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Optimization Distribution Of Activity Based Costing Using Agent Based Technologies

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Abstract

The article describes a distribution of cost with base the activities that will result from the negotiations with the salesmen with base the use agent based technology. The purpose is to solve the optimization problem, taking into account constraints such as the salesmen capacity and income increase in a uniform way and the company's turnover increase. In this approach a Sales schedule (ABC activity costing) is developed dynamically by all of the concerned participants. The negotiation methodology used allows agents to negotiate with other agents in a certain geographical area based on their sales capacity, commission percentage and the area's sales turnover. A simulation model based on Repast3 has been developed to evaluate the algorithm accuracy and the system's convergence. By executing this prototype with various utility functions, interesting results have been achieved showing a convergence in total company's turnover, salesmen capacity and salesman income.

Keywords: *ABC Cost Method, Sales Departments, Agents, Cooperative Distributed Problem Solving, Multi-Agent Systems, Compensatory Negotiation Methodology.*
JEL Classification**: **G35

1. Introduction

One of the major problems in many large corporations is distributing the cost in an effective way to all departments and of course in the same dynamic one to sales departments also to develop and maintain efficient sales plans. In those plans, salesmen are assigned to specific geographical areas and their tasks are constantly rescheduled. In task-rescheduling problems, discrepancies between the needed resources for tasks and the resources available to salesmen are a major cause of change and of course on the other hand to minimize the cost of the organization. These discrepancies are inevitable, because it is difficult to take into account the cost and the sales income and consider at the same time the availability of each salesman.

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Each time the company employs new salesmen it is necessary to change the Sales schedule (ABC activity costing) and of course the cost programme, because resource discrepancies cause additional costs, either through relocating surplus resources or bringing in new resources. Therefore, if they try to change the master sales schedule, in order to accommodate their desires, their motives for changing it may cause conflicts among salesmen. It is necessary of course to find a new way to distribute the cost and the sales. That is because any move affects the sales of other salesmen, their income and the sales of the company as a whole. In most cases, these conflicts cannot easily be resolved simply by moving salesmen, since such moves would affect the resource profiles of succeeding salesmen, which cause additional costs or losses for the salesmen. Therefore, there is a need to use a coordination methodology for the salesmen' Sales schedule (abc activity costing) optimization process that ensures overall optimality, and on the other hand to minimize the cost using various activities.

The purpose of the present paper is to solve the optimization problem by taking into account the most important constraints, and to find a better way to distribute the costs which are the following:

The salesmen capacity and income should increase in a uniform way in a classic theoretical model. In addition if the cost for the company is distributed by the activities that will result from the negotiations will be much better their distribution for the enterprises. If the enterprise finds a better way to cost under the base of supplies, the faculties of each salesman and the geographic regions, kilometric distances, etc, it will accomplish achieves much better distribution of cost and consequently fairer system of cost accounting. Admitting that the salesman sales capacity increases proportionally to the geographical area's potential turnover, and that the income of salesmen increases proportionally to the area's potential turnover and the salesman commission percentage, then the salesmen rescheduling should take place in such a way as to provide them all equal opportunities to increase their sales capacities and turnover. Finally the company's turnover should always increase in the fastest possible way.

The need for detailed information on a company's operating costs is crucial for all organizations, in order to take proper financial decisions that will allow companies to maintain or even improve their competitive position. For many years businesses operated under the assumption that costing information correspond more or less (but always to an adequate degree) to the cost prices of produced products and offered services. Unfortunately such an assumption was true only in a small amount of cases.

Traditional costing systems were designed to function many decades before, when companies produced only a small variety of products and when direct labor and material were the primary cost factors. The amount of general expenses was relatively low and their improper allocation would not lead to a significant distortion of information with regards to product costs. The expenses associated with

collecting economic data were high and therefore companies did not have the necessary data in order to develop a more efficient costing method. ABC forms a concept that was only recently developed, aiming at eliminating all the disadvantages that characterized traditional costing systems.

In recent years, business reality is characterized by phenomena such as increased competition and higher production and distribution costs, as a result of product diversification and the fact that they serve specialized customer needs better. Companies, in responding to these competition changes, have been seeking ways to strengthen their operations and collect more accurate data for decision taking purposes.

Precise knowledge in costing elements of business activities, both at a general and a product-specific level constitutes an important factor in taking strategic business decisions; the costing system used by a company forms an essential information resource for taking such decisions.

Within the context of increasing competition, the activity based costing method was developed with the aim to contribute to a better acknowledgment of expenses relating to the creation of new products (or services), resulting in better and more detailed information on actual product costs for businesses to rely their decisions on. This way, Activity Based Costing helps managers to take more stable and conscious decisions with regards to making their company's products available in the market and to act towards continuously improving their business processes.

The ABC method is a costing method designed in such a way as to provide managers with cost information for strategies and decisions that will potentially affect the company's dynamics and, consequently, its fixed expenses. Normally, the ABC system complements a company's existing costing system and does not replace it. In reality, companies that implement ABC systems maintain two costing systems at the same time: the traditional one used to prepare external financial statements and the ABC system used for internal decision-taking and administrative activities (Garrison and Noreen, 2004).

2. A Review On Bibliography

Traditional costing systems, either those recording overhead expenses based on direct labor or the money value of sales, or direct costing systems that completely disregard overhead expenses for calculating product, services and customer costs were already considered as old. Distinguished researchers in the field of management accounting had already started implementing alternative costing systems based on the transactions that take place in a company.

Traditional costing systems are designed to provide results in a scale of unit costs for the company's products, with the aim to inform third users on its financial statements.

Ginoglou (2001) states certain criteria for the implementation of ABC systems in a productive business. More specifically:

(a) Variety of produced products: The availability of products with different costing structures distorts the results of the traditional method, as such method produces the average cost for all products.

(b) Support needs of products: The distribution of support costs for the various products is proportional to the production activity of these products, which induces the corresponding support costs. The most important factors that reduce or increase support costs are the different levels of complexity and vulnerability of product production machinery, and improvements or changes of production processes.

(c) Requirements in common procedures: A separate criterion should be the level of existence of common activities that support production as well as other business operations relating to production, either directly or indirectly. The higher the use of common operations among products (such as production, planning, technical support, research and development, quality control and management) the more imperative the need to implement ABC.

(d) Distribution of time-related costs: This criterion shows whether a company's costing system is capable of properly and promptly detecting and recording changes in the support requirements of the various products.

According to Goebel et al. (1998), ABC acknowledges that literally all activities that take place in a company support production, marketing and the distribution of its products and services. This kind of approach of organizational activities allows for a substantial assessment of both industrial and support business costs (e.g. marketing, sales, advertising and management) on individual products, distribution channels, departments and customers.

Landry et al. (1997) believe that an organization usually implements ABC for two main purposes: first of all, to obtain a deep understanding of the structure of its costs in terms of procedures and, secondly, to establish the actual value of its products, usually in the form of reserves.

Akyol et al. (2004) describe ABC as a methodology that estimates the cost and performance of activities, resources and cost objects. According to researchers, it is an economic model that establishes cost pools or activity centers within an organization, and attributes costs to cost drivers based on the extent of use of each activity. One might say that ABC includes the analysis of an organization into activities (Smith, 1992). ABC has attracted a lot of attention in the field of

management accounting research, both with regards to the ability of activities not related to volume to explain cost behavior, as well as the perceptible value of ABC systems in organizations (Ittner et al., 1997).

Cooper and Kaplan (1992) have expressed the notion that ABC systems have two important characteristics. First of all, the activities carried out are not required in proportion with the total volume of produced (or sold) product units. Requirements depend on the diversification and complexity of the product mix and the consumer mix. Secondly, ABC systems do not constitute models representing the way with which costs and expenses change in the short term. Such systems estimate the costs of the resources used to perform activities in order to produce various products. During a given period, the production of products and services, marketing, sales and distribution to customers create a demand for organizational activities. The quantity of each service provided for the products is estimated using cost drivers, such as the number of hours needed to set up the machinery, the number of purchase orders processed, the number of receipts that have been received, the number of hours of direct labor and machine hours, the number of parts in maintenance, etc. By adding up the costs for all resources produced to carry out individual product activities, the ABC model estimates the cost of the resources used during that period for all company products.

Goebel et al. (1998) have discovered that ABC requires by marketing executives to re-determine their thoughts with regards to fixed and variable expenses and the margins affecting the decision-taking process. All executive staff with decision taking and profit responsibilities should operate in an ABC environment, emphasizing on procedures of product development, industrialization and distribution, as well as on the cost of activities necessary for the integration of the above-mentioned services. This requires focusing on the added value for each stage of the process instead of just providing a simple number for the cost of a product.

Krupnicki and Tyson (1997) report that those involved in an ABC program should invest a lot of time on the actual factors that produce costs in their businesses, by observing operations, interviewing employees and applying quantitative methods, such as regression analysis. A company that does not commit the necessary resources is certain to achieve disappointing results.

Even though it is clear that the primary role of an ABC system is to provide information relating to the cost of the production line, in reality it offers much more to enterprises. The ABC methodology offers valuable help since it allows managers to perform several important activities, such as: a) detect high operating expenses per product unit and find ways to reduce them, b) calculate with precision the company's profitability compared with the one deducted by using traditional accounting methods, c) determine whether a product or service is worth to sell or if

it should be replaced with new products and services, and d) decide whether the internal development of products and services is profitable or should be outsourced.

The ABC methodology does not replace the accounting system already used and established in a company. On the contrary, it operates more like a safety control means to validate the economic result found by using traditional accounting methods. It is important to mention that traditional financial accounting does not examine in depth the reasons for the costs but is more interested in the collective financial result. To this extent, the ABC methodology works as a supplement, ensuring the necessary in-depth analysis of accounting facts that will lead managers to making rational decisions. To this end, Palmer and Vied (1998) claim that, despite unanimously agreeing on the benefits gained from ABC measurements, there is dispute on the way with which theory on ABC can turn into action within an organization.

Mitchell (1994) states that the broad use of ABC in many problematic areas of conventional management accounting (such as stock evaluation, cost behavior and variance analysis) does not mean that this method is a cure for all. The implementation of an ABC system should be handled with caution. Users of costing information must bear in mind that the method is not to be regarded as free of arbitrariness when it comes to assessment nor considered to be precisely indicative of real mechanisms for resource consumption. Moreover, it must not be thought that ABC systems provide solutions to cost control problems that are free of behavioral issues or that exclude alternative approaches. Therefore, ABC applications appear to be more suitable for guidance purposes rather than for providing final decisions in critical business issues.

Mecimore and Bell (1995) state that enterprises are moving from giving emphasis to products towards focusing on processes, and then towards focusing on the Strategic Business Unit (SBU[5]). In fact, according to the authors, the completion of ABC development must include the interconnection of activities among the various business units, creating an ABC system that provides information on the company as a whole.

Akyol et al. (2004), mention that the total cost of a product within an ABC environment is equal to the cost of raw materials and the sum of individual activity costs that add up value during the production process. In reality, the ABC method models the use of organizational resources based on the activities performed, and links the cost of these activities with their derivatives, such as products, customers and services. Each product requires a number of activities, such as planning, mechanics, purchasing, production and quality control. Each activity consumes resources from various categories. Cost drivers often constitute measures of performed activities (e.g. the number of units produced, labor hours, equipment operating hours, the number of orders received).

Cagwin and Bouwman (2002) carried out a research which indicated a positive synergy from the use of ABC and other systems at the same time (e.g. Just-In-Time - JIT, Total Quality Management, etc.). When companies use ABC along with other strategic business schemes, the net improvement in financial performance is higher compared to the net improvement that would result from applying only one of the above systems. Furthermore, there is a positive relationship between ABC and a higher Return on Investment (ROI), when ABC is implemented in complex and diversified enterprises, within environments in which costs are relatively high and when only a limited number of inter-company transactions limit the benefits. There are certain indications that other factors (complex information technologies, lack of overcapacity and competitive environment) also have a positive impact on the performance of ABC systems. Finally there are indications that the successful implementation of an ABC system forms a factor towards improved financial performance of companies.

Drake et al. (1999) examined the way with which the costing system and the mobilization structure interact within a company. Through their research, they discovered that production costs are lower and profits are higher when ABC is associated with motivation towards group activities, which strengthen cooperation. On the other hand, higher production costs and lower profits occur when the ABC system is associated with motivation towards competition. In this case, employees proceed to innovations from which only they gain, and use their information on cost drivers and activities only to increase their individual productivity. The Net Operating Income represents the Earnings Before Interest and Taxes (EBIT). The Net Operating Income is used, since the base (the denominator) includes the operating assets. Therefore, for reasons of consistency, the Net Operating Income is used as a numerator. On the other hand, Operating Assets include cash, liabilities accounts, stocks, buildings and equipment, and other assets used for production purposes within an organization.

Gordon and Silvester (1999) examined the performance results of companies that were connected with an ABC application. Their originality lies in the evaluation of results in the US capital market following their announcement on implementing an ABC system. Therefore, their measurement of success is based on publicly available data of the capital market on the examined companies. Moreover, the time on which a company has introduced an ABC system is also based on publicly available information. The announcement time of ABC implementation on behalf of the examined companies is usually around the end of the 1980s: a period when the US was characterized by a clear tendency towards ABC. Therefore, in that period, a reaction by the capital market towards ABC implementation was very likely to occur, as at the time the capital market entailed a massive character. In actual terms, at that time significant results should have been observed in the capital market. Yet, analysis has shown that the installation of an ABC system was not

associated with any significant reaction in the capital market (either positive or negative). Researches believe that these results should be considered by companies that intend to install an ABC system, in terms of the costs and benefits that derive from the adoption of such a method.

Gordon and Silvester recognize that the performance assessment of a company with regards to the application of ABC with the use of capital market returns has limitations. On our part, we may indicatively mention the degree to which markets are effective, especially considering the level of information on ABC and the financial data available to investors, as well as the ability of investors to interpret given information in rational terms. It should be pointed out that ABC is not used for the preparation of financial statements for external users. Certain businesses use ABC in their published financial statements, although most of them do not (Garrison and Norren, 2004). Therefore, if the precise data of a specific ABC adopted by a company are not known to investors, it is difficult to expect a relatively proper incorporation of such information to the price of the company's stock market shares (limited company).

Geishecker (1996) say that ABC should not be promoted as a financial system, but as part of a broader Activity Based Management (ABM) system. Where the ABC determines how much something costs, the ABM determines how a certain activity drives a company. A successful ABM forms an inter-functional choice that combines traditional financial data with non-financial information, to provide strategic assistance in planning, operating and evaluating a company. It is an analytical tool for making decisions, as with its help costing, planning, orders and every other function can be carried out based on the activities.

Turney and Stratton (1992) support that with the two-dimensional ABC system (one dimension for cost assessment and one for processed), large progress is made in cost management. ABC becomes a real cost management system that supports product costing as well as performance improvement. The primary element for creating a two-dimensional ABC model is the use of micro-activities (or detailed tasks) and macro-activities (or task summaries). Micro-activities are labor units in a section in which they are dealt with on a daily basis and are part of the dimension of processes. They constitute the central point of focus for improvements. Detailed information (relating or not relating to costs), including cost drivers and performance measurements, is included in micro-activities. Micro-activities are not used for product costing. The cost of micro-activities is included in macro-activities. Macro-activities are sets of interrelated micro-activities and form part of the cost assessment dimension. Their main purpose is to facilitate the description of high production costs. Yet, they are concise enough to lead to the improvement of individual activities. The cost of macro-activities is included in the products with the use of one activity driver that lowers costs and the complexity of the ABC model, as activity drivers are not associated with micro-activities. Moreover, it maintains the accuracy

of the described production costs, as the micro-activities included in a macro-activity are used in the same way by all products.

Gupta and Galloway (2003) point out that the strategic value of an ABC/ABM system lies in the provision of useful knowledge in decision making processes, since it does not just offer financial data but also examines processes and activities, in order to establish the areas that add value or those that don't. By considering such a system purely as an accounting system, we disregard its real value. The fact of establishing activities within the limits of sections using an ABC/ABM system might force managers to consider their company processes and to review their organizational models. The ABC/ABM system relates to a complete change of models, emphasizing on the interconnection of all business aspects.

1. The Sales Plan Rescheduling Problem

Sales schedule (ABC activity costing) optimization is not an easy task for sales departments, because consideration of each salesman's motives and capacities will be generally unknown by sales departments in cases involving many salesmen in complex sales plans. Furthermore, sales departments have little incentive to accommodate the salesmen' motives. The companies are trying to motivate salesmen by distributing them justly in geographical areas with high revenue and use their commission percentage as a means to balance their income. The company should always have the maximum revenue for each combination of salesmen with geographical areas. A distributed coordination methodology that allows salesmen to evaluate the impact of their changes and make appropriate decisions based on the evaluation is, therefore, needed.

In order to develop and apply a distributed coordination methodology, we identified the following requirements for the developed system:

- Geographical areas are distributed on the landscape.
- A space is populated with agents representing salesmen.
- Agents are rescheduled periodically in such a way as to maintain the Utility of each replacement positive.
- Rescheduling takes place whenever an important event occurs such as: a change in the geographical area sales capacity, or a change in a salesman's capacity or a change in the salesman's commission percentage.
- Such events are produced randomly by the system causing it to reschedule its sales agents.

- If an agent is not replaced then the system redistributes resources that have been assigned to that geographical area. The money is proportional to the area's turnover and the agent's commission.
- The company's total turnover equals the sum of the agent's turnover minus the sum of each agent's commission.
- All sales tasks include the necessary information (geographical area performance, salesman capacity etc).
- All salesmen maintain the necessary information at the sales task-level.
- Minimal dependency information is available about other salesmen so that they can interact with each other.
- Salesmen should have communication channels to express their schedule perspectives to others, and
- A conflict-resolution strategy should be devised in case of conflicts.

The research started by investigating whether the distributed frameworks in construction and AI planning can provide theoretical foundations for satisfying the above conditions. According to many researchers (Keesoo et al., 1987; Khedro et al., 1993; Gomes et al., 1994; Jin et al., 1993) current distributed frameworks do not provide a conflict resolution strategy based on a cost model, even though some of them provide various conflict resolution strategies for interactions between participants. ProcessLink (Petrie et al., 1998) identifies dependencies among tasks and participants but does not specify a conflict resolution strategy. Thus, we needed to develop a distributed coordination methodology that included a cost model and a conflict-resolution strategy based on the cost model.

A number of distributed coordination methodologies in Cooperative Distributed Problem Solving (CDPS) and Multi-Agent Systems (MAS) research were reviewed, but nothing was found concerning applications for Sales schedule (abc activity costing)optimization. Even for project schedule problems that are in a way similar to our project a number of shortcomings was found (Keesoo et al., 2000).

Allowing the transfer of utility is important for Sales schedule (abc activity costing)optimization, as it is for construction project schedule optimization. When a salesman reschedules his sales, the rescheduling has external effects on succeeding salesmen plans and the company's profit, causing additional costs or loss of profits for the affected salesmen and thus for the company. Therefore in Sales schedule (abc activity costing)optimization we will get a globally optimal schedule if all alternatives are considered.

Keesoo et al., (2000) has showed that allowing the transfer of utility units for compensation would lead to individually rational and globally optimal solutions in CDPS and MAS systems. In other words, agents try to maximize their utilities while compensating other agents, which are forced to make disadvantageous agreements. Consequently, the agents find a globally optimal solution without

rendering the position of other agents worse. This globally optimal solution will increase the social welfare and this social welfare will be distributed directly to agents.

Many implicit mechanisms of the transfer of utility were proposed in a number of papers about CDPS and MAS. However, Keesoo et al., (2000) proposed an explicit and direct mechanism for the transfer of utility in their paper that is more efficient than using incentives or reward mechanisms, which we may find in some market-based systems (Malone, et al, 1988; Wellman, 1993; Shoham and Tanaka, 1997). Unified negotiation protocol (Rosenschein et al., 1994) does not provide an explicit way of transferring utilities, so it uses an implicit way –working together after flipping a coin.

An important thing is that most CDPS and MAS applications employ pair-wise negotiation mechanisms that are unsuitable for coordinating tightly coupled schedules like sales schedules. Keesoo et al., (2000), has extended the current CDPS and MAS research to produce a globally optimal solution by allowing the transfer of utility for compensation of disadvantageous agreements and by developing a negotiation protocol suitable for coordinating the tightly coupled construction schedules; we will then use that solution so as to solve the current sales coordination dilemmas in the sales scheduling within corporations.

In their work to develop sales agents for virtual manufacturing, Choi et al (2000) proposed a virtual manufacturing-based sales agent (VMSA) with multi-agent architecture to support the sales activity for parts manufacturers in an Internet environment. The sales activity of most parts manufacturing companies is originated from buyers' orders. On deciding whether to accept an order or not, as well as negotiating with buyers, sales persons need information such as load and schedule of production lines, as well as the manufacturability of the order. Manufacturability analysis, process planning, and scheduling are therefore key features in developing an agent of sales activity for the parts manufacturing business. The process of promotion, receipt, and selection of orders of the parts manufacturers is closely coupled with the load status of the production lines.

2. Sales Schedule (Abc Activity Costing) Optimization On Cdps And Mas

Sales optimization is a completely new area of research. In Sales optimization, agents can reallocate their initially assigned resources whenever the timing of the tasks is undesirable. This means that there are resource discrepancies between resource requirements and resource availability. However, this resource reallocation causes transaction costs. When they try to change the timing of their tasks, the changes cause external costs to succeeding agents. Therefore, agents have to evaluate the transaction costs associated with the reallocation of their resources and the external costs for changing the timing of tasks before they make decisions.

3. Addressing Compensation In Sales Scheduling (Abc Activity Costing)

Compensatory Negotiation Methodology was first introduced to project planning optimization by Keesoo et al. (2000). This method seemed to have advantages over other methods in resolving the problem of transferring utility units "money" among software agents for compensation of disadvantageous agreements. We will apply this method to resolve the problem of transferring utility units among sales agents to compensate disadvantageous agreements.

In the following we will try to formalize agent utility function, the multi-connection negotiation protocol by which agents interact with each other, and a monetary compensation strategy that agents use to generate a sales solution.

A utility function serves as a means for the agent to evaluate a possible decision. The utility function produces utility units that are represented as real valued numbers "such as money", which describe the cost or benefit of alternatives for the agent. The utility is common for all agents and is distributed among them for compensation.

In our research, we quantify the benefit based on the profit compensation among the salesmen of a company, when rescheduling the sales plan and the cost based on the expected loss (which can be a positive or negative quantity) in turnover due to the transfer of salesmen. Thus, the utility function will be generated by subtracting these two quantities. In order to achieve this quantification we have made the following assertions:

$\mathbf{C_i}$: the sales capacity of salesman (i) in a scale 1-10

This is a rather arbitrary value that for the purpose of the prototype will be assigned by the system to each salesman arbitrarily.

$\mathbf{P_k}$: the sales performance (in sales turnover) of a geographical area (k).

This quantity can be estimated by dividing the sales turnover T_i of every salesman that worked in the area by its sales capacity C_i and then by finding the mean value. This will give an indicator of the turnover of this area per salesman capacity unit.

$$\mathbf{P_k} = \sum_{i=1,n} \frac{T_i}{C_i} \Big/ n \qquad \textbf{(1)}$$

$\mathbf{Co_{ik}}$: the commission percentage of each salesman (i) in the area (k)

The type of the commission scheme is divided into three categories. In the first the commission is variable and depends upon the area's turnover. The company uses this scheme when it wants to compensate the revenues of their salesmen. In this scheme the commission percentage is conversely proportional to the area's turnover. In the second scheme the commission percentage is fixed and in the third scheme there is no commission at all.

The expected sales turnover for a salesman (i) in a geographical area (k) $E_{ik,}$ will be calculated by multiplying the sales turnover P_k of the area with the salesman capacity $C_{i.}$

$$\mathbf{E_{ik} = P_k * C_i} \quad \textbf{(2)}$$

Thus, the expected income for a salesman (i) in a geographical area (k) $I_{ik,}$ will be calculated by multiplying the expected sales turnover E_{ik} of the salesman in the area, with the salesman commission percentage $Co_{i.k}$ in the area.

$$\mathbf{I_{jk} = E_{ik} * Co_{ik}} \quad \textbf{(3)}$$

The company's benefit will be calculated by finding for each salesman (j) the salesman that will replace the first (i). That will give us the maximum difference among the expected company's turnovers in the area (k). The company's turnover is calculated by the expected turnover for the salesman minus his/her commission.

$$\mathbf{Benefit_c} = \underset{i=1,n}{Max}[\, E_{ik} * (1 - Co_{ik}) - E_{jk} * (1 - Co_{jk}) \,] \quad \textbf{(4)}$$

The benefit in moving a salesman (i) from a geographical area (k) to an area (m) can be calculated by subtracting his/her incomes:

$$\mathbf{Benefit_s} = I_{ik} - I_{im} \quad \textbf{(5)}$$

As we want to compensate revenues of all salesmen, we have to take into account not only the company's benefit when replacing a salesman but also the salesman's benefit. The total benefit can be found by adding the two benefits after normalization, which will be done by multiplying each benefit with a weight factor.

$$\mathbf{Benefit = Benefit_{s*}\, w_s + Benefit_{c*}\, w_c} \quad \textbf{(6)}$$

Concerning the cost we have three possible sources and thus:

- $\mathbf{TC_k}$: the transportation cost of a salesman from the geographical area (k) to the company's premises.

- $\mathbf{TC_k}$ fixed transportation cost related only to the distance.

- $\mathbf{CC_{ikm}}$: the cost incurred by the salesmen sales capacity increase, when moving him from a geographical area (k) to another area (m). The sales capacity increases proportionally to the area's turnover. Therefore when moving an agent from an area to another with a lower turnover the agent's capacity increases in a slower way. This will increase the capacity divergence between agents. To compensate that divergence, we introduce this cost calculated by

subtracting the sales capacity increase of each salesman (i) in the area (k) C_{ik} from the sales capacity increase of each salesman (i) in the area (m) $C_{im.}$ The sales capacity increase C_{jk} of each salesman (i) in an area (k) is calculated by multiplying the area's turnover P_k with a fixed coefficient c and multiplying the difference with the expected sales turnover of the geographical area (k).

$$\mathbf{CC_{ikm}} = (P_m - P_k) * c \quad \mathbf{(7)}$$

Thus, the total cost $\mathbf{SC_{ikm}}$ of the salesman (i), who is moved from a geographical area (k) to another area (m) will be the sum of the following two partial costs:

$$\mathbf{SC_{ijk} = TC_k + TC_m + CC_{ijk}} \quad \mathbf{(8)}$$

$$\mathbf{Utility = Benefit - Cost} \quad \mathbf{(9)}$$

Example 1

Suppose a salesman (i) with capacity 4 is assigned to the geographical area (k) that has a potential turnover of 100000€ and a commission percentage of 1%, and a salesman (j) with capacity 6 is assigned to the geographical area (k) with a potential turnover of 80000€ and a commission percentage of 1.5%. Suppose the transport cost of area (k) is 500€ and of area (m) is 300€. The cost of replacing salesman (i) with salesman (j) is:

Cost = 2*(50+30) + (80000 – 100000) * 0.001 = 140 *(Based on formulas (6) and (7))*

The benefit of rescheduling is:

$\mathbf{Benefit_c}$ = (80,000 *4 /100) * (1- 0.015) – (80000 * 6/100) *(1 – 0.01) = 315.2 – 475.2 = -160 *(Based on formulas (2) and (4))*

$\mathbf{Benefit_s}$ = (80,000 *4 /100) * 0.015 – (100,000 * 6/100) * 0.01 = 48 – 60 = -12 *(Based on formulas (3) and (5))*

Benefit = -160+12 = -148 *(Based on formula (6))*

Utility = -148 – 140 = -288 *(Based on formula (9))*

Therefore, the utility of replacing a salesman (i) with another salesman (j) is -288€. Calculating the utility units with cooperation of other agents, an agent can make an appropriate decision quantitatively.

The utility function produces utility units for agents based on the cost ratios input by users. Therefore, agents are assumed to be honest in their work. However, there are concerns about whether the users provide agents with incorrect cost ratios to take advantage of other agents (Keesoo et al., 2000). Since the same cost ratios are used to calculate both the benefit and costs, the users might take actual losses even though their agents make profitable deals. In some cases, an agent could produce higher profit from proceeding agents than actual costs with an incorrect cost ratio, but its calculated benefits using the same cost ratio will be much higher than the actual benefits, so that other agents will also take advantage of the inflated benefits and the agent might end up with losses. More research will be needed to verify that a truth revelation is the dominating strategy in most cases.

4. System's Architecture

We used Repast3 (Repast) as the agent platform to implement the system and evaluate it. Repast was developed at the University of Chicago's Social Science Research Computing lab specifically for creating agent-based simulations. We made the following assumptions:

- Every salesman covers only one geographical area.
- There are more areas than salesmen. The system has to take into account the areas that are not covered by salesman. So every salesman will investigate the possibility to replace a salesman in an area or to undertake another free area. In that case only the transportation cost and the benefit of this area should be considered.

- In each Repast tick the salesman change areas rescheduling themselves. Each tick can represent a time period such as a day, week or month. Their aims are to:
    - Increase the company's overall income.
    - Increase their income.
    - Increase their capacity.
- The commission percentage follows the three schemes explained in equation (1) of the previous paragraph.
- The salesman sales capacity increases proportionally to the area's turnover.
- The salesman turnover increases proportionally to their capacity.
- The salesman income increases proportionally to their commission percentage and their turnover.
- The area's turnover decreases proportionally to the turnover moved to the agent's turnover (i.e. the company turnover).

5. The Main Algorithm

Although it may seem intuitively obvious that some form of `intelligence' or adaptation is necessary in bargaining agents, Gode and Sunder (1993) presented results indicating that their zero-intelligence (ZI) agents can exhibit human-like behavior in CDA markets. Considering the results in such projects, we decided to adopt the Zero-Intelligence-Plus (ZIP) agents, instead of developing knowledgeable agents (Cliff et al., 1998), which only know salesmen' tasks, geographical area characteristics, cost profiles and only have basic reasoning capabilities. The consequence is that agents need to obtain a complete knowledge for their decisions through multi-linked negotiations, where one agent negotiates with another agent, which in turn needs to negotiate with a third and so on, until the last agent. This multi-linked negotiation is inspired by the work of Keesoo et al. (2000) and Neiman et al. (1994).

For the needs of the prototype we used the Repast framework. In each Repast round every agent performs the following sequence of actions.

- The agent asks each one of the others, which are their characteristics (commission, capacity etc.) and the area's left turnover.
- The agent calculates the Utility of replacing this agent and stores the result in a table.

- The agent does the same for the free uncovered areas.
- The agent chooses the one with the highest utility and asks to replace the salesman.
- The replaced salesman goes to the company's premises.
- The process is repeated for all salesmen.

6. Sales Ontology

This ongoing research focuses on sales rescheduling salespersons. Sales rescheduling is different from schedule relocation or coordination problems in terms of its need of ontology. In task reallocation schedule coordination problems, abstract information, such as earliest start time is enough for negotiation. In sales rescheduling, the ontology on rescheduled salesmen should be defined for collaboration among software agents. Things that need to be specified are the knowledge structures used to define sales activities and the relationships among these activities (Albers et al., 1999). The criteria that we take into account when defining our sales ontology for activities are: clarity, coherence, extendibility, minimal encoding bias and minimal ontological commitment (Gruber, 1995).

The multi-agent prototype system will be first developed and tested using Repast. In a next step the system can be used to perform the Charrette test (Clayton et al., 1998) that tests the effectiveness of software systems. After the analysis of the preliminary test, the main test will be conducted by comparing two sales schedules: one is a conventional "manual" schedule and the other is an innovative computer-aided sales schedule. The variables to be tested will be the usability, speed, and accuracy of the prototype system.

7. The Prototype

We executed the prototype using 200 geographical areas and 40 salesmen. We spread the turnovers randomly to the areas using a max of 30MEuro per area. In each area we assigned a commission percentage proportional to the area's turnover. Finally, we randomly assigned a capacity to each salesman between 0-10.

The execution results can be seen in the following graphs. They show the evolution in the total company turnover, the salesmen turnover and the salesmen capacity in the 100^{th} round and in the 2000^{th} round.

FIGURE 1

THE SHAPE CONTAINING ALL GEOGRAPHICAL AREAS IN GREEN AND SALESMEN IN BLUE

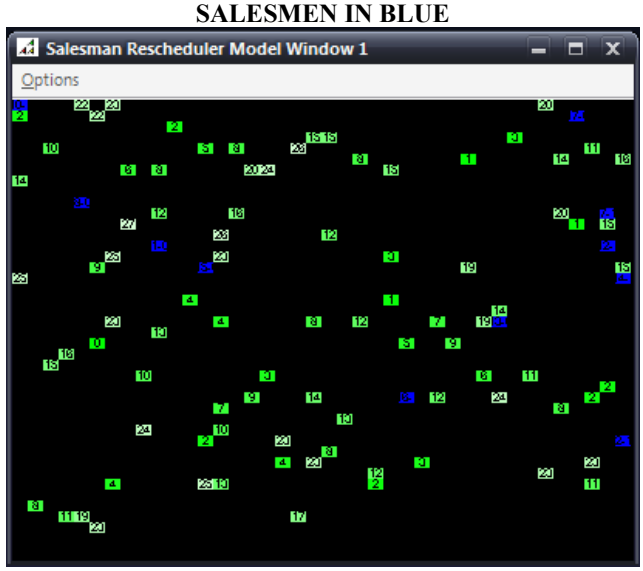


FIGURE 2 THE SALESMEN'S CAPACITY AFTER 10 ROUNDS

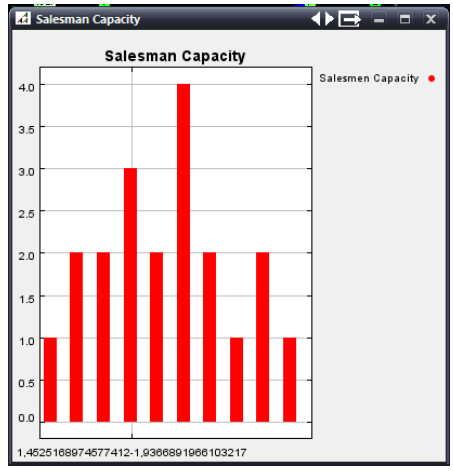


FIGURE 3 THE SALESMEN'S CAPACITY AFTER 50 ROUNDS

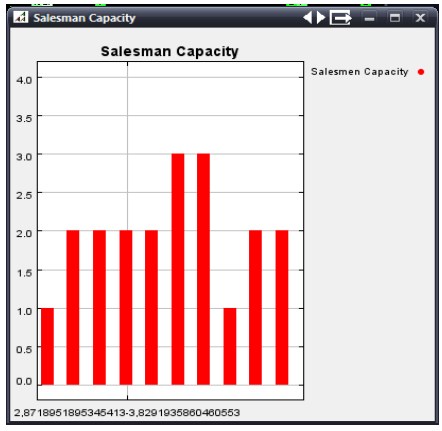


FIGURE 4: THE SALESMEN'S TURNOVER AFTER 10 ROUNDS

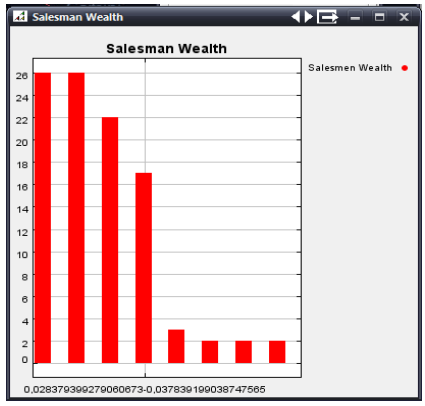


FIGURE 5: THE SALESMEN'S TURNOVER AFTER 500 ROUNDS

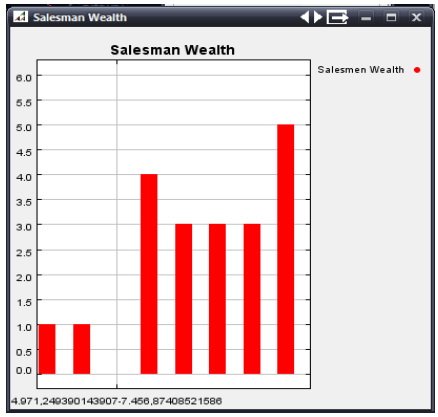
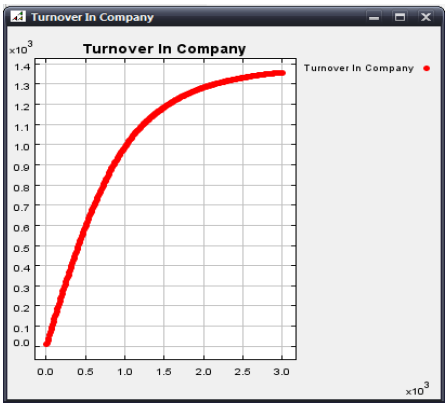


FIGURE 6: THE COMPANY'S TURNOVER AFTER 3000 ROUNDS



Trying different utility functions we discovered that we have a better convergence if we consider the following benefit function for the company:

$$\textbf{Benefit}_c = \underset{i=1,n}{Max}(E_{ik} - E_{jk}) \quad \textbf{(10)}$$

and then modifying the utility function as following:

$$\textbf{Utility} = \textbf{Benefit}_c - \textbf{Cost} \quad \textbf{(11)}$$

The explanation to this is that if we consider as total benefit the maximum turnover for the agents, then we take into account both the increase of the company's turnover and the salesmen profit. This will lead all three curves to convergence. As one can easily deduce from the above diagrams, the systems converges in a state where the company's turnover does not increase anymore and the salesmen capacities and incomes are equalized.

In the diagram concerning the salesmen income the y axis represents the number of salesmen and the x axis their income in money. It is obvious that there is a salesmen concentration in the wealthiest part of the diagram (right). The salesmen increase their income uniformly.

In the diagram concerning the salesmen capacity the y axis represents the number of salesmen and the x axis their capacity. Moreover, a salesmen concentration in the right part of the diagram, the one with the highest capacity, is obvious. That means that the salesmen uniformly increase their capacities.

8. Conclusions And Future Research

From this ongoing research one can deduce that software agents can help optimize a Sales schedule (ABC activity costing)for both companies and salesmen. Keeping salesmen satisfied while increasing the company's turnover is a major advantage since this will lead to an optimal working environment. Since it is one of the first efforts to model a sales plan optimization process with a multi-agent systems framework, the results are very satisfactory.

It is expected that this research will lead to a new approach for developing and rescheduling sales activities within companies of any kind and size. Also, the research will provide a foundation to develop a sales scheduling coordination system that will allow companies to identify and analyze their resource constraints in a given schedule, and help them explore and exploit many alternatives for a better solution.

In conclusion, as shown in similar multi-agent prototype systems, this approach can lead to the development of distributed Sales schedule (ABC activity costing) optimization frameworks and can provide a foundation for facilitating collaboration among salesmen and sales managers within a company. It is expected that our research will provide a foundation to develop a sales scheduling co-ordination system that will allow companies to identify and analyze their resource constraints in a given schedule, and help them explore and exploit many alternatives for a better solution.

References

1. Akyol, D.E., Tuncel, G., and Bayhan, G.M., 2004, 'A comparative analysis of activity-based costing and traditional costing', Transactions on Engineering, Computing and Technology, 3, 87 – 90.
2. Albers, M., Jonker, M., Karami, M. and Treur, J., 1999, 'An Electronic Market Place: Generic Agent Models, Ontologies and Knowledge', Proceedings of Agents 99 Workshop on Agent Based Decision-Support for Managing the Internet-Enabled Supply-Chain, Seattle, Washington, 71-80.
3. Cagwin, D., and Bouwman, M.J., 2002, 'The association between activity-based costing and improvement in financial performance', Management Accounting Research, 13, 1 – 39.
4. Choi, H. R., Kim, H. S., Park, Y. J.; Kim, K. H., Joo, M. H., 2000, 'A sales agent for part manufacturers: VMSA Decision Support Systems', 28, 4, 333-346.
5. Clayton, M., Kunz, J. and Fischer, A., 1998, 'The Charrette Test Methods. Technical Report, No. 120', Center for Integrated Facility Engineering, Stanford University, USA.

6. Cliff, D. and Bruten, J., 1998, 'Simple Bargaining Agents for Decentralized Market-Based Control, Technical Report, HPL-98-17', Hewlett Packard Laboratories, Bristol.
7. Cooper, R., 1990, 'Cost classifications in unit-based and activity-based manufacturing cost systems', Journal of Cost Management, Fall, 4 – 14.
8. Cooper, R., and Kaplan, R.S., 1992, 'Activity-Based Systems: Measuring the Costs of Resource Usage', Accounting Horizons, 6, 3, 1 – 12.
9. Drake, R.A., Haka, S.F., Ravenscroft, S.P., 1999, 'Cost System and Incentive Structure Effects on Innovation, Efficiency and Profitability in Teams', The Accounting Review, 74,3, 323 – 345.
10. Elton, E.J., Gruber, M.J., Brown, S.J., Goetzmann, W.N., 2003, 'Modern Portfolio Theory and Investment Analysis', 6th edition, John Willey and Sons, Inc, USA.
11. Garrison, R.H., and Noreen, E.W., 2004, Managerial Accounting, Mc-Graw Hill Irwin, International Edition.
12. Geishecker, M.L., 1996, 'New Technologies Support ABC', Management Accounting (US), 77, 42 – 48.
13. Ginoglou, D., 2002, 'Activity-Based Costing: A Survey For The Greek Companies', European Applied Business Research Conference in Rothenburg Germany Proceedings Book.
14. Ginoglou, D., Tahinakis, P., and Protogeros, N., 2004, 'Accounting Information System: An activity-based costing analysis for evaluation of environmental activities in Greece', International Conference Academy of Business and Public Administration Disciplines, New Orleans, Louisiana, USA.
15. Goebel, D.J., Marshall, G.W., and Locander, W.B., 1998, 'Activity-Based Costing Accounting for a Market Orientation', Industrial Marketing Management, 27, 497 – 510.
16. Gode D., & Sunder S., 1993, 'Allocative efficiency of markets with ng zero-intelligence traders: Market as a partial substitute for social individual rationality', Journal Political Economics, 101,1, 119-137.
17. Gordon, L.A., and Silvester, K.J., 1999, 'Stock market reactions to activity-based costing adoptions', Journal of Accounting and Public Policy, 18, 229 – 251.
18. Gomes, P., Tate, A. and Thomas, L., 1994, Distributed Scheduling Framework,, Proceedings of the International Conference on Tools with Artificial Intelligence, Piscataway, NJ: IEEE.
19. Gruber, T., 1995, 'Toward Principle for the Design of Ontologies Used for Knowledge Sharing', International Journal of Human-Computer Studies, 43, 5-6, 907-928.
20. Gupta, M., and Galloway, K., 2003, 'Activity-based costing/management and its implications for operations management', Technovation, 23, 131 –

138.
21. Innes, J., Mitchell, F., and Sinclair, D., 2000, 'Activity-based costing in the U.K.'s largest companies: a comparison of 1994 and 1999 survey results', Management Accounting Research, 11, 349 – 362.
22. Jin, Y., and Levitt, E., 1993, 'Modeling Organizational Problem Solving in Multi-Agent Teams', Intelligent Systems in Accounting, Finance and Management, 2, 247-270.
23. Kaplan, R.S., 1994, 'Management accounting (1984-1994): development of new practice and theory', Management Accounting Research, 5, 247 – 260.
24. Keesoo, Kim, Boyd, C., Paulson, Jr. Charles, J., Petrie, Jr. and Lesser, V., 2000, 'Compensatory Negotiation for Agent-Based Project Schedule Optimization and Coordination', Fourth International Conference on Multiagent Systems (ICMAS 2000).
25. Khedro, T., Genesereth, R. and Teicholz, M., 1993, 'Agent-Based Framework for Integrated Facility Engineering', Engineering with Computers, 9, 2, 94-107.
26. Krupnicki, M., and Tyson, T., 1997, 'Using ABC to Determine the Cost of Servicing Customers', Management Accounting (US), 79, 40 – 42.
27. Landry, S.P., Wood, L.M., and Lindquist, T.M., 1997, 'Can ABC Bring Mixed Results?', Management Accounting (US), 78, pp. 28 – 30.
28. Malone, W., Fikes, E. and Howard, T., 1988, 'Enterprise: A Market Like Task Scheduler for Distributed Computing Environment', The Ecology of Computation, 177-205.
29. Mecimore, C.D., and Bell, A.T., 1995, 'Are we ready for fourth-generation ABC?', Management Accounting (UK), January, 22 – 26.
30. Mitchell, F., 1994, 'A commentary on the applications of activity-based costing', Management Accounting Research, 5, 3/4, 261 – 277.
31. Neiman, D., Hildum, D., Lesser, V. and Sandholm, T., 1994, 'Exploiting Meta-Level Information in a Distributed Scheduling System', Proceedings of the 12th National Conference on Artificial Intelligence, Menlo Park, CA, AAAI Press.
32. Petrie, C., Goldmann, S. and Raquet, A., 1998, 'Agent-Based Project Management. Technical Report, No19981118', Center for Design Research, Stanford University, USA.
33. Repast (Recursive Porus Agent Simulation Toolkit), http://repast.sourceforge.net/.
34. Rosenschein, S. and Zlotkin, G., 1994, 'Rules of Encounter: Designing Conventions for Automated Negotiation among Computers', MIT Press., USA.
35. Shoham, Y. and Tanaka, K., 1997, 'A Dynamic Theory of Incentives in Multi-Agent Systems', Proceedings of the Fifteenth International Joint Conference on Artificial Intelligence, California, USA.

36. Turney, P.B.B., 1992, 'Activity-based management', Management Accounting (US), 73, 20 – 25.
37. Wellman, M. P., 1993, 'A Market-Oriented Programming Environment and Its Application to Distributed Multicommodity Flow Problems', Journal of Artificial Intelligence Research, 1,1-23.