



HPC

A Highly Priced Commodity for Financial Institutions

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HPC in Finance

- R&D in the banking industry is plagued by two phenomenons
 - Massive data feed
 - Computationally challenging models for the derivatives business

HPC in Finance



➤ Orders of magnitude

- More than 800,000 billions € of notional
- A universe of more than 10,000 securities
- Typical books of derivatives : $10^5 / 10^6$ open positions at the bank level

➤ Questions

- how much information to process ?
- What does it take to process it ?

How much information ?



How much information ?



-AFG19.45	-HON31.68	-OIH29.15	-THV28.78
-AMS35.97	-HSD24.54	-OLK68.94	-TRE46.35
-AUF36.36	-HUM19.55	-OPI47.49	-TTV57.67
-BGT42.74	-IOM84.19	-OQE76.32	-UHI33.94
-BNK37.61	-INL75.97	-PAB84.98	-UJR1.26
-CDD27.72	-ISC97.97	-PBG92.12	-UTV92.70
-CGH75.42	-ITI32.48	-PSD80.75	-UVU20.59
-CXS13.40	-JEM77.12	-PXW24.77	-UGF10.10
-DAS46.45	-JJK27.95	-QDW68.13	-UHG53.18
-DDB26.64	-JRT92.90	-QSA73.27	-UNN69.98
-DRT67.94	-KML59.34	-RAE15.97	-URT63.21
-DSR64.83	-KNZ44.60	-RCF55.54	-WAK39.99
-EAV90.56	-LIJ88.46	-RTG10.80	-WBG39.85
-EBU51.82	-LMH77.39	-RUL17.53	-WCF23.86
-EXC28.91	-MDA56.21	-SFW97.84	-WFP65.42
-FGT75.10	-MIP98.72	-SKU66.45	-XDM79.12
-FHT52.55	-MMD75.80	-SWR33.48	-XTC93.78
-GHT28.13	-MZAS150	-SZA44.44	-YAT22.70
-GNH20.50	-NAA73.31	-TAG75.71	-YIH56.78
-GPP63.62	-NBF72.66	-TBB16.55	-ZBB65.61

How much information ?



- Electronic markets – mostly in the equity and the foreign exchange worlds
 - Order-driven markets
 - New data arrive under the form of a new « order »
 - Order to buy/sell at, below or above a given price (limit order)
 - Order to buy/sell at the best available price (market order)

How to process it ?

I. Algorithmic Trading



- Based on these data, actions are performed
- Two typical computationally challenging problems are:
 - Constrained-time optimization for high frequency trading
 - strategies based on « recent history » (intraday data)
 - must simulate the whole order book evolution and react faster than $10^{-3}/10^{-4}$ seconds
 - Back-testing and optimization
 - Selection of optimal investment strategies in a large universe (« stock/fund picking » for CPPI-like strategies)
 - Storing the data *via* RAM may prove challenging (5 years of intraday data for 1,000 stocks : 1 To)

How to Process it ?

II The Derivatives Business



Options ODX4 E (23-Nov-07) on DE_eurex, 1, yfedmdaxf, DE_DAX Dec07 FDAX, spot=7514.88, fwd=7515.68

Vol	Bid	Ask	Strike	Bid	Theo	Ask	ss	Last	ss	Delta	Status	Status	Curve		
27.13	1	165.20	169.36	177.70	7350.00	3.50	3.76			-0	Trading	Trading	0.03		
26.30	1	5 11...	5 120.70	124.18	131.10	7400.00	8.50	8.56	12.70	5 10.00	70	-0	Trading	Trading	0.03
25.46	1	3 8...	3 80.20	83.53	88.60	7450.00	17.60	17.93	21.70	20 22.00	90	-0	Trading	Trading	0.01
24.62	1	53 5...	3 48.90	50.01	52.10	7500.00	31.20	34.33	36.40	20 40.00	70	-0	Trading	Trading	0.00
23.79	0	12 2...	1 21.10	25.51	26.30	7550.00	54.60	59.81	62.90			-1	Trading	Trading	0.00
22.96	0	58 1...	5 6.40	10.53	10.50	7600.00	86.90	94.61	97.30	20 10...	20	-1	Trading	Trading	0.02
22.17	0	28 2.00	14 0.40	3.31	3.50	7650.00	131.90	137.56	14...			-1	Trading	Trading	0.02
21.43	0	20 1.20	10	0.74	2.00	7700.00	170.00	184.07	190...			-1	Trading	Trading	0.01
20.77	0			0.11	4.00	7750.00	227.50	234.32	24...			1	Trading	Trading	0.01
20.18	0			0.01	7.20	7800.00	284.20					-1	Trading	Trading	0.00
19.69	0			0.00		7850.00	334.17					-1	Trading	Trading	0.00
19.29	0			0.00		7900.00	384.14					-1	Trading	Trading	0.00
18.98	0					7950.00	434.12					-1	Trading	Trading	0.00
18.76	0					8000.00	484.10					-1	Trading	Trading	0.00
18.62	0					8050.00	534.07					-1	Trading	Trading	0.00
18.55						8100.00	584.05					-1	Trading	Trading	0.00
18.52						8150.00	634.03					-1	Trading	Trading	0.00
18.52						8200.00	684.00					-1	Trading	Trading	0.00
10.62						8250.00	733.90					-1	Trading	Trading	0.00

Reference, All

Position	Bid Size	Bid	Ask	Ask Size	Last	Last Size	Name	Fixed/RT	Pricing_Level	Off
N/A					0.00		DE_DAX		0.00	

How to Process it ?

II The Derivatives Business



- Example : an equity derivatives trading floor
 - 2,000 cash securities
 - Models require the simulation of the future life of each security
 - Each simulation of the future requires on average
 - 2,000 time steps
 - 100,000 Monte Carlo paths per security
 - The number of simulation per security depends on the sensitivities required (the « greeks » in quant lingo)
 - Cross-security effects (correlation effects) act as a quadratic growth factor for the number of sensitivities

How to Process it ?

II The Derivatives Business



- Based on actual performances in the industry :
 - At Investment Bank A :
 - » 10 PetaFlops would allow for a basic pricing in 1 second
 - At investment bank B
 - » 45 Petaflops would allow for a basic pricing in 1 second
- ... but the worst is yet to come !

How to Process it ? II The Derivatives Business



- Scenario-based tasks
 - Most decisions are anticipated using scenario-based simulations (« stress tests ») that run overnight
 - ... and should run within minutes/secondes whenever a market move is anticipated (FED announcements, news,...)
 - Typical stress testing requires a hypercube of deformation for each relevant parameters
 - Example : « volatility scenario »:
 - » deformation of the market data of all equity options
 - » ~200 points/security...
 - Plus all the cross-influences!!!

HPC for the banking industry



- From a scientific point of view:
 - The production models are still simplistic...
 - ... and yet, computationnally untractable in the current industrial environment
 - What is required
 - More Flops
 - More RAM
 - Better Network...
 - ... more power and more brains!