

## Review on Rare Itemset Mining

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**Abstract**— These Data mining is the procedure of analyzing unseen patterns of data according to different point of view for classification into useful information, which is collected and gathered in common areas, such as data warehouses, for proficient investigation, data mining algorithms, assisting business decision making and other information requirements to eventually cut costs and raise profits. Data mining is also recognized as data discovery and knowledge discovery. Frequent itemset mining is a significant task in data mining to discover the hidden, interesting associations between items in the database based on the user-specified support and confidence thresholds. Patterns detected by the Association Rule Mining technique are highly useful patterns as are playing vital role in decision making. In this paper we have focused on the other side of the ARM technique which should also get equal emphasis while decision making as the patterns which are not frequent can be more valuable as those are the Rare Itemsets. The fundamental technique of finding the frequent patterns can be used reversely for Rare Itemset Mining. In this paper the brief study of the technique available for Rare Itemset Mining is discussed and explored the utility of the Rare Itemsets in the decision making.

**Keywords**— Data Mining, Association Rule Mining, Frequent Itemset, Rare Itemset, Minimal Rare Itemset

### I. INTRODUCTION

In the current decade the amount of database has increased tremendously. This rapid development has led major interest to develop various tools which can be used to handle the data as well as extract the desired information moreover knowledge. The term data mining or knowledge discovery in database has been implemented for a field of research dealing with the automatic discovery of hidden information or knowledge within the databases. The hidden information within databases, mainly the interesting association relationships among sets of objects that lead to association rules may reveal useful patterns for decision support, financial predict, marketing policies, even medical diagnosis and many other applications [24]. Data mining is the method of determining interesting, meaningful, and understandable patterns hidden in large data sets [21]. Now a day's organization collects numerous data and this data is stored in form of transaction [2]. In the area of business, corporate and customer data are becoming recognized as a tactical asset. The ability to extract valuable knowledge unseen in these data and to act on that knowledge is becoming increasingly important in today's competitive globe. The entire process of application of a computer based methodology, including new techniques, to find out knowledge from data is called data mining [17]. Knowledge Discovery in Database (KDD) aims at finding meaningful and useful information in substantial

amounts of data. Two primary issues in KDD, having many applications in a variety of domains, are frequent itemset mining (FIM) and association rule mining (ARM) [22][21]. In this paper we present a study of literature of the various techniques and current scenario of research in mining Rare itemset. The various techniques for finding the Rare Itemsets have been discussed and also we presents the open research issues of the field Rare Itemset Mining.

Rest of the paper is organized as follows, Section I contains the introduction of Rare Itemset Mining, Section II contain the basic Preliminaries, Section III focused on Frequent Itemset Mining, Section IV contain the literature and procedure of Rare Itemset Mining, section V concludes the paper with future directions.

### II. PRELIMINARIES

#### A. Data Mining

The word "data mining" is mostly used by statisticians, database researchers, and the MIS and business communities. The term Knowledge Discovery in Databases (KDD) is usually used to refer to the overall procedure of discovering valuable knowledge from data, where data mining is a particular step in this process [15][12]. The purpose of data mining is to recognize valid novel, potentially useful, and understandable correlations and patterns in existing data.

Detection of useful patterns in data is known by different names (including data mining) in different communities (e.g., knowledge extraction, information discovery, information harvesting, data archaeology, and data pattern processing). Data mining emerged in 1990s and has a big impact in business, industry, and science. Only the information extraction is not sufficient to help in decision making. It is essential, to build up a powerful way for analysis of such data for the extraction of interesting knowledge that could help in decision-making. Data Mining, popularly known as Knowledge Discovery in Databases (KDD), refers to the nontrivial extraction of implicit, previously unknown and potentially useful information from data in databases [20]. Data Mining is a group of techniques for efficient automated detection of previously unidentified, valid, new and understandable patterns in large databases. The patterns must be actionable so that they may be used in an enterprise's decision making method [13]. The goal of data mining is to extract higher-level hidden information from an abundance of raw data [14]. Data mining has been used in a variety of data fields. Data mining can be regarded as an algorithmic process that takes data as input and yields patterns, such as classification rules, itemsets, association rules, or summaries, as output [32]. Data mining tasks can be categorized into two classes, Descriptive Mining and Predictive Mining. The Descriptive Mining techniques such as Clustering, Association Rule Discovery, and Sequential Pattern Discovery are used to find human-interpretable patterns that describe the data. The Predictive Mining techniques like Classification, Regression, and Deviation Detection use some variables to predict unknown or future values of other variables [27]. Over the years Data Mining is used to know the consumer buying behaviour using different techniques. Researcher opts for Market Basket Analysis for the data analysis because Market Basket Analysis is a tool of knowledge discovery about co-occurrence of nominal or categorical items. Market Basket Transaction or market Basket Analysis is a data mining technique to obtain association among data sets. The discovery of remarkable association relationship among vast amounts of customer transaction records can help in several business decision making processes such as catalogue design, cross marketing and loss-leader analysis [3].

#### B. Association Rule Mining

Mining Associations is one of the techniques involved in the process and among the data mining problems it might be the most studied ones. Discovering association rules is the heart of data mining. Mining for association rules among items in huge database of transactions has been recognized as an important area of database research. The original problem addressed by association rule mining was to find a correlation among sales of different products from the analysis of a large set of data [8]. Association Rule Mining (ARM) is the procedure of generating rules based on the

association between the set of items. As information keeps on growing and its complexity increments, data information structures and calculations are being produced to match this improvement (development). Association Rule Mining procedure can be partitioned into two stages. The first step includes discovering all large itemsets (or frequent itemsets) in DB (database). When the frequent itemsets are revealed, association rules are formed. Association standard mining is broadly utilized as a part of market-basket investigation [6]. For example let us suppose there is a supermarket in which massive quantities of data continuously being processed to sell and purchase. The supermarket applies market basket analysis to study the customer buying behaviour and extract the patterns that occur most frequently in the database. For example, 65 percent of customers who buy computer will also likely to buy the pendrive too. Association rule mining is the procedure of finding interesting relationship, patterns between the unrelated data in the transactional databases or data repositories [2]. Association rules mining (ARM) [21] is one of the most widely used techniques in data mining and knowledge discovery and has tremendous applications like business, science and other domains. Make the decisions regarding marketing conducts such as, e.g., promotional pricing or product placements. The concept of Association Rules for discovering regularities between products in large databases has introduced by Rakesh Agrawal et al, 1994[1],[5]. Mining association rules can be divided into two steps: the first is generating frequent itemsets and the second is generating association rules. The major challenge in association rule mining is to recognize frequent itemsets. Finding frequent itemset is one of the significant steps in association rule mining. Since the solution of second sub-problem is straight forward, most of the researchers had focus on how to generate frequent itemsets. ARM is widely used in market-basket analysis. For example, frequent itemsets can be found out by analyzing market basket data and then association rules can be produced by forecasting the purchase of other items via conditional probability [1], [5]. In example of an association rule would be "If a customer buys a computer, he is 80% likely to also purchase pen drive." So Association rule mining is the most important and well explored data mining technique, which is used by most of the organizations for decision making so that they improve the profit and enhance their performance in terms of sales and good product quality [25]. There are lots of application areas where item set mining is employed such as retail business, bioinformatics and medicine, fraud detection and network intrusion detection and many more[2].

### III. FREQUENT ITEMSET MINING

The concept of mining frequent itemsets was first introduced by Agrawal et al. [22], he has proposed algorithm Apriori for finding the Frequent Itemsets occurred in the database

[4]. Frequent itemset mining is a motivating branch of data mining. In frequent itemset mining, the base data obtained form of sets of instances (also called transactions) that each has a number of features (also called items). The Apriori algorithm works by first scanning the database to discover all frequent 1-itemsets, then proceeding to find all frequent 2-itemsets, then 3-itemsets etc. At every iteration, candidate itemsets of length  $n$  are generated via joining frequent itemsets of length  $n-1$ ; the frequency of each candidate itemset is calculated before being added to the set of frequent itemsets. The objective of Frequent Itemset Mining is to identify all the frequent itemsets in a transaction database [25]. Apriori algorithm is useful for searching the association rules among items in market-basket data [23]. Association rules use two main constraints, i.e. minimum support and minimum confidence. The mining process is divided into two sub process. First to find the itemsets those are having occurrences in the database more than or equal to the minimum support value and later in the second phase generating association rules which satisfies the minimum confidence [2]. Hence Apriori is a bottom-up, breadth-first search algorithm. Hash-trees are used to store frequent itemsets and candidate frequent itemsets. As Apriori holds the downward closure property, only candidate frequent itemsets, whose all subsets are also frequent, are generated in each database scan. There are various variants of Apriori developed such as, [28], [10], [4] has presented [9]. The Advantage of the Apriori algorithm is perfect pruning of infrequent candidate item sets (with infrequent subsets) [26]. While on the other hand, the disadvantage of Apriori algorithm is that can require a lot of memory (since all frequent itemsets are represented) and support counting takes very long for large transactions [29]. Below is the standard Apriori Algorithm:

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 $I_1 = \{I \mid \text{arg } e \text{ 1-item sets}\};$ 
For ( $k = 2; I_{k-1} \neq \emptyset; k++$ ) do begin
 $C_k = \text{apriori-gen}(I_{k-1});$  //New Candidates
For all transactions  $T \in D$  do begin
 $C_T = \text{subset}(C_k, T);$  //Candidates contained in T
for all candidates  $c \in C_T$  do
c.count ++;
end
end
 $I_k = \{c \in C_k, c.\text{count} \geq \text{minsup}\}$ 
end
Answer =  $\bigcup_k I_k$ ;

```

**Fig.1 Apriori Algorithm**

#### IV. RARE ITEMSET MINING

As we have worked on Frequent Itemset Mining and using Apriori it is clear that Frequent Itemset Mining produces more appropriate patterns which majorly help in decision making. Here in this section of paper we focused on the main factor of the topic i.e. Rare Itemset Mining. In this section, the related significant work discussed.

Agrawal et al in 1993 has proposed Apriori algorithm, which is used to obtain the itemsets which appear frequently in the database and known as Frequent Itemsets. This FIM has extended by many researchers [22].

Liu et al. in 1999 noted that some individual items can have low support and even they cannot be part of the associations generated by Apriori, even though they have very high confidence. This problem is solved by specifying the constraint that the frequent items can have a higher minimum support and the rare items can have lower minimum support [4].

Later on significant effort has been made by Lin et al. in 2006 & Poovammal and Ponnaivaikko in 2009, to alleviate the problems in the previous work, for which they added the measure of lift or conviction, which obtained the minimum support dynamically from the item support [30][7].

Relative Support Apriori Algorithm (RSAA) is proposed by Yun et al. in 2003 for generating rare itemset rules without the need to specify the support threshold by the user. This algorithm allocates high support threshold for items with low frequency and low support threshold for items with high frequency [11].

Apriori-Inverse algorithm by Koh and Rountree in 2005 has been proposed. In this work the algorithm is used to generate rules that may contain items over the maximum support threshold called as perfectly sporadic rules. This algorithm is much faster than Apriori in finding perfectly rare itemsets, that are a subclass of rare itemsets containing itemsets whose all subsets are rare [31].

Szathmary et al. in 2007 has proposed the algorithm Apriori-Rare which finds all minimal rare itemsets. This algorithm finds out two sets of items. One is Maximal Frequent Itemset (MFI) and another is minimal Rare Itemset (mRI). An itemset is referred as a MFI if it is frequent but not all its supersets, similarly an itemset is referred as a mRI if it is rare but all its proper subsets are not. It also finds the generator which generates the Frequent Itemsets (FIs) [16].

Adda et al. described ARANIM algorithm for Apriori Rare and Non-Present Itemset Mining to mine rare and non present itemsets in [12]. In the proposed approach the

technique is same like Apriori and the mining idea is that if the item-set lattice representing the itemset space presented in classical Apriori approaches is traversed in a bottom-up manner, than the equivalent properties for the Apriori exploration is provided to discover rare item-sets [18].

Apriori-rare, it is a alteration of the Apriori algorithm which is used to mine frequent itemsets. To extract all rare itemsets from minimal rare itemset (mRIs), a prototype algorithm called —A Rare Itemset Miner Algorithm (Arima) was proposed in [30]. Arima generates the set of all rare itemsets and splits those into two sets: the set of rare itemsets with a zero support and other with non-zero support. If an itemset is rare then any extension to that itemset will also result to a rare itemset [16].

Adda et al. proposed a framework in which is used to represent different categories of interesting Patterns. A common framework was presented to mine patterns based on the Apriori approach. The generalized Apriori framework was represented to mine rare itemsets. The Apriori algorithm, called AfrIM for Apriori Rare itemset to mine rare itemsets was proposed which performs a level-wise search. The backward traversal method is used with a property that leads to prune out potentially non-rare itemsets in the mining process. This includes an anti-monotone property and a level wise exploration of the itemset space[19].

Let us consider an example of Transaction Dataset shown below: In Table I we represent a dataset, denoted by D, where the alphabet letters are considered as items. We aim to extract the set of items that are rare frequently occurred in the transactions. The number of times an itemset occurs in the database is called the itemset support. In this example we have set a minimum support value is equal to 3.

We can see the extraction of Rare Itemset in our example. In the Dataset shown in Table 1 the procedure of Apriori is reversly used to do the Rare Itemset Mining.

**Table 1: Transaction Table**

ID	TRANSACTIONS
T1	{a,b,c,d}
T2	{b,d}
T3	{a,b,c,e}
T4	{c,d,e}
T5	{a,b,c}

Itemsets	Support
{a}	3
{b}	4
{c}	4
{d}	3
{e}	1-DISCARDED

Itemset	Support
{ab}	3
{ac}	3

{ad}	1- DISCARDED
{ae}	1- DISCARDED
{bc}	3
{bd}	2- DISCARDED
{be}	1- DISCARDED
{cd}	2- DISCARDED
{ce}	2- DISCARDED
{de}	1- DISCARDED

**Step 1 for Rare Itemset Generation**

Rare Itemsets	Support
{e}	1

Itemset	Support
{abc}	3
{abd}	1- DISCARDED
{abe}	1- DISCARDED
{acd}	1- DISCARDED
{ace}	1- DISCARDED
{ade}	1- DISCARDED
{bcd}	1- DISCARDED
{bce}	1- DISCARDED
{bde}	0- DISCARDED
{cde}	1- DISCARDED

Itemset	Support
{abcd}	1- DISCARDED
{abde}	0- DISCARDED
{abce}	0- DISCARDED
{acde}	1- DISCARDED
{bcde}	0- DISCARDED

**Step 2 Rare Itemset Generation**

Rare Itemset	Support
{abd}	1
{abe}	1
{acd}	1
{ace}	1
{ade}	1
{bcd}	1
{bce}	1
{bde}	0
{cde}	1

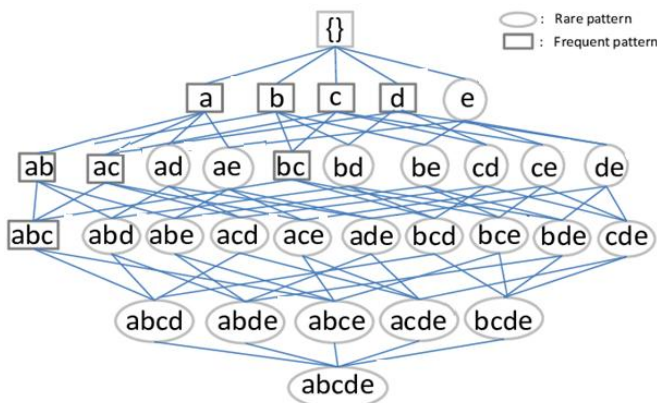
Itemset	Support
{abcde}	0- DISCARDED

**Step 3 Rare Itemset Generation**

Rare Itemset	Support
{abcde}	0

**Figure 1: Process of Rare Itemset Generation**

The above example shows the working of extraction of Rare Itemsets. The tables with RI shows the Rare Itemsets which are actually the pruned itemsets in Frequent Itemset Mining. The set of all rare itemsets split into two sets: the set of rare itemsets having a zero support and the set of rare itemsets with non-zero support. Rare itemsets are generated by growing each itemset in the MRM set. In fact, if an itemset is rare then any extension of that itemset will result a rare itemset. To make the distinction between zero and non-zero support itemsets, the support of each extended itemset is calculated. The set of all itemsets that can be generated from the transaction database are presented by a diagram of the subset lattice for five items with the associated frequencies in the database. The lattice has each level of itemsets having the same length. The top element in the lattice is the empty set and each lower level  $k$  contains all of the itemsets of length  $k$ , also denoted  $k$ -itemsets and the last level contains an itemset composed of all items i.e. (a, b, c, d, e). Lines between nodes show a subset relationship between itemsets. For each itemset we computed its support. The set of rare itemsets we are looking for are those in the lattice with support less than 3. The rest of itemsets are frequent (having support greater or equal to 3). In Figure, rare itemsets are drawn with ovals where frequent itemsets are drawn with rectangles. The dotted oval gives the Rare Itemsets with Zero support [19].



## V. CONCLUSION AND FUTURE SCOPE

This study presented different approaches for finding both frequent and rare itemset mining based on the Apriori framework. A Rare Itemset mining is an apparent topic in data mining. Survey on different Rare Itemset Mining algorithms is presented in this paper. This survey will be helpful for developing new efficient and optimize techniques for Rare Itemset Mining. The open research opportunities in this field can be in the form of Novel Applications development by applying existing pattern mining algorithms in new ways, the performance can be enhanced in terms of memory and time utilization and can discover more complex and meaningful type of patterns.

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