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Significance of Intelligent Agents in Strengthening Consumer Relationship Management

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Abstract

This paper aims to establish smooth relationship between customer and commodities in order to improve sales in a retail supermarket enterprise using agent based system. The goal is to show how an intelligent agent based approach is a suitable choice to automate the process of advance promotional policy planning. Shopping behavior of customers and many external factors as discounts, promotional offers, advertisement regularly affect the sales of retail store. The research proposes a suitable/feasible intelligent agent based architecture in order to investigate the effect of inducing variations in these external factors on shopping behavior of customers. The paper mainly focuses on timely identification and capturing continuous variations through intelligent agents. The study also shows that if the changing requirements of customers are timely and efficiently captured in such a highly competitive retail market scenario, it can further influence the buying behavior of customers thereby benefiting the store in predicting future sales. Intelligent agents thus give an opportunity for a new approach in the field of analytics. The methodology uses fuzzy simulation to induce and trap variations within such a dynamic environment and proposes recommendations in the form of rules.

Keywords: agent-based software engineering, evolutionary system, fuzzy inference system FIS, intelligent agent, multi-agent system MAS.

I. INTRODUCTION

Agent based software development is one of the promising approach to support runtime adaptation. An agent's dynamic ability is characterized by its mental components such as beliefs, capabilities, choices, and commitments [1]. Along with the mental components intelligent agents also possess various other characteristics as autonomy, proactive, collaborative, cooperative, and adaptive to changes in the environment [2]. Integration of these characteristics enables the agents to not only capture evolving requirements but also sense the future requirements. Initially the agents have less knowledge about their domain and the requirement acquisition process helps in engraving learning capability in agents. Their ability to learn in due course makes them more experienced and knowledgeable so they become evolvable. The flexibility in intelligent agent allows it be an entity that commands its own behavior autonomously, thus have the ability to adapt to changing environment. The autonomy allows agents to control its state and behavior making it more flexible in nature. During runtime the agent based architecture can be reconfigured to automate the process of dynamic adaptation responding to changes in the environment [3]. The agent-oriented software development can be a suitable iterative approach to support developing such an evolutionary system capable of handling evolving requirements in a large, complex and distributed application. Thus, in order to facilitate the continuous process of dynamic update, an agent-based architecture has been proposed in my previous work [4]. This multi-agent system (MAS) architecture is composed of intelligent agents where each agent has been designated a specific role. The proposed architecture has an intelligent requirement gathering agent which plays an important role in successful implementation of dynamic adaptation process. In order to accomplish required functionality, an agent based approach using fuzzy-based data modeling over a defined rule base reasoning is adapted. Fuzzy simulation of the case study is done to show the way the requirement gathering agent makes decision. It decides on an action in response to an event based on fuzzy logic and rules.

Section II is the domain related literature survey. The Section III of the paper focuses on the proposed MAS architecture describing the specific roles of each component comprising of intelligent agents. Section IV explains the subject test case: Establishing consumer – commodity relationship in retail supermarket. Section V, VI and VII describes system modeling, fuzzy simulation and result for the exemplar case study. Finally Section VIII refers to conclusion and future work.

II. LITERATURE SURVEY

This section contains related literature on agent-based software development supporting runtime software evolution. In an aim to develop a flexible framework using intelligent agents Rodrı´guez-Fortiz and Lorca have presented an architectural model to construct cooperative and evolutionary agent-based software systems. Here, a software system consists of a set of agents which interact by executing actions and learning the system functionality thus providing

intercommunication and coordination among them. The system architecture they have presented is dynamic in nature as the modeled system can evolve and be adapted to its new functions [3].

An intelligent agent based framework for implementing a complex monitoring system handling different types of knowledge has been proposed by authors to exploit the role of intelligent agents in monitoring systems for many engineering applications. The proposed framework was applied onto Gas Insulated Substation (GIS) exemplar case study. The study concludes that such an intelligent agent based framework can become a useful and economical tool for designing a monitoring system to integrate different and complex knowledge to provide decision in terms of classification [5].

Ranjan and Mishra have proposed an agent-based system which provides a clear separation between the requirement gathering and analysis phases for open and adaptive systems. Authors have also demonstrated that development of such a system may continuously change and evolve to meet new requirements. Gaia and ROADMAP models have been used by them to explain the proposed agent-based modeling method [6].

The advantages of agent-based and component-oriented methodologies have been highlighted by Qu, Wang, Zhong, Zou and Liu. By combining the key features of both the approaches an agent component-based architecture has been proposed. This flexible architecture presents the agent components which are reusable thus can redefine the software development process [7].

In an effort to prove the importance of agents in improving the software development process Nachamai, Vadivu and Tapaskar have discussed the usefulness of Agile and Agent Oriented software development process to meet the needs of dynamic changing requirements of the customers. Their proposed model is iterative and incremental and accepts the changes in requirements at any stage of development [8].

Ashabi and Salah have explained the need and importance of software agents in software engineering. The paper presents the key characteristics of software agents that may be beneficial in designing and developing many complex as well as dynamic applications with its autonomous nature. It also presents the Agent-oriented software engineering paradigm [9].

Mostafa, Ahmad, Mustapha and Mohammad have explored many opportunities lying under agent-based software development approach. The paper presents a research survey to provide an insight to software agents and MAS. In addition to providing concepts of agents in terms of its characteristics, types, architecture and development platforms, paper also explains the role of MAS in modeling complex distributed problems. The concept of collective intelligence in agents has been described as an emergent criterion to support software adaptation [10].

III. OVERVIEW OF AGENT ARCHITECTURE

In our previous work we have proposed an intelligent agent based architecture as shown in Fig. 1 in order to facilitate runtime software evolution [4].

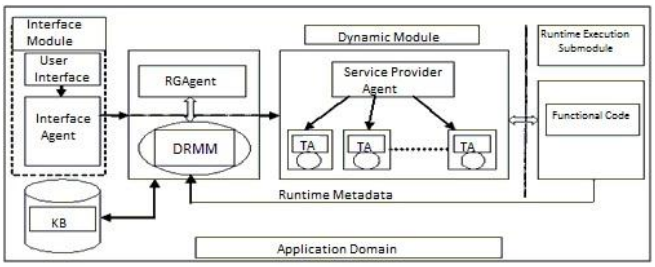

Fig 1. Intelligent agent architecture

The MAS architecture is composed of a set of intelligent agents, dynamic runtime monitoring mechanism (DRMM) and knowledge base (KB) which interact with runtime execution sub-module that contains the implementation code.

Main intelligent agents in the architecture are:

- Interface Agent (IA)
- Requirement Gathering Agent (RGAgent)
- Service Provider Agent (SA)
- Task Agent (TA)

The proposed architecture significantly provides data abstraction by hiding the complicated implementation details. Each intelligent agent, focus on specific issue of the whole problem thus cooperating with each other in achieving the common goal. The automated and continuous information gathering and autonomous decision recommendation are the main striking features of this architecture. The working of architecture in terms of its agent components has been described in the earlier work [4]. The role model of system generated using MaSE agentTool III [11] diagrammatically specifies the roles of each agent with their related tasks as shown in Fig. 2. The proposed multi-agent architecture although contains various agents but the scope of our study focuses only on the overall behavior of the model during runtime. This mainly encompasses the study of role, responsibility and working mechanism of RGAgent.

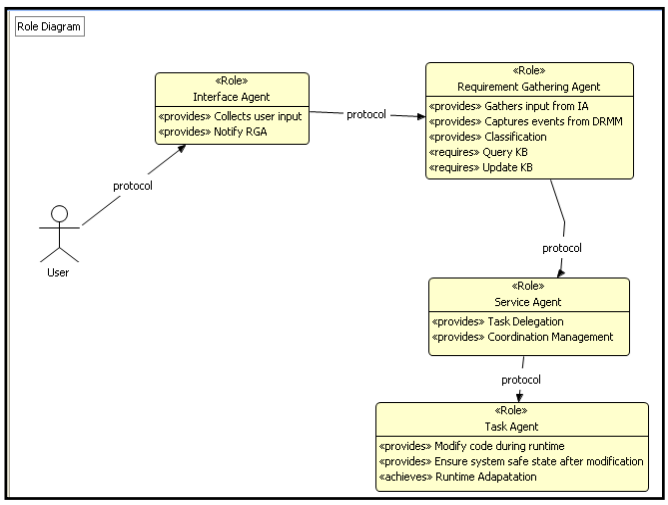

Fig 2. role diagram of the agent architecture

III.I Requirement Gathering Agent

RGAgent is the soul of the proposed MAS architecture which is responsible for requirement acquisition and decision making affecting runtime adaptations. RGAgent plays three major roles in the architecture as:

- Automated monitoring agent
- Classifier and decision maker

The workflow of RGAgent within architecture has been shown in Fig. 3.

1. It perceives the environment by actively sending and listening notifications to and from other agent components such as Interface Agent.
2. Also, it captures the environment state by capturing runtime data.
3. System performs rule-based classification, of the collected data.
4. For a new state, it decides on which and how well to modify the system behavior during runtime.
5. Next course of action is task delegation to Service Agent to actually modify the behavior dynamically.

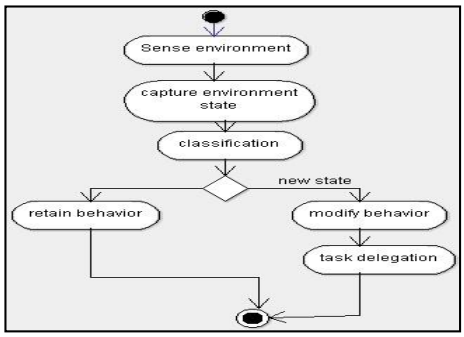

Fig 3. activity diagram showing workflow of RGAgent

III.II Significance

This study mainly concentrates on decision making based on capturing continuous changing data using intelligent agents. Such data if timely captured can significantly improve the performance of the application. Aim of the study is to show that influence of such input data on the runtime will have a significant impact whether positive or negative on the outcome of subsequent agents. The intelligent agents thus will further aim at implementing the recommended modifications to existing system dynamically at runtime.

Our research process is nurturing this concept and this paper works on identifying the solutions to the following research question:

How significant will be the outcome if the changes are captured timely?

IV. TEST CASE

This paper considers the problem of improving consumer-commodity relationship in terms of predicting those consumers who may play a major role in improving sales in retail store. This relationship can be further strengthened by planning promotional policy in advance for the retail superstore. Retail Superstore System is basically a computerized system with an objective of efficiently handling all the marketing and sales activities prevailing in a supermarket outlet. The system includes Point Of sales (POS) activities and other marketing activities as stock verification, automated feedback recording from customers, promoting sales using various advertisements and promotional policies, price and inventory management [12][13]. In a competitive market environment, consumer is one of the major entities that can impact many business activities such as sales and marketing. In a bid to survive through current tough market, the client tries to establish a better connect with their customers. In this regard, predicting futuristic demand for a product may provide opportunities to improve the consumer-commodity relationship thereby improving sales. The policy makers of the enterprise who are responsible for decision making under this scenario may require new functionality to be added or other changes in the legacy system. Since, there exist various segments of commodities in a super market ranging from daily grocery items to trendy ones, thus planning for the future demand becomes a complex task to be carried out manually [14].

Many authors have proposed different methodologies to automate the process of forecasting demand. Trusov, Bodapati and Crnkovic have proposed an analytical approach in order to forecast product demand in a retail market scenario. The demand depends on two key factors broadly categorized as product attributes and market control variables. The paper mainly focuses on gathering and analyzing past as well as current data and proposes rule-based modifications to sales forecast. The methodology is a combination of many techniques as statistical models, data mining and combinatorial optimization to predict the sales forecast for a commodity [15].

To predict daily demand for a commodity Hasin, Ghosh and Shareef have identified 11 major factors that can affect the demand. Authors have then applied fuzzy neural network approach to forecast demand in a retail market [14].

Aburto and Weber have proposed a hybrid approach combining Autoregressive Integrated Moving Average (ARIMA) and neural networks to forecast demand of a commodity in a Chilean Superstore chain [16].

Kamthania, Pahwa and Madhavan have analyzed the user behavior and based on market segmentation described a decision making process, using principal component analysis (PCA) and clustering technique k-mode. This process helps business strategy makers to target potential customers.

Authors have also developed a business intelligence tool for visualizing the process [17].

IV.I Real World Cases as Motivation

The design objective of the proposed architecture is to capture evolving needs and support runtime adaptation. The following two real time cases have motivated us to nurture this concept. The study thus focuses on how effective it would be to capture the changing market scenario to improve the relationship between consumer and commodity.

Pay through Mobile (PayTM) is an emerging company of India that has significantly expanded its business by adapting to the changing requirements of Indian consumers. This case has supported our research quest of advantages of identifying new and changing requirements in the respective domain. To support evolving need of digital payment even for a small amount, PayTM has emerged as a leading e-payment portal along with e-commerce market in order to establish a strong relationship with the consumers. The marketing strategy using various promotional offers and future planning strategy employed by PayTM thus lead to increase in the profit of organization by attracting many consumers [18][19].

Case of Reliance Jio is another motivation to show how various external variables influence the market scenario. Since introduction of Reliance Jio in India, it has offered many attractive promotional features such as 4G data connectivity and free voice calling. These offers have attracted many consumers including non-users towards Reliance Jio. The company is continuously attracting customers with exciting offers using coupons on payment with JioMoney App [20].

IV.II Establishing Consumer-Commodity Relationship

The consumer-commodity relationship has been established as a function of consumer's general attribute as shown in Fig. 4. Five relationship influencing attributes have been chosen, on the basis of general aspects of consumer only. Commonly used attributes of consumers are age, sex, income, education and occupation. In some areas the income variable plays a major role whereas occupation, age, sex, education in other areas. Consumers are also grouped based on the frequency of user visit and usage capacity. Based on usage proportion, the consumers can be new, heavy, medium, light as well as non-user whereas major type of users can be potential, regular and new among others. Also, there are many other external market influencing decision factors that affect the consumer's thinking process towards a product. Such external influence factors as promotional activities, recommendations, introduction of new brand, new technology in market and others, also play a major role in deviating consumer's behavior towards a commodity [21]. Choice is the consumer's willingness towards external influence. A very recent external influence real time factor is the introduction of Goods and Services Tax (GST) in India. It is the biggest tax reform that has been implemented in India from July 1, 2017 and the GST factor has affected the prices of various commodities [22]. Price fluctuations due to GST have also affected the buying pattern of consumers. Sudden introduction of this external factor may require modification in the sales strategic planning in the retail market accordingly. This scenario further gives confidence to our concept of dynamic modification.

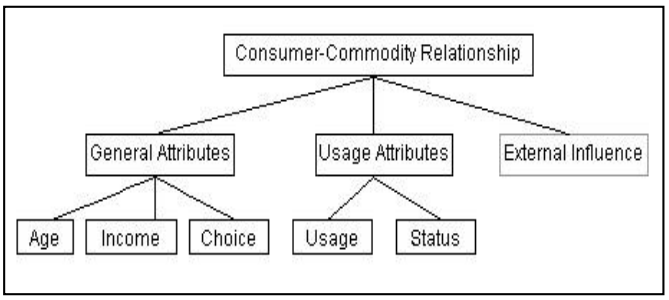

Fig 4. consumer-commodity relationship attributes

V. SYSTEM MODELING

This section mainly models the system by defining various parameters for the case study. In this section, we have not only focused on how the architecture processes the predefined data to establish consumer-commodity relationship but also shown that this interaction can be effective in predicting future sales and procurement.

V.I Consumer-behavior Tracking Process

Fig. 5 shows how the consumer's behavior can be monitored and tracked using agents. The whole process can be modeled using intelligent agents and is composed of following components:

- **Consumer detail**

  It is a repository of consumer's profiles. The record contains information about all the attributes mentioned in figure 4.

- **Consumer behavior tracking Agent (CBTAgent)**

  The CBTAgent clones the functionality of RGAgent as that of monitoring agent, classifier and decision recommender. It periodically monitors the consumer's buying behavior and classifies the input data as per the attribute values. It further simulates, analyzes the data and gives recommendations to subsequent agents.

- **Sales resources**

  It represents the repository of sales record for the retail superstore.

- **Procurement Agent (PAgent)**

  The PAgent after analyzing the in-stock goods and current sales activates the procurement process based on the decision recommendation by CBTAgent.

- **Procurement process**

  Procurement is a business process that streamlines the task of purchasing goods.

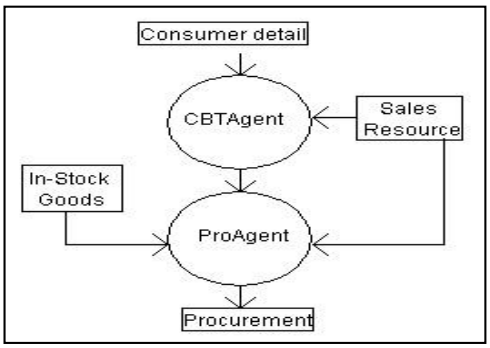

Fig 5. consumer behavior tracking process

V.II Criteria and Assumptions

The following criteria have been considered for evaluating the performance of RGAgent of the proposed system:

1. Dynamically introducing new influencing variable strongly impacts the decision making process.
2. Variations in input to prior strongly influences the outcome of other subsequent agents.

Also, as the simulation process need not necessarily depict the whole complexity of the retail work domain, some assumptions have been imposed. The underlying assumptions maintain a simpler and conceptually feasible simulation process.

- Ruling out publishing advertisement on monthly basis.
- Ruling out providing discount per expenditure.
- Product range is grocery items.
- All input and target data are normalized in the range [0…1]

VI. FUZZY REASONING

Fuzzy simulation of the test case has been done using Mamdani Rule-based Fuzzy Inference System (FIS) to identify and capture the demand influencing variables [23]. RGAgent acts as a fuzzy agent to handle the issue of recommendation during sudden changes in the current sales scenario within a supermarket. From the input set using rule-based reasoning, it identifies the behavior of potential customers. It further helps in recommending decisions regarding planning with an objective to increase the number of potential customers thereby improving their basket size. The system further analyzes for sound customers to attain the objective of establishing and maintaining good consumer relationship. The characteristic feature is that the rule-set can also be modified in due course as and when new market condition emerges dynamically.

VI.I Simulation Cases

The simulation process considers two independent cases for the exemplar case study. Rule set is kept small so that it may be easily handled by the proposed architecture. As the Fig. 2 shows the RGAgent plays three major roles in the architecture as monitoring agent, classifier and decision maker. Whenever a new event is fired there are two cases for RGAgent. Both the case analyzes the recommended decision by processing general consumer attributes.

- Case 1: Establishing consumer-commodity relationship with non-influenced consumer.
- Case 2: Establishing Consumer-commodity relation with influenced consumers.

In first case, the consumer's behavior remains unaltered under the presence of external market influencing variable. Whereas, in second, the consumer's buying behavior is influenced by the external influence variables. The research tries to analyze the effect of adding external variable dynamically in both the cases.

The experimentation contributes in identifying the measure of external influence factor, as threshold value to contribute in decision making. In the decision making process we have defined two terms to prioritize the customers as potential and sound customers. Potential customers are a set of customers that are prioritize for being the target customers who are most likely to become key future customers for an organization whereas sound customers are those potential customers who are financially sound.

VI.II Reasoning Methodology

Reasoning methodology followed is as below:

1. Universe of discourse determines all input and output system variables. Visit frequency (Vf), Income (In), Monthly total expenditure (Texp) and Choice (Ch) are taken as input variables and Potential customers (Pc), Sound customers (Sc) are the output variables.
2. In quantization, value of each system variable is converted into linguistic variables as VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), and VERY HIGH (VH). The value ranging between 0 to 1 as shown in Table 1.The set of variables are expressed as fuzzy set and triangular membership function is used.
3. Fuzzy rules are framed using IF (condition) - THEN (action) type of structure to map input with output. Some of the heuristic rules formed for the present fuzzy system are specified below.

   IF (Vf *is* L/M/H) and (Texp *is* VH/H) THEN (Pc *is* H).

   IF (In *is* VH/H) and (Pc *is* M/H) THEN (Sc *is* H).

   IF (In *is* M) and (Pc *is* M) THEN (Sc *is* M).

   IF (In *is* VL/L) and (Pc *is* M/H) THEN (Sc *is* M).

IF (In *is* VH/H) and (Pc *is* H*)* and (INF is L/H) THEN (Sc *is* H).

IF (In *is* VL/L) and (Pc *is* H*)* and (INF is L/H) THEN (Sc *is* M).

IF (In *is* VL) and (Pc *is* M*)* and (INF is L/H) THEN (Sc *is* L).

4. Fuzzy inference system CCR and CCR2 has been designed as shown in Fig. 6 and 7. CCR maps Vf and Texp to Pc whereas CCR2 maps In and Pc to Sc. To analyze the effect of introducing additional input dynamically to an agent on the outcome, Ch has been added to CCR2 fuzzy system shown in Fig. 8 referred as CCR2 (updated). The fuzzy agent RGAgent activates the framed rules through both the FIS to obtain the output. The sequence of actions involves RGAgent to identify potential customers at an instant of time based on total expenditure monthly. It further recommends the actions needed to be implemented in terms of adding influencing variables to improve the frequency of potential as well as sound customers. The increase in buying capacity thus influences the total sales as well as increases the demand for many consumer durables.
5. Simulation run (R)

   Following data cleaning and normalization, the simulation uses:

   - A set of 250 unique customer's data.
   - The salaried category of customers was chosen for the simulation.

Set of 150 consumers are chosen for Case1 whereas rest of the customers for Case2. The simulation has been averaged over 5 runs. Each simulation run requires two fuzzy systems to identify potential as well as sound customers as the data passes through both FIS. In order to show dynamic behavior of the system, values of some input variables are varied as an effect of introducing different promotional factors as external influence.

This dynamic variation will enable intelligent agents to reschedule the customers from potential to sound customer's category. Rescheduling recommends dynamic changes in terms of planning advance advertisement policy.

For case 1 the data subset with attributes {Vf, Texpense} are chosen as input through CCR. The fuzzy reasoning system then identifies the probable potential customers (Pc) from the input data set. The system also assigns a linguistic range to the Pc to identify the extent to which this output can further influence the probability of Pc being sound customers (Sc).

The second step demonstrates the system's capability to identify sound customers from the set of potential customers with two different possibilities. The output of first simulation step Pc and Ch also serve as input to second fuzzy reasoning system CCR2 thereby increasing the complexity of decision making process. Attributes {In, Pc} are processed by CCR2 and {In,Pc,Ch} in updated CCR2. Both CCR2 and updated CCR2 then determine how many probable Pc can further be treated as sound customers.

Assuming constant unit step increase in visit frequency, 10% increase in monthly expenditure and 10% annual rise in salary in first quarter, data for the first input subset are then varied dynamically in subsequent runs. The data variation is directly proportional to the amount of added external influence parameter such as discount given on total purchase value. The system then captures these variations and determines the overall influencing probability to decision making in the domain in terms of potential and sound customers.

Table-1. Quantization table for the test case

Input/Output Parameters	**Linguistic Range**				
Vf	L	M	H		
In	VL	L	M	H	VH
Texp	VL	L	M	H	VH
Ch	L	H			
Pc	L	M	H		
Sc	L	M	H		

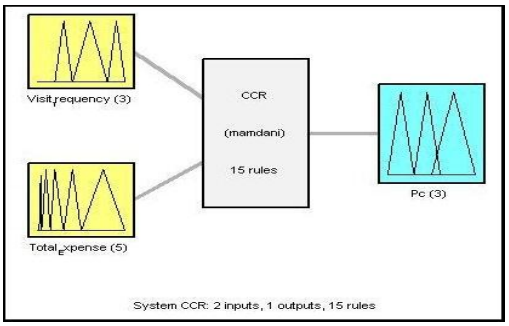

Fig 6. fuzzy inference system CCR

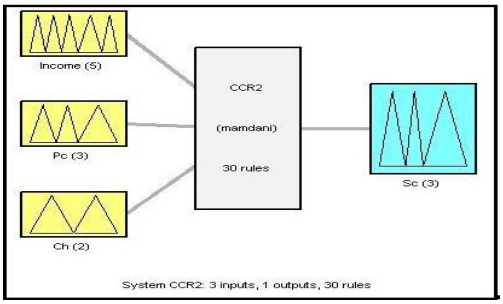

Fig 7. fuzzy inference system CCR2

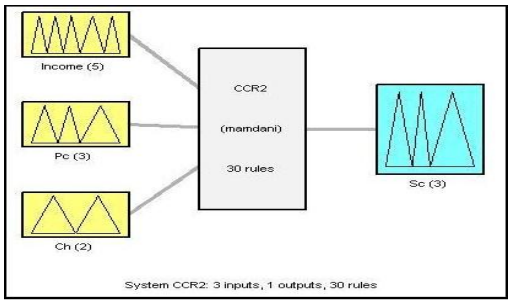

Fig 8. fuzzy inference system CCR2(updated)

VII. RESULT

The simulation results obtained here suggest that an intelligent agent based system has an added advantage with respect to its applicability in the area of dynamic adaptation when the requirements are timely captured over the traditionally developed system. As per the simulation result, variation in percentage for high potential and sound customers per simulation run for all cases are plotted in Fig. 9,10,11and12. Quadratic curve has been fitted to the dataset "Pc vs. R", "Sc vs. R", "Sc (updated) vs. R" for case1 and case 2 to calculate root mean square error (RMSE). Calculated root mean square error (RMSE) for each case has been stored in Table 2. Also, mean absolute percentage error (MAPE) has been computed and stored in Table 3 for both the cases so as to evaluate the performance of system in terms of percentage error. Analysis of data indicates the following findings as result of the fuzzy simulation and shows that both criteria1 and 2 satisfies.

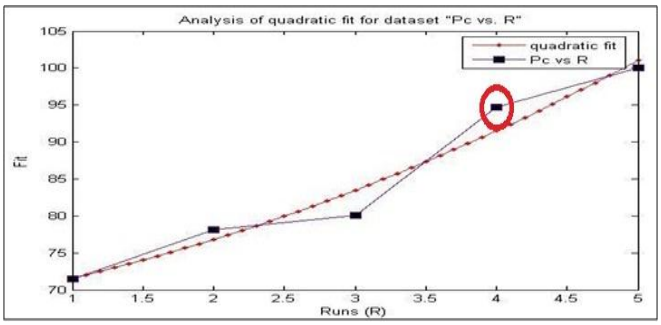

Fig 9. dataset "Pc vs R" and quadratic fit for case 1

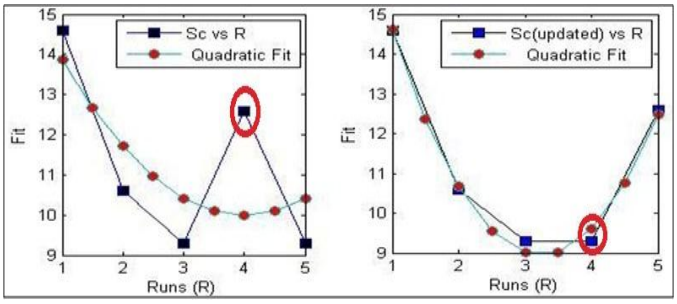

Fig 10. dataset "Sc vs R" and quadratic fit for case 1

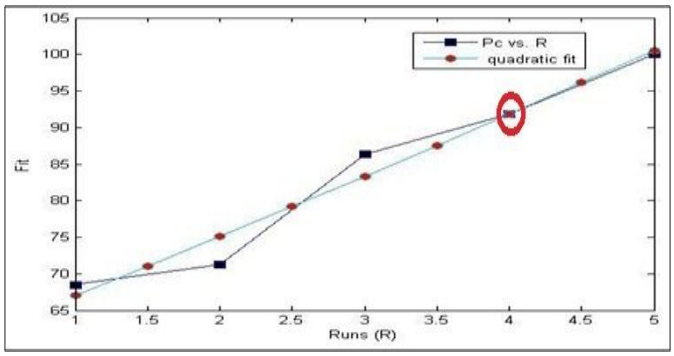

Fig 11. dataset "Pc Vs R" and quadratic fit for case 2

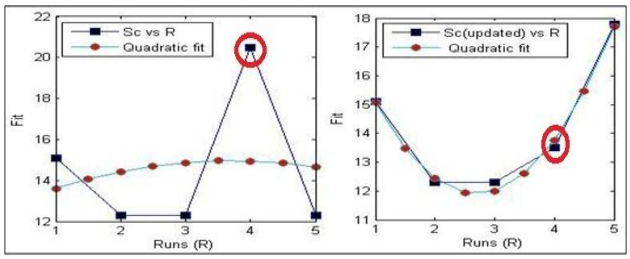

Fig 12. dataset "Sc Vs R" and quadratic fit for case 2

Table 2. Calculated RMSE for each case

Data Set	**RMSE**
Case 1	
Pc Vs R	3.468
Sc Vs R	2.356
Sc(updated) Vs R	0.3529
Case 2	
Pc Vs R	3.62
Sc Vs R	4.986
Sc(updated)Vs R	0.3033

Table 3. Calculated MAPE for each case

Data Set	**MAPE**
Case 1	
Sc	12.07
Sc(updated)	1.68
Case 2	
Sc	18.85
Sc(updated)	1.22

Analysis of data indicates the following findings as result of the fuzzy simulation and shows that criteria 1 and 2 satisfy.

1. The changing frequency of Pc, at each, iteration, signifies a strong change in the values of Sc and Sc (updated) for both the cases as shown in Fig. 9,10,11 and12. This proves that there is a strong influence of prior agent (CBAgent) on the subsequent agent (PAgent) thus supporting our criteria 2.
2. Changes in RMSE for case 1, case 2, case2(updated) shown in Table 2 signify that influence of any input data change during runtime will definitely influence the overall outcome as decision recommendation. Thus, the polynomial behavior of error strongly signify that with

the change of marketing strategy , the sales department will have a strong (positive or negative) influence in any case thereby satisfying criteria 1 and 2.

3. Table 2 also shows that although there is a slight increase in RMSE when comparing case1 to case2 but a significant decrease in RMSE associated with Sc (updated). Thus the dynamic rule-set modification by introducing Ch input factor claims further reduction in RMSE. This variation signifies that more refined outcome can be achieved if rule-set size is increases dynamically by timely capturing changes, thereby satisfying criteria 1.
4. The result in Table 2 suggests that decision recommended by CBAgent serving as requirement gatherer in consumer-behavior tracking process is highly influenced by RMSE. This explains that with the information available from CBAgent (decision recommender), the PAgent should assess how much to be procured based on all inputs considered which in this case are sound customers and in-store products.
5. The experimentation contributes in recommending the fourth quarter as the time frame for implementing the decision making process as all decision parameters at the point are either positively influenced or neutral as marked under red circle in Fig. 9,10,11,12.
6. Table 3 shows that MAPE has been significantly reduced from 12.07 to 1.68 for case 1 and from 18.85 to 1.22 for case 2. Lower MAPE indicates improvement in prediction performance of system. This clearly demonstrates that effective decision making by RGAgent at runtime may significantly improve the system performance.
7. Finally, this case study signifies that there is a greater advantage of agent behavior over online basis rather than offline. Also, as the size of input variation is concerned it is always challenging on estimating how the change will influence on its connected agent.

VIII. CONCLUSION

Retail market is dominated by key customers whose contribution belong from the high category of potential and sound customers. As the study shows, potential customer's regular buying behavior can further be influenced by various discounts and other attractive promotional factors. Their shopping behavior may change which may be in the form of rise in buying capacity per visit or increasing shopping frequency in a retail store. Simulation results also suggest that dynamically modifying key parameters makes the system more reflective to changing requirements and better decision recommendation as outcome can be generated. In this case, it is in the form of better promotional policy as marketing strategy. Agent-based methodology allows capturing consumer's general buying behavior complexity with realism and simulation proposes an online modification process in the form of fuzzy rules. The rule modification clearly shows that current behavior of a goal based intelligent agent may influence the behavior of subsequent agents. The results of test case propose that intelligent agents may also play a major role in predictive analysis in order to improve and innovate the business processes. In future, the defined objectives of the proposed architecture can be further implemented on an agent based language platform.

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