

Multi-Agent Simulation of Financial Markets

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Abstract. This paper discusses the principal reasons for, and prospective opportunities of, simulating financial markets using an architecture based on artificial agents. The paper then discusses in detail the design and architecture of a simulator for financial markets. The Gaia methodology was employed in the development of MAFiMSi (Multi-Agent Financial Market Simulator), a general-purpose financial market simulator of a dealer-type market. MAFiMSi is implemented as a library of C++ classes that currently support a stand-alone market simulation.

1 Introduction

Simulation of financial markets is a new fast growing research area with two primary motivations. The first is the need to provide a development testbed for the ever increasing automation of financial markets. The second is the inability of traditional computational mathematics to predict market patterns that result from the choices made by interacting investors in a market.

Section 2 surveys the current state of financial market automation. Section 3 discusses the importance of simulation to help understand the patterns that arise from different investment strategies; it briefly surveys the literature and identifies some open problems, including the design of a general-purpose financial market simulator.

The design of a multi-agent simulator of a financial market is the subject of Section 4. It is a challenging task due to the operational complexity and computationally costly decision support. We discuss an approach in which the complexity of the financial market functionality is decomposed into relatively simple tasks and processes. In general, we separate the transactional and decision-support intelligence of the market agents. Further, market entities are singled out and defined as software objects; the interaction protocols are specified; and the simulator architecture is presented.

We conclude with the discussion of possible applications of the simulator, stressing its extensibility to handle other marketplaces, such as emerging markets, energy and bandwidth markets, etc.

2 Automation of Modern Financial Markets

We define market automation as the execution of trades by software agents based on goals specified by human agents.

Modern financial market professionals recognize the benefits of financial market globalization, worldwide trading through electronic interconnectivity, and around-the-clock market accessibility, as a means to increase liquidity and market efficiency. Automation is seen as a way to achieve these ends. Frank Zarb, chairman and CEO of NASD, formulated a vision of digital, global, continuously available security trading with real-time quotation and order execution systems accessible worldwide over the Internet via a number of computing devices in his speech to the National Press Club in 1999 [Zar99]. It forecasts rendering physical trading floors obsolete and completely replacing them by electronic transactions. Complete automation is necessary to support 7/24 availability.

This vision of financial market automation is not isolated. It is a part of a wider phenomenon of globalization and development of digital economy. The technology that can turn this vision into reality has arrived. The trend to automation is supported by developments in electronic commerce, agent technology, and achievements in mathematical and computational finance.

This section gives a brief introduction into the operations of financial markets and survey the current state of financial market automation. Electronic Communication Networks (ECNs) are of special interest here due to their pioneering role in automation of securities trading.

2.1 Securities Markets

Modern financial markets deal in standardized obligations in place of goods and commodities. In the current trading paradigm, the actual order execution, or securities exchange, is separated from an investor by several levels of intermediaries (see Figure 1). In general, a hierarchical structure is a characteristic feature of modern securities trading. Access to the actual financial market is open only to authorized brokerage houses. Institutional and retail customers contact a broker to place their orders. Once an order is initiated by an investor (placed with a broker) it goes through three distinct stages: order routing, execution, and clearing and settlement. Routing involves communicating, possibly through a number of intermediaries, the details of an order from a broker with whom the order has been placed to a market agent, human or software, responsible for order execution. Execution involves agreement to exchange securities, while clearing and settlement commits the transaction by