

Exposure Dashboard Development at JPMorgan Chase & Co.

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Abstract

As JPMorgan Chase & Co. moves towards increasing trade volumes through its electronic trading capabilities, the ability to oversee its counterparty exposure becomes important. As part of this initiative, this project will look into the design and development of a web-based Broker Exposure Dashboard that will capture the user requirements, and design and develop a dashboard, which will provide a variety of exposure analytics to show metrics of their risk to any/all brokers in real-time, clearly and concisely.

Authorship

The writing of this report was a joint effort between Bansari and Matt. Bansari wrote the introduction, the Forex and Exposure sections of the background, the business requirement and design sections of the methodology and findings, and all sections of the recommendations, with the exception of the section written by Matt. She also wrote the abstract. Matt wrote the JPMorgan history and the technologies sections of the background, the implementation sections in the methodology and findings, and the dynamic layout recommendation, as well as the authorship and acknowledgements. He also edited the paper for spelling, grammar, and formatting.

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1 Introduction

With the low yields and depressed growth all around the world, retail traders, investors and fund managers are all actively looking for an asset class that offers unparalleled returns and the foreign exchange market presently appears to be the solution. The foreign exchange market (abbreviated forex or FX) is the biggest and most liquid market in the world. Every day over \$5 trillion worth of trades occur in this marketplace; a number that has been only been increasing exponentially in the past few years, as evidenced in Figure 1. (Bank For International Settlements, 2013)

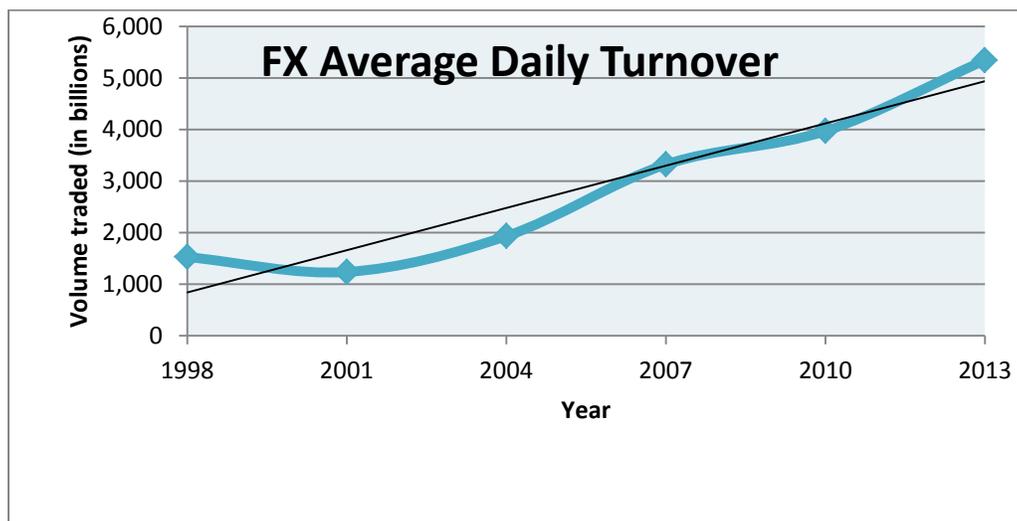


Figure 1: Global daily FX turnover¹

As a result of increasing demand, trade transaction costs such as the spread have decreased, technology in this market is fast evolving and the value-added service offered by the financial brokerage firms has increased ten-fold. One of the major factors attributed to this increasing market growth is the rise of electronic trading. As seen in figure 2 below, there has been a steady increase in the rise in FX volume traded electronically from 2006 to 2009 in Americas, Europe and Japan. Note that the slight dip in these numbers in 2008 can be attributed to the market credit crises causing the liquidity to dry up. The volume has picked itself up quickly since then, proving that electronic trading is going up. (King, 2010)

¹ "Foreign exchange turnover in April 2013: preliminary global results." Bank For International Settlements. Sept 2013. Web. 3 Oct. 2013. <<http://www.bis.org/publ/rpfx13fx.pdf>>

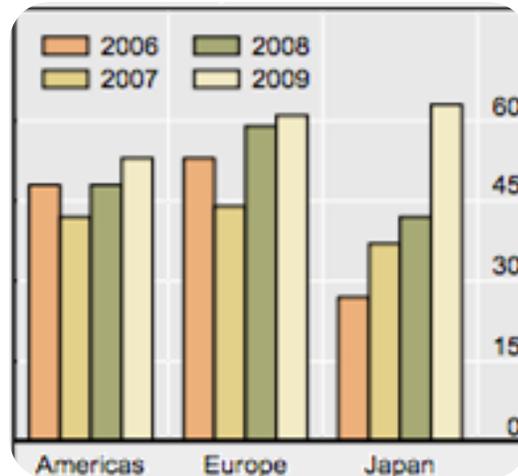


Figure 2: Increase in electronic trading in FX market²

Electronic trading increases the order entry speed as computers respond quicker to the market conditions. It also allows trade consistency and minimalizes emotions thus resisting the urge to overtrade. While it is in many cases better than human control the system is still not a completely infallible system and a recent example of this is Knight Capital Group's case.

Knight Capital's is a cautionary tale on the need for a closer look at how the technology could cause as much damage as it can profit. Knight Capital lost about half a billion dollars and its reputation as a market maker because of a "technological breakdown" in August 2012. The reason behind the breakdown is believed to be the use of decommissioned software that was accidentally reactivated when a new program was installed.

As a world leader in banking, JPMorgan Chase & Co. has a need to stay ahead of its competitors in cutting edge technology to compete in this fast evolving market. In the past 4 years JPMorgan's business strategy was to move all its businesses from the existing Comet platform to Minerva but because of integration issues they have decided to stay with Comet for its FX platform. Lack of investment in the Comet platform, outdated technology and increasing user demand has resulted in a need to reinvest and enhance the existing Comet platform, giving rise to the FX Renovation project. JPMorgan plans to achieve its goals by refining its platform for the traders, improving its trade evaluation engine and integrating an Auto execution engine.

As JPMorgan's business thus moves to increase volumes and frequency through new electronic capabilities and reduce the latency of trade flow through global execution desks as a

² King, M., & Rime, D. "The \$4 trillion question: what explains FX growth since the 2007 survey?" Dec 2010. Web. 3 Oct. 2013. <http://www.bis.org/publ/qtrpdf/r_qt1012e.pdf>

part of the FX Renovation project, the ability to keep a close handle on its counterparty exposure becomes paramount. Thus as a part of this initiative we will be helping JPMorgan design and build a web-based broker exposure dashboard. This will provide a variety of exposure analytics to oversee risks management and limit management to all/any brokers in real-time, clearly and concisely. The few advantages of the dashboard would be real-time visibility, increased trade transparency and enhanced management reporting.

2 Background

2.1 Background and History of JPMorgan Chase & Co.

JPMorgan Chase & Co. as we now know it is a Global Financial Holding Company headquartered in New York City, and active in 60 countries. They currently stand as the second largest bank in the world and the largest bank in the United States by assets. Ranked at number 18 on the Fortune 500, JPMorgan Chase saw \$108.2 billion in revenue in 2012, as well as a 12% increase in profits from 2011 to \$21.3 billion (Fortune 2013). JPMorgan Chase & Co combines two of the world's top financial brands: JPMorgan and Chase both committed to serving millions of people in the United States and many of the world's best corporate, institutional and government clients.

JPMorgan Chase & Co. has a history of more than 200 years of predecessors with the earliest being The Manhattan Company in 1799; a waterworks company that also functioned as a bank thanks to a clause added in the charter by one of its founders, Aaron Burr. The more direct connection to the present institution though came in 1871 when J. Pierpont Morgan Sr. and Anthony Drexel formed a private partnership called Drexel, Morgan and Co. By the turn of the 20th century when two of the senior firm partners passed away, the bank under J. Pierpont Morgan Sr. was consolidated and renamed JPMorgan and Co. In 1877, John Thompson formed Chase Bank.

During the 1929 stock market crash, two banks, Commercial National Bank and City National Bank of Commerce, merged to form City National Bank and Trust Co. that would eventually become BankOne. In the mid-1950's Chase National Bank merged with the earlier mentioned Bank Of The Manhattan Company to form Chase National Bank. After numerous mergers and name changes, JPMorgan & Co. was bought by Chase Manhattan in 2001 forming the now known name JPMorgan Chase & Co. They later merged with BankOne Corporation four years later to make it the company it is today.

2.2 Forex Industry Review

Forex can be defined as the market that trades in currencies from different countries. Forex is the largest financial market and the most liquid market in the world, and any currency backed by an existing nation can be traded on forex. Currencies are traded through a broker/dealer and the prices are quoted in currency pairs, usually in four decimal places, except for the Japanese Yen which is displayed in two decimal places. If the forex quote for EUR/USD = 1.3768, the

currency on the left, in this case the Euro, is termed as the base currency, and US Dollar, the currency on the right, is the counter currency. The base currency always equates to 1. A forex trade occurs on the basis of what the market believes is the relative strength of one currency compared to another. Various factors like country background, safety, technological advances, natural disasters, economic issues, social issues, and political issues can all influence the price movement of one currency to another.

Forex is a speculative market and Forex traders make money by speculating the movement of currency rates. This can be done in two ways. The first is expecting the prices to rise and buying, which is called long position. The second way is short position, which is selling when speculating the prices to fall. The forex spot market has neither a physical location nor a central exchange. It operates through an electronic network of banks, corporations and individuals, trading one currency to another. The lack of a physical exchange enables it to operate on a 24 hour basis. The few uses of forex transactions would be to pay for goods and services in a foreign currency, transact in financial assets and reduce the risk of currency movements by hedging their exposure in other markets.

2.3 JPMorgan's Role in Currency Trading

JPMorgan offers competitive pricing across 300 currency pairs in cash and derivative products. (JPMorgan Chase & Co., 2013) JPMorgan presently provides clients two tools: MorganDirect Professional and MorganDirect Commercial³ to enable them to trade electronically. MorganDirect Professional offers direct access to the market and AlgoX for clients to trade electronically using algorithms. AlgoX is their algorithmic suite to trade electronically at the best prices possible. It is also available on mobile. MorganDirect Commercial integrates trade execution with confirmation, settlement, and payment, making it time and cost effective.

2.4 FX Exposure

2.4.1 Exposure Overview

Exposure is the amount of funds invested in a particular type of security and/or market sector or industry and usually expressed as a percentage of total portfolio holdings. Thus, it is the amount an investor has at risk or the amount he/she can lose. Exposure may be calculated in

many ways and the maximum values may be specified using a currency amount or a percentage of the value of the account(s) being considered. (JP Morgan Chase & Co, 2013)

The exposure analytics we will be using for this project are:

1. Gross exposure: The gross exposure type for currency trades is the sum of the notionals of the trades in the group under consideration. The notional for a currency trade is the equivalent of the buy currency amount in the currency of the limit.

The formula for gross exposure:

$$gross = notional = buy\ amount$$

The Intraday gross exposure will be the gross notional at that particular time period for that day. The quarterly gross exposure can be defined as the gross notional for that quarter.

2. Net exposure: The net exposure is the sum of the net of the buy and sell exposure amounts of each currency. The net exposure is calculated in the same way as the positive net with the exception that any negative values retain their sign. The result of including negative values is that there is no need to split into currency pairs.
3. Positive net exposure: The positive net exposure is the absolute net exposure of each currency where the negative signs are ignored when the first currency is being sold and/or the sum for each currency pair is calculated. To calculate the positive net exposure, the gross exposures are categorized by their currency pairs (first currency being chosen alphabetically) and those where the first currency is being sold are negated. The sum for each currency pair is calculated and the sign ignored only when adding all currency pairs.
4. Gross MTM exposure: The sum of the positive Mark-to-Market (MTM) values for FX trades. Gross MTM ignores trades with a negative MTM. MTM value is the value of the buy currency in the currency of the limit less the value of the sell currency the currency of the limit at today's rates. The formula for mark-to-market value (**MTM**) is:

$$MTM = buy\ amount\ at\ settlement\ date - sell\ amount\ at\ settlement\ date$$

5. P&L (Net MTM) exposure: The Profit and Loss (P&L) exposure is sum of all corresponding mark-to-market (MTM) values for the trades including negative MTM trades by the counterparty.

6. The Daily Rate will be the rate of change in the intraday gross exposure from the start of the day to the present time.

$$\text{Daily Rate} = \frac{100 * (\text{Gross exposure} - \text{Start of the day Exposure})}{\text{Start of the day Exposure}}$$

7. Quarterly Rate will be the rate of change in the gross exposure from the start of the quarter to the present time.

$$\text{Daily Rate} = \frac{100 * (\text{Gross exposure} - \text{Quarterly exposure})}{\text{Quarterly exposure}}$$

2.4.2 JPMorgan's Limit Engine

Limit in this context can be defined as the maximum for a measure of exposure. Limits are used to contain the effect of a single counterparty failing and the limits used in the limit engine can be broken down into:

- Regulatory limits: The rules for a fund to qualify under a regulation
- Client guidelines: The rules specified by the client to limit their exposure.
- Internal limits: Limits set by JPMorgan to protect JPMorgan Asset Management

For the purpose of this project we will be focusing on the house limits applied on each of the brokers internally by JPMorgan Asset management. These limits are determined taking into consideration the various regulatory limits and also client guidelines to protect JPMorgan Asset Management from high exposure. (JP Morgan Chase & Co, 2013)

2.5 Exposure Dashboard

2.5.1 Business Implementation

This exposure dashboard will predominantly be used by JPMorgan's:

- FX traders as part of their trade execution process,
- Risk Management team for limit management, and
- Senior Management Team to provide a clear view on where the firm is positioned from an exposure to market perspective.

The Dashboard will initially be implemented for the EMEA FX trading desk situated in London and the global counterparty risk management team.

2.5.2 Business Impact

The dashboard will give the users a better handle on what their real-time exposure is to other banks and increase transparency thus enabling better trading. The dashboard will also reduce the risk to the company if other banks default and provide active monitoring of market movements reducing the market movements' risk. The exposure dashboard can also be used to provide reporting tools for management reporting process.

2.6 Technologies Utilized

2.6.1 HTML/CSS & JavaScript

Websites are written in a multitude of programming languages. Each has a purpose, which can include describing the visual layout of the page, the styling, the user experience and interactions, and getting information from a server. All webpages are first written in HTML, or Hyper-Text Markup Language, which creates the skeleton of the webpage. Hyper-text is simply text which can act as more than text, such the blue links within text to other web pages, which are common across the internet (HTML & CSS - W3C 2013). CSS, or Cascading Style Sheet, is a language for styling an HTML web page to make it look different (HTML & CSS - W3C 2013). JavaScript is a web programming language which allows websites to have advanced functionality, beyond simply displaying text and pictures (JavaScript Web API's - W3C 2013).

Made most simply, a webpage can be a single file written in HTML. A web browser, like Google Chrome, could open a locally stored HTML file and display the web page described in the file. Within the file, one could add CSS styling and JavaScript functionality simply by properly declaring those sections of code as CSS or JavaScript. However, it is more common, especially in larger projects, to put HTML in one file, CSS in another file, and JavaScript in a third file, and linking them together in the HTML file using the proper link tags. This method allows the code to be cleaner, more readable, and easier to edit.

As the structure of a webpage, HTML provides methods for creating sections of the page. These can be titles, headers, tables, lists, pictures, and more. These sections can be given labels in form of classes and identities. Classes apply to multiple sections, while identities apply to single section. For example, cells in a table could each belong to the same class, "cell," while

they can each also have an identifier, such as “cell_1.” These labels allow CSS and JavaScript to apply to classes and identities as specified by the programmer. Each table cell could receive the same styling by being part of the “cell” class, while containing different information thanks to their different identities.

CSS describes the appearance and, to some extent, the functionality of the webpage. Attributes such font, text size, colors, and the alignment of sections are all described in the CSS file. Some behavior can also be described in the file, such as changing the color of links after they have been clicked on and changing the cursor’s appearance when hovering over certain sections.

JavaScript is a web scripting language which allows web sites to act in an asynchronous way. This means web applications can be created with updating sections and user interaction without loading a new page. For example, a user can type their name into a form, push a button, and see their name appear on the webpage without the webpage having to reload. This asynchronous behavior was crucial to the development of the exposure dashboard.

2.6.2 WebSockets

Web pages can be either static or dynamic. If they are static, they load once and all the information that would have loaded to the page is presented. No new information is added to the page unless the user refreshes the page. For some sites, a static page is optimal because no new information is necessary for the user after the web page is fully loaded. However, the site we created for JPMorgan required constantly updating fields of information, and user interactions that changed the information on the page. We needed a dynamic page, which could load new information and change the display without reloading the page. To accomplish this, we used WebSockets.

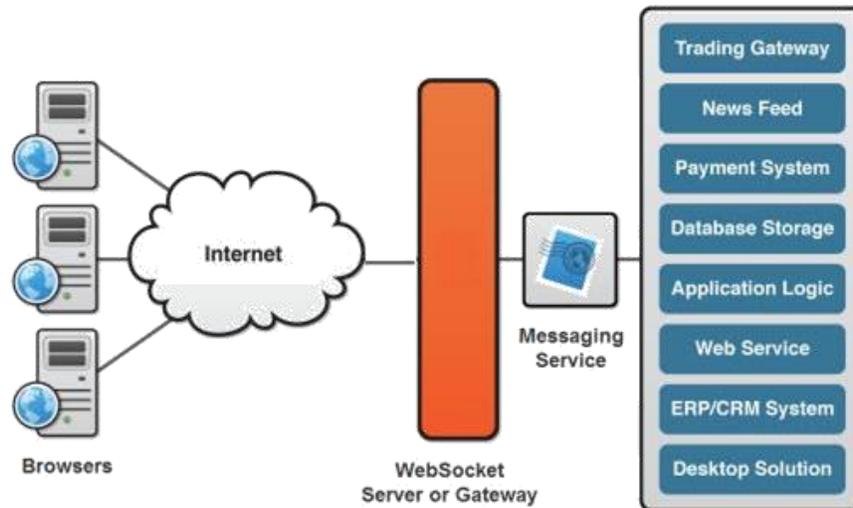


Figure 3: A visual explanation of WebSockets⁴

WebSockets allow for bidirectional communication between a server and client, such as a web page (WebSocket.org 2013). A server can regularly send messages of information the client, which can be displayed immediately without reloading the webpage. The client can also send messages to the server, such as requests for specific information. For example, a user could select an option in a dropdown list, have their selection sent through a WebSocket to a server, and have the server send back the information about the user’s selection. This could then be displayed with JavaScript, all without reloading the webpage.

⁴ Image from <http://www.websocket.org/aboutwebsocket.html>

3 Methodology

James Black was our primary supervisor and sponsor for the project. James is one of the leaders for the changes to the Comet Limit Engine, which he wanted us to help with. He tasked us with the development of a new online dashboard for the Forex brokers that was intended to show the exposures of each of JPMorgan's 25 brokers including custodians, as well as the company's total exposure. To develop the dashboard, we broke the design process into 3 steps as shown in figure 4:

1. Establish the business requirements for the exposure dashboard.
2. Design a user interface for the dashboard, which displays all relevant information in a clear and concise way.
3. Implement the user interface design, as well as the server connection to send and receive data.

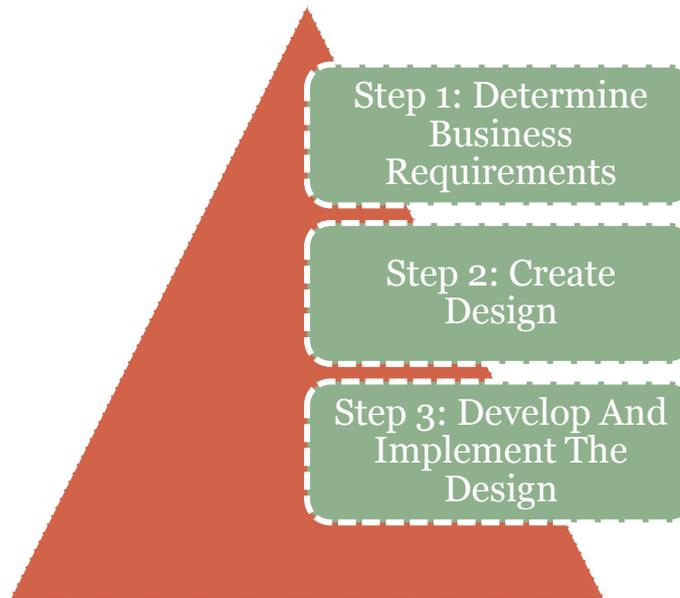


Figure 4: Dashboard design process

3.1 Business Requirements & Dashboard Design

3.1.1 Data flowchart

The exposure dashboard will trigger the limit engine by requesting a data report. The limit engine will then collect the house limits from Limit Database in the limit engine, the forex exchange rates from the Market Data, trade allocations from Infohub for start of the day trades and the trade allocations for the trades during the day would use limit engine itself. The engine will then use this data to calculate the requested detailed exposures for that broker and its

comparison with the house limit. The engine will then send a detailed report to the Exposure Dashboard that will process the data into the predefined format.

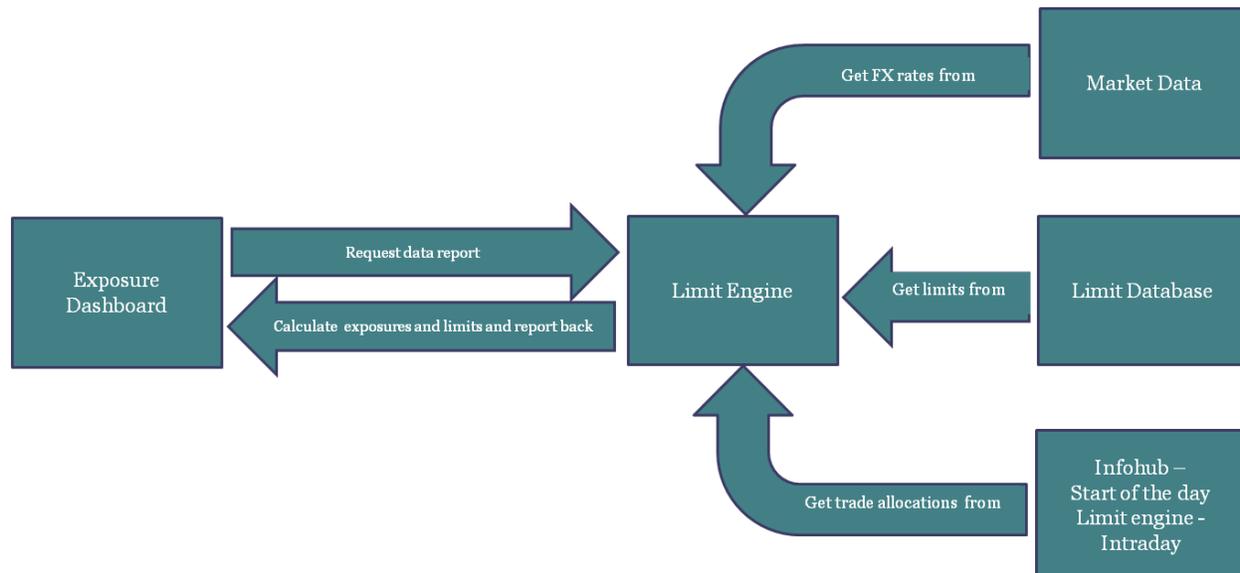


Figure 5: Data flow

3.1.2 Dashboard Design

The dashboard was divided into two major halves: The main dashboard screen and the detailed broker screen. A list of all 25 brokers including the custodians that JPMorgan is exposed to was gathered with their respective house limits. House limits are usually measured against Gross exposure and therefore gross exposure was going to be used for the main interaction the user would have with the brokers and their exposures. Some of the other reasons for using gross exposure were of using gross exposure were that gross exposure is more widely accepted, an absolute value and not a netted one and users care more about hedging his exposure rather than betting as done in MTM exposures. The main broker screen would therefore display all the 25 brokers JPMorgan deals with and their intraday gross exposure. The intraday gross exposure would be regularly updated once a trade occurs giving the user a real-time handle on their exposure. An intraday rate and quarterly rate value were also added to the main dashboard to display the rate of change in the exposure during that day and during that quarter.

The detailed dashboard for the brokers would look into detailed exposure analytics for each broker over various time periods. It would include various amenities like a functionality to be able to view the exposure for any time period, for any currency and also access to multiple exposure analytics calculated by the limit engine that JPMorgan presently uses for reporting

purposes. These could all be mapped on the graph on the screen and the user could use the screen for a report for that broker/brokers, the currency/currency's they deal in and JPMorgan itself for the required time period. This screen would also include a summary of all the exposure analytics used, namely, intraday gross exposure, quarterly gross exposure, net exposure, positive net exposure, gross MTM exposure and net MTM exposure.

3.2 Dashboard Implementation

We developed the dashboard using the IntelliJIdea⁵ integrated development environment. This software allows for easy web development using Java, HTML, CSS, and JavaScript all in the same program. IntelliJIdea also allows the user to launch and debug their web application, as long as a server container is provided.

As neither of us understood web application development prior to the start of the project, we both learned with the help of online available resources. Codecademy⁶ provides free online classes and tutorials for HTML, CSS, and JavaScript, as do many other websites.

3.2.1 Server & Database Establishment

There are two pieces to the backend of the exposure dashboard. The first is the limit engine database, which stores the relevant exposure data, and the database-side Java interface used to retrieve information from that database. The limit engine stores the data in tables, from which we can ask for specific information. To store the graph data, we also created a new table in the database. This table will fill with data as it is collected by the server. Data is retrieved from the database through SQL programs, and these programs are run by the data-base side Java interface. However, at the conclusion of our project we had not fully developed the database side of the backend. We helped write the SQL scripts, but there was never an established connection between the database-side Java interface, and the second piece of the backend, which was the client-side Java interface.

The client-side Java server, (henceforth simply referred to as “the Java server”), delivers data to the dashboard. This data is sent using a WebSocket. We used the Vert.X⁷ libraries to create a WebSocket server, basing our code on the Vert.X examples available on their website.

⁵ More information on IntelliJIdea can be found at <http://www.jetbrains.com/idea/>

⁶ Found at <http://www.codecademy.com/>

⁷ Vert.X is a publicly available application platform, which provides API's for numerous languages, including Java. More information about Vert.X can be found at <http://vertx.io/>

We then wrote methods to send and receive data through the WebSocket. We use the WebSocket to send data to the client in the form of formatted String messages, which are declared as either graph data or limit data, so the client can properly parse and use the message. The data fields are separated by colons, “:”, to make parsing simple. This code can all be found in the LimitsWebSocket.java file, located in Appendix B. Main.java, also found in Appendix B, runs the WebSocket described in the methods found in LimitsWebSocket.java. The web application is launched with Tomcat⁸ 7 web server container.

3.2.2 User Experience Implementation

The dashboard displays the data from the Java server, and allows a user to interact with the dashboard to change what data they see. We wrote the visual layout of the webpage in HTML and CSS. Asynchronous behavior was required to update the data fields and allow user interaction with the dashboard, so JavaScript was also used. We used JavaScript to implement the client side of the WebSocket, which included creating a WebSocket instance, and writing methods to determine the WebSocket’s behavior when messages are received and sent. By utilizing JQuery’s user interface library for JavaScript we were able to display new page elements at the user’s request without having to reload the webpage, which saves the user time and creates a better user experience. The broker detail page is revealed using JQuery’s API. The graph on the detail page was created with Google Charts. Google provides a simple API, requiring the developer to simply state the type of chart to display, and what data to use.

⁸ Tomcat is an Apache based server platform. More information can be found at <http://tomcat.apache.org/>

4 Findings

4.1 User Interface Design

4.1.1 Dashboard Front Page

The main screen of the exposure dashboard consisted of 25 broker boxes in a 5x5 grid and an overall exposure to JPMorgan banner at the top as displayed in figure 6.

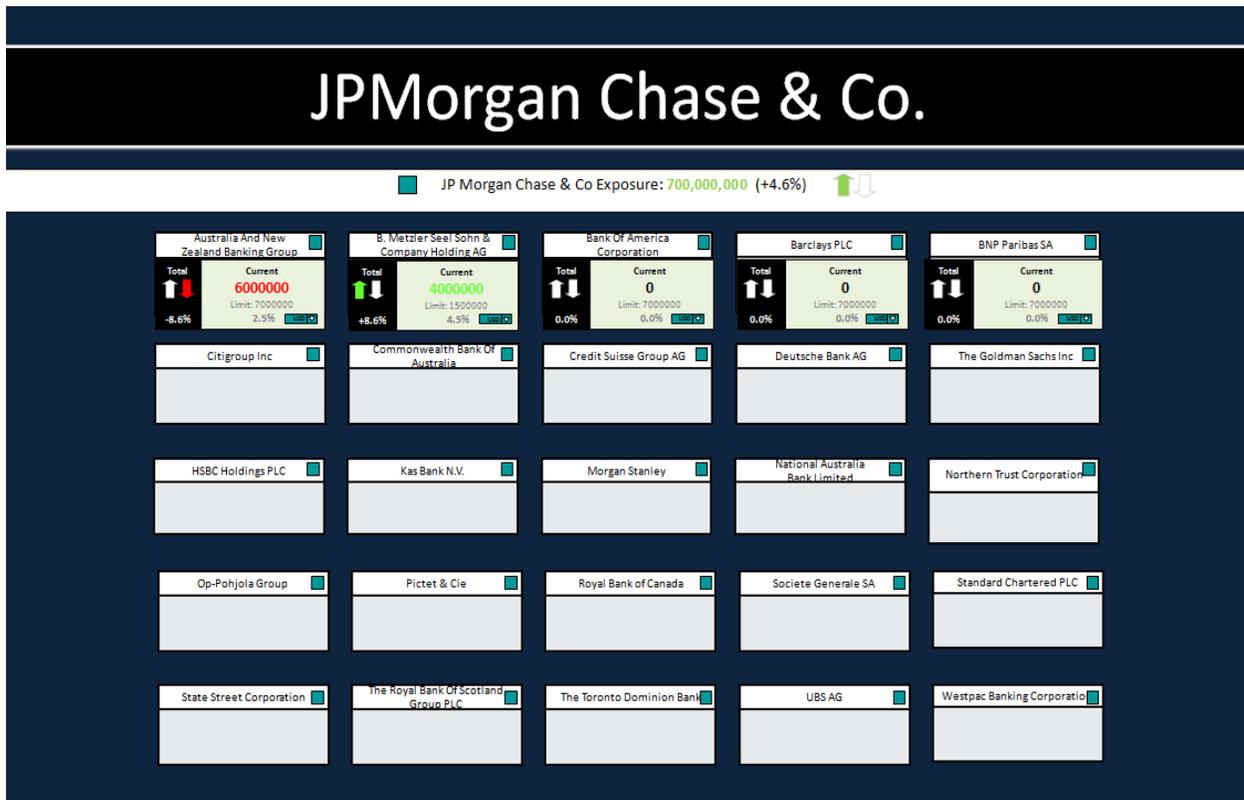


Figure 6: The front dashboard screen

Each of the broker boxes includes the rate of change in the quarterly exposure, the house limit on a broker, the real-time intraday gross exposure, and the rate of change in the intraday exposure as shown in figure 7.

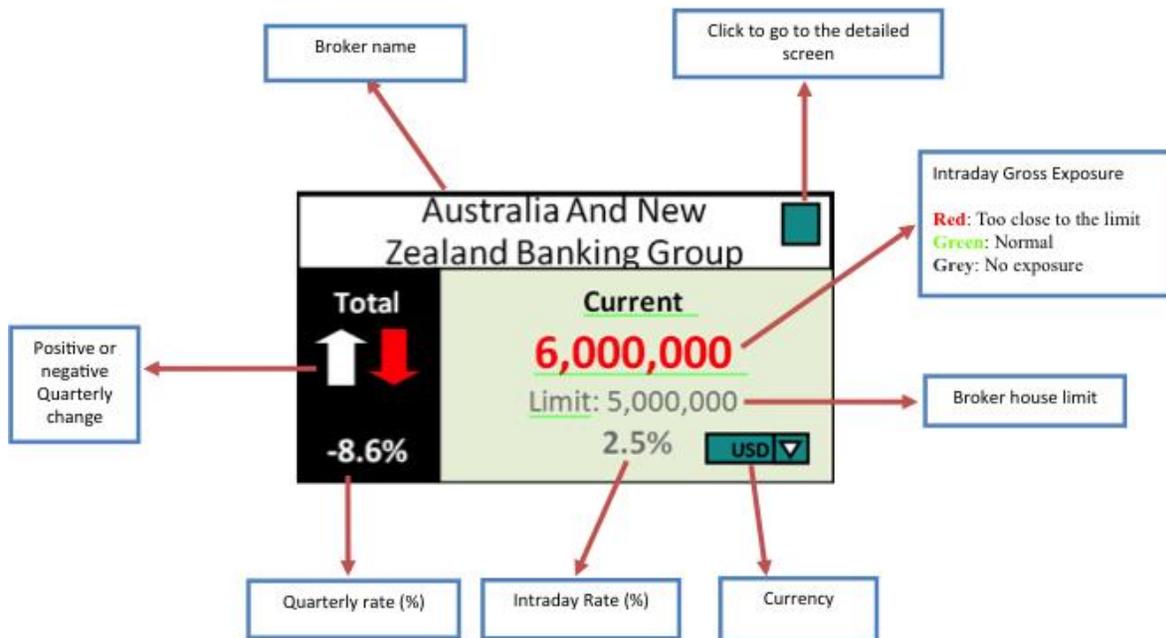


Figure 7: A broker box

The top of the broker box will consist of the name of the broker and a button to link the user to that broker's customized detailed broker screen. The current section includes the intraday gross exposure of that broker and the rate of change in exposure from the beginning of the day to the current time. The Intraday gross exposure will also have the functionality of warning the user if a certain broker is too close to the limit or passes the limit by turning that exposure red. Otherwise, the intraday gross exposure would be in green except when there is no exposure on the broker as those times it would be grey. There will be an option to change the currency the exposure is displayed as for both the brokers and for JPMorgan total.

The rate in the total part of the broker box would be the overall rate of change for the broker from the beginning of the quarter to the present time. The arrows above this rate will indicate whether the quarterly rate for that quarter for that broker has gone up or down. All four types of data will be constantly updated every time a trade occurs. The house limit extracted from the limit engine on the other hand will stay constant as defined by the limit engine. The currency dropdown is for multi region support and providing a customized global facility.

The blue button on the top right of the broker box will link to the detailed screen for that particular broker.

4.1.2 Detailed Broker Screen



Figure 8: Broker detail screen⁹

The user will open the detailed broker screen by clicking the blue button next to the broker name. The graph used in the detail screen example in figure 8 is from Yahoo Finance's exchange rate graphs to show clearly how the dashboard would look once implemented. For convenience, the detailed broker screen can be broken down into two big halves: The top half consisting of the brief exposure report, the broker details and timestamp and the bottom half consisting of the two toolbars and the graph.

The top right will include a summary of calculations of all the exposure analytics for that particular broker as shown in figure 9. This report will consist of the intraday gross exposure, quarterly gross exposure, net exposure, positive net exposure, gross MTM exposure and net MTM exposure. While all the exposures will be refreshed every time a trade occurs. The Gross MTM and Net MTM are calculated overnight, so their value would not change during the day.

⁹ Graph taken from <http://uk.finance.yahoo.com/echarts?s=USDJPY%3DX#symbol=;range=2y;compare=;indicator=volume;charttype=area;crosshair=on;ohlvalues=0;logscale=off;source=undefined;>

Intraday Gross Exposure:	6,00,000
Quarterly Gross Exposure:	9,00,000
Net Exposure:	9,07,409
Positive Net Exposure:	8,63,946
Gross MTM Exposure:	9,87,659
Net MTM Exposure:	2,39,752

Figure 9: Brief Report

The top left corner will include of the broker name, exposure selected, the daily rate in the selected exposure and time. The exposure and the change in exposure will on default be the same as the broker box on main screen that is the current exposure for that broker and the daily rate. This can be changed using the exposure type and/or currency option in the toolbar below in figure 10.



Figure 10: Toolbar I

Below the top left corner will be the toolbar above the graph shown above in figure 10. This toolbar will allow the user to calculate and/or compare the exposure a broker has on a certain currency using the currency selection dropdown in figure 11. On default, the graph will consist of all the currencies. The user can select one or more currencies it wants to see its exposure for and also compare exposure a broker has for a particular currency to the exposure to all the currencies.



Figure 11: Currency selection box

This toolbar also allows the user to change the exposure analytic plotted on the graph using the exposure selection drop-box shown in figure 12. This drop-box will include the intraday gross exposure, quarterly exposure, net exposure, positive net exposure, gross MTM and

net MTM exposure. On default, the graph will be plotted for the intraday gross exposure. The user can also choose the type of chart it wants displayed using the chart settings in figure 13. The line type will determine whether the graph will be an OHLC, candlestick, line or mountain graph. The chart scale will decide if the data scale would be log or linear. The Chart cursor will decide if the cursor would be a trackball or cross hair cursor. The user will have the option of being able to turn off the cursor if required in this settings option. On default, the line type will be a line graph, the chart scale linear and the chart cursor a trackball. Once the user has selected the options they want for the broker's graph, they can click either the get chart or the reset button to display the new graph based on user specifications below the chart toolbar.



Figure 12: Exposure type box

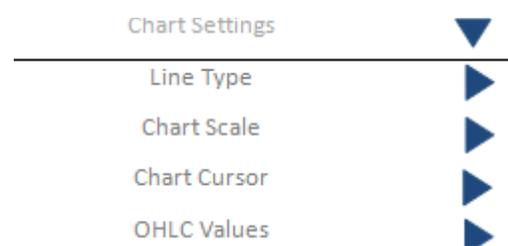


Figure 13: Chart settings option

By default, the chart will be real-time graph from the beginning of that day to the present time. The user can also specify the time period used for the graph using the toolbar below the graph shown in figure 14. This include pre-set time period options specific to the FX traders including T+1 day, T+2 days, 1 month, 3 months and year to date and also an option to select specific dates desired using dropdown to and from date options. The rate of change during that period will be displayed on the rightmost side of the toolbar. Lastly this toolbar will also consist of a print report option on the leftmost side that enables the user to print the screen



Figure 14: Toolbar II

4.1.3 Detailed Screen for JPMorgan's Total Exposure

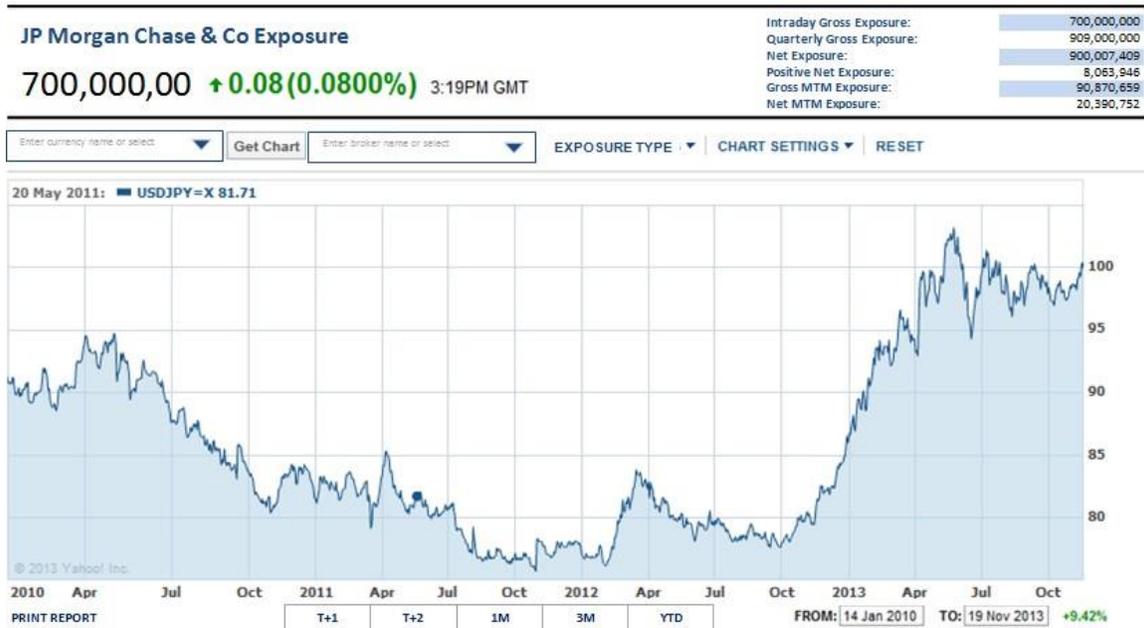


Figure 15: Overall exposure detailed dashboard

This screen will open when the blue box next to overall JPMorgan Chase & Co Exposure is selected. This exposure will be the sum of the exposures for all the 25 brokers. In addition to the broker detailed screen, this will include broker dropdown box in the chart toolbar as shown in figure 16. This will consist of all the 25 brokers on the main screen. This box allows the user to select broker specific exposure, compare exposure for two or more brokers or compare a certain broker/brokers exposure to the overall exposure as shown below in figure 13.



Figure 16: Chart toolbar for overall exposure

4.2 Dashboard Implementation

We successfully created a prototype exposure dashboard. In its current form, the dashboard displays information sent from the Java server, both of whom communicate via a WebSocket. Due to the lack of a database connection, the numbers displayed are randomly generated by the server and sent over every 500 milliseconds to the dashboard. However, this

proves the WebSocket is fully functional, and sending real information from the Java server can be easily done with the interface we developed. The message can be formatted the same way it is now, which means the client-side JavaScript WebSocket can still parse and present the information properly.

The broker screen is displayed by clicking on the name of a broker. The screen also displays data generated by us. However, this data never changes, and is simply a hard coded message from the server. The screen shows the name of the broker clicked on, the latest exposure sent in the graph data message, and an annotated timeline showing the exposure data over time. Hiding the screen simply requires you click on the broker's name again.

4.2.1 Database Connection

We implemented the WebSocket successfully in Java on the server side and JavaScript on the client side. We used Vert.X's libraries to create the Java WebSocket, which sends data to the client. Using the provided example on the Vert.X website, we were able to simply set the port for the WebSocket to create a WebSocket server. The web application is then launched with a Tomcat server container.

On the client side, we simply needed to create a WebSocket object, and write the method for handling new messages from the server. By connecting to the same port the server is connected to, messages can be passed between the two parties.

4.2.2 User Interface Implementation

Based on the designs created by Bansari, we created the website. The front page can be seen in the figure below.

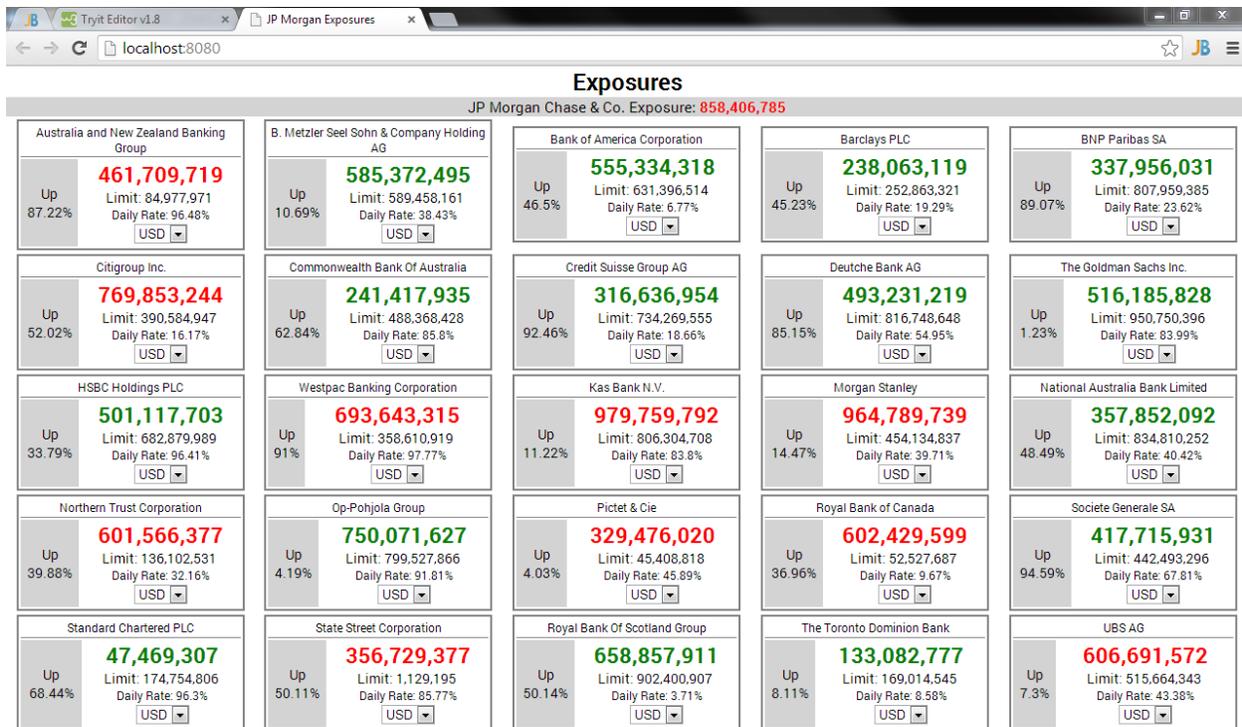


Figure 17: The front page of the dashboard

At the top is the title of the page. Below is JPMorgan's total exposure to all its brokers. The grid displays information on each broker, including the intraday gross exposure to the broker and the limit on that exposure, as well as the daily rate, quarterly rate, and the currently displayed currency. The grid was created as an HTML table, with each broker box being a cell within the grid table. The broker boxes themselves are also tables. The page is styled with the CSS file we wrote, which can be found in Appendix B.

The broker names are formatted as the top table row of the box, and the exposure section is the bottom row. The bottom row is broken into 2 columns, one for the quarterly change, and the other for the general exposure information. The colors of the exposures change according to JavaScript code which compares the limit to the exposure. When the exposure exceeds the limit, jQuery is used to change the CSS styled color of the text from green to red. If the exposure goes back below the limit, the color is changed back to green. The currency drop-down boxes were created using the HTML <select> and <option> tags. They currently do not affect the dashboard, because there is no connection to the database which provides the exchange rates. However, we made a method prototype for later development. The method will send the selected currency to the server, which will send back the conversion rate. These rates can be saved by the dashboard, or sent each time they are selected, depending on how often new rates are needed.

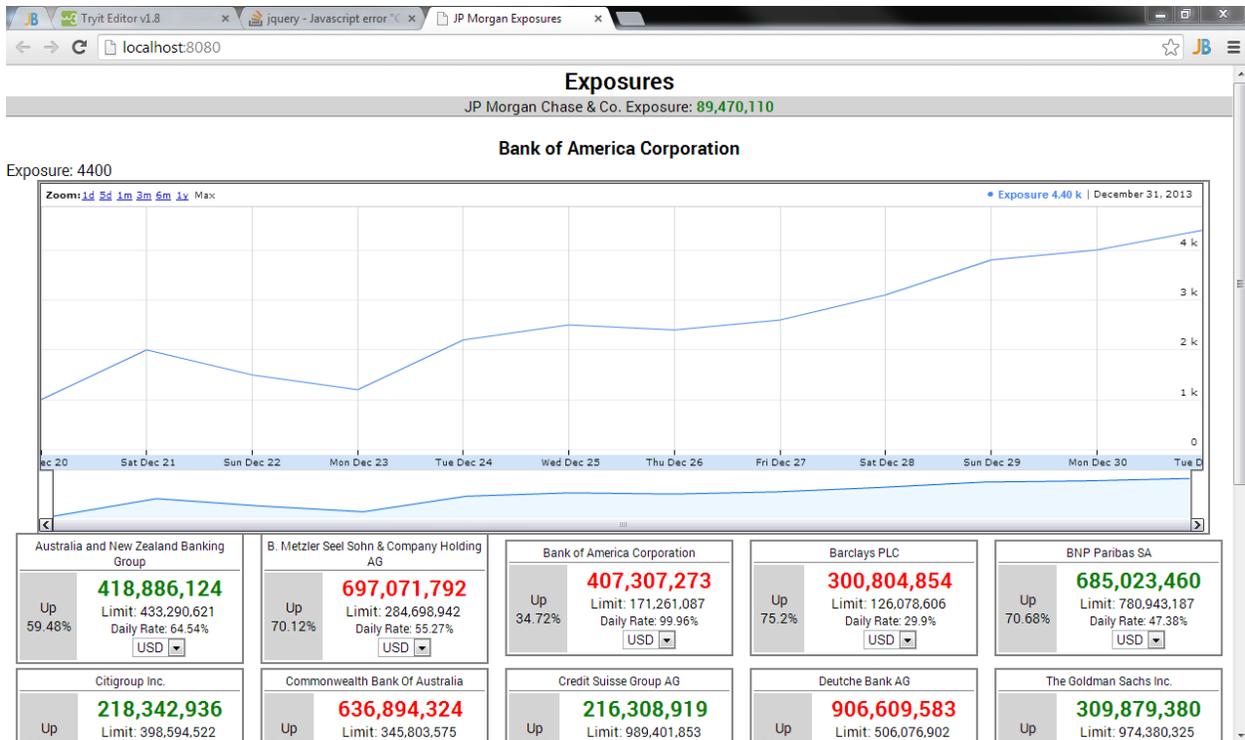


Figure 18: The implemented detailed screen

To display more information on an individual broker, we used jQuery to display a hidden broker information section. This was done using jQuery's Toggle() method, provided by their API. This section contained a graph of the exposures to the broker over time, and the current exposure to the broker. The graph was created using Google's public chart application programming interface (API) for JavaScript, called Google Charts. Their API allows us to easily create a timeline graph and dynamically add data to a data table used by the graph. The code for this can be found in Appendix B, in the limits.js file. The graph itself allows a user to select a specific time window to look at by sliding the select bars on the window below the graph. They can also see pre-designed windows by clicking on the time links in the top left of the graph. In the top right they can see the current exposure and the time of that exposure. Moving their mouse across the graph automatically selects points, and the top right status changes according to the automatically selected point.

5 Recommendations

The design for the dashboard has not been fully integrated into the dashboard created due to the short span of time this project runs for. Once fully integrated there are other functionalities that could be added to the detailed screen.

The detailed screen could include an option of displaying exposure according to the instrument type. JPMorgan & Co currently has exposures only for spots, forwards, swaps, NDF's and rollovers. A spot transaction is the buy or sell of one currency for another taking place usually within two days of the dealing date. A forex forward is a contract to exchange a predefined amount of one currency for another at an agreed date in the future, based upon the exchange rate defined at the contract's trade date. Forex swap is a contract that simultaneously agrees to buy or sell an amount of currency at an agreed rate and to resell or repurchase the same amount of currency for a later value date from the same counterparty at an agreed rate. An NDF (Non deliverable forward) is very similar to a conventional forward foreign exchange contract except that the contract is on a thinly traded or non-convertible foreign currency where the profit or loss at the time at the settlement date is calculated by taking the difference between the agreed upon exchange rate and the spot rate at the time of settlement, for an agreed upon notional amount of funds.¹⁰ Both swap trades and NDF's are therefore a combination of spot and forward trades and thus are treated as two trades in the limit engine.

The detailed dashboard could also include a functionality to view and compare the exposures for a particular account under a broker using the account ID. The account ID is already provided to each account by the limit engine. This can give the user an in depth and customized exposure that it requires. Lastly, another functionality that could be added can be the ability to view exposure by geographical location based on where the trade originally originated. In its current form, the dashboard's structure is written using HTML tables. These made the layout of the web application simple, but also made the web page very rigid. It has been discussed users may be interested in being able to rearrange the broker boxes, which could add a customization option to the application. There are tools to create the type of customization, but they are not currently implemented. It is our recommendation the future developers on the project work to get this functionality implemented, which will require a redesign of the layout.

¹⁰ (<http://www.investopedia.com/terms/n/ndf.asp>)

JQuery and other JavaScript tools allow for drag-and-drop functionality. Elements of a web page can be easily moved, but the formatting for them conflicts with the current HTML table based implementation. Redesigning this formatting would allow the users to move the boxes, allowing them to move the most relevant brokers to the top of the page, for example. Adding to this functionality, it would be useful to save this custom layout for each user individually, so they each have a personal dashboard relevant to them. This could be done using cookies, which save information about the user for later use by the web page.

While this will originally be implemented over just the EMEA trading desk in London, after gauging the user interest and observing the helpful functionality of the dashboard the same dashboard could be utilized over various other JPMorgan trading desks worldwide. Several other dashboards for measures important to the user could also be built based on the exposure dashboard. Some examples of such measures would be trade volume, profit and loss, exchange rate, money flow and volatility of important currency pairs.

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Appendix A: Business Requirements

1 Introduction

1.1 Purpose

The purpose of this document is to define the business requirements for designing a Foreign Exchange Broker Exposure dashboard.

1.2 Scope

The project is aimed primarily for use by our FX trading desk and the counterparty risk monitoring team. This document will list the known exposures and provide notes on:

- What the dashboard will include,
- Business implementation and impact,
- Dashboard design and
- Future recommendations.

The below list is a general guide to the priorities in terms of business areas although this may clearly be overridden subject to business justification and / or time and budgetary constraints.

1. Real-time gross exposure for the 25 brokers and the overall exposure JPMorgan is exposed to;
2. Real-time exposure for other exposure analytics - Net, Positive Net, Gross MTM and Net MTM
3. Exposure for a particular currency that has been traded with a broker and a comparison between two or more currency exposures.
4. Exposure and change in exposure at various periods in time.

1.3 Exposure Overview

Exposure is the outlay of funds invested in a particular type of security and/or firms. It is the amount an investor has at risk or the amount he/she can lose. Exposure may be calculated in many ways and the maximum values may be specified using a currency amount or a percentage of the value of the account(s) being considered.

The exposure analytics used for this project are:

1. Gross exposure: The gross exposure type for currency trades is the sum of the notionals of the trades in the group under consideration. The notional for a currency trade is the equivalent of the buy currency amount in the currency of the limit.
2. Net exposure: The net exposure is sum of the net of the buy and sell exposure amounts of each currency.
3. Positive net exposure: The positive net exposure is the absolute net exposure of each currency where the negative signs are ignored when the first currency is being sold and/or the sum for each currency pair is calculated.
4. Gross MTM exposure: The sum of the positive Mark-to-Market (MTM) values for FX trades. Gross MTM ignores trades with a negative MTM. MTM value is the value of the buy currency in the currency of the limit less the value of the sell currency the currency of the limit at today's rates.
5. P&L (Net MTM) exposure: The Profit and Loss (P&L) exposure is sum of all corresponding mark-to-market (MTM) values for the trades including negative MTM trades.

1.4 Business Implementation

- This will predominantly be used JPMorgan's
 - FX traders as part of their trade execution process,
 - Risk Management team for limit management
 - Senior Management Team to provide a clear view on where the firm is positioned from an exposure to market perspective.

The Dashboard will initially be implemented for the EMEA FX trading desk situated in London and the global counterparty risk management team.

1.5 Business Impact

The dashboard will:

- Give the users a better handle on what their real-time exposure is to other banks,
- Enable better trading,
- Increase transparency,
- Reduce the risk to the company if other banks default,
- Provide active monitoring of market movements and thus reduce market movement risk and
- Provide reporting tools for management reporting purposes.
Enter broker name or select

1.6 Data Process

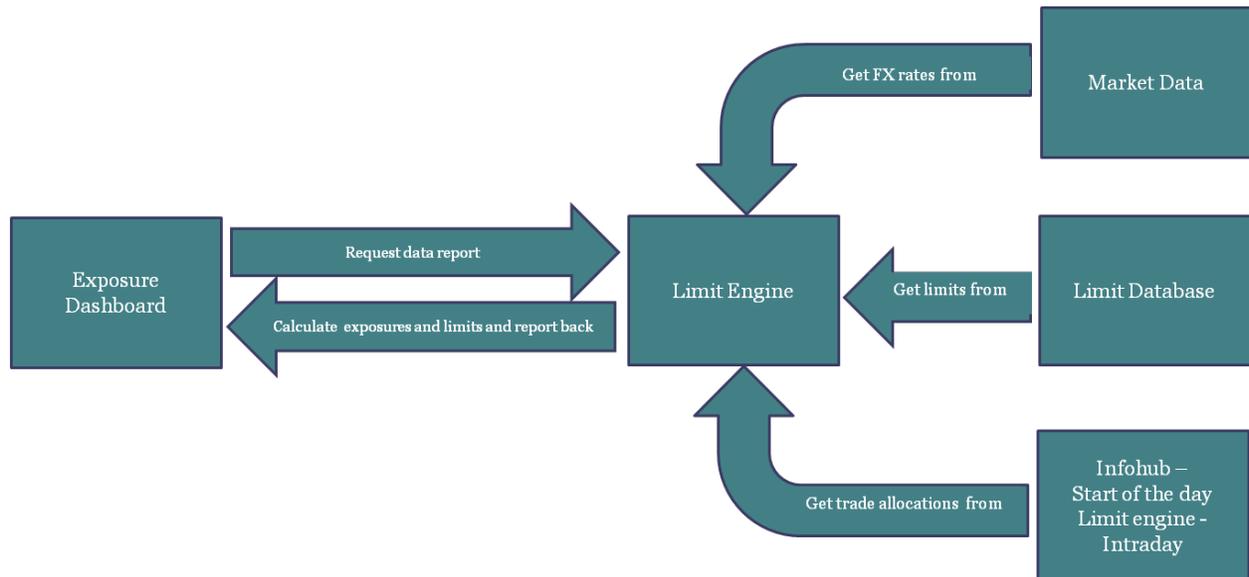


Figure 19: Data flow

Steps

1. Exposure Dashboard sends data request to the Limit Engine
2. Limit Engine gets limits from Limit Database
3. Limit Engine gets overnight FX rates from Market Data
4. Limit Engine gets traded allocations from infohub for start of the day trade data.
5. Limit Engine calculates the exposures and compares them to the house limits.
6. Limit Engine sends detailed exposures to Exposure Dashboard.
7. Exposure dashboard processes the data into the predefined format.

1.7 Exposure Calculation

Gross exposure is the sum of all notionals. The formula for gross exposure:

$$\text{gross} = \text{notional} = \text{buy amount}$$

The **Intraday gross exposure** will be the gross notional at that particular time of the day.

The **Net Exposure** is sum of the net of the buy exposure and sell exposure of each currency. The net exposure is calculated in the same way as the positive net with the exception that any negative values retain their sign. The result of including negative values is that there is no need to split into currency pairs.

For **Positive Net Exposure**, the gross exposures are categorized by their currency pairs (first currency being chosen alphabetically) and those where the first currency is being sold are negated. The sum for each currency pair is calculated and the sign ignored only when adding all currency pairs.

The formula for mark-to-market value (**MTM**) is:

$$\text{MTM} = \text{buy amount at settlement date} - \text{sell amount at settlement date}$$

Net MTM would be the sum of all the MTM transactions by the counterparty.

Gross MTM would be calculated the same way as Net MTM with the exception that all the negative MTM's would be ignored

The **Intraday Rate** will be the rate of change in the gross exposure from the start of the day to the present time.

$$\text{Intraday Rate} = \frac{100 * (\text{Gross Exposure} - \text{Start of the day Exposure})}{\text{Start of the day Exposure}}$$

The **Quarterly Rate** will be the rate of change in the gross exposure from the start of the quarter to the present time.

$$\text{Quarterly Rate} = \frac{100 * (\text{Gross Exposure} - \text{Quarterly exposure})}{\text{Quarterly exposure}}$$

2 Design

2.1 Main Dashboard

The main screen of the Exposure Dashboard will consist of 25 broker boxes in a 5X5 grid and an overall exposure to JPMorgan Banner. The broker boxes will include the quarterly rate, the house limit on a broker, real-time intraday gross exposure and the intraday rate for all the 25 Brokers listed on the grid.

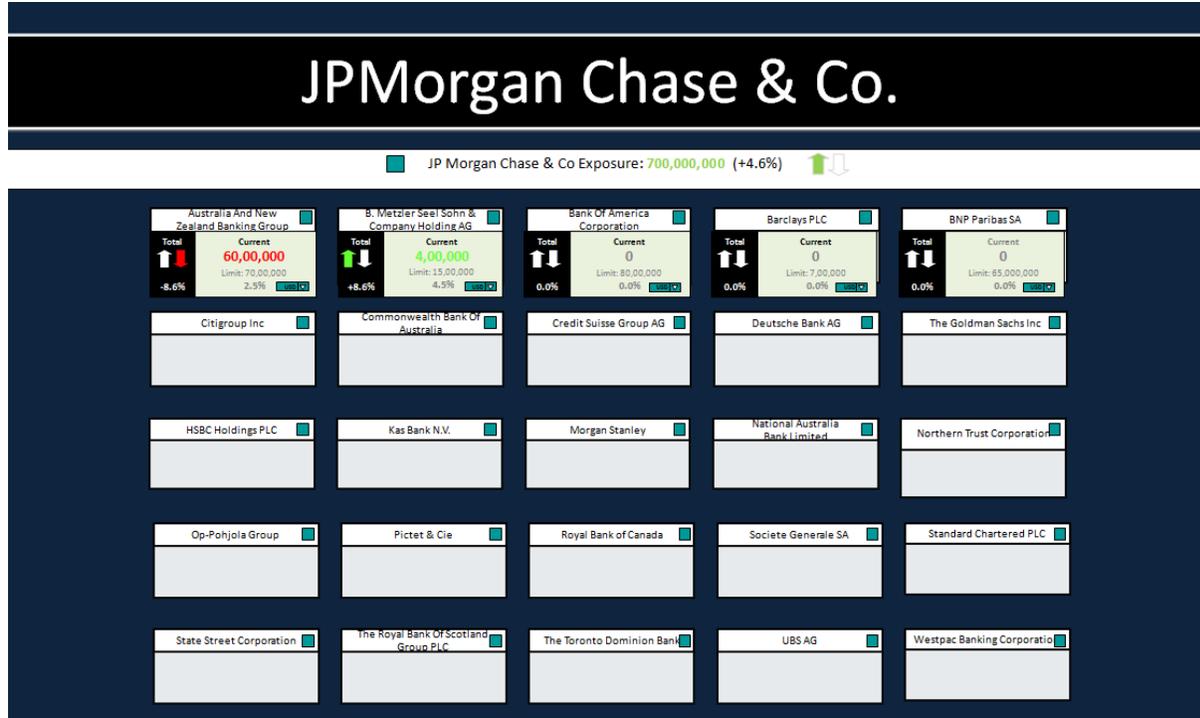


Figure 20: Main dashboard screen

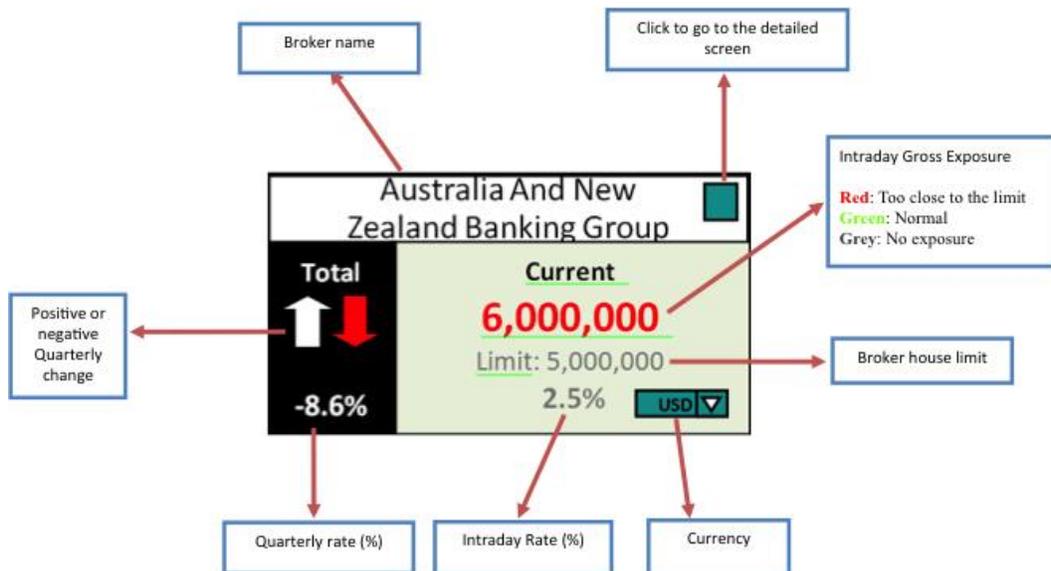


Figure 21: Broker box

- The exposure value shown in Figure 3 will be the Intraday Gross Notional exposure of that particular broker.
 - Intraday exposure will normally be displayed in green except:
 - When the exposure is too close to the house limit. The number will automatically turn red so as to warn the user.
 - When there is no exposure on a particular broker. Then the number will just be 0 and in grey.
- The intraday rate of the broker box would be the rate of change in exposure from the beginning of the day to the gross exposure at the present time.
- The rate in the total part of the broker box would be the quarterly rate of change for the broker for that quarter.
 - The arrows above the quarterly rate will indicate whether the rate is going down or up for that quarter.
- All the four types of data will be constantly updated every time a trade occurs.
 - The limit on the other hand will stay constant as defined by the limit engine.
- The Broker box will also consist of an option to change the currency that the data is being displayed in where the total and the intraday rate will stay constant and the limit and exposure will display the currency the user wants to view the data in.
- The broker box will also consist of a functionality that will link that broker to its detailed screen.

2.2 Detailed Screen



Figure 22: Broker detail screen

For convenience, the detailed broker screen can be broken down into two big halves: The top half consisting of the brief exposure report, the broker details and timestamp and the bottom half consisting of the two toolbars and the graph.

Intraday Gross Exposure:	6,00,000
Quarterly Gross Exposure:	9,00,000
Net Exposure:	9,07,409
Positive Net Exposure:	8,63,946
Gross MTM Exposure:	9,87,659
Net MTM Exposure:	2,39,752

Figure 23: Brief report

- The brief exposure on the top right report will include the calculation of all the exposure analytics for that particular broker as shown in figure 4.
 - The exposure analytics used would be: Intraday Gross Exposure, Quarterly Gross Exposure, Net Exposure, Positive Net Exposure, Gross MTM and Net MTM Exposure.
 - While all the other exposures will be refreshed every 10 seconds to give an intraday real-time value, the Gross MTM and Net MTM will stay constant as they are calculated overnight and their intraday value wouldn't change.
- The top left corner will include of the broker name, exposure selected, the intraday rate in the selected exposure and time.
 - The exposure and the change in exposure will on default be the same as the broker box on main screen that is the intraday gross exposure for that broker and the intraday rate.
 - This can be changed using the exposure type and/or currency option in the toolbar below in figure 6.



Figure 24: Chart toolbar

- Below the top left corner will be the toolbar above the graph shown above in figure 6. This toolbar will allow the user to:
 - Calculate and/or compare the exposure a broker has on a certain currency using the currency selection drop-box in figure 7.
 - On default, the graph will consist of all the currencies
 - The user can select one or more currencies it wants to see its exposure for and also compare exposure a broker has for a particular currency to the exposure to all the currencies.
 - Change the exposure analytic plotted using the exposure selection drop-box shown in figure 8.
 - This will include the Intraday Gross Exposure, Overall Gross Exposure, Net Exposure, Positive Net Exposure, Gross MTM and Net MTM Exposure.
 - On default, the graph will be plotted for the Intraday Gross Exposure
 - Choose the type of chart the broker wants displayed using the chart settings in figure 9.
 - The line type will determine whether the graph will be an OHLC, Candlestick, Line or Mountain graph.
 - The chart scale will decide if the data scale would be log or linear.
 - The Chart cursor will decide if the cursor would be a trackball or cross hair cursor. The user will have the option of being able to turn off the cursor if required in this settings option.

- On default, the line type will be a line graph, the chart scale linear and the chart cursor a trackball.
- Once the user has selected the options he wants for his graph he can click either the get chart or the reset button to display the new graph based on user specifications below the chart toolbar.



Figure 25: Currency selection dropdown box

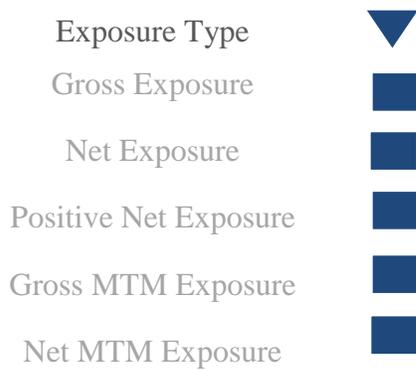
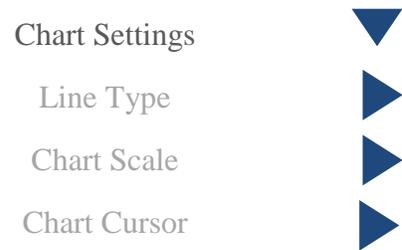


Figure 27: Exposure selection dropdown box

Figure 26: Chart Settings



- On default, the chart will be real-time graph from the beginning of that day to the present time.
- The user can also specify the time period used for the graph using the toolbar below the graph shown in figure 10.
 - This include pre-set time period options specific to the FX traders including T+1 day, T+2 days, 1 month, 3 months and year to date and also an option to select specific dates desired using dropdown to and from date options.
 - The rate of change during that period will be displayed on the rightmost side of the toolbar.
 - Lastly this toolbar will also consist of a print report option on the leftmost side which enables the user to print the screen

PRINT REPORT

T+1	T+2	1M	3M	YTD
-----	-----	----	----	-----

FROM: 14 Jan 2010 TO: 19 Nov 2013 +9.42%

Figure 28: Option to select the time period

2.3 Detailed Screen For JPMorgan Chase & Co Exposure



Figure 29: Screen for overall exposure

- This screen will open when the blue box next to overall JPMorgan Chase & Co Exposure is selected
- This exposure will be the sum of the exposures for all the 25 brokers.
- In addition to the broker detailed screen, this will include broker dropdown box in the chart toolbar as shown in figure 12.
 - This will consist of all the 25 brokers on the main screen
 - This box allows the user to select broker specific exposure, compare exposure for two or more brokers or compare a certain broker/brokers exposure to the overall exposure as shown below in figure 13.



Figure 30: Chart toolbar for overall exposure

Enter broker name or select

Overall

Australia And New Zealand Banking Group

B. Metzler Seel Sohn & Company Holding Ag

Bank Of America Corporation

Barclays Plc

Bnp Paribas Sa

Citigroup Inc

Commonwealth Bank Of Australia

Credit Suisse Group Ag

Deutsche Bank Ag

The Goldman Sachs Inc

Hsbc Holdings Plc

Kas Bank N.V.

Morgan Stanley

National Australia Bank Limited

Northern Trust Corporation

Op-Pohjola Group

Pictet & Cie

Royal Bank Of Canada

Societe Generale Sa

Standard Chartered Plc

State Street Corporation

The Royal Bank Of Scotland Group Plc

The Toronto Dominion Bank

Ubs Ag

Westpac Banking Corporation



Figure 31: Broker dropdown box

3 Future Recommendations

The dashboard can be implemented over other trading desks globally

New functionality that can be added to the Dashboard:

- Exposure by the instrument type – Spot, Futures, NDFs, Options and Forwards
- Exposure for a particular account using the account ID
- Exposure by geographical location
- Exposures for prime brokers

Dashboards for other technical indicators can be developed based on the exposure dashboard. For example dashboards to measure trade volume, profit and loss, the money flow or the volatility of certain currency pairs.

Appendix B: Source Code

index.jsp – The HTML file

```
<%@ page import="com.jpmorgan.FakeLimitsEngine" %>
<%@ page import="com.jpmorgan.HelloWorld" %>
<%--
    Created by IntelliJ IDEA.
    User: R544181
    Date: 19/11/13
    Time: 10:46
    To change this template use File | Settings | File Templates.
--%>
<%@ page contentType="text/html; charset=UTF-8" language="java" %>
<html>
<head>
    <meta http-equiv="Content-Type" content="text/html; charset=us-ascii">
    <link rel="stylesheet" type="text/css" href="style.css"/>
    <script src="jquery-2.0.3.js"></script>
    <script src="http://www.google.com/jsapi"></script>
    <script src="limits.js"></script>
    <script src="jquery-ui.js"></script>
    <link rel="stylesheet" type="text/css" href="ui.core.css"/>
    <link rel="stylesheet" type="text/css" href="ui.theme.css"/>
    <title>JPMorgan Exposures</title>
</head>
<body>
<h2>Exposures</h2>
<div class="broker" id="broker26">
    JPMorgan Chase & Co. Exposure: <span id="broker26_exposure">--</span>
</div>
<div id="panel">
    <h3 id="broker_name">Broker Name</h3>
    Exposure: <span id="graph_exposure">--</span>
    <div id="graph" style="width: 1200px; height: 360px;"></div>
</div>
<div id="grid_div">
<table id="grid">
```

```

<tbody>
<%----- First Row ----->
<tr>
  <td>
    <table id="broker1">
      <tbody>
        <tr>
          <td class="broker" colspan="2">Australia and New Zealand
Banking Group</td>
        </tr>
        <tr>
          <td class="change">
            <span id="broker1_direction">--</span><br>
            <span id="broker1_change">--</span>%
          </td>
          <td class="exposure">
            <span id="broker1_exposure">--</span><br>
            <span class="limit">Limit:
              <span id="broker1_limit">--</span>
            </span><br>
            <span class="daily_rate">Daily Rate:
              <span id="broker1_dailyRate">--</span>%
            </span><br>
            <select class="exchange" id="broker1_currency"
onchange="exchangeCurrency()">
              <option>USD</option>
              <option>GBP</option>
              <option>EUR</option>
            </select>
          </td>
        </tr>
      </tbody>
    </table>
  </td>
  <td>
    <table id="broker2">
      <tbody>
        <tr>
          <td class="broker" colspan="2">B. Metzler Seel Sohn & Company
Holding AG</td>
        </tr>
        <tr>
          <td class="change">
            <span id="broker2_direction">--</span><br>
            <span id="broker2_change">--</span>%
          </td>
          <td class="exposure">
            <span id="broker2_exposure">--</span><br>
            <span class="limit">Limit:
              <span id="broker2_limit">--</span>
            </span><br>
            <span class="daily_rate">Daily Rate:
              <span id="broker2_dailyRate">--</span>%
            </span><br>
          </td>
        </tr>
      </tbody>
    </table>
  </td>

```

```

                <select class="exchange" id="broker2_currency"
onchange="exchangeCurrency()">
                    <option>USD</option>
                    <option>GBP</option>
                    <option>EUR</option>
                </select>
            </td>
        </tr>
    </tbody>
</table>
</td>
<td>
    <table id="broker3">
        <tbody>
            <tr>
                <td class="broker" colspan="2">Bank of America
Corporation</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker3_direction">--</span><br>
                    <span id="broker3_change">--</span>%
                </td>
                <td class="exposure">
                    <span id="broker3_exposure">--</span><br>
                    <span class="limit">Limit:
                        <span id="broker3_limit">--</span>
                    </span><br>
                    <span class="daily_rate">Daily Rate:
                        <span id="broker3_dailyRate">--</span>%
                    </span><br>
                    <select class="exchange" id="broker3_currency"
onchange="exchangeCurrency()">
                        <option>USD</option>
                        <option>GBP</option>
                        <option>EUR</option>
                    </select>
                </td>
            </tr>
        </tbody>
    </table>
</td>
<td>
    <table id="broker4">
        <tbody>
            <tr>
                <td class="broker" colspan="2">Barclays PLC</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker4_direction">--</span><br>
                    <span id="broker4_change">--</span>%
                </td>
                <td class="exposure">
                    <span id="broker4_exposure">--</span><br>

```

```

        <span class="limit">Limit:
          <span id="broker4_limit">--</span>
        </span><br>
        <span class="daily_rate">Daily Rate:
          <span id="broker4_dailyRate">--</span>%
        </span><br>
        <select class="exchange" id="broker4_currency"
onchange="exchangeCurrency()" >
          <option>USD</option>
          <option>GBP</option>
          <option>EUR</option>
        </select>
      </td>
    </tr>
  </tbody>
</table>
</td>
<td>
  <table id="broker5">
    <tbody>
      <tr>
        <td class="broker" colspan="2">BNP Paribas SA</td>
      </tr>
      <tr>
        <td class="change">
          <span id="broker5_direction">--</span><br>
          <span id="broker5_change">--</span>%
        </td>
        <td class="exposure">
          <span id="broker5_exposure">--</span><br>
          <span class="limit">Limit:
            <span id="broker5_limit">--</span>
          </span><br>
          <span class="daily_rate">Daily Rate:
            <span id="broker5_dailyRate">--</span>%
          </span><br>
          <select class="exchange" id="broker5_currency"
onchange="exchangeCurrency()" >
            <option>USD</option>
            <option>GBP</option>
            <option>EUR</option>
          </select>
        </td>
      </tr>
    </tbody>
  </table>
</td>
</tr>
<div id="chart"></div>
<%----- Second Row -----%>
<tr>
  <td>
    <table id="broker6">
      <tbody>

```

```

<tr>
  <td class="broker" colspan="2">Citigroup Inc.</td>
</tr>
<tr>
  <td class="change">
    <span id="broker6_direction">--</span><br>
    <span id="broker6_change">--</span>%
  </td>
  <td class="exposure">
    <span id="broker6_exposure">--</span><br>
    <span class="limit">Limit:
      <span id="broker6_limit">--</span>
    </span><br>
    <span class="daily_rate">Daily Rate:
      <span id="broker6_dailyRate">--</span>%
    </span><br>
    <select class="exchange" id="broker6_currency"
onchange="exchangeCurrency()" >
      <option>USD</option>
      <option>GBP</option>
      <option>EUR</option>
    </select>
  </td>
</tr>
</tbody>
</table>
</td>
<td>
  <table id="broker7">
    <tbody>
      <tr>
        <td class="broker" colspan="2">Commonwealth Bank Of
Australia</td>
      </tr>
      <tr>
        <td class="change">
          <span id="broker7_direction">--</span><br>
          <span id="broker7_change">--</span>%
        </td>
        <td class="exposure">
          <span id="broker7_exposure">--</span><br>
          <span class="limit">Limit:
            <span id="broker7_limit">--</span>
          </span><br>
          <span class="daily_rate">Daily Rate:
            <span id="broker7_dailyRate">--</span>%
          </span><br>
          <select class="exchange" id="broker7_currency"
onchange="exchangeCurrency()" >
            <option>USD</option>
            <option>GBP</option>
            <option>EUR</option>
          </select>
        </td>
      </tr>
    </tbody>
  </table>

```

```

        </tr>
        </tbody>
    </table>
</td>
<td>
    <table id="broker8">
        <tbody>
            <tr>
                <td class="broker" colspan="2">Credit Suisse Group AG</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker8_direction">--</span><br>
                    <span id="broker8_change">--</span>%
                </td>
                <td class="exposure">
                    <span id="broker8_exposure">--</span><br>
                    <span class="limit">Limit:
                        <span id="broker8_limit">--</span>
                    </span><br>
                    <span class="daily_rate">Daily Rate:
                        <span id="broker8_dailyRate">--</span>%
                    </span><br>
                    <select class="exchange" id="broker8_currency"
onchange="exchangeCurrency()">
                        <option>USD</option>
                        <option>GBP</option>
                        <option>EUR</option>
                    </select>
                </td>
            </tr>
        </tbody>
    </table>
</td>
<td>
    <table id="broker9">
        <tbody>
            <tr>
                <td class="broker" colspan="2">Deutsche Bank AG</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker9_direction">--</span><br>
                    <span id="broker9_change">--</span>%
                </td>
                <td class="exposure">
                    <span id="broker9_exposure">--</span><br>
                    <span class="limit">Limit:
                        <span id="broker9_limit">--</span>
                    </span><br>
                    <span class="daily_rate">Daily Rate:
                        <span id="broker9_dailyRate">--</span>%
                    </span><br>
                    <select class="exchange" id="broker9_currency"
onchange="exchangeCurrency()">

```

```

                <option>USD</option>
                <option>GBP</option>
                <option>EUR</option>
            </select>
        </td>
    </tr>
</tbody>
</table>
</td>
<td>
    <table id="broker10">
        <tbody>
            <tr>
                <td class="broker" colspan="2">The Goldman Sachs Inc.</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker10_direction">--</span><br>
                    <span id="broker10_change">--</span>%
                </td>
                <td class="exposure">
                    <span id="broker10_exposure">--</span><br>
                    <span class="limit">Limit:
                        <span id="broker10_limit">--</span>
                    </span><br>
                    <span class="daily_rate">Daily Rate:
                        <span id="broker10_dailyRate">--</span>%
                    </span><br>
                    <select class="exchange" id="broker10_currency"
onchange="exchangeCurrency()" >
                        <option>USD</option>
                        <option>GBP</option>
                        <option>EUR</option>
                    </select>
                </td>
            </tr>
        </tbody>
    </table>
</td>
</tr>
<%----- Third Row -----%>
<tr>
    <td>
        <table id="broker11">
            <tbody>
                <tr>
                    <td class="broker" colspan="2">HSBC Holdings PLC</td>
                </tr>
                <tr>
                    <td class="change">
                        <span id="broker11_direction">--</span><br>
                        <span id="broker11_change">--</span>%
                    </td>
                    <td class="exposure">
                        <span id="broker11_exposure">--</span><br>

```

```

        <span class="limit">Limit:
          <span id="broker11_limit">--</span>
        </span><br>
        <span class="daily_rate">Daily Rate:
          <span id="broker11_dailyRate">--</span>%
        </span><br>
        <select class="exchange" id="broker11_currency"
onchange="exchangeCurrency()" >
          <option>USD</option>
          <option>GBP</option>
          <option>EUR</option>
        </select>
      </td>
    </tr>
  </tbody>
</table>
</td>
<td>
  <table id="broker12">
    <tbody>
      <tr>
        <td class="broker" colspan="2">Westpac Banking
Corporation</td>
      </tr>
      <tr>
        <td class="change">
          <span id="broker12_direction">--</span><br>
          <span id="broker12_change">--</span>%
        </td>
        <td class="exposure">
          <span id="broker12_exposure">--</span><br>
          <span class="limit">Limit:
            <span id="broker12_limit">--</span>
          </span><br>
          <span class="daily_rate">Daily Rate:
            <span id="broker12_dailyRate">--</span>%
          </span><br>
          <select class="exchange" id="broker12_currency"
onchange="exchangeCurrency()" >
            <option>USD</option>
            <option>GBP</option>
            <option>EUR</option>
          </select>
        </td>
      </tr>
    </tbody>
  </table>
</td>
<td>
  <table id="broker13">
    <tbody>
      <tr>
        <td class="broker" colspan="2">Kas Bank N.V.</td>
      </tr>
      <tr>

```

```

        <td class="change">
            <span id="broker13_direction">--</span><br>
            <span id="broker13_change">--</span>%
        </td>
        <td class="exposure">
            <span id="broker13_exposure">--</span><br>
            <span class="limit">Limit:
                <span id="broker13_limit">--</span>
            </span><br>
            <span class="daily_rate">Daily Rate:
                <span id="broker13_dailyRate">--</span>%
            </span><br>
            <select class="exchange" id="broker13_currency"
onchange="exchangeCurrency()">
                <option>USD</option>
                <option>GBP</option>
                <option>EUR</option>
            </select>
        </td>
    </tr>
</tbody>
</table>
</td>
<td>
    <table id="broker14">
        <tbody>
            <tr>
                <td class="broker" colspan="2">Morgan Stanley</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker14_direction">--</span><br>
                    <span id="broker14_change">--</span>%
                </td>
                <td class="exposure">
                    <span id="broker14_exposure">--</span><br>
                    <span class="limit">Limit:
                        <span id="broker14_limit">--</span>
                    </span><br>
                    <span class="daily_rate">Daily Rate:
                        <span id="broker14_dailyRate">--</span>%
                    </span><br>
                    <select class="exchange" id="broker14_currency"
onchange="exchangeCurrency()">
                        <option>USD</option>
                        <option>GBP</option>
                        <option>EUR</option>
                    </select>
                </td>
            </tr>
        </tbody>
    </table>
</td>
<td>
    <table id="broker15">

```

```

        <tbody>
        <tr>
            <td class="broker" colspan="2">National Australia Bank
Limited</td>
        </tr>
        <tr>
            <td class="change">
                <span id="broker15_direction">--</span><br>
                <span id="broker15_change">--</span>%
            </td>
            <td class="exposure">
                <span id="broker15_exposure">--</span><br>
                <span class="limit">Limit:
                    <span id="broker15_limit">--</span>
                </span><br>
                <span class="daily_rate">Daily Rate:
                    <span id="broker15_dailyRate">--</span>%
                </span><br>
                <select class="exchange" id="broker15_currency"
onchange="exchangeCurrency()">
                    <option>USD</option>
                    <option>GBP</option>
                    <option>EUR</option>
                </select>
            </td>
        </tr>
        </tbody>
    </table>
</td>
</tr>
<%----- Fourth Row -----%>
<tr>
    <td>
        <table id="broker16">
            <tbody>
            <tr>
                <td class="broker" colspan="2">Northern Trust
Corporation</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker16_direction">--</span><br>
                    <span id="broker16_change">--</span>%
                </td>
                <td class="exposure">
                    <span id="broker16_exposure">--</span><br>
                    <span class="limit">Limit:
                        <span id="broker16_limit">--</span>
                    </span><br>
                    <span class="daily_rate">Daily Rate:
                        <span id="broker16_dailyRate">--</span>%
                    </span><br>
                    <select class="exchange" id="broker16_currency"
onchange="exchangeCurrency()">
                        <option>USD</option>

```

```

                <option>GBP</option>
                <option>EUR</option>
            </select>
        </td>
    </tr>
</tbody>
</table>
</td>
<td>
    <table id="broker17">
        <tbody>
            <tr>
                <td class="broker" colspan="2">Op-Pohjola Group</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker17_direction">--</span><br>
                    <span id="broker17_change">--</span>%
                </td>
                <td class="exposure">
                    <span id="broker17_exposure">--</span><br>
                    <span class="limit">Limit:
                        <span id="broker17_limit">--</span>
                    </span><br>
                    <span class="daily_rate">Daily Rate:
                        <span id="broker17_dailyRate">--</span>%
                    </span><br>
                    <select class="exchange" id="broker17_currency"
onchange="exchangeCurrency()">
                        <option>USD</option>
                        <option>GBP</option>
                        <option>EUR</option>
                    </select>
                </td>
            </tr>
        </tbody>
    </table>
</td>
<td>
    <table id="broker18">
        <tbody>
            <tr>
                <td class="broker" colspan="2">Pictet & Cie</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker18_direction">--</span><br>
                    <span id="broker18_change">--</span>%
                </td>
                <td class="exposure">
                    <span id="broker18_exposure">--</span><br>
                    <span class="limit">Limit:
                        <span id="broker18_limit">--</span>
                    </span><br>
                    <span class="daily_rate">Daily Rate:

```

```

        <span id="broker18_dailyRate">--</span>%
    </span><br>
    <select class="exchange" id="broker18_currency"
onchange="exchangeCurrency()" >
        <option>USD</option>
        <option>GBP</option>
        <option>EUR</option>
    </select>
    </td>
</tr>
</tbody>
</table>
</td>
<td>
    <table id="broker19">
        <tbody>
            <tr>
                <td class="broker" colspan="2">Royal Bank of Canada</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker19_direction">--</span><br>
                    <span id="broker19_change">--</span>%
                </td>
                <td class="exposure">
                    <span id="broker19_exposure">--</span><br>
                    <span class="limit">Limit:
                        <span id="broker19_limit">--</span>
                    </span><br>
                    <span class="daily_rate">Daily Rate:
                        <span id="broker19_dailyRate">--</span>%
                    </span><br>
                    <select class="exchange" id="broker19_currency"
onchange="exchangeCurrency()" >
                        <option>USD</option>
                        <option>GBP</option>
                        <option>EUR</option>
                    </select>
                </td>
            </tr>
        </tbody>
    </table>
</td>
<td>
    <table id="broker20">
        <tbody>
            <tr>
                <td class="broker" colspan="2">Societe Generale SA</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker20_direction">--</span><br>
                    <span id="broker20_change">--</span>%
                </td>
                <td class="exposure">

```

```

        <span id="broker20_exposure">--</span><br>
        <span class="limit">Limit:
          <span id="broker20_limit">--</span>
        </span><br>
        <span class="daily_rate">Daily Rate:
          <span id="broker20_dailyRate">--</span>%
        </span><br>
        <select class="exchange" id="broker20_currency"
onchange="exchangeCurrency()" >
          <option>USD</option>
          <option>GBP</option>
          <option>EUR</option>
        </select>
      </td>
    </tr>
  </tbody>
</table>
</td>
</tr>
<%----- Fifth Row ----->
<tr>
  <td>
    <table id="broker21">
      <tbody>
        <tr>
          <td class="broker" colspan="2">Standard Chartered PLC</td>
        </tr>
        <tr>
          <td class="change">
            <span id="broker21_direction">--</span><br>
            <span id="broker21_change">--</span>%
          </td>
          <td class="exposure">
            <span id="broker21_exposure">--</span><br>
            <span class="limit">Limit:
              <span id="broker21_limit">--</span>
            </span><br>
            <span class="daily_rate">Daily Rate:
              <span id="broker21_dailyRate">--</span>%
            </span><br>
            <select class="exchange" id="broker21_currency"
onchange="exchangeCurrency()" >
              <option>USD</option>
              <option>GBP</option>
              <option>EUR</option>
            </select>
          </td>
        </tr>
      </tbody>
    </table>
  </td>
  <td>
    <table id="broker22">
      <tbody>
        <tr>

```

```

        <td class="broker" colspan="2">State Street Corporation</td>
</tr>
<tr>
    <td class="change">
        <span id="broker22_direction">--</span><br>
        <span id="broker22_change">--</span>%
    </td>
    <td class="exposure">
        <span id="broker22_exposure">--</span><br>
        <span class="limit">Limit:
            <span id="broker22_limit">--</span>
        </span><br>
        <span class="daily_rate">Daily Rate:
            <span id="broker22_dailyRate">--</span>%
        </span><br>
        <select class="exchange" id="broker22_currency"
onchange="exchangeCurrency()" >
            <option>USD</option>
            <option>GBP</option>
            <option>EUR</option>
        </select>
    </td>
</tr>
</tbody>
</table>
</td>
<td>
    <table id="broker23">
        <tbody>
            <tr>
                <td class="broker" colspan="2">Royal Bank Of Scotland
Group</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker23_direction">--</span><br>
                    <span id="broker23_change">--</span>%
                </td>
                <td class="exposure">
                    <span id="broker23_exposure">--</span><br>
                    <span class="limit">Limit:
                        <span id="broker23_limit">--</span>
                    </span><br>
                    <span class="daily_rate">Daily Rate:
                        <span id="broker23_dailyRate">--</span>%
                    </span><br>
                    <select class="exchange" id="broker23_currency"
onchange="exchangeCurrency()" >
                        <option>USD</option>
                        <option>GBP</option>
                        <option>EUR</option>
                    </select>
                </td>
            </tr>
        </tbody>
    </table>

```

```

    </table>
</td>
<td>
    <table id="broker24">
        <tbody>
            <tr>
                <td class="broker" colspan="2">The Toronto Dominion Bank</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker24_direction">--</span><br>
                    <span id="broker24_change">--</span>%
                </td>
                <td class="exposure">
                    <span id="broker24_exposure">--</span><br>
                    <span class="limit">Limit:
                        <span id="broker24_limit">--</span>
                    </span><br>
                    <span class="daily_rate">Daily Rate:
                        <span id="broker24_dailyRate">--</span>%
                    </span><br>
                    <select class="exchange" id="broker24_currency"
onchange="exchangeCurrency()">
                        <option>USD</option>
                        <option>GBP</option>
                        <option>EUR</option>
                    </select>
                </td>
            </tr>
        </tbody>
    </table>
</td>
<td>
    <table id="broker25">
        <tbody>
            <tr>
                <td class="broker" colspan="2">UBS AG</td>
            </tr>
            <tr>
                <td class="change">
                    <span id="broker25_direction">--</span><br>
                    <span id="broker25_change">--</span>%
                </td>
                <td class="exposure">
                    <span id="broker25_exposure">--</span><br>
                    <span class="limit">Limit:
                        <span id="broker25_limit">--</span>
                    </span><br>
                    <span class="daily_rate">Daily Rate:
                        <span id="broker25_dailyRate">--</span>%
                    </span><br>
                    <select class="exchange" id="broker25_currency"
onchange="exchangeCurrency()">
                        <option>USD</option>
                        <option>GBP</option>

```

```

        <option>EUR</option>
    </select>
</td>
</tr>
</tbody>
</table>
</td>
</tr>
</tbody>
</table>
</div>
</body>
</html>

```

style.css – The CSS file

```

@import
url(http://fonts.googleapis.com/css?family=Ubuntu+Mono:400,400italic,700,700i
talic);
@import
url(http://fonts.googleapis.com/css?family=Roboto:400,300,500,700,300italic,4
00italic);

body {
    margin: auto;
    font-family: 'Roboto', 'Deja Vu Sans Mono', 'Bitstream Vera Sans Mono',
'Monaco', sans-serif;
    background-color: white;
    color: black;
}

h1 {
    text-align: center;
    margin-bottom: auto;
}

h2 {
    text-align: center;
    margin: auto;
}

h3 {
    text-align: center;
    margin-bottom: auto;
}

#broker26 {
    background-color: lightgray;
    height: 20px;
    font-size: 15px;
    text-align: center;
}

#broker26_exposure {
    background-color: lightgray;

```

```

        font-weight: bold;
    }

#grid {
    border: none;
    height: 70%;
    width: 100%;
    margin: auto;
}

table {
    border: solid gray 2px;
    height: 118px;
    width: 235px;
    margin: auto;
}

tr {
    margin: auto;
}

td {
    margin: 0;
}

.broker {
    font-size: 12px;
    text-align: center;
    border-bottom: solid gray 1px;
    height: 20px;
    cursor: pointer;
}

.broker:hover {
    text-decoration: underline;
}

.change {
    text-align: center;
    border: none;
    font-size: 14px;
    background-color: lightgray;
}

.ui-icon {
    display: inline-block;
}

.ui-icon ui-icon-arrowthick-1-n{
    margin: auto;
    border: 1px solid;
    icon: auto;
}

.exposure {

```

```

        font-size: 22px;
        font-weight: bold;
        text-align: center;
    }

    .limit {
        font-size: 14px;
        font-weight: normal;
    }

    .daily_rate {
        font-size: 12px;
        font-weight: normal;
    }

    .exchange {
        margin: auto;
    }

    #panel {
        display: none;
    }

    #graph {
        margin: auto;
        border: none;
    }

```

main.java – The main program

```

package com.jpmmorgan;

import com.jpmmorgan.core.ILimitsEngine;
import com.jpmmorgan.server.LimitsWebSocket;
import org.vertx.java.core.impl.DefaultVertx;

import java.util.HashMap;
import java.util.Map;

/**
 * Created with IntelliJ IDEA.
 * User: R544181
 * Date: 20/11/13
 * Time: 13:15
 * To change this template use File | Settings | File Templates.
 */
public class Main extends HashMap{

    public static void main(String[] args) throws InterruptedException {

        ILimitsEngine limitsEngine = new FakeLimitsEngine();

        LimitsWebSocket server = new LimitsWebSocket(limitsEngine);
        server.setVertx(new DefaultVertx());
    }

```

```

        server.start();

        Thread.sleep(100000000);
    }
}

```

LimitsWebSocket.java – The Java WebSocket Server

```

package com.jpmorgan.server;

import java.io.*;

import com.jpmorgan.FakeLimitsEngine;
import com.jpmorgan.core.ILimitsEngine;
import org.vertx.java.core.Handler;
import org.vertx.java.core.buffer.Buffer;
import org.vertx.java.core.http.HttpServerRequest;
import org.vertx.java.core.http.ServerWebSocket;
import org.vertx.java.platform.Verticle;

import java.text.DecimalFormat;
import java.util.Random;
import java.util.Formatter;

/**
 * Created with IntelliJ IDEA.
 * User: R544181
 * Date: 20/11/13
 * Time: 16:54
 * To change this template use File | Settings | File Templates.
 */

public class LimitsWebSocket extends Verticle {

    private Writer writer = null;
    private final Random random = new Random(System.currentTimeMillis());
    private static final DecimalFormat decimalFormat = new
DecimalFormat("#.##");
    private ILimitsEngine limitsEngine;

    public LimitsWebSocket(ILimitsEngine limitsEngine) {
        //To change body of created methods use File | Settings | File
Templates.
        this.limitsEngine = limitsEngine;
    }

    public void start() {

        vertx.createHttpServer().websocketHandler(new
Handler<ServerWebSocket>() {
            public ServerWebSocket ws;

            public void handle(final ServerWebSocket ws) {

                this.ws = ws;

```

```

        startPushingData(ws);

        ws.dataHandler(new Handler<Buffer>() {
            @Override
            public void handle(Buffer buffer) {
                System.out.println("Net client receiving: " +
buffer);
                ws.writeTextFrame("chart_data:" + buffer +
":12:4400:" + "2013:11:20:1000:2013:11:21:1500:" +
"2013:11:22:1600:2013:11:23:2000:2013:11:24:2200:2013:11:25:2500:2013:11:26:2
600" +
":2013:11:27:2600:2013:11:28:3100:2013:11:29:3800:2013:11:30:4000:2013:11:31:
4400");
            }
        });

    }
    }).requestHandler(new Handler<HttpRequest>() {
        public void handle(HttpRequest req) {
            if (req.path().equals("/limitengine"))
req.response().sendFile("websockets/ws.html"); // Serve the html
        }
    }).listen(8081);
}

private void startPushingDataFromEngine(final ServerWebSocket ws) {

    limitsEngine.addLimitChangeNotification(new
ILimitsEngine.ILimitChangedNotification() {
        @Override
        public String limitChanged(String broker, double limit) {

            int whichBroker = random.nextInt(26) + 1;
            int exposure = random.nextInt(10000000);
            float dr = random.nextFloat() * (100);
            float cr = random.nextFloat() * (100);
            int limit = random.nextInt(100000);
            String data = "exposure_data" + whichBroker + ":" + exposure
+ ":" + decimalFormat.format(dr) + ":"
+ decimalFormat.format(cr) + ":" +
limit;

            ws.writeTextFrame(data);

            return null; //To change body of implemented methods use
File | Settings | File Templates.
        }
    });
}

private void startPushingData(final ServerWebSocket ws) {

```

```

Thread t = new Thread(new Runnable() {
    @Override
    public void run() {

        for (int i = 0; i < 2000000000; i++) {
            try {
                Thread.sleep(500);
            } catch (InterruptedException e) {
                e.printStackTrace();
            }

            Random random = new Random(System.currentTimeMillis());
            int whichBroker = random.nextInt(26) + 1;
            long exposure = random.nextInt(1000000000);
            float dr = random.nextFloat() * (100);
            float cr = random.nextFloat() * (100);
            long limit = random.nextInt(1000000000);
            String data = "exposure_data:" + whichBroker + ":" +
exposure + ":" + decimalFormat.format(dr) + ":"
                                                                    + decimalFormat.format(cr)+
":" + limit;
            ws.writeTextFrame(data);
        }
    }
});
t.start();
}
}

```