Optimal Strategy Development Framework for SCM Trading Agent

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ABSTRACT

The framework and methodology to develop an optimal management strategy is suggested. The methodology is based on the Local Tournaments method and the row of changes made in the management basic strategy to generate and develop the strongest strategy. The software package recommending the optimal strategy from the set of strategies based on the Matrix of Tests, Strategy Builder tool for Strategic Plans development, TAC SCM Software and controlled server are deployed in the framework. The effectiveness of these 4 tools was proved by their application to different strategy assessment problems and having them in one framework in conjunction with effective and efficient strategy development algorithm give us a power tool for optimal management strategy development.

Keywords

Agent, strategy, management, DSS, evaluation, simulation, tournaments

1. INTRODUCTION

In competitive environments it is typical to require to act according to optimal strategies. In corresponding simulation models it is supposed that the solutions have to deliver recommendations on how to interpret the real world and how to act in it.

The Optimal Strategy Development Framework is designed to develop a scale consistent with on-the-job performances of management strategies and allowing to measure them in oligopoly competitions.

In the *Management Optimal Strategy Provision* (MOSP) problem a company is competing on oligopolistic market for some success criteria (max cumulative profit, max return on investment, etc.) and is going to make decisions in market situations that are consistent with the best strategy at least for defined periods of the competition *[13]*.

Most computer based methods to solve the MOSP problem focus more on constructing strategy plans. Advanced man-machine interactive tools already exist to help managers in planning and testing corresponding strategies by human teams compete in simulated environments [*3*]. However, complete models including strategy plans generation, plans transformation into strategies followed by strategies static and dynamic testing in competitive environments are developed minimally. The suggested framework that provides a venue for regular improvement of strategies by injection of common knowledge and achievements from the management theory and methodology as well as individual experiences from the experts.

To advance in the MOSP problem solution by simulating an adequate model it needs to create an effective and efficient strategy development algorithm that will be able to acquire regular management knowledge to improve the quality of the development strategy.

In our model of oligopoly competition a few companies compete for maximal profit. They form various Strategic Plans that describe qualitative changes of basic competition parameters - Price and Quality of goods produced by the [3].

The best strategy selection by Matrix of Tests is realized as a version of on-the-job performance assessment ideology based on the following three basic assumptions [*12*]:

1. Absolute scale orders the companies by their on-the-job integrated competition performances in all oligopoly competitions with all other competing companies;
2. Any two companies may be ordered by the absolute scale using local computational resources;
3. There are adequate game models to simulate oligopoly competitions.

The Trading Agent Competition in Supply Chain Management game (TAC SCM) is used as one of such model simulating the oligopoly competition [9].

Supply Chain Management (SCM) is an approach of planning and coordinating the activities of organization across the supply chain, from purchasing raw material procurement to delivering finished goods to the end-customer.

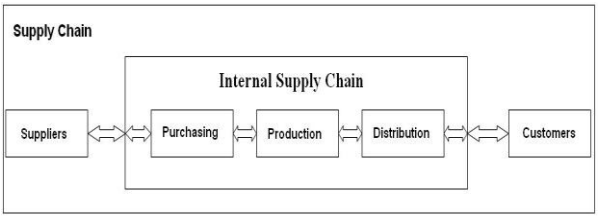

Figure 1: Supply Chain

The Trading Agent Competition Supply Chain Management game (TAC SCM) was designed to capture many of the challenges involved in supporting dynamic supply chain practices and provides a competitive benchmarking environment for developing and testing agent-based solutions to supply chain management. Autonomous software agents compete against each other as computer manufacturers on the oligopolistic market: each agent must purchase components such as memory and hard drives from suppliers, manage a factory where computers are assembled, and negotiate with customers to sell computers [*4*]. The game has been designed jointly by a team of researchers from the e-Supply Chain Management Lab at Carnegie Mellon University, the University of Minnesota, and the Swedish Institute of Computer Science (SICS), with input from the research community [http://www.sics.se/tac/].

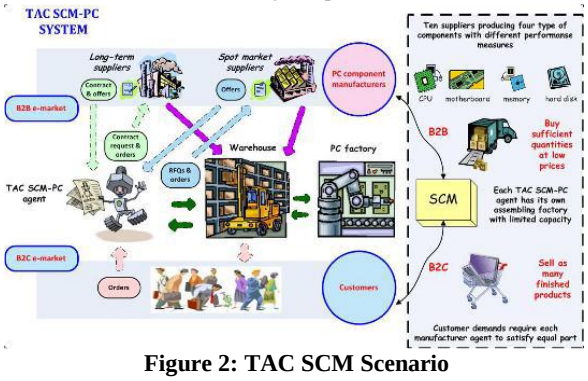

Figure 2: TAC SCM Scenario

2. OPTIMAL STRATEGY DEVELOPMENT FRAMEWORK

The MOSP problem is the core of many applications, particularly, constructing an advisor that will recommend decisions for a company in its oligopoly competitions or developing a scale for measuring its management strategy. As one of solutions for this problem the Optimal Strategy Development Framework was designed and implemented.
The framework consists of several software tools along with implemented *Method of Local Tournaments* [*11*] that is proposed as a core algorithm for the strategies assessment.
Initially the Method of Local Tournaments was developed to assess optimal strategies in the chess. But it is also applicable to the Management Optimal Strategy Provision problem as well.

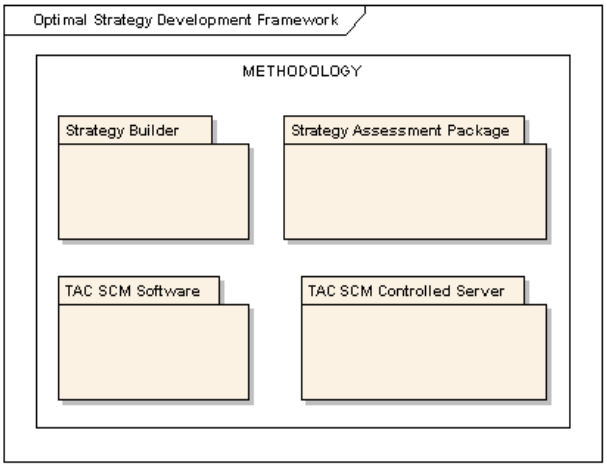

Figure 3: Optimal Strategy Development Framework

The software package assessing and recommending the optimal strategy (Strategy Assessment Package) is a tool for Optimal Strategy Provision in sets induced by testing and to recommend the best strategy based on the given Matrix of Tests [*2*] and optimality criterion [*7*]. Having the Matrix of Tests as an input the package transforms it to selected optimality criteria's matrix, performs some calculations/estimations and outputs as the result the best strategy from the given set of tested strategies. The Borda, Condorcet, Copeland, Simpson and multistage elimination tree optimality criteria are used in the package for estimation [*6*].
This package may be used for recommendation of the "best" in variety of multi-criteria evaluation and assessment problems. The package can be easily expanded by adding other optimality criteria/methods to it.

The Strategy Plans Builder is a tool developed for visual design and edition of strategy plans (SP) [*1*]. The Builder is provided by specific scripting language for strategy plans definition, description and edition. When the design or change of a SP is done the plan description is translated into the text representation according to specified structured format that is used by the tool.
This software tool facilitates easy development and tracking of different strategy plans. The advantage of this tool is that it doesn't require any development skills from the person running the agent; any non-programmer can develop and further run his own strategy plans for the agent.

TAC SCM Software consists of AgentWare – a sample of the trading agent, a Server for the TAC SCM game, and a simple game data toolkit for reading the game logs. The TAC SCM Server is an open-source server for the Trading Agent Competition that should be used to run the developed trading agent on the server to test its strategy and qualify its behaviour [http://www.sics.se/tac/].

TAC SCM Controlled Server is the tool described in the [*15*] that allows market conditions to be repeated across multiple games.

Described above tools in conjunction with advanced analyzing methodology create a cross-functional, multi-competitor, market-driven simulation model of oligopoly competition. It simulates the interrelationships between customers, competitors (agents in case of TAC SCM), and suppliers [8]. The Framework is used to develop and test the agent's strategies using the business principles that are familiar to the managers, intuitive and easy to apply. The strategic decision made by agents are evaluated and accepted in case they improve agent's strategy.

3. METHOD OF LOCAL TOURNAMENTS

The Method of Local Tournaments gives two approaches to the solution of the MOSP problem:

- the first approach is the ranking of given strategies according to their performance (optimality);
- the second approach consists of generation of new strategies based on the given one and further comparison of the created and old strategies.

In both cases the comparison of strategies is done taking into account the *Quasi Transitivity Constraint* described in *[14]*.
According to this constraint for ordering O* strategy f is considered better/stronger than strategy g (i.e. the location of f is better than g in ordering O*) if there are b samples of strategies such that f wins and g loses games against each of them. This approach is known as a "Local Tournament".
Both approaches are used in the methodology algorithm implemented into the Optimal Strategy Development Framework [10].

4. STRETGY TESTING

To find the most optimal strategy for the agent strategies should pass through the "static" testing first and then through the "dynamic" testing [*2*].
Phase I - Static testing: after development of a strategy for an agent it should be tested on the TAC SCM game simulator. In this case only one agent with developed strategy is run on the market. In case the agent profit isn't positive to the end of the game the strategy is considered as bad and requires to be improved.
Using the Strategy Builder tool the strategy is changed slightly and the game is run again with the same agent but with the updated strategy. To the end of the game the strategy is evaluated and the result is compared with the previous game.
These steps are repeated while the strategy that gains some money for the agent in the game will developed.
Other words, the strategy has to be enough perspective at least without any other competing strategies on the market.
Using this phase a row of strategies is generated. Then during the phase II all strategies that passed static testing will be ordered according to their on-the-job performance. In case of the framework already contains some predefined set of strategies that are already ordered and considered as an "ideal" ordering O^* the new generated strategies ordering will be isomorphic imbedded into that ideal ordering.

Phase II - Dynamic testing: the strategy should be compared with other strategies on-the-job performance simulation. For this phase at least 2 strategies should compete on the market. So, the game simulation is started with 2 different strategies that passed the static testing phase.
For the more precise results it is recommended to run the same strategies against each other several times in the different market situations, but all strategies should be tested on the same set of markets conditions. To control the market the TAC SCM Controlled Server should be used. Results of each simulation are recorded into the Matrix of Tests [5]. Having the Matrix of Tests for some set of strategies the Strategy Assessment package is used to order the strategies and suggest the optimal one from the set induced by dynamic testing on the TAC SCM game.
To reduce the Matrix of Tests and escape the comparison of one strategy with all already existed and ordered strategies the Quasi Transitivity Constraint is applied.

Using sequentially phase I and phase II different groups of strategies will be generated and ordered according to their on-the-job performance in TAC SCM game.
Described algorithm is implemented into the additional module of the framework. That module is going to be used to change the initial strategy by using different heuristic methods and then run the described above process to assess the new strategy and put it in the order on the absolute scale.

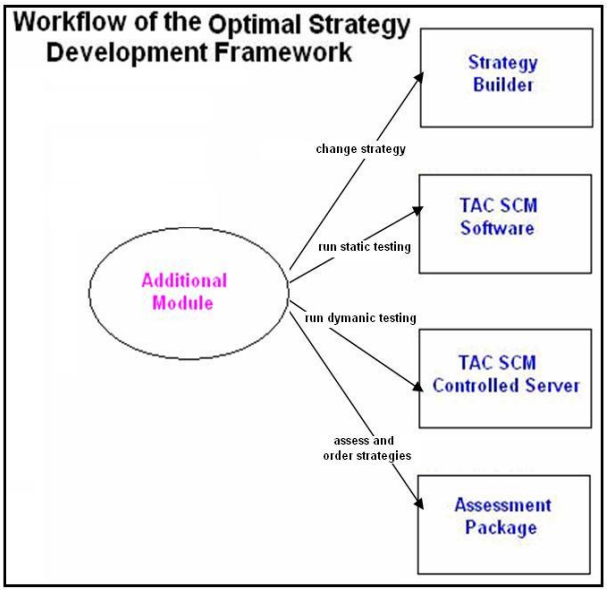

Figure 4: Workflow of the Optimal Strategy Development Framework

5. CONCLUTIONS

The Optimal Strategy Development Framework is a model of the knowledge-driven decision support system that is aimed to generate or recommend a competitive management strategy or a set of strategies that prove their intelligent behavior on the oligopoly competition. The framework includes the oligopoly market simulator (TAC SCM software), the tool simulating the same market conditions for different strategies (TAC SCM Controlled Server), tool for strategies development (the Strategy Plans Builder) and package for strategies assessment based on their testing results (the software package assessing and recommending the optimal strategy). Also a method of Local Tournaments is used to coordinate the work of the mentioned tools.

The framework workflow is implemented in additional module that consists of the main 4 steps (Figure 4):

- Creation and modification of the strategy;
- Static testing of developed strategies;
- Dynamic testing on the strategies passed the static testing;
- Strategies assessment and ordering based on the dynamic testing results.

The Optimal Strategy Development Framework is a user-friendly tool that was developed taking in account a specialized problem-solving expertise that was gained during the years of study and investigations the MOSP problem by our research team. This "expertise" includes the knowledge of Management Strategies Assessment domain, understanding of problems within it, and skills and tools that were developed to solving these problems.

6. ACKNOWLEDGEMENT

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