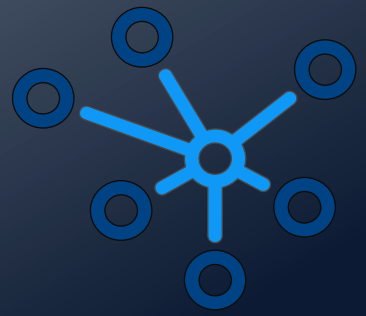


LMS

LIQUID-MARKETS SOLUTIONS

THE POWER OF THE POSSIBLE™

High-Speed FPGA Design for Electronic Trading

September 28, 2022

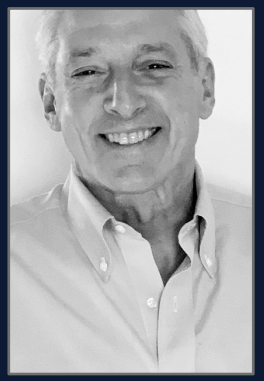
Deep Understanding of Finance Services & Technology

Senior Leadership

Seth Friedman
CEO & Product Vision

MD Morgan Stanley, Nomura
20+ years at the forefront of electronic trading

Established MS's electronic trading business and later designed, and in 2010, deployed Nomura's FPGA-based order validation system (NXT Direct) then the world's fastest DMA platform, only now surpassed by LMS Naros.Systems™.



Alex Stein, PhD
CEO, North America

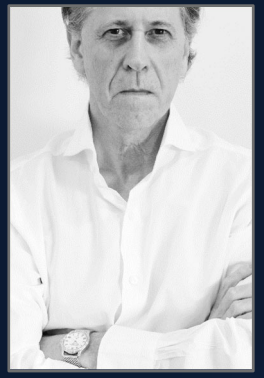
MD GM Equity Trading, Two Sigma
20+ years in FinTech

Built Two Sigma's global Alpha Capture program. Previously co-founded four startups including FarSight Financial, the first US Internet broker. Alex began his career in DEC's semiconductor group.

Ted Johnson
General Counsel

Partner Paul Hastings (Managing Partner, Japan), Orrick, Herrington & Sutcliffe LLP

25+ years as international deal lawyer in M&A, private equity, venture finance & tech-driven transactions. Japan Steering Committee, American Bar Association, Fulbright Scholar



Campbell Gunn
Chief Operating Officer

MD Goldman, Dresdner, T. Rowe Price
35+ years senior leadership at the most successful global financial services firms

Formerly Head of T. Rowe Price Japan, Asia CIO for Dresdner RCM, and Asian Equity Head at Goldman Sachs Asset Management. Award-winning equity portfolio manager.

Senior Professionals Who Defined, Managed, or Created Technology

Securities Trading Summary – Yesterday and Today

Nomura says the competition to send the order the fastest goes back to the old days of pit trading, but today the edge is not won by the tallest and loudest person in the pit but by the brokerage with the fastest and most robust technology.

"Once a decision's been made it's important to get that decision on to the market as quickly as possible and that's been the goal for trading forever [regardless of the type of trading you do]," said Seth Friedman, head of stat-arbitrage prime services for Asia-Pacific at Nomura.

Financial Times, December 16, 2010

Securities Trading Purpose

Primary Market

- Purpose: Fund Business Activities
- New Securities Issuances
- Indirect Sales by Issuer to Investor(s) via a Broker
- Direct Sales by Issuer to Investor(s)
- Issuer Paid for Purchase by Buyer

Secondary Market

- Purpose: Investment Profit
- Purchases or Sales of Previously Issued Securities
- Occurs on Public Markets or Privately Negotiated Over-the-Counter
- Seller Paid for Purchase by Buyer

Securities Trading History

Key Dates

- 1309: First Stock Exchange Established (in Bruges) by the Van der Buerse Family
- 1540: First Commodities Exchange Established in Lyon
- 1611: Amsterdam Stock Exchange Established; Dutch East India Company First Publicly Traded Company
- 1697: First Futures Exchange Established in Osaka (Dojima Rice Exchange)
- 1698: First Stock Exchange Established in London at Jonathan's Coffee House
- 1790: First Stock Exchange Established in the United States (Philadelphia Stock Exchange)
- 1867: Invention of Ticker Tape to Distribute Securities Price & Volume Data via Telegraphic Lines
- 1985: Morgan Stanley Implements Automated Multi-Day Holding Arbitrage Strategy
- 1986: London Stock Exchange Introduces Trading via Electronic System
- 1995: Swiss Exchange Introduces Trading via Electronic System
- 1999: Tokyo Stock Exchange Trading Floor Closed; All Transactions Conducted via Electronic System
- 2005: New York Stock Exchange Introduces Trading via Electronic System

Securities Trading History

Trading Pit

Dojima Rice Exchange, Osaka Japan

Jonathan's Coffee House, London England

Chicago Mercantile Exchange, Chicago United States

Securities Trading History

UBS Trading Floor – Stamford Connecticut

1998

2008

2016

Securities Trading Communication Infrastructure

Ticker Tape Machine

Dealerboard

Mainboard in Immersion Cooling Tank

Securities Trading Venues

Securities Exchange

A facility, approved and regulated by a government authority, where publicly-listed securities, including stock, bonds, warrants, electronically tradable funds, options, futures, and other financial instruments are listed, bought and sold. Regulated exchanges must set, and enforce, rules and regulations, regarding listing criteria. Exchanges are required to disseminate order book information to exchange participants and data vendors and are therefore considered to be “lit”.

Alternative Venue

Alternative venues are facilities which may, to a greater or lesser degree, be approved and regulated by a government authority. Securities are not listed on alternative venues. In regard to securities trading, there is little difference, from a practical standpoint, between an alternative venue and an exchange. Alternative venues are required to disseminate order book information to exchange participants and data vendors and are therefore considered to be “lit”.

Dark Pool

A type of alternative venue which is privately operated and for which access controlled and restricted by the operator. Order book information is not disseminated to participants or data vendors and therefore are considered to be “dark”. Price discovery is opaque and trades must occur within a certain percentage of the then current price on a securities exchange. All trades must be disseminated, albeit with a significant delay, via designated reporting mechanisms.

Securities Trading Principles

Buy & Hold

Summary

Open	3,605
Close	6,420
ChgNet	2,815
Shares	1,000
OpenValue	3,605,000
CloseValue	6,420,000
P&L - Gross	2,815,000
Broker Fee	282
P&L - Net	2,814,719

Securities Trading Principles

Buy w/Daily Optimization

Summary

Open	3,605
Close	6,420
ChgNet	2,815
Shares	1,000
OpenValue	3,605,000
CloseValue	6,420,000
P&L - Gross	3,958,410
Broker Fee	396
P&L - Net	3,958,014

Daily Capture Increases P&L 40.62%

Securities Trading Principles

Overnight

Securities Trading Principles

Intraday

Securities Trading Exchange Outages

Intraday

Tokyo Stock Exchange paralysed by hardware glitch in worst-ever outage
October 1, 2020

LSE chief pledges to resolve ‘unacceptable’ Eikon outages
August 6, 2021

After Mishaps, Nasdaq Loses Standing to Rivals
August 22, 2013

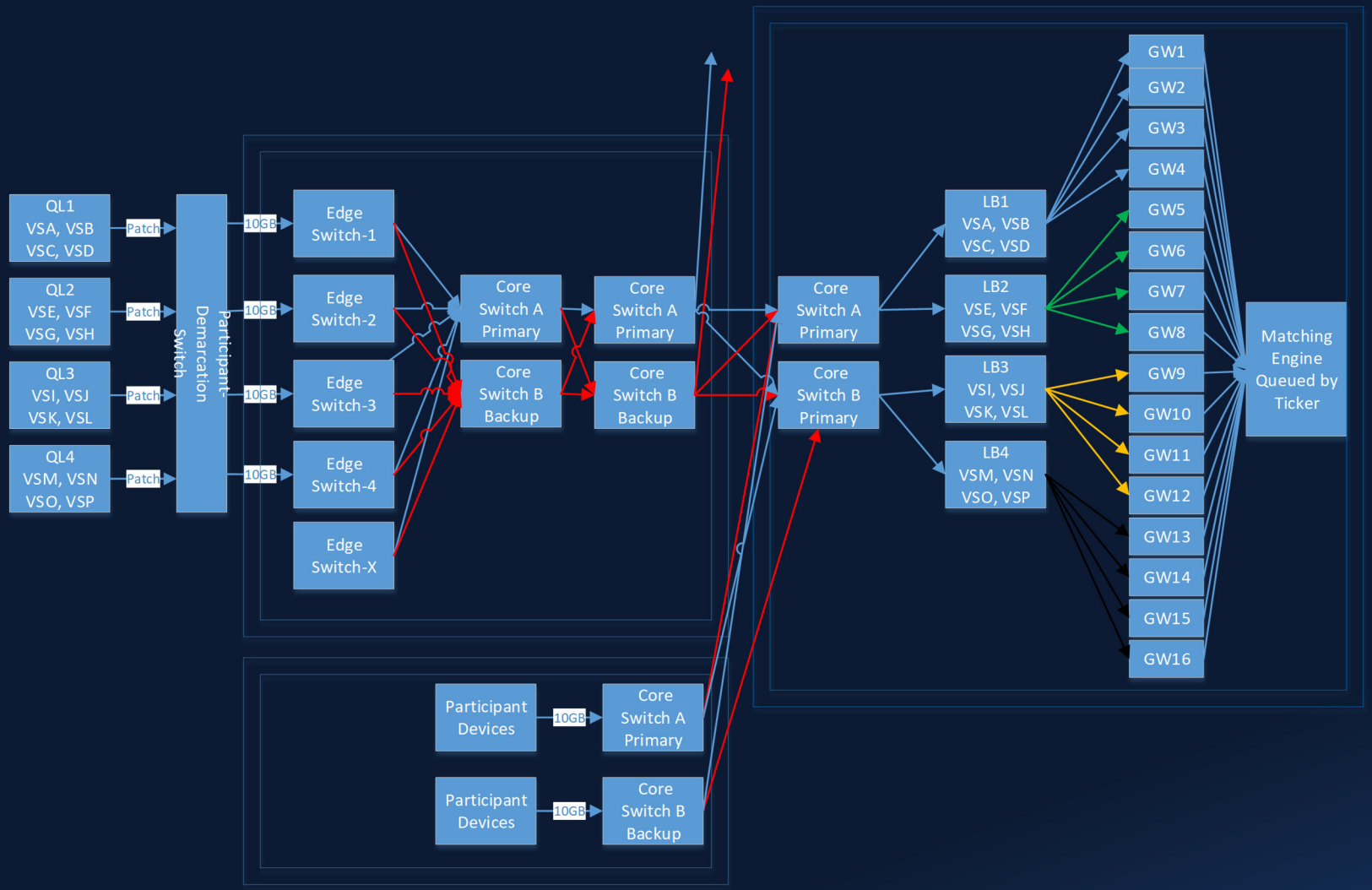
Hong Kong’s exchange operator blames ‘software issues’ for chaos that brought derivatives trading to a standstill
September 5, 2019

The Stock Market Bell Rings, Computers Fail, Wall Street Cringes
July 15, 2015

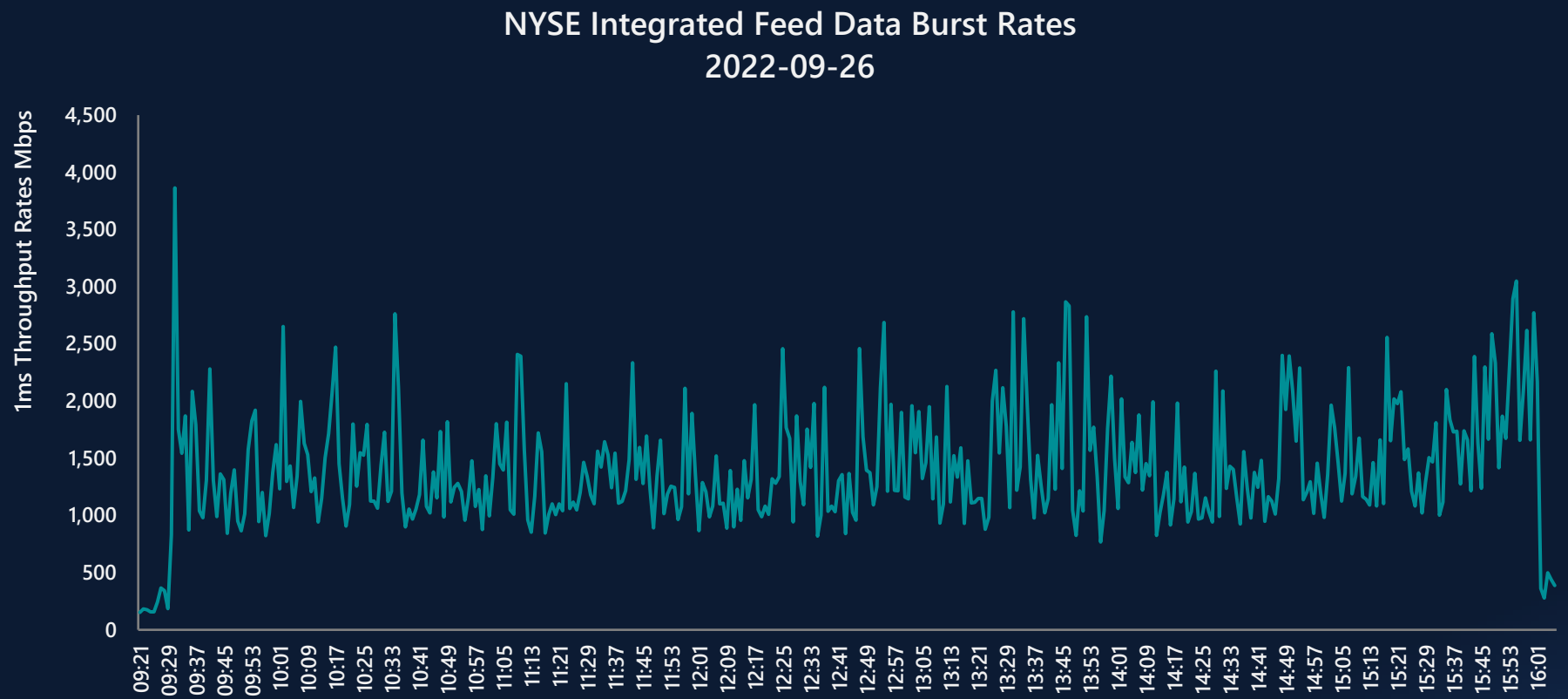
Merrill Lynch Japan at root of Tokyo Stock Exchange system glitch, informed sources say
October 9, 2018

Deutsche Boerse says software glitch caused trading outage
July 1, 2020

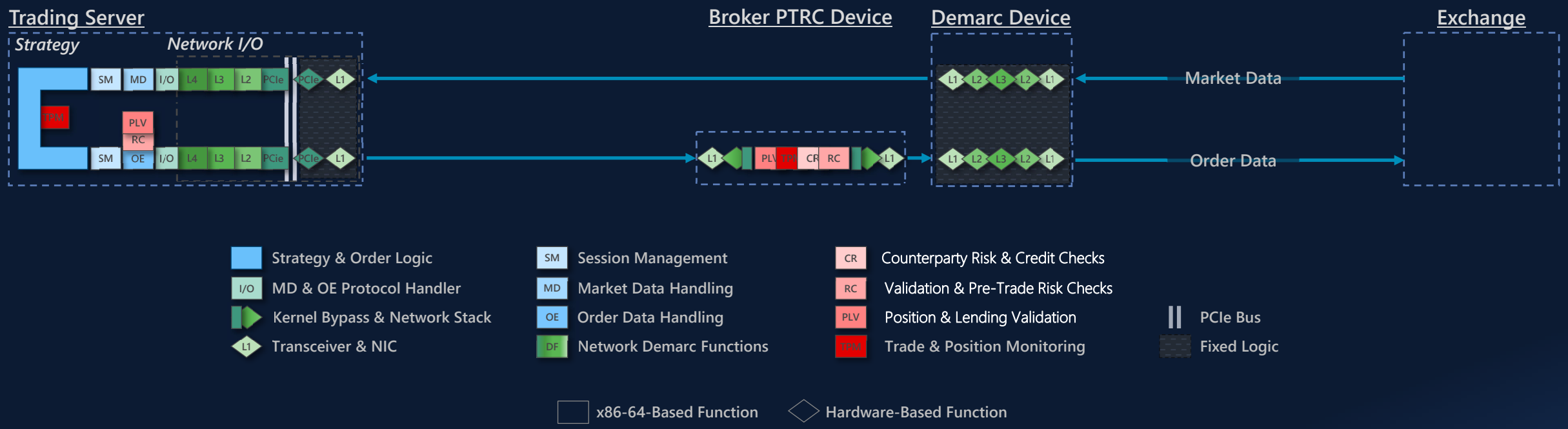
Securities Trading Exchange Infrastructure



Securities Trading Significant Small Payload Transmissions



Problem: The Totality of Network Latency Exceeds 10.5µs



“Why The $#!&%$ Are My Orders Not Getting Done?”

Why Indeed?

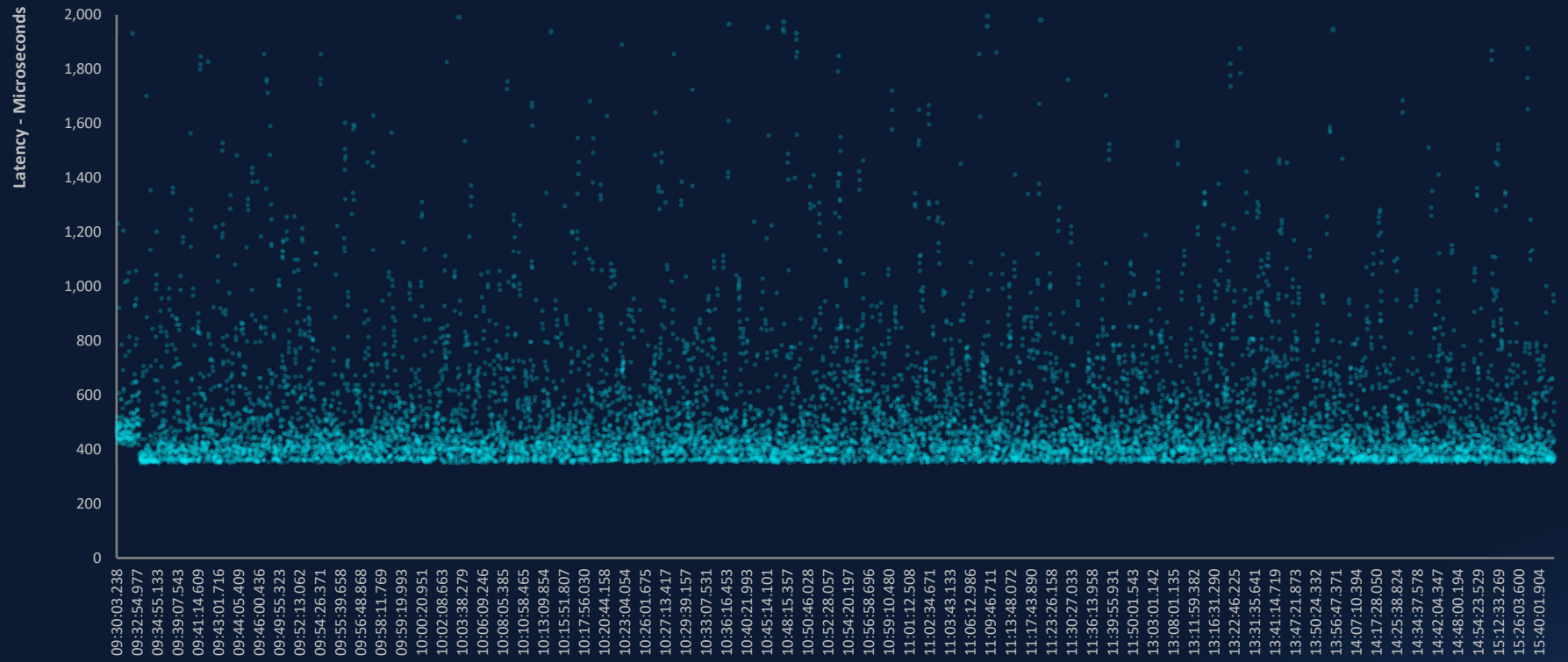
Claims…

- “Sub-microsecond Latency”
- “Near-zero Jitter”
- “Highly Scalable”
- “Predictable, Deterministic System Performance”
- “Industry’s Highest Message Rates”
- “…ultra-high bandwidth, ultra-low latency, ultra-scale connectivity…”
- “…superior small packet performance with sub-microsecond hardware latency…”

The Truth Differs From Their Claims…

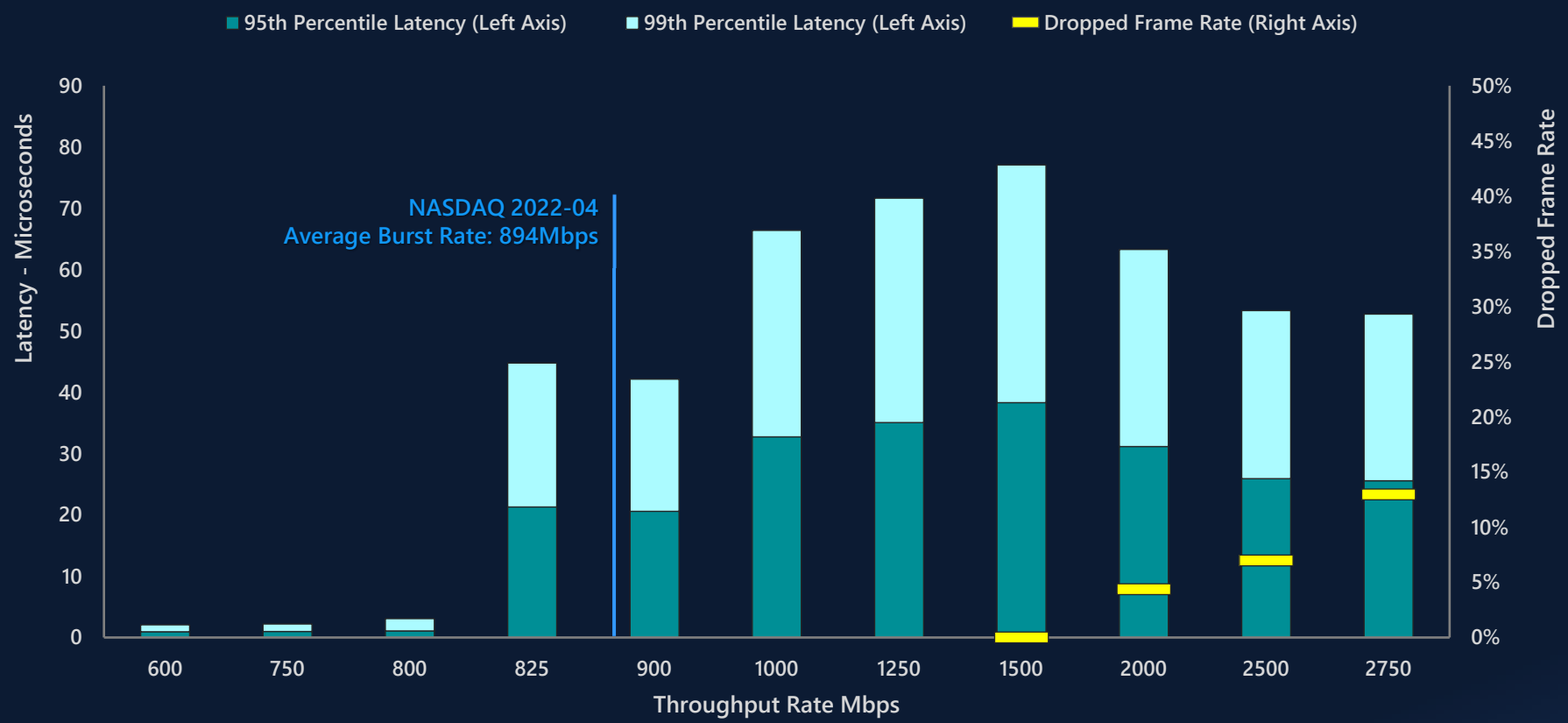
Problem: CPU-Centric NICs

All Day: Open to Close: New Order Acknowledgement RTT



It's the Network Stack

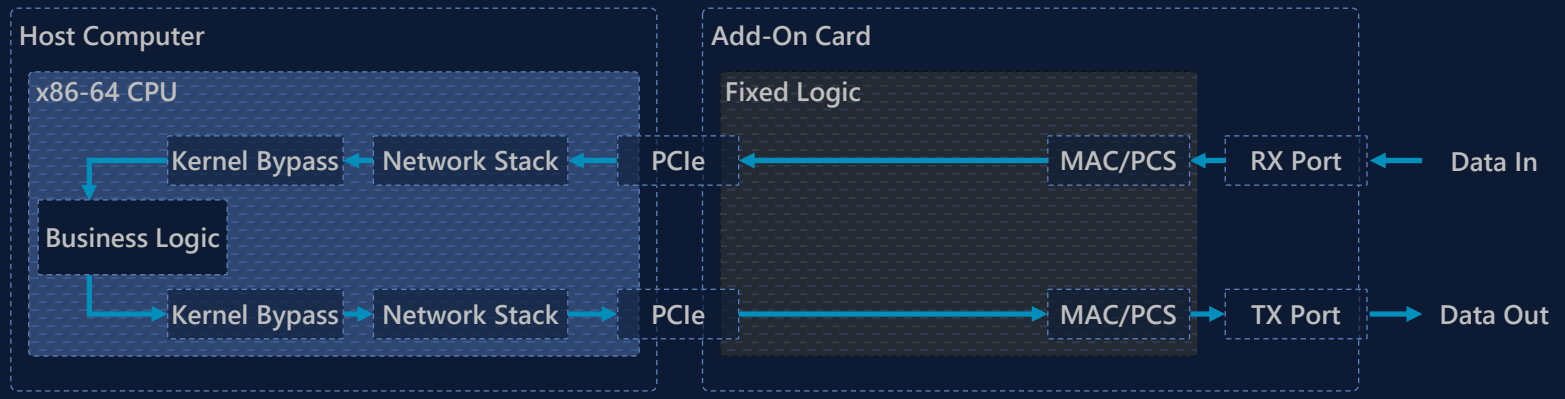
Problem: CPU-Centric NICs



Tested By Naros.TaSR™

20 Step Variable Rate Run | 50,000 Frames Per Run | 1 Million Frames | 64B UDP Payload | L2 SOF to SOF | Excluding Business Logic | 10-Frame Buckets

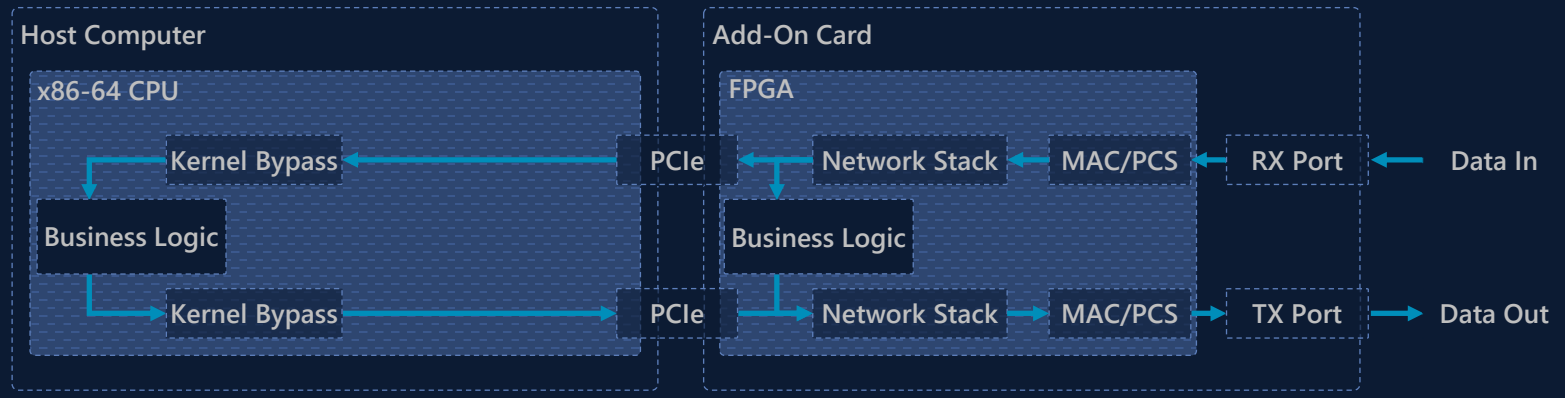
Problem: CPU-Centric NICs



- General-Purpose Network I/O
- CPU-Centric Compute & Transport
- PCIe-Dependent Data Receive & Transport
- Software-Implemented Logic
- Microsecond-Scale Performance Capability

CPU-Centric Transport & Compute Constrains Performance

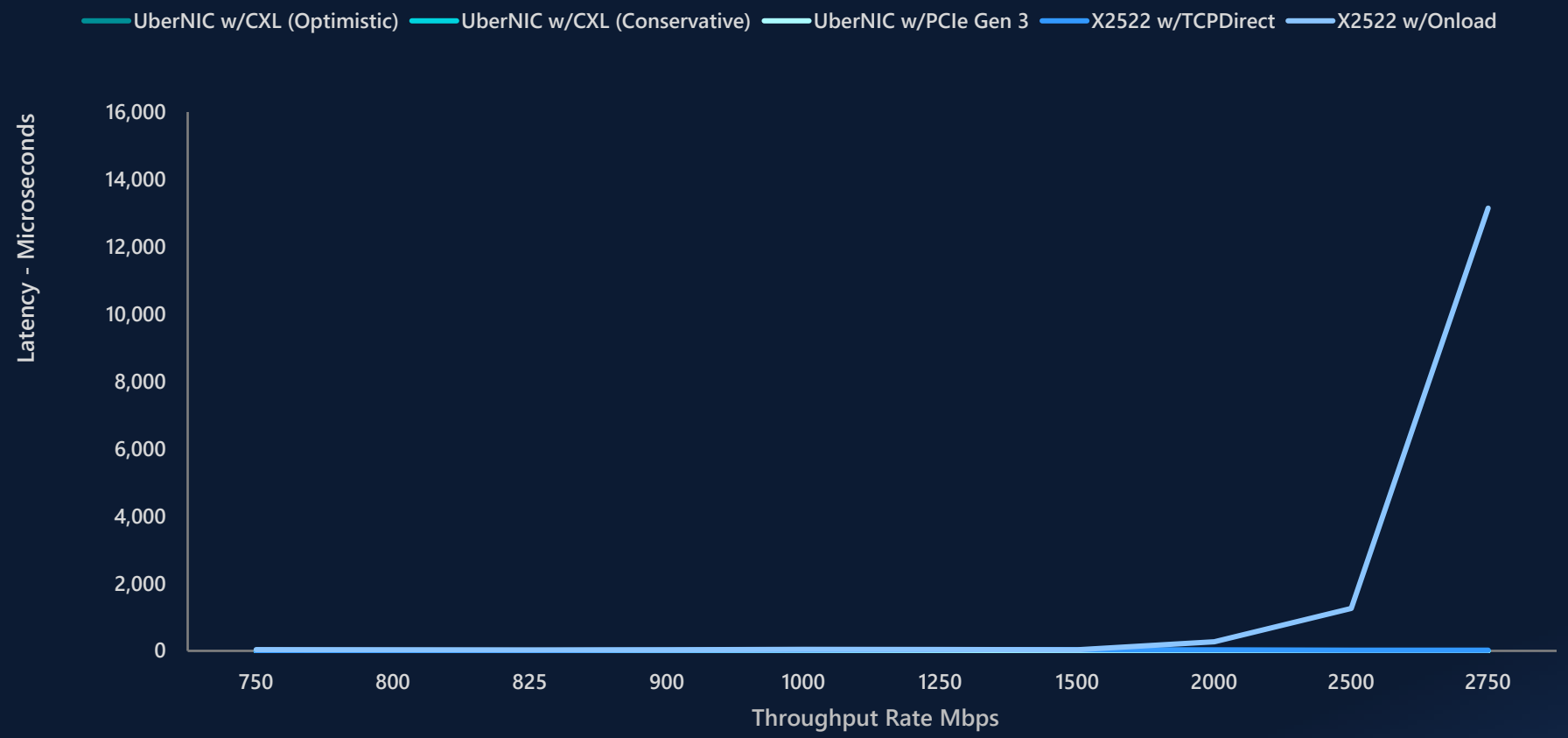
Solution: FPGA-NAC General Purpose Ethernet Adapter



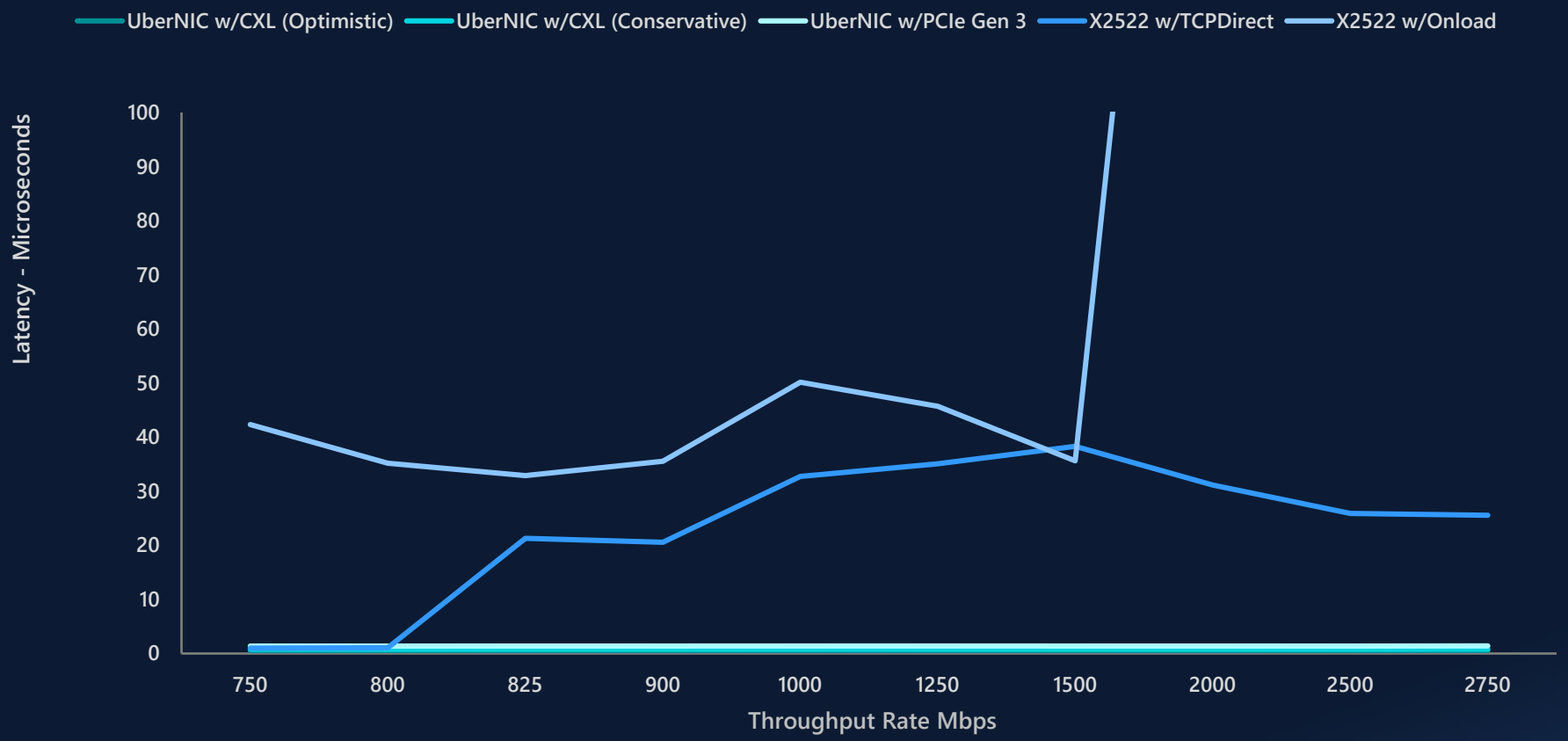
- Specific-Purpose Ultra-Performant Network I/O
- NAC-Centric Transport + NAC-Centric & CPU-Centric Compute
- PCIe-Independent Data Receive & Transport
- Field Reprogrammable Logic Implemented Directly on Silicon
- Nanosecond-Scale Performance Capability

FPGA NAC-Centric Transport & Compute Unleashes Performance

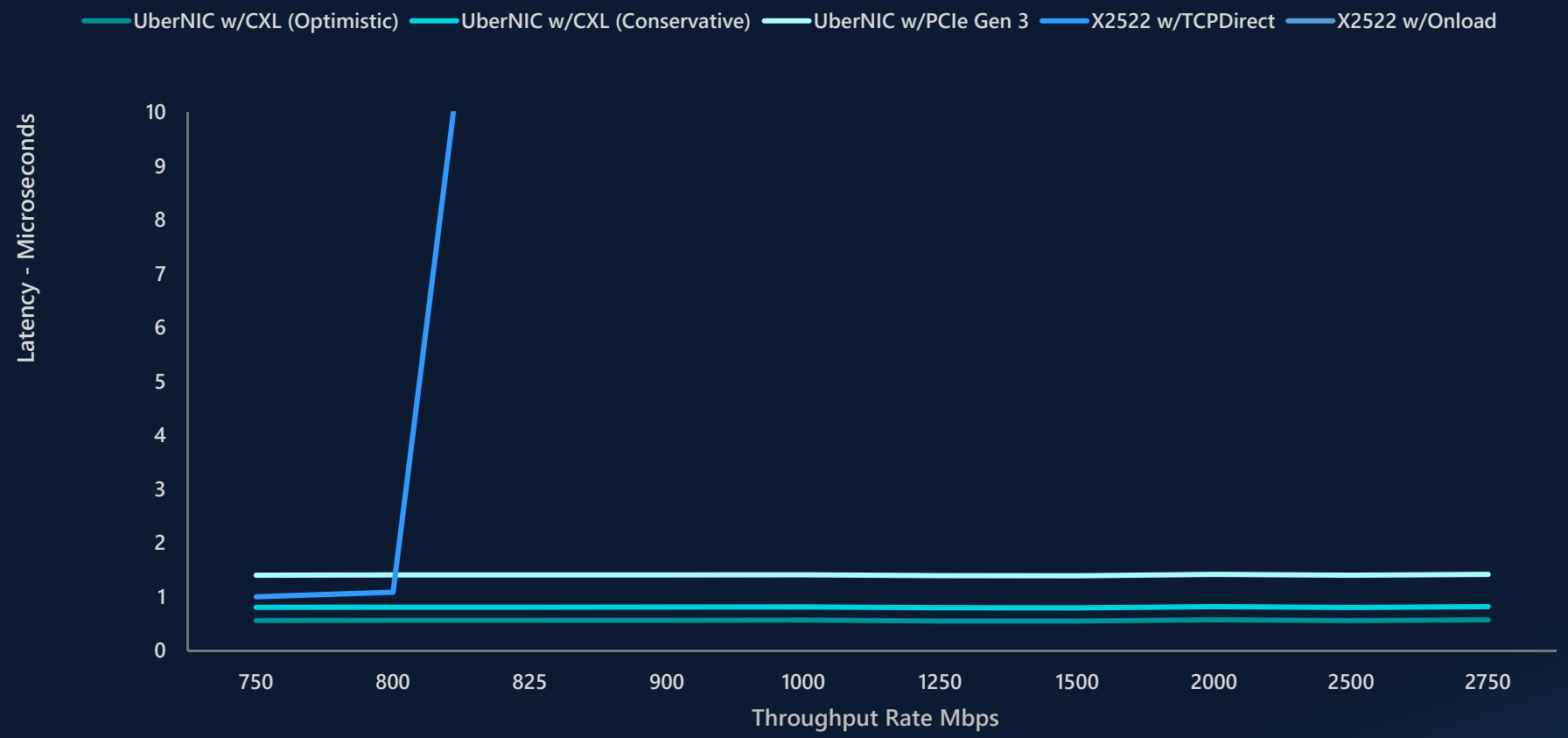
Performance Summary: 95th Percentile – 500,000 Feet



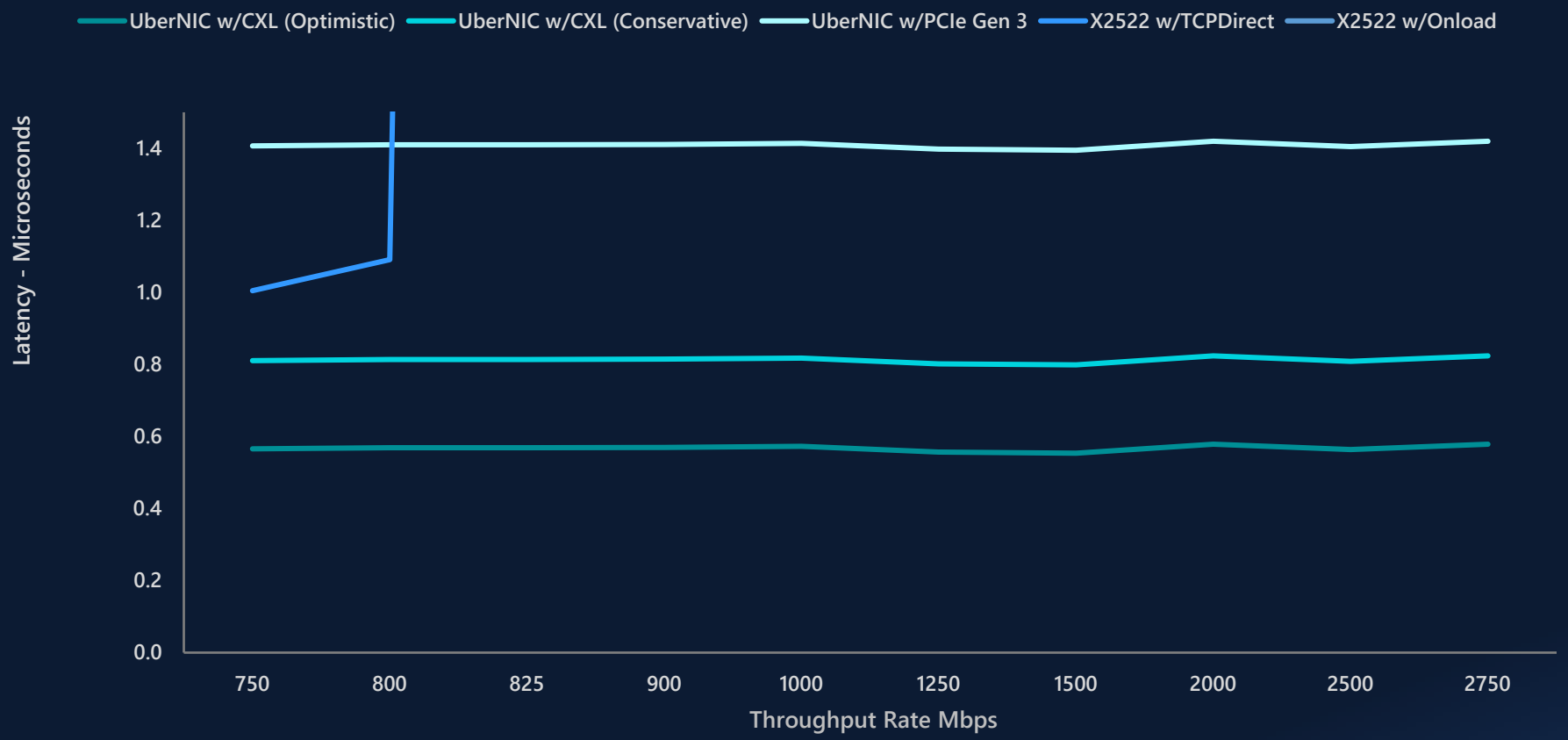
Performance Summary: 95th Percentile – 50,000 Feet



Performance Summary: 95th Percentile – 5,000 Feet



Performance Summary: 95th Percentile – 500 Feet



A Uniquely Comprehensive Family of FPGA-Based Solutions

LMS Naros.Systems™ Logic Library

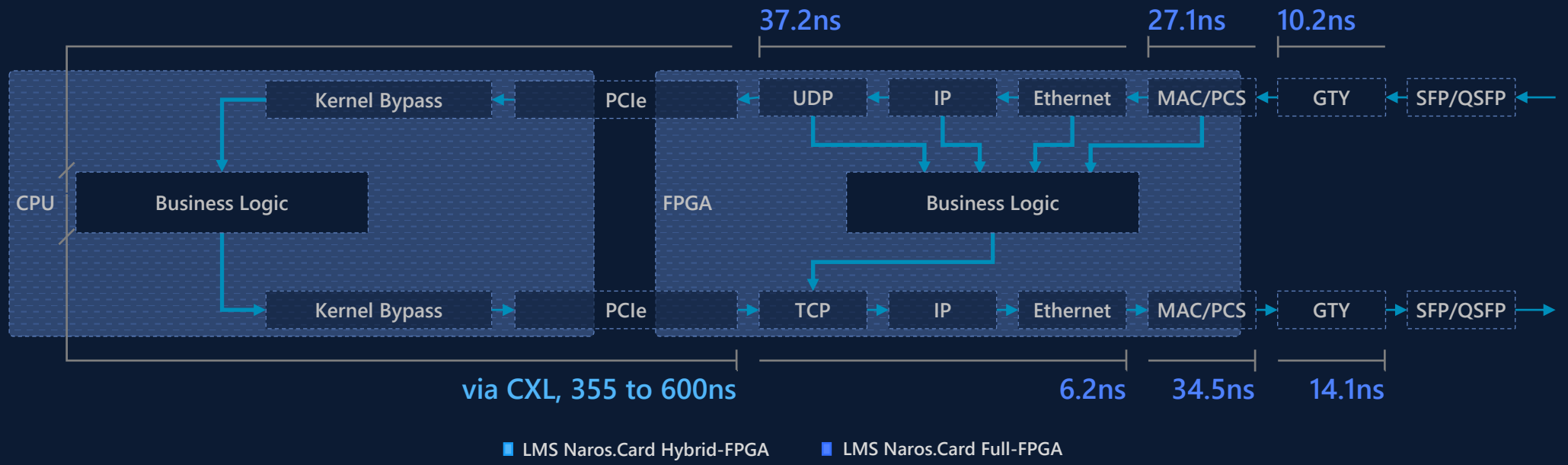
- L1 — **Network Stack** — MAC/PCS
- L2 — **Network Stack** — Ethernet, VLAN, Arp, etc.
- L3 — **Network Stack** — IP, ICMP, IGMP, etc.
- L4 — **Network Stack** — UDP, TCP, BGP
- PCIe — **x86-64 I/O** — PCIe Transfer
- I/O — **x86-64 I/O** — Kernel Bypass & Sockets I/O
- API — **x86-64 I/O** — MD & OE Lightweight API
- DI — **FPGA to FPGA I/O** — MD & OE Defined Interface
- TS — **Tool** — PTP, NTP, Clock Timestamp
- PC — **Tool** — Internal PCAP & Replay
- SM — **Venue Interaction** — Session Management
- MD — **Venue Interaction** — Market Data Handler ("MD")
- OE — **Venue Interaction** — Order Entry ("OE")
- QA — **Venue Interaction** — Quantitative Analytics
- MDQ — **Venue Interaction** — Multi-Dimension Queue
- CR — **Risk & Operations** — Counterparty Risk & Credit Checks
- RC — **Risk & Operations** — Validation & Pre-Trade Risk Checks
- PLV — **Risk & Operations** — Position & Lending Validation
- TSR — **Risk & Operations** — Trade & Settlement Reporting
- TPM — **Risk & Operations** — Trade & Position Monitoring

x86-64-Based Function FPGA-Based Function

Logic Deployable Individually or in Combination to Meet a Variety of Needs

ÜberNIC™ Component Performance

Our Transport Supports Hardware and Software Business Logic - Simultaneously

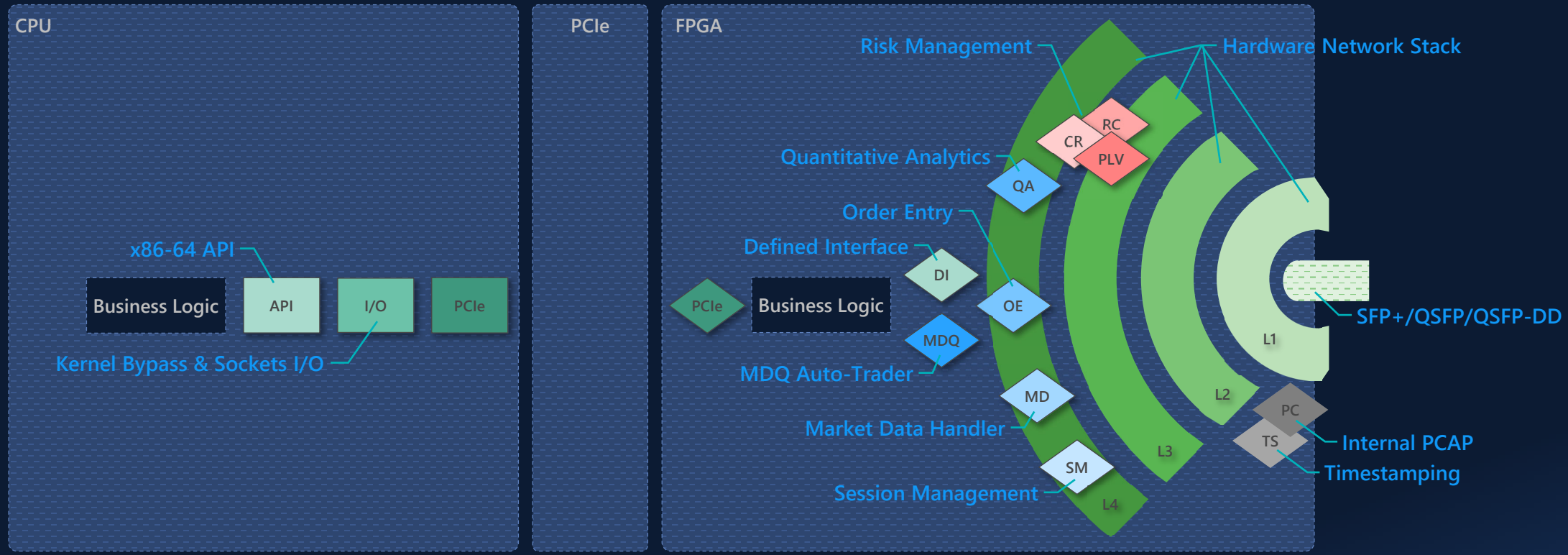


Tested By Naros.TaSR™

1 Million Frames | 64B UDP Payload | L2 SOF to SOF | Constant Throughput @ Rate | 90th Percentile | Excluding Business Logic

We Identify, Extract, & Deliver Every Possible Performance Advantage

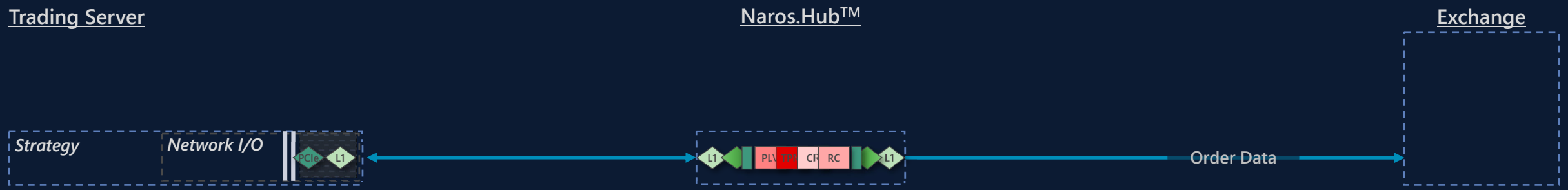
Naros.Systems™ Logic Deployment Visualization



A Common IP Core Enables LMS to Serve the Entire Trade Plant, Data Center, and Beyond

Naros.Hub™ Inline PTRC System

Patented & Fully Compliant Solution Latency <91ns



Strategy & Order Logic
I/O MD & OE Protocol Handler
Kernel Bypass & Network Stack
L1 Transceiver & NIC

SM Session Management
MD Market Data Handling
OE Order Data Handling
DF Network Demarc Functions

CR Counterparty Risk & Credit Checks
RC Validation & Pre-Trade Risk Checks
PLV Position & Lending Validation
TPM Trade & Position Monitoring

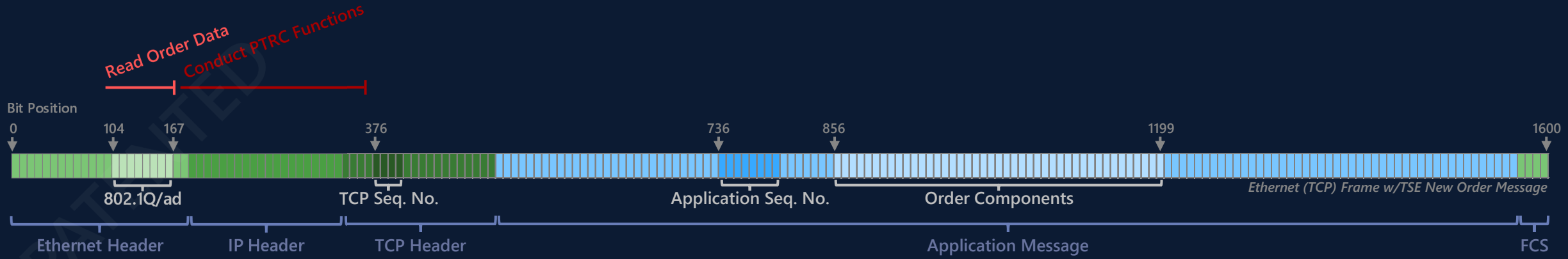
PCIe Bus
Fixed Logic

x86-64-Based Function
Hardware-Based Function

Understanding Innovative Inline PTRC Methods & Mechanisms & How You Win

Naros.Hub™ & TSE Order Messages – Outpaces Other "Introduced" Systems

Patented Mechanisms & Methods Unleash Performance



- Broker-Controlled PTRC Device Intersects Network Path Between Trading Server and Exchange; PTRC Begins After Bit 104
- 64bit Alternative Representation Transmitted Within 802.1Q/ad Tags (Stripped/Replaced On-The-Fly); Minimal (<91ns) Latency
- Order Components Arrive Well Before TCP & Application Sequence Numbers Eliminating Compromising Choices
- Incorporation of Relevant Network-Functions (BGP, etc) Eliminates Boundary Demarc Device

Naros.Hub™ Eliminates Buffering While Delivering Total Compliance w/Exchange Procedures

Naros.Card™ Your Strategy & Our Stack

Patented & Fully Compliant Zero Latency Solution

Strategy & Order Logic
MD & OE Lightweight API
Kernel Bypass & Network Stack
Transceiver & NIC
Session Management
Market Data Handling
Order Data Handling
Network Demarc Functions
Counterparty Risk & Credit Checks
Validation & Pre-Trade Risk Checks
Position & Lending Validation
Trade & Position Monitoring
Timestamp
Internal PCAP
PCIe Bus
Reprogrammable Logic

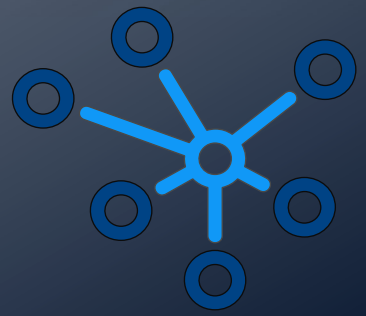
x86-64-Based Function
Hardware-Based Function

Understanding Naros.Card™ & How You Win

LMS Naros.Systems™

DELIVERING ON THE PROMISE

Improved ROI | Unmatched Capabilities | ESG-Compliant



LMS

LIQUID-MARKETS SOLUTIONS

THE POWER OF THE POSSIBLE™

Where other providers have questions, roadmaps, or claims…

LMS Has Solutions

Lets.Talk@liquid-markets.com

CH: +41-79-877-6185 | US: +1-212-784-6145 | JP: +81-50-5539-9608 | SG: +65-8515-8557