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Intelligent Decision Making Technique for Marketing Using Hypothetical Database and Fuzzy Multi-Criteria Method

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Abstract: Marketing organizations use databases to locate potential customers and to generate sales lead. A number of software systems have been playing a key role in supporting the decision making activities in recent years but common problem in all that they cannot handle fuzzy data appropriately for "what-if" analysis. This paper proposes intelligent scenarios analysis system framework for marketing decision support which deals with crisp and fuzzy data like linguistic variable. Applying new approach "Hypothetical Database" for derived data that permits decision manager to manage views according to the need of organization and/or market environment. View in Hypothetical Database provides versatility in "What-If" analysis by using versions of "What-If" database and reduce data redundancy and data storage in updating. Using Fuzzy database will help to handle imprecise and uncertain information like "Linguistic variable" in a more human oriented process. Finally, the projected scenarios selected by decision manager will be aligned in a hierarchy according to the distance from "Ideal Vector" by using Fuzzy Multi-Criteria Decision Making method.

Keywords: Marketing Decision Making, What-If analysis, Hypothetical Database, Fuzzy Database, Multi-Criteria Decision Making.

1. INTRODUCTION

Marketing intelligence is a critical function that supports survival of organization specially in crises. In last two decades it has been widely accepted that marketing plays a key role in contributing to an organization competitive success [1]. Researchers agreed that marketing functions should enter the managerial process in the initial stages [2]. The marketing manager must adopt one of the strategies out of several to choose the best, e.g., increased government revenues and pure product profits etc.

An organizational database contains various type of information. In consumer marketing, for example, the database may consist a consumers demographics data (age, income, family members, birth date), psychographics data (activities, interest and opinions) & buying behavior (buying preferences & the Recency, Frequency and Monetary value (RFM) of past purchases). Organizations use databases to locate potential customers and to generate sales lead. They can collect customer database to master about them in depth and then harmony their market offerings and communication to the distinct way and choices of target market. In all, an organization's database can be an important repository of knowledge for building stronger long-term customer relationships etc.

The higher management of an organization usually leans on "What-if" analysis that heavily relies on database. A number of software systems have been playing a key role in supporting the decision making activities in recent previous years. In business organization too, number of tools are often used to support "What-If" analysis. For instance spreadsheets provide pliable and interactive environment for "What-If" analysis, however, it shows deficiency in integration with huge database. Similarly, OLAP tools are used in business community but lack the analytical ability of spread sheets and these are not capable for optimum "What-If" analysis. The common problem in both tools is that they cannot handle linguistic variable such as "Customer" with terms "average, good, best" for "what-if" analysis.

Marketing decision making usually use simplest facts, integrating uncertain knowledge by using linguistic features of human reasoning to achieve target result. In this manner, it is proposed an intelligent scenario analysis system for marketing based on hypothetical database [3] and fuzzy multi-criteria decision method. The hypothetical database uses relational database and modify the feature of conventional view in relational database. Independent Updated Views (IUVs) in hypothetical database provide the provision of modification in view by using Differential Table (DT) while original database remains unchanged. This characteristic of IUV helps the decision maker to define finite number of "What-If" scenarios on which decision is made without changing in the original database. To deal uncertainty of data (like linguistic variable) fuzzy logic provides meaningful and powerful representation of measurement uncertainties and vague concepts in natural language

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[4]. Therefore, we represent selected data of "What-If" scenarios in fuzzy database to deal with crisp as well as fuzzy information. Fuzzy logic provides advantages for decision making where multiple criteria are used and multi independent variables are given as linguistic variables. For improved and imperious performance, the business organization cannot rely on single independent variable (such as customer need, customer behavior, customer demography etc.). Therefore, decision manager need to consider number of independent variables that justify specific requirements by their strategy. A Fuzzy Multi-Criteria Decision Making (FMCDM) method is used to achieve the target result based on various criteria and independent variables.

The rest of this paper is organized as follows: Section 2 will provide the theoretical background of hypothetical database, Fuzzy database and Fuzzy Multi-Criteria Decision Making methods. Proposed system architecture is given in section 3. Conclusion is presented in the last section.

2. LITERATURE REVIEW

2.1. Hypothetical Database

The term Hypothetical Database (HD) was first coined in [3] for the purpose of exploring alternative scenarios of database snapshots. The Hypothetical Relation (HR) contents are defined in terms of actually stored / main relation contents with specified additions and deletions. For this purpose they used Differential File (DF) [5]. Differential File does not store as the main relation of database do but instead it stores only addition, deletion and modification that have been hypothetically made to the underlying database. DF contains all the attributes same as underlying relation plus a special Tuple ID (TID) column that shows unique tuple ID. The TID column is used to record the insertion or deletion of tuple from the main relation. As per [6] a modified version of the algorithm given by [7] was proposed in which timestamps column was introduced for each tuple in the DF. Timestamps for each tuple allow the most recent changes be visible in the HR.

The modified form of HR was proposed in [8] called Independently Updated View (IUV). IUVs are virtual relations defined on a conventional view called parent view(PV) [9] of the IUV. An IUV is an updated version of its PV. An IUV does not store data physically instead a Differential Table(DT) is used to store physically the differences between IUV and its PV. An IUV can be created by retrieving its parent view & associating into it the changes stored in the differential table. An advantage of Parent Table(PT) or PV is that it may be obtained from base table, a relational view or a created IUV. Generally, the version of PT is defined by IUV, however, if PT is defined on another IUV then IUV based on this PT is called 'Version of versions' as discussed in [10]. Similarly, version hierarchies can be obtained by forming numbers of IUVs on the same PT and further IUV is obtained by using of previous IUVs as parent table.

In [11] materialized IUV was introduced. For materialized IUV, no differential table (DT) is used instead IUV tuple is stored itself with two extra columns named "OPCODE" & "TS (TimeStampt)". The management of materialized IUV is same as virtual IUV only the difference is DT. Overlapping updates raised in [9,10] was also resolved in [11]. An algorithm was given for both virtual and materialized IUVs which resolved data inconsistency produced by overlapping updates. Recently, hypothetical database concept was used in software testing by [12]. Advantage of hypothetical database in software testing is that the original database remains same when different test suits (e.g. insert, delete & modify) are tested. This property of HDB is not present in traditional database testing.

2.2. Fuzzy Relational Database

It is basic fact that in marketing management, information is often imprecise and uncertain. Such information cannot be represented and processed by using traditional database. So, dealing with marketing imprecise and uncertain information, fuzzy database is the appropriate choice for decision makers or marketing managers. According to [13] fuzzy relational database (FRDB) is an extension of relational database which allows fuzzy attributes values and fuzzy truth values, both of these are expressed as fuzzy sets. Generally, a fuzzy database can be defined as "A database that is able to serve imprecise information (Vague or uncertain) using fuzzy logic".

Various Fuzzy data models have been revolved so far, using fuzzy set, similarity relation and possibility distribution. The prominent are as follows:

1) Buckle-Petry Model [14]: In which they innovated similarity relations in the relational model.

2) Prade-Testemale Model [15]: Based on possibility theory they established Fuzzy

Relational DataBase (FRDB) model which provides the integration of vague or uncertain data in the possibility theory.

3) Umano-Fukami Model [16]: Based on possibility theory they introduced an extension of relational data model that props a fuzzy data and fuzzy query.

4) GEneralised model of Fuzzy RElational Database (GEFRED) [17]: Introduced by [17], this model comprises heterogeneous combination of previous models. It consists generalized fuzzy domain and relation.

5) In [18] authors narrate an approach of database model to apply the concept of fuzzy EER model. This model is called Fuzzy EER model. They define a database schema, called FIRST-2, to restate Fuzzy EER model into it. FIRST-2 permits the fuzzy information representation in traditional relational database. Fuzzy Meta-knowledge Base (FMB) is introduced by using FIRST-2 schema. In addition, SQL language with fuzzy extension, called FSQL, is also introduced by the authors.

6) Likewise, in [19] a new fuzzy relational data model has been derived using the notion of Generalized Priority Constraint Satisfaction Problem (GPCSP) given by [20]. For using priority queries in FRDB they developed Priority Fuzzy SQL (PFSQL) query language that have the conditions in WHERE clause of the query to put different priority i.e. importance degree. Fuzzy relational data model given in this paper represents fuzzy value in different way, however, practically it is a subset of FIRST-2 models given by [18].

7) Similarly, [21] presented the migration strategy from Relational Database (RDB) to Fuzzy Relational Database (FRDB) based on GEFRED model. Two migration techniques were given, named, "Partial" and "Total". In "Partial" migration a metabase called Fuzzy Metaknowledge Base (FMB) is added while the existing schema and data of the database remain intact. In "Total" migration, contrary to "Partial" migration, "Schemas", "Data" and "Programs" are converted into fuzzy environment. They used a FSQL server to deal with flexible queries.

2.3. Fuzzy Multi-Criteria Decision Making Methods

In the previous decades the intricacy of business decision increased swiftly, hence researcher developed and implemented various sophisticated and efficient quantitative analysis techniques for corroborating and assisting business decision making. According to [22] Multi-Criteria Decision Making (MCDM) is a progressive field of Operational Research(OR). MCDM delivers decision makers with a broad range of tactics, which are tailored for the intricacy of business and marketing decision problems.

Various classical methods for MCDM have been introduced such as "Analytic Hierarchy Process(AHP)", "Technique for Order Performance by Similarity to Idea Solution(TOPSIS)", "Preference Ranking Organization METHod for Enrichment Evaluation(PROMETHEE)", "ELimination and choice Expressing Reality (ELECTRE)" etc. These classical MCDM methods only deal with exact information provided by the decision maker. Whereas business and marketing problems are exponentially variable and are mostly depends on guess approximate values.

In many situations decision maker may provide imprecise and ambiguous information about alternatives with respect to relevant attributes. Therefore, classical MCDM methods cannot productively deal decision making problem with imprecise and linguistic information. To remedy this shortcoming fuzzy MCDM methods were developed. Fuzzy set theory are capable to deal with cloning of human knowledge and recognized as a significant problem modeling and solution technique. Modern MCDM methods empower decision makers to deal with crisp as well as fuzzy information by using Fuzzy set theory approaches. According to [23] approximately 16.66% scientific researches in MCDM methods used fuzzy sets or fuzzy relations theory.

A number of Fuzzy MCDM methods have been developed for decision making in business management. [24] proposed the unification of intuitionistic fuzzy preference relation to get weight of criteria and intuitionistic fuzzy TOPSIS method to arrange alternatives in a hierarchy for handling fuzzy information in facility location problem. [25] used fuzzy least-mean-square(LMS) neural network to determine weight for decision maker preferences in selection location problem using these weights in fuzzy TOPSIS method to make better decision.

Likewise, in marketing management, [26] studied the utilization of MCDM model integrating DEMATEL with ANP and VIKOR methods. To minimize interrelated relational ships gaps and to accomplish required levels they rank the priorities in brand marketing strategies. [27] proposed the improvement in Fuzzy TOPSIS method by adding empirical knowledge of an expert represented by fuzzy rule working as fuzzy rule based system. They named the proposed method as Fuzzy F-TOPSIS(Fuzzy Flexible TOPSIS) and applied on customer relationship management problem. [28] developed a framework that integrate graph theory based Fuzzy DEMATEL approach in Fuzzy MCDM method to find the customers need on the basis of customer choice model. [29] proposed linguistic intersection method (LIM) which deals with the MCDM problem in a fuzzy environment to make decision on linguistic variable. They used four MCDM method and intersected to get the optimum alternative ranking.

3. SYSTEM ARCHITECTURE

In this section, a framework is presented in graphical form (Figure **1**) known as graphical model for decision making of an intelligent scenario analysis system for marketing based on hypothetical database and fuzzy multi-criteria decision method. This will

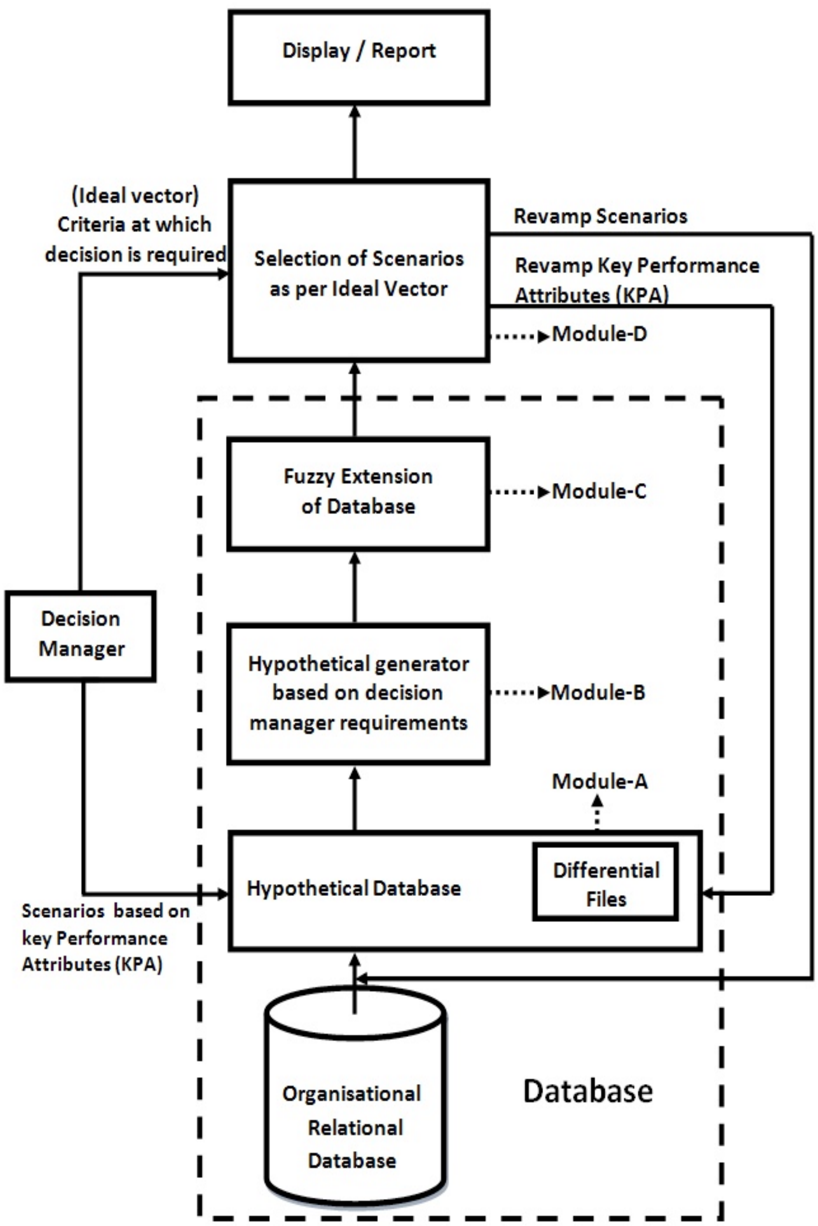

Figure 1: Proposed system architecture.

improve agility, competitiveness and profit of an organization. The proposed system is for manager or higher management of an organization who wants to set strategies for the best choice of marketing for optimal decision making.

According to [30] "what-if" scenarios are not prediction instead they deliver changing views of the future by searching numerous paths of variation that tend to a vast range of alternative possible upcoming. With the help of "what-if" scenarios decision maker become well informed by taking possible upcoming issues into consideration [31]. In this vein, hypothetical database provides a finite number of "what-if" scenarios those can be generated through IUVs which represents upcoming scene of selected "market domain", which is our research topic.

3.1. Hypothetical Database from ORD

The most popular database in commercial organization is relational database. In the proposed system Organizational Relational Database (ORD) is considered as shown in Figure **1** and assumed to be static for a specific time until the required decision process is completed. In the proposed framework, using a new concept of "Hypothetical Database", shown in Figure **1** (module-A), derived from relational database (defined in the previous section 2.1). The capability of views in hypothetical database with respect to relational database brings it prominent in the current relational database technology. As discussed(in previous section 2.1) the IUVs can be updated according to the need of decision maker without changing occur in the base relations from which it was derived. This significant feature of IUVs does not exist in conventional database views.

Using hypothetical database decision maker can generate scenarios through IUVs according to market problem. The attributes on which decision is taken we called them "Key Performance Attributes(KPA)". These KPA either come from one relation or more than one relation from the ORD. In Figure **1** (module-A) the decision maker must provide KPA from ORD to define PV using standard SQL. These KPA are primitive data on which IUVs can be generated. For each IUV a separate DT is defined and collected in differential files log as shown in Figure **1** (module-A).

IUV provides versatility in "what-if" analysis by using version of "what -if" databases. Figure **2** shows that the formation of IUVs hierarchy based on view PV1 derived from three relations i.e. Customer, Purchase, and Product in the ORD. Each IUV has distinct DT, for example in Figure **2** IUV "$Sce_{1.2}$ ($Scenario_{1.2}$)" associating with $DT_{1.2}$ .The suffix "1.2" represents the scenario is derived from parent view "1" and lies in hierarchy "2". Finite number of versions can be defined from any PV. All the versions contain same key performance attributes (KPA) as PV, only changes occur in value of KPA. Through this structure of IUV an organization can generate number of required scenarios from the primitive data(i.e. PV) and can establish market strategy about customers and/or products for future trends.

If decision maker wants some modification/review in IUV derived already, this can be done by using the property of IUVs that " IUV can be origin of another

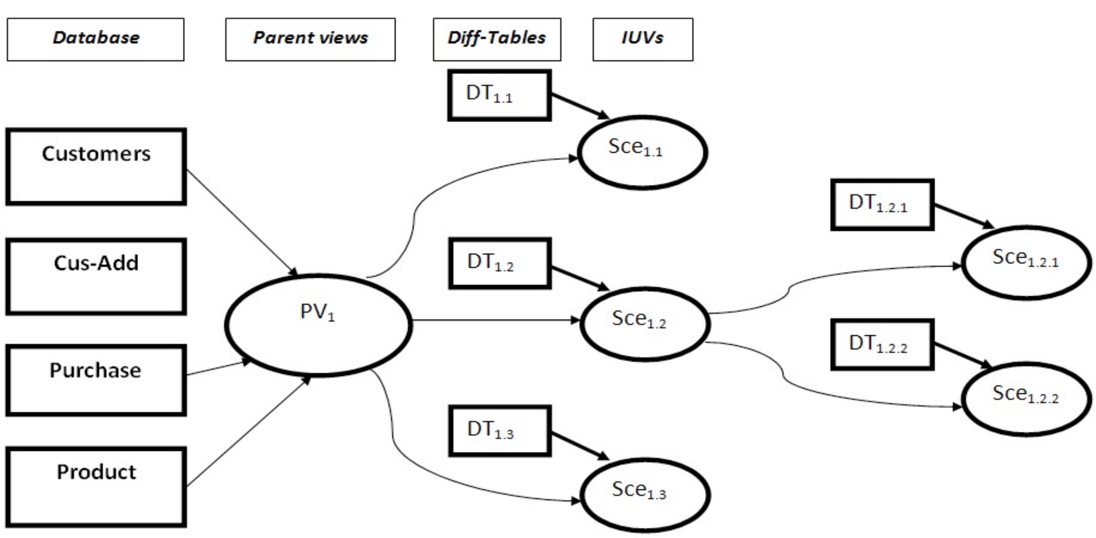

Figure 2: Hypothetical database hierarchy structure.

IUV". It is shown in Figure **2** as $Sce_{1.2}$ originates further two IUVs those are $Sce_{1.2.1}$ and $Sce_{1.2.2}$. These are two new versions derived from existing IUV i.e. $Sce_{1.2}$. This characteristic of IUV is called "Versions of versions". Economy in storage space is worth noting. The system storage is reduced by using IUVs, since it only stores updates in a separate differential file. Handling the IUVs hierarchy structure will be discussed in future work.

3.2. Hypothetical Generator

Scenarios are created by decision manager according to the needs of organization and/or market environment. In the proposed architecture the decision maker can generate finite IUVs by using KPA defined in PV or can generate new PVs. The parent views and selected IUVs are then stored in a pool called hypothetical generator as shown in Figure **1** (module-B). The hypothetical generator consist of all the parent views and selected IUVs in given scenes.

3.3. Fuzzy Extension of Database

Attributes in the marketing database may consist of "deterministic" and "nondeterministic". Deterministic attributes may be constant and fix values such as customer income, purchased amount, etc. whereas nondeterministic attributes may consist perception and feeling about the object for example customer behavior, personality, lifestyle and many others. The deterministic attributes can be handled by using conventional relational database but to treat nondeterministic attributes, such as customer behavior, fuzzy databases are used as most natural tool. In fuzzy set theory "Linguistic Variables" can be used for relative reasoning through which an appropriate decision can be taken. In Figure **1** (module-C), fuzzy database will be created about the required set of data by using technique already introduced in the literature. For fuzzy database, attributes come from the base relation(s) on which parent view was derived in module-A, so that nondeterministic attributes can be treated using fuzzy sets, possibility distributions or simply membership degree. Now a better communication can be attained from fuzzy database since natural languages can be used in term of linguistic variables. Hence, both qualitative and quantitative information can be utilized for future marketing strategies using relational database.

3.4. Selection of Scenarios as per Ideal Vector

For improved and imperious performance, the organization cannot rely on single independent variable (such as customer need, customer behavior, customer demography etc.). Alternately, decision manager need to consider number of variables that justify specific requirements by their strategy. Consequently, the setup of specific number of variables through management strategy evolves intricacy that is hard to clone. Therefore, the imperious performance for organization consistently produce positive output from various variables those are suitable with the marketing strategy.

To achieve above goal Fuzzy Multi-Criteria Decision Making (FMCDM) method will be used in Figure **1** (module-D) in the proposed architecture. Number of Fuzzy MCDM methods have been developed such as FAHP, FPROMETHEE, FTOPSIS, FFTOPSIS etc. to analyze and select the best alternative in fuzzy environment. Furthermore, researchers have been established hybrid FMCDM methods in which one FMCDM method is being used to calculate criteria weights and the other FMCDM method is being applied for ranking of alternative. We will develop a FMCDM method dealing the homogeneous scenarios problem with deterministic and nondeterministic KPAs and will provide the hierarchy of scenarios according to the closeness to "Ideal Vector" provided by decision manager.

If the decision maker needs to improve result according to ideal vector then the system will provide two ways

(a) Reconstruction of scenarios.

(b) Alteration the values of KPA in the existing scenarios.

To reconstruct new scenarios, the proposed system goes to ORD and whole process starts from the beginning. In this stage the decision maker can provide one or more new KPA to design new scenario, which can lead better result. The other way is alter the values of KPA in the existing scenario to achieve new scenario. In this approach decision maker can change one or more value(s) to prepare new scenarios that can route nearer relative to ideal vector.

4. CONCLUSION

In the decision making steps, advantages can be achieved from merger of theoretical and experimental knowledge and use for the treatment of crisp and vague data, not only in the representation but also at the time of decision making. In order to explore the possible scenarios from the organizational relational database in marketing problems, a new concept of hypothetical database has been applied. With the aim to deal with nondeterministic data, fuzzy database technique was used that already exists in the literature. Since organizations need to consider a set of variables that justify specific requirements by their strategies, therefore, FMCDM method was used in the proposed architecture to analyze and select the best alternative in fuzzy environment. In the future work we would like to derive algorithm that manage "What-If" hierarchy structure. We will also develop a FMCDM method dealing the homogeneous scenarios problem with deterministic and nondeterministic KPAs ,that will provide the hierarchy of scenarios according to the closeness to "Ideal Vector" provided by decision manager. The proposed system architecture will be helpful for Strategic, Tactical managers and the agile organization where decision makers have to adopt to market and environmental changes in cost effective and productive ways.

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