OVERVIEW

- High Performance Computing
- Field Programmable Gate Arrays (FPGAs)
- Graphics Processing Units (GPUs)
- Timing and Synchronization
- HPC Applications in Financial Services
- Industry Adoption Challenges
High Performance Computing

- Low Latency
- High Throughput
- Big Data

- Solutions
  - Grid/cluster/multi-core
  - Hardware Acceleration
  - Storage
  - Timing and Latency Measurements
FPGA Overview

- Field Programmable Gate Array
- Customizable Integrated Circuit (IC)
  - ‘Reconfigurable ASIC’
  - Millions of configurable gates on a single chip
- Parallel Execution – 100, 1000, and more cores
- Low Power Usage
- No Operating System
- Hardware Description Language (HDL)
FPGA – Implement Any Digital Logic

www.WallStreetFPGA.com
FPGA Applications

- Aerospace and Defense
- Automotive
- Broadcast
- Consumer Electronics
- Data Centers
- High Performance Computing
- Industrial
- Medical
- Wireless and Wired Communications

www.WallStreetFPGA.com
GPU Overview

- Graphics Processing Unit
- Specialized CPU for graphics and analytics
- 100s of cores
- Programmed using OpenCL and CUDA
- General Purpose GPUs (GPGPUs)
GPGPU Applications

- Scientific Computing
- Bioinformatics
- Fast Fourier Transforms (FFTs)
- Image Analysis
- Parallel Computing
- Many others…
Other Chips?

- Tilera
- Analog Devices Blackfin
- ARM
- Clearspeed
- And others...

High barrier to entry for new chip companies
Look for hybrid (SoC) chips

www.WallStreetFPGA.com
Timing and Synchronization

- Driver is HFT on a Global Scale
- Latency Measurements and Monitoring
- Clock Strata (Stratum 0...)
- If you cannot measure it, you cannot improve it
- Heisenberg principle

www.WallStreetFPGA.com
Timing and Synch Protocols

- Network Time Protocol (NTP)
  - RFC 5905 (v4), RFC 1305 (v3)

- Precision Timing Protocol (PTP)
  - IEEE-1588v2 (2008)

- Global Positioning System (GPS)
Timing Challenges

- Software is at its limits
  - Cannot measure below microseconds
  - Jitter is unpredictable

- Probes always add delay to system
  - Hardware probe effects are easier to control

- Network Time Protocol (NTP) is not accurate enough
Latency Monitoring Technology

- Software probes, OS/chip specific APIs
- Hardware probes (e.g. FPGA), network card/switch
- Precision Timing Protocol (PTP) IEEE-1588v2
- Synchronized to GPS
  - Measurements can be correlated globally

www.WallStreetFPGA.com
HPC Applications in Financial Services

- Market Data Handling and Inline Analytics
- Algorithmic Acceleration
  - Option Pricing, Moving Averages, etc.
- Order Entry and OMS (e.g. FIX)
- Order Matching
- Structured News Analysis
- Timestamping, Latency Monitoring
- In-memory databases
- Regulatory (e.g. SEC/CFTC mandated or suggested)
  - Pre-Trade Risk Checks (SEC's 15c-3 Market Access Rule)
  - “Kill Switch”
## HPC Approaches

- Buy vs. Build
- Network Cards and Hardware
- Accelerator Cards
- RAM Banks
- Specialized Appliances
- Development Platforms – Build

www.WallStreetFPGA.com
Technology Closing Remarks

- Not all cores or clock cycles are equal
- Hybrid Computing – why only optimize the software when you can optimize both (hardware and software)
- Seek Contextual & Traceable Latency Measurements
- Explore HPC tools/solutions outside of Finance
HPC Adoption Challenges

- Cost-Benefit
- Software-centric
- Buy vs. Build

- Level of Abstraction
- Development Time

- Finding people who know both HPC and Finance
- Everyone is ‘the fastest’…
CONTACT INFO

terry@WallStreetFPGA.com

WallStreetFPGA.com

Twitter: @WallStreetFPGA

LinkedIn Group “Wall Street FPGA” (over 500 members)