# Automated Trading Software - Design and Integration in Business Intelligence Systems

Cristian PĂUNA
Economic Informatics Doctoral School - Academy of Economic Studies
cristian.pauna@ie.ase.ro

*After the introduction of the electronic execution systems in all main stock exchanges in the world, the role of the automated trading software in the business intelligence systems of any financial or investment company became significant. Designing of reliable trading software to build and send automated orders based on quantitative mathematical models applied in the historical and real-time price data is a challenge for nowadays. Algorithmic trading and high-frequency trading engines become today a relevant part of any trading system and their specific characteristics related with the fast execution trading process and capital management involves specific measures to be used. Smart integration of the trading software in the business intelligence systems is also a sensitive theme for any financial and investment activity, a plenty of functional, control and execution issues being subjects of researches for future improvements. This paper wants to gather together more particular aspects on this subject, based on the experience of last years, opening the way for future topics.*
***Keywords:*** *automated trading software (ATS), business intelligence systems (BIS), business process management (BPM), algorithmic trading (AT), high-frequency trading (HFT).*

## 1 Introduction

Trading shares in an organized stock market is already a stand-alone activity for hundreds of years. Since the transfer of an equity from a seller to a buyer for the money is a sustained process, it underwent a whole series of significant transformations.

After some organized markets appeared between the 15th and 16th century in Belgium and Netherlands, "the United East India Company was chartered in 1602" in Amsterdam and "a new bourse was begun in 1608" [1]. It was founded the first company with shares that can be bought and sold by the shareholders and this new trading shares activity does not affect the main activity of the company. "Altogether, 1,143 investors subscribed to the initial capital of the of the Company's Amsterdam chamber" [2]. "The Dutch pioneering several financial innovations that helped lay the foundations of modern financial system" [3]. It was only a step to the continuous trading of shares in the incipient stock market. A new era has begun, more stock exchanges was developed worldwide.

It is well known the image of a trading floor in a stock exchange, where the communications where made in open outcry language until recently. Even "until 2009 trades on the floor of the New York Stock Exchange always involved a face-to-face interaction" [4]. In this system all bids and offers were made out of the open market, giving all participants the chance to compete with the best price. All estimations were based on the last closed price, on the whole price history using the latest fundamental news, but no estimation was possible to be made based on the real-time price movement as we are used today.

In the last decades, introducing the electronic systems in the stock exchange activity was a significant step. Electronic trading (ET) is the method that use information technology to bring together buyers and sellers in a virtual market place using an electronic trading platform and a network that links all participants. The huge difference is now that the real-time price is available, which makes possible a more accurate prediction. The second important difference is that all orders are executed electronically, in a very fast

execution process, fact that affect the volatility and the speed of the price movement.

ET was born practically in 1971 when National Association of Securities Dealers Automated Quotations (NASDAQ) was founded. "NASDAQ was the world's first electronic stock market" [5]. After that, in 1987 Globex trading system was founded by CME Group, "conceived in 1987 and launched fully in 1992" [5]. It allowed access for ET of treasuries bonds, commodities and foreign exchange. A little bit later, the rival ET system CBOT (Chicago Board of Trade) was implemented, "an electronic trading platform that allowed for trading to take place alongside that took place in the CBOT pits" [5].

The fast IT development was a key factor in the ET domain. In the years of 2010 and 2011 massive investments were made in technology in all main stock exchanges in the world. This process determined the majority or the classical trading floors to be changed in ET systems, the classical brokers were removed from the trading chain and all trading orders were made and processed electronically. The impact was tremendous in reducing the costs of transactions, gather the liquidity and increasing the transparency of the price movement.

In this new context, the activity of any financial or investment company is driven by a BIS which is developed and optimized individually and related with the objectives of each institution. ET allowed a BPM to be automatized. In this process, using an ATS has become today a necessity for any trading and investment systems, to permit a quick adaptability to the market conditions that are changing practically every second.

Using technology to analyze real-time price has allowed the development of a new type of trading based on mathematical and statistical algorithms: algorithmic trading (AT). Computer software generate automatically buy and sell orders without any human intervention to trade individual financial instruments. High-frequency trading (HFT) term "has gained some significant attention due to the flash crash in the U.S. on May 6, 2010" [6]. It is a specialized form of AT characterized by high turnover and especially by high order-to-trade involved ratios, generating a huge number of trades. We will see below the place occupied by AT and HTF through the ATS in the BIS of a financial or investment company.

## 2 Business Intelligence Systems using Automated Trading Software

It is well known that BIS comprises the strategies and informational technologies for data analysis. Once applied IT in the trading activity, the BIS that includes ET turned into a special architecture, as a result of the main role played by the ATS.

The real-time data analysis for prediction and risk management in the ET systems place ATS to be the main engine in the BIS of a financial or investment company. Because the profit is obtained directly from the actions of the ATS, the real-time data mining processes in ET have become the priority research subjects in the latest years. The low-latency data flux together with the fast speed data mining processes allows a very fast build for the buy and sell orders. ATS is linked directly with the liquidity and capital infrastructure to obtain the profit.

*Even the real-time data are continuously stored in the data warehouse of the BIS together with the historical data, the real-time flux is used in parallel by the ATS to ensure the rapidity of the trading decisions and actions. After the data mining process and order execution, all resulting data are reversed in the data flow to be stored in the data warehouse. After that the BIS is aligned again with the usual configuration, all BIS results being obtained with the data already stored. However some reports are automatically generated by the ATS.*

The particularity of the BIS with ATS is the special management of the real-time data flux to ensure a low-latency

functionality. The real-time data flux includes the price time series provided by data sources linked directly with the stock exchanges, real-time fundamental data and news provided by specialized external sources and the real-time capital and liquidity data provided by external sources linked directly with the bank and brokerage system.

The key of success using BIS with ATS in a financial or investment company, is how the real-time data flux is organized and used, how the real-time data mining process is made together with the risk and capital management and how fast can be sent and executed the trading orders in the brokerage system. In Figure 1. is presented the data floe of BIS with ET:

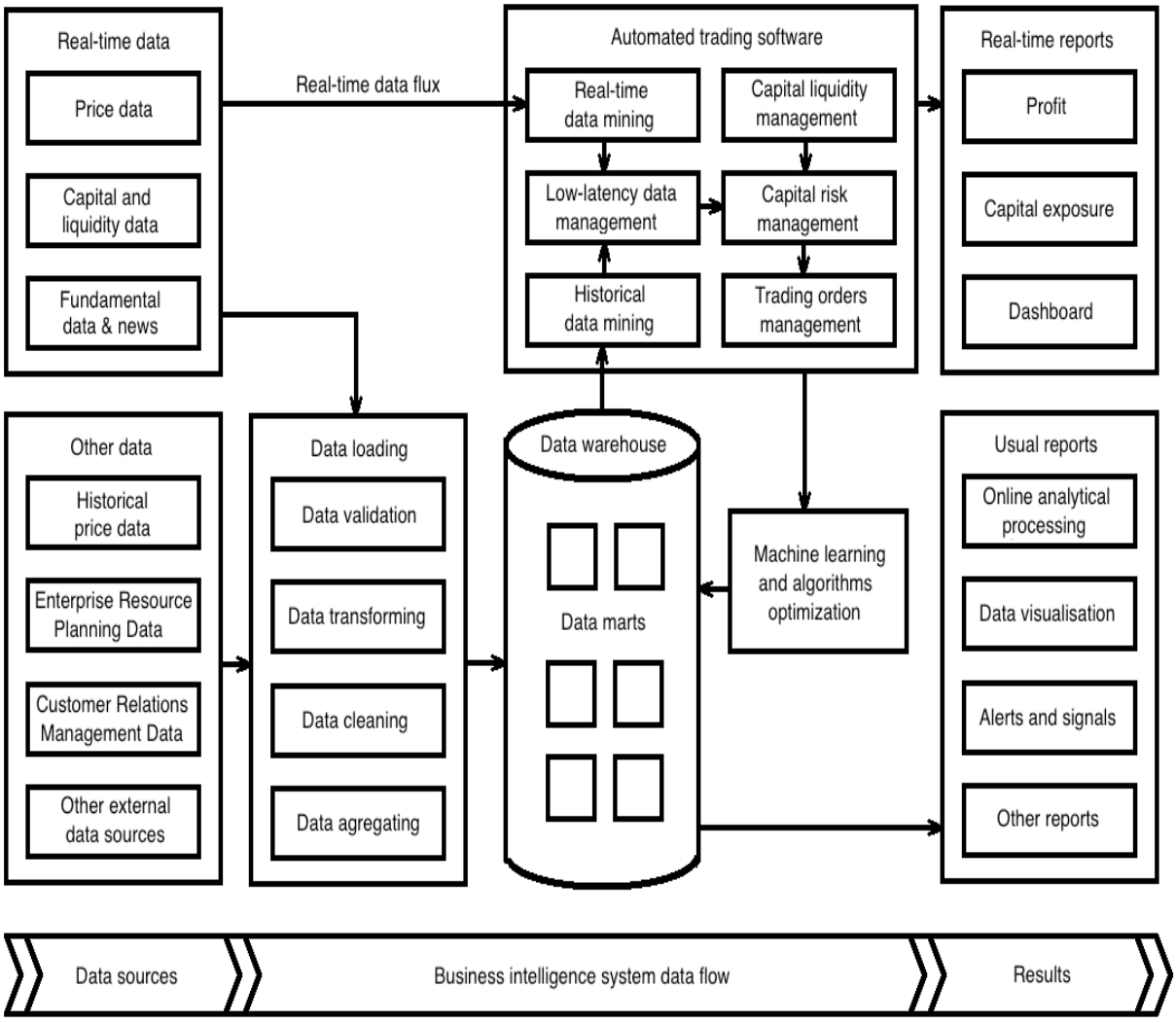


**Fig. 1.** Data flow of the Business Intelligence System using Automated Trading Software

It is well known today that "researchers believe the Cloud is a big part of the future of business intelligence" [7]. In the new time of the analytic data management of BIS, to solve the most problems regarding the complexity, costs and inflexibility, the cloud computing is a solution for majority systems. It is found that due to the specificity of information managed in BIS with ATS, there is a significant latency in the process of adoption of the cloud technologies in the companies using ET. There is no documented argumentation for this assertion except the personal experience in this field in the last ten years. Due to the specificity of the processed

data, due to the fact that the data mining procedures and the obtained results are strictly confidential and because of the speed and low-latency requested in the BIS with ATS, the cloud technology adoption is systematic delayed in many BIS in the financial and investment field. The classical "in house secured" BIS solution is still preferred.

### 2.1 Algorithmic trading

*Algorithmic trading* (AT) term refers to "any form of trading using sophisticated algorithms (programmed systems) to automate all or some part of the trade" [8]. Triggering from the notion of algorithm, as to be a finite set of precise instructions performed in a prescribed sequence to achieve a goal, especially a mathematical rule or procedure used to compute a desired result, the algorithmic trading activity ca be defined as to be the process of using computers programmed to follow a defined set of instructions for placing trades in order to generate profit at a speed and frequency that is impossible for a human trader. The main characteristics of the AT is the complexity and large computing volume ensuring in the same time a very high speed for the process of data mining, price prediction and building and sending the trading orders, which is also the intended purpose. Considering the different aspects of the processes involved in algorithmic trading, we can have some several categories of systems in this field:

- depending on the level of automation: semiautomated and automated trading systems;
- depending on the algorithm type used: statistical, neural or arbitrage trading systems;
- depending on the frequency of orders: long term, medium term and short term systems.

The long term trading systems are usual named as investments systems, being characterized by a small number of trades made to be profitable on long term (several weeks, even months). The short term trading systems are usual named and assimilated as to be high-frequency trading systems (HFT). These systems implied a very high number of orders, rapid order execution and cancelation, very short holding periods (seconds, minutes, hours), low-latency data and speed data-mining required and a specific focus on a high liquid equities [6].

### 2.2 Data mining in financial trading

In AT data is processed to find a profitable solution to buy or to sell an equity in a specified moment of time. The basic principle is very simple. Computers do everything using well-established algorithms. However, developing a stable and profitable system is a very laborious job, paying a very particular attention to the used algorithms.

Since statistics became widespread in the context of computer emergence, we can see several types of analytic tools: "descriptive analytics focus on reports of what has happened", "predictive analytics extend statistical and/or artificial intelligence to provide forecasting capability", "diagnostic analytics can apply analysis to sensor input to direct control systems automatically" and "prescriptive analytics applies quantitative models to optimize systems, or at least to identify improved systems" [9]. Considering the specifics of each methodology, "data mining includes descriptive and predictive modelling", "operations research includes all four" categories [9].

In financial trading we use descriptive modelling to analyse the past evolution of the price movement of an equity. This process is sometimes called "historical data-mining" (HDM) and the results help to understand the general trend and movement circumstances of a price. The HDM process use all available historical data in the warehouse (Figure 1.) and it is a significant part of the data management procedures in any trading system.

Predictive analysis which is involving different forecasting models in practically

present in majority fields of the human activity. In financial trading the predictive analytics is practically the main engine of each trading system. Using the real-time price data and the historical data, the predictive models try to determine the probability for a price increasing or decreasing. Because this process is using the real-time data flux, sometimes is called as "real-time data mining" (RTDM). The process is using the real time data without any pre-cleaning or validation filter and must provide a fast and reliable response to the low-latency data management module of the trading system (Figure 1.). In this process the algorithms used are very important but we know also that the "speed is nature of the scripting or programming language used" [10]. This means a very significant role in the process of design and development of a trading system the optimization of all used resources.

In the RTDM are included different types of mathematical algorithms for prediction. Some of them are using typical statistical functions together with different mathematical functions and price transformations. Classical algorithms based on moving averages or regressions are well known. However for a better efficiency, very complex algorithms are designed in this section and this is the key of success in any trading or investment company. Large amount of resources and effort are spent here, a better algorithm being what any investor want.

Other algorithms in RTDM are based on neural networks methods. On this chapter the algorithms try to use a continuous optimization to find the best way to the optimal solution. Usual this type of data-mining algorithms are combined with the statistical functions.

The third category in RTDM is the arbitrage type. These methods are based only on the real-time data price and are used in all trading procedures regarding equities with non-centralized price. Today is well known the huge interest in the arbitrage algorithms adapted for all cryptocurrencies, big difference between the sell and the buy price of a cryptocurrency in two different exchanges being a huge opportunity for profit. Important investment are made latterly in this field to develop algorithms and to reap all these opportunities.

## 3. Automated trading software

An ATS is a software which is receiving the real-time and historical price data of an equity, generates the signals for buying and selling of the equity based on well-determined algorithms, sets the volume of trading based on the capital liquidity and the capital a defined risk level, builds the trading orders and send them to the brokerage account without any human intervention.

The purposed objective of the ATS is to generate profit into the investor's account. Once established the algorithms and the functional parameters, the ATS will run continuous and automatically, being the main part of any automated trading system. The design of an ATS must take care about some specific requirements: a). low-latency data processing; b). fast trading orders processing; c). profitable trading strategies with measurable capital exposure level; d). automated capital risk management.

The low-latency data processing and fast data orders processing are required to ensure that the trading orders arrive in the brokerage account system before the price is changed. This is a defining requirement for ATS because an order with an obsolete price is ignored and will not be executed. Consequently the processing speed is the first design direction for an ATS.

The second design direction is the measurable risk involved by the ATS. Not all trading strategies are suitable, some of the strategies can not measure priori the risk involved. In an ATS can be included any profitable strategy with a measurable capital exposure level. With this parameter the capital risk management will be possible to be automatically made, in this

way the trading strategy will be integrated with the risk management procedures.

Receiving the real-time and historical data, ATS applies different data-mining methods to extract information and to calculate probabilities for an increasing or decreasing of the price based on different trading strategies. Depending on the time frame used for each strategy, there are several categories between high-frequency trading and investment strategies: very-short term, short term, medium term and long term strategies.

Once a buy or a sell opportunity was found, a trading signal is generated. The trading signal is a record that includes the action (buy/sell), the price and the code of the equity. This signal can not be yet executed because the volume of the transaction is still missing.

In the capital and risk management module, using the information about the available capital liquidity (C), based on the capital exposure level for each (i=1, 2, ... n) used trading strategy ($\xi_i$) we can calculate the volume of the current transaction ($V_i$). The total capital exposure level (R) of the ATS is the maximum limit of the exposure level:

$$V_i = C * \xi_i \text{ with } R \geq \xi_1 + \xi_2 + ... + \xi_n \quad (1)$$

In this way the total capital exposure of any ATS can be controlled to the maximal value (R). With an automated stop loss at that maximal value, the risk can be limited and controlled.

## 4. Conclusions

In the context of ET, the ATS occupies a central place in the BIS of any financial or investment company. ATS has become today a necessity in this environment, to permit a quick adaptability to the market conditions that are changing very fast. The computational and data processing speed is the first design requirements of any ATS.

Based on more trading strategies, applied on very-short, short, medium or long term, the ATS require a real-time price and capital liquidity data flux together with the historical price data. The data mining process, where the trading strategies are included, is organized in two individual modules: the real-time data mining module and the historical data mining module, depending on what data type are mined. The results are processed by a low-latency data management module which incorporates the trading signals. Based on the information provided by the capital and risk management module, the trading signals are transformed into trading orders and are sent into the brokerage account system. The speed for building and sending orders to the capital account is very important because the trading orders must arrive in the brokerage system before the price is changing, otherwise the obsolete price orders will be ignored and not executed.

The second design direction for an ATS is the measurable risk involved by the trading system. It is required by the automated capital and risk management process. This requirement is obtained by incorporating into the ATS only trading strategies with measurable capital exposure level. Knowing the capital exposure involved by each trading strategy, the total risk exposure involved by the ATS can be in real-time calculated, and therefore can be limited as needed. Together with the real-time capital liquidity informations it is possible to build an automated capital management process that will manage in real time the capital and the risk involved.

Because the profit in any financial or investment company is made directly by the actions of the ATS, the design and integration in BIS has gained a special attention. Thinking that we have only about ten-twelve years of ATS in the context of a history of hundreds of years of financial trading in the stock exchanges, we can say that we are still on the beginning in this domain, large research and improvements are still to come in the trading automation.

**References**

[1] V. Barbour, *Capitalism in Amsterdam in the Seventeenth Century*, University of Michigan Press, 1963, ISBN 978-0404613136, pp. 17.

[2] L. Petram, *The World's First Stock Exchange*, Columbia University Press 2014, ISBN 978-0231163781, pp. 9.

[3] Wikipedia - Electronic trading - Internet:https://en.wikipedia.org/wiki/Stock_market, January 29, 2018 [January 31, 2018].

[4] Wikipedia - Open outcry - Internet: https://en.wikipedia.org/wiki/Open_outcry, January 9, 2018 [January 28, 2018].

[5] Wikipedia - Electronic trading - Internet:https://en.wikipedia.org/wiki/Electronic_trading, December 1, 2017 [January 28, 2018].

[6] P. Gomber, B. Arndt, M. Lutat, T. Uhle, *High-Frequency Trading*, Business & Information Systems Engineering Journal, April 2013, pp. 6-15.

[7] S. Ouf, M. Nasr, *The Cloud Computing: The Future of BI in the Cloud*, International Journal of Computer Theory and Engineering, Vol. 3, No. 6, 2011, pp. 750.

[8] P. Treleaven, M. Galas, V. Lalchand, *Algorithmic Trading Review*, Communication of the ACM, 2013, vol 56, no. 11, pp. 78.

[9] D.L. Olson, D. Wu, *Predictive Data Mining Models*, Springer Science Business Media Singapore, 2017, ISBN 978-981-10-2543-3, pp. 5-6.

[10] J.O. Katz, D.L. McCormick, *The encyclopedia of trading strategies*, McGraw-Hill, New York, USA, 2000 ISBN 978-007-0580990-2, pp. 22.

**Cristian PĂUNA** graduated the Faculty of Cybernetics, Statistics and Economic Informatics of the Academy of Economic Studies in 1999 and also he is a graduate of the Faculty of Aircrafts of the Polytechnic University of Bucharest in 1995. He got the title of Master of Science in Special Aerospace Engineering in 1996. In the last decades he had a sustained activity in software development industry, especially applied in the financial trading domain. Based on several original mathematical algorithms he is the author of more automated trading software. At present he is the Principal Software Developer of Algo Trading Service Ltd. and he is involved as PhD student in Economic Informatics Doctoral School of the Academy of Economic Studies.