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Mobile Business Analytics Financial analytics application Design for iPhone *Master of Science Thesis in Interaction Design*

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Göteborg, Sweden, January 2010

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Mobile Business Analytics
Financial analytics Application Design for iPhone

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Cover picture: Some screen shots of the design.

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Abstract

The purpose of this thesis was to design a business analytics application for touch phones. Different visualizations were explored for finding the ways of visualizing data, as well as the limitations and possibilities that only existed on touch phones were taken into considerations.

The target user of this thesis was the assets managers. Since they were not accessible during the design process, lots of market research was done as well as an interview with a consultant with domain knowledge to understand the users.

The design was evaluated and refined several times, first between the designers then by the usability test. Paper prototypes were used as well as Flash and hi-fi images for the user tests, and last version of design was revised based on the user test.

As a result, a flash demo was made to show a general usage of the application, and a guidelines report provides the design concept in details.

Keywords: information visualization, financial analytics, stock market, iPhone, touch phones, gestures, interaction design, TIBCO Spotfire

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1. Introduction

This chapter generally introduces the motivation of this thesis, as well as the research purpose and delimitation. The dispositions of each chapter are introduced at the end of this chapter.

Mobile phones have gradually become part of our everyday lives. Their looks have evolved as well as their functionalities. Nowadays, because of fast developing technologies like 3G, wireless network, many mobile phones are not just stand-alone devices to communicate among users, but also allow them to access to the world. Mobile users are no longer satisfied with only the basic “offline” functions, they need more benefits from the “online” mobile services, such as being able to surf on internet, read news, send emails, look up different information, and so on. These services bring a lot of conveniences together with the special characteristics of the mobile phones, which allows users to access information anytime anywhere.

In the financial market, people rely more and more on the analytics, which enable users to find out the patterns, trends, details of the data easily by observing the visualized information. This is rather important for the actors of the financial market who need to make quick decisions based on analyzing the massive market data. Many analytics tools have been commonly used by these people because of their advantages, but, most of them are stationary. So why not migrate the financial analytics from the conventional desktop platform to mobile phones, and enable users to have more accessibility?

Designing a good mobile user interface is challenging because the limitation of the size of the mobile screen must be considered and many alternatives must be figured out instead of using the existing solutions made for the desktop. As a specific case of mobile phone, the touch phones require even more work in design. Unlike a conventional mobile phone, the interaction with a touch phone is independent from the buttons and much more intuitive. Because of this, the gestures must be studied in order to make the design integrated with gestures naturally and hence increase the user satisfaction.

1.1 Research questions and purpose

This thesis was proposed by TIBCO Software Spotfire and the assignment was to design a business analytics specifically aimed at a mobile platform. Different than designing for the desktop platform, some limitations as well as possibilities that only exist on the mobile

platform must be kept in mind, especially for touch phones where gesture interactions should also be taken into considerations.

The primary research question of this thesis was formulated as follows:

How to design an attractive business analytics that makes a good application of the touch phone features and provides a great user experience?

To be able to answer this question a number of questions need to be addressed: Who would be the target user? What are their needs and tasks? What are the cutting-edge technologies within this field? What possibilities and limitations do the specific interaction techniques (e.g. touch) imply?

1.2 Delimitations

Some delimitations have been made to keep this thesis research in a reasonable scope. From the description of this thesis proposal, the purpose was to design a business analytics for touch phones. However “business” is a rather big topic, based on the requirements from an authentic customer case the focus was narrowed down to the financial market, and the usage of the design was defined into more details: to monitor the stock and fund market information.

Although it was decided at the very beginning that the touch phone platform would be an interesting case to design for, still, there are so many various touch phones to choose from. Considering the trend and popularity, iPhone was then chosen as the platform to design with, where its gestures and standard controls were to be used.

1.3 Deliverables

There are several deliverables the company expected to see as the results of this thesis: a prototype that demonstrates the design concepts, the prototype could be digital images made with Photoshop or animations made with Flash; a design guidelines report which helps future implementation and evaluation of the design.

1.4 Disposition

Here an overview of the structure of this dissertation is provided. This report consists of eight main chapters, and brief descriptions of each chapter are given as follows:

Chapter 1 Introduction

This chapter gives an introduction of the project, where the research questions and purpose of the study are presented, as well as the delimitations to the primary proposals and what deliverables are expected.

Chapter 2 Background

This chapter introduced some background knowledge of this project. Brief information of the TIBCO Software Inc. Spotfire as well as their major products is introduced. Background knowledge in the finance area includes the existing financial analytics applications, which are considered as the competitors in the thesis project, is explained. The target user group information is presented at the end of this chapter.

Chapter 3 Theory

This chapter describes the interaction design and information visualization theory this project was based on. The mobile interaction design is mainly presented from the perspective of the use context. Then narrow down to iPhone design along with the iPhone interface design, including the standard iPhone controls used in the project. Information visualization theory relevant to mobile device is described along with the data visualization visualizations.

Chapter 4 Method

This chapter presents the methodologies used in the study; it explains the design process model and the methods and techniques used in design. How these methods were conducted in practice is also introduced briefly.

Chapter 5 Realization

This chapter describes the actual process of this project, which was followed by the goal-directed design process theory. Firstly, User needs and requirements collected through the pre-study, based on which the requirement and basic framework of the application were built. The framework/application structure was defined after mockups, and details of the application were then designed and evaluated in several iterations including a user test.

Chapter 6 Results

The chapter describes the result of the project. The style and structure of the application are presented as well as the design pattern. Data visualization management is introduced along with the theory used by. Innovation of interaction design is explained with interaction gestures.

Chapter 7 Discussion

This chapter discusses the issues in design process and the project result, including the problems and difficulties met during the process, the decisions made on design solutions,

from both negative and positive prospective. The discussion is associated with the theories mentioned before. The possibility of future works is also discussed in this chapter.

Chapter 8 Conclusion

This chapter summarizes this thesis project work by answering the primary research questions. It concludes how the issues promoted at the beginning of the project were addressed during this project work. A general design recommendation for future work is also presented here.

2. Background

This chapter introduces the background of this project, includes brief information of the TIBCO Software Inc. Spotfire and their major products. Some background knowledge of the finance market and information about the target user group are also described here.

4.1 TIBCO Software Inc. Spotfire

TIBCO software Inc. provides enterprise software that helps companies to achieve service-oriented architecture (SOA) and business process management (BPM) success. Spotfire, which established in 1996, joined TIBCO as TIBCO Software Inc. Spotfire in 2007. TIBCO Spotfire's interactive information visualization and analytic solutions offer users a radically faster business intelligence experience and adaptable to specific industry and business. It helps people to draw conclusion among huge data and make decisions quickly. Most customers of TIBCO Spotfire are big companies and organizations, including industry leaders among the Global 2000.

TIBCO software Inc. Spotfire develops analytics software for desktop users, and wants to extend their services to the mobile users. Therefore, this thesis is a research on how to develop a business analytics application on the mobile platforms.

4.1.1 TIBCO Spotfire

The TIBCO Spotfire offers a series of product, including PC application and web player. All those platforms provide interactive visualized analysis environment based on computer. It transfers plain data to all kinds of visualizations and enhances the analytics experience. An analysis file in TIBCO Spotfire consists of several pages towards different purposes. The content in pages can be chosen and resized by users. Each page contains 3 main views, visualization, filter panel, and details-on-demand.

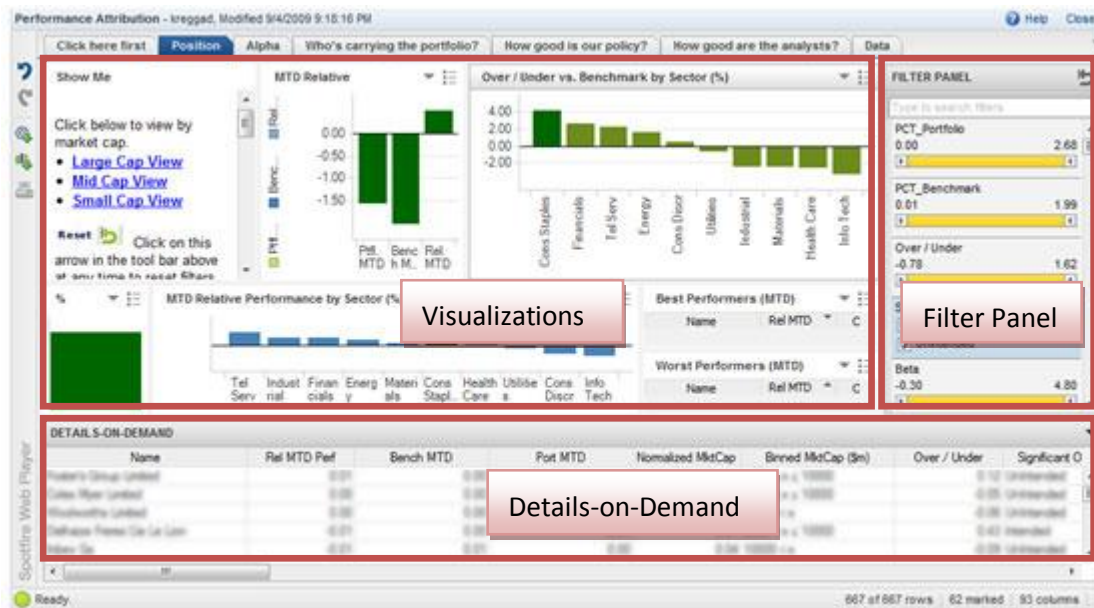


Figure 1: Spotfire Web Player

In the visualizations area, more than 10 visualization display mediums can be chosen by users, which are table, bar chart, scatter plot, line chart, tree-map, box plot, etc. Users can activate and inactivate each of them, and mark items (e.g., a bar segment, a pie sector, a line) in visualizations. The marking items trigger corresponding changes of other visualizations as well as items shown in details-on-demand. A tooltip with detailed information about the item is shown, when a user hovers the mouse around the item. The values of axis can be changed by the legend selector.

The filter panel, containing check box and slider selectors, is used for filtering the user needed data. By adjusting filters, users reduce the unwanted information and drill down to the things they are interested. The visualizations update instantly to reflect the change of filter panel. The search function at the top of filter panel makes sure the desired filter can be found quickly.

The Details-on-demand window, usually placed in the lower right corner of the application, displays the value table of marked items in the visualizations.

4.2 Finance Market (working circumstance, context)

In the finance market buyer and seller exchange their financial securities through credit facility. It achieves the currency lending and financial intermediation, processing of various bills and securities trading activities of the market. Financial intermediation, using variety of financial instruments regulating the activities of surplus fund, is the general term for all financial transaction. The composition of the financial market is very complex. Usually, it is

divided into capital market and currency market according to the dealing of trading tools. The currency market is for short-term capital intermediation and the capital market is factoring long-term funds. The capital market includes long-term credit market and securities market. The securities market is financing through the issuance of securities, including bond market, stock market, fund market, insurance market, and financial leasing market.

The stock market is the place for stock issued and exchanged; it also refers as the place for trading and transferring the issued stocks. Stock transactions are achieved through the stock market. In addition to stock, securities contain state bonds, corporate bonds, and mortgage-backed bonds and so on. Stock trading is only an integral part of bond trading; the stock market is only a variety market of the bond market. At present, the stock market is only a franchised place for stocks. The stock market is one of the main ways for listed company to get more finance. The changes of the stock reflect the efficiency of the company. The economic development relates to stock market closely. The Stock market is a barometer of the market economy.

The stock exchanges are organizations to provide buying and selling of stocks and other securities. It provides only the security listed on the exchange. The major stock exchanges in the world are like NASDAQ, New York Stock Exchange in USA; London stock exchange, Frankfurt stock exchange, Nordic stock exchange Group OMX in Europe; and Tokyo stock exchange, Hong Kong stock exchange in Asia.

Fund, referred as securities investment fund here, is an indirect securities investment. Fund management companies collect funds from the investors through different fund units. Fund is trust by trustee (qualified bank). Fund managers manage and use the funds to invest in stocks, bonds and other financial instruments. The investors share the investment risks and earnings.

4.2.1 Information and data

Information and data in financial market are very important to investors. These information and data, including real time data, historical data and technical analysis (technical indicators), help investors to make decisions on their securities.

4.2.1.1 Stock

In the stock market, stock indices, real time and historical price, and technical indicators are the elements concerned by investors. These elements are introduced as following.

Stock Indices

The stock indices, prepared by the stock exchange or financial services, indicate the volatility of the stock market. It helps investors to make decision of buying or selling a security. Indices could be used as a benchmark for judging the performance of an actual stock portfolio, comparing the individual stock price with the whole movement in the market (Wyss, O'Neill, 2000). Stock indices can be calculated by samples (a small number of representative stock), weighted average, and non-weighted average. There are different types of stock indices. Some are indices in a stock exchange. A "global" stock market index includes some large international companies. National indices reflect the performance of the local stock market, such as FTSE 100 in Great Britain, CAC 40 in French, OMX Nordic 40 in Nordic countries, etc. Some indices are beyond a stock exchange, such as Dow Jones Total Stock Market Index represents almost every publicly traded company in USA. Some stock indices have several versions based on different priorities of the components for various purposes.

Stock price and indicator

Stock price means the selling and buying price for stock at stock exchanges. Besides the real time price, the historical price is useful to analyze the trend; the OHLC (Open-high-low-close) illustrated the movement in each day. Stock indicators facilitate analyzing of the stock market. Fundamental analysis indicators evaluate the intrinsic value of the stock and predicate the long-term trend. It includes average volume, P/E, EPS, etc. Technical analysis indicators, resulted by studying of stock price, volume and market data, predict the short term volatility of the stock price. It includes moving average, Bollinger band, keltner channels, etc.

4.2.1.2 Fund

Return and risk of fund and fund portfolio are the key information for a fund, which are introduced as following.

Fund return and risk

The performance of fund is measured by returns on fund. The returns calculated in different time frames are important indices to evaluate the quality of fund. Fund risk can be indicated in different ways, such as standard deviation, beta, alpha, etc. These methods are also adapted to different time frames. There is strong relationship between the risk and returns of fund. Higher return is expected for higher risk fund.

Fund portfolio

Fund portfolio is the collection of investments for a fund. The assets in portfolios could include stock, bonds, cash, etc. fund portfolio information could be shown by sector weightings and top holdings.

4.2.2 Financial tools

Various financial applications are used for accessing the updating market information, and they are also designed for different platform such as desktop applications, web applications, and mobile applications. People choose different ways depending on their different goals and the use context.

4.2.2.1 iPhone application

Financial applications on iPhone provide the dynamic fluctuation of finance market wherever you are, whenever you needed. Most of them are simple and meet the quick check requirement from mobile users. By studying and comparing with Bloomberg [7], Swissquote [8], Google Finance Application [9], 128128 Q [10], and iStockmanager [11], the common features of iPhone financial application are generated as following:

News, which delivers the latest information on the market, is a basic element that can be found in most applications. Some applications only provide the headlines of updated news, while others allow users to explore the full articles. Some of them support the edit function on news, such as enable or disable certain news categories, move the order of categories, etc.

To access the market information is an important function of iPhone financial applications. Four types of information are available on the market. They are equity indices for securities, commodities list, bond list and currencies list. The list of indices can be categories by regions. Industry mover and stock mover are under each index. Industry mover could be shown on drill down pie chart (Bloomberg) or table. Stock movers are usually shown in tables with different sorting orders, such as sorting by leaders, laggards, volume, and turnover.

Quote view is available on almost every application. The information of a quote includes key statistics, news, and chart. The key statistics gives an overview from the economic perspective. Chart shows the trend with different time frame, as well as real time data (price). Most iPhone applications do not support comparison function between quotes. Taking the advantage of the multi-touch gestures in chart enhances the user experience of the direct manipulation. Bloomberg does a good example in this area. It uses the rotation gesture to change the view (enlarge the chart to full screen), and have a cursor on chart

moving with dragging fingers. By many applications, a quote can be added to the portfolio/watch list directly from the quote page.



Figure 2: Bloomberg-quote view



Figure 3: Google Finance for Android-quote

Unlike the financial web applications and pc applications, the portfolio management on iPhone is quite simple. Most of them use *watch lists* instead of portfolios. The information of an item in a watch list includes name/ticker, real-time information (last price, changes), etc.

Most applications provide an auto-complete function in Search page, as well as the search history review.

4.2.2.2 Web applications

The finance web application provides a platform for both common users and professionals to get the information and analysis in the finance market. Common features of finance web application are generated by studying some major web applications, including Google Finance [22], Yahoo Finance [23], MSN Money [24], AOL Money & Finance [25], CNN Money [26], Reuters [27], Morning Star [28] and New York Times [29]. The three main functions are chart monitor, which shows the real time and historical data as well as technical indicator, portfolio management, and search function.

Most chart monitors are interactive, and show the trends of stocks, indices and funds. These trends can be shown in different forms, such as OHLC chart, candlestick, mountain (filled line), dots, and line (See Chapter3: Information Visualization Display Medium). The time

frame of the chart can be set by fix term option or customized by a slider control or text field. Price chart shows when there is only one quote in a chart. If other quotes are added, change percentage is shown instead of price for comparison. Event markers are attached to the trend line with different letters, representing different types of events. For instance, “s” represents splits, “d” represents dividends, “e” represents earnings, “n” represents news flags, and etc. An interactive cursor is moving with the mouse, and the information of a specific day is shown. Besides the performance trends, technical indicators are also available by ways of adding a new chart or overlay.



Figure 4: Google Finance-Chart

With the portfolio function, users can create and manage their own portfolios as well as browse the top performance portfolios managed by others in the web application. The settings in portfolio include name, default currency, benchmark and portfolio strategy. Users can add any transaction to a portfolio. Information for a new transaction includes holding types (stock, mutual fund, EFT, cash), price, purchase type (buy, sell, buy to cover, sell short, etc.), shares, date, commission, etc. Different views available for portfolios in table form are overview, basic information, performance, fundamental, real-time, analysis, details, holdings, customize. Common visualizations used in portfolio are pie chart for the allocation and line chart for the performance. Moreover, news and important events for the holdings in portfolios could be listed besides. Some web applications have a simple version of portfolio, which is called watch list. It lists the quotes concerned by the users without transactions.

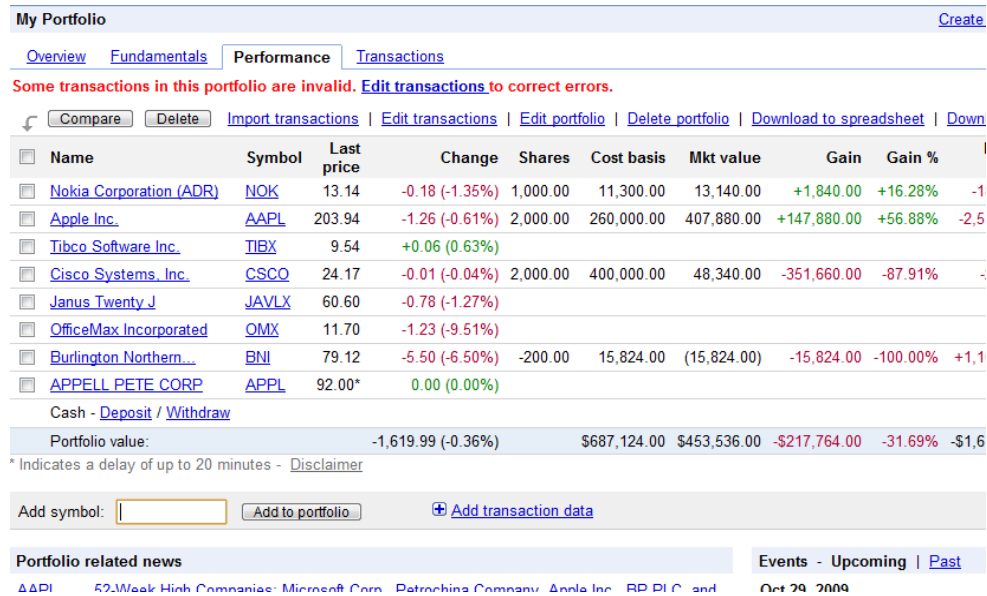


Figure 5: Google Finance-portfolio performance view

Search and screener in finance web applications allow users to access the desired quote quickly. Every web application has the search text field; some of them are equipped with the auto-complete function. The screener for the stock and fund are quite different. The criteria for stock screener are based on popularity, price (real time and historical), valuation (market cap, P/E), Dividend, financial ratios, margins and growth. While the fund screener are based on fund type (group, family, category), ratings (Morningstar ratings), returns by different time frame, purchase type (front load), and holdings type (net assets, turnover, market cap). The setting controls of criteria include setting the boundaries with slider control, buttons (highest, lowest, changes), and drop down list and text box.

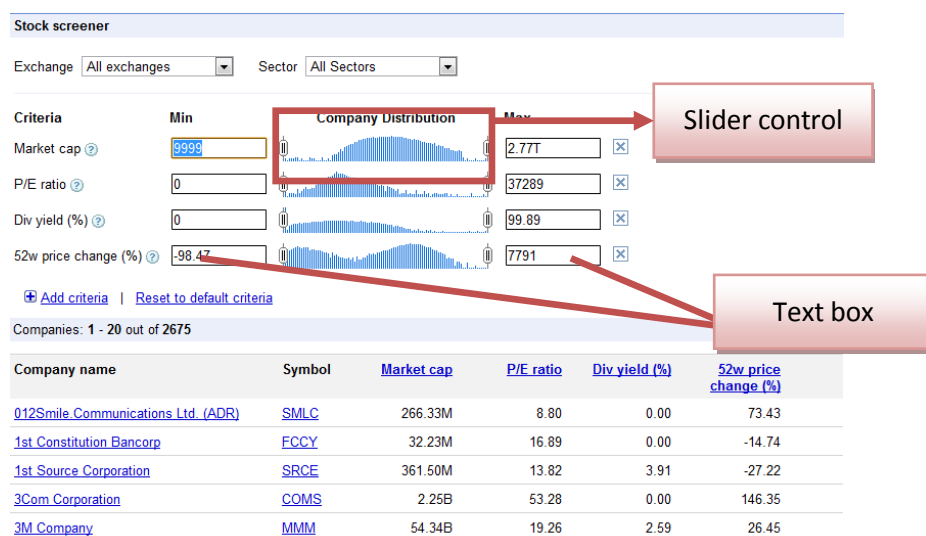


Figure 6: Google Finance-Stock Screener

The other information like the news in the market, the industry sector movement, and the expert analysis are also accessible on the web application. One good example of using visualizations in these areas is the horizontal stacked percent bar chart for industry sector summary in Google Finance.

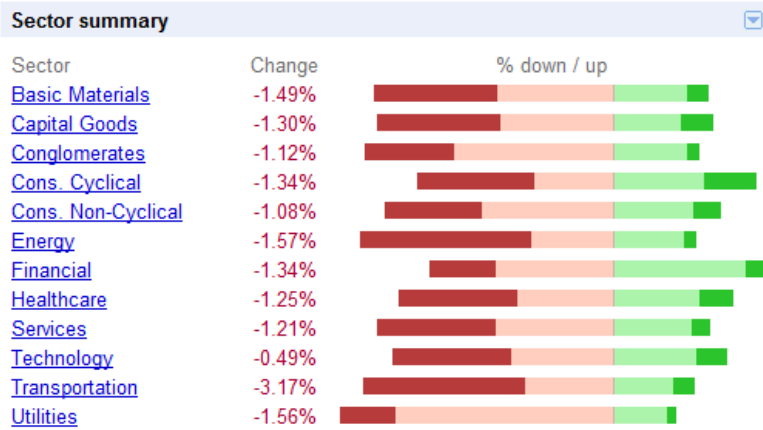


Figure 7: Google Finance-Industry Sector Summary

4.3 Users and Target users

The first step of the usability process is to study the intended users and the use of the product. (Nielsen, 1994) But upon that more questions are to be addressed: who are the users that the product is designed for? Who are the potential customers? Once when the users of the product are defined, their tasks, needs, and goals can be studied and used in the design and evaluation of the product.

4.3.1 Authentic customer case

A bank was suggested by TIBCO Spotfire as an authentic case of the product. They had shown great interests in the development of the product, and they were looking forward to presenting the product to their customers: the assets managers, who are from different banks and institutes, and help individual investors to manage their assets, whose requirements should be considered into the design. However, the design is not only based on their needs but also for a more general use.

Their motivations of the mobile financial analytics are: to use it as a complementary tool to the Web Player that Spotfire has published for their customers; to show their customers that they are following the cutting-edge technologies. They expressed that many of their employees were having iPhones, and some of them were already used to the financial analytics application “Bloomberg”, which was also what they would expect the product to turn out to be like. Compared to the Web Player, it is supposed to be used for quick check-

ups, not too much exploration, yet still has a guided and controlled way for the users to get details.

From the bank's requirements, 3 levels of the potential customers could be found: on the top level is the bank, who was asking the product for their customer (the employee of the bank can also be considered as the end user), then are the assets managers who act as the customers of the bank; at the bottom are the individual investors, who were helped by the assets manager with their investments or assets. In this chain, the assets manger is the focus of the target user.

4.3.2 Target user of the project

The target user of this project was generally defined and categorized into two groups:

Assets managers (stock actors): also called investment managers, fund managers, portfolio managers. They help customers with the management of financial assets (e.g. stocks, bonds, real-estate, and currencies), and handle collective investment plans, such as funds and portfolios, and give professional suggestions on what to invest. They are used to dense data environment, a typical working scenario is that looking at many charts on a screen simultaneously, monitoring the movements in the market, and read lots of data on papers. They are well-trained to recognize and analyze the different types of charts. Other actors in the stock market such as *stock brokers* who are trading deals with stocks, bonds, currencies, or *analysts* who are responsible for all investments recommendations, may also be considered as part of this user group.

Common users/ individual investors: this can be anyone who has investment on the stock market or simply interested in the market that want to look up information there. They can be the customers of the assets managers, who also want to observe the development of their invested assets themselves. They can also simply be the iPhone users who want to explore the stock market, regardless of financial investment experience or background knowledge.

5 Theory

This chapter describes theories mainly from two areas relevant to this project, interaction design and information visualization. In the interaction design part, the mobile user context is described first, then narrowed down to iPhone design concepts. In the information visualization part, the constraints of mobile data visualization are described as well as the data visualization visualization.

5.1 Interaction Design

Everyday people have to use various types of interactive products, such as computer, mobile phone, remote control, ATM, and so on. Therefore interaction design is to design these products to support people in their everyday and working lives. (Preece, 2002) To measure whether an interaction design is good or poor, the usability of the design is the most important concern, where the basic question is whether the product meets users' needs and requirements. Five attributes of usability have been defined by Nielsen (1993): Learnability, Efficiency, Memorability, Errors, and Satisfactory, which can be interpreted as requirements from user's perspective: easy to learn, efficient to use, easy to remember how to use, low error rate, and pleasant to use.

5.1.1 Mobile User Characteristics

Being as a special case of Human Computer Interaction (HCI), the interaction between people and mobile devices has been the focus of many studies. As people rely more and more on mobile devices in daily life, the needs and requirements from mobile users are increasing. Therefore in order to carry out a design that meets users' needs and expectations the characteristics of the users must be known and kept in mind as well as the principles for mobile interface design.

From the psychology viewpoint, different characteristics of mobile users could have an impact on how they use mobile applications, it is important to be aware of the differences between different groups of users as a mobile information designer, and develop a product that is usable and accessible for a wide range of people. (Steve Love 2005) Several characteristics that could affect a mobile user's use and perception of a mobile device are considered as follows:

5.1.1.1 Spatial Ability

Spatial Visualization Ability is one of the factors that make up the spatial ability, which refers to the extent to which individuals can deal with spatial relations and the visualization of spatial tasks. (Steve Love 2005).

When this is applied to cases of mobile interaction design, because only a limited amount of information can be presented on the small mobile screen at one time, the hierarchical design of the information is crucial. How to enable individuals with low SVA to visualize the system they are currently accessing? Too many levels (e.g. four or five levels) of information would confuse users with low SVA and bring them difficulties in finding the way to navigate back. (Steve Love 2005).

5.1.1.2 Personality

People with different personalities may have different attitudes towards computers, as well as different preferences and requirements. Schneiderman (1992) suggests that a clear understanding of personality and cognitive styles can be helpful in designing systems for a specific community of users. In the case of mobile interaction, a study of investigating people's perception of the personality of a synthetic voice versus a pre-recorded voice was conducted by Love and two other colleagues (Love et al, 2000). During the research, they found the synthetic voice was perceived as being less agreeable and conscientious in comparison to the pre-recorded voice. It also proved the ideas from Reeves and Nash (1999) that people preferred interacting with a computer system that similar personality to participants their own can be perceived. Love (2005) also points out that "personality does appear to have an impact on people's attitudes and behavior when using mobile devices in public places", which suggests that the context of use should be considered when designing the mobile application.

5.1.1.3 Memory

Memory is thought to be comprised of two related structures: short-term memory (STM) and long-term memory (LTM). LTM is assumed to be permanent where meaningful information and knowledge are stored in an inactive state, while STM, as a form of working memory, holds information temporarily in an active state, the capacity of STM is limited. The working memory is concerned with processing and temporary storage of visual and verbal information. (P. Johnson 1992 "Human computer interaction"; Steve Love 2005)

When it comes to human-mobile interaction, the designer must consider the user memory load when presenting the information on a small mobile screen: how to reduce the complexity of the information? How to design the structure and navigation of the

information that user's working memory won't overload and feel in control? (Steve Love 2005).

5.1.1.4 Previous experience

Previous experience here can be experience of the actual interface used to perform a certain task, or related skills and knowledge to a task domain. (Steve Love 2005) A user with experiences may act differently than those who don't when performing a same task, and with less time. An example that shows the impact of a user's task domain knowledge is the use of terminology in interface design: for users with extensive domain knowledge specialized terminology and higher density of information can be used, while for users with little domain knowledge more explanation of what the system is doing and clear terminology should be used. In order to shift users from novice to expert user, the ease-of-learning must be considered in the design, such as an online help system which assists the novice user without interrupting the experts. (Nielsen)

When this is applied to the mobile interaction, different mobile devices have various kinds of navigational control keypad. How to transfer the users' skills from one kind of navigation way to another? (Steve Love 2005) In a case of designing a mobile application, the designer may think how to relate the design to the users' previous experience, so that to make the application easy to start with for the beginner users.

5.1.2 iPhone user interface design

The iPhone interface has some unique constraints. The small screen size with relatively high resolution allows the user to see more details on the screen, but there is still no room for unnecessary design elements. Distributing information spatially is better than stacked information in deep hierarchies (Tufte, 2008). It helps the user to navigate easily on the small screen. In the iPhone, multi-touch gestures and visual keyboard are used instead of mouse and physical keyboard. Taking the benefit that it enhances the direct manipulation experience.

The context of use must be taken into account when designing user interfaces for iPhone. Unlike designing an interface for desktop use, the designer must keep in mind that mobile devices are not stationary. They can be used in dynamic environments, such as in a public place with noise, on a train, in a café, they may be used while users are walking. There are much more distraction or disruption can happen when interaction with mobiles than desktop computers, therefore designers must take the context of use into considerations to minimize the negative impact on the use of mobiles. (Love, 2005)

Accommodating different users with different needs and expectations is very important. For example, for users who use voice mail on a regular basis they would like access the information as quickly and efficiently as possible, while for users who use it only occasionally they are expecting some help that lead them where they want to go. Therefore, a designer must try to provide a design solution that satisfies both groups of users. (Love, 2005)

The Characteristics of the application should be simple and easy to use, help user to do the quick checkup to find necessary information. The use of the application should be obvious. The layout makes important information outstanding, which means the key information is bigger, and frequently used, high-level information is near the top of the screen. Minimize the text input, and let the user choose options instead of typing letters as much as possible. Express information succinctly and concisely. Provide fingertip-size targets and let the user tap accurately with minimum effort. (iPhone User Interface Design Guidelines, 2009)

There are three application styles in iPhone based on visual and behavioral characteristics, data model, and user experience. “A productivity application enables tasks that are based on the organization and manipulation of detailed information iPhone design rules.” Users quickly find their needs and perform necessary actions to complete the task. It organizes data hierarchically, so users can progressively drill down to find the desired level of details. For instance email is a productivity application. Utility applications realize quick checkup functions. Users check the status of something in a summary view without drill down. The configuration panel is in the back view of it. For instance the weather report is a utility application. An immersive application is a full-screen application with visualization content. Users use immersive applications for fun (game, movie) or perform simple tasks. It uses nonstandard controls and custom navigational methods rather than the standard way. Designers could choose the style of application depending on the purposes; mix of styles is also an option if needed. (iPhone Human Interface Guidelines, 2009)

5.1.2.1 iPhone user interface design principles

An attractive and logical interface enhances user experience, inspires a positive emotional attachment in users and earning their loyalty. Apple had defined some human interface principles for UI designers to achieve this goal. They are metaphors, direct manipulation, see and point, feedback, user controls, and aesthetic integrity. (iPhone Human Interface Guidelines, 2009)

Metaphors means model the application’s objects and acts as those in real world as well as previous experience, such as using iPhone standard controls or other similar products or services in a new application. Metaphors cut down the time and effort of learning the use of the application. Users usually do not want to spend a lot of time on learning new techniques

unless they are easy to learn and saving time compared to the old techniques. (iPhone Human Interaction Design Guideline, 2009s; Love, 2005)

Direct manipulation makes people feel controlling tangible things. The multi-touch gestures allow users to manipulate the interface directly rather than using some intermediate devices. To enhance the sense of it, the object visualization should be consistent with the actions performed by users. (iPhone Human Interface Guidelines, 2009)

See and point offers the user a list of choices than open-ended input. It saves user's time to remember and reduce the possibility of error. (iPhone Human Interface Guidelines, 2009)

Feedback system helps users to accomplish their task more effectively. It enables users to see the feedbacks of their actions, and satisfies their expectations. The feedback of the system is used to inform users what is happening, or present results of user manipulations. Cooper (2007) suggests that a better way to inform users is with modeless feedback, which is built in the structure and doesn't stop the normal flow of activities and interaction. Design a supportive system is also very important, such as how to support users in case of wireless disconnection and continue working afterwards without losing data? (iPhone Human Interaction Design Guideline, 2009s; Love, 2005)

The users control in an iPhone application should be simple and straight forward for the user to remember; give opportunity to cancel operation; and give confirmation to users. (iPhone Human Interface Guidelines, 2009)

Aesthetic integrity is not about how beautiful but how well the appearance integrated with its function. Different styles of application require different appearance to facilitate enabling the task. (iPhone Human Interface Guidelines, 2009)

5.1.2.2 Multi-touch Gestures

Gestures interaction design is one of the most challenging and interesting parts in the design. Making a good use of the gestures design enhances the user experience, and makes the application more intuitive, otherwise, the application would be intrusive and clumsy to use.

iPhone OS users enjoy a great sense of direct manipulation because of the Multi-Touch interface. Using gestures, people feel a greater affinity for, and sense of control over, the objects they see on screen, because they do not use any intermediate device (such as a mouse) to manipulate them. To make sure users get feedback of the actions, "the Objects on the screen remain visible while the user performs actions on them, and the result of the user's action is immediately apparent" (iPhone Human Interface Guidelines, 2009). With

correct feedback the users feel gestures are more natural or learnable, which means they would learn the techniques easily and be able to apply them on the same or similar situations again.

People use their fingers to operate the unique Multi-Touch interface of iPhone OS–based devices, tapping, flicking, and pinching to select, navigate, and read web content and use applications. They give users a sense of immediacy and connection to the device. (iPhone human Interface guidelines: support gestures appropriately, 2009) However, fingers have one major problem: the fingertips are much bigger than a mouse pointer. Therefore, to design a good user interface for a finger-based input system, the coverage of the fingertips and alternatives for replacing the mouse pointer must be considered.

The gestures users make to interact with iPhone OS–based devices are: Tap, Drag, Flick, Swipe, Double Tap, Pinch Open, Pinch Close, Touch and Hold.

- Tap: To press or select a control or item (analogous to a single mouse click).
- Drag: To scroll or pan.
- Flick: To scroll or pan quickly.
- Swipe: In a table-view row, to reveal the Delete button.
- Double tap: To zoom in and center a block of content or an image. To zoom out (if already zoomed in).
- Pinch open: To zoom in.
- Pinch close: To zoom out.
- Touch and hold: In editable text, to display a magnified view for cursor positioning.

It is important to avoid defining new gestures, especially if these gestures perform actions users already associate with the standard gestures.” (iPhone human Interface guidelines: support gestures appropriately, 2009) The common gestures make users find the application easy to use. Besides, an iPhone application would be used frequently as a tool for quick check-ups, so too complicated gestures would confuse users and affect the flow of the application.

5.2 Information visualization

Information visualizations use computer-supported technologies of visualization and interaction to amplify human cognition with abstract information (Card, 2008; Card et al., 1999). There are three parts of information visualization introduced in this section, data representation, data presentation, user interaction. Data representation is using the visualization to encode complex data and *provides the viewer with qualitative understanding of its information contents, turning complicated sets of data into visual insights* (Bhargava,

2003). It helps the user to generate the conclusion and make decisions without reading massive data. Data presentation is all about patterns. Good data presentation arranges patterns appropriately to individual or group data. User interaction allows the user to manipulate data and extract the result from a dataset as they desired.

5.2.1 Visual perception

Vision is the most important sense of people, which perceive more information than all of our other senses combined. Several visual cues can be processed by human eyes simultaneously (Ware, 2000). Humans' visual system captures and perceives patterns rapidly when it presents appropriately. Thus understanding how the visual perception system works is very important for information presentation. (Ware, 2004; Few, 2006)

5.2.1.1 Preattentive processing

“Preattentive processing of visual information performs automatically on the entire visual field detecting basic features of objects in the display” (Treisman, 1985). People identify certain colors or shapes from context before they attend consciously. Understanding preattentive processing helps to improve the intuitiveness in the information visualization and make the human visual system analyze the images naturally. The features that are preattentively processed can be categorized as: *form, color, motions and spatial position* (Ware, 2004). Form refers to differences in size, shape, orientation, etc. Color has elements of intensity and hue. Motion can have a pop-up effect by flicker and direction of motion. The most common use of spatial position is the 2D position. However, quantitative data can't be processed preattentively with these features introduced below. For the color, intensity can be detected limitedly but not hue. 2D position can be detected unconsciously. Intensity of color, size, flicker and motion can be perceived preattentively with limitation. Shape, hue of color and orientation cannot be quantitatively perceived at all. To strengthen preattentive processing, two features combined can be used.

5.2.1.2 Gestalt principle of visual perception

The gestalt theory studied first in Germany around 1920's, it is the German word for pattern. It describes how people group visual elements with six principles: similarity, continuation, closure, enclosure, connection, and proximity. The human visual system perceives the closure pattern as a closed shape. In statics graph design, closure shape could be more efficient than enclosure shape, for example, the x axis and y axis form a border of a graph rather than an enclosing box. (Few, 2006)

5.2.2 Visualizing qualitative information in handheld devices

An excellent statistic graphics shows qualitative information with several levers of detail in a small area without distortions. It introduces the substance to the viewer rather than the

form of visualizations, such as mythology and graphics. The viewers get the complex idea craftily and efficiently with least ink and smallest space. However, the graphics can distort the data information when misemployment occurs, thus the designer should present the figure numbers and provide clear and thoroughly labels to explain the chart. The using context should also be taken into account, since the understanding from different target groups varies. (Tufte, 1983)

Handheld devices with unique constraints generate requests to the statistic graphics. One character of the handheld device is that it is portable, which limits the screen size. Tufte defines the data-ink ratio as data-ink divided by total ink used to print the graphics to indicate the efficiency of the graph. Maximum data-ink is more critical on small screens than normal screens. Every bit of ink on the graph represents new information rather than visualization atheistic. To achieve this goal, designers should erase non-data-ink and redundant data-ink. In practice, the scale of axis should not beyond the maximum data, the designer should erase the grid lines if numbers are already marked on the graph, and avoid heaving grid line etc. (Tufte, 1983) The mobility of the handheld leads the limited bandwidth. Although the speed increases rapidly with new technology, however it is still limited in practice. Overload information aggravate this problem. Antoine de St. Exupery said perfection is “not when there is no longer anything to add, but when there is no longer anything to take away”. Simplicity is the best. Eliminate the information that obviously not support the purpose of showing the substance (Maeda, J., 2006). (Few, 2004)

Ruddle states micro-macro reading “is a method for presenting large quantities of data at high densities in a way that a broad overview of the data is given and yet immense amount of detail is provided” It reveals both the global and local information in the same graph with hierarchical layers of contextual reading. The overview gives the structure outline and the context of data, and the focus shows the fine details. For a small screen device, it is hard to show all the levels at the same time; therefore navigation among these levels is a challenge for designers. A common way to present the hidden details is using tooltips. (Tufte, 1990; Ruddle, 2002)

5.2.3 Dashboard design

An information dashboard is a powerful solution to provide and organize needed up-to-date information, according to Few (2004). Users obtain the information on a single screen with a glance. Any type of information can be contained in a dashboard, including graphs and text. For mobile device user, monitoring the real-time information from the dashboard is important. The small screen of the mobile makes only a tiny dashboard can be displayed. Thus using KPIs (key performance indication) and making it small and clear is suitable. The

information organized by the business functions; collocated items belong to the same group (Few, 2006). The graph on the dashboard maybe is too small to see clearly, therefore the zoom-in and drill-down functions are available for viewing the details.

5.2.4 Visualizations

“Tables and graphs help us think about information to better understand it, and then to communicate what we’ve learned to others.”(Tufte, 1983) Each of the mediums has its advantages and disadvantages. It will be effective only if one chooses a correct medium serving the corresponding purpose. All the visualizations used in this project are introduced as following.

5.2.4.1 Table

Using a table is the common way to show synthesis data with details. Viewers get plenty of information in a limited space. However, it lacks of the overview of the information as well as information comparisons compared to other visualization mediums. Therefore table are useful when individual information and precise data is concerned. (Anders Wallgren, 1996; Few, 2004)

The phone screen is quite small, so it is hard to show many columns and rows at the same time. An interactive table is needed in this case. There should be some way to show more columns, such as changing the column header; to access to more rows, such as going to the next page or using the dropdown bar to fold some rows (the dropdown bar will be introduced in Chapter6:Designed controls).

5.2.4.2 Tree-map (drill down)

A tree-map use 100% available display space to show the hierarchical structure of information. The tree structure splits whole space into groups of rectangular bounding box. Each level of the groups has the corresponding nodes. The nesting child nodes with their parents show the hierarchy. In the tree-map, the viewers not only capture the structure of information quickly but also access the detailed content by interactive actions. They can access information of each rectangle for example tooltips shows more details, by the action of hitting on the rectangle. Moreover, they can extract the information they need by customizing the tree-map variables. User control panels are equipped for user configurations. Each node in the tree-map has its own weight, which presents by the size of the node. The user can customize the weight determinant. The color (hue, saturation, and brightness), texture, shape border and etc are other properties indicating some variables and be customized. Color is the most important element among them due to that it draws attention strongly and helps to make decisions quickly. The color bar exists to illustrate the

color information. A boarder is needed in case of an adjacent rectangular box has a similar color. The color of the boarder should be different from all possible colors of the rectangles.

The tree-map is becoming commonly used for stock market nowadays. Companies can be classified into different types of sectors depending on different purposes. Size can be weighted by the market capitalization, or other factors. Color represents the price performance at most of the time. The green to red states the most decreasing price to the most increasing price. The drill down tree-map exists for big data sets. It allows users to drill down to access the next level tree-map. (Martin Wattenberg, 1999; Brian Johnson & Ben Schneiderman, 1991)



Figure 8: Tree-map [1]

5.2.4.3 Scatter plot

A Scatter plot shows how the variables co-vary with each other. Each spot in a scatter plot illustrates an individual, the position of the spot is defined by two variables, x and y axis; more variables can be shown by the color and size of spots. The scatter plot is a very informative visualization. It shows the trends of the data, as well as indicates the outlier. The grid helps to locate the maximum and minimum, and compare one value when the other value is the same. However, the scatter plot also has its limitations. It is difficult to read. It doesn't have strong visually effect compared to other visualizations, viewers could hardly have some deep impression at first sight. The scatter plot cannot generate clear results of large dataset, for it would be too cluttered in the chart. (Anders Wallgren, 1996; Tufte, 1983)

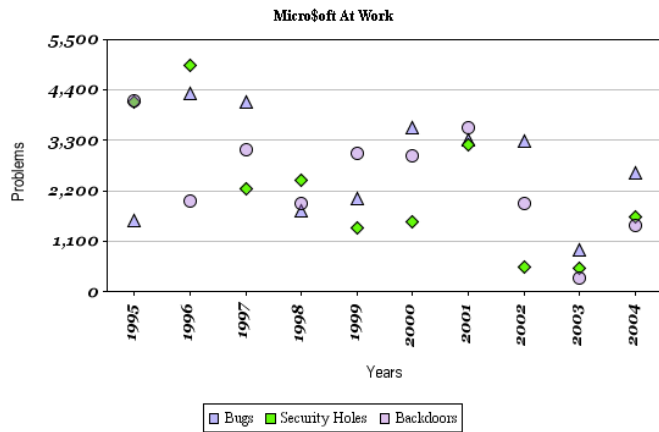


Figure 9: Scatter plot [2]

5.2.4.4 Bar chart

A bar chart shows discrete data, such as numbers, proportions or other ratios, in different columns. There are many types of bar charts to satisfy different visualization purposes, they are horizontal bar chart, grouped bar chart, stacked bar chart, etc. The most popular use of bar charts in financial market is the volume chart. (Anders Wallgren, 1996)

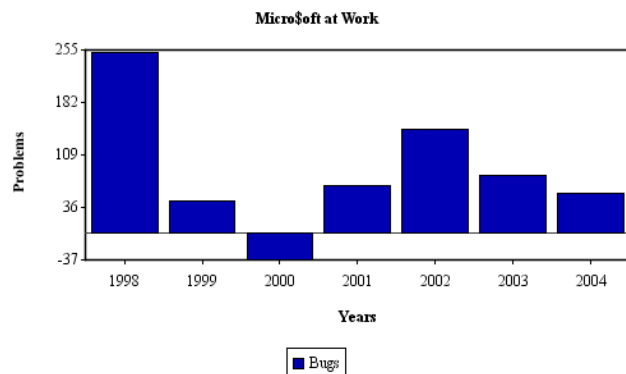


Figure 10: Bar chart [2]

5.2.4.5 Pie chart

A pie chart shows the percentage of total that each group stands for in the total categorical membership. Since it is difficult for eyes to measure the percentage in a circle, a pie chart is better for overview. The percentage value shows besides each section. The Color of each sector is a variable indicating other information. A color bar is added to illustrate the meaning of color. In a pie chart, 3-7 sections are most suitable, since too many sections make it crowded and gives no place for text information. A Static Pie chart provides too thin information to viewers sometimes. The drill down pie chart allows the viewer to drill down

to sub categories and let the viewer go further in their area of interests. (Anders Wallgren, 1996)

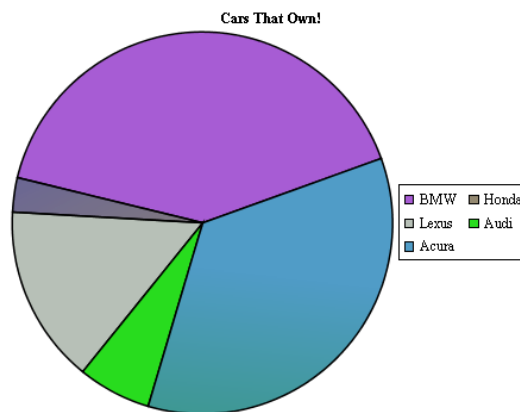


Figure 11: Pie chart [2]

5.2.4.6 Line chart

A line chart plots continuous data as points and then joins them with a line. It is usually used to describe some developments over time. If some analytics problem relevant with time is concerned, a line chart is a choice to present data. It not only shows the long term trends, but also analyzes the temporary deviation. The interim data can be inferred from the graph line. Moreover, a line chart is a good visualization to compare multiple continuous data sets. The limitation of line charts is that only the continuous data can be presented.

When drawing a line chart, horizontal and vertical grid lines can be added to help viewers identify the level of data and timing of changes in the chart. The legend could be placed both inside and outside of the plot area, in most case it is placed outside the plot area. If the designer keeps the legend inside, it should be simple and causing least disturbance. The x-axis of a line chart is time series value usually. It should be placed in the middle of the period (vertical grid line), since most time values represent a period of time, like day, month, and year. These periods correspond to the time values. The grid line passing through the time value should be avoided, unless the time values represent a point of time.

Two data sets with very different levels of values are difficult to compare in the normal line chart, therefore an index chart is the solution for this. It defines the starting point of the different data sets as a same value, and compares these developments among them. The index chart cares about the comparison of different series rather that what levels they are. (Anders Wallgren, 1996)

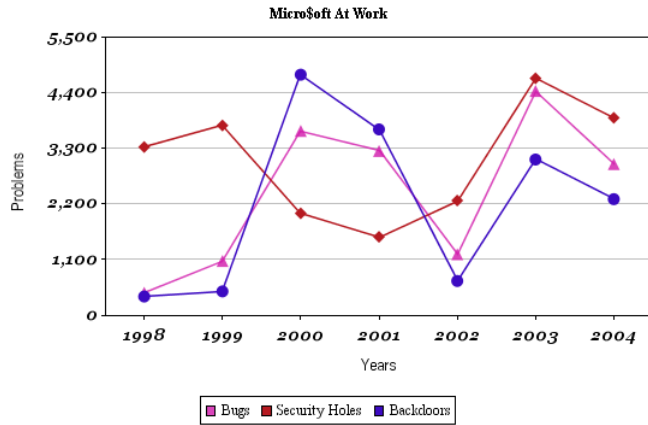


Figure 12: line chart [2]

5.2.4.7 Mountain Chart

The mountain chart is a line chart with shading bottom. It shows the development of data over time. It is an alternative of line chart. It is used commonly in the financial market to present single data series development over time.

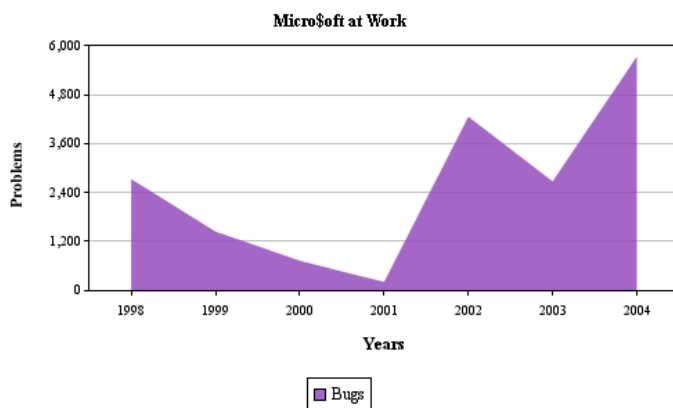


Figure 13: mountain chart [2]

5.2.4.8 Candlestick chart

A Candlestick chart shows the prices development including open, high, low and close price value over time. It is arranged with many candlesticks one next to the other. Each candlestick is composed of an upper shadow, real body and lower shadow. The top of the upper shadow represents the high price and the bottom of lower shadow represents the low price. If the Close price is higher than Open price, the real body is white and the top of the body represents the close. Otherwise the real body is black and the top of the real body represents the open (Andre Suslik Spritzer & Carla MS.D.S. Freitas, 2006; [1]).

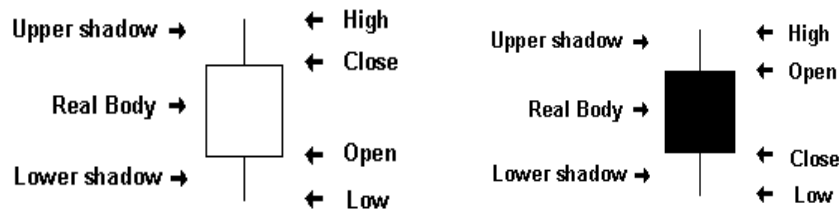


Figure 14: white and black candlestick [3]



Figure 15: candlestick chart [3]

5.2.4.9 OHLC chart

An OHLC chart shows the open, high, low, and close price information over time as the candle stick chart. It shows more accurate information compared to the line chart. An OHLC chart is composed of many OHLC bars. Each OHLC bar has two ticks on its both sides, the left one represents open price and right one represents close price. The top and bottom of the bar represents the high and low price separately. [4]

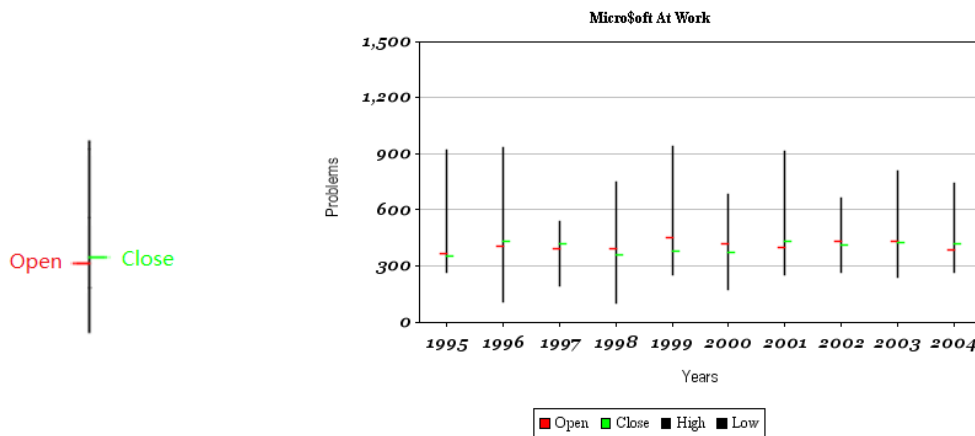


Figure 16: OHLC bar [2]

Figure 17: OHLC chart [2]

5.2.5 Interaction with information visualization

How can we design an information visualization that is interactive? Theus (2006) pointed out that direct manipulation is at the core for interactive statistical graphics, which means the

interface should be the focus where the data can be highlighted, selected, and manipulated, and the objects can be queried. More details of interaction aspects that should be considered in design were explained:

Linking: “Linking is used to (optionally) propagate attributes of the data” (Theus, 2006), in this case related data on the graphics are highlighted and associated, which helps to sort or categorize the data of interests.

Selection: It is the act of choosing an object or a control (Cooper, 2007) Different tools can be used for data selection for different purposes, such as point, rectangle, polygon, slice, etc.

Highlighting: Highlighting is a transient attribute of the data and usually compares to the complete sample. It helps users to spot selected data.

Queries: graphics are good at communicating qualitative information (e.g. observing the trends, patterns outliers). Therefore, queries are used to get more information within limited display on interactive graphics. The level of detail of a query is decided on the design purpose.

In relation to direct manipulation a concept called “dynamic queries” was introduced by Christopher Ahlberg et al (1992), who is the founder of Spotfire and makes it the core technology of the company. He conducted an experiment that allowed users to query a visualized database with graphical widgets (e.g. slider), where trends and exceptions from search results could be found easily. According to their test results they found that the control panel for manipulating the query must be placed in a logical way to reduce eyes and mouse movement; the direct manipulation tools were easy for the novice users to use; the search time must be immediate so that users feel in control and have a sense of causation.

In addition to those aspects on interface design, respond time is also crucial for providing an interactive visualization. According to Colin Wave (2004) at the lowest level of interactive visualization process the data manipulation loop, even a fraction of a second’s delay can seriously disrupt the performance of tasks on higher-level (exploration and navigation loop).

6 Method

This chapter presents the methodologies used in the study; it explains the design process model and the methods and techniques used in design. How to conduct these methods in the practice is also introduced briefly.

6.1 Design process

Recently many technology-focused companies have come to realize the importance of user research in order to create good products, which serves users' goals and brings them good user experience, however, the nature of the research is still in question. The conventional market research is quite useful for selling products but falls short for focusing on how people actually use the products, and how to translate user research into design solutions with various methods is also an issue to address. (Cooper, 2007) Therefore, to bridge the gap between the research results and design solutions, Cooper proposed a development process called: goal-directed design process. (See Figure 21)

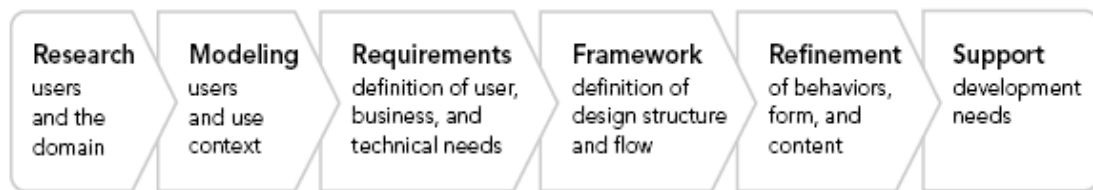


Figure 18: Design Process (Cooper, 2007)

According to the definition of Goal-Directed Design, the designer's role is no longer to provide a visual facelift on the implementation model but to provide a design based on a true product definition: the goals of users, the needs of business and constraints of technology. In this way, the researchers and designers are no longer separated individuals where a systematic means of translating and synthesizing the research into design solutions is needed, designers themselves are learnt to be the researches, immerses in the users' world and observe users' needs and requirements from a design perspective. (Cooper, 2007)

The Goal-Directed Design process is divided into six phases: Research, Modeling, Requirements Definition, Framework Definition, Refinement, and Support. When it came to the design process of this thesis project, some parts of the process development were

referred to the Goal-Directed Design. Some methods from them were also used during the design process.

6.1.1.1 Research

This phase is for the field study of the product, where qualitative data about potential users or actual users of the product are collected. It also includes defining the project goals and schedules, reviewing the competitive products and relevant technologies, interviewing ~~with~~ stakeholders to understand the product vision and constraints, and interviewing and observing potential or actual users to understand their needs and behavior. The techniques used in this phase are observation, interview and persona. (Cooper, 2007)

For this thesis project, the phase called pre-study is related to the research phase, the activities during this phase includes defining the objectives of the project, initiating the time line, reviewing the existing cutting-edge technologies and competitive products.

6.1.1.2 Modeling

During this phase the behaviors and workflow patterns discovered through analysis of the field research are synthesized into domain and user models. Domain models can include information flow and workflow diagrams while user models are personas that describe the users' behavior, attitudes, aptitudes, goals and motivations. (Cooper, 2007)

6.1.1.3 Requirements Definition

This phase is to focus on meeting the goals and needs of specific user persona, it involves an analysis of persona data and functional needs, prioritized and informed by persona goals, behaviors, and interactions with other personas in various contexts. The output of this process is a requirements definition that balances users, business and technical requirements of the design to follow. (Cooper, 2007)

In relation to the process of this thesis project, the task analysis phase was similar to the combination of the modeling and requirements definition phases, in which the output task analysis result was based on analysis of the results from the research phase, some scenarios were generated to study the use context along with a persona represented as a user model, and a phone interview with the stakeholder was conducted as well for analyzing the users' tasks.

6.1.1.4 Framework Definition

This is the phase where designers create the overall product concept, and define the basic frameworks for the product's behavior, visual design and physical form. Two critical methodological tools were used to synthesize the framework: a set of general interaction design principles and interaction design patterns. "The output of this process is an

interaction framework definition, a stable design concept that provides logical and gross formal structure for the detail to come.” (Cooper, 2007)

In the case of this project, the framework was defined based on the requirements collected from the previous process. The definition of the framework was represented as detailed information architecture. Mockups were used to generate design ideas/solutions, from which the design concept was formulated along with the logical structure of the information.

6.1.1.5 Refinement

This phase is similar to framework definition but with more focus on the detail and implementation. Designers are focusing on the task coherence and interface design in high details, such as the definition of the system style, sizes, icons, and other visual elements. The output of this process is a form and behavior specification. (Cooper, 2007)

In this thesis project, there are three iterations of evaluating and refining design in the refinement. The first iteration started with hi-fi prototypes which evolved from the mockups from the previous phase, then refinement was made based on evaluations of these prototypes, and a new iteration started with the revised version as the output from the previous iteration. The evaluations in this phase were done based on design principles and user tests, after the user test, the third iteration was implemented, and the final version was generated.

6.1.1.6 Support

The main concern in this phase is to maintain conceptual integrity of the design under changing technology constraints. It helps the development team to adjust the design solutions if they are faced with development challenges and technical questions.

In relation to this thesis project, a guideline was created to provide the development team the concept of the design in case of future implementation.

6.2 Methods

Different methods were used in different stages of the design process for different purposes. At the pre-study stage, some methods were used to understand the users and their tasks, and identify their needs and establish the requirements. At the design stages, some methods were used to generate ideas, evaluate and refine the design, and some methods were used to help collecting user data during the test, the ways the users performed the tasks were measured. The methods may be used together as a combined method or modified somehow from the original definitions to be fit to the project and get better results.

6.2.1 Functional Analysis

Instead of analyzing the way users do the task, function analysis analyzes the underlying functional reason for the task. (Nielsen, J., 1993) It is a technique originating in industrial design, where sources of information are typically diverse, and its purpose is to gather and analyze the diverse information, and determine what functions are desirable that should be considered in the design and what are not necessary or should be changed. (Löwgren & Stolterman, 2004) However, because of the limitation on the user's interaction pattern, the functional analysis should be coordinated with a task analysis. (Nielsen, J., 1993)

Because of the limitation of the access to the end-user, more attention was put on the hard facts in the project to understand the users. By analyzing the different functions of the competitive products, common features can be summarized, and the priorities of the functions can be noted. (See Appendix 1: Competitive Analysis) It is an indirect but much less time-consuming way to elicit user requirements.

6.2.2 Persona

Personas are fictitious characters created to represent the different user types; they help guide decisions about features, navigation, interactions, and even visual design. The descriptions include: user goals, skills, working environment, attitudes, etc.

The persona created for the project was based on the background research and interviews result from the representative user. (See Appendix 6: Persona) It was established before the design of the system; it helped to identify the user needs before design and to review the design from the user's perspective during the design process.

6.2.3 Scenario

Scenarios are used to describe human activities or tasks in a story, and depict the possible interactions with the system, which allow exploration and discussion of contexts, needs and requirements. Using scenarios designers can see what end-users do now, how they perform tasks. It is a good way to confirm the user requirements, and minimize the misconceptions between designer and end-user. (Preece, 2002; Faulkner 2000)

In the project, scenarios were used to describe different situations when the users interacting with the mobile devices. (See Appendix 5: Test Scenario) Similarly to Persona, scenarios were generated from previous background studies and interview results. It helped to analyze the user tasks and behaviors for the later system design.

6.2.4 Personal interview

"Interviews with individual users can be productive because the interviewer can pursue specific issues of concern". (Shneiderman, B., 1992) There are different kinds of interviews

that serve different purpose. These range from “structured” to “unstructured” and all stages in between.

In the unstructured interview, the interviewer asks users a series of open-ended questions and let the users steer the interview in the direction of their interests, it encourages the interviewee to talk in depth and reflects the user’s needs. This type of interviewing technique is probably most appropriate in the early stage of the design process, when usability engineers are trying to capture general information about the users, their tasks and their environment (Faulkner, 2000).

In a structured interview on the other hand, questions are planned in advance and answers are expected to be chosen from a list of suggested answers, “it makes no attempt to gather individual opinions but attempt to find a gross respond.” (Faulkner, 2000) Because these interviews only go through a set of questions with pre-planned answers, compared to the unstructured interview, they are easy to manage and save time for the interviewer.

In between these two extremes come the semi-structured interviews, in which questions are prepared to be used if necessary, unlike a structured interview it invites interviewees to express their opinions, more personal responses and ideas can therefore be collected. Prompted interviews are flexible interviews but with a built-in means to prevent the interviewee from drying up, questions like “What do you mean when you say...”, “Can you explain that in a little more detail” will encourage interviewee to say more or expand upon important issues (Faulkner, 2000)and minimize misunderstandings as well.

The interviewer plays an important role during the interview. “The interviewer can continuously evaluate the user’s replies, making it possible to rephrase questions that seem to have been misunderstood.” (Nielsen, J., 1993) In the unstructured interview, as interviewees are encouraged to explain themselves, in order to ensure unbiased responses, the interviewer should stay neutral during the interview and not agree or disagree with user statements. (Nielsen, J., 1993) However, it is important to let users believe that usability engineers are really interested in what they have to say. (Faulkner, 2000)

Several interviews were used to elicit user requirements and feedbacks for the project. An unstructured interview by phone was conducted during the data collecting process; it aimed at getting information about the target users and their requirements. Some unstructured interviews were used during the user test. When a user mentioned some interesting points or gave some ambiguous answers, the interviewer would ask the users to explain more in order to elicit more information. After the user test, semi-structured/unstructured interviews were conducted immediately to collect the user feedbacks.

6.2.5 Brainstorming

The aim of this technique is to stimulate a group of people to generate many ideas quickly, it is easy to operate and can be used in any stage of the design process. (Jones, 1992) It was introduced by Osborne in 1950s, and broadly consists of three steps: collecting a group of people for producing the ideas, generating ideas and structuring the results. (Löwgren & Stolterman, 2004) During the idea generation session, the initial questions or problems motivating the brainstorming should not be discussed or elaborated, to avoid giving any hints of solutions and make it easier for people to start generating ideas of diversity. As the ideas generated, no criticism or judgment should be put on them and all the wild ideas are welcome, the participants should try to combine the ideas or improve them upon the ideas suggested by others. The point of this is to get inspiration from others and have new, unexpected good ideas. When all the ideas are collected, they will be classified to be used for the future work. (Löwgren & Stolterman, 2004; Jones, 1992)

Brainstorming was used at many stages of the design process in the project. Because of the distance work between the designers, a digital mockup tool as well as Photoshop was used to assist representing ideas. At the beginning of the design process, this method was used to generate ideas for designing different solutions of general user tasks defined from the previous phase. As the design progressed, the method was used for more detailed designs, like for generating the solutions for a specific user task.

6.2.6 Prototyping

A prototype is a limited representation of a design. It allows stakeholders to discuss ideas with an envisioned product; it helps communication between team members and also provides an effective way to test the designer's own idea. (Preece, 2002) There are different kinds of prototypes used with different purposes: low-fidelity prototypes like paper-based prototypes (e.g. Storyboard, sketching); high-fidelity prototypes like digital-based prototypes (e.g. Photoshop, Flash).

Different prototypes were used in the project to present and communicate ideas. For low-fi prototypes a digital mock-ups tool called "balsamiq" for GUI drawing was used, the prototypes were used mostly at the brainstorming session, to provide different solutions. Photoshop and Flash were used to create hi-fi prototypes. The High-simulated images from the second design iteration were printed on papers so that users could interact with it during the usability test, Flash prototypes on the other hand were used to give test users better understanding of the animation and interaction of the system.

6.2.7 Heuristic Evaluation

Heuristic evaluation is known as “discount evaluation”, because compared to other usability methods it is fast, cheap, and easy to use, no users and special facilities are needed. (Preece, 2002) During the evaluation sessions a list of recognized usability principles, which are called Heuristics, are used to inspect the user interface elements. However, in addition to the original heuristics which are rather general, the evaluator can consider other relevant design guidelines, or results from market research to tailor the heuristics. (Jakob, Robert 1994)

Besides the original Heuristics, another design guideline the “iPhone User Interface Guidelines” was mostly referred to during the design process. After the first hi-fi prototype was finished, heuristic evaluation was implemented by the designers. Based on the evaluation a revised design was then created, which is later used for the usability test.

6.2.8 Cognitive walkthrough

“The cognitive walkthrough provides a detailed, step-by-step evaluation of user interaction with an interface in the process of carrying out a specific task.” (Jakob, Robert 1994) The focus is put on evaluating designs for ease of learning, by simulating the user’s action sequences for each task and find potential problems. It is useful for examining a small part of a system in detail, whereas heuristic is useful for examining whole or parts of the system. (Preece, 2002)

Based on the task analysis result, a list of user tasks was used to carry out the cognitive walkthrough. The designers were simulating the users to perform the tasks and tried to inspect the learnability of the system where a series of questions were kept in mind: is this interaction easy to learn? Without manuals can users find the actions by exploring? Are the actions natural to take?

6.2.9 Formative vs. Summative Evaluation

Formative evaluation is used at the early stages of the design process, it helps to evaluate and refine the design. Methods used in formative evaluation are focusing on collecting qualitative information, such as how users interact with the system, how the system meets the users’ needs and so on.

Summative evaluation on the other hand is useful when the design is complete, and much more likely requires quantitative data. (Faulkner, 2000) It gives a measurement of the overall performance of the user and system.

6.2.10 Observation

Observation is the simplest of all usability methods, since it takes the observer very little work (e.g. taking note) for not to interfere with the user, yet it is the most direct way of

analyzing user tasks and gathering user requirements. One advantage of this method is that unexpected use behavior can be found which the developer would not have considered. (Nielsen, J., 1994)

This method was used during the usability test. When the user was performing the tasks, their behaviors were observed, from which the flow of the system could be found out: which tasks took users longer time to figure out, which tasks were easy to be accomplished. Besides the user behaviors their emotions or satisfaction of the design were also observed, so that the strength and weakness of the design could be noted.

6.2.11 Thinking Aloud

This technique involves users to verbalize their thoughts while they are performing a set of specified tasks. By doing so it enables designers to understand how users view the system, and easily identify their major misconceptions. (Nielsen, J., 1994) However, as it may seem very unnatural to most people, it could bring some impacts to the results: slow down the task performances; learn the interface or solves problems faster. (Nielsen, J., 1994)

This method was used in the usability test, the users were given a series of tasks, and as users performing the tasks they were allowed to express how they made the actions or how they feel about the interfaces. However, this method wasn't implemented so strictly nor being applied on every user, because not all the users were used to verbalize every step they made, interview questions were used together to encourage users to talk more about their motivations, requirements and experiences.

6.2.12 Coaching method

Different than other usability test methods where the experimenter tries to interfere with the user as little as possible, the coaching method involves steering the user in the right direction while using the system. (Nielsen, J., 1994) During the coaching process the test user is allowed to ask any system-related questions. It is normally used to study the novice users to discover their information needs or in cases when expert users are unavailable. (Nielsen, J., 1994)

The coaching method was used in the usability test in order to provide the users a better understanding of the system. Since some users didn't have experience of using the iPhone, so some necessary explanations about the iPhone standard controls were given. Also, since the prototype was not interactive, some brief descriptions about the system feedbacks were given to let users visualize the responses or results of the actions they made. As the test users performing the tasks, they were allowed to ask questions about the interfaces where

they felt confused. This method helped to clear the user misconceptions as well as to observe the information needs from the users.

7 Realization

This chapter describes the real process of this project, which followed the goal-directed design process theory. Firstly, user needs and requirements collected through the pre-study; then the requirement and basic framework of the application were built based on that. The real Framework/application structure defined after the mockup, and the details of the application were designed in 3 iterations.

7.1 Pre-study

Before the real design start, research has been done to understand the user's goal. Since there was no chance to reach the real user at the beginning, the relevant data was collected by studying similar applications on the market and literature reading. In this phase, literature and internet sources in the information visualization and mobile interaction design areas were studied. Financial applications including pc applications, websites, and iPhone applications gave inspiration for design and helped the task analysis. Moreover a user interview, personas, and scenario have been done to get a better understanding of the user context.

7.1.1 Literature and cutting-edge technology studies

In the first two weeks, literature in information visualization and mobile interaction were studied, such as Tufte's book, which is classic in this area, and some other books about information visualizations as well as relevant papers and websites. In addition, mobile interaction literature, such as iPhone Human Interaction Design Guidelines, mobile concept design, and multi-touch gesture design were studied. Cutting edge technologies in these areas are concerned through the entire process.

7.1.2 Financial applications

All types of financial applications were studied, especially the website and iPhone applications. By summarizing the features of each application, designers get inspiration from the interaction design, the choice of visualization, and needed data and information for mobile financial analytics. The financial applications for the iPhone that were studied include Finanzen.net [12], Stockcharts [13], Simplex FX [14], TickerPicker [15], Fund Watch [16], StockWatch [17], Fonestock [18], StockAdvisor [19], PortfolioLive [20], Share Prices [21], iStockManager [11], 128128Q [10], Google Finance for Android [9], Swissquote [8], Bloomberg for iPhone [7]. After studying each application, interaction features and visualizations choice for different purpose were recorded and compared. The most outstanding applications were chosen to be used for the task competitive analysis [See

appendix1]. Seven tables were made for comparing differences among the applications in seven most common features/ functions: configuration, search quote view, portfolio, market, news, and chart. From the table, one can see what tasks can be done in each application. The most important tasks were those realized by most applications. After that, the task analysis of the financial mobile application was generated.

The financial web applications were also explored and studied. Visualization utility and visualization interaction features were summed up in stock and fund separately. The visualizations as well as the interaction design were used mostly in the chart of stock/fund.

7.2 Requirements Definition

After the pre-study phase, a task analysis draft based on the task analysis of web applications and iPhone applications was generated. This draft was verified by scenario, persona and pre-sales interview later. As the output of this requirements definition, the task analysis was refined several times and defined finally [See appendix2]. In this project, the application functions cover 6 main areas, market, portfolio/portfolios overview, fund monitoring, stock monitoring, search, and alert. The application was decided to be a productivity application, for it enabled the users to accomplish important tasks, and explore detailed information as well. However, it was also considered as an immersive application as it offered a full-screen mode.

7.2.1 Scenario and persona

Scenario [See appendix5] and personal [See appendix6] was implemented in order to help to generate task analysis. In the scenario, all use case actions were considered in stock and fund monitoring as well as portfolio management. It was used to verify the task analysis during the process. The persona describes a typical user for the application. We took that into consideration in the user-oriented design.

7.2.2 Phone interview

A phone interview was conducted during the task analysis phase. The interviewee was a consultant of Spotfire, whose job was to provide professional services to the bank which was introduced as the authentic case of the project, such as customizing analysis files for the bank. With experience of working with the bank, he had quite much domain knowledge of the Finance market, and understood the needs of the assets managers. The goal of this phone interview was to try to elicit the needs and requirements of the target user of the project and to learn the context of use of the financial analytics, as well as to clear some misunderstandings or misconceptions. A list of interview questions was prepared and printed out on paper before the interview; the questions were categorized by different aspects, or purposes. The questions cover everything from general requirements to specifics,

with both open-ended and close-ended [see Appendix 3: Phone Interview]. The reason for this was the uncertainty of the answers from the interviewees, which also helps to elicit useful user requirements as much as possible.

The interviewer was sitting in an empty and quiet room with a loudspeaker phone, due to the absence of one of the designers, and the supervisor in the company was helping taking notes during the interview process. Quite few of the prepared questions were asked during the interview, because as some of these questions were asked at first the results didn't turn out to be satisfied, the interviewee quite often gave answers with misunderstanding, more explanations had to be added for him to understand the questions first. It might have been caused by the disadvantage of phone conversation in which the voice quality was decreased and facial expressions were hidden, or by the lack of enough understanding of the interviewee, such as their domain knowledge in the area. Hence, lots of time would be wasted if the interviewer had asked all the questions as planned. Therefore, the plan was adjusted and allowed the interviewee to steer the interview by himself. Let the interviewee to talk about what he thought the needs and requirements of the target users were, and explained about their working context. When some interesting topic triggered the interviewer, the interviewee was asked to explain to a certain level of details until the idea was clear and the interviewer was satisfied. The duration of this phone interview was about 30 minutes, although there were some misunderstandings and confusions, still some important information and user requirements were gathered in the latter part of the interview [see Appendix 3: Phone Interview], and the interview results helped to confirm some understandings about the user from the data collection in the pre-study and were used to evaluate and redesign the task analysis formulated earlier.

7.3 Framework Definition

After requirements definition, design ideas were collected, including application style, framework proposal, and visual design. A mockup tool was used for brainstorming, collecting all possibilities of solution design. During the mockup process, the information structure was refined, and the framework was defined.

7.3.1 Low-fidelity prototype-mockup

The basic application layout was consistent with most productivity applications for the iPhone; a status bar was on the top, navigation bars were under the status bar, and the tab bar was at the bottom with sub function buttons. Based on the task analysis, the application had five sub-functions as tab buttons: Market, Portfolio, News, Search, and Alert. Each of them can access quote view of specific stock or fund. The GUI mockup tool "Balsamiq" was

used [30] to brainstorm and collect all ideas. The quote view and portfolio were the most essential parts of the design, which were designed to several versions in each part.

In the quote view, a dashboard summarized the key information related to this stock or fund. The stock, fund and index had different content quote view, but sharing the same layout for consistency. After information for each item was listed, the quote view layout was generated with the theory of dashboard design and inspiration from similar products. Inspired by the Bloomberg app [7], the rotate gesture was used to go to stock/fund chart in horizontal view from a quote view page. In the stock/fund chart, more functions in this application were designed compared to other existing iPhone products, such as quote comparison. To organize the information in chart, two ways of navigations were tried out. One was keeping the different information spatially in one page rather than using different pages; the other was to use the toggle button in the navigation bar to toggle between different views. For setting the parameters and types of chart, a pop-up window was chosen. When the settings panel popped up the chart background was darker.

Two versions of fund quote view and chart are shown below:



Figure 19: mockup-fund1



Figure 20: mockup-fund2

Portfolio monitoring design in the mockup was different compared to other existing iPhone finance applications. It showed portfolios with transactions rather than watch list, and offered different visualizations. The browsing ways designed for portfolios were table list, dashboard with iPhone album browsing look, and dashboard distributed spatial. Each of them had some advantages. The table list gave key status and total statistics clearly with economic space. The dashboard offered key status and visualizations with sparkle line. The album look was fun to play with; while the distributed spatial dashboard displayed several portfolios information in one page. Navigation between different visualizations naturally was a challenge in portfolio management. In solution 3, a segmented control (see Chapter6: Standard Controls) was used to realize this navigation with least hierarchy. The user configuration was tried in two ways. One was using the settings button on the navigation bar of the vertical visualizations page, where the filters can be accessed. The other solution was using the horizontal screen to show the visualizations and configuration buttons on the same page



Figure 21: mockup-portfolio1



Figure 22: mockup-portfolio2



created with Balsamiq Mockups - www.balsamiq.com

Figure 23 Mockup-portfolio3

7.3.2 Application Structure

The structure of the application formed after the mockup design. The five main categories were the same as the first idea, news, market, portfolio, search, and alert. Since too many hierarchies of levels made users to ask the question “where am I”, each of the main categories had at most three sub levels.

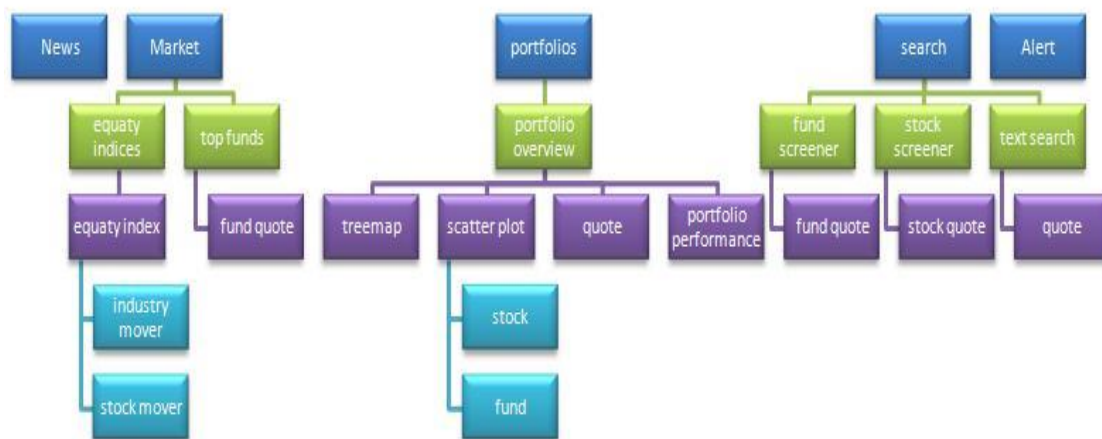


Figure 24: Application Structure

7.4 Refinement

After the framework definition, the five main functions were designed in detail. A series of standard controls for this application as well as visualizations were designed. Three iterations were implemented in this process to make the design as perfect as possible. After the first iteration, a self evaluation was conducted, and after the second iteration, a user test was conducted. The result of the third iteration was the final result of this project, after that no more evaluation or test was conducted.

7.4.1 First iteration

Several versions were produced in the mockup for each of the main categories; each version had its advantages and disadvantages, it was difficult to decide which to use with the low-fidelity prototype. So the designers started to use Photoshop to simulate the different solutions made in the mockups. The Photoshop versions were considered as the high-fidelity prototype in this project. Compared to the low-fidelity prototype, the high-fidelity prototype referred more levels of details, enhanced the visual experience, and looked more realistic in interaction. After having designed with Photoshop, the designers found that the interface looked very different in Photoshop compared to the mockup tool, and the design was developed to adapt to the changes.

First the brand color for the application was chosen. Since green and red were used to represent increase and decrease in financial color code, the brand color should be different than these. Two versions of colors set had been tried out. One was the white background with iPhone typical blue, and using gold as highlight. The other version was having black background with dark cyan and gold for the text and highlights. The latter one had been

chosen, since black looked cool and professional and brought out the contents, it was a trendy color for iPhone application.

In quote view, the limited screen size of the iPhone required simplifying the information, only the most important information was chosen to be shown in quote view. Different ways of organizing information were tried. The information was organized according to the functions, and the relations. Co-located items belonged to the same group was more logic to users (Few, 2006). The most important information was notable and drew users' attentions by quick glance. The figure below shows the version the designer agreed upon at this stage. For industry movers, visualizations needed to show the overview information of sectors as well as sector details at the same time. Horizontal stacked bar charts which satisfied with these requirements was chosen.



Figure 25: PS-index quote view



Figure 26: PS-industry move (Stacked bar)

Chart design took a lot of time in this phase. Firstly, the designers decided to distribute charts spatially instead of using pages to stack the information in time. Thus users can locate themselves easier (Tufte, 2008). In the visualizations design, the background of the chart was deleted. Darker color was chosen for the chart frame line, which maximized the data-ratio-ink (Tufte, 1993). The pop-up windows for filtering in the mockup were deleted, since Cooper motioned to avoid pop-up windows in handheld device (Cooper, 2007). Using a slide out panel perform the setting function instead. Most of the controls were grouped on the top of the screen to reduce the eye and finger movement (Ahlberg, 1992). The user could touch on the legend to delete it. Multi-touch gestures were used in the interactive chart to achieve appropriate purpose.



Figure 27: PS-chart

In the portfolios overview, details of each portfolio as well as comparison between them were showed at the same time in the first iteration. The Line chart on the upper left showed the trends of them and the table in the lower half of the screen showed some detail

information of each portfolio. In portfolio view, a dashboard showed the overview information. When the user rotated the screen, the portfolio performance chart showed in full screen. Scatter plot and tree-map was used to show the stock and fund monitoring in portfolio.



Figure 28: PS-portfolio view

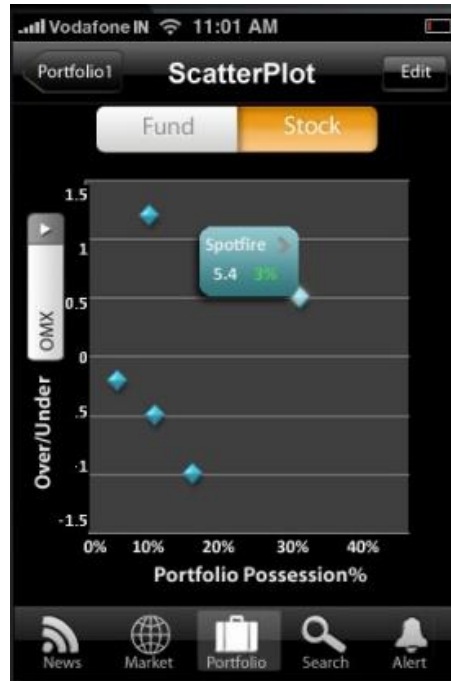


Figure 29: PS-Portfolio scatter plot

7.4.1.1 Evaluation

After the high-fidelity prototype, the self evaluation was conducted supported by iPhone Human Interaction Design Guidelines and Nielsen's Usability Heuristic. Some flaws conflicting with those design rules were identified. The controls in the design were not consistent in some parts. Too many colors were in one page sometimes. Portfolios management was disordered. The visualizations were not efficient enough and the interaction needed to be improved

7.4.2 Second iteration

In the second iteration, designers improved design based on the evaluation of first iteration. The standard controls and some view patterns in the application were defined; visualizations were improved. The branding color was changed to match with the Spotfire icon. The usability test was conducted at the end of this iteration.

Since the controls were varied in the first iteration, a standard controls library was established at the beginning of second iteration (see also Chapter6: Standard Controls & Designed Controls). iPhone standard controls were utilized as much as possible according to

the iPhone Human Interaction Design Guidelines, however, some controls were designed for this project especially when the standard controls provided couldn't match with application using context.

Since green and red are used for increase and decrease, different color represents different legends in chart, plus brand color gold and dark cyan, some pages were too colorful. Designers decided to use dark cyan only as brand color at first. Later, considering the consistency with Spotfire, Spotfire blue was chosen instead of dark cyan as brand color.

The quote dashboard for fund, stock and index had the same layout with some small differences. In this iteration, designers moved the mover button in index quote view to the navigation bar, making the three views exactly the same. The different buttons in the right of navigation bars allowed each of them to access different functions. For the industry mover, the drill down pie chart was used instead of a horizontal stacked bar chart, since the horizontal stacked bar chart did not contain the proportion information of each sector.



Figure 30: PS1-quote view



Figure 31: PS1-industry mover

In the chart design, designers focused on the interaction design in this iteration. The optional controls of chart showed on the top of the screen by the slide panel, however, triggered by tapping on the controls in chart in previous versions. The shortness of this was users need to move their finger and eyes to continue the configuration (from in the chart to

the top of screen), and the slide out panel covers the key information on the top. Therefore line button (see also in Chapter 6: Designed Controls) was designed instead, which showed when user taps on the chart. Moreover, gestures were defined clearly, following the theory listed in Chapter 3 “interaction with information visualization”.



Figure 32: PS1-fund chart

The portfolios management was disordered with too many hierarchies. Since simple is the best, everything that was unnecessary was deleted in the overview dashboard for the portfolio. Slide dots were used to navigate between the table and different visualizations. The visualizations were redesigned. Since color and size can be preattentive by the users effectively, different colors and size were used to represent different information. These attached features of patterns maximized the data-ratio-link. The users could also rotate the screen to change the orientation of the chart. In the horizontal view, the expandable panel was designed for the configuration, which was adapted to the context here.

Portfolio1

Name	Chg%	Shares
Apple Inc.	+28.1%	1232
TIBCO Inc.	+3.2%	232
Nokia	-12.3%	823
Apple Inc.	+28.1%	1232
TIBCO Inc.	+3.2%	232
Nokia	-12.3%	823
Total	+23.2%	- USD

Figure 33: PS1-portfolio table

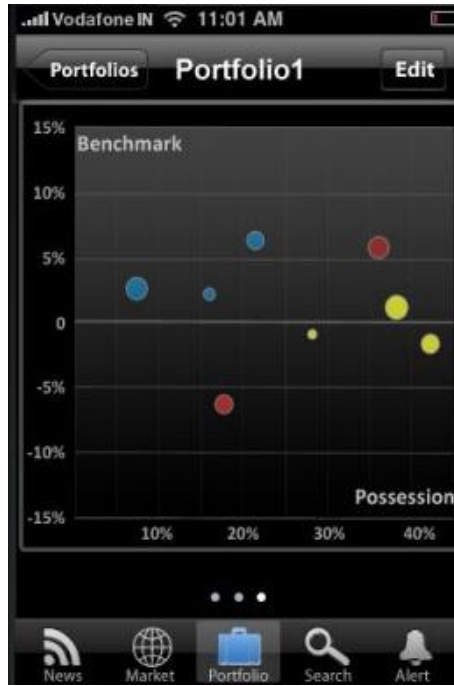


Figure 34: PS1-portfolio scatter plot



Figure 35: PS1- portfolio scatter plot (full screen)



Figure 36: PS1- portfolio scatter plot (full screen, expandable panel)

7.4.2.1 Flash

A flash version of the application was made for the usability test. The Flash application focused on the portfolio management and the chart, which were built with most visualizations and interaction. It was made since it demonstrated the work flow of the application and interaction better than the static pictures.

7.4.2.2 Usability test

User testing with real users is the most fundamental usability method for it provides direct information about how people use computers and what their exact problems are with the concrete interface being tested. (Nielsen, 1993) The user test was executed in the end of the 2nd iteration of the design process. The main purpose was to evaluate the interface of the hi-fi prototype from the user's viewpoint. During the user tests how users actually perform the tasks was studied by observing how their interaction with the prototypes, and the requirements elicited from the user test were collected.

7.4.2.2.1 Test users

Ten people volunteered to participate in the user tests, and they were the employees of Spotfire and from different positions (e.g. developer, designer, manager), with various background and skills. It was very difficult and not so realistic to ask the assets managers to come over to perform the user test, since they were very busy with their work. However the diversity of the participants for the user test was believed to represent the diverse characteristics of the target users.

7.4.2.2.2 Test plan

Before the usability test, a specific test plan was made, which includes: a list of pre-test interview questions that aimed at understanding the background of the users; a list of pre-defined tasks which users were supposed to perform by interacting with the prototype; and

a list of post-test interview questions to debrief the users' general impression of the prototype. Different tools (prototypes) were used in the test, the paper prototype was made from the Hi-fi prototype: some screens designed with Photoshop, and was then cut into pieces with real iPhone size for users to interact with while performing the test tasks; some screens were tailored and saved on an iPod touch to provide a realistic feeling for the users; a Flash application was used to demonstrate the interaction with the product, the usages of gestures, so that gave the users a better understanding of the design.

7.4.2.2.3 Pilot test

A pilot test was conducted before the actual user test. It was for trying out the test procedure first so that the plan can be adjusted or refined before the actual user test as well as some mistakes found in design can be changed. (Nielsen, 1993) A student who was also doing her thesis in the same company was invited to do the pilot test, although she couldn't really represent the target user, still, she contributed a lot for evaluating the test procedures as well as the interface design. For example, based on this pilot test some phrases in both interview questions and task instructions were refined in order to avoid misinterpretation and be more comprehensible for the test users, and some tasks were removed or marked as optional due to the time limit, some minor mistakes in the interface design that weren't noticed before were corrected immediately. In addition to some weakness of the test plan were revealed from the pilot test, the test instructor/ interviewer also had gained some experience and practice on how to steer the user tests, how to guide users to perform tasks and encourage them to "think-aloud" their thoughts and ideas.

7.4.2.2.4 Running the test

The user test was taken place in a quiet room of the company, one of the designers of this project was the test instructor for the test, besides the test user another girl was sitting non-disturbing aside and helping taking notes of what users have said. The paper prototype and the task list were arranged before the test users came (see figure below). Five screens represented what would be shown when each icon button on the tab bar was tabbed, and they were placed in consistent with the order of the icons. The reason for this is to simulate the accessibility of these five categories, enable users to navigate between different parts easily and feel being in control.



Figure 37: Usability test setups

When a user test started, some simple questions were asked about their experience of using the iPhone and financial investment on the stock market, then the instructor choose the tasks for the user according to the time availability, which can be from the user’s schedule or the time interval between two tests. Users were encouraged to express their thoughts or ideas using think-aloud technique while doing the tasks. The instructor was sitting besides the user, observing the user’s actions and listening to his/her comments, also prompted questions when some explanations from the user are needed, such as a reason for a certain action, further explanation for their comments, information confirmation, and so on. The “think-aloud” method was implemented following some principles suggested by Nilsen (1993), the experimenter did not give “yes” or “no” answers to tell or hint the test users what should they do or is it right to do, instead, asked what they expect to happen if they do so. No bias was shown when users criticized, instead, showing interests in what they said, so that users were encouraged to express their opinions freely without pressure. The instructor made notes of the critical parts that were overlooked by the designer but emerged when users acted unexpectedly or had difficulties in performing a task. The coaching method was adopted in some sense in the task test, because the paper prototype was not interactive some explanations of the interaction pattern were given to the users to provide them a better image of the product, especially to those who didn’t have iPhone use experience before and had little ideas about the iPhone standard controls. Some financial terminologies were also explained for those who had little knowledge about the stock market. After the tasks a post-test interview was given to the users to get their impressions about the design, depending on the time availability some interviews were conducted as a face-to-face interview and some were sent via email. Both ways of conducting the post-test interviews had advantages and disadvantages, the questions were better interpreted by users in face-

to-face interview and user answers could be easily understood as well, while more comments or suggestions were found from answers collected by emails for some users are reluctant to give comments face to face.

7.4.2.2.5 Test results

After the user testing, the answers from both pre-test and post-test interviews and the notes from user behavior observations were collected. All the information was used to analyze and conduct the results of the user tests, where the information was grouped into five main categories: errors, the design mistakes which were not noticed before and must be corrected; confusing part, the places users often found confusing or not so understandable; user attempts, the observations of what users attempted or expected to do while performing a certain task; good suggestions, reasonable suggestions prompted by users while they were interacting with the prototype. Each category was also marked in different colors for different parts of design, such as news, alert, portfolio, search, and quote view/chart, so that they would be easy to refer to for the revised design of each part later. [See Appendix 4: Usability Test]

By analyzing the summary of the user test results, some major common problems were picked out in the interface design, in which different subjects were covered, such as consistency, easy to use, flow of the system, understandability, etc. Based on these identified problems the according solutions were provided to meet user requirements on the revised version in the 3rd iteration of the design process.

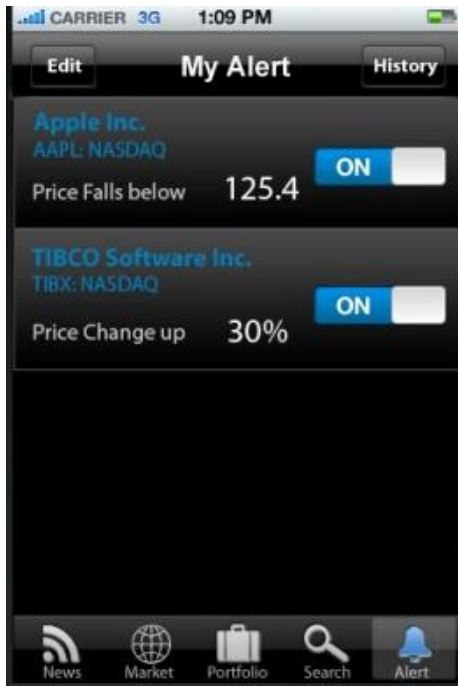


Figure 38: Alert page (version 2.0)

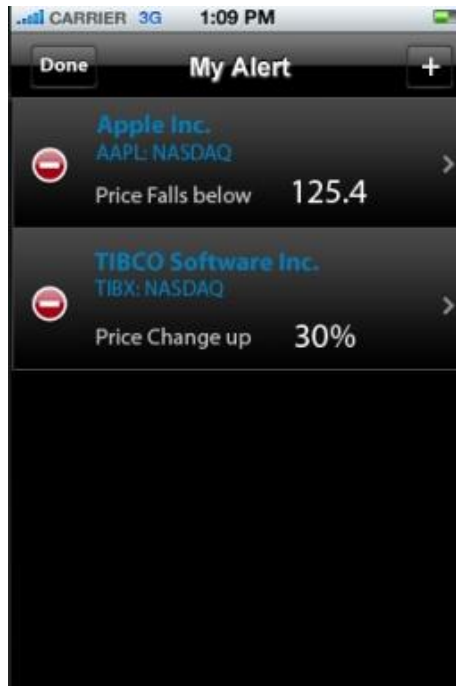


Figure 39: Alert edit page (version 2.0)

Add an alert: When users were asked to add alert, they always tried to find an “add” or “+” button first, it took them a while before they tap “Edit” button to look up “add” in the edit page.

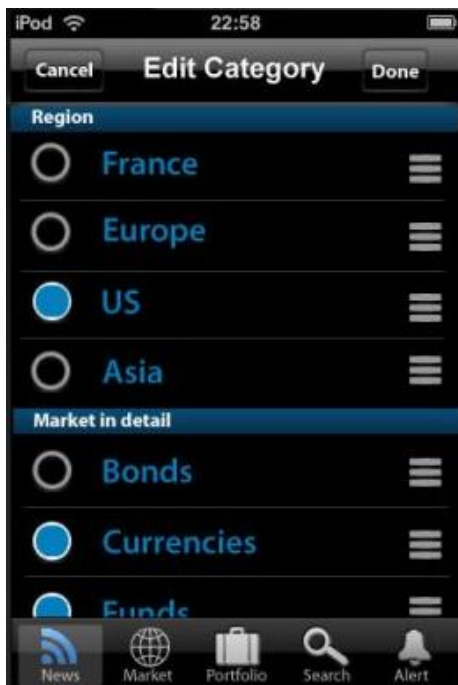


Figure 40: News category Edit page (Version 2.0)

Edit News category: The check buttons for choosing news categories were considered as mutual button by most users at first for their appearance related to radio button.



Figure 41: Fund quote view (Version 2.0)

Information in quote view: in stock quote view, users were confused by the left column and right column quote information, some of them said that because the right column was under that historical chart thumbnail, so they might assume its information were historical but not sure. In the case of fund quote view, when the users were asked to find fund portfolio, they expected to find it in the content of the page instead of tapping on a button in the top right corner to access the information, where the name “Portfolio” also confused them whether it meant fund portfolio or their own portfolio. When the users were asked to enable the interactive chart in full screen, most users chose to tap on the chart while some users with iPhone experience performed the rotate gesture immediately.



Figure 42: Stock chart (Version 2.0)

Stock performance chart: When the users were interacting with the charts, they were quite clueless in finding the way of changing chart types; however, once they learnt they just needed to tap on the chart, they could duplicate and apply the same gestures on similar tasks quickly, such as changing the technical indicator on the lower chart. To enable the chart line cursor to read values on a chart seemed less intuitive for users, many of them tried single tap on the plot line in the chart. Some users also declared that the delete sign on the legend felt like a stop sign or cancel button, and the usage of this sign seemed inconsistent with others.



Figure 43: Fund chart (Version 2.0)

Fund performance chart: In Fund chart, the “table” button which means fund return table was rather confusing for most users, some users even considered it as a back button to the table view.



Figure 44: Table view of fund portfolio (Version 2.0)

Table view: Many users assumed the little triangle on the column header as a sorting tool, instead of getting more columns of data, especially when they saw the numbers were placed in neither ascending nor descending order.



Figure 45: Tree-map (Version 2.0)

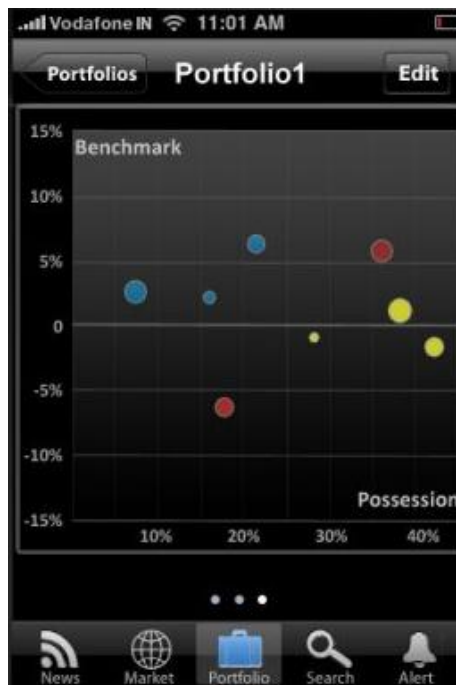


Figure 46: Scatter plot (Version 2.0)



Figure 47: Scatter plot-full screen (Version 2.0)

Portfolio visualization: When the first page of portfolio1 was presented to the users, none of them noticed the page dots easily, even for experienced iPhone users; and instead of rotating to interact with charts in horizontal view, they would rather try to interact directly when it was vertical, for the charts were already big enough for them.

Scatter plot: For the scatter plot chart in the interactive mode (see Figure 49), many users felt difficulties in finding the settings panel, and when asked to change the stock benchmark they attempted to tap on the text "Benchmark". Users were surprised that the interaction pattern here seemed quite different than the one in the stock/fund chart, which was confusing and needed more consistency.

Besides some problems or weakness of the system design were found from the users tests, some good ideas or suggestions were also reflected from the user tests, and some of them were found so interesting that they were even considered in the revised design in the later design process. [See Appendix 4: Usability Test]

The strengths of the system design were found out from the users' reaction when they learnt the interactions of the interface, as well as the positive comments given in the post-interview when being asked about their general impressions. Most users rated quite high on the theme of the prototype, around 4 or 5 (where 5 was the top), their general impression of the application were professional, informative, easy to use, powerful, accessible, etc. Many people thought the flow of the design was logical, and easy to follow, even for those who were not familiar with iPhone applications, they got the sense that the prototype invited them to explore. The feedback on information presentation were also quite positive, most users found the information was accessible and the presentation was clear, and many users expressed that they liked the way they could drill-down to details to view more information if needed. The tab bar had gained quite a lot of praise, although a large amount of

information was available to the users, they still felt in control that they could switch between different parts to accomplish different tasks.

7.4.3 Third iteration

In this process the revised design from the 2nd iteration, which was based on the interface evaluation in the user test, was refined. The goal was to increase the usability of the system by solving the problems identified in user tests and enhancing the strength of the design. The results of this iteration were considered as the final design version.

In this iteration, different possible solutions were discussed to meet the user requirements elicited from the previous iteration, and then several changes were made according to that, which includes adding the missing part, coordinating the inconsistent design patterns, removing unnecessary parts, making some changes in the information visualizations, etc.

Some major changes were done to the portfolio part. In the revised design the page dots were discarded, instead, the segmental buttons were placed on the top to switch between pages, the new design also allowed users to interact with the charts directly without enabling full screen to enter the interactive mode of the chart. Because the plot area in vertical view was limited, to save more space the tooltip was then designed on the same place as the tab bar, where users can read the key numbers without disturbing the perception of visualization by finger or tooltip coverage. The setting of the benchmark in the scatter plot was placed on the plot area on the x-axis, as a form of a button with text of the benchmark name, this design aimed to provide a more natural way of quick access (users only need to tap to change benchmark) to compare portfolios to different benchmarks. To make the visualizations in portfolio consistent with stock/fund chart, the sliding panel designed in the previous version was removed, and a settings button on the top right was used instead to access the settings, in a much less obtrusive way. Some new features were added in tree-map user settings, such as customizing the colors of the tree-map to their own preferences. This design was hinted by some user who said that the default green and red wasn't friendly for colorblind users, and the design turned out not only solving problems of the colorblind users but also offered all the users a certain degree of fun with the gesture interaction. Some missing interface designs were added to make the system more complete, such as an "edit portfolio" page where users can manage the securities of this portfolio, "edit portfolios" page where users manage all the portfolios, and the page for adding a security to portfolio from its quote view.

Finding the add button in an edit page was a main confusing part for the most users, as described in the test results, users were always looking for a quick way to add an item to the list instead of going through the complicated edit page. Therefore, in our revised design we

separated the add button from edit page, and both of them were placed on the top right on the navigation bar, and this was applied to different parts to provide system consistency to the users.

Some minor changes had also been made to increase the usability of the system according to the user requirements. A cross was used to delete a legend in stock/fund chart, and when the cross sign of a legend was enabled its according plots would be hidden, which provides users an option to preview the plot when the legend was deleted as well as a confirmation of delete, and another tap is needed to delete the legend totally. The fund return table view in fund chart was moved to its quote view, and for the fund quote view the fund portfolio button was placed in the content of the page, in line with performance button that provided the fund return table, in this case brought users a sense that the information behind the buttons were related to the contents. The “add to portfolio” button therefore was placed on the top right on the navigation bar in all quote views. The information given on the quote view was with clearer definition that differentiated historical information and real-time information. The pie chart used for fund was also redesigned, so that it looked like a static pie chart but was still consistent with drill-down pie chart fashion. The numbers in the table view were placed with descending order which represented they were sorted automatically, and minimized the chance of misinterpreting the triangle button in the column header as a sorting tool. The plots of stock chart and fund chart were replaced with simulated data, which brought a more professional feeling to the application.

Some user had prompted a good question during the user test: “why did I get to the page that says ‘screener’ when I tap on ‘Search’ on tab bar”. For many test users, according to their experiences the first thought of a search function was the text search, therefore the text search was used as the default page for search, and when the page was flipped over they would see the screener page, where they can query the database with selected criteria.

After the changes were made based on the user test results, heuristics and general guidelines were used to evaluate the interface design as well as a walkthrough. The output of this iteration was then considered as the final version of the project design.

6 Result

The chapter describes the result of the project. The style and structure of the application are presented as well as the design patterns. Data visualization management is introduced along with the theory used by. Innovation of interaction design is explained with interaction gestures.

6.1 Application

Two aspects were considered in the application design of this project, the style of the application and the information structure in turns of application functions. Defining the style of an application is very important, for a good style is an icon of the application that makes itself recognizable and memorable to the users, and a good information structure enable users to access their desired information. All these aspects are directly related to the user experience.

6.1.1 Style

There are three application styles defined by the iPhone Guidelines (iPhone Human Interface Guidelines): productivity application, utility application, immersive application. Based on its requirements on visual and behavior characteristics, data model and user experience, the project was designed using both the Productivity and immersive application styles.

It is considered as a productivity application in general, because it keeps the user being focused on the information and the task, quickly finding what they need and completing the task. The data are organized hierarchically, which requires the user to drill down through successive levels of detail until the desired level is reached. Overall, it works as a tool to help users to do the routine check-ups, to keep their eyes on the updates of the stock market.

However, it also offers different interactive charts, where users can manipulate the visualized information. So in this mode, the application was designed with the immersive style: full-screen, no large amount of text-based info, and focus on visual contents and user experience. Non-standard controls and custom navigational methods were used to let users discover themselves would be part of user experience.

Therefore, a combination of both the productivity style and immersive style makes the product its own style. When it works as productivity application, the goal is to keep users focused on completing tasks, so there are no fancy colors or animations to disturb users performing the task; when the chart is in the interactive mode, the application is considered as working with immersive style, where more visualization and gestures design are engaged.

According to the usability of the product and requirements from the customers, the product was supposed to bring users a professional feeling. Therefore, black was chosen as the background color, comparing to earlier trials with white background, this color brings out the graphical interface better and makes the application appear professional and trendy as well. The other main color is blue, which was picked up from the “TIBCO” logo, in a way consistent with the company’s icon, as well as bringing calm to the user as they are using the application.

6.1.2 Information Structure

The information of application interface was designed according to the task analysis results, where users’ needs and requirements were the focus. The information consists of five main parts: “News”, “Market”, “Portfolio”, “Search”, and “Alert”. (See Figure 48)

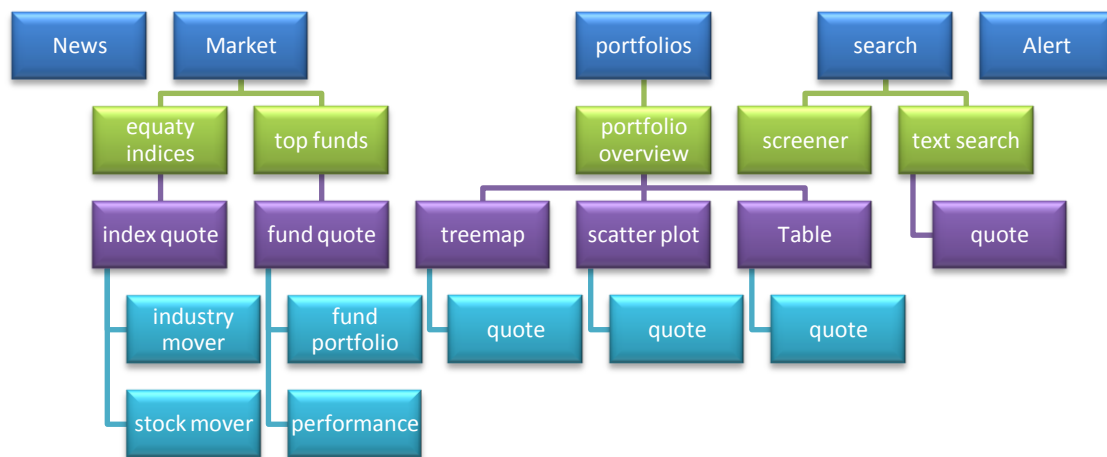


Figure 48: Information structure

One of the principles for designing the information structure of the application is that the sub levels for each part should be limited; in the case of this project no more than 3 sub levels. The limited sub-levels design helps the users with different spatial abilities to create mental maps and explore levels of information details without losing control.

The icon buttons to access the five different parts are placed on the tab bar, which stays at the bottom and are visible to the users all the time. Users can access to any part to perform their tasks, since the categorization of the information was task-oriented, the users only need to stay in one part to accomplish the task. However, they can switch to other tasks anytime without having finished the current one, and if they come back to the previous task the page will be still there. A scenario for this could be a user finds some interesting stock

while reading a piece of news and wants to look it up, then he/she jumps to the Search page to get more information about this stock, after that goes back to continue reading the rest of the story in the News page.

6.1.2.1 News

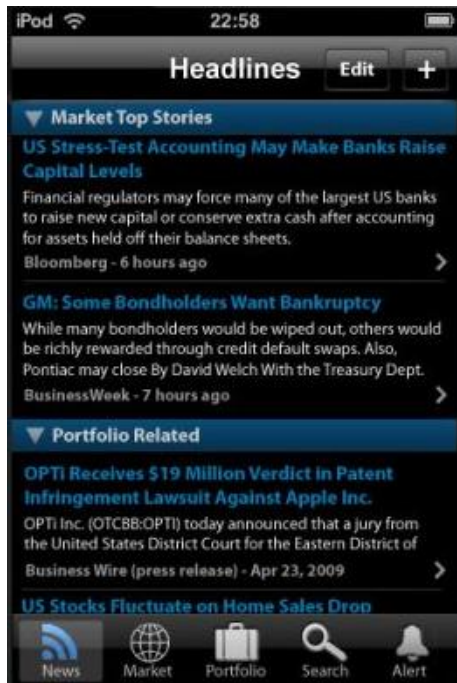


Figure 49: News headlines page

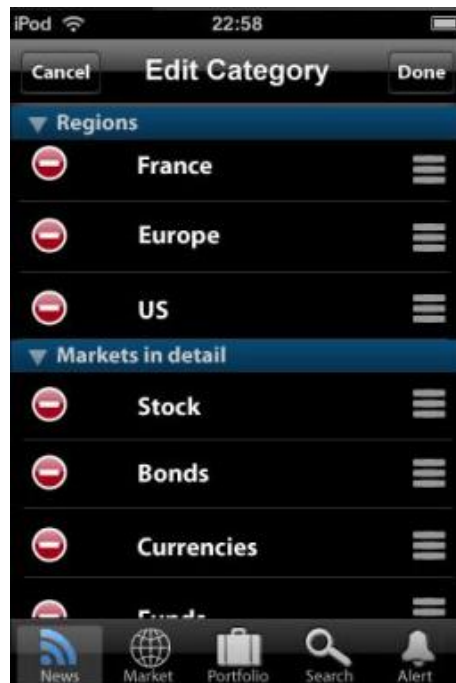


Figure 50: News category edit page

This is the place where updating news are offered (See Figure 49). By default, the headlines are grouped into two categories: market top stories and portfolio related. “Market top stories” contains the stories from the market of a default region (e.g. Europe), and “portfolio related” contains the news of the companies whose stock the user had invested in their portfolio. Users can change the range of the information according to their preferences, such as by the region of interests or type of the security. (See Figure 50)



Figure 51: News story page



Figure 52: Forward News

By tapping the headlines, users can read the full news story (see Figure 51), and forward it to others by mail, SMS, or Bluetooth (see Figure 52).

6.1.2.2 Market

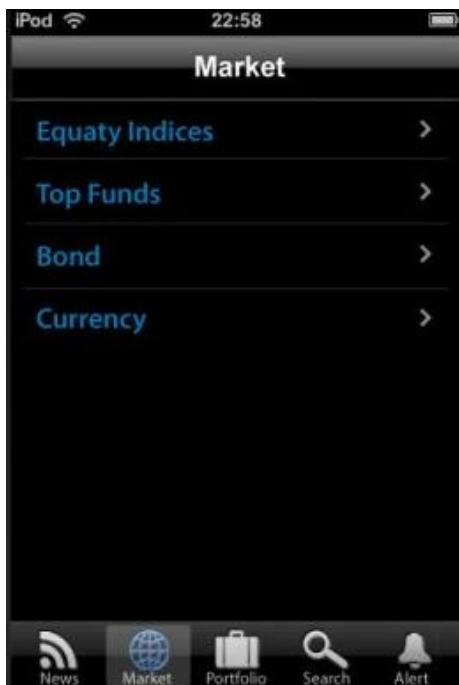


Figure 53: Market page

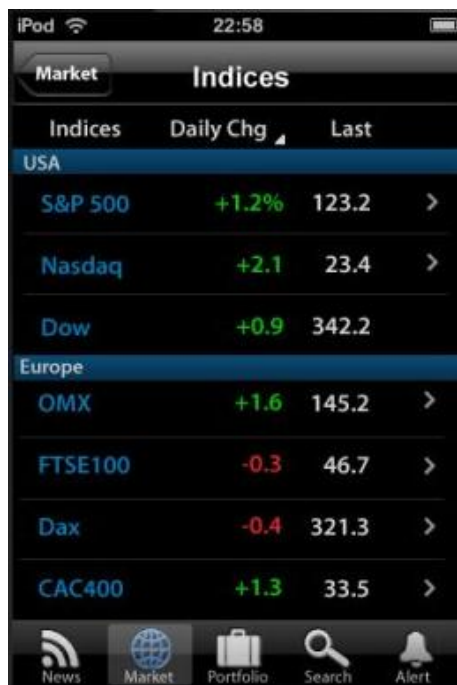


Figure 54: Market indices page

The information in Market is split into four parts: Equity Indices, top funds, bond, currency. (See Figure 53) From the previous phone interview with the person in the field, they are the four pillars in the market, and are essential for the assets managers to learn about the market, however for this project the design was focus on stock and fund.

The prices and changes of different indices are shown on the indices page. (See Figure 54) They are grouped by region, such as USA, Europe, to provide a better comparison and enable users to focus on their own investment area. By hitting the column header with the triangle on bottom right, the current column can be replaced with another column of information. Two colors are used to represent raise or fall, as well as “+” “-” sign.



Figure 55: Market top fund page



Figure 56: Change return period

Top fund provides a ranking list by their return values (see Figure 55), unlike indices which are grouped by regions they are grouped by major security types of the fund portfolio. And within each security type the funds are placed in descending order with the return values. The period for the return values can be chosen by the users, by tapping on the button on the top right with the text of selected period (see Figure 56).

6.1.2.3 Portfolio

Portfolio is the most important part out of the five parts, lots of work and efforts had been made to carry out a useful portfolio that integrated with the power of information visualization as well as great navigation methods and gestures design. It is supposed to be

innovative and stand out from its competitors, as well as to be consistent with Spotfire's interaction style somehow.



Figure 57: Portfolio Page

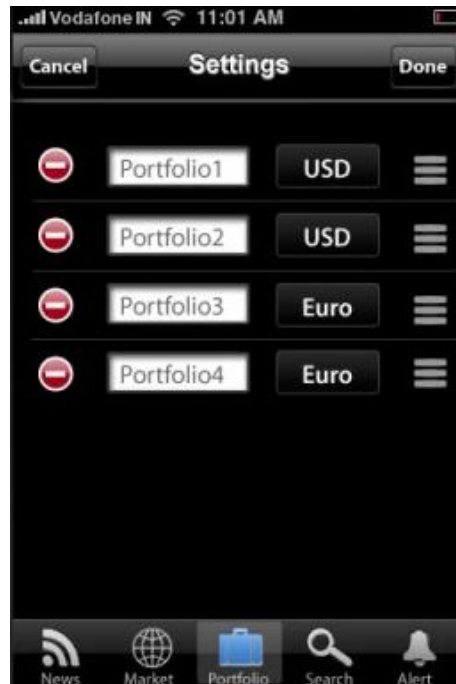


Figure 58: Portfolio settings page

On the first page of the portfolio, a table of all the portfolios (see Figure 57) created by the user is shown. Here users can have an overview of performance of all the portfolios, such as total daily change and return values. The portfolios are grouped by the currencies, but the user can still view the total values of all the portfolios calculated in a same custom currency. By tapping on the “edit” button on the top right, users can add, remove portfolios or change portfolio names and their currency as well as the list order in the edit page. (See Figure 58)

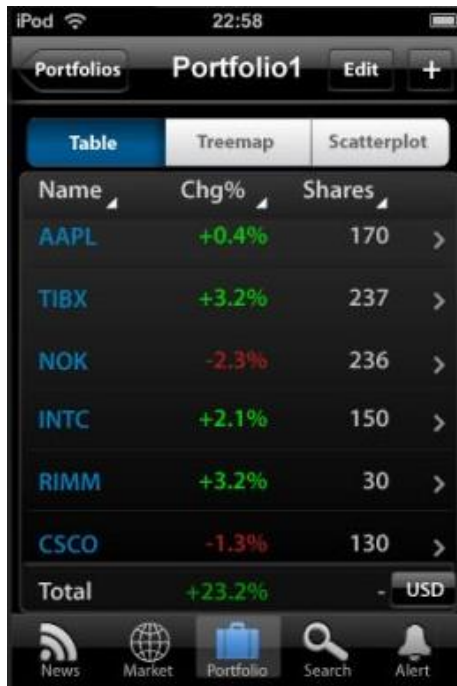


Figure 59: Portfolio table page

When users go to a certain portfolio, the developments of the securities of this portfolio are represented in three different forms: Table view (see Figure 59), tree-map (see Figure 60), and scatter plot (see Figure 61). The segmented buttons placed on top of the page is to enable users to switch between the views. The table view is a static form with numeric information such as change, shares to represent each security's performance, while the tree-map and the scatter plot are interactive information visualization, where users can manipulate the data and easily see the trends, relationships, outliers, patterns etc.



Figure 60: Portfolio tree-map page

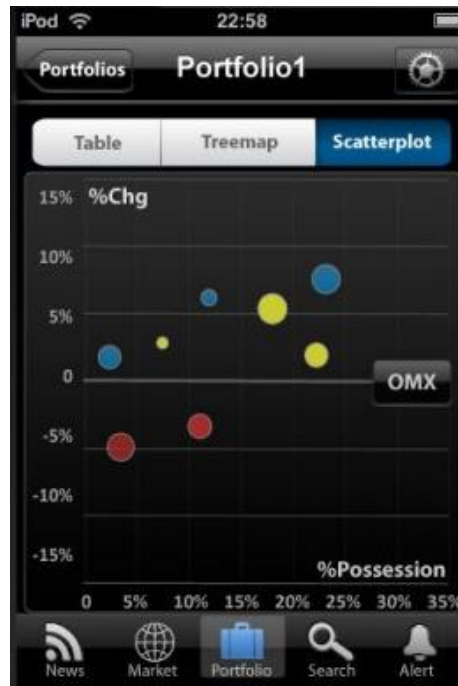


Figure 61: Portfolio scatter plot page

The Tree-map enables users to monitor the overall performance of the portfolio. (See Figure 60) By default, the securities in the portfolio are categorized by types first (e.g. stock, fund), and then by industry sectors for the 2nd sub-level; the size of each square represents the holdings of the stock, and the color shows whether the price is raising or falling. Therefore, users can tell the overall performance easily by looking at the areas of different colors, they can also drill-down to view information in further level, or view prices of a stock by tapping on its area, if they want to drill-down even more they can tap on the tooltip with prices to go to the stocks' quote view. Customization options are also provided for the users who want to set their own preferences for different purposes.

The Scatter plot enables users to compare portfolio performance to different benchmarks (e.g. OMX, NASDAQ, DOW, etc). (See Figure 61) Each spot stands for a certain security, different characteristics can be used to categorize the securities, such as sectors, prices, holdings, and so on, so that helps users to find the inner patterns and see the relationship between the stocks and indices and evaluate the performance. Similarly to the tree-map visualization, when users tap on a spot, the corresponding stock's price information can also be seen on the tooltip where the user can access the quote view as well. Depending on users' purpose different periods can also be set for the performance comparison.

6.1.2.4 Search

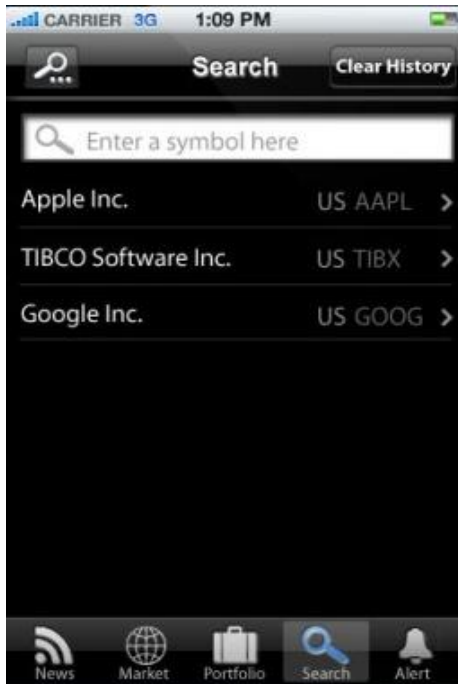


Figure 62: Text search page



Figure 63: Screener search page

Two different kinds of search are provided to the users in the search page: text search (see Figure 62) and screener (see Figure 63). Users can choose any of them by flipping the page. The text search is used when users remember the name or the ticker of the stock, according to the name users typed in the text box a hint list with many suggestions will be shown below, so that even the users cannot remember exactly the name or ticker they are still able to find it. The screener is more like a concept search or filter, where users set a set of different criteria and tries to find the stocks or funds that meet these criteria.

6.1.2.5 Alert

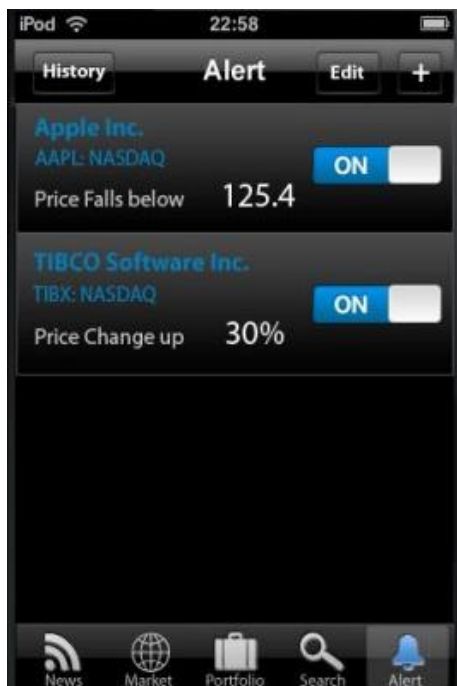


Figure 64: Alert page

Taking advantage of the fact that the mobile phone is with the users most of the time, designing the alert function seems rather essential. The first page of the alert function (see Figure 64) was designed to be consistent to the alarm function in the iPhone clock application, and shows the alerts that have been set previously can switch ON and OFF.

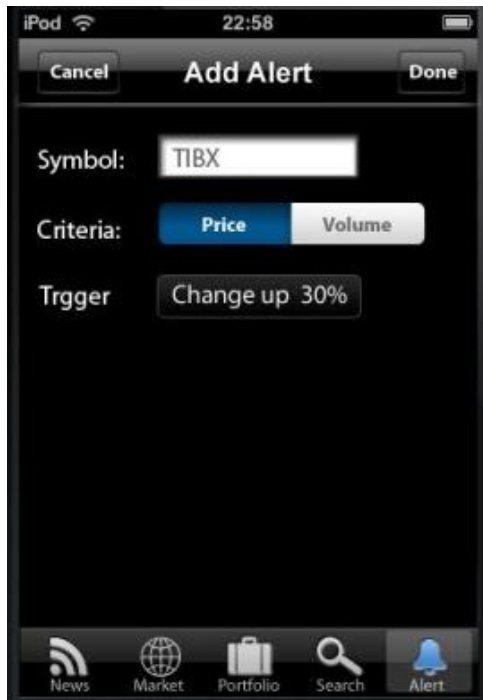


Figure 65: Add Alert page

In the "add alert" page (see Figure 65), users can type the stock name and set alert with one of the two criteria: price and volume for the stock. In the edit page, users can remove the alert. There are cases that users miss the alert for some reasons, so the "history" provides a review of the alerts that have been triggered.

6.1.2.6 Quote view



Figure 66: Stock quote view

Quote view page is the fundamental page for each stock (see Figure 66), fund, and indices, which can be accessed from the market, search, and portfolio pages. It provides quotes and important related information. From here users can read key statistics to this security or indices, related news and information about the company. The last price and changes are shown in big size to stand out of the page, so that users can catch it immediately when they open the page. Since the key statistics are updating, the update time is placed on the top left of the page, so that users can see how fresh the information is. On the right to the last price there is the thumbnail of the performance chart, which is also an icon to access the interactive chart. By tapping on the top right button on the navigation bar users can add this stock to the portfolio: a page for adding security to a certain portfolio will slide up, and users can choose which portfolio to add to, the type of transaction, and set the purchase price and shares.

The quote view pages are all sharing the same style and similar layout, regardless of it is for stock, fund or indices. However, because of the different characteristics between Indices quote view and fund quote view, different information is presented.



Figure 67: Indices quote view

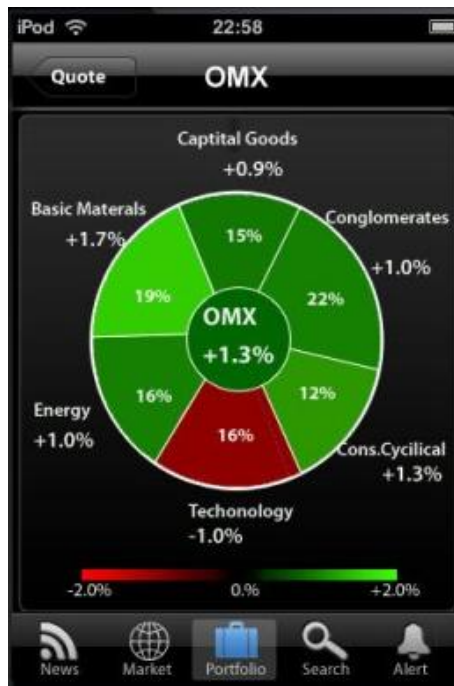


Figure 68: Industry mover page

In the indices quote view (see Figure 67) there is “stock mover” which provides users a table list of the leading stocks and lagging stocks, and the “industry mover” (see Figure 68) presents an interactive pie chart to the users to view the performance by industry, users can tap on the sector to drill-down to get more detailed information within the sector.



Figure 69: Fund quote view

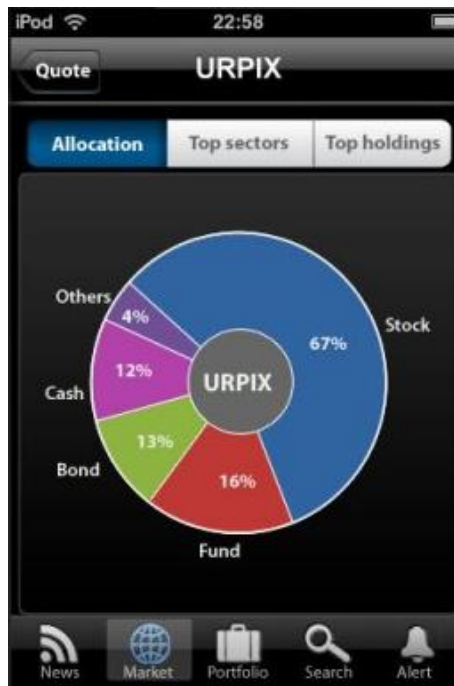


Figure 70: Fund portfolio page

In the fund quote view (see Figure 69) there is “Fund portfolio” (see Figure 70) which provides information such as the allocation, top sectors, and top holdings of this fund. In the allocation view users can see the type allocation of this fund, in “Top sector” users can see the sector distribution of this fund, both of them are represented in a form of a static pie chart. The holdings, on the other hand, are the company names of the securities according to the allocation. The “Performance” provides a table of return values for different periods of this fund.

6.1.2.7 Chart

This is one of the most important parts in the project, for information visualization has always been the design focus and how to provide users an easy way to perceive rich information and the direct manipulations of data should be addressed. The design of the stock chart or fund chart was inspired from the competitive analysis, and some essential features from the Spotfire web player were immersed into the design.



Figure 71: Stock Chart

The stock chart (see Figure 71) is enabled from the quote view of a stock. There are two main charts making up the stock chart: price performance chart and technical indicator. By default, the current prices are listed above the chart; however, users can read values on a specific day by activating the cursor on the price performance as well. The price performance chart can be chosen to be presented in four typical forms: candlestick, line, mountain or OHLC. The period of the performance can also be selected in different fixed time periods. Different multi-touch gestures were used for users to have direct manipulation with data, for example, users can pinch-in to zoom in a certain area and panning the chart in order to view the plot pattern in details or pinch out to zoom out to have an overview of the performance in a longer period. The technical indicator chart provides different technical indicators, such as volume, RSI, P/E, etc. They are the visualized calculations for users to analyze the performance. The stock chart also allows users to compare this stock to two other stocks or indices, simply type the name or ticker in the text box, then the hints shows like in the search page, once the user successfully adds one comparison, a legend will be shown right above the chart, with the ticker and comparison percentage on the legend button. In this case, the comparison mode, the last price of the stock being compared is changed to comparison percentage as well, so that users can see the differences between two stocks easily and in a more reasonable way. There are two purposes by single tapping on the legend button: to confirm the delete of the legend, in case of tap on it by mistake; to hide the plot of this legend temporary, so that if there are three stocks users can compare only two of them without being disturbed by the third one. A special case in comparison mode is that when the user activates the chart cursor the prices according to the stock will be shown on the top bar instead of the place that is occupied by legends, and the text box for adding a stock will be hidden then. But since this is in a temporary mode it does not bring the user the sense of inconsistency. The reason to design in this way is because of the visual

perception, when the legends are close to the chart, users feel it's easier to refer and associate them to the chart.



Figure 72: Fund chart

Fund chart (see Figure 72) is basically the same as stock chart, but a risk chart is used here instead of Technical indicators, this is learnt from the Spotfire customized web player. This risk chart is the visualized version of a risk table that can be found in many financial web applications, which offers users full period risk estimations in different calculations.

6.2 Standard Controls

In iPhone OS, UIKit provides the default appearance of views and controls. iPhone users are familiar with the look and behavior of standard view and controls. Their previous experience helps them to recognize and make use of them. If iPhone OS changes the looks and behavior of standard views and controls, these standard controls in applications continue to work and will be up to date with the new standard. Due to these reasons, Apple recommends developers to use the standard user interface element as much as possible. (iPhone Human Interface Guidelines, 2009)

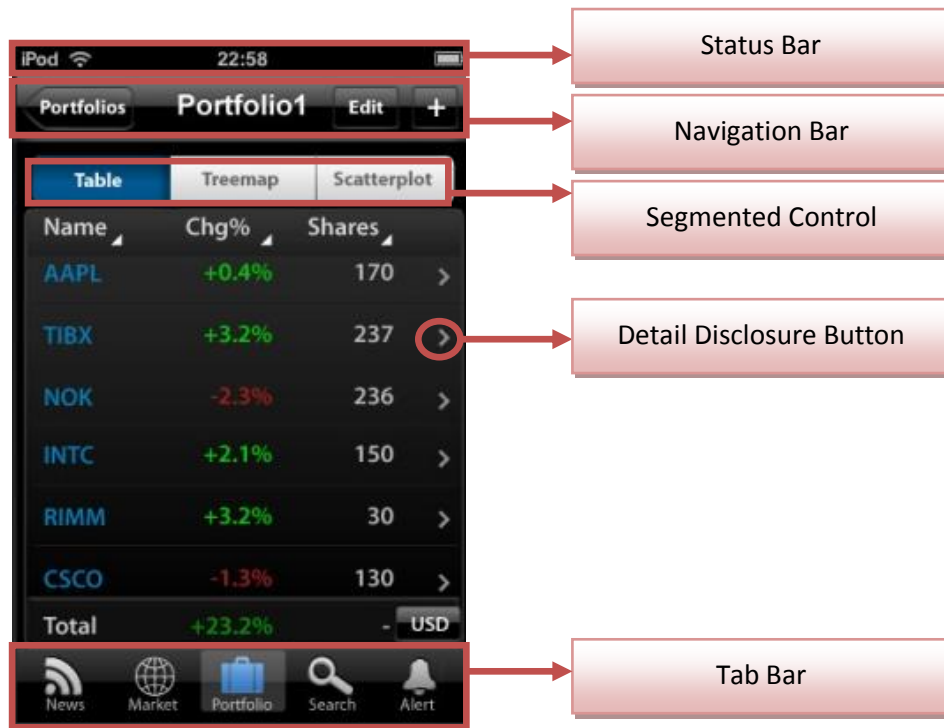


Figure 73: iPhone Standard Controls-Status Bar, Navigation Bar, Segment Control, Tab Bar

6.2.1 Status bar

The status bar (see Figure 73) shows important information about the device; including cell signal strength, the current network connection, and the battery charge (iPhone Human Interface Guidelines, 2009). It always shows on the top of vertical screens, and hides in the immersive application style, like the horizontal screens of charts. In the standard there are three colors available, gray, opaque black, and translucent black. The opaque black is chosen, since it consistent with the theme of the application.

6.2.2 Navigation bar

The navigation bars display the current view and contains controls that act on the view's contents, in addition to navigational controls when appropriate (iPhone Human Interface Guidelines, 2009). In the designs of this thesis, all the pages have a navigation bar. For the vertical screen (see Figure 72), it appears at the top of the application screen, just below the status bar. Most vertical views have the same display of the navigation bar. The title of the current view shows in the middle of the navigation bar. The back button appears on the left with the text of previous page's title. It is very important because it always gives users options to reverse steps. The management buttons are on the right (like add, edit, setting, etc). The navigation bar in the edit view is an exception, which has "Cancel" and "Done" button on the left and right. For the horizontal view (see Figure 74), the navigation bar is also on the top of the screen. The title is displayed on the left and other controls for the current view are shown after the title, for example in the chart. The project chooses the

black color with bordered style (standard style) for the navigation bar as well as all the controls on it.



Figure 74: Navigation bar (Horizontal)

6.2.3 Tab bar

The tab bar (see Figure 73) provides different subtasks related to the overall function of the application, it appears at the bottom edge of the screen (iPhone Human Interface Guidelines, 2009). This project uses tab bars as the menu of the application, which the user can access from any pages on the vertical screen, meaning the user can switch the function at any time. It is hidden in the horizontal screen. There are five buttons on the tab bar, representing the five functions of the application, which are news, market, portfolio, search alert. The design of the icons on the button is the same as default: image on the top, and text below the image. Since the suitable icons couldn't be found in "standard icons of tab bar tabs", the icons are designed especially for this application.

6.2.4 Segmented controls

A segmented control (see Figure 73) is a linear set of segments, each of which is functions as a button that can display a different view. When users tap a segment in a segmented control, an instantaneous action or visible result should occur. The height of segmented controls is fixed; and the length of segmented controls can be customized. Be aware of that users must be able to comfortably tap a segment without worrying about tapping a neighboring segment, the maximum number of segment is five. Each segment can contain image or text, but not both, and mixing text and image in a single segmented control should be avoided. (iPhone Human Interface Guidelines, 2009) This project uses the segmented control for different views of portfolio, the fund portfolio and settings. Blue and white are used for the segment, blue segment means being selected, while the white segment means unselected.

6.2.5 Action Sheet

An action sheet (see Figure 75) displays a collection of alternatives that are associated with a task users initiate by tapping a button in an application. It gives users additional choices related to the action they are currently taking by a few buttons, and the "Cancel" button is available for the user to dismiss this task. It emerges from the bottom of the application screen and hovers over its views (iPhone Human Interface Guidelines, 2009). This project uses the action sheet for sending news (sharing news with others).



Figure 75: Action sheet, give user options of sending ways or cancel the task

6.2.6 Picker

A Picker (see Figure 76) can be used to display any set of values, especially for well-known sets like months, weekday, etc. Each wheel of the picker can stock one kind of data; there can be up to 4 wheels in a picker. Users spin wheel (wheels) until the desired value appears. There is a control bar on the top of the picker, which contains buttons like “Cancel”, “Done”, etc; it provides options to execute or cancel the task. The size of the picker is fixed; it is the same as the keyboard. It can't have the label as header like time, hours, it has the unit close to the value instead, like 10 minutes, 2 hours, etc. (iPhone Human Interface Guidelines, 2009). The picker can be always shown or appears when needed, in this project, the latter way is chosen. It is triggered by the wheel picker button only (see Design controls: wheel picker button). When tapping on the button, the picker shows, and the outline of the button changed to be blue to indicate the selection.

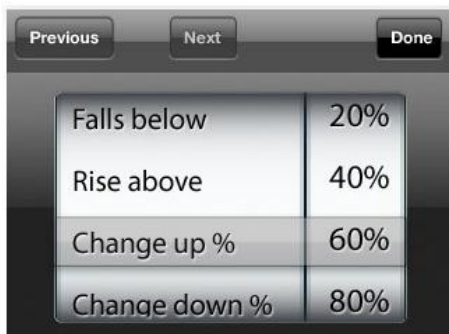


Figure 76: Picker with the control bar

6.2.7 Detail disclosure button

A detail disclosure button (see Figure 73) reveals additional or more detailed information about something (iPhone Human Interface Guidelines, 2009). In this project it is used in many places, like in the table view, tooltips, etc. It help user to access more detail content of the item.

6.2.8 Switch controls

A switch control (See Figure 77) presents to the user two mutually exclusive choices or states. It is only used to show only one of two possible choices at a time, users slide the control to reveal the selected choice and hide the other one (iPhone Human Interface Guidelines, 2009). This project has on and off switch controls in the alert view.

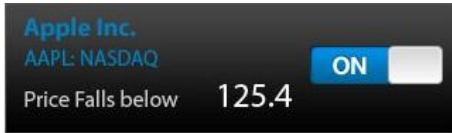


Figure 77: Switch at “on” state

6.2.9 Delete control button

Users tap this delete control button to reveal (see Figure 79) and hide (see Figure 78) the Delete button for each list item. To give additional feed back to users the horizontal minus symbol inside this button becomes vertical when users tap it to reveal the Delete button (iPhone Human Interface Guidelines, 2009). It was used in the table view and edit view in this project.



Figure 78: Delete control button (delete button hide)



Figure 79: Delete control button (delete button reveal)

6.3 Designed controls

The standard controls of iPhone are used in this project as much as possible according to the iPhone Human Interaction Guidelines. However when they don't meet the needs of the application, some other controls is designed. There are two groups of designed controls in this project, one is standard designed controls, and the other is controls for horizontal visualization of data (Chart).

6.3.1 Standard designed controls

Standard designed controls are designed in this project, they are used everywhere in the application. They include wheel picker trigger control, expandable panel, dropdown bar, table header selectors, tooltips, color palette, etc.

6.3.2 Wheel picker trigger control

This is a button used to trigger the wheel picker, which looks like a normal button with white outline (see Figure 80). The picker wheel shows when users tap on it, and the outline of trigger button changes to blue as highlight (see Figure 81).

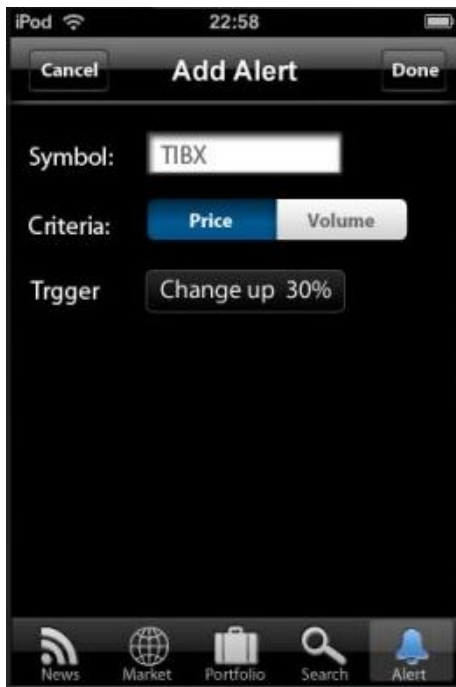


Figure 80: wheel picker trigger control



Figure 81: wheel picker trigger control

6.3.3 Expandable panel

The expandable panel is a panel that can be expanded to show more information when needed. Users want to browse items as much as possible in one page, however too much information cluttered may confuse users. The expandable panel is used in this situation. The most important information shows in the folded mode (default mode, see Figure 81). If more information is needed, users can tap on the arrow to get the full view by expanding the panel. This is used in the edit portfolio view. On the default panel view (folded mode), only ticker, delete button, and date appear; buy or sale status, shares, and price is shown on the expanded panel (See Figure 83).

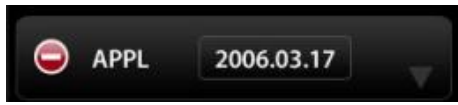


Figure 82: Expandable panel in folded mode



Figure 83: Expandable panel in unfolded mode

6.3.4 Dropdown bar

Users tap this element to reveal or hide the list of items below it. The arrow on the left of the bar indicates the status of the list. It points towards to the right when the items are hidden and it points downward when items appear. It used in some of the tables views in this project. (See Figure 84)



Figure 84: Dropdown bar in folded and expanded

6.3.5 Table header selector

iPhone has limited size of screen. In the table view of vertical screen, usually, only three columns can be shown. So the table header selector is used when there are more columns of information needed. It is designed as a white triangle at the right bottom corner of the header of column. The column of information changes when user taps on the table header selector. (see Figure 85)

Name ▾	Chg% ▾	Shares ▾
AAPL	+0.4%	170 >
TIBX	+3.2%	237 >

Figure 85: Table header selector

6.3.6 Tooltip for vertical visualization of data (Tree-map & Scatter plot)

Tooltips (see Figure 86) provides the detailed information of a selected item. If the user taps on one item, the tooltip panel slides up from the bottom of the screen with the detailed information about the selected item. The tooltip panel covers the tab bar, and is bigger than the tab bar to draw more attention from the users. The exit button and detail disclosure button appear on it to provide more options. In this project, tooltips are used in the Tree-map and the Scatter plot of the portfolios.

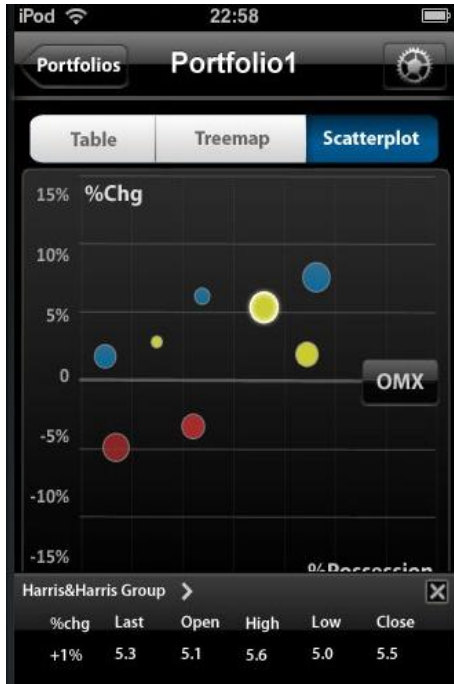


Figure 86: tooltips in scatter plot, the bright outline point is selected

6.3.6.1 Color palette for color bar setting

This circle color palette (see Figure 87) is designed to enhance the user experience and make the application more user friendly for the color-blind. Taking advantage of direct manipulation, users can spin the palette to get the desired color. This is used in tree-map settings for the user to change the color theme of the tree-map according to their preferences. It appears when the user taps on the color drop box beside the color bar. The color pointed by the triangle arrow represents the left most color in the color bar.



Figure 87: Color palette in Tree-map settings.

6.3.7 Controls for horizontal visualization of data (Chart)

The stock/fund chart is the only case to use the immersive application style in this design. The controls designed for charts are different from other designed controls.

6.3.8 Cursor

The cursor is a moving line with points to indicate the cross point on lines. It appears after the users touch and hold the finger on the screen for a while on the chart. The cursor keeps a slight distance from the touch point, avoiding being covered by users' fingers. More information of the points is shown besides the cursor or on the navigation bar. Considering most people are right-handed, the cursor and the information is designed to appear on the left of the touch point when it is activated. (see Figure 88)



Figure 88: cursor in chart

6.3.8.1 Legend button

In the chart, a legend button represents the added quote. The information on a legend button includes the color code, ticker and the change percentage in default view (see Figure 89). After the cursor is activated, the percentage value changes according to the cursor's position. When the user taps the button, an exit icon appears (see Figure 90). In this case the corresponding quote line in the chart would disappear. When the user taps on the button again, the legend would be deleted. To cancel this task, touch anywhere else than the delete icon on the screen, or it would be canceled automatically if the user waits for a while. This design allows users to hide and reveal the quote line. The legend button is used in the stock chart and fund chart in this project.



Figure 89: Legend button (default)



Figure 90: Legend button, tapping on it to reveal the delete icon

6.3.8.2 Line button

Line button is a set of buttons placed in a line, each of the buttons represents an option for the chart. The options could be changed to different form of visualizations, like mountain chart, line chart, etc; or chart resulted from different calculations, like volume chart, RSI chart, etc. The line button appears after a single tap on the plot area in the chart. (See Figure 91)



Figure 91: Line button in stock price chart, type of “Line” is selected

6.3.8.3 Expandable button

Expandable button is a single button in default mode (see Figure 92), and expands to be a line of buttons when the user taps on the single button (see Figure 93). This project used the expandable button for representing different time frames.



Figure 92: Expandable button in default



Figure 93: Expandable button in stock chart, "5D" (5 days) is selected

6.4 Interaction gesture design

Most gestures used in the design consist of the standard gestures, because “it’s important to avoid defining new gestures, especially if these gestures perform actions users already associate with the standard gestures.” (iPhone human Interface guidelines: support gestures appropriately)

The Most common gestures used in the design are: tap and drag. Thus, users would find the application is a coverable and easy to use, besides, the application would be used frequently as a tool for quick check-ups, and too complicated gestures would confuse the users and affect the flow of the design.

The only exception is for the charts, which were designed with the immersive style, in which custom gestures can be appropriate. Because this provides an environment for users to manipulate the information visualizations, it invites them to explore and get their desired information.

New gestures (usage) designed in the project are:

- *Pinch open*: this is used for information visualization charts, to enable users to read more details on the chart or easier to tap on the target.
- *Pinch close*: return to normal size or see bigger overview.
- *Drag*: for the tables, users can scroll to read more rows; for the chart, users can move the chart to view hidden information.
- *Touch and hold*: this is used on stock/fund chart, when the user keeps a finger on a chart for a while, the time marker (cursor) shows. The reason to use touch and hold to activate the marker is because that the marker follows the finger as it moves on the chart, and disappears as the finger moves off the screen. And it would not show

if the user would simply just zoom in/out or move the chart. It is quite similar to enable the text cursor with the same gesture.

- *Rotate*: rotate (90 degrees) is use to enable the chart in the quote view, as the chart is lied horizontally, it avoids showing the chart in the wrong direction, that user still has to rotate again to view the chart.

6.5 Information visualization design

The design of Information visualization is very important in the application; it makes this application stand out from other iPhone financial applications. The visualization design in this application uses the information as the interface rather than computer debris. It also associates the correct interaction affordance, which interprets the interface to users. In addition, the workflow of the visualization is natural, and the same patterns are used as much as possible. There are four kinds of visualizations in this application totally; they are chart, tree-map (drill down), pie chart/drill down pie chart, and scatter plot.

6.5.1 Quote chart (Stock/ fund chart)

The only immersive application style used in this project is for the quote chart. Different visualization visualizations are used in this part. The function of this page is to monitor stock or fund performance. The layout of quote chart can be split into three parts. The top area is the controls panel with information displays. The middle part, occupying the biggest area is the performance chart of the stock or fund. And the bottom of the screen is the technical indicator chart for stock, or risk chart for fund. (see Figure 93)



Figure 94: quote chart

The top part shows the open, high low, close (OHLC) information of the stock as well as the time information was updated. It shows the latest information by default. The historical OHLC numeric information shows when the cursor in the visualization area is activated (see next paragraph). The text area allows users to add a new quote by entering ticker names and

pressing “add” button to execute. The auto-complete function is associated with the text area. Legend buttons represent the added quote appearing above the plot area. After the legend buttons appear and the OHLC information of default quote hides. The OHLC information will appear when the cursor is activated; it covers the quote added panel.



Figure 95: quote chart-multiline

Both the middle part and bottom part are the visualizations. The types of visualizations can be changed by a single tap on each of the two charts. If users tap on the stock or fund performance chart, different types of visualizations are available with the line button. If the user taps on the stock technical indicator or fund risk chart, the types of indicators or fund risk shows with corresponding visualization. Touch and hold gesture activates the cursor, and the cursor follows finger moves. The top information for the default quote changes with movement of cursor.

The y axis of visualizations varies with the types of charts. The x axis (time axis) in the middle of two charts is shared by both of them. The time value is placed in the middle of the period (vertical grid line), since it represent a period of time. The time period of both charts can be changed by the expandable button on the right of the x axis. It also can be customized by the pinch open/close gesture. The axis is not beyond the maximum value of data to maximize the data-ratio-ink. The frames for the visualizations are very light, avoiding drawing too much attention from the views; however they still can help to read the chart.

There are three default colors used for the chart: white, blue and grey. The white is mainly used for different values, such as time, price, volume, because it pops out from the dark background, so it is easy for the viewers to notice the interesting figures; and the light grey is used for labels which is non-intrusive when reading the values; the blue color picked from TIBCO’s icon represents the default stock/fund. After adding some comparison quotes, more colors are used to represent the added stocks/fund.

6.5.2 Pie chart

Two types of pie charts are used in this project, one is static pie chart, and the other is drill down pie chart. Static pie chart (see Figure 95) is for showing the proportion of fund allocation. The fund name shows in the center of the pie chart with a smaller circle. Sectors are in different colors with white outlines. category names and the proportion numbers show besides each of the sectors, since viewers can not get the number of the proportion purely by the visualization. The maximum number of sectors in pie charts is seven or eight, since too many sections makes the pie chart cluttered and no space for the information text. If the pie chart has more than eight sectors, the light weighted sectors are grouped with the name of “others”.

Static pie chart provides relatively thin information. When it doesn't meet the needs, a drill down pie chart (see Figure 96) was designed, which allow viewers to go further to sub categories. In this project, the layout of the drill down pie chart is pretty much like the static pie chart, but provides more information. The drill down pie chart is used to illustrate the industry mover in index. The color of sectors represent the changes, a color bar is available underneath for reference. The white frame of sectors here can separate the adjacent sectors when their color is similar. Information of sectors, such as sector name, changes and the proportion percentage, are shown beside the sectors. Users can tap on any sector to go further and access the next level pie chart. for example, the user taps on “energy” sector, the pie chart of energy appears, the center circle shows the “energy” and its changes. User can tap on “energy ” to go up to upper level “OMX”, and also tap on sub sectors of energy to drill down further.

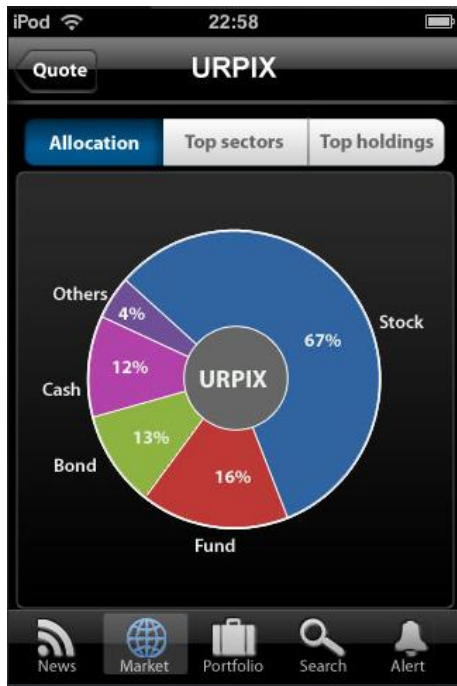


Figure 96: fund portfolio allocation

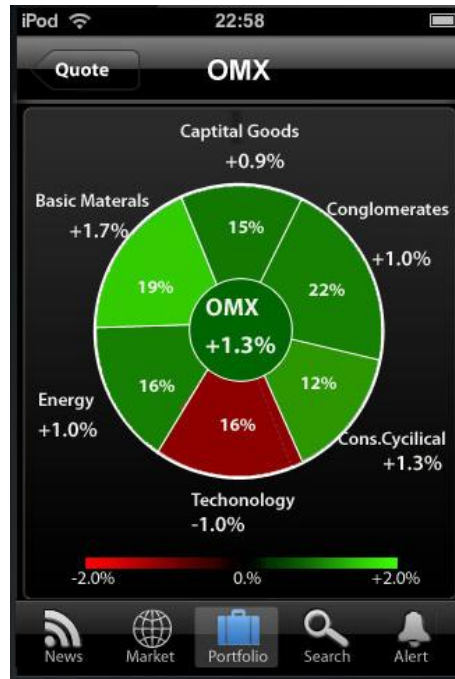


Figure 97: index industry mover

6.5.3 Tree-map

In this project, tree-map is used to monitor the changes of fund/stock in the portfolio. The basic elements of a tree-map are rectangular boxes; they are grouped by each of the categories in a hierarchical system. The category names of the next level are in button form, which means users can tab on it to drill down. The Figure 97 shows the first level tree-map. The user presses “stock” button on that page to access the stock section (see Figure 98). In the stock section, the title of current level “stock” is on the top of the tree-map in button form, which the user can press it to go back to the first level. The next sub-level of stock section, “IT”, “Energy”, “Financial”, “Others” are in button form and can be pressed to drill down further.

The color of a rectangle represents the change of the stock/fund. The color bar shows under the tree-map to illustrate the meaning of colors. Gray frames outline rectangle boxes to separate them in case two adjacent rectangle boxes have similar colors. Key status of stock/fund, includes stock/fund name, price and changes, shown in rectangle. When users tap on the rectangle box, the rectangle box shows a press down effect and a tooltip slides up from the bottom of screen, covering the tab bar and the color bar. The detail disclosure button is on the tooltip to access the quote of the stock/fund.



Figure 98: portfolio-tree-map



Figure 99: portfolio-tree-map (sub level with tooltip)

The settings button is on the right of the navigation bar in each page of the tree-map. Users can tap on it to access a configuration page (see Figure 99). The color palette is triggered by the color box besides the color bar. It changes the color theme of the tree-map. The span slider control changes the brightness of color. Other criteria, such as category group, size, color and period appear under the color controls. The current selected items of criteria are presented by the wheel picker trigger button, and can be changed by a wheel picker after users tap on the button.



Figure 100: portfolio-tree-map setting

6.5.4 Scatter plot

The scatter plot (see Figure 100) is used to monitor stock/fund in a portfolio benchmark chart. Each of the spots represents a stock/fund. The position of them are defined by two variables which are x axis and y axis. The Y axis shows the change percentage compared to the benchmark; while the x axis shows the possession percentage in the portfolio. A light grid frame on the chart helps to read the position of each spot in the chart. The benchmark can be changed by the benchmark button, which is an expandable button on the right end of the benchmark line. The detailed information of spots is shown by tooltips.

The configuration of scatter plot (see Figure 101) can be accessed by pressing the settings button on the right of the navigation bar. The criteria settings are just like the tree-map.

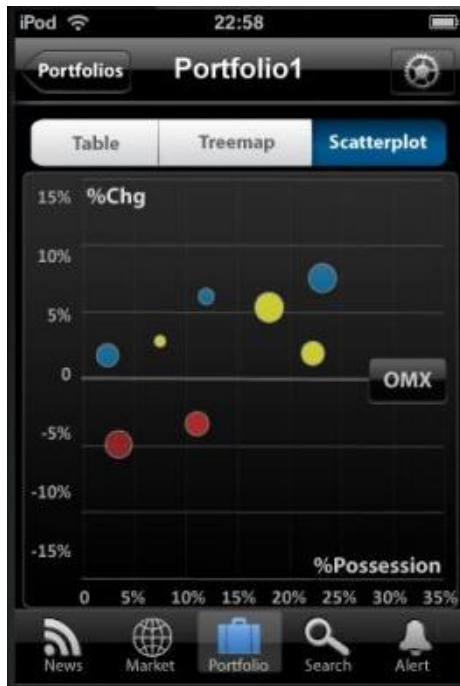


Figure 101: portfolio-scatter plot

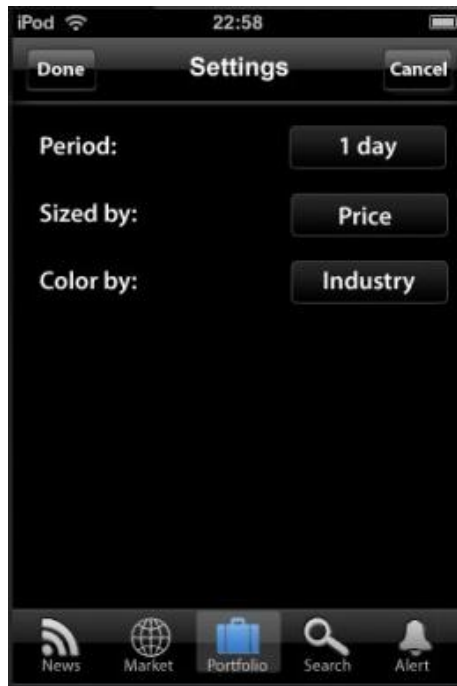


Figure 102: portfolio-scatter plot setting

7 Discussion

This chapter discusses the issues in the design process and the project result, including the problems and difficulties met during the process, the decisions made on design solutions, from both negative and positive perspective. The discussion is associated with the theories mentioned before. The possibility of future works is also discussed in this chapter.

7.1 Realization

The initial time plan made at the beginning (See Appendix: Timeline *initial plan*) turned out to be rather practical in our project. The execution of the timeline plan was satisfied and all the exercises were keeping a nice pace (See Appendix: Timeline *actual process*), until the project proceeded to the usability test phase. In the plan, only 4 weeks were assigned to the user testing and the iteration phase, which includes the user tests and an interface design guidelines as one of the deliverables of this project. By the initial process definition there was supposed to be two rounds of user testing: first, let the User experience (UX) team people evaluate the prototypes, then invite other people without user interface expertise to evaluate the revised design from previous user tests, in this way the iterations are formed. The guidelines must be made based on the revised design after the user tests at that time so that they can be referred by the summer interns who were supposed to implement the design. However, in practice the time span as well as the workload in this phase was underestimated by the initial plan. First of all, having two rounds of user tests is rather unpractical especially for the case of a research study, it is not easy to arrange for the usability test, such as sending invitations to people and arranging time schedule with them, together with preparation of interview questions, user tasks design, all of them add lots of workload. Second, the process of users test itself is time consuming, up to the number of users, it could take days to have it finished, and in case of this project because of big amount of test users, two solid days were used just for users to evaluate the prototypes by performing the tasks. Last but not least, the summary of the test results, as well as collecting late post-interview answers, and categorizing the views of users from interview notes turned out to be a quite tough work because of the number of users. Therefore, as the usability test of this project was done as well as the summary of results more than two weeks were already used. The following revised design work also took much longer time than expected, because other than some design mistakes were corrected some major changes in design concept were also made, where brain storming and discussions were needed to solve problems for the new design, so it took almost 4 week work to complete the final design

version. And also because of the company decided not to implement the design at the moment, the deadline for delivering the guidelines became flexible, and more time was available for the final version design. All these reasons make up the delay of the thesis report writing compared to the initial time plan.

Other than the reasons mentioned above that affected the execution of the plan, another concern is the range of the design concept, although the topic had already been narrowed down from business analytic to financial analytic, still, the time seemed tight for the detailed design of every aspect. Because the range of the design concept is quite wide, the distribution of the time used on each part is therefore hard to handle. Although the charts and portfolio were the focus of the design, it is difficult to spare much more time to them when so many other aspects needed to be covered. Therefore, if the design concept of the project could have been limited for example only to portfolio, then much more time could have been devoted to the design of the information visualization, more innovations and considerations may have been done.

One of the biggest challenges in this project is the remote collaboration between the two designers of the project; one was located in Gothenburg where Spotfire was, while the other one was located in Helsinki. This new way of cooperation certainly had brought some difficulties during the design process, but also some design advantages that benefited the project. The weakness was shown in different areas during the different phases of the design process, and the main one compared to the onboard co-working was that the designers cannot have real-time, face-to-face discussion, which results in relatively poor communication sometimes. The low working efficiency had also been one of its weaknesses, especially in the brainstorming and mockup phases of the process: traditionally, in brainstorming sessions or when the designers need to create mockups, the sketches or drawings can be used to represent ideas immediately and feedbacks are received right away from each other, but for this project a digital tool was used to present ideas, although it is a drag-and-drop tool, still, it was not as easy as hand drawing and much more time was spent on even just the operations of the tools. Working separately naturally led two designers to do parallel designs, which means designers were focused on their own designs, more concentration can be put on their own design as well as exploring and developing their ideas without any interrupts. However there are also disadvantages, since the ideas were evaluated by the other designer when the solid concept had already completed, the designers could only be inspired by the other's completed works, the dynamic stimulations of ideas were missing. It also sometimes slowed down the process for without oral explanation quite much time was used to understand the other's idea.

Blog was a great tool to assist remotely collaborated designers, for it motivated designers to keep on track of the design process and brought the communication gap between them closer. Almost all the activities, prototypes, results were posted on the blog, it helped the designers to keep up with each other's pace, and get to know the other's working progress, share information as well as inspiring each other. It also provided a perfect working log for later review of the design process for the report writing.

Difficulties to access the target users the assets managers is another harsh reality this project had to face to, and alternatives must be used to elicit users' requirements and needs. Therefore, focus was put on the hard facts to understand the users such as market research, field studies, competitors, etc. Because these existing competitive products were created probably based on proper task analysis with the real users where the target users of this project is included. By analyzing their design, users' need and requirements can be quickly learnt from function analysis, which was also a so called short-cut to do the usability design when users were not available for the task analysis. Learning and extracting the essentials from others' experiences also saved a lot of time from the user interviews and user observations. However, being unable to access real users did bring some problems in initiating user scenarios and personas, or forming the user images in a designer's head. The tasks can be initiated quickly based on analyzing the subjective facts but the goals of users cannot be defined easily, users were categorized in certain user types that assumed by designers. Therefore, if there were some special needs or requirements from real users, they would be hidden from the designers, and the gap between designers and users may also affect the user experience or satisfaction of the design because of misconceptions from the designers.

7.2 Result and future work

The small screen of mobile phones leads the navigation issues. This application optimized the navigation in an iPhone user context in following ways. Firstly, the application simplified the hierarchies of information. It has only three sub levels of main functions, in case users get lost in too many hierarchies of levels. It allowed users to surface back to the top level easily. Different organizations of the portfolio had been tried during the process, the final version was chosen as the one with least hierarchies. Distributing the information spatially rather than stacking by time was also one way to minimize the hierarchies. Take the quote view dashboard for instance, all the information related to this quote is contained in one page. Secondly, the tab button could switch between the five main functions easily. Thirdly, the application allowed users to access the last page with the back button. For example, users could switch their functions by the tab button, and use the back button to access the previous page.

In the interaction perspective, feedback, interaction affordance, and interaction consistency were emphasized in the design process. Feedback was available to respond effective user actions. When the user rotated the phone to change the orientation, the graphic interface would rotate along with the user movement; a processing view appeared during the loading time. Interaction affordance in the application interpreted information to users. Some designs were associated with good interaction affordance in the application. Such as in the drill down tree-map, only clickable sector titles were in button form, which told the users which sectors contained more levels of information. Some parts of design needed to be improved in interaction affordance, such as in the design of the pie chart, there was no big difference of drill down pie chart and normal pie chart. Users would not know which one was drill down from the interface. Interaction consistency enables users to learn the application easily. In this application, the same design patterns were used as much as possible. Such as in the navigation bar, the layout was always more or less the same. The dashboard design of the quote views had the same layout; no matter it was a stock or fund quote. Standard controls were created for this application, once users learned they could use it everywhere.

Chart design was considered quite successful in this application. The users could access the information they wanted with least steps. The default view was quite simple; users could choose to drill down to get the specific information by interaction with the chart. It allowed users to explore to certain degree. Such as user could add some quotes to compare to the default quote, however the maximum number of added quote was two. In the immersive application style users interact with the information rather than computer administrative debris, such as tap on the chart to show the options of chart type. Moreover, the cursor moving with the fingers of the user enhanced the direct manipulation of the application.

Portfolio was a unique design part which made this application different. Visualizations were available to monitor the securities in the portfolio. The application only offers the vertical visualizations. Was it necessary to offer the horizontal view by rotating? Although the vertical visualizations had the basic interactions and configuration functions, users might always want to have bigger visualizations. More interactions and configuration could be designed like the stock/fund chart. In the vertical screen, segmented controls were used to navigate between table and different visualizations, which kept these data visualizations in the same level. Users could switch between these visualizations easily. However, the navigation of the segmented controls was static. Dynamic navigation could be used to enhance the user experience. One proposal of dynamic navigation uses the iPhone album view in a horizontal screen. The user can browse several visualizations at same time, including the current visualization in the middle and the others stacked on the two sides.

Users can tap on the visualizations to maximize them, interacting with them like stock/fund chart. Another thing can be developed is configuration of portfolio visualization. More configurations could be available at portfolio visualizations. In the scatter plot, the axes are fixed now; this could be changed in the edit view along with other things. Since the scatter plot displays the relationship between two variables. The choice of axis could be paired previously, speeding up the configuration process for the users.



Figure 103: horizontal portfolio view draft

In the visualization design in the application, designers tried to max the data-ratio-ink in several ways. The grid frames of the chart and scatter plot was light, which can help to read the value without drawing too much attention. The axis was never beyond the content of the chart too much. The visualizations chosen for the application were also supporting maximum data-ratio ink. The tree-map uses the entire space to illustrate information; the scatter plot is also visualization with high data-ink-ratio. For visualizations having low data-ratio-link, like pie chart, drill down function was designed to provide further information. The preattentive processing concept was used in representing some key information, which should be noticed by viewers at first sight. Color is one of the feature can be perceived by user preattentively. It is used to represent changes in everywhere, which was consistent with the international practice. Color was also used to distinguish different categories in the scatter plot.

The dashboard design was used only in the quote view of stock/fund/index. The design was just to follow the principle by Few. The information having connection with each other were adjacent in space. The daily information was below the latest information, while the historical information was below the historical chart. The three quote view had a similar layout, which is easy for the user to learn.

The result is an interface design covering the entire application; every main piece of functions as well as the details is taken into consideration. Designing every possibly situation takes a long time and distributes our attention. If the designers could have concentrated on the portfolio and quote views, dedicating to visualizations and innovation designs, more advanced design patterns would be proposed in these areas.

7.3 Design recommendation

At the end this project, some design recommendations were concluded as following. These recommendations were based on the early research on mobile touch phones, and design experiences from this project as well.

Design disciplines for iPhone application (in general)

- Use standard controls as much as possible unless it can't meet the requirement or in the immersive application style.
- The usage of the designed controls and gestures should be consistent in the application design. For example, in this project, the gesture *rotation* was used to enable chart in full-screen.
- Limit the hierarchy of the application in case users losing control during the navigation.
- Provide feedback to each effective user actions.
 - ✓ Provide user the experience a high degree of *pliability*. Gives immediate appropriate reaction that is tightly coupled to the physical action a user takes.
- Make sure the interface is designed with *affordance* which interprets the application functions correctly. For example, using rectangular shape representing buttons.
- Avoid giving too complex functions, use close-ended (e.g. wheel-picker) input rather than open-ended (e.g. text box) input.

Design discipline for iPhone application (from information visualization's perspective)

- The way of presenting data is corresponds to the importance level of data; keep the most important information standing out from others. For example, using bright colors or bigger size to indicate the data importance.
- Use the same layout or view for similar pages, collocate the information by the relationship between them.
- Enhance the user experience of *direct data manipulation*
 - ✓ the object visualization should be consistent with the actions performed by users
- Maximize the *data-ink ratio* on the limited screen
 - ✓ For the information visualization that is with low data-ink ratio (e.g. pie chart), attach more functions, such as enabling users to drill-down to view further details.
- Take advantage of *preattentive* processing concept to individual or group data
 - ✓ Color and size are the features used mostly to group and individual data, and they can be perceived by users *preattentively*.

8 Conclusion

This chapter summarizes this thesis project work by answering the primary research questions. It concludes how the issues promoted at the beginning of the project were addressed during this project work.

To be able to answer the primary research question: “How to design an attractive business analytics that makes good use of the touch phone features and provides a great user experience?”, this project were focused on addressing a number of questions: “Who would be the target user? What are their needs and tasks? “, “What are the cutting-edge technologies within this field?”, “What possibilities and limitations does the specific interaction techniques (e.g. touch) imply?”, and to be able to answer such questions lots of research such as market research and user study as well as relative technologies were done. Different solutions were also proposed for visualizing information on a touch mobile concerning the limitations on the small screen as well as the gesture design.

The target user was defined at the very beginning of the project: the main target user was the professionals, the assets managers; common users who have investments or interests in the financial market were also considered as the minor users, but their needs and tasks were left as an important study of the project. By analyzing on the hard facts such as functions of competitive products, background and working context of the users, user needs and tasks were elicited. They were then translated into the design solution that provides several essential tasks for analyzing financial market: read updating news, check up quotes, search stocks and set alert for stocks.

As the necessary information was learnt, the next step was to learn how to present the information on the iPhone. The limitation of the visible area on the mobile device was an inevitable concern for designing information presentation, and the design of hierarchies of information becomes crucial when big amount of data is to be presented. The system should have logical information hierarchies and with reasonable number of levels of details, so that users are able to drill-down into more details as well as find their way back and feel in control of the system. This project kept eyes on the cutting-edge technologies both in the field of gestures designs on touch phones and interactive information visualization throughout the design process, which brought inspirations to the project and helped it up-to-date, by studying what technology was available the design could be made innovative but

realistic. Different possibilities were also discovered during the design process, for example, although lots of research have explored the use of the interactive tree map visualization in financial software, it is still not yet common for mobile financial analytics, while the scatter plot were hardly seen in any financial analytics. These visualizations were used in the portfolio design in this project, by making good use of the features of them together with gesture design for iPhone, so that to enable users to directly manipulate data and get the information they need in an easy and quick way.

This project defines that designing a financial analytic tool for iPhone means optimizing the specific interaction features the iPhone platform offers, adopting the power of the information visualization, and seeking for a solution as a combination of these two advantages, so that users can perform their tasks intuitively and have their goals fulfilled. Compared to the conventional desktop financial analytics it provides users mobility of use, despite of the limitations of mobile devices a large number of data were designed with hierarchical layers which enable users to drill-down to details to reach their desired information and also find their way back, by providing different levels of information both assets managers and common users can use it to serve their different purposes. As easy to learn was one of the principles for designing the user interfaces, basic tasks can be achieved here such as monitoring markets, managing personal portfolios, searching stocks, setting alerts for certain stocks, etc. But having the information visualized the users are offered an quick way to perceive data, performance of either an index, a certain stock or even personal portfolio the patterns, outliers, relations can be recognized immediately. By using most intuitive interaction, the touch gestures, users can access more precious information. Hence, the gestures and information design were considered as the spotlights for this project, by making good use of both it is assumed to provide a great design that goes beyond the user's expectations and thus increase their excitements and user experience.

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- [4] <http://www.learntechnicaltrading.com/BeginnersTrading/ChartAnalysis/OpenHighLowCloseOHLCCChart.aspx>
- [5] http://www.edwardtufte.com/bboard/q-and-a-fetch-msg?msg_id=00036T
- [6] http://lap.umd.edu/lap/Papers/Dissertations/Alonso_Dissertation_1998/partI.html

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- [7] Bloomberg <http://www.apptism.com/apps/bloomberg>
- [8] Swissquote <http://www.apptism.com/apps/swissquote>
- [9] Google Application for Android <http://googlemobile.blogspot.com/2009/03/finance-for-android-app.html>
- [10] 128128 Q <http://www.apptism.com/apps/128128q>
- [11] iStockmanager <http://www.apptism.com/apps/istockmanager-brokerage-services-by-td-ameritrade>
- [12] Finanzen.net, <http://www.apptism.com/apps/finanzen-net>

[13]Stockcharts, <http://www.apptism.com/apps/stockcharts>

[14]Simplex FX, <http://www.apptism.com/apps/simplex-fx>

[15]TickerPicker, <http://www.apptism.com/apps/aaplpicker>

[16]Fund Watch, <http://www.apptism.com/apps/fund-watch>

[17]StockWatch, <http://www.apptism.com/apps/stockwatch>

[18]Fonestock, <http://www.apptism.com/apps/fonestock>

[19]StockAdvisor, <http://www.apptism.com/apps/stockadvisor>

[20]PortfolioLive, <http://www.apptism.com/apps/PortfolioLive>

[21]Shareprices, <http://www.apptism.com/apps/shareprice>

Financial Web applications

[22]Google Finance, <http://www.google.com/finance>

[23]Yahoo Finance, <http://finance.yahoo.com/>

[24]MSN Money, <http://moneycentral.msn.com/home.asp>

[25]AOL Money & Finance, <http://money.aol.com/>

[26]CNN Money, <http://money.cnn.com/>

[27]Reuters, <http://www.reuters.com/finance>

[28]Morning Star <http://www.morningstar.com/>

[29]New York Times, <http://www.nytimes.com/pages/business/index.html>

Mockup Tool

[30]Balsamiq, <http://www.balsamiq.com/>

Appendix 1: Competitive Analysis

News	Bloomberg	Swissquote	GoogleApp	128128Q	iStockmnger
Sort type (manual/symbol/daily change)		+			
Changes in % (on/off)		+			++
News multilingual (on/off)		+			
Preferred market		+			
login type: bank, premium		+			
Default time period			+		
Continually update price (on/off)			+		
Username/Password	+				+
Remember password (on/off)					++

"+" iPhone settings

"+" Settings in application

Table 1: setting/configuration comparison table for iPhone application

Search		Bloomberg	Swissquote	GoogleApp	128128Q	iStockmnger
Independent	Auto-complete list	+		+	+	+
Search	Add stock from the result list				+	
Search in "Edit" stock	Choose market	+	+			
	Text-field search	+	+			+
History		+				

Table 2: search comparison table for iPhone application

Portfolio		Bloomberg	Swissquote	GoogleApp	128128Q	iStockmnger	
My Stocks/ Whatchlist/ Quotes	Name	+		+	+	+	
	Ticker	+	+		+	+	
	Price(Last)	+	+		+	+	
	High & Low						
	Bid & Ask					+	
	Value	+					
	Value Change	+					
	Position	+					
	Bought at	+					
	P & L	+					
	Time	+					
	Chg/%Chg	+	+		+	+	
	Refresh	+	+				
	Search					+	
	Sum					+	
	Real-time updating					+	
	Change view					+	
	Edit stock	Add	+	+			+
		Add search	+	+			+
		Delete	+	+		+	+
Order		+			+	+	
Position		+					
Price		+					
Indices						+	
Portfolio list (edit/add/delete portfolios)				+			

Table 3: portfolio comparison table for iPhone application

Quote view		Bloomberg	Swissquote	GoogleApp	128128Q	iStockMnger
Chart		+	+	+	+	+
Related news		+	+	+		+
Company summary		+	+			
Real-time info	Time	+	++	+	+	
	Bid , Ask		++		+	+
	Bid size, Ask size		+			
	Open			+	++	+
	Volume	+	++	+	+	+
	Change (%Change)	+	++	+	++	+
	High, Low (today)	+	++	+	+	+

	Close		+ +		+	+
History	P/E	+			+	+
	High , Low	+	+	+	+	+
	Average volume			+		
	Year return	+				
	Turn over				+	
	Market Capital	+		+	+	
	Nominal				+	
	Day range				+	
	Shares traded				+	
	Earning/Share				+	
	Dividend/Share				+	+
	Lot size/ Currency				+	
	Last size					+
	% below high					+
% above low					+	

"+" app has the feature

"+"app has the feature in back view, or other page

Table 4: quote comparison table for iPhone application

Market		Bloomberg	Swissquote	GoogleApp	128128Q
Stock movers	winners/losers	+	+		+
	Volume				+
	turnover				+
Industrial mover	chart	+			
	table	+			
Equity indices list		+	+	+	+
Equity indices quotes		+	+	+	+
Commodities		+			
Currencies		+			
Bonds		+			
Funds					

Table 5: market comparison table for iPhone application

News	Bloomberg	Swissquote	GoogleApp	128128Q	iStockmnger
Choose & order categories	+				
Categorize headlines	+				
Headlines list	+	+		+	+
Date & time	+	+		+	
Full articles	+	+		+	
Source				+	
Email the story	+				

Refresh button		+			
Show related News only if previous page is quote view				+	

Table 6: news comparison table for iPhone application

Chart		Bloomberg	Swissquote	Google	128128Q	iStockMgr	Yahoo
Trend chart		+	+	+	+	+	+
Volume chart		+	+		+		
Chart visualization	Open/high/low/close				+		
	Candlestick				+		
Cursor		+					
Panning & zooming		+			+		
Change x-axis		+			+		
Change y-axis		+					
Date Range	1 day	+	+			+	+
	1 week		+			+	+
	1 month						+
	2 months	+					
	3 months					+	+
	6 months	+	+			+	+
	1 year	+	+			+	+
	2 year						+
	5 years	+					
	All		+				

Table 7: chart comparison table for iPhone application

Appendix 2: Task Analysis

Market
<ul style="list-style-type: none"> • Equity Indices
<ul style="list-style-type: none"> ○ stock mover(Leader & Lagger)
<ul style="list-style-type: none"> ○ industry sector overview
<ul style="list-style-type: none"> ○ industry mover
<ul style="list-style-type: none"> ○ monitoring selected stock
<ul style="list-style-type: none"> • Fund
<ul style="list-style-type: none"> ○ top performance fund list
<ul style="list-style-type: none"> ○ monitoring selected fund
<ul style="list-style-type: none"> • Commodities (quote)
<ul style="list-style-type: none"> • bonds (quote)
<ul style="list-style-type: none"> • currencies (quote)
Portfolios/portfolio overview
<ul style="list-style-type: none"> • overview of a portfolio/portfolios performance
<ul style="list-style-type: none"> • to see the allocation of holdings in a portfolio/portfolios
<ul style="list-style-type: none"> • all funds in the a portfolio/portfolios overview
<ul style="list-style-type: none"> ○ performance(net return) in table and chart
<ul style="list-style-type: none"> ○ return and risk comparison
<ul style="list-style-type: none"> ○ related funds board
<ul style="list-style-type: none"> • all stocks in a portfolio/portfolios overview
<ul style="list-style-type: none"> ○ overview of the performance in each industry sectors
<ul style="list-style-type: none"> ○ view all holdings in different views: summary/basic, fundamental, performance, transactions, customize
<ul style="list-style-type: none"> ○ best and worst in a portfolio/portfolios

○ compare all stocks in a portfolio/portfolios with a benchmark
• related news
• monitor selected fund/stock
• edit portfolio
○ add remove portfolios
▪ edit holdings in the portfolios
Fund monitoring
• Key stats
• Chart
○ Fund net value historical trend(compare to others)
○ Rollin risk(compare to others)
○ price chart(growth of \$10,000 over 8 yrs/ annual performance)
• holdings information:
○ asset allocation
○ Industry sectors
○ top holdings
• related news
• more information:
○ fund historic
○ purchase information
○ monitoring other relative funds
○ monitoring related stocks (chart, price, change)
Stock monitoring
• key stats
• Chart

○ price chart, volume chart
○ compare to other stocks/indices
○ technical indicator
○ different chart types available
○ event markers
• summary
• related news
Search
• text searching(auto-complete)
• search history
• add stocks from result list
• stock screener
• fund screener
Alert
• time alert: at certain time daily
• data alert: prices/volumes reach certain points

Appendix 3: Phone Interview

Interview Plan

Interviewee

Mark: Consultant, Professional services. He took part in customizing analysis files for the BNP bank, has specific information about the BNP bank, and knows more information about assets managers' needs.

Questions

Background
1. Can you describe your job in Spotfire?
2. Who do you mostly contact with? (Banks? Assets Managers? Stock broker? Analysts?)
PC apps
1. What application/software are the finance analysts working with on a daily basis?
2. What are the goals (most important functions) of this software?
Mobile apps
1. Have they started using the mobile finance tools?
2. what are these tools?
3. What are the tasks they would like to perform on mobile?
4. Could you provide some scenarios of the assets managers using the mobile tools
Information
1. What kind of information do you think they would prefer to monitor on mobile than computer?
2. What market information they need to know: stocks, bonds, funds, currencies, commodities?
1. Do they often check information on different stock exchanges? (what's the market coverage)
2. What is the basic information of each of them they want to see instantly? what kind of overview they would expect to see?
3. Which one of them has real-time information that they need to check

frequently? (you mean real time by updating)
4. Which one of them (markets) is the most important, that they would require further information (more details)?
5. sorting data: by sectors? top movers? by region? Quote list sorting?(by symbol, price, change)
6. Are technical indicators necessary? Presentation for stock: professional charts needed?
3. Which market information (stocks, bonds, funds, currencies, commodities) they need to check mostly (stock /fund performance and risk analysis) ?
1. Preferred presentation ways
2. Advantages/disadvantages of these presentations?
Problems/possibilities
1. Do you experience any problems with the Spotfire in the finance market? which functions do you think is the best? worst?
2. Can you think of any features which do not exist in the current software, but the customers would like?
Portfolio
1. In general, how many portfolios does an assets manager usually need to monitor at a time?
2. Do you think the customers need to monitor all the customer portfolios on the mobile phone?
3. Do you think it is necessary to let customers manage (create, delete, edit) their portfolio?
4. What overview information of portfolios do you think they want to have? (the sum)
5. What would be the most intuitive way for them to get an overview of all the portfolios instantly (graph/tables)?
6. What kind of comparison do you think they would expect to have?
7. Industry Sectors, Asset allocating, add transaction.
8. Do you think add alert function to the fund mobile application will be helpful?
1. What information needs to alert to customers?
About the BNP file
1. What does "groups" (management team) mean?

1. the relationship with the bank
2. the relationship with the assets manager
2. What is "benchmarks" in the web file (it is all numbers), what are the bench names represent? there is statics about the use of each benchmark, why it is interested to customers?
3. What kind of information does "Fund historic" emphasize to tell?
4. "1Mth exception"?
5. There are many views in the file, which ones do you think are very important for user? Which ones do you think can be ignored if the user has limited time/in the mobile case?

Result

This interview is more focus on portfolio management part.

Good-to-have Features:

1. Overview of portfolios (categorized in sectors, % of share, market values. tree-map?)
2. Performance of portfolios in a time period (day, month, year...)
3. Securities in portfolios compare to benchmarks
4. Alert (time based alert: trigger at certain time, data based event alert: trigger by data events)

Other key notes:

1. 1-5 portfolios to monitor at same time, portfolios are often with different properties.
2. Meaningless to compare between portfolios, or individual securities. more compare to benchmark.
3. view in different currencies
4. splits of market: bonds, currencies, equities
5. mobile app should be very simple, with core information, "not too much drill-down levels"(Maria suggests)
6. not necessary view different exchanges
7. volatilities
8. risks

Appendix 4: Usability Test

Interview plan

Interview:

Background, pre-test questions, expectation (more information from finance people)

Solving test tasks:

Carried out with prototype, think-aloud to comment while doing the test

Debriefing:

General impression of the prototype, post-test questions will be asked

Tools:

Printed paper of real iPhone-size, Digital image on iPhone, Flash demo

Cover topics: the content (structure, information), the interface, accessibility (find what they need easily), excitement, conveniences

Pre-test interview questions:

Name/ Sex/ Job position

1. How much is your finance knowledge? if rate yourself 1 to 5?
2. Do you invest on stock or funds market or have related experience?
3. Do you have an iPhone/ iPod touch? (Have you had any experience using iPhone/ iPod touch?)

If Yes:

1. Can u give some names of the apps that impressed you?
2. Have you used related financial analytics apps?

Post-test interview questions:

1. How much do you like the theme of the prototype? (the color, look and feel?) rate from 1-5.
2. How do you think the flow of the prototype? Is it easy or difficult to follow?
3. What do you think about the presentation of the information? Which visualization do you like most?
4. Is there any interaction part you like most? Why?

5. Can you point out some things that impressed you most? Why?
6. Is there anything you find confusing/ illogical?
7. Do you feel anything is missing out?
8. What do you think still needed to be improved? Why?
9. Can you describe this prototype with 3 words?

Test tasks:

News:
<ul style="list-style-type: none"> • Read a piece of news in "market top stories", and email it
<ul style="list-style-type: none"> • Edit category choose "Europe" "Funds" as the only categories
Market:
<ul style="list-style-type: none"> • look at the top funds in 6 month return
<ul style="list-style-type: none"> • look at OMX's quote, find the top movers of this index
Quote & chart (Stock):
<ul style="list-style-type: none"> • look up the TIBCO's quote
<ul style="list-style-type: none"> • find the last price, change(change%), today's high/low price, historical high/low price
<ul style="list-style-type: none"> • add this quote to portfolio
<ul style="list-style-type: none"> • enable the chart in full screen
<ul style="list-style-type: none"> • look at the chart in the range of 3months
<ul style="list-style-type: none"> • view the chart in other chart types
<ul style="list-style-type: none"> • view different technical indicator(lower chart) for this stock
<ul style="list-style-type: none"> • read specific values(last, open, high, low, close) on different dates
<ul style="list-style-type: none"> • compare this stock to "apple", "Nasdaq"
<ul style="list-style-type: none"> • find the return % in all stocks
<ul style="list-style-type: none"> • delete the legend of "apple"
Quote & chart (Fund):
<ul style="list-style-type: none"> • find the total assets, the yield%
<ul style="list-style-type: none"> • Look at the fund's portfolio, how much percent of the holdings are stock? What are the top holdings? Top sector?

<ul style="list-style-type: none"> • enable the chart in full screen
<ul style="list-style-type: none"> • change the fund risk to Beta
<ul style="list-style-type: none"> • compare this fund to "Coagx" "Omx", read their return% values
<ul style="list-style-type: none"> • look up the performance/risk values in table
Alert:
<ul style="list-style-type: none"> • turn off the alert for "apple" stock
<ul style="list-style-type: none"> • delete alert for TIBCO
<ul style="list-style-type: none"> • add an alert for TIBCO, set the criteria as "price falls below 50"
<ul style="list-style-type: none"> • check alert history
Search:
<ul style="list-style-type: none"> • set screener for stock, "1 year total return" "-20%" to "30%"
<ul style="list-style-type: none"> • edit criteria for stock: add "6 months total return".
<ul style="list-style-type: none"> • add an criteria "3 months return"
<ul style="list-style-type: none"> • search for "apple" stock
<ul style="list-style-type: none"> • view the search result in "risk" criteria
Portfolio:
<ul style="list-style-type: none"> • go to portfolio1, look at the total return in kronor
<ul style="list-style-type: none"> • read the visualized portfolio information
<ul style="list-style-type: none"> • drill-down to details on the tree-map: find the best and worst performance, look at certain sector in tree-map, and change the period to be 1 year. go to TIBCO's quote view.
<ul style="list-style-type: none"> • drill-down to details on the scatter plot: change the benchmark, tap on the leftmost dots, go to TIBCO's quote view

Result

Color code: [Portfolio](#), [quote view & Chart](#), [Search](#), [news](#), [Alert](#)

Errors: (things must be changed)

- 1 [horizontal tree-map: numbers in color bar is wrong](#)
- 2 [fund portfolio's "top holdings", "top sectors": the numbers doesn't sum up as 100%, and not sorted either](#)

- 3 quote high/low and historical high/low has the same number
- 4 "table" button in fund chart is blue
- 5 "edit" button sometimes on the left button, sometimes on the right button (should be on the left side)
- 6 chart is not correct, 8 data points in 5 days
- 7 the risk chart in fund chart is always multiline
- 8 (tap twice to zoom out to the tree-map, after filtered by the IT)

Confusing parts:

- 1 What are the "movers"?
- 2 what is the "risk chart"
- 3 How to change chart type?
- 4 Both high/low values on the left and right are the same, what's the difference?
- 5 What is the "portfolio" in fund's quote view? my own portfolio?
- 6 What is "table" button in fund chart?

User Attempts:

1. Assume the news edit category buttons is mutual (single choice), tried out first.
2. try to find add button for adding alert on first page, (on the upper right corner)
3. hard to notice page dots in portfolio
4. feels the Portfolio vertical visualization chart can be interacted, would not think about rotate at all
5. cannot notice the panel hidden in portfolio visualization charts
6. tap on the benchmark text on scatter plot chart to change benchmark
7. takes a while to find fund portfolio button, tend to read in the contents in the quote view
8. in quote view, assume the right part is historical values first, then read numbers to differentiate today's high/low and historical high/low
9. tap on pie chart in fund's portfolio to read more
10. in chart, tap the time to read values or tap on the line to read values
11. At first very difficult to figure out how to change chart type, once learnt, quickly know who to change technical indicator.
12. tap to reach full chart
13. in chart, the delete sign in legend feels like a stop sign or cancel
14. assume to use little triangle in table view to sort instead of getting more columns in table

Good Suggestions/ ideas: (things we might adopt)

1. an add button (maybe "+") in "Alert" instead of in "edit" page
2. home page of "search" should say "Search" in title bar instead of "Screener", it is better have "text search" page as the home page

3. in **search**, the "+" and "edit" or "-" in separate place, for example in "edit", remove criteria, and in the main page a "+" sign, allows a screen/panel slide up and let user to choose from there
4. fewer options in **search**, so less complicated. add more 'columns' with sorting capabilities
5. have a **portfolio** setting for particular mix of market sectors, enable users to compare the actual portfolio to the target mix. (E.g. 10% Bonds, 25% Large Cap stocks...)
6. have personal preferences settings for the time period of the **quote** information (real time, day, week)
7. some context menu to help
8. in **portfolio**, have personal preferences settings for default currency, have a top3 favorite ones, so don't take so long to find the currency wanted.
9. in **portfolio**, personal preferences settings for things like time spend, color, preferred visualization type
10. add (buy/sell) stocks capability, name the watch list, in **portfolio**
11. have color bar in vertical **tree-map** visualization too
12. When the **tree-map** showing few company there (where there's big area for each company), more information (e.g. historical prices) should be presented instead the default ones.
13. **tree-map** can to be sized by my own holdings
14. have tickers besides the bubbles in **scatter plot**, so that user don't have to tap to see which stock it is
15. "Back" button on the **quote view** if the quote is got from the tree-map/scatter plot, always able to go back to the visualizations.
16. in **quote view**, the "add to portfolio" buttons doesn't seem common in iPhone. it is in line with the text, usually should be on the bar.
17. **Industry mover's** pie chart's size information doesn't present (what's the %?)
18. the color gradient is not obvious in the **industry mover** pie chart
19. able to check/uncheck the legend in **charts**, so able to switch any other 2 stocks to compare
20. finger may hide the volume values when moving the cursor in **chart**
21. Instead of calling the "table" button maybe call "metrics" or "KPI" in fund **chart**.
22. more attention should be paid to the terminology (fund's portfolio and personal portfolio)
23. Consistent in names for the back buttons, "back" or names of the back page?
24. needs same interaction pattern for both **chart** and portfolio **visualizations**
25. red green color may not be for color blind, the colors are too close to read differences
26. blue text is little bit hard to read on the black background

Appendix 5: Test Scenario

Stock
<ul style="list-style-type: none"> • performance and risk analysis
<ul style="list-style-type: none"> ○ lookup real-time and historical price trend of a specific stock for different relative periods
<ul style="list-style-type: none"> ○ compare one stock performance to Benchmarks (or another stock performance) for different relative periods
<ul style="list-style-type: none"> ○ look up the technical indicators for a specific stock for different relative periods
<ul style="list-style-type: none"> • portfolios
<ul style="list-style-type: none"> ○ get an overview of the portfolios performance, lookup the changes for different relative period
<ul style="list-style-type: none"> ○ compare the stocks performance in the portfolio to the customized benchmark
<ul style="list-style-type: none"> ○ get an overview of the shares of the portfolio, e.g. categorized by industry sectors
<ul style="list-style-type: none"> ○ lookup the best/worst performance of stock in the portfolio for different relative periods
Fund
<ul style="list-style-type: none"> • performance
<ul style="list-style-type: none"> ○ Lookup the Performance Measure of a Management Team for a particular Relative Period. <i>E.g. What is the 1M return of funds managed by the Alpha team?</i>
<ul style="list-style-type: none"> ○ Compare the Performance Measures for different Management Teams for a particular Relative Period. <i>E.g. Compare the 1M, 3M and YTD returns for all management teams.</i>
<ul style="list-style-type: none"> ○ Lookup the Return Measure of a Fund for a particular Relative Period. <i>E.g. What is the 1M return of Asia fund X3b relative to December 2008?</i>
<ul style="list-style-type: none"> ○ Compare the Performance Measure of multiple funds for different Relative Periods. <i>E.g. Compare the 1M return for all funds managed by the Alpha Team.</i>
<ul style="list-style-type: none"> ○ Compare the Performance Measure for particular Funds that contain a selected Share Type. <i>E.g. Compare 1M, 3M, YTD, 1Y, 2Y, 3Y, and 5Y return for all funds with institutional shares.</i>

<ul style="list-style-type: none"> • risk
<ul style="list-style-type: none"> ○ Lookup the Risk Measure of a Fund for a particular Relative Period. <i>E.g. What is the Standard deviation of the Fund 12X13B?</i>
<ul style="list-style-type: none"> ○ Compare the Risk Measure and Return Measure for different Management Teams for a particular Relative Period. <i>E.g. compare the 1M Return and the 1M Standard deviation for funds managed by different management teams.</i>
<ul style="list-style-type: none"> ○ Compare Risk Measure and Return Measure for a particular Share Type. <i>E.g. What is the Standard Deviation and 1 Month Return for institutional shares?</i>
<ul style="list-style-type: none"> ○ Identify Risk Measure patterns (Rolling Risk) over time for the Fund(s). <i>E.g. Look at the standard deviation trend of Fund 12X13</i>
<ul style="list-style-type: none"> ○ Compare Risk Measure patterns over time for the Funds. <i>E.g. compare the standard deviation trend of fund 12X13B and Fund JK321.</i>
<ul style="list-style-type: none"> • attributions
<ul style="list-style-type: none"> ○ Look-up contribution of a specified Security to the Performance Measure of specified Fund. <i>E.g. what is the contribution of US Government Bonds to the 1 Year Return of the Alpha Fund?</i>
<ul style="list-style-type: none"> ○ Compare the contribution of the Securities to the Performance Measure of a Fund. <i>E.g. compare the contribution of different securities that makes up the Alpha fund. Which securities make up the bulk of the return of the fund?</i>

Appendix 6: Persona

This persona describes a typical user within our target customers group of the product. Our fictional user is named Eva Green.

Eva is a 41 years old asset manager. She works for one of the biggest bank of France since 7 years back. Her job is to help the customers to balance their risk and reward in managing investment portfolios. Based on the risk and return analysis, she recommends the optimized investment portfolio among all the investment possibilities. Then Eva helps the customers to execute this investment.

After graduating from top university of business in France, she went to London to study finance of her master, and worked in an international bank for 8 years there. She lives with her husband and a 7 years old son.

As an asset manager with rich experience, Eva has more than 50 customers at a time. The communications between the customers and she are by phone and email very often. She may not at the office for the whole day; travel is very common for her. However, she need to be available to her customers and at any time, no matter she is on the way to New York or having breakfast in a restaurant of London.

The daily work for Eva is monitoring the market and customer portfolios, which means the amount of information of stock, fund, bond, currency. She is looking at her computers all the time when she is at office, and check the information by her iPhone when she is off office. she has several finance application installed on her iPhone 3G, which allowed her to access the information of market and customer portfolios quickly at any time. When she is out of office, she checks the real time price, trend, risk and return comparison, customer's portfolios, etc on the mobile phone, and makes decision in a short time.

Eva doesn't have the background of software, she prefer simple to use and intuitive finance software, since she doesn't have much time to learn it. As a professional asset manager for 15 years, although she isn't good at doing the risk analysis herself, she is well trained to all kinds of visualization mediums and analysis patterns. She is skilled of finding the needed answers among huge visual data, however access the data directly and finish the task very fast is the most important thing for mobile case.

Appendix 7: Timeline

Initial plan:

Research (2~3 weeks)

- Spotfire software training
- Literature reading
- Browsing relative cutting-edge technologies, applications for touch phones (Gestures studying, PC-to-mobile comparison) [on going through the whole process]
- Gathering data

Task Analysis (3~4 weeks)

- Analyze the target group
- Analyze customer requirements
- Analyze and decompose the task (use case/scenario)

Generating Design Concept (8~9 weeks)

- Design the ways for performing different tasks (with gestures)
- Information representation (information arrangement)
- Mock-ups
- Prototypes

Testing and Iteration (4 weeks)

- Usability test within UX team and people without domain knowledge
- Prototype design iterations
- Write document/guidelines for summer interns

Summer Vacation (29th July – 14th Aug)

- The supervisor in the company will be away from mid-July
- preferably a 2-week vacation

Final prototype and report writing (5~6 weeks)

TIBCO INC. (SPOTFIRE)

Guidelines for iPhone Financial Analytics

Design patterns

Shanna Lu & Lin Li

8/18/2009

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Introduction

At the beginning the goal of the project was to design the user interface of the business analytics on iPhone platform, works as a complementary tool for the Spotfire's business software on PC. However, it should not be directly mapped from the pc version, more new methods of interactions should be encouraged, as well as creative look and feel and gestures design, yet consist with the same conveniences the interactive system provides to the user.

Later, as the BNPParibas bank was inducted as an instance of our potential customer, the design goal was narrowed down as a financial tool targeting for the assets managers.

According to the bank's requirements, they expected to see the application as a complementary tool to the Spotfire's web player file that was customized for them, and it should be attractive and clear. Users have their fixed way to do the check-ups, but can also drill down to explore more details as they want. Another motivation is to use the application as an early adopter showing the bank is following up the cutting-edge technology too. They would expect an end product like "Bloomberg".

Therefore, the goal is to design a financial analytic tool which both fulfills BNPParibas bank's requirements, yet still aims for a more general use. The main use cases would be Portfolio monitoring, to get quick and easy answers by quick checks of the stock performance and risk. Because of the special character of the mobile application, the UI is simpler and it's easier for quick access, despite the user might be moving. And because it's designed on iPhone (touch phone) platform, more gestures designs would be integrated which invites users more direct interactions with the application to get what they need. The "iPhone Human face Guidelines" was considered as the guideline to assists the interface design.

Framework of the contents (data hierarchies)

According to the previous studies on customer requirements, the contents were categorized into five main parts: “News”, “Market”, “Portfolio”, “Search”, and “Alert”. (See Figure 1)

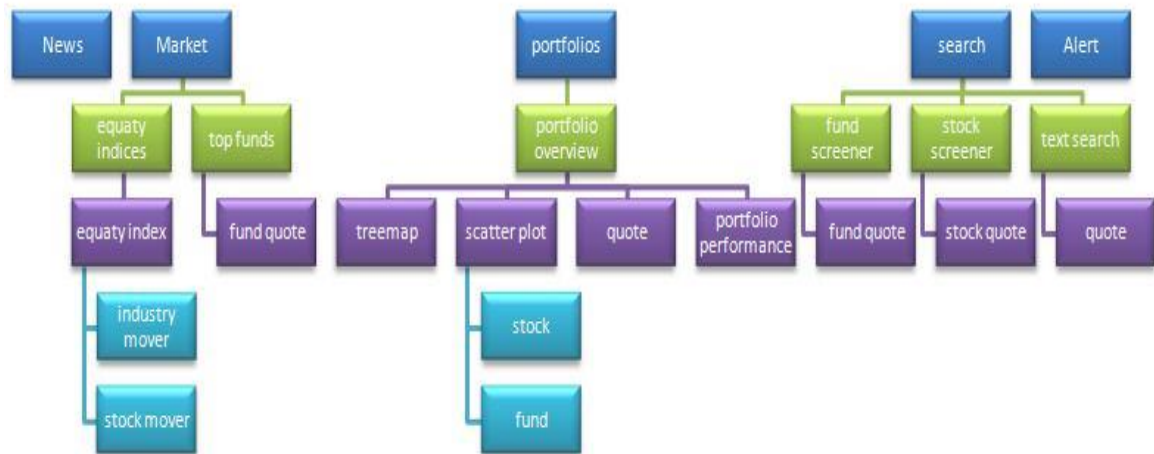


Figure 104: Structure of the project design

The five main categories on the top level are listed on the tab bar, which is present at the bottom of the screen most of them, therefore user can navigate among them or access to them easily. And each category has max. 4 sub-levels, no deeper drill-downs, thus provide users a great mental map with which they can find their ways without losing controls.

News - it provides updating news, users can read headlines, drill down to read full article as they want, and forward news to others. (See Figure 2)

They can set the interesting news categories in preferences as well. (See Figure 3)

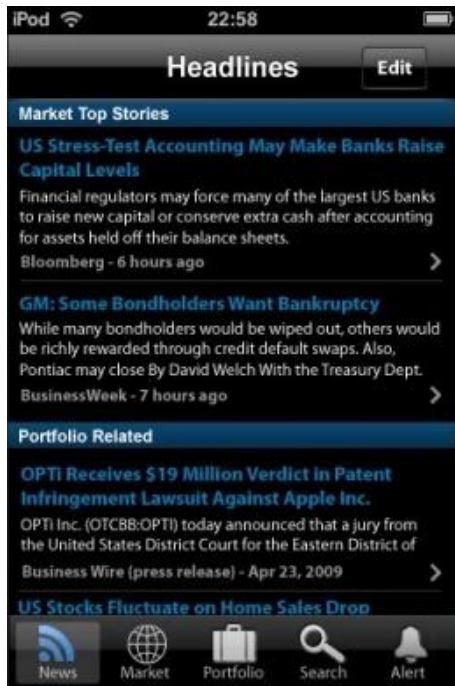


Figure 105: First page of News

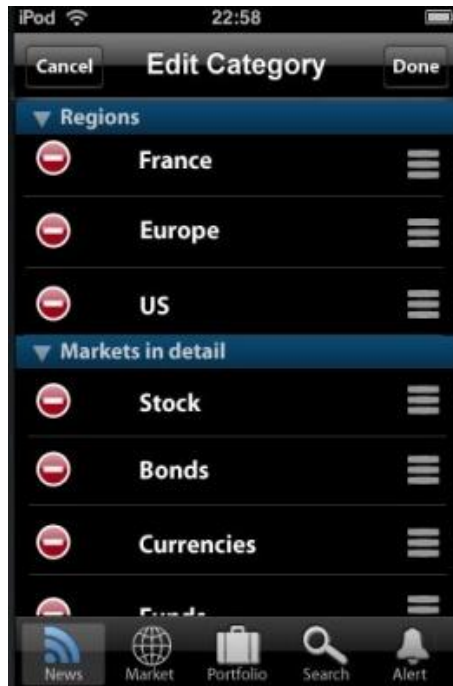


Figure 106: Edit News category

Market - provides updating prices, information, user can explore indices, Funds, bonds, currencies. (See Figure 4)

- Indices: a table shows a list of indices and their price performance (eg. %Chg), user can drill down to view the index's quote view: (See Figure 5)
 - Index quote view: Key stats, index summary
 - Performance Chart: interactive chart showing price performance of this index
 - Stock Movers: company list of the both gainers and losers within the index, user can drill down to the company's quote.
 - Industry Movers: interactive pie chart, showing gainer and loser in industry distribution, user can drill down to subtle sectors to views industry movers in details.
- Top Funds: a table shows a list of top funds and their performance, users can drill down to view the fund's quote view: (See Figure 6)
 - Fund quote view: Key stats, related news, fund summary
 - Performance Chart: interactive chart showing price performance of this fund

- Fund portfolio: fund allocations (stock%, bond%, cash%, etc.), Top sectors: sectors distribution in pie chart, Top holdings of this fund where user can drill down the view the holding's quote (Stock quote view).
- Performance: view fund performance/risk table
- Bonds: a table shows a list of bonds and their prices.
- Currencies: a table shows currencies' exchange rates.

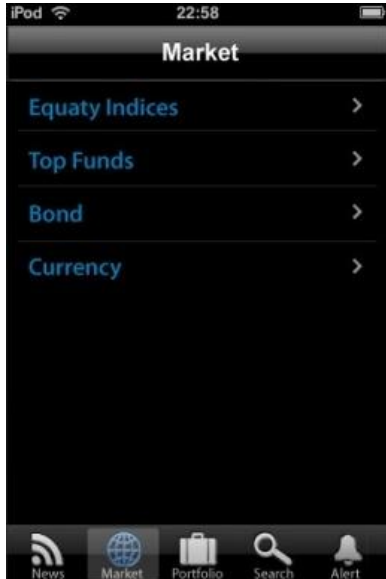


Figure 107: First page of Market



Figure 108: Indices list



Figure 109: Top fund list

Portfolios - a table shows user's portfolio list, and their performance in different currencies, user can define different portfolios and manage them. They drill down to monitor a certain portfolio: (See Figure 7)

Portfolio Table: provides overview of a portfolio performance. (See Figure 8)

- Treemap: Users can monitor their stock/funds performance in treemap visualization, have a quick overview which is gaining or losing. And they can filter the treemap by sector or drill down to a certain company to get quotes. (See Figure 9)
- Scatterplot: user can monitor their stock/funds performance against benchmarks, looks for outliers, and drill down to a certain company to get quotes. (See Figure 10)

Portfolio	Daily Chg	Value
USD		
Portfolio1	+4333	73324
Portfolio2	+83229	9342
Euro		
Portfolio3	+6645	43243
Portfolio4	-4345	65654
Total	+90231	182.8k

Figure 110: First page of Portfolio

Name	Chg%	Shares
AAPL	+0.4%	170
TIBX	+3.2%	237
NOK	-2.3%	236
INTC	+2.1%	150
RIMM	+3.2%	30
CSCO	-1.3%	130
Total	+23.2%	-

Figure 111: Portfolio table



Figure 112: Treemap

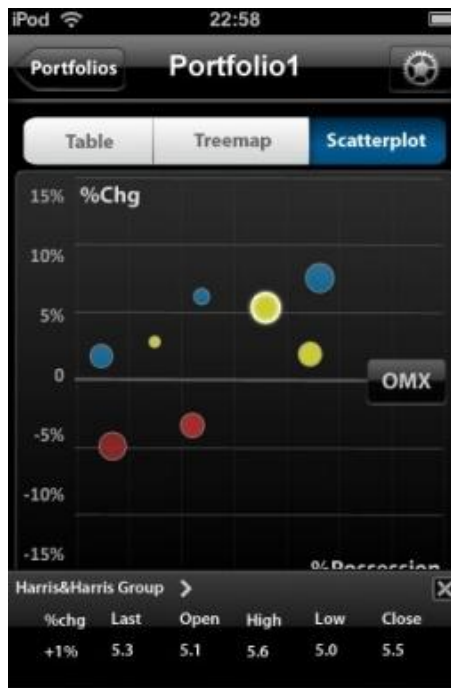


Figure 113: Scatterplot

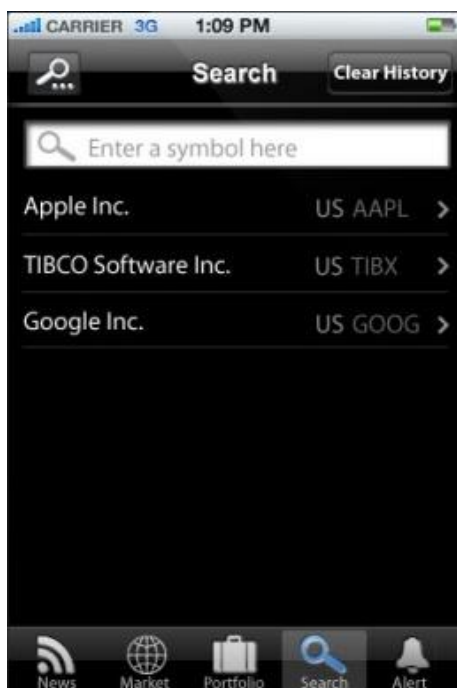


Figure 114: Default page of Search



Figure 115: Screener (flip page of Search)

Search - provides a text box to search by names/ticker directly (See Figure 11), or screener to filter the stock/funds with several defined criteria (See Figure 12).

Alert - takes advantage of mobile feature that it is always along with its user; user can set alerts for as the price or volume raise or fall to a certain number in a similar way setting a clock alarm, and get the alert message in time. They can also view the alert history to see activated ones in case of missing the alert.

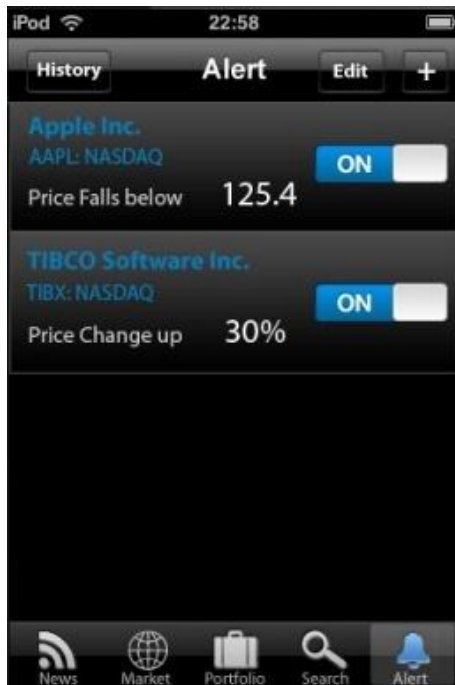


Figure 116: Default page of Alert

User interface (rationale)

Application Style

The requirement for the GUI design was quite flexible, no strict rules such as using the same colors or controls as the Spotfire software uses. It should consist with the iPhone look and feel as all other iPhone applications, yet still has its own style.

There are three application styles defined: productivity application, utility application, immersive application. (“iPhone Human interface Guidelines”: Choosing an application style) Based on its requirements on visual and behavioral characteristics, data model and user experience, the project was designed with both Productivity application and immersive application styles.

It is considered as productivity application in general, because it keeps user focus on the information and the task, quickly find what they need and complete the task. The data are organized hierarchically (See Figure 1), which requires user to drill down through successive levels of detail until the desired level is reached. Overall, it works as a tool to help users to do the routine check-ups the updates on the stock market.

However, it also offers different interactive charts, where users can manipulate the visualized information. So as in this mode, the application was designed with immersive style: a full-screen, no large amount of text-based info, and focus on visual contents and user experience. Non-standard control and custom navigational methods are appropriate as let users discovery themselves would be part of user experience.

Therefore, a combination of both productivity style and immersive style makes the product its own style. When it works as productivity application, the goal is to keep user focus on completing tasks, so there are no fancy colors or animations to disturb user performing the task; when user interacts with the charts, the application is considered as immersive style, more visualization and gestures design were engaged.

According to the usability of the product and requirements from the customers, the product was supposed to bring users professional feeling. Therefore, for the color we chose black as the background, because comparing to earlier trials on white background, it brings out the graphical interface better and looks professional and trendy as well. The other main color is blue, which was picked up from the “TIBCO” logo, in a way consist with company’s icon, as well as brings calm to the user as they are using the application.

Gesture interaction design

Gesture interaction design is one of the most challenge and interesting parts during the interface design. Making a good use of the gestures design enhances the user experience, and makes the application more intuitive, otherwise, the application would be intrusive and clumsy to use.

iPhone OS users enjoy a heightened sense of direct manipulation because of the Multi-Touch interface. Using gestures, people feel a greater affinity for, and sense of control over, the objects they see on screen, because they do not use any intermediate device (such as a mouse) to manipulate them. (iPhone human Interface guidelines: Direct manipulation)

The correct feedback of the gestures interaction is also important, which enhances the sense of direct manipulation in your iPhone application, make sure that:

- Objects on the screen remain visible while the user performs actions on them
- The result of the user's action is immediately apparent

With correct feedback the users feel gestures are more natural or learnable, which means they would learn the techniques easily apply on the same or similar situation again.

People use their fingers to operate the unique Multi-Touch interface of iPhone OS-based devices, tapping, flicking, and pinching to select, navigate, and read web content and use applications. They give users a sense of immediacy and connection to the device. (iPhone human Interface guidelines: support gestures appropriately) However, fingers have one major problem: the fingertips are much bigger than a mouse pointer. Therefore, to design a good user interface for a finger-based input system, the coverage of the fingertips and alternatives for replacing the mouse pointer must be considered.

The gestures users make to interact with iPhone OS-based devices are: Tap, Drag, Flick, Swipe, Double Tap, Pinch Open, Pinch Close, Touch and Hold.

- Tap: To press or select a control or item (analogous to a single mouse click).
- Drag: To scroll or pan.
- Flick: To scroll or pan quickly.
- Swipe: In a table-view row, to reveal the Delete button.
- Double tap: To zoom in and center a block of content or an image. To zoom out (if already zoomed in).
- Pinch open: To zoom in.
- Pinch close: To zoom out.
- Touch and hold: In editable text, to display a magnified view for cursor positioning.

Most gestures used in the design consist with the standard gestures, because “it’s important to avoid defining new gestures, especially if these gestures perform actions users already associate with the standard gestures.” (iPhone human Interface guidelines: support gestures appropriately)

Most common gestures used in the design are: tap and drag. Thus, users would find the application is a coverable and easy to use, besides, the application would be used frequently as a tool for quick check-ups, too complicated gestures would confuse the users and effect the flow of the design.

Only exception is for the charts, which was designed with immersive style, in which custom gestures can be appropriate. Because this provides an environment for users to manipulate the information visualizations, it invites them to explore and get their desired information.

New gestures (usage) designed in the project are:

- *Pinch open*: this is used for information visualization charts, so that enable users to read more details on the chart or easier to tap on the target.
- *Pinch close*: return to normal size or see bigger overview.
- *Drag*: for the tables, users can scroll to read more rows; for the chart, users can move the chart to view hidden information.
- *Touch and hold*: this is used on stock/fund chart, when the user keeps a finger on chart for a while, the time marker (cursor) shows. The reason to use touch and hold to activate the marker is because that the marker follows the finger as it moves on the chart, and disappears as the finger off the screen. And it would not show if user were simply just zoom in/out or move the chart. It is quite similar to enable the text cursor with the same gesture.
- *Rotate*: rotate (90 degrees) is use to enable the chart in the quote view, as the chart is lied horizontally, it avoids showing the chart in wrong direction, that user still have to rotate again to view the chart.

Application controls

Standard iPhone controls:

In iPhone OS, UIKit provides the default appearance of views and controls. iPhone users are familiar with the look and behavior of standard view and controls. Their previous experience helps them to recognize and use it. If iPhone OS changes the looks and behavior of standard views and controls, these controls you used in your application continues to work and up to date with the new standard. Due to these reason, Apple recommends developer to use the standard user interface element as much as possible. (iPhone Human Interface Guidelines, 2009)

Status bar

Status bar shows the important information about the device; include cell signal strength, the current network connection, and the batter charge (iPhone Human Interface Guidelines, 2009). The contents and display of the status bar are exactly the same as the standard view. It always shows on the top of vertical screen, and hide when full screen shows, like horizontal screen of chart. In the standard there are three color available, gray, opaque black, and translucent black. The opaque black is chosen, since it consistent with the theme of the application.



Figure 117: status bar

Navigation bar

Navigation bars display the current view and contains controls that act on the view's contents, in addition to navigational controls when appropriate (iPhone Human Interface Guidelines, 2009). In this application, all the pages have navigation bar. For the verticle screen, it appears at the upper edge of the application screen, just below status bar. Most vertical view has the same display of the navigation bar, the title of current view shows on the middle of navigation bar, the navigation button is put on the left (mostly are back button with text of previous page), and the manage button is on the right (like add, edit, setting, etc). The exception is the edit view, which has "Cancel" and "Done" button on the left and right of navigation bar. For the horizontal view, the navigation bar is on the top of the screen. The title is displayed on the left, and other controls for the current view shows after the title, for example the chart. The project chooses the black color with bordered style (standard style) for the navigation bar as well as all the controls on it.

Tab bar

Tab bar provides different subtasks related to the overall function of the application, it appears at the bottom edge of the screen (iPhone Human Interface Guidelines, 2009). This project use tab bar as the menu of the application, it is able to access from everywhere on the vertical screen, means the user can switch the function at any time. It hides in the horizontal screen. There are five buttons on the tab bar, represents five functions of the application, which are news, market, portfolio, search alert. The design of the icon on the button is the same as default, icon on the top, and text below the icon. Since the suitable icon couldn't be found in "standard icons of tab bar tabs", the icons are designed especially for this application.



Figure 118: tab bar, alert is in active

Action Sheet

An action sheet displays a collection of alternatives that are associated with a task users initiate by tapping a button in an application. It gives users additional choices related to the action they are currently taking by a few buttons, and the "Cancel" button is available for the user to dismiss this task. It emerges from the bottom of the application screen and hover over its views (iPhone Human Interface Guidelines, 2009). This project uses the action sheet in forward news.

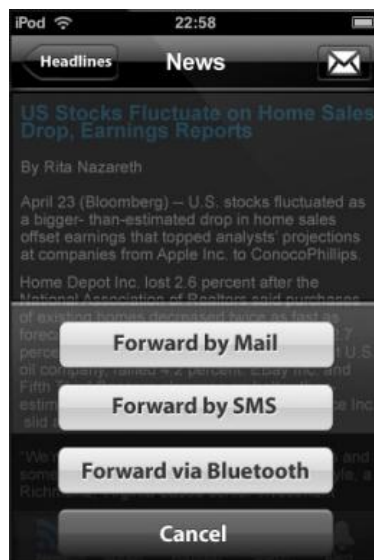


Figure 119: Action sheet, give user options of send mail or cancel the task

Segment controls

A segmented control is a linear set of segments, each of which functions as a button that can display a different view. When users tap a segment in a segmented control, an instantaneous action or visible result should occur. The height of segmented control is fixed; and the length of segment control can be customized. Be aware of that users must be able to comfortably tap a segment without worrying about tapping a neighboring segment, the maximum number of segments is five. Each segment can contain image or text, but not both, and mixing text and image in a single segmented control should be avoided. (iPhone Human Interface Guidelines, 2009) This project used segment control in different views of portfolio, the fund portfolio and settings. Brand blue and white are used for the segments, a blue segment means being selected, while the white segment means unselected.



Figure 120: Segment control

Picker

Picker can be used to display any set of values, especially for the well-known set like months, weekday, etc. Each wheel of picker can stock one kind of data; there can be up to 4 wheels in a picker. Users spin wheel (wheels) until the desired value appears. There is a control bar on the top of the picker, which contains buttons like "Cancel", "Done", etc; it provides options of execute or cancel the task. The size of the picker is fixed; it is the same as the keyboard. It can't have the label as header like time, hours, it has the unit close to the value instead, like 10 mins, 2 hours, etc. (iPhone Human Interface Guidelines, 2009). Picker can be always shown or appear when needed, in this project, the latter way is chosen. It is triggered by a button with white outline. When tapped on the button, the picker shows, and the outline of the button turns out to be blue.

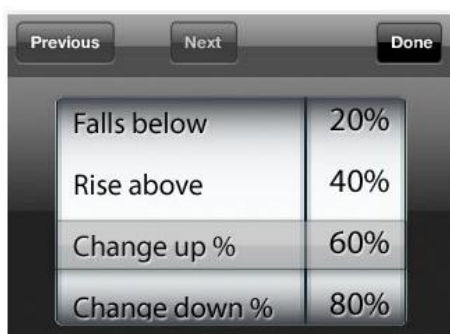


Figure 121: Picker with the control bar

Detail disclosure button

A detail disclosure button reveals additional or more detailed information about something (iPhone Human Interface Guidelines, 2009). In this project it used in many place, like in the table view, on the tooltip, etc. It help user to access more detail content of the item.

Switch controls

A switch control presents to the user two mutually exclusive choices or states. It only used to show only one of two possible choices at a time, users slide the control to reveal the selected choice and hide the other one (iPhone Human Interface Guidelines, 2009). This project has on and off switch controls in alert.

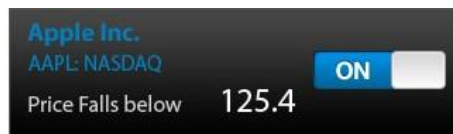


Figure 122: Switch at “on” state

Delete control button

Users tap this element to reveal and hide the Delete button for each list item. To give additional feed back to users the horizontal minus symbol inside this button becomes vertical when users tap it to reveal the Delete button (iPhone Human Interface Guidelines, 2009). It was used in the table view and edit view in this project.



Figure 123: Delete control (default)



Figure 124: Delete control (vertical)

Designed control

Expandable panel

Expandable panel is a panel can be expanded to show more information when needed. Users want to browse items as more as possible in one page, however some item contains many information occupied quite big space. Expandable panel is used in this situation. It folded at default mode shows the most important information. If the more information needed, users can click the arrow to get the full view by expanding the panel. This is used in edit portfolio view. On the default panel view (folded mode), only ticker, delete button, and date appears; buy or sale status, shares, and price is shows on expand panel.



Figure 125: Expandable panel in folded status



Figure 126: Expandable panel in unfolded status

Dropdown bar

Users tap this element to reveal and hide the list of item below it. The arrow on the left of the bar gives more feed back to the users by direction. It towards to the right when the items hided, and it towards down when items appears. It used in some of the tables and news in this project.



Figure 127: Dropdown bar in folded and expanded

Table header selector

Iphone has every limited space of screen. In the table view of vertical screen, there are usually three columns shows. The table header selector is used when it needs more than three columns. It is a white triangle besides the header of column. The columns changes by clicking the table header selector.



Name	Chg%	Shares
AAPL	+0.4%	170
TIBX	+3.2%	237

Figure 128: Table header selector

Tooltip for vertical visualization of data (Treemap & Scatterplot)

Tooltips is conjunction with user touch in the vertical visualization. When the users touch the item, tooltip panel comes up from the bottom of the screen with the detail information of the selected item. Tooltip panel covers the tab bar, and bigger than the tab bar to draw more attention from the users. The exit button and detail disclosure button appears on it to provide more options. In this project, it used in Treemap and Scatteplot of portfolios.

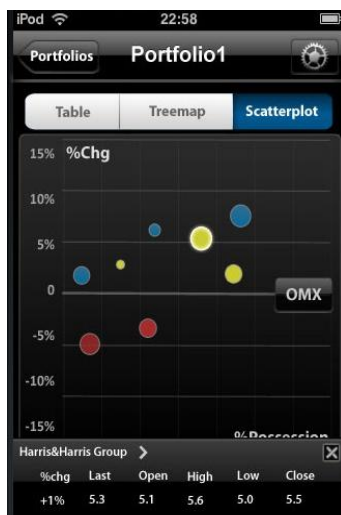


Figure 129: tooltips in scatter plot, the bright outline point is selected

Color palette for color bar setting

This circle color palette is designed to enhance the user experience. It takes advantage of the direct manipulation, users can spin the palette by spin it use finger to get their desired color. This is used in treemap settings for user to change the color theme of the treemap according to their preferences. It appears when user taps on squared button on the left to the colorbar. The color the triangle arrow points to represents the chosen color for the left most color on the colorbar.



Figure 130: Color palette in Treemap settings.

Controls for horizontal visualization of data (Chart)

Cursor

Cursor is a moving line with point to indicate the position on the chart users touched. It appears after the users touch and hold for a while on the chart. The cursor keeps a distance from the touch point, avoiding covering by users' hands. More information of this point is shows besides the cursor. Since most people are left hand, the cursor and the information should appear on the left of the touch point when it allowed.



Figure 131: cursor in chart

Legend button

In the chart, the variables appear on the legend button. It allows the data from each variable to be identified. The color maker, ticker and the last value of the variable are appear on the legend button for default view. The value of the variable changes with the cursor, it shows the value of the cursor position. The legend button also provides delete option by a tap. The delete icon appears when users touch the button, and cancels the task by touch any where than the delete icon on the button. The legend button is used in the stock chart and fund chart in this project.



Figure 132: Legend button (default)



Figure 133: Legend button, tapping on it to reveal the delete icon

Line button

Line button is a linear set of buttons, each of the button represent a option for the chart. the options could be different form of visualizations, like bar chart, line chart, etc; and also could be different type of chart, like volume chart, RSI chart, etc. Line button appears after a single tap on the chart.



Figure 134: Line button in stock price chart, type of "Line" is selected

Expandable button

Expandable button shows the selected button for the default mode, and a linear set of buttons slide out by a tap on the expandable button. This project used the expandable button to represent different time frames.



Figure 135: Expandable button in stock chart, "5D" (5 days) is selected

Information Visualizations

Stock chart (fund chart)



Figure 136 Line chart

There are different mediums used for visualizing stock data. The most common charts for showing the development of stock market prices would be: line chart, OHLC, and Candlestick. Obviously, charts give a direct depiction of the differences and patterns in the set of data, from which the reader can see major differences or similarities immediately.

And unlike traditional charts which are static only for monitoring, more charts used today can be interacted with, from financial website such as Google Finance, MSN money to mobile applications such as iPhone Stocks, Bloomberg, they all offering different options for users to manipulate the charts to get more details, the figures from the tables. Therefore, it combines the advantages from both chart and table.

In the chart area, two charts are used for visualizing the market data for the selected security. The price chart at above is for price development, and the other one below is for technical indicator or risk chart (for fund chart), which is "An indicator is a result of mathematical calculation, based on prices and/or volume. The figures received are used for forecasting price changes." [1]

For the price chart, there are four types of visualizations provided to show the stock price movement: Line chart, mountain, OHLC, Candlestick. The line chart is set as the default chart (See Figure 17), however, by single tapping within the plot area, a line of buttons for

different types of visualizations appears from the bottom of the plot area, where user can switch between these types while having a good preview of the chart without finger covering. The y-axis label is not present, for the users can easily acknowledge that it is either showing the price or percentage change in comparison mode if they read the y-axis values. The x-axis is shared by both price chart and TI (Technical indicators) in stock chart, While in fund chart, the risk chart is shown with maximum time, regardless the time period selected for the price chart. At the right-most along the x-axis is the period select button, where users can select different fixed time period of the market development.

Same as the price chart, a single tap on the plot area of the technical indicator, a line of different TI buttons appears, with different calculations: Volume, RSI, MACD, P/E, Yield, and Distribution. However unlike price chart, it shows right below the top frame line of the plot area, the reason for it is to avoid the chart being covered by the buttons, and to be consistency where the line buttons shown (between two charts).

Similarly, in the case of fund chart, different mathematical methods for calculating the risk can be chosen in the risk chart: Alpha, Beta, Information Ratio, Sharp Ratio, and Tracking Error. The risk chart is referenced to the Spotfire analysis file for the BNP Paribas banks and designed to be consistent.

Above the plot area on the right there are four key figures: open, high, low, close. As default, the last updated numbers will be shown, and as users activate the cursor, the numbers of the marked time will be shown instead. However, if there are comparisons added to the chart, the legends will be shown instead of numbers, because in this case the focus move on the comparing the stocks/funds other than the single stock/fund and also the legends should always keep close to the chart for easy reference. The change percentages are shown on the legend.

There are three default colors used for the chart: white, blue and grey. The white is mainly used for different values, such as time, price, volume, because it pops out from the dark background, so for the users it is easy to notice the interesting figures; the blue color picked from TIBCO icon is used for representing the selected stock/fund plots and the ticker title, and the light grey is used for labels which is non-intrusive when reading the values. When comparisons are added, colors with the same tone are used for representing different stocks/fund.

Pie chart (Drill down pie chart)

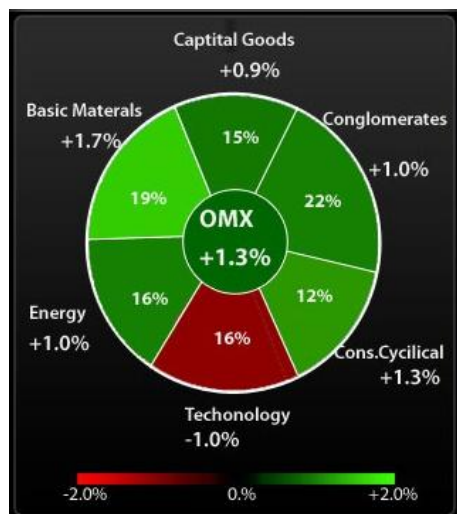


Figure 137: Pie chart

“Pie chart is suitable to illustrating percentage distributions of qualitative variable.” Since it difficult for eyes to measure the percentage from a circle, it is best for overviews. (Graphing statistics & Data, 1996) The pie chart in this project is like the normal one, adding a center circle. It is used for presenting the current level. The key information of each sector of the pie chart is inside or besides the sector. It shouldn’t have too many sectors in a pie chart, since it makes no space for the sector information. Seven or eight sectors are the maximum, the left light-weight sectors are grouped in “others”. The color of each sector could also be used to indicate some information if needed, like the in the stock index industry pie chart, the color represents the daily changes. If the color represents something, the illustration should be besides the chart, like the color bar.

Just a static pie chart is not enough and gives too thin information in certain place. A good visualization allows users drill down and find data about anything that seems important (information visualization, Colin Ware, 2004). The drill down pie chart is chosen in this situation to give an overview and provide an option to go next level information of each sector. The users could tap on each sector to go to next level, and touch the circle in the center to go to upper level. This project use static pie chart for the fund portfolio, and drill down pie chart for the stock index industry.

Drilldown Treemap



Figure 138: Treemap

Treemap is a data visualization technique good at making use of space and presenting the hierarchy data. The basic element of treemap are rectangular boxes, they are grouped by each category in hierarchy system. Users can click on title of the next hierarchy (in button form) to see that part's structure. The title of the current hierarchy is on the top of treemap in a button form, users can go back to the previous level by tapping on it. The meaning of the size and the color of the rectangular boxes can be customized by users in setting. The color bar is under the treemap. The detail information of each rectangular box is giving by tooltips, which appears when users tap on the box (see Tooltips in Application Control). The selected rectangle is at pressed mode.

The project use treemap in users' portfolio. It gives an overview of the change in the portfolio. The setting button on right of the navigation bar provides the options of what the color and size represent. It could be color by daily changes, 1 month changes, 1 year changes, etc; and size by market cap, proportion in the portfolio, etc.

Scatterplot

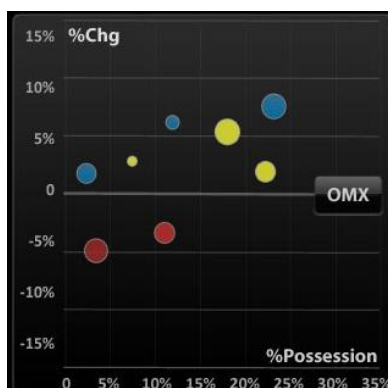


Figure 139: Scatterplot

Scatter plot are collection points display on a Cartesian coordinate system. The position of each point is determined by two variables which are x axis and y axis. The size and color of the point can be customized by users in settings. The detail information of each point appears by tapping on it (see Tooltips in Application Controls). The selected point is outline with bright color.

This project uses scatter plot shows how stocks and funds perform relative to certain benchmark; the benchmark could be chosen by users. The y axis and x axis represents the changes over benchmark and the possession of the stock/fund in the portfolio. The meaning of size and color, and the time frame can be customized in the settings.

References:

Book:

1. iPhone Human Interface Guidelines
2. Graphing statistics & data: creating better charts (Anders Wallgren, Britt Wallgren, Rolf Persson, and Ulf Jorner)

Internet source:

- [1] <http://www.metaquotes.net/techanalysis/indicators/>