Financial Risk Analytics Acceleration Framework Using Intel FPGAs, Apache Spark, and Persistent DataFrames

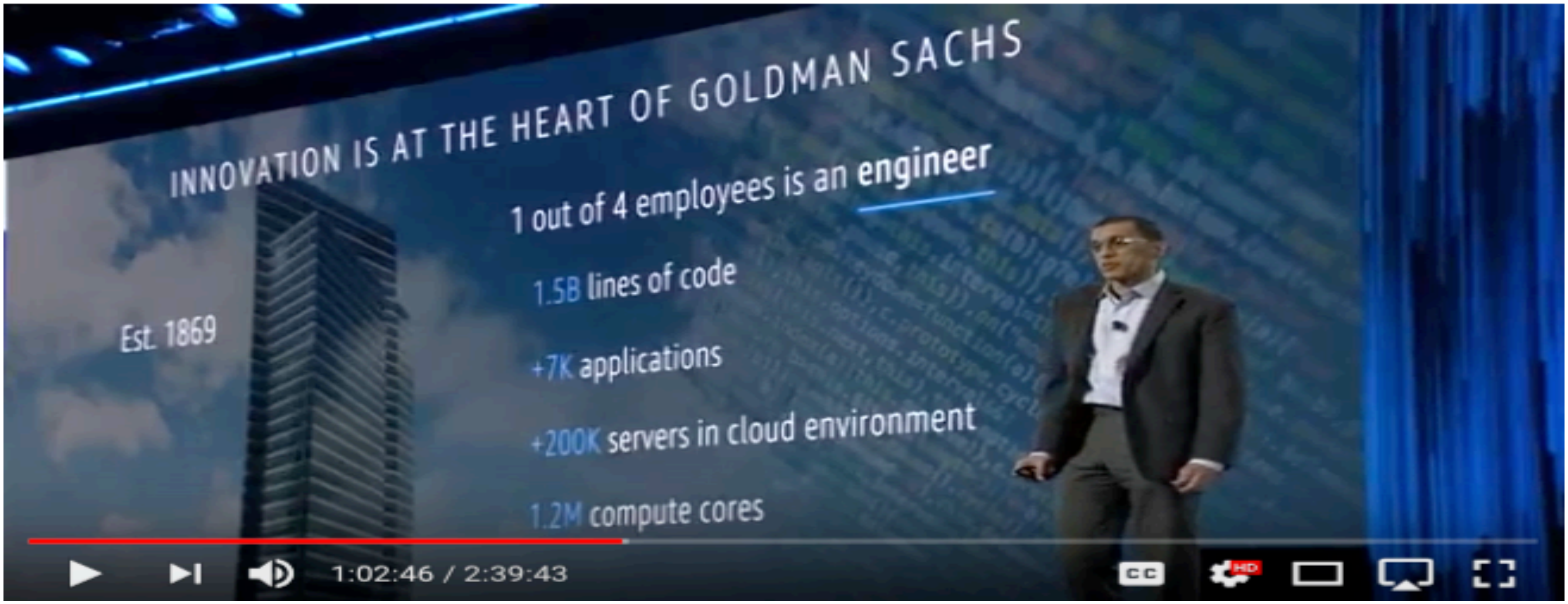
Reza Sadri, Levyx
Mutema Pittman, Intel

June 2018

#HWCSAIS15

Modern Financial Institutions are Cutting-Edge Technology Companies

Goldman Sachs at AWS Re:Invent Keynote 2017



Risk Management is a Critical Capability

Risk Management is Driving Insatiable Demand for More Compute

Market Need for Improving the Metrics of Financial Risk Analysis

Time = Money for financial firms

- Investing in new approaches using alternative data
- Budgets shifting from compliance to competitive advantage models

Shift to public cloud enables Risk Management for more areas:

- More data
- More diverse data
- More calculations
- Sharing live data becomes important

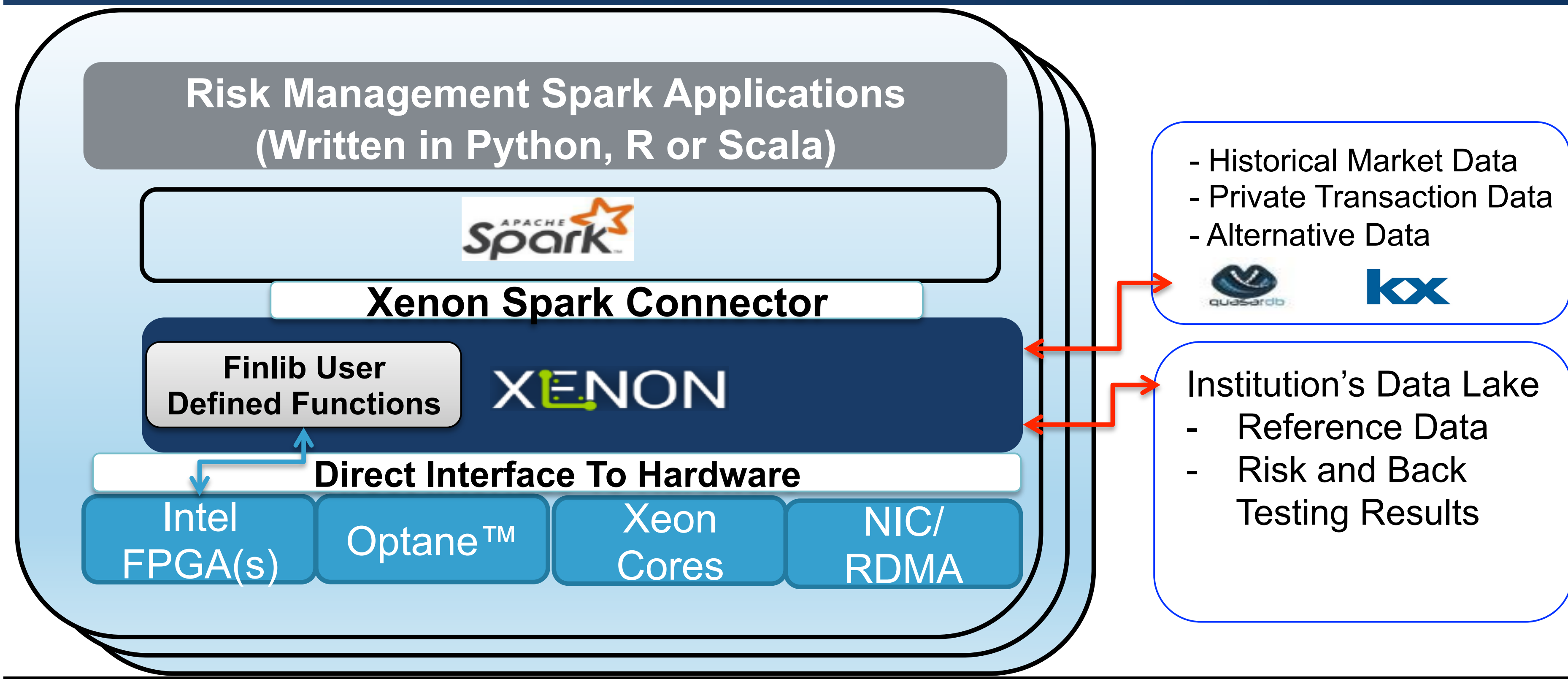
Case Study: Financial Risk Analytics

- Application: Risk analytics acceleration framework (financial backtesting)
- Current solution: Deploy a cluster of CPUs or GPUs with complex data access
- Challenge: Compute intensive, time consuming applications --10+ hours for financial backtesting
- Solution Value Proposition:
  - > 5x performance improvement using FPGA acceleration and SSD-optimized data engines
  - Financial Derivatives calculations of risk and pricing simultaneously
  - Integrated solution with Apache Spark, SSD access and FPGA implementation abstracted away

Why Persistent Dataframes are Important

- Reside on Flash, cached in memory → better use of hardware
- Same exact syntax
- No need to re-compute after the job is done
- Shareable across jobs

Using Levyx Xenon™ with Intel's Optane™ and FPGA/Finlib in a Risk Analytics Platform



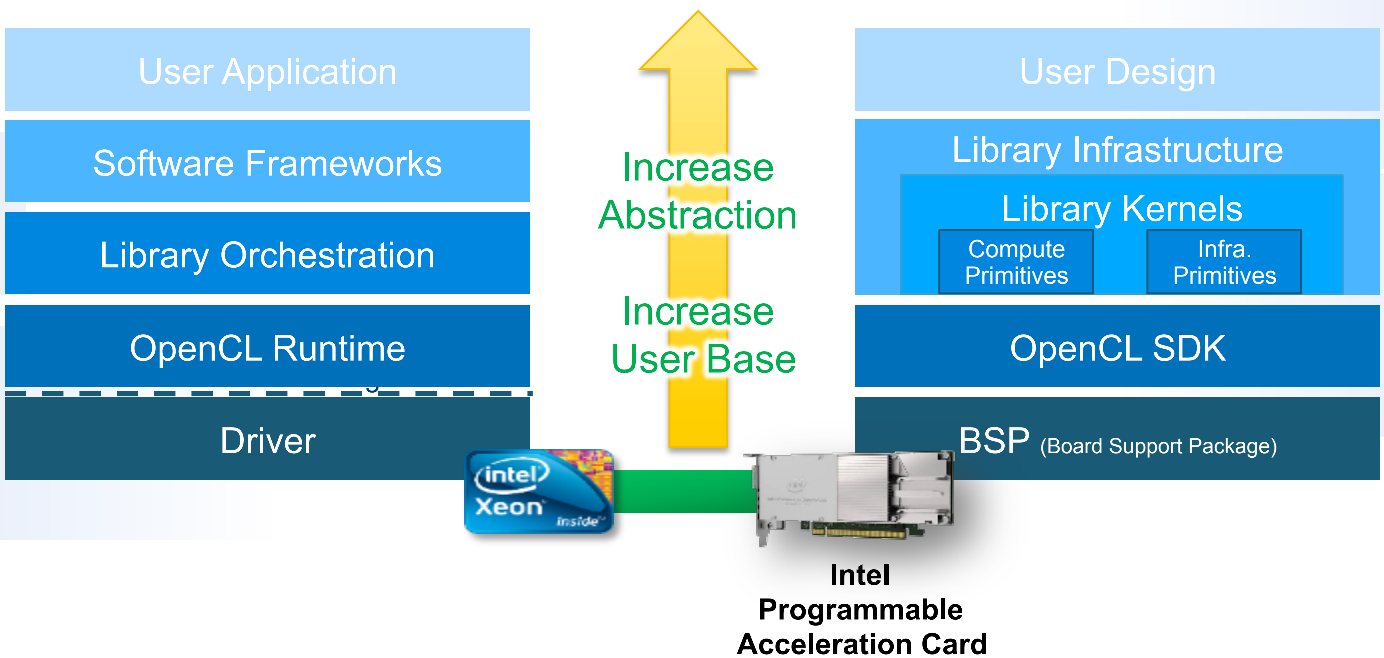
Levyx Xenon™ Combined With Intel FPGAs & SSDs is 3X Faster than Conventional Spark

SYMBOLS	# OF OPTIONS	XENON/FPGA TIME OPTIONS/SEC	SPARK CALCULATION OPTIONS/SEC
4	584,396,032	53,681,757	17,218,533
20	2,968,752,864	54,329,582	18,697,911
80	11,309,534,720	45,834,352	16,867,758

Symbols: The number of stock symbols used i.e. IBM, APPL, MSFT, etc.
Options: An individual "Black-Scholes Function" call to value a specific Call or Put option with a specific set of parameters as might be traded on the Chicago Board of Options Exchange

FPGA Acceleration Stack with Libraries

Libraries are callable from high level languages (e.g. C/C++, Python) and software frameworks (MKL) - making FPGA accelerated computation easy to access



FinLib – Functionality Roadmap

FinLib Phase 1, v1.0 Models		FinLib Phase 2, v2.0 Models		FinLib Phase 3, v3.0 Models	
Model	**Vanilla Products**	**Model**	**Complex Products**	**Model**	**Product**
Black-Scholes	European exercise, pricing & risk	OIS/Libor curve bootstrapping and fwd curve construction	Futures, forwards	Value at Risk	Risk calculations for portfolios
Black-Scholes-FFT	European exercise – market calibration	Default curve bootstrapping and survival curve construction	Credit default swaps	Expected Shortfall	Risk calculations for portfolios
Garman-Kohlhagen	European exercise – foreign currency	Credit models - reduced form and structural models	CDS options, CDOs, TRS, asset swaps	Expected Loss	Risk calculations for portfolios
Curran	European exercise – arithmetic averge	Interest rate models - e.g. Libor Market Model, SABR, SMM	Caps, floors, swaptions, Diffs, CMS/CMT	Scenario generation, simulation & evaluation	Risk calculations at the enterprise level
Cox-Ross-Rubenstein	American exercise – spot and futures	Foreign exchange models - e.g. Local and stochastic volatility and Levy	Barriers, binaries, Asians, lookbacks	Liquidity and collateral evaluation models	Risk calculations at the enterprise level
Bjerksund-Stensland	American exercise – very fast approximation	Equity derivatives models - e.g. LV, SV, SJV and stochastic time change	Compounds, choosers, range accruals, ELNs	Market risk	Risk calculations at the enterprise level
Merton	European exercise – on dividend paying stocks	Commodity derivatives - e.g. LV, SV and variance jumps, Gabillion	Forward starting structures, binaries, barriers	Operational risk	Risk calculations at the enterprise level
Kirk	European exercise – lognormal spread	Hybrid instruments - e.g. LV, SV, VG, coupled stochastic + short rate	Monte Carlo copulae, semi-analytic methods		
Bachelier	European exercise – normal spread	Calibration functions, PDEs solvers, Monte Carlo methods	Arbitrary payoffs		

Completion of all three FinLib phases will provide functionality equivalent to top commercial financial analytics libraries

Summary

- Using of accelerated standardized risk functions to compute JIT large-scale data tables using FPGAs yields breakthrough performance
- No custom coding required
- DRAM consumption “right-sized” using Flash/NVM
- Bypass kernel for I/O