LEAN

Business Motivations and Goals for Open Source Software

Radically open-source algorithmic trading engine

OPEN SOURCE STRATEGY FORUM 2018

QUANTCONNECT

Counter Intuitive Motivations For Open Source

Increasing Productivity

By coding less....

Instil Trust in Product

By exposing all your flaws...

Increase Adoption

By giving clients the freedom to leave...

LEAN   www.quantconnect.com/lean

Agenda

Introduction to QuantConnect and the LEAN project.

Effectively Competing Against Larger Players.

Challenges of Building Hard Technology.

Keeping Up With Pace of Innovation Required.

Circa: 2012. Algorithms, Secrets and Software

Algorithmic trading industry is incredibly secretive, attributing trading advantages to sophisticated highly engineered software.

High Value, High Expense
Complex software requiring large investments of engineering and infrastructure expense.

Signal Value
Algorithmic trading signals directly convert into potential investment returns.

Tight Contracts

Funds employ restrictive non-competes and lock ups on employees to keep details about their algorithmic trading a secret.

Legal Risk

FBI arrests Sergey Aleynikov for alleged theft of Goldman code, for using a git repository.

Expensive Financial Data

Exchange monopolies keep tight grip on the available financial data, driving up prices making it difficult for individuals to procure data required for analysis.

LEAN   www.quantconnect.com/lean

What is QuantConnect?

We are a global community of engineer, scientist and quants passionate about algorithms and finance.

www.quantconnect.com/about

WE BELIEVE IN COLLABORATION, RADICAL OPENNESS AND COMMUNITY.

WE BELIEVE GENIUS IS DISTRIBUTED.

WE BELIEVE THE FUTURE OF INVESTMENT WILL BE AUTOMATED.

ALGORITHMIC TECHNOLOGY

FINANCIAL DATA

POWER COMPUTING

University
API
My Projects
Data Manager
Live Projects
Support

main.py | Emotional Sky Blue Salamander

Build | Backtest | Go Live | Results

| $6,330.80 | -$1.00 | $0.00 | 25.32 % | $31,330.80 |
| Unrealized | Fees | Net Profit | Return | Equity |

Strategy Equity

Zoom 1m 3m 1y All   RSI-FB

$32,000
$30,000
$28,000
$26,000
$24,000

0%
-2.5%
-5%

Jan '13 Feb '13 Mar '13 Apr '13 May '13 Jun '13 Jul '13 Aug '13 Sep '13 Oct '13 Nov '13 Dec '13 Jan '14

Equity
Daily Performance

Select Chart:

Strategy Equity
RSI-FB
STD
RSI
BB
ATR

Select Stockplot

Select Benchmark:

S&P 500

Ranking

Your algorithm is ranked # 129,337, and is better than 50 % of the community.

ATR

Zoom 1m 3m 1y All

$4
$3
$2
$1
$0

Mar '13 May '13 Jul '13 Sep '13 Nov '13 Jan '14

ATR

BB

Zoom 1m 3m 1y All

$170
$160
$150
$140
$130

Apr '13 Jul '13 Oct '13 Jan '14

Price

RSI

Zoom 1m 3m 1y All

$75
$50
$25
$0

Apr '13 Jul '13 Oct '13 Jan '14

RSI4(SPY_day)

IndicatorSuiteAlgorithm

Console 3

C#

LEAN is a radically open-source cutting-edge algorithmic trading technology.

Since launching in 2012, LEAN has:

grown to over
65K
quants globally

created
1.2M
algorithms

deployed
36K
live strategies
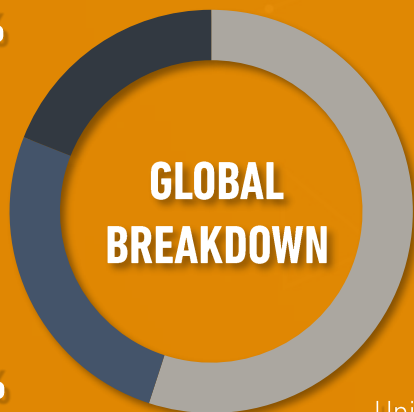
traded
1.25B
volume

LEAN

Global Open Source Community

Global community of engineers, scientists and quants, all united by a passion for the financial markets. Funds leverage LEAN to fast-track their strategy development.
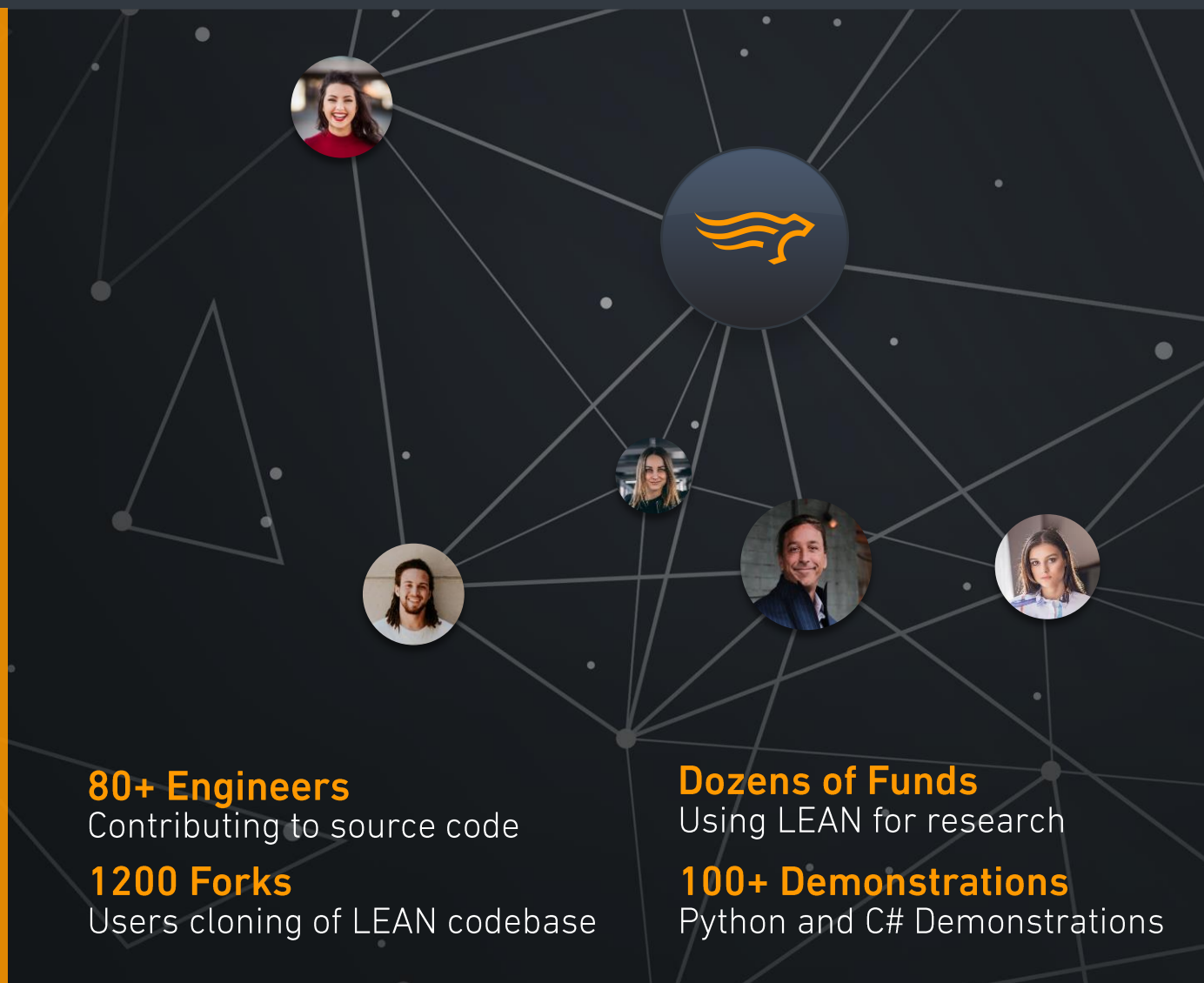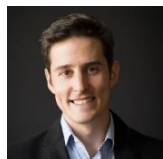
19%
Asia

GLOBAL BREAKDOWN

26%
Europe

55%
United States

www.github.com/quantconnect/lean

80+ Engineers
Contributing to source code

1200 Forks
Users cloning of LEAN codebase

Dozens of Funds
Using LEAN for research

100+ Demonstrations
Python and C# Demonstrations

Core Team

Jared Broad
CEO, Biomedical Engineer
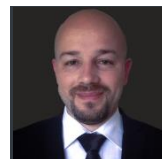
Alexandre Catarino
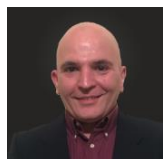Quantitative Development
CQF, PhD Philosophy
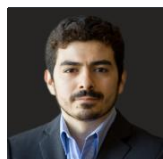
Gustavo Aviles
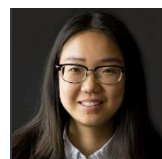COO, Industrial Engineer
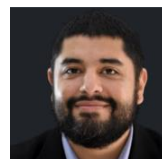
Juan Jose
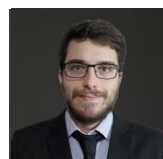Data Engineering
PhD Economics

Stefano Raggi
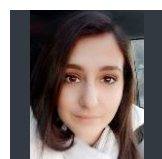Cloud Engineer
Computer Engineer

Jing Wu
Financial Engineering
Alpha Engineering

Martin Molinero
Open Source Engineering
Software Engineer

Briana Bigio
Biomedical Engineering
Operations

QC HQ: Seattle, WA

#1. Competing against larger, well funded competitors.

Others You May Know

Quantopian

Quantiacs

ALGOTrader
ALGORITHMIC
TRADING PLATFORM

RiceQuant

NUMERAI

≈ +$100M
VC Funding

QUANTCONNECT

As of 2017, less than
$1M Funding

Grown through organic community word of
mouth, users investment and bootstrapping.

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Closed Source Humble Beginning

2014, Closed Source

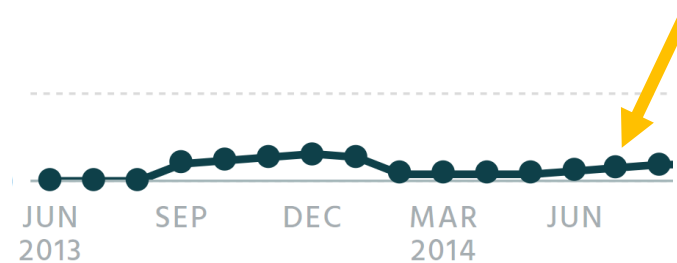Equities

Equities

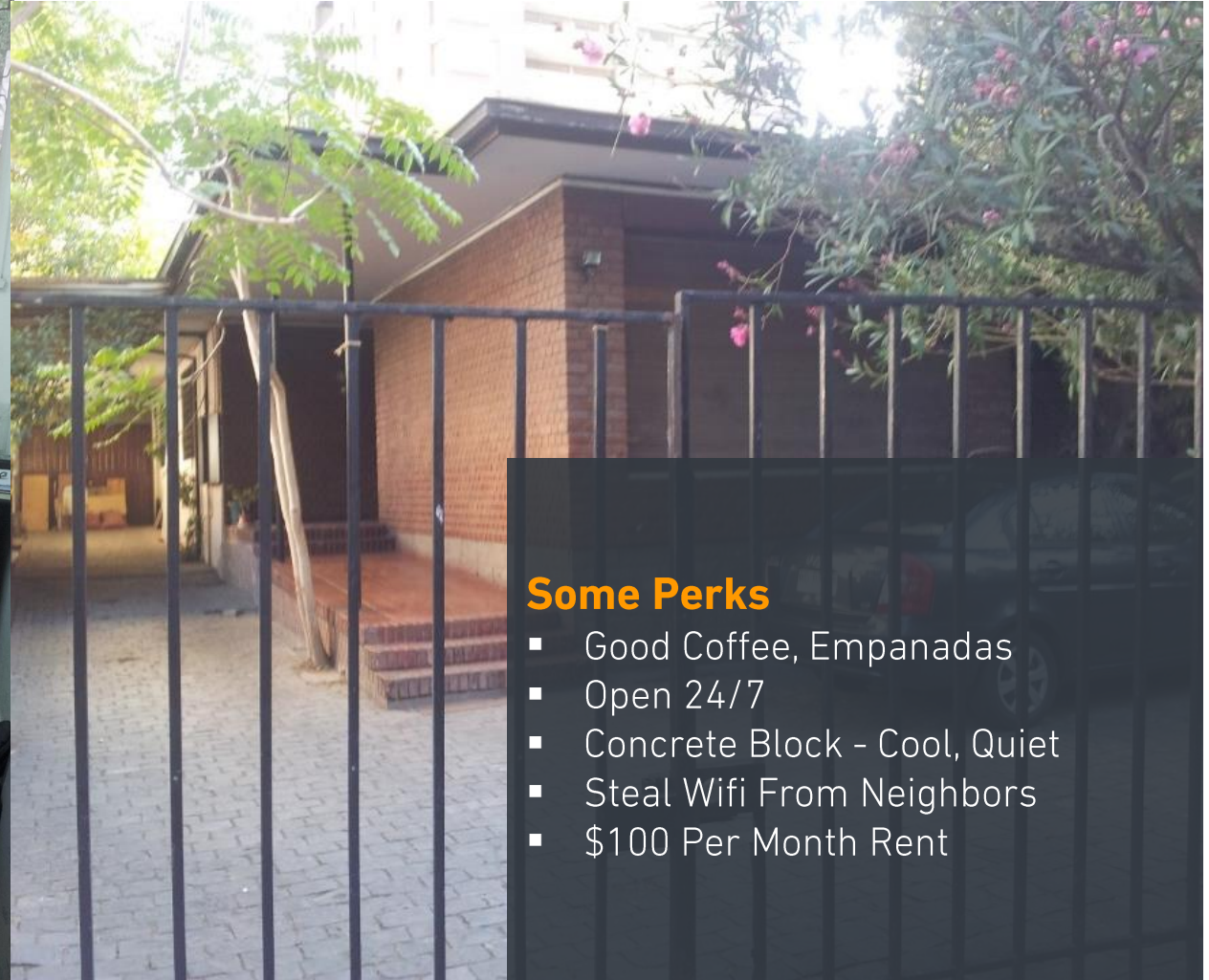2012 – Launch, $40k Angel (Start Up Chile)

2014 – Broke.

2,000 Accounts
but
4 Clients - $76/mo

(2 of them family)

JUN
2013

SEP

DEC

MAR
2014

JUN

What are we doing this for?
PS: Quantopian had $7M in Funding
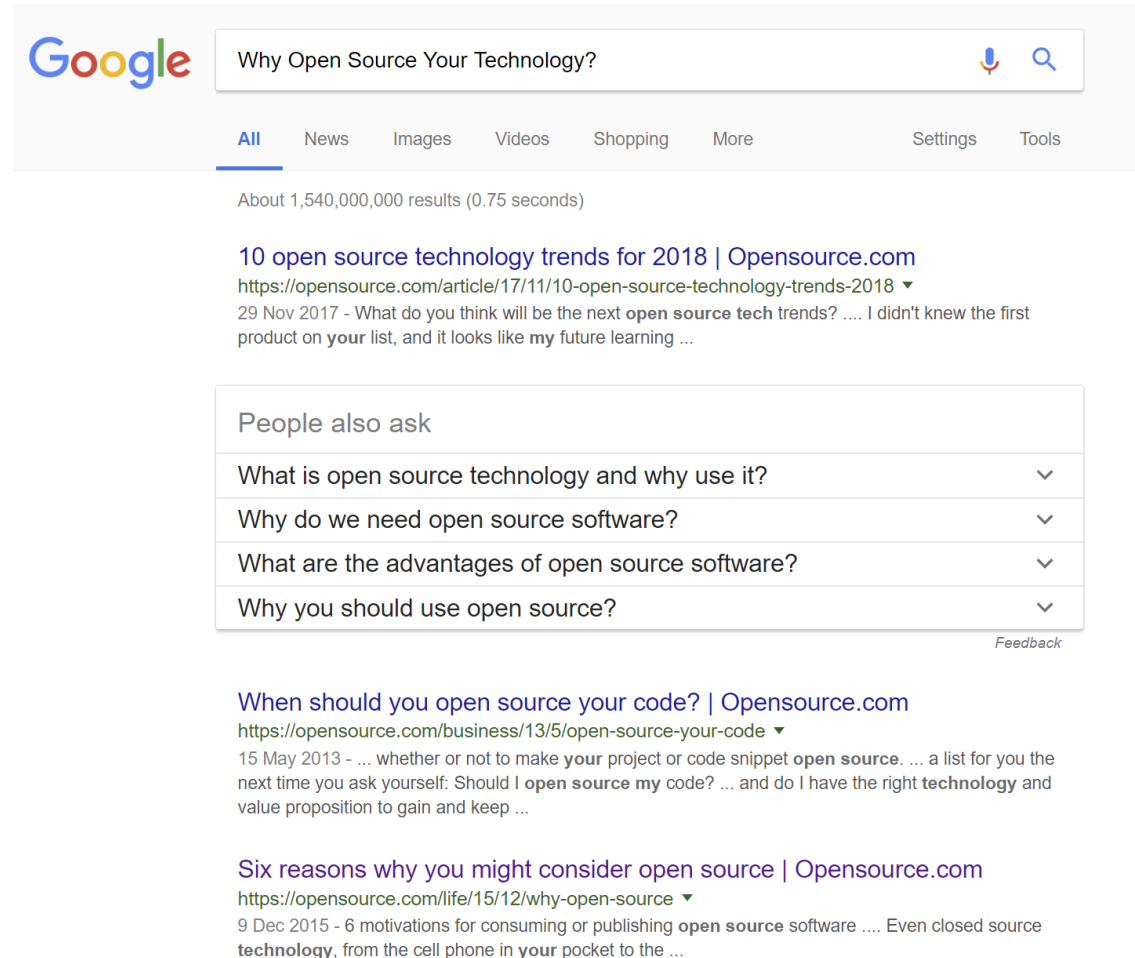
LEAN

The Cupboard

Some Perks
- Good Coffee, Empanadas
- Open 24/7
- Concrete Block - Cool, Quiet
- Steal Wifi From Neighbors
- $100 Per Month Rent

Why Open Source?

Solid esoteric reasons to open source...

But little evidence to risk it all on a gamble.

Why Open Source?

Our Bet...

The majority of people will pay for

convenience and *ease of use.*

Our value isn't from code, its in

usage of the code.

Crowd Funding

What do we have to lose?

Lets find **"The 100":** at least 100 people passionate about the project

enough to sign up at **$10**/mo.

If we do, we'll open source the project.

(Or if we can't, we'll quit and go get day jobs).

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Crowd Funding: Day 1

YES!!!

Welcome to the QuantConnect Algorithm Development Terminal

♥ Want to see QuantConnect Open Sourced?

We want to open source QuantConnect to get you backtesting in Visual Studio but we need your help! If we reach 100 passionate fans we'll open it to the world!

Reached 12 of 100 Supporter Target!

Upgrade today to Open Source QuantConnect

A special thank-you our supporters

Ryan Hill, Pravin Bezwada, Jimmie Butler, Nick Cusato, Sam Collins, Mattias Surer, Michael Hahn, Mark Meras, Madhan, Paul Radke, Nik Milev, Scott Yacko

⊳ Starter Algorithms

Click any project below to clone the template and start coding.

Basic Template

Barebones template algorithm, purchasing a single stock and making a single trade. You can use this as a skeleton to build your strategy.

50d-10d Exponential Moving Average Cross

Exponential moving average cross strategy using the 50 day moving average of close prices, with a debouncing 0.1% tolerance.

SPY Dollar Averaging

Investing at small regular intervals through 2012-2014 averaging the S&P500 index. This is a traditional entry technique for a long term investor.

⊳ My Algos

Project Name	Last Modified

Introduction to QuantConnect

Introduction to the
QuantConnect Algorithm Terminal

Jared Broad

We believe in a transparent and level playing field in the financial markets; that the crowd is better than an individual bank or hedge fund, and that genius does not live in a cubicle in NYC. We believe that you, our

📢 Latest News

Latest news and updates from the team at QuantConnect -

⚡ [New Feature] Custom Order Tagging

You can now tag orders with a short string of custom information. This lets you record critical information relating to the order which will display next to the order in the trades tab!

```
// Set via set holdings as the final optional argument
SetHoldings(symbol:"SPY", percentage:0.80, liquidate: false,
tag:"Custom information");
//Or manually create the order:
Order(symbol:"SPY", quantity:100, type:OrderType.Market,
asynchronous:false, tag:"Custom information")
```

🔧 [Update] Debugging Enhancements, Memory Leak Fixes

We're released a new build of the server today which has some good improvements for your debugging and backtesting: - Code errors in the Initialize() function will now be properly reported to console - Code errors in custom data creation will also be reported to console - Fixed memory leaks

Post Crowdfunding

(extra ramen flavours)

Open Source Caused Feature Explosion

Equities — 2012 - Launch

Equities — 2014

Forex / Live Trading — 2014, 2015

CFDs — 2015

Futures / Options — 2016 – Really Hard

Crypto — 2017 –100% Open Source Contribution

Open Source!

82 contributors

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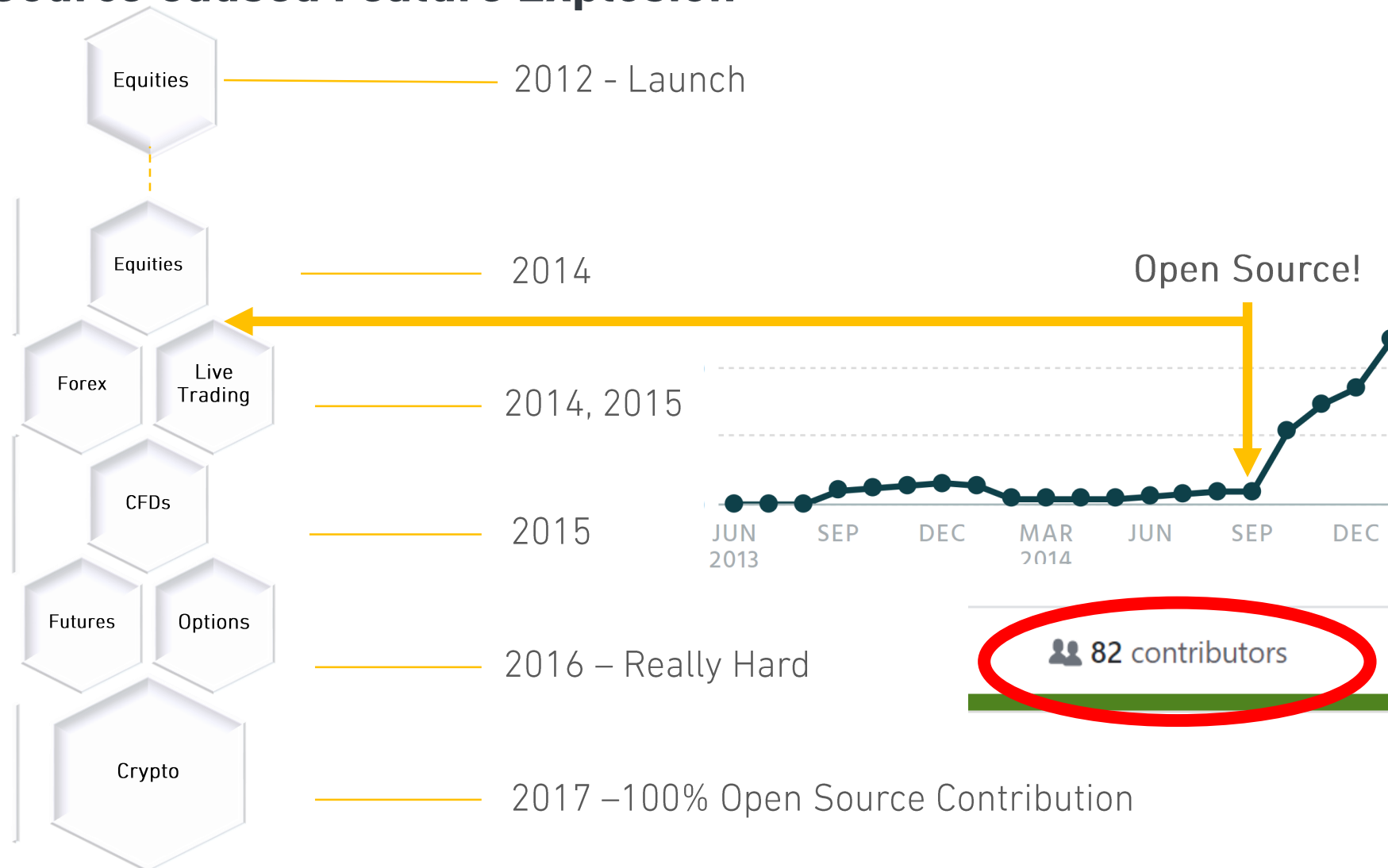
#2. Algorithmic trading is a difficult and error prone technology.

Difficult Technology, High Impact

FINANCIAL TIMES
myFT

FT Trading Room **Knight Capital Group Inc** + Add to myFT

Knight Capital glitch loss hits $461m

Save

Arash Massoudi in New York OCTOBER 17, 2012

Knight Capital said losses from an August 1 trading error had grown to $461.1m as the electronic trading and market-making company said it had begun the process of recovering from the glitch, which sent it to the brink of bankruptcy.

The company suffered the self-imposed wounds when its trading systems malfunctioned 11 weeks ago, causing the inadvertent purchase of billions of dollars worth of shares in 148 stocks on the New York Stock Exchange.

The losses from unwinding those mistaken positions were initially reported as having cost the company $440m but that figure was raised by $20.1m on Wednesday as Knight reported quarterly results.

A portion of those losses came after Knight decided that it could no longer trade those positions itself and sold them in a so-called block trade to Goldman Sachs, the US investment bank, which has refused to detail how much money it made from the deal. But analysts at Morgan Stanley on Wednesday estimated that the deal added about $200m to the bank's revenues in the third quarter.

Overall, Knight's net losses were $389.9m for the three months to September 30, compared with a profit of $26.9m the same time a year ago. Knight said it had negative revenues of $189.8m, compared with sales of $397.4m for the same period a year ago as its trading revenues and commissions were affected heavily by the

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(I) INVESTOPEDIA

Flash Crash

What is 'Flash Crash'

A flash crash is an event in electronic securities markets wherein the withdrawal of stock orders rapidly amplifies price declines. The result appears to be a rapid sell-off of securities that can happen over a few minutes, resulting in dramatic declines. A flash crash, like the one that occurred on May 6, 2010, is exacerbated as computer trading programs react to aberrations in the market, such as heavy selling in one or many securities, and automatically begin selling large volumes at an incredibly rapid pace to avoid losses. Flash crashes can trigger circuit breakers at major stock exchanges like the NYSE, which halt trading until buy and sell orders can be matched up evenly and trading can resume in an orderly fashion.

Next Up

| FLASH FREEZE | STOCK MARKET CRASH | FLASH SERVICES PMI | > |

BREAKING DOWN 'Flash Crash'

Shortly after 2:30 p.m. EST on May 6, 2010, a flash crash began as the Dow Jones Industrial Average fell more than 1,000 points in 10 minutes, the biggest such drop in history, at that point. Over one trillion dollars in equity was evaporated, although the market regained 70 percent by the end of the day. Initial reports that the crash was caused by a mistyped order proved to be erroneous, and the causes of the flash were attributed to a Navinder Sarao, a futures trader in the London suburbs, who plead guilty for attempting to "spoof the market," by quickly buying and selling hundreds of E-Mini S&P Futures contracts through the Chicago Mercantile Exchange.

There are have been other flash crash type events in recent history wherein the volume of computer generated orders outpaced the ability for the exchanges to maintain proper order flow:

- August 22, 2013. Trading was halted at the Nasdaq for more than 3 hours when computers at the NYSE could not process pricing information from the Nasdaq.
- May 18, 2012 - Facebook's IPO. While not a flash crash per se, Facebook shares were held up for more than 30 minutes at the opening bell as a glitch prevented the Nasdaq from accurately pricing the shares causing a reported $460 million in losses.

Dow Jones

AP Twitter hack causes panic on Wall Street and sends Dow plunging

Market recovers after hackers tweeted from the official AP feed that two explosions had hit the White House

Heidi Moore *in New York and* **Dan Roberts** *in Washington*
Tue 23 Apr 2013 20.41 BST

51 61

⏱ This article is over **5 years old**

Wall Street collided with social media on Tuesday, when a false tweet from a trusted news organization sent the US stock market into freefall.

The 143-point fall in the Dow Jones industrial average came after hackers sent a message from the Twitter feed of the Associated Press, saying the White House had been hit by two explosions and that Barack Obama was injured. The fake tweet, which was immediately corrected by Associated Press employees, caused a sensation on Twitter and in the stock market.

White House officials were unimpressed. An AP reporter apologized for the Twitter hacking at the start of the daily White House press briefing, saying the tweet had been deleted as soon as it was discovered. A stoney-faced Jay Carney, Obama's personal spokesman, thanked the reporter but did not look amused. "The president is fine. I was just with him," added Carney.

The market recovered within a few minutes of the misunderstanding, but the incident left traders catching their breath and speculating once more about their vulnerability to breaking news in the age of social media. It also raised new questions over Twitter's security procedures.

The panic, however brief, demonstrates how tightly intertwined Wall Street has become with Twitter, a site that acts as both chatroom and news service, where journalists and publications regularly send out breaking news.

There were also concerns over what many suggested was the lurking menace of trading algorithms that scan the news and trade quickly, causing "flash crashes".

The Dow Jones Industrial Average measures the financial performance of 30 major US companies and is often used as measure of the health of the wider

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Community Review

The global open source community provide incredible validation and review.

Peer Review

Create customized impact models to handle order impact on fills.

Rapid Feedback

Quickly obtain feedback from engaged pool of users. Collaborate in chatrooms directly with consumers.

Improving Regression and Unit Testing

The community helps us implement new regression and unit tests, finding the thousands of edge cases.

Instilling Trust of Clients

Winning trust of community is critical with such mission critical software.
Why should clients trust a start up with limited track record?

Transparency
Public visibility into code issues and flaws, along with list of work in progress.

Voice
Ability to communicate concerns and contribute, be heard publicly.

Regression
Public unit and regression testing displaying success and failures.

Travis CI

Recruiting and Building an Audience

Building an audience of fans is critical to any sustainable business.

Industry Attention
Attracted the attention of industry, investors and clients.

Powerful Recruiting
Our entire team was sourced from the open source project. Love hard problems.

Strong Retention
People are voluntarily working on LEAN, gives us strong retention.

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#3. Complex needs made it difficult to keep pace with innovation.

Nearly Infinite Complexity

1000 Models * 1000 Different Implementations

Slippage Models
Transaction Fee Models
Market Impact Models
Custom Data Implementations
Order Filling Models
Brokerage Models
Margin Model
Margin Call Model
Brokerage Implementations
Data Downloader Implementations
Indicator Implementations
History Providers
Settlement Models
Asset Class Models
Result Handling Implementations
Messaging Implementations
Transaction Processing Model

Realtime Events Management
Data Feed Implementations
Algorithm Setup Implementations
Logging and Debug Management
Algorithm Settings Models
API Implementations
Brokerage Setup Factories
Caching System Implementations
Streaming Data Provider
Corporation Action Implementations
Universe Selection Implementations
Alpha Generation Implementations
Portfolio Construction Implementations
Point Price Providers
Trade Builder for Statistics Creation
Regression Algorithm Implementations
Risk and Execution Model Implementations

Codesign Focus

Provide Examples, Review

Provide template example implementations and detailed thoughtful review feedback to community.

Define Interfaces

Define how the software communicates.

Write Documentation

Invest heavily in beautiful HTML documentation to help the community learn quickly.

Codesign Focus

Bitfinex

Crypto exchange implementation shared back to the community from a hedge fund using LEAN.

Binance

Crypto exchange implementation shared back to the community from a hedge fund using LEAN.

Alpaca

Commission free brokerage, algorithmic trading competitor to Robinhood, submitted a brokerage implementation to LEAN.

Core Fears of Lock In

Understanding the true fears of clients of vendor lock-in and how to
eliminate them with open source.

Fear of bugs which are not patched.

Unpatched issues in the code base making business inefficient.

Fear required features not prioritized.

Critical features and improvement required but no pathway to implement them.

Fear price hikes make business unsustainable.

Pricing changes in the software will force the company to
move to another platform.

Phasing Out Brokerage Integrations

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Open Up Technology

Opening up the platform allowed clients freedom to evolve at their own pace, along with eliminating lock in fears, increasing adoption.

Freedom
Open source gives clients freedom to modify, fix, extend the software.

Lock In Dissolves
Fears of vendor lock in dissolve and adoption improves.

Self Direction
Soliciting community involvement gives self direction and control.

LEAN

www.quantconnect.com/lean

Choosing an Appropriate License

What is your value proposition to clients?

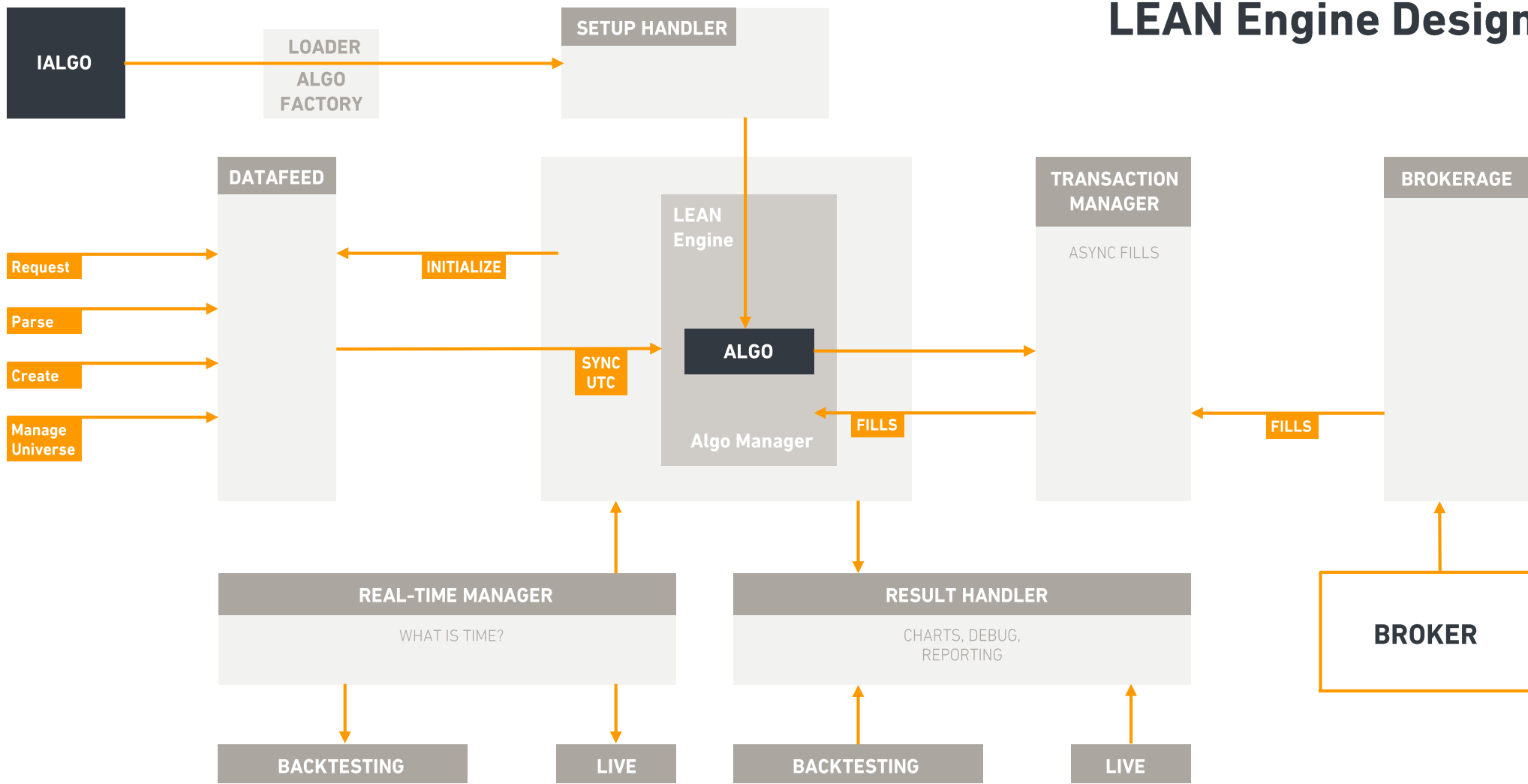Unpatched issues in the code base making business inefficient.

Who are your target users?

Unpatched issues in the code base making business inefficient.

quantconnect.com/lean
opensource@quantconnect.com

LEAN Engine Design

IALGO

LOADER

ALGO FACTORY

SETUP HANDLER

DATAFEED

Request

Parse

Create

Manage Universe

INITIALIZE

LEAN Engine

SYNC UTC

ALGO

Algo Manager

TRANSACTION MANAGER

ASYNC FILLS

FILLS

FILLS

BROKERAGE

REAL-TIME MANAGER

WHAT IS TIME?

RESULT HANDLER

CHARTS, DEBUG, REPORTING

BROKER

BACKTESTING

LIVE

BACKTESTING

LIVE

Each component of the LEAN Engine is customizable and pluggable. With slight configuration changes, you can route to new brokerages and select new datafeeds.
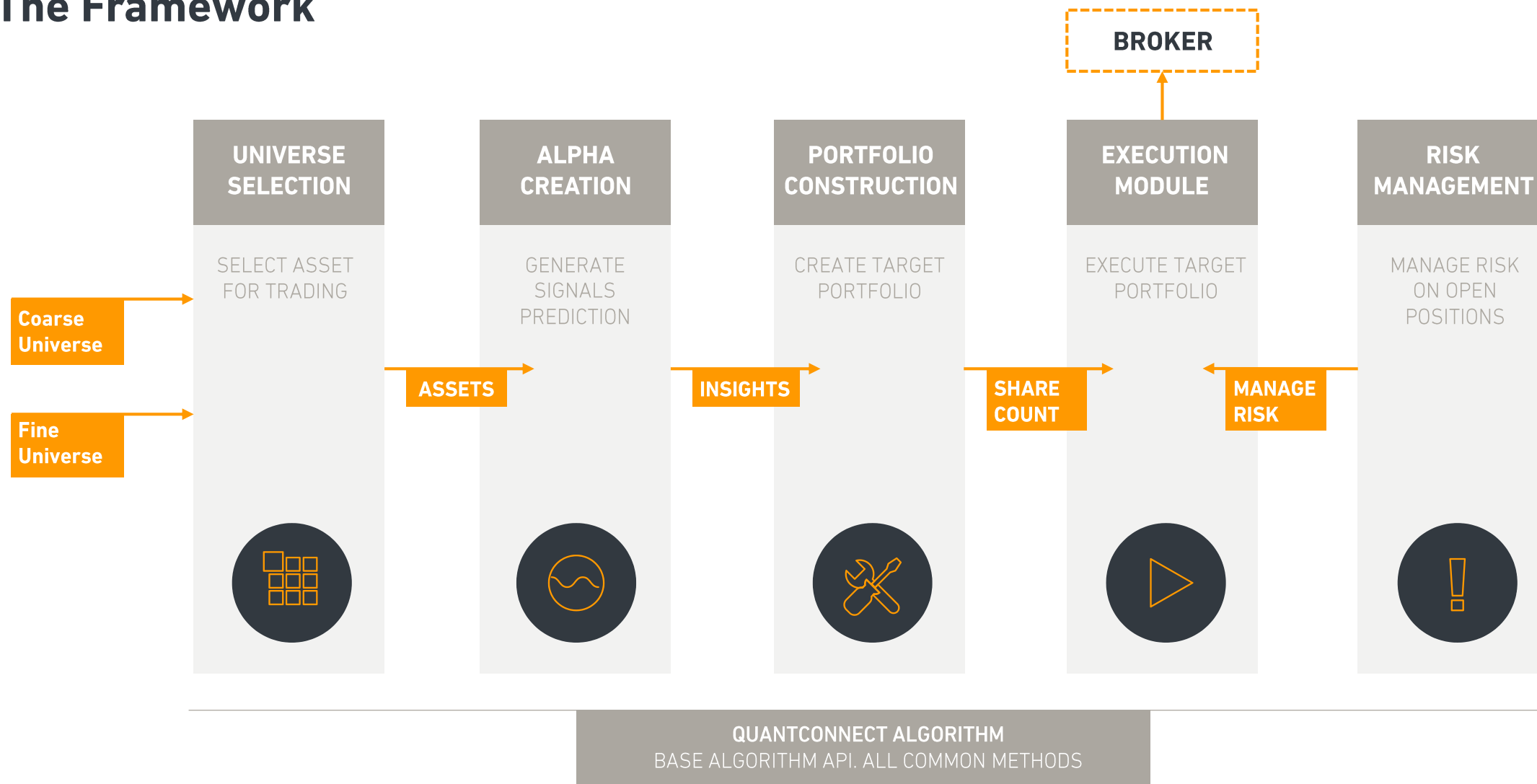
Data Integrations

US Equities and Fundamental Data

QuantQuote provides US equities data to tick resolution; survivorship bias free. Trade and NBBO quote support for backtesting. Paired with MorningStar fundamental data for professional grade equities backtesting.

Multi-Market Forex and Contracts for a Difference (OANDA/FXCM)

Currency trading across multiple exchanges and marketplaces; with spread modelling for accurate order fills. Supporting markets FXCM, OANDA and Interactive Brokers.

Futures and Options (AlgoSeek)

AlgoSeek provides tick by tick future trades and quotes, and minute resolution options support. LEAN can backtest and trade option and future chains.

Cryptocurrency Support (Kaiko/GDAX)

Kaiko and GDAX supply cryptocurrency trade and quote data at tick resolution, enabling trading across major currencies in US. Binance and Bitfinex are also planned additions.