TATA CONSULTANCY SERVICES
Experience certainty.

Optimizing Performance of Financial Risk Calculations

Amit Kalele
Easwar Subramanian

March 19th, 2015

Agenda

GPUs in Risk Problems

- Real Time Risk Management
  - Principal Component Analysis
- Incremental Risk Charge
  - Cumulative distribution
- Value at Risk
  - Portfolio (Re) valuation

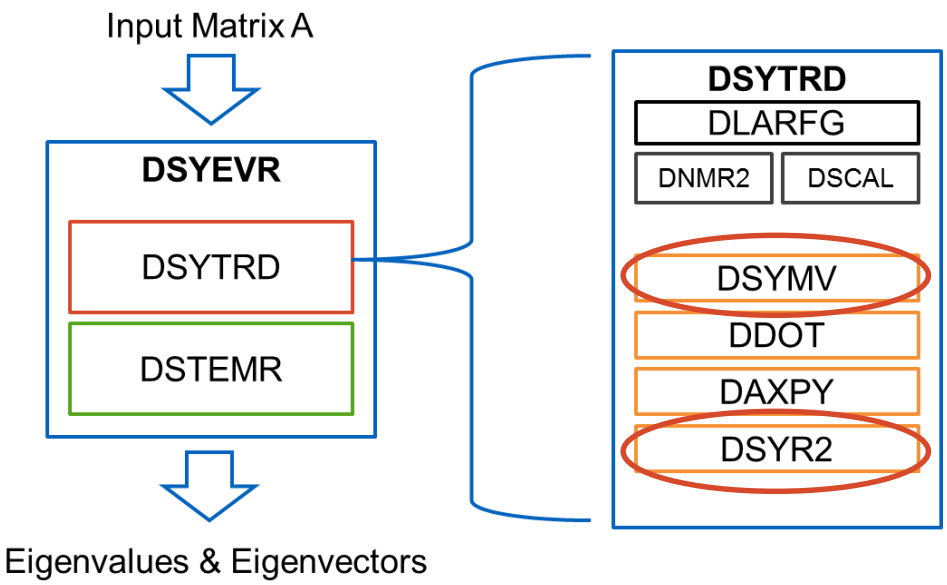
PCA in RTRM

- Principal component analysis (PCA) – An important and compute intensive part of the RTRM application.
- PCA – Computes most important risk factors associated with a portfolio
- Bottleneck – Computation
- Solution – Parallel computations on Multicore systems
  - NVIDIA GPUs
  - Intel MIC

PCA Using DSYEVR

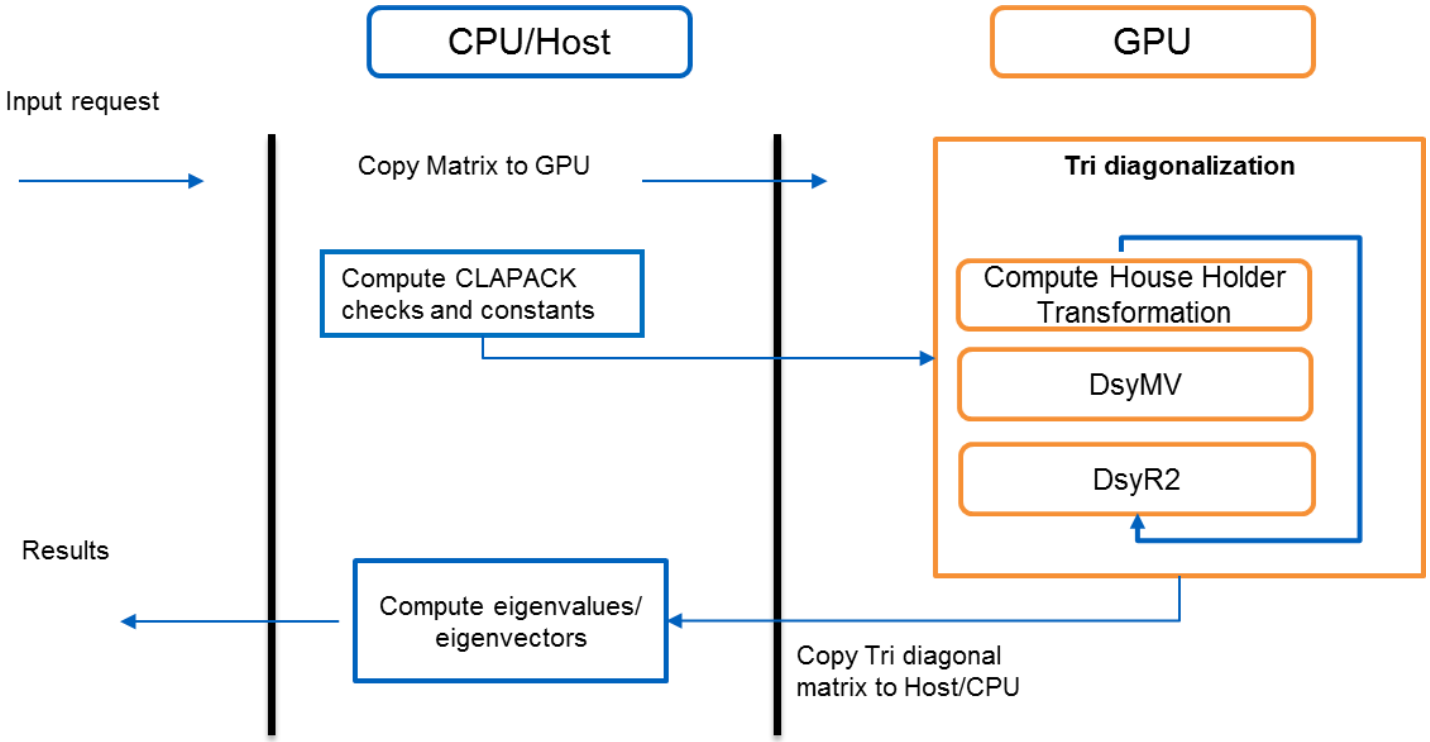
- Principal component analysis (PCA) – Eigenvalue and Eigenvector computations
- CLAPACK Algorithms
  - DSYEVD
  - DSYEVR
- Tri Diagonalization most compute Intensive
  - Consumes around 98% of time for partial spectrum
- Accelerate Tri Diagonalization

DSYTRD Routine

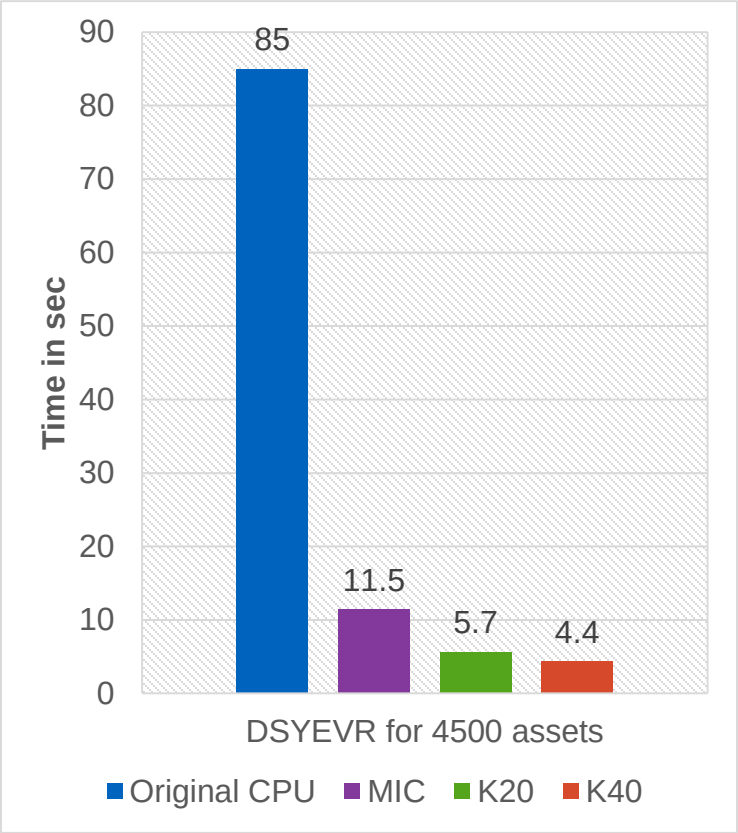


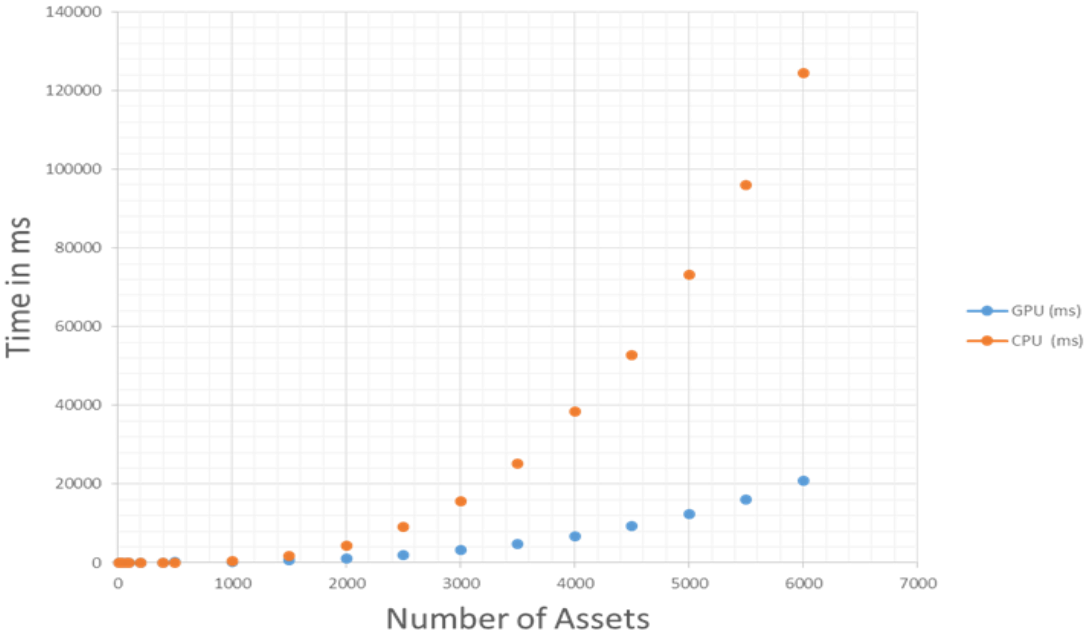
- CLAPACK Tri Diagonalization was completely re-coded using cuBLAS routines
- Minimum Data transfer between Host/GPU

Offloading Tri Diagonalization to GPUs



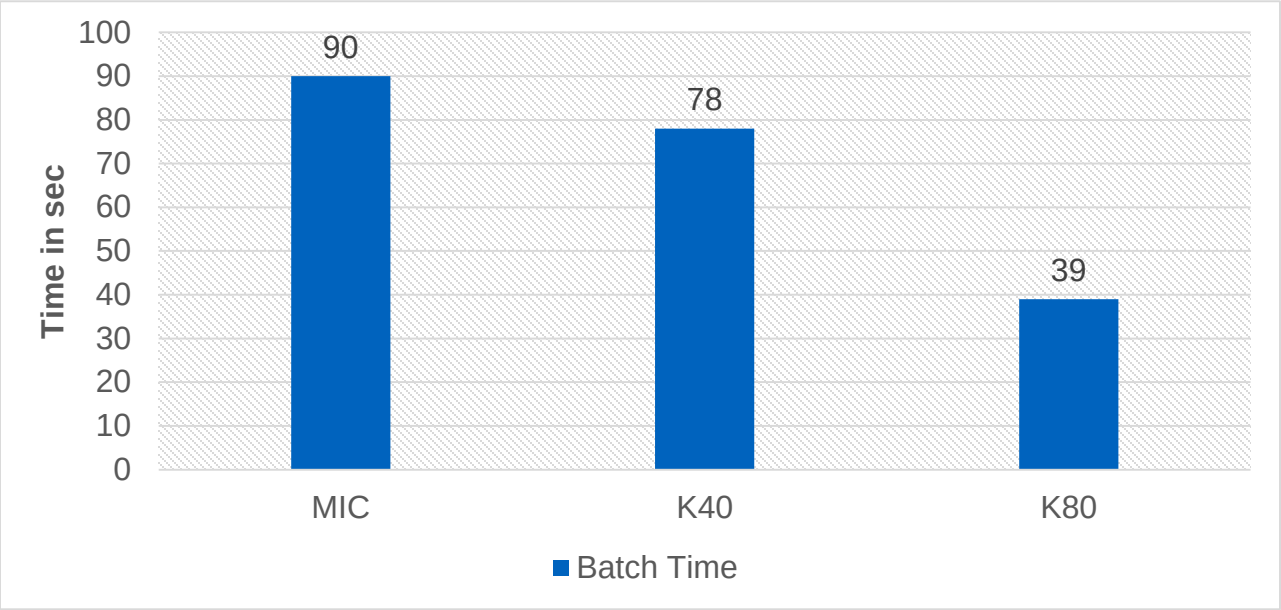
Results





Concurrent PCA Performance Summary

- Batch of 4000 PCA request – Sequential time is 677 sec
- Around 3000 request were of size < 1000



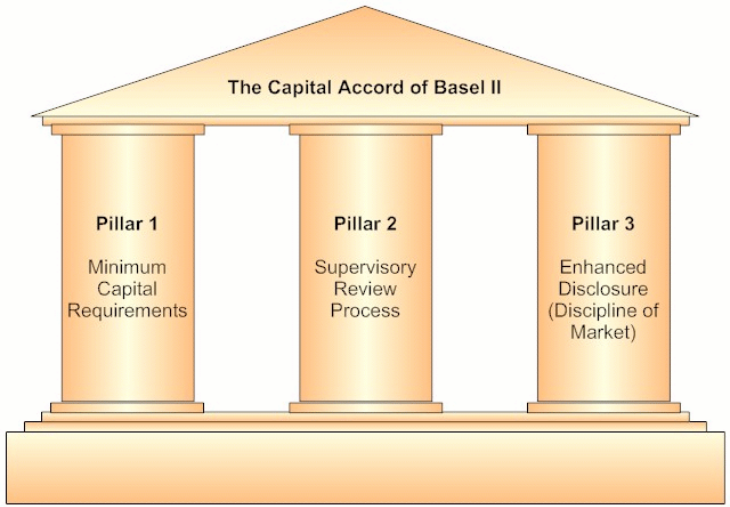
Comments and Further Scope

- Good scale up and performance for large size problems
- For assets < 700, CPU performs better
- Work in Progress
  - Block Reduction
    - Householder Transformations on Block of vectors
  - Possible to achieve 1.4x – 1.8x further gain

TATA CONSULTANCY SERVICES
Experience certainty.

Incremental Risk Charge

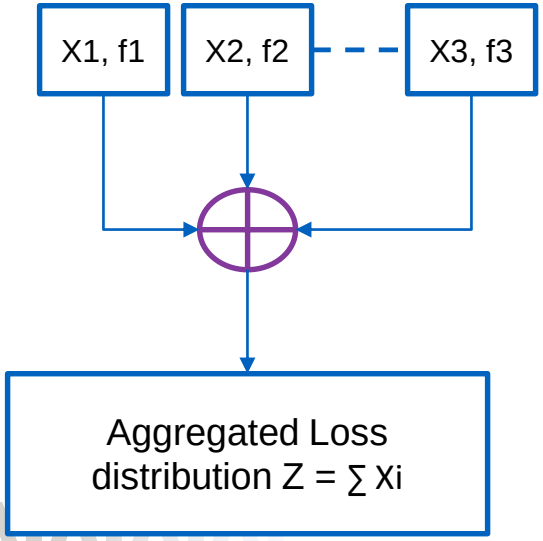
IRC



- To cover credit migration and default risk
- Additional capital charge
  - Incremental Risk Charge (IRC)

IRC Computations

- Estimate credit loss
  - Loss event – defaults, market crash, terror, calamity etc.
  - Severity of loss events – Impact
  - Cumulative effect of all the events



X_i – random variable
Severity of loss due to a random event & common distribution (function) F, and f_i as probability density functions

- To estimate Z
  - Need to predict future random events with their severity of loss
  - Need to find the cumulative distribution F

IRC Computation

Estimate severities X_i

Calculate distribution F

Calculate cumulative distribution function for random variable Z

Simulate X_i using Monte Carlo

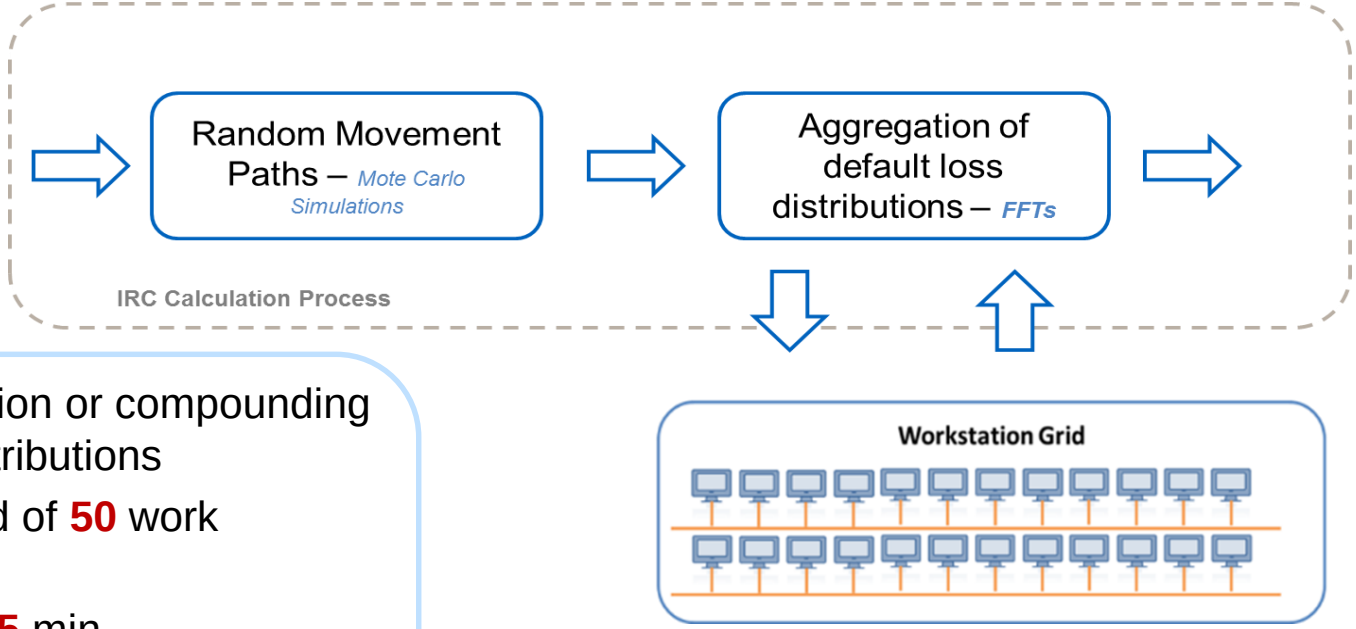
Compute distribution function F by possibly curve fitting on simulation results

Panjer recursions, FFTs etc.

FFTs are computational Bottleneck
{f0, f1, …fm-1} DFT →{f^0, f^1,…,f^m-1} → INV-DFT→ f

FFTs are efficient for M = 2 powers, Cooley-Tukey Radix 2 Algorithm, O(NlogN complexity)

FFTs in IRC



- FFTs for aggregation or compounding of default loss distributions
- Offloaded to a grid of **50** work stations
- Compute time – **45** min
- Consumes over 90% of total time
- Solution – Optimize FFT computations

Complexity

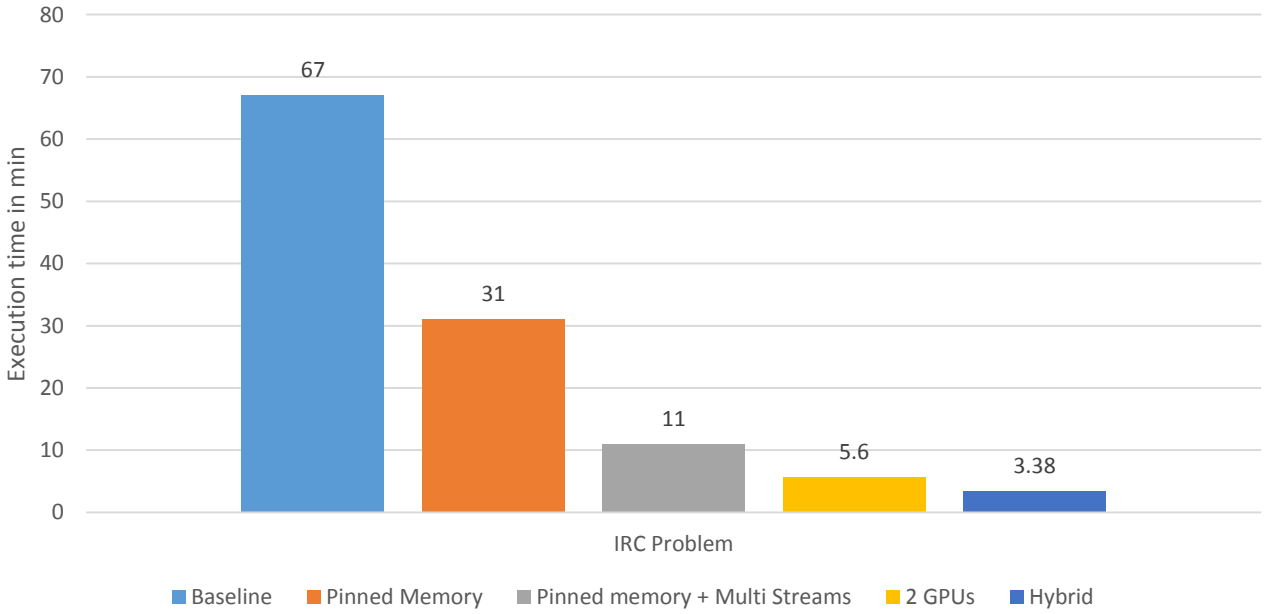
IRC Calculations – Compute and Data intensive

- Computations
  - FFT computations for 133 scenarios
  - Each scenario consisting of 160,000 arrays
  - Each array with 32768 elements *(doubles)*

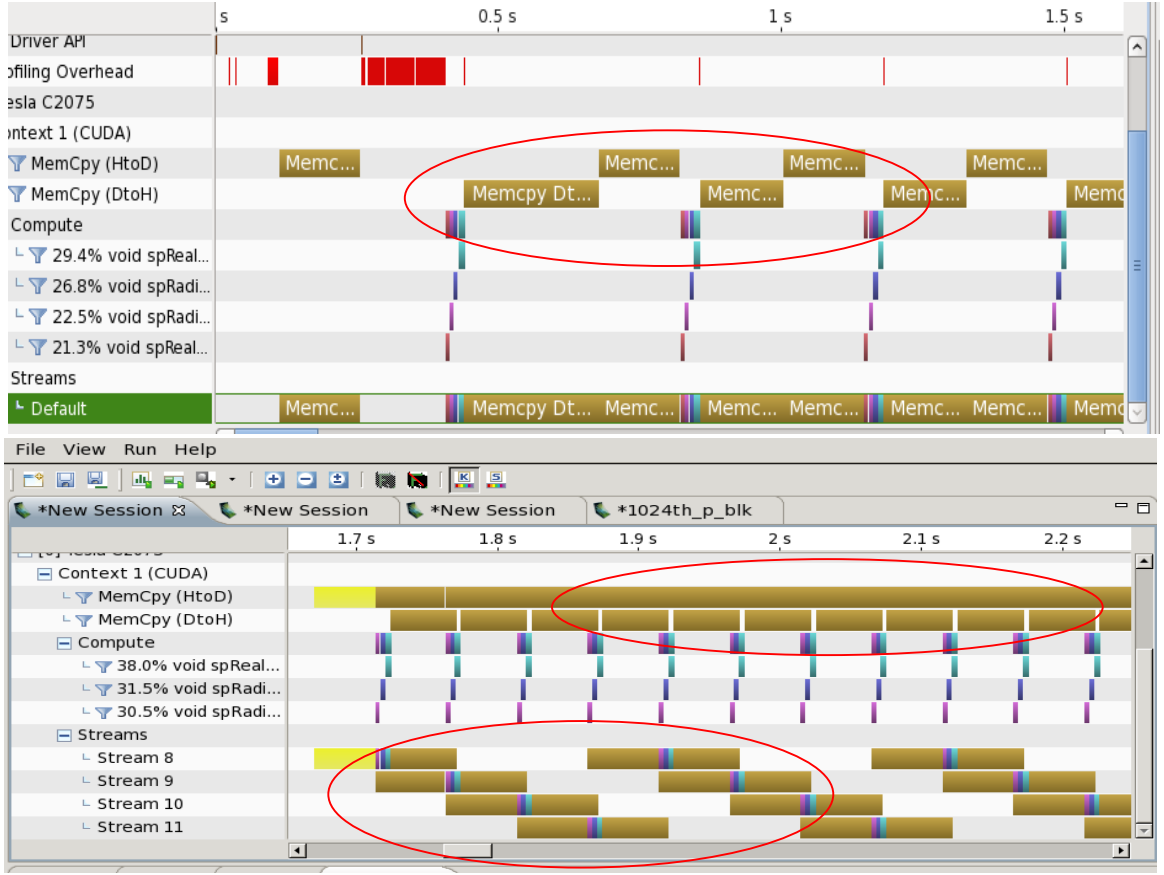
- Data
  - Each scenario translates into ~37GB of data
  - Total data – ~4.9TB

Performance Optimization on GPU

- Pinned Memory, Multiple streams, Hybrid (CPU+GPU)

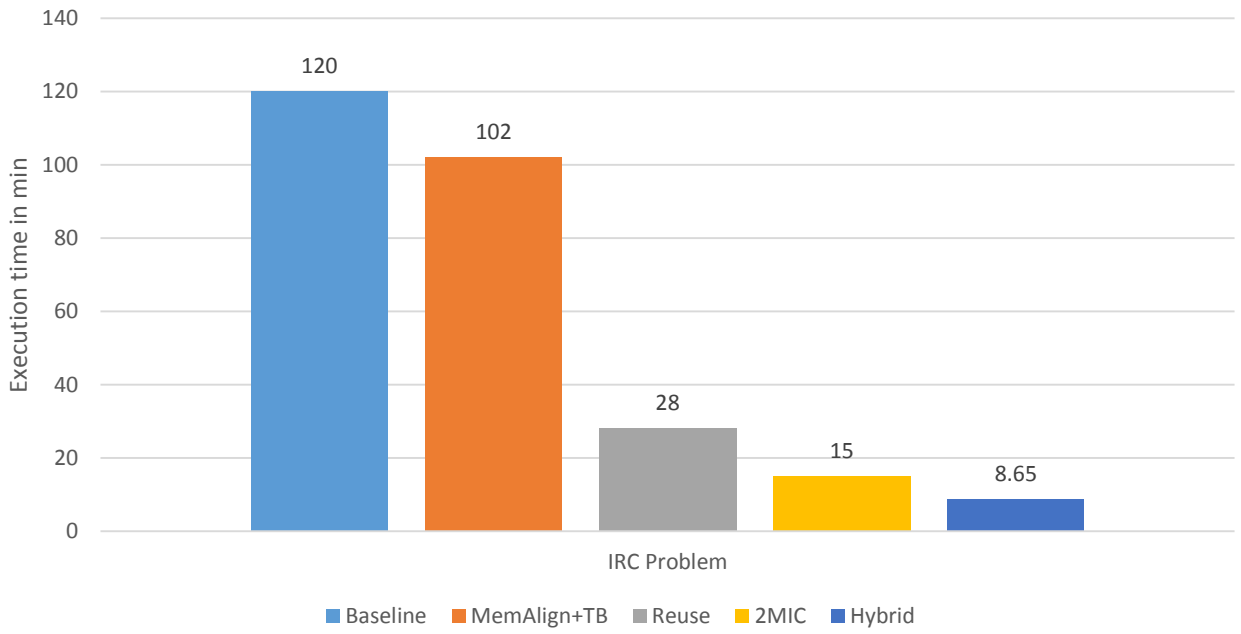


Overlapping With Streams

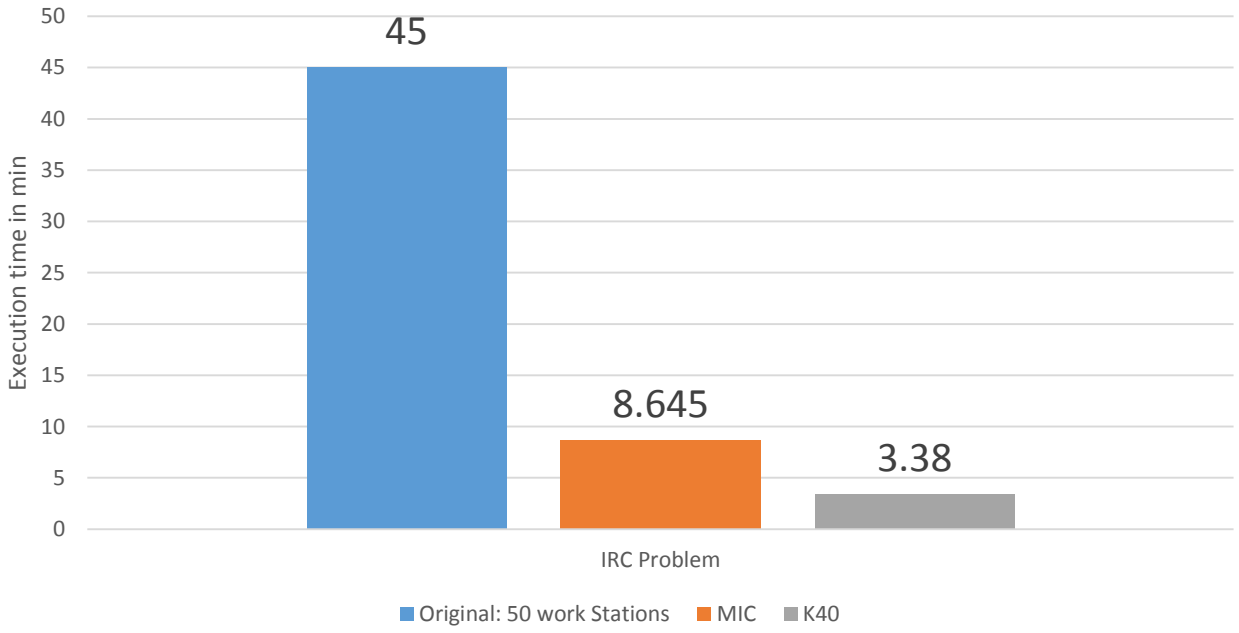


Performance Optimization Intel MIC

- Thread binding, Memory Alignment, Reusing FFT descriptor, Symmetric or Hybrid computations



Performance on Various Platforms



TATA CONSULTANCY SERVICES
Experience certainty.

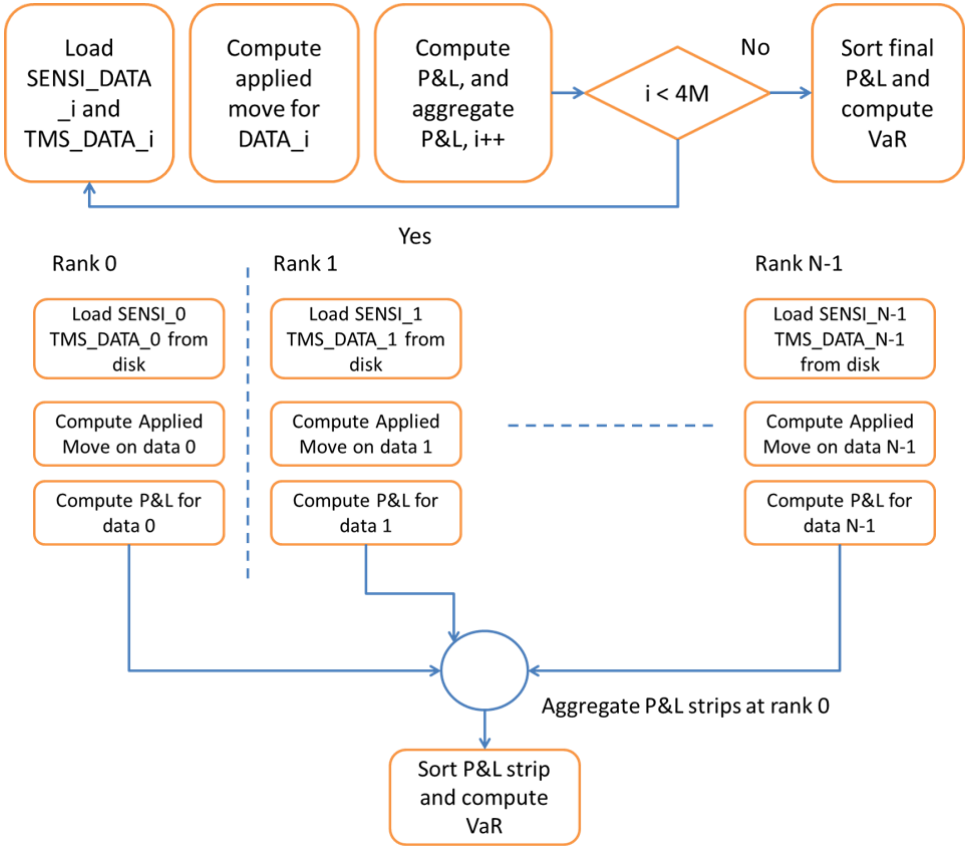
Value at Risk

HVaR Computations

- Retrieve historical data and generate future scenarios based on historical data-
- Re-valuate each contract in the portfolio for every possible future scenario
- Contract values for a particular scenario are summed to obtain a portfolio value for that scenario
- Evaluate profit and loss (P&L) numbers by comparing current portfolio value and portfolio values obtained for each scenario
- Compute portfolio VaR from P&L values at the desired confidence level

HVaR on GPU

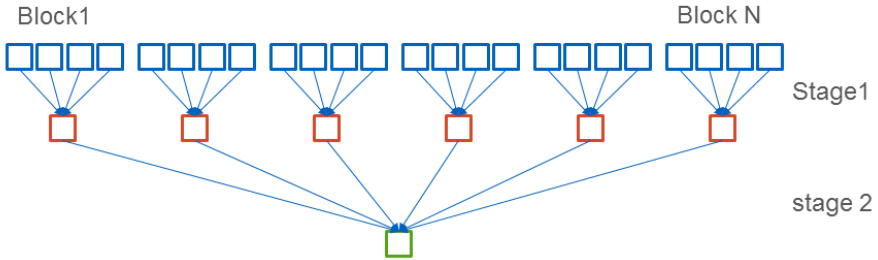
- Historical VaR
- 4 million sensitivities (IR & FX gamma and delta)
- 1 year of historical data for each
- Serial execution time 63 sec
  - Significant when number of computations 500~1000



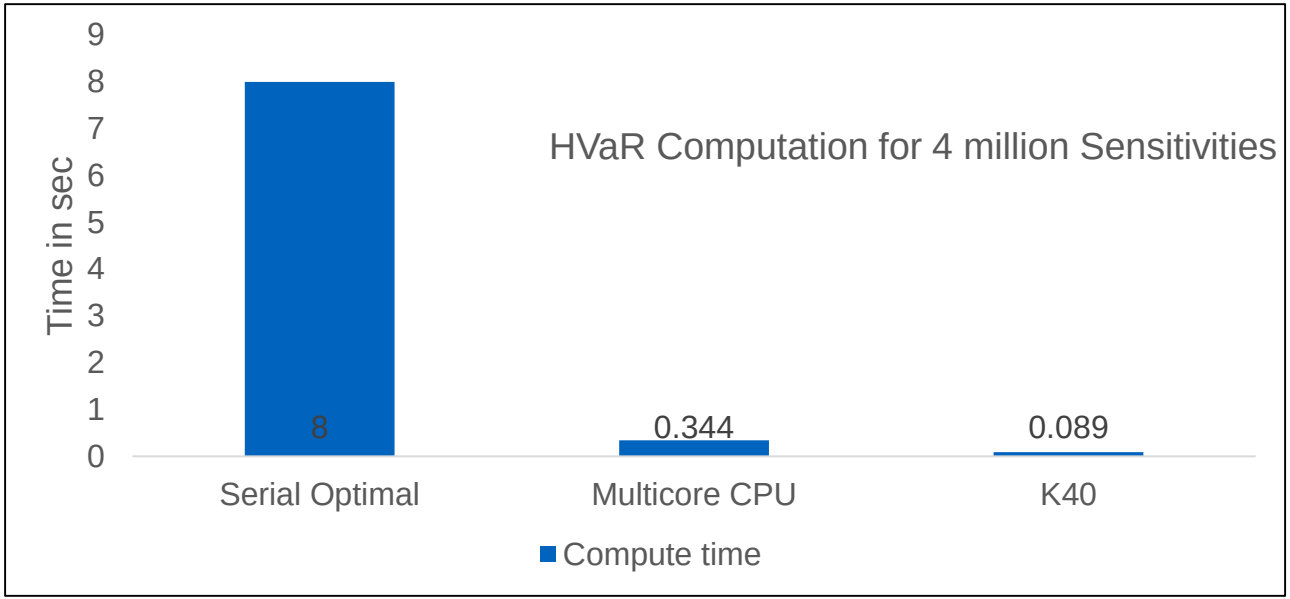
Performance Optimization

- Optimized serial code – 63 → 8sec
- Shared memory, Data access coalescing, Multi Stream for overlap
- Hybrid Computing – aggregation in two stages
  - Massive reduction on GPU
  - 2nd stage on CPU while GPU reduces bigger array

Data transfer/ Compute Overlap



Results



Conclusions

- Real Time Risk Management
  - Principal Component Analysis
    - Tri Diagonalization offloaded to GPU – 19x
- Incremental Risk Charge
  - Cumulative distribution
    - FFT computations offloaded to GPU – 13x
    - Hardware reduction 50 workstations → 1 server with 2 GPUs
- Value at Risk
  - Portfolio (Re) valuation
    - (Re) pricing of portfolio – 89x

Acknowledgement

Sincere thanks to Pradeep Gupta
NVIDIA Pune, India

TATA CONSULTANCY SERVICES
Experience certainty.

Thank You

IT Services
Business Solutions
Consulting