

ALGORITHMS IN LOGIC



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FPGA Tick-To-Trade:
Fast, Flexible, and Feature Rich

John W. Lockwood, PhD, CEO

Trading Systems have evolved

- **From Specialists in the pit**

- Trade on behalf of clients
- Make markets by buying and selling
- Trade in seconds to minutes (1 to 60 seconds)



- **To Software Trading**

- Automated trading using software from the desktop
- Trade in milliseconds to seconds (0.001 to 1 seconds)



- **To Optimized Software**

- Bypass the operating system kernel
- Run in servers at co-located datacenters
- Trade in microseconds to milliseconds (0.000001 to 0.001 seconds)



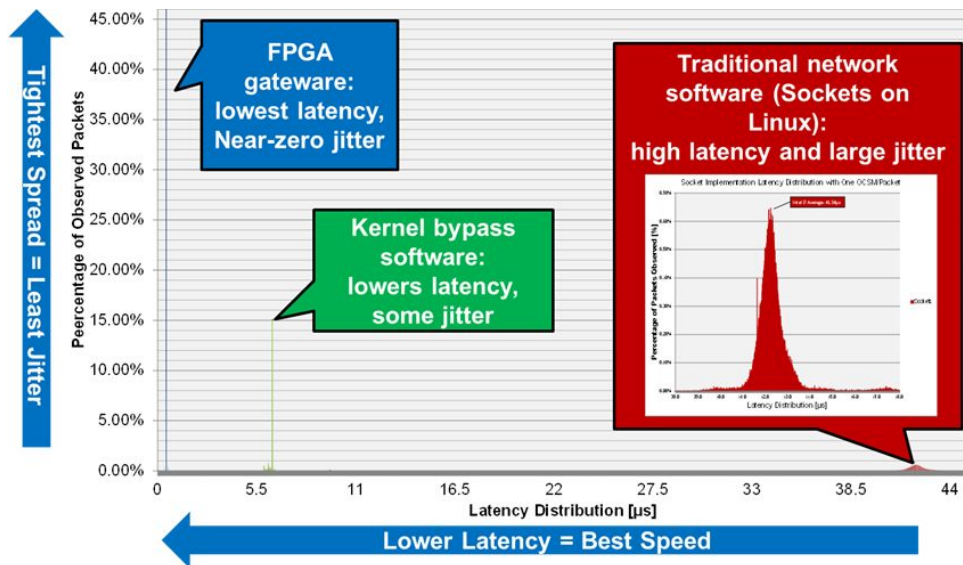
- **To FPGA-Accelerated Trading**

- Algorithms implemented in gateware instead of software
- Run on Field Programmable Gate Arrays (FPGA)
- Trade in nanoseconds using logic (< 0.000001 seconds)



Background: Winners and Losers

- Gateway is fast
 - Sub-microsecond Latency
- Gateway is deterministic
 - No jitter like software



- **Firms with Fast FPGA Trading Systems**

- Win most of the profits
- Use FPGAs to achieve fast Tick-to-Trade
- Consume raw, direct feeds from the market
- Instantly reacts to trading situations



- **Firms with software-only systems**

- Miss trading opportunities
- Losing alpha
- Drop out of the market



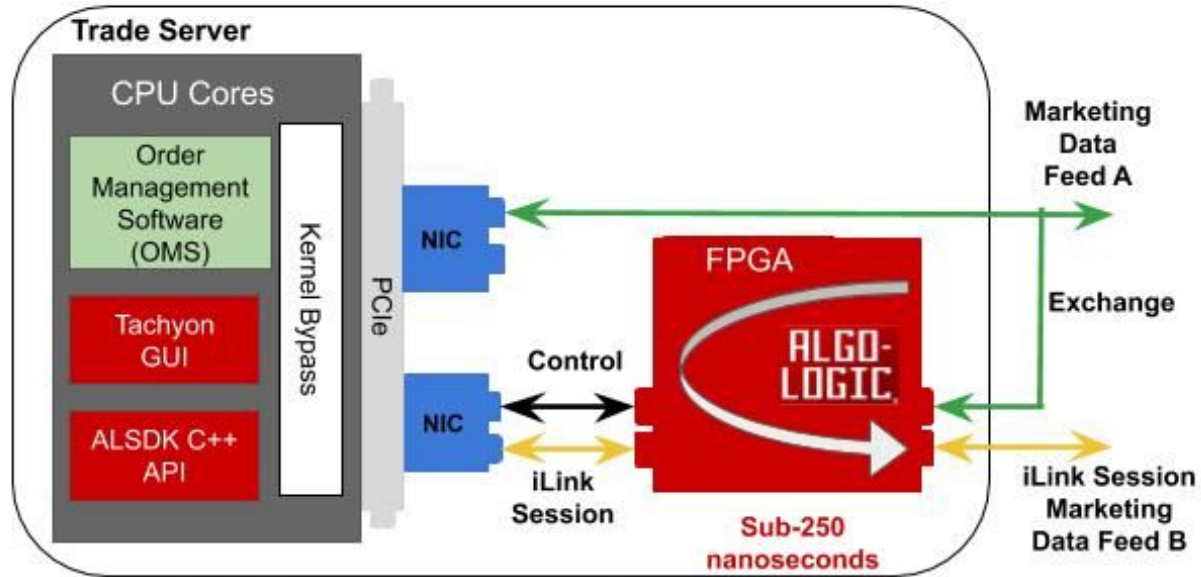
Algo-Logic enables you to trade faster

- **Fast**
 - Time-critical trade algorithms run in FPGA logic
 - Deep, sub-microsecond response time
 - Always respond faster than software
- **Flexible**
 - Easy transition from software to FPGA logic
 - Parameters defined in software and adjusted through APIs
 - Code written with High-level synthesis (HLS) generates business logic
- **Feature Rich**
 - React to book updates, public market data events, private reverse-path messages
 - Instantly associate actions with data using Key Value Store (KVS)
 - Support for the new CME iLink 3 binary orders

Deployment of an Algo-Logic Trading System

Algo-Logic's Tick-to-Trade Gateway

- Directly consumes MDP3 Market Data
- Sends orders on iLink or iLink 3
- Sub-250ns Trade Response Latency
- APIs and passthrough to software OMS

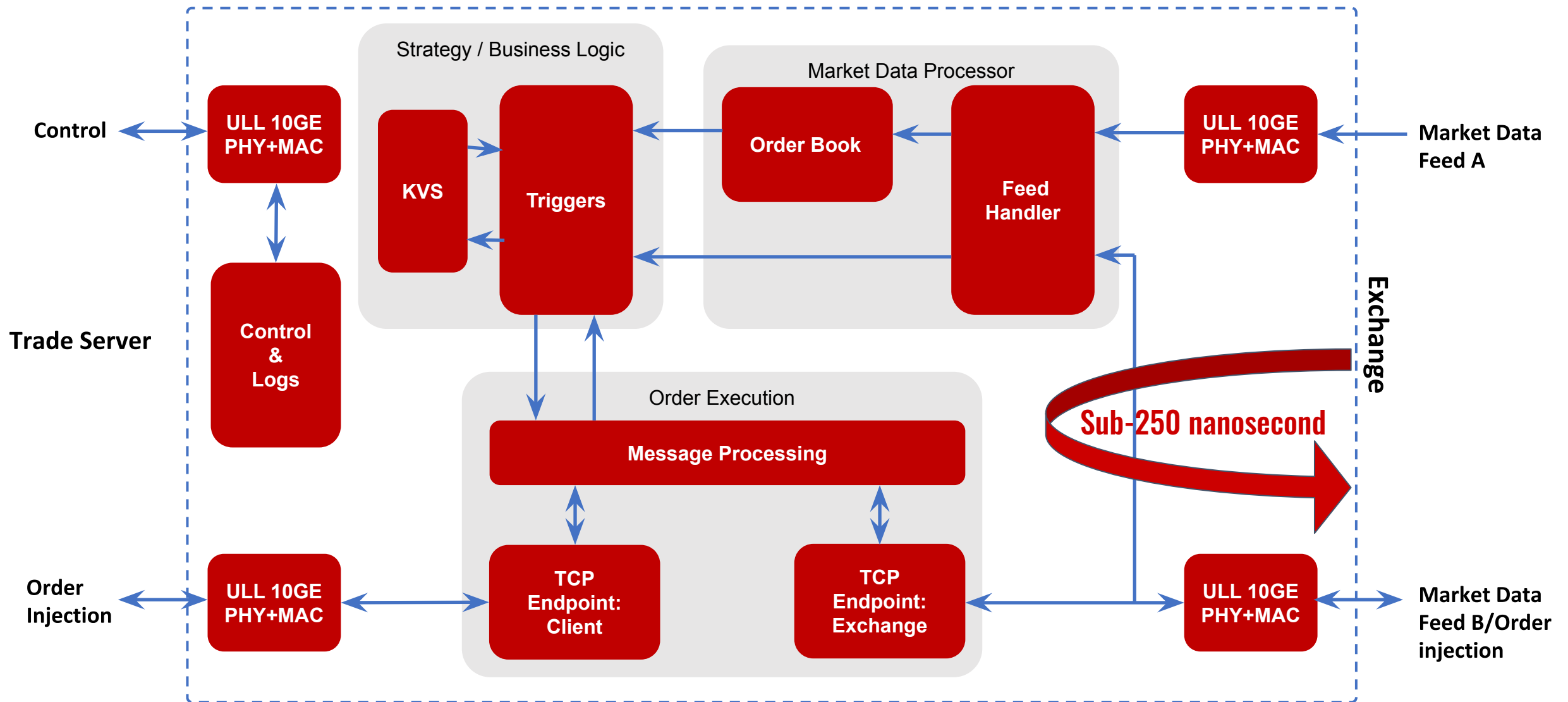


Hardware

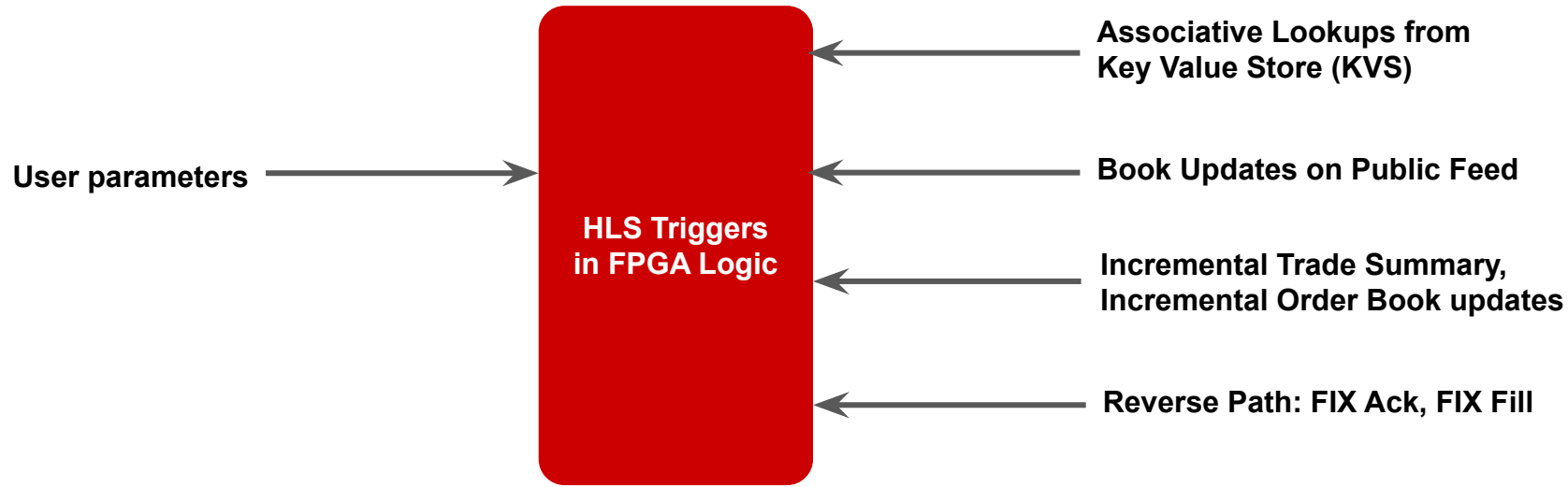
- Card Installed in standard rack-mount server
- Exablaze V5P with Xilinx Ultrascale+ FPGA
- 2 x QSFP => 8 x 10GE ports



Algo-Logic's Tick-to-Trade FPGA Gateway



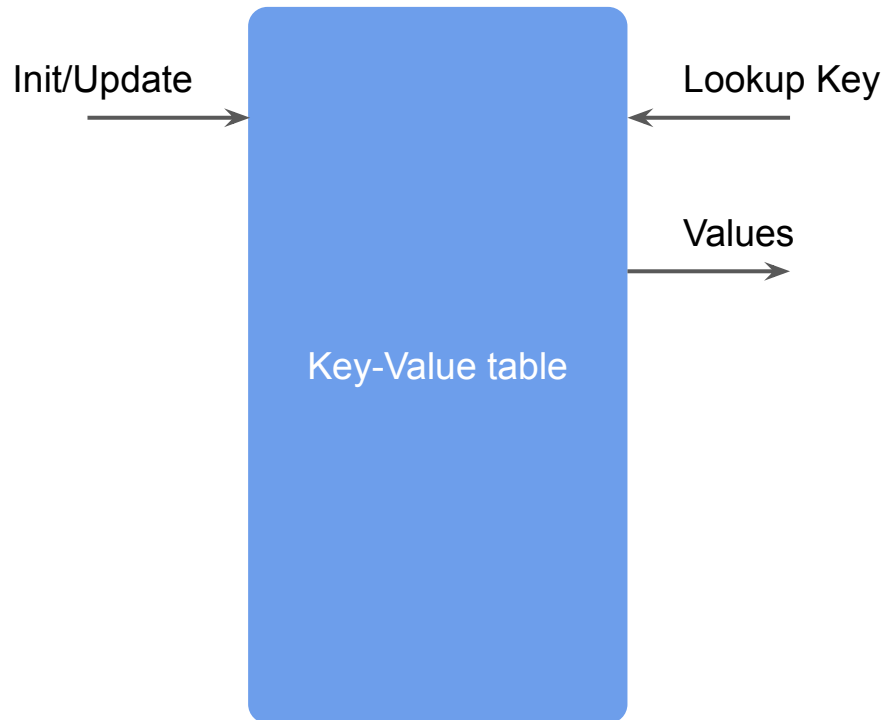
HLS Business Logic



FPGA Trigger Logic = fn{CME Market Data + FIX execution reports + User parameters + Key-value table}

CME Market Data	Incremental Trade update, Incremental order book update, Book snapshots
FIX execution reports	Reverse path information form FIX Ack, FIX Fill
Trigger parameters	Trigger parameters passed vai C++ API
On-chip KVS	Associate parameters for trading with related data

Key-Value Table for fast associative matching

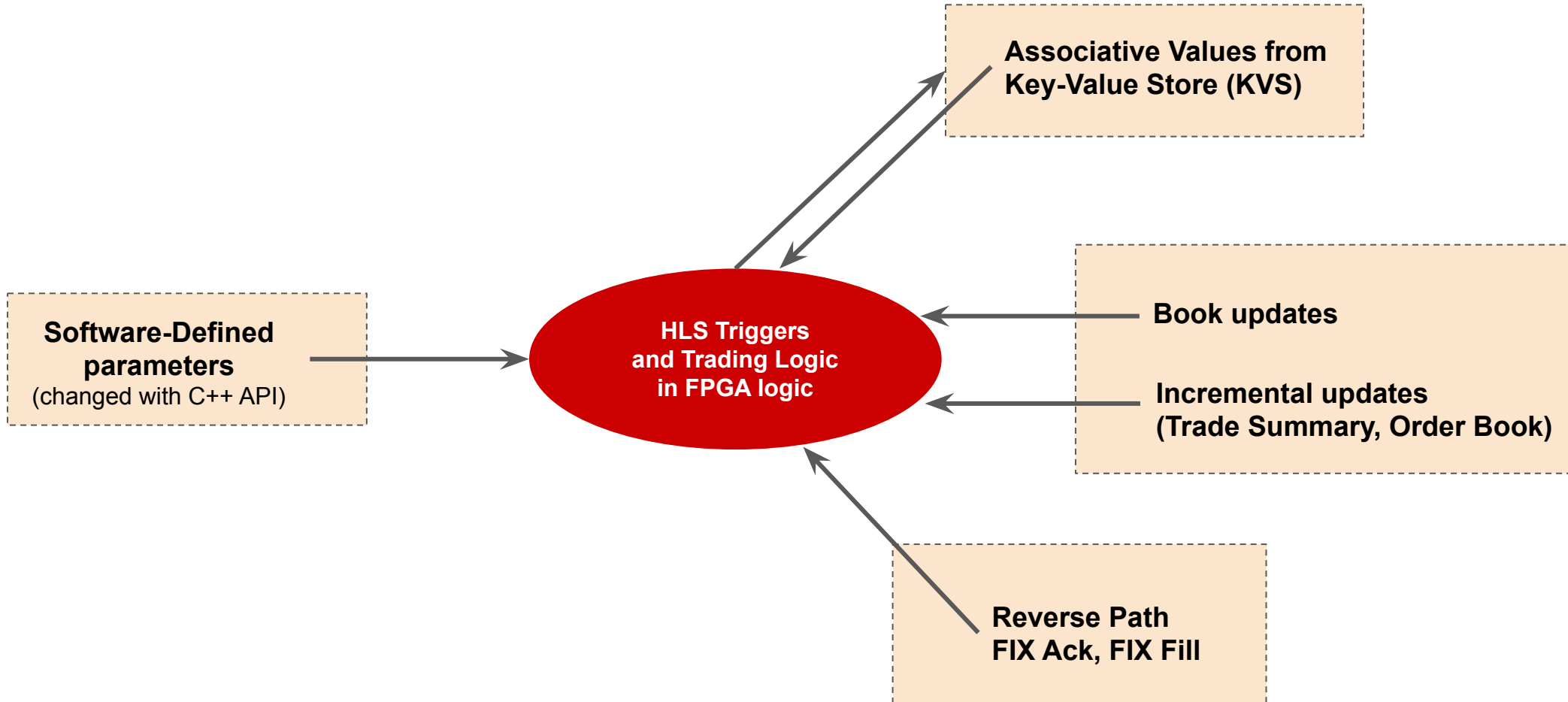


- Associates values with named keys
- Ultra-low-latency KVS entirely on-chip
- Example
 - Key = SecurityId in CME MDP
 - Value = <Prices, Qty, Trading parameters>
- Trigger Logic can operate based on key-value pair lookup
- Software update values via C++ API

Example events

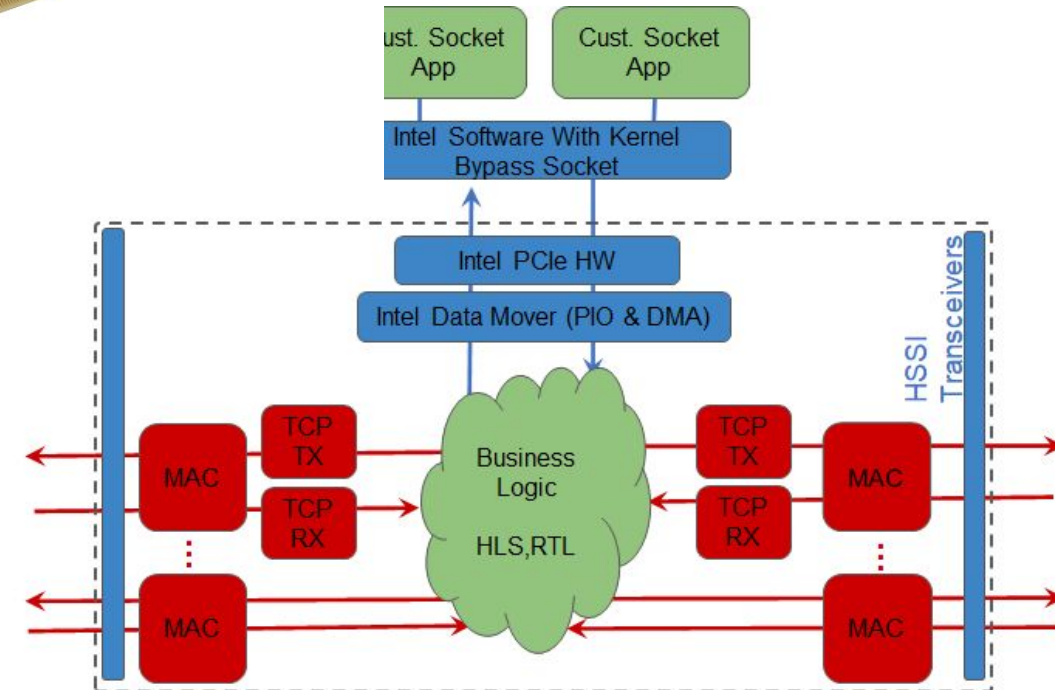
- Reverse Path
 - Complete FILL
 - Partial FILL
- Order Book => Change in Best Bid/Offer Price/Qty
- Market Data
 - Trade @price_level
 - A new level price level added
 - A price level deleted

HLS Triggers and Trading Logic



Pre-Trade Risk Checks on the Intel PAC D5005

- **Algo-Logic Provides**
 - Ultra-Low Latency MAC
 - TCP Endpoint in Logic
 - APIs for C/C++ software apps
 - Gateway interface to HLS
- **Intel Platform Enables**
 - Fast Data Mover to host CPU
 - High Level Synthesis (HLS)
 - Latest Stratix 10 FPGA
- **Combined Platform**
 - Ideal for hybrid trading
 - Pre-Trade Risk Checks (PTRCs)
 - Hardware/software applications



Summary

FPGAs trading systems are faster than software systems

- Respond to the market as fast as 250 nanoseconds

Algo-Logic Systems are flexible

- Software APIs integrate with software OMS
- HLS enables tuning of triggers and business logic

Algo-Logic's trading systems are feature rich

- Respond immediately to reverse-path ACKs and fills
- New support for binary encoded orders with iLink3
- Flexible associative lookups supported with on-chip Key Value Store

To learn more reach out to us at sales@algo-logic.com