FPGA-Accelerated Market Making for CME

ALGORITHMS IN LOGIC

ALGO-LOGIC®

HTTP://ALGO-LOGIC.COM

John W. Lockwood, CEO, PhD

STAC® SUMMIT

High technology in finance

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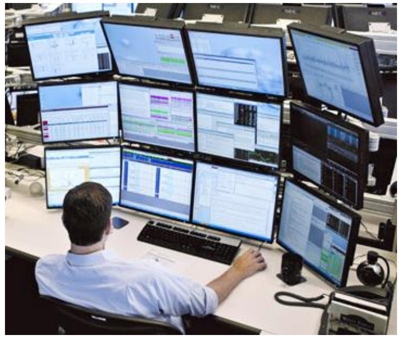
The Speed of Marketing Marking has Evolved

- **From Specialists in the pit**
  - Human speed response
  - Make markets by buying and selling
  - Trade in <u>seconds to minutes</u> (1 to 60 seconds)

- **To Software Trading**
  - Automated trading using software from the desktop
  - Trade in <u>milliseconds to seconds</u> (0.001 to 1 seconds)

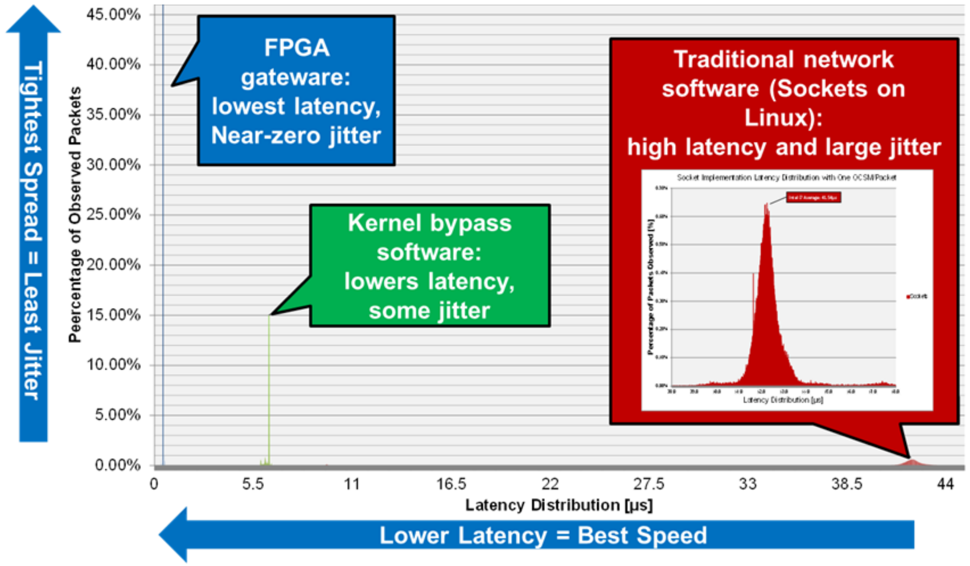


- **To Optimized Software**
  - Faster software with kernel bypass of the operating system
  - Run in servers at market co-Location datacenters
  - Trade in <u>microseconds to milliseconds</u> (0.000001 to 0.001 seconds)

- **To FPGA-Accelerated Trading**
  - Implement algorithms in logic
  - Run on Field Programmable Gate Arrays (FPGA)
  - Updates Quotes with Tick-to-Trade in <u>under a microsecond</u>

Competitive Marketing Makers Respond in Less Than 1 Microsecond

– Gateware in FPGA is fast
  • Sub-microsecond Latency
– Gateware is deterministic
  • Near-zero jitter
  • Like hardware, unlike software



From: Implementing Ultra Low Latency Data Center Services with Programmable Logic, *IEEE Micro* (Not a STAC Benchmark)

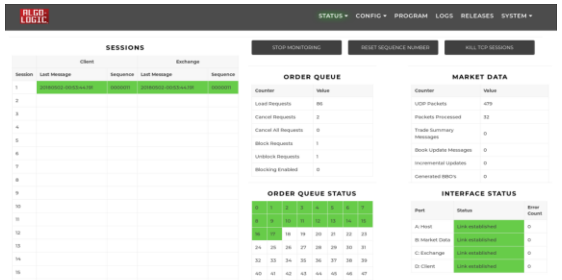
- **Firms with faster trading systems**
  – Use FPGAs for instant Tick-to-Trade
  – Instantly reacts to adverse situations
  – Win most of the HFT profits

- **Firms with slower trading systems**
  – Still rely on software to trade
  – Respond slowly to market changes
  – Lose alpha due to missed trades

Algo-Logic's FPGA-Accelerated Tick-To-Trade System

Trade Server

Algo-Logic GUI



Algo-Logic Management Software

Algo-Logic C++ API

Order Management System (OMS)

CPU Cores

NIC

10G 10G

RAM

FPGA

RAM

10G

10G

FPGA Card

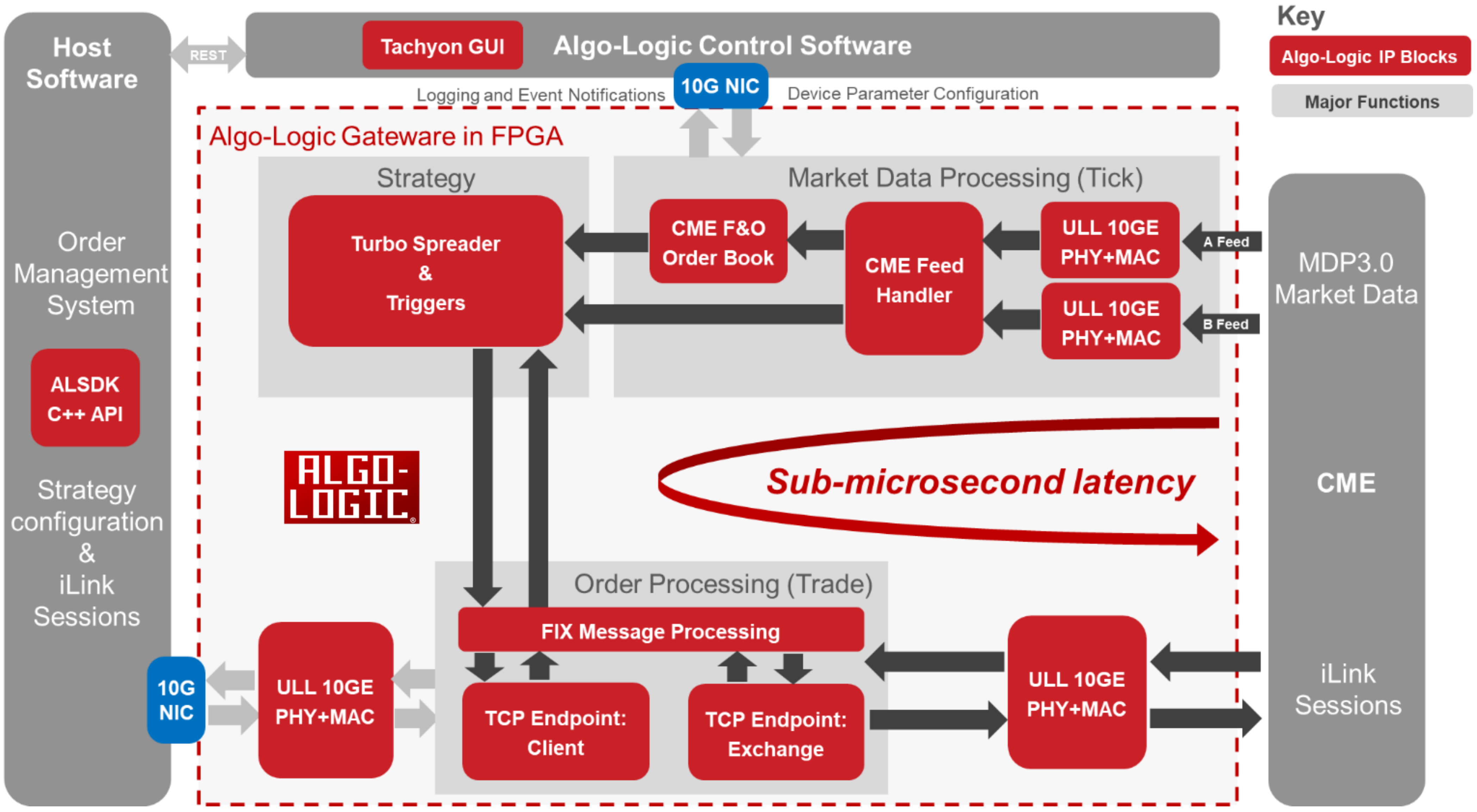
Exchange

Market Data

iLink Session

10GE Links

Algo-Logic's Futures and Options Trading System in FPGA



Available for trading on all CME group markets (CBOT, COMEX & NYMEX). Supports futures trading of:

Example: Algo-Logic's API to Accelerate Quoting in FPGA

Legs of the spread	CME Eurodollar Futures
Lean leg	GEM8
Lean leg	GEZ8
Quote leg	GEM8-GEZ8

```
finance::Spreader spreader; // Create spreader object

spreader.LeanParam1(securityID, priceMultiplier); // 1st Lean Leg parameter
spreader.LeanParam2(securityID, priceMultiplier); // 2nd Lean parameter

spreader.setTickSize(TickSize); // Quoting parameter initialization
spreader.setBidEdge(BidEdge);
spreader.setAskEdge(AskEdge);

// Pre-load Quote Bid and Ask order queues
spreader.setBidQuoteOrder(bid.queue, client, bid.ClientOrderId, SessionId, quoteSecurityId);
spreader.setAskQuoteOrder(ask.queue, client, ask.ClientOrderId, SessionId, quote.SecurityId);
```

Algo-Logic’s Trading Systems

Pre-built FPGA base systems for market making

- Achieves best-in-class trading latency
- Enables Quick Time-to-Market
  - No need to hire and train an army of Verilog developers

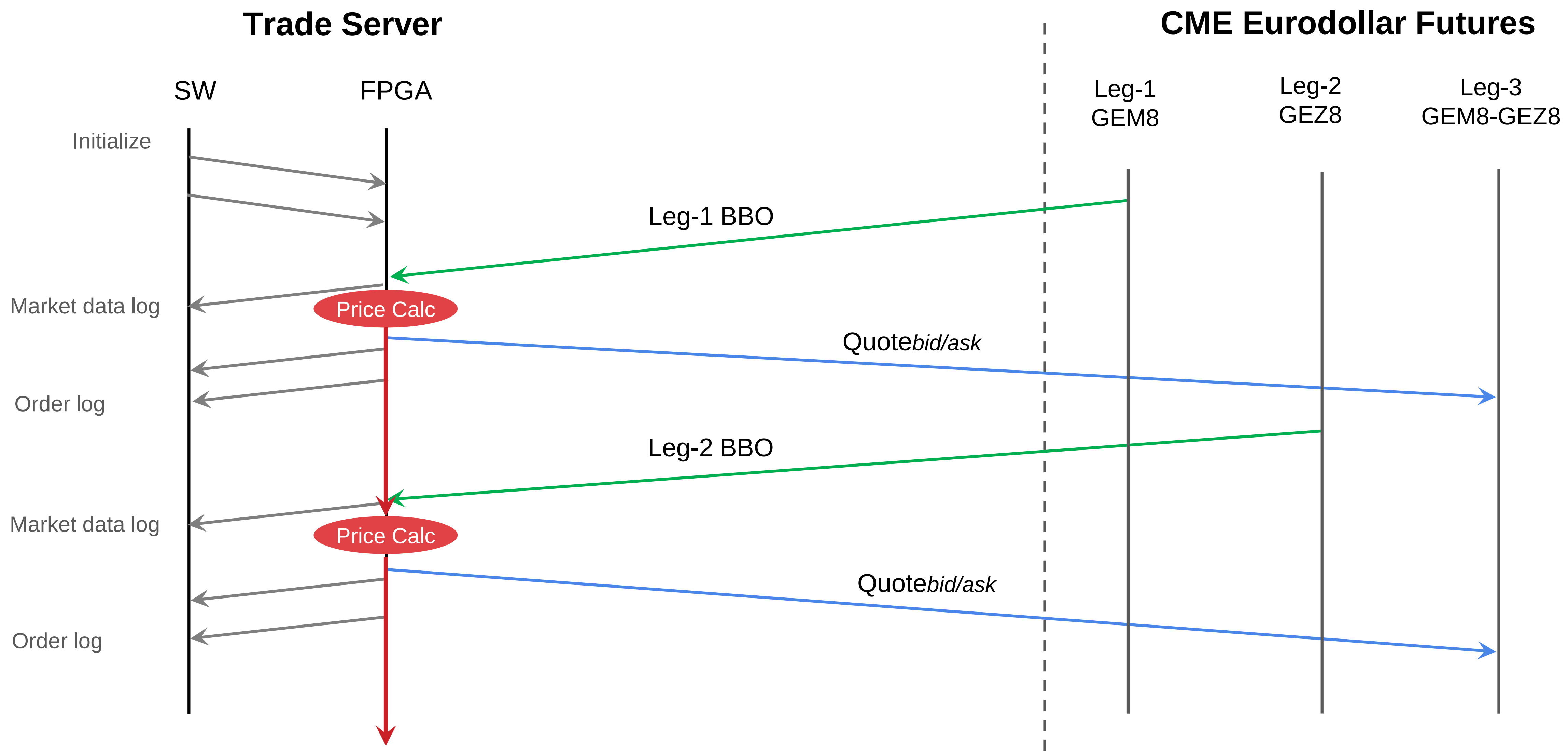
C/C++ Application Programming Interface (APIs)

- Interfaces to Existing OMS Software (in-house or commercial)
- APIs set up and control operation of pre-built FPGA modules

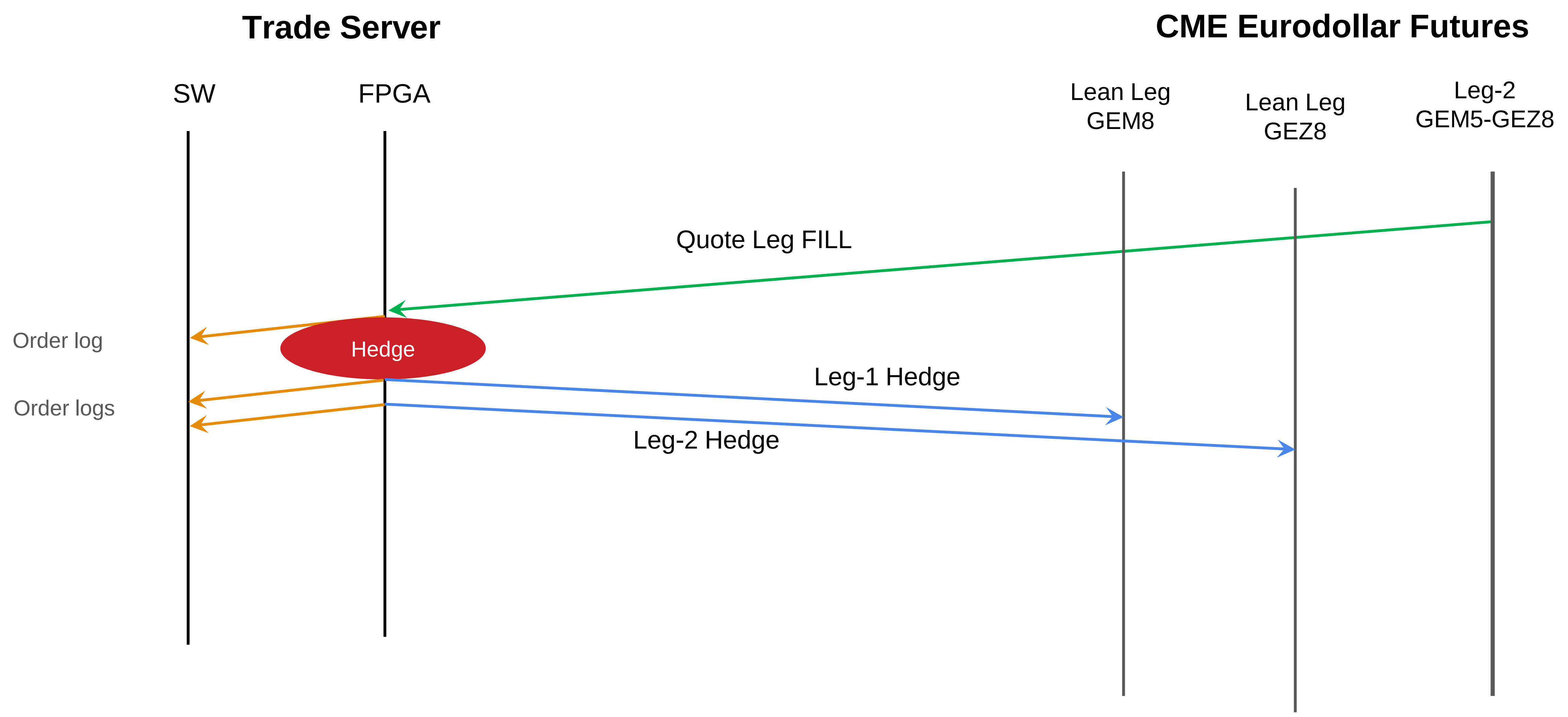
Web interfaces for initial control and configuration

- Easy to control and configure the FPGA
- Extensible RESTful APIs

Turbo Spreader: Quoting a Calendar Spread from two Outright Lean Legs



Hedging on a Filled Quote



Latest Features of Algo-Logic Turbo Spreader

- **Advanced Turbo Spreader:**
  - Multi-leg turbo spreading, quote cancel, and on fill triggers
  - Configurable lean legs with full support for quoting one or two leg of a spread or strategy
  - Quoting configurations allowing independent and simultaneous quoting instances
  - Support for CME products with up to 9 decimals of price precision
  - Single API call to inject preloaded quote or hedge order with modified price, quantity, and order IDs
  - Auto-reload enables multiple hedges and quotes to be sent using pre-loaded FIX order

- **Quote Cancellation:**
  - Ultra-low-latency mass quote cancellation
    - by product, instrument group, or each instrument

- **On fill trigger:**
  - Instantly reacts to market data or order fill
    - Whichever comes first, to trigger response order(s)

Come meet with Algo-Logic at the 2018 FIA Conference this week in Chicago
http://algo-logic.com/news-page