MINING ACTIONABLE PATTERNS IN BIGDATA FOR ENHANCED HUMAN EMOTIONS

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ABSTRACT

Action Rules are rule based systems that extract actionable patterns which are hidden in big volumes of data. Huge amount of data gets generated from Education sector, Business field, Medical domain and Social Media, in a single day. In the technological world of big data, massive amounts of data are collected by organizations, including in major domains like financial, medical, social media and Internet of Things(IoT). Mining this data can provide a lot of meaningful insights on how to improve user experience in multiple domain. Users need recommendations on actions they can undertake to increase their profit or accomplish their goals, this recommendations are provided by Actionable patterns. For example: How to improve student learning; how to increase business profitability; how to improve user experience in social media; and how to heal patients and assist hospital administrators. Action Rules provide actionable suggestions on how to change the state of an object from an existing state to a desired state for the benefit of the user. The traditional Action Rules extraction models, which analyze the data in a non distributed fashion, does not perform well when dealing larger datasets. In this work we are concentrating on the vertical data splitting strategy using information granules and creating the data partitioning more logically instead of splitting the data randomly and also generating meta actions after the vertical split. Information granules form basic entities in the world of Granular Computing(GrC), which represents meaningful smaller units derived from a larger complex information system. We introduced Modified Hybrid Action rule method with Partition Threshold Rho. Modified Hybrid Action rule mining approach combines both these frameworks and generates complete set of Action Rules, which further improves the computational performance with large datasets.

KEYWORDS

Emotion Detection, Meta Action, Information granules.

1. INTRODUCTION

In this technological world of data, data mining focuses on various techniques to extract some surprising, very interesting, and unknown knowledge patterns from massive data. Extracting these data is useful in multiple domains, this allows the different fields to generate a valuable data which can be used to analyze the user patterns. These techniques embrace the relationship of data objects with other objects (Clustering) or classes (Classification) to unwrap useful patterns in the data. It is now highly recommended to use data mining to achieve better results and higher profits [1]. Rule-based learning is a simple data mining method that identifies, learns, or develops 'rules' to store, operate, or apply. Association Rules and Decision Trees are fragments of rule-based methods that generate rules to associate patterns and classify data, respectively. In general, we constitute rules as given in Equation 1, where the *antecedent* is a conjunction of conditions, and the *consequent* is the resulting pattern in the given data for the given conditions in antecedent.

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$$condition(s) \rightarrow result(s) \quad (1)$$

Action rule is the process of knowledge extraction developed in context to advocate possible transitions for an individual to move from one state(negative) to another state (positive). For example, recommending the business to improve customer satisfaction [2] and sentiment analysis on Twitter [3]. Action rules follow the representation, similar to Equation 1, as given in Equation 2, where Ψ represents a conjunction of stable features, $(\alpha \rightarrow \beta)$ represents a conjunction of changes in values of flexible features and $(\theta \rightarrow \varphi)$ represents desired change in decision action which is beneficial to the user.

$$[(\Psi) \wedge (\alpha \rightarrow \beta)] \rightarrow (\theta \rightarrow \varphi) \quad (2)$$

Action Rules recommending Actionable pattern are prone to acquire definite form of cost to the user [4], [5]. Cost for actions in Action Rules include time, energy, money, or human resources. Actions being recommended can cause both positive(*benefits*) and negative(*loses*) effects for users [6]. Thus, Action Rules recommendations system should take on low cost to the users to make them plausible actions. The existing approaches [7–10] do not consider the cost effectiveness for recommendations. In [4] [11], the concept of cost of the Action Rules is introduced and refined. Searching for the low cost Action Rules from huge dataset can really be very time-consuming and will require a distributed and scalable approach for extracting them in a practicable timeframe.

Distributed Processing frameworks like Hadoop [12] and Spark [13] have been introduced to make data mining and big data processing faster and easier. The data processing work is distributed among the multiple nodes, each of which on their part of the data performs computations, by these frameworks. In this work, we use Apache Spark [13] framework for implementing a scalable solution to the proposed Action Graph method, and make it suitable for big data. Spark provides APIs such as GraphX [14] for a productive parallel processing in large graphs.

In this paper, we propose an extension to our previous work on distributed actionable pattern mining with Spark [15]. We extract actions rules from the business and survey datasets, that help to obtain better, desirable outcome for future. We focus on hierarchically structured recommender system to improve the efficiency of a company’s growth engine. The NPS dataset used for this research contains answers to a set of questionnaire sent to a randomly chosen groups of customers. It covers 34 companies called clients. The purpose of the questionnaire is to check customer satisfaction in using services of these companies which have repair shops all involved in a similar type of business (fixing heavy equipment). Authors [16] present the concept of semantic similarity between companies. More semantically similar the companies are, the knowledge extracted from their joined NPS datasets has higher accuracy and coverage.

Action Rule Mining literature consists of two major frameworks namely: Rule-Based approach and Object-Based approach. In this work we focus on Hybrid Action Rule mining method, which combines the above two frameworks with the advantage of scalability with large datasets. Primarily, we emphasis on Opinion Mining from Text to suggest Actionable Recommendations. The Actionable Patterns may suggest ways to alter the user’s sentiment or emotion to a more positive or desirable state. We extract action rules from business data and student survey data. In this work we propose a new Modified Hybrid Action Rule [17] mining approach that improves the computational performance, which combines the above two frameworks with the advantage of scalability with large datasets. We propose a new Threshold Rho - which allows the user to choose the number of data partitions. This yields Faster Scalable processing. We are applying the method to Student Survey Data, however this method can be used for Improving Customer Satisfaction as well. We also aim to suggest ways to improve the Teaching Methods and Student

Learning and how to change detractors to promoters in business . We implement and test our system in Scalable Environment with BigData using the Apache Spark platform.

2. RELATED WORK

Data Science plays a pivotal role in shaping the modern world, [18] paper focus on understanding its evolution, addressing challenges, and anticipating future trends which are crucial for researchers, practitioners, and policymakers alike. Text mining can help identify patterns, trends, and relationships in text data that would be difficult or impossible to identify through manual analysis. The paper [19] demonstrates the systematic review on text mining techniques and their applications in identifying new research trends. Natural Language Processing represents a cutting-edge technological paradigm with transformative implications for legal documentation. The paper [20] navigates the potential implications of employing NLP for legal documentation, emphasizing its role in improving access to justice, bridging linguistic gaps, and fostering inclusivity within the legal system.

The authors of the paper [21] provides an overview of a user-friendly NPS based Recommender System for driving business revenue. This technique hierarchically designed recommender system for improving NPS of clients that is driven mainly by action rules and meta-actions. The paper presents the main techniques used to build the data-driven system, including data mining and machine learning techniques, such as action rules and meta actions, hierarchical clustering, as well as visualization design. The system implements domain specific sentiment analysis performed on comments collected within telephone surveys with end customers. AI and Machine Learning integration with AWS Sage Maker: provides a comprehensive exploration of the current landscape and forward-looking possibilities in integrating artificial intelligence (AI) and machine learning (ML) using Amazon Web Services (AWS) SageMaker. The paper [22] adeptly navigates through the overview of AWS SageMaker, shedding light on its capabilities and features.

Authors in this paper [23], try to reduce those negative side effects by extracting personalized action rules. They propose three object-grouping schemes with regards to same negative side effects to extract personalized action rules for each object group. The Authors Kuang and et.al in their paper [24] propose a new strategy to improve NPS (Net Promoter Score) of certain companies called HAMIS. Those companies are involved in heavy equipment repair in the US and Canada. The authors of paper [16] present preliminary results of a flexible hierarchically structured recommender system for improving NPS of a company in a global competitive market. Clients are compare in terms of the similarity of their knowledge concerning the meaning of three concepts: promoter, passive, and detractor. The questionnaire sent to the customers allows them to enter statements in the text format explaining their ratings. Information included in these statements helps us to find triggers for action rules. The triggers are also called meta-actions [25], [26]. Kuang and Ras talk about building a recommender system in their paper [27] which is driven by action rules and meta actions for providing proper suggestions to improve revenue of a group of clients (companies) involved with similar businesses. They collect feedback from customers and use them as their dataset. The paper proposes a strategy to classify and organize meta-actions in such a way that they can be applied most efficiently to achieve desired goal. In their previous work, [16] they propose and implement the method of mining meta-actions from customers’ reviews in text format.

Recently various domains like medicine [28], education [29], and business [30] started adopting data science research in their respective problems. Many research studies have focused on using the copious real world datasets for healthcare applications and decision making using such knowledge extraction and data mining techniques [31]. For example, in context to hospital readmission, researchers and scientists created a machine learning model to predict patient readmissions by considering some basic patient admission characteristics and their billing codes [32]. Some emphasis on predicting the liklihood of patient readmitting to the hospital, modelled as risk prediction, using Support Vector Machines, Neural Networks, and Random Forests [33]. Similarly, there is a study on using logistic regression to measure the relationship between early readmission and diabetes [34], and a study on using a classic data mining technique like Support Vector Machine to predict readmission [35] using other features such as patient demographics, admission type, disease type, and clinical procedures undertaken. There is an interesting study that came into focus in the recent years related to designing a personalized procedure graphs,that gives a probability on patient's future procedure and recommend hospitals in making decisions for a patient [36,37]. Ras and Tzacheva [4] introduced the concept of cost and feasibility of Action Rules as an interesting measure. They proposed a graph based method for extracting plausible and low cost Action Rules. Ras and Tzacheva [4] proposed a heuristic search of new low cost Action Rules, where objects supporting the new set of rules also supports the existing rule set but the cost of reclassifying them is much lower for the new rules. Later, Tzacheva and Tsay [11] proposed a tree based method for extracting low cost Action Rules. Some research, apart from Action Rules has been done on extracting Actionable knowledge. For example, Yang, et.al [38] considered *Customer Attrition* in Customer Relationship Management (CRM) in telecommunications industry and the cost complexities involved in gaining profit to all customers. They proposed a method that extract low cost Actionable patterns for converting undesired customers to loyal ones while improving the net profit of all customers. Karim and Rahman [39] proposed another method to extract cost effective actionable patterns for customer attrition problem in post processing steps of Decision Tree and Naive Bayes classifiers. Su, et.al [5] proposed a method to consider positive benefits that occurs by following an Action Rule apart from all costs that incur from the same rule. Cui, et.al [40] proposed to extract optimal actionable plans during post processes of Additive Tree Model (ATM) classifier. These actionable patterns can actually change the given input to a desired one with a minimum cost. Hu, et.al [41] proposed an integrated framework to gather the cost minimal actions sets to provide support for social projects stakeholders inorder to control risks involved in risk analysis and project planning phases. Lately, Hu, et.al [42] developed an ensemble framework and cost sensitive method to predict software project risk predictions and conducted large scale analysis over 60 models 327 real world project samples.

Due to the advent of big data, some research [26], [15], [43] started applying distributed computing frameworks like MapReduce [12] and Spark [13], recently have been done to extract actionable recommendation completely in a clustered setup. Bagavathi [26] proposed a method to distribute the data in random to multiple sites, combining results from all sites and taking average on parameters like Support and Confidence. Bagavathi [15] handle the load balancing by uniformly distributing the data into partitions based on the decision attribute. Authors [43] introduces a new method of projecting the database into smaller chunks, for handling data with large number of attributes, and extract action rules from them effectively.

Table 1. Example Decision System T

X	**A**	**B**	**C**	**D**
x_1	Y	N	N	D_1
x_2	Y	H	Y	D_2
x_3	Y	H	Y	D_1
x_4	N	N	N	D_2
x_5	N	H	N	D_1
x_6	N	N	Y	D_2
x_7	N	H	Y	D_2
x_8	N	H	N	D_1

In this work, we prefer to use rule based systems in order to recommend various steps to improve User's emotions including Student Surveys and Customer's Net Promoter Score (NPS) for businesses . Rule based systems are one of the most commonly used machine learning methods like regression, classification and association [44] because it is simple to understand and easy to use. Action rules are such rule based systems that designed to recommend actionable insights, for example recommendations for businesses to gain profit by finding interesting actionable patterns in the data [45]. In the literature, action rules are extracted using two different methods. First method is a rule based approach, in which first the intermediate classification rules are extracted using efficient rule generation algorithms such as LERS or ERID. From these extracted rules, action rules are generated with systems like DEAR [7], which extracts Action Rules from two classification rules, or ARAS [8], which extracts Action Rules using a single classification rule. Second method is object-based approaches, in which the Action Rules are extracted directly from the given decision table without involving any intermediary steps. Systems ARED [10] and Association Action Rules [9] works in the object-based approach. Algorithms, except association action rules, runs much faster with the aim of extracting rules that provides maximum benefits to the user and extracts only limited recommendations.

In this work we propose a Modified Hybrid Action Rule mining approach with Additional Threshold Rho- for the Number of Partitions which further improves the computational performance from our previous method that has only one threshold [17]. This allows for Faster and more Scalable processing. We will apply our method to the Student Survey Data, and NPS business data however this method can be used for healthcare data as well. We are focusing on our work to suggest ways to improve the Teaching and Student Learning methods and also how to improve Customer Satisfaction, like the status change from detractors (Customers with Negative Emotions) to promoters (Customers with Positive Emotions) in business. We implement and test our system in Scalable Environment with BigData using the Apache Spark platform.

3. BACKGROUND

In this section, we give some basic idea about Decision system, Action Rules, Spark and GraphX frameworks to understand out methodology.

3.1. Decision System

Consider a decision system given in Table 1. Information System can be represented as T = (X,A,V) where,
X is a nonempty, finite set of objects: X = $\{x_1,x_2,x_3,x_4,x_5,x_6,x_7,x_8\}$
A is a nonempty, finite set of attributes: A = *A,B,C,D* and V_i is the *domain* of attribute *a* which represents a set of values for attribute $i|i \in$ A. For example, $V_B = N,H$.
An information system becomes Decision system, if $A = A_{St} \cup A_{Fl} \cup d$, where *D* is a *decision attribute*. The user chooses the attribute *d* if they wants to extract desired action from $d_i : i \in V_d$. A_{St} is a set of *Stable Attributes* and A_{Fl} is a set of *Flexible Attributes*. For example, *ZIPCODE* is a Stable Attribute and *User Ratings* can be a Flexible Attribute. Let us assume from Table 1 that $C \in A_{St}$. A, B $\in A_{Fl}$ and $D \in d$. and the decision maker desires Action Rules that triggers the decision attribute change from D_1 to D_2 throughout this paper for examples.

3.2. Information System

Consider a information system given in table 2. Information system can be represented as $Z = (X,M,V)$where, *X* is set of objects $\{x_1,x_2,x_3,x_4,x_5,x_6,x_7,x_8\}$ in the system; *M* is non-empty finite set of attributes $\{A,B,C,E,F,G,D\}$; *V* is the domain of attributes in *M*, for instance the domain of attribute *B* in the system *Z* is $\{B_1,B_2,B_3\}$.

Table 2. Information System Z

X	**A**	**B**	**C**	**E**	**F**	**G**	**D**
x_1	A_1	B_1	C_1	E_1	F_2	G_1	D_1
x_2	A_2	B_1	C_2	E_2	F_2	G_2	D_3
x_3	A_3	B_1	C_1	E_2	F_2	G_3	D_2
x_4	A_1	B_1	C_2	E_2	F_2	G_1	D_2
x_5	A_1	B_2	C_1	E_3	F_2	G_1	D_2
x_6	A_2	B_1	C_1	E_2	F_3	G_1	D_2
x_7	A_2	B_3	C_2	E_2	F_2	G_2	D_2
x_8	A_2	B_1	C_1	E_3	F_2	G_3	D_2

The information system in table 2 becomes a Decision System if the attributes M are classified into flexible attributes M_{fl} , stable attributes M_{st} and decision attributes d, $M = (M_{st},M_{fl},\{d\})$.
From table 2 $M_{st} = \{A,B,C\}$, $M_{fl} = \{E,F,G\}$, and $d = D$.

3.3. Action Rules

In this subsection, we give definitions of action terms, action rules and the properties of action rules [45]

Let T = (X,A ∪ d,V) be a decision system, where d is a decision attribute and V = $\cup V_i : i \in$ A. Action terms can be given by the expression of $(m,m_1 \rightarrow m_2)$, where $m \in A$ and $m_1,m_2 \in V_m$. $m_1 = m_2$ if $m \in A_{St}$. In that case, we can simplify the expression as (m,m_1) or $(m = m_1)$. Whereas, m_1 6= m_2 if $m \in A_{Fl}$

Action Rules can take the form of $t_1 \cap t_2 \cap .... \cap t_n$, where t_i is an atomic action or action term and the Action Rule is a conjunction of action terms to achieve the desired action based on attribute D. Example Action Rule is given below: $(a,a_1 \rightarrow a_2).(b,b_1 \rightarrow b_2) \longrightarrow (D,D_1 \rightarrow D_2)$

Properties of Action Rules Action Rules are considered interesting based on the metrics such as Support, Confidence, Coverage and Utility. Higher these values, more interesting they are to the end user.

Consider an action rule R of form:
$(Y_1 \rightarrow Y_2) \longrightarrow (Z_1 \rightarrow Z_2)$ where,
Y is the condition part of R; is the decision part of R
Y_1 is a set of all left side action terms in the condition part of R
Y_2 is a set of all right side action terms in the condition part of R
Z_1 is the decision attribute value on left side
Z_2 is the decision attribute value on right side

In [45], the support and confidence of an action rule R is given as

$$Support(\mathcal{R}) = min\{card(Y_1 \cap Z_1), card(Y_2 \cap Z_2)\}$$
$$Confidence(\mathcal{R}) = [\frac{card(Y_1 \cap Z_1)}{card(Y_1)}] \cdot [\frac{card(Y_2 \cap Z_2)}{card(Y_2)}]$$

Later, Tzacheva et.al [11] proposed a new set of formula for the calculation of Support and Confidence of Action Rules. Their idea is to reduce the complexities in searching data several times for Support and Confidence of an Action Rule. The new formula are given below.

$$Support(\mathcal{R}) = \{card(Y_2 \cap Z_2)$$

$$Confidence(\mathcal{R}) = [\frac{card(Y_2 \cap Z_2)}{card(Y_2)}]$$

Tzacheva et. al [11] also introduced a concept of utility for Action Rules. Utility of Action Rules takes a following form. For most of cases Utility of Action Rules equals the Old Confidence of the same Action Rule.

$$Utility(\mathcal{R}) = [\frac{card(Y_1 \cap Z_1)}{card(Y_1)}]$$

Coverage of an Action Rule means that how many decision from values, from the entire decision system S, are being fully covered by all extracted Action Rules. In other words, using the extracted Action Rules, *Coverage* defines how many data records in the decision system can successfully transfers from Z_1 to Z_2

3.4. Cost of Action Rules

Generally, there is a cost associated with changing an attribute value from one class to another class- the more desirable one. The cost is a subjective measure, in a sense that domain knowledge from the experts or user in the field is necessary in order to determine the costs associated with taking the actions. Costs could be moral, monetary, or a combination of the two. For example,changing the marital status from 'married' to 'divorced' has a moral cost; whereas ,lowering the interest percent rate for a customer is a monetary cost for the bank; in addition to any monetary costs which may be incurred in the process. Feasibility is an objective measure, i.e. domain independent. According to the cost of actions associated with the classification part of the action rules, a business user may be unable or unwilling to proceed with them. The definition of cost was introduced by Tzacheva and Ras [4] as follows:

Assume that $S = (X,A,V)$ is an information system. Let $Y \subseteq X$, $b \in A$ is a *flexible* attribute in S and $v_1,v_2 \in V_b$ are its two values. By $\wp_S(b,v_1 \to v_2)$ we mean a number from $(0,\omega]$ which describes the average cost of changing the attribute value v_1 to v_2 for any of the qualifying objects in Y . These numbers are provided by experts. Object $x \in Y$ qualifies for the change from v_1 to v_2, if $b(x) = v_1$. If the above change is not feasible, then we write $\wp_S(b,v_1 \to v_2) = \omega$. Also, if $\wp_S(b,v_1 \to v_2) < \wp_S(b,v_3 \to v_4)$, then we say that the change of values from v_1 to v_2 is more feasible than the change from v_3 to v_4. Assume an action rule r of the form:

$(b1,v_1 \to w_1) \wedge (b2,v_2 \to w_2) \wedge ... \wedge (bp,v_p \to w_p) \Rightarrow (d,k_1 \to k_2)$

Table 3. Meta-actions Influence Matrix for S

	a	**b**	**d**
M_1, M_2, M_3		$(b_1 \to b_2)$	$(d_1 \to d_2)$
M_1, M_3, M_4	(a_2)	$(b_2 \to b_3)$	
M_5	(a_1)	$(b_2 \to b_1)$	$(d_2 \to d_1)$
$M2$, $M4$		$(b_2 \to b_3)$	$(d_1 \to d_2)$
$M1$, $M5$, $M6$		$(b_1 \to b_3)$	$(d_1 \to d_2)$

If the sum of the costs of the terms on the left hand side of the action rule is smaller than the cost on the right hand side, then we say that the rule r is *feasible*.

3.5. Meta Action

As an action rule can be seen as a set of atomic actions that need to be made happen for achieving the expected result, meta-actions are the actual solutions that should be executed to trigger the corresponding atomic actions, Table 3 below shows an example of influence matrix which describes the relationships between the meta-actions and atomic actions influenced by them.

3.6. Spark

Spark [13] is a framework that is quite similar to MapReduce [12] to process large quantity of data in a parallel fashion. Spark introduces a distributed memory abstraction strategy called Resilient Distributed Datasets(RDD) that can perform in-memory computations on nodes distributed in a cluster. Results of each operation are then stored in memory itself, which can be accessed for future processes and analyses, which in-turn creates another RDD. Thus, Spark cuts-off the larger number of disk accesses for storing intermediate outputs like in Hadoop MapReduce. Spark functions in two stages: 1. *Transformation*, 2. *Action*. During the *Transformation* stage, computations are made on data splits and results are stored in the worker nodes memory as RDD. While the *Action* stage on an RDD collect results from all the workers and send it to the driver node or save the results to a storage unit. With RDDs Spark helps machine learning algorithms to skip innumerable disk access during iterations.

4. DATASET DESCRIPTION

To test our methods, we use two datasets: *Student Survey Data* [17], and the Net Promoter Score dataset data [21]. Student survey data aims to evaluate student emotions and overall satisfaction with course teaching methods and group work experience. The survey is designed to get meaningful insights on students' feelings towards the Active Learning methods and other factors that can help students in their learning process. The data is collected in the courses which implement the Active Learning methods and teaching style. This survey dataset contains 50 attributes. The original data contains 549 instances and 59 attributes. Data is collected in classes employing Active Learning methods to assess student opinions about their learning experience in the years 2019, 2020. The data size on disk is 59 Kilobytes. For scalability purpose to test the performance of our proposed method with BigData, we replicate the original Student Survey Data 100 times. The replicated dataset has a total of 54900 instances. Size on disk is 5.815 Megabytes. We also used a sample of Net Promoter Score dataset [21] for our experiments. The NPS (Net Promoter Score) dataset is collected customer feedback data related to heavy equipment repair. The entire dataset consists of 38 companies, located in multiple sites across the whole United States as well as several parts of Canada. Overall, there are about 340,000 customers surveyed in the database over time span of 2011-2015. Customers were randomly selected to answer a questionnaire which was specifically designed to collect information relevant to NPS (structured into so-called ”benchmarks”). All the responses from customers were saved into database with each question (benchmark) as one feature in the dataset. Benchmarks include numerical scores (0-10) on certain aspects of service: e.g. if job done correctly, are you satisfied with the job, likelihood to refer, etc. The dataset also contains customer details (name, contact, etc.) and service details (company, invoice, type of equipment repaired, etc.). The decision attribute in the dataset is *PromoterStatus* which labels each customer as either *promoter*, *passive* or *detractor*. The decision problem here is to improve customer satisfaction / loyalty as measured by Net Promoter Score. The goal of applying action rules to solve the problem is to find minimal sets of actions so that to ”reclassify” customer from ”Detractor” to ”Promoter” and the same improve NPS. For our experiments, we used survey given by customers for 2 companies over the year of 2015. We have used 17-california and 30-35 datasets for our method. Each of NPS data consists of around 1500 unique surveys from multiple customers with around 25 unique questions. The original data for 17-california contains 547 instances and 23 attributes and the dataset for company 30-35 contains 3335 instances and 23 attributes.

5. METHODOLOGY

In our paper, we propose Action Rule extraction techniques to generate action rules. Graph based method to search for optimal low cost Action Rules. In this section, the algorithm for Action Rules are described wisely.

5.1. Distributed Action Rules Extraction Algorithm

In this work, for the extraction technique we focused on distributed Association Action Rules [43] in order to extract the actionable knowledge from big data using Spark framework. Association Action Rules method is not appropriate for big data due to high dimensional data and lacks efficiency in run time. By using the vertical data partitioning technique as proposed in [43], we create partitions of data sets by splitting the data according by attributes in a high dimension data. We perform Association Action Rule extraction algorithm on each partitions of data in parallel, which allows much faster computational time for Association Action Rules extraction in Cloud platforms. Association Action Rules algorithm is quite similar to Association Rules extraction algorithm with the A-priori method [46]. Association Rules find patterns that occur most frequently together in the given data set. The most popular algorithm for extracting Association Rules is Apriori algorithm [47]. Apriori algorithm starts with 2 element pattern and continues *n* iterations until it finds the *n* element patterns, where *n* is the number of attribute in the given data set. Sample Association rule, that means when a pattern $a_1 \cap b_2$ occurs together in the data, pattern $c_1 \cap d_2$ also occurs in the same data, are given below.

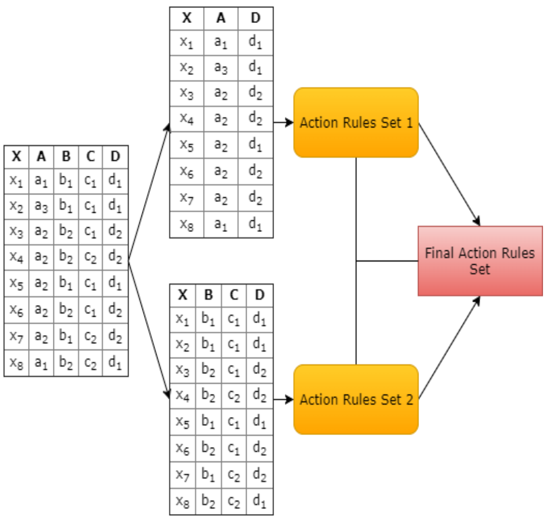

Fig.1. Example Vertical Data Distribution for Table 1

Figure 1 presents an example vertical data partitioning with the sample Decision system in Table 1. The actionable knowledge extraction algorithm runs separately on each data partition, does transformations like *map(), flatmap()* functions and combine results with *join()* and *groupBy()* operations. We later combine action rules from different partitions to get the final set of action rules.

5.2. Vertical Split - Data Distribution for Scalable Association Action Rules

Authors Bagavathi et al. [43] in method 2 propose the extraction of Action Rules basically by splitting the data in vertical order, which is in contrast to traditional horizontal split, which is performed by parallel processing systems. This method follow Association Action Rules [9] which is based on iterative method to extract all the possible action rules. To overcome the expense and computational complexity , the authors in [43] proposed vertical data split method for parallel processing along with faster computation. In this method, the data is split in vertical order into 2 or more partitions, with each partition having only a small subset of larger attributes. Fig. 1explains the example of Data partitioning using Vertical Data Distribution in *Distributed Action rules extraction algorithm*, the first section of methodology.

5.3.Hybrid Action Rule Mining

There is a disadvantage of computing preexisting decision rules in generating the Action Rule by Rule-Based method using LERS [48] .The process requires complete set of attributes which is difficult to implement in distributed cloud environment. We can implement the Object-Based method in distributed cloud environment by splitting the data vertically[43], where subsets of the attributes are taken for scalability. However, since this method is iterative it takes longer time to process huge datasets.

This approach-Hybrid Action Rule mining [49] combines the Rule-Based and ObjectBased methods to generate complete set of Action Rules. It provides better performance and scalability for large datasets, in compare to Iterative Association Action Rule approach. The pseudocode of the algorithm is given bellow in the Fig. 2.

```
Algorithm(certainRules, decisionFrom, decisionTo, support, confidence)
    (where certainRules are provided by algorithm LERS)
    for each rule r in certainRules
        if consequent(r) equals decisionTo
            Form ActionRuleSchema(r)
            ARS ← ActionRuleSchema(r)
        end if
    end for
    for each schema in ARS
        Identify objects satisfying schema
        Form subtable
        Generate frequent action sets using Apriori
        Combine frequent action set to form Action Rules
        (Such that the frequent action sets satisfy the decisionFrom → decisionTo)
        Output ← Action Rules
    end for
```

Fig.2. Hybrid Action Rule Mining Algorithm.

The Algorithm approaches with the Information System as follows. The information system in table 2 contains the following attributes: flexible P_{fl} , stable P_{st} and decision d, $P = (P_{st},P_{fl},\{d\})$. From table 2 $P_{st} = \{A,B,C\}$, $P_{fl} = \{E,F,G\}$, and $d = D$.

The following example re-directs the decision attribute D from $d_2 \rightarrow d_1$. The algorithm Fig. 2. to extract the classification rules that are certain initially uses the LERS method and then generates Action Rule schema as given in the following equations " 3" ," 4".

$[B_1 \wedge C_1 \wedge (F, \rightarrow F_1) \wedge (G, \rightarrow G_1)] \rightarrow (D, D_2 \rightarrow D_1).$ (3)

$[(E, \rightarrow E_1)] \rightarrow (D, D_2 \rightarrow D_1).$ (4)

$[B_1 \wedge C_1 \wedge (F, \rightarrow F_1) \wedge (G, G_3 \rightarrow G_1)] \rightarrow (D, D_2 \rightarrow D_1).$ (5)

The algorithm then creates sub-table for each of the Action Schema. For example " 3", generates the following sub-table shown in table 4. The Hybrid Action Rule Mining Algorithm involves the Association Action Rule extraction algorithm in parallel on each of the sub-tables. The algorithm generates the following Action Rules Equation " 5" based on the sub-table shown in table 4.

Table 4. Subtable for Action Rule Schema

X	B	C	F	G	D
x_1	B_1	C_1	F_2	G_1	D_1
x_3	B_1	C_1	F_2	G_3	D_2
x_6	B_1	C_1	F_3	G_1	D_2
x_8	B_1	C_1	F_2	G_3	D_2

This Hybrid Action Rule algorithm is implemented in Spark [50] and runs separately on each of the sub-table and performs the transformations like map(), flatmap(), join(). The method of this algorithm is shown in Fig. 3. Our new Threshold algorithm method Fig. 4

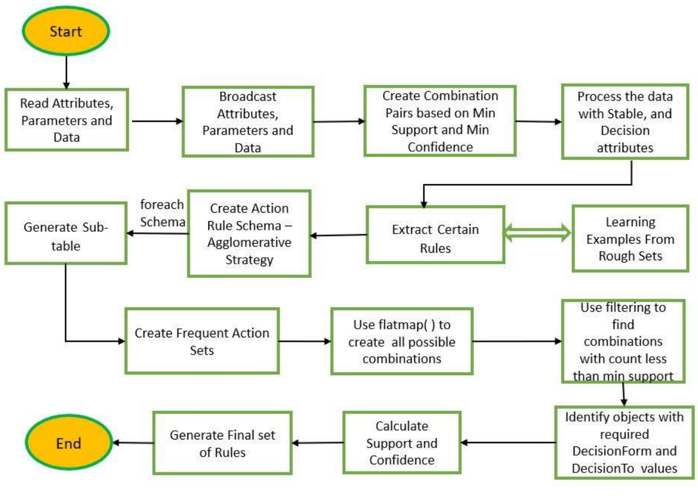

Fig.3. Hybrid Action Rule Mining Algorithm - Flowchart.

5.4. Modified Hybrid Action Rule Mining with Partition Threshold Rho

We propose a Modified Hybrid Action Rule Mining with Partition Threshold Rho which provides scalability with big data. It presents a significant improvement over the previous method - Hybrid Action Rule Mining, which has a major disadvantage. If the Size of the Intermediate Table becomes very large it affects the performance and the scalability of this method. Our proposed new method solves this problem, as the Threshold ρ allows the user to control the size of the table and it increases the computational speed.

Our proposed method - Modified Hybrid Action Rule Mining with Partition Threshold Rho - is presented in the Fig. 5 and the proposed methodology is depicted in the Fig. 4.

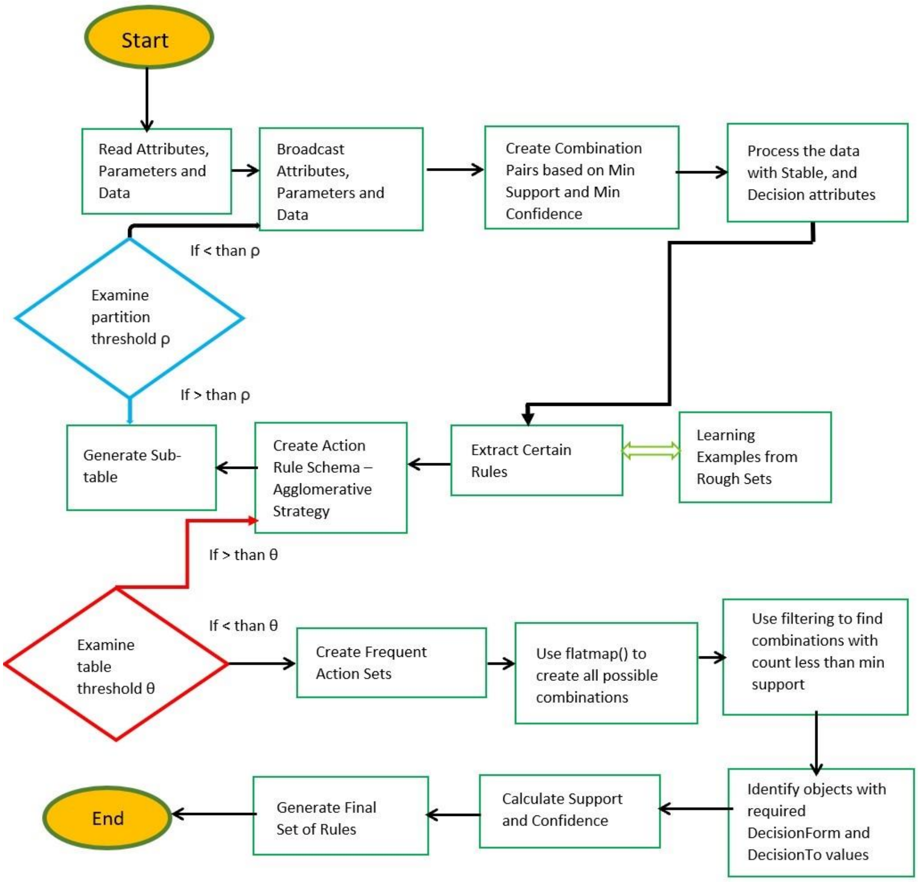

Fig.4. Hybrid Action Rule Mining Algorithm(New Threshold) - Flowchart.

```
Algorithm(certainRules, decisionFrom, decisionTo, support, confidence)
        (where certainRules are provided by algorithm LERS)
        for each rule r in certainRules
            if consequent (r) equals desisionTo
                    Form ActionRuleSchema (r)
                    ARS <- ActionRuleSchema (r)
            end if
        end for
        for each schema in ARS
                Identify objects satisfying schema
                Form partition
                While partition size > Rho ρ
                Form subtable
                While subtable size > Theta θ
                    Divide subtable until subtable < Theta θ
                Generate frequent action sets using Apriori
                Combine frequent action set to form Action Rules
                (such that the frequent action sets satisfy the
                        decisionFrom -> decisonTo)
                Output <- Action Rules
        end for
```

Fig.5. Hybrid Action Rule Mining with Threshold Algorithm.

5.5. Vertical Data distribution method with Meta Action

Meta-actions, are a tabular format to trigger action rules discovered from user data. Meta actions are the actions that need to be executed in order to trigger corresponding [51] and it can be one or more than one set to invoke action rules in our method a set of meta actions triggered the generation of action rules.

In our paper, we present a approach for partitioning the given data using information granules. We give a new algorithm to generate meta action as the intermediate state before extraction of all Action Rules, based on the algorithm proposed in [52] and [9]. We test how fast our new method works with two different data sets one with the NPS dataset and the other is Student Survey dataset and compared to our previous distributed Action Rule extraction algorithms. A brief description about our vertical data distribution process with meta- actions has been given in Figure 6. We check validity of the new data distribution method by comparing number of Action Rules generated by our method and rule coverage of Action Rules from system with classical Association Action Rules [9] on a single machine and SARGS [15] systems.

6. EXPERIMENTS AND RESULTS

In this work we use, student survey data which focus on student emotions. We applied the data in all the three experiments and compared the Computational time. We also used a sample of NPS (Net Promoter Score) data [21] for our experiments that aims to evaluate Promoter Status. We applied NPS (Net Promoter Score) data for Vertical Split - Data Distribution method only. See section IV. Dataset Description.

We compare our proposed method with the Vertical Split - Data Distribution for Scalable Association Action Rules method and Hybrid Action Rule mining method. We achieve faster computational time through our new proposed method for Student Survey method.

6.1. Experiment 1 - Vertical Data Split Method Implementation in Spark AWS Cluster

We perform this experiment on the Student Survey Data - using Amazon Web Services (AWS) cluster with two nodes, 4 vCore and 16GiB memory and EBS Storage 64GiB. For very large data this method requires additional resources. We find we must provide extra 32 Gigabytes of memory to complete computation on the replicated data in 2400 seconds. Otherwise, the method receives OutOfMemory Exception with our replicated Student Survey Data. This occurs because of iterative nature of the algorithm with large data that causes computational overhead and requires extra hardware memory resources to work successfully. This method only works for Association Action Rules because it considers only subset of the attributes.

We plan to continue this experiment with NPS (Net Promoter Score) Business data by applying the Hybrid Method and Modified Hybrid Method with Partition Threshold Rho. The result is shown in our previous paper [54].

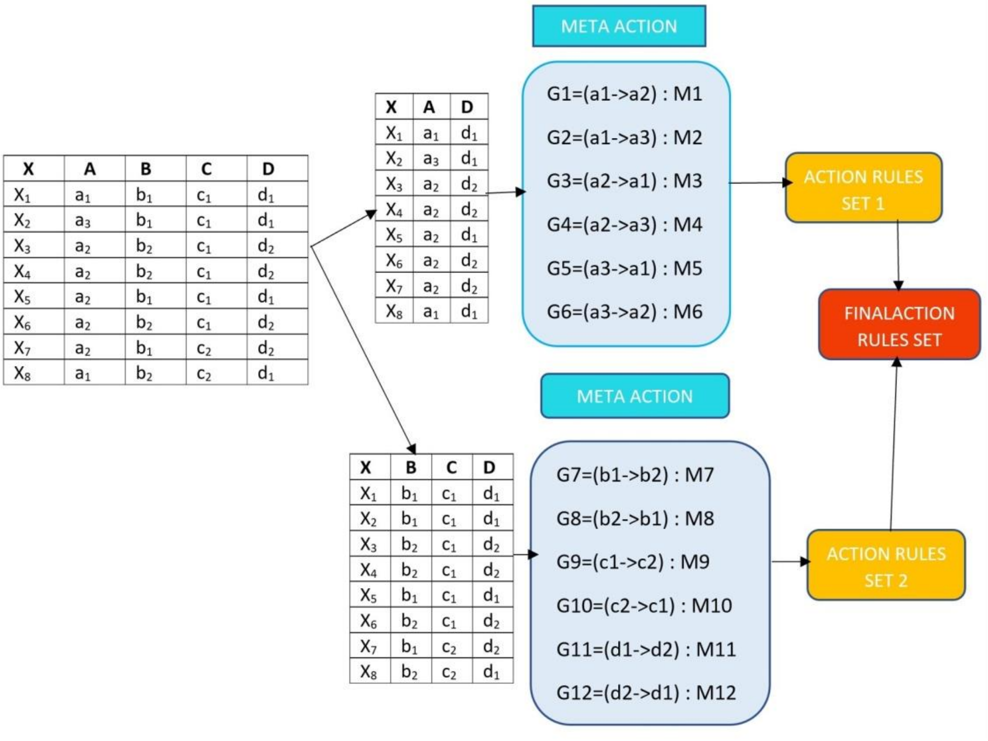

Fig.6. Vertical Data Split with Meta Action for Table 1

6.2. Experiment 2 - Hybrid Method Implementation in Spark AWS Cluster

We perform this experiment on the Student Survey Data with Hybrid Action Rule Mining Method - using Amazon Web Services (AWS) cluster with two nodes, 4 vCore and 16GiB memory and EBS Storage 64GiB. This method takes 5088 seconds to complete computation on our replicated Student Survey Data. The result is shown in our previous paper [54].

6.3. Experiment 3 - Modified Hybrid Action Rule Mining with Partition Threshold Rho Implementation in Spark AWS Cluster

We perform this experiment on the Student Survey Data with our proposed Modified Hybrid Action Rule Mining Method - using Amazon Web Services (AWS) cluster with two nodes, 4 vCore and 16GiB memory and EBS Storage 64GiB. Our proposed method takes 3900 seconds to complete computation on the replicated Student Survey Data. We experiment with 3 different Threshold values of ρ ::: 5, 10 and 15 and θ ::: 5, 10 and 15. The runtime comparison for different Threshold values for two different thresholds θ and ρ implemented on Student Survey data is shown in the below table 6. For Student Survey data Threshold value of $\rho = 5$ and $\theta = 15$ provides optimum performance.

Selected Action Rules generated by this method are shown in table 5. The Action Rule 1 in table 5 says when Team Formation changes from 2BelowAverage to 4Perfect and the Number of Team Members changes from 5to7 to 8to10 then the Student Emotion changes from Sadness to Joy. This rule has support of 21 and confidence of 62%. This shows how having a good team and increased number of Team Members enhances a Student’s Emotion from Sadness to Joy.

6.4. Runtime Comparison of the above 3 Implementations with Respect to Student Survey Data in Spark AWS Cluster

We compare the execution runtime of the above-described implementations: Vertical Data Split Method in Spark AWS Cluster, Hybrid Method Implementation in Spark AWS Cluster and Hybrid Method with Threshold Implementation in Spark AWS Cluster. The runtimes are given below in table 7 and table 8. Our proposed Hybrid Method with Threshold (Modified Hybrid Method with threshold rho) shows improved performance over the previous Hybrid Method and shows the best performance with standard memory.

6.5. Experiment 4 - Vertical Data Split generating Meta Action with NPS Data

To test our methods, we use dataset: the *Net Promoter Score* data [53]. We used a sample of Net Promoter Score dataset [53] for our experiments. The NPS (Net Promoter Score) dataset is collected customer feedback data related to heavy equipment repair. The entire dataset consists of 38 companies, located in multiple sites across the whole United States as well as several parts of Canada. Overall, there are about 340,000 customers surveyed in the database over time span of 2011-2015. Customers were randomly selected to answer a questionnaire which was specifically designed to collect information relevant to NPS (structured into so-called ”benchmarks”). All the responses from customers were saved into database with each question (benchmark) as one feature in the dataset. Benchmarks include numerical scores (0-10) on certain aspects of service: e.g. if job done correctly, are you satisfied with the job, likelihood to refer, etc. The dataset also contains customer details (name, contact, etc.) and service details (company, invoice, type of equipment repaired, etc.). The decision attribute in the dataset is *Promoter Status* which labels each customer as either *promoter, passive* or *detractor*. The decision problem here is to improve customer satisfaction / loyalty as measured by Net Promoter Score. The goal of applying action rules to solve the problem is to find minimal sets of actions so that to ”reclassify” customer from ”Detractor” to ”Promoter” and the same improve NPS. For our experiments, we used surveys given by customers for 4 companies over the year 2015. Each NPS data consists of around 1500 unique surveys from multiple customers with around 25 unique questions.

For all, *Net Promoter Score* data, we choose *Promoter Status* as a decision attribute and we collect Action Rules to convert Detractors to Promoters of a company from a list of surveys that the customers have participated in.

Due to space limitations, we show the Action Rules extracted using our methods in different tables: Table 9, Table 10, Table 11 and Table 12. In These Action Rules provide actionable recommendations to users who wants to achieve the desired decision action. We give example Action Rules for all NPS datasets: in Table 9, Table 10, Table 11 and Table 12. For example, consider AR_{N2} which recommends that if the company can improve user’s ratings on *Completion of repair correctly* from *5 points* to *10 points* and improve user’s ratings on *Technician communication* from *3 points* to *9 points*, the company can convert some *Detractors* to *Promoters* with support of 2.0 and confidence of 90.0%. Meta Actions are provided by experts, but we have some probable predictions of Meta Actions. In Figure 7, we are showing the Meta Action for a particular Action Rule. Each Meta Action corresponds to a particular Action Rule. Each figure represents the Action Rule table it belongs to. For example figure 7 belongs to Table 9 and figure 8 belongs to Table 12.

7. CONCLUSION

The ultra-connected world generates massive volumes of data stored in computer databases and cloud environments. Analysts need to examine these large datasets to extract useful knowledge and present it to decision makers. Most decision makers encounter numerous decision rules resulting from action rules mining. Moreover, dataset's volume presents new challenges in extracting patterns, such as high computing costs or unreasonable time to extract relevant rules. However, emotion analysis has attracted researchers. Social media, online surveys, customer surveys, blogs, and industrial and educational data generate large amounts of data. Valuable insights of people's opinions and emotions are hidden in this data. We are searching for emotions in data - this can apply to Student Surveys as well Customer Satisfactions opinions such as the NPS (Net Promoter Score) data. Our proposed method - Modified Hybrid Action Rule Mining with Partition Threshold Rho to Student Survey Dataset and NPS (Net Promoter Score) business Dataset. In our results we suggest ways of improving Customer Emotions that may be a Student or maybe a Businessperson. The Student Survey data contains student opinions regarding the use of Active Learning methods, Teamwork and class experiences. The NPS data contains the customers' opinion regarding their service experience with the business. The discovered Action Rules help to enhance the user Emotion from Negative to Positive and from Neutral to Positive. Today, a completely automated and accurate solution is yet to be found. At the same time, there is still a great demand in industry domains for such systems, because every business wants to know how customers perceive their products and services.

8. FUTURE WORK

Our proposed method improves the processing time. However, the quality of rules may decrease. In the future, we plan to use Correlation of Attributes and run classical Clustering Algorithm. This obtains optimal Vertical Partitioning which is flexible. We plan to apply Agglomerative strategy to change levels of vertical partitions. We also plan to examine the Quality of the Action Rules using F-Score.

Table 5. Sample Action Rules ::: Sadness to Joy ::: - Student Survey Data - Hybrid Method with Threshold.

Enhance Student Emotion - Sadness → Joy
1. *AR1SadnesstoJoy* : (*TeamSenseofBelonging*, 2*BelowAverageSenseofBelongingtotheTeam* →3*AverageSenseofBelongingtotheTeam*)∧(*NumberofTeamMembers*,5*to*7→10*orMore*)=⇒ (*StudentEmotion*,*Sadness* →*Joy*)[*Support* : 20.0,*Confidence* : 59.0%]
2. *AR2SadnesstoJoy*:(*NumberofTeamMembers*,5*to*7→8*to*10) ∧ (*TeamWorkHelpedDiversity*,2*Occasionally*→3*Often*) ∧ (*GroupAssignmentBenefit*,*None* → *AllofThem*) =⇒ (*StudentEmotion*,*Sadness* → *Joy*)[*Support* : 20.0,*Confidence* : 100%]
3. *AR3SadnesstoJoy*:(*NumberofTeamMembers*,5*to*7 → 8*to*10) ∧ (*GroupAssignmentBenefit*,*None* →*SharedKnowledge*) =⇒ (*StudentEmotion*,*Sadness* → *Joy*)[*Support*:34.0,*Confidence*: 85.0%]

Table 6. Threshold values - ρ and θ Run Time for Student Survey Data

Threshold	Threshold	Time in Second
5	5	447
5	10	355
5	15	352
10	5	452
10	10	643
10	15	455
15	5	354
15	10	354
15	15	353

Table 7. Runtime Comparison of the above 3 implementations with respect to Student Survey Data.

Method	Time Taken
Vertical Data Split Method * with additional resources: 32 GB cluster memory	2400 seconds
* with standard memory	OutOfMemoryException
Hybrid Method	5088 seconds
Modified Hybrid Action Rule Mining with Partition Threshold Rho	3900 seconds

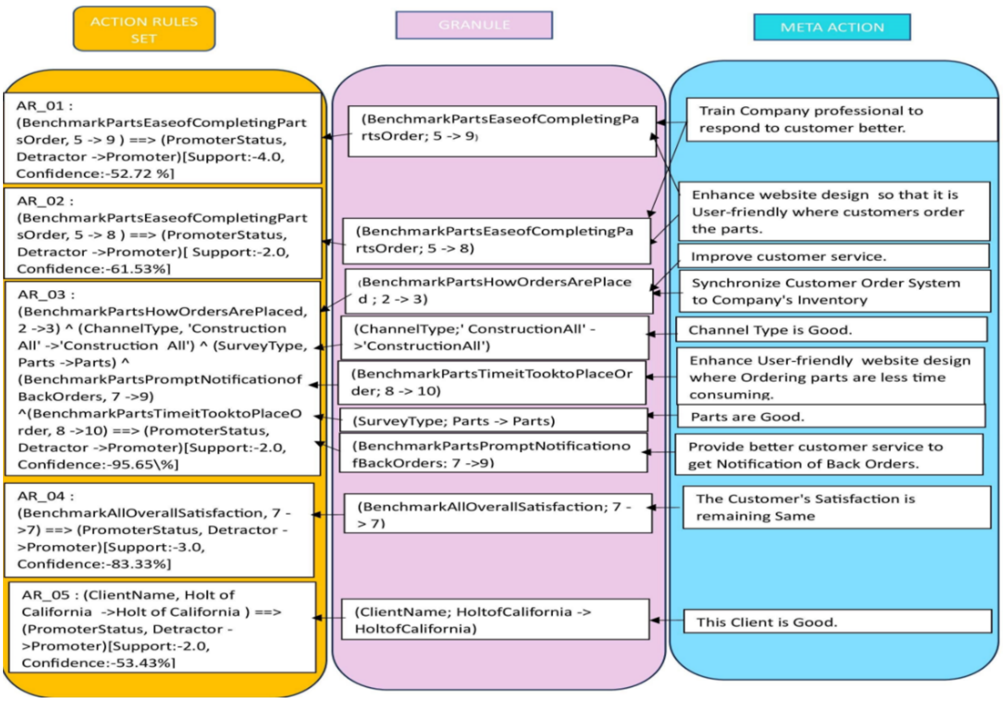

Fig.7. Example Meta Action for Table 9 From Action Rule 1 - To Action Rule 5

Fig.8. Example Meta Action for Table 12 From Action Rule 16 - To Action Rule 20

Table 8. Runtime Comparison of the above 3 implementations with respect to NPS Data.

Method	Time Taken
Vertical Data Split Method * with additional resources: 32 GB cluster memory	2400 seconds
* with standard memory	OutOfMemoryException
Hybrid Method	5088 seconds
Modified Hybrid Method	4002 seconds

Table 9. Action Rules of NPS datasets: 17 California part1ActionRules

17 California part1 Action Rules
AR_{N1} : (*BenchmarkPartsEaseofCompletingPartsOrder*,5 → 9) =⇒ (*PromoterStatus*,*Detractor* → *Promoter*)[*Support* : −4.0,*Confidence* : −52.72%]
AR_{N2} : (*BenchmarkPartsEaseofCompletingPartsOrder*,5 → 8) =⇒ (*PromoterStatus*,*Detractor* → *Promoter*) [*Support* : −2.0,*Confidence* : −61.53%]
AR_{N3} : (*BenchmarkPartsHowOrdersArePlaced*,2 → 3) ∧ (*ChannelType*, *ConstructionAll* →*ConstructionAll*)∧(*SurveyType*,*Parts* → *Parts*)∧(*BenchmarkPartsPromptNotificationofBackOrders*, 9) ∧ (*BenchmarkPartsTimeitTooktoPlaceOrder*,8 → 10)=⇒ (*PromoterStatus*,*Detractor* → *Promoter*)[*Support* : −2.0,*Confidence* : −95.65%]
AR_{N4}: (*BenchmarkAllOverallSatisfaction*,7 → 7)=⇒ (*PromoterStatus*,*Detractor* →*Promoter*) [*Support* : −3.0,*Confidence* : −83.33%]
AR_{N5} : (*ClientName*,*HoltofCalifornia* → *HoltofCalifornia*) =⇒ (*PromoterStatus*,*Detractor* →*Promoter*) [*Support* : −2.0,*Confidence* : −53.43%]

Table 10. Action Rules of NPS datasets: 17 California part2ActionRules

17 California part 2 Action Rules
AR_{N6} : $(ChannelType, NotDefined \rightarrow NotDefined) \wedge (Division, Parts \rightarrow Parts) \wedge (SurveyName, PartsPartsDivision \rightarrow PartsPartsDivision) \wedge (BenchmarkAllOverallSatisfaction, 7 \rightarrow 10) \wedge (BenchmarkPartsKnowledgeofPersonnel, 9 \rightarrow 10) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -2.0, Confidence : -66.66666666666666\%]$
AR_{N7} : $(BenchmarkPartsPartsAvailability, 3 \rightarrow 10) \wedge (ChannelType, ConstructionAll \rightarrow ConstructionAll) \wedge (SurveyType, Parts \rightarrow Parts) \wedge (BenchmarkAllOverallSatisfaction, 3 \rightarrow 7) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -2.0, Confidence : -72.72727272727273\%]$
AR_{N8} : $(ChannelType, PowerSystemsAll \rightarrow PowerSystemsAll) \wedge (Division, EPS - -Parts \rightarrow EPS - -Parts) \wedge (SurveyType, Parts \rightarrow Parts) \wedge (BenchmarkAllLikelihoodtobeRepeatCustomer, 5 \rightarrow 10) \wedge (BenchmarkPartsEaseofCompletingPartsOrder, 5 \rightarrow 10) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -3.0, Confidence : -91.66666666666666\%]$
AR_{N9} : $(BenchmarkPartsPromptNotificationofBackOrders, 7 \rightarrow 10) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -3.0, Confidence : -92.3076923076923\%]$
AR_{N10} : $(BenchmarkPartsExplanationofDeliveryOptionsCosts, 7 \rightarrow 8) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -2.0, Confidence : -100.0\%]$

Table 11. Action Rules of NPS datasets: NPS action rules 30 35 part1ActionRules

NPS action rules 30 35 part 1 Action Rules
AR_{N11} : $(BenchmarkPartsPartsAvailability, 4 \rightarrow 9) \wedge (Division, WagnerHeavyEquipment - Parts \rightarrow WagnerHeavyEquipment - Parts) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -2.0, Confidence : -84.90566037735849\%]$
AR_{N12} : $(BenchmarkPartsPartsAvailability, 3 \rightarrow 10) \wedge (SurveyType, Parts \rightarrow Parts) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -1.0, Confidence : -93.17180616740089\%]$
AR_{N13} : $(BenchmarkAllOverallSatisfaction, 3 \rightarrow 10) \wedge (SurveyType, Parts \rightarrow Parts) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -2.0, Confidence : -88.87\%]$
AR_{N14} : $(BenchmarkPartsPartsAvailability, 2 \rightarrow 10) \wedge (ChannelType, PowerSystemsEngine \rightarrow PowerSystemsEngine) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -1.0, Confidence : -89.36170212765957\%]$
AR_{N15} : $(BenchmarkPartsPartsAvailability, 1 \rightarrow 8) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -1.0, Confidence : -36.4583333\%]$

Table 12. Action Rules of NPS datasets: NPS action rules 30 35 part2ActionRules

NPS action rules 30 35 part 2 Action Rules
AR_{N16} : $(BenchmarkAllOverallSatisfaction, 1 \rightarrow 10) \wedge (Division, WagnerHeavyEquipment - Parts \rightarrow WagnerHeavyEquipment - Parts) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -5.0, Confidence : -63.74946374946375\%]$
AR_{N17} : $(BenchmarkAllOverallSatisfaction, 5 \rightarrow 9) \wedge (BenchmarkPartsTimeitTooktoPlaceOrder, 9 \rightarrow 10) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -4.0, Confidence : -73.17180616740089\%]$
AR_{N18} : $(BenchmarkAllLikelihoodtobeRepeatCustomer, 5 \rightarrow 7) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -4.0, Confidence : -85.35866261398176\%]$
AR_{N19} : $(BenchmarkAllDealerCommunication, 1 \rightarrow 9) \wedge (BenchmarkAllLikelihoodtobeRepeatCustomer, 3\ 8) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -4.0, Confidence : -96.342962962962955\%]$
AR_{N20} : $(BenchmarkPartsHowOrdersArePlaced, 2- > 3) \wedge (BenchmarkPartsPartsAvailability, 8- > 9) \implies (PromoterStatus, Detractor \rightarrow Promoter)[Support : -4.0, Confidence : -73.17180616740089\%]$

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