800,000	186x
CDS	432,000	13,904,000	32x
CDS Bootstrap	14,000	872,000	62x

For more information or to request a demo, please contact:

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