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# BVICAM's
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# Editorial

It is a matter of both honor and pleasure for us to put forth the sixth issue of BIJIT; the BVICAM's International Journal of Information Technology. This issue of the journal presents a compilation of ten papers that span a broad variety of research topics in various emerging areas of Information Technology and Computer Science. Some application oriented papers, having novelty in application, have also been included in this issue, hoping that usage of these would enrich the knowledge base and facilitate the overall economic growth. This issue shows our commitment in realizing our vision "*to achieve a standard comparable to the best in the field and finally become a symbol of quality"*.

As a matter of policy of the Journal, all the manuscripts received and considered for the Journal by the editorial board are double blind peer reviewed independently by at-least two referees. Our panel of expert referees posses a sound academic background and have a rich publication record in various prestigious journals representing Universities, Research Laboratories and other institutions of repute, which, we intend to further augment from time to time. Finalizing the constitution of the panel of referees, for double blind peer review(s) of the considered manuscripts, was a painstaking process, but it helped us to ensure that the best of the considered manuscripts are showcased and that too after undergoing multiple cycles of review, as required.

The ten papers that were finally published were chosen out of more than eighty papers that we received from all over the world for this issue. We understand that the confirmation of final acceptance, to the authors / contributors, is delayed, but we also hope that you concur with us in the fact that quality review is a time taking process and is further delayed if the reviewers are senior researchers in their respective fields and hence, are hard pressed for time.

We wish to express our sincere gratitude to our panel of experts in steering the considered manuscripts through multiple cycles of review and bringing out the best from the contributing authors. We thank our esteemed authors for having shown confidence in BIJIT and considering it a platform to showcase and share their original research work. We would also wish to thank the authors whose papers were not published in this issue of the Journal, probably because of the minor shortcomings. However, we would like to encourage them to actively contribute for the forthcoming issues.

The undertaken Quality Assurance Process involved a series of well defined activities that, we hope, went a long way in ensuring the quality of the publication. Still, there is always a scope for improvement, and so we request the contributors and readers to kindly mail us their criticism, suggestions and feedback at bijit@bvicam.ac.in and help us in further enhancing the quality of forthcoming issues.

**Editors**

# C O N T E N T S

# A Framework for Hierarchical Clustering Based Indexing in Search Engines

**Parul Gupta**[1] and **A.K. Sharma**[2]

*Submitted in May 2010; Accepted in June 2011*

**Abstract -** ***Granting efficient and fast accesses to the index is a key issue for performances of Web Search Engines. In order to enhance memory utilization and favor fast query resolution, WSEs use Inverted File (IF) indexes that consist of an array of the posting lists where each posting list is associated with a term and contains the term as well as the identifiers of the documents containing the term. Since the document identifiers are stored in sorted order, they can be stored as the difference between the successive documents so as to reduce the size of the index. This paper describes a clustering algorithm that aims at partitioning the set of documents into ordered clusters so that the documents within the same cluster are similar and are being assigned the closer document identifiers. Thus the average value of the differences between the successive documents will be minimized and hence storage space would be saved. The paper further presents the extension of this clustering algorithm to be applied for the hierarchical clustering in which similar clusters are clubbed to form a mega cluster and similar mega clusters are then combined to form super cluster. Thus the paper describes the different levels of clustering which optimizes the search process by directing the search to a specific path from higher levels of clustering to the lower levels i.e. from super clusters to mega clusters, then to clusters and finally to the individual documents so that the user gets the best possible matching results in minimum possible time.***

***Index Terms - Inverted files, Index compression, Document Identifiers Assignment, Hierarchical Clustering***

## 1. INTRODUCTION

The indexing phase [1] of search engine can be viewed as a Web Content Mining process. Starting from a collection of unstructured documents, the indexer extracts a large amount of information like the list of documents, which contain a given term. It also keeps account of number of all the occurrences of each term within every document. This information is maintained in an index, which is usually represented using an inverted file (IF). IF is the most widely adopted format for this index due to its relatively small size occupancy and the efficiency involved in resolution of the keywords based queries. The index consists of an array of the posting lists where each posting list is associated with a term and contains the term as well as the identifiers of the documents containing the term. Since the document identifiers are stored in sorted order, they can be stored as the difference between the successive documents so as to reduce the size of the index. Storing the differences require coding of small integer values [7] which can be encoded with a small number of bits and also aids in compressing the index. So if the similar documents [1] are assigned the closer document identifiers, then in the posting lists, the average value of the difference between the successive documents will be minimized and hence storage space would be saved. For example, consider the posting list ((job;5) 1, 4, 14, 20, 27) indicating that the term job appears in five documents having the document identifiers 1,4,14,20,27 respectively. The above posting list can be written as ((job; 5) 1, 3, 10, 6, 7) where the items of the list represent the difference between the successive document identifiers. The figure 1 shows the example entries in the index file.

| Term | No. of docs in which term appears | Doc ids of docs in which term appears | Doc ids stored with difference coding scheme |
|---|---|---|---|
| Job | 50 | 12,34,45,49… | 12,22,11,4… |
| Engineer | 59 | 15,20,34,55… | 15,5,14,21… |
| Fresher | 15 | 3,6,9,12… | 3,3,3,3… |
| Analyst | 5 | 2,4,5,8,9 | 2,2,1,3,1 |

**Figure 1: Example Entries in the Index File**

Clustering is a widely adopted technique aimed at dividing a collection of data into disjoint groups of homogenous elements. Document clustering [3] has been widely investigated as a technique to improve effectiveness and efficiency in information retrieval. Clustering algorithms attempt to group together the documents based on their similarities. Thus documents relating to a certain topic will hopefully be placed in a single cluster. So if the documents are clustered, comparisons of the documents against the user's query are only needed with certain clusters and not with the whole collection of documents. The fast information retrieval can be further achieved by hierarchical clustering in which the similar clusters are merged together to form higher levels of clustering. In this paper, the proposed heuristic exploits a text clustering algorithm that reorder the collection of documents on the basis of document similarity. The reordering is then used to assign close document identifiers to similar documents thus reducing differences between the document identifiers and enhancing the compressibility of the IF index representing the collection. The proposed clustering algorithm aims at partitioning the set of documents into k ordered clusters on the basis of similarity measure so that the documents on the web are assigned the identifiers in such a way that the similar documents are being assigned the closer document identifiers. Further the extension of this clustering algorithm has been presented to be applied for

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hierarchical clustering [5] in which similar clusters are clubbed to form a mega cluster and similar mega clusters are then combined to form super cluster. Thus the different levels of clustering have been defined which aids in better indexing. As a result of clustering, the size of the index gets compressed and moreover, it also optimizes the search process by directing the search to a specific path from higher levels of clustering to the lower levels i.e. from super clusters to mega clusters, then to clusters and finally to the individual documents so that the user gets the best possible matching results in minimum possible time.

## 2. RELATED WORK

In this paper, a review of previous work on document clustering algorithms is given. In this field of clustering, many algorithms have already been proposed but they seem to be less efficient in clustering together the most similar documents thus making the use of clustering less effective. K-means algorithm [4, 6] has been proposed in this direction, which initially chooses k documents as cluster representatives and then assigns the remaining nk documents to one of these clusters on the basis of similarity between the documents. New centroids for the k clusters are recomputed and documents are reassigned according to their similarity with the k new centroids. This process repeats until the position of the centroids become stable. Computing new centroids is expensive for large values of n and the number of iterations required to converge may be large.

Another work proposed was the reordering algorithm [1] which partitions the set of documents into k ordered clusters on the basis of similarity measure. According to this algorithm, the biggest document is selected as centroid of the first cluster and n/k1 most similar documents are assigned to this cluster. Then the biggest document is selected and the same process repeats. The process keeps on repeating until all the k clusters are formed and each cluster gets completed with n/k documents. This algorithm is not effective in clustering the most similar documents. The biggest document may not have similarity with any of the documents but still it is taken as the representative of the cluster.

Another proposed work was the threshold based clustering algorithm [8] in which the number of clusters is unknown. However, two documents are classified to the same cluster if the similarity between them is below a specified threshold. This threshold is defined by the user before the algorithm starts. It is easy to see that if the threshold is small, all the elements will get assigned to different clusters. If the threshold is large, the elements may get assigned to just one cluster. Thus the algorithm is sensitive to specification of threshold.

Fuzzy Co-clustering of Web Documents is a technique to simultaneously cluster data (or objects) and features. In case of web, web documents are the data, and the words inside the documents are the features. By performing simultaneous clustering of documents and words, meaningful clusters of highly coherent documents can be generated relative to the highly relevant words, as opposed to clusters of documents with respect to all the words as in the case of standard clustering algorithm. FCCM algorithm proposed in this direction is aimed at clustering data in which attributes can be categorical (nominal) and the distance or similarity between two patterns is not explicitly available. FCCM accomplishes this task by maximizing the degree of 'aggregation' among the clusters. The major drawback of FCCM is that it poses problems when the no. of documents or words is large. Moreover this algorithm is less effective when data has large number of overlapping clusters.

In this paper, the proposed algorithm has tried to remove the shortcomings of the existing algorithms. It produces a better ordering of the documents in the cluster. This algorithm picks the first document as cluster representative, then selects the most similar document to it and puts it in the cluster, it further selects document which is most similar to the currently selected document and repeats until the first cluster becomes full with n/k documents. The same process is then repeated to form the rest of the clusters. Thus the most similar documents are accumulated in the same cluster and are assigned consecutive document identifiers. Thus the algorithm is more efficient in compression of the index.

## 3. PROPOSED ALGORITHM FOR CLUSTERING BASED INDEXING

Let D ={D1, D2,. . ., DN} be a collection of N textual documents to which consecutive integer document identifiers 1, . . . ,N are initially assigned. Moreover, let T be the number of distinct terms ti, i = 1, . .. , T present in the documents, and t the average length of terms. The total size CSize (D) [27] of an IF index for D can be written as:

$$Csize\ (D) = CSize_{lexicon}\ (T.\ \mu t) + \sum Encode_m\ (d\_gaps\ (\ ti\ )\ )$$

where $CSize_{lexicon}$ (T. μt) is the number of bytes needed to code the lexicon, while d_gaps (ti) is the d_gap [28] representation of the posting list associated to term ti, and Encodem is a function that returns the number of bytes required to code a list of d gaps according to a given encoding method m.

The compression of index is achieved by applying clustering to the web pages so that the similar web pages are in the same cluster and hence assigned closer identifiers. A clustering algorithm has been proposed, which converts the individual documents into k ordered clusters, and hence documents are reassigned new document identifiers so that the documents in the same cluster get the consecutive document identifiers. The clustering of the documents is done on the basis of similarity between the documents, which is first of all calculated using some similarity measure. The proposed architecture for the clustering based indexing system is given in figure 2.

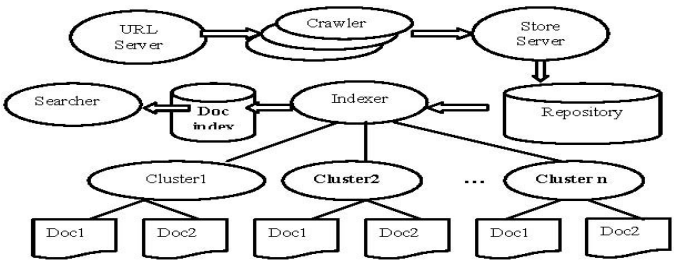


**Figure 2: Architecture of Clustering based indexing System in Search Engines**

**A. Computing The Similarity Matrix**

Let D={D1, D2,……Dn) be the collection of N textual documents being crawled to which consecutive integers document identifiers 1…n are assigned. Each document Di can be represented by a corresponding set Si such that Si is a set of all the terms contained in Di. Let us denote that set by D* such that D*={S1,S2,…….. Sn}. The similarity of any two documents Si and Sj can be computed using the similarity measure [1]:

**Similarity_measure (Si, Sj) = |Si ∧ Sj | / |Si U Sj |**

INPUT – The set D*= {S1, S2, S3, S4…Sn} where Si is a set of all the terms of document Di.

–The number k of clusters to create.

OUTPUT – k ordered clusters representing a reordering of D

The algorithm that calculates the similarity of each document with every other document using the similarity_measure given above is given in figure 3.

```
Algorithm docum_similarity:

for i=1 to n
begin
  sim[i][i]=0;
  for j=i+1 to n
  begin
       sim[i][j]=similarity_measure(Si, Sj)
       sim[j][I]=sim[i][j]
  end for
end for
```

**Figure 3: Algorithm for computing similarity matrix**

The above algorithm constructs the document similarity matrix [15]. The number of calculations performed leads to formation of the upper triangular matrix. The rest of the values in the similarity matrix are assigned automatically as we know similarity_measure (i, j)= similarity_measure (j, i).

**B. The Algorithm**

The clustering algorithm which clusters together the similar documents is given below:

```
Algorithm docum_clustering
i=1
for f=1 to k                          // for number of clusters
begin
cf=0        //Initially cluster is empty with no document in it
for e=1 to n/k          // for number of documents in one cluster
begin
for j=1 to n
          Select max from sim[i][j]
                    cf=cf U Si
                    D*=D*- Si
                    for l= 1 to n
                    begin
                              sim[i][l]=0
                              sim[l][i]=0
                    end
i=j
end
end
```

**Figure 4: Algorithm for Clustering (docum_clustering)**

It may be noted that the algorithm starts with the first cluster which is empty initially. The first document from the collection is considered and put in the first cluster. Now, using the similarity matrix, the most similar document to it is considered. All the entries of the row and column associated with the first document are made zero as this document cannot be added to any other cluster. The most similar document picked is put in the same cluster. Now the second document that was considered takes the role of the first document and the most similar document to it is considered and this procedure repeats for n/k times when the first cluster gets full. Thus at the end, we get k clusters each with n/k number of similar documents.

**C. Example Illustrating Clusters Formation**

Having discussed the algorithm, let us now have panoramic view as to how the clustering of the documents takes place. For e.g. if we have 10 documents – A, B, C, D, E, F, G, H, I, J & value of k is 2 i.e. 2 clusters are to be made, then according to the algorithm, the similarity among the documents is computed using the similarity measure and hence the formed upper triangular similarity matrix will be:

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 0 | 5 | 3 | 6 | 9 | 8 | 2 | 3 | 4 | 1 |
| B | | 0 | 5 | 4 | 6 | 2 | 3 | 5 | 7 | 8 |
| C | | | 0 | 5 | 2 | 3 | 6 | 9 | 4 | 7 |
| D | | | | 0 | 2 | 3 | 6 | 5 | 4 | 9 |
| E | | | | | 0 | 8 | 5 | 3 | 6 | 5 |
| F | | | | | | 0 | 8 | 9 | 5 | 2 |
| G | | | | | | | 0 | 6 | 5 | 4 |
| H | | | | | | | | 0 | 3 | 6 |
| I | | | | | | | | | 0 | 5 |
| J | | | | | | | | | | 0 |

**Figure 5: Initial Similarity Matrix**

Now from the computed values in the upper triangular matrix,

the matrix can be completed as follows using the property that similarity_measure(i,j) = similarity_measure(j,i). The full similarity matrix is given in the figure 6. According to the clustering algorithm,

- 1st cluster will have A, then E, then F, then H & lastly C
- 2nd cluster will have J, then D, then G, then I & lastly B

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 0 | 5 | 3 | 6 | 9 | 8 | 2 | 3 | 4 | 1 |
| B | 5 | 0 | 5 | 4 | 6 | 2 | 3 | 5 | 7 | 8 |
| C | 3 | 5 | 0 | 5 | 2 | 3 | 6 | 9 | 4 | 7 |
| D | 6 | 4 | 5 | 0 | 2 | 3 | 6 | 5 | 4 | 9 |
| E | 9 | 6 | 2 | 2 | 0 | 8 | 5 | 3 | 6 | 5 |
| F | 8 | 2 | 3 | 3 | 8 | 0 | 8 | 9 | 5 | 2 |
| G | 2 | 3 | 6 | 6 | 5 | 8 | 0 | 6 | 5 | 4 |
| H | 3 | 5 | 9 | 5 | 3 | 9 | 6 | 0 | 3 | 6 |
| I | 4 | 7 | 4 | 4 | 6 | 5 | 5 | 3 | 0 | 5 |
| J | 1 | 8 | 7 | 9 | 5 | 2 | 4 | 6 | 5 | 0 |

**Figure 6: Full Similarity Matrix**

The output after calculating similarity for first five documents will be :

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B | 0 | 0 | 0 | 4 | 0 | 0 | 3 | 0 | 7 | 8 |
| C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| D | 0 | 4 | 0 | 0 | 0 | 0 | 6 | 0 | 4 | 9 |
| E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| G | 0 | 3 | 0 | 6 | 0 | 0 | 0 | 0 | 5 | 4 |
| H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| I | 0 | 7 | 0 | 4 | 0 | 0 | 5 | 0 | 0 | 5 |
| J | 0 | 8 | 0 | 9 | 0 | 0 | 4 | 0 | 5 | 0 |

**Figure 7: Matrix after formation of first cluster**

## 4. PROPOSED HIERARCHICAL CLUSTERING ALGORITHM

The lack of a central structure and freedom from a strict syntax is responsible for making a vast amount of information available on the web, but retrieving this information is not easy. One possible solution is to create a static hierarchical categorization of the entire web and using these categories to organize the web pages. Organizing Web pages into a hierarchy of topics and subtopics facilitates browsing the collection and locating results of interest. In hierarchical clustering algorithm, after the cluster of similar documents have been formed, the similar clusters are merged together to form the mega clusters using the same similarity measure as is used to cluster together the documents. The framework for the hierarchical clustering is shown in figure 8.

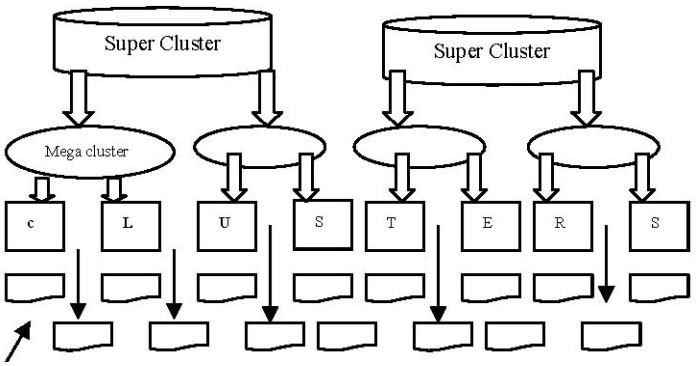


**Figure 8: Hierarchical Clustering**

### A. Computation of Similarity Matrix of Clusters

The algorithm that computes the similarity matrix for the similar clusters is given below. In this algorithm, D={S1,S2….Sk} where Si is a set of terms in the cluster ci.

```
Algorithm cluster_similarity
for i = 1 to k
begin
   sim [i][i] = 0
   for j = i+1 to k
   begin
         sim [i][j] = similarity_measure (Si, Sj)
         sim[j][i] = sim[i][j]
   end
end
```

**Figure 9: Algorithm for similarity matrix of clusters**

### B. Algorithm for Hierarchical Clustering

The hierarchical clustering [9] algorithm that aims at forming the mega clusters out of the similar clusters is given in figure 10.

In this algorithm, the first mega cluster is considered which is initially empty. The first cluster from the collection is considered and put in the first mega cluster. Now, using the similarity matrix, the most similar cluster to it is considered. All the entries of the row and column associated with the first cluster are made zero as this cluster cannot be added to any other mega cluster. The most similar cluster picked is put in the same mega cluster. Now the second cluster that was considered takes the role of the first cluster and the most similar cluster to it is considered and this procedure repeats for k/m times when the first mega cluster gets full. Now the second mega cluster is considered and the same procedure repeats until all the mega clusters get full. Thus at the end, we get m mega clusters each with k/m number of clusters such that the clusters within the same mega cluster are similar.

```
Algorithm mega_clustering
i=1
for f=1 to m
begin
     cf = 0
      for e = 1 to k/m
      begin
            for j = 1 to k
            select max from sim [i][j]
            cf = cf U si
            D= D-si
            for l=1 to k
            begin
                 sim [l][i] = 0
                 sim [i][l] = 0
           end
           i=j
     end
end
```

**Figure 10: Algorithm for Mega Clustering**

### C. Example Illustrating Hierarchical Clustering

For e.g. user has to fire a query "Jobs for Computer Engineers having 5 to 10 years experience". Now since the hierarchy of clusters has been formed, so the search will proceed in the manner as shown in the figure 12. The search will start from the super cluster "Job", will be directed to the mega cluster "COMP. ENGG.", then will reach the cluster "5 TO 10 YRS EXPERIENCE" and finally will reach the individual relevant documents. Thus the search follows a specific path from super cluster to the individual document as shown in figure 11.

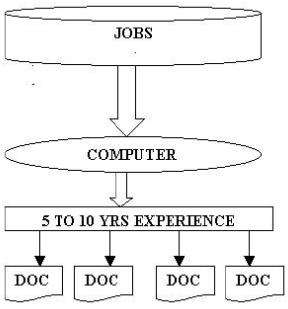


**Figure 11: Search Path**

## 5. IMPLEMENTATION OF PROPOSED WORK

For indexing the documents, firstly we have to parse the documents. After that similarity matrix is created and then k means algorithm is applied for creating the clusters. Clusters will be created at first level .For creating clusters at second level same procedure is applied again and then finally hierarchical clustering is done for indexing.

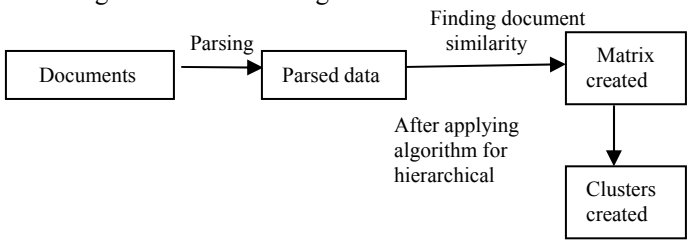


**Figure 11: Work Flow of Implementation**

### A. Snapshots of Implemented Work

1. Given input & parsed data, the following snapshot represents the parsed data which is the initial step for indexing the data.


**Figure 12: Given and Parsed data**

### 2. Clustered data

The data is now clustered according to the similarity of words.The following figure shows the clusters created that are created after matching the similarity of documents with each other.

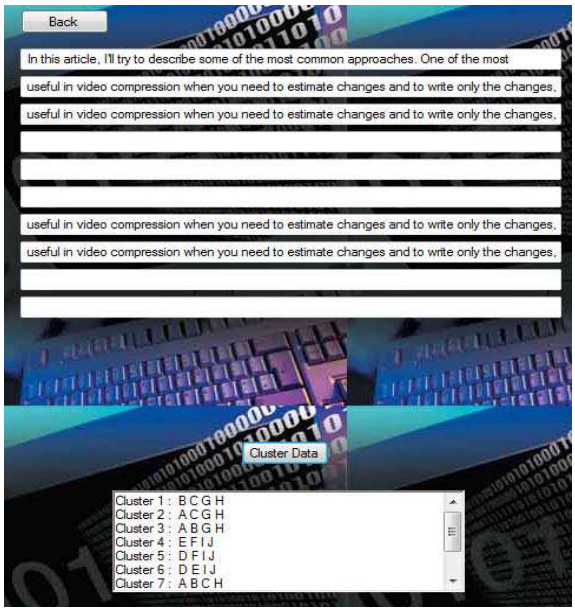


**Figure 13: Clustered data**

### B. Results

*A- Graph Representing the Created Clusters at First Level*

At first level, less no of clusters are created. As at first level the similarity between two documents is less.

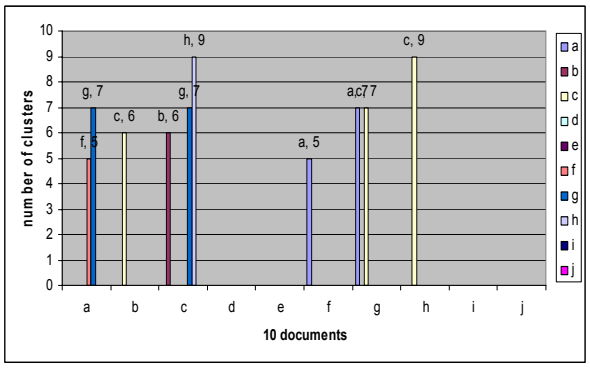


**Figure 14: Clusters created at first level**

***B-Graph Representing the Created Clusters at Second Level***

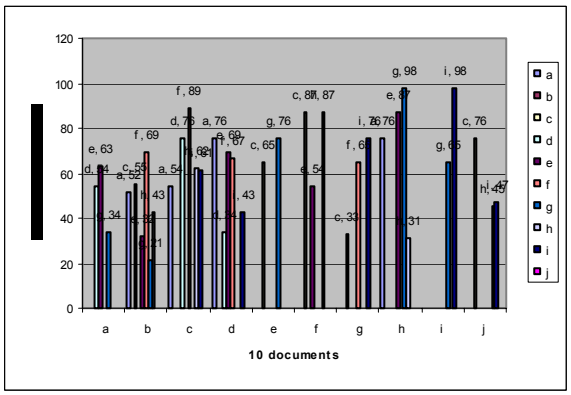


**Figure 15: Clusters created at second level**

At second level, more no of clusters are created in comparison to first level. As the similarity between two documents is more.

## 6. CONCLUSIONS

In this paper, an efficient algorithm for computing a reordering of a collection of textual documents has been presented that effectively enhances the compressibility of the IF index built over the reordered collection. Further, the proposed hierarchical clustering algorithm aims at optimizing the search process by forming different levels of hierarchy. The proposed algorithm is superior to the other algorithms as a summarizing and browsing tool. A critical look at the literature indicates that in contrast to the earlier proposed algorithms, the proposed work produces a better ordering of the following advantages:

**1. Compression of Index Size:** The size index of the index is compressed as similar documents are assigned closer document identifiers.

**2. Reduction in Search Time:** The search time gets reduced as the search gets directed to a specific path from super cluster to mega clusters, then to clusters and finally to the individual documents.

**3. Fast retrieval of relevant documents:** Since the similar documents get clustered together in the same cluster, the specific query relevant documents can be rapidly picked from that cluster.

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# Web 3.0 in Education & Research

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**Abstract -** ***The continuous evolution of the Internet has opened unimaginable opportunities and challenges in web based education and learning. The traditional version of web i.e. Web 1.0 started as a Read only medium; the next version Web 2.0 established itself as Read/Write medium. Now the currently evolving version of web, viz., Web 3.0 is said to be a technologically advanced medium which allows the users to Read/Write/Execute and also allows the machines to carry out some of the thinking so far expected only from the human beings. In a short time, Web 2.0 and now Web 3.0 have created new tools and technologies for facilitating web based education & learning. To begin with, this paper discusses some definitions of the Web 3.0, its evolution and characteristics. Next, we have discussed about the possible future Web 3.0 technologies, trends, tools and services that will assist in the areas of online learning, personalization and knowledge construction powered by the Semantic Web.***

**Index Terms - Web 3.0, Semantic Web, Educational Technology, Online Learning, 3D learning environments, e-learning.**

## 1. INTRODUCTION

For about last two decades, the World Wide Web(WWW) is being used to improve communication, collaboration, sharing of resources, promoting active learning, and delivering of education in distance learning mode. The WWW helps teachers in planning suitable online delivery structure, sharing goals of learning, and activities for their courses.

In recent years, many of the universities and educational institutions world wide offer online services such as for admissions, virtual (online) learning environments in order to facilitate the lifelong learning and to make this compatible with other educational management activities. For example, a teacher may create a purely Web-based delivery system including online handouts in respect of student's activities, projects and lists of resources for reference. The students and other learners may access web based material anytime from any where in the world, being connected through Internet.

Since the 1990s when the World Wide Web was established, it has evolved from the earlier versions, viz. Web l.0 to Web 2.0, and finally is evolving into the newest version, viz., Web 3.0. In respect of different versions of web, the Wikipedia states: *"Web 1.0 is Read Only, static data with simple markup for reading. Web 2.0 is Read/Write dynamic data through web services customize websites and manage items. Web 3.0 is Read/Write/Execute."* In Web2.0, user not only reads information from the internet, but also provides information through internet to share with others. Currently we have many popular Web 2.0 interactive applications like *Blog, Podcast, Mashup, Tag, RSS/Atom, Wiki, P2P, Moblog, Adsense* and so on. Compared with Web 2.0, there is not a very clear definition available for Web 3.0 till now. Web 3.0, to be discussed in detail below, is a term used to describe the future of the World Wide Web. Views of different pioneers on the evolution of Web 3.0 vary greatly. Some believe that emerging technologies such as the *Semantic Web* will transform the way the Web is used, and lead to new possibilities in artificial intelligence based applications. Other visionaries suggest that increase in Internet connection speeds, modular web applications, or advances in computer graphics will play the key role in the evolution of the new version of World Wide Web [1].

## 2. DEFINITIONS OF WEB 3.0

The term *'Web 3.0'* was first coined by John Markoff of the New York Times in 2006 [6], and first appeared significantly in early 2006 in a Blog article "*Critical of Web 2.0 and associated technologies such as Ajax"* written by *Jeffrey Zeldman.* Major IT experts and researchers support different approaches to the future Web. There is complete agreement among the experts about how Web 3.0 will evolve. Below we discuss the opinions of pioneers in the field in this respect.

Tim Berners-Lee, coined the term *Semantic Web*, and promotes the concept of conversion of Web into a big collection of databases [2].

About Web 3.0, Tim Berner Lee [3] says:

"People keep asking what Web 3.0 is. I think maybe when you've got an overlay of scalable vector graphics - everything rippling and folding and looking misty-on Web 2.0 and access to a semantic Web integrated across a huge space of data, you'll have access to an unbelievable data resource."

Netflix founder, *Reed Hastings* [4] thinks that Web 3.0 would be a full video Web as stated below:

"Web 1.0 was dial-up, 50K average bandwidth; Web 2.0 is an average 1 megabit of bandwidth and Web 3.0 will be 10 megabits of bandwidth all the time, which will be the full video Web, and that will feel like Web 3.0"

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Yahoo founder, *Jerry Yang* thinks that the new era of tools & techniques for creating programs, data, content and online applications will blur the distinction between professional, semi-professional and consumers. At the TechNet Summit in November 2006, Yang stated [4]:

"Web 2.0 is well documented and talked about. The power of the Net reached a critical mass, with capabilities that can be done on a network level. We are also seeing richer devices over last four years and richer ways of interacting with the network, not only in hardware like game consoles and mobile devices, but also in the software layer. You don't have to be a computer scientist to create a program. We are seeing that manifest in Web 2.0 and Web 3.0 will be a great extension of that, a true communal medium…the distinction between professional, semi-professional and consumers will get blurred, creating a network effect of business and applications. " Finally, we consider what Google's CEO, Eric Schmidt [5] stated:

"Web3.0 as a series of combined applications. The core software technology of Web3.0 is artificial intelligence, which can intelligently learn and understand semantics. Therefore, the application of Web3.0 technology enables the Internet to be more personalized, accurate and intelligent."

These are some of views about Web 3.0 of the different experts of IT industry. Next, we discuss some of characteristics of Web 3.0.

## 3. CHARACTERSTICS OF WEB 3.0

Four characteristics of Web 3.0, as given below, can be summarized from the above definitions and descriptions.

### 3.1 Intelligence:

Experts believe that one of the most promising features of Web 3.0 will be *Web with intelligence, i.e.,* an *intelligent web*. Applications will work intelligently with the use of Human-Computer interaction and intelligence. Different *Artificial Intelligence* (AI) based tools & techniques *(such as, rough sets, fuzzy sets, neural networks, machine learning etc)* will be incorporated with the applications to work intelligently. This means, an application based on Web 3.0 can directly do intelligent analysis, and then optimal output would be possible, even without much intervention of the user. Documents in different languages can be intelligently translated into other languages in Web3.0 era. Web 3.0 should enable us to work through natural language. Therefore, users can use their native language for communication with the others around the world [6].

### 3.2 Personalization:

Another characteristic of Web 3.0 era is Personalisation. Personal or individual preferences would be considered during different activities such as information processing, search, formation of personalized portal on the web. *Semantic Web* would be the core technology for Personalisation in Web 3.0 [7] [8].

### 3.3 Interoperability:

In the context of Web 3.0, the terms Interoperability, collaboration and reusability are basically interrelated. Interoperability implies reuse, which is again a form of collaboration. Web 3.0 will provide a communicative medium for knowledge and information exchange. When a person or a software program produces information on the Web and this information is used by another, then the creation of new form of information or knowledge takes place [24]. Web 3.0 applications would be easy to customize & they can independently work on different kinds of devices. An application based on Web 3.0 would be able to run on many types of Computers, Microwave devices, Hand-held devices, Mobiles, TVs, Automobiles and many others. Pervasive Web is the term used to describe this phenomenon where web is operable to a wide range of electronic devices.

### 3.4 Virtualization:

Web 3.0 would be a web with high speed internet bandwidths and High end 3D Graphics, which can better be utilised for virtualisation. The trend for future web refers to the creation of virtual 3-Dimensional environments. An example of the most popular 3-D web application of Web 3.0 is *Second Life* [7].

## 4. TECHNOLOGY TRENDS FOR WEB 3.0

Based upon the above definitions, it is likely that the new generation of web applications will have some specific core technologies to support them. In this section, we present some of the major trends in terms of technologies that might become the building blocks of the next generation of the Web. Figure 1 depicts the evolution of the web in terms of the core technologies, the content and services available to end users.

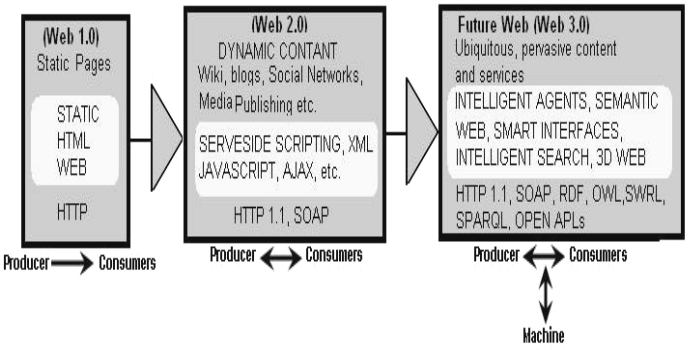


**Figure 1: Evolution of the Web**

### 4.1 Semantic Web:

The extension of the World Wide Web that provides an efficient & easier way to share, find and combine data & information from distinct sources is called Semantic Web. In the simplest terms, we can define Semantic Web as a relationship between things, described in a manner which makes people and machines able to understand. We may say,

Traditional World Wide Web = Web of Documents with Limited Interoperability,

Semantic Web = Web of Integrated, Linked meaningful Data.

Semantic Web is all about data integration. The Semantic Web converts "display only" data to meaningful information by using *metadata*. *Ontologies*, which contain the *vocabulary*, *semantic relationships*, and *simple rules* of *inference* and *logic* for a specific domain, are accessed by software *agents*. These agents locate and combine data from many sources to deliver relevant information to the user [23].

One of the objectives of Semantic Web is to identify and provide the exact required data that matches the keywords provided by the user. For example, if we search keyword *datamining* through Google, yahoo or any of search engines, millions of web pages appear as search results out of which a few may have some relevant information and all other pages may be useless. Web 3.0 in terms of Semantic Web is the third generation of World Wide Web in which machines will have the ability to read Web contents like Human beings and also the ability to follow our directions. For example, if you order to check the schedules of all the show timings of a film in theaters, for your preferred timings, within a 20 km radius, then it follows and provides the appropriate information in respect of your preferences.

**4.2 The 3D Web:**

This trend of the future World Wide Web refers to the formation of virtual 3-dimensional worlds on the Web. The use of 3D graphics will be extensively utilized in the development of Web 3.0 tools or applications. High speed Internet, quicker processing speeds, higher screen resolutions, 3D gaming technology and augmented reality will transform the Web browsing into a 3D experience, where you actually move through the virtual corridors of the Web, as a virtual *avatar* of your real self [2]. Recently several Internet-based elementary virtual worlds, such as *Radar Networks* [9], *Second Life* [11], *IMVU* [12], *Active Worlds* [13], and *Red Light Center* [10], have gained huge attention by the public worldwide. Users of these virtual worlds are growing in a big way everyday. For instance, at the end of March 2008, *Second Life* had more than 13 million accounts with around 38,000 users logged on at any particular moment [14]. These types of environments allow users to experience new things which they may never be able to have in their real life. Users create avatars on the Web and allow them to reside in the virtual worlds. The residents or avatars of these virtual worlds can explore, interact with other residents, socialize, participate in different activities, create and serve different types of services. The possible interactions in these virtual worlds occur through text, chat messaging, audio chat, and/or with video.

**4.3 The Social Web:**

The Social Web explains the interaction of people with one another using the underlying technologies of World Wide Web. Technology advancements in Web 3.0 will take the current social computing to a new level called *Semantic Social Computing or Socio-Semantic Web* which will develop and utilize knowledge in all forms, e.g., content, models, services, & software behaviors [15]. Semantic Web and, in general, Artificial Intelligence technologies will add underlying knowledge representations to information, tags, processes, services, software functionalities and behaviors. The wisdom of crowds will come not from the consensus decision of the group, but from the semantic and logical aggregation of the ideas, thoughts, and decisions of each individual in the group. Instead of linking documents only, the future Social Web will link people, organizations, and concepts automatically.

**4.4 The Media Centric Web:**

The most of traditional search engines provide search results on the basis of text inputs. Web 3.0 searches will not restrict them only to the text based searches. Web 3.0 searches will be able to find out the related similar media objects based on its features. The search engines would be able to take input(s) as a media or a multi-media object and will be able to search out related media objects based on its features [2]. For example, to search images about cars, we need to provide an input as an image of a car and the search engine should be able to retrieve images of cars with similar features. The same kind of search possibilities should be applied with other media objects such as audio and video. The work in this direction is already going on. Some good examples of this kind of technology can be found on software like *Ojos Riya* [16] photo sharing tool that allows to automatically *tag* images using face recognition, similarly the site *Like.com* [17] enables the user to search for products based on similar images.

**4.5 The Pervasive and Ubiquitous Web:**

Remarkable developments in technologies such as wireless communications, wireless networking, mobile computing devices, artificial intelligence, software agents, Enabling technologies (e.g., Bluetooth, BANs, PANs, 802.11 wireless LANs), embedded systems, wearable computers have led to the evolution of Pervasive & Ubiquitous computing platforms. According to Peter Robinson [25], Ubiquitous and pervasive computing may be defined as the task of embedding small and mobile devices into existing IT and computing infrastructures, so that it allows users to access and manipulate information where and when it matters, even while on the move. The scope and use of web services will not limit us only to computers and mobiles but web services will be equally available in clothing, appliances, and in automobiles and much more. We need not evoke these services every time; they will work and perform their task themselves cooperatively and automatically. The involvement of user to devices to access and work would be almost nothing. For example, using the future web services we

can find windows and curtains that check the weather and automatically open and close accordingly; home appliances that know our daily routines and preferences and communicate to each other to provide us with a more comfortable living [2]. As stated above, Web services would play an important role in this direction and device embeddable form of light weight web services will be required. The communication between different types of devices and the Web would be possible with the help of *Service Oriented Architectures (SOA)* and related technologies for ensuring cross-platform interoperability. Some leading software companies are working in this direction. Microsoft has released a *development API* [19] also, it has released exceptional innovations featured product called *Life Ware* [19], which is an excellent example of what this technology can bring in the future [20].

## 5. TOOLS AND SERVICES OF WEB 3.0 FOR EDUCATION & RESEARCH

The learning in Web 2.0 emphasizes the active participation of internet users and interaction among social communities, through *social network tools* or *social software* such with Blog, wiki, social book marking and social networking. The tools & services of Web 3.0 technologies would foster a more open approach to learning. Web 3.0 has been proposed as a possible future web consisting of the integration of high-powered graphics *(Scalable Vector Graphics or SVG)* and semantic data. There have also been discussions around 3-D social networking systems and immersive 3-D internet environments that will take the best of virtual worlds (*such as Second Life*) and gaming environments and merge them with the Web.

About Web 3.0 in learning, the *Tony Bingham*, ASTD President and CEO says:

"In the Semantic Web, content will find you—rather than (you) actively seeking it, your activities and interests will determine what finds you, and it will be delivered how you want it and to your preferred channel. The Semantic Web provides tremendous potential for learning."

We are in the beginning of a new revolution in information management and sharing that will make more and more content available to any combination of human and computer processing, allowing new means of collaboration between and across disciplines.

Web 3.0 offers many tools and services for different kind of web applications on Internet, as shown in figure below.

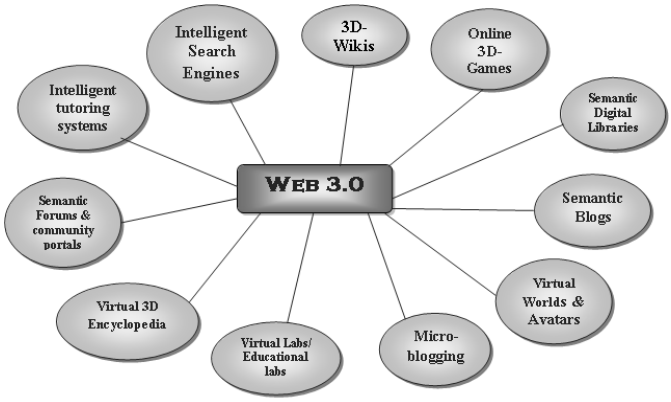


**Figure 2: Web 3.0 Tools & Services**

Next, we describe briefly some of the Web 3.0 tools and services which are useful for the education and research:

### 5.1 Learning with 3D-Wikis / Virtual 3D Encyclopedia:

A *Wiki* is a system that allows one or more people to build up a collection of knowledge in a set of interlinked web pages, using a process of creating and editing pages. Wikis are playing significant role in content creation, publishing, editing, revising, and collaborating for knowledge creation. Wikis are being used for maintaining and building a repository of content and material. Students are able to work collaboratively and post large items. Ease of use of the wiki software makes it a simple matter for an editor (faculty) to delete/revert or modify the content. With the evolution of 3D web, researchers & technocrats have been working on new projects to bring a new dimension to the world of Wikis & encyclopedia. Some examples of this kind of technology can be found on software like *Copernicus-3D Wikipedia (see http://copernicus.deri.ie)* [18]. Suppose a Learner had performed the search and chose one of the results related to information about a specific geographical region, the camera will move to the particular place on the spinning globe to send relevant audio/video information. For instance, the camera will "fly" towards the island of Ireland as a result of searching for *irish heritage park*; eventually, the article about the Irish Heritage Park in Williamsburg will be presented to the user alongwith the video on irish heritage park [18]. 3D Wikis would be able to provide rich & effective environment involving all media and animation, for learners, so that they can have better impact on learning & knowledge.

### 5.2 Learning with 3D Virtual worlds & Avatars:

As mentioned earlier, a 3D virtual world is a mix of 3D gaming technology, augmented reality, simulated environment powered with Internet technology where users interact through movable *avatars.* Users create *avatars* on the Web and allow them to reside in the virtual worlds. Learners can create their own *avatars* on the web & reside in these worlds. Virtual worlds can be seen as the beginning of new era of e-learning as they allow

learners to do role-play, 3D modeling, simulations, creativity and their active involvements. There is a huge space for conducting research relating to the pedagogical benefits of teaching and learning in 3D virtual worlds. Recently several web based 3D virtual worlds, such as *Second Life* [11], *IMVU* [12], *Active Worlds* [13], and *Red Light Center* [10], have gained attention by the students and teachers for education & learning worldwide. Educators may conduct classes in a variety of different settings within a 3D virtual world where they can interact in real like environment of a class. Educators & learners may collaboratively conduct sessions from geographically dispersed locations in a shared virtual 3D space. They can allow educators & learners in conducting meetings, seminars, presentations, digital exhibitions where learners can come and interact like the same way we do in our real life. 3D virtual worlds available today and in coming future will be very helpful across a diverse range of disciplines including education, medicine, business, commerce, science, communication, media, art, architecture and design, law, computer science, language learning, history and geography to mention but a few.

**5.3 Intelligent Search Engines:**

In the last few years, learning processes have benefited from the technological evolution of the web. The dispersion of the web has permitted the introduction of new educational processes, which are more flexible for accessing the resources for learning. Now a days Internet has become the most useful and powerful source of information. In order to effectively deal with the huge amount of information on the web, advanced web search engines have been developed for the task of retrieving useful and relevant information in multimedia form for its users [21].When you use a traditional Web search engine, the engine isn't able to really understand your search. It looks for Web pages that contain the keywords found in your search terms. The search engine can't tell if the Web page is actually relevant for your search. It can only tell that the keyword appears on the Web page. A Web 3.0 era of Agents based-search engine could find not only the keywords in your search, but also interpret the context of your request. It would return relevant results and suggest other content related to your search terms. Experts believe that Web 3.0 will provide users with richer and more relevant experiences. Experts also believe that with Web 3.0, every user will have a unique internet profile based on that user's browsing history. Web 3.0 will use this profile to tailor the browsing experience to each individual. That means that if two different learners, each performed an internet search with the same keywords using the same service, they would receive different results determined by their individual profiles [22]. Students will also benefit from knowledge construction powered by the Semantic Web. A Semantic Web *Agent* based search engine will return a *multimedia report* rather than just a list of hits. A smart agent can return local lectures, relevant blogs, books and television programs about the topic to the learner. Ontologies will link the learner's needs and characteristics so that personalized agents can search for learning material based on the learners' needs [23]. Learners can apply the same kind of search possibilities with other media objects such as *image*, *audio*, and *video*. Some examples of this kind of technology can be found on software like *Ojos Riya* photo sharing tool that allows to automatically tag images using face recognition [16], or *Like.com* which enables the user to search for products based on similar images [16].

**5.4 Online 3-D Virtual Labs / Educational labs / Simulations or 3D Web:**

3D rich graphical user interfaces will act as a powerful platform for the users to participate and perform collaborative activities, sharing results and exchanging media information among participants in a more natural way [26]. The following are some of the examples of 3-D Virtual Labs/Educational labs/Simulations or 3D Web based applications that will shape future education:

1. **To visit places those are not accessible:** Visiting different places in virtual worlds would benefit learners in many ways. Ancient places where students can reach there in a small span of time virtually. For example, to take a look at ancient places like Tajmahel, Red fort or Rome, Students can interact & experience with the environment of the places, other students and can have their teacher as guide through the web. Similarly, they can see the Egyptian pyramids or visit an Egyptian village in the same way. There is so much scope where we can teach the students and give them a safe and economic way of experiencing such things.

2. **To promote student collaboration*:*** Students can come together & meet virtually in diverse and attractive manner. They can collaborate & work on common projects. Students & Educators may have discussions, talk, connect, and chat on the common projects. Additionally, they can fly over and move things around in a 3D world. They can even use & work in multiple 3D worlds instantaneously.

3. **To promote assessment through Project Based Learning:** For instance, students can do research and create a (virtual) village in, say, the Roman Empire. Additionally, a whole group of students around the world could create this environment while attending a distance learning course. This way they can work together on a project & able to experience the interesting ways of learning at a distance.

4. **To develop scenarios and simulations**: High end graphics and rich 3D internet applications can be utilized to make simulation based environments or Labs where learners can learn or even do experiments. These Labs are so-called dry labs. These Web based Labs can prove to be quite

beneficial for online learners. They could go to an immersive virtual science lab to do experiments. After the simulation, students could go offline into a real science lab to perform the correct experiment and see how it works [27]. High level scientific experiments could be conducted, and expert technical training could be obtained, in ways that a university or school could not afford. For example, imagine splitting atoms, conducting surgery, flying a plane or exploring inhospitable environments.

## 6. CONCLUSION

Web 3.0 is more than a set of useful and new technologies and services. Web 3.0 technologies offer an array of services to make a true online classroom a reality. Because of its very nature Web 3.0 services will be having positive impact on teaching and learning. Web 3.0 technologies offer benefits of 3D-wikis, 3D Labs; Intelligent Agent based search engines, Virtual environments like Avatar and Semantic Digital Libraries etc. In our vision of the Web 3.0, we foresee a scenario where such ubiquitous technologies will create a convergence of real and virtual environments, where the user will seamlessly interact with humans and machines either through virtual means or in the real world. These benefits can be directly aligned to the existing best practices in online education, and make further authenticated and effective educational environment.

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# A Study to Examine the Digital Divide Factors: Jammu and Kashmir Perspective

**Preeti Dubey[1], JeevanJyoti[2]** and **Devanand[3]**

*Submitted in July 2010; Accepted in February 2011*

**Abstract -** ***Digital divide refers to a substantial asymmetry between two or more populations in the distribution and effective use of information and communication resources. Despite the boom in the availability of access to communication resources since the beginning of the 1990s, the divide is deepening and the differences in the usage of communication resources between countries and regions intensifying. Even though the rural areas have benefitted to some extent from the boom in access to communication resources, the regional divide is more pronounced within the developing countries. Factors influencing digital divide vary from region to region. In an attempt to find the factors responsible for the digital divide in Jammu and Kashmir region, a pilot survey was conducted. This paper reports on the results of this pilot study. The study was conducted by floating questionnaires and by interviewing people of rural as well as urban areas. Questions were related to internet access, its usage, problems faced in its use etc. On analysis of data, many other observations other than the digital divide factors have been reported. It was found during the study that the government is providing facilities for internet access but awareness of these initiatives is still lacking. People residing in rural areas are hesitant to use internet due to lack of English language proficiency. This paper is a result of the pilot survey to examine the factors responsible for the regional digital divide and will help in suggesting methods to bridge this divide.***

**Index Terms - ICT, Digital Divide, Internet, Community Information Centers, Common Service Centers**

## 1. INTRODUCTION

The world we live in has been changing rapidly with the emergence of the ubiquitous society bringing forward extraordinary benefits and opportunities together with new challenges. The ability to create and utilize information plays a significant role in the economic and social structure of our lives. Greater awareness of the importance of information in defining our future has compelled nations across the world to commit themselves to the progressive development of ICT industries. On the other hand, ICT development has also deepened the problem of serious digital divide between developed and developing countries. The digital revolution has facilitated a fast transition from the industrial economy to the IT network-based information economy, causing the resulting digital divide to deepen economic disparities or polarization in wealth [1]. The digital divide affects many nations of the developing world. The term encompasses inadequate funding, a lack of necessary computer and Internet skills, and a lack of English-language proficiency that hinder expansion and use of digital information resources [2].

The rest of the paper is structured as follows: A brief introduction of Digital Divide, formulation of hypothesis, methodology of data collection, a brief introduction to the questionnaire, data analysis and finally the conclusion of the paper is presented.

## 2. DIGITAL DIVIDE

Information and Communication Technologies (ICTs) can be both a unifying and a divisive force. Its divisive aspect is known as the "digital divide", which relates to the difference between those who have digital access to knowledge and those who either lack it or don't use it effectively. The digital divide can be defined as the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regards both to their opportunities to access ICTs and to their use of the Internet for a wide variety of activities. As the Internet has rapidly grown to underlie almost every aspect of the global economy, the term "digital divide" has often been referred to Internet access [3]. It is a divide that affects and reinforces fundamental economic and social divides between and within countries and is threatening to further exacerbate these inequalities. Those who are "connected" are in for a greater advantage in terms of competing on a global basis, increased share in the market, increased knowledge, increased productivity and higher growth. Those who are not will be condemned to diminished knowledge, low GDP, increased unemployment and deepening marginalization. Developing countries and non-privileged groups have difficulty in "connecting" and difficulty in using Information Technology (IT) effectively because of anyone or more of the following: illiteracy, poverty, low level of skills, high cost of access, and even, poor mastering of the English language [4] .

### 2.1 Digital Divide Notions

The digital divide is a problem of multiple dimensions. Kling[5] (1998) sees the divide from (1) a technical aspect referring to availability of the infrastructure, the hardware and the software of ICTs, and (2) the social aspect referring to the

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skills required to manipulate technical resources. Norris[6] (2001) describes (1) a global divide revealing different capabilities between the industrialized and developing nations; (2) a social divide referring to inequalities within a given population; and (3) a democratic divide allowing for different levels of civic participation by means of ITCs. And Keniston[7](2003) distinguishes four social divisions: (1) those who are rich and powerful and those who are not; (2) those who speak English and those who do not; (3) those who live in technically well- established regions and those who do not; and (4) those who are technically savvy and those who are not.

### 2.2 Digital Divide: Indian Preview

India, a union of states, is the second most populous nation in the Asian region behind China. The country has achieved impressive progress in the field of science and technology and is emerging as one of the strongest economies in the developing world. Information and communication technologies have brought significant changes in development of the Indian society through information dissemination. In India, the benefits of IT are beginning to be seen and the impact of these benefits is creating a great change. It is also true that the use of digital technologies in the world has not only improved people's day–to–day life but it has also divided the world into information rich and information poor, *i.e.* the information haves and have–nots. The unequal access to information and communication technologies has led to a massive divide digitally. Although India has been one of the emerging super powers in IT, the benefits have been remarkably slow, particularly in rural and remote areas. Besides socio–economic factors, geographic, educational and attitudinal factors have been some of the challenges for the government when introducing IT–oriented programs. Although underserved communities in India are gaining access to computers and the Internet, their benefits are limited because of the factors namely, Political Instability, Infrastructural barriers, Literacy and skill barriers, Economic barriers, Content barriers, Linguistic Diversity [8-9].One formidable obstacle to ICT diffusion is language. There is a self-perpetuating cultural hegemony associated with ICTs (Keniston, 2002). By the year 2000, only 20% of all Web sites in the world were in languages other than English, and most of these were in Japanese, German, French, Spanish, Portuguese, and Chinese. But in the larger regions of Africa, India, and south Asia, less than ten percent of people are English-literate while the rest, more than two billion, speak languages that are sparsely represented on the Web. Because of the language barrier the majority of people in these regions have little use for computers. Those who do not use computers have little means to drive market demands for computer applications in their language [8]

## 3. HYPOTHESIS

On the basis of above review of literature following hypothesis was framed for the study:

Following are the factors responsible for the regional Digital Divide:

i) Internet Access
ii) Unawareness of the ICT programmes and the advances in technology
iii) Linguistic Diversity
iv) Internet Cost

## 4. METHODOLOGY FOR DATA COLLECTION

The objective of the pilot study was to elicit through questionnaires and interviews the major barriers to the use of internet. Convenient sampling was used to collect data for the pilot study, some people were chosen from rural areas and some from the urban areas of Jammu. Interviews and questionnaires and were used as tools to extract the required data. The survey included questions on telephone service, household income, race, age, educational attainment, geographic region, language preferred to read and write computer ownership; access to technical resources, interest in obtaining access, and attitudes toward technology. Location of internet access and reasons for using the Internet information needs and the way in which people use information were also studied.

## 5. GENERATION OF SCALE ITEMS

The questionnaire was designed after intensive literature review. Questions were based on the problems studied in the literature[1-7] such as availability of resources (telephone, computer, internet etc) at home and office , internet access after school/office, awareness of e-services, availability of internet access points such as Community Information Centers (CICs) and Cyber Cafés, knowledge of e-services, problems faced in using the internet etc. The questionnaire consisted of 35questions out of which 11 were of demographic profile and in the rest of questions the respondents were requested to select the response that best indicated their answer on each statement, using a five point Likert scale where 1=Strongly Agree, 2=Agree,3=Indifferent, 4=DisAgree,5=Strongly Disagree. Sample Size for the Pilot study was conveniently taken as fifty. The questionnaire is shown in the appendix.

## 6. DATA ANALYSIS

The pilot survey was conducted to study the factors responsible for the digital divide in Jammu and Kashmir. Other observations made during data analysis include division in the usage of ICTs along the line of Gender, education and age. The details about the various digital divide factors studied in the literature were found to be:

### 6.1 INTERNET ACCESS

Workplace (office, school, college etc) was found to be the most common place for internet access. Most offices and schools provide internet (broadband) access; therefore people indulge in internet activities at work, only 22% of the respondents did not have internet facility at work.

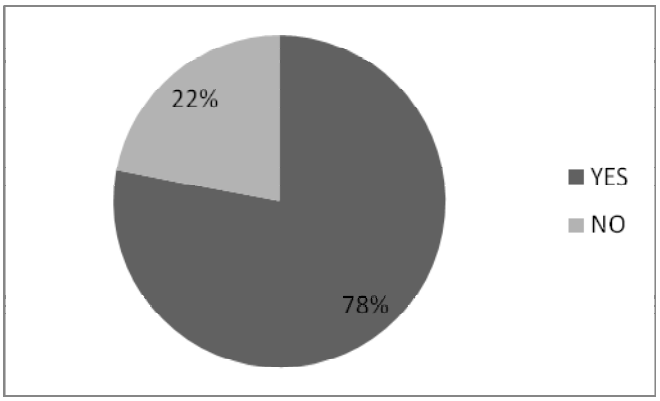


**Figure1: Availability of Internet Connection at Workplace**

It was calculated that the respondents who did not have internet provision at work either used internet at home or visited a cyber café. Out of these respondents, 55% had internet connection at home, 27% visited cyber café, and 18% respondents had never used internet. Respondents who had never used the internet quoted that there was no need for them to use it .i.e. they were not aware of the activities they could be engaged with on the internet.

The mean value for the Access Factor as a digital dividend has arrived at 1.59, indicating it to be another factor responsible for the digital divide (t 1.076, p > .05).

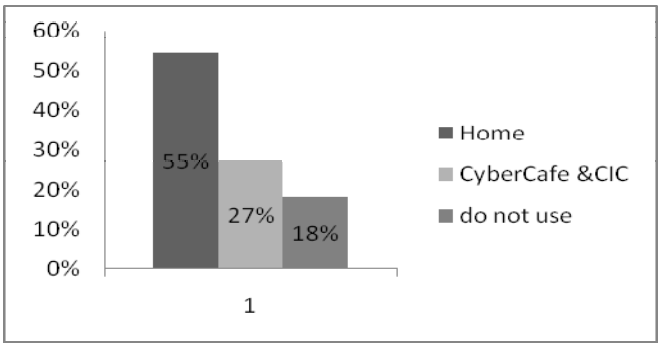


**Figure2: Internet usage Options for those without internet access at work place**

**6.2 AWARENESS OF GOVT.INITIATIVES**

The role of e-Government generally refers to the delivery and administration of Government products and services over an IT infrastructure, such as the provision of information electronically using Internet portals, online tax assessment and electronic voting. The J&K state government is disseminating information online via various websites such as jkpsc.com, jmc.nic.in, jandk.bsnl.co.in etc. Banks also have their own websites to deliver information and services. Government has also opened up Community Information Centers (CICs) and common Service Centers (CSCs) to provide internet access to the people.

**6.2.1 Community Information Centers (CICs)**

The Government of J&K has opened up 135 Community Information Centers (CICs) in various locations for internet access at nominal rates. The CICs provide some basic services that include internet browsing, e-mail, printing, data entry, word processing and training for the local populace on the fundamentals of computers. Some or all of these services are provided by all CICs. In addition, a large number of CICs offer several services with a G2C orientation. Services offered by CICs may be classified into five main categories, namely:

1. IT education and training
2. E-mail and internet access
3. Information dissemination
4. Citizen-centric applications
5. Entertainment and news [10]

**6.2.2 Common Service Centers/ Khidmat Centers (CSCs)**

Common Service Centers/ Khidmat Centers are centers opened by Jammu & Kashmir bank to avail all basic banking services offered it. They help the bank to deliver core banking services to the people at their door-step while bringing more and more public spaces within the fold of formal financial channels. Besides, these centers create employment at grass-root level and throw opportunities for youth, particularly from rural areas [11]. Calculations show that only 32% of the respondents were aware of these facilities and only 10% had visited them. It is now clear that government is taking initiatives to provide internet access to people, indicating that awareness of the government initiatives is a major obstacle towards bridging the digital divide. Government must frame policies to make people aware of such initiatives, so that these efforts show good results. The fundamental problem of extending access to all in a society and all geographic areas still remains. There is a need to open more of such centers to increase the access rate.

The mean value for the awareness parameter has arrived at 2.86 on the five point scale, which reflects that awareness is causing digital divide. The hypothesis also stands accepted as there is no difference in expected and observed value (t 1.206, p > .05).

**6.3 Cost**

Significant changes have taken place in the telecommunications policy and market in India in the last few years. Favorable government policies and lower costs have created a platform for rapid growth. This boom in the telecommunication industry has lead to a drop in the communication costs. Telephone and internet today are affordable, yet the mean value for cost as a digital dividend has arrived at 2.70. The hypothesis again stands accepted as there is no difference in expected and observed value (t .559, p > .05).

**6.4 Language**

Language is the primary vector for communication. Less than 5 percent of people can either read or write English (Census 2001). Only a small, rich, successful and English speaking minority in India is 'connected'. Lack of English language proficiency has created a 'computer fear'. On discussing issues relating to use of e-services, most respondents mentioned language issues. In spite of the availability of all the information online, people visit government office to seek information. The lack of software and instructions in minority languages also presents a huge barrier to ICT adoption.

The mean value for language as a dividend influencing the digital divide has arrived at 2.22. The hypothesis also stands accepted as there is no difference in expected and observed value (t 1.532, p > .05).

**6.4 Descriptive Statistics**

| Mean Score of Access, Awareness, Cost and Language | | | |
|---|---|---|---|
| | N | Mean | Std. Deviation |
| ACCESS | 50 | 1.5892 | .58610 |
| AWARENESS | 50 | 2.8552 | .92766 |
| COST | 50 | 2.7000 | 1.26572 |
| LANGUAGE | 50 | 2.2196 | 1.01376 |

**Figure3: Shows the Factors Responsible For The Digital Divide**

**7. OTHER OBSERVATIONS:**

Some other observations that were made during the pilot survey are discussed below:

**1. Qualification** has a major contribution in the usage of internet. It was observed that most users of e-services (such as e-billing, e-shopping, e-ticketing etc) were professionals or technically educated. They believe online activities save time and are also hassle free. Other respondents mostly indulged in entertainment activities such as chatting, downloading music, surfing etc. They were hesitant to use services that required monetary transactions due to lack of trust.

**2. Gender** has no significant contribution to the digital divide. There is no gendered difference in the usage of computers. On data analysis, it was noticed that the 50 families questioned, consisted of a total of 227 people, of these 114 i.e. 50.2% had knowledge of computers, 50 out of 114 were females accounting to 48.9% of the computer literates.

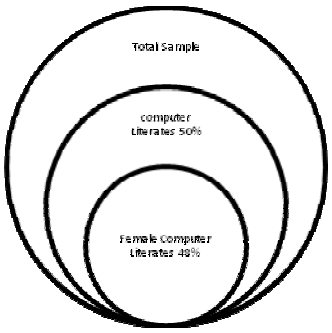


**Figure3 : Female computer users**

**3. Activities** done online differ by age and also by profession. People of different age groups indulge in different activities online. Most Common online activities include Emailing, chatting, music/movie download, games and social network, matrimony and search engines. E-Services that included monetary transactions are used mainly by professionals. Activities also differ from region to region.

The following table shows the ranking of internet activities in rural and urban areas.

| Area Wise Preference of Internet Service | | |
|---|---|---|
| Internet Service | Urban Area | Rural Area |
| Email | 1 | 2 |
| Chat | 4 | 5 |
| Music/Movie Download | 5 | 3 |
| Games | 6 | 4 |
| Shopping | 8 | 8 |
| Information Seeking | 2 | 1 |
| Social network | 3 | 6 |
| Matrimony | 7 | 7 |

**Figure 4: Shows the Ranking of Internet Services**

**8. DISCUSSION AND CONCLUSION:**

The digital divide is a multifaceted problem. This paper reports on the factors responsible for the digital divide, according to a pilot survey conducted in J&K .Much of the digital divide effort is focused on extending telecommunication infrastructure and supplying terminals to users. However, illiteracy and a lack of communication and IT skills are major components of the digital divide and must be considered and addressed alongside efforts to expand the physical network. The factors found in the study are found to be similar to those in the literature review. Many initiatives have been taken to provide internet access; costs have also been cut-down to make ICTs affordable. Attempts have been made to make the web language free, yet the digital divide remains. We need to develop models of collaboration among researchers, social scientists, technologists, etc. so that local requirements are met in a technology innovation.

## LIMITATIONS AND FUTURE SCOPE

It is necessary to recognize the limitations of the current study. One limitation is the small sample size. To examine the digital divide factors accurately, a larger sample is desirable. Another limitation is the convenient sampling method used. Future research needs to focus on larger cross section of internet users by employing more diversified samples.

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## APPENDIX A-LIST OF FIGURES

Fig1 shows the percentage wise availability of Internet Connection at Workplace and confirms that internet is mostly used at workplace.

Fig2 shows Internet usage Options (home, CIC, cybercafé) for those without internet access at work place.

Fig3 shows the female computer users accounting to 49% of the computer literates in the sample.

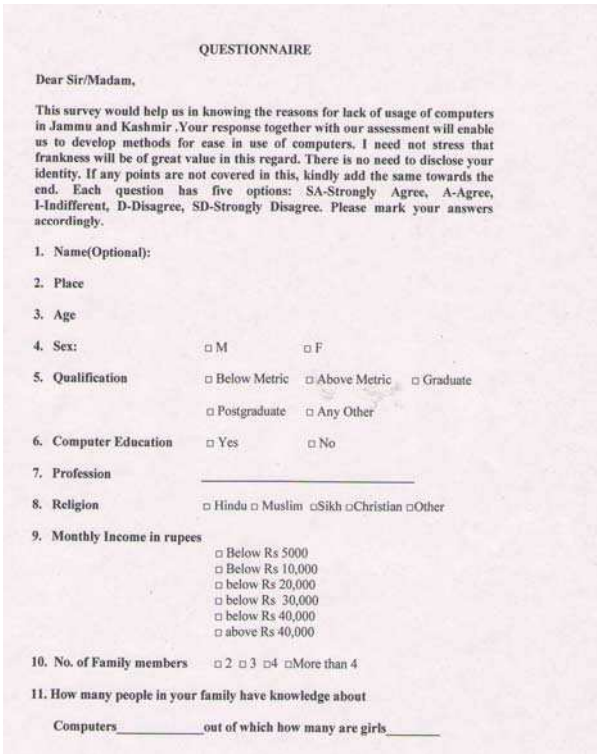
## APPENDIX B-LIST OF TABLES

Table 1 shows the descriptive statistics i.e. the mean score of the digital divide factors (Access, Awareness, Cost and Language).

Table 2 shows the area wise (Rural/Urban) ranking of Internet Services.

## APPENDIX C-QUESTIONNAIRE USED IN THE PILOT SURVEY

The Questionnaire used for the pilot survey is given below:



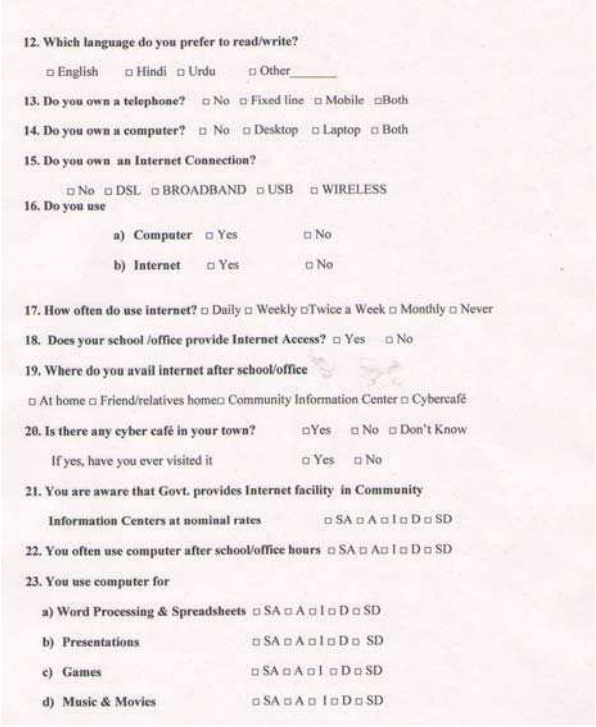
QUESTIONNAIRE

Dear Sir/Madam,

This survey would help us in knowing the reasons for lack of usage of computers in Jammu and Kashmir .Your response together with our assessment will enable us to develop methods for ease in use of computers. I need not stress that frankness will be of great value in this regard. There is no need to disclose your identity. If any points are not covered in this, kindly add the same towards the end. Each question has five options: SA-Strongly Agree, A-Agree, I-Indifferent, D-Disagree, SD-Strongly Disagree. Please mark your answers accordingly.

1. Name(Optional):
2. Place
3. Age
4. Sex: □ M □ F
5. Qualification □ Below Metric □ Above Metric □ Graduate □ Postgraduate □ Any Other
6. Computer Education □ Yes □ No
7. Profession _____
8. Religion □ Hindu □ Muslim □Sikh □Christian □Other
9. Monthly Income in rupees
   - □ Below Rs 5000
   - □ Below Rs 10,000
   - □ below Rs 20,000
   - □ below Rs 30,000
   - □ below Rs 40,000
   - □ above Rs 40,000
10. No. of Family members □ 2 □ 3 □4 □More than 4
11. How many people in your family have knowledge about

    Computers_____out of which how many are girls_____



12. Which language do you prefer to read/write?

□ English □ Hindi □ Urdu □ Other_____

13. Do you own a telephone? □ No □ Fixed line □ Mobile □Both

14. Do you own a computer? □ No □ Desktop □ Laptop □ Both

15. Do you own an Internet Connection?

□ No □ DSL □ BROADBAND □ USB □ WIRELESS

16. Do you use

a) Computer □ Yes □ No

b) Internet □ Yes □ No

17. How often do use internet? □ Daily □ Weekly □Twice a Week □ Monthly □ Never

18. Does your school /office provide Internet Access? □ Yes □ No

19. Where do you avail internet after school/office

□ At home □ Friend/relatives home□ Community Information Center □ Cybercafé

20. Is there any cyber café in your town? □Yes □ No □ Don't Know

If yes, have you ever visited it □ Yes □ No

21. You are aware that Govt. provides Internet facility in Community Information Centers at nominal rates □ SA □ A □ I □ D □ SD

22. You often use computer after school/office hours □ SA □ A□ I □ D □ SD

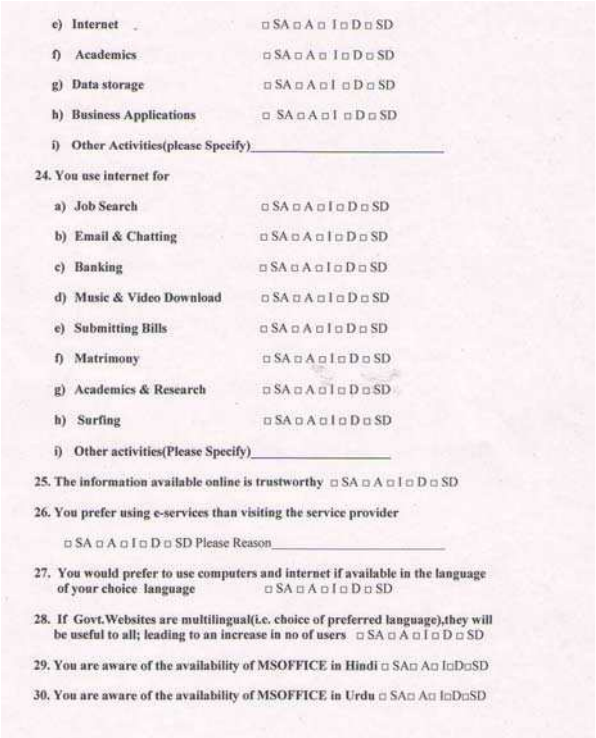
23. You use computer for

a) Word Processing & Spreadsheets □ SA □ A □ I □ D □ SD

b) Presentations □ SA □ A □ I □ D □ SD

c) Games □ SA □ A □ I □ D □ SD

d) Music & Movies □ SA □ A □ I □ D □ SD



e) Internet □ SA □ A □ I □ D □ SD

f) Academics □ SA □ A □ I □ D □ SD

g) Data storage □ SA □ A □ I □ D □ SD

h) Business Applications □ SA □ A □ I □ D □ SD

i) Other Activities(please Specify)_____

24. You use internet for

a) Job Search □ SA □ A □ I □ D □ SD

b) Email & Chatting □ SA □ A □ I □ D □ SD

c) Banking □ SA □ A □ I □ D □ SD

d) Music & Video Download □ SA □ A □ I □ D □ SD

e) Submitting Bills □ SA □ A □ I □ D □ SD

f) Matrimony □ SA □ A □ I □ D □ SD

g) Academics & Research □ SA □ A □ I □ D □ SD

h) Surfing □ SA □ A □ I □ D □ SD

i) Other activities(Please Specify)_____

25. The information available online is trustworthy □ SA □ A □ I □ D □ SD

26. You prefer using e-services than visiting the service provider

□ SA □ A □ I □ D □ SD Please Reason_____

27. You would prefer to use computers and internet if available in the language of your choice language □ SA □ A □ I □ D □ SD

28. If Govt.Websites are multilingual(i.e. choice of preferred language),they will be useful to all; leading to an increase in no of users □ SA □ A □ I □ D □ SD

29. You are aware of the availability of MSOFFICE in Hindi □ SA□ A□ I□D□SD

30. You are aware of the availability of MSOFFICE in Urdu □ SA□ A□ I□D□SD

# Measuring IT Effectiveness in Banks of India for Sustainable Development

**Sanjay Dhingra**

*Submitted in May 2011; Accepted in July 2011*

**Abstract -** ***Banks in India have invested heavily on deployment of information technology (IT) in the past one decade. IT over the years has become business driver rather than a business enabler. Sustainable development of banks depends heavily on effective use of IT. This calls for measuring the effectiveness of IT in these banks. This paper identifies the economic methods of measuring IT effectiveness on the basis of review of literature on the subject.***

**Index Terms = Information Technology (it), effectiveness, sustainable development, economic methods**

## 1. INTRODUCTION

In the past decade banks in India have invested heavily in the information technology. Total expenditure incurred on computerization and development of communication networks by public sector banks(PSBs) alone between September 1999 and March 31, 2009 is Rs. 17897 crore. Today, information technology seems to be the prime mover of all banking transactions. Trends show that banks in India have been endeavoring to leverage technology to bring about improvements in; quality of customer services, scale and specialization in products, alternative sources of income particularly from fee-based services, geographical reach through communication networks and electronic delivery channels, risk management practices, housekeeping, internal control systems and regulatory compliance and cost efficiencies and scale economies. In other words, banks in India started perceiving IT as a tool to achieve improvement in the efficiency (more output with less input) and effectiveness (outcomes). An indication of the extent of investment and percolation of IT in different categories of banks is evident from the data presented in Table1.

| Parameter | Nationalized Banks | State Bank Group | Other Public Sector Bank | Old Private Sector Banks | New Private Sector Banks | Foreign Banks |
|---|---|---|---|---|---|---|
| Banks | 19 | 07 | 01 | 15 | 08 | 31 |
| Branches | 39376 | 16062 | 510 | 4673 | 4204 | 293 |
| ATMs | 15938 | 11339 | 900 | 2674 | 12646 | 1054 |
| Fully Computerized Branches (%) | 92.9 | 100 | 100 | - | 100 | 100 |
| IT expenditure (in crore incurred between September 1999 and March 2009 | 11802 | 6095 | - | - | 3110* | - |

**Table 1.1: IT Percolation in Banks in India (as on March 2009) * Estimated amount**

Source: RBI's Report on Trend and Progress of Banking in India, 2008-2009

It is clear from the data, shown in Table 1 that banks have invested heavily over the years in information technology systems. Looking the dependence of banks on IT, there is no doubt that, IT over the years has become business driver rather than a business enabler. This is clear that banks sustainable development depends heavily on effective usage of IT. Therefore measuring the IT effectiveness is the major concern of management today. In our paper we have identified the methods of measuring IT effectiveness by reviewing the earlier studies on the subjects. Earlier studies have measured the IT effectiveness using both economic as well as non economic measures. Our paper reviews only those studies which have used the economic methods for measuring the IT effectiveness.

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## 2. REVIEW OF LITERATURE

Although banking is among the most IT-intensive industries and among those that started early to rely massively on computers for their operations, the large bulk of applied literature on bank technology includes very few studies on this topic, mainly because of the paucity of appropriate quantitative information. An analysis of earlier studies on

banking, in terms of their focus, method used as well as the main findings, is presented in Table 2.

| Author(s) | Sample | Technique(s) Used | Main Findings |
|---|---|---|---|
| [Alpar and Porembski,1989] | 30 German banks | DEA | Potential for cost savings from greater IT use was significant in 1989 and in 1994, the effects of IT on cost efficiency were small |
| [Alpar and Kim,1990] | 175 U.S. banks | Translog Function | IT contributed to reduction in demand deposits and increase in time deposits. IT also helped to increase in other loans and decrease in installment loans. IT was also responsible for saving labor. |
| [Parsons, Gotieb and Denny,1993] | 5 Canadian banks | Translog Function | There was a 17 to 23 percent increase in productivity with the use of computers. The returns were very modest compared to the levels of IT investments. |
| [Wang et al.,1997] | 22 U.S banks | DEA | Inefficiency in IT-related value added activities always lead to overall inefficiency. Around 64 percent of units that had efficient IT- related activity also had perfect overall efficiency. |
| [Prasad and Harker ,1997] | | Cobb-Douglas Production Function | Additional investment in IT capital had no real benefits and may be more of strategic necessity to stay within the competition. However the results indicated that there were substantially high returns when investment in IT labor was increased. |
| [Soteriou and Zenios,1999] | Bank branches of Cyprus | DEA | Micro-environment in the branches had an effect on their efficiency and urban branches had better efficiency than rural branches. |
| [Department of Banking Supervision, RBI, 2002] | All scheduled commercial banks of India | Ratios | Higher performance levels had been achieved without corresponding increase in the number of employees. Also operating expenses of the banking system had declined during the study period, indicating the positive impact of computerization. |
| [Takemura,2003] | Japanese banks | Cobb-Douglas Production Function | IT capital has either positive or no effect on productivity |
| [Rao et al.,2003] | Indian banks | Cobb-Douglas Production Function | E-business capital and e-business as well as non e-business labor made positive contributions to output. Non e-business capital has either insignificant or negative impact on productivity |
| [Chen and Zhu,2004] | 22 banks of U.S. | DEA | Applying the developed model on the data of 22 banks for the period 1987 to 1989, they concluded that IT budget was not efficiently utilized in the study period. |
| [Li,2007] | All Taiwan banks | DEA and SFA | Low operational efficiencies existed in the banking industry during the study period, 1996 to 2000. These inefficiencies were in nature ascribable to a combination of both wasteful over use of information technology resources and inappropriate scale of information technology investments. |

| Author(s) | Sample | Technique(s) Used | Main Findings |
|---|---|---|---|
| [Beccalli,2007] | 737 European banks | Ratios and SFA | Investment in IT services from external providers (consulting services, implementation services, training and education, support services) had a positive influence on accounting profits and profit efficiency, while the acquisition of hardware and software reduced banks' performance. |
| [Chandrasekhar and Sonar,2008] | 29 Indian banks | DEA and Malmquist Index | Private sector banks had a slight edge over their industry counterparts during the study period of 2001 to 2006. Further, on the technology front as well as in exercising managerial control, substantial scope existed for improvement, across the sector. |

**Table 2: Analysis of the Earlier Studies on Impact of IT on Banks**

## 3. METHODS OF MEASURING IT EFFECTIVENESS

Literature survey reveals that along with the performance ratios, econometric and linear programming approaches are available to measure the IT effectiveness. Performance ratios are widely used in all sectors of business. The best known ratios are for financial and production managers. The financial ratios regarding liquidity, capital adequacy, earnings and liability are widely used measures of organizational performance. While in banking sector intermediation cost, interest spread, operating expenditure, cost to income ratio, return on assets, return on equity, business per employee, income per employee and business per branch, among others, are some of the commonly used ratios for assessing the efficiency and productivity of a banking unit. However, they have disadvantages like (i) each single ratio must be compared with some benchmark ratio one at a time (ii) while the calculation of a set of financial ratios is relatively easy, the aggregation of those ratios can be quite complicated, which requires experienced judgment (iii) financial ratios do provide information on the overall financial performance of an organization, but provide little information about the amount by which performance could be improved or the area where the effort should be focused in order to improve performance (iv) ratio analysis also fails to consider the multiple input-output characteristics of business enterprises and cannot give an overall clear picture of organizational operations because firm performance may exhibit considerable variation, depending on the indicators selected. Looking at the disadvantages of ratios as a performance measurement technique, in the recent banking literature the attention has mostly been directed to the latter two techniques of frontier efficiency analysis, namely, econometric approach and linear programming approach, which can provide comprehensive insights beyond those available from financial ratio analysis for evaluating and improving IT effectiveness.After seminal study by [Farrell, 1957], methodological development in frontier efficiency analysis has been growing at a rapid pace. Presently, there are multitudes of techniques, arametric and nonparametric, stochastic and deterministic are available for performance measurement. The essential differences among these techniques based on the differing assumptions used in estimating the shape of the frontier and the distributional assumptions imposed on the random error and inefficiency.

There are at least five different types of approaches in the literature that have been employed in measuring IT effectiveness. Of those, three are econometric approaches i.e. stochastic frontier approach (SFA), distribution-free approach (DFA) and thick frontier approach (TFA), which are parametric, and two linear programming approaches which are nonparametric i.e. data envelopment analysis (DEA) and free disposal hull (FDH). Each of the approaches has weaknesses, as well as strengths relative to the other. The literature has not yet come to a consensus about the preferred approach for determining the best-practice frontier against which relative efficiencies are measured. In general, parametric approaches are stochastic, which distinguish the effects of inefficiency from the effects of noise. A key drawback of parametric approaches is that they usually specify a particular functional form that presupposes the shape of the frontier. If the functional form is misspecified, measured effectiveness may be confounded with the specification errors. In sharp contrast to parametric approaches, nonparametric approaches are inherently bounding techniques, and so they impose less structure on the frontier. They are deterministic and do not allow for random error owing to luck, data problems or other measurement errors. If random errors do exist, measured effectiveness may be confounded with these random deviations from the true efficiency frontier. Most of studies on banking have used either SFA or DEA approach to calculate the effectiveness. Both the DEA and SFA approaches have their individual strengths and weaknesses. The SFA approach has the advantage of allowing for random shocks and measurement errors. Another advantage of the SFA approach is that it is possible to analyze the structure, and investigate the determinants of, producer performance. Therefore, it has a more solid grounding in economic theory. On the other hand, weaknesses with the whole family of econometric approaches to efficiency measurement (to which SFA belongs) are (i) It is risky to impose a priori assumptions on the production

technology by choosing a functional form (e.g. Cobb–Douglas, translog, etc.), given that most of the distributional characteristics of the production technology are a priori unknown (ii) The precise specification of the error structure is difficult (sometimes even impossible) to ascertain. In addition, such specification is likely to introduce another potential source of error (iii) The continuity presumed in this approach may lead to approximation errors.

Compared with the stochastic parametric frontier approach, DEA has advantages in measuring the relative efficiency of banks. First, DEA is non-parametric frontier approach and does not require, rigid assumptions regarding production technology and specific statistical distribution of the error terms. Second, DEA is amenable for small sample studies. Third, as a non-parametric frontier technique, DEA identifies the inefficiency in a particular bank by comparing it to similar banks regarding as efficient. Other DEA advantages are [Banker and Morey, 1986, Sengupta, 1988] identification of bad from good performers by generating an overall, easy to interpret efficiency score; independent measurement units (giving great flexibility in selecting outputs/inputs); and manipulation of uncontrollable, environmental factors, e.g. competition. However, the DEA model does not allow for measurement error or random shocks. Instead, all these factors are attributed to (in) efficiency, a characteristic that inevitably leads to potential estimation errors.

## 4. CONCLUSION

In this paper author on the basis of review of literature has identified methods of measuring IT effectiveness in banks of India. There are at least five different types of approaches in the literature that have been employed in measuring IT effectiveness. Of those, three are econometric approaches i.e. stochastic frontier approach (SFA), distribution-free approach (DFA) and thick frontier approach (TFA), which are parametric, and two linear programming approaches which are nonparametric i.e. data envelopment analysis (DEA) and free disposal hull (FDH). Most of studies on banking have used either SFA or DEA approach to calculate the effectiveness. Advantages and disadvantages of each method are also discussed in the paper.

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# An Empirical Evaluation of LIKE Operator in Oracle

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**Abstract -** ***In database systems, user makes query and that query will be responded by the DBMS. Generally, there are a variety of methods for computing the response of the given query. It is the responsibility of the query processor to transform the query as entered by the user into an equivalent query that can be computed more efficiently. Query optimization is the process to find a good strategy or best query evaluation plan for processing a query. In the today's competitive environment, query optimization is one of the important criteria based on which one can compare the available commercial RDBMSs. The objective of this study is to discuss about techniques used by the Oracle for optimizing the queries and to present a comparative study of the various costs involve to execute the LIKE Operator based queries. This comparative study is based on empirical study done on Oracle 8i, Oracle 9i and Oracle 10g.***

**Index Terms -** ***Query Optimization, Oracle, Cost Control, LIKE Operator, Pattern Matching in DBMS***

## 1. INTRODUCTION

Query optimization is one of the important issues in database systems. A query may be expensive in terms of cost of execution if it is not optimized. In centralized database management systems, an efficient query processor would try to minimize the utilization of computing resources, such as storage space and processor time. In distributed environment, apart from the storage space and processor time; the costs of communication delays, setups and transmission have to be minimized. *Total cost* and *response time* are the good measures to compare the cost of queries in terms of resource consumption. [DB01]

Oracle is one of the most popular and efficient commercial RDBMS. Oracle claims that it uses both rule-based query optimizer and cost-based optimizer. The goal of the cost-based optimizer is the best *throughput (i.e.* the least amount of resources necessary to process all rows accessed by the SQL statement). Also, Oracle claims to optimize a statement with the goal of best *response time (i.e.* the least amount of resources necessary to process the first row accessed by a SQL statement). In general, it uses the cost-based approach. Oracle Corporation is continually improving its cost-based optimizer. The rule-based approach is available for backward compatibility with legacy applications. [WO01]

The objective of this study is to present the comparative performance of LIKE Operator of query optimizers used in Oracle 8i, 9i and 10g by using large volume of hypothetical data.

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## 2. METHODOLOGY

This study is based on hypothetical data which is generated using an algorithm to generate random strings of variable length. The table is populated with 11 columns and $10^5$ records. The table contains the strings based on all alphabets and blank space of maximum of 100 characters in each column.

For the analysis, the queries based on LIKE predicated are executed on the table (both without index and with index) on different versions of Oracle. This study broadly covers the three versions of Oracle, i.e., Oracle 8i, Oracle 9i, and Oracle 10g. The query execution plan and response time are observed and analyzed with help of different tools of Oracle.

## 3. THEORETICAL ASPECT OF QUERY OPTIMIZATION

Query optimization is the process to derive a number of query-evaluation plans to execute the query and selects the most efficient plan. It is the responsibility of the query optimizer to come up with a least-cost query-evaluation plan that computes the same result as the given relational-algebra expression (or, at least, is not much costlier than the least-costly way). There are several optimization criteria that have to be taken into the consideration at the time of optimization. [GH01] [GH02]

To find the least-costly query-evaluation plan, the optimizer needs to generate alternative plans that produce the same result as the given expression, and to choose the least-costly one. Generation of query-evaluation plans for and expression involves three steps:

1. Generating logically equivalent expressions using equivalence rules
2. Annotating resultant expressions to get alternative query plans
3. Choosing the cheapest plan based on estimated cost

a. **Rule-Based Optimizer:** Rule-based optimizer generates the equivalent optimal query evaluation plan by using the *equivalence rules* for the given relational algebraic query. It generates expressions equivalent to a given expression by means of *equivalence rules* that specify how to transform an expression into a logically equivalent one. *The optimization based on equivalence rules is very expensive in space and time*. [SK01]

b. **Cost-Based Optimization:** A cost-based optimizer generates a range of query-evaluation plans from the given query by means equivalence rules, and chooses one with the least cost. In general, with *n* relations, there are (2(n-1))! / (n-1)! different join orders. Brute-force method introduce large overhead in the optimization process because it will evaluate the cost of each evaluation plan separately, compare their costs and selects the least cost query-evaluation plan. This overhead can be reduced by applying the theory of ***dynamic programming,*** which can also be used for finding optimal query-evaluation plan optimistically. [SK01] The cost of an operation depends on the size and order statistics of its inputs. To estimate the cost of an operation some statistics about database relations are required, which are stored in database-system catalogs. The statistics has to be updated every time a relation is modified so that accurate statistics can be maintained. The updation of statistics may incur a substantial amount of overhead. [GH01] [GH02]

c. **Heuristics-Based Optimization:** The cost of optimization is the major drawback of cost-based optimization even with dynamic programming. The number of choices can be reduced by using *heuristics* that must be made in a cost-based fashion which will reduce the cost of optimization. Some systems use only heuristics; others combine heuristics with partial cost-based optimization. [GH01] [GH02]

d. **Materialized Views:** Materialized view is one of the concepts which can also be used for query optimization. A materialized view is a view whose contents is computed and stored, which can be used to speed up query processing e.g. indices. If base relations are modified then incremental maintenance is needed to efficiently update these views. In query optimization, materialized views are treated just like regular relations. [GH01] [GH02] Most database systems provide tools to help the database administrator with index and materialized view selection. These tools examine the history of queries and updates, and suggest indices and views to be materialized. The Microsoft SQL Server Database Tuning Assistant, the IBM DB2 Design Advisor, and the Oracle SQL Tuning Wizard are examples of such tools.

## 4. QUERY OPTIMIZATION IN ORACLE

A large variety of processing techniques are supported by Oracle in its SQL processing engine. SQL processing engine has four main components: parser, optimizer, row source generator, and SQL execution engine (*figure 1*).

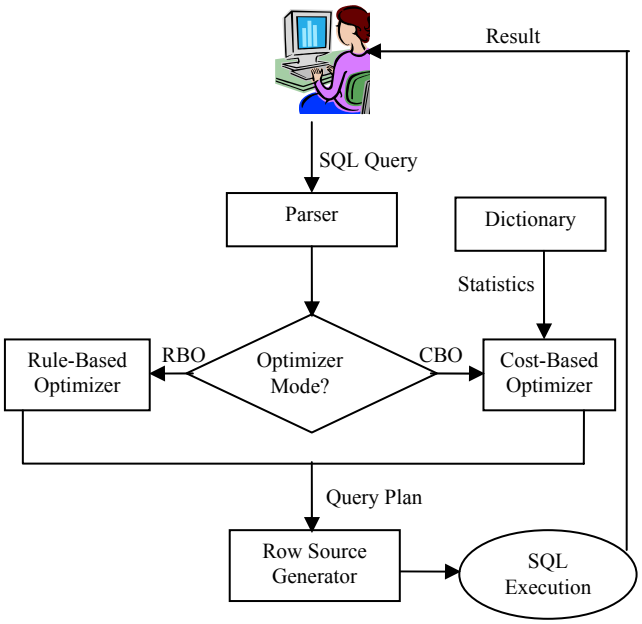


**Figure 1: SQL Processing Architecture (adapted from [WO01])**

The syntax and semantics analysis of the SQL statements is done by parser. The optimizer uses internal rules and/or costing methods to determine the most efficient way of producing the result of the query. The optimizer returns an optimal query plan for execution. The Oracle provides two types of optimizers: cost-based optimizer (CBO) and rule-based optimizer (RBO). The execution plan for the SQL statement is generated by the row source generator with the help of the query plan received from the optimizer. The execution plan is a collection of row sources structured in the form of a tree. Each row source returns a set of rows for that step. Each row source produced by the row source generator is executed by the SQL execution engine to produce the results of the query.

By default, optimizer mode is cost-based optimizer with the goal of *best throughput.* Also, Oracle can optimize a statement with the goal of *best response time*. In general, Oracle uses the cost-based approach but it also supports rule-based approach. *Oracle Corporation is continually improving the cost-based optimizer and adding the new features which will work only with the cost-based optimizer.* The rule-based approach is available for backward compatibility with legacy applications [WD01].

The cost-based architecture is shown in *figure 2*. By using the parsed query, the query transformer to determines if it is advantageous to change the form of the query so that it enables generation of a better query plan. *Four different query transformation techniques are employed by the query transformer: view merging, predicate pushing, sub-query unnesting, and query rewrite using materialized views.* [GH01] [GH02] Any combination of these transformations might be applied on the received parsed query.

The estimator generates three different types of measures: selectivity, cardinality, and cost. The selectivity, which represents a fraction of rows from a row set, lies in the value range 0.0 to 1.0. There are several types of cardinality measures: effective, join, distinct, and group cardinality. The cost represents units of work or resource used in performing an operation. The cost-based optimizer uses disk I/O, CPU usage, and memory usage as units of work. The plan generator computes the cost of different possible plans for a given query and selects the one that has the lowest cost.

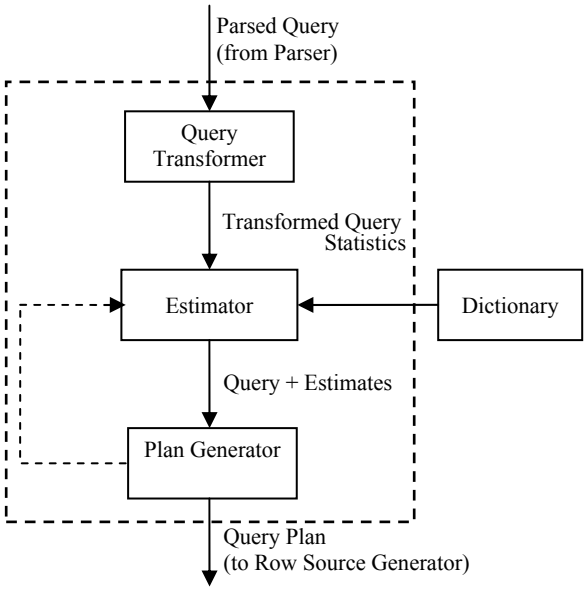


**Figure 2: Architecture of Cost-Based Optimizer (adapted from [WO01])**

In Oracle, large set of processing techniques is used in one engine. Many different join and index methods, parallel query, etc. e.g., nested loops, sort-merge, and hash joins, anti-joins, semi-joins, B-tree, bitmap, reverse, functional, and domain indexes, clusters and hash clusters, index-organized tables, nested tables, materialized views, partitioning, join indexes, index joins, index skip-scan, etc. are used. No single technique is best for everything. Oracle provides many different ones, and the optimizer determines which the best for each individual query is. [WD01]

## 5. EXPERIMENT

### 5.1 The Environment

All the experiments are performed on the same machine in which Microsoft Windows 2000 Advanced Server Version 5.0 OS with Service Pack 4 is installed. The experiments are performed on three different versions of Oracle that is Oracle 8i Release 8.1.7.0.0, Oracle 9i Release 9.0.1.0.0 and Oracle 10g Release 10.1.0.0.0

### 5.2 The Queries

A table consisting of 11 columns of VARCHAR2 data type is used for the experiment. Each column can store a string of maximum 100 characters. The table is populated with 100000 records. The following 8 queries are used in the experiments for observing the EXPLAIN PLAN and SQL Trace results. Experiments are performed using both without index and with index.

| Query No. | SQL Statement |
|---|---|
| 1 | `SELECT C1 FROM T1 WHERE C1 = 'VMPNODLHHCRWPEPSABCDXDKQYKWYDGFSFTHNNQGDQ';` |
| 2 | `SELECT C1 FROM T1 WHERE C1 LIKE 'VMPNODLHHCRWPEPSABCDXDKQYKWYDGFSFTHNNQGDQ%';` |
| 3 | `SELECT C1 FROM T1 WHERE C1 LIKE '%VMPNODLHHCRWPEPSABCDXDKQYKWYDGFSFTHNNQGDQ%';` |
| 4 | `SELECT C1 FROM T1 WHERE C1 LIKE '%VMPNODLHHCRWPEPSABCDXDKQYKWYDGFSFTHNNQGDQ';` |
| 5 | `SELECT C1 FROM T1 WHERE C1 = 'ABC';` |
| 6 | `SELECT C1 FROM T1 WHERE C1 LIKE 'ABC%';` |
| 7 | `SELECT C1 FROM T1 WHERE C1 LIKE '%ABC%';` |
| 8 | `SELECT C1 FROM T1 WHERE C1 LIKE '%ABC';` |

**Table 1: List of SQL Statements used for Experiments**

## 6. COST COMPARISON AMONG ORACLE 8i, 9i AND 10g

The costs of the queries are compared on the basis following 5 parameters:

**CPU Time** = CPU Time in seconds executing
**Elapsed Time** = Elapsed Time in seconds executing
**Disk** = Number of physical reads of buffers from disk
**Query** = Number of buffers gotten for consistent read
**Current** = Number of buffers gotten in current mode (usually for update)

The various measured costs of above mentioned eight queries are represented in the Table 2 to Table 9 and Figure 3 to 10 respectively. The overall measured cost of all eight queries is represented in Table 10 and Figure 11.

| Cost in | CPU Time (in ms)* | Elapsed Time (in ms)* | Disk | Query | Current* |
|---|---|---|---|---|---|
| Without Index (in 8i) | 900 | 8900 | 3480 | 7460 | 400 |
| With Index (in 8i) | 0 | 500 | 2 | 3 | 0 |
| Without Index (in 9i) | 1200 | 12900 | 10361 | 15964 | 1200 |
| With Index (in 9i) | 0 | 100 | 2 | 3 | 0 |
| Without Index (in 10g) | 600 | 17500 | 0 | 7521 | 0 |
| With Index (in 10g) | 0 | 2800 | 0 | 3 | 0 |
| With Bitmap Index (in 9i) | 0 | 0 | 0 | 3 | 400 |
| With Bitmap Index (in 10g) | 0 | 6000 | 0 | 3 | 0 |

**Note:** *** - denotes value of respective column is multiplied by 100**

**Table 2: Cost Comparison of Query 1**

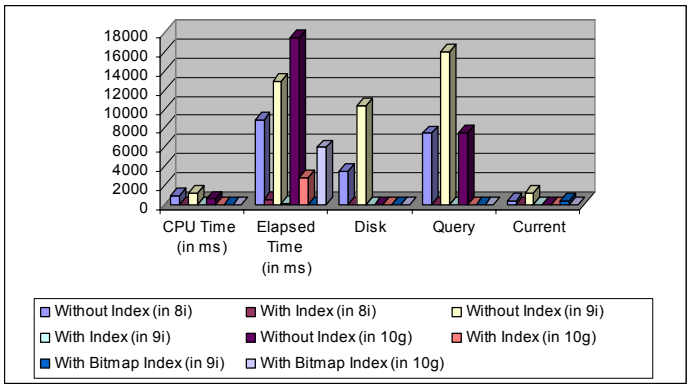


**Figure 3: Cost Comparison of Query 1**

| Cost in | CPU Time (in ms)* | Elapsed Time (in ms)* | Disk | Query | Current* |
|---|---|---|---|---|---|
| Without Index (in 8i) | 800 | 8600 | 3480 | 7460 | 400 |
| With Index (in 8i) | 0 | 0 | 0 | 3 | 0 |
| Without Index (in 9i) | 600 | 12500 | 10361 | 15964 | 1200 |
| With Index (in 9i) | 0 | 0 | 0 | 3 | 0 |
| Without Index (in 10g) | 600 | 600 | 0 | 7521 | 0 |
| With Index (in 10g) | 0 | 600 | 0 | 3 | 0 |
| With Bitmap Index (in 9i) | 100 | 100 | 0 | 3 | 400 |
| With Bitmap Index (in 10g) | 0 | 400 | 0 | 3 | 0 |

*Note:* * - *denotes value of respective column is multiplied by 100*

**Table 3: Cost Comparison of Query 2**

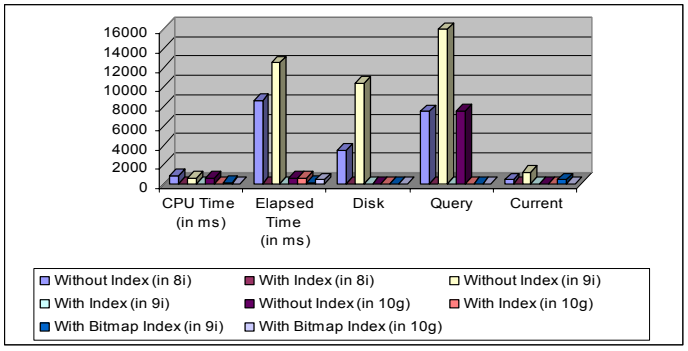


**Figure 4: Cost Comparison of Query 2**

| Cost in | CPU Time (in ms)* | Elapsed Time (in ms)* | Disk | Query | Current* |
|---|---|---|---|---|---|
| Without Index (in 8i) | 1200 | 8600 | 3480 | 7461 | 400 |
| With Index (in 8i) | 0 | 2800 | 876 | 880 | 600 |
| Without Index (in 9i) | 300 | 12500 | 10361 | 15965 | 1200 |
| With Index (in 9i) | 100 | 2300 | 1812 | 1816 | 600 |

| Cost in | CPU Time (in ms)* | Elapsed Time (in ms)* | Disk | Query | Current* |
|---|---|---|---|---|---|
| Without Index (in 10g) | 3400 | 3500 | 0 | 7522 | 0 |
| With Index (in 10g) | 3200 | 4000 | 0 | 886 | 0 |
| With Bitmap Index (in 9i) | 500 | 500 | 5 | 2077 | 400 |
| With Bitmap Index (in 10g) | 3400 | 3900 | 0 | 1008 | 0 |

*Note:* * - *denotes value of respective column is multiplied by 100*

**Table 4: Cost Comparison of Query 3**

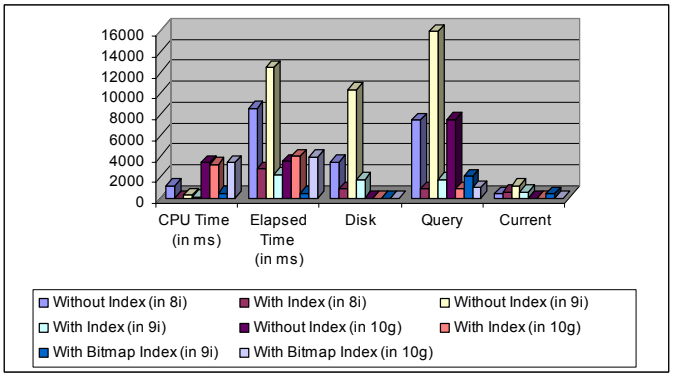


**Figure 5: Cost Comparison of Query 3**

| Cost in | CPU Time (in ms)* | Elapsed Time (in ms)* | Disk | Query | Current* |
|---|---|---|---|---|---|
| Without Index (in 8i) | 800 | 8600 | 3480 | 7460 | 400 |
| With Index (in 8i) | 100 | 200 | 0 | 879 | 600 |
| Without Index (in 9i) | 700 | 12800 | 10361 | 15964 | 1200 |
| With Index (in 9i) | 100 | 100 | 0 | 1815 | 600 |
| Without Index (in 10g) | 600 | 600 | 0 | 7521 | 0 |
| With Index (in 10g) | 400 | 400 | 0 | 885 | 0 |
| With Bitmap Index (in 9i) | 500 | 500 | 0 | 2077 | 400 |
| With Bitmap Index (in 10g) | 300 | 600 | 0 | 1007 | 0 |

*Note:* * - *denotes value of respective column is multiplied by 100*

**Table 5: Cost Comparison of Query 4**

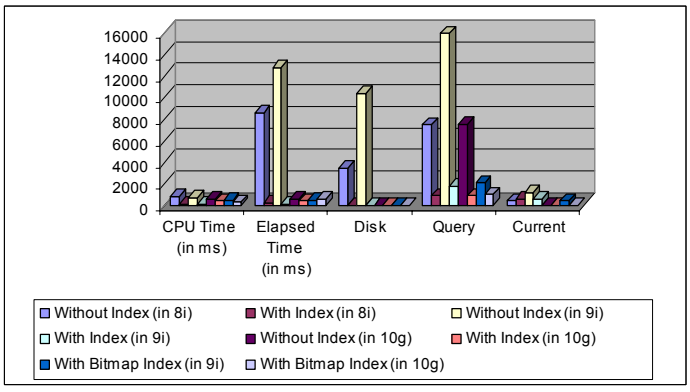


**Figure 6: Cost Comparison of Query 4**

| Cost in | CPU Time (in ms)* | Elapsed Time (in ms)* | Disk | Query | Current* |
|---|---|---|---|---|---|
| Without Index (in 8i) | 800 | 8700 | 3480 | 7460 | 400 |
| With Index (in 8i) | 0 | 0 | 0 | 3 | 0 |
| Without Index (in 9i) | 1200 | 12300 | 10361 | 15964 | 1200 |
| With Index (in 9i) | 0 | 0 | 0 | 3 | 0 |
| Without Index (in 10g) | 300 | 300 | 0 | 7521 | 0 |
| With Index (in 10g) | 0 | 0 | 0 | 3 | 0 |
| With Bitmap Index (in 9i) | 0 | 0 | 0 | 3 | 400 |
| With Bitmap Index (in 10g) | 0 | 0 | 0 | 3 | 0 |

*Note:* * - denotes value of respective column is multiplied by 100

**Table 6: Cost Comparison of Query 5**

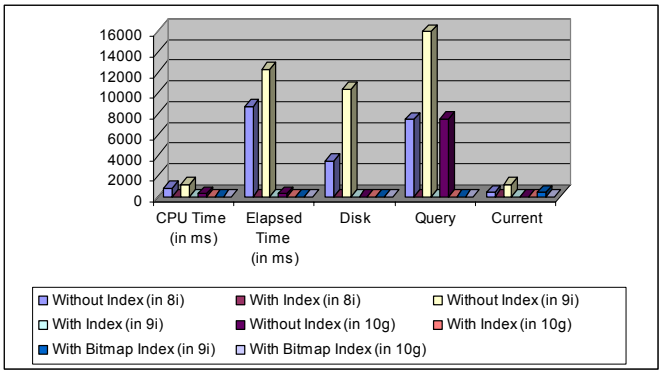


**Figure 7: Cost Comparison of Query 5**

| Cost in | CPU Time (in ms)* | Elapsed Time (in ms)* | Disk | Query | Current* |
|---|---|---|---|---|---|
| Without Index (in 8i) | 600 | 8300 | 3480 | 7461 | 400 |
| With Index (in 8i) | 100 | 200 | 0 | 880 | 600 |
| Without Index (in 9i) | 1000 | 12800 | 10361 | 15965 | 1200 |
| With Index (in 9i) | 100 | 100 | 0 | 1816 | 600 |
| Without Index (in 10g) | 600 | 700 | 0 | 7522 | 0 |
| With Index (in 10g) | 100 | 600 | 0 | 886 | 0 |
| With Bitmap Index (in 9i) | 0 | 0 | 0 | 3 | 400 |
| With Bitmap Index (in 10g) | 0 | 400 | 0 | 4 | 0 |

*Note:* * - denotes value of respective column is multiplied by 100

**Table 7: Cost Comparison of Query 6**

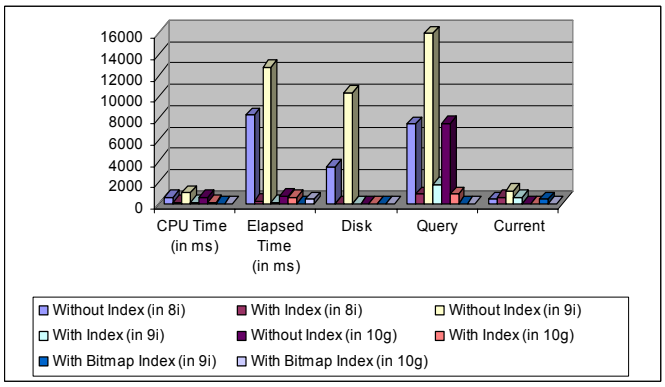


**Figure 8: Cost Comparison of Query 6**

| Cost in | CPU Time (in ms)* | Elapsed Time (in ms)* | Disk | Query | Current* |
|---|---|---|---|---|---|
| Without Index (in 8i) | 800 | 7000 | 3481 | 7476 | 400 |
| With Index (in 8i) | 800 | 700 | 0 | 896 | 600 |
| Without Index (in 9i) | 1500 | 13400 | 10362 | 15979 | 1200 |
| With Index (in 9i) | 300 | 300 | 0 | 1831 | 600 |
| Without Index (in 10g) | 3200 | 3600 | 0 | 7538 | 0 |
| With Index (in 10g) | 3400 | 4200 | 0 | 902 | 0 |
| With Bitmap Index (in 9i) | 600 | 600 | 0 | 2077 | 400 |
| With Bitmap Index (in 10g) | 2900 | 3200 | 0 | 1024 | 0 |

*Note:* * - denotes value of respective column is multiplied by 100

**Table 8: Cost Comparison of Query 7**

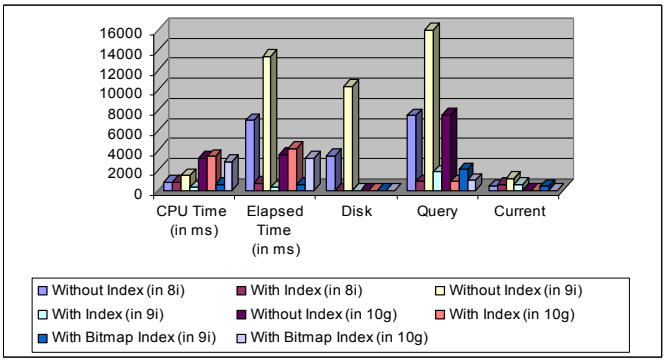


**Figure 9: Cost Comparison of Query 7**

| Cost in | CPU Time (in ms)* | Elapsed Time (in ms)* | Disk | Query | Current* |
|---|---|---|---|---|---|
| Without Index (in 8i) | 500 | 8800 | 3480 | 7460 | 400 |
| With Index (in 8i) | 300 | 300 | 0 | 880 | 600 |
| Without Index (in 9i) | 1700 | 12600 | 10361 | 15965 | 1200 |
| With Index (in 9i) | 300 | 300 | 0 | 1816 | 600 |
| Without Index (in 10g) | 400 | 600 | 0 | 7522 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| With Index (in 10g) | 300 | 1100 | 0 | 886 | 0 |
| With Bitmap Index (in 9i) | 200 | 300 | 0 | 2077 | 400 |
| With Bitmap Index (in 10g) | 300 | 1000 | 0 | 1008 | 0 |

*Note:* ** - denotes value of respective column is multiplied by 100*

**Table 9: Cost Comparison of Query 8**

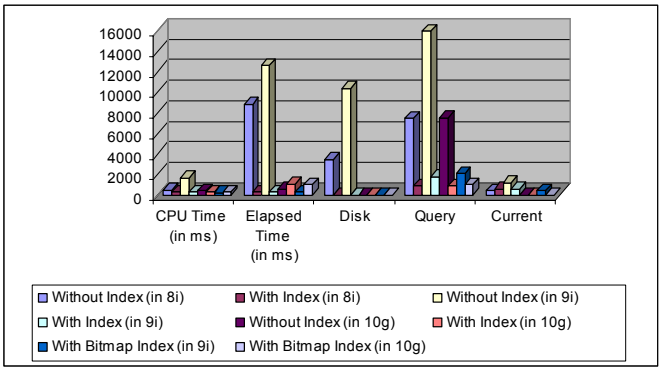


**Figure 10: Cost Comparison of Query 8**

| Total Cost in | CPU Time* (in ms) | Elapsed Time* (in ms) | Disk | Query | Current# |
|---|---|---|---|---|---|
| Without Index (in 8i) | 6400 | 67500 | 27841 | 59698 | 32000 |
| With Index (in 8i) | 1300 | 4700 | 878 | 4424 | 30000 |
| Without Index (in 9i) | 8200 | 101800 | 82889 | 127730 | 96000 |
| With Index (in 9i) | 900 | 3200 | 1814 | 9103 | 30000 |
| Without Index (in 10g) | 9700 | 27400 | 0 | 60188 | 0 |
| With Index (in 10g) | 7400 | 13700 | 0 | 4454 | 0 |
| With Bitmap Index (in 9i) | 1900 | 2000 | 5 | 8320 | 32000 |
| With Bitmap Index (in 10g) | 6900 | 15500 | 0 | 4060 | 0 |

*Note:* ** - denotes value of respective column is multiplied by 10,*
*# - denotes value of column is multiplied by 1000*

**Table 10: Comparison of Total Costs of All 8 Queries**

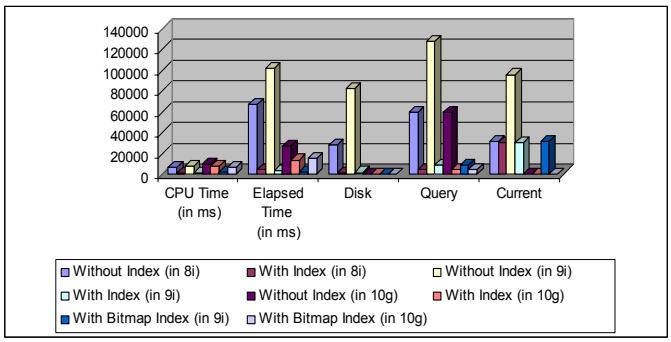


**Figure 11: Comparison of Total Costs of All 8 Queries**

## 7. SUMMARY AND CONCLUSIONS

The study is being completed taking into consideration the different parameters which is been mentioned in the objective of my study. It includes both descriptive and empirical study and the conclusions drawn are having far reaching implications. On the basis of the study I had concluded:

a. The cost of FIRST_ROW (response time) and ALL_ROWS (throughput) is same in all these three versions of Oracle. It might be due to in ALL_ROWS Oracle computes the statistics based on block available in SGA.
b. In case of without index table, exact match and pattern matching has same cost in all these three versions of Oracle. Because Oracle performs full table scan (compares with each row) if no index is available on the queried column(s).
c. In Oracle 9i, the cost of evaluation plan is almost double of the cost in Oracle 8i. This cost in Oracle 9i might be decreased if the size of RAM is increased so that the disk swapping can be reduced.
d. In Oracle 10g, estimated statistics and computed statistics shows the different results whereas in Oracle 8i and Oracle 9i both estimated and computed statistics shows the same results. It means Oracle 10g using different approach for estimating and computing statistics as compared to Oracle 8i and Oracle 9i.
e. In Oracle 10g, the cost of execution plan is less than the Oracle 9i but slightly greater than that of Oracle 8i. It may be due to that Oracle 10g is managing the memory more efficiently as compared to the Oracle 9i but Oracle 10g has more overhead than that of Oracle 8i.
f. In case of non-indexed table, CPU time and elapsed time in Oracle 8i is lesser than that of Oracle 9i. The Oracle 9i is basically the rewrite of the Oracle 8i with some more features which involve more overhead.
g. In case of indexed table, CPU and elapsed time in Oracle 9i is lesser than that of Oracle 8i. In Oracle 9i, the indexes are more optimized than that of Oracle 8i.
h. CPU time in Oracle 10g is more than that of Oracle 8i and Oracle 9i but the elapsed time is inversed. Oracle 10g is having the grid support. It assumes that all the queries are distributed queries therefore it requires more CPU time as compared to Oracle 8i and Oracle 9i.
i. In case of bitmapped indexed table in Oracle 9i, elapsed time is lesser than that of normal indexed table but the CPU time is inversed.
j. In case of bitmapped indexed table in Oracle 10g, CPU time is lesser than that of normal indexed table but the elapsed time is inversed.
k. Bitmapped indexes in Oracle 9i are more optimized than that of Oracle 10g.

The above conclusions are based on hypothetical data. These may differ in actual environment with larger volume of data and/or different system configuration. The experiments are

performed using 256 MB RAM, therefore if larger amount of RAM is used than the result may be slightly varied.

Further, the results indicate that the query optimizer performance of Oracle 9i may only be due to a rewrite of the Oracle 8i query optimizer rather than any new algorithm's implementation (as the results do not differ by much). Some more features are added into the Oracle 9i. The indexes in Oracle 9i might be more optimized than that of Oracle 8i. Oracle 10g has grid support which is beneficial in distributed environment. Due the grid support, a lot of overheads are included in the Oracle 10g. Oracle 10g may be assuming all queries to be distributed queries, therefore it requires more CPU time. From the observations of the experiments, it has been noticed that the prefixed substring in LIKE operator requires 'full table scan' irrespective of whether index is used or not. Therefore, there is scope to improve the cost of LIKE '%.....%' by design of new implementations for this operator.

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# The Impact of Patent Applications Filed on Sustainable Development of Selected Asian Countries

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*Submitted in May 2011; Accepted in July 2011*

***Abstract - Innovative activity underpins economic productivity and growth. Countries that generate innovation, create new technologies, and encourage adoption of these new technologies grow faster than those that do not. In some industries patenting is identified as the most important means of protecting IP and is increasingly used as a strategic asset by companies to create sustainable competitive advantage – although, in others, secrecy is used to safeguard proprietary knowledge. The basic purpose of this paper is to see the impact of patent filing on economic growth of the country leading to sustainable development of the economy. For this, the paper analyzed and tested the data of 9 countries for the period of 10 years (2000-2009). The results concluded that it was a mixed result in case of Asian countries. Only, technology based countries' economies were affected by patent applications filed.***

***Index Terms - Intellectual Property Rights (IPR), economic growth, Gross Domestic Product (GDP), Asian countries, Patents, Sustainable development***

## 1. INTRODUCTION

Intellectual Property rights (IPR) are legally enforceable rights relating to creations of the mind and include inventions, literary and artistic works, and symbols, names, images, and designs used in commerce. A number of individual rights are covered by IP like Patents, trademarks, copyrights, designs and trade secrets, [1] For sustainable development, economic growth of the country is very essential. Patent of new invention is one of the ways economic growths. The recent history seems to show that technology and knowledge are important factors for economic growth and development. Since the creation of the first mechanism to protect inventions in 15 $^{th}$ century, the patent system has evolved with a view to promote innovation and encouraging economic development. By offering exclusive rights for a limited period, an inventor may recover R&D costs and investments [30]. A patent for an invention is granted by government to the inventor. When a patent is granted, the *right* becomes the property of the inventor, which – like any other form of property or business asset – can be bought, sold, rented or hired. The patent is not a monopoly, but gives the inventor the *right* – normally for 20 years from the date when the patent application was first filed – to stop others from making, using or selling the invention without the permission of the inventor. Patent provides a great strength to the technology driven companies across the world and also helps in creating wealth to the economies of all developed, developing and least-developed countries. Many researchers revealed that there is a direct and/or proportionate relationship between Patent registration and economic growth of a country. This article will reveal such relationship between the country's percentage GDP (Gross Domestic Product) growth and the percentage change in the patent application filed among selected Asian countries for the period of 10 years (2000-2009) resulting in its sustainable development.

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## 2. REVIEW OF LITERATURE

Intellectual property helped make possible the conditions for innovation, entrepreneurship and market-oriented economic growth that shaped the 20th Century. A critical enabling tool increasingly is intellectual property protection [31]. The contribution of technological innovation to national economic growth has been well established in the economic literature, both theoretically as well as empirically [27]. Many studies had evidently proved that there is a relationship between number of Patent application filed and economic growth of that country. Patent is a better performance variable but does also suffer from serious limitations. Patents can be expected to reflect conditions (red tape, financial sector quality, etc) that affect the decision to innovate [32]. Porter and Ketels argue that true competitiveness is measured by economic productivity – determined by capital intensity, labour force skills and total factor productivity – and productivity growth is influenced by trade, investment and innovative activity. They suggest that countries' economies, in terms of their characteristic competitive advantage and modes of competing, evolve through various stages, namely, Factor-driven stage, Investment-driven stage and innovation-driven stage. All these stages are on the basis of their competitive advantage. [2]

Another study [3] revealed that there is an evident relationship between Intellectual Property Rights (IPR) and sustainable development of the country. The author analysed the recent developments and indicated that there are an increasing number of links between intellectual property protection and sustainable development which need to be addressed. A number of studies have empirically demonstrated the ability of weaker IPRs in stimulating domestic innovative activity in developing

countries. In fact stronger IPRs may actually adversely affect innovative activity by stifling the absorption of knowledge spillovers that are important determinants of innovative activity. More and more researchers have endogenously determined by technical change resulting from decisions of profit-maximising agents. Some authors provide surveys of such innovation and R & D based endogenous growth models [25] [26]. The OECD report on "Intellectual Property as an Economic Asset" [4], which draws on Kaplan and Norton [5], highlights the fundamental role IP plays in business performance and economic growth in knowledge-based economies. The report points out that, increasingly, a large proportion of the market value of a company is determined by its intellectual assets – which, as intangible assets, have monetary value and add to the company's balance sheet to increase enterprise value. Indeed, substantial value placed on patents [6] and patenting innovations substantially increases (up to 47%) the value realized from them. [7]

The most recent of these studies have expanded the analysis to include economic growth as measured by per capita output (GDP). [28] An economic author developed an error correction model to determine the equilibrium rate of entrepreneurship as a function of the stage of development of an economy. The idea of the equilibrium rate has its roots in the choice between self employment and wage-employment that exists in the labour market. Also using data for 23 OECD countries, this study derived the equilibrium rates of entrepreneurship and showed that deviations from these rates significantly and negatively influence GDP growth. In a related area, [29] an author applied this formulation to study the impact of small business prevalence and reached a similar conclusion. Any country deviating from the equilibrium rate of entrepreneurship incurs a growth penalty in terms of foregone economic growth. In this way, depending on whether a country's actual rate of entrepreneurship is above or below its equilibrium rate, there is technically both a negative and positive relationship between economic growth and the rate of entrepreneurship.

In an important contribution, [8] the authors compiled an index of patent rights for 60 countries between 1960-90. The GP (Ginarte and Park) Index focused only on patent rights, as published in law, with no attention to enforcement. Nevertheless, the index has been widely applied in subsequent studies as a measure of the strength of the national patent rights regime. The authors used the index to study the relation of economic growth, investment, and R&D expenditure to patent rights. They found no relationship between stronger patent rights and economic growth. However, among richer countries (with above median income), stronger patent rights were positively related to investment and R&D. There was no such relation among poorer countries.

## 3. OBJECTIVE

This article will discuss the relationship between two variables – Patent application filed growth rate and GDP growth rate among 9 selected Asian countries. The basic objectives are:

1. To find out the relationship between Patent applications filed growth rate and GDP growth rate.
2. To identify the salient features of all the Asian countries which make them patent friendly or restrict them to compete with other Asian countries in terms of patent applications filed and economic growth.

## 4. RESEARCH METHODOLOGY

This article selected 9 Asian countries as a sample namely, India, China, Japan, Indonesia, Brunei, Vietnam, Singapore, Malaysia, Thailand and Philippines. These countries were selected randomly out of all Asian countries. A correlation was set up for 10 years record of both patent application filed and GDP growth rate of all 9 Asian countries. The article's hypothesis is that there is a direct relationship between the number of patent application filed and GDP growth rate. It means

$H_o$ = There is no relationship between Patent applications filed growth rate and GDP growth rate.

$H_1$ = There is/may have a direct relationship between Patent applications filed growth rate and GDP growth rate.

For testing this hypothesis, Student's T-test was used as it is one of the most appropriate correlation testing techniques for small sample.

## 5. PATENT RIGHTS IN DIFFERENT ASIAN COUNTRIES

Regarding the present IP scenario in Asia, it has been quoted that almost every region in Asia Pacific has at some point or other been accused of not providing adequate protection to IP rights. It is also a fact that most countries in Asia Pacific that have developed strong technological capabilities, including Korea, Taiwan, China and India, have built their capabilities on the basis of poor IP rights enforcement. [9] After this study, things had been changed variedly. Many changes took place in the laws and by laws of the countries world wide. Our sample countries also went through few changes which helped them in fostering their position in terms of secured patents to the world and hence increased the number of patents filed in the present time. This change had variedly impacted the economic conditions of those countries.

### 5.1 India

There is a well-established statutory, administrative and judicial framework to safeguard intellectual property rights in India, whether they relate to patents, trademarks, copyright or industrial designs. As far as patents are concerned first recognition to patents was provided in 1856 by British government on the basis of United Kingdom Act of 1852. After many modifications in 1872, 1888, 1911 and 1949, in 1970, the first independent Act was passed by Joint Committee of Indian government. In 1999, another Patents (Amendment) Act, 1999 passed by the Indian Parliament on December 20, 1999 to amend the Patents Act of 1970 that provides for establishment

of a mail box system to file patents and accords exclusive marketing rights for 5 years. It was again amended in 1999 in the name of Patents (Second Amendment) Bill, 2002 to further amend the Patents Act, 1970 and make it TRIPS compliant. The third amendment was made in 2004 in the name of Patent amendment Ordinance, 2004 w.e.f. 1st January, 2005. All these amendments made a great impact on the number of applications for the filing of patent applications. This can be seen in Table 1A and Table 1B.

| | Thailand | Japan | Vietnam | Phillipines | Malaysia |
|---|---|---|---|---|---|
| **1999** | 6897 | 405655 | 1142 | 3361 | 5842 |
| **2000** | 7746 | 436865 | 1239 | 3636 | 6227 |
| **2001** | 7994 | 439175 | 1286 | 2605 | 5934 |
| **2002** | 7726 | 421044 | 1211 | 918 | 4937 |
| **2003** | 8574 | 413092 | 1150 | 1942 | 5062 |
| **2004** | 8942 | 423081 | 1431 | 2695 | 5442 |
| **2005** | 10885 | 427078 | 1947 | 2972 | 6286 |
| **2006** | 9821 | 408674 | 2166 | 3261 | 4800 |
| **2007** | 10339 | 396291 | 2860 | 3473 | 2372 |
| **2008** | 10561 | 391002 | 3199 | 3311 | 5403 |
| **2009** | 9730 | 348596 | 2890 | 2997 | 5737 |

**Table 1A: Number of Patents Applications Filed Among the Asian Countries**

| | India | China | Indonesia | Singapore |
|---|---|---|---|---|
| **1999** | 8954 | 16203 | 153 | 6679 |
| **2000** | 4824 | 26427 | 170 | 7720 |
| **2001** | 8503 | 31198 | 103 | 8133 |
| **2002** | 10592 | 41379 | 123 | 8070 |
| **2003** | 11466 | 58770 | 99 | 7908 |
| **2004** | 12613 | 68944 | 74 | 7951 |
| **2005** | 17466 | 97565 | 107 | 8606 |
| **2006** | 24505 | 128767 | 56 | 9164 |
| **2007** | 28940 | 160502 | 26 | 9955 |
| **2008** | 35218 | 203257 | 21 | 9692 |
| **2009** | 36812 | 229096 | 96 | 8736 |

**Table 1B: Number of Patents Applications Filed Among the Asian Countries**

The irony is that the increase in patent application numbers did not affect much the growth rate of GDP of India. It was because of the reason that India is an agriculture based economy rather than technology based economy. The difference can be seen in Fig. 1.

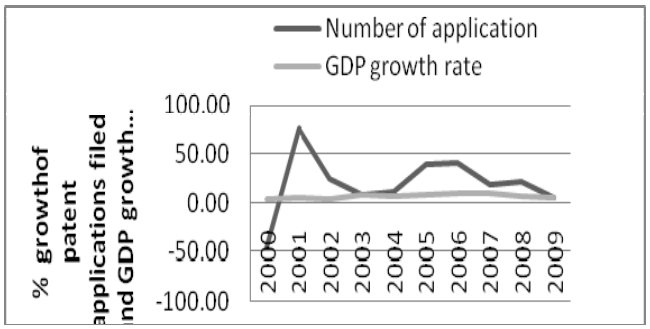


**Figure 1: Comparison of Patent Application Filed and GDP Growth Rate of India**

### 5.2 China

Chinese history of patenting starts from 1985, when Ist Chinese patent law was framed. In 1992, after signing the Sino-US MOU (Memorandum of Understanding) on the protection of IPR, the Patent Law was reframed in a more protective manner. It was further amended in 2000 creating a huge number of patents registered with China with a growth rate of 63%. Since then, year after year China had gone through many changes in IPR laws and the last amendment was made in 2009 including Utility Models and Design patents in it. Right now, China is in a very strong position of technical advancement along with highest growth rate of GDP in Asia. The relationship of number of patent application filed and GDP growth can be seen with the help of Fig. 2.

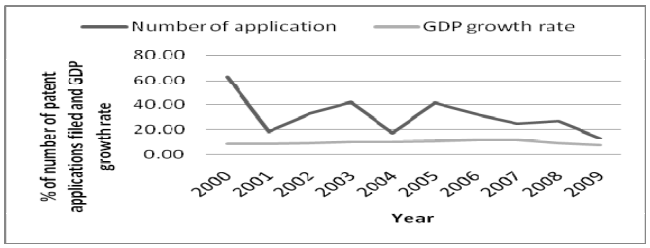


**Figure 2: Comparison of Patent Application Filed and GDP Growth Rate of China**

### 5.3 Japan

The first Japanese patent Law was established in 1871 although it was abandoned with in a year. So, the proper functioning of Patent Law was known to be from April 18, 1885, when Patent Monopoly Act was enacted. In 1978, Japan acceded to the Patent Cooperation Treaty (PCT). In 1980, the JPO adopted the International Patent Classification, discarding its own patent classification. [10] In 2002, Japan Patent Office declared computer programs patentable. It is based on first to file basis. Although Japan is tech savvy country but in last decade, there is a decline in terms of patent application filing. It is affecting the GDP growth also. It can be seen in Figure 3.

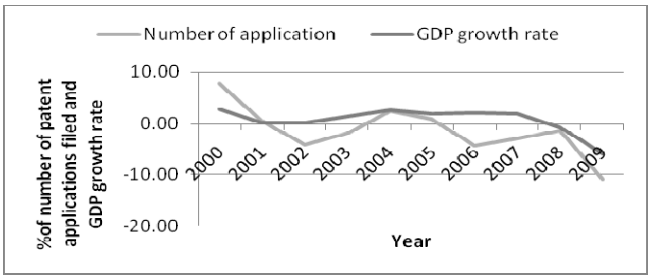


**Figure 3: Comparison of Patent Application Filed and GDP Growth Rate of Japan**

### 5.4 Indonesia

In Indonesia, patent law was first introduced in 1991. After the ratification of TRIPs (Trade Related Intellectual Property Rights), amended patent law was introduced in 2001.despite of all amendments and membership of many conventions, application of patent law in Indonesia was not an easy job in Indonesia. Its IP protection is still one of the weakest in world. [11] as per Indonesian Patent Office, the number of patent registered is very much varying from year after year. In 2009, it was 96 as compared to 21 in 2008. [12] In this country, patent applications do not make much impact on GDP growth rate. This can be seen through Figure 4.

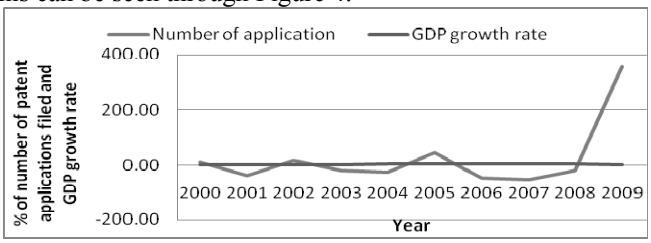


**Figure 4: Comparison of Patent Application Filed and GDP Growth Rate of Indonesia**

### 5.5 Singapore

The Patents Act came into force on 23 Feb 1995 and provided Singapore with its own patent system. The Patents Act (Cap. 221) and its subsidiary legislation, which consists of the Patents Rules, the Patents (Patent Agents) Rules, and the Patents (Composition of Offences) Regulations, form the legislation governing patent law in Singapore. [13] Whilst it is not mandatory to apply for patent protection in Singapore first before seeking patent protection overseas, any person resident in Singapore is required to obtain written authorization from the Registrar of Patents for an invention, before he files or causes to be filed outside Singapore an application for a patent for that invention. It is one of the developed countries in WIPO list. Singapore is technology based country so both patent registered are highly correlated with each other. This can be seen with the help of Figure 5.

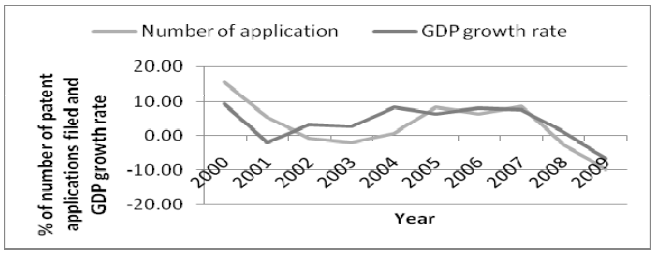


**Figure 5: Comparison of Patent Application Filed and GDP Growth Rate of Singapore**

### 5.6 Thailand

Thailand is a country where intellectual property has generated much controversy. In the late 1980s, the debate about controversial changes to the Copyright Act to strengthen the position of rights holders even led to dissolution of parliament and the calling of new elections. [14] The discussion subsequently shifted to patents and pharmaceuticals during the 1990s. In view of the AIDS crisis in Thailand, the government was much criticized for failing to use existing compulsory licensing mechanisms for pharmaceuticals because it feared a negative impact on foreign investment. [15] The first Patent Act was formed in 1979. It was then amended in 1992 and then in 1999. [16] Regarding patent applications, Thailand is getting quite a good number of patent applications year after year. It was10,561 in 2008 and 9730 in 2009. The GDP growth rate is also moving in almost same direction except in 2005 and 2006. This fact can be seen through Figure 6.

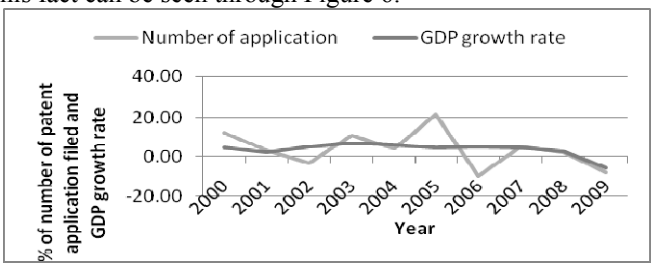


**Figure 6: Comparison of Patent Application Filed and GDP Growth Rate of Thailand**

### 5.7 Vietnam

The protection of intellectual property rights was first introduced in Vietnam in 1981 by the promulgation of the Ordinance on Innovation and Invention 1981 ("Ordinance 1981") [17] The Ordinance on the Protection of Industrial Property Rights enacted in 1989 ("Ordinance 1989") marked a turning point for the industrial property laws of Vietnam. [18] For the first time in the history of the country's IP protection, the concept of "industrial property" was introduced in a legal instrument. Ordinance 1989 provided the fundamentals for the protection of inventions, utility solutions, industrial designs, trademarks, and appellation of origin in the country. Most importantly, Ordinance 1989 specifically recognized patent

rights as exclusive rights. It was then amended in the name of Civil code 1995. a proper Intellectual Property Rights Law was formed in 2005. [19] The number of patent applications and GDP growth rate are highly correlated in Vietnam and hence can be said that there is a impact of GDP growth rate on number of patent applications filed. This can be seen in the Figure 7.

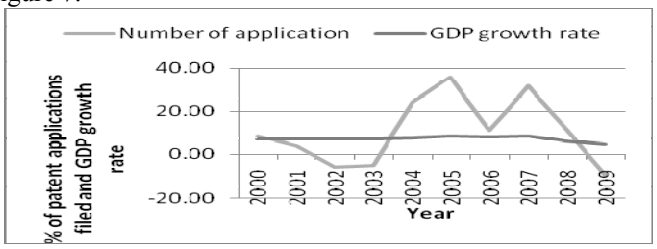


**Figure 7: Comparison of Patent Application Filed and GDP Growth Rate of Vietnam**

### 5.8 Philippines

The Philippines is the country with the longest tradition of intellectual property protection in the region, reaching back to decrees introduced by the Spanish colonial power in the early 19th century. [20] After a period of IP protection via Presidential decrees during the Marcos regime, the Philippines was the first country in Southeast Asia to adopt a comprehensive intellectual property code following WIPO models in 1995. The Code covers patents, utility models, trade marks and geographical indications, copyright, industrial designs, layout designs of integrated circuits and undisclosed information. It was then amended in 2006 and 2008. Regarding the number of patent application and GDP growth rate, Philippines is not a tech savvy country and hence there is no direct relationship between GDP growth rate and Number of patent applications filed. It can also be seen in Figure 8.

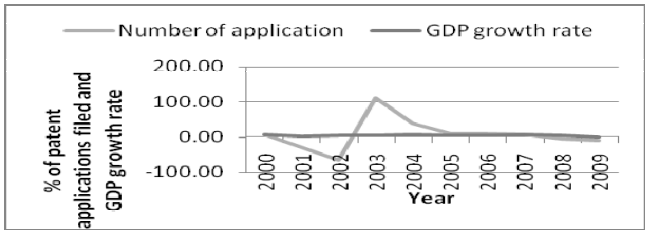


**Figure 8: Comparison of Patent Application Filed and GDP Growth Rate of Philippines**

### 5.9 Malaysia

The Malaysian Patent System generally originates from the United Kingdom Patent System. In 1983, the local system was introduced via the Patents Act 1983. Accordingly, a complete set of governmental mechanism was established and therefore allowing examination and subsequently registration of patents. [21] On May 16 2006, Malaysia became the 131st contracting state to the World Intellectual Property Organisation Patent Cooperation Treaty. The treaty was to enter into force in Malaysia on August 16 2006. Regarding the patent applications filed in Malaysia, it is in a speculating position as compared to GDP growth rate which is more or less steady year after year. It is shown wit the help of Figure 9.

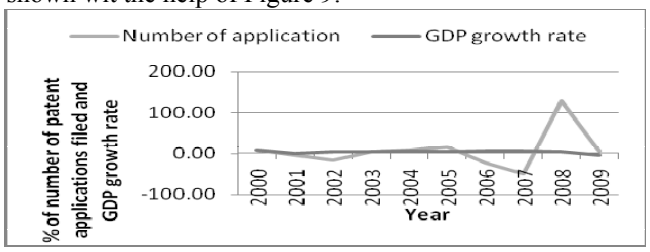


**Figure 9: Comparison of Patent Application Filed and GDP Growth Rate of Malaysia**

### 5.10 Data Analysis

The data collected from different sources was analyzed to see whether there exists a relation between country's GDP growth rate and Number of patent applications filed by domestic applicants and foreign applicants. It was then tested on hypothesis with 5 % level of significance. Student's T-test is used in it.

On the basis of data collected it was discovered that it was a mixed expression of Asian countries regarding the filing of patent applications and its relationship with GDP growth rate of the respective country. Out of the sample of 9 countries, 5 countries, namely, India, China, Indonesia, Philippines and Malaysia (having there t-value less than 1.86) were having no effect of number of patent applications filed over GDP growth rate and other 4 countries, namely, Singapore, Thailand, Japan, and Vietnam (having there t- value more than 1.86) have an impact of number of patent applications over GDP growth rate. This fact is clearer in Table 2.

| S.No. | Country | r | r*r | t-value | Student's t-value at 5% sig. |
|---|---|---|---|---|---|
| 1 | India | 0.29 | 0.08 | 0.86 | 1.86 |
| 2 | China | -0.19 | 0.04 | 0.55 | 1.86 |
| 3 | Indonesia | -0.45 | 0.20 | 1.43 | 1.86 |
| 4 | Singapore | 0.74 | 0.55 | 3.14 | 1.86 |
| 5 | Thailand | 0.93 | 0.86 | 6.99 | 1.86 |
| 6 | Japan | 0.75 | 0.56 | 3.19 | 1.86 |
| 7 | Vietnam | 0.86 | 0.75 | 4.87 | 1.86 |
| 8 | Philippines | 0.16 | 0.03 | 0.46 | 1.86 |
| 9 | Malaysia | -0.04 | 0.00 | 0.13 | 1.86 |

**Table 2: T-Test for GDP Growth Rate and Number Of Patent Applications Filed Relation for the Period 2000-2009.**

Also, three countries, namely, China, Indonesia and Malaysia were having negative correlation. It shows that there is a negative relationship between number of patent applications filed and GDP growth rate. The main reason behind this negative relationship is non-dependency or lesser dependency

of GDP growth on number of patent filed. Also, in most of the years, when Number of patent applications was more, there was a fall in the GDP growth rate and vice- versa. It shows there are many other factors which are affecting the GDP growth rate than innovations and their registration as patents.

## 6 CONCLUSION AND RECOMMENDATIONS

Many studies have explored the relationship between economic growth, competitiveness, innovation, IP and their sustainable development. These studies have generally used R&D investment or the number of patents filed as proxies for innovation [22][23][24]. The article examined the correlation between patent applications filed and financial growth of 9 selected countries of Asia. This study has considered only one variable for studying the financial effect of patent applications filed on economy of the country .i.e. GDP growth rate. Out of the data collected, it was discovered that half of the selected Asian countries were not having any concerns with number of patent applications filed. They have other GDP growth affecting factors like, agriculture, service industry, assembling of new technology from outside, etc.

With the help of literature review in this study, it can also be concluded that in few countries like Singapore, Philippines, the IPR regime is likely to affect growth indirectly by encouraging the innovative activity that in turn is the source of total factor productivity improvement leading to the overall development of the country.

The countries having positive correlation (namely, Singapore, Thailand, Japan, Vietnam) depicts, leaving all other factors of affecting GDP, innovations are the major factor affecting GDP growth rate.

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# Two Level Caching Techniques for Improving Result Ranking

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*Submitted in November 2010, Accepted in July 2011*

**Abstract -** ***Due to the rapid growth of the Web from a few thousand pages in 2000 to its current size of several billion pages, users increasingly depend on web search engines for locating relevant information. One of the main challenges for search engines is to provide a good ranking function that can identify the most useful results from among the many relevant pages, and a lot of research has focused on how to improve ranking, We present an effective caching scheme that reduces the computing and I/O requirements of a Web search engine without altering its ranking characteristics. The novelty is a two-level caching scheme that simultaneously combines cached query results and cached inverted lists on a real case search engine. A set of log queries are used to measure and compare the performance and the scalability of the search engine with no cache, with the cache for query results, with the cache for inverted lists, and with the two-level cache. Experimental results show that the two-level cache is superior, and that it allows increasing the maximum number of queries processed per second by a factor of three, while preserving the response time.***

**Index Terms: Search Engines, Query Processing, Retrieval, Ranking, Cache Design**

## 1. INTRODUCTION

Large web search engines have to answer thousands of queries per second with interactive response times. Due to the sizes of the data sets involved, often in the range of multiple terabytes, a single query may require the processing of hundreds of megabytes or more of index data. To keep up with this immense workload, large search engines employ clusters of hundreds or thousands of machines, and a number of techniques such as caching, index compression, and index and query pruning are used to improve scalability. In particular, two-level caching techniques cache results of repeated identical queries at the frontend, while index data for frequently used query terms are cached in each node at a lower level. Popular search engines receive millions of queries daily, a load never experienced before by any IR system. Additionally, search engines have to deal with a growing number of Web pages to discover, to index and to retrieve, and must handle very large databases. To compound the problem, search engine users want to experience small response times as well as precise and relevant results for their queries. In this scenario, the development of techniques to improve the performance and the scalability of search engines without degrading the quality of the results becomes a fundamental topic of research in IR. One effective alternative for improving performance and scalability of information systems is caching. The effectiveness of caching strategies depends on some key aspects, such as the presence of reference locality in the access stream and the frequency at which the database being cached is updated.

In this paper we describe and evaluate the implementation of caching schemes that improve the scalability of search engines without altering their ranking characteristics. The starting point of the work is TodoBR, a state-of-the-art full scale operational search engine that crawls the Brazilian Web. We enhanced the current implementation of TodoBR by integrating three caching schemes. The first one implements a cache of query results, allowing the search engine to answer recently repeated queries at a very low cost, since it is not necessary to process those queries. The second one implement a cache of the inverted lists of query terms, thus improving the query processing time for the new queries that include at least one term whose list is cached. The third caching scheme combines the two previous approaches and will be called two-level cache.

Each of the first two strategies presents advantages and disadvantages. A hit in the cache of query results avoids query processing, while a hit in the cache of inverted lists reduces the amount of I/O associated with answering a query, but does not avoid the query processing costs. On the other hand, the hit ratio associated with inverted lists is usually higher than the hit ratio for whole queries, which may pay o_ the query processing cost. The motivation behind the third strategy is to exploit the advantages of the first two strategies to improve even further the overall performance and scalability of the search engines.

Our experimental evaluation yields some key results. The two-level cache is superior and allows increasing the maximum throughput by a factor of three, relative to an implementation with no cache. Furthermore, the throughput of the two-level cache is up to 52% higher than the implementation using just cache of inverted lists and up to 36% higher than the cache of query results. Our work is distinct from previous ones because it presents experimental results on the effectiveness of different caching strategies implemented on a real case search engine.

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Our main contribution is the two-level caching scheme we proposed which yields superior performance. Our results can be replicated to other Web search engines since there is high similarity between workload characteristics present in the logs of TodoBR search engine and in the logs of other large search engines.

## 2. SEARCH ENGINE ARCHITECTURE

Web search engines are IR systems that take a query as input and produce as a result a set of links to relevant Web pages related to the query. Search engines seek, collect and index Web pages on a massive scale. To speed up query processing, all queries are answered using the index and without accessing the text directly.

Efficient query evaluation requires specialized index techniques when the text collection is large. Our search engine server implementation uses an inverted file as index structure, a popular choice to implement large scale IR systems. An inverted file is typically composed of a vocabulary, which contains the set of all distinct terms in the collection, and an inverted list for each term of the vocabulary. The inverted list of a term t is a list of the identifiers of the documents containing t with the respective frequency of occurrences of t on each document.

The ranking method used for the experiments is based on the vector space model. In the vector space model, the documents and the queries are represented as vectors in a space with dimensions given by the size of the vocabulary. The answers to the queries are the documents with the highest similarity values, where the similarity is computed by the cosine of the angle between the query vector and each document vector. The inverted file is used during query processing time to compute the similarities of each document of the collection against the query.

For large document databases, the cost of evaluating the cosine measure may be potentially high, because it assigns a similarity measure to every document containing any of the query terms, requiring a read and some processing on the whole inverted list of each term of the query. This task may be expensive since some of the terms can occur in a high proportion of the documents present in the database.

An effective technique to compute an approximation of the cosine measure without significant changes in the final ranking for each query is already proposed. We use it to process the queries submitted to the search engine server. This query evaluation technique uses early recognition of which documents are likely to be highly ranked to reduce costs of query processing. Queries are evaluated in 2% of the memory of the standard cosine implementation without degradation in retrieval effectiveness. Disk traffic and CPU time are also reduced because the algorithm processes only portions of the inverted lists which have information that can change the ranking.

## 3. CACHE DESIGN

In this section, we describe in detail the strategies for implementing the three caches in a search engine, that is, caching of query results, caching of inverted lists, and a two-level cache that combines both.

### 3.1 Cache of Query Results

Our strategy for caching query results is to keep in memory the list of documents associated with a given query. For each document we store its URL, its title, and a 250 character abstract. The very first implementation issue of this caching strategy is determining the number of document references that should be cached for each query. It is remarkable that the number of documents that match a given query is often huge.

However, the great majority of the users request at most the first 30 references that match a query. In TodoBR we also observe the same behavior, since most of the users (70%) do not request more than 10 references, and 90% of the query requests are for at most the first 50 references. Thus, we limited our cache of query results to 50 references, resulting in a storage requirement of 25 kilobytes per query result cached. This implementation decision allows our cache to satisfy most of the queries without wasting memory, and also exploits the spatial locality among queries. Figure 1 (a) shows the architecture of the search engine including the cache of query results. Whenever a user submits a query to the search engine, it checks whether the cache is storing the associated query results and the reference rank is below the caching threshold, in our case 50. If there is a cache hit, the query result is immediately returned to the user, at a very low cost, since the response only needs to be formatted and sent to the user, a cost inherent to any query. Otherwise, the search engine processes the query normally, occasionally caching it, whenever the reference rank is below the threshold.

The second major issue is the replacement policy for the query results, that is, how we determine which query results should be evicted from the cache whenever a new set of results is to be cached and the cache is full. In this first implementation we adopted LRU (least recently used) as replacement policy, since the TodoBR logs present a good temporal locality. Markatos has proposed alternative cache replacement policies for caching query results, such as SLRU (segmented LRU) and FBR (frequency based replacement), but they did not improve the cache hit ratio significantly. Furthermore, Markatos did not exploit spatial locality in his work, in the sense that a query result for the first ten documents is handled independently from the result for the next ten documents of the same query.

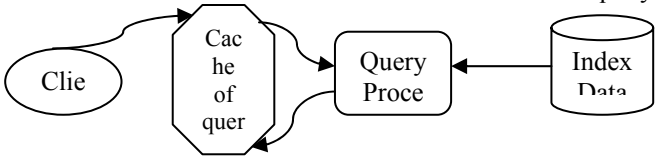



**Figure 1(a): Query Results**

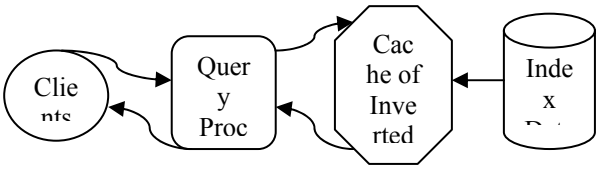



**Figure 1(b): Inverted Lists**

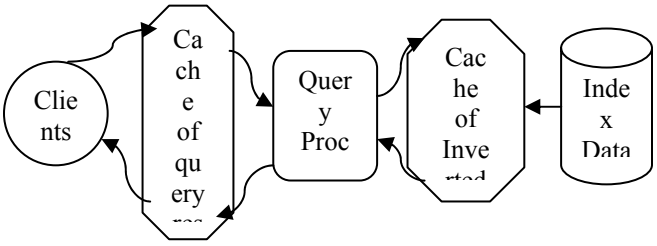



**Figure 1(c): Two Levels**

### 3.2 Cache of Inverted Lists

Our strategy for caching inverted lists is to keep in memory the list of Web documents associated with a given query term. In practice, our enhanced search engine caches the inverted lists for each term as they are accessed, and uses these lists to answer further queries that contain the same terms. In this case, the integration with the search engine is straightforward, since it acts as a specialized buffer for the index, which is usually stored in secondary memory. The main motivation for caching inverted lists is the good reference locality that is usually observed among individual search terms. Since the term locality is even greater than the query locality, and thus may attain a higher cache hit ratio, caching inverted lists is a good strategy for improving the scalability of search engines. The implementation of caches of inverted lists has to face two issues related to the high variance in the size of the inverted lists: the size of the cached lists and the internal organization of the cache.

These issues are discussed in the remaining of this section. The size of the inverted lists is a function of both the term popularity in the collection and the number of documents being indexed. For large collections, these lists may also become very large, making cache of inverted lists to fail in practice, since they require considerable cache space to store the whole list. To address this problem, we turn to an important characteristic of the filtered vector model processing technique. In this technique, the inverted lists are sorted by the frequency of occurrence of the term in each document, and the query processing exploits the frequency variance by using just the documents in which the term is most frequent. As a consequence, the lists are not fully traversed or are not traversed at all, depending on the relevance of the term on the collection and on the query it. In summary, the vector model allows naturally handling the problem associated with large inverted lists.

Since lists are almost always partially processed, we set out to cache parts of lists. The frequency-sorted inverted lists can be partitioned in different ways. The lists are naturally divided into blocks of documents in which the term appears with the same frequency, and these are the smallest units of algorithm processing. These blocks present interesting properties regarding their size and access pattern. The first blocks of each list are small, consisting of few documents, and are much more frequently accessed than the blocks at the end of the lists, which contain the documents in which the term appears a few times. In the model, given an inverted list of a term t, for some integer v (usually 2 to 4), a fraction (v - 1)/v of the document identifiers have frequency 1 ($f_{d,t} = 1$); of the remainder a fraction (v - 1)/v have fd.t = 2, and so on. If v is 2, for example, half of the list will correspond to the block of documents in which the term appears only once. Blocks could be the objects to be cached, but their size distribution spans several orders of magnitude, making caching much more complex. Since the objects cached by a Web cache (html files, images, etc), also present extremely high variable sizes.

Using blocks as cacheable objects presents some advantages, but requires prefetching strategies and specific admission and replacement policies. For example, the first blocks of the lists tend to be very small and are generally accessed together. If no prefetching is done when the first block of a list is requested by the cache to the disk, there is a large number of disk seek operations to retrieve several small objects.

Another issue arises when the cache requests the last block of some large list. This is likely to be a large block, and its admission into the cache could cause the eviction of several other smaller but much more accessed blocks. These mechanisms and policies are certainly worthy of further study, but in this work we conjecture that much of the advantages of caching blocks can be attained by using a simpler alternative approach, namely to "page" the lists, i.e., to divide them into equally sized pages. We should observe that, based on the aforementioned distribution of sizes of blocks, the first pages of an inverted list may contain several blocks, while the last blocks of the list may span several pages. In this work we employed a page of 4 kilobytes which is also the disk block size. In our implementation, the cache only has knowledge of pages, and this makes for much simpler cache design. Furthermore, by varying the size of the pages, we can balance the tradeoff between the number of seek operations and the volume of bytes transferred from the disk. At one extreme, in which each byte of the inverted list is considered to be a page, there will be at least as many misses in the cache as the amount of bytes needed to answer a given workload of queries. The number of seek operations is maximal, while the volume of bytes transferred is minimal.

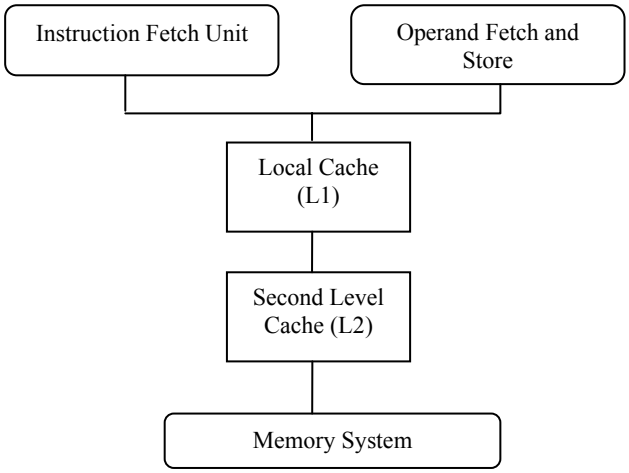
At the other extreme we consider a large page size, such that each list requires at most one miss in the cache. In this case, the number of seek operations is minimal, but the volume of bytes transferred is much larger than what is needed to answer the queries. Large pages have an amortizing effect on the disk seek time, and implicitly exploit spatial locality among list blocks, but may, on the other hand, cause the cache to store irrelevant parts of lists. Depending on the combination of factors, such as the costs associated with a disk seek operation and with the transferring of a byte, one can find an optimal page size. Other factors that should be taken into consideration are the disk block size and some operating system cache in effect. Figure 1 (b) illustrates the architecture of a search engine that embeds the cache of inverted lists. The query is processed as in the implementation with no cache up to a request to read a block, which is mapped to a page, from the inverted list, when the cache is checked. The disk is accessed only in the case of a miss in the cache of inverted lists. Again, we employed LRU as replacement policy. Although the cache of inverted lists avoids disk accesses, every query submitted to the system must still be processed, and gains in performance depend on the computational platform where the search engine runs.

**3.3 Two-Level Cache**

As discussed in the previous sections, each of the two cache architectures presents advantages and disadvantages. The cache of query results avoids processing queries which are already in the cache, while a hit in the cache of inverted lists only avoids disk accesses. On the other hand, the hit ratios obtained for the query results are smaller than the hit ratios obtained by the cache of inverted lists. These observations led us propose and test a third cache option, which combines the two caching strategies. We call this option two-level cache.

Figure 1 (c) shows the architecture of the search engine with a two-level cache system. Each request for the search engine is checked first in the cache of query results. If it is a hit, the query is answered immediately, otherwise the query is processed and the cache of inverted lists is used to reduce the number of disk accesses.

a. The L1 cache receives addresses from the prefetch and returns instructions either from the cache or from the next level of the memory hierarchy. The cache also receives addresses from the execution unit and reads or writes operands, again from the cache or from the next level of the hierarchy. The handling of writes varies with different write algorithms. If separate Ll instruction and data caches are present, they respond to the instruction fetch and instruction execution units, respectively.
b. The L2 cache receives addresses from the Ll cache (or caches) and reads or writes operands from its storage or from the primary memory system. The handling of writes varies with different write algorithms.




**Basic Two-Level Simulation Model**

1. The bus is a half-duplex data path connecting the caches to the memory system. Devices on the bus must arbitrate for bus ownership before commands or data can be sent.
2. The primary memory consists of a number of interleaved memories. Simulation parameters include the interleaving factor, access time, and cycle time of main memory.

**4. WORKLOAD CHARACTERIZATION**

In order to assess the behavior of the three cache implementations we consider in this paper, we perform an analysis of a partial log of queries submitted to TodoBR, comprising 100,256 queries. There is a total of 37,450 unique queries, and 23,751 unique terms in the log. We focus on aspects relevant to both levels of caching we consider, namely the characteristics of the stream of queries present in the log relevant to the cache of query results and of the stream of page references generated by the query processor - influencing the behavior of the cache of inverted lists.

In the case of the cache of inverted lists, we study its behavior under two different workloads, the first one with all the queries, and the second one with only the unique queries. To understand the reasons for this consideration, let us examine what happens to the cache of inverted lists under different configurations of the cache of query results. When used stand alone, the cache of inverted lists receives from the query processor a page workload originated from all of the queries received by the search engine. This is precisely the workload represented by the `All Queries' workload.

On the other hand, suppose a two-level implementation in which the cache of query results is large enough not to have any miss caused by eviction from the cache, i.e., it can store the results of every query that it receives. In this situation, the query processor, and thus the cache of inverted lists, will only process the unique queries, for all the repetitions will be handled by the cache of query results. The workload the cache of inverted lists will be subject to is well represented by the

`Unique Queries' workload. There will be a smooth transition from one workload to the other for varying sizes of the cache of query results, meaning that we can have valuable insight of the performance of the cache of inverted lists for a wide range of situations. A very small cache of query results will generate a workload at the cache of inverted lists similar to the `All Queries' workload, while a large cache of query results will generate a workload close to the `Unique Queries' workload.

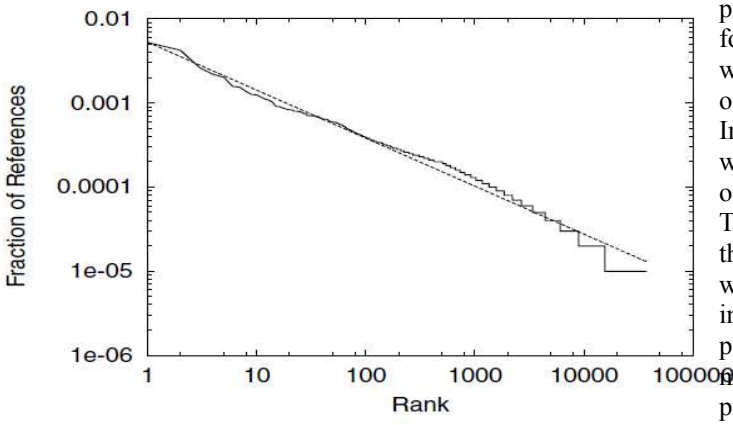



**Figure2**

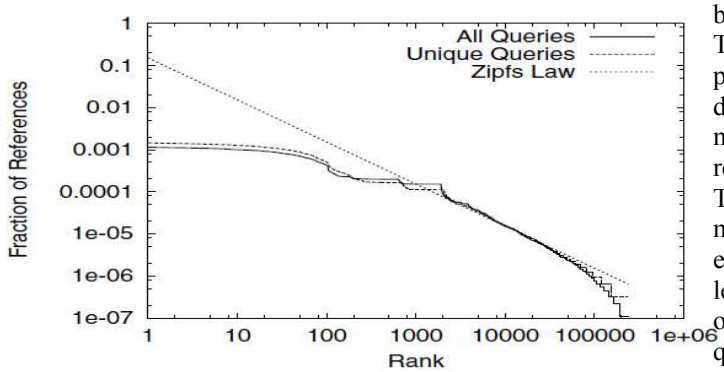



**Figure3**

### 4.1 Popularity

We start our workload characterization by analyzing the popularity of both queries and pages of the cache of inverted lists. We define popularity of an object as the number of references to the object, and the popularity rank as a list of all objects sorted by decreasing popularity, that is, the most popular object is the first in the rank.

For a reference stream to order good opportunity for caching, it ought to exhibit temporal locality among its references. In fact, the authors conclude that popularity is the main source of locality, specially in dealing with reasonably sized caches, and that a reference stream whose objects popularity follow a Zipf-like distribution exhibit a high degree of temporal locality. Zipf's law relates the popularity rank p of an object, to the probability P that it is requested, by $P \sim 1/p$, and has been applied to several distinct contexts, such as words in natural language and accesses to web pages. We call a Zipf-like popularity distribution the one in which the relation between P and p is given by $P \sim 1/p^{\alpha}$. This is a generalization of Zipf's law and in a log-log plot of popularity versus rank appears as a straight line with slope - α. The smaller α is, the less skewed the distribution is, showing weaker temporal locality and worse cache ability.

We verified that the references to queries follow a Zipf-like distribution. In Figure 2 we plot the relative popularity, i.e., the probability of accessing each query, versus the popularity rank for the queries stream, together with a Zipf-like distribution with an α parameter of 0:59, obtained by a least-squares fitting of the data.

In Figure 3 we examine the popularity distribution for both workloads of the cache of inverted lists. We can notice a pair of similar curves, labeled `All Queries' and `Unique Queries'. There are two regions in these two curves, one up to roughly the rank 2,500, with large at segments, and one after this point, which is approximately an straight line in the log-log plot with inclination of -1. The flat region occurs due to the page access pattern. The first pages of each list are accessed in group, meaning that they should have approximately the same probability of being accessed. This suggests, for caching effects, that the pages making up at region should necessarily be stored in the cache if it is to have a good level of efficiency. The second region, which comprises more than 90% of the pages, exhibit a Zipf-like behavior, and is well fit by one such distribution with $\alpha = 1$. This indicates that the distributions much more skewed than that of the queries' popularities, resulting in greater temporal locality.

The distribution does not vary much for both workloads, meaning that there is opportunity for caching inverted lists even if this caching is to be done after a fully efficient first level cache of query results. In order to further investigate this opportunity, we collected statistics of the number of distinct queries in which each term appears. In the situation of a fully effective cache of query results, resulting in the `Unique Queries' workload to the cache of inverted lists, the terms that appear in only one query shall not generate a hit, because their pages will only be seen once by the cache of inverted lists. We found out that approximately 40% of the terms appear in more than one query, evidencing the extra locality that can be exploited by the cache of inverted lists.

### 4.2 Cache Miss Ratios

To assess the behavior of a cache under a LRU replacement policy, we generated the successive stack distances from the log. The marginal distribution of stack distances can be used to determine the miss ratio for a cache at different sizes. Let D be the random variable corresponding to stack distance, and let FD be the cumulative distribution function for D. The miss ratio m(x) for a cache holding x objects is given by

$$P[D > x] = 1 - F_{\alpha}(x) = m(x)$$

The first observation from the graph is the minimum miss ratio we can obtain under this query workload, which is around

40%. This is the miss ratio that an infinite cache would exhibit, and is due to the first occurrence of each query. The most important fact the graph shows is how fast the miss ratio decreases as we increase the capacity of the cache, relative to the TodoBR log we considered. We can observe a 'knee' in the curve close to 10 megabytes, indicating that a relatively small fraction of the queries accounts for a significant portion of the accesses.

This is a good indicator of the cache size that offers a good compromise between space and hit ratio. After this point, small decreases in the miss ratio come at the expense of large increases in cache size. It is with these considerations that we choose, for the following experiments, a cache size of 20 megabytes for query results. We point out that the fact that a cache of this size

holds most of the working set of the workload is much more important than the size itself, which should be determined in a case by case basis, by analyzing the miss ratio curve for the workload.

We can see similar miss ratio versus cache size curves for the cache of inverted lists under the two workloads considered. One can notice that the cache size at which there is a significant decrease in the miss ratio is much larger than in the case of the cache of query results, suggesting that the working set of the pages requires more cache space.

However the asymptotic miss ratio observed is much lower in the case of the cache of inverted lists, even for the `Unique Queries' workload. This shows the greater temporal locality present in the reference to pages, as was inferred from the popularity distributions. The miss ratio of the `All Queries' workload is considerably lower than the one of the `Unique Queries' workload, because in the latter only the repetition of terms across different queries do cause hits at the cache. Still, a 250 megabytes cache of inverted lists subject to the `Unique Queries' workload, i.e., the worst case workload for the second level cache, can achieve hit ratios of 80% on top of the misses at the first level.

We have a final word on the scalability of the characteristics presented herein. As we increase the length of the request stream submitted to the cache, the popularity distribution of queries and thus the marginal distribution of stack distances tend not to change much, meaning that a relatively small cache size should still be effective. Furthermore, the miss ratio tends to decrease as we increase the length of the request stream.

## 5. EXPERIMENTAL RESULTS

We present in this section experimental results that show the practical impact of the three caching schemes discussed on the scalability and on the average response time of the search engine as a whole.The experimental environment comprises two machines running Linux operating system version 2.2.16. The search engine runs on a Pentium III 550 MHz machine with 512 megabytes of main memory, and a 36 gigabytes SCSI disk. The client runs on a AMD K6 450 MHz machine with 256 megabytes of main memory. The two machines are connected directly by an 100-megabit fast Ethernet.

We employ the software Httperf to read a log of 100,256 queries submitted to TodoBR and to generate workload to the various server implementations at controlled rates. It measures the performance of the server from a client perspective, reporting, among other information, the average response time for the client to receive an answer, the throughput of the server, and occasional error rates.

The overall amount of server main memory used for the various cache implementations was set to 270 megabytes, based on the results presented in Section 5. In the two-level cache the memory was divided into two partitions: 20 megabytes for caching query results and 250 megabytes for caching inverted lists. A cache of 270 megabytes shows to be enough to achieve good performance in all cache schemes studied in this work and accounts for only 6.5% of the overall index size of TodoBR.

| Implementations | Processed Queries | Fetched Pages |
|---|---|---|
| No Cache | 100,365 | 5,509,684 |
| Cache of Inverted List | 110,296 | 446,269 |
| Cache of Query Results | 39,098 | 1,892,377 |
| Two-Level Cache | 49,128 | 456,275 |

**Table1**

Table 1 shows the counts for submitted queries and inverted list pages retrieved from disk, as an indication of CPU and disk demands for the four implementations. We can observe that caching query results reduces significantly (up to 62%) the number of queries that need to be processed.

On the other hand, caching inverted lists reduces the number of page reads by an order of magnitude. The two-level cache shows to be a good compromise in terms of performance, since it gets close to the best results, that is, the number of queries processed increases by only 21%, and the number of pages retrieved increases by only 3%.

At low request rates, the best performance was achieved by the cache of query results, which presents the lowest processing costs, closely followed by the two-level implementation, while the cache of inverted lists gives response times close to the implementation with no cache. This result is explained by the overhead associated with handling inverted lists and the gains inherent to the file system cache provided by the Linux operating system, which reduces the time to read a disk page.

At higher request rates the disk throughput saturates and the cache of inverted lists effectively improves the engine performance when compared to the implementation with no cache. The differences in the amount of disk operations also

explain the better scalability of the two-level cache. As shown in Table 1, the two-level cache presented a miss ratio in terms of query results close to the miss ratio of the cache of query results. On the other hand, the total number of disk reads in the two-level cache was only 20% of the total number of reads performed when caching only query results.

An immediate consequence of the better performance provided by the two-level cache is a better overall throughput. The maximum throughput obtained by the two-level cache is 64 queries per second, while the maximum for the system with no cache was 22 queries per second. For the cache of inverted lists, the maximum throughput was 42 queries per second. For the cache of query results, the maximum throughput was 47 queries per second.

## 6. CONCLUSIONS

In this paper, we have proposed and evaluate experimentally a new multi-level caching architecture and scheme for web search engines that can improve query throughput and improve search engine scalability without modifying the ranking of query results. We have implemented and evaluated three different caching schemes on the search engine TodoBR, and compared the performance of these implementations to the original engine with no cache. The experiments show that the two-level cache provides the maximum throughput among all implementations, and that it is superior to the implementation with no cache by a factor of three. Furthermore, the throughput of the two-level cache is up to 52% higher than the implementation using just inverted lists and up to 36% higher than the cache of query results. The analysis of the TodoBR logs indicates that the miss ratios of both caches tend to decrease as we consider larger request streams. We are also interested in studying the impact of caching in search engines which are based on other ranking algorithms, such as ranking based on link analysis. The changes in the ranking algorithm can affect the cache system because the access pattern for the inverted lists may change and extra information may have to be retrieved from other index structures apart from the inverted lists. To our knowledge there is no published work on how to apply pruning to such types of ranking functions, which are not based on a simple combination of the scores for different terms.

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# Exploring Alternative Topologies for Network-on-Chip Architectures

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**Abstract** - ***With increase in integration density and complexity of the system-on-Chip (SOC), the conventional interconnects are not suitable to fulfill the demands. The application of traditional network technologies in the form of Network-on-Chip is a potential solution. NoC design space has many variables. Selection of a better topology results in lesser complexities and better power-efficiency. In the proposed work, key research area in Network-on-chip design targeting communication infrastructure specially focusing on optimized topology design is worked upon. The simulation is modeled using a conventional network simulator tool packet tracer 5.3, in which by selecting proposed Topology 35.7 % reduction in traversing the longest path is observed.***

**Index Terms - NoC, SoC, Routing, Mesh, packet tracer**

## 1. INTRODUCTION

Recent technological development in the field of integrated circuits has enabled designers to accommodate billions of transistors. The level of integration has enhanced computational power enormously. The exponential decrease in the feature size has enabled integration of heterogeneous IP cores on a single chip leading to a new era of integration circuits known as System-on-Chip. However, as the number of components and their performance continue to increase, the design of power, area and performance efficient communication infrastructure is gaining equal importance. The traditional methods of connecting these heterogeneous IP Cores are not meeting the demands of these very complex structures. Furthermore, with technology scaling, traditional global interconnects cause problems like synchronization errors, unpredictable delays and high power consumption. [1] Traditional bus and crossbar based methods to communication become very inefficient, resulting in massive numbers of wires, failed timing closure, increased heat and power consumption, and routing congestion leading to increased die area. The Network–on-Chip approach promises the alternative to traditional bus-based and point-to-point communication structures. The networking methods have been dealing with same kind of problems on traditional computer networks. It indicates that NoC designers can borrow the concept of conventional computer networking with necessary customization to suit demands of SoCs.

The SoCs consists of heterogeneous IP-Cores such as Video processors, Image processors, memory blocks etc. Each of these cores is connected to NoC through a network interface or network adapter module. The NoCs contain a network of routers responsible for end to end delivery of the packets from IP-cores. The communication demands of these IP-cores vary depending on the application running on it. The network interface provides seamless integration of theses IP-Cores and network. Locating the interconnect logic closest to each IP block results in fewer gates, fewer and shorter wires, and a more compact chip floor plan. Having the option to configure each connection's width, and each transaction's dynamic priority assures meeting latency and bandwidth requirements. The routers are connected to each other through links. The origin of NoC has also been viewed as a paradigm shift from computation centric to communication-centric design as well as the implementation of scalable communication structures. The modular architecture of NoC makes chip structure highly scalable and well controlled electric parameters of the modular block improve reliability.

As the network communication latency depends on the characteristics of the target application, computational elements and network characteristics (e.g. network bandwidth and buffer size [2]. First of all the target applications and their associated traffic patterns and bandwidth requirements for each node in the network is determined. This application partitioning and knowledge of overall system architecture significantly impact the network traffic and helps determine the optimal network topology. Optimal network topology creates immense impact of design cost, power and performance and helps designers to choose effective and efficient routing algorithms and flow control scheme to manage incoming traffic.

The design space of a NoC is very large, and includes topology choice (mesh, torus, star, etc.), circuit switched or packet switched, and other parameters (link widths, frequency, etc.). Because the traffic patterns of most SoCs can be known, a custom generated network topology and physical placement of components yields better performance and power than a regular-pattern network [4]. A NoC's buffers and links can consume near 75% of the total NoC power [5], thus there is significant benefit to optimizing buffer size, link length and bandwidth of a NoC design.

Generally speaking, determining the optimal topology to implement any given application does not have a known theoretical solution. Although the synthesis of customized architectures is desirable for improved performance, power consumption and reduced area, altering the regular grid-like structure brings into the picture significant implementation issues, such as floor planning, uneven wire lengths (hence, poorly controlled electrical parameters), etc. Consequently,

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ways to determine efficient topologies that trade-off high-level performance issues against detailed implementation constraints at micro- or nano-scale level need to be developed.

## 2. BACKGROUND

Network-on-Chip (NoC) is an emerging paradigm using packet switched networks for communications within large VLSI system-on-Chip. NoCs are poised to provide enhanced performance, scalability, modularity, and design productivity as compared with previous communication architectures such as busses and dedicated signal wires. With the emergence of large number of cores in general purpose and system-on-chip (SoC), NoCs are likely to be prevailing on-chip interconnect fabric. [6]

The early work and basic principles of NoC paradigm were outlined in various seminal articles, for example [7-17] and few text books [18-20]. However, the aforementioned sources do not present many implementation examples or conclusions.

Networking concepts from the domains of telecommunication and parallel computer do not apply directly on chip. From a networking perspective, they require adaptation because of the unique nature of VLSI constraints and cost e.g. area and power minimization are essential; buffer space in on-chip switches are limited, latency is very important, etc. At the same time, there are new degrees of freedom available to the network designer, such as the ability to modify the placement of network endpoints. From the view point of VLSI designer, many well understood problems in the real aim of chip development methodology get a new slant when they are formulated for a NoC based system, a new trade-offs need to be comprehended. Therefore, the field offer opportunities for noble solutions in network engineering as well as system architecture, circuit technology, and design automation. [6]

Current complex on-chip systems are also modular, but most often the modules are interconnected by an on-chip bus. The bus is a communication solution inherited from the design of large board- or rack-systems in the 1990's. It has been adapted to the SoC specifics and currently several widely adopted on-chip bus specifications are available [31-34].

While the bus facilitates modularity by defining a standard interface, it has major disadvantages. Firstly, a bus does not structure the global wires and does not keep them short. Bus wires may span the entire chip area and to meet constraints like area and speed the bus layout has to be customized [35]. Long wires also make buses inefficient from an energy point of view [36]. Secondly, a bus offers poor scalability. Increasing the number of modules on-chip only increases the communication demands, but the bus bandwidth stays the same. Therefore, as the systems grow in size with the technology, the bus will become a system bottleneck because of its limited bandwidth.

Recently, network-on-chip (NoC) architectures are emerging as a candidate for the highly scalable, reliable, and modular on-chip communication infrastructure platform [11]. The NoC architecture uses layered protocols and packet-switched networks which consist of on-chip routers, links, and network interfaces on a predefined topology. There have been many architectural and theoretical studies on NoCs such as design methodology [10], [11], topology exploration [21], Quality-of-Service (QoS) guarantee [22], resource management by software [23], and test and verifications [24].

In large-scale SoCs, the power consumption on the communication infrastructure should be minimized for reliable, feasible, and cost-efficient implementations. However, little research has reported on energy- and power-efficient NoCs at a circuit or implementation level, since most of previous works have taken a top-down approach and they did not touch the issues on a physical level, still staying in a high-level analysis. Although a few of them were implemented and verified on the silicon [25], [26],they were only focusing on performance and scalability issues rather than the power-efficiency, which is one of the most crucial issues for the practical application to SoC design.

Network-on-Chip (NoC) architectures employing packet-based communication are being increasingly adopted in System-on-Chip (SoC) designs. In addition to providing high performance, the fault-tolerance and reliability of these networks is becoming a critical issue due to several artifacts of deep sub-micron technologies. Consequently, it is important for a designer to have access to fast methods for evaluating the performance, reliability, and energy-efficiency of an on-chip network. [27]

While on-chip networks have been proposed and studied in the academic literature, to date there have been very few implementations of routed on-chip networks. Dally and Towles [10] proposed a 2D torus network as a replacement for global interconnect. They claim that on-chip network modularity would shorten the design time and reduce the wire routing complexity. On-Chip routed networks have also been proposed for use in SoCs such as in CLICHÉ [12] , in which a 2D mesh network is proposed to interconnect a heterogeneous array of IP blocks.

A performance analysis also shows that dynamic resource allocation leads to the lowest network latencies, while static allocation may be used to meet QoS goals. Combining the power and performance figures then allows an energy-latency product to be calculated to judge the efficiency of each of the network [28].

In his work, Nikolay K. Kavaldjiev , used run-time reconfigurable NoC for streaming DSP applications taking the advantage of a global comunication architecture that avoids limitation by structuring and shortening the global wires. He also proposed an architecture of a virtual channel router, which in contrast to conventional architectures is able to provide predictable communication services and has a lower implementation area and cost than conventional architectures. Dynamic reconfiguration is essential to support the dynamically changing demands of the application domain: the system operates in a constantly changing environment. The user demands change (e.g., starting/terminating applications), the environmental conditions change (e.g., available networks, wireless channel conditions) and the available power budget

also changes (decreasing battery budget or connected to the mains). The set of running applications and tasks in the system adapts dynamically to these changes. The run-time reconfiguration modifies the system communication demands. For example, a new data stream may be needed or some of the old streams may be redirected or replaced. The NoC must be able to handle such dynamically changing traffic conditions. Run-time changes in part of the traffic must be possible without disturbing the rest of the traffic. The network reconfiguration time must be short enough to enable adequate system reaction time and reconfiguration must be transparent to the user. [30]

The major goal of communication-centric design and NoC paradigm is to achieve greater design productivity and performance by handling the increasing parallelism, manufacturing complexity, wiring problems, and reliability. The three critical challenges for NoC according to Owens et al. are: power, latency, and CAD compatibility [17]. The key research areas in Network-on-Chip design can be summarized as [29]:

Communication infrastructure: topology and link optimization, buffer sizing, floorplanning, clock domains, power

Communication paradigm: routing, switching, flow control, quality of service, network interfaces

Benchmarking and traffic characterization for design and runtime optimization

Application mapping: task mapping/scheduling and IP component mapping.

## 3. METHODOLOGY

Network-on-Chip is a new paradigm for interconnecting today's heterogeneous IP cores based System-on-Chips (SoCs). In SoC's IP Cores are connected to network of routers using network interfaces and network is used for packet switched on-chip communication. Conventional computer design tools i.e. Packet Tracer 5.3 utility from CISCO are used for network design and simulation. It provides a versatile practice and visualization environment for the design, configuration, and troubleshooting of network environments. The work done by us uses same tool to compare two topologies. The 2-D mesh is currently the most popular regular topology used for on-chip networks in tile-based architectures, because it perfectly matches the 2-D silicon surface and is easy to implement. However, a number of limitations have been proved in the open literature, especially for long distance traffic. In this type of topology, every node has a dedicated point to point link to every other node in the network. This means each link carries traffic only between the two nodes it connects.

If N is total no of nodes in network. Number of links to connect these nodes in mesh = N (N-1)/2 Each node should have (N-1) I/O ports as it require connection to every another node.

The advantages are:

1. No traffic problem as there are dedicated links. Robust as failure of one link does not affect the entire system.
2. Security as data travels along a dedicated line.
3. Points to point links make fault identification easy.

The disadvantages are:

1. The hardware is expansive as there is dedicated link for any two nodes and each device should have (N-1) I/O ports.
2. There is mesh of wiring which can be difficult to manage.
3. Installation is complex as each node is connected to every node.

As earlier studies have shown that maximum power is consumed by links and interconnect infrastructure. Reducing interconnects and links will result in lower power consumption but can also affect the performance and reliability negatively. The topology suggested by us reduces the number of links thus resulting into lower power consumption keeping same level of reliability and performance levels.

## 4. SIMULATION

As shown in figure 1 and figure 2, the number of links in the mesh topology is 24 while in proposed topology the number of links are 20. The number of hops a packets traverses in the longest path is 5 in Figure 1 while 4 in Figure 2. The time taken by a packet to traverse the longest path is 0.014 sec in Mesh topology while 0.009 sec in proposed topology as shown in table 1 and table 2. The percentage reduction in time a packet takes on longest path is 35.7 %.

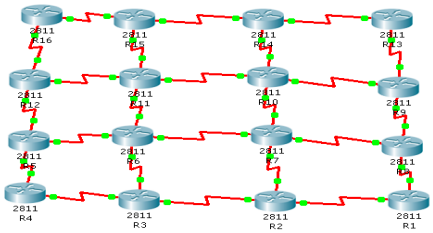

**Figure 1: Mesh topology**

| S.No. | Source Node | Destina-tion Node | Interme-diate Node | Time Elapsed (sec) |
|---|---|---|---|---|
| 1 | R1 | R16 | R8 | 0.003 |
| 2 | RI | R16 | R9 | 0.005 |
| 3 | R1 | R16 | R13 | 0.008 |
| 4 | R1 | R16 | R14 | 0.011 |
| 5 | R1 | R16 | R15 | 0.013 |
| 6 | R1 | R16 | R16 | 0.014 |

**Table 1: Result analysis of Mesh topology**

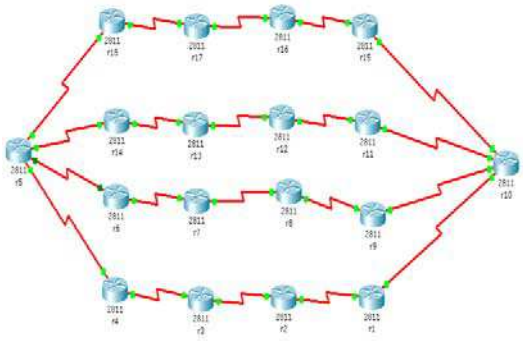

**Figure 2: Proposed topology 1**

| S. No. | Source Node | Destinati-on Node | Inter m-ediate Node | Time Elapsed (sec) |
|---|---|---|---|---|
| 1 | R1 | R18 | R10 | 0.003 |
| 2 | RI | R18 | R15 | 0.004 |
| 3 | R1 | R18 | R16 | 0.005 |
| 4 | R1 | R18 | R17 | 0.007 |
| 5 | R1 | R18 | R18 | 0.009 |

**Table 2: Result analysis of proposed topology 1**

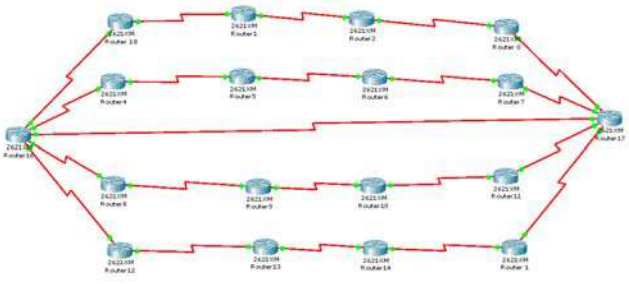

**Figure 3: Proposed topology 2**

| S.No. | Source Node | Destinati-on Node | Interm-ediate Node | Time Elapsed (sec) |
|---|---|---|---|---|
| 1 | R1 | R18 | R17 | 0.001 |
| 2 | RI | R18 | R16 | 0.002 |
| 3 | R1 | R18 | R18 | 0.003 |

**Table 3: Result analysis of proposed topology 2**

Comparison of proposed topology 2 and 3 shows further improvement in total flight time in traversal of a packet on the longest path. Addition of one link between R17 and R16 reduces the traversal time as well as number of hops.

## 5. CONCLUSION

The results achieved in terms of time and reduction in number of links displayed here is encouraging and motivates us to take the work further. As discussed earlier the NoC technology can borrow the tools and techniques from conventional computer network technology with required customization. In our future work, we intend to test same on a standard NoC benchmark. The other design parameters on NoC will also be explored.

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# Efficiency Metrics

**Tamanna Siddiqui[1], Munior Ahmad Wani[2]** and **Najeeb Ahmad Khan[3]**

*Submitted in May 2011, Accepted in June 2011*

***Abstract - Software measurement is a challenging but essential component of a healthy and highly capable software engineering culture. It is an integral part of the state-of the-practice in software engineering. More and more customers are specifying software and/or quality metrics reporting as part of their contractual requirements. Software Engineering has always been a matter of concern for every individual involved in software development starting from analysis phase to delivery phase or even at the maintenance time. There have been novel approaches for developing program complexity metrics. In this regard we have proposed the Efficiency Metrics, which can calculate the efficiency of a programmer and can also calculate the exact time taken by the development team to complete the software development under various complexities. Over and above we have also developed a relation between time and efficiency.***

***Index Terms - LOC, Mean, Standard Deviation, Low, Medium, High, Errors, Delay Time, Committed Time***

## 1. INTRODUCTION

There have been novel approaches for developing program complexity metrics. The first which was developed by Halstead[16], uses a series of software science equations to measure the complexity of a program. McCabe[17], uses graph theoretic measures to define a cyclomatic complexity metric. Albretch[18], who hypothesized that the amount of function to be provided by an application program can be estimated form an itemization of the major components of data to be used or provided by it. In this regard we have proposed the Efficiency Metrics, which can calculate the efficiency of a programmer and can also calculate the exact time taken by the development team to complete the software development under various complexities. Fear is often a software practitioner's first reaction to a new metrics program. People are afraid the data will be used against them, that it will take too much time to collect and analyze the data, or that the team will fixate on getting the numbers right rather than on building good software [20]. Creating a software measurement culture and overcoming such resistance will take diligent, congruent steering by managers who are committed to measurement and sensitive to these concerns. Software metrics, presented in various textbooks, e.g. [11],[12],[13],[14] and conferences and workshops [12], has a long tradition in theory, while considerably shorter in terms of industrial applications. Software metrics relies on the underlying theory, called representational measurement theory, posing some requirements on a correct definition, validation, and use of software metrics. From practical point of view, there are several further questions of importance, e.g. how to identify the right metrics to use, how to introduce a metrics programme, and how to keep it alive. Software process and product metrics are quantitative measures that enable software people to gain insight into the efficacy of software process and the projects that are conducted using the process as a framework. Basic Quality and productivity data is collected. This data is then analyzed, compared against the past averages, and assessed to determine whether quality and Productivity improvements have occurred or not [7]. Metrics are also used to pinpoint problem areas so that remedies can be developed and the software process can be improved [5].

A comparison of software metrics by Halstead, McCabe and Albrecht, in terms of their ability to measure software productivity has led to the conclusion that in the areas where it is applicable, the function point metric is the best of the three[14]. It should be noted that the values of Halsted's metrics becomes available only after the coding is done and therefore can be of use only during the testing and maintenance phase. The increasing demand of the software industry across the globe is that it needs both the development of improved software metrics and improved utilization of such metrics.[1] Software metrics can be classified into product metrics & Process Metrics or Objective Metrics & Subjective Metrics. On these bases many Software Models and Software Metrics have been proposed like Size Metrics by Boehm & Johns [8], Function point Metrics by Albrecht, Bang Metrics by Demark, Information Flow Metrics by Kafure & Henry etc. Measurement is the process by which numbers or symbols are assigned to attributes of entities in the real world in such a way as to describe them according to clearly defined unambiguous rules. A good measurement program is an investment in success by facilitating early detection of problems, and by providing quantitative clarification of critical development issues. Metrics give you the ability to identify, resolve, and/or curtail risk issues before they surface. Measurement must not be a goal in itself. It must be integrated into the total software life cycle — not independent of it [10]. Different type of measurement for different parameters of software product is possible through different types of metrics. Proposed research work is an effort to present a Delay metrics, which will solve the problem of time delay in software development.

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## 2. RELATED WORK

Many Researchers have been working on the exact time of development and they have also succeeded to some extent. Halstead and Raleigh has been able to find the development time however the results would have been more accurate, had the efficiency of the programmers also been taken into consideration.[1][2] Goal-question-metric (GQM) is an effective technique for reducing the average time and to close a defect by 40 percent within three months. However it too lacks the programmers efficiency in its calculations [4], because the distribution of reasons for delay varied widely from one department to another, it is recommended that every department should gain an insight into its reasons for delay in order to be able to take adequate actions for improvement [2]. The field of software engineering especially in the field of software metrics the success rate is not that good because most of the software development companies avoid to follow the proposed metrics. Project initiation is a good time to choose the appropriate measures that will help developer to assess project performance and product quality [6]. To plan measurement activities carefully will take significant initial effort to implementation and the payoff will come over time [3].

Yin and Winchesters Metrics [15], which depend on design structure can be useful in identifying sections of a design that may cause problems during coding, debugging, integration and modification. This metrics is available from the design phase onwards and hence can be used to predict values like the number of errors in the system, time for system testing, time for rectification of errors etc. Henry and Kafura's Metrics[15] is an appropriate and practical basis for measuring large scale systems. The major elements in the information flow analysis can be directly determined at design time, thereby allowing any corrections in the system structure with the minimum cost. Also by observing the patterns of communication among system components, it is possible to define measurements for complexity, module coupling, level interactions and stress points in the design. These critical system qualities cannot be derived from simple lexical measures. In a nutshell we can say that this metric is to determine the complexity of a procedure which depends on two factors: the complexity of the procedure code and the complexity of the procedures connections to its environment[15]. Once the errors are predicted by Yin and Winchester Metrics and the complexity of the code calculated by Henry and Kafura;s metrics, there is a need to develop a metrics which will calculate the exact time of development being the complexity of a procedure or program its important parameter[19].

Background of the early depicted Software Models:

### 2.1 COCOMO Model

The most fundamental calculation in the COCOMO model is the use of the Effort Equation to estimate the number of Person-Months required to develop a project. Most of the other COCOMO results, including the estimates for Requirements and Maintenance, are derived from this quantity. The original COCOMO 81 model was defined in terms of Delivered Source Instructions, which are very similar to SLOC. The major difference between DSI and SLOC is that a single Source Line of Code may be several physical lines. For example, an "if-then-else" statement would be counted as one SLOC, but might be counted as several DSI. However the efficiency of the programmer is not taken into consideration while performing such calculations to meet the deadlines of the client.

### 2.2 Waterfall model

The waterfall model however is argued by many to be a bad idea in practice, mainly because of their belief that it is impossible to get one phase of a software product's lifecycle "perfected" before moving on to the next phases and learning from them. A typical problem is when requirements change midway through, resulting in a lot of time and effort being invalidated due to the "Big Design Up Front". Only a certain number of team members will be qualified for each phase, which can lead at times to some team members being inactive. Had the programmers efficiency been checked before handing them over this job, the project manager could have assigned high efficiency programmers for coding.

### 2.3 Spiral model

In spiral model the software is developed in a series of incremental releases with the early stages being either paper models or prototypes. Later iterations become increasingly more complete versions of the product. Major flaws identified in spiral model is that Demands considerable risk-assessment expertise and has not been employed as much proven models .

### 2.4 Java Execution model

Though this model can check the performance of the software developed in Java but still lacks the time and efficiency constraints.[21]

Any of these COCOMO, WaterFall or Spiral models have been run in the software industry but when there are sharp deadlines for the completion of the project by client, such models become obsolete without housing the efficiency metrics.

### 2.5 Relation with Defect Removal Efficiency

Defect Removal Efficiency (DRE) is a measure of the efficacy of your SQA activities.. For eg. If the DRE is low during analysis and design, it means you should spend time improving the way you conduct formal technical reviews.

$DRE = E / ( E + D )$

Where E = No. of Errors found before delivery of the software and D = No. of Errors found after delivery of the software. [22]

Remedy: If DRE is low during analysis and design, we could find the efficiency of programmers and put the best ones for coding purposes to meet the deadlines of client in time bound and result oriented fashion.\

### 2.6 Feature Performance Metrics

Firstly, relative value is measured by the impact that each feature has on customer acquisition and retention. Secondly, feature value is compared to feature cost and specifically development investment to determine feature profitability. Thirdly, feature sensitivity is measured. Feature sensitivity is defined as the effect a fixed amount of development investment has on value in a given time. Fourthly, features are segmented according to their location relative to the value to cost trend line into: most valuable features, outperforming, underperforming and fledglings. Finally, results are analyzed to determine future action.[23]

## 3. PROPOSED WORK

If there are twenty programmers hired by the company, though there language skills, technical knowledge and aptitude is checked by the recruitment team, however it is not necessary that all of them would be having same expertise in a particular programming language or their level of aptitude and typing skills. So it is necessary to check their efficiency before assigning them the projects. Based on the efficiency, the work force management team of the organization shall assign the programmer a particular module of development where he/she can give their best with less assistance. If we don't measure our current performance and use the data to improve our future work estimates, those estimates will just be guesses. Because today's current data becomes tomorrow's historical data.

We have tried this efficiency metrics at the initial phase of the software, after analysis. The team leader (project in charge) took up the manpower for his assigned project, based on this efficiency metric. He picked up the people whose efficiency rated (7-9) for very complex modules, (4-6) for normal modules and (3-4) for easy modules, be it designing or coding.

In this paper we propose efficiency metric in which we are using three constants:

| | | |
|---|---|---|
| Programmers Status | 1 | Fresher |
| | 2 | Intermediate |
| | 3 | Experienced |
| Function complexity | 1 | Low |
| | 2 | Medium |
| | 3 | High |
| Efficiency Constant | 100 | % calculator |

The proposed efficiency metric is defined as:

$$E_{(Prog)} = \sqrt{\frac{F_{(c)} x LOC_{(d)} x e}{P_{(s)} \times T_{(c)}}}$$

Where,

$E_{(Prog)}$ is the efficiency of a programmer in a project.
$F_{(c)}$ is the function complexity
$LOC_{(d)}$ is the lines of code developed for assigned function.
$P_{(S)}$ is the programmer's status.
$T_{(c)}$ is the total time consumed (in minutes) for developing the Lines of code.
e is an efficiency constant and its value is 100.

## 4. EXPERIMENT

In Table 1, value of fifth column is the value of efficiency of programmer, which is obtained by the proposed metric.

| Programmer Status | F( c) | LOC (d) | T( c) | E (prog) |
|---|---|---|---|---|
| 1 | 1 | 5 | 3 | 3 |
| 2 | 1 | 5 | 2 | 4 |
| 3 | 1 | 5 | 1 | 8 |
| 1 | 2 | 7 | 7 | 2 |
| 2 | 2 | 7 | 6 | 3 |
| 3 | 2 | 6 | 3 | 6 |
| 1 | 3 | 9 | 13 | 2 |
| 2 | 3 | 8 | 11 | 3 |
| 3 | 3 | 8 | 8 | 4 |

**Table 1: A Table (Sample Data) Calculating the Efficiency of a Programmer for a Software Development Project**

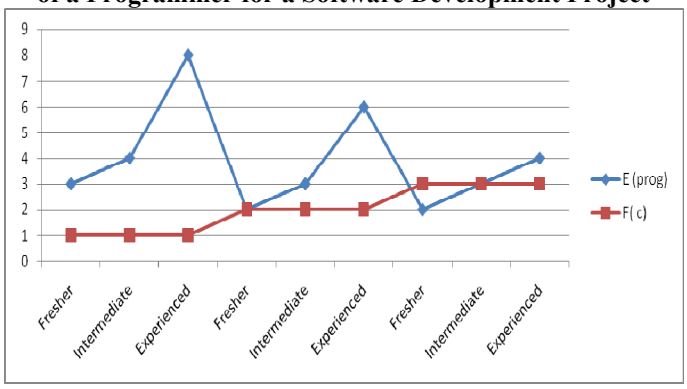


**Figure1: Efficiency Graph**

Figure 1 shows the efficiency of different programmers at development of functions of different complexities.

By having a look at the chart 1 above, it is clear that the efficiency of programmers do not vary much when we need to

develop programs of simple complexity however there is much difference once we go on higher complexity levels. Higher complexity level projects demand more experienced programmers for the completion within the stipulated time period.

| **Meeting the committed deadlines before testing the manpower with efficiency metrics.** | | | **Meeting the committed deadlines after testing the manpower with efficiency metrics.** | |
|---|---|---|---|---|
| Committed deadline after analysis | 75 days | | Committed deadline after analysis | 75 days |
| Deviation from committed time | 22 days | | Deviation from committed time | 6 days |

**A relation between time taken and efficiency:**
We have analyzed the data of Oriole InfoTech (A software company of repute) as depicted in Table 2, where programmers of any status are given the suite to develop, and we have found that as time taken for development of code is more, the efficiency of the programmer is less. (Table -2) is an extraction of the two parameters Time and Efficiency from Table -1

| T(c) | E (prog) |
|---|---|
| 3 | 3 |
| 2 | 4 |
| 1 | 8 |
| 7 | 2 |
| 6 | 3 |
| 3 | 6 |
| 13 | 2 |
| 11 | 3 |
| 8 | 4 |

**Table 2**

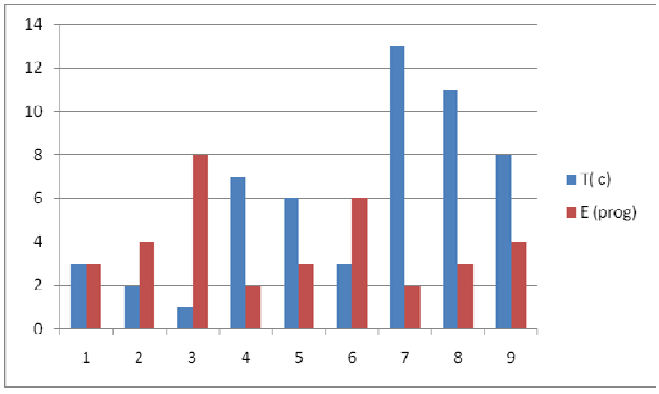


**Figure 2: Time and Efficiency Graph**

From the above Table-2, we have depicted the following bar graph which clearly states that the efficiency of a programmer is inversely proportional to time.

$$E \propto \frac{1}{T}$$

Where,
T(c) is the time consumed in development and
E(Prog) is the efficiency of the programmer.

## 5. CONCLUSION

Though the changes in the analysis, design and code are certain, we can still calculate the efficiency of the manpower (Programmers) before we involve them in a project of development. We shall be able to reap better results by assessing the past development data from knowledge bases of various companies and learn by the development hurdles which they have faced. The programmer's efficiency table shall be able to calculate the efficiency of the programmer to an appropriate level based on his a+ptitude, typing and programming skills. This efficiency shall allow us to forecast the manpower required for development of a project under certain level of complexity, to be very close to the deadline of the client.

## FUTURE SCOPE

Since Yin and Winchester metrics plays a vital role in the design phase of software development, Henry and Kafura's metrics serves as a base for our efficiency metrics as it helps us to access the complexity of a procedure. Both these metrics are helpful till the design phase however become obsolete when we enter the coding domain of software development. So our efficiency metrics will help us to a great extent in the coding part of the software development process. However the proposed software metrics is rarely followed by the companies of repute because of the reasons best known to them [6]. So it would be better if all the software companies of repute tie up with good academic institutions so that the researchers get the exact past development data to come up with an appropriate knowledge base which will help us to make future software metrics to maintain and manage domestic and global deadlines.

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# Process Benchmarking through Lean Six Sigma for ERP Sustainability in Small & Medium Enterprises

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*Submitted in May 2011; Accepted in July 2011*

***Abstract - Enterprise Resource Planning was a term restricted purely to elite class. ERP for small business calls for voluminous investments. But the question that kept ringing in the market was can everyone afford it? The answer was a stubborn no initially but not anymore. The world is changing, and new opportunities are appearing every day. Globalization, once the domain for only large companies, is now presenting new markets for growth for small to mid market companies.***

***In today's competitive manufacturing environment, it takes more than quick fixes, outsourcing and downsizing to consistently achieve growth and profit objectives. While these options may yield temporary financial relief, they will not lead the way to long-term growth and profitability. For companies to grow and consistently exceed bottom line expectations, they need to get lean. And to get lean they should master eight basics of Lean Six Sigma. Today every organization strives to optimize its operations, further based on the type of problems, combining Lean and/or Six Sigma tools with traditional project management techniques for ERP Implementation can be a powerful combination for ERP Sustainability in Small & Medium Enterprises.***

***Index Terms - ERP, Lean, Six Sigma, SIPOC, DMAIC, DMADV, TOC, BPI, Process Benchmarking, STOPE etc.***

## 1. INTRODUCTION

***Profit = (Price – Cost) x Volume***

Profit with Growth remains in top of mind as Small and Medium Enterprises (SMEs) develop Enterprise Resource Planning (ERP) strategies. For years SMES have followed the lead of the larger corporations in terms of "how" and "what" to select regarding ERP systems. That leadership role is currently faltering due to Corporate disillusionment with single 'corporate standard' implementation and Corporate focus shift from large scale purchases to integration. Results are scrap, rework and warranty costs that negatively impact profitability, quality and shipment problems that deliver less than acceptable customer satisfaction.

ERP implementations represent high-risk projects that need to be managed properly. Small and medium organizations must identify the critical issues that affect the implementation process and know when in the process to address them effectively to

ensure that the promised benefits can be realized and potential failures can be avoided[1][2].

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Once having taken the hurdles and having decided to fend for themselves, the SME buyers should be more focused and relevant. To Get to Root Causes for failed ERP implementation, what is required first is a company-wide, in-depth understanding of the fundamentals of Six Sigma and then a total commitment to the consistent and tenacious execution of eight basics of Lean Six Sigma [20].

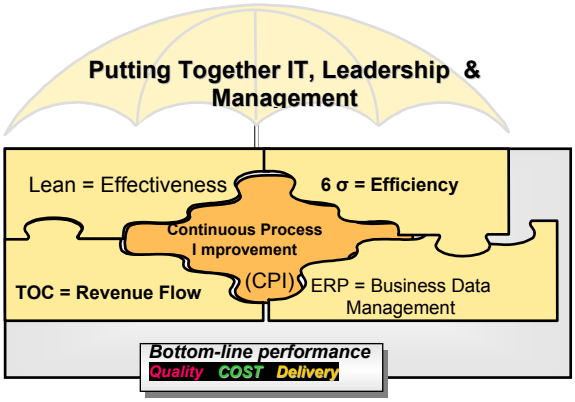



**Figure1: Process, Tools and Business Results**

As shown above in Figure 1, this research paper is *not* about Lean Manufacturing, TOC (Theory of Constraints), Six Sigma or ERP; It is about relating them functionally to each other; It is about synergy and interactions between these elements and It is about their relationships to the rest of the business enterprise[5][25].

## 2. BACKGROUND

Despite the large investment, most SMEs make in ERP software, benefits are by no means guaranteed. Many industry leaders, including Panorama Consulting Group, have published papers regarding the evasive nature of ERP benefits. Their **2010 ERP Report** outlines, 67.5% of companies surveyed fail to realize at least half of the business benefits they expected from their ERP systems[6][21]. In addition, over one in three companies surveyed (40%) realized major operational disruptions after implementation go-live, such as the inability to ship products or to close the books. Finally, 71.5% of executives and 67.1% of employees are at least somewhat satisfied with their ERP solutions. Factors that have a critical effect on the ROI of the ERP investment as

mentioned in Figure 2 should be carefully managed as part of an overall ERP benefits realization plan[23][24].

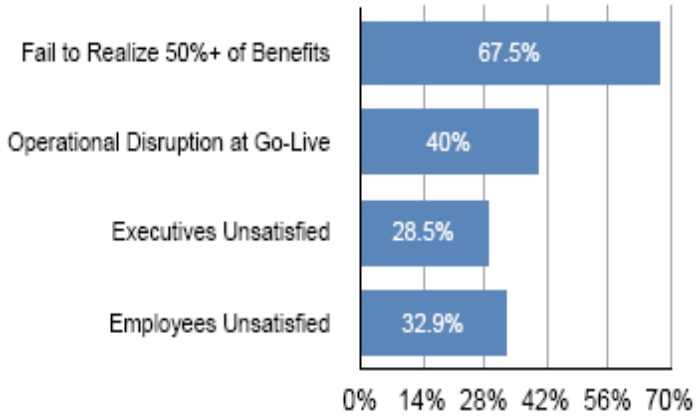



**Figure 2: ERP Results (%)**

To know how to get the best from an ERP package, it is important to first analyze the key factors that are responsible for ERP failures. Some major factors are described below [3][17]:

1. **Incorrect Expectations:** In an ERP implementation, inaccurate expectations signify a lack of understanding of the complexities of ERP implementation standard. Cost and Schedule overruns are common.
2. **Inaccurate Data:** Accurate data is the lifeline of an ERP system. Experience has that at least 98% of inventory records and bills of material must be accurate to make the system usable to control the business.
3. **Improper Gap Analysis:** Lack of perfect tuning between IT professionals, Business owners and End users only compounds the problem, at the other side.
4. **Inability to Calculate Hidden Costs:** In addition to the cost of purchase, most organizations often fail to factor in hidden costs during evaluation, consulting, implementation, training, transition, delayed ROI and post implementation support. All the above factors can lead to cost overruns, schedule overruns and functionality overruns. This ultimately results in negative ROI and a prolonged payback period.
5. **Elongated Implementation Time:** It often leads to fatigue, stressed and dubious state of mind in users which affect the growth period of ERP, to a greater extent.
6. **Inability to Accurately Map Business Processes:** If the ERP package is implemented by professionals who do not have adequate knowledge about the business, it leads to improper mapping of the business processes. Since ERP systems attempt to get the most out of planned information, they are most useful when the existing procedures of the organization as well as the data structures can be adapted to match those implemented by the ERP. Compatibility issues with the new ERP system is mostly found when going live with the new system[7].
7. **Lack of Proper Monitoring System:** It hampers the quality of the end system. As most of the ERP systems are not flexible, not ready to upgrade automatically in the varied system lead to the improper flow of information that hampers the quality decisions taken in time.
8. **Disheveled Knowledge Base:** Companies often lack tools to capture and record the knowledge gained during implementation and further use of this as checklist. Thus redundancy of the same process often wastes the precious time and resources.
9. **Inadequate Training & Documentation:** Several organizations often train users only during initial implementation stages and rarely provide additional training for new employees and those who have undertaken job rotations. Consequently system knowledge and usage tend to dip significantly after implementation. Documentation is also scarce and poorly maintained [8][9].

## 3. PROCESS BENCHMARKING THROUGH BEST BPI FOR SMES ERP

By Selecting the ***Best Business Process Improvement*** efforts, success is realized in a Lean Six Sigma deployment as depicted in Figure 3 below:

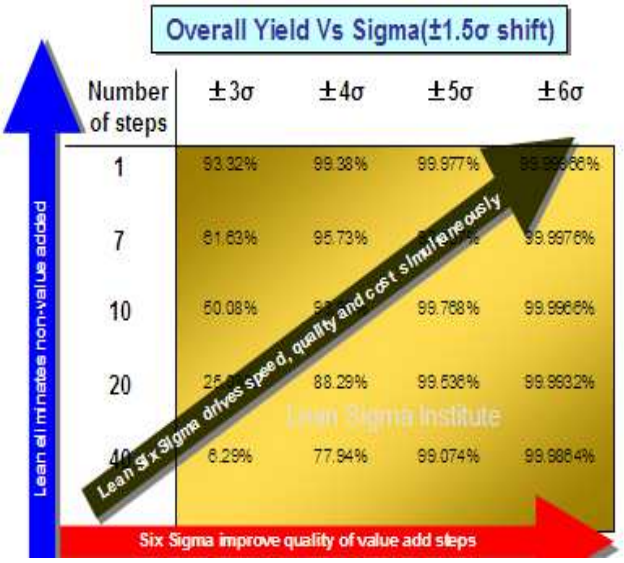



**Figure 3: Best BPI with Lean Six Sigma**

Lean eliminates non-value added steps or waste from the process while Six Sigma improves quality of value adds steps by reducing the variability in the process. A six-sigma process is one in which 99.99966% of the products manufactured are free of defects, compared to a one-sigma process in which only 31% are free of defects[10][23]. Without the solid execution of Lean Six Sigma basics, companies will seldom achieve their full growth and profit potentials of ERP. Here are the eight

basics of Lean Six Sigma which every manager should know and implement [20][21]:

**(i) Information Integrity:** It is not uncommon for front office management to become disenchanted with computerized systems results when time schedules and promised paybacks are not achieved. It is a given that acceptable systems results cannot be achieved when systems are driven by inaccurate data and untimely, uncontrolled documentation.

**(ii) Performance Management:** Measurement systems can be motivational or de-motivational. The individual goal-setting of the 1980s is a good example of de-motivational measurement - it tested one individual or group against the other and while satisfying some individual egos, it provided little contribution to overall company growth and profit. Today, the balanced scorecard is the choice of business winners.

**(iii) Sequential Production:** It takes more than systems sophistication for manufacturing companies to gain control of factory operations. To achieve on-time shipments at healthy profit margins, companies need to replace obsolete shop scheduling methodology with the simplicity of sequential production. Manufacturing leaders have replaced their shop order "launch and expedite" methodology with continuous production lines that are supported by real-time, visual material supply chains…sequential production. The assertion that sequential production only works in high production, widget-manufacturing environments is myth.

**(iv) Point-of-Use Logistics:** Material handling and storage are two of manufacturing's high cost, non-value-added activities. The elimination of the stock room, as it is known today, should be a strategic objective of all manufacturers. Moving production parts and components from the stockroom to their production point of use is truly a return to basics and a significant cost reducer.

**(v) Cycle Time Management:** Long cycle times are symptoms of poor manufacturing performance and high non-value-added costs[11]. Manufacturers need to focus on the continuous reduction of all cycle times. Achieving success requires a specific management style that focuses on root cause, proactive problem solving, rather than "fire-fighting".

**(vi) Production Linearity:** Companies will never achieve their full profit potential if they produce more than 25 percent of their monthly shipment plan in the last week of the month or more than 33 percent of their quarterly shipment plan in the last month of the quarter. As companies struggle to remain competitive, one of the strategies by which gains in speed, quality and costs can be achieved is to form teams of employees to pursue and achieve linear production.

**(vii) Resource Planning:** One of the major challenges in industry today is the timely right sizing of operations. Profit margins can be eroded by not taking timely downsizing actions, and market windows can be missed and customers lost by not upsizing the direct labour force in a timely manner. These actions demand timely, tough decisions that require accurate, well-timed and reliable resource information.

**(viii) Customer Satisfaction:** It does no good to have the best products and services if the customer's perception of "as received" quality and service is unsatisfactory. Companies need to plan and implement proactive projects that breakdown the communication barriers that create impressive customer perceptions [12][13].

## 4. NEW TECHNOLOGY FOR THE NEXT DECADE

Lean Six Sigma is a relatively new quality improvement methodology resulting from the combination of the individual Lean and Six Sigma methodologies. It started in the late 1990s when both AlliedSignal and Maytag began cross-training employees in the two frameworks and combined aspects of each. A focus on Lean occurs when short-term gains are desired and business leaders believe that a value stream map will reveal appropriate solutions; Six Sigma is preferred when the problem is not obvious, and/or when a longer time frame is required. Lean Goals focuses on eliminating waste from processes and increasing process speed by focusing on what customers actually consider quality, and working back from that. Lean Methods include Value Stream Mapping that involves clarifying the customer base, listing the process steps, establishing which steps are value-add, and reworking the process so the value-add steps flow without interruption[18][19].

Six Sigma is a business management strategy originally developed by Motorola, USA in 1981. As of 2010[update], it enjoys widespread application in many sectors of industry. Six Sigma is a rigorous and a systematic business management methodology that utilizes information and statistical analysis to measure and improve a company's operational performance, practices and systems by identifying and preventing 'defects' in manufacturing and service-related processes in order to anticipate and exceed expectations of all stakeholders to accomplish effectiveness.

Each Six Sigma projects follow two important project methodologies, as ***DMAIC*** and ***DMADV***. While DMAIC is used for projects aimed at improving an existing business process, DMADV is used for projects aimed at creating new product or process designs [13][19][20].

### 4.1 The DMAIC Project Methodology

The DMAIC project methodology has five phases as mentioned below:

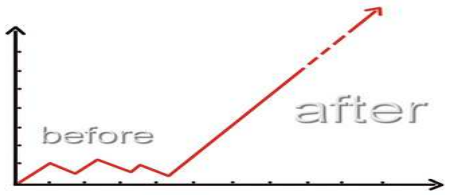
**(i) Define** the problem, the voice of the customer and the project goals specifically. Design goals that are consistent with customer demands and the enterprise strategy. The results of the Define phase go into the **Project Charter** as the goals, objectives and deliverables of the project as shown in Figure 4 below:

| | | | |
|---|---|---|---|
| Project Title:<br>From ... to ... statement | | | |
| Project Number: | | Last update: | |

| General information | | | |
|---|---|---|---|
| Division: | | Business Unit: | |
| Project Location: | | Unit Name: | |
| Belt:<br>MBB: | | Category of Project: | ☐ Black Belt<br>☐ Green Belt |
| Project Initiator: | | | |
| Project Champion: | | Strategic Impact:<br>(Tick One) | ☐ Zero Defects<br>☐ Zero Broken Promises<br>☐ Zero Accidents<br>☐ Zero Loss making Business |
| Process Owner: | | | |
| Project Team Members: | | | |
| Project Resources: | | Project Start Date: | |
| Finance: | | Project Target Completion Date: | |

**Figure 4: Six Sigma Project Charter Template**

**(ii) Measure** key aspects of the current process and collect relevant data. ***Measure, Measure, Measure.*** It is often said that we can't achieve what we don't measure, and it's true. It is important to measure our current baseline operational performance and establish post-go-live ERP performance measures. This step is the key to an effective ERP benefits realization program. At the end of the Measure phase, one should have a detailed process map that clearly shows how our process is currently performed, as well as data and charts that tell how well these processes meets customer requirements.




**Outcomes**

**Figure 5: Six Sigma Measure Phase**

It is critical that the metric be ***Real, Reliable and Repeatable. 'Real'***, because it must be relevant to the business. The metric must address a real business problem and measure it in business terms. The metric must be ***'Reliable'***, in the sense that it leaves no room for doubt and includes a drill-down to any underlying facts. Lastly, the metric must be, ***'Repeatable'***, because you will need to show historical trends in order to show the progress of the Master Data Management program.

**(iii) Analyze** the data to investigate and verify Cause-and-Effect Relationships. Determine what the relationships are, and attempt to ensure that all factors have been considered. Seek out root cause of the defect under investigation.

During the Analyze phase, we might use a ***Ishikava Fishbone Analysis (Cause-effect diagram)*** (Figure 6) to analyze the causes of disintegrated master data. We begin the fishbone by showing the undesirable effect of, 'Duplicate Disintegrated Customer Data', in a box on the right side of the diagram. Then we list the various causes that produce this effect including Architecture causes, Governance causes, Organization causes and Process causes along arrows pointing into the Effect.

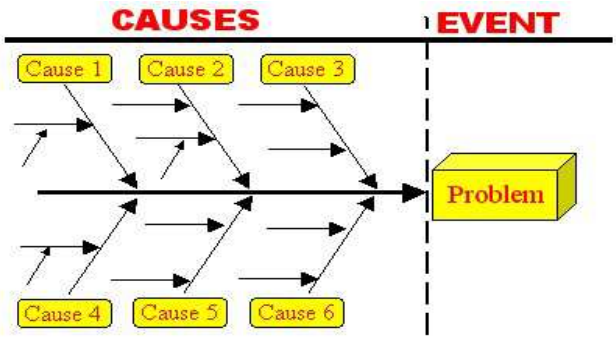



**Figure 6: Ishikava Fishbone Analysis**

**(iv) Improve or Optimize** the current process based upon data analysis using techniques such as design of experiments, mistake proofing, and standard work to create a new, future state process. Set up pilot runs to

establish process capability. We can use ***SIPOC (Supplier Input Process Output Customer)*** in the Improve phase to brainstorm improvements to the process.

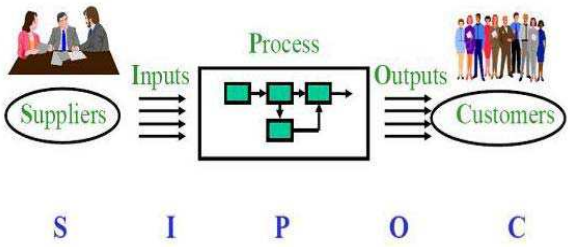



**Figure7: SIPOC in Improvement Phase**

The SIPOC diagram in Figure 7 depicts the new improved process, 'Unique ID Service', and lists Order Management as the supplier function. They supply the input of customer name that is matched in the, 'Unique ID Service', into the output, 'Matched Customer'. And Strategic Procurement might be the customer of this process.

**(v) Control** the future state process to ensure that any deviations from target are corrected before they result in defects. Control systems are implemented such as ***statistical process control, production boards and visual workplaces*** and the process is continuously monitored as depicted in Figure 8 below:

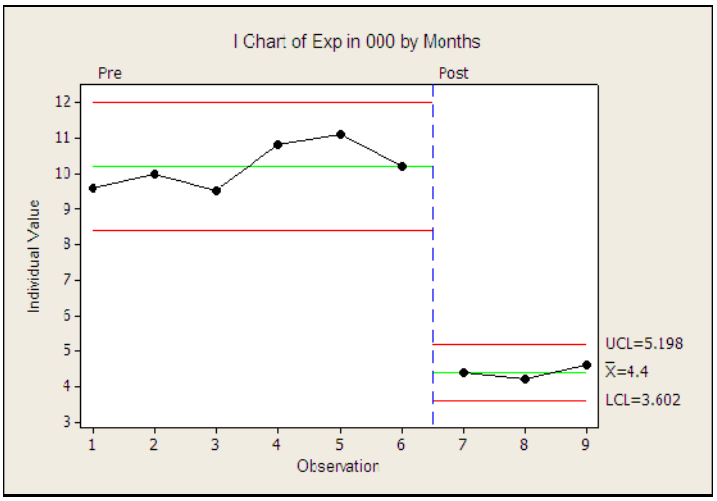



**Figure8: DMAIC Control Phase**

### 4. 2 The DMAIC Project Methodology

While the DMADV project methodology, also known as DFSS ("**D**esign **for** **S**ix **S**igma"), [12] features five phases:

1. ***Define*** design goals that are consistent with customer demands and the enterprise strategy.
2. ***Measure*** and identify CTQs (characteristics that are **C**ritical **to** **Q**uality), product capabilities, production process capability, and risks.
3. ***Analyze*** to develop and design alternatives, create a high-level design and evaluate design capability to select the best design.
4. ***Design*** details, optimize the design, and plan for design verification. This phase may require simulations.
5. ***Verify*** the design, set up pilot runs, implement the production process and hand it over to the process owner(s).

### 4.3 Difference between DMADV and DMAIC Methodology

The difference between DMADV and DMAIC as one can see now, exists only in the way last two steps are handled. In DMADV, instead of the Improve and Control steps which focuses on readjusting and controlling by one way or other, deals with redesigning the process to fit customer needs [27]. There is a new viewpoint in Six Sigma circles that DMADV is for designing new products and services and that it may not be successful on existing business processes and products. Although the argument is valid to some extent, it can be noticed that the I letter of DMAIC is not far removed from the D letter of DMADV. Here design is an extended concept of improvement. Let's simply put it the other way around. One can implement DMADV when we don't have an existing product, which we are aiming to create from scratch. The second occasion when we can think of using DMADV is when in actual practice, DMAIC hasn't yielded the result you were looking for despite best efforts to make improvements.

### 4. 4 which one is better and when?

In a nutshell, the latter reason can be summarized as: Use DMADV when process improvement either fails or doesn't deliver to your expectations. There are occasions when planned DMAIC has turned into DMADV ultimately. Black Belts must take credit for this, in my view, as this reflects their in-depth subject knowledge. The combination of the rigor of Six Sigma with the simplicity and practicality of Lean Enterprise gives organizations a larger cadre of tools to solve a broader range of problems. The result is the faster creation of value at the lowest possible cost. But it is imperative that the lean mindset begins at software selection that must continue through ERP implementation, and doesn't stop until well after go-live.

## 5. Key Tools for Use While Identifying BPI Efforts for ERP Selection

The two primary tools for identifying and prioritizing BPI efforts are the Tree diagram and the Benefits/Effort

Matrix. A **Tree Diagram** is simply a tool for organizing ideas (Figure 9). It branches off from the value drivers, which are major opportunity areas for value creation and Lean Six Sigma BPI efforts. Each value driver has many opportunity areas for BPI efforts. Many ideas that emerge from the opportunity areas are still too broad for a Lean Six Sigma BPI effort, and specific efforts must be identified. BPI effort ideas then go through the BPI effort selection process [28].

**Figure 9: Tree Diagram**

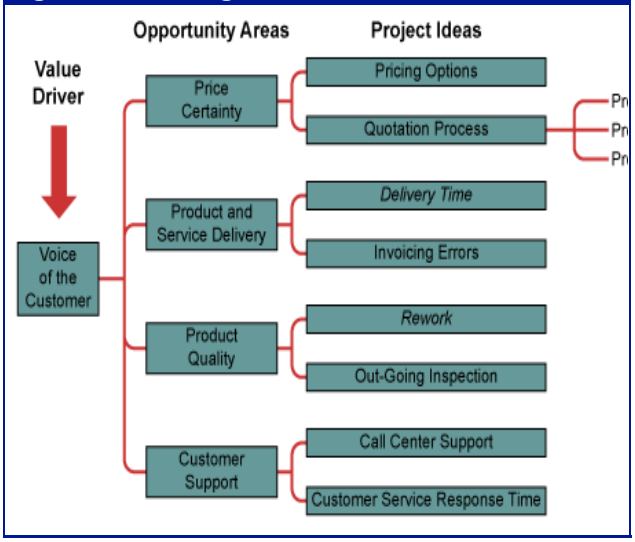



**Figure 9: Tree Diagram of BPI for ERP Selection**

While a ***Benefits/Effort Matrix*** helps practitioners must determine the benefits associated with a BPI effort compared to the effort (resources, time, etc.) necessary to proceed (Figure 10).

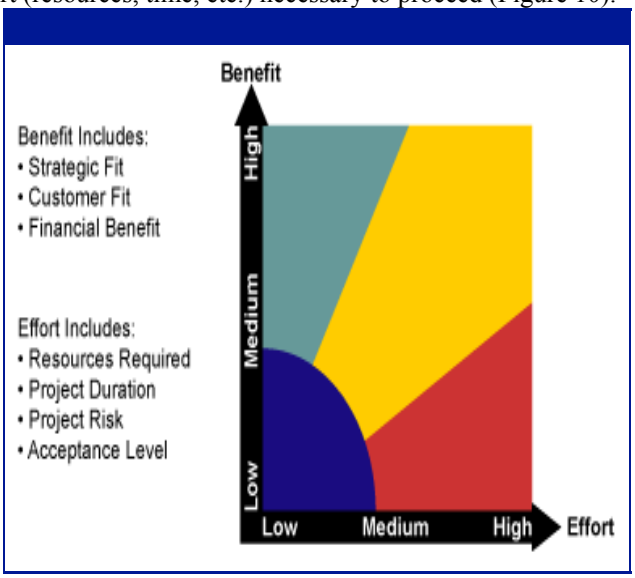



**Figure 10: Benefits/Effort Matrix of BPI for ERP Selection**

Once practitioners identify BPI efforts, they should establish a labeling system, such as numbering them, and place them within the matrix. BPIs with high benefits that require low effort are the most desirable opportunities, while BPIs with low benefits but also low effort should be considered as potential quick hits. Opportunities that require high effort and offer low benefits are the less desirable.

## 6. HOW SUCCESSFUL ERP SELECTIONS ARE MADE BY SME?

The top things to look for, look at, and look beyond when evaluating an ERP purchase. ERP selection is not just about wants and want-nots from the various people in the organization. It should be a long lasting purchase that provides one with the feeling of a partnership [13] [14]. One is not just buying software; one is also buying into a vendor and their company culture.

The analysis has addressed some critical selection factors from the survey results conducted on SME project leaders for ERP implementation [4][17]. These critical selection factors are:

a) **System Functionality Requirements**: Requirement of the system to suit business. Systems will need to support a more integrated style of business processes, including womb-to- tomb management of customer, company, contractor and supplier relationships.
b) **Business Drivers:** Financial benefit to the company of the selected system.
c) **Cost Drivers:** Direct cost of the implementation in terms of outlay and resources.
d) **Flexibility:** Ability to tune or optimize the system to meet unique requirement of the company.
e) **Scalability:** Size of the system to suit the business and ability to grow with the business.
f) **Usability:** Systems must support the emerging point-and click generation.
g) **Reliability:** Systems must achieve the uptime goal of 24 hours a day, seven days a week, with 99.9999 percent availability as the backup goal. Systems also need to be safe and resistant to illegal penetrations [15][16].
h) **Agility:** Demand for shorter Web response times will grow as people tire of the World Wide Wait.
i) **Supportability:** Systems must improve their capabilities in a smooth evolution rather than through a constant barrage of herky-jerky upgrades and bug fixes.
j) **Integrity:** Complexity will drive the movement toward component-based integration so that more organizations will move toward a distributed system built around a tiered architecture.

## 7. BOTTOM LINES FOR SMES BUYERS DEFINED

Once having taken the hurdles and having decided to fend for themselves, the SMB buyers should be more focused and relevant. They should include [9] [14]:

1. How scalable and how diverse is the potential vendor's product today?
2. Does the ERP provider have a track record of supporting large as well as medium sized and small business with one set of software?
3. Are they thinking about their customer and how they will assist them crossing over the next technological paradigm shift?
4. Have they exhibited a track record of helping their customer base in the past over prior technological shifts?
5. Does the ERP software company have a general discrete focus, a niche focus or are they strong in both?
6. Does a vendor have a role in high growth 'legacy system modernization' market space?
7. Do they intend to extend their software with business intelligence and enterprise information integration initiatives that make it easier to talk to other ERP software?

## 8. EVALUATING ERP SUSTAINABILITY & PERFORMANCE MEASUREMENTS IN SMES

The company should have a scale for evaluation right from the beginning stage. The company must periodically make a note of the work done. Any discrepancies will be brought to the vendor's notice immediately [17][18]. The vendor should extend his full fledged cooperation in making sure that the work gets done as promised. Then only it is possible to scale ERP best practices.

### 8. 1 Calculating ROI

ROI helps to directly account the performance of ERP software programs. The ROI on ERP will not be merely achieved by ERP implementation. The returns will be achieved only if the procedures are followed properly.

### 8.2 Unfailingly Observing Contracts Terms

The performance of ERP software can be gauged on the basis of its working in relation to the terms of contract. ERP software that accords to contractual terms in relation to working definitely indicates better performance than vice versa.

### 8.3 Customizing ERP Software

Customizing is an integral part of ERP solutions. This is a crucial decision which needs to be taken by the organization as it is detrimental in ERP'S success. The rate of customization is directly proportional to ERP success. Customization tends to pose a challenge to time and the funds allocated. The challenge of a successful management lies in balancing them and making both ends meet. It is a difficult task but the success speaks for the process.

### 8.4 Enhancements through ERP Innovations

The innovations of new ERP applications help users to include all the specific details in ERP system itself. This means they don't have to input these details into the ERP systems every time they login. This also implies that the operators need not recompile ERP software as and when there is a change in the attributes or methodology of data fed. Customization has also helped the users to act independently rather than depending on the vendors whenever a modification is required.

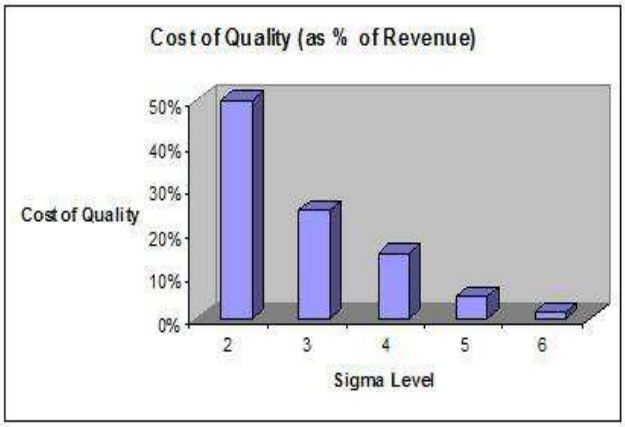



**Figure10. Comparison of Sigma Levels with Cost of Quality**

### 8.5 Sound knowledge about ERP System

The features are it old or new or modern or traditional will not be of any use unless the users are aware of the ERP Systems features and modalities. This knowledge has to be imparted to the end users apart from IT personnel [19][20][22]. They should have a clear knowledge about the entire system in finger tips. If questioned or demanded they must be capable of bringing that particular function into effect. The services of an expert ERP consultant will come in handy for an organization to supply this information to the user. The consultant will make a decision on the basis of the organizational needs and system configuration.

## 9. DISCUSSIONS & CONCLUSION

Does Lean Six Sigma Work in Smaller Companies for better ERP implementation? This million dollar frequently surfaces when we talk about the power of Lean relates to the installation of an ERP system in an organization. The typical response is: "we don't need a lean focus because our ERP system uses standard templates of best practices". This is the wrong answer. The templates for SAP, Oracle and others are generally not lean. They are structured, organized and SOX compliant, but not Lean. In no large measure this is due

to ERP systems and their templates being transaction / data/ planning/ scheduling driven, Lean focuses on continuous cost reduction and process improvement with the minimum number of transactions and processes. Therefore it is best to remove the non value added activities and then insert the IT systems supporting the Lean operation [29]. Given how hard it is to alter an ERP system once it is installed, the case for a pre-ERP Lean initiative is quite strong. A well implemented Lean ERP infrastructure is a major competitive advantage, but it does have to be sequenced properly.

Implementing Six Sigma offers many small and medium sized companies the same benefits as larger companies: an improved bottom line. Most companies today operate between three and four sigma, where the cost of quality is 15 to 25% of revenue. (See graph below).

As the company moves to Six Sigma Quality Levels, their Cost of Quality decreases to one to two percent of revenue. These dramatic cost savings come as their quality costs move from "Failure Costs" (such as resolving customer complaints) to "Prevention Costs" (such as through Six Sigma projects and other customer focused activities)[30]. The modern ERP market is experiencing both growth and challenges. The extent of customization does not solely decide the success of ERP [23]. ERP can be the road to prosperity if one can implement revolutionary approach to product and process improvement/ benchmarking through the effective use of statistical methods in Lean Six Sigma skills [24][25].

## FUTURE STUDY

This study will provide practitioners a deep insight into the benefits of aligning business process with a target ERP system in the period prior to the go-live along with the following points:

1. Tailoring ERP system functionality to customer requirements [6] [9].
2. ERP system as a business tool for growth of SME having limited resources (money, people, time) with which to evaluate and implement ERP [12].
3. Continuous Evaluation of Critical Success Factors (CSFs) for various ERP software to meet essential business needs, unique to each business [8] [11].
4. Change Management in relation to STOPE framework (Strategy, Technology, Organization, People and Environment).
5. Future Direction of ERP, Project Management and Lean Six Sigma Technology [9] [22].

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# BIJIT - BVICAM's International Journal of Information Technology

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State the objectives of the work and provide an adequate background, with a detailed literature survey or a summary of the results.

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A Theory Section should extend, not repeat the information discussed in Introduction. In contrast, a Calculation Section represents a practical development from a theoretical basis.

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The main conclusions of the study may be presented in a short Conclusion Section. In this section, the author(s) should also briefly discuss the limitations of the research and Future Scope for improvement.

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**ACKNOWLEDGEMENT**

If desired, authors may provide acknowledgements at the end of the article, before the references. The organizations / individuals who provided help during the research (e.g. providing language help, writing assistance, proof reading the article, sponsoring the research, etc.) may be acknowledged here.

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Please ensure that every reference cited in the text is also present in the reference list (and vice versa). The references in the reference list should follow the standard IEEE reference style of the journal and citation of a reference.

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As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading if desired, or can be included in the reference list, as well.

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Text: Indicate references by number(s) in square brackets in line with the text. The actual authors can be referred to, but the reference number(s) must always be given. Example: '..... as demonstrated [3,6]. Barnaby and Jones [8] obtained a different result ....'

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Two sample examples, for writing reference list, are given hereunder:-

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[1] I. J. Cox, J. Kilian, T. Leighton, and T. Shamoon, "Secure spread-spectrum watermarking for multimedia", *IEEE Transactions on Image Processing*, Vol. 6, No. 12, pp. 64 – 69, December 1997.

**Reference to a book:**

[2] J. G. Proakis and D. G. Manolakis – Digital Signal Processing – Principles, Algorithms and Applications; Third Edition; Prentice Hall of India, 2003.

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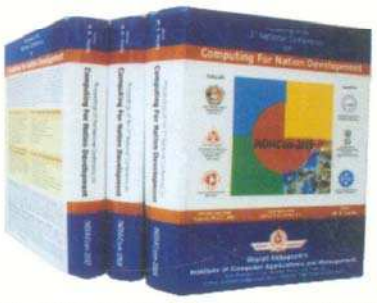

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