2015 Fall Competition
Case Packet

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Contents

1 Introduction

Traders@MIT welcomes you to our 8th Annual Intercollegiate Trading Competition! We are excited to be holding the competition again this year and are confident that it will provide a rich and challenging learning experience.

Our competition consists of both open-outcry and electronic trading. Teams will be ranked overall based on their total weighted rankings from each of the five cases. You will also have several opportunities to speak with our attending sponsors:

Platinum: DRW, Wolverine

Gold: DE Shaw, Hudson River Trading, Flow Traders, Bank of America Merrill Lynch, Morgan Stanley, Jane Street Capital, Group One Trading, Goldman Sachs

Silver: IMC, Belvedere, Optiver, SIG, Element, 3Red, Eclipse Trading Technologies, Volant Trading, Akuna Capital, Spot Trading

The remainder of this packet contains the competition schedule, descriptions of the cases that will be presented, logistical notes, and other preparatory information. We recommend that you read it thoroughly and build the necessary models before the day of the competition.

1.1 Schedule of Events

Friday, November 13

8:00PM	–	10:00PM	Networking at Champions Sports Bar, Sponsored by Wolverine Trading

Saturday, November 14

9:00AM	–	9:45AM	Check-In and Breakfast at MIT Sloan Tang Center (Room 345)
9:45AM	–	10:00AM	Opening Remarks by Wolverine Trading
10:00AM	–	11:00AM	Case 1: Quant Open Outcry
11:00AM	–	12:00PM	Case 2: Options
12:00PM	–	1:45PM	Lunch at Boston Marriott Cambridge
2:00PM	–	3:00PM	Case 3: Sales and Trading
3:00PM	–	4:00PM	Case 4: Price Discovery
4:00PM	–	5:00PM	Case 5: Foreign Exchange
5:00PM	–	6:00PM	Networking at Boston Marriott Cambridge
6:00PM	–	6:30PM	Awards Ceremony at Boston Marriott Cambridge

DRW Trading will be taking the top three teams out to dinner immediately after the awards

ceremony. Please make sure to plan return trips accordingly.

1.2 Directions

Check-in and all cases will take place at the MIT Sloan Tang Center (Building E51) in room 345. Its address is

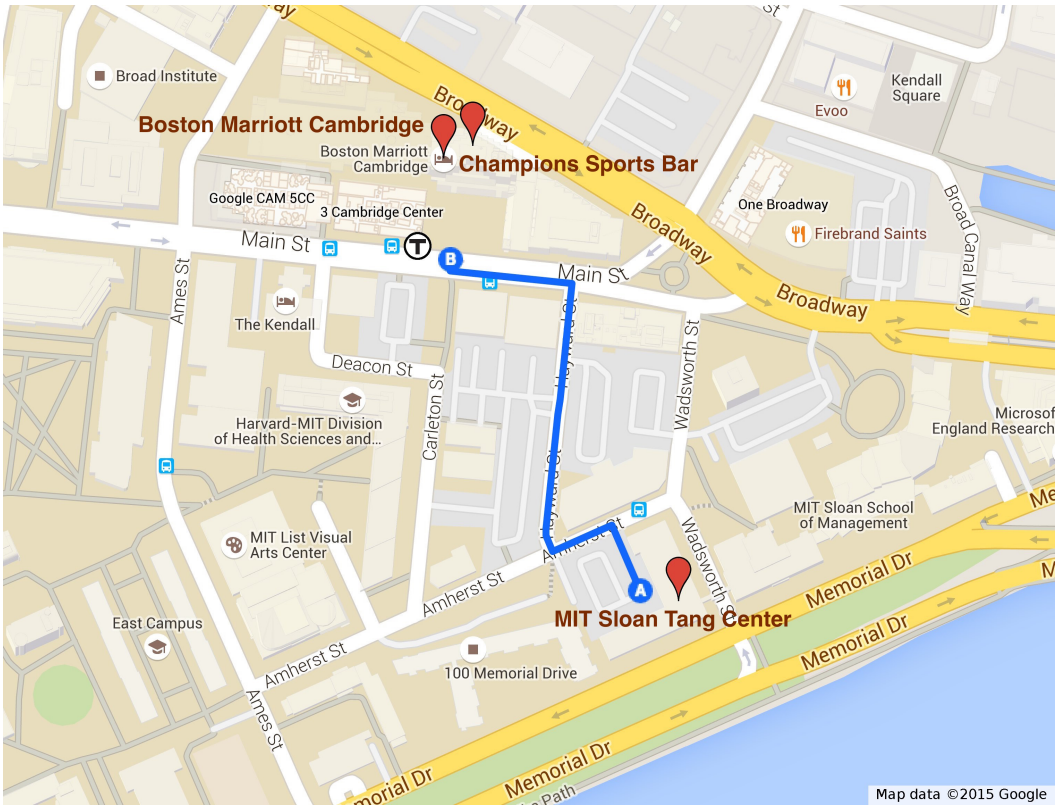
MIT Building E51
70 Memorial Drive
Cambridge, MA 02139

The Friday night networking session will be held at the Champions Sports Bar in Cambridge from 8PM-10PM on November 13th. It will be sponsored by Wolverine Trading and is a great chance to meet representatives from Wolverine as well as your fellow competitors. The address is

Champions Sports Bar
2 Cambridge Center
Cambridge, MA 02142

Lunch, the Saturday afternoon networking session, and the awards ceremony will all take place at the Boston Marriott Cambridge.

Boston Marriott Cambridge
50 Broadway
Cambridge, MA 02142



1.3 Scoring and Awards

We will determine each team's final rank from weighting each team's rank in the five cases. The case weights are

Case	Weight
Quant Outcry	10%
FX	15%
S&T	25%
Options	25%
Price Discovery	25%

We will award cash prizes to the top three overall teams and the top team in each case.

1.4 Requirements

All trading will be done on MangoCore, an in-browser trading platform. We require that all competitors use the browser Google Chrome.

In addition, all competitors must attend at least one remote practice session. We will be holding 4 online practice sessions: 11/3, 11/5, 11/10, and 11/12 at 8pm EST on each day.

1.5 Piazza

We have created a Piazza forum to answer questions about cases:

http://www.piazza.com/tradersmit/fall2015/tamit2015

The access code is **tamit2015**. Traders@MIT executive board members will do our best to reply to all questions within 24 hours. If you have questions specific to your team, feel free to contact us directly at traders@mit.edu.

1.6 Attire

The Friday networking session is business casual, and the competition day on Saturday is business formal. Our Gold and Platinum sponsors will be in attendance.

2 Quantitative Outcry

2.1 Overview

During the Quant Open Outcry case, teams of two will trade TAMIT Index futures. Each team consists of a trader, who will trade on the floor of the trading room, and an analyst, who will be located in the gallery seating section of the room.

Teams will construct pricing models based on historical index levels and the indicators explained below. Analysts can view the current indicators on the MangoCore web interface or get this data programmatically, as described in the API section. These values should be used to construct pricing models. Teams should construct their pricing model **before** the day of the competition. Analysts will use their models and convey trading instructions to traders.

The case will last for 40 minutes, divided into two 15-minute heats and one 10-minute blitz heat. This time will correspond to one year of simulation. There will be one release per week. During the first two heats, a reading for each of the indicators will be released every 30 seconds to the analysts. During the final blitz round, readings will be released every 10 seconds. Note that this data will not be available to pit traders. Indicator releases can be considered accurate and free of errors. Although pit traders cannot see indicator releases, both traders and analysts will be able to see the underlyings market in real time on the projector screen.

Accurately forecasting the index level and rapidly relaying trading instructions will result in higher profits. The TAMIT Index will begin trading at a value of 1000, and the final value for each heat will depend on the economic indicators. Note that the index returns are noisy – you should not expect to predict them perfectly from the indicator values.

Correlations between the TAMIT Index and the indicators may or may not stay fixed throughout the entire event, so it is suggested that analysts keep track of the accuracy of the model and consider re-running analyses when necessary.

2.2 Constructing a Useful Pricing Model

There are various indicators that affect the TAMIT Index, mostly types of economic data.

We provide 50,000 data points of historical data for the level of the TAMIT Index and the economic indicators. You may use this data to estimate a model to predict the TAMIT Index. This data is saved as `outcry_data.csv` in the shared Dropbox folder.

Each team is advised to develop a model (using, for example, Excel or Python) to determine

the relationship between economic indicators and the TAMIT Index. New indicator values should be entered into the Excel model when they are released, in order to predict the next-period index value. The provided historical data should be considered accurate for modeling the future position of the TAMIT Index.

The following indicators will be available:

1. Gross Domestic Product (GDP)
2. Money Supply (MS)
3. Consumer Price Index (CPI)
4. Producer Price Index (PPI)
5. Consumer Confidence Survey (CCI)
6. Unemployment Rate (U)
7. Housing Starts (HS)
8. Employment Cost Index (ECI)
9. Gold Price (Gold)

Each indicator has a different effect on the TAMIT index; it is your job to model these effects using the provided appendix of historical data. More specifically, it is your goal to build a model that can, given the indicator values up to time t and the index values up to time $t-1$, predict the value of TAMIT for time t. Here are a few suggestions for building a good model:

1. Use the mathematical software of your choice to fit the historical data to a linear regression. You want to discover a model of the form

$$y = c_0 x_0 + c_1 x_1 + \cdots + c_n x_n,$$

   with the independent and dependent variables chosen in a manner that fits the context of this case. Note that the linear dependence may be between transformations on the provided values, like the derivative $dx \approx x_t - x_{t-1}$ or proportional difference dx/x.

2. To model proportional change in a regressor, note that $dy/y = d\log y$. Then, the proportional change between times $t-1$ and t for an indicator can be approximated by $\log(\text{INDICATOR})_t - \log(\text{INDICATOR})_{t-1}$. The proportional change in the TAMIT index can be similarly estimated.

3. At time t, you will have all the indicator values up to time t and all the index values up to time $t-1$. Incorporate dependence on as few or as many previous values as you see necessary.

4. Some indicators may have no effect on the TAMIT index.

Note that you and your analyst will be using this model on the day of the competition, so make sure it is easy for your analyst to use in predicting index values.

2.3 Starting Values

The starting values of the indicators on the day of the competition are given below in Table 3.2. Use these values in your trained model to predict the value of the TAMIT index.

Indicator	Starting Value
GDP	17
MS	1180
CPI	-0.7
PPI	-0.5
CCI	96
U	6
HS	591
ECI	0.6
Gold	1400

2.4 Rules

Each team must switch off as trader/analyst every period. During the trading period, traders must provide both a bid and an ask price. For example, you can say: "500 at 1200", meaning that you are willing to buy at 500 and sell at 1200. You cannot retract an offer once you have made one.

In order to complete a transaction, the two parties must fill out an order form. Both sides of the trade must present this form to a Traders@MIT executive board member. We reserve the right to reject all poorly written trade forms.

2.5 Scoring

Each team's outstanding positions at the end of the trading session will be cash settled. The payoff at the end of the year for a future contract can be calculated as:

$$\text{Payoff} = \$10 \cdot (S_T - F) \text{ for a long position, and}$$
$$\text{Payoff} = \$10 \cdot (F - S_T) \text{ for a short position,}$$

where S_T is the spot level of the TAMIT index at the end of one year, and F is the futures level specified by the TAMIT futures contract. The futures level will depend on the supply and demand from other traders.

The quality of analysts' models will not factor into your final score; however, accurate estimates of the index will greatly assist you in achieving higher profits. Teams will be scored based on their total PNL over the two heats.

3 Options

3.1 Overview

In this case, you will use news releases to trade European options on T@MIT, an equity index. Your ability to earn profits will depend on your ability to:

1. predict changes in implied volatility across different strike prices
2. identify, enter, and exit appropriate positions
3. hedge positions to reduce risk

This case is relatively complex. We strongly recommend investing time in understanding the relevant concepts and building a useful model before the competition.

For the rest of this case description, we will simply refer to European options as options.

3.2 Options Basics

Options come in two flavors: A *call* option confers the right to buy a given product (the underlying) at a fixed price (the strike price) on – but not before – a given date (the expiration date). Likewise, a *put* option gives the right to sell the underlying at the strike price on the expiration date.

For example, imagine that an investor is holding an Apple call option at a strike of $100 and expiry of November 15th. (S)he would exercise the right to buy if the price of Apple was greater than $100 on November 15th.

The price or value of an option depends on the volatility of the underlying. *Volatility* is the standard deviation of the logarithmic return distribution of the underlying. Intuitively, it is a way to quantify how much the price will fluctuate. There are two relevant measures of volatility:

- Realized volatility is the volatility of the underlying over some past time period and is generally estimated as the sample standard deviation of the annualized log returns during the period.
- Implied volatility is the volatility of the underlying that when used in a pricing model returns the current market price of the option. We will explore this concept more later.

An interesting feature of call options is that we can create a "synthetic" put option of the same strike and expiry by using a futures contract, and vice-versa. This is known as put-call parity. For example, assuming the same strike and expiry, we can buy a call option and sell a future to "create" a put option. The formula for put-call parity is given in the next section.

Options can be either in-the-money, out-of-the-money, or at-the-money. In-the-money refers to an option that is profitable if it were to be exercised. Out-of-the-money is defined analogously. At-the-money refers to an option that is whose strike price is at the spot price.

3.3 Options Pricing Models

Given the current price of the underlying (the *spot* price) S, strike price K, risk-free interest rate r, volatility σ, current time t, and expiration time T, the Black-Scholes formula for the value C of a call option on a non-dividend-paying asset is

$$C = N(d_1)S - N(d_2)Ke^{-r(T-t)}$$

where

$$d_1 = \frac{ln(\frac{S}{K}) + (r + \frac{\sigma^2}{2})(T-t)}{\sigma\sqrt{T-t}}$$

$$d_2 = d1 - \sigma\sqrt{T-t}$$

and $N(x)$ is the standard normal cumulative distribution function. Briefly, the Black-Scholes formula and related extensions assume the spot price follows a geometric Brownian motion, which is equivalent to claiming that incremental logarithmic returns are normally-distributed and have a constant standard deviation. In reality, returns are not typically normally distributed. They tend to have a higher probability of extreme events than would be the case under a normal distribution ("heavy tails"), particularly for extreme negative events. The Black-Scholes formula does give a fast and relatively accurate approximation, and is widely used as a basic model. The value P for a corresponding put option can be obtained from put-call parity, which for European options is as follows:

$$C + Ke^{-r(T-t)} = P + S$$

3.4 Volatility Smile and Skew

With these pricing formulas, we can estimate implied volatility. Not surprisingly, options with different strike prices often have different implied volatilities. Typically options that are more out-of-the-money or in-the-money will have higher implied volatilities. This effect is known as the *volatility smile*. Moreover, options with strike prices much lower than the current spot price often exhibit higher implied volatility than options with strike prices equally higher than the current spot price. This effect is known as the *volatility skew*. Figure 1 shows the effect of the October 1987 stock market crash on index options.

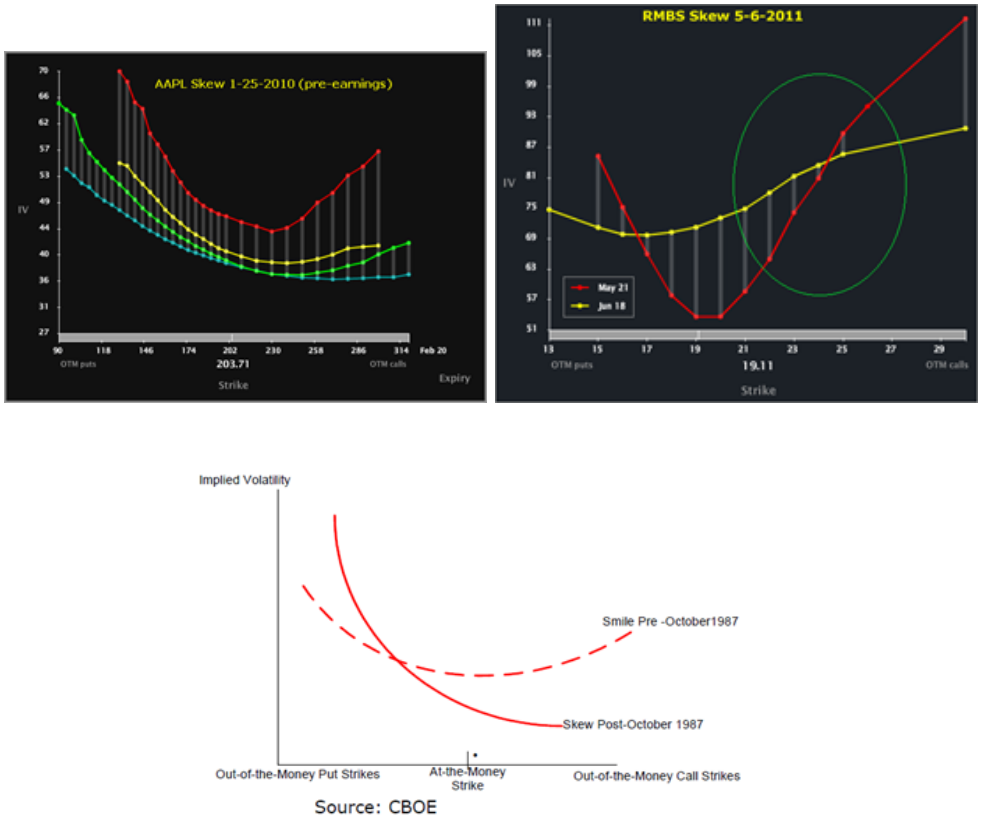


Figure 1: The S&P 500 Implied Volatility Curve Pre- and Post-1987

As seen above, an increase in the perceived likelihood of extreme negative events can increase volatility skew. Similarly, a belief of increased likelihood in extreme events in either direction compared to more typical events unchanged can make the volatility smile more pronounced. Note however, that these effects are not equivalent to that of belief that price movements will on average be larger than they have been in the recent past; this instead causes a parallel shift upward in the implied volatilities of at all strike prices. These effects can occur simultaneously.

Here are two examples. The left is from just prior to an earnings release for a stock. Note the pronounced curvature and asymmetry in the front-month options (red). Also note that the overall level of volatility for the front-month options is higher than for longer-dated options, indicating that most of the variability in price is expected to occur in the near-term:

In contrast, the chart on the right comes from a company that engages in numerous patent lawsuits. A particular one is expected to reach a decision soon, and the decision will be either very good or very bad for the future of the company. The front-month options again exhibit a substantial volatility smile, but it is more symmetrical this time. Also, subsequent volatility remains high in this example given the risks of other ongoing litigation and R&D. However, these later risks are expected to be less binary than the impending decision: market participants predict the later return distribution will have thinner tails, so the implied volatility surface is flatter.

3.5 Greeks and Hedging

Options have various risk factors, commonly called the “Greeks." The Greeks describe the effects of changes in various parameters on the price of the option. We can think of the Greeks as

representing exposure to market risk. Hedging is the process of minimizing such risk across each Greek.

The simplest and most important Greeks are:

- Delta: the rate of change of an option's value relative to a change in the underlying. It is always positive for calls and always negative for puts. Traders can think of delta as how many shares of the underlying to sell in order to hedge their option.
- Gamma: the rate of change of delta relative to a change in the spot price, and it is always positive. Gamma determines how quickly you must adjust a delta hedge when price changes.
- Vega: the rate of change of an option's value relative to the volatility of the underlying. It is always positive, and can only be hedged by selling other options.
- Theta: the rate of change of an option's value relative to time. It is always negative; options lose value fastest when they are close to expiring.

Expressions for the Greeks from differentiating Black-Scholes are below. Note these can become unstable for options very close to expiry: where $N(x)$ is the standard normal cumulative

Table 3.1: Formulas for Greeks

Greek	**Calls**	**Puts**
Delta	$N(d_1)$	$N(d_1)$
Gamma	$\frac{N'(d_1)}{S\sigma\sqrt{T-t}}$	$\frac{N'(d_1)}{S\sigma\sqrt{T-t}}\ N(d_1)$
Vega	$SN'(d_1)\sqrt{T-t}$	$SN'(d_1)\sqrt{T-t}$
Theta	$-\frac{SN'(d_1)\sigma}{2\sqrt{T-t}} - rKe^{r(T-t)}N(d_2)$	$-\frac{SN'(d_1)\sigma}{2\sqrt{T-t}} + rKe^{r(T-t)}N(-d_2)$

distribution function and $N'(x)$ is the standard normal probability density function.

3.6 Volatility Arbitrage

Volatility arbitrage aims to take advantage of inconsistent future and current volatilities. For a certain underlying P, profits can come from differences between the anticipated future realized volatility of P and current implied volatilities of options for P. Profits can also come from differences between current and future implied volatilities.

For example, suppose a trader believes that the future realized volatility for a given product will be higher than the current implied volatility of a call option on that product. Then the trader believes the option is cheaper than it should be, so (s)he buys it, hedges by shorting some amount of the underlying, and adjusts the hedge as the price of the underlying changes.

One of the most common types of volatility arbitrage is called volatility surface relative value trading, which is what you will be doing in this case. It involves attempting to earn profits by predicting changes in the shape of the volatility smile.

Suppose you expect an increase in the curvature of the volatility smile due to news releases. Then you could buy options far out on the curve, perhaps hedge some vega exposure by shorting options with strike prices closer to the current spot price (at-the-money options) if you have no view on the future overall level of volatility, and then hedge your delta exposure by holding a position in the underlying equal and opposite to the remaining delta of your options portfolio. This leaves you exposed only to changes in the curvature of the smile. Trading on anticipated changes in skew or broad shifts in volatility across the entire option chain are just special cases of this approach.

3.7 Case Information

The tradable instruments are options and futures on the T@MIT index, the latter solely for hedging. Both are cash-settled. Note the options underlying is the index, not the futures contract.

There are eight options in each round of the case: four puts and four calls. Options expire at the end of each round and their tickers are subsequently re-used. All tickers are as follows:

Table 3.2: Tradeable Options

Strike Price	**Put Option Ticker**	**Call Option Ticker**
$90	T90P	T90C
$95	T95P	T95C
$100	T100P	T100C
$105	T105P	T105C
$110	T110P	T110C

The ticker for futures on the index is “TMXFUT”. The ticker for the T@MIT index itself is "TMX". The index is viewable but not tradable.

To successfully trade this case, you should make a pricing model to show the current volatility smile, your current portfolio Greeks, and any refinements or derived metrics that help you trade faster and better. This will allow you to quickly pursue arbitrage opportunities and to hedge your positions. You should also pay attention to news releases, which could help predict future market movements.

3.8 Case Specifications

There will be four 7.5-minute periods. Each period represents one month of trading. One team member will trade while the other monitors a pricing model and advises the trader. Team members will switch roles after each period. Trading activity by both partners during any given round is grounds for disqualification. Unlike the SEC, we have granular audit logs – please don’t make us use them.

All tradable instruments expire at the end of each round. Each round begins with the T@MIT index at 1000. The continuously compounded risk-free interest rate is 0%.

The contract multiplier for options on the T@MIT index is 10. Options have a trading fee of $0.05 per contract per transaction. There is a gross trading limit of 20,000 options contracts, and a net limit of 10,000 options contracts. Options that expire in-the-money pay out their intrinsic values.

The contract multiplier for futures on the T@MIT index is 20. Futures have a trading fee of $0.10 per contract per transaction. There is a gross trading limit of 2500 futures contracts, and a net limit of 2500 futures contracts. All future contracts are cash-settled upon expiry.

All outstanding positions at the end of each period will be automatically closed out at their fair prices. Winners will be determined by total P&L across the four rounds.

4 Equities Sales & Trading

4.1 Overview

During this case, teams will trade on four different stocks. Unlike the other cases, traders in this case may act as both proprietary traders and agency traders for institutional clients.

The goal of an agency trader is to be a source of liquidity to clients. A successful agency trader must be cautious about which and how many orders to accept. Clients such as pension funds, mutual funds, and hedge funds may request to buy or sell a certain amount of a certain stock at a certain price at various times during the case. For example, you might get a request that says, "The Oregon Teachers Retirement fund wants to sell 10,000 shares of BRB to you at $30.10. Accept/Decline?" As an agency trader, you can earn money both from the spread between the price paid by the client and that at which you are able to execute, and a commission proportional to the dollar size of the order. At no point during the case do you have to accept an order from any client – you may always choose to prop trade. You will have 30 seconds to decide whether or not to accept an order. At the end of the 30 seconds, if you have not acted, the order will be declined by default.

Should you wish to hold on to your positions from clients, you will be subject to market risk. If you wish to minimize this risk and profit purely from market making, you can offload your positions onto the market. However, most client orders will be sufficiently large that immediate execution would result in adverse market impact. You can reduce risk while offloading the position by hedging your exposure according to market and industry correlations. Each stock has a historical beta coefficient against the T@MIT Index, and an extremely liquid market in T@MIT Index futures is available against which positions obtained through institutional orders may be hedged. Stocks also have correlations across industry groups, which can be exploited depending upon liquidity.

4.2 Case Information

During each trading period, your goal will be to maximize your P&L. Stocks may be positively or negatively correlated with each other, and the strength of these correlations varies. Additionally, in each of the four rounds, you will have an initial endowment of some number of shares. If those shares are tradable, you may sell them at any point during the period. If not, you may either hedge your position with a long or short position in the T@MIT Index futures or a correlated stock, or accept the risk of holding on to the position without a hedge.

There will be news announcements from several reputable sources throughout each case pe-

riod. These will be useful in predicting changes in price paths.

There will be four 7.5-minute trading periods, each equivalent to 3 months of time. Your initial endowment will be $\$1,000,000$. The interest rate is 5% per year, and the compounding interval is 30 seconds.

Company Name	**Industry**	**Ticker**	**Beta**
Friendly Neighborhood Bank	Finacial	FNB	0.7
Wind & Tomato Fund	Commodities	WTF	-0.4
Technology Co.	Technology	TC	1.5
Basic Bodily Needs	Consumer Staples	BBN	0.2

Table 4.1: Available equities and their betas

	1		2		3		4	
FNB	500	Yes	None	No	None	No	1000	Yes
WTF	None	Yes	500	No	500	Yes	1500	No
TC	500	No	500	Yes	None	Yes	None	No
BBN	None	Yes	None	Yes	1000	No	None	Yes

Table 4.2: Initial endowment and tradability per equity per period

4.3 Margin Requirements and Trading Costs

A trading fee of 2 cents per share is charged on every stock transaction. All stocks are marginable. A margin loan of 50% of an equity's value is given for long positions, and margin collateral of 150% of an equity's value is required for short positions.

The index value will start between $300 and $400, and the futures contract multiplier is 20. A trading fee of $2 per contract will be charged for every futures transaction. Initial margin of $5000 per contract is required to open a long or short position in the futures. The maximum order size is 50 contracts.

There is no maintenance margin, so margin calls will not be issued, but negative cash balances will be treated as loans and will accrue interest at the posted interest rate. As always, margin balances are deducted from your buying power, and you must have sufficient buying power to enter into any margined position.

4.4 Scoring

All outstanding positions at the end of each period will be closed out at a randomly chosen price. We suggest that you close out all positions prior to the end of the round in order to avoid liquidation at a loss. You will be ranked according to overall P&L.

5 Price Discovery

5.1 Overview

EXE, CPP, HS, PYPY, RB have just issued their earnings reports for the most recent quarter, and as highly traded stocks, many analysts are continuously predicting the target price of these 5 stocks. However, these analysts are not always accurate, and their predictions should be considered holistically. Additionally, there is an index of these stocks, each with a weight of 1, trading under the ticker IDX.

In this case, traders will analyze predictions to come up with a maximum likelihood estimate of the true price of the 6 products (5 stocks + 1 index).

There are four 10-minute periods. One team member will trade while the other performs analysis. Team members will switch roles after each period.

When a number of traders hold potentially different information or views on a particular security, the markets provide a mechanism for price discovery. In this case, traders can take price estimates they receive from research analysts to deduce the true value of each stock.

5.2 Case Meta-information

In the first period, all securities are tradeable, potentially allowing for arbitrage opportunities between the basis securities and the index. In the subsequent cases, all but one security is tradeable.

For each period, the true prices of each security are independently and randomly drawn from a uniform distribution. The true prices are known to be within the following bounds:

	minimum	maximum
EXE	30	50
CPP	40	80
HS	70	100
PYPY	40	80
RB	20	60

You should not rely on pricing data from past periods to help you in the upcoming periods.

Traders begin each period with an endowment of $1,000,000 in cash. Each period represents one quarter of the year, and the risk free rate is 0% so there is no interest paid on cash balances.

Fees are $0.005 per contract, and rebates are $0.0025. The fine for self-trading is $0.01. The position limit is ±1000 for each basis security. Orders that violate this limit will be rejected.

5.3 Predictions

During each period, each trader will receive many stock predictions from analysts. Each prediction is a sample from a multivariate normal distribution with mean equal to the true prices of the securities.

The standard deviation for a news release from source s at time t seconds, for any ticker is:

$$\frac{q[s](600-t)}{60}$$

Intuitively, this means that certain news sources are more reliable than others, and that predictions are more accurate as time goes on.

Traders will receive estimates from Buzzfeed, The Associated Press, Seeking Alpha, and @ETFGodfather (on Twitter). Not in any particular order, the quality vector q is [0.5, 0.7, 1.3, 3.5]. It is the trader's and analyst's responsibility to discover how reputable each source is. The quality of each source is constant throughout all periods. For example, if Buzzfeed has a quality of 1.3 in round 1, it will have a quality of 1.3 in all other rounds. Competitors will receive a news release once every few ticks, and each news release will only contain the information from one of the four predictors.

An example of the body of a news report is:

> EXE estimated to be worth 39.70; CPP estimated to be worth 73.68; HS estimated to be worth 49.03; PYPY estimated to be worth 12.62; RB estimated to be worth 45.83

The correlation coefficients for the multivariate normal are given as follows:

	EXE	CPP	HS	PYPY	RB
EXE	1	-0.64372484	0.09173378	-0.25319211	0.6453473
CPP	-0.64372484	1	-0.65889412	0.50111104	-0.12582015
HS	0.09173378	-0.65889412	1	-0.19964734	-0.17288262
PYPY	-0.25319211	0.50111104	-0.19964734	1	-0.37187632
RB	0.6453473	-0.12582015	-0.17288262	-0.37187632	1

5.4 Other Market Participants

In this case, the primary other market participants are market makers. These market makers are not particularly intelligent and simply make a market around the last transaction price.

The secondary other market participant is a trader that randomly posts market orders for randomly selected products.

Of course, participants will also be trading directly against each other.

5.5 Position Close-Out

Any non-zero position in a security will be closed out at the end of the trading period with the actual price computed from the earnings report of the next quarter. *Note that this price may be significantly different from the last transaction price of the security.*

The risk free interest rate is 0% and there are no dividends paid for any of the underlying stocks.

5.6 Scoring

A team's score for this case is sum of the PNLs across all four periods. This score is then normalized as the relative rank amongst all teams.

6 Algorithmic Trading: Foreign Exchange

6.1 Overview

The foreign exchange market is the global platform for trading currencies and currency products. As the largest and most liquid market in the world, FX trading is characterized by the availability of high leverage to take profit on minute daily currency fluctuations. The FX market is heavily dependent on macroeconomic news and events. However, this case will be focused on trading algorithmically, so your trading algorithm should be less dependent on such parameters. **We will provide you with a skeleton python API to help you get started on your algorithm.** You will also be able to click trade on top of your algorithm, but again, we emphasize that you will greatly increase your PNL by creating a well-written algorithm.

6.1.1 Understanding Foreign Exchange Bid/Ask Quote

FX quotes are given in terms of currency pairs. The first currency listed is the base currency, and the second currency listed is known as the quote currency. When you are going "long" or buying a currency pair, you are buying the base currency and selling the quote currency. The base currency is quoted in terms of its value relative to the other currency in the pair. For example, if the USD/JPY exchange rate is given as:

$$\text{USD/JPY} = 106.78$$

This means that US$1 = 106.78 Japanese yen. To provide an example where the USD is the quote currency, examine the EUR/USD rate:

$$\text{EUR/USD} = 1.2508$$

This means that 1 Euro = US$1.2508, where the Euro is the base currency and the USD is the quote currency.

In the FX spot market, these currency pairs can be bought and sold at the given bid/ask price. The bid is the price the counterparty is willing to buy the pair from you, and the ask is the price they are willing to sell the pair to you. Remember, "buying the pair" means buying the base currency and selling the quote currency, while "selling the pair" means selling the base currency and buying the quote currency.

6.2 Case Information

In this case, you will be trading pairs of the following 5 underlying currencies: USD (US dollar), EUR (Euro), JPY (Japanese yen), CHF (Swiss franc), and CAD (Canadian dollar).

You will be able to trade 8 currency pairs, listed below:

USD/CAD	EUR/USD	USD/CHF	USD/JPY
EUR/CAD	EUR/JPY	EUR/CHF	CHF/JPY

Case details:

Starting Endowment Per Round	US$100,000
Trading Periods	3
Period Time	15 min/period
Fees	$0.005/contract
Fines	Trading with yourself: $0.008/contract
Constraints	Position limits will be enforced; see below. Orders that would cause you to go outside your position limit will be rejected. You may only place a maximum of 300 orders/sec.
Information Provided	Occasional macroeconomic news

Position limits for the underlying currencies:

Currency	Position Limits
USD	±1,000,000
EUR	±950,000
JPY	±121,000,000
CHF	±1,010,000
CAD	±1,280,000

Note: Position limits for underlying currencies do not imply position limits on each currency pair. For example, you can be long 10 million contracts of USD/CAD, short 10 million contracts of EUR/CAD, and be long 10 million contracts of EUR/USD, and you would not be outside your position limits.

6.3 Trading Tips and Strategies

There are a variety of trading strategies in the FX market. Algorithms can make money by market making, identifying arbitrage opportunities, trading trends, and more. If you are completely new to algorithmic trading, this section will explain the basics most likely helpful in writing your algorithm. In addition to optimizing your algorithm, you should also **take note that you are allowed to set parameters that are changeable in real time (while the case is running)**. This allows you to adapt your algorithm based on live market conditions. As mentioned before, you may also click trade; however, remember that solely click trading will not be as effective as a well-written algorithm.

We will provide servers to backtest your code on. If your code is consistently profitable when traded on historical data, there is a better chance it will be profitable during the competition.

We now explain the concept of triangular arbitrage, which you can implement in your algorithm. The motivation behind triangular arbitrage is to take advantage of price discrepancies between three currencies. For example, theoretically the price of the pair EUR/JPY should equal the price of the pair EUR/USD times the price of the pair USD/JPY. If not, then an arbitrage opportunity exists. Suppose that

$$\begin{aligned} \text{EUR/JPY} &= 134 \\ \text{EUR/USD} &= 1.12 \\ \text{USD/JPY} &= 119 \end{aligned}$$

Note that $1.12 \cdot 119 = 133.28 < 134$. We can make money by buying the two currency pairs EUR/USD and USD/JPY, and selling EUR/JPY. Explicitly, we can convert 13328 yen to US$112 by buying 112 contracts of USD/JPY. Next, we can can convert US$112 to 100 Euro by buying 100 contracts of EUR/USD. Finally, we can convert 100 Euro to 13400 yen by selling 100 contracts of EUR/JPY. Overall, we made a profit of $13400 - 13328 = 72$ yen. Our profit from this trade is US$72/119, or about US$0.61.

6.4 Position Close-Out and Scoring

Any non-zero position in a security will be closed out at the end of the trading period with the closing price. The risk free interest rate is 0% and there are no dividends paid for any of the underlying stocks.

You will be ranked by the sum of your PNLs in US dollars across three rounds. Your PNL during the case will be displayed in US dollars–our grading script will make the necessary currency conversions in real time. This score is then normalized as the relative rank amongst all teams.

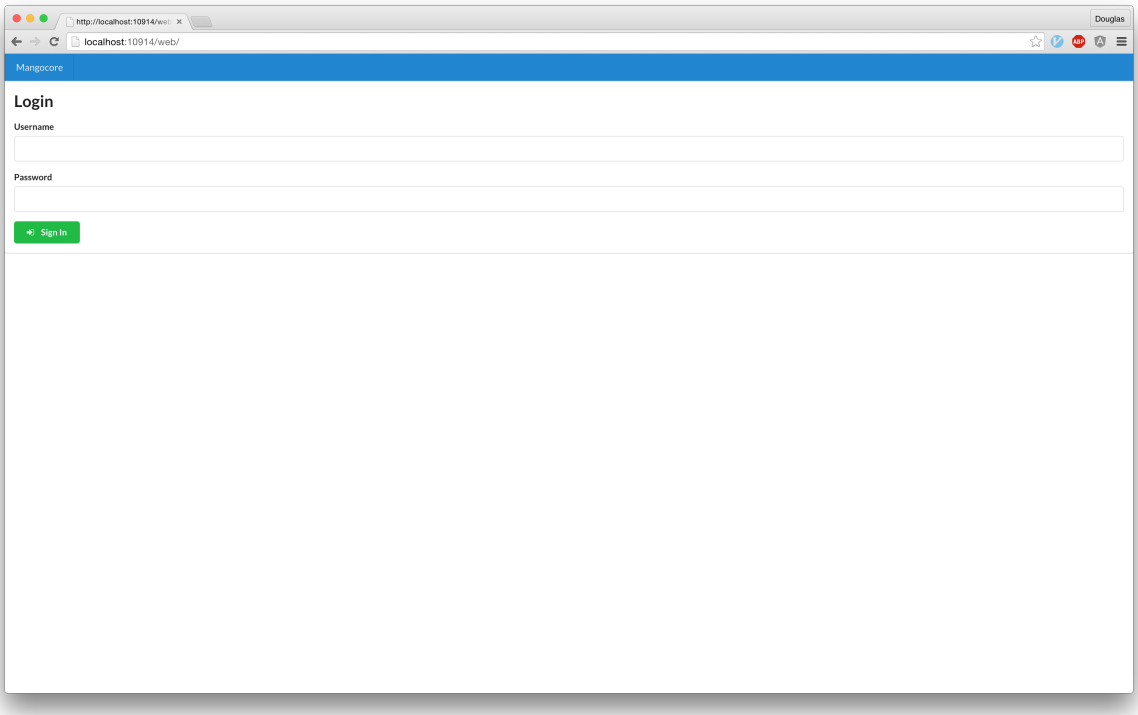
7 MangoCore Web Interface User Guide

7.1 Overview

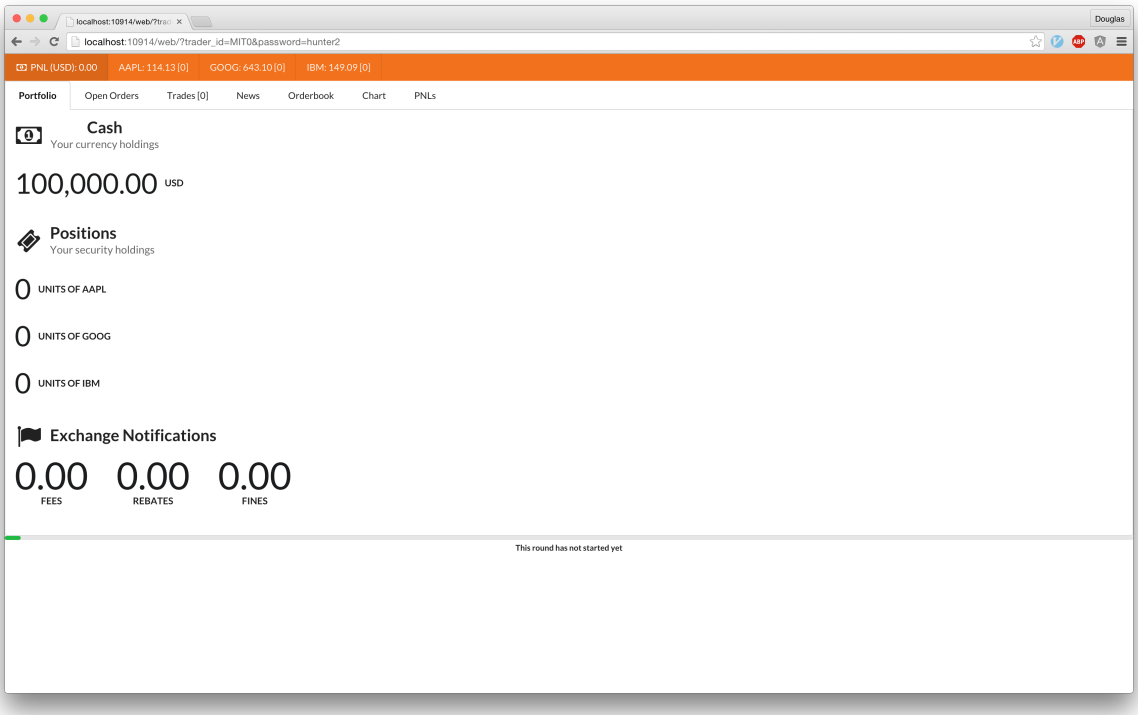
MangoCore is our general-purpose broker and exchange system for educational purposes. It is not connected to live exchanges and does not process real money. For these cases, you can interact with the simulator either through our web interface or through its JSON API. To access our web interface, go to http://m.angocore.com/web with a modern web browser.

7.2 Navigation

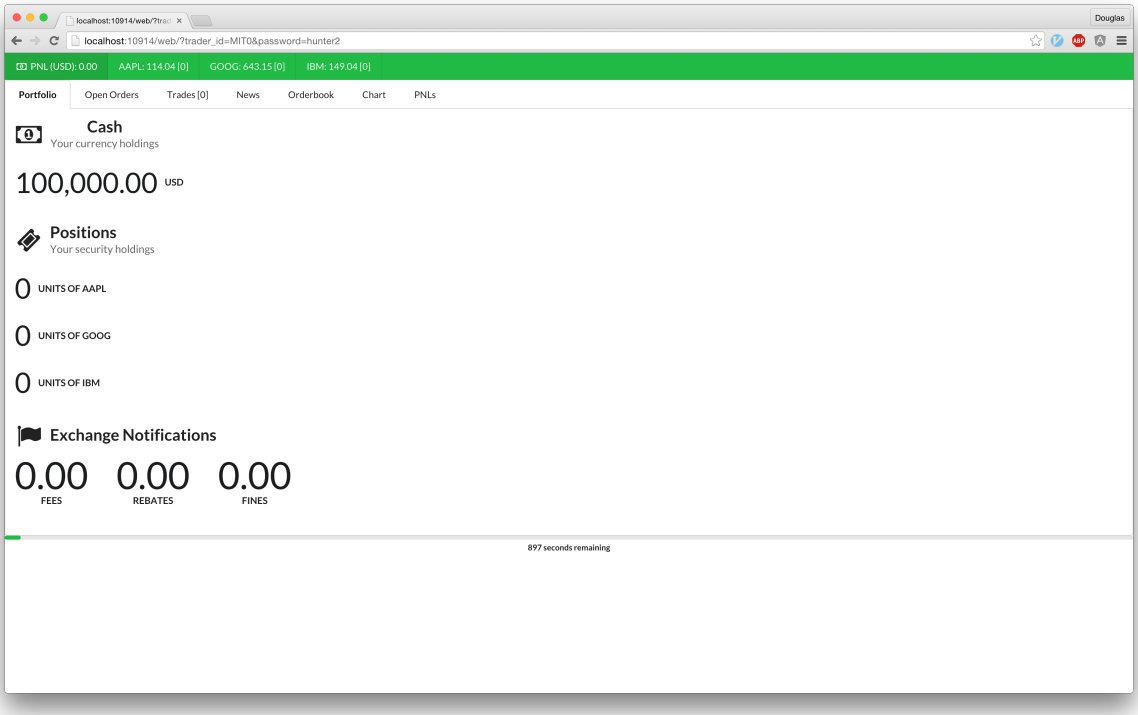
You will initially be presented with a login screen:



After logging in, but before the case starts, the summary bar at the top will be orange.



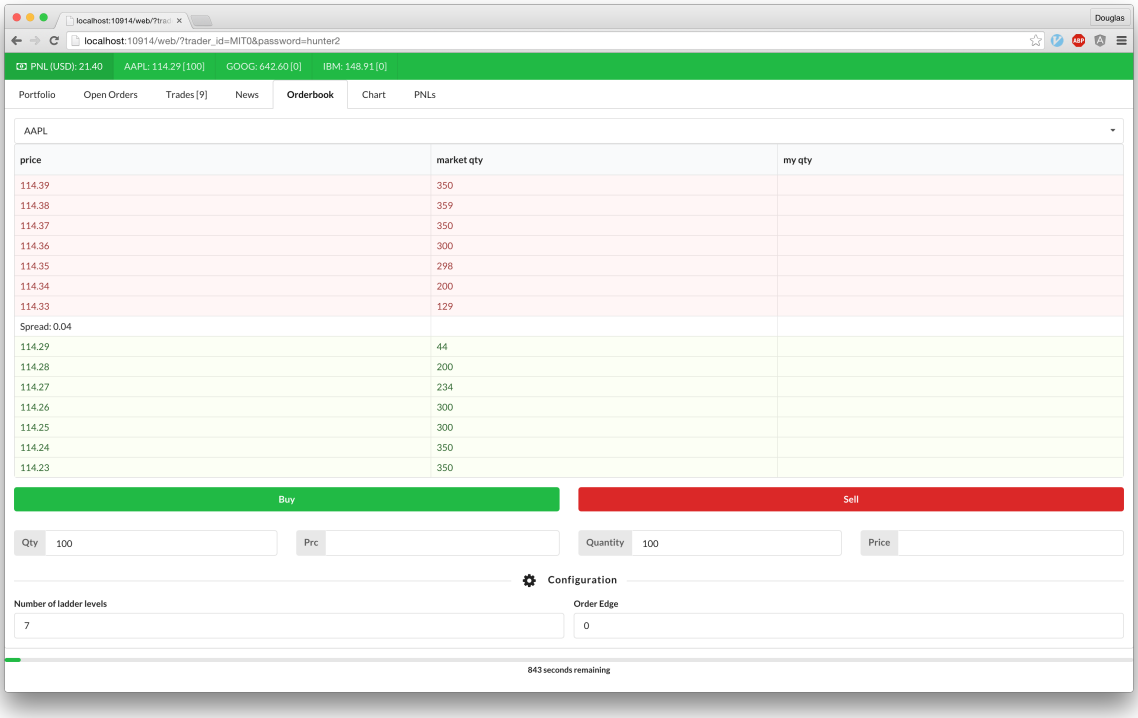
Once the case starts, the summary bar will be green. The summary bar at the top of the screen shows your PNL (profit and loss), as well as the market price and your current position for each security. You can view your portfolio, your open orders, released news, the orderbook, and charts of the product price paths in each tab. To view multiple tabs at once, you can open additional browser windows with Mangocore.



7.2.1 Orderbook

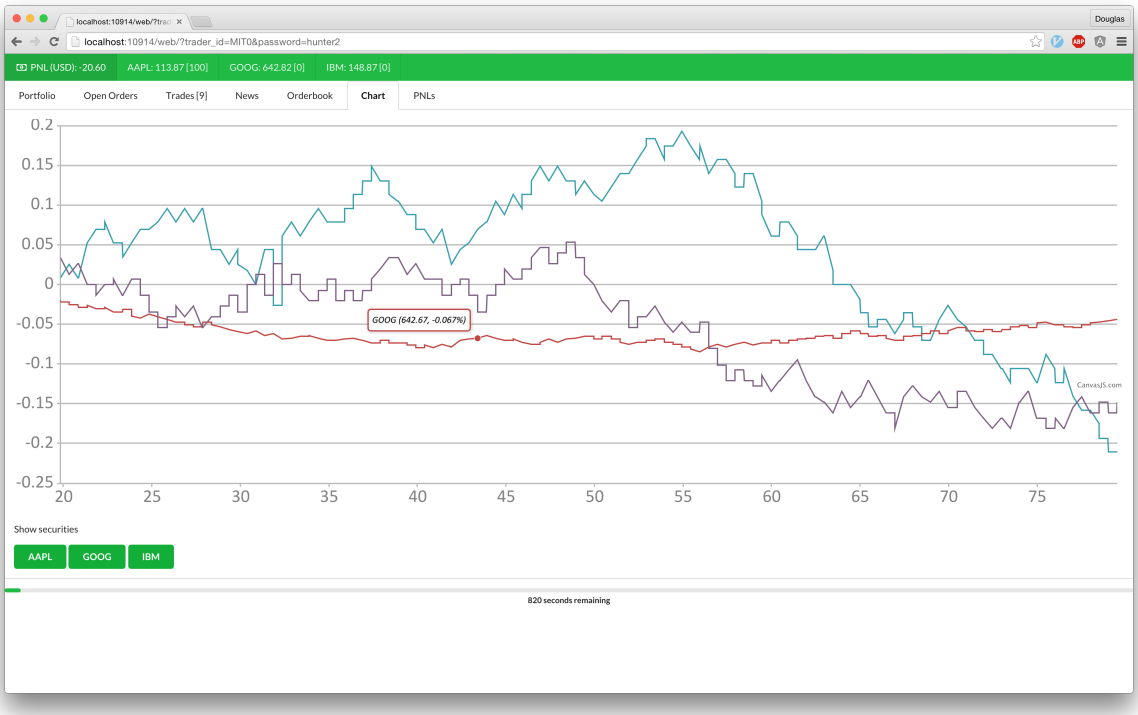
The orderbook shows a ladder with only the price levels corresponding to orders in the market. In the center of the ladder the current spread between the highest bid and lowest ask is shown. Like orderbook 1, there are also "Buy" and "Sell" buttons, which behave the same way. Alternatively, the upper half of the ladder highlighted in red can be clicked to submit limit orders to sell at the corresponding price. The lower half of the ladder highlighted in green can be clicked to submit limit orders to buy.

If there is an error such as exceeding position limits, it will be shown at the bottom of the screen in a yellow bar.



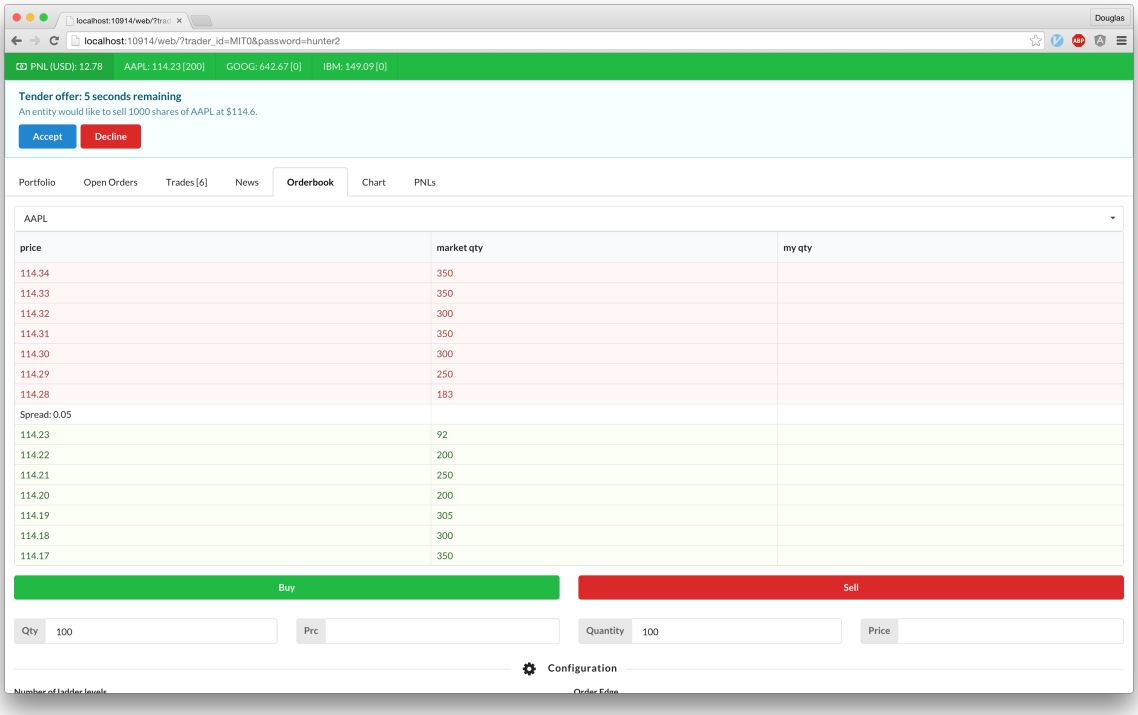
7.2.2 Chart

The chart shows the relative change in the price of securities over time. The horizontal axis represents time. The vertical axis represents the percentage deviation of the security's price from its starting price. The buttons on the bottom control which securities are shown on the chart. Mousing over the lines in the chart shows the security's name and price.



7.2.3 Tender Offers

Some cases have tender offers. These will be displayed at the top of the screen in a blue bar. You will have a limited amount of time to accept or decline these tender offers.



8 MangoCore API

8.1 Overview

MangoCore interfaces with external clients with a JSON API over a websocket connection. Users can use this API to programmatically query our simulator servers, which may be helpful for cases that are suited for higher frequency trading. This guide details how to set up a local server for testing as well as the JSON message formats available.

8.2 Server setup

To run the server locally, grab the executable for your operating system and start it. The server will open up a port on localhost:10914 and you can connect to it by openning up a websocket connection to `ws://localhost:10914/#trader0`. *Note: you cannot use your given traderid locally because the provided binaries default to a small set of recognized traderids that will not include your assigned traderid*

To run your algorithm on our server, switch the host from `localhost:10914` to `m.angocore.com` and `trader0` to your given trader ID.

8.3 Registration

When establishing a connection, every client must send a register message to the server:

```
{
    "message_type":"REGISTER",
    "token":"kfnwxw29"
}
```

Optionally, clients may also send a token to uniquely identify messages.

The server will reply with an acknowledgement to the client:

```
{
    "message_type": "ACK REGISTER",
    "case_meta": {
```

```
        "case_length": 300,
        "securities": {
            "AAPL": {
                "tradeable": true,
                "starting_price": 100,
                "underlyings": {
                    "AAPL": 1
                }
            },
            ...
        },
        "underlyings": {
            "AAPL": {
                "name": "AAPL",
                "limit": 1000
            },
            ...
        }
    },
    "end_time": "0001-01-01T00:00:00Z",
    "market_states": {
        "AAPL": {
            "ticker": "AAPL",
            "bids": {},
            "asks": {},
            "last_price": 100,
            "time": "2015-03-21T20:54:05.530846913Z"
        },
        ...
    },
    "trader_state": {
        "cash": {
            "USD": 100000
        },
        "positions": {
            "AAPL": 0,
            "IBM": 0,
            "IDX": 0
        },
        "open_orders": {},
        "pnl": {
            "USD": 0
        },
        "time": "2015-03-21T20:54:05.530826573Z",
        "total_fees": 0,
        "total_fines": 0,
        "total_rebates": 0
    },
    "token":"kfnwxw29"
}
```

This rather verbose response essentially gives you a copy of the market state, copy of your trader state, and some meta information on fees.

8.4 Passive Information

8.4.1 Pings

The server will periodically ping clients and send a message like so:

```
{
    "message_type": "PING"
}
```

This is primarily to prevent browsers from closing the websocket connection and has nothing to do with trading logic.

8.4.2 Market Updates

Sometimes, you will receive market updates for securities:

```
{
    "message_type": "MARKET UPDATE",
    "market_state": {
        "ticker": "AAPL",
        "bids": {
            "99.86": 350,
            "99.87": 350,
            "99.88": 300,
            "99.89": 300,
            "99.90": 300,
            "99.91": 99,
            "99.92": 170
        },
        "asks": {
            "100.07": 133,
            "100.08": 200,
            "100.09": 250,
            "100.10": 300,
            "100.11": 300,
            "100.13": 350,
            "100.14": 350
        },
        "last_price": 100.07,
        "time": "2015-03-21T21:12:17.764384883Z"
    }
}
```

The key/value pairs in bids/asks represent price:quantity pairs. You will generally receive market updates every 500ms, as opposed to following every API call that may modify the state of the order books. However, you will receive every trade notification so you may be able to maintain an orderbook estimate that can be more accurate.

Additionally, you can ping the market with micro-orders to discover the top of the book. You will want to do this sparingly because of the trading limits (see the last section)

8.4.3 Trader Updates


```
{
    "message_type": "TRADER UPDATE",
    "trader_state": {
        "cash": {
            "USD": 100000
        },
        "positions": {
            "AAPL": 0,
            "IBM": 0,
            "IDX": 0
        },
        "open_orders": {},
        "pnl": {
            "USD": 0
        },
        "time": "2015-03-21T20:54:05.530826573Z",
        "total_fees": 0,
        "total_fines": 0,
        "total_rebates": 0
    }
}
```


As with market updates, you will generally receive trader updates every 500ms. However, you will be able to calculate your precise trader state at any moment in time based on other information you receive.

8.4.4 Trades

Other times, you will receive trade notifications


```
{
    "message_type": "TRADE",
    "trades": [
        {
            "trade_id": "AAPL:12",
            "ticker": "AAPL",
            "buy_order_id": "AAPL:88",
            "sell_order_id": "AAPL:48",
```

```
            "quantity": 50,
            "price": 100.07,
            "buy": true,
            "time": "2015-03-21T21:12:17.764311405Z"
        },
        {
            "trade_id": "IDX:7",
            "ticker": "IDX",
            "buy_order_id": "IDX:5",
            "sell_order_id": "IDX:84",
            "quantity": 87,
            "price": 399.96,
            "buy": false,
            "time": "2015-03-21T21:12:17.764356237Z"
        }
    ]
}
```

You will receive every trade notification (not just the ones concerning your orders) immediately (after network/processing latencies of course).

8.5 Submitting and Canceling Orders

To place an order, send a message like

```
{
    "message_type": "MODIFY ORDERS",
    "orders": [
        {
            "ticker": "AAPL",
            "buy": true,
            "quantity": 100,
            "price": 20,
            "token": "sqv6ajor"
        }
    ],
    "token": "ze12a9k9"
}
```

Notice that you can send multiple orders in one message. If no price is specified, then the order is treated as a market order. If a price is specified, then the order is treated as a limit order.

Similarly, you can submit cancels like so:

```
{
    "message_type": "MODIFY ORDERS",
```

```
    "cancels": [
        {
            "ticker": "AAPL",
            "order_id": "AAPL:8779",
        }
    ],
    "token": "07c4bo6r"
}
```

You may also submit orders and cancels within the same message. If you do so, the cancels will be processed before the orders.

```
{
    "message_type": "MODIFY ORDERS",
    "cancels": [
        {
            "ticker": "AAPL",
            "order_id": "AAPL:8779",
        }
    ],
    "orders": [
        {
            "ticker": "AAPL",
            "buy": true,
            "quantity": 100,
            "price": 20,
            "token": "sqv6ajor"
        }
    ],
    "token": "ze12a9k9"
}
```

After submitting such a message, you will receive an acknowledgement

```
{
    "message_type": "ACK MODIFY ORDERS",
    "cancels":{
        "AAPL:8879":null
    },
    "orders": [
        {
            "order_id": "AAPL:900o",
            "ticker": "AAPL",
            "buy": true,
            "quantity": 100,
            "price": 99.92,
            "token": "sqv6ajor"
        }
    ],
```

```
    "token": "ze12a9k9"
}
```

A null value for the cancel indicates that it was successful.

8.6 News

You will receive a message every time news is released. The message will contain a news headline, source, and body, as well as the tick on which the news is released and the price charged for the news item:

```
{
    "message_type": "NEWS",
    "news": {
        "headline": "Apple releases new Macbook",
        "source": "Ars Technica",
        "body": "Today, Apple releases a new shiny device for everyone.",
        "time": 235,
        "price": 1234
    }
}
```

Certain news sources are free; you will always receive news from these sources. The price for each news item from free news sources is always zero. Other news sources are "premium" news sources, which you must subscribe to in order to receive news. These sources charge a fee for each news item you receive while subscribed. You can subscribe and unsubscribe from news sources by sending:

```
{
    "message_type": "SUBSCRIBE NEWS",
    "subscribes": ["The Wall Street Journal", "Bloomberg"],
    "unsubscribes": ["The Onion", "New York Post"],
    "token": "e23sle9w"
}
```

The "subscribes" or "unsubscribes" lists may be omitted if they are empty. For example, to subscribe to a single news source:

```
{
    "message_type": "SUBSCRIBE NEWS",
    "subscribes": ["The Wall Street Journal"],
    "token": "ew378ifs"
}
```

Note that it may not be possible to unsubscribe from news sources, depending on the case.

After submitting such a message, you will receive an acknowledgement:

```
{
    "message_type": "ACK SUBSCRIBE",
    "subscribes": {
        "The Wall Street Journal": null,
        "Bloomberg": "Cannot subscribe to news source
            (Bloomberg) that you are already subscribed to"
    }",
    "unsubscribes": {
        "The Onion": null,
        "New York Post": null
    },
    "token": "e23sle9w"
}
```

Each value in the "subscribes" and "unsubscribes" maps indicates an error encountered while trying to subscribe to a news source. A null value indicates no error. Either of the maps may be omitted if empty.

8.7 Tender Offers

Some cases will include tender offers in the following format:

```
{
    "message_type": "TENDER OFFER",
    "tender_offer": {
        "buy": false,
        "offer_id": "AAPL:0",
        "price": 100,
        "quantity": 400,
        "ticker": "AAPL",
        "time": 10,
        "time_remaining": 30
    }
}
```

To accept a tender offer, send back a response:

```
{
    "message_type": "ACCEPT TENDER OFFER",
    "token": "oeoh6w29",
    "tender_offer": {
        "buy": false,
        "offer_id": "AAPL:0",
        "price": 100,
        "quantity": 400,
        "ticker": "AAPL",
        "time": 10,
        "time_remaining": 10
```

```
    }
}
```

You will then receive an acknowledgement from the server. If there are no errors, then the transaction was successful.

```
{
    "message_type": "ACK TENDER OFFER",
    "token": "oeoh6w29",
    "tender_offer": {
        "buy": false,
        "offer_id": "AAPL:0",
        "price": 100,
        "quantity": 400,
        "ticker": "AAPL",
        "time": 10,
        "time_remaining": 10
    }
}
```

If there are errors, the transaction was rejected and did not take place.

```
{
    "message_type": "ACK TENDER OFFER",
    "token": "oeoh6w29",
    "error": "Potentially exceeding risk limit for AAPL underlying",
    "tender_offer": {
        "buy": false,
        "offer_id": "AAPL:0",
        "price": 100,
        "quantity": 400,
        "ticker": "AAPL",
        "time": 10,
        "time_remaining": 10
    }
}
```

8.8 Message Limits

There are limits for how frequently you may send messages: you may send a maximum of 25 pieces of information per second, where a piece of information is defined as a message, order, or cancel. For example, a message with 6 orders and 2 cancels counts as $1 + 6 + 2 = 9$ pieces of information. Any piece of information past this limit of 25 gets discarded. Also to note, messages are either entirely processed or entirely discarded. In other words, if you have sent 20 pieces of information in the last second and you attempt to send 10 more pieces in your next message, nothing in your next message will be processed (but we will record that you have tried to send 30 pieces of information in this past second).

If you send over 250 pieces of information in any second, your connection will be immediately killed (this isn't because we don't like you; we just don't want you to overload our network and starve other connections).

We will be monitoring server load and if it seems that our limits are too strict, we will relax them.

8.9 More Information

You will run your algorithms on your computers - we will not run them for you. Our server will be running somewhere (possibly in a public cloud, possibly in a box somewhere on MIT, etc). You may wish to optimize latency by trying to find where our server is.

If your client falls more than 5 seconds behind in receiving information, we will kill the connection.

8.10 Backtesting

A brief note about back-testing: profits that you see in your backtesting may not be the same as profits you may see during the actual competition. This may be due to competition (other market makers decreasing your edge), increased latencies (your algorithm will not be running on the same machine as the exchange), and other factors. You may want to simulate these pessimistic conditions in your backtesting to make it more rigorous.