BM&FBOVESPA
The New Exchange

Accelerating Derivatives Contracts Pricing Computation with GPGPUs

GTC 2015

Alexandre Barbosa / Daniel Magalhães

AGENDA

BM&FBOVESPA
The New Exchange

- Presenters Background
- BMFBOVESPA Overview
- ClearingHouse Overview
- CORE Risk System Concepts
- Solving the problem
- GPU x CPU
- The Future

Briefly Background

- Alexandre Barbosa:
  - Associate Director at BMFBOVESPA.
  - Bachelor of Information Systems
  - MBA in Capital Markets and Derivatives
  - Responsible for Pricing Systems, Risk Calculation Systems and Risk Scenarios Management Systems

- Daniel Magalhães
  - Manager at BMFBOVESPA.
  - Bachelor in Computer Science
  - MBA in Capital Markets and Derivatives
  - Responsible for Calculation Risk System and Risk Scenarios Management System

Briefly Background - Team

- Rodrigo Kuba:
  - System Analyst at BMFBOVESPA.
  - Bachelor of Information System
- Felipe Mosca
  - IT Consultant
  - Bachelor of Information Systems
  - MBA in Capital Markets and Derivatives
- Jairo Panetta
  - CS Consultant
  - PhD Computer Sciences
- Pedro Pais Lopes
  - CS Consultant
  - MsC Computer Sciences

BMFBOVESPA

- *"BM&FBOVESPA is a company that manages the organized securities and derivatives markets, providing registration, clearing and settlement services.* ***It acts as central counterparty, guaranteeing financial liquidity for the trades executed in its environments***"

- Trading Markets: Equities, Futures, Commodities, Securities, FX, ETF

- ClearingHouse
  - Central Conterparty
  - Post Trading Integration Project

Post Trading Integration Project

- What is the project?

- Objectives:
  - More efficient capital allocation for participants
  - Adoption of a **common risk management model** for all markets, permitting:
    - an unified vision of portfolio risks
    - one-pot margining
    - enhanced safeguards
    - integration of financial instruments across different central counterparties (CCPs)
  - Harmonization and integration of all four clearinghouses' models, processes, rules and systems

Overview – Old model

Equities & Corporate Debt Clearinghouse	Derivatives Clearinghouse	Securities Clearinghouse	FX Clearinghouse
Cash equities, equity derivatives & lending	**Financial & commodity derivatives**	**Government bonds**	**Spot FX**
Rulebook & Manual	Rulebook & Manual	Rulebook & Manual	Rulebook & Manual
Participant structure	Participant structure	Participant structure	Participant structure
Participant & client registration	Participant & client registration	Participant & client registration	Participant & client registration
Give-up & allocation	Give-up & allocation	Give-up & allocation	Give-up & allocation
Position control	Position control	Position control	Position control
Netting & settlement	Netting & settlement	Netting & settlement	Netting & settlement
Risk management	Risk management	Risk management	Risk management
Collateral pool	Collateral pool	Collateral pool	Collateral pool

Overview - Current model

Post Trading Integration Project

- Financial Times:

August 17, 2014 1:28 pm

BM&FBovespa to launch clearing house

By Samantha Pearson in São Paulo Author alerts

Brazil's BM&FBovespa is set to launch its new clearing house today in a move that will inject R$20bn ($8.8bn) into the country's markets and open up a new line of business for the exchange operator.

After four years of developing the platform, the exchange operator is in talks with three other emerging market countries to sell them a blueprint for the clearing house's technology, BM&FBovespa's chief operating officer Cícero Vieira told the Financial Times.

The São Paulo-based company, which enjoys a near-monopoly over the Brazilian market, will first transfer exchange-traded and over-the-counter derivatives to the new clearing house, followed by equities next year – the culmination of a R$1.5bn project to revamp Brazil's trading infrastructure.

More

ON THIS TOPIC

Lex BM&FBovespa

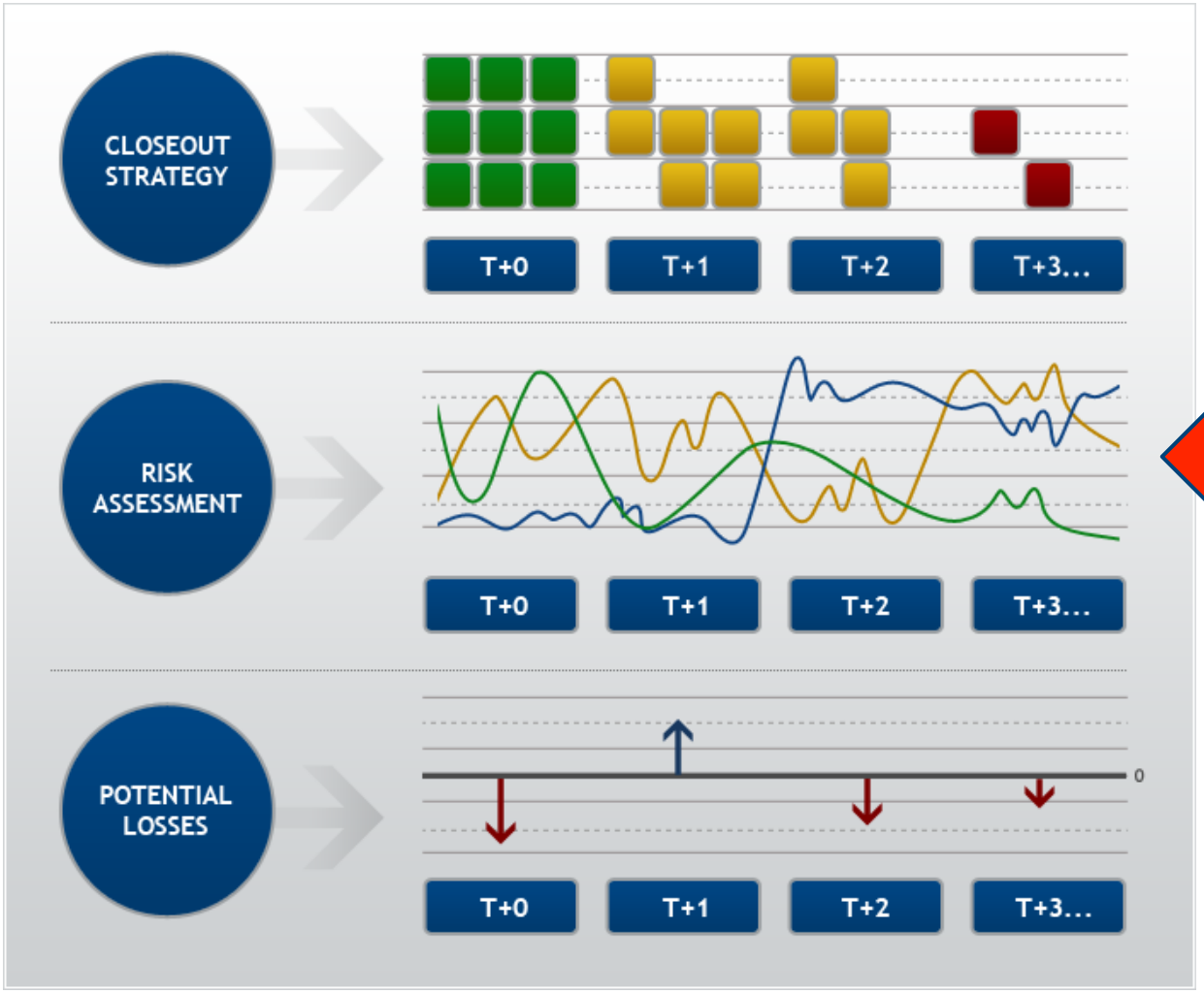
Overview

- What is CORE?

  "Closeout Risk Evaluation"

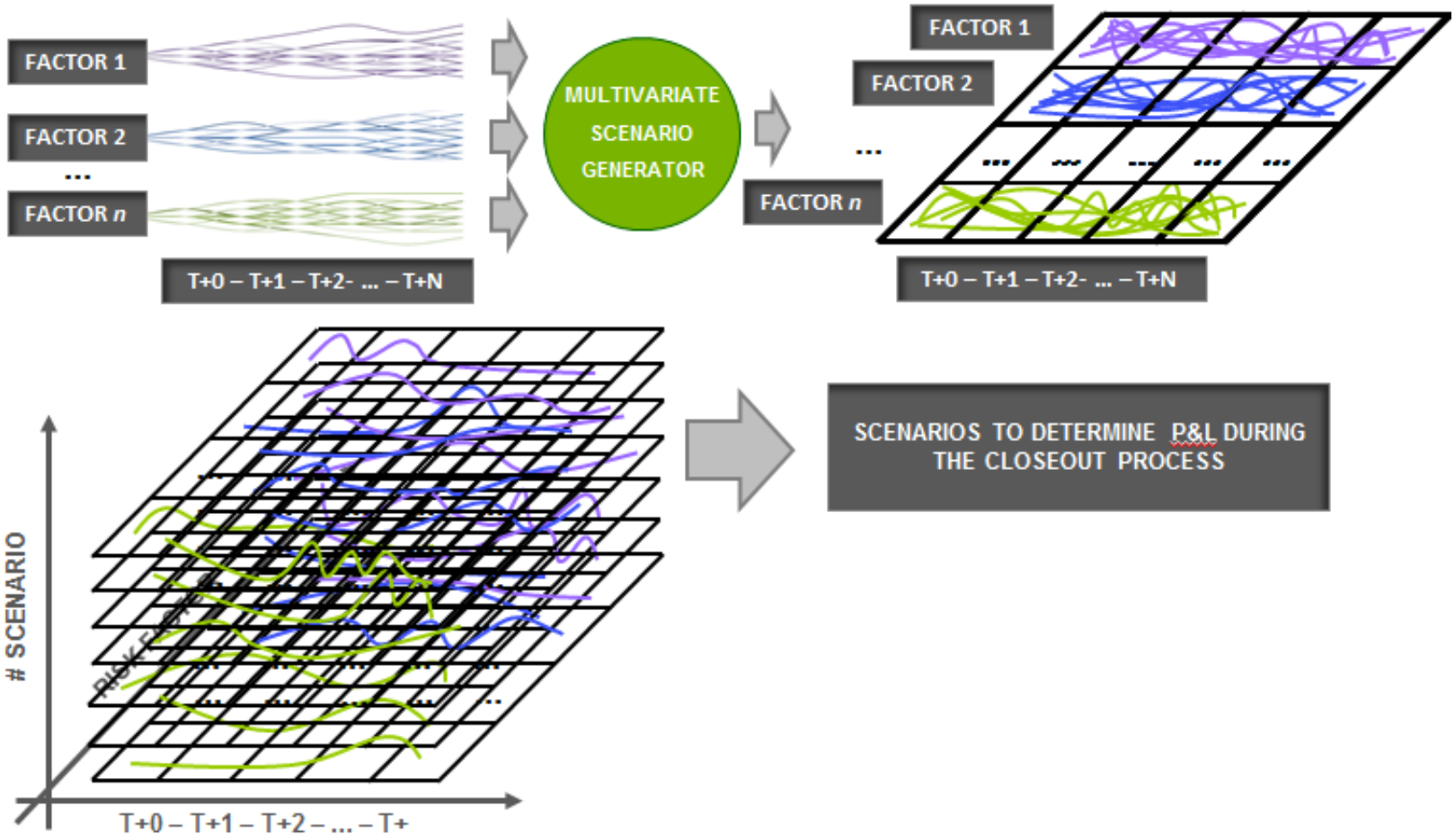
- New BMFBOVESPA Risk Model for Clearinghouses and others financial institutions which acts as a Clearing

Overview



Issue in Valuation

Overview


FACTOR 1
FACTOR 2
...
FACTOR n
T+0 – T+1 – T+2- ... – T+N
MULTIVARIATE SCENARIO GENERATOR
FACTOR 1
FACTOR 2
...
FACTOR n
T+0 – T+1 – T+2- ... – T+N
SCENARIO
Risk Factor
T+0 – T+1 – T+2 – ... – T+
SCENARIOS TO DETERMINE P&L DURING THE CLOSEOUT PROCESS

Information to be processed

- Risk Factors: 300
- Number of stress risk scenarios: 100,000 for each risk factor
- Prices calculated for contracts: 1.3 Billion
- Risk Calculations per day: 100,000

Valuation Issue

- What is valuation?
  - Calculate the price of a contract in each stress risk scenario 100,000x
  - Every portfolio risk calculation

- Sample:
  - Garman Option Pricing:

$$P_G(S;K;i;c;\sigma;T;\varphi) = \varphi \times \left(S \times e^{-c.T} \times \mathrm{N}(d_1) - K \times e^{-i.T} \times \mathrm{N}(d_2)\right)$$

$$d_1(S;K;i;c;\sigma;T;\varphi) = \varphi \times \frac{\ln(S/K) + \left(i - c + \frac{\sigma^2}{2}\right) \times T}{\sigma \times \sqrt{T}}$$

$$d_2(S;K;i;c;\sigma;T;\varphi) = \varphi \times \frac{\ln(S/K) + \left(i - c - \frac{\sigma^2}{2}\right) \times T}{\sigma \times \sqrt{T}}$$

Valuation Issue

- Regular Client Portfolio with only “Garman Option Pricing”

# Prices	# Contracts In a portfolio	Avg Time (CPU)	Avg Time (GPU)
100,000	1	2.700 (ms)	250ms
200,000	2	2 x 2,700 (ms)	2 x 250ms
1,000,000	10	10 x 2,700 (ms)	10 x 250ms
5,000,000	50	50 x 2,700 (ms)	50 x 250ms

- It takes around 2 minutes to calculate a portifolio with 50 different contracts
- We have portfolios with more than 200 different contracts!!!!

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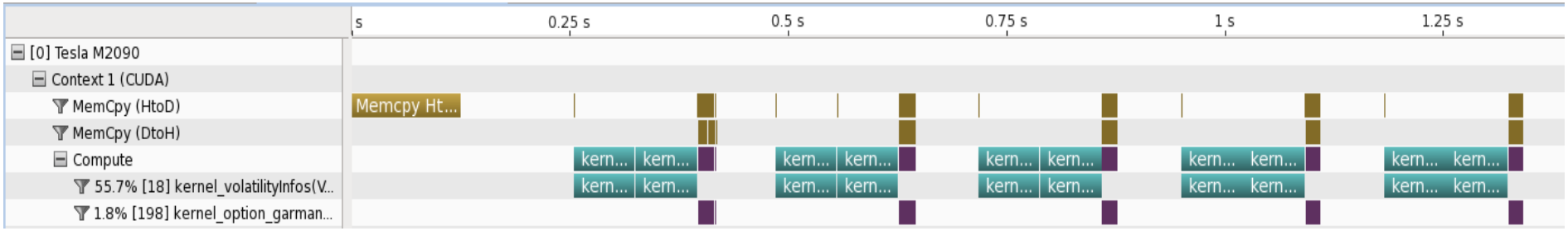
Valuation Issue – 1st architecture with GPU

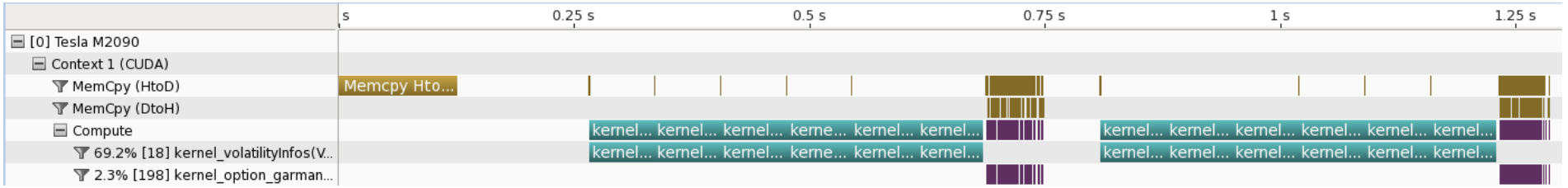
- Using GPU to process the valuation
- 2 CPUs threads demanding calculation for 1 GPU



Configuration	Total Time	Obs
32 CPU Threads	00:08:50	
1 GPU – 2 Threads	00:12:11	2 Threads per GPU
8 GPUs – 16 Threads	00:02:11	2 Threads per GPU

Valuation Issue – Overloading GPU

- 6 CPUs threads demanding calculation for 1 GPU
- Better usage of GPUs



Configuration	Total Time	Obs
32 CPU Threads	00:08:50	
1 GPU – 2 Threads	00:12:11	2 Threads per GPU
8 GPUs – 16 Threads	00:02:11	2 Threads per GPU
8 GPUs – 48 Threads	00:01:44	6 Threads per GPU

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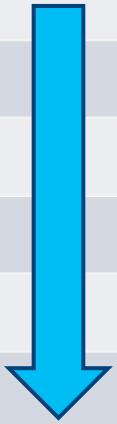
Comparing the results

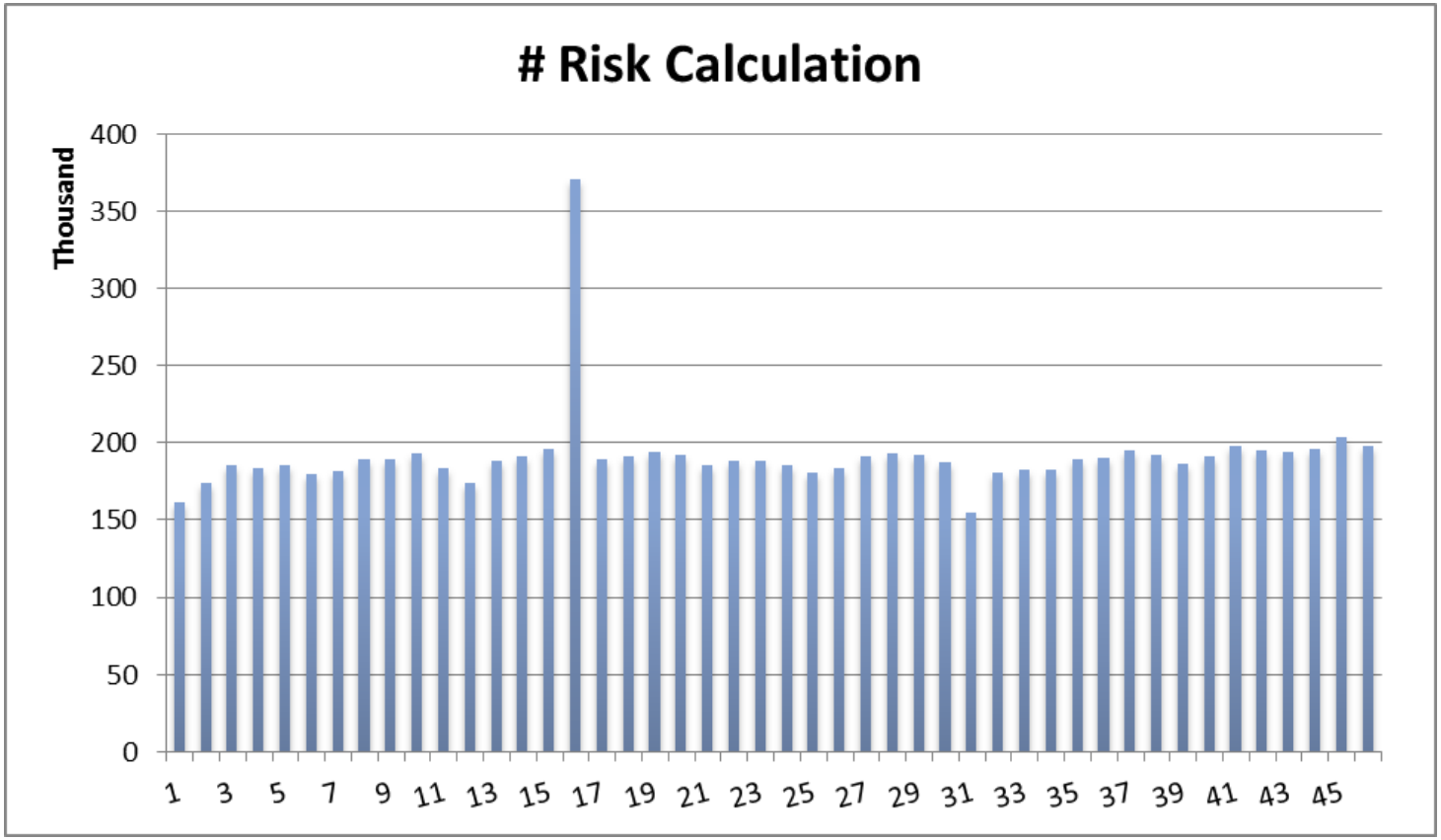
- Server: Intel(R) Xeon(R) CPU E5-2690 0 @ 2.90GHz
  - # Cores: 8, # Sockets : 2, Total: 16
  - GPU: NVidia Tesla M2090

Configuration	Total	Obs.
32 CPU Threads	00:08:50	
1 GPU - 1 Thread	00:16:14	1 thread per GPU
1 GPU - 2 Threads	00:12:11	2 threads per GPU
8 GPUs - 8 Threads	00:02:50	1 thread per GPU
8 GPUs - 16 Threads	00:02:11	2 threads per GPU
8 GPUs - 32 Threads	00:01:50	4 threads per GPU
8 GPUs - 48 Threads	00:01:44	6 threads per GPU



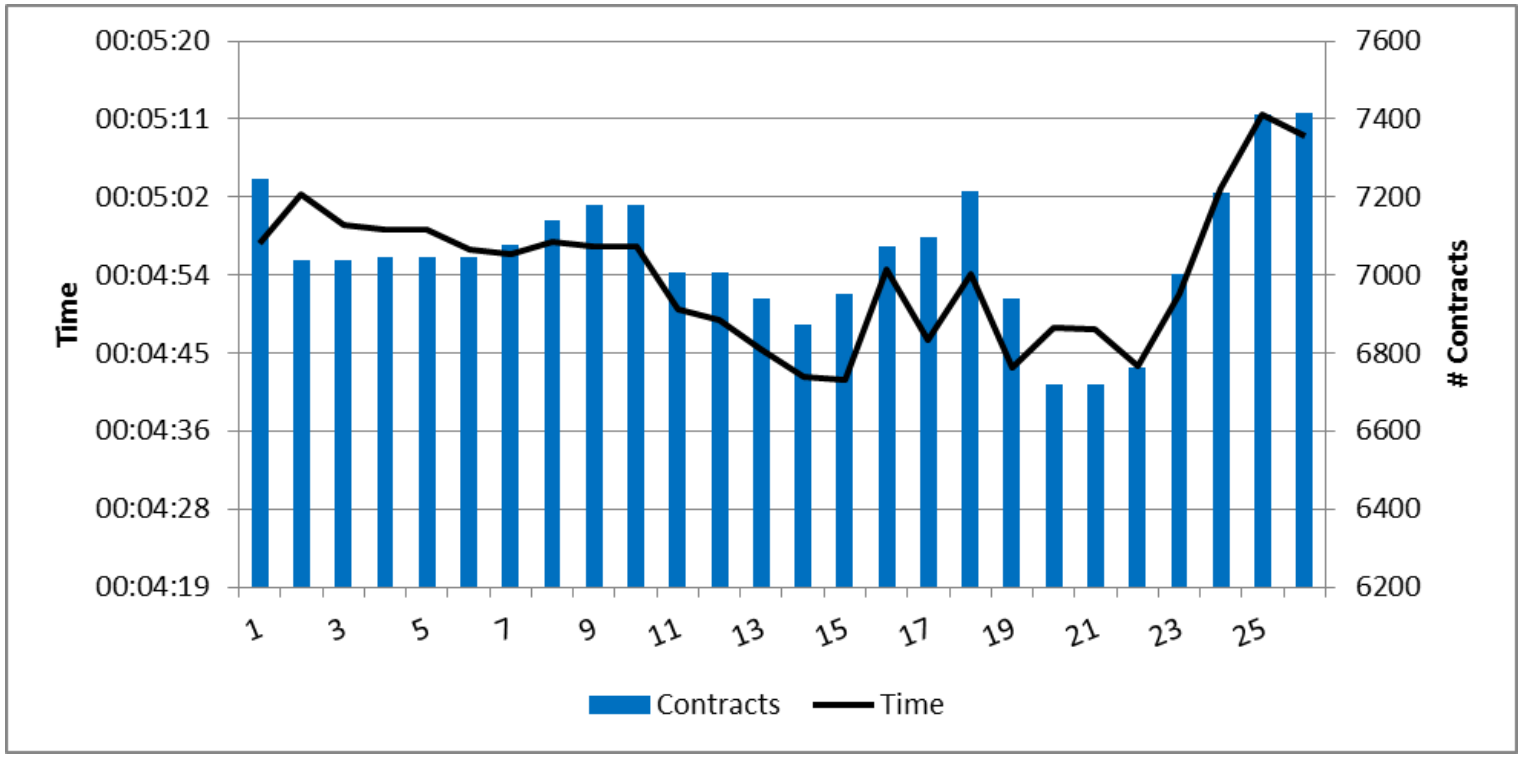
Daily Usage

- CORE
  - Calculate 10,000 portfolios every 5 minutes

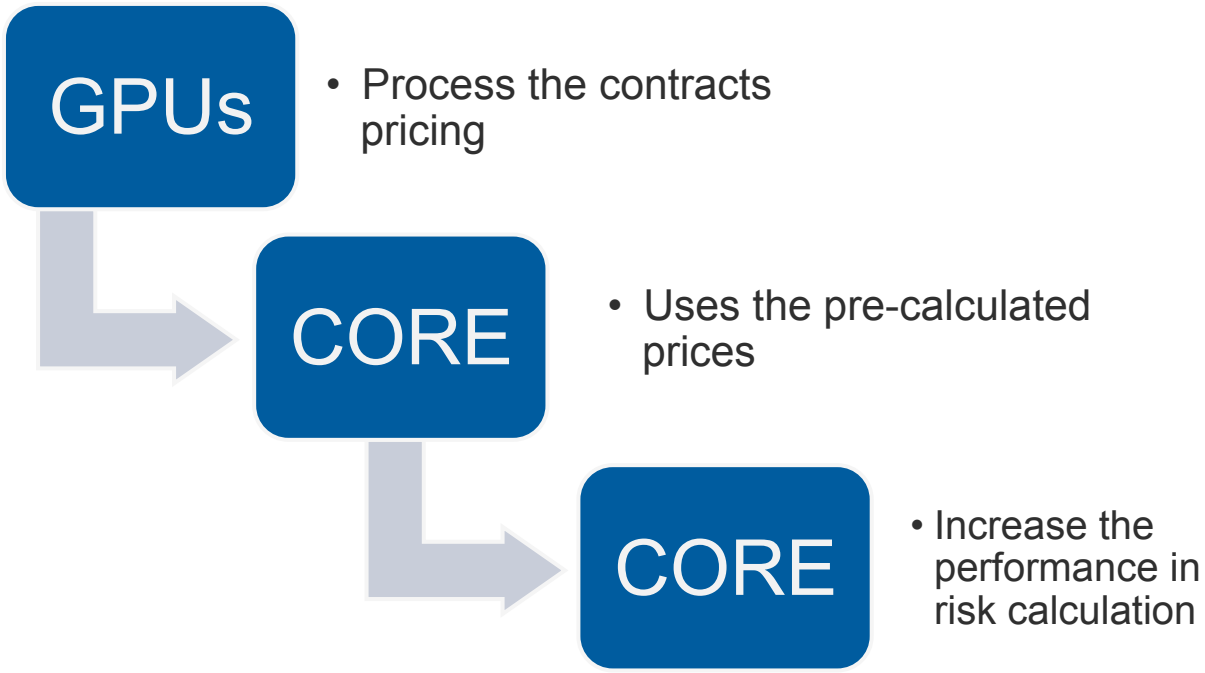


Daily Usage

- CORE
  - Pricing of 7,000 contracts x 100,000 stress risk scenarios
  - Total time spent in the process: 5 minutes



Conclusion


GPUs
• Process the contracts pricing
CORE
• Uses the pre-calculated prices
CORE
• Increase the performance in risk calculation

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CORE V2

- What is CORE V2?
  - Equities as a tradable instrument
  - Derivatives on equities
- Pricing for 33.000 contracts: 6 billions
- Risk calculations: 10 millions per day

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