CLOUD COMPUTING EMPOWERED MOBILE ALGORITHMIC TRADING SERVICE - COPING WITH THE CHALLENGES FROM AUTOMATIC SECURITY TRADING

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ABSTRACT

The ubiquitous accessibility of communication networks, variously selectable mobile applications, and increasing computing capability of mobile devices have jointly enabled the new generation of mobile financial investment services – mobile algorithmic trading. In this paper we propose Mobile Algorithmic Trading System (MATS) to cope with the pressure from professional investors having adopting algorithmic trading and the ever-volatile security market, taking advantage of the innovations in mobile communications. Empowered by cloud computing and advanced security market infrastructure, such as Electronic Communications Networks, Direct Market Access (DMA), MATS is able to help investors optimize their investment operation against market fluctuation and make profit with lower risk.

1. INTRODUCTION

So far, there has been many popular mobile financial services applications on iOS or Android systems, such as Yahoo Stock APP, Scottrade Mobile, CNBC Real-Time, and mobile E*Trade, Interactive Brokers, etc. In particular, the mobile trading applications, or mobile trading services, allow users to access the real-time security product information almost ubiquitously, submit trading orders to order management system instantly, and receive the trading results conveniently. However, as more and more online traders pour into the security market a large number of orders, the security prices and market fluctuations become more dynamic. Particularly, since security markets respond promptly to new information and excess returns decrease over a short period of time, investors may miss important trading opportunities or take a wrong movement due to their

misuse or misprocessing of the massive information (Muntermann, 2009). In this way, proving more powerful mobile trading services becomes a common necessity.

In another aspect, individual online traders are facing more and more pressures from the algorithmic trading (AT), which is getting popular among professional brokers (Coggins et al., 2004). AT is defined as the use of computer algorithms to optimize trading operations. After the reformation of decimalization in 2001, AT is getting popular quickly, because of its lower trading cost, reduced trading risk, and higher trading revenue in securities exchange markets. Now AT has been accepted by both the selling side and the buying side. It is estimated that in 2009 AT is responsible for 73% of trading volume in the equity market in the U.S. (Kim and Kaljuvee, 2007, Hendershott et al., 2011). Guided by a carefully configured strategy, the back-end AT system can help the investor to sell or purchase securities or stocks systematically in multiple markets, and handle emerging market risks timely in accordance with dynamics of security markets (Giddings, 2008).

Although mobile devices offer a real time access to financial markets almost anywhere, the human users cannot compete with computers in processing mass data and placing orders in speed and accuracy. The small screen cannot show trade information effective, touch screen is unable input trade orders quickly and precisely and the network access quality effects real time property directly. To cope with these challenges, there are more and more available applications for regular computers, taking the advantage of their increasing computing power, but still far from enough to the mobile devices. In this way, the ordinary mobile traders are in the adverse position compared to the professional brokers. Meanwhile, the AT-enabled security market has become much more volatile and riskier to many people. For example, the 2010 Flash Crash happened on May 6, 2010 at 2:45p, was a United States stock market crash in which the Dow Jones Industrial Average plunged about 900 points in a short moment (Lauricella, 2010). Obviously to avoid the impact of the AT on individual security traders is beyond the capability of manual online trading.

To help those users using mobile devices to trade stocks as effective as using a computer platform, this paper is intended to propose the scheme how to incorporate algorithmic trading technology into mobile security trading system. To facilitate technical analysis of algorithmic trading, a computing platform powerful enough to handle the mass data storage, quick retrieval and real time calculate demand is crucial. To make a mobile algorithmic trading system feasible, there are two main problems to be solved. The first one is how to allocate the proper computing tasks in the mobile devices. Traditional mobile MFS applications are based on thin-client application architecture because of the limited computing capability of mobile devices, and rely heavily on the remote servers. Now the more powerful and smart mobile devices allow some computing tasks being scheduled locally, though these features are still limited. Therefore, optimizing the computing resource allocation is necessary. The second problem is how to support the heavy computing tasks with instantaneous response time at the server side since algorithmic trading consumes heavily the computing resource. As Agopyan et al (2010) indicate, well

developed cloud computing application utilities for AT can provide versatile information services in data collection, analytics, trading, and risk management, particularly in a high frequency trading platform. Thus we propose that cloud computing technology is applied to reinforce the implementation of the mobile algorithmic trading services, in which mobile device only sends compound instructions and accepts treated data, leaving the data storage and computing done by server or grid computing system.

2. PRINCIPLES OF MOBILE ALGORITHMIC TRADING SERVICES (MATS)

Algorithmic trading, which is also called program trading, automated trading, black-box trading, qualitative trading, can be defined both in generalized sense or narrow sense. In the narrow sense, algorithmic trading is a system which splits a block trading order into several small orders and automatically submits these orders to exchange market quotation system in the appropriate time with the optimized price and quantity. In the generalized sense, algorithmic trading is a system used to collect security markets data and to automatically make trading decisions based on configured trading strategies, in this papers we adopt the generalized definition, which typically includes three types of trading models.

1) **Quantitative trading**, by which the trading rules are enforced by adopting proprietary quantitative models.
2) **High frequency trading**, intended to take advantage of opportunities intraday. It is a specialized type of quantitative trading focused on exploiting short term gains.
3) **Statistical arbitrage**, representing a systematic trading approach based on a fusion between real-time and historical data analysis to take advantage of the mispricing of financial instruments while minimizing overall risk.

Compared with traditional execution transaction orders by traders, AT has several advantages, including lower trading cost, reduced security holding risk, anonymity, flexibility of trading strategy, ability to capture trading opportunities in short time (Kissell et.al., 2005). Taking the case of block-trade order splitting, solely executing the traded volume could cause the market overreaction with the price moving towards an adverse direction. Thus, AT splits a big block-trade order into multiple small ones and delivery them successively in a small interval to reduce the market impact (Gsell, 2008). Because AT handles trading orders based on the analysis of historical data and the optimized trading strategies, AT can avoid the effects from emotions and subjective biases which have been the main causes the irrational transactions. There are diversified trading strategies. The two most prominently used trading strategies are VWAP (volume weighted average price) and TWAP (time weighted average price). The issue is that they are both computationally costly and demand heavy computing overheads.

With the evolution of AT technology, the security market has stepped into the millisecond era, meaning that a few milliseconds could lose or gain a lot for a firm from a trade (Kim and

Kaljuvee, 2007). As getting market information spontaneously and monitoring real time price volatility are crucial for investors, DMA and Financial Information Exchange Protocol (FIX) were proposed (Johnson, 2010).

Based on the above discussions a mobile algorithmic trading system (MATS) is designated to provide traders advanced features of the security market access, which must be able to operate with the advanced trading strategies interactively and consolidate with the processes in remote servers with timely performance. And MATS is characterized in: 1) Extended user interface for strategy decision making and preference configuring (the client side), 2) the needs for powerful computing capacity at the server side, and 3) the unique protocol between mobile applications and the security market (the server side).

3. DESIGN OF MATS

MATS is currently designated to offer three kinds of services: portfolio recommendation, automatic security management, and algorithmic trading. The portfolio recommendation service offers advices to investors which portfolio meets their needs based on the outcomes from security market analyses. The automatic security management service is provided by a subsystem which monitors market fluctuation in real-time and makes trading decisions according to the authorization granted by investors. The algorithmic trading service delivers all transaction orders effectively and costless to the market regarding their priorities. Typically, MATS will have several different trading strategies selectable to the investors.

3.1 Architecture of MATS

Mobile devices can delivery instant operation orders, but its capability of storage and computing power is far from enough to meet the requirements from AT. According to the statistical data of Securities Industry Automation Corp (Kim and Kaljuvee, 2007), the message traffic of finance market is growing quickly from 56,000 messages per second in Nov. 2004 to 200,000 messages per second in Nov. 2006. The information of financial market is not only excessive, but also dispersive. A message generated from one market may be correlated to the one in another market, so as mobile devices are clearly incapable of supporting key AT services. On the other hand, an ordinary investor is unable to monitor stock volatility in front of a computer all day long, and only mobile devices can be the medium to communicate market information and delivery orders in time anywhere. In this way, MATS becomes an intelligent trading system to connect mobile users with high frequent exchange quotation systems to facilitate investors in optimizing the implementation of their trading decisions through the AT technology. A basic structure of MATS is presented in Figure 1. The real MATS should be in a more elaborately designed structure with the components that support more powerful functions. At this stage, we only provide an illustrative diagram to address the main principles and mechanisms of MATS.

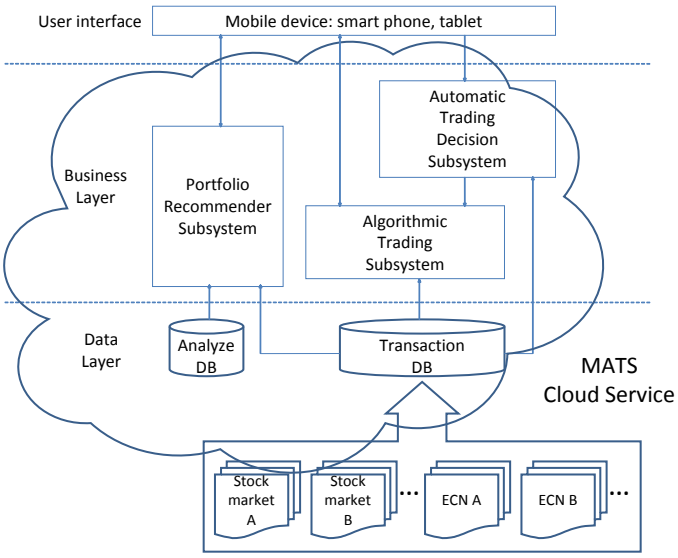

Figure 1. The Structure of MATS

Based on the structure in Figure 1, investors can access MATS by mobile devices and make use of the utilities provided by the system. When receiving a consultation instruction, Portfolio Recommender Subsystem will extract relevant information from two databases, Analyze database and Transaction Database. Analyze Database contains recent macroeconomic data, industry analysis, and the financial data of list companies created by analysts. The consultation instruments may include investment preferences, such as the expected duration of this investment, risk tolerance degree, targeted market, and so on. Then the Portfolio Recommender Subsystem will match these requirements with the investor's trading records and the required analysis data. Finally, an optimized investment recommendation, including the composition of investment portfolios, holding interval, expected return, and volatility, is feedback to the mobile device.

Algorithmic Trading Subsystem plays a central role in MATS, all trading instructions, from either Automatic Trading Decision Subsystem or the investor, are executed by this subsystem. Since security trading is sensitive to time delay, missing a single millisecond may cause an order not being matched. The primary improvement of MATS is fast transaction of the order, which is the time interval from the spot of a trading opportunity to the execution of exchange system, compared to the disadvantage of ordinary mobile stock trading system (MSTS). There are at least four network nodes in the ordinary mobile transaction system: mobile devices, wireless router, order management system of broker and stock exchange system. Algorithmic trading system can connect the quotation system of the exchange market by the DMA technology to access liquidity pools, and deliver and execute orders instantly. Algorithmic Trading Subsystem can deliver orders to different security markets at the same time owing to Electronic Communication

Networks (ECN), which offer services of accessing multiple markets. This can be handled through proprietary methods or algorithms for selecting the market venue that is likely to provide the best combination of speed, quality, price, and certainty of the order execution for investors. The design of communications between Algorithmic Trading Subsystem and financial markets is based on the FIX Protocol.

As abovementioned, Algorithmic Trading Subsystem can be used to minimize the impact on the market and reduce the transaction cost by splitting a block-trade order into small orders then submitted them to the limit book of exchange market in appropriate moments. All these automatic operations rely on the analysis of high frequency transactional data saved in Transaction Database. The data sources are scattered globally, because a list company may issue shares in different stock exchange market. Another important factor is the widely used ECN (a kind of electronic communication network facilitating trading outside of stock exchange, where investors post limit orders and exchange with others if their orders matched). By these ECNs securities can be traded outside of the exchange quotation system, after American stock exchanges close, and investors can transform their securities in a globalized financial market scope. To meet the requirements of fast data storage, immediate message retrieval and computation under the restriction of loose data source distribution and diversified mobile devices, we designed Algorithmic Trading Subsystem on a cloud computing platform.

4. IMPLEMENTATION

In this part the ideas of MATS described above are implemented and tested, which consists of three parts: mobile client, background function realization, and cloud computing support.

4.1 Mobile client

The client side is responsible for the delivery of instructions and feedback of operation results by the mobile wireless network. We developed a prototype MATS client for iPhone Beta 1.0 in Object C programming language on the iOS platform (Figure 2). There are five basic functions in the MATS client for iPhone Beta 1.0.

1) **Portfolio recommendation**, where the mobile client user sets his preferences of portfolio including risk preference, investment sector, types of securities, available fund, and expected holding period, and where he gets personalized portfolio recommendation from the portfolio recommender subsystem.
2) **Portfolio management,** where the mobile client user sets portfolio parameters including portfolio type (hedging, arbitrage, or speculate) and security (stock, commodities future， stock index futures, or bond) to automatically trade or manage with the automatic trading decision subsystem, and reviews the trading results of the orders processed by Algorithmic Trading Subsystem.

3) **Algorithmic trading configuration,** where the mobile client user chooses the pricing model for the security, the algorithm to be applied in trade, and the parameters of the algorithm.
4) **Authorization management,** where the mobile client user sets the level of access authorization to the MATS.
5) **Account setting,** where the mobile client user sets his account (user name and account code) and personal information.

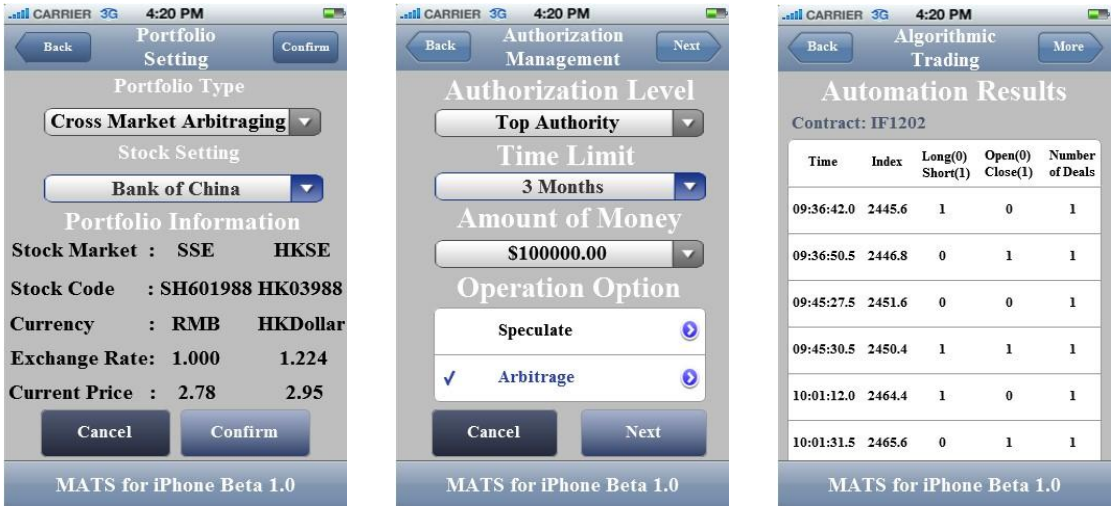

Figure 2. Screenshots of MATS Operation

4.2 Server side functions

The portfolio selection, strategy recommend, and trading execution are implemented at the server side. In accordance with the diversified trading strategy preferences and risk bearing ability of investors, the amount of available fund, and anticipated holding interval from analysis database, Portfolio Recommender Subsystem generates optimized portfolio and strategy based on CAPM (capital assets pricing model) or other pricing models. As mentioned above, Automatic Trading Decision Subsystem keeps monitoring market volatility to prevent the losses caused by sudden fluctuations. Automatic Trading Decision Subsystem of MATS (see Figure 1) is unique in that it is able to make trading decisions as soon as possible when breaking news in the markets are happening, because it is supported by iNews security prediction system that monitors the news about markets on the Internet and that predicts security based on the Internet news, where iNews security prediction system is an ongoing research project sponsored by Ministry of Education since 2011. Investors can set different levels of authority in terms of their personal preferences. If an investor fully trusts in Automatic Trading Decision Subsystem, he may grant a top authority to it. Thus, when a stock price drops dramatically or it has significant drop trend based on the technical analysis, Automatic Trading Decision Subsystem will offer corresponding transaction order to Algorithmic Trading Subsystem. The medium authority allows this subsystem trading securities after a warning message is confirmed by the investor, if the user sets a low authority to

Automatic Trading Decision Subsystem, it will only behaves as an early warning system and the securities will be traded by investors themselves.

The Algorithmic Trading Subsystem of MATS can automatically place an order every 500ms to trading system of security exchange market by DMA. The development of communication between Algorithmic Trading Subsystem and financial markets is based on Securities Trading Exchange Protocol, which is based on Financial Information Exchange Protocol 4.4.

Currently, the operation of MATS is based on range breakout and relevant parameters (highest price, lowest price and closing price of the previous day) to generate trading strategies. To facilitate the application of MATS, we choose the most prominently trading strategy VWAP.

4.3 Cloud computing technical support

The financial market message traffic increase rapidly, the data is mass and the data source is scattered all round earth. To facilitate rapid data storage, computation and transaction, a computer cloud will be employed by MATS to perform major computational tasks in a concurrent manner. To facilitate services of MATS we are to adopt SaaS (Software as a Service) model to our cloud computing system. In this way, MATS is provided to the users as a kind of cloud service. Although major time-critical features of MATS must be performed in the servers co-located at security market sites to minimize the latency, some functions of Portfolio Recommender Subsystem, Automatic Trading Decision Subsystem, Algorithmic Trading Subsystem, and databases of MATS could be running on the leased servers. These servers access the data sources in different security market via the Internet, process macro-orders, and monitor news about the markets on the Internet. These servers receive instructions from the iPhone client users and send operation results back to users via Mobile communication networks. Large servers for MATS can be leased from cloud service providers or operated in proprietary server farms. As an example, the leased servers are co-located to Shanghai Stock Exchange, so that the Algorithm Trading Subsystem is able to receive the latest market data in a few milliseconds (the market data is updated in Shanghai Stock Exchange every 500 milliseconds) and react to the financial market just in several milliseconds by improved communication protocols for MATS. Cloud investors do not build the cloud infrastructure and platform, on which the application is running, but the MATS service provider can update algorithms for them in real time to adapt market dynamic.

5. CONCLUSION AND FURTHER RESEARCH

In this paper we proposed the idea of mobile algorithmic trading system (MATS), which could be considered the next generation of mobile financial investment services. Empowered by algorithm trading, cloud computing, mobile wireless network, and advanced mobile devices, MATS provides faster, more accurate, more intelligent and more convenient mobile investment services

than traditional MSTS. With well planned strategies, MATS is expected to make more profits from security markets for its users. In the future, as the adoption of information technology to the security evolves, telecommunication network is more accessible, and mobile computing devices get more advanced, MATS is expected to become a major mobile investment means with more effective and efficient services to investors.

Once the architecture is proved feasible in practice, the implementation of the MATS client applications can be ported to more mobile devices, such as iPad, Android phone, and notebook computer. In addition, trading algorithms as well as the implementation of cloud computing applications will be further improved and optimized at the same time to serve the investors in the real markets.

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