

Linking Strategies of Organizations to Multi Agent System Typologies

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Abstract—This paper relates the organizational strategy to Multi Agent System typologies. Multi Agent System is a collection of intelligent agents and have ability to perform more complex tasks which are out of individual capability. We use the typology of Miles and Snow *et al.* (1978) and Porter (1980) for organizational strategies. These are primarily cost leader and differentiation strategies. The organizations following cost leader strategy adopt a Multi Agent System which is more centralized in decision making whereas organizations with differentiator strategy adopt Multi Agent System which is decentralized and have dynamic decision making capability, loose coupling and service reusability.

Index Terms—Multi agent system, organization strategies, cost leader, differentiators.

I. INTRODUCTION

Information Technology is a crucial aspect in an organization. Proper information exchange helps in better integration of members both within and outside the organization [1]. This is the reason why information technology has always been a top priority of any organization which is to improve and use it extensively to reap the benefits and gaining competitive advantage over other firms [2], [3]. Today's organizations are becoming more complex so new technologies are coming up to make things simple, efficient, better and for this systems are built in such a way that it has less human intervention, systems which are more automated, systems which can think act react on its own thus take their own decisions. In an era where a lot of research is going on distributed artificial intelligence, a topic of research which has gained quite importance is Multi Agent System.

II. THEORETICAL DEVELOPMENT

A. Multi Agent System

Wansup Um *et al.* explain Multi Agent System as a collection of agents or a network of agents [4]. These agents are intelligent and work according to their goals and have certain characteristics. They are autonomous which is they are able to carry out tasks without human interventions. Such agents are also sociable that is they can interact with other agents to get information or pass on information and tasks. Agents like this can be customer or sales agent or can be agents of other companies as well. Agents are reactive therefore they respond to changes in tasks in a timely fashion. Agents are also proactive since they are self-learning agents

therefore they can change their behavior based on previous experiences or data and thus build new activities.

S. Srinivasan *et al.* in their paper has talked about further more abilities and functions of Multi Agent Systems [5]. Agents as explained before are intelligent, powerful, versatile and efficient. This agent has only a part of the information and with limited knowledge and resources they need to take decisions and fulfill objective or goals. This is done by breaking the tasks into sub problems allocating to each subagents and so agents communicate with each other for information and can communicate very fast which makes them extremely robust. Building and designing such agents is itself a complex task, as in how they should handle conflicts, what programming language to use, what should be the network and communication protocols.

Thierry Moyaux *et al.* in their paper have explained about motivations of Multi Agent System and their applications [6]. As explained before the nature of today's organizations being so much complex and distributed globally, therefore there was a need of a system which itself will be decentralized and distributed. In contrary to previous systems which apply the behavior programmed during designed time, Multi Agent System continuously co-ordinates with other agents and jointly performs activities which are not designed previously. Thus Multi Agent System modularizes complex systems helping organizations to increase more flexibility. Today Multi Agent System has widespread applications, it has applications in manufacturing systems where agents communicate with each other and co-ordinate to run a production system. It has gained importance in telecommunications network, transport systems where vehicles are thought to be as agents and can communicate to each other to increase safety and reduce traffic congestions. Further it is being used in hospitals for patient monitoring, rescue operations. Even air traffic controls, spacecraft and nowadays ecommerce websites are using it as well to bid for the best price.

Pooja Jain *et al.* and Tapia *et al.* has described how these agents can be connected with each other for communication in between them. They have said that distributed systems can be best designed using Service Oriented Architecture also known as SOA. SOA is an architectural style for building software applications [7], [8].

Srinivasan *et al.* argued that Multi Agent System together with SOA helps in increasing business flexibility by helping to be coupled in a loosely fashion and thus allowing services to be reused and increase in scalability [5]. Advantages of using SOA is that it provides modularity since it can use the same code again in various applications and easy to modify. Since applications can be written in any programming language and can be used with other applications written in

different programming languages, it helps in reduction of technological dependency. This helps to increase interoperability better communication and easy to understand no matter which platform it runs on. SOA has an advantage of having a service registry where all public information of all available services is stored thus agents can locate required services in service registry.

Fernando Bellas *et al.* and Cheng Tao *et al.* have described a different framework of building Multi Agent Systems. Common Object Request Broker Architecture commonly known as CORBA is also a middleware just like SOA. CORBA has been thought to be as a more powerful too when used in legacy systems. CORBA has less interoperability as compared to SOA but it has overall control of the authority. [9], [10].

B. Organizational Strategy

Information Technology helps in speed in speed and flexibility of decision making and plays a key strategic role in business and to achieve this it should be aligned with the various organization strategies [1].

An organizational strategy is plan of action adopted by an organization for achieving a long term goal or solution to a problem. Over a period of sixty five years a lot of strategic typologies of organizations have been published. Among them, Miles and Snow in 1978 and Porter are the most popular strategic typologies and have been used by many researchers over time [2], [11].

Miles and Snow categorized organizations into four types Prospectors, Defenders, Analyzers, Reactors [11]. Each of the organizations follow different types of methods and procedures of tackling organizational problems.

Defenders- Defenders are the most stable form of the organization. They cater to certain portion of the market and offer product at cheapest price or high quality and maintain a strict control of entry of competitors. This type of organizations invest heavily on production process to increase their efficiency and have little focus on research and development. Overall control of the organization is centralized, there is division of labor as well as communication system is strictly hierarchical. Hamid Tavakolin has said that this type of organizations has more centralized information technology strategy and the user departments has less responsibilities over IT activities[12].

Prospectors- This type of organizations continuously looks for new opportunities like new markets, new products, and maintain a broad product range by having multiple, flexible and prototypical technologies with the help of strong finance, marketing and research and development division. The main objective of prospectors is gaining and maintaining industry leadership in product innovation and profit and efficiency. Das *et al.*, said that Information Technology systems in these organizations are more decentralized, flexible and are used more extensible [13].

Analyzers- Analyzer type of organizations is a combination of both prospectors and defenders thus having a traditional customer base as well as look for new market opportunities. They have a large engineering group as well as presence of moderate amount of technical rationality. The structure of these organizations is more centralized and they have a complex, expensive coordination mechanism.

Reactors- This type of strategy is adapted when other three strategies fail or are not pursued properly. The organizational structure is very unstable due to top managers failing to figure out the organizational structure as well as which type of strategy to follow as a result top managers continue to run the strategy structure relationship in spite of vast environmental changes.

According to Porter a firm adopts different organizational strategies skills, resources, supportive organizational arrangements and control systems to gain competitive advantage based on which it can be divided into low cost or differentiation. A third division is called focus along with this two competitive advantages which is based on scope of activities.

Cost Leadership- This type of firms has a large number of products and serves many industries. The products they offer are of low cost, the reason might be due to economies of scale, propriety technology, preferential access to raw materials and other factors. Also this type of firms has standardized set of products with low customization. According to Porter (1980) Cost Leadership is the main strategy adopted by the firm unless there is a major technological changes which might allow them to change its cost position.

Differentiation- This kind of firms follow a unique set of approach which are valued by the customers. They position their product, services which are market alike. They charge a premium from their customers for their extra features. These features may be the product itself, their delivery approach or marketing strategy and various others.

Focus- This kind of firms focuses on niche buyers. It focuses on a specific attribute and has restrictive competitive scope in the industry. According to Porter this type of firms optimizes the strategy for its target segment and thus the firm gains a competitive advantage on its target segment even though it has does not have competitive advantage at all.

C. Organizational Structure

An organization structure can be defined as a process of dividing, grouping and co-coordinating various functional areas of an organization. It helps to underpin power and accountability, determining how responsibilities are allocated enabling effective participation among people. Choice of an organizational structure depends on organization's strategy, function and mission, its size, budget culture etc.

Based on this an organizational structure can be divided into five ways. These are standardization, specialization, centralization, formalization and complexity of workflow [14], [15].

Standardization- This type of organizations offers a basic standardized product in different markets by having standardized procedures and process. Thus it helps in reduction of design and research and development costs and also helps in increase in efficiency. Similarity in market conditions, customer needs, preferences and tastes is the driving force behind this kind of structures.

Specialization- Organizational tasks are divided into subtasks and people are allocated to execute only one of these tasks [16]. It is divided into vertical task specialization based on different units of people having different level of authority or horizontal specialization when operational tasks are

divided among different people and units. Tasks or duties are distributed among number of positions and there is division of labor in the organization [16]. When each person does only limited number of tasks Specialization is higher whereas low level of specialization means people do a wide variety of tasks.

Centralization- An organization is centralized when all the decision and evaluation are done by top management people in the organization [17], [18]. Disadvantage of this kind of structure is communication and participation among the people in the organization decreases which leads to slow down of development because implementation and creation of innovative ideas reduces [19], [20].

Formalization- In this type of organization rules, procedures, instructions and communications are written within an organization. Cordon- Pozo *et al.* says that formalization helps to improve collaboration, cooperation and integration among organizational staff thus it allows employees to deal more effectively with contingencies because they include the best practice learnt from experience and incorporated into organizational structure [21].

Complexity of Work Flow- According to Fredrickson and Robbins complexity of workflow refers to the degree of differentiation that exists within an organization [18], [22]. The three dimensions of workflow complexity are horizontal, vertical and spatial. Number of tasks, level of education and training refers to horizontal complexity. Vertical complexity refers to number of hierarchical levels in an organization and spatial complexity refers to geographical location of plants, offices and personnel. Higher the complexity of workflow higher is the expertise bases which helps in creation of greater amount of knowledge thus solving a wide range of problems.

III. THEORETICAL FRAMEWORK

According to Ross *et al* the success of business driven by information technology depends on adaptability, responsiveness and alignment of benefits from information system and therefore it must be aligned with organizational requirement [23]. Vishvakarma *et al.* assert that there must be a match between information system architecture and organizational strategy to take full benefit from the information system implementation [24]. Hamid Tavakolin and Das *et al.* has said Information Technology in Defenders are more Centralized than Prospectors because Information Technology has to be aligned to prevailing organization structure [12], [13]. So Multi Agent System which is the most advanced form of Information Technology has to be more centralized in Defenders than in Prospectors. The type of Multi Agent System can be SOA based or CORBA based or any other type. CORBA based systems have peer to peer integration whereas SOA based systems are process oriented. As Fernando Bellas *et al.* and Cheng Tao *et al.* said that CORBA is mainly used for legacy systems and has less interoperability [9], [10]. Less interoperable CORBA based systems are more centralized as there is less interaction between the modules or agents whereas more interoperable SOA based systems are decentralized as there is more interaction between the modules or agents. So CORBA based Multi Agent System may be more applicable to Cost Leader

type companies because cost leader companies are more centralized where as more interoperable SOA based Multi Agent System may be applicable to Differentiator type companies where integration efforts are much more. This has led to development of our following hypothesis.

Hypothesis 1: Multi Agent System adopted by Cost Leaders is more centralized whereas those adopted by Differentiators are more decentralized.

IV. METHODOLOGY AND DATA COLLECTION

The concept of Multi Agent System is fairly new and not many industries are either using it or making it. Collection of data regarding Multi Agent System its applications and strategy of the organizations was very difficult. Few companies are currently in the process of building Multi Agent System and relevant information from them revealed that it is being used by various types of company's banks, hospitals, oil and gas, transportation, health care and software companies. Information was collected from the internet regarding the names of companies who might be using Multi Agent System. Primary research also showed that there very few companies in India who are using it which lead to a conclusion that the only way to collect data was through mails, and telephonic survey.

The research tool used for this survey was a structured questionnaire. This questionnaire was then circulated among more than 300 people of various organizations through mails and then they were validated over telephonic survey as well. The respondents were top level information system executives and managers of the organization. Among them twenty organizations was identified who are using multi agent system. The reason for low response rate was the concept of Multi Agent System was fairly new and only a handful of organizations are using. The data revealed that most of these organizations were top electronic goods manufacturers, banks and software companies.

The questionnaire consists of basically four sections. The first section was regarding Multi Agent System as in whether they are using Multi Agent System or not, to what extent Multi Agent System is being used with service oriented architecture. This section also consists of questions on centralization of Multi Agent System and to what extent it has helped them to increase agility in the organization. The next section consists of five sections which are questions related to level of standardization, specialization, formalization, standardization and complexity of workflow in the organization. The third section is divided into six groups where questions are related to level of environmental uncertainty from technological, government, socioeconomic, supplier, customer, and competitors. The last section is about the level of integration in the organization and the extent to which the organization uses multi agent system.

V. DATA ANALYSIS AND RESULT

Previous researches have pointed out companies who have adopted defender or cost leader strategy has high standardization, centralization, specialization, formalization and low complexity of workflow whereas companies

adopting differentiator or prospector strategy has low standardization, centralization, specialization, formalization and high complexity of workflow. But with advances in technology and use of integrative devices as pointed out by Lawrence and Lorsch, integrative devices like Multi Agent System and others centralization, formalization, standardization as well as specialization will tend to gone higher [33]. The data also revealed the same so complexity of workflow is taken up as means to classify companies into prospector and differentiator. Below is the data of 20 organizations that are currently using multi agent system. Both Complexity of Workflow and Service oriented Architecture data are tabulated on a 7 point scale. For complexity of workflow value below 3.5 is taken as companies who has adopted cost leader strategy and above 3.5 as differentiator strategy.

In case of service oriented architecture value of 1.4 or less is taken as companies who are not using Service Oriented Architecture along with multi agent system.

TABLE I: SURVEY DATA OF ORGANIZATIONS

Company	Complexity of Workflow	Strategy	Service Oriented Architecture
A	6.0	Differentiator	2.8
B	1.0	Cost Leader	4.2
C	2.8	Cost Leader	5.6
D	5.8	Differentiator	2.8
E	1.4	Cost Leader	0
F	2.8	Cost Leader	0
G	7.0	Differentiator	4.2
H	5.6	Differentiator	4.2
I	5.3	Differentiator	2.8
J	5.5	Differentiator	5.6
K	5.5	Differentiator	5.6
L	4.8	Differentiator	4.2
M	6.0	Differentiator	2.8
N	5.3	Differentiator	4.2
O	6.0	Differentiator	1.4
P	4.9	Differentiator	1.4
Q	3.2	Cost Leader	1.4
R	3.4	Cost Leader	5.6
S	2.6	Cost Leader	1.4
T	2.9	Cost Leader	1.4

Chi Square Test

Chi square test or χ^2 test is a statistical hypothesis test. It is used here to test independence of variables or whether there is a pattern of dependency in between them. If there is dependency it can be claimed that the variables are statistically dependent. Chi Square test used over here is used to prove that there is statistically significant difference between Multi Agent System adopted by Defender and Prospector companies. The difference in Multi Agent System is whether they are using Service Oriented Architecture along with Multi Agent System or not.

Chi squared value equals 4.432 with 1 degrees of freedom.

The two-tailed P value equals 0.0353

The association between rows (groups) and columns (outcomes) is considered to be statistically significant.

TABLE II: CHI SQUARE TABLE

	Service Oriented Architecture	Others	Total
Cost Leader	3	5	8
Differentiator	10	2	12
Total	13	7	20

Thus the above result proves Hypothesis 1 that there is significant difference between type of Multi Agent System adopted by Cost Leaders and Differentiators.

SOA based Multi Agent System is adopted by differentiator type companies to achieve a greater level of integration among different members of system.

VI. CONCLUSION

Multi Agent System is a fairly new concept and the level of adoption by the companies in their regular business activities is also less, data suggests that only 5% of the companies are using Multi Agent System greater than 90% in daily activities. There are greater no of companies who are using Multi Agent System in 40% to 50% of their activities. Multi Agent System has also helped the companies to increase agility in their business and it has also helped to increase the level of integration in the organization.

Further research work on this area should be done to understand the type of Multi Agent System adopted by Defenders whether it is only CORBA based or any other type. As level of adoption of Multi Agent System increases in organizations collection of data will be easy. The idea of CORBA based on Multi Agent System for defenders is still now a limited to literature and data collected from few of the organizations.

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