

Outsourcing High Performance Infrastructure in the HFT Ecosystem

Technology, Speed, & Cost Reduction

September 12th, 2017

In the past, market advantage was fueled by driving execution latencies lower with many of the gains coming from higher performance networking. Today, however, improvements in network latency performance have slowed due to a deceleration of latency gains in networking processors as well as the limitations of the speed of light. This has resulted in the commoditization of infrastructure. As the latency gains from the infrastructure continue to equalize, an opportunity to outsource the last of the high-performance infrastructure to a third party becomes viable.

Additionally, sophisticated support services such as precision timing are becoming offerings from third parties. Fully utilizing these services allows the firm to concentrate its resources on the algorithms, new media content, and heuristic processing to better advantage the firm in the market. Today we will discuss the drivers to commoditization of the infrastructure as well as a holistic environment to support advanced trading methodologies.

- Introductions (5 min.)
 - Andrew F. Bach
 - Senior Technical Advisor, Pico
 - Matt Cushman
 - CEO, Engineers Gate Market Technologies
- Outsourcing Ultra High Performance Infrastructure (15 min.)
 - Andrew F. Bach, Presenter
- Achieving Market Advantage through Effective Partnership in the HFT Space (15 min.)
 - Matt Cushman, Presenter
- Questions & Answers (10 min.)

Introductions and Presenters

Andrew F. Bach, Pico

Matt Cushman, Engineers Gate



- Senior Technical Advisor at Pico
- Over 30 years of experience specializing in network/telecommunications, security, and financial technologies.
- As a Global Financial Technologies leader, he established strategic direction, led all aspects of technology development and implementation, and provided formal supervision and coaching for the Architectural, Security, and Infrastructure functions, while setting the vision to inspire and drive continuous improvements. Furthermore, he possesses a successful track record providing strategic leadership and guidance for the development, integration, maintenance, and customization of network/telecommunications technologies across an enterprise.



ENGINEERS | GATE

- CEO of Engineers Gate Market Technologies
- Knight/KCG 2002-2011
 - Managing Director and Head of Quantitative Research
- Citadel 2011-2013
 - Senior Managing Director
- PhD in Mathematics from The University of Chicago
- MS and BS in Mathematics from Carnegie Mellon University
- Series 4, 7, 24, 57, 63

Outsourcing Ultra High Performance Infrastructure

Using precision timing as an example

Andrew F. Bach, Pico

Pico* is a leading infrastructure service provider, focused on today's global capital markets community. Utilizing ultra-low latency networking and state-of-the-art cloud technologies, our mission is to provide innovative solutions which empower our clients to lead the next set of generational advancements in the markets.

Founded in 2009, Pico has since grown to over 130 employees, 4 offices, 19 data centers and solutions across asset classes. It is with the help of these employees and leading automation tools that we are able to deliver outstanding service quality. We continuously train our staff to fulfill these high expectations to customer satisfaction.

Pico's client base encompasses a full spectrum of market participants; banks, broker dealers, technology vendors, asset managers, trading firms, family offices, hedge funds, and liquidity venues.

*Pico Quantitative Trading LLC and its affiliates (collectively, "Pico") offers premium technology hosting and managed services, specializing in trading technology via its offices and locations around the world. To learn more, visit: www.picotrading.com

Product & Service Offering

- Data Center Management
- Technology & Managed Infrastructure
- Network Connectivity
- Data Delivery & Storage
- Public Cloud Access
- Procurement

Value Proposition

- Cost Savings
- Latest Technology & Faster Refresh Rates
- Client Service & Support
- Subject Matter Expertise
- Engineering Excellence
- Lab Environment Services

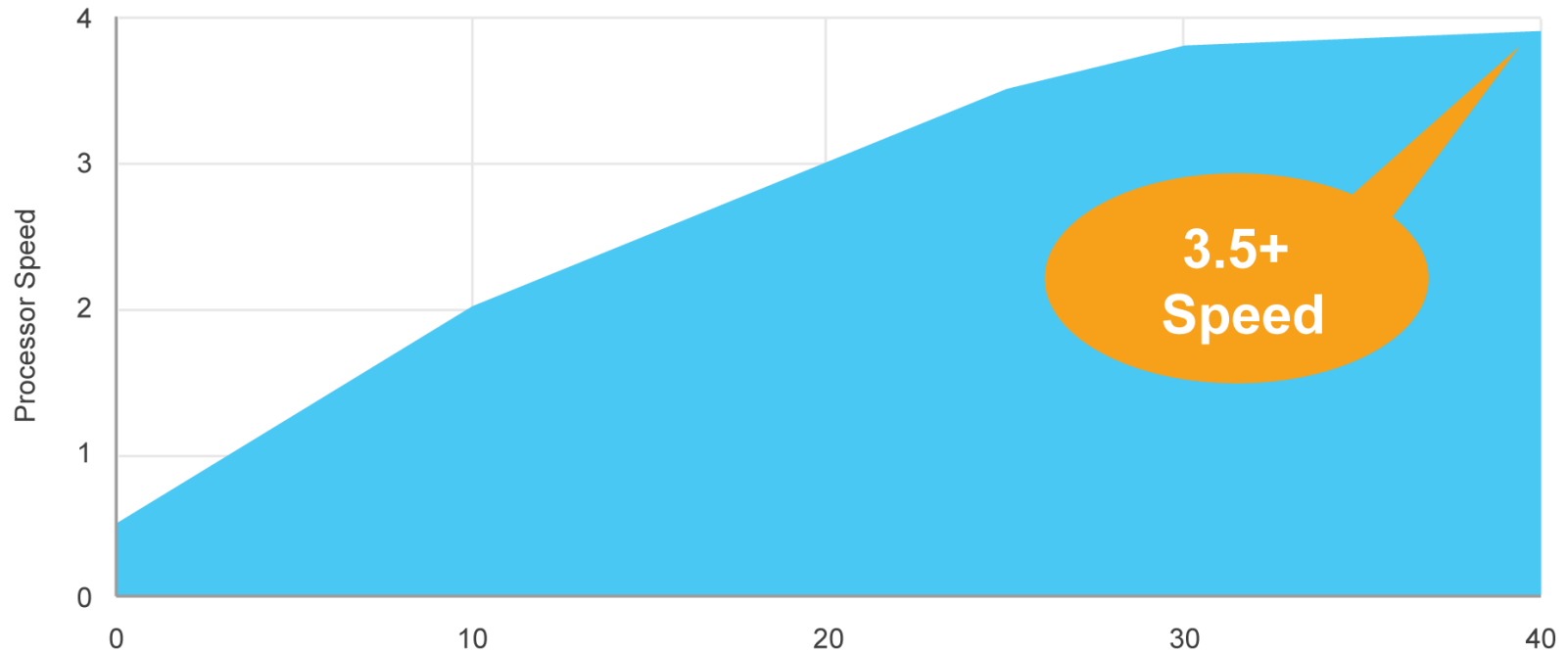
The content provided in this presentation or in any other information, data or content (whether written or oral), notice or document supplied or otherwise made available to you or your agents and/or advisors in connection with this presentation contains confidential and proprietary information of Pico. Please see the Legal Notice at the end of this presentation for more information.

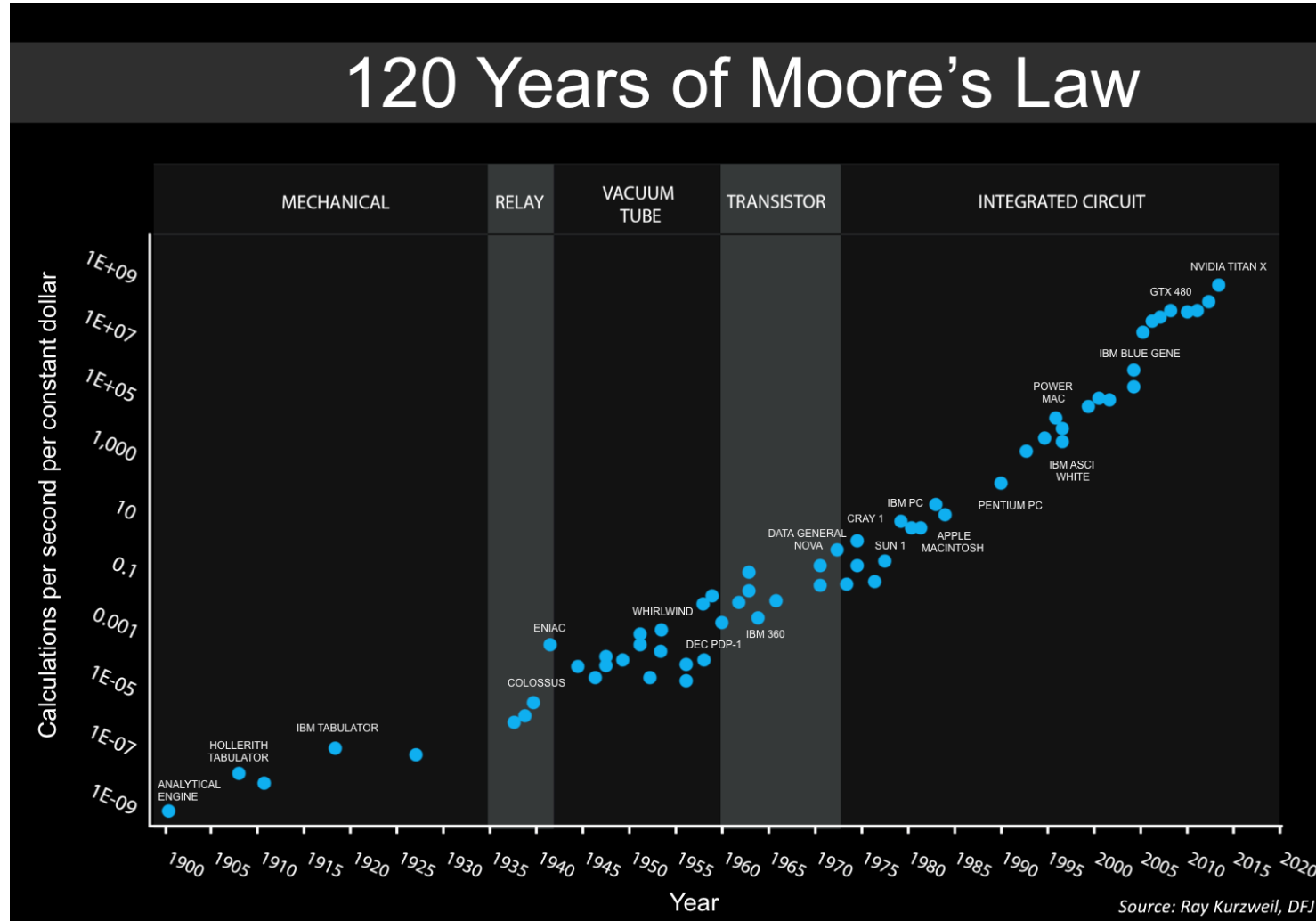
© Pico 2017. All rights reserved. The Pico symbols and word marks are among the registered and unregistered trademarks of Pico. All other trademarks are the property of their respective owners.

- State of Current Technology and Trends
 - Processor Trends
 - Networking Trends
- Innovation Trends
- Ultra High Performance Ecosystem as a Service
- Precision Time as a Service (PicoTempo™)
- Closing Thoughts

- Speed
- Transistors
- Distribute and parallelize processing

Technology: Processor Trend: Speed

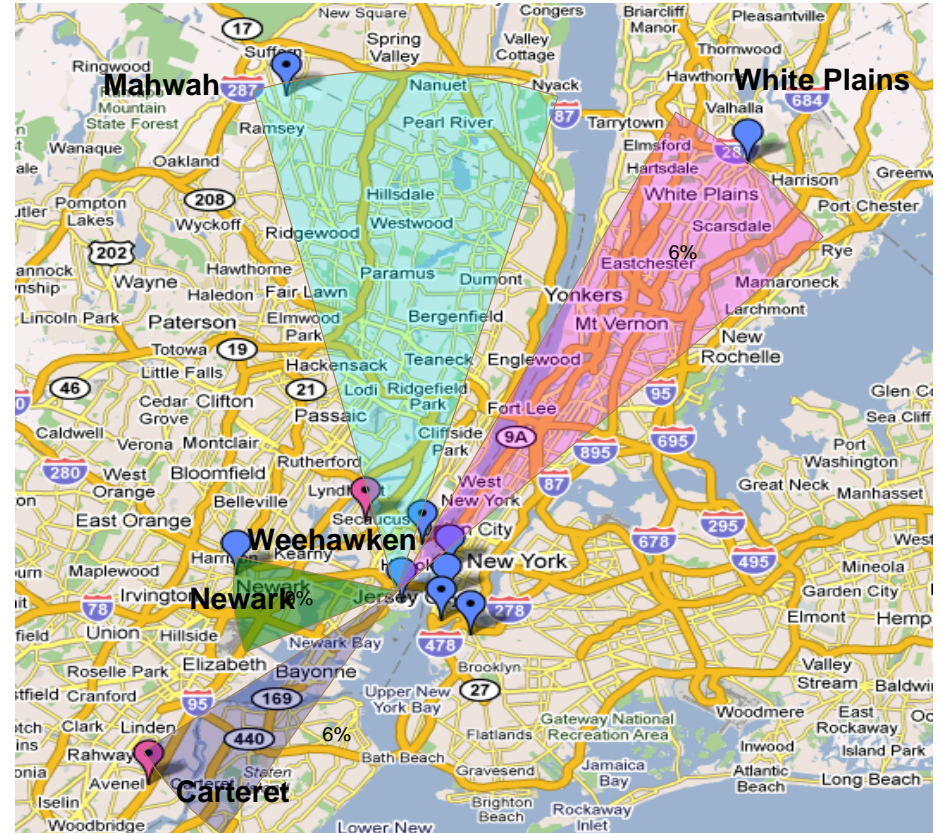


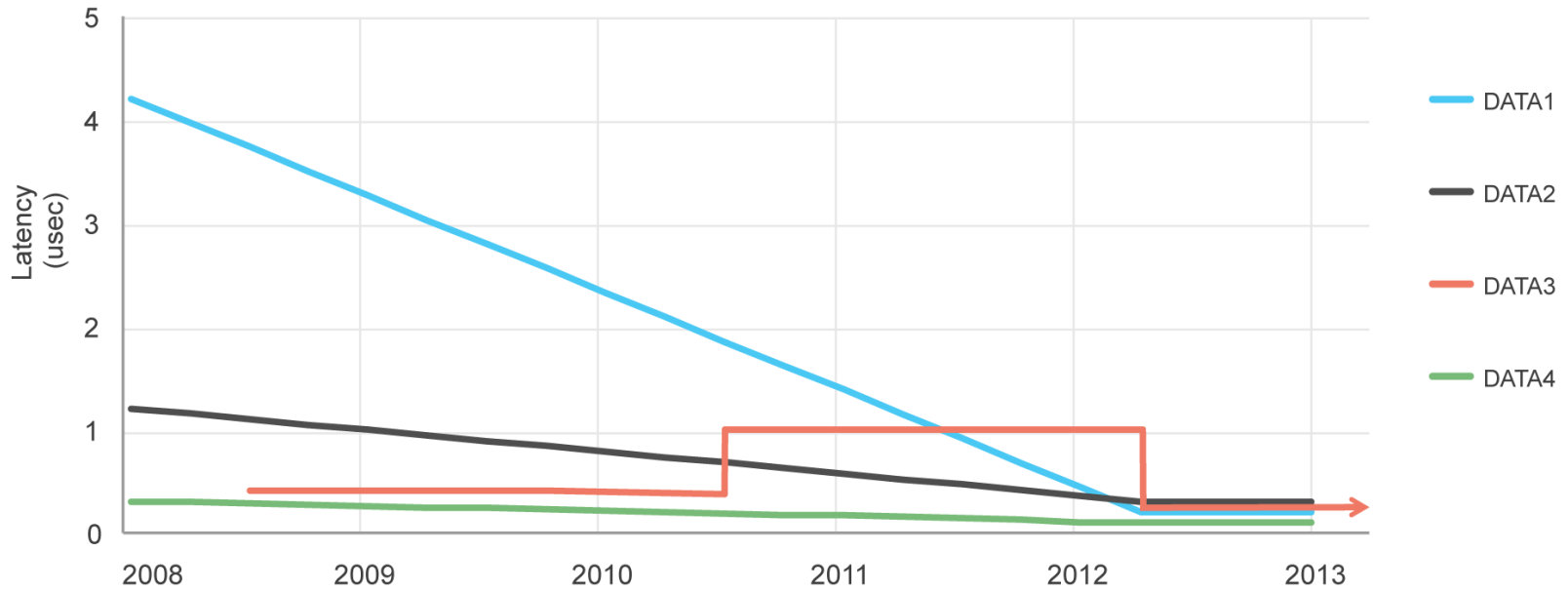


- Process as close to the data as possible
- Massive parallelization – burn even cheaper transistors
- Embed applications in hardware

- Light speed barrier
- Processing speed
- FPGA

- Light speed barrier – for now
- Distance is the enemy
- How straight is straight





- Using transistors instead of GHz to achieve speed
- Brings processing closer to the data
- Massively parallel solution
 - Computational power at many parallel points in the application
 - Processing can now occur in the:
 - Network switches
 - NICs
 - Servers as a add-in application accelerator

- More and richer data sets
 - Market Data
 - News feeds
 - Social media feeds
- Massively parallel
 - CPU core count continues to increase
 - FPGA in network switches
 - FPGA in NICs
- Firms secret sauce
 - Now embedded in hardware

- Information services - rich data sets
 - > 150 market data feeds
 - News services
 - Historical data
- Advanced infrastructure
 - L3, L2, and L1 network switches
 - FPGA enabled platforms
 - Servers
 - Precision timing
- Optimized connectivity and data paths
 - Straight path selection
 - Global locations
- Cloud and cloud access

- GNSS downlink challenges
 - Weather (space & planetary)
 - Jamming
 - Other challenges
- Long term stability & integrity
 - Requires a Stratum I source
 - Traceability
 - Long term logging
- Multiple delivery requirements
 - NTP
 - PTP
 - PPS

- Network hardware adds little to market advantage
- Extensive data sets are required to complete the real time information stream required to compete effectively requiring massive processing
- Precision timing requires specialized engineering skills, & equipment BUT does not contribute to market advantage

Thank You!

Achieving Market Advantage through Effective Partnership in the HFT Space

Teaming with a High Performance Infrastructure Provider

Matt Cushman, Engineers Gate

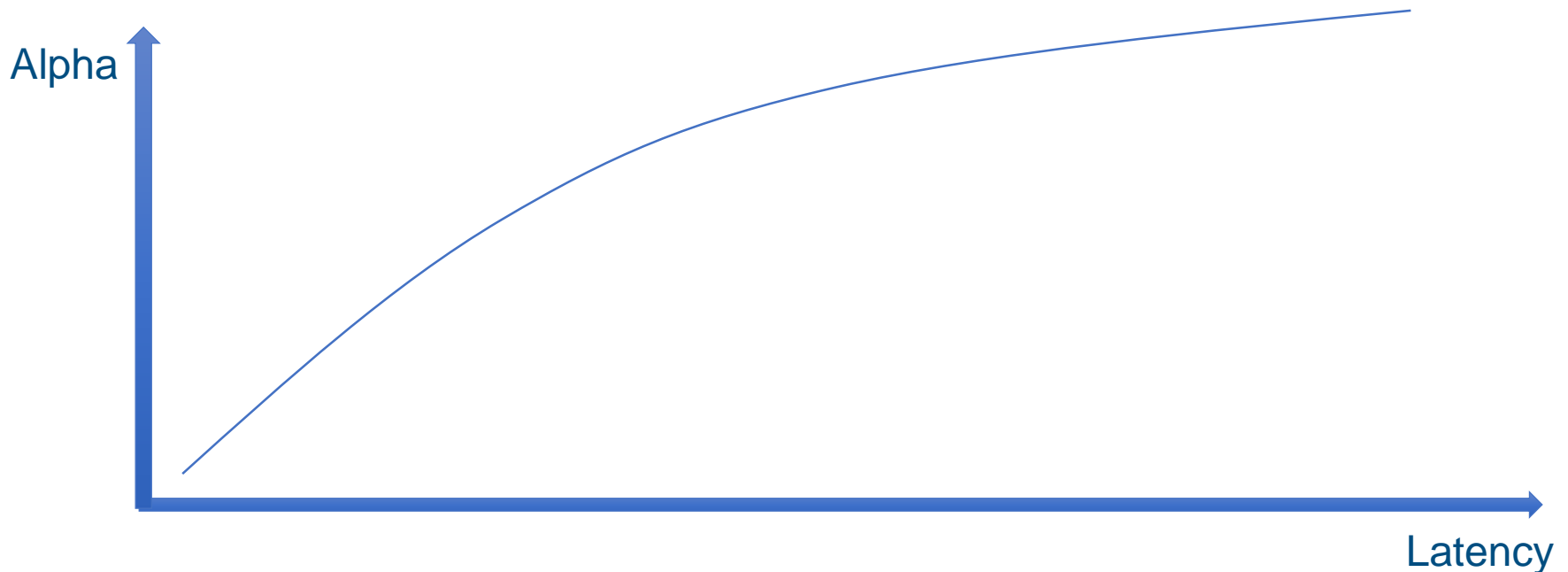
ENGINEERS	GATE
-----------	------

- Founded in early 2014 by a team led by Glenn Dubin
- Multi-manager quant trading platform focused on medium frequency stat-arb and intraday trading/market making
- Founded as broker dealer, Engineers Gate Market Technologies (EGMT) in 2016

Why Partner with an Infrastructure Provider?

- More precisely, WHEN to partner with an infrastructure provider?
- More easily target an optimal tradeoff between predictive intelligence and speed
- Benefit from the network effect of connectivity

- By analogy with CAPM, there is an efficient frontier of speed (latency reduction) versus intelligence (alpha)
- Successful firms need to target a point (or points) on the frontier to be successful



- Public markets/exchanges lead towards a winner-take-all dynamic for a given trade.
- Latency/speed is nearly a linear order among traders.
- Alpha is not truly a linear order. Two traders can have incremental predictive power even using similar models and data.
- How to invest precious trading resources:
 - Focus on proprietary latency reductions, which can be dominated by faster competitors?
 - Focus on proprietary alpha, which is less easily dominated by another trader?
- Alpha generally seems to be the logical choice

- If latency is a linear order, then latency tradeoffs are essentially fungible and hence commodities.
- It's easy to evaluate relative impact of certain technology enhancements (e.g. using switch A versus switch B will reduce latency by 200 ns).
- Today, HFT-oriented hosting partners can offer very fast connectivity on both the market data and order entry side (say, low single digit microsecond latency on each side).
- Incremental improvements are possible with proprietary solutions, but would be well within acceleration limits achievable by less expensive means for many applications (such as enhancements to market data processing, model evaluation time, etc).

- US equities in 2017
 - 12 active trading exchanges
 - Several dozen active ATSs with more coming and going frequently
 - 3 major data centers
 - Many potential executing brokers
 - Different market data providers (fiber and multiple wireless sources for most direct feeds in each remote colo)
 - Even the exchanges may offer different flavors of the same data (e.g. FPGA versus software feeds)
- Hardware, cross connect, and the effort involved in managing all of this can become onerous and costly.

- Hosting partners already have connectivity established with most potential counterparties.
- Have relationships with exchange data providers, brokers, etc and can provide advice on relative benefits and costs of different data and connectivity solutions.
- Have leading (if commodity) hardware already in place to support most trading strategies.
- Impact on the client: faster and cheaper deployment.

- Do I need absolutely the fastest possible latency for all of my trading strategies?
- Have I wrung out all possible latency improvements elsewhere in my trading platform? (software, broker risk checks, become a BD).
- Do I have a team experienced with selecting, configuring, monitoring and debugging bleeding edge networking hardware?
- Am I already using all of the absolute fastest market data solutions (hardware accelerated market data feeds, wireless data).
- Do I have a footprint large enough to warrant racks of hardware in multiple data centers and proprietary links between data centers?
- If the answer is “No” to any of the above, it’s worth exploring how an infrastructure partner may make sense.
- Finally.. It’s not a binary “yes or no” decision. A firm may choose to manage some of their own footprint while using a partner for other parts, and even pick and choose what components of their partner’s offering makes sense for them.

Thank You!

LEGAL NOTICE

The content provided in this presentation or in any other information, data or content (whether written or oral), notice or document supplied or otherwise made available to you or your agents and/or advisors in connection with this presentation (the “Information”) contains confidential and proprietary information of Pico. The Information may not be reproduced or redistributed or publicized or disclosed to any person outside the recipient's organization, in whole or in part, for any purpose, without the prior written consent of Pico. The Information is provided solely for informational purposes, and is not intended to provide legal, tax, investment or accounting advice, nor should it be construed as a recommendation, or an offer to buy or sell, or the solicitation of an offer to buy or sell any security, financial product or to participate in any trading strategy. No determination of your suitability for, or the appropriateness of, any service provided by Pico has been made. Any performance data provided in the Information represents past performance and is not necessarily indicative of future performance. The Information may contain forward-looking statements, which by their nature involve risks and uncertainties. Future results may vary from what is presented in the Information and in no event are guaranteed. Pico undertakes no obligation to update the Information. The Information is provided as is, with no representation or warranty made or implied, and Pico assumes no responsibility for the accuracy, completeness or reliability of the Information, and Pico disclaims all liability for any use you or any other party may make of the Information. The Information, in any form, is not intended for distribution to, or use by, any person or entity in any jurisdiction or country where such distribution or use would be contrary to local law or regulation.

Pico Global Ltd, an affiliate of Pico Quantitative Trading LLC, is a private limited company registered in England and Wales, Company No. 09365923, with registered offices at c/o Katten Muchin Rosenman UK LLP, Paternoster House, 65 St. Paul's Churchyard, London, England, EC4M 8AB.