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AgEx: A Financial Market Simulation Tool for Software Agents

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Title:
AgEx: A Financial Market Simulation Tool for Software Agents

Authors:
Paulo André Castro, Jaime Sichman

Outline

- Introduction
  - Motivation
  - Related Work
- AgEx Architecture
  - Main Components
  - Communication Language and Ontology
  - Simulation Mechanism
  - Trading Strategies
- Using AgEx
  - Simulated Experiments Setup
  - Trader Performance by Year
  - Trader Performance by Asset
  - Broker's Fee Influence
- Conclusions

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Motivation

- Many researchers have addressed the problem of creating mechanisms to automate the administration of assets. It is possible to observe the use of many reasoning techniques, for instance: neural networks, reinforcement learning, multiagent systems , BDI architectures , SWARM approaches and many others (Castro and Sichman, 2009)
- One big obstacle to research in automated portfolio management is the need for a test bed for the designed agents and systems. This test environment should be able to simulate financial markets as close to reality as possible.
- This kind of tool is fundamental to research in automated portfolio management, but it is not really part of it. It is an infrastructure that could be reused by a lot of researchers.
- Our paper presents an open source financial market simulation tool developed by us with special features that makes it different from others tools currently available.

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Related Work

- There are some simulations tools that may be used to simulate stock markets like: eAuctionHouse (Wurman et al, 1998), eMediator (Sandholm, 2000), PXS (Kearns and Ortiz, 2003), SFI (LeBaron, 2002), JASA (Phelps, 2007)
- These systems are compared using desirable features by a financial market simulation tool

System	eAuctionHouse	eMediator	PXS	SFI	JASA	AgEx
Real Price mode	No	No	Yes	No	No	Yes
Live Price Mode	Yes	Yes	Yes	Yes	Yes	Yes
Open Source	No	No	No	Yes	Yes	Yes
Use ontology	No	No	No	No	No	Yes

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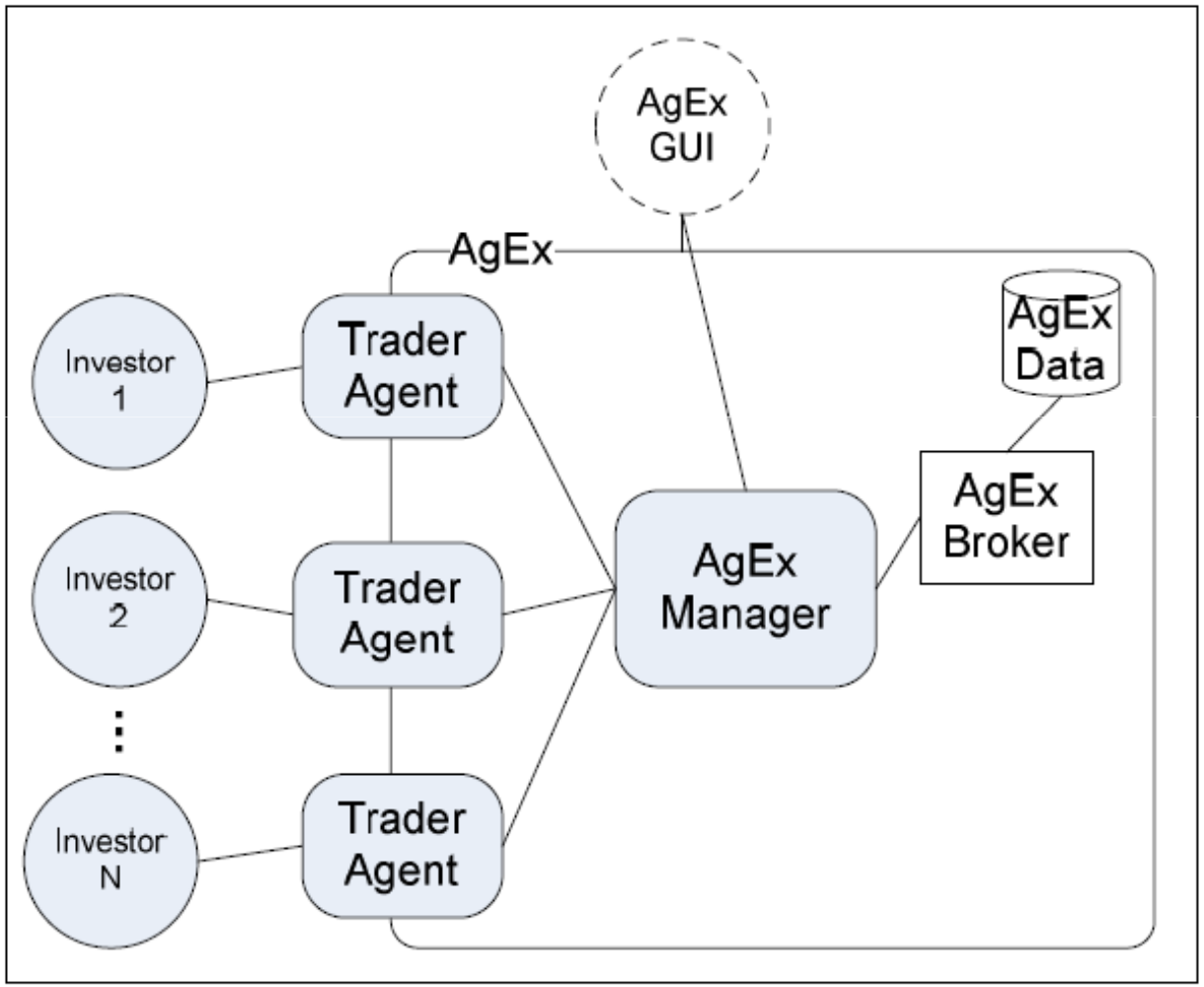
AgEx Architecture



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Main Components of AgEx Architecture

- **AgEx Data**: This data repository keeps daily (and/or intraday) quotes of selected stocks
- **AgEx Broker**: This component process all trading orders according to current prices
- **AgEx Manager**: This agent receives, validates and responds orders and request stock information sent by any trader agent.
- **Trader Agents**: These agents get stock information and deliberate what to do (buy, sell or hold) according to a specific **trading strategy**

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AgEx Communication and Ontology

- We decided to use JADE as communication infrastructure within AgEx society (manager and traders), because it is adherent to agent communication language (ACL)
- In order to interchange concepts and agent actions through messages, we developed a **specialized ontology** to AgEx based on a content reference model defined by FIPA (Foundation for Intelligent Physical Agents)
- This ontology includes the main concepts, predicates and possible actions needed by trader agents. The possible concepts includes *Order, Order Result, Query, Query Result, Asset Concept, Error and Terminate* …
- These concepts, predicates and actions are used to create content for any message exchanged within an AgEx society.

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Simulation Mechanism

- AgEx has two simulation modes
  - Historical price mode (default)
  - Live price mode
- In Historical price mode, simulation uses asset information from real stock markets.
  - This information is composed by assets prices (open, high, down and close prices) and volume (shares traded by assets).
  - This kind of simulation is particularly useful when the research is focused on the development of trading strategies that do not account the influence of the trader in the market
  - In fact, this effect may be despised since the amount of assets traded by the agent is much smaller than the volume traded in the market
- However, researchers interested in analyzing the effect of some trader strategy in the market may use the live price mode. In this mode, the prices and volume are defined exclusively by the orders submitted from the trader agents

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Simulation Mechanism

- AgEx controls the simulation time and registers in the end of each cycle the position of each trader (money, shares, stock prices and orders). Furthermore, it creates files with the results of all traders
- Real quote information is essential to perform simulation of markets in historical price mode. Fortunately, several web sites (like Yahoo Finance, for instance) provide this kind of information free of charge.
- AgEx provides an GUI to import data downloaded from Yahoo Finance

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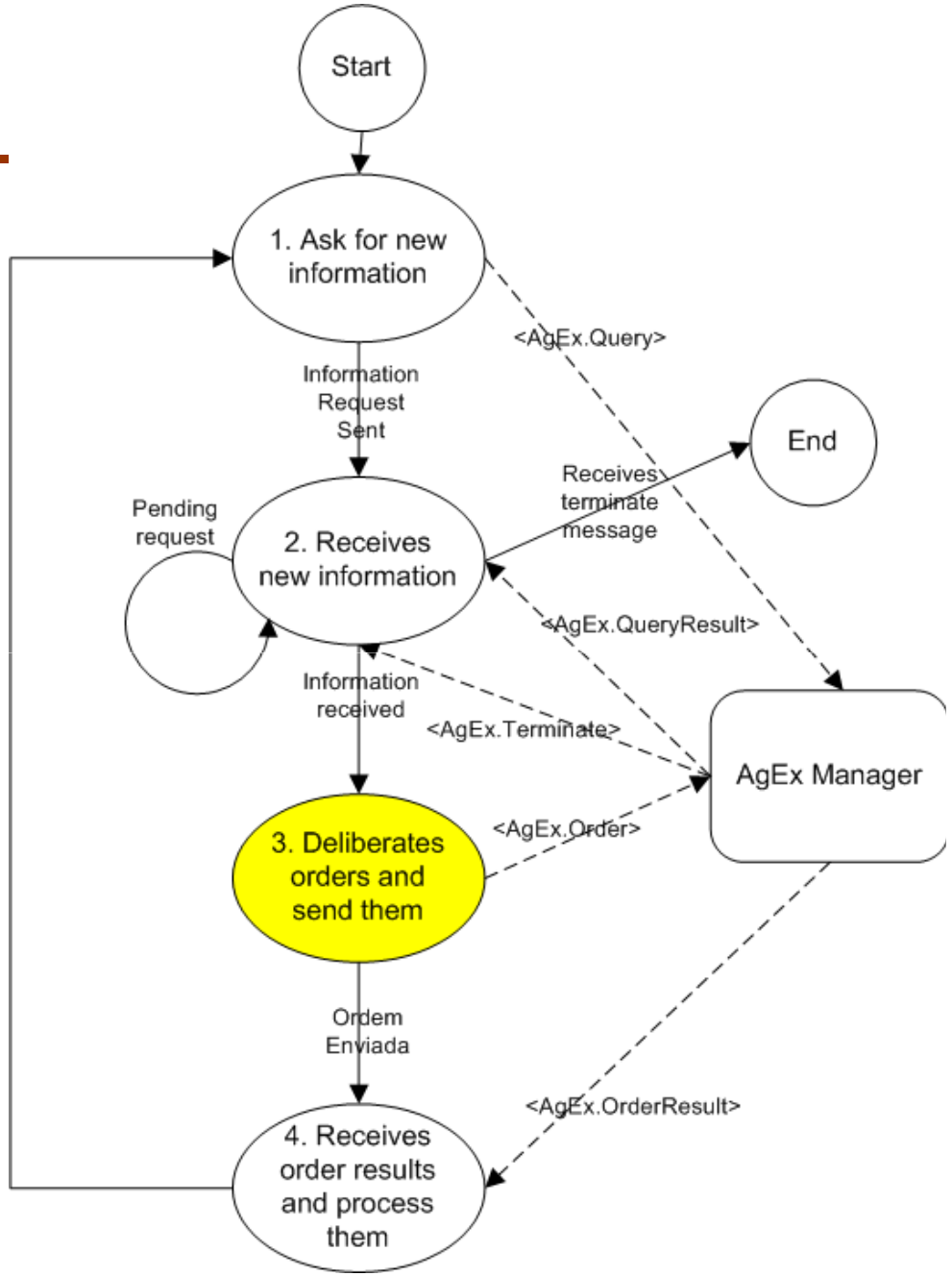
Trader Agent Life Cycle



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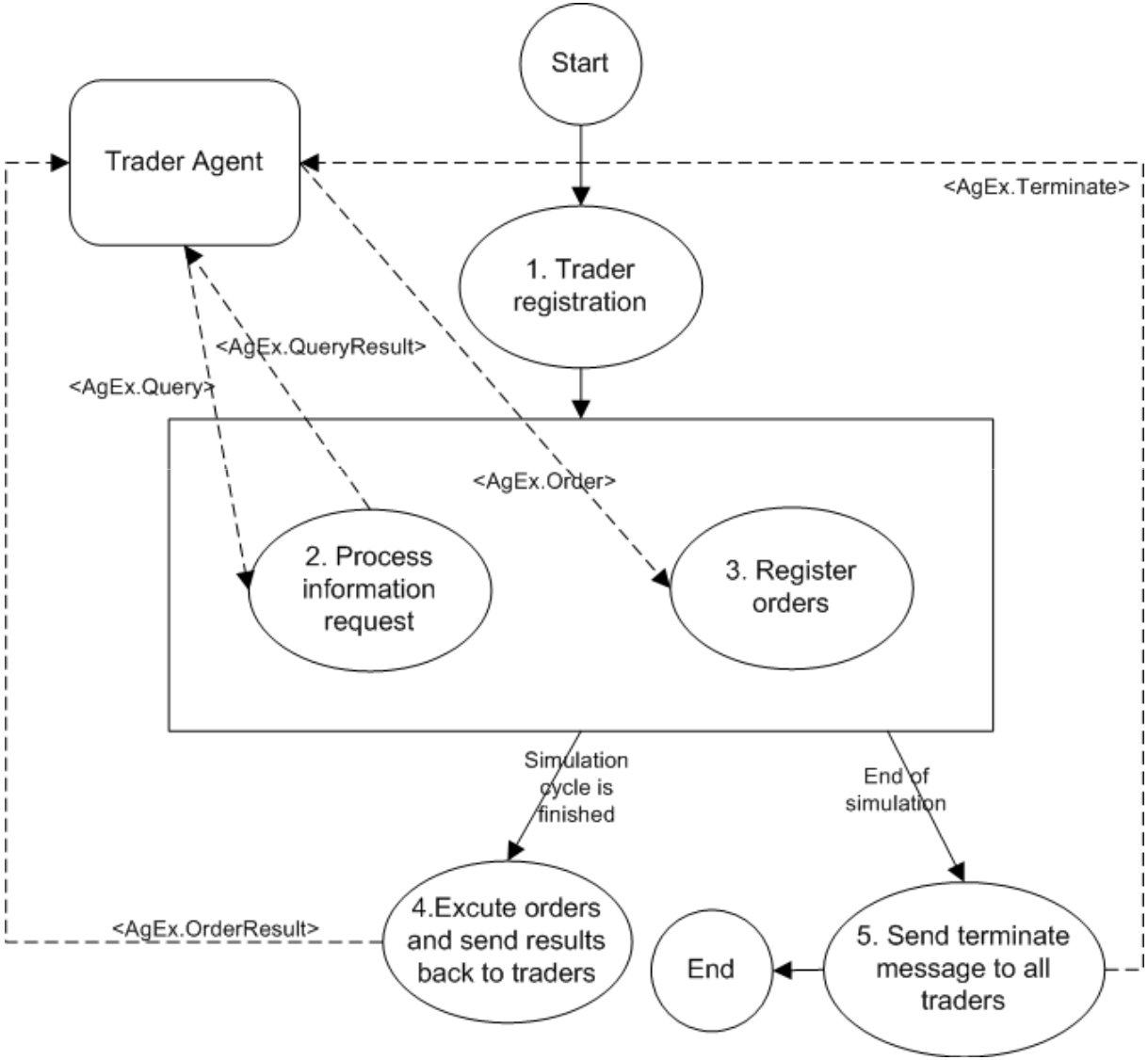
Manager Agent Life Cycle



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Trading Strategies

- In order to validate our tool, we implemented six trading strategies as AgEx Trader Agents
- The selected strategies were:
  - Relative Strength Index (RSI)
  - Sthocastic
  - Moving Average (MA)
  - Moving Average Convergence/Divergence (MACD)
  - Price Oscillator (PriOsc)
  - Buy and Hold
- Detailed information about these strategies may be found at (Castro and Sichman, 2007)

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Society definition XML File

- AgEx societies are defined by xml files.
- Below you may find an example, with two trader agents (RSI and Moving Average) that will connect to a remote manager.

```
  <?xml version="1.0" encoding="UTF-8"?>
<society-agex>
  <manager  remote_manager="yes" hostname="161.24.2.126"
  port="1099"/>
 <trader name="RSI" initial_capital="1000000"
 path="agex.traders.RSI">
        <asset id="AAPL" initial_shares="0"/>
        <asset id="ADBE" initial_shares="0"/>
        <param  value="para1" />  </trader>
 <trader name="MA" initial_capital="1000000"
 path="agex.traders.MA">
  <asset id="AAPL" initial_shares="0"/> </trader>
</society-agex>
```

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Experimental Simulation Setup

- Real data from Nasdaq Exchange
- Long Period :
  - January 1,1989 to December 31, 2007.
- Daily Quotes
- Most relevant companies were selected
  - Nasdaq 100 Index
  - Long time series of stock prices

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Selected Stocks

ID	Name	ID	Name
AAPL	Apple Inc	DELL	Dell Inc
ADBE	Adobe Sys. Inc	INTC	Intel Corporation
ALTR	Altera Corp	JAVA	Sun Microsystems
AMAT	Applied Materials Inc.	MSFT	Microsoft Corp.
AMGN	Amgen Inc	ORCL	Oracle Corp.
CMCSA	Comcast Corp	PCAR	PACCAR Inc.
COST	Costco Wholesale Corp.	ROST	Ross Stores Inc.

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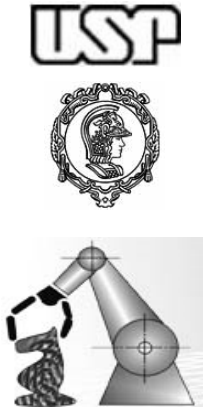
Trader Evaluation

- Automated traders evaluation may use same criteria used to evaluate human traders (and others criteria, if needed as time response, reliability, etc.)
- We analyzed the implemented traders using **risk** and **return** in an annual basis
- Risk is measured by standard deviation of daily returns
- Return is defined as percentile increase/decrease of agent's assets.



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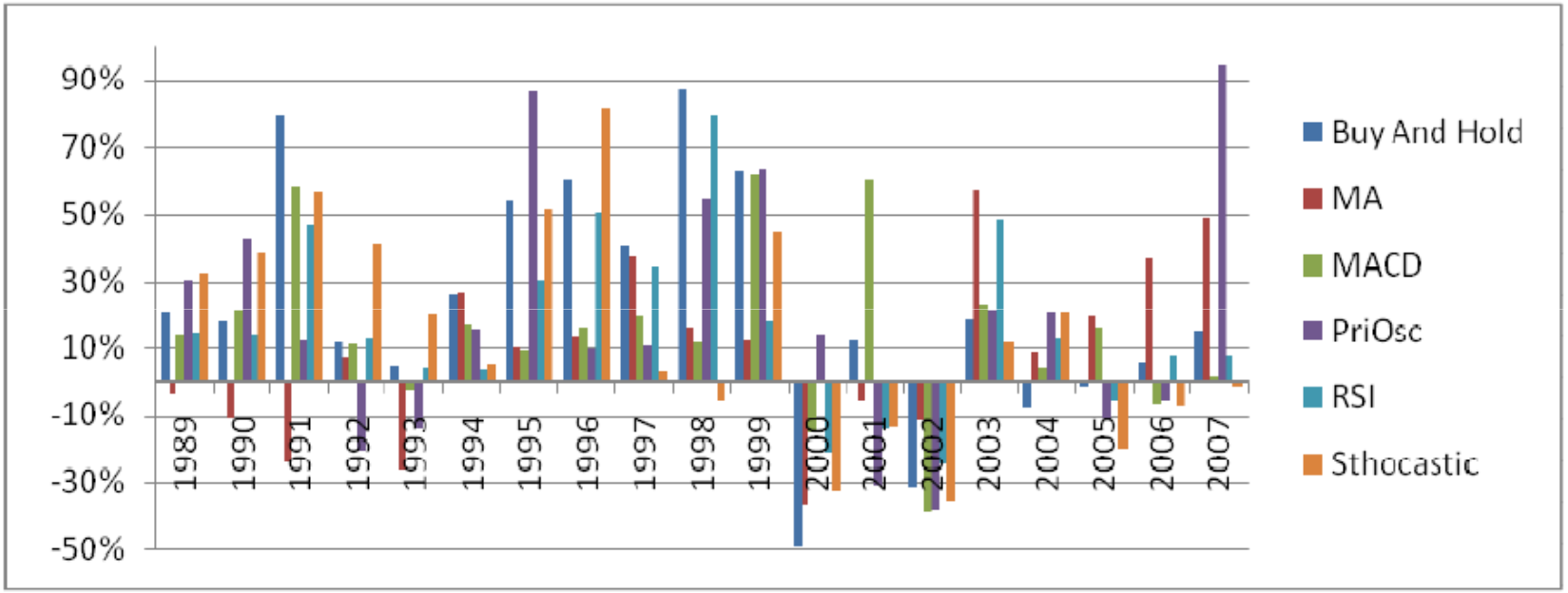
Trader Agent's Return by Year



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Return Medals Table

Trader	*Ranking*	*1o.*	*2o.*	*3o.*
Buy And Hold	4	3	6	6
MA	2	5	2	1
MACD	5	1	3	4
PriOsc	1	6	1	1
RSI	6	0	5	5
Sthocastic	3	4	2	2
Total	**-**	**19**	**19**	**19**

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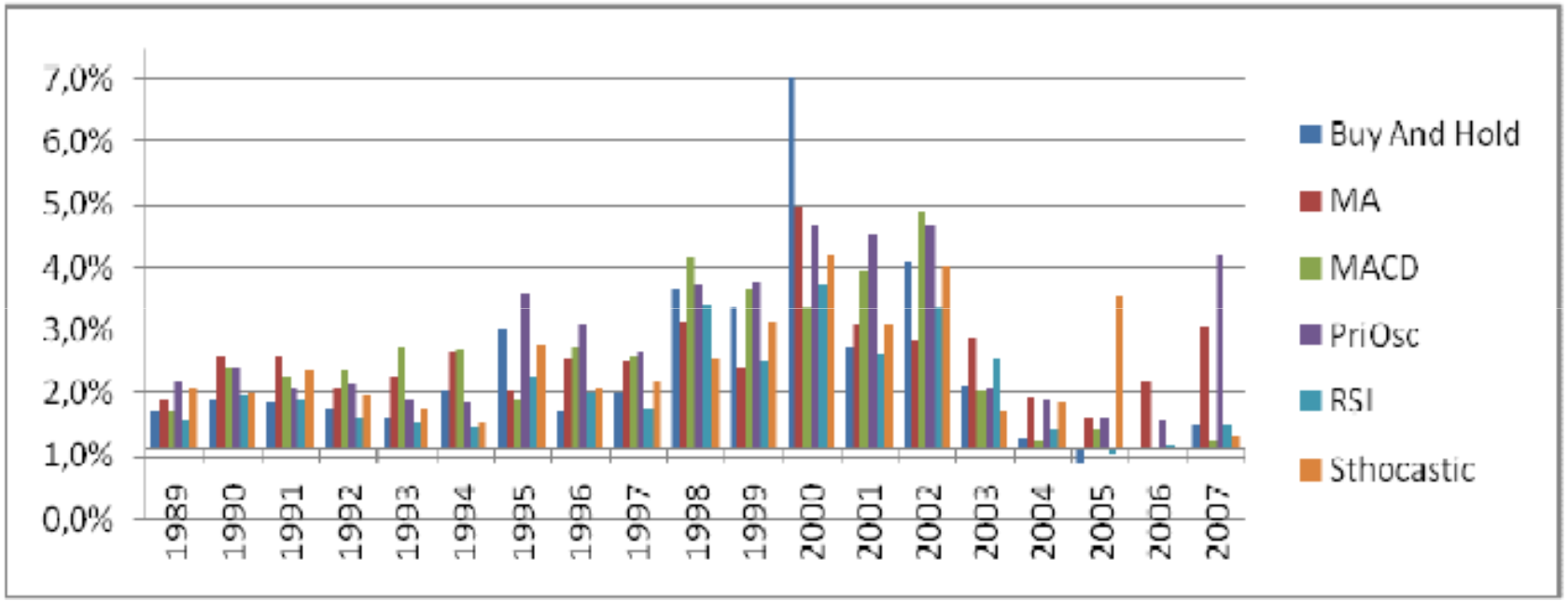
Trader Agent's Risk by Year



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Risk Medals Table

Trader	Ranking	1o.	2o.	3o.
Buy And Hold	2	4	6	5
MA	5	2	7	2
MACD	3	4	0	4
PriOsc	6	0	3	2
RSI	1	6	2	1
Sthocastic	4	3	1	5
Total	**-**	**19**	**19**	**19**

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Return & Risk Medals Tables

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MACD	5	1	3	4
PriOsc	1	6	1	1
RSI	6	0	5	5
Sthocastic	3	4	2	2
Total	**-**	**19**	**19**	**19**

Trader	**Ranking**	**1o.**	**2o.**	**3o.**
Buy And Hold	2	4	6	5
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MACD	3	4	0	4
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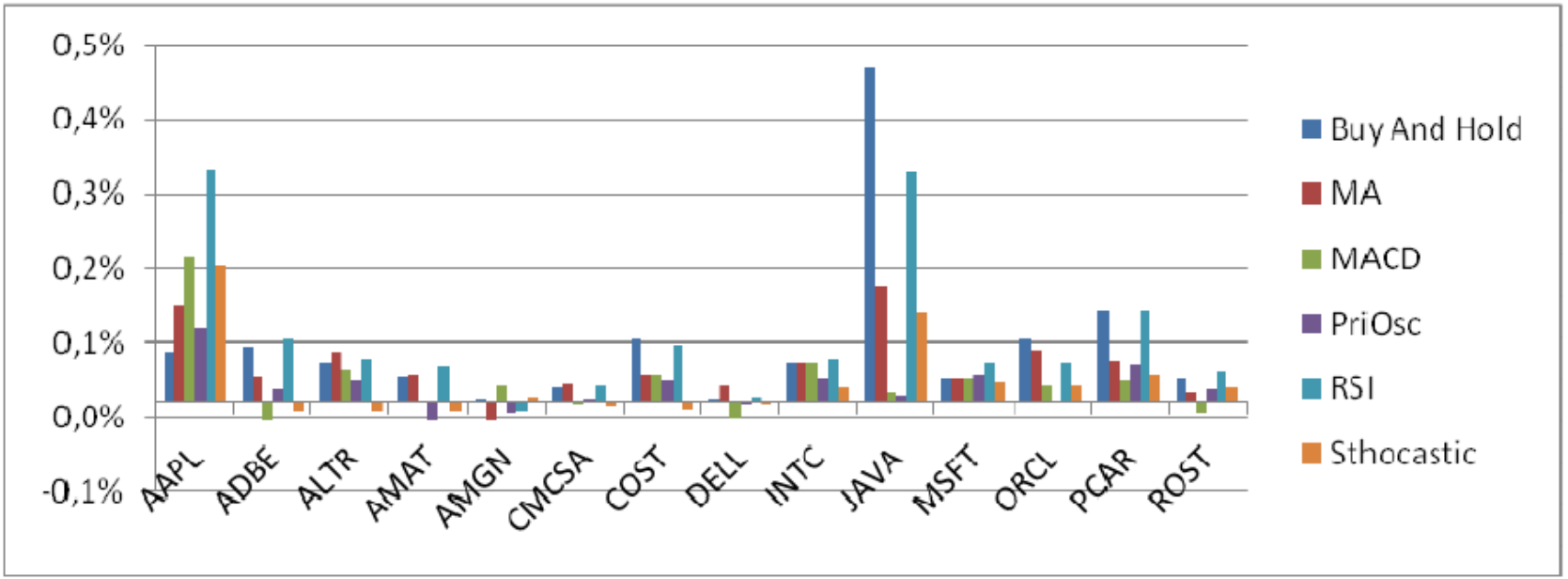
Trader Performance by Asset

- We have performed a group of simulations sessions using data from 2003 to 2007
- Each trader was assigned to trade with only one of the 14 assets for the whole period



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Broker's fee influence on performance

- It is a common assumption in trading strategy design that as broker's fees will be charged from all traders no matter its strategy, then strategies could be designed and compared among themselves without concern about fees, because they would reduce profitability of all traders in an neutral way
- AgEx allows broker's fees simulation (as a fixed amount by operation and/or a percentile of the transaction volume).
- Therefore, we used this feature to verify this common assumption.

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Return Results with fees

Trader	*Ranking*	*1o.*	*2o.*	*3o.*
Buy And Hold	2	5	4	6
MA	3	4	2	2
MACD	5	1	2	2
PriOsc	1	6	1	2
RSI	6	0	8	4
Sthocastic	4	3	2	3
Total	-	**19**	**19**	**19**

Return Results without fees

Trader	*Ranking*	*1o.*	*2o.*	*3o.*
Buy And Hold	4	3	6	6
MA	2	5	2	1
MACD	5	1	3	4
PriOsc	1	6	1	1
RSI	6	0	5	5
Sthocastic	3	4	2	2
Total	-	**19**	**19**	**19**

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Conclusions

- Using AgEx, we could realize that the effort to implement trader agents was significantly reduced
- Furthermore, AgEx is adherent to international standards of agent communication (FIPA standards)
- We have performed a significant amount of simulated experiments and analyzed the obtained results
- The comparison among traders dealing with and without fees showed that the presence of fee may harm less one agent than others
- The results also showed that there is no dominant strategy among those analyzed along the time and no agent presented best performance for all papers

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Conclusions 2

- Moreover, these conclusions made us believe that new strategies mixing information from existing traders may achieve good results
- In fact, we have used AgEx to develop this kind of mixed trading strategy
- We have used fuzzy logic and multiagent negotiation to solve conflict among trader strategies. We have achieved stimulants results and we intend to publish them in the near future
- Finally, we believe that AgEx can be very useful for others researchers trying to develop new strategies for automated asset trading.

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You may find more information about AgEx and download it at:

http://agex.sourceforge.net

Thank you!

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