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Contents:

S.No.	Title Name	Page No.
	Version I	
1.	Pattern Discovery Using Apriori and Ch-Search Algorithm **Prof.Kumbhar S.L. || Mahesh Aivale || Kailas Patil || Pravin Jadhav|| Baliram Sonawane**	01-06
2.	Efficient Data Distribution in CDBMS based on Location and User Information for Real Time Applications **Tejas Bhatt || Mr. Manjunath H**	07-13
3.	On An Optimal control Problem for Parabolic Equations **M. H. Farag || T. A. Nofal || A. I. El-Nashar || N. M. Al-Baqmi**	14-21
4.	Reuse Options of Reclaimed Waste Water in Chennai City **K.Deepa || M. Krishnaven**	22-28
5.	Recommendation of Data Mining Technique in Higher Education Prof. Priya Thakare Guide **Ajinkya Kunjir || Poonam Pardeshi || Shrinik Doshi || Karan Naik**	29-34
6.	Qualitative Analysis of a Discrete SIR Epidemic Model **A. George Maria Selvam || D. Jerald Praveen**	35-39
7.	Cost Optimization in Multi Cloud Platforms using Priority Assignment **Anoop Abraham Eapen || Vineetha V Nair**	40-44
8.	Integrated Circuitry For Better Energy Transfer Through Resonant Coupling **M.Gayathri Devi || S.Soundharya || T.Pavithra || V.Rubini**	45-52

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Pattern Discovery Using Apriori and Ch-Search Algorithm

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Abstract:
The association rule describes and discovers the relations between variables in large databases. Generally association rules are based on the support and confidence framework. In apriori algorithm, association rules are used for finding minimum support & minimum confidence. But this method can lead to loss of rules i.e. negative rules are lost. Hence Ch-Search algorithm is introduced which uses its strongest rule i.e. commonly used the Coherent rule which promotes information correctness and leads to appropriate decision making among the same item sets. The coherent rule discovers positive as well as negative outcomes, and does not require finding minimum support & minimum confidence frameworks leading to no loss of any rules. The paper describes how the Ch algorithm is used by coherent rule for exact pattern discovery in large databases over apriori algorithm.

Keywords: *Data Mining, Association Rule, Apriori algorithm, Support, Confidence, Coherent Rule, Ch-Search Algorithm etc…*

I. INTRODUCTION

Data Mining is the process of uncovering or discovering hidden and potentially useful information from larger amount of database. Database Mining is normally done using a data ware house, hidden information is not very obvious and not visible directly but rather is interpreted in some manner when it is discovered. Data mining process normally consists of two broad categories such as descriptive information & predictive information. The descriptive information we find patterns that are human interpretable something that human can understand we try to discover that kind of patterns from my set of data.

The Association rules are a simple if/than statement that shows the relations among the variables in large database. Association rules are created by analyzing data for frequent if/then patterns and using the frameworks as like support and confidence to identify the most important relationships. Support indicates that how frequently the items appear in the database. Confidence indicates the several times if /then statements have been found to be true. In data mining, association rules that very useful for analyzing and predicting customer behavior.

Association rule is an implication expression of form X->Y where X and Y are item sets. We can say that for pattern "customers who purchase item A also intend to buy item B together" is represented by above equation A=>B Thus association rules are important for knowing all possible relationships between large numbers of possible combinations of items.

Frequent Pattern: Frequent pattern are pattern (such as item set, sub sequence or structure) that appear in a data set frequently.

1. Item set: Item set is non empty set of items. Its cardinality can be one to any positive number. Any transaction contains item set of constant size(x).

2. Frequent item sets: Frequent item sets are sets which occurs one item at a time. The set of item that have at least a given minimum support. In simple words item sets which occur frequently.
   The item sets which are below threshold are called as infrequent item sets. The frequent and infrequent item sets are subsets of the superset. Both indicate its presence of item set. This distinguishes them from absence of item set which is same item set being absent from the same set of transaction record.
   Consider 3 items in database such as X, Y and Z.
   X transaction contains only item A.
   {A} is presence of item set.

Now Y and Z are said to be absent from this transaction. Thus {B} and {C} are absence of item sets and are represented by - {B} and -{C} resp.

3. Subsequence pattern: If items occur frequently, it is called frequent sub-sequence pattern.
4. Structured pattern: A sub structured such as sub tree, sub graph, or sub lattice that can be combined with item set or sequence if a sub structure occurs frequently, it is called as frequent structured pattern. Association rules are discovered from frequent item sets. The minimum support threshold must be pre-set by user for determining frequent item set. Rules generated by {A} item set that are present or frequent item set are called positive association rules And rules involving absence of item set i.e. {B} and {C} are called negative association rules.

Generation of association rule can be consisting of two sub problem:

1. Finding Frequent item sets whose occurrences exceed a predefined minimum support
2. Deriving Association rules from those frequent item Sets.

II. APRIORI ALGORITHM

Apriori Algorithm was first proposed by R.Agrawal & Shrikant in 1994 in during their research working market basket analysis. The basic idea of the apriori Algorithm was to generate the candidate key & frequent item sets .The algorithm uses two keywords such as support & confidence.

a) Support is nothing but the probability of the buying the product i.e. the number of instances in the given to the total number of records in data-set.

$$\text{Support}=\text{freq}(x, y)/N$$

Where N is the number of records in dataset

b) Confidence is nothing but the relative probability of buying the product i.e. how often the consequent item occurs in combination of antecedent and consequent item.

$$\text{Confidence} = \text{freq}(x, y)/x$$

For example, if a person buys a product such as mobile, he can also buy memory card too. So the shop keeper keeps memory card with mobile, this is support & in confidence a person buys a memory card, he can also buy headphone or battery or cover with it. This relational probability is helpful in keeping your relation in the product so actually this algorithm is useful in finding the frequent pattern.

For smaller database or data-set frequent pattern can be found out easily here, in the example of mobile shop there were only 10 or 20 pieces reducing the transaction at last. But when large database/ & data-set are used such as in big bazaar & mall can have thousands of data items that leads to thousands of transaction. In such cases the database is iterative scanned that is very difficult. Hence apriori type approach must be used to reduce the complexity & computing time.

Two important steps in apriori algorithm are:

1. Find all item set that have minimum support (Frequent item set also large item set)
2. Use frequent item set to generate rules. The candidate generation function F [k-1] and return a super-set (called the candidate) of the set of all frequent K-item set. It has two steps:
   i) Join Step: Generate all possible candidates
      Item set Ck of length k.
   ii) Prune Step: Remove those candidates in Ck
      That cannot be frequent.

2.1 Generate Frequent Item Set

1. Count support of each individual item
2. Create a set F with all individual items with min support.
3. Creates “Candidate Set” C [K] based on F [K-1]
   Check each element c in C[k] to see if it meets min support.
4. Return set of all frequent item sets.

2.2 Generate Candidate Sets

1. Create two sets differing only in the last element, based on some seed set.
2. Join those item sets into c.
3. Compare each subset s of c to F [K-1] – if s is not in F [K-1], delete it.
4. Return final candidate set.

Example of generation candidate
L3= {123,124,134,135,234}
Use the concept self joining = L3* L3

- 1234 from 123 & 124
- 1345 from 134 & 135

Then use concept pruning (removing)

- 1345 is removed because 145 are not in L3.

So candidate set is
C4= 1234

2.3 Apriori Algorithm Examples with Working

Database: D, Minimum Support: 0.5

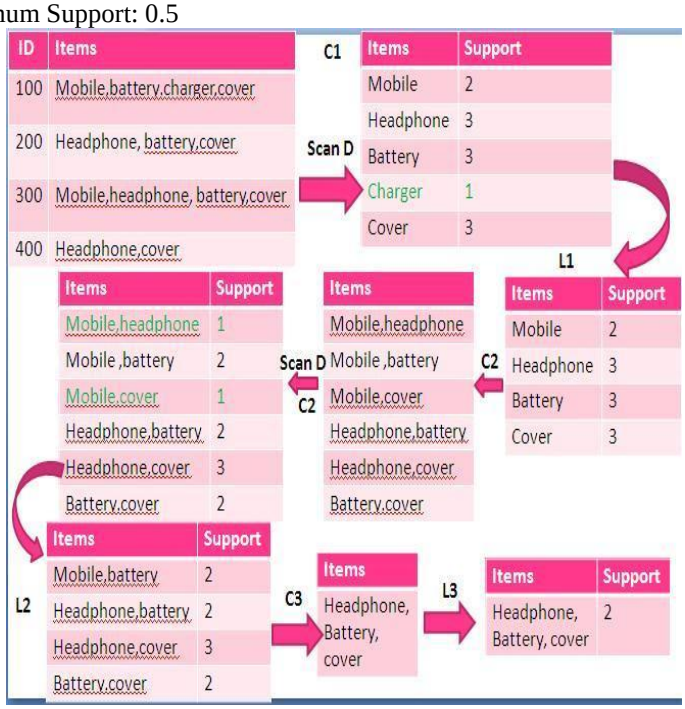

Fig -1: Apriori Algorithm Example

Workout of the example of apriori algorithm: Here is the database of mobile shop with minimum Support 0.5. There are four transactions each has unique ID.

In the first stage scan the entire database as sequential scanned which generates C1 i.e. candidate item set in which support is calculated. Here in the example mobile is occur 2 times, headphones occurs 3 times & so on in database D,then generate the frequent item set are stored in L1 in that charger item set occur one time so it is less than minimum support i.e.

Support=1/4=0.2

When support value < minimum support

Then this entry shall be pruned i.e. remove and then C2 is generated with possible combination of item sets in L1. Then again the entire database is scanned with item sets present with C2 calculate the support value.L1 is calculated using pruning method (support value < minimum support) i.e. L2. C3 consist of possible combination generated by scanning entire database & then again using pruning method (support value < minimum support) i.e.L3 is generated.

III. COHERENT RULE

We propose a system to discover pattern report as coherent rules. Based on the properties of propositional logic and therefore the coherent rules are discovered. In table 1, some item are present that contains relations between a rule on sequence (RHS) C, & a rule antecedent (LHS). The rule antecedent A consist of a combination of item called an antecedent item set X , The rule consequence C consist of a combination of item called an antecedent item set Y.The antecedent item set X may present at represent as X & absence it represent as ¬X, consequence item set Y may represent as Y & absence it represented as ¬Y.

Table -1: antecedent and consequence items set

		A rule consequence (RHS), C		
		Y	¬Y	Total
A rule antecedent (LHS), A	*X*	*Q1*	*Q2*	*A1*
	¬*X*	*Q3*	*Q4*	*A2*
	Total	*C1*	*C2*	*m*

Rules

i. X⇒Y is mapped to propositional logic implication
p→q if and only if Q1>Q2, Q1>Q3 and Q1>Q4.

ii. X⇒¬Y is mapped to propositional logic implication
P→¬q if and only if Q2>Q1, Q2>Q3, Q2>Q4.

iii. ¬X⇒Y is mapped to propositional logic implication
¬p→q *if* and only if Q3>Q1, Q3>Q and Q3>Q4.

iv. ¬X⇒¬Y is mapped to propositional logic implication
¬p→¬q if and only if Q4>Q1, Q4>Q2, and Q4>Q3.

Having mapped each called pseudo implication.

By pseudo implication, that is near by a real implication according to propositional logic. It is not a genuine implication since there are differences pseudo implication is true or false based on comparison of support. Coherent Rules are a pair of antecedent and consequence item sets, X and Y represents using a pair of rules the truth table value for equivalent. E.g. X⇒Y, ¬X⇒¬Y where,

i) X⇒Y is mapped to logic equivalent p≡q if and only if Q1>Q@, Q1>Q3, Q4>Q2 and Q4>Q3

ii) X⇒¬Y is mapped to logic equivalent p≡¬q if and only if Q2>Q1, Q2>Q4, Q3>Q1 and Q3>Q4. And also has ¬X⇒Y is mapped to logic equivalent ¬p≡q if and only if Q2>Q1, Q2>Q4, Q3>Q1 and Q3>Q4.

iii) ¬X⇒¬Y is mapped to logic equivalent ¬p≡¬q if and only if Q1>Q2, Q1>Q3, Q4>Q2 and Q4>Q3

Having mapped each rule is called pseudo implication of equivalent. Coherent rules by using the properties of the positive and negative rules on the condition: Set (positive rule) > Set (negative rule) at preselected consequence item set.

IV. CH-SEARCH ALGORITHM

In Ch-search algorithm there is no need to preset minimum support to find out association rules. Coherent rule are found based on logical equivalence. Also further these rules are utilized as association rule. In Ch-search, it is not needed to create frequent item set and association rule within each item set.

Input: D – a database, Y – a consequence item set
Output: CR – a set of coherent rules

[1] $CR \leftarrow \emptyset$
[2] $I \leftarrow$ find a set of unique items from D
[3] Let $A = I - Y$
[4] $Y.count \leftarrow$ total counts of Y in D
[5] $O_{P(A)} \leftarrow$ virtually map the power sets of A to the indices of a binary system
[6] For each i-th element of the power sets of A in order of O_i,
(i) $X \leftarrow \{P_i : i \in P(A)\}$
(ii) $S(X,Y) \leftarrow XY.count$
(iii) $S(\neg X,Y) \leftarrow Y.count - S(X,Y)$
(iv) if $S(X,Y) > S(\neg X,Y)$,
if equation (2) is met, $CR = CR \cup (X,Y)$
Loop [6] until $i = |P(A)|$
(v) remove all power sets of A having the i-th element
[7] return CR

* For example, given 3 items, the first item set *null* – a member in the power sets of X, item set $X_{i=1\_}$ is indexed using binary number '0', item set $X_{i=2\_}$ is indexed using '1_2', and item set $X_{i=3\_}$ is indexed using '10_2'.

Basically, in apriori algorithm, negative rules are not found. But in case of Ch-search algorithm, negative rules are found and used to implement both positive and negative rules found.

"Patterns are discovered based on generated rules which are more efficient.

i) Positive Rules: Some of the association rules consider only items enumerated with transactions, such rules are called positive association principle.
Ex. mobile =>headphone

ii) Negative Rules: Negative association rules consider the same items, & also negated items.
Ex. ¬mobile =>¬headphone. "[Galphad,2013]

The Algorithm presented in this paper extends the support-confidence framework with correlation coefficient threshold. With finding confident positive rules having a strong correlation, the algorithm discovers negative association rules with strong negative correlation found between the strongest correlated rules, followed by rules with moderate and small strength values. After finding the association rules it was found that patterns are more efficient than the rules. In association rules only those attributes are considered as strongly responsible to find the result.

In case of the patterns all the attributes are considered.

eggs = 1 and aquatic = 1 and predator = 1 and legs = 1 and hair = 0 and feathers = 0 and milk = 0 and airborne=0 and toothed = 0 and backbone= 0 and breaths = 0 and venomous = 0 and fins = 0 and tails = 0 and domestics = 0 == INVERTEBRATE

Patterns are more efficient than rules [4].

V. PROPOSED SYSTEM

Throughout apriori algorithm observed that, there are some issues such as multiple scan from the database, low accuracy, candidate technology process complicated, more space, time, memory etc. Therefore other approach has to be found out which can work on these problems. In theoretically, Ch-Search Algorithm generates correct & valid style, and generate association rule using proposed algorithm instead of any minimum support threshold criteria like apriori algorithm also produce standard association rules using propositional logic & classify the test files using generated rule & pattern & finally look when placed against system result with apriori criteria.

The proposed architecture for apriori & Ch-Search Algorithm:

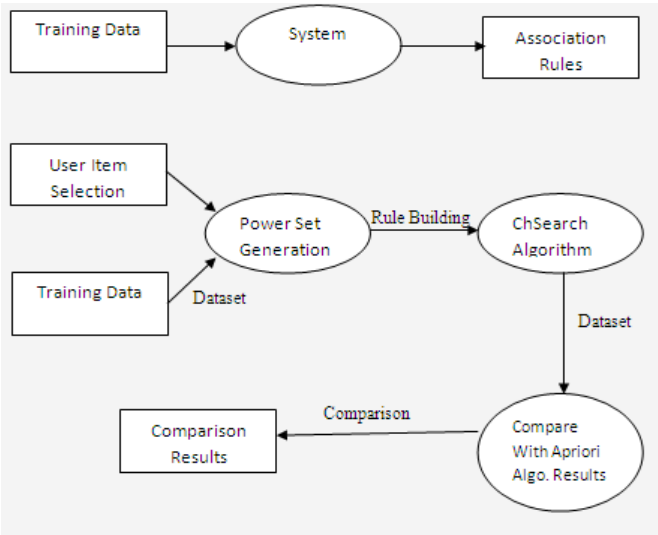

Fig.2: Pattern Discovery using apriori & Ch-Search Algorithm

VI. CONCLUSIONS

In this paper, generalized framework is used to discover association rules that have the proportional logic, & a specified framework (Coherent Rules Mining framework) with a basic algorithm to generate coherent rules from a given data set. The contribution of this work mainly focused on discovery of coherent rules through a complete set of interesting association rules that are implication according to propositional logic. The Search for coherent rules does not require a user to pre-set a minimum support threshold. In contrast an association rule is typically not implication according to propositional logic and infrequent item set a coherent rule mining framework can thus be appreciated for its ability to discover rules that are both implication and complete according to propositional logic from a given dataset.

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Efficient Data Distribution in CDBMS based on Location and User Information for Real Time Applications

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ABSTRACT:

In today's world users need to store data in every application and applications has a lot number of users data stored at databases. The retrieval time of data depends on how many records a database contains and not the configuration of the server. The less the number of records the less the retrieval time. Many methods are available when it comes to data partitioning, each with its own functionality for a specific application and requirement. This paper focus on the methods of data partitioning and the effective algorithm to partition the data equally between N numbers of nodes running on the cloud having database with same entities which contain the distributed data of user used in real time user application. Proposed method concentrate on data distribution in real time "user" application where user activities are primary requirement.

Key Words: *Data, Database, Data Distribution, Data Partitioning, Horizontal Partitioning, Vertical Partitioning, Cloud Database, User Information, Database Server, Nodes, CDBMS, OLAP, Fragmentation, Index.*

I. INTRODUCTION

In real time application with user interaction needs to store many records of user and all data of user is distributed among the databases in order to reduce data retrieval time. [1] CDBMS is a cloud database management system where databases are running at different nodes which are running over one or more clouds. This provides data availability and prevent failure from node crash. The challenge over here is to distribute user data in such a way that all databases gets same amount of data in the form of records and since the size of database is equal, it is easy to distribute workload among the cloud nodes. It means with every insertion of record the data of user has to be got spited in such a way that the possibility of equal records in all databases is more. The outcome of this approach is all nodes have same size of database which helps to distribute workload and the data retrieval time also gets reduced as the number of record in one data table is lesser compared to without distribution.

Data distribution approaches changes with the change of the application and the requirement. A real time user application has two main modules Signup and Login. To speed up the user operations it is likely to distribute data in such a way that each module needs only specific data and other data can be ignored. While signup, user actually insert the data which has two type of information, one is personal info and one is login info. The idea here is to separate this two info so that while searching other users the login info can be ignored and while login to the application the personal info can be ignored.

There are two main methods of data partitioning

1) Horizontal Partitioning: here the data is partitioned based on row attributes or we can say row based partitioning.
2) Vertical Partitioning: here the data is partitioned based on dimensions or we can say column based partitioning.

Example:

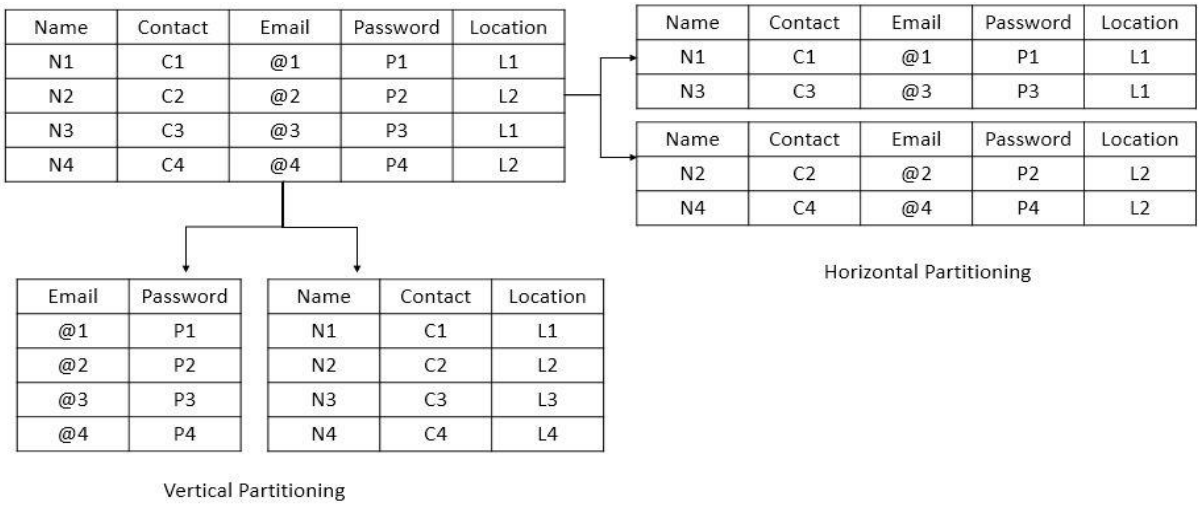

Fig 1: Partitioning Methods

II. LITERATURE SURVEY

[2] There are four main partitioning strategies available. First one is range partitioning where the records which comes under same range stored in a particular partition. For example age is an attribute which can be used as rang partitioned data such as all users with age 21 to 30 get stored in same partition. Second is list partition where records get stored in same partition which has attribute value defined in the list such as user's records with Asian countries gets store in same database (horizontal partitioning based on location). Third is hash partitioning where a hash function returns a value for a record to get store in particular partition. And fourth is composite partitioning which is the mix of all the above partitioning methods. [2] Many techniques of databases are implemented such as (1) selectively based partitioning, where the relation is partitioned based on selective joins on which sub queries are computed and merged to get the whole query. (2) Second technique is of fragmenting data which is used in data warehousing where minimum response time is required and in order to do that parallel execution of queries is necessary. In this approach the data distribution is carried out by generating star schemas which contains fact table (table with key attributes) and dimension tables (tables with attributes). To develop "best" dimension tables greedy algorithm is used. Such kind of queries are called OLAP (On-Line Analytical Processing) queries. (3) Mars, this is an approach where data distribution techniques applied to support reload in main memory database system. To prevent failure, database from archive memory (AM) to main memory (MM) is required. In this approach the partitioning approach (Horizontal or Vertical) is based on what kind of operation is needed. For deletion and updating horizontal partitioning is appropriate whereas when it comes to insertion, single vertical partitioning is better. (4) Genetic algorithm based clustering approach, in this approach clusters of data are created based on access of data. Since accessing data from database returns only a subset of the database it is more likely to put related searched data together in one Server(s)/Site(s) which forms clusters of data. (5) Physical and Virtual Partitioning in OLAP, as On-Line Analytical Processing (OLAP) requires high performance by reducing response time, intra query parallelism used where each query executes on every subsets of query tables. Virtual partitioning is a process where clusters of data subsets created on actual physical data and on that virtual partitioned of data query parallelism occurs. Combining physical and virtual partitioning makes it more flexible for intra query parallelism. (6) Near Uniform Range Partitioning, for databases with mass data it is more likely to partition the data based on range. Traditional range partitioning approach doesn't work on increased partitioning. Increased partitioning algorithms allowed the data being partitioned in each range which makes it easy to maintain partitions automatically, effectively and rapidly. (7) Dynamic vertical partitioning, in this approach the data is partitioned vertically based on information, queries and data attributes without manual work of DBA (Database Administration). An active rule-based statistic collector gathers information which can be used for vertical partitioning and based on those information data is partitioned vertically automatic and without intervention of DBA. There are chances that fragmented data can be again re-fragmented based on upcoming new data attributes and user queries. (8) Fine-grained Indexing, websites where user insertion operations are more than the retrieval or updating operations uses Shinobi system which indexes the database horizontally and create indexes based on frequently accessed data and drop those indexes which are infrequently accessed which provides great space management and fast query processing.

III. PROPOSED METHOD

Existing system works on distributing data based on location in list partitioning approach but it becomes non useful when users from one locations are more than the users from other location. Proposed method is for the real time application where the data gets distributed as it arrives to the system. This method focus on equal distribution of data when the probability about the number of users from specific location cannot be determined. Proposed method uses horizontal and vertical both partitioning approaches to equalize the records between number of databases when users with one location are more than the users with other location.

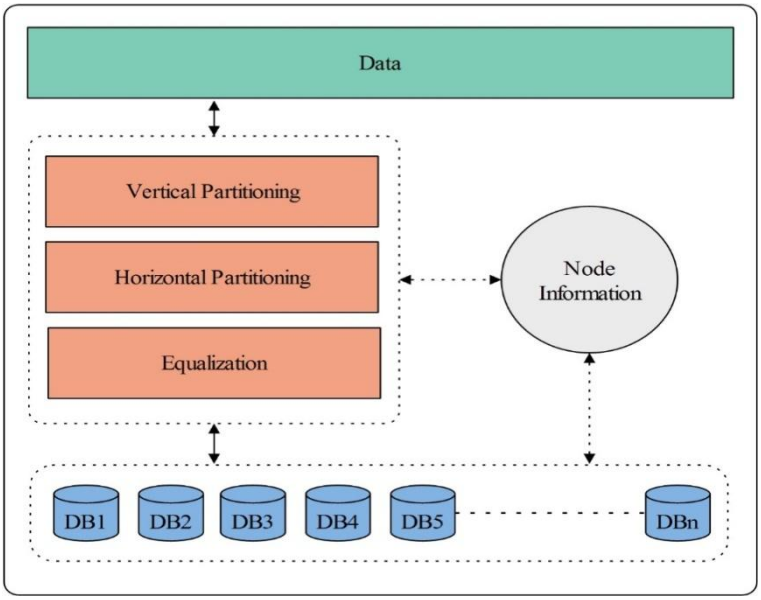

Fig 2: Overall Architecture

Step 1: Horizontal Partitioning based on location

As shown in Fig 3 when three records gets horizontally partitioned between two different databases based on location, record 1 gets inserted into DB1 and record 2 and 3 gets inserted into DB 2 as record 2 and 3 have same location. Now there is no equal number of records in databases. (DB1: 1 record, DB2: 2 records)

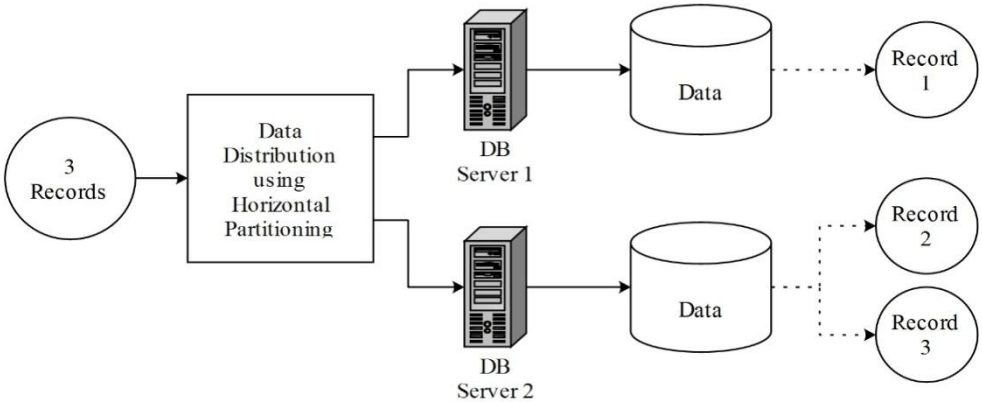

Fig 3: Horizontal Partitioning

Step 2: Apply Vertical Partitioning on each record stored at different database server

To prevent unequaled distribution vertical partitioning is applied on records stored at each database. As shown in Fig 4 it results in double in number of records. Initially DB1 had one record which got partitioned vertically and hence now there are 2 records in DB1. Initially DB2 had two records which got partitioned vertically and hence now there are total 4 records in DB2. (DB1: 2 record, DB2: 4 records)

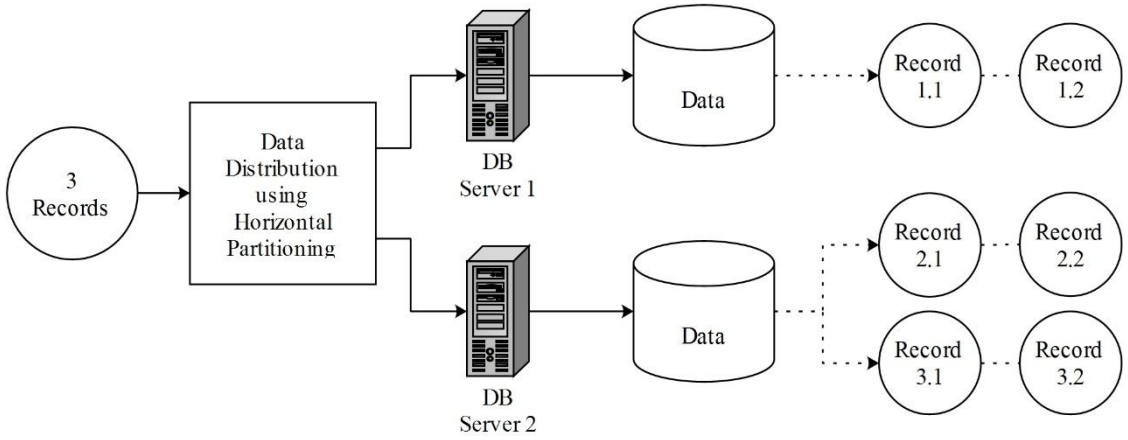

Fig 4: Vertical Partitioning

Step 3: Exchange the vertically partitioned data between both nodes

The final step is the equalization by exchanging the vertically partitioned records which in this case record 1.2 in DB1 moves to DB2 and records 2.2 and 3.2 in DB2 moves to DB1. Finally there are equalized databases where both databases have same number of records which in this case DB1 has 3 records and DB2 also has 3 Records as shown in Fig 5. (DB1: 3 record, DB2: 3 records) – Equalization

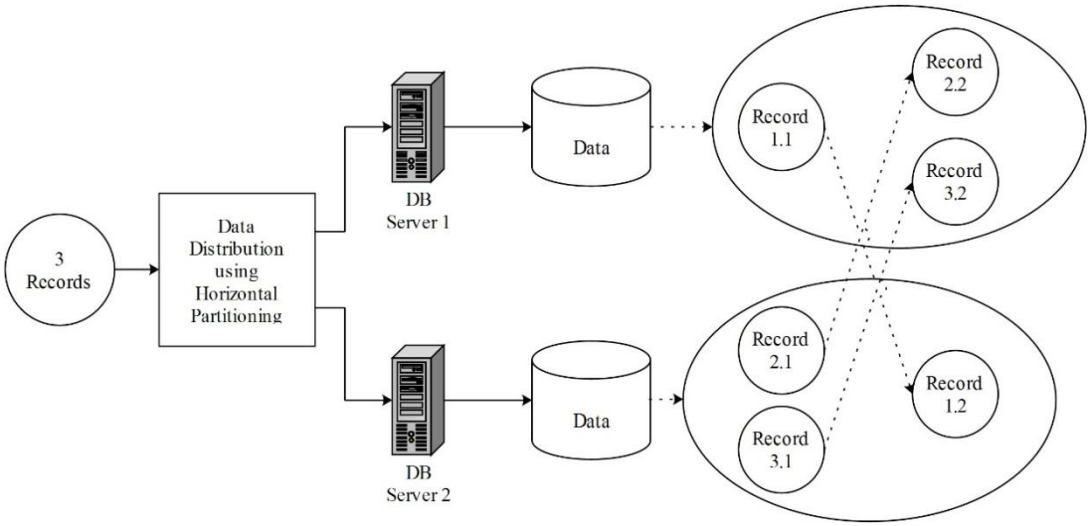

Fig 5: Equalization

General Method for N number of databases

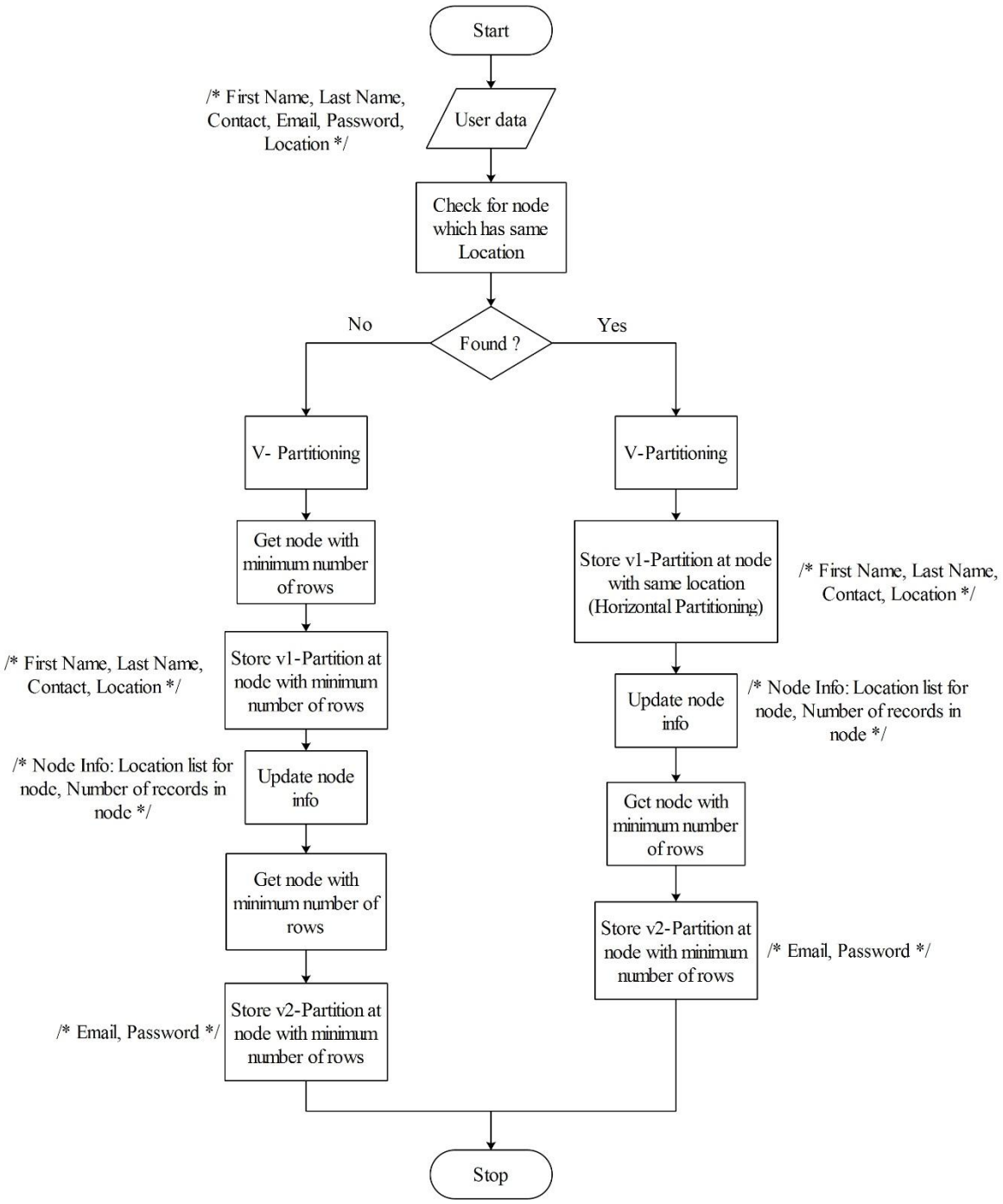

Fig 6: General Method

As shown in Fig 6, first the availability of user location is checked into node information, if it found then the data is partitioned vertically and one part of partition stored into the node having records with same location which is nothing but horizontal partitioning of data and other part of the partitioned data stored at the node with minimum number of records (rows). After storing first partition the node info gets updated to determine the node with minimum number of records later time. If node with same location not found in node info means if the arriving record is with totally new location then first it gets vertically partitioned and the first partition gets inserted into the node with minimum number of records and the node info gets updated and the second partition gets stored into the node with minimum number of record at that time. Which node has which location and how many records the node contains, that information is stored in node info table which gets updated whenever a partitioned record gets inserted in any node. As any real time application which interact

with users have two main modules that are Signup and Login. During signup module the data distribution takes place. Since only user email and password has to be checked and other data is not necessary during login module, vertical partition splits the data inn such a way that email and password attributes treated as one vertical partition and other data treated as another vertical partition. This approach of dividing login and user data reduces time of data retrieval and increase the performance by balancing the workload. Specialty of this approach is the user data and login data of a same user can not be in the same database which indirectly improves the security.

IV. CONCLUSION

Note: Insertion of a record actually insert two records in two different databases which are nothing but two vertical partitions of main record.

If the number of databases is an odd number 1, 3, 5 …. n then every n insertion gives equalized distribution of data.

Equalization factor E for Odd Number of Nodes		
Number of Nodes (Databases)(n)	Equalized Factor E (n)	Description
1	E = 1	Equalized data per 1 transaction
3	E = 3	Equalized data per 3 transaction
5	E = 5	Equalized data per 5 transaction
7	E = 7	Equalized data per 7 transaction
9	E = 9	Equalized data per 9 transaction
n	E = n	Equalized data per n transaction

If the number of databases is an even number 2, 4, 6 …. n then every n/2 insertion gives equalized distribution of data.

Equalization factor E for Even Number of Nodes		
Number of Nodes (Databases)(n)	Equalized Factor E (n/2)	Description
2	E = 2/2 = 1	Equalized data per 1 transaction
4	E = 4/ 2 = 2	Equalized data per 2 transaction
6	E = 6/2 = 3	Equalized data per 3 transaction
8	E = 8/2 = 4	Equalized data per 4 transaction
10	E = 10/2 = 5	Equalized data per 5 transaction
n	E = n/2	Equalized data per n/2 transaction

Above readings shows that it is more likely to have even number for this approach as it takes more transactions for fully equalized distributed data if the number of nodes are in odd number but it takes half number of transactions if the number of nodes are in equal number.

Almost equal distribution can be achieved using this approach as there are some exceptional case that records with a particular location increase continuously which leads to unequaled distribution. Probability of this exceptional case can be reduced by taking the smallest non unique attribute for horizontal distribution. For example in location based horizontal distribution it would be appropriate to take city or state as a parameter to compare and not country or continent. Doing this we are actually reducing the probability that more than one user can be from one location. The probability that more than one users can be from same location reduced with the level of location reduced in the manner of Continent -> Country -> State -> City.

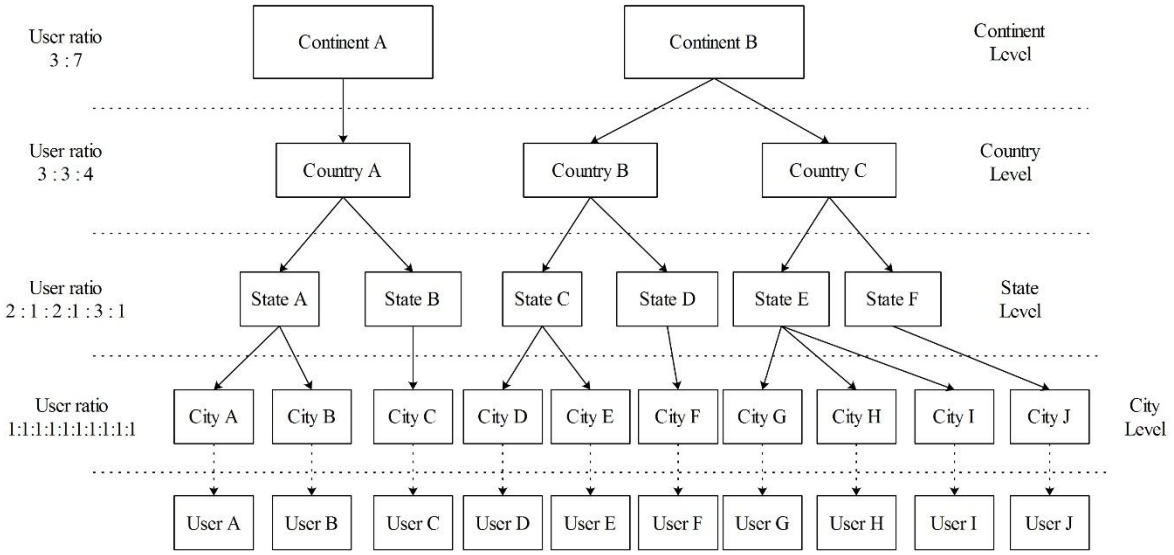

Fig 7: Probability of users from same location

As shown in Fig 7 For example, 10 users can be from same country which leads to unequaled distribution but there are more probability that those 10 users might be from different cities of the same country which increase the probability of more equalized data distribution.

Using this approach however data can be distributed based on location but also there are more chances that all the databases having same number of records which helps to reduce workload as all nodes can share the workload equally.

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On An Optimal control Problem for Parabolic Equations

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ABSTRACT:
Consideration was given to the problem of optimal control of parabolic equations. The existence solution of the considering optimal control parabolic problem is proved. The gradient of the cost functional by the adjoint problem approach is obtained. Lipschitz continuity of the gradient is derived.

Keywords: *Optimal control problem, parabolic Equations, Existence solution, Fréchet gradient, Adjoint problem, Lipschitz continuity.*

I. INTRODUCTION AND STATEMENT OF THE PROBLEM

The optimal control problems governed by partial differential equations have developed very fast in the last 30 years, and it has brought a promising and vital researching domain to the subject of mathematics. The optimal control problems governed by partial differential equations concern many applications in physics, chemistry, biology, etc., such as materials design, crystal growth, temperature control, petroleum exploitation, and so on. The relative details can be seen in [1-4], and so on. The partial differential equations involved in these problems include elliptic equations, parabolic equations and hyperbolic equations [5-7]. The reference [1] considered the problem of optimization of the optimal control parabolic problem with control in boundary and right hand side of the equation. In the present paper, the control action in the initial and boundary conditions of the considering optimal control parabolic problem.

Let the considered process be described in $\Omega_T = \{(x,t): x \in (0,l)\ ,\ 0 < t < T\}$ by the following problem:

$$\begin{cases} u_t = (\lambda(x)\ u_x)_x + v_o(x,t), & (x,t) \in \Omega_T\ , \\ u(x,0) = v_1(x)\ , & x \in (0,l), \\ u_x(0,t) = 0\ ,\ -\lambda\ (l)\ u_x(l,t) = k\ [u(l,t) - v_2(t)] & t \in (0,T]. \end{cases} \tag{1}$$

where $u(x,t)$ is the solution of the system (1), the constant $k > 0$ is called the convection coefficient or heat transfer coefficient , $\lambda(x) > 0$, $\lambda(x) \in L_\infty[0,l]$ and $V = V_\circ \times V_1 \times V_2$ is the set of admissible controls where $V = \{v = (v_o(x,t), v_1(x), v_2(t)) : v_o(x,t) \in L_2(\Omega_T), v_1(x) \in L_2(0,l), v_2(t) \in L_2(0,T)\}$ is a closed and convex subset in $V \subset L_2(\Omega_T) \times L_2[0,l] \times L_2[0,T]$.

The problem of optimal control lies in determining admissible controls $v \in V$ minimizing together with the corresponding generalized solution of problem (1) the functional

$$f_\alpha(v) = \beta \int_0^l [u(x,T) - z(x)]^2\, dx + \alpha \int_0^T [v_2(t) - w(t)]^2\, dt \tag{2}$$

In (2), $z(x)$ and $w(t)$ are given functions, respectively, from $L_2[0,l]$ and $L_2[0,T]$, T is a fixed time and β, α are given positive numbers.

II. EXISTENCE SOLUTION OF THE OPTIMAL CONTROL PROBLEM

In this section, we give the definition of the weak solution of the problem (1) and the existence solution of the optimal control problem (1)-(2).

The weak solution of the problem (1) will be defined as the function $u \in L_2(\Omega_T)$, which satisfies the following integral identity:

$$\int_0^l u(x,T)\,\zeta(x,T)\,dx - \int_0^l v_1(x)\,\zeta(x,0)\,dx - \iint_{\Omega_T} [u(x,t)\,\zeta_t(x,t) - \lambda(x)\,\zeta_x(x,t)\,u_x(x,t)]\,dxdt$$

$$- k\int_0^T [u(l,t) - v_2(t)]\zeta(l,t)dt = \iint_{\Omega_T} v_0(x,t)\,\zeta(x,t)\,dxdt \quad , \ \forall\ \zeta(x,t) \in L_2(\Omega_T). \tag{3}$$

Evidently, under the above conditions with respect to the given data, the weak solution $u \in L_2(\Omega_T)$ of the direct problem (1) exists and unique [8,9].

We define a solution of the optimal control problem (1)–(2), according to [10], as a solution of the minimization problem for the cost functional $f_\alpha(v)$, given by (2):

$$f_\alpha(v_*) = \inf_{v \in V} f_\alpha(v) \tag{4}$$

Evidently, if $f_\alpha(v_*) = 0$, then the solution $v_* \in V$ is also a strict solution of the optimal control problem (1)–(2), since $v_* \in V$ satisfies the functional equation $u(x,t;v)\big|_{t=T} = z(x)$, $x \in (0,l)$. Further, in the view of the weak solution theory for parabolic problems, one can prove that if the sequence $\{v^{(n)}\} \subset V$ weakly converges to the function $v \in V$, then the sequence of traces $\{u(x,T;v^{(n)})\}$ of corresponding solutions of problem (1) converges in $L_2(\Omega_T) - norm$ to the solution $\{u(x, T; v)\}$, which means $f_\alpha(v^{(n)}) \to f_\alpha(v)$, as $n \to \infty$. This means the functional $f_\alpha(v)$ is weakly continuous on V, hence due to the Weierstrass existence theorem [11] the set of solutions $V_* = \{v \in V : f_\alpha(v_*) = (f_\alpha)_* = \inf f_\alpha(v)\}$ of the minimization problem (2) is not an empty set.

III. FRÉCHET DIFFERENTIABILITY OF THE COST FUNCTIONAL AND ITS GRADIENT

The principal result in this section is Theorem 3.1. Its proof will be prepared by two lemmas.
Let us consider the first variation

$$\Delta f_\alpha(v) = f_\alpha(v + \Delta v) - f_\alpha(v) = 2\beta \int_0^l [u(x,T;v) - z(x)]\,\Delta u(x,T;v)\,dx + \beta \int_0^l [\Delta u(x,T;v)]^2\,dx$$

$$+ \alpha \int_0^T [\Delta v_2(t)]^2\,dt + 2\alpha \int_0^T [v_2(t) - w(t)]\,\Delta v_2(t)\,dt \tag{5}$$

of the cost functional (2), where

$$v + \Delta v = \{v_0(x,t) + \Delta v_0(x,t), v_1(x) + \Delta v_1(x), v_2(t) + \Delta v_2(t)\} \in V$$

$$\Delta u(x,t;v) = u(x,t,v + \Delta v) - u(x,t,v) \in L_2(\Omega_T).$$

Evidently the function $\Delta u = \Delta u(x,t;v)$ is the solution of the following parabolic problem

$$\begin{cases} \Delta u_t = (\lambda(x)\,\Delta u_x)_x + \Delta v_0(x,t) & , \quad (x,t) \in \Omega_t \\ \Delta u(x,0) = \Delta v_1(x) & , \quad x \in (0,l) \\ \Delta u_x(0,t) = 0 \quad , \; -\lambda(l)\Delta u_x(l,t) = k[\Delta u(l,t) - \Delta v_2(t)] & , \quad t \in (0,T] \end{cases} \tag{6}$$

Lemma 3.1.

Let $v = \{v_0(x,t), v_1(x), v_2(t)\}$, $v + \Delta v = \{v_0(x,t) + \Delta v_0(x,t), v_1(x) + \Delta v_1(x), v_2(t) + \Delta v_2(t)\} \in V$ be given elements. If $u = u(x,t;v) \in L_2(\Omega_T)$ is the corresponding solution of the direct problem (1) and $\psi(x,t;v) \in L_2(\Omega_T)$ is the solution of the adjoint parabolic problem

$$\begin{cases} \psi_t = -(\lambda(x)\psi_x)_x & , \quad (x,t) \in \Omega_t \\ \psi(x,T) = 2\beta\,[u(x,T;v) - z(x)] & , \quad x \in (0,l) \\ \psi_x(0,t) = 0 \quad , \quad -\lambda(l)\psi_x(l,t) = k\,\psi(l,t) & , \quad t \in (0,T] \end{cases} \tag{7}$$

then for all v ∈ V the following integral identity holds:

$$2\beta \int_0^l [u(x,T;v) - z(x)]\,\Delta u(x,T;v)\,dx = \int_0^l \psi(x,0;v)\,\Delta v_1(x)\,dx + \iint_{\Omega_T} \psi(x,t;v)\,\Delta v_0(x,t)\,dx\,dt + k\int_0^T \psi(l,t;v)\,\Delta v_2(t)\,dt \quad , \quad \forall\, v \in V \tag{8}$$

Proof: Let us use the final condition at $t = T$ in (7) to transform the left-hand side of (8) as follows:

$$\begin{aligned} & 2\beta \int_0^l [u(x,T;v) - z(x)]\,\Delta u(x,T;v)\,dx \\ &= \int_0^l \psi(x,T;v)\,\Delta u(x,T;v)\,dx \\ &= \iint_{\Omega_T} [\psi(x,t;v)\,\Delta u(x,t;v)]_t\,dx\,dt \\ &= \iint_{\Omega_T} [\psi_t(x,t;v)\,\Delta u(x,t;v) + \psi(x,t;v)\,\Delta u_t(x,t;v)]\,dx\,dt \\ &= \iint_{\Omega_T} [-(\lambda(x)\,\psi_x(x,t;v))_x\,\Delta u(x,t;v) + \psi(x,t;v)\,(\lambda(x)\,\Delta u_x(x,t;v))_x]\,dx\,dt \\ &\qquad + \iint_{\Omega_T} v_0(x,t)\,\psi(x,t;v)\,dx\,dt \\ &= \int_0^T [-\lambda(x)\,\psi_x(x,t;v)\,\Delta u(x,t;v) + \psi(x,t;v)\,\lambda(x)\Delta u_x(x,t;v)]_{x=0}^{x=l}\,dt \\ &\qquad + \iint_{\Omega_T} v_0(x,t)\psi(x,t;v)\,dx\,dt\,. \end{aligned}$$

Taking into account the boundary conditions in (7) and (8) for the functions $\psi(x,t;v)$ and $\Delta u(x,t;v)$; we obtain (8).

We will define the parabolic problem (7) as an adjoint problem, corresponding to the inverse problem (1)–(2). The parabolic equation (7) is a backward one, and due to the "final condition" at t = T it is a well-posed initial boundary-value problem under a reversal of time.

Now we use the integral identity (8) on the right-hand side of formula (5) for the first variation of the cost functional $f_\alpha(v)$. Then we have

$$\Delta f_\alpha(v) = \iint_{\Omega_T} \Delta v_0(x,t)\psi(x,t;v)\,dx\,dt + k\int_0^T \psi(l,t;v)\Delta v_2(t)\,dt + \int_0^l \psi(x,0;v)\,\Delta v_1(x)\,dx$$

$$+ 2\alpha\int_0^T [v_2(t) - w(t)]\Delta v_2(t)\,dt + \alpha\int_0^T [\Delta v_2(t)]^2\,dt + \beta\int_0^l [\Delta u(x,T;v)]^2\,dx \qquad (9)$$

Taking into account the above definition of the scalar product in V and the definition of the Fréchet-differential we need to transform the right-hand side of (9) into the following form:

$$\Delta f_\alpha(v) = \left\langle f_\alpha'(v), \Delta v \right\rangle_V + \alpha\int_0^T [\Delta v_2(t)]^2\,dt + \beta\int_0^l [\Delta u(x,T;v)]^2\,dx \qquad (10)$$

This formula provides further insight into the gradient of the functional $f_\alpha(v)$ via the solution of the adjoint parabolic problem (7). Due to the definition of the Fréchet-differential, we need to show that the last two terms on the right-hand side of (10) are of order $O\left(\|v\|_V^p\right)$, with $p \geq 1$.

The following result precisely shows an estimate for the last two terms in (1) in order $O\left(\|v\|_V^2\right)$.

Lemma 3.2.

Let $\Delta u = \Delta u(x,t;v) \in L_2(\Omega_T)$ be the solution of the parabolic problem (6) corresponding to a given $v \in V$. Then the following estimate holds:

$$\int_0^l [\Delta u(x,T;v)]^2\,dx \leq \frac{c_0}{\varepsilon}\|\Delta v\|_V^2 \quad , \quad \forall\, \Delta v \in V \qquad (11)$$

where $\|\Delta v\|_V = \left[\iint_{\Omega_T} |\Delta v_0(x,t)|^2\,dx\,dt + \int_0^l |\Delta v_1(x)|^2\,dx + \int_0^T |\Delta v_2(t)|^2\,dt\right]^{1/2}$

is the norm $L_2(\Omega_T) - norm$ of the function $\Delta v \in V$, and the constants c_0, $\varepsilon > 0$ are defined as follows:

$$c_0 = \max\{1,k\} \quad , \quad \lambda_* = \min_{0\leq x\leq l}\lambda(x) > 0 \quad , \quad \varepsilon = \min\left\{\frac{l^2}{\lambda_*}, \frac{2k}{k+2l}\right\} \qquad (12)$$

Proof.

Multiplying both sides of the parabolic equation (10) by Δu, integrating on Ω_T, $\Delta u\,\Delta u_t = \frac{1}{2}\left[\Delta u^2\right]_t$, $(\lambda(x)\Delta u_x)_x \Delta u = (\lambda(x)\Delta u_x \Delta u)_x - \lambda(x)(\Delta u_x)^2$ and using the initial and boundary conditions we obtain:

$$0 = \iint_{\Omega_T} \Delta u\,[\Delta u_t - (\lambda(x)\,\Delta u_x)_x - \Delta v_0(x,t)]\,dx\,dt$$

$$= \frac{1}{2}\iint_{\Omega_T} \left[\Delta u^2\right]_t \, dt \, dx + \iint_{\Omega_T} \left(\lambda(x)\Delta u_x \, \Delta u\right)_x dx \, dt + \iint_{\Omega_T} \lambda(x)\left(\Delta u_x\right)^2 dx \, dt + \iint_{\Omega_T} v_0(x,t)\Delta u(x,t) \, dx \, dt$$

$$= \frac{1}{2}\int_0^l \left[\Delta u(x,T;v)\right]^2 dx + k\int_0^T \left[\Delta u(l,t;v)\right]^2 dt - k\int_0^T \Delta u(l,t;v)\Delta v_2(t)\,dt$$

$$+ \iint_{\Omega_T} \lambda(x)\left(\Delta u_x(x,t;v)\right)^2 dx \, dt - \iint_{\Omega_T} v_0(x,t)\Delta u(x,t;v)dx \, dt - \frac{1}{2}\int_0^l \left[\Delta v_1(x)\right]^2 dx$$

This implies the following energy identity

$$\frac{1}{2}\int_0^l \left[\Delta u(x,T;v)\right]^2 dx + k\int_0^T \left[\Delta u(l,t;v)\right]^2 dt + \iint_{\Omega_T} \lambda(x)\left(\Delta u_x\right)^2 dx \, dt$$

$$= \iint_{\Omega_T} v_0(x,t)\Delta u(x,t;v)\,dx \, dt + k\int_0^T \Delta u(l,t;v)\Delta v_2(t)\,dt + \frac{1}{2}\int_0^l \left[\Delta v_1(x)\right]^2 dx \qquad (13)$$

for the solution $\Delta u = \Delta u(x,t;v)$ of the parabolic problem (13). We use the ε-inequality $\alpha\,\beta \le \frac{\varepsilon\,\alpha^2}{2} + \frac{\beta^2}{2\varepsilon}$, $\forall\,\alpha,\beta \in R$, $\forall\,\varepsilon > 0$, on the right-hand side integrals of this identity. Then we have

$$\iint_{\Omega_T} v_0(x,t)\Delta u(x,t;v)\,dx \, dt + k\int_0^T \Delta u(l,t;v)\Delta v_2(t)\,dt + \frac{1}{2}\int_0^l \left[\Delta v_1(x)\right]^2 dx$$

$$\le \frac{\varepsilon}{2}\iint_{\Omega_T} \left[\Delta u(x,t;v)\right]^2 dxdt + \frac{1}{2\varepsilon}\iint_{\Omega_T} \left[\Delta v_0(x,t)\right]^2 dxdt + \frac{k\varepsilon}{2}\int_0^T \left[\Delta u(l,t;v)\right]^2 dt$$

$$+ \frac{k}{2\varepsilon}\int_0^T \left[\Delta v_2(t)\right]^2 dt + \frac{1}{2}\int_0^l \left[\Delta v_1(x)\right]^2 dx \quad , \quad \forall\,\varepsilon > 0 \qquad (14)$$

Further, we estimate the term $\left[\Delta u(x,t)\right]^2$ by applying the Cauchy inequality,

$$\left[\Delta u(x,t)\right]^2 = \left[\int_x^l \Delta u_\xi(\xi,t;v)d\xi - \Delta u(l,t;v)\right]^2$$

$$\le 2\left(\int_x^l \Delta u_\xi(\xi,t;v)d\xi\right)^2 + 2\left(\Delta u(l,t;v)\right)^2$$

$$\le 2l\int_0^l \left[\Delta u_x(x,t;v)\right]^2 dx + 2\left(\Delta u(l,t;v)\right)^2$$

Now integrate the both sides of this inequality on Ω_T

$$\iint_{\Omega_T} \left[\Delta u(x,t;v)\right]^2 dxdt \le 2l^2\iint_{\Omega_T} \left[\Delta u_x(x,t;v)\right]^2 dxdt + 2l\int_0^T \left[\Delta u(l,t;v)\right]^2 dt \qquad (15)$$

and use this estimate on the right-hand side of (14):

$$\iint_{\Omega_T} v_0(x,t)\,\Delta u(x,t;v)\,dx\,dt + k\int_0^T \Delta u(l,t;v)\,\Delta v_2(t)\,dt + \frac{1}{2}\int_0^l \left[\Delta v_1(x)\right]^2 dx$$

$$\le \varepsilon\, l^2 \iint_{\Omega_T} \left[\Delta u_x(x,t;v)\right]^2 dxdt + (\varepsilon\, l + \frac{k\varepsilon}{2})\int_0^T \left[\Delta u(l,t;v)\right]^2 dt + \frac{1}{2\varepsilon}\iint_{\Omega_T} \left[\Delta v_0(x,t)\right]^2 dxdt$$

$$+ \frac{k}{2\varepsilon}\int_0^T \left[\Delta v_2(t)\right]^2 dt + \frac{1}{2}\int_0^l \left[\Delta v_1(x)\right]^2 dx$$

This inequality with (14) implies

$$(\lambda_* - \varepsilon\, l^2)\iint_{\Omega_T} \left[\Delta u_x(x,t;v)\right]^2 dxdt + (k - \varepsilon\, l - \frac{k\varepsilon}{2})\int_0^T \left[\Delta u(l,t;v)\right]^2 dt + \frac{1}{2}\int_0^l \left[\Delta u(x,T;v)\right]^2 dx$$

$$\le \frac{1}{2\varepsilon}\iint_{\Omega_T} \left[\Delta v_0(x,t)\right]^2 dxdt + \frac{k}{2\varepsilon}\int_0^T \left[\Delta v_2(t)\right]^2 dt + \frac{1}{2}\int_0^l \left[\Delta v_1(x)\right]^2 dx \qquad (16)$$

Requiring the positivity of the terms $k - \varepsilon l - \frac{k\varepsilon}{2}$ and $\lambda_* - \varepsilon l^2$ we get bound (12) for the parameter ε >0. With this parameter ε >0, from estimate (16) finally we obtain:

$$\frac{1}{2}\int_0^l \left[\Delta u(x,T;v)\right]^2 dx \le \frac{1}{2\varepsilon}\iint_{\Omega_T} \left[\Delta v_0(x,t)\right]^2 dxdt + \frac{k}{2\varepsilon}\int_0^T \left[\Delta v_2(t)\right]^2 dt + \frac{1}{2}\int_0^l \left[\Delta v_1(x)\right]^2 dx$$

The required estimate (13) follows from this inequality by choosing the constant $c_0 > 0$ as in (16), which completes the proof.

The lemmas 3.1, 3.2 imply that the last integral in (10) is bounded by the term $O\left(\|\Delta v\|_V^2\right)$. Thus by the definition of Fréchet-differential at $v \in V$

$$\Delta f_\alpha(v) = \left\langle f_\alpha'(v), \Delta v \right\rangle_V + \alpha\int_0^T \left[\Delta v_2(t)\right]^2 dt + \beta\int_0^l \left[\Delta u(x,T;v)\right]^2 dx \ ,$$

We obtain the following theorem:-

Theorem 3.1.

Let conditions in the considered problem hold. Then the cost functional is Fréchet-differentiable, $f_\alpha(v) \in C^1(V)$. Moreover, Fréchet derivative at $v \in V$ of the cost functional $f_\alpha(v)$ can be defined by the solution $\psi \in W_2^{1,0}(\Omega_T)$ of the adjoint problem (7) as follows:

$$f_\alpha'(v) = \{\ \psi(x,t;v),\ \psi(x,0;v);\ k\ \psi(l,t;v)\} \qquad (17)$$

IV. LIPSCHITZ CONTINUITY OF THE GRADIENT

Any gradient method for the minimization problem (4) requires an estimation of the iteration parameter α_k > 0 in the iteration process

$$v^{(n+1)} = v^{(n)} - \alpha_n f'_\alpha\left(v^{(n)}\right) \quad , \quad n=0,1,2\ldots. \tag{18}$$

where $v^{(0)} \in V$ is a given initial iteration. Choice of the parameter α_k defines various gradient methods [12], although in many situation estimations of this parameter is a difficult problem. However, in the case of Lipschitz continuity of the gradient $f'_\alpha(v)$ the parameter α_n can be estimated via the Lipschitz constant as follows:

$$0 < \delta_0 \le \alpha_n \le 2/(L + 2\delta_1) \tag{19}$$

where δ0, δ1 > 0 are arbitrary parameters.

Lemma 4.1.

Let conditions of Theorem 3.1 hold. Then the functional $f_\alpha(v)$ is of Hölder class $c^{1,1}(V)$ and

$$\left\| f'_\alpha(v+\Delta v) - f'_\alpha(v)\right\|_V \le L\left\|\Delta v\right\|_V , \tag{20}$$

where

$$\left\| f'_\alpha(v+\Delta v) - f'_\alpha(v)\right\|_V^2 = \iint_{\Omega_T} (\Delta\psi(x,t;v))^2 dxdt + k^2 \int_0^T (\Delta\psi(l,t;v))^2 dt$$

$$+ \left(\frac{l^2}{\lambda_*} + \frac{l}{k} + \frac{k}{2}\right) \int_0^l (\Delta\psi(x,0;v))^2 dx \tag{21}$$

and the Lipschitz constant $L > 0$ is defined via the parameters c_0, ε >0 in (16) as follows:

$$L = 4\sqrt{\frac{\beta c_0}{\varepsilon}\left(\frac{l^2}{\lambda_*} + \frac{l}{k} + \frac{k}{2}\right)} > 0 \tag{22}$$

Proof.

The function $\Delta\psi(x,t;v) = \psi(x,t;v+\Delta v) - \psi(x,t;v) \in W^{1,0}(\Omega_T)$ is the solution of the following backward parabolic problem:

$$\begin{cases} \Delta\psi_t = (-\lambda(x)\Delta\psi_x)_x & , \ (x,t) \in \Omega_t \\ \Delta\psi(x,T) = 2\beta\ \Delta u(x,T;v) & , \ x \in (0,l) \\ \Delta\psi_x(0,t) = 0 \quad , \quad -\lambda(l)\Delta\psi_x(l,t) = k\ \Delta\psi(l,t) & , \ t \in (0,T] \end{cases} \tag{23}$$

Multiplying both sides of Eq. (23) by $\Delta\psi(x,t;v)$, integrating on Ω_T and using the initial and boundary conditions, as in the proof of Lemma 3.2, we can obtain the following energy identity:

$$\iint_{\Omega_T} \lambda(x)\left[\Delta\psi_x(x,t;v)\right]^2 dxdt + k\int_0^T \left[\Delta\psi(l,t;v)\right]^2 dt + \frac{1}{2}\int_0^l \left[\Delta\psi(x,0;v)\right]^2 dx$$

$$= 2\beta \int_0^l \left[\Delta u(x,T;v)\right]^2 dx \tag{24}$$

This identity implies the following two inequalities:

$$\begin{cases} \lambda_* \iint_{\Omega_T} \left[\Delta\psi_x(x,t;v)\right]^2 dx\ dt + \frac{1}{2}\int_0^l \left[\Delta\psi(x,0;v)\right]^2 dx \le 2\beta\int_0^l \left[\Delta u(x,T;v)\right]^2 dx \\ k\int_0^T \left[\Delta\psi(l,t;v)\right]^2 dt + \frac{1}{2}\int_0^l \left[\Delta\psi(x,0;v)\right]^2 dx \le 2\beta\int_0^l \left[\Delta u(x,T;v)\right]^2 dx \end{cases}$$

Multiplying the first and the second inequality by $\frac{2\,l^2}{\lambda_*}$ and $\frac{2\,l}{k}$, correspondingly, summing up them, and then using the inequality (15) we obtain:

$$\iint\limits_{\Omega_T} \left[\Delta\,\psi\,(x,t;v)\right]^2 dxdt \;+\; \left(\frac{l^2}{\lambda_*}+\frac{l}{k}\right)\int_0^l \left[\Delta\,\psi\,(x,0;v)\right]^2 dx \;\le\; 4\beta\left(\frac{l^2}{\lambda_*}+\frac{l}{k}\right)\int_0^l \left[\Delta\,u\,(x,T;v)\right]^2 dx\ .$$

Let us estimate now the second integral on the right-hand side of (21) by the same term. From the energy identity (24) we can also conclude

$$k^2\int_0^T \left[\Delta\,\psi\,(l,t;v)\right]^2 dt \;+\frac{k}{2}\int_0^l \left[\Delta\,\psi\,(x,0;v)\right]^2 dx \;\le\; 2\,\beta\,k\int_0^l \left[\Delta\,u\,(x,T;v)\right]^2 dx$$

This, with the above estimate, implies

$$\iint\limits_{\Omega_T} \left[\Delta\,\psi\,(x,t;v)\right]^2 dxdt \;+\; k^2\int_0^T \left[\Delta\,\psi\,(l,t;v)\right]^2 dt \;+\; \left(\frac{l^2}{\lambda_*}+\frac{l}{k}+\frac{k}{2}\right)\int_0^l \left[\Delta\,\psi\,(x,0;v)\right]^2 dx$$

$$\le\; 4\beta\left(\frac{l^2}{\lambda_*}+\frac{l}{k}+\frac{k}{2}\right)\int_0^l \left[\Delta\,u\,(x,T;v)\right]^2 dx$$

Using this in (21) and taking into account Lemma 3.2 we obtain (20) with the Lipschitz constant (22).

V. CONCLUSION

Consideration was given to the problem of optimal control of parabolic equations. The existence solution of the considering optimal control parabolic problem is proved. The gradient of the cost functional by the adjoint problem approach is obtained. Lipschitz continuity of the gradient is derived.

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Reuse Options of Reclaimed Waste Water in Chennai City

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ABSTRACT:
In the present research work Sholinganallur taluk which comes under the zone of Chennai city expansion area was taken for management of wastewater effectively. Overlay operation in GIS tool was performed by selected decentralized wastewater treatment site map on reclassified landuse map. A 1000 m buffer map was created around each decentralized wastewater treatment sites to suggest various reuse options. The landuse map within the buffer zone comprises of detailed classification of ward number and its boundary. The settlement area which falls in the buffer zones includes number of households and population density, educational institutions like schools, colleges, industrial buildings like IT buildings, manufacturing buildings, government offices, shopping complex, hospitals, hotels, restaurants, etc., public areas like parks, pavement area etc. and crop land, forest area, salt pan, sand bar etc. Reuse of treated wastewater is broadly categorized into two purposes namely potable and non potable purposes. Treated waste water for potable purpose such as for drinking and recharge of ground water require higher standard of water quality. Whereas the non potable reuse such as domestic purpose like gardening, toilet flushing, car washing, industrial reuse, recreational, agriculture, landscape irrigation, wetland applications etc requires low standard of treated waste water quality. The reuse options considered in the present study are the urban, Industrial, recreational, groundwater respectively.

Keywords: *GIS, Overlay analysis, Decentralisation, Wastewater*

I. INTRODUCTION

Asano etal (1996) described that wastewater reclamation and reuse is a type of wastewater treatment system and its quality is attained after treatment process. Application of wastewater for various level of reuse purpose purely depends on the characteristics of wastewater attained after treatment. Asano and Levine (1996) clearly stated that the level of wastewater treatment required for a particular purpose purely depends on the quality of the end-use. Rose (1999) recommended that sustainable manner of wastewater treatment must be given attention in domestic and industrial wastes. Nhapi et al (2002) stated that, wastewater reuse is an approach to turn the useful component of wastewater into a resource. Great care must be exercised when reusing the reclaimed wastewater which may contain chemical and biological substances that may create some harmful effects on public health. MetCalf & Eddy (2005) included rainwater and storm-water collected by urban sewer system was also considered as wastewater. Raw wastewater contain organic matters, toxic compounds and nutrients which results in eutrophication and release of harmful gases. Massoud et al (2009) defined the wastewater reclamation as a treatment process which treats wastewater to predetermined levels of water quality, further facilitating its reuse. Water reuse includes the use of treated waste water for all beneficial purpose, including agricultural, irrigation, industrial cooling and other non potable or potable applications. Pinkham et al (2004) discussed that integrated wastewater planning improves upon conventional wastewater facility planning by representing whole system costs and benefits of wastewater management systems. Vigneswaran and Sundaravadivel (2004) explained that the reuse of treated wastewater for specific direct or indirect reuse purpose is mainly depends on the standard of treated wastewater attained after treatment. Parkinson and Tayler (2003) pointed out that the view of conventional or centralized wastewater treatment systems involve advanced collection and treatment processes that collect, treat and discharge large quantities of wastewater. GTZ (2009) and Werner et al (2010) developed, EcoSAN which promotes the extraction of water, energy and nutrient resources found in wastewater for beneficial reuse locally in agriculture and to increase sustainability of wastewater management. centralized systems for wastewater collection and disposal require disproportionately large investments which are unaffordable to the majority of the peri-urban poor people (Seidenstat et al 2003 and USEPA 2004). Fraganol et al (2001) suggested that decentralized wastewater treatment system is an

effective technique in planning and decision-making, design of physical infrastructure and management arrangements for operations and maintenance.

II. STUDY AREA

Shollinganallur Taluk comes under the administrative boundary of Kancheepuram district. The study area is located between latitudes 12 15' 20"N and 12 58' 12"N and longitudes 80 9'12" and 80 16'9"E, covering a total area of 118 km^2. The physiographic units present in the study area (Figure 1) are alluvial plain, hard rock areas and coastal plain. The present population of Shollinganallur Taluk as per 2011 Census is 3,33,534.

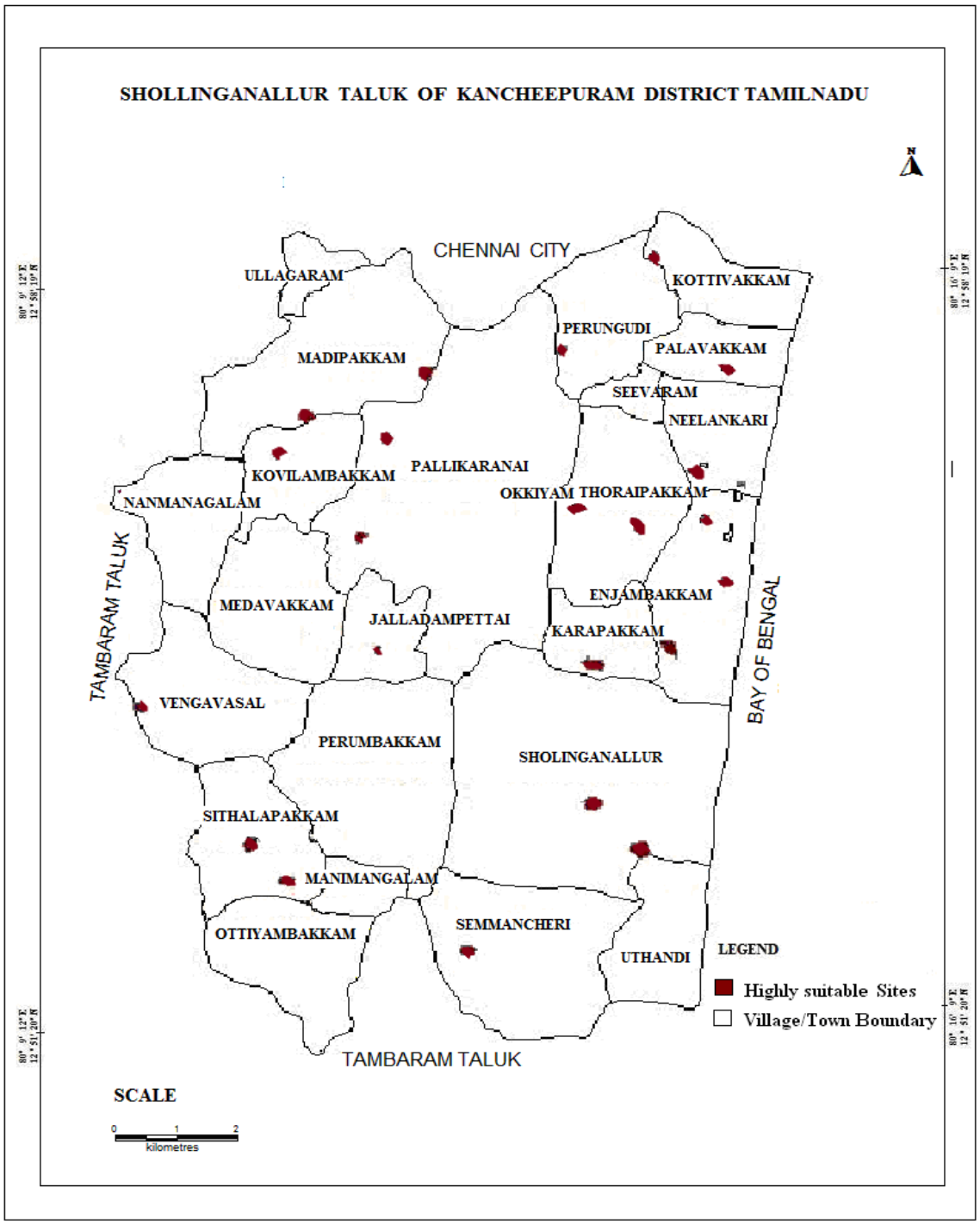

Figure 1. Study Area Map

III. METHODOLOGY

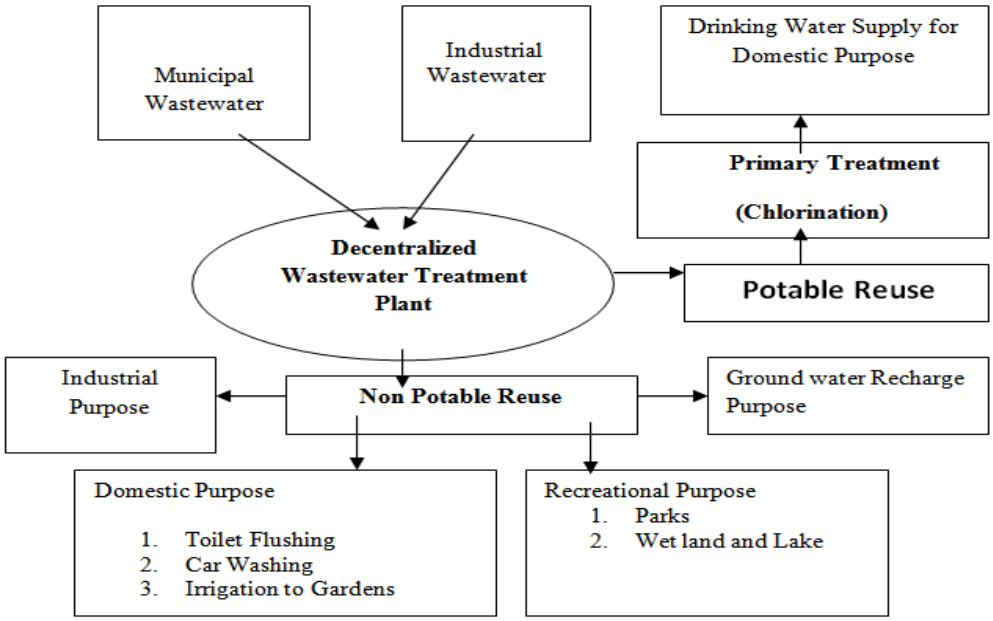

Figure 2 Methodology Flow chart of reclaimed water for various reuse options

IV. Results and Discussion

The buffer zone of 1000 m created around each decentralized wastewater treatment sites is presented in Figure 3. Each decentralized wastewater treatment site was analysed for possible reuse options. The percentage of various landuse types which is covered by the buffer zone of each decentralized wastewater treatment site are listed in Table 1.

Urban reuse

The daily consumption of water by a single person is listed in Table 2. From the table 2 it is observed that 59.3% of water consumed for drinking, bathing, washing clothes, cooking and dish washing purpose daily and 40.7% of water consumed for vehicle washing, floor cleaning, gardening and toilet flushing purpose. Therefore it is understood that the consumption of 59.7% of water depends on fresh water, whereas 40.7% does not depends on fresh water. Thus usage of 40.7% fresh water could be replaced by treated waste water. The effective reuse of treated wastewater from the treatment plants was suggested by redirecting the treated water for urban settlements by means of dual water supply system for gardening, toilet flushing, car washing and floor washing purposes. The percentage of reuse treated waste water for municipal purpose was calculated and presented in Table 3 below. The total volume of wastewater generated in study area for the present scenario is 47 MLD and 30 years projected future scenario is 69 MLD. Out of 24 suggested decentralized treatment plant sites, 14 sites are located in the urban settlements where the capacity of each treatment plant assumed to treat a quantity of 3 MLD of wastewater. The total capacity of wastewater to be treated by urban decentralized treatment plants is 42 MLD. From the Table 3 the quantity of treated wastewater to be reused for municipal purpose is 31.8 MLD. This results an effective replacement of 46.5% of fresh water or ground water.

Industrial reuse

The total number of industries present around the proposed decentralized treatment plant sites within the buffer zone of 1 km is about 336, which is shown in Table 3. The industrial categories considered are the hospitals, IT buildings, Government offices, schools, colleges, small scale private industrial companies, hotels, restaurants, shopping complex etc. An approximate total number of population working in these industrial sector was found to be about 2, 34,975. The projected population for 30 years is 4, 22,955. It is estimated that about 18% of treated wastewater could be consumed for toilet flushing and 10% will be marketed to the small scale manufacturing industries located near by the decentralized wastewater treatment sites.

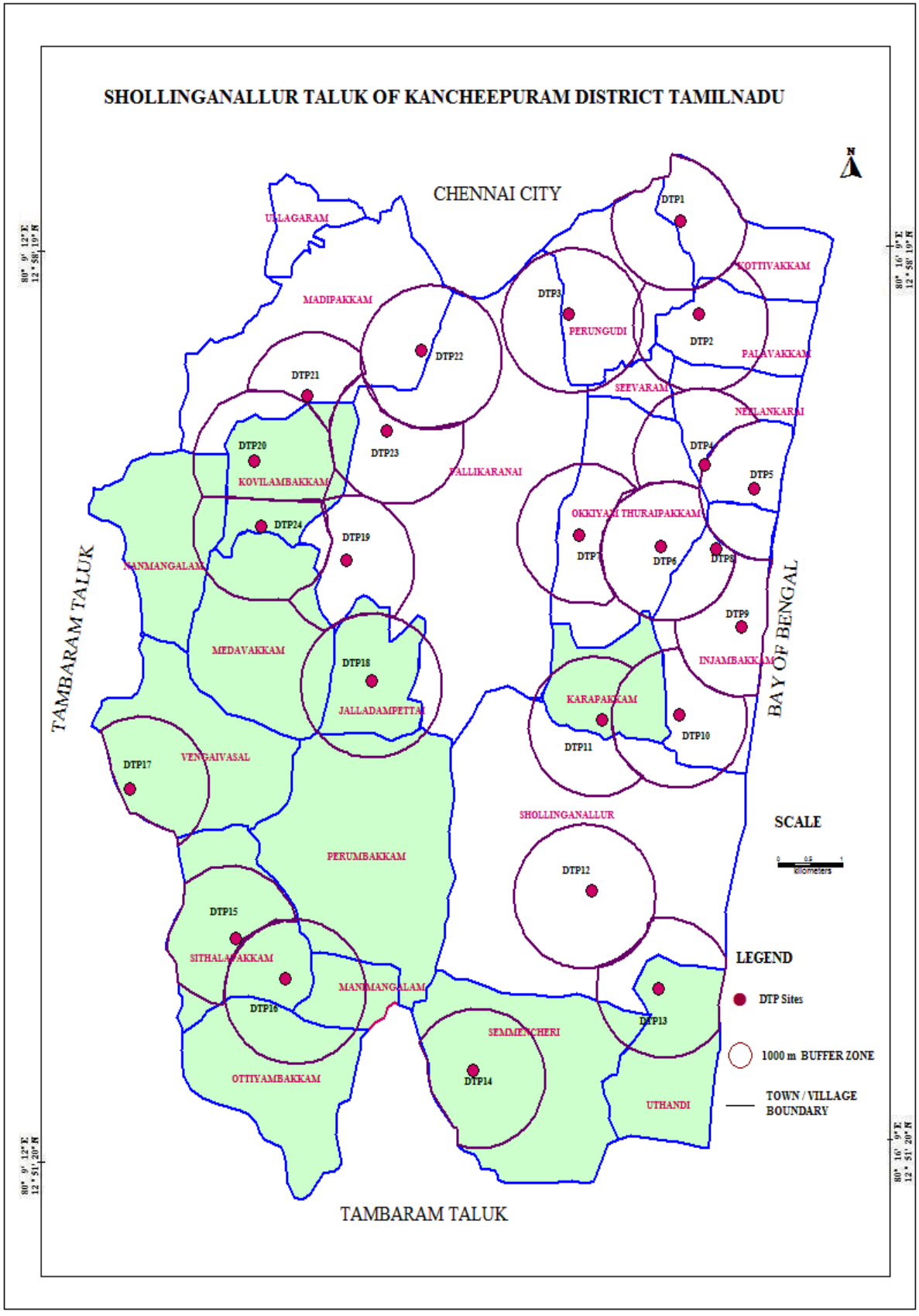

Figure 3 Buffer Zone Map

Table 2 Water Consumption for Different Category

SI. No.	Category of Water Consumption	Quantity of water Consumed (Litre/person /day)	Percentage
1	Drinking	5	3.7
2	Bathing	30	22.3
3	Washing Clothes	30	22.3
4	Cooking	5	3.7
5	Dish Washing	10	7.3
6	House Cleaning / Floor Washing	5	3.7
7	Car Washing	5	3.7
8	Toilet Flushing	30	22.3
9	Gardening	15	11.0
Total		**135**	**100**

Source: CPHEEO 2003

Recreational reuse

From the above Table 3 it is observed that 1.151 km^2 area come under recreational purpose such as pavement gardens, public parks. Approximately 1 liter of water per day can be used to irrigate 1sq feet of the pavement area. It is estimated that about 18% of treated waste water can be used for public gardens, parks and road way plants.

Table 3 Quantity of Wastewater Reuse

DTP Site Number	Number of House holds	Present Population	Projected Population	Quantity of reclaimed Water for Municipal Reuse (Mld)	Number of Industries
1	3100	12400	23375	1.25	27
2	3800	15200	28285	1.53	14
3	4220	16880	31411	1.70	28
4	2123	8492	15802	1.0	17
5	1340	5360	9974	0.52	6
6	4060	16240	30220	1.63	31
7	1450	5800	10793	0.58	10
9	650	2600	4838	0.26	4
10	380	1520	2829	0.15	6
11	3020	12080	22479	1.2	23
12	2300	9200	17120	1.02	21
13	2359	9436	17559	1.01	34

14	933	3732	6945	0.38	7
15	1245	4980	9267	0.50	15
16	760	3040	5657	0.31	6
17	836	3344	6223	0.33	11
18	1210	4840	9007	0.48	9
19	1965	7860	14626	0.79	12
20	2570	10280	19130	1.03	16
21	984	3936	7324	0.40	12
22	3256	13024	24235	1.31	15
23	1800	7200	13398	0.72	7
24	627	2508	4667	0.25	5
Total	**44988**	**179952**	**334867**	**31.87**	**336**

Groundwater reuse

Indirect reuse provides treated wastewater by discharging it into surface water bodies or groundwater aquifer prior to reuse such as in groundwater recharge. Groundwater aquifers provide natural mechanism for treatment, storage and subsurface transmission of treated waste water (Asano et al 1996). About 7.5 % of the treated wastewater can be recharged through soil aquifer treatment method. It is a one such method where the unsaturated soil acts as natural filter media. The selection of possible locations for application of soil aquifer treatment was considered based on the evaluation of decentralized treatment plants sites by analysing various factors such as aquifer quality, water table depth, soil salinity and soil texture.

Table 1 Percentage of Landuse Classification in Buffer Zone

DTP Site Number	Buffer Area (Km^2)	Settlement Area (Km^2)	Industrial Area (Km^2)	Recreational Area (Km^2)	Other Area (Km^2)
1	0.48	0.29	0.11	0.05	0.03
2	0.79	0.52	0.15	0.08	0.04
3	1.03	0.87	0.01	0.09	0.06
4	0.40	0.32	0.01	0.06	0.01
5	1.31	1.1	0.01	0.10	0.10
6	0.72	0.58	0.01	0.11	0.02
7	0.25	0.18	0.02	0.01	0.04
9	0.48	0.15	0.01	0.02	0.3
10	0.79	0.37	0.0	0.02	0.39
11	0.71	0.53	0.02	0.10	0.06
12	0.40	0.12	0.04	0.03	0.21
13	1.31	0.33	0.10	0.21	0.67
14	0.72	0.32	0.05	0.15	0.30
15	0.25	0.05	0.02	0.01	0.17
16	0.48	0.22	0.10	0.02	0.16
17	0.79	0.20	0.03	0.02	0.54
18	1.03	0.23	0.01	0.03	0.76
19	0.40	0.15	0.04	0.02	0.19

20	1.31	0.86	0.13	0.20	0.12
21	0.72	0.44	0.06	0.10	0.19
22	0.25	0.12	0.01	0.01	0.11
23	0.48	0.24	0.02	0.03	0.19
24	0.79	0.36	0.06	0.04	0.33
Total	**15.89**	**8.55**	**1.12**	**1.151**	**5.09**

V. CONCLUSION

The effective reuse of treated wastewater from the treatment plants was suggested by redirecting the treated waste water for urban settlements by means of dual water supply system for gardening, toilet flushing, car washing and floor washing purposes. This results an effective use of 46.5% of treated wastewater instead of the usage of fresh water supply as surface water and groundwater. The treated wastewater of about 10% and above can be marketed to the industries located near by the decentralized plants for non potable purpose. Further 18% of water can be used for public gardens, parks and road way plants situated along the road ways. About 7.5 % of the treated wastewater can be recharged through Soil Aquifer Treatment Method.

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Recommendation of Data Mining Technique in Higher Education Prof. Priya Thakare Guide

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ABSTRACT

In this paper we will discuss about the problem that are faced by higher education institutions. One of the biggest challenges that higher education faces today is predicting the right path of students. Institutions would like to know, which students will enroll in which course, and which students will need more assistance in particular subject and what efforts should be taken for weak students. Also some time management needs more information about student like their overall result, interest in co-curricular and extra-curricular activities and about the success of new offered courses. One way to effectively address the challenges for improving the quality of students and education is to provide new knowledge related to the educational processes and entities to the system. This knowledge can be extracted from historical data that reside in the educational organization's databases using the techniques of data mining technology. If data mining techniques such as clustering, decision tree, association, classification and prediction can be applied to higher education processes, it can definitely help improve students' overall performance, their life cycle management, selection of course and predict their dropout rate.

KEYWORDS: *Data mining, Higher education, Clustering, Decision tree, neural network, classification, prediction, association rule analysis.*

I. I.INTRODUCTION

One of the significant facts in higher learning institution is the explosive increase of educational data. These data are increasing rapidly without any benefit to the management and institutions. We believe that to manage this vast data is difficult task, but by new techniques and tools we can easily process the large amount of generated data in business processes and extract some useful knowledge and information from it. Data mining is a technique of extraction hidden predictive information from large databases; it is a powerful new technology with great potential to help higher learning Universities or institutions to focus on the most important information in their data warehouses. Data mining tools predict future trends and behavior patterns, allowing institution to make proactive, knowledge-driven and appropriate decisions. The automated, prospective analyses offered by data mining technology move beyond the analyses of past events provided by retrospective tools typically of decision support systems. Data mining tools can answer institution questions that traditionally were too time consuming in past to resolve. Higher education institutions can use classification technique, for a comprehensive analysis of student characteristics, or use estimation and prediction technique to predict the likelihood of a variety of outcomes, such as transferability, choosing elective, choosing right career path, drop out and course success.

A. Data mining tools and algorithms

Machine Learning
Artificial Intelligence
Emulating human intelligence
Neural Networks for prediction
Biological models and psychological models.
SLIQ (Supervised Learning in Quest)

B. Phases of Data Mining

Data mining is an iterative process that typically involves the following phases:
Problem definition
Data exploration
Data preparation
Modeling
Evaluation

C. Tools of Data Collection & Analysis

Various tools are needed for project are for analyzing data, designing, implementation and some developing software tool such as:

MYSQL DATBASE
EXCEL
MS ACCESS
SPSS
METLAB TOOL
WEKA DATA MINING TOOL
TANGARA DATA MINING TOOL
WEB MINER
V.B 6.0

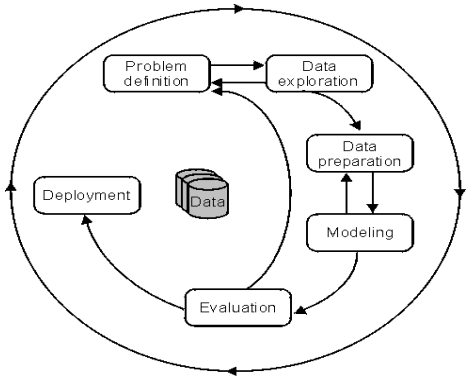

Fig 1.1 Data Mining Process

II. II.DATA MINING: A WAY TO IMPROVE TODAYS HIGHER LEARNING INSTITUTIONS

Data mining is a powerful, new and emerging technology with great potential in information system. It can be best defined as the automated process of extracting useful knowledge and information including, patterns, associations, trees, changes, trends, anomalies and significant structures from large or complex data sets that are not classified. Our main idea is that the hidden patterns, associations, classification and anomalies that are discovered by data mining techniques can help bridge this knowledge gap in higher learning institutions. The knowledge discovered by data mining techniques would enable the higher learning institutions in making better decisions, having more advanced planning in directing students, predicting individual behaviors with higher accuracy, predicting the dropout rates and enabling the institution to allocate resources and staff more effectively. It results in improving the quality, effectiveness and efficiency of the processes. The term data mining is often used to apply to the two separate processes of knowledge discovery and prediction. Knowledge discovery provides explicit information that has a readable form and can be understood by a person at user end. Forecasting, or predictive modeling provides predictions of future events which can help in betterment and may be transparent and readable in some approaches and opaque in others such as neural networks. Data mining relies on the use of real world data. These data are extremely vulnerable to co-linearity because data from the real world may have unknown relations with each other. Data mining is the entire process of applying computer-based methodology, including new techniques and technologies for knowledge discovery. This paper presents how various data mining techniques can be implemented in the field of higher education to discover some meaningful patterns or relations that can further improve the overall performance and quality of higher education and students' respectively.

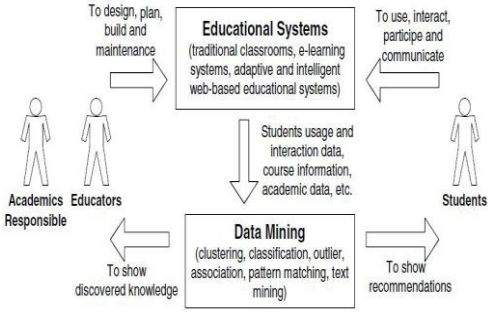

Fig 2.1. The cycle of applying data mining in educational systems

III. III.PROPOSED ANALYSIS GUIDELINE (DM-HEDU) FOR APPLICATION OF DATA MINING IN HIGHER LEARNING INSTITUTION

In this section, we propose a new analysis guideline to present a roadmap or the area of data mining application in higher learning institution. Its adopted and primary name is DM-HEDU (Data Mining in Higher Education System). As today's higher learning institutions deal with powerful and strong business competitors in a highly competitive environment, they have to look for a new, faster and innovative solution to overcome the problems and achieve a high academic institutional standard. Therefore, this guideline may assist the institutions and organizations to identify the ways to improve their processes and help to take decisions. In the previous literature studies we have not discovered a complete guideline which gathers most of the possible processes to improve the level of higher education learning institution through data mining. The idea of the proposed guideline is presented in Fig. 1.1 The importance of DM-HEDU guideline in a higher education learning institutions can be viewed from different perspectives as follows:

Our DM-UEDU guideline can be used for unifying a common context to identify the current gaps and further works in future for any data mining application in a higher education based on the processes of higher education learning institution. It also provides a great opportunity for researchers to be known with the existing area of research and development in the field of higher education learning. There are numerous areas in which data mining can be applied. Following table shows the attributes which can be used in higher education learning:

ID	Objective	Data Mining Method	Explicit Knowledge	Educational Process
1	Use of Data Mining in correct scores	Prediction	The patterns of previous student test score associated with their marks, attendance ,extra-curricular activities and so on.	Planning-Course assessment.
2	Creating meaningful learning outcome typologies	Cluster analysis	The patterns are generated based on previous student's learning outcome	Evaluation-Student assessment
3	Academic planning and intervention transfer prediction	Prediction	The success rate patterns of previous students who had previously transferred subjects	Evaluation-Student assessment
4	Predicting students' overall performance	Classification	Classified pattern of previous students based on their performance throughout the year	Evaluation-Student assessment
5	Improving quality of graduate student by data mining approach	Association, Classification	Characteristic patterns of previous students who took a particular major and The patterns of previous students which were likely to be good in a given major Counseling	Student major counseling

Table 3.1: Summary analysis of previous study

A.ID 1: Uses of Data Mining in CRCT Scores

This study (Gabrilson, 2003) attempts to analyze the most effective factor in determining students' score in various subjects. It presents that the useful and meaningful discovered patterns targeting the various relationship of different types of variables are the major factors affecting the students test score. Using data mining prediction technique, these factors are thus successfully identified.

From this case study the effectiveness of data mining in predicting the most effective and necessary factors in student test score can be concluded. It results in improving the evaluation and also helps in student assessment process. Improving this process has a direct impact in improving transition rate of a higher learning institution and thus decreases the drop-out rate.

B.ID 2: Creating Meaningful Learning Outcome Typologies

This case study aims at creating meaningful learning outcome typologies using data mining techniques. The main objective of obtaining typologies of students is to be able to improve students' performance through predefined clusters of behavior. These clusters help higher education universities to better identify the requirements of each group and make better decision on how to behave with them in terms of educating, offering courses and curriculum, required time for teaching and so on. It results in having more student satisfaction of their studies, course offering, and class's lectures. From this study we can conclude the effectiveness of data mining in developing typologies of students in higher educational domain. The result has a great impact in improving educational achievement of a higher education learning through improving the evaluation-student assessment process.

C.ID 3: Academic Planning and Interventions Transfer Prediction

This case study presents data mining advantages in predicting students' likelihood of transferability for on time intervention. It notifies the institution the types of students who are most at risk of not transferring to a higher level before they know about it. The outcome enables institutions in predicting the likelihood of student transferability. Data mining can link student's academic behavior with their final transfer outcomes. Therefore these kinds of identifications help the institutions to pay more attention to those who require more academic assistance by setting extra classes, consultation hours with the university's counselors and psychologies.

From this study, we conclude the predictions of student's likelihood of transferability assist decision makers with an additional tool to identify those who are not much likely to transfer. As a result, this prediction provides a great potential impact on improving the transition rate of an educational university through improving the student assessment process of an educational domain.

D.ID 4: Predicting a Student's Performance

This case study uses the data mining classification technique to predict the students final grades based on their web-use feature. By discovering the successful patterns of students in various categories, the institute can predict the final grade of each single student. Therefore it helps to identify students who are at risk early and allow the faculty to provide appropriate advice.

From this case study, we can conclude that data mining is effective in predicting student's performances in the educational domain. The result has deep impact in improving the transition rate, and the process indicator of a higher learning institute by improving the student assessment process to some extent.

E.ID 5: Improving Quality of Graduate Students by Data Mining

A study is done by Kitsana (2003) to improve the quality of graduate students with the help of data mining. The objective of our project is to discover and study the knowledge from large sets of engineering student's databases records. The discovered knowledge in the form of patterns is useful in assisting the development of new curricula, improving of existing curricula and most important, helping students to select the appropriate elective. The final result represents the most appropriate elective for each single student. The extracted patterns are useful for university counselors or supervisors who are supposed to counsel and supervise new students.

F. Advantage of Data mining in Academics

Data mining gives the answers of questions like:

Q: Who is the weak/strong student?
Q: Who are the students taking most credit hours?
Q: Which is the interesting subject of the students?
Q: What type of course can institute offer to attract more students?
Q: How can faculty help weak students?
Q: How the overall college result can be improved?
Q: Is the teaching pattern satisfactory or need to be changed?
Q: Which is the most appropriate elective for the student?

IV. DATA ANALYSIS AND INVESTIGATION

A. Domain Understanding

In this phase the higher education is wholly analyzed and the main data mining objectives are set and targeted accordingly.

B. Data Understanding

In this phase, the required raw data and attributes of students and faculties are collected based on the pre-defined objectives. According to our data mining goal, the raw data is related to:

1) Student demographic and academic knowledge.
2) Lecturer demographic and academic knowledge.

3) Course information and contents.
4) Semester status information and planning.

The data are then described and explored by (i) identifying pre-defined initial format of data, (ii) the meaning and description of individual attributes of student and faculty and (iii) determining the relation of attributes with each other. The final part verifies the quality of data by determining the completeness and correctness of data.

C. Data Preparation

This phase of data mining is the final step of directly dealing with data. The dataset produced in this section is used for modeling and the major analysis task. The importance of data preparation is to maximize visibility of the relationship that exists between input and output data sets, which is captured with a modeling tool. Prepared data enables data mining technique to generate a better and efficient model.

V. DATA MINING MODELING

The knowledge obtained from data mining techniques gives the managerial decision makers the useful information for for taking making proper decisions. The models are classified in two main categories: predictive models and descriptive models.

• Descriptive model describes the data set in a concise and summarized manner and presents the interesting and important general properties of the data. It explains the extracted patterns in existing data, which may be used to guide managerial decisions.

• Predictive model predicts behavior based on previous data and uses data with known results to build a model that can be used in future to explicitly predict values for different data (Two Crows Corporation, 1999).

A. Predictive Data Mining Models

Model A: Predicting Student Success Rate for Individual Student

This model is developed to predict the student success rate for individual students and to predict the student dropout rate. The explicit knowledge discovered from this model can be used by student management system to consult individual student based on his performance in successful course taking and choosing appropriate electives. Within this procedure, if the students are predicted to be unsuccessful, then they are provided with extra consultation and extra efforts are taken by faculty and the universities to help them to get improved in the course. If they are successful, new personal policies for the successful student course taking are set.

For classification method, the experiments are conducted through decision tree using Supervised Learning In Quest algorithm (SLIQ) (Mehta et al., 1996) and neural classification. For prediction method the experiments are conducted using neural prediction (Han and Kamber, 2001) and Radial Basis Function (RBF).

Model B: Predicting Student Success Rate for Individual Lecturer

This model is developed to predict the student success and failure rate for individual lecturer. The explicit knowledge discovered from this model can be used by management for general and managerial decision-making. It can be used to support policies and procedures, which are set at top-level management. This model is applied through prediction (neural network) and classification (SLIQ and neural network) techniques.

Model C: Model of Lecturer Course Assignment Policy Making

This model is developed to describe the characteristics pattern and way of teaching of lecturers who plan to take the course. The knowledge discovered from this model can be used for general decision making at top-level management. It helps in knowing how the lecturer teaches.ie.is his teaching pattern fruitful or not. It assists in supporting the current managerial rules and regulations in lecturer course assignment policy making and it also helps to set new strategies and plan for managerial decision makers on those lecturers who plan to conduct the course.

V. CONCLUSION AND FUTURE WORK

The current education system does not involve any prediction about fail or pass percentage of students based on their performance. The system doesn't deal with student dropouts. Since the proposed model identifies the weak and lagging students, the teachers can provide support and academic help for them. It also helps the teachers to act before a student drops or plan for recourse allocation with confidence gained from knowing how many students are likely to pass or fail. Among several innovation in recent technology, data mining is making a great impact and comprehensive changes in the field of higher education. Such activities will definitely guide to better decision making procedures and will improve the quality of education.

As a further work, we would like to enhance other data mining processes in higher learning institution by referring to DM-HEDU analysis guideline. These processes are according to first class priorities of the institutions. Other work can be generating student and lecturer models for the other type of course offered in the

institute. Since the application of data mining brings a lot of advantages in higher learning institution and even helps in improving the quality of students and education, it is recommended to apply these techniques in other academic institution like primary and secondary schools, language institutions, institutions for special students and private and government colleges especially in India.

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Qualitative Analysis of a Discrete SIR Epidemic Model

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ABSTRACT:
The dynamical behaviors of a discrete-time SIR epidemic model are analyzed in this paper. Existence and stability of disease-free and endemic equilibria are investigated. Basic reproduction number for the system is computed. Numerical simulations show that the system has complex and rich dynamics and can exhibit complex patterns, depending on the parameters. Also the bifurcation diagrams are presented.
KEYWORDS: *Epidemic model, difference equations, stability, bifurcation.*

I. INTRODUCTION

Infectious diseases have tremendous influence on human life. Every year millions of human beings suffer or die of various infectious diseases. Controlling infectious diseases has been an increasingly complex issue in recent years. Mathematical models have been extensively used in the study of spread of epidemics and diseases. The models aim to capture the major factors that are responsible for the progression of diseases, and can forecast how diseases spread. The results obtained from these models are useful in predicting how infectious diseases develop and spread. Kermack and McKendrick derived the simple classical SIR model in 1927. In the classical epidemiological SIR model, a population of total size N is divided into S susceptible numbers, I infective numbers, and R recovered numbers.

II. FORMATTING YOUR PAPER

Analytical and numerical studies of system of difference equations models in epidemiology have uncovered a number of interesting dynamical behaviors including stable steady states, oscillation, limit cycles and chaos. In recent years, several authors formulated and studied natural discrete approximation to the continuous epidemic models obtained by applying Euler's Method. In this paper, we consider the SIR epidemic model as a system of difference equations. In this model, the susceptible host population is assumed to follow the logistic growth with a specific growth rate constant r. The force of infection is $\frac{\beta S(n)I(n)}{1+aS(n)}$. The parameter a measures the inhibitory effect, γ is the natural recovery rate of the infective individuals. Also μ and λ represent the per capita death rates of infective and recovered. Throughout this paper, we assume $a \neq 0$.

$$\begin{aligned} S(n+1) &= rS(n)[1-S(n)] - \frac{\beta S(n)I(n)}{1+aS(n)} \\ I(n+1) &= \frac{\beta S(n)I(n)}{1+aS(n)} + (1-(\mu+\gamma))I(n) \\ R(n+1) &= \gamma I(n) + (1-\lambda)R(n) \end{aligned} \qquad (1)$$

We restrict our attention to the reduced model described by the system of following two equations.

$$\begin{aligned} S(n+1) &= rS(n)[1-S(n)] - \frac{\beta S(n)I(n)}{1+aS(n)} \\ I(n+1) &= \frac{\beta S(n)I(n)}{1+aS(n)} + (1-(\mu+\gamma))I(n) \end{aligned} \qquad (2)$$

A point x^* is said to be a fixed point (or equilibrium point) of a map f if $f(x^*) = x^*$. It is important to develop qualitative or graphical methods to determine the behavior of the orbits near fixed points. We consider the equilibria of system. The system admits the Equilibrium points $E_0 = \left(\frac{r-1}{r}, 0\right)$ (the disease free equilibrium since I and R components are zero), $E_1 = \left(\frac{K}{A}, \frac{1+r}{A} - \frac{rK}{A^2}\right)$ where $K = \mu + \gamma$ and $A = -\beta + a\mu + a\gamma$, (endemic equilibrium of the model).

III. DYNAMIC BEHAVIOR OF THE MODEL

The purpose of this paper is to study the nonlinear dynamics of system. Mathematically, the stability of the equilibrium points starts with linearization of the system (1). The stability of these equilibrium points can be investigated by linearization. The Jacobian Matrix for the reduced system (2) is

$$J(S,I,R)=\begin{bmatrix} r-2rS-\frac{(1+aS)\beta I-\beta SIa}{(1+aS)^2} & -\frac{\beta S}{1+aS} \\ \frac{(1+aS)\beta I-\beta SIa}{(1+aS)^2} & \frac{\beta S}{1+aS}+(1-K) \end{bmatrix} \qquad (3)$$

Trace $J(S,I,R)=r-2rS-\frac{(1+aS)\beta I-\beta SIa}{(1+aS)^2}+\frac{\beta S}{1+aS}+(1-K)$ and

Det $J(S,I,R)=\left(r-2rS-\frac{(1+aS)\beta I-\beta SIa}{(1+aS)^2}\right)\left(\frac{\beta S}{1+aS}+(1-K)\right)+\left(\frac{(1+aS)\beta I-\beta SIa}{(1+aS)^2}\right)\left(\frac{\beta S}{1+aS}\right)$

Lemma 1. Let

$$p(\lambda)=\lambda^2+p_1\lambda+p_2=0 \qquad (4)$$

be the characteristic equation for a matrix defined by (3). Then the following statements are true:

- If every root of equation (4) has absolute value less than one, then the equilibrium point of the system (1) is locally asymptotically stable and equilibrium point is called a sink.
- If every root of equation (4) has absolute value greater than one, then the equilibrium point of the system (1) is a source.
- The equilibrium point of system (1) is called hyperbolic if no root of equation (4) has absolute value equal to one. If there exists a root of equation (4) with absolute value equal to one, then the equilibrium point is called non-hyperbolic.

Proposition 2. The disease free equilibrium point E_0 is a

Sink if $1<r<3$ and $-\left(\frac{2-K(r+a(r-1))}{r-1}\right)<\beta<\frac{K(r+a(r-1))}{r-1}$

Source if $r>3$ and $\frac{\beta(r-1)}{r+a(r-1)}-\gamma>\mu>2+\frac{\beta(r-1)}{r+a(r-1)}-\gamma$

Non hyperbolic if $r=1$ and $\frac{K(r+a(r-1))}{r-1}$

Proof:

$$J(E_0)=\begin{bmatrix} -r+2 & -\frac{\beta(r-1)}{r+a(r-1)} \\ 0 & \frac{\beta(r-1)}{r+a(r-1)}+(1-K) \end{bmatrix} \qquad (5)$$

The Eigen values of the matrix $J(E_0)$ are $\lambda_1=-r+2$, $\lambda_2=\frac{\beta(r-1)}{r+a(r-1)}+(1-K)$. In view of Lemma, we see that, E_0 is a sink if $1<r<3$ and $-\left(\frac{2-K(r+a(r-1))}{r-1}\right)<\beta<\frac{K(r+a(r-1))}{r-1}$. E_0 is a source if $r>3$ and $\frac{\beta(r-1)}{r+a(r-1)}-\gamma>\mu>2+\frac{\beta(r-1)}{r+a(r-1)}-\gamma$. Also E_0 is non-hyperbolic if $r=1$ and $\frac{K(r+a(r-1))}{r-1}$.

The basic reproduction number R_0 is defined as the average number of secondary infections that occur when one infective is introduced into a completely susceptible host population. R_0 is also called the basic reproduction ratio or basic reproductive rate. For our system $R_0=\frac{\beta(r-1)}{(r+a(r-1))(\mu+\gamma)}$ is the reproduction number.

$$J(E_1)=\begin{bmatrix} r-\frac{2rK}{A}-\frac{\beta K\left(1+r-\frac{rK}{A}\right)(1+a)}{(A+aK)^2} & \frac{-\beta K}{A+aK} \\ \frac{\beta K\left(1+r-\frac{rK}{A}\right)(1+a)}{(A+aK)^2} & \frac{\beta K}{A+aK}(1-K) \end{bmatrix} \qquad (6)$$

Trace $J(E_1)=p_1=r-\frac{2rK}{A}-\frac{\beta K\left(1+r-\frac{rK}{A}\right)(1+a)}{(A+aK)^2}+\frac{-\beta K}{A+aK}(1-K)$

$$\text{Det } J(E_1) = p_1 = \left(r - \frac{2rK}{A} - \frac{\beta K\left(1 + r - \frac{rK}{A}\right)(1 + a)}{(A + aK)^2}\right)\left(\frac{\beta K}{A + aK}(1 - K)\right)$$
$$- \left(\frac{\beta K\left(1 + r - \frac{rK}{A}\right)(1 + a)}{(A + aK)^2}\right)\left(\frac{\beta K}{A + aK}\right)$$

IV. NUMERICAL EXAMPLES

In this section, we present some numerical simulations of system (1) to illustrate our results. The numerical examples substantiate the analytical results obtained in the previous section. Numerical study of nonlinear discrete dynamical systems gives an insight in to dynamical characteristics. The time plots for S(n); I(n); R(n), phase portraits and bifurcation diagrams for the system (1) are presented. Dynamic behaviors of the system (1) about the equilibrium points under different sets of parameter values are studied.

Example 1. Take $r = 2.95, \beta = 0.8, \gamma = 0.15, \mu = 0.00999.$

Since R_0 then the disease-free equlibrium is globally asymptotically stable for any period.

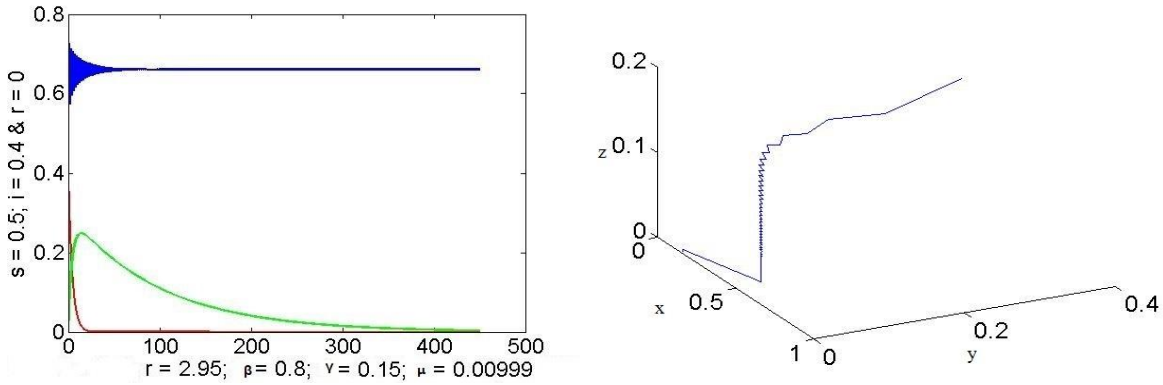

Figure 1. Dynamical Behavior of Trivial Equilibrium points $R_0 < 1$

Example 2. Take $r = 2.7, \beta = 0.35, \gamma = 0.059, \mu = 0.00999.$

Since $R_0 > 1$ then the endemic equilibrium is globally asymptotically stable for any period.

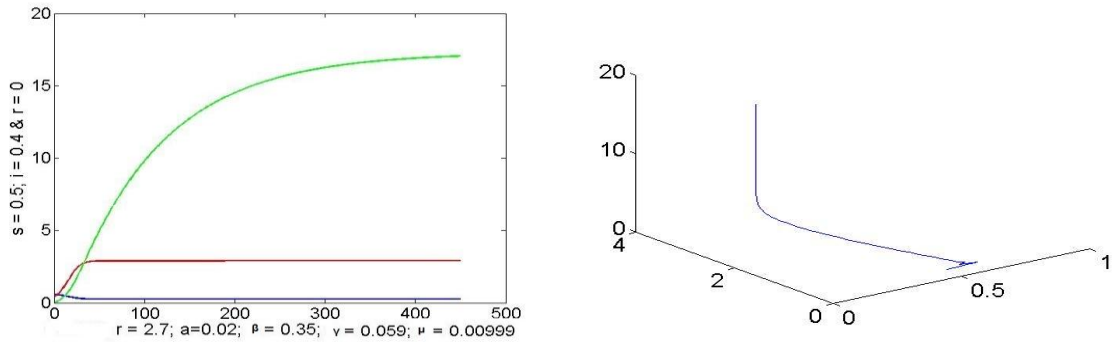

Figure 2. Dynamical Behavior of Trivial Equilibrium points $R_0 > 1$

Example 3. Take $r = 2.95, \beta = 1.7, \gamma = 0.15, \mu = 0.00999$. The system exhibits oscillatory behaviour and the phase portrait is reduced to a limit cycle.

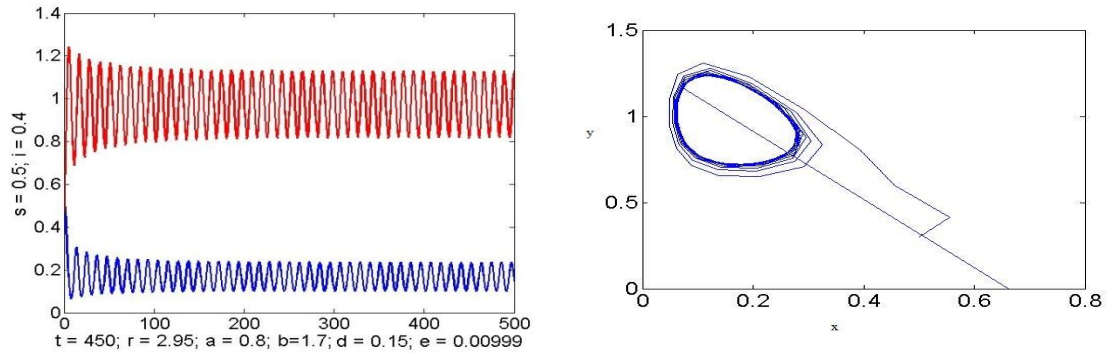

Figure 3. Time plot of Interior Equilibrium Point

Example 4. Take $a = 0.8, r = 2.95, \mu = 0.009, \gamma = 0.05, \lambda = 0.0099$. Also β is given three different values $\beta = 0.097, 0.068, 0.19$ together with the other parameter such that $R_0 < 1$. The infection dynamics is illustrated in the Figure-4.

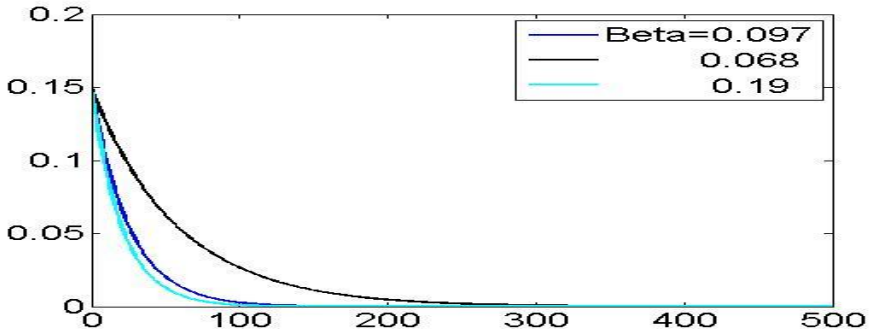

Figure 4. variation of Beta

V. BIFURCATION

Bifurcation theory is the mathematical study of changes in the qualitative behavior of a given family and the solutions of a family of differential equations. Most commonly applied to the mathematical study of dynamical systems, a bifurcation occurs when a small smooth change made to the parameter values (the bifurcation parameters) of a system causes a sudden 'qualitative' or topological change in its behaviour. In general, the term bifurcation refers to the phenomenon of a system exhibiting new dynamical behavior as a parameter is varied. The numerical analysis of bifurcation problems is concerned with the stable, reliable and efficient computation of solutions to nonlinear problems. The technique of linearization used for stability analysis may fail at bifurcation points, for near such points the dynamical behaviors of the system may differ qualitatively from those of its linearized system. The Neimark Saker bifurcation for discrete dynamical systems corresponds to the Hopf bifurcation in the continuous case. We use the numerical simulations to display bifurcation diagram for susceptible population.

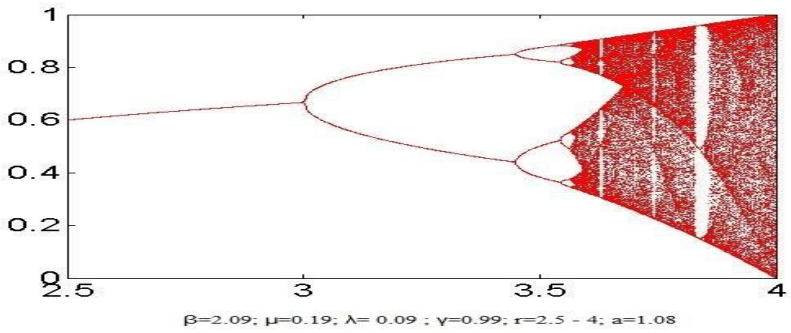

Figure 5. Bifurication

The following diagrams exhibit the change in the dynamical nature of $S(n)$ for values of r chosen from different ranges in the bifurcation diagram.

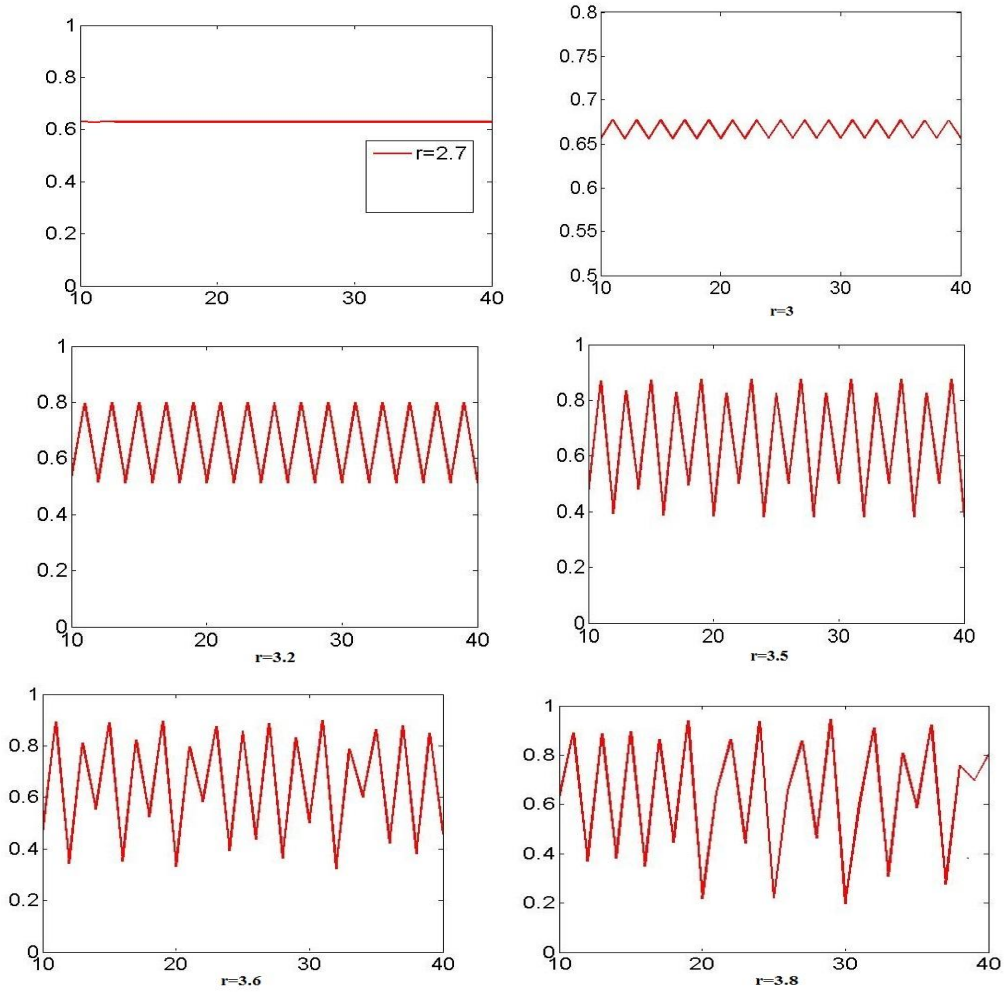

Figure 6. Dynamics in different values of r

In the present paper we examined the bifurcation of a mathematical model for the spread of an infectious disease. In order to eradicate the disease, the basic reproduction number R_0 must be lowered than a threshold. The basic reproductive number R0 determines the existence of the equilibrium. When $R_0 \leq 1$, model (1) has a unique disease-free equilibrium. When $R_0 > 1$, model (1) has a disease-free equilibrium and a unique endemic equilibrium.

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Cost Optimization in Multi Cloud Platforms using Priority Assignment

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ABSTRACT

Cloud computing is one of the emerging technologies today. The cost and pricing schemes that are often associated with the cloud services offered can be misleading to most users. Cost optimization is very important as far as cloud services are concerned. In this paper, a priority assignment function is introduced, which assigns priority to the data, based on which the data storage and encryption is performed, depending on the priority assignment which in turn reduces the unnecessary cost and time complexity that is associated with data storage.

KEYWORDS: *Virtual Machine, Virtual Machine Monitor, Directed Acyclic Graphs, Transformation Oriented Framework etc…*

I. INTRODUCTION

Cloud computing is one of the emerging technologies today. Different categories of people use the services that are offered by the cloud today ranging from individuals to large organizations. Costs that are often associated with the cloud services can be very high. Hence it is very important that the operations that are associated with the cloud needs to be optimized. One of the performance challenges facing traditional cloud computing environments is rooted in their architecture. First-generation cloud platforms were housed in a relatively small number of relatively large, high-capacity data centers. Even when these large data centers are housed in the world's largest networks, the average distance between the data center and the end user can be more than 1500 miles. Optimizing the cloud for maximum performance involves a more distributed cloud, with capacity located in many locations, closer to end users. This reduces the number of network 'hops' that every request, every piece of data, every bit of content must make to reach the end user. The shorter the distance, the fewer network hops, the greater the speed, and the better the user experience. The cloud services offered often removes the problems associated with actual physical hardware manipulation. The cloud also provides task execution environments and facilities by allocating virtual machines to the tasks. The virtual machines are designed so as to support different execution needs. They are generally allocated depending upon the type of tasks that are to be executed by the user who is requesting to perform the tasks. The cloud service providers make use of the pay as you go pricing scheme, where the user will be billed on the basis of a particular time slot that is allotted to him. This scheme is often advantageous to many users as the get to access resources of much larger capacity, for each time interval. The data storage part is also important, as the data that is to be stored into the cloud should be stored in such a way that the overall cost that is associated with the data storage is also reduced.

II. RELATED WORK

There had been many approaches towards cost optimization in cloud systems. There are different operations that were performed on tasks, as well as on files that are stored on to the cloud so as to improve the cost factor. Earlier papers discuss operations such as merge, promote, demote, split, move and co scheduling operations on tasks so as to improve the VM utilization as well as to reduce the overall costs. Different tools that are associated with workflow management such as Pegasus[12], [1]workflow execution environments such as DagMan and Condor are discussed in detail in previous studies. Some studies discuss cost optimization in cloud systems by optimally under clocking the VM's so as to decrease the overall power consumption by using mechanisms such as DVFS[8]. Grid workflow execution strategies[5] based on algorithms such as the ADOS algorithm have also been discussed in previous studies.

III. EXISTING SYSTEM

Before specifying our existing system, we need to have an understanding regarding the following concepts:

3.1 VM:

The virtual machine instance is the actual platform that is designed to carry out the workflow execution. It may be different for different tasks depending upon the time and resource constraints that are imposed by the particular task.

3.2 VMM:

There are different virtual machines that are used for the execution of the different tasks. They have to be maintained and usually are present as a pool of VM's. The Virtual Machine Monitor is responsible for the management of the virtual machines[1]. The Virtual Machine Monitor keeps track of the various virtual machines, to which task they are allocated, when they will be freed etc.

3.3 DAG:

Directed Acyclic Graph is generated by breaking down the jobs[1]. They represent how the workflow proceeds. The various operations that are specified are also performed on workflows. Our existing system performs the specified workflow optimization operations which is performed on workflows for optimizing them. Each task or job is broken down into corresponding DAG's. The DAG's specify the operations that are performed in a job.

The existing system introduces ToF, in which 2 schemes based on which workflow optimization takes place. It also introduces a planner, which governs how the following operations are to be performed so as to obtain the most optimal result. The existing system, when compared to other systems, reduces the overall cost of workflow execution. However, there is no hint of how the data post processing, will be stored in the cloud databases. There will be different types of information that are present in the cloud. So, providing the same level of security to all the data is not a good or as optimal method of storage in the cloud. As shown in the figure, the workflows are put in a FIFO queue and on its basis the optimization is carried out. The optimizer repeatedly checks, whether any possible optimizations can be employed on the DAG's. Two operations - Merge and Demote are the main schemes and Move, Promote, Co-Scheduling, Split, etc. are the auxiliary schemes. The transformation model is responsible for performing the various transformations, while the time of action is specified by the planner. The auxiliary schemes support the execution of the main schemes. The transformation model is responsible for performing the various transformations, while the time of action is specified by the planner.

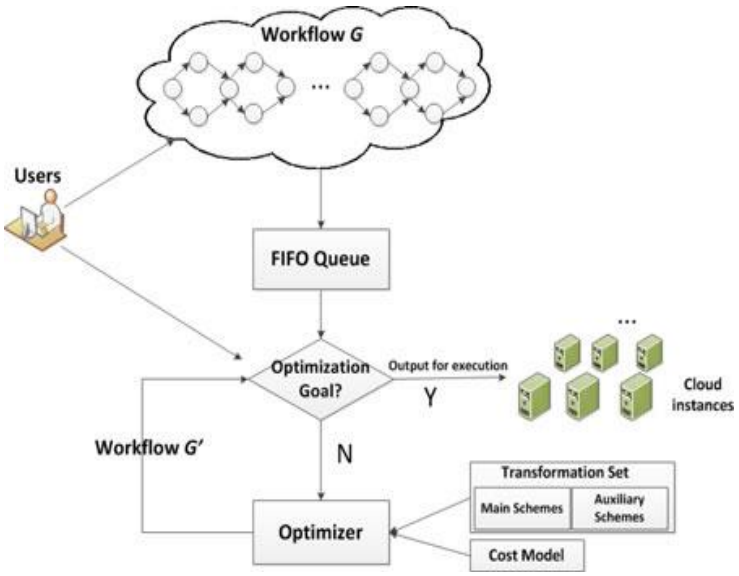

Figure 3.1 ToF Overview

3.1 ToF Optimization Algorithm

ToF optimization algorithm is used in the existing system for performing the various operations on the tasks. The algorithm operates on the tasks, and initially it pretends to apply the Merge and Demote[1] operations on the task. It checks whether by the application of any of these operations, the time assignment of any task will skip the deadline. If so, then the operations cannot be performed. Else, if it is possible to apply these operations, then the operation that will bring about the most optimization will be applied.

The main objective of the application of the ToF optimization framework is to maximize the optimization potential, i,e, by reducing the overall cost and time needed for the execution of that particular task. The other operations, i.e, auxiliary operations are also applied, if the main operations can be performed; i.e, the time constraints are not violated. The operations are done until no Figure 3.2 illustrates the ToF Algorithm.

3.2 Planner

Planner is the next important component that is associated with the optimization framework. Although the operations are needed for performing the cost and time reduction, i.e, optimization, the operations have to be applied systematically to the various task that arrive to be executed. The planner has the following properties:

1. The evaluation of the searching space that is associated with the conduct of the operation is a tedious task. Besides using the main as well as the auxiliary schemes alternatively, so as to reduce the overhead that is associated with searching unnecessary tasks. The planner also makes use of the cost model, so as to prune off the unnecessary operations, that does not yield any favourable results.
2. The planner that is used within this scheme is rule based. i.e, it works on the basis of a set of rules, consisting of certain conditions and actions. The conditions denote the situations to be met for the actions to be performed.
3. The planner is ran periodically, so as to make the system dynamic and work in real time[1]. i.e, the tasks should be allocated periodically to new VM instances. The pay as you go pricing scheme of the cloud structure means that the service that is offered can be used for a particular time period only.

Algorithm The optimization process of ToF for workflows in one plan period.

```
Queue all coming workflows in a queue Q;
for each workflow w in Q do
    Determine the initial assigned instance type for each task in w;
repeat
    for each o_m in main schemes (i.e., Merge and Demote) do
        Pretend to apply o_m and check whether the earliest start or
        latest end time constraint of any task in w is violated after
        applying o_m;
        if No time constraint is violated then
            Estimate the cost reduced by performing o_m using the
            cost model;
    Select and perform the operation in main schemes which has
    the largest cost reduction;
    for each o_a in auxiliary schemes (i.e., Move, Promote, Split
    and Co-scheduling) do
        Pretend to apply o_a and check whether the earliest start or
        latest end time constraint of any task in w is violated after
        applying o_a;
        if No time constraint is violated then
            Estimate the cost reduced by performing o_a using the
            cost model;
    Select and perform the operation in auxiliary schemes which
    has the largest cost reduction;
until No operation has a cost reduction;
return Optimized instance assignment graph for each workflow.
```

Figure 3.2 ToF Algorithm

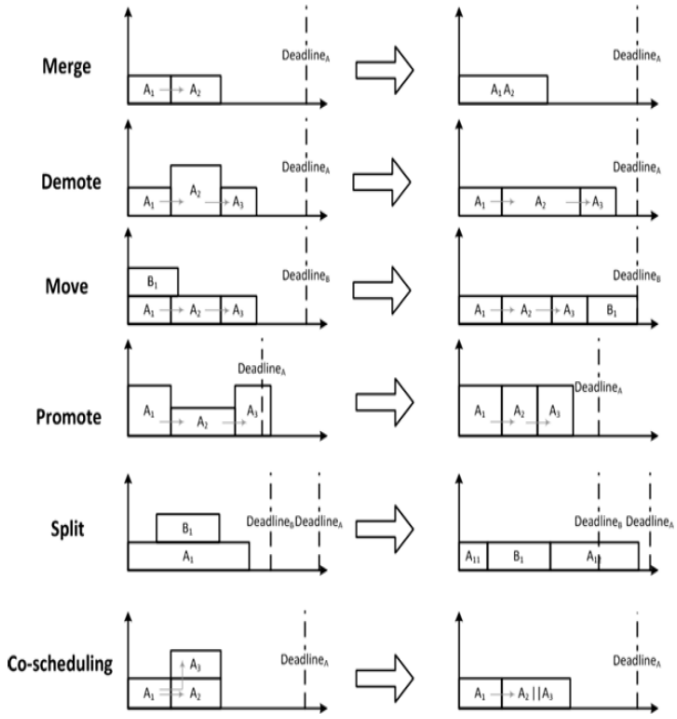

Figure 3.3 Instance time chart based on transformation operations

Figure 3.3: ToF operations

Name	Category	Description	Formulation
Merge	Main	Merge multiple tasks to the same instance to fully utilize partial hour.	$\mathcal{M}(V_i(t_0,t_1),V_i(t_2,t_3)) \rightarrow V_i(t_0,t_3)$
Demote	Main	Assign a task to a cheaper instance type.	$\mathcal{D}(V_i(t_0,t_1)) \rightarrow V_j(t_2,t_3)$, where $i > j$
Move	Auxiliary	Delay a task to execute later.	$\mathcal{V}(V_i(t_0,t_1)) \rightarrow V_i(t_2,t_3)$, where $t_3 = t_2 + (t_1 - t_0)$
Promote	Auxiliary	Assign a task to a better instance type.	$\mathcal{P}(V_i(t_0,t_1)) \rightarrow V_j(t_2,t_3)$, where $i < j$
Split	Auxiliary	Stop a running task at some checkpoint and restart it later.	$\mathcal{S}(V_i(t_0,t_1)) \rightarrow V_{i1}(t_0,t_2),V_{i2}(t_3,t_4)$
Co-scheduling	Auxiliary	Assign two or more tasks to the same instance for execution.	$\mathcal{C}(V_i(t_0,t_1),V_i(t_2,t_3)) \rightarrow V_i(min(t_0,t_2),max(t_1,t_3))$

IV . PROPOSED SYSTEM

In the proposed system, a mechanism is employed that ensures only the relevant data that is stored within the cloud databases are secured with relevant algorithms. A priority assignment feature is also proposed, which helps to assign priority to the information that has to be stored in the cloud. The system is explained with the concept of a multi cloud implementation, where the data is stored in different cloud databases. The encryption is done on the basis of the priority that is assigned to each data, and those data which are not assigned any priority will be considered as general data, and will be stored in a separate database. This removes a portion of the burden that is associated with encryption and decryption and helps to reduce the cost further, as far as any cloud service provider is concerned. It also helps to reduce unnecessary precautions that are taken to protect the data that is stored within the cloud. There will be significant cost reduction in large data storage structures, or in places where huge amounts of data are produced from the execution of tasks, that need to be stored within the cloud.

4.1 Priority Assignment

The priority assignment can be made to tasks by the the user. The execution as well as the storage of the result will depend upon the priority that is assigned. Based on the priority, it is decided, whether to provide encryption before the data is stored within the secured cloud storage, or to store it without encryption separately. Hence the overhead of encryption and decryption for unnecessary data as well as the cost associated with it is reduced. This improves the overall performance of large task execution clusters, where a lot of output data may be generated as the result. The priority assignment truly becomes a boon in such scenarios, where the bulk of information can be chosen to store on priority basis.

V. EXPERIMENTATION & RESULTS

The simulation is carried out using two systems, on which one of them runs the VM application and the other runs the client side. Both systems are powered by intel dual core processors with 1GB of RAM. The systems are interconnected via LAN. The admin system illustrates the admin, which is responsible for performing the various operations on the tasks that are provided by the user. The VM is hosted on the system, which is responsible for performing the various operations on the tasks that are provided by the user. The system is simulated with the help of one user as well as one arithmetic operation that is given to the virtual machine. The cost is evaluated by setting predefined cost parameters that is set based on the evaluation criteria of similar other systems, such as the ToF. The overall cost i.e, the cost of the operations as well as the data storage combined, is slightly lower for this scheme as compared to the earlier scheme, where additional modules are used for storing the computation results. Additionally, our scheme also deals with the data storage service, post processing. The comparative study is done, by considering the ToF.

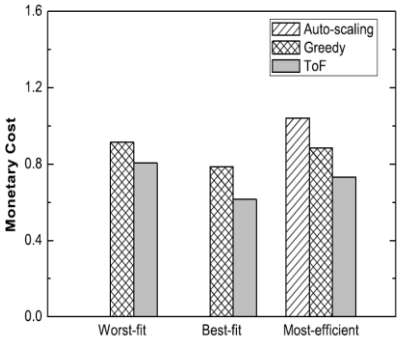

Figure 5.1 Comparison of ToF with other schemes

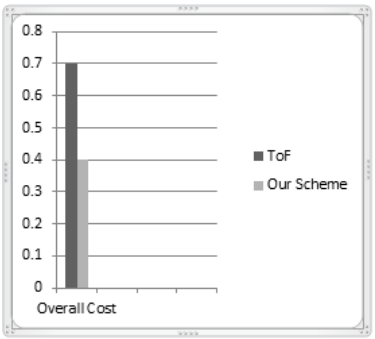

Figure 5.2 Comparison of ToF with our scheme

VI. CONCLUSION

The cost optimization for workflows is one of the most important activities, that is being carried out by different cloud vendors to reduce their overall execution time as well as the total monetary cost. Our system includes the advantages that are proposed by the ToF scheme, as well as the reduction in unnecessary cost incurred due to the provision of security to all the data, that is provided. The storage as well as the retrieval part is also simplified due to the removal of encryption to non important data. The system focuses primarily on cost reduction. Less focus has been given on reducing the computation time as well the batch processing of similar tasks, which can be enhanced, to further improve this scheme.

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Integrated Circuitry For Better Energy Transfer Through Resonant Coupling

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ABSTRACT

In this modern era, electricity has become the life's heart.Even a moment without electricity makes you thinking as though you go dry. The major source of transmission of conventional form of electricity is through wires. The continuous research and development has stepped forward a major quantum leap,which aids transmission of electricity without the medium of wires. This paper describes an authentic idea to annihilate the haphazard usage of wires which implicates lot of confusion in particularly regulating them. When we fantasize a future in which transmitting power wirelessly is feasible in cell phones, household robots, mp3 players, laptop computers and other portable electronics which can charge by their own without getting plugged, pardoning us from that eventual, universal power wire.Bulky batteries of these devices might not be even required to operate.Power can be transmitted efficiently upto 95% in this method through non-radiative means.This mechanism mainly involves the principle of using resonance inductive coupling wherein both the transmitter and the receiver operates at resonant frequency.Power transmission gets more efficacious when both the coils are strongly coupled. The transmitter emits a non-radiative magnetic field resonating at KHz frequencies and the receiving unit load resonates in that field.Compared with prevalent magnetic inductive coupling energy transmission devices, the efficiency of the proposed system is much higher.

KEYWORDS*—non-radiative; resonating inductive coupling; strong coupled;KHZ frequency; efficiency higher*

I. INTRODUCTION

With a large source coil and three receiver coils,wireless transmission of power is being demonstrated in this paper. Lumped capacitors that terminate coil the coils are used to achieve resonance between the coils.Though we are aware of wireless power transmission through radio waves and laser beams,both are not feasible.Thats because radio waves spread in the air and so much of the power gets wasted.In the case of laser,power transmission is possible only when there is line of sight without any obstacles in between.Laser usage for power transmission could also become dangerous during certain circumstances,thus these methods prove to be implausible. Wireless transmission of electricity through resonance magnetic coupling has formidable impacts like immense transmission probity and flat loss and can be transmitted to all over the globe and exclude the need for a faulty, costly, and capital accelerated grid of cables, towers, and substations. The cost of electrical energy used by the customer would be reduced hence getting rid of wires, cables, and transmission towers.

The cleaving up of resonant frequency is observed experimentally and described theoretically for multiple receivers.While taking into the analogy of a single receiver system which is at resonance, more than 50% of the power given by the definite source is delivered to the load but in the case of a multiple receiver system, a means for capturing frequency shifts and continuous retuning of the abided capacitances that end each receiver coil is done so as to widen the performance. In this way,a proficient wireless channel for power transmission can be entrenched and the completeness could be achieved as high as 60%–90% with a distance of about 1cm–3m between the transmitter and the receiver. In other words, this system works with a relative high competency even if there is misalignment due to the operating conditions in a factual situation.

A. Mutual coupling between the coils

In this paper, we describe about two new augmentations:

1) We demonstrate power transfer from a single resonant source coil to multiple resonant receivers, concentrating on the resonant frequency splintering issues that arise in various receiver applications.

2) We show that resonant coupling systems with either single or multiple receivers can be designed using a relatively simple circuit description.The design accurately takes into account mutual coupling between the coils.This description makes it clear that steep Q ringing coupling is the key to the productivity of the system,through an application where the primary coil is inductively coupled to the power source and the receiving coils are anteriorly coupled to the loads.

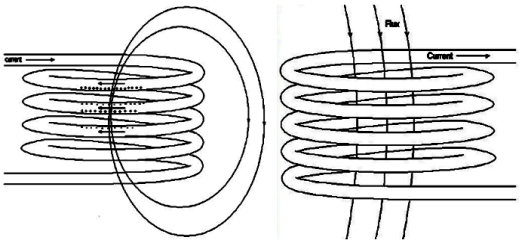

Fig. 1. Mutual coupling between the transmitter and receiver coils

II. RESONANT MAGNETIC COUPLING METHOD

In this method,a circuit model is developed to describe the system with a single receiver, and extended to describe the system with three receivers. With parameter values chosen to obtain good fits, the circuit models yield transfer frequency responses that are in good agreement with experimental measurements over a range of frequencies that span the resonance. An efficient method for wireless power transfer would enable advances in such diverse areas as embedded computing, mobile computing, sensor networks, and microrobotics. The need to minimize energy consumption is often the main design driver in applications where devices need to operate untethered. Energy consumption often restricts or severely limits functionality in such applications. The work described in this paper is motivated by potential application of magnetic resonant coupling as a means for wireless power transfer from a source coil to multiple receivers.Through simple experimental setups and corresponding circuit models, we address issues that are involved in applying the basic mechanism to both a single receiver and multiple receivers with sizes much smaller than the source coil. In the case of wireless electricity transfer systems,the resonant nature of the process ensures that the interaction between the source and device is sufficiently strong and the interaction with non-resonant objects is minimal.

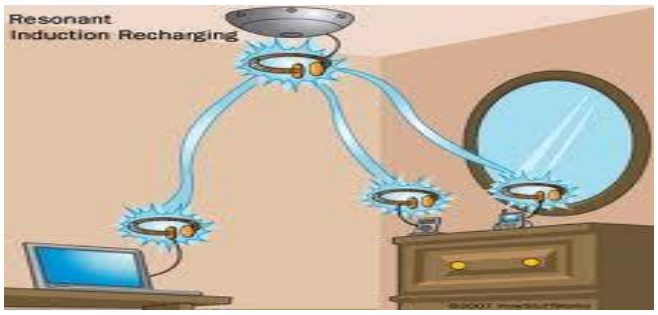

Fig. 2. Inductive recharging through magnetic resonance

A. Comparison with the inductive coupling

Traditional inductive coupling methods have limited transmission distance due to weak coupling between the source and loads. This occurs in the charging of conventional electric toothbrushes. The tooth brush with the receiving coil is placed on the source cradle for getting charged. The efficiency is as low as 1-2%. Using magnetic resonance the transmitting source coil frequency exactly matches the frequency of the receiving coils at resonance. Since the energy transfer is maximum at resonance, magnetic resonance coupling is found to have an efficiency of about 95% .

III. PRINCIPLE OF WORKING OF THE PROPOSED MODEL

A. Resonance

Resonance is a property that exists in many different physical systems. It can be thought of as the natural frequency at which energy can most efficiently be added to an oscillating system. A playground swing is an example of an oscillating system involving potential energy and kinetic energy. The child swings back and forth at a rate that is determined by the length of the swing. The child can make the swing go higher if she properly coordinates her arm and leg action with the motion of the swing. The swing is oscillating at its resonant frequency and the simple movements of the child efficiently transfer energy to the system. Another example of resonance is the way in which a singer can shatter a wine glass by singing a single loud, clear note. In this example, the wine glass is the resonant oscillating system. Sound waves travelling through the air are captured by the glass, and the sound energy is converted to mechanical vibrations of the glass itself. When the singer hits the note that matches the resonant frequency of the glass, the glass absorbs energy, begins vibrating, and can eventually even shatter. The resonant frequency of the glass depends on the size, shape, thickness of the glass, and how much wine is in it.

B. Resonant magnetic coupling

Magnetic coupling occurs when two objects exchange energy through their varying or oscillating magnetic fields. Resonant coupling occurs when the natural frequencies of the two objects are approximately the same.The power sources and capture devices are specially designed magnetic resonators that efficiently transfer power over large distances via the magnetic near-field. The proprietary source and device designs and the electronic systems the control them support efficient energy transfer over distances that are many times the size of the sources/devices themselves.

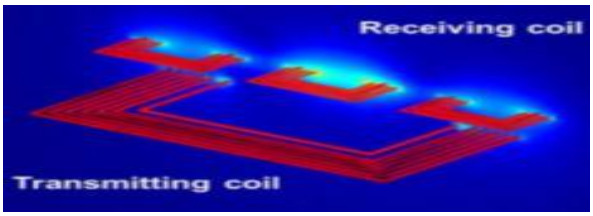

Fig. 3. Resonant magnetic coupling between the coils

IV. THEORY AND DESIGN OF THE PROPOSED MODEL

Wireless Power Transmission using magnetic resonance coupling, is one of the efficient ways to transfer power between points without the use of conventional wire system. Wireless power transmission is very much useful in areas where wire system is unreachable or impossible. This is done using charging a resonant coil from AC and then transmitting the subsequent power to the resistive load.

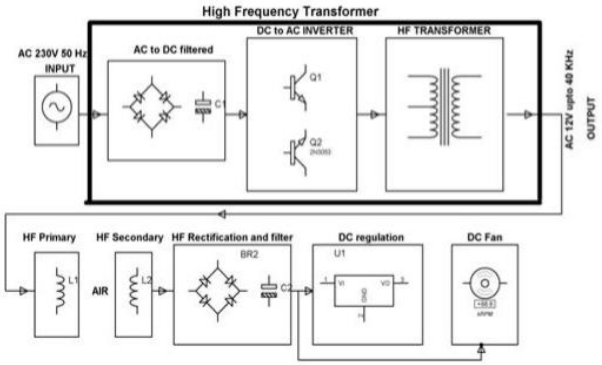

Fig. 4. Block diagram of the proposed model

The transmitter coil in this wireless power transmitter section is given 230v ac supply.This high frequency alternating current, which is linked with the wireless power transmitting coil, would create an alternating magnetic field in the coil due to induction, to transmit energy.In the wireless power receiver section, the receiver coils receives that energy as an induced alternating voltage (due to induction) in its coil and a rectifier in the wireless power receiver section converts that AC voltage to a DC voltage. This dc is converted to ac through an inverter circuit and this gets transmitted to receiver coils where ac is again coverted to dc through rectifier circuit and this dc is supplied to the load circuits.

A. Transmitter section

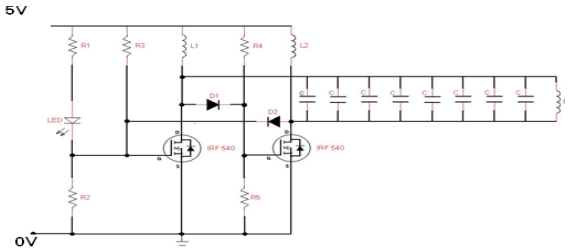

Fig. 5. Circuit diagram of transmitter section

The Transmitter section of wireless charger circuit consists of a transmitter coil, an AC power source and an inverter circuit.

AC power Source: A constant AC voltage is provided by a AC power source, and this AC signal is given as input to the step down transformer circuit. Then ac power is given to an inverter circuit.

Inverter Circuit: The inverter circuit consists of 555 timer and *irfz44n* mosfet circuits for generating and switching frequencies.With this both the transmitter and receiver circuits are made to oscillate at same resonant frequency. This oscillation aids power transfer between the coils in the form of magnetic waves.

B. Receiver section

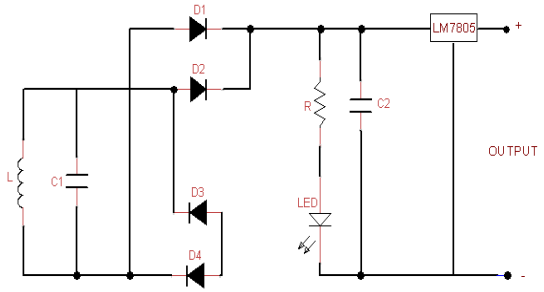

Fig. 6. Circuit diagram of receiver section

Fig. 7.

The receiver section consists of receiver coil, rectifier circuit and a voltage regulator IC. The AC current flowing through the transmitter coil creates a magnetic field. When we place the receiver coil with in a specific distance from this transmitter coil, the magnetic field in the transmitter coil extends to this receiver coil, and it induces an AC voltage and generates a current flow in the receiver coil of the wireless charger.

*Rectifier circuit***:** The ac power from the receiver coil is given to a rectifier circuit and converted to 12v dc.

Voltage regulator ic: : For transmitting power to the receiver devices this 12v power is regulated to 5v using 7805 regulator ic.

C. Parameters for design and hardware implementation

The operating frequency of is determined by the resonance formula given below

$F = ½ \times \pi \times \sqrt{(LC)}$

The equation for finding the inductance of a single layer air core coil is given below.

L = 0.001N(a/2)2/(114a+254l)H

At the transmitter end,

L = 0.001 N1 (a/2)2 / (114a + 254l) H

Now we are applying the desired values for the coil,

L = 0.001×14× (0.013/2)2 / ((114×0.013) + (254×5)) H

L = 0.1431uh

At the receiver end,

L = 0.001N2(a/2)2/(114a+254l)H

L = 0.001×7× (0.009/2)2 / /((114×0.009) + (254×1.6)) H

L = 0.1546uh

The capacitance value is chosen to be

C = 1000uf

Frequency of about 40khz is applied to the transmitter coil through 555timer and mosfet irfz44n circuits.

The resonant frequency of both the coils is around 12khz. Frequency matching is established through oscillation of both the coils in their resonant frequencies.This enables wireless electricity transfer to take place between the two coils which charges devices at the receiver end.

D. Hardware prototype model

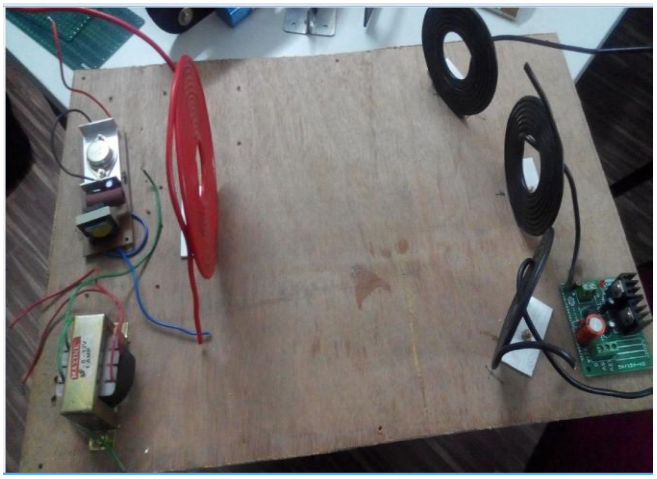

Fig. 8. Hardware prototype model of the proposed system

E. Hardware output results of charging mobile and tablet

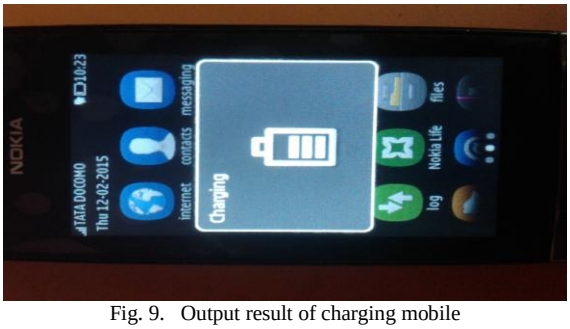

Fig. 9. Output result of charging mobile

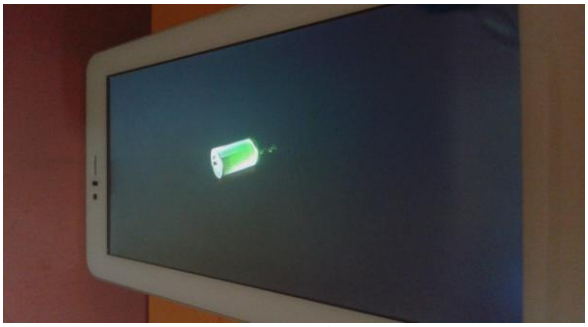

Fig. 10. Output result of charging tablet

F. Simulation results

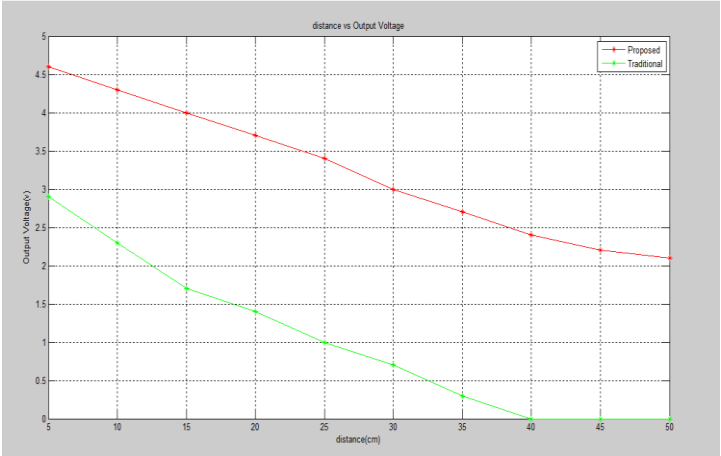

Fig. 11. Variation of distance with output voltage

Based on the empirical modeling four coils(a transmitter and 3 receiver coils)made of copper wire were selected to resonate at a frequency of 40 KHz. The source coil was made of a 14 turn helical coil and the three load helical coils were made of 7 turns each.The source coil is wound around a diameter of 130mm and the load coil around 90mm.The source coil is made of 5m length copper wire and the load of 1.6m copper wire.Distance was varied upto a range of 50cms,which was found to be practically impossible with the existing methods.This large distance of power transmission with a higher efficiency and steady output voltage value was obtained only because of proper frequency matching between the source and the load coils. Various graphs indicating relationships between distance range,frequency,efficiency and output voltage were simulated in MATLAB environment.

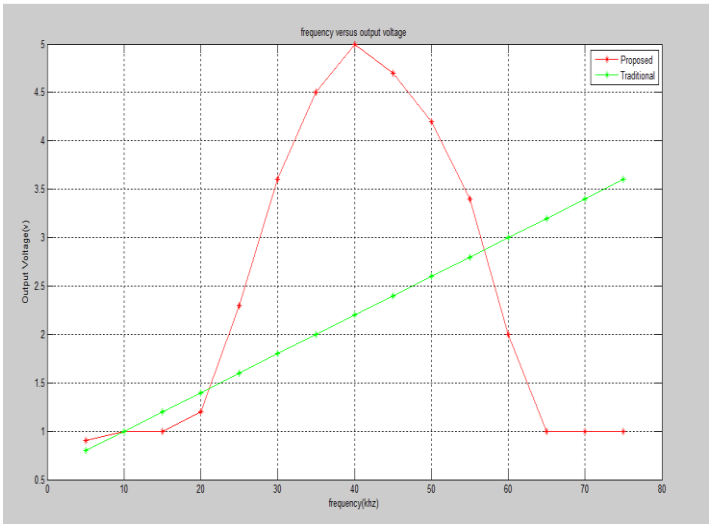

Fig. 12. Variation of frequency versus output voltage

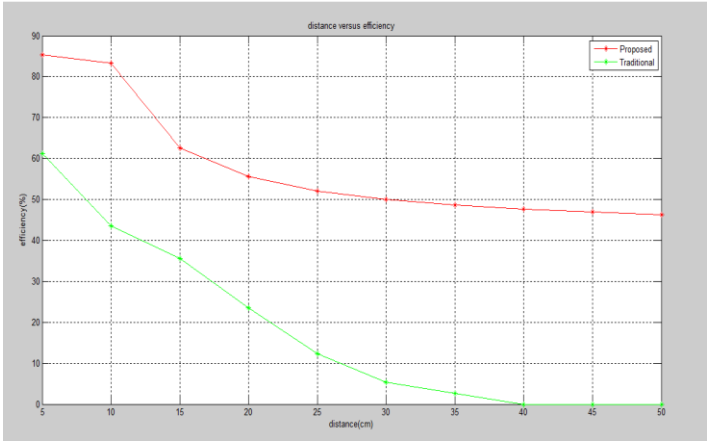

Fig. 13. Variation of distance versus efficiency

V. MERITS OF THE PROPOSED MODEL

Completely eliminates the existing high-power transmission line cables, towers etc..and the cost of transmission and distribution becomes less. It uses resonant magnetic fields to reduce wastage of power and hence efficiency of this method is higher than wired transmission.It aids easy power transmissio to the places where there is no wired transmission as it does not interfere with radio waves.The system can replace the use of power cables and batteries and so the power failure due to short circuit and fault of cables would be completely prevented. Though there is fear of effects due to electromagnetic induction rays,repeted study in this area proves that the radiation level is much lower than that from cellphones or microwave oven and is hence proved to be 100% safe on living tissues.

VI. FEATURES AND APPLICATIONS

Power transfer through magnetic coupling can be used in a wide variety of applications and environments. This technology is reliable,efficient and environment friendly as it is safe,efficient and travels over distance. The technology provides:

Direct Wireless Power— The power needed by the device is provided wirelessly and no batteries are necessary.

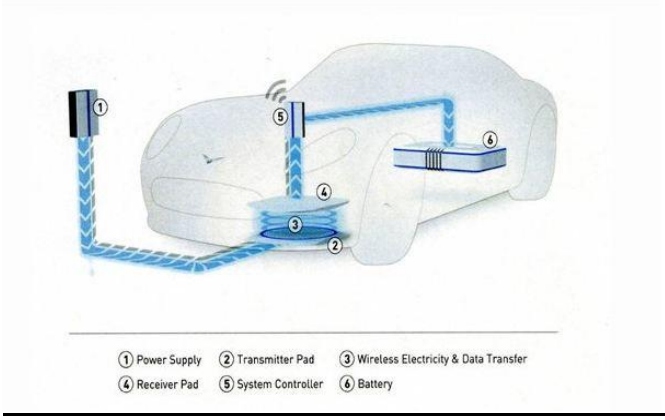

Fig. 14. Direct wireless power transfer without using batteries in a electric car

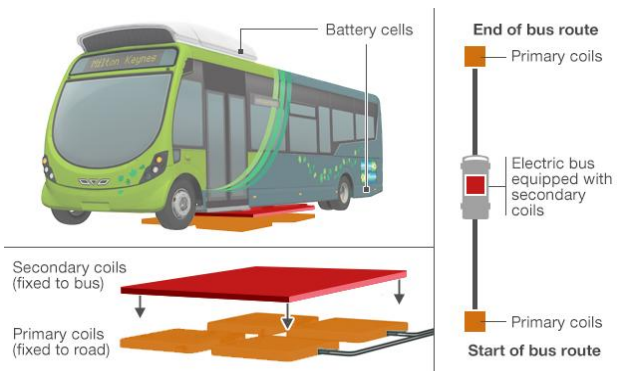

Fig. 15. Direct wireless power transfer without using batteries in a electric bus

Automatic Wireless Charging —A device with rechargeable batteries charges itself automatically when in use or at rest without replacing batteries or using power cords.

Fig. 16. Automatic wireless charging of electronic gadgets without using power chord or battery replacement

VII. CONCLUSION

In this paper, a wireless energy transfer system for power transmission and recharging of electrical devices is studied. In order to showcase its performance, comparable traditional inductive magnetic coupling model is built. Experimental results are reported to demonstrate the effectiveness and characteristics of the proposed method. In summary, the feasibility of this system is demonstrated using practical measurements in order to make meaningful performance comparisons. Wireless electricity transfer will make products more Convenient as there will never be run out of battery power since no manual recharging or changing batteries which inturn reduces use of disposable batteries. It totally eliminates unsightly, unwieldy and costly power cords by reducing product failure rates. It directly uses efficient electric grid power for charging instead of inefficient battery charging and thus it is more environment friendly.

VIII.FUTURE WORK

1. In our future work,we are planning to embed our receiver end circuitry of receiver coil with rectifier and regulator circuits in target devices circuitry during manufacturing so that no external chargers are required to charge the devices.The transmitter end circuitry placed in a circular case when positioned at a distance from the target device,the device will get charged automatically.
2. We are also planning to extend the distance of transmitting power to about 20 metres distance.

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