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Preface

The Fourth International Conference on Computer Science, Engineering and Applications (CCSEA-2014) was jointly organized by AIRCC and Vel Tech Dr. RR & Dr. SR Technical University, Chennai, India and conducted at the Vel Tech Dr. RR & Dr. SR Technical University during March 7-8, 2014. The First International Conference on Information Technology, Control, Chaos, Modeling and Applications (ITCCMA-2014), Third International Conference on Embedded Systems and Applications (EMSA-2014), Second International Conference on Data Mining and Knowledge Management Process (DKMP-2014), Third International Conference on Cloud Computing: Services and Architecture (CLOUD-2014) and Third International Conference on Software Engineering and Applications (SEA-2014) were collocated with the CCSEA-2014. The conferences attracted many local and international delegates, presenting a balanced mixture of intellect from the East and from the West.

Computer Science and Information Technology (CS & IT) series is an open-access Computer Science Conference Proceedings (CSCP) series and the goal of this series is to bring together researchers and practitioners from academia and industry to focus on understanding CS & IT and to establish new collaborations in these areas. Authors are invited to contribute to the conference by submitting articles that illustrate research results, projects, survey work and industrial experiences describing significant advances in all areas of Computer Science and Information Technology.

The ITCCMA-2014, CCSEA-2014, EMSA-2014, DKMP-2014, CLOUD-2014 and SEA-2014 Committees rigorously invited submissions for many months from researchers, scientists, engineers, students and practitioners related to the relevant themes and tracks of the workshop. This effort guaranteed submissions from an unparalleled number of internationally recognized top-level researchers. All the submissions underwent a strenuous peer review process which comprised expert reviewers. These reviewers were selected from a talented pool of Technical Committee members and external reviewers on the basis of their expertise. The papers were then reviewed based on their contributions, technical content, originality and clarity. The entire process, which includes the submission, review and acceptance processes, was done electronically. All these efforts undertaken by the Organizing and Technical Committees led to an exciting, rich and a high quality technical conference program, which featured high-impact presentations for all attendees to enjoy, appreciate and expand their expertise in the latest developments in computer network and communications research.

In closing, ITCCMA-2014, CCSEA-2014, EMSA-2014, DKMP-2014, CLOUD-2014 and SEA-2014 brought together researchers, scientists, engineers, students and practitioners to exchange and share their experiences, new ideas and research results in all aspects of the main workshop themes and tracks, and to discuss the practical challenges encountered and the solutions adopted. The book is organized as a collection of papers from the ITCCMA-2014, CCSEA-2014, EMSA-2014, DKMP-2014, CLOUD-2014 and SEA-2014

We would like to thank the General and Program Chairs, organization staff, the members of the Technical Program Committees and external reviewers for their excellent and tireless work. We sincerely wish that all attendees benefited scientifically from the conference and wish them every success in their research. It is the humble wish of the conference organizers that the professional dialogue among the researchers, scientists, engineers, students and educators continues beyond the event and that the friendships and collaborations forged will linger and prosper for many years to come.

Sundarapandian Vaidyanathan
Jan Zizka

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IMAGE SEGMENTATION BY MODIFIED MAP-ML ESTIMATIONS

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ABSTRACT

Though numerous algorithms exist to perform image segmentation there are several issues related to execution time of these algorithm. Image Segmentation is nothing but label relabeling problem under probability framework. To estimate the label configuration, an iterative optimization scheme is implemented to alternately carry out the maximum a posteriori (MAP) estimation and the maximum likelihood (ML) estimations. In this paper this technique is modified in such a way so that it performs segmentation within stipulated time period. The extensive experiments shows that the results obtained are comparable with existing algorithms. This algorithm performs faster execution than the existing algorithm to give automatic segmentation without any human intervention. Its result match image edges very closer to human perception.

KEYWORDS

Maximum a Posteriori, Maximum Likelihood, graphcut

1. INTRODUCTION

Image Segmentation is part of Image analysis which leads us to automated comprehension of the image by the computer. There has been tremendous work done in the field of Image analysis. Many researchers have developed numerous algorithms to achieve segmentation but till this date no algorithm has surpassed the segmentation performed by the humans. Also there are issues regarding the execution time of these algorithms. Since tremendous amount of time is spent in performing the various complex tasks it takes more time. There has been always a quest for segmentation algorithm which will work with all types of images and give good performance. In this paper we had modified the pixel relabeling algorithm in such a way it ultimately leads to faster execution which gives comparable results with the original existing algorithm [1].

1.1 Related Work

Available image segmentation algorithms can be classified into two groups: contour-based approaches and region-based approaches. Contour-based approaches try to find the boundaries of objects in an image, while region-based approaches attempt to split an image into connected regions. In contour-based approach we generally start with some spline curve and we refine it by

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shrink and expansion operations minimizing energy function. One problem existing in these algorithms is that they are easy to get trapped in local minima. In addition, they need manually specified initial curves close to the objects of interest. Region-based approaches try to classify an image into multiple consistent regions or classes. Thresholding is the simplest segmentation method but its performance is usually far from satisfactory.

Watershed segmentation [2] is one of the traditional region-based approaches. It is used for images containing touching objects. It finds high intensity regions and low intensity regions. It suffers from over-segmentation. The various morphological operations are used to handle this problem. Usually, watershed is used for the segmentation of foreground and background (two-class) of an image. For a general color image with many different regions, it often gives a bad result. Hence it is not used widely.

The K-means algorithm [3] is the basic one. However, the K-means is not good enough because it does not take account of the spatial proximity of pixels. It is, thus, often used in the initialization step for other approaches.

Expectation-maximization (EM) [4] performs segmentation by finding a Gaussian mixture model in an image feature space. EM is not suitable for images containing different number of regions. The disadvantage of EM is that it does not change the number of regions during the segmentation, which leads to wrong segmentation. Theoretically, the minimum description length (MDL) principle [4] can be used to alleviate this problem, but the segmentation has to be carried out many times with different region numbers to find the best result. This takes a large amount of computation, and the theoretically best result may not accord with this perception.

In [5], a mean shift algorithm is proposed for image segmentation. Mean shift is a nonparametric clustering technique which neither requires to know the number of clusters in advance nor constrains the shapes of the clusters However, it often obtains over-segmented results for many natural images.

Recently, a number of graph-based approaches are developed for image segmentation. Shi and Malik's [6] normalized cuts are able to capture intuitively salient parts in an image. Normalized cuts are one of the popular spectral clustering algorithms. Normalized cuts are not suitable for image segmentation because adhoc approximations are to be considered to relax the NP-hard computational problem. These vague approximations are ambiguous leading to unsatisfactory results. Also, due to this, spectral clustering algorithms suffer from the expensive computational cost.

Another popular segmentation approach based upon MRFs is graphcut algorithm [7]. This algorithm relies on human interaction, and solves the two-class segmentation problem only, i.e., separating an image into only background and object regions, with some manually given seed points.

In [9], authors have used Fuzzy Rule based graphcut to achieve perfect segmentation. This method definitely gives better results but is time consuming for segmenting large number of images.

All of the above techniques have their advantages and disadvantages. Some techniques suffer from over-segmentation while some of the techniques suffer from under-segmentation. The MAP-ML [1] algorithm overcomes the disadvantages in above algorithms and gives result more closely to human perception.

We are going to implement the MAP-ML algorithm on the Berkeley database containing 500 natural images of size 321 x 481 (or 481x321), with ground truth segmentation results obtained from human subjects for evaluating segmentation algorithm and we will compare the results with those obtained by state-of-the-art image segmentation algorithms such as Mean Shift and Normalized Cuts. Section 2 introduces the probability framework used in the algorithm. Section 3 discusses the proposed modified MAP-ML Algorithm. Section 4 discusses the results obtained. Section 5 concludes our work.

2. PROBABILISTIC MODEL

For a given image *P*, the features of every pixel *p* are expressed by a 4-D vector

$$I(p)=(I_L(p), I_a(p), I_b(p), I_t(p))^T \tag{1}$$

where $I_L(p), I_a(p), I_b(p)$ are the components of p in the L*a*b*color space, and $I_t(p)$ denotes the texture feature of *p*. In this seminar, the texture contrast defined in [2] (scaled from [0, 1] to [0,255]) is chosen as the texture descriptor. Fig. 3.4 shows an example of the features.

The task of image segmentation is to group the pixels of an image into relevant regions. If the problem is formulated as a labeling problem, the objective is then to find a label configuration $f = \{f_p | p\}$ where f_p is the label of pixel p denoting which region this pixel is grouped into. Generally speaking, a "good" segmentation means that the pixels within a region *i* should share homogeneous features represented by a vector $\varphi(i)$ that does not change rapidly except on the region boundaries. The introduction of $\varphi(i)$ allows the description of a region, with which high level knowledge or learned information can be incorporated into the segmentation. Suppose that there are *k* possible region labels.

A 4-D vector

$$\varphi(i) = (\bar{I}_L(i), \bar{I}_a(i), \bar{I}_b(i), \bar{I}_t(i))^T \tag{2}$$

is used to describe the properties of label (region), where the four components of $\varphi(i)$ have the similar meanings to those of the corresponding four components of I(p).

Let $\varphi = \{\varphi(i)\}$ be the union of the region features. If P and φ are known, the segmentation is to find an optimal label configuration$\hat{f}$, which maximizes the posterior possibility of the label configuration.

$$\hat{f} = \arg\max_{f} \; Pr\,(f \,|\, \varphi, P) \tag{3}$$

where φ can be obtained by either a learning process or an initialized estimation. However, due to the existence of noise and diverse objects in different images, it is difficult to obtain φ that is precise enough. Thus, an iterative method is used to solve the segmentation problem.

Suppose that φ^n and f^n are the estimation results in the nth iteration. Then the iterative formulas for optimization are defined as

$$f^{n+1} = \arg\max_{f} Pr\,(f|\varphi^n, P) \tag{4}$$

$$\varphi^{n+1} = \arg\max_{\varphi} Pr\,(f^{n+1}|\varphi, P) \tag{5}$$

This iterative optimization is preferred because (4) can be solved by the MAP estimation, and (5) by the ML estimation.

2.1. MAP Estimation

Given an image P and the potential region features φ, f is inferred by the Bayesian law, i.e., $\Pr(f|\varphi, P)$ can be obtained by

$$\Pr(f|\varphi, P) = \frac{\Pr(\varphi, P|f)\Pr(f)}{\Pr(\varphi, P)} \propto Pr(\varphi, P|f)\, P\, r(f) \tag{6}$$

which is a MAP estimation problem and can be modeled using MRFs.

Assuming that the observation of the image follows an independent identical distribution, $\Pr(\varphi, P|f)$ is defined as

$$\Pr(\varphi, \mathrm{P}|\mathrm{f})\ \alpha \prod_{\mathrm{p}\in\mathrm{P}} \exp\left(-\mathrm{D}(\mathrm{p}, \mathrm{f_p}, \varphi)\right) \tag{7}$$

where $D(p, f_p, \varphi)$ is the data penalty function which imposes the penalty of a pixel p with a label f_p for given φ. The data penalty function is defined as

$$\begin{aligned} D(p, f_p, \varphi) &= ||I(p) - \varphi(f_p)||^2 \\ &= (I_L(p) - \bar{I}_L(f_p))^2 + (I_a(p) - \bar{I}_a(f_p))^2 + (I_b(p) - \bar{I}_b(f_p))^2 + (I_t(p) - \bar{I}_t(f_p))^2 \end{aligned} \tag{8}$$

MRF's whose clique potentials involve pairs of neighboring pixels only is considered. Thus

$$\Pr(f) \propto \exp\left(-\sum_{p\in P} \sum_{q\in N(p)} V_{p,q}(f_p, f_q)\right) \tag{9}$$

where *N(p)* is the neighborhood of pixel p. $V_{p,q}(f_p, f_q)$, called the smoothness penalty function, is a clique potential function, which describes the prior probability of a particular label configuration with the elements of the clique(p, q). The smoothness penalty function is defined as follows using a generalized Potts model [7]:

$$V_{p,q}(f_p, f_q) = c.\exp\left(\frac{-\Delta(p,q)}{\sigma}\right).T(f_p \neq f_q) = c.\exp\left(\frac{-|I_L(p) - I_L(q)|}{\sigma}\right).T(f_p \neq f_q) \tag{10}$$

where $\Delta(p, q) = -|I_L(p) - I_L(q)|$, called brightness contrast, denotes how different the brightnesses of p and q, c>0 is a smoothness factor, $\sigma > 0$ is used to control the contribution of $\Delta(p, q)$ to the penalty, and T(.) is 1 if its argument is true and 0 otherwise. $V_{p,q}(f_p, f_q)$, depicts two kinds of constraints. The first enforces the spatial smoothness; if two neighboring pixels are labeled differently, a penalty is imposed. The second considers a possible edge between p and q; if two neighboring pixels cause a larger Δ, then they have greater likelihood to be partitioned into two regions.

In this algorithm, the boundaries of the segmentation result are pulled to match the darker pixels which are more likely to be edge pixels.

From (6), (7), and (9) the equation can be written as,

$$\Pr(f|\varphi, P) \propto \left(\prod_{p\in P} \exp\left(-D(p, f_p, \varphi)\right)\right). \exp\left(-\sum_{p\in P} \sum_{q\in N(p)} V_{p,q}(f_p, f_q)\right) \tag{11}$$

Taking the logarithm of (11), the following energy function is as:

$$E(f,\varphi) = \sum_{p\in P} D(p, f_p, \varphi) + \sum_{p\in P} \sum_{q\in N(p)} V_{p,q}\,(f_p, f_q) \tag{12}$$

where $E(f,\varphi) \propto -\log \Pr\,(f|\varphi, P)$. It includes two parts: the data term

$$E_{data} = \sum_{p\in P} D(p, f_p, \varphi) \tag{13}$$

and the smoothness term

$$E_{smooth} = \sum_{p\in P} \sum_{q\in N(p)} V_{p,q}\,(f_p, f_q) \tag{14}$$

From (12), it is clear that maximizing $\Pr(f|\varphi, P)$ is equivalent to minimizing the Markov energy $E(f,\varphi)$ for a given φ .In this paper, graphcut algorithm is used to solve this minimization problem.

2.2. ML Estimation

A 4-D vector φ(i) given by equation 2 is used to describe the properties of label (region). The ML estimation $\varphi = \varphi(i)$ is obtained, where

$$\varphi(i) = \frac{1}{num_i} \sum_{f_p=i} I(p) \tag{15}$$

with num_i being the number of pixels within region i. Here (15) is exactly the equation to obtain $\bar{I}_L(i)$, $\bar{I}_a(i)$, $\bar{I}_b(i)$ and $\bar{I}_t(i)$ and in (2).

3. PROPOSED MODIFIED MAP-ML ALGORITHM

The MAP-ML [1] is used to segment the image by each object in the same image. The algorithm starts with finding the texture and contrast feature of every pixel present in the image. The texture and contrast feature is used to segment the outline of the each object in the image and labelling is used to delete the unwanted portion of the image and segment each object by each color. The K-means Algorithm is used for initializations of the regions. The MAP estimation is used to detect the edges of the image and the color space is used to segment the images by colors. The graph cut algorithm is an unsupervised algorithm used for over segmentation and computation problem. We had modified the existing MAP-ML [1] algorithm and the modified algorithm is given below:

Algorithm: Modified MAP-ML Image Segmentation:
Input: an RGB color image.
Step 1: Convert the image into L*a*b* space and calculate the texture contrast [4].
Step 2: Use the K-means algorithm to initialize features of region φ
Step 3: Find the standard deviation σ (camera noise) for the image
Step 4: Iterative optimization.
4.1: MAP estimation-
Estimate the label configuration f based upon current φ using the graph cut algorithm [8].
4.2: Relabeling-
Remove small regions (same label configuration) having less than 100 pixels. Reorder the labels in proper sequence, obtaining a new f
4.3: ML estimation-
Refine φ based upon current f
Step 5: If f do not change between two successive iterations or the maximum number of iterations is reached, go to the output step; otherwise, go to step 4.
Output: Multiple segmented regions of the image.

After step 4.1, it is possible that two non adjacent regions are given the same label. The MAP estimation is an NP-hard problem. Boykov et al. [8] proposed to obtain an approximate solution via finding the minimum cuts in a graph model. Minimum cuts can be obtained by computing the maximum flow between the terminals of the graph. In [8], an efficient Maxflow algorithm is given for solving the binary labelling problem. In addition, an algorithm, called α expansion with the Maxflow algorithm embedded, is presented to carry out multiple labelling iteratively. In this algorithm, the α expansion algorithm is used to perform step 4.1. To increase the speed of the algorithm we had used Maxflow 3.01 algorithm.

In the original MAP-ML Algorithm [1], the authors had initiated the MAP-ML algorithm with default 10 labels and then in the iteration each region is labelled uniquely. Since the number of labels is unique and increases with each iteration, the time to execute the MAP Estimation goes up. So instead of that we had kept the initial number of labels=10 by default but we had not uniquely labelled the regions so thereby the image will have utmost 10 or less than 10 labels hence the time to take the MAP Estimation is less comparative to original MAP-ML Algorithm. To achieve the equivalent result as the original we had calculated the standard deviation (camera noise) for each image automatically since it will be different for each image. It is calculated by taking expectation of all the pairs of neighbors in an image. So we had obtained results as near as possible to the original algorithm in less amount of time.

Briefly we can say that the modified algorithm has three enhancements over Original MAP-ML:

1) Use of Maxflow 3.01 Algorithm with the reuse trees option
2) Unlike original algorithm the regions are not labelled uniquely
3) For every image sigma (standard deviation) is calculated. Sigma is an important factor used in deciding the smoothness penalty for an image. Here it is calculated based on average value of all pairs of neighbors in an image.

4. EXPERIMENTAL RESULTS

Our algorithm is tested on the Berkeley benchmark for evaluating segmentation algorithms and compares the results with those obtained by state-of-the-art image segmentation algorithms. The Berkeley database contains 500 natural images of size 321 x 481 (or 481 x 321), with ground truth segmentation results obtained from human subjects.

The compared algorithms in these experiments include: Mean Shift (MS) [5] and Normalized cuts (NC) [6]. In this algorithm, the initial cluster number in the K-means algorithm is set to 10 and the smoothness factor c is 100. The region number in NC is set to 20, which is the average number of segments marked by the human subjects in each image.

In the MS algorithm the default parameters used are hs=15, hr=13, and the minimal region=20 pixels are chosen. Since NC cannot handle an image of size 321 x 481(or 481 x 321) due to the overflow of the memory, all the input images for them are shrunk into a size 214 x 320 (or 320 x 214), and the segmentation results are enlarged to their original sizes.

All the above experiments had been conducted on Intel Core 2 Duo 2.2 GHz 4GB RAM Windows 7 platform. The code has been developed in JAVA which makes it portable.

4.1. Qualitative Comparison Results

The part of the images in the Berkeley benchmark is classified into 7 sets ("Landscape", "Grassplot and Sky", "Craft", "Human", "Bird", "Felid" and "Buildings"), and show the segmentation results obtained by the three algorithms in Figure 1-7.

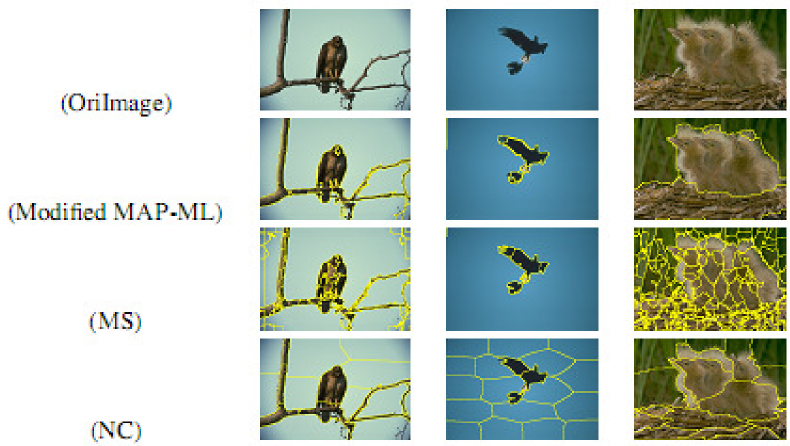

Figure 1. Results obtained on "Bird" images

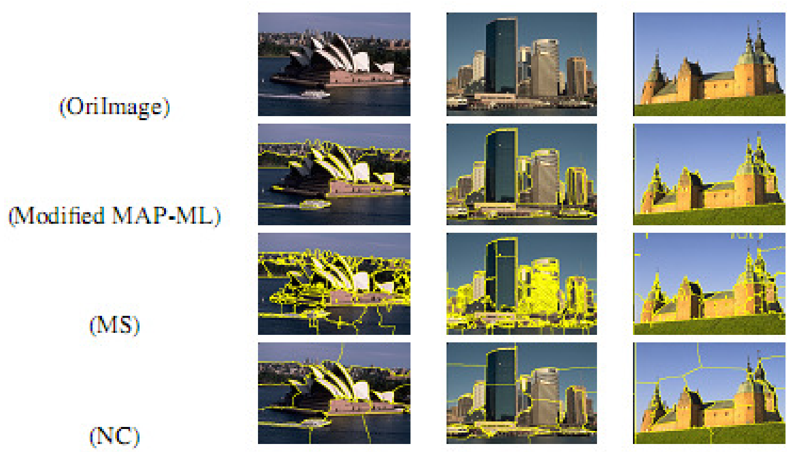

Figure 2. Results obtained on "Buildings" images

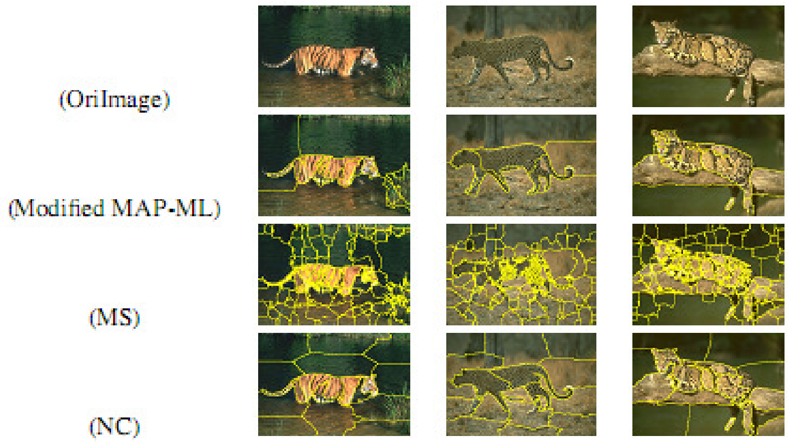

Figure 3. Results obtained on "Feline" images

Figure 4. Results obtained on "Craft" images

Figure 5. Results obtained on "GrassPlot and Sky" images

(OriImage)

(Modified MAP-ML)

(MS)

(NC)

Figure 6. Results obtained on "Landscape" images

(OriImage)

(Modified MAP-ML)

(MS)

(NC)

Figure 7. Results obtained on "Humans" images

From these examples, the following observations are seen:

NC tends to partition an image into regions of similar sizes, resulting in the region boundaries different from the real edges. MS give strongly over-segmented results. Compared with these other algorithms, it is easy to see that this algorithm obtains the best results, in which the generated boundaries match the real edges well and the segmented regions are in accordance with human perception.

4.2. Quantitative Comparisons Results

Quantitative comparisons are also important for objectively evaluating the performance of the algorithms. There have been several measures proposed for this purpose. Region differencing and boundary matching are two of them. Region differencing measures the extent to which one segmentation can be viewed as a refinement of the other. Boundary matching measures the average displacement error of boundary pixels between the results obtained by an algorithm and the results obtained from human subjects. However, these two measures are not good enough for segmentation evaluation. For example, a segmentation result with each pixel being one region obtains the best score using these two measures. A strongly over-segmented result, which does not make sense to human visual perception, may be ranked good.

In these experiments, two more stable and significant measures, variation of information (VoI) and probabilistic rand index (PRI) are used to compare the performances of the three algorithms, to objectively evaluate image segmentation algorithms. Consider a set of ground truths, labelled by K persons, $\{S_1, S_2 \ldots S_K\}$, of an image consisting of *N* pixels. Let S_{test} be the segmentation result to be compared with the ground truths. Then the PRI value is defined as

$$PRI(S_{test}, \{S_k\}) = \frac{1}{\binom{N}{2}} \sum_{p<q} [p_{pq}^{-c_{pq}} (1 - \bar{p}_{pq})^{1-c_{pq}}] \tag{16}$$

where (p, q) is a pixel pair in the image, $c_{pq} = T(l_p^{S_{test}} = l_q^{S_{test}})$ denotes the event of a pair of pixels p and q having the same label in the test result S_{test} ,and $\bar{p}_{pq} = \frac{1}{K} \sum_{k=1}^{K} T(l_p^{S_k} = l_q^{S_k})$ is regarded as the probability of p and q having the same label. The VoI value is defined as

$$VoI(S_{test}, \{S_k\}) = \frac{1}{K} \sum_k [H(S_{test}) + H(S_k) - 2I(S_{test}, S_k)] \tag{17}$$

where H and I denote the entropy and the mutual information, respectively.

VoI is an information-based measure which computes a measure of information content in each of the segmentations and how much information one segmentation gives about the other. It is related to the conditional entropies between the region label distributions of the segmentations. PRI compares an obtained segmentation result with multiple ground truth images through soft non uniform weighting of pixel pairs as a function of the variability in the ground truth set. The value of VoI falls in [0,∞], and the smaller, the better. The value of PRI is in [0,1], and the larger, the better.

The average values of PRI and VoI for the three algorithms are given in Table 1. In this table, the second column shows the average PRI and VoI values between different human subjects, which are the best scores. From these results, one can see that this algorithm outperforms the other algorithms because it obtains the smallest VoI value and the largest PRI value. Among other algorithms, MS gives sometimes better PRI values to this algorithm. However, their VoI values are much larger than algorithm.

Table 1. Average Values of PRI and VOI on the images.

	Human	Modified MAP-ML 10 Labels	Modified MAP-ML 20 Labels	NC	MS
PRI	0.8961	0.7876	0.7954	0.7501	0.7769
VOI	0.9219	2.220	2.215	2.8327	3.747

To demonstrate the performances of these algorithms on each image, the PRI and VOI curves are shown in Figure 8 (default 10 labels) and Figure 9 (default 20 labels). It is clearly observed that modified algorithm performs the best. There is slight trade off between speed and accuracy in the modified MAP-ML Algorithm. The elapsed time calculated between original MAP-ML and modified MAP-ML Algorithm is shown in Figure 10.

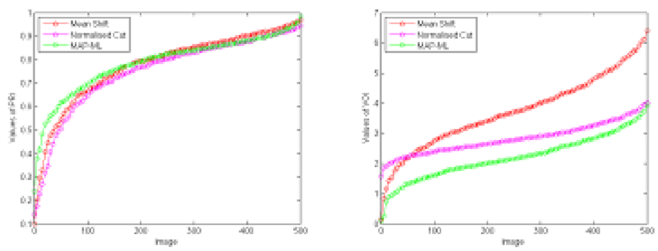

Figure 8. PRI and VOI values achieved on individual images by the three algorithms when default labels are 10. The values are plotted in increasing order.

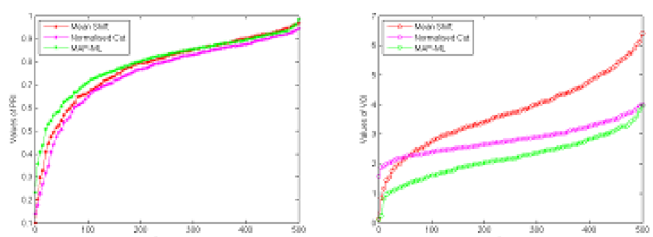

Figure 9. PRI and VOI values achieved on individual images by the three algorithms when default labels are 20. The values are plotted in increasing order.

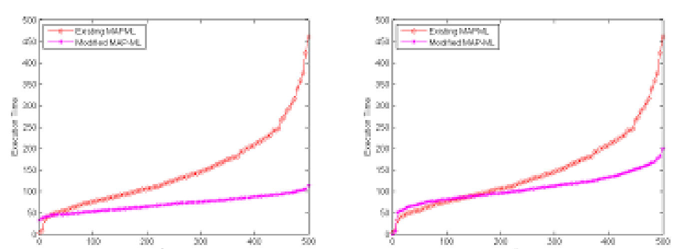

Figure 10. Elapsed time Comparison between Original MAP-ML and Modified MAP-ML Algorithm when default labels are a) 10 and b) 20. The values are plotted in increasing order.

4.3. Application

So far, general segmentation has two main applications. The first one is the group of algorithms for specific objects, like for medical image. The second one is as a part of the algorithms for the other algorithms, like recognition, classification; et al. Good segmentation results may improve the final results. This image segmentation can be used as a part of video surveillance system such that our final goal is to cutout the moving objects video sequences and track the objects.

5. CONCLUSION

We had implemented our modified MAP-ML algorithm which gives comparable results with the original MAP-ML algorithm performing the image segmentation. Thus from the experimental results we had successfully shown that the modified MAP-ML algorithm takes less time to execute as compared to the original MAP-ML algorithm giving nearly same results as the original algorithm.

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ENERGY AND LATENCY AWARE APPLICATION MAPPING ALGORITHM & OPTIMIZATION FOR HOMOGENEOUS 3D NETWORK ON CHIP

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ABSTRACT

Energy efficiency is one of the most critical issue in design of System on Chip. In Network On Chip (NoC) based system, energy consumption is influenced dramatically by mapping of Intellectual Property (IP) which affect the performance of the system. In this paper we test the antecedently extant proposed algorithms and introduced a new energy proficient algorithm stand for 3D NoC architecture. In addition a hybrid method has also been implemented using bioinspired optimization (particle swarm optimization) technique. The proposed algorithm has been implemented and evaluated on randomly generated benchmark and real life application such as MMS, Telecom and VOPD. The algorithm has also been tested with the E3S benchmark and has been compared with the existing algorithm (spiral and crinkle) and has shown better reduction in the communication energy consumption and shows improvement in the performance of the system. Comparing our work with spiral and crinkle, experimental result shows that the average reduction in communication energy consumption is 19% with spiral and 17% with crinkle mapping algorithms, while reduction in communication cost is 24% and 21% whereas reduction in latency is of 24% and 22% with spiral and crinkle. Optimizing our work and the existing methods using bio-inspired technique and having the comparison among them an average energy reduction is found to be of 18% and 24%.

KEYWORDS

Network on Chip, Mapping, 3D Architecture, System on Chip, Optimization

1. INTRODUCTION

The scaling of microchip technologies has resulted into large scale Systems-on-Chip (SoC), thus it has now become important to consider interconnection system between the chips. The International Technology Road-map for Semiconductors depicts the on-chip communication issues as the limiting factors for performance and power consumption in current and next generation SoCs [1] [2] [3]. Thus Network on chip has not only come up with an alternative for the SoC, it has also solved the problem faced in the traditional bus based architecture and is an efficient approach towards optimal designs. Although various works has been done in the optimization of the design and the major area where the design need to be focused are Topology, Scheduling, *Mapping, and Routing* [2]. Each area plays an important role in delivering better

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performance of the system, but in this paper stress is been given on the mapping of the IP core onto the 3d architecture.

By mapping of the IP core we mean, assigning the task in the form of the characterization graph to the given architecture following the design constraint such as area, latency, communication energy and communication cost which should be minimum. As today's application are becoming much more complex their average communication bandwidth are in Gbps and as technology is scaling down, in future a single application would be running on single core thus the bandwidth requirement of link would increase, therefore attention is also given onto its minimization. Figure 1 shows the mapping of the IP core onto 2D mesh architecture. Assigning the given application onto the given architecture is very important from energy point of view, sometime the topology also matters more in optimizing the design [4]. Topology helps in determining latency, traffic pattern, routing algorithm, flow control, and makes huge impact on design cost, power, and performance. Mapping of the IP core onto NoC tile could be done by either assigning a single core onto each tile or by assigning multiple IP core on each of the tile (Scheduling). Each of the mapping procedure has its own merits and demerits. In this we are presenting a similar approach of mapping single IP core on each NoC tile.

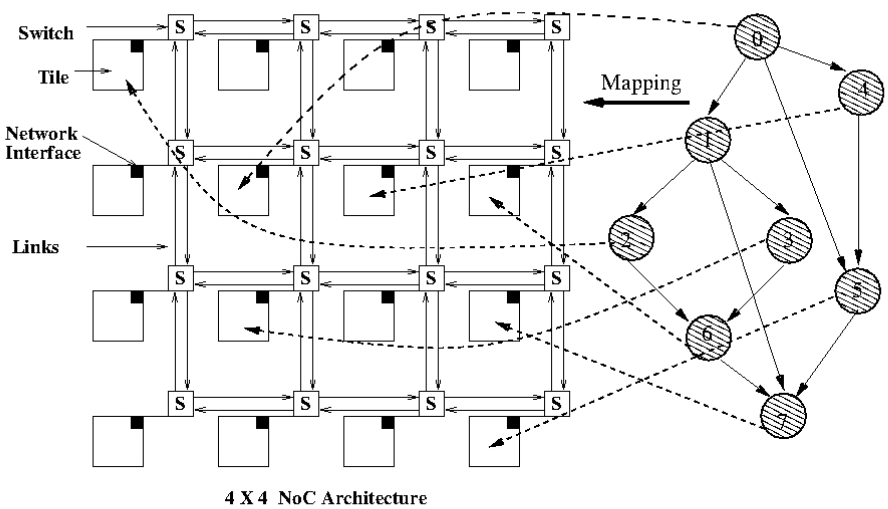

Figure 1. Mapping of cores onto tiles in NoC architecture (2D-Mesh).

In addition [5], include a automated design technique based on Hybrid particle swarm optimization that solve the problem of routing decision with the objective of minimum communication energy consumption. PSO is a technique which randomly places an IP core and tries to minimize the objective function based on swarm intelligence. In this paper hybrid PSO is combined with our proposed algorithm and previously proposed algorithm [6].

2. Related Work

Various mapping algorithm has been discussed by the researchers in their literature. *Branch-and-Bound* [7], *Binary Particle Swarm Optimization* (BPSO) [8], based on latency and energy aware, *Diagonal map* [9], are few mapping algorithm which is for 2D NoC architecture but they are also applicable on 3D architecture and shows better results compared to 2D. Task priority based [6], multiple v_{dd} [10] [11] and thermal aware mapping [12], are few work done by the researchers in the field of 3D NoC.

Energy and performance aware mapping using Branch and Bound (PBB) [7] maps the IP core on the basis of the PBB technique in which mapping complexity increases exponentially as the number of the core increases. Another concept of mapping in which the author has focused on latency and energy using the BPSO [8] has proposed mapping as the NP-hard problem and thus the heuristic approach is needed for finding the solution. Author has compared result with the Genetic algorithm and found BPSO optimal. In D-map [9] procedure, mapping is based on the concept that IP core which is communicating maximum with the rest of the core should be placed on those NoC tile which has greater number of the neighboring tile attached to it thus in 2D architecture diagonal tiles are having maximum number of the neighboring tiles.

In mapping procedure using *multiple* v_{dd} Kostas and Dimitrios, [10] [11] has claimed energy of the system could be saved either applying better mapping or the routing procedure or by supplying less voltage to the system and making the design itself optimal. As not each of the router function every time so author divided the whole of the architecture into two layer and each of the layer functioning at different voltage of $v_{dd_{high}}$ and $v_{dd_{low}}$. IP core with greater communication volume are placed onto layer with $v_{dd_{high}}$ and those with low in $v_{dd_{low}}$ when they need to communicate they do with level converter. In his continuing paper [10] author has compared results with different benchmark of MWD, MPEG, VOPD, MMS etc.

In [6] author has proposed two different method of mapping procedure on 3D NoC design *Crinkle* and *Spiral* and task are organized on the task priority list which is based on the basis of the maximum communication volume or maximum out-degree. In [12], author has targeted communication aware used the *Genetic algorithm* for finding out the optimal mapping solution. In [8], author proposed a heuristic mapping algorithm based on chaotic discrete particle swarm optimization technique. The algorithm resolves the mapping problem to optimize the delay and energy consumption and showing better results than genetic algorithm. In [5], author proposed a routing technique, based on the Hybrid Particle Swarm Optimization (PSO) Algorithm is applied on the 2D-Mesh NoC platform to balance the link load and this algorithm is combined with genetic algorithm, and shown a better results. In [13] author has proposed optimal multi-objective mapping algorithm for NoC architecture.

3. DEFINITIONS

Definition 1: An application characterization graph (APCG) G = (C,A) is a directed graph, where each vertex c_i represents selected IP/core, and each directed arc $a_{i,j}$ characterizes the communication from c_i to c_j . Each $a_{i,j}$ has application specific information such as:

- *v*($a_{i,j}$) is the arc volume from vertex c_i to c_j , i.e. the communication volume (bits) from c_i to c_j.
- *b*($a_{i,j}$) is the arc bandwidth requirement from vertex c_i to c_j.

Definition 2: A NoC architecture can be uniquely described by the triple Arch(*T(R, Ch, L)*, P_R , *Ω(C)*), where:

1) T(R,Ch,L) is directed graph describing the topology. The routers (R), channels (Ch) and the Layers (L) in the network have following attributes:

a) ∀ *(ch)* ϵ *Ch*, *w(ch)* gives the bandwidth of the network channels.
b) ∀ *(r)* ϵ *R*, *I(ch, r)* gives the buffer size(depth) of the *channel ch*, located at *router r*.
c) ∀ *(r)* ϵ *R*, *Pos(r)* specifies the position of *router r* in the floor plan.
d) ∀ *(l)* ϵ *L*, *Layer(l)* specifies the layer of topology.

2) P_R(r,s,d) describes the communication paradigm adopted in the network.

s,d,r ϵ R, n $\subset$ R defines the routing policy at *router r* for all packets with *source s* and *destination d*.

3) Ω *: C → R*, maps each core c_i ϵ C to a router. For direct topologies each router is connected to a core, while in indirect topologies some routers are connected only to other routers.

4. Problem Formulation

As we are aiming for the minimization of the total communication energy and the total communication energy (E_{total}) depends on *Latency, number of hops count, links energy, and switch energy* [7] [13], therefore minimization of each of these factor will result into reduction of global E_{total}. Thus our problem has been formulated as:

Given an APCG *G(C,A)* and a network topology *T(R, Ch, L)*;

Find a mapping function Ω : C → R which maps each core c_i ϵ *C* in the APCG to a router *r* ϵ *R* in *T(R, Ch, L)* so that we get :

$$min \{ \sum v(a_{i,j}) \times e(r_{map(c_i),map(c_j)}) \}$$

such that:

$$\forall c_i \in C, \text{map}(c_i) \in T$$
$$\forall c_i \neq c_j \in C, \text{map}(c_i) \neq \text{map}(c_j)$$

where $e(r_{i,j})$ is the average energy consumption of sending 1-bit of data from tile t_i to t_j on which core c_i and c_j are mapped respectively.

Various energy consumption model has been discussed in [7][2], the 1 bit energy consumption in the NoC architecture as proposed in [7] which is calculated as:

$$E_{Bit}^{t_i,t_j} = n_{hops} \times E_{S_{Bit}} + (n_{hops} - 1) \times E_{L_{Bit}} \quad (1)$$

where , $E_{L_{Bit}}$ is the per bit link energy, $E_{S_{Bit}}$ is per bit switch energy , $E_{Bit}^{t_i,t_j}$ is the total energy when one bit is moved from tile T_i to tile T_j , n_{hops} represent the total number of the hops.

Based on below proposed algorithm performance of the system will increased as our approach reduces the number of hops between source and destination. The performance of the system is evaluated on the basis of total communication cost which is calculated as

$$Cost = \sum_{\forall j=1,2,3\ldots|V|, i\neq j} \{ b_{a_{i,j}} \times n_{hops}(i, j) \}$$

Latency: In a network, latency is a synonym for delay, is an expression of how much time it takes for a packet of data to get from one designated point to another and so that average latency is calculated as:

$$Latency_{avg} = \frac{\sum_{\forall j=1,2,3\ldots|V|, i\neq j} \{ n_{hops} \times Comm.Volume \times \rho \}}{\eta}$$

where, ρ = constant related to delay
η = Total number of times transfer occurred of communication volume between source and destination.

5. PROPOSED ALGORITHM

Assignment of an IP core onto the given architecture is called a *mapping*. When we map an IP core onto the given architecture we always try to place those core which is communicating maximum($core_{i,j}^{max}$) closer to each other, limiting the number of hops travelled by data between two related cores, thus the E_{total} gets reduced. As in 2D architecture diagonal tiles(tiles with degree 4) are having greater number of communicating links, so placing $core_i^{max}$ onto these tile and placing rest of unmapped core w.r.t this mapped core onto neighboring tile would reduce the number of hop count thus E_{total} would minimize [9].

Similar approach when carried out with the 3D NoC in which the topology is 2D layered architecture shown in Figure 2, the diagonal tiles of each layer has four adjacent links and one *uplinks* and *downlinks* each. The mapping of highest out-degree core onto diagonal tiles gives the flexibility of assigning highest communicating unmapped cores much closer to mapped cores. This helps to minimize the number of hops travelled by data between two communicating core, which is our aim to minimize the total energy consumption. Question arises how to find the IP core and arrange them such that it could be mapped in regular fashion. In this paper we have used the concept of maximum out degree. We find those cores which is having maximum out degree and order them in an array of descending order, if there are two or more IP cores which is having same number of the out-degree then we differentiate them on the basis of the *Rank* which is calculated as:

$$Ranking\ (Core_i) = \sum_{\forall j=1,2,3\ldots|V|, i\neq j} (comm_{i,j} + comm_{j,i})$$

where $comm_{i,j}$ represents the communication volume(in bits) transferred from $core_i$ to $core_j$. The core to be mapped next is the unmapped core which communicates maximum with the mapped core.

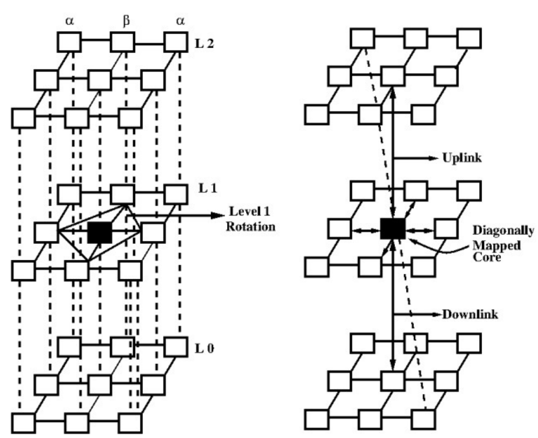

Figure 2. Mapping of highest out-degree cores onto diagonal tiles (shown in dark shaded).

After arranging the IP cores on the basis of the out-degree and rank, the core with maximum out-degree is mapped onto the diagonal tiles. Each layer in the architecture is having only one tile which comes in the list of the diagonal tiles to which these highest out-degree IP core will be mapped. While mapping we leave the diagonal end tiles as it is having at most only three tile to which it can communicate. After mapping the core onto the diagonal tile the position of the next unmapped core is found on the basis of the lozenge shape, in which we apply two rotation namely α and β rotation. α rotation works out in clockwise direction for odd numbered column and β in anti-clockwise direction for even numbered column discussed in literature [9]. While mapping the IP core onto the each layer we apply this rotation for intra-layer tiles only for finding the position of the next empty tile, but during the mapping process their is possibility that position of the next empty tile could not be there in the same layer so we need to change the layer. While applying the rotation we need to change the level of the rotation, the maximum number of the level which can be changed in each rotation is $2\times(n-1)$, where n is the dimension of the architecture($n\times n\times n$). In calculation of the energy, latency is also important which is dependent on the routing procedure. In our work we have used the *XYZ* routing algorithm for finding out the number of the hops count.

Following the Algorithm 1 the number of hops count between the two related cores is reduced, which in turn reduces the total communication energy consumption given in Equation 1.

Algorithm 1 Mapping Algorithm for 3D NoC

Input: APCG *G(C,A)* and $(n\times n\times n)$ 3D NoC Topology *T(R, Ch, L)*.
Output: Array *M[ ]* containing corresponding tile numbers for $c_i \in$ C.
Initialize: *Mapped[ ]* = -1;*UnMapped[ ]* = $c_i \in$ C
Mapping() {
Sort ($c_i \in C$)
Store in *OD[ ]*. { in descending order of outdegree & Ranking().}
for $i = 0$ to $n - 3$ **do**
    OD[i].mapto() → $(n^2 + n + 1) \times (i + 1)$;
    Mapped[i] = OD[i];
    Remove OD[i] from UnMapped[ ];
end for
while *UnMapped[ ]* ≠ *empty* **do**
    for all $c_i \in$ *UnMapped[ ]*, select c_i where:
    max comm(i,j) { where i ∈ *UnMapped[ ]* , j ∈ *Mapped[ ]*;}
    positionof(j); //(row, column, layer) of c_j
    colno = (j.mapto())%n
    if *(colno% 2 ≠ 0)* **then**
        while *(flag = 0)* **do**
            alpharotation()
            if *empty tile found* **then**
                return t_k, *set flag = 1*;
            else
                layer+ + || layer- - || (both)
                alpharotaion()
            end if
        end while
    else
        while *flag = 0* **do**
            betarotation()
            if *empty tile found* **then**
                return t_k, *set flag = 1*
            else
                layer+ + || layer- - || (both)

```
            betarotation()
          end if
        end while{returns empty tile(t_k) using Lozenge shape path.}
        OD[ i ].mapto() → t_k
        Mapped[i] = OD[ i ]
        Remove OD[ i ] from UnMapped[ ]
    end if
end while
calculate_energy() {calculates energy for the mapping generated.}
```

---

6. Bio-inspired Optimization Algorithms

In this section brief description of the implemented algorithms like Hybrid PSO, Hybrid ARPSO and Hybrid QPSO is discussed.

6.1 Particle Swarm Optimization (PSO)

Particle Swarm Optimization (PSO) is based on the movement and intelligence of swarms [14]. The fundamental idea behind PSO is the mechanism by which the birds in a flock (swarm) and the fishes in a school (swarm) cooperate while searching for food. Each member of the swarm called particle, represents a potential solution of the problem under consideration. Each particle in the swarm relies on its own experience as well as the experience of its best neighbor. Each particle has an associated fitness value. These particles move through search space with a specified velocity in search of optimal solution. Each particle maintains a memory which helps it in keeping the track of the best position it has achieved so far. This is called the particle0s personal best position *(pbest)* and the best position the swarm has achieved so far is called global best position *(gbest)*. After each iteration, the *pbest* and *gbest* are updated for each particle if a better or more dominating solution (in terms of fitness) is found. This process continues iteratively, until either the desired result is converged upon, or its determined that an acceptable solution cannot be found within computational limits. In search of an optimal solution particles may trap in local optimal solution, therefore some heuristics can be used to help particles get out of local optimum. It is proved that PSO Algorithm 2 for IP mapping has worked much better than various proposed algorithms for routing and task mapping in NoC.

Due to a decrease of diversity (because of clustering of particle) in search space, the PSO tends to suffer from problem of premature convergence which leads to sub optimal solution. The attractive and repulsive PSO (ARPSO) algorithm proposed in [15] overcomes the problem of premature convergence. ARPSO switches between two phases to find an optimal solution:

1) Attraction Phase
2) Repulsion Phase.

In Attraction Phase, particle attracts each other, as in the basic PSO algorithm. In Repulsion Phase, the individual particle is attracted by its own previous best position *(pbest)* and repelled by the global best position *(gbest)*. In this way there is neither total attraction nor total repulsion but a balance between two.

Algorithm 2 PSO Algorithm for IP Mapping

Let *G[ ]* be the current best particle after various simulations.
Let *nb_eval* keeps track on the evaluation number in a simulation.

Let *n_exec* keeps track on the simulation number, it is initialized to 0.
Let *total_cost_min* is the minimum energy achieved in a simulation.
Let *min_cost* is the minimum energy achieved in all simulations executed.
Input: APCG, NoC Topology
Output: Mapping Sequence

```
n_exec ← n_exec + 1
for s = 0 to S do
    initialize X[s] and V [s] randomly
    X[s].f ← objfn(s) {evaluating total_cost(objective function) using Equation 1}
    P[s] ← X[s] {local best position of the s^th particle}
end for
P[best] ← min_total_cost(P[s])
while nb_eval < eval_max do
    for s = 0 to S do
        update V [s] and X[s] using equation 2 and 3
        X[s].f ← objfn(S)
        if X[s].f < P[s].f then
            P[s] ← X[s] {updating local best position of the s^th particle}
        end if
        if X[s].f < P[s].f then
            P[s] ← P[best] {updating global best position}
        end if
    end for
total_cost_min ← P[best]
end while
if total_cost_min < min_cost then
    min_cost ← total_cost_min
    G[ ] ← P[best]
end if
if n_exec < n_exec_max then
    goto 1
end if
```

---

qPSO proposed in [16], another variant of PSO in which authors present the hybridization of PSO with quadratic approximation operator (QA), is implemented to solve IP mapping problem to get an optimal NoC design. The hybridization is performed by splitting the whole swarm into two sub swarms in such a way that the PSO operators are applied on one sub swarm, whereas the QA operator is applied on the other sub swarm, ensuring that both sub swarms are updated using the global best particle of the entire swarm.

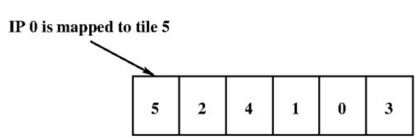

Figure 3. A particle representing a solution.

Basic PSO algorithm is implemented to find the optimal solution for IP mapping problem in NoC designs. Dimension or size (D) of the particle is set equal to the number of tiles in the NoC topology. Firstly, initial population with discrete values is generated having number of particles equal to the swarm size (S) and each particle is initialized with the initial velocity (V) and position (X). Particle for IP mapping is represented as shown in Figure 3, n^{th} IP is mapped on x_n, where n is the index in particle. For IP mapping problem objective or fitness function (f) is to minimize *Total Communication Cost* described in Equation (1). Then these particles move into the search space in search of an optimal solution by updating their velocity and position towards its previous best solution (*P[s]*) and the global best solution (*P[best]*) using Equations (2) & (3).

$$v_i^{k+1} = wv_i^k + rand_1(0, c_1) \times \left(pbest_i - x_i^k\right) + rand_2(0, c_2) \times (gbest - x_i^k) \tag{2}$$

and,

$$x_i^{k+1} = x_i^k + \lfloor v_i^{k+1} \rfloor \tag{3}$$

where,
$\lfloor i \rfloor$: gives floor value of i
v_i^k : velocity of agent i at iteration k
w : weighting function
c_1 and c_2 : acceleration coefficients
rand : uniformly distributed random number between 0 and 1
x_i^k : current position of agent i at iteration k
A modification is done in the position updating equation, the floor value of the updated velocity is added to the previous position for getting the new position of the particle, since the search space of IP mapping problem is discrete and the new velocity of particle may be real. For generating the integral position the floor value of velocity is taken. For performing experiments the values of various parameters for PSO are shown in Table 1(based on intensive experiments).

Table 1

PSO PARAMETERS AND THEIR VALUES

Parameter	Value
c_1	1.2
c_2	1.3
w	0.721348
Swarm Size (S)	200
Dimension of the Search Space (D)	No. of tiles
Maximum No. of Simulations	100
Maximum No. of function evaluations in each simulation	150000

Similarly, ARPSO is also applied to this problem, modification of the particle's position in repulsion phase of ARPSO is mathematically modeled according to the following equations:

$$v_i^{k+1} = wv_i^k + rand_1(0, c_1) \times \left(pbest_i - x_i^k\right) - rand_2(0, c_2) \times (gbest - x_i^k) \tag{4}$$

and,

$$x_i^{k+1} = x_i^k + \lfloor v_i^{k+1} \rfloor \tag{5}$$

ARPSO is applied to solve the IP mapping problem in NoC design for all the four benchmarks considered. The procedure to implement ARPSO is same as basic PSO except one parameter i.e. *ator*, which is the number of evaluations after which algorithm enter into repulsion phase from attraction phase. For performing experiments the values of various parameters for ARPSO are shown in Table 2 (based on intensive experiments).

Similarly, qPSO is also applied, the parameter settings for qPSO are shown in Table 3 (based on intensive experiments).

It is worth mentioning that DMAP proposed in [9] is one of the best mapping algorithms in terms of communication energy consumption as it results in a fraction of second. By having the DMAP result and knowing evolutionary nature of PSO algorithm, different mappings with all reasonable ranges of communication energy can be obtained. To do this, DMAP result is injected into population initialization step as a particle in basic PSO algorithm, this result in a new PSO algorithm named HPSO (Hybrid PSO). DMAP result is also injected into population initialization step as a particle in Attractive-Repulsive PSO (ARPSO), qPSO algorithms, this result in a new PSO algorithms named HARPSO, HqPSO shown in Figure 4.

Table 2

ARPSO PARAMETERS AND THEIR VALUES

Parameter	Value
c_1	1.2
c_2	1.3
w	0.721348
ator	5000
Swarm Size (S)	200
Dimension of the Search Space (D)	No. of tiles
Maximum No. of Simulations	100
Maximum No. of function evaluations in each simulation	150000

Table 3

QPSO PARAMETERS AND THEIR VALUES

Parameter	Value
c_1	2.8
c_2	1.3
w	0.719
Coefficient of Hybridization (CH)	30%
Swarm Size (S)	200
Dimension of the Search Space (D)	No. of tiles
Maximum No. of Simulations	100
Maximum No. of function evaluations in each simulation	150000

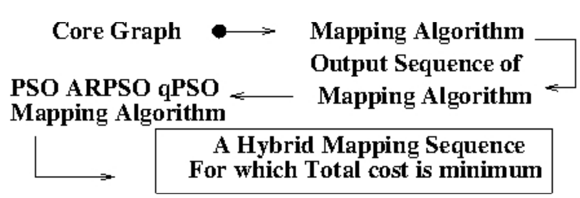

Figure 4. The procedure to achieve optimal mapping solution using HPSO, HARPSO and HQPSO.

7. EXPERIMENT RESULTS

In this section we present our experimental results derived from simulations of a combination of different real life applications and E3S benchmark. Our algorithm is compared with two other NoC-targeted mapping algorithms, and results are illustrated and analyzed in details.

Our proposed algorithm has been implemented in C++ and tested with different real life applications (Video Object Plane Decoder (VOPD), Telecom, MMS (Multi-Media System), MWD (Multi-Window Display)), randomly generated benchmarks using TGFF [17] and with E3S benchmark. These tasks are mapped over 3×3×3 3D NoC architecture. We have worked out with XYZ-routing algorithm which provides a deadlock free minimal routing technique. Results obtained are compared with results of various proposed approaches like Spiral, Crinkle which are proposed in literature [6].

Various parameter constraints that have been taken for performing the experiment are shown in Table 4. Number of benchmark over which the system has been tested having a 16 tasks *VOPD*, 16 task *MMS*, 12 tasks *Multi window display*, 16 tasks *Telecom*, 27 task *random* application and E3S(Embedded System Synthesis Benchmarks Suite) application which has 24 tasks *auto industrial*, 12 tasks *consumer*, 13 tasks *networking*, 5 tasks *office automation*.

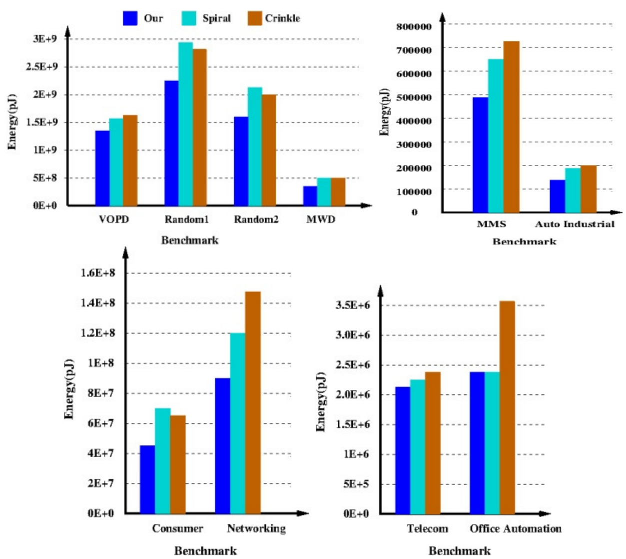

Figure 5. Energy Consumption with different benchmarks using various approaches.

By implementing existing and our proposed algorithms and comparing their result, we found that our algorithm gives optimal result. Testing our proposed algorithm with real life application, random benchmarks and E3S benchmark, we have noticed that our approach give better result (Figure 5) and provide improvement in the communication energy consumption (Figure 9). As discussed above, the average improvement in latency with various benchmarks is shown in Figure 10.

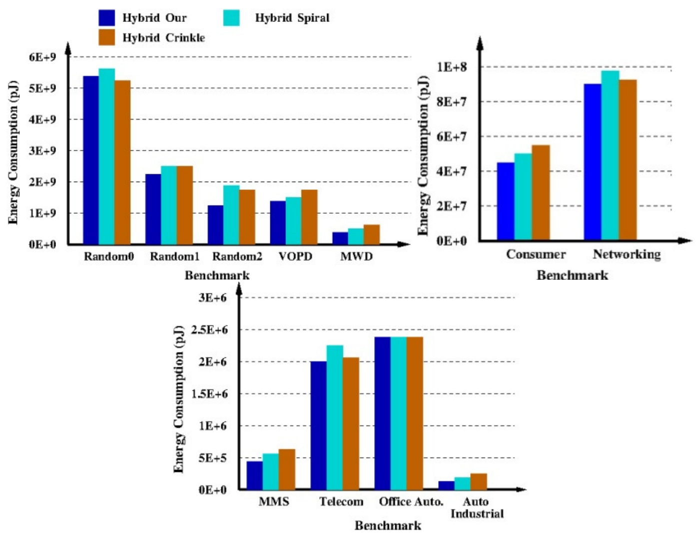

Figure 6. Comparison of Hybridization technique of pso algorithm with Our, Spiral, Crinkle & shows optimal energy consumption results with various benchmarks.

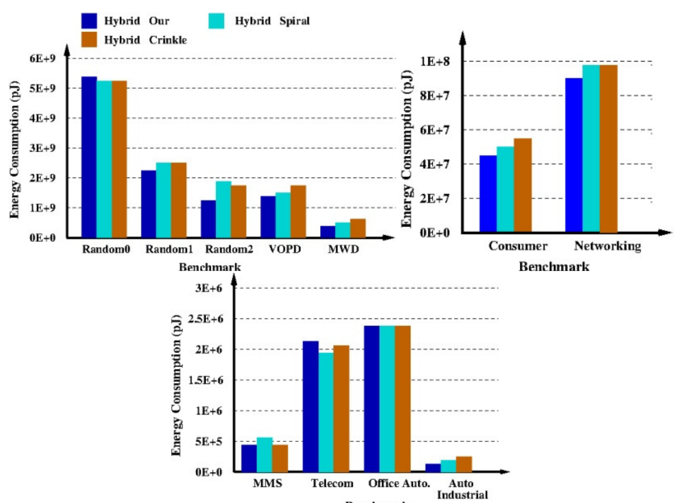

Figure 7. Comparison of Hybridization technique of arpso algorithm with Our, Spiral, Crinkle & shows optimal energy consumption results with various benchmarks.

Implementing various optimization technique like hybrid particle swarm optimization, ARPSO, QPSO and comparing the result of Hybrid PSO+Our approach, Hybrid PSO+Spiral and Hybrid PSO+Crinkle is shown in Figure 6 and the comparison of Hybrid ARPSO+Our approach, Hybrid ARPSO+Spiral and Hybrid ARPSO+Crinkle is shown in Figure 7 and the comparison result for Hybrid QPSO+Our approach, Hybrid QPSO+Spiral and Hybrid QPSO+Crinkle is shown in Figure 8 provide optimal results compare to mapping algorithms. Improvement in the consumption of energy is shown in Figure 11 which is the average of above discussed, all optimization algorithm.

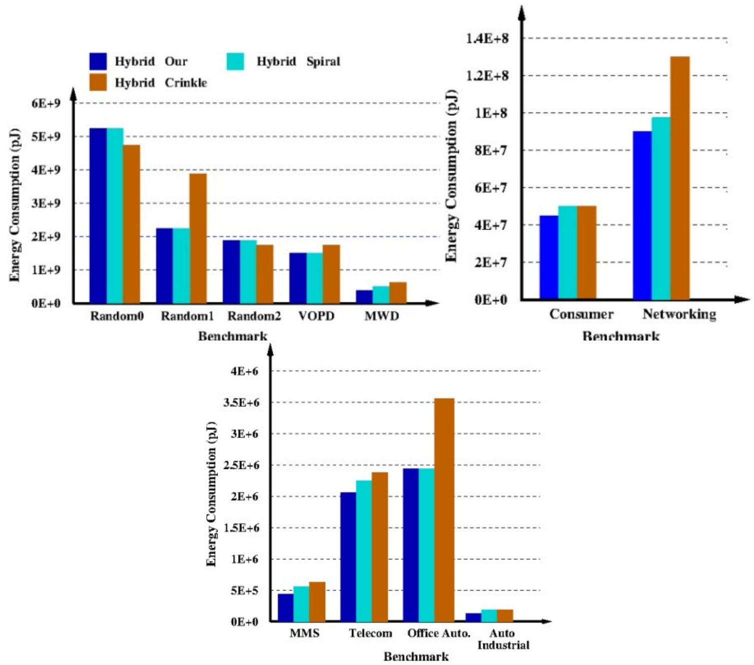

Figure 8. Comparison of Hybridization technique of qpso algorithm with Our, Spiral, Crinkle & shows optimal energy consumption results with various benchmarks.

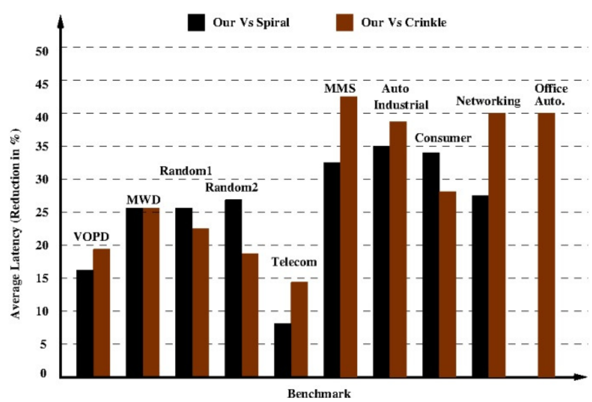

Figure 9. Energy Consumption reduction in % with various benchmarks.

Table 4.

BIT ENERGY VALUES FOR LINK AND SWITCH

Link	Switch
0.449pJ	0.284pJ

8. Conclusion

In this paper, an efficient energy aware mapping algorithm for 3D NoC has been proposed. As each of the mapping procedure aim at minimizing the number of the hops count between the two communicating core, thus our proposed algorithm also reduced the number of the hops count. On

3D architecture the diagonal tiles of each layer is having greater number of the links so when this algorithm is tried with various real life application and E3S benchmarks, showed better reduction in the communication energy as compared to other mapping algorithm such as crinkle and spiral. Since the number of tiles in the 3D NoC architecture is more so this architecture shows better results when tried with an application having greater number of the IP cores. Thus trying the design with random benchmark generated using TGFF [17] shows better result as compared to existing techniques. Compared to the Hybrid PSO and the proposed algorithm, has a better optimization effect when combined with various mapping algorithm.

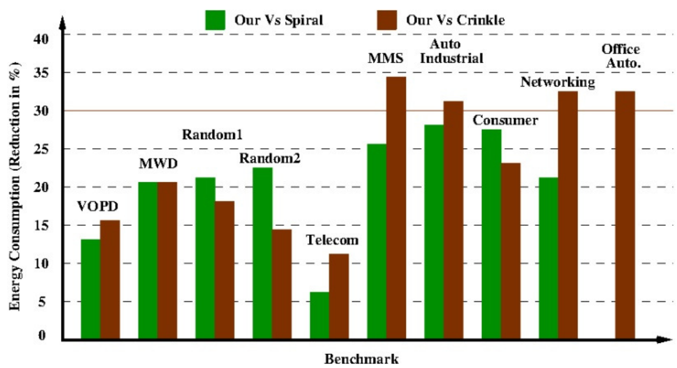

Figure 10. Average Latency reduction in % with various benchmarks.

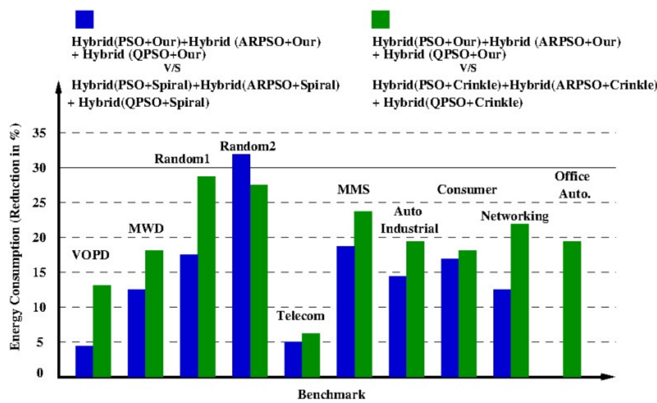

Figure 11. Average energy consumption reduction in % with various benchmarks in case of optimization algorithms.

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AN EFFICIENT FEATURE SELECTION IN CLASSIFICATION OF AUDIO FILES

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ABSTRACT

In this paper we have focused on an efficient feature selection method in classification of audio files. The main objective is feature selection and extraction. We have selected a set of features for further analysis, which represents the elements in feature vector. By extraction method we can compute a numerical representation that can be used to characterize the audio using the existing toolbox. In this study Gain Ratio (GR) is used as a feature selection measure. GR is used to select splitting attribute which will separate the tuples into different classes. The pulse clarity is considered as a subjective measure and it is used to calculate the gain of features of audio files. The splitting criterion is employed in the application to identify the class or the music genre of a specific audio file from testing database. Experimental results indicate that by using GR the application can produce a satisfactory result for music genre classification. After dimensionality reduction best three features have been selected out of various features of audio file and in this technique we will get more than 90% successful classification result.

KEYWORDS

Data Mining, Feature Extraction, Audio Classification, Gain Ratio, Pulse Clarity

1. INTRODUCTION

Data mining is the process of analyzing the data and discovering previously unknown pattern from large dataset. The data sources can be any databases, the web, data warehouses, transactional data, data streams, spatial data, or information repositories. The aim of this process is to extract information and summarizing it into an understandable structure for further use. Data mining functionalities include discovering frequent patterns, associations, and correlations; classification and regression; and clustering analysis are found in [1].

Classification is the task of generalizing known structure to apply to the new dataset. Data classification is a two-step process learning or training phase and classification step. In learning phase a classification model is constructed which describes a predetermined set of data classes or concepts. In case of classification the test data are used to estimate the accuracy of the classification rules. The accuracy of a classifier on a test data set is the percentage of the test data set tuples that are correctly classified by the classifier. If the accuracy of the classifier is considered acceptable, the classifier can be used to classify future data set for which the class labels unknown.

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Feature selection is the process of selecting a subset of relevant features by eliminating features with no predictive information and selected features are further used in classifier model construction. The data set may contain redundant or irrelevant features. Redundant features are not providing any information in comparing to currently selected features, and irrelevant features provide no useful information in any context. Feature selection techniques are often used in domains where there are many features and comparatively few data points. The basic objectives of this technique are to avoid overfitting, provide faster and cost-effective models and improvement of model performance and efficiency. The usefulness of feature selection is to reduce the noise for improvement of accuracy of classification, interpretable features to identify the function type and dimensionality reduction to improve the computational cost. Feature extraction is a special form of dimensionality reduction in which extracted features are selected such a manner that the feature set will extract relevant information from large data set to achieve the goal using reduced data set.

An attribute selection measure provides rankings for each attribute describing a set of training tuples mentioned in [1]. The attribute which is having maximum value for the measure is chosen as splitting attribute. The splitting criterion indicates the splitting attribute and may also indicate a split-point or a splitting subset. More specifically it selects an attribute by determining the best way to separate or partition the tuples into individual classes.

The paper [2] briefly focused on feature construction, feature ranking, multivariate feature selection, efficient search methods, and feature validity assessment methods. It also described filters that select variables by ranking them with correlation coefficients. The subset selection method is also discussed here. It also includes wrapper methods that assess subsets of variables according to their usefulness to a given predictor.

The paper is organized as follows: Section II starts by describing the literature survey and related work of this paper. Section III includes system design and module description. Feature selection is introduced in Section IV. Section V mainly focused on Gain Ratio. We briefly discuss data analysis and experimental evaluation in Section VI. Finally, we conclude the paper in the last section.

2. LITERATURE SURVEY AND RELATED WORK

Most of the previous studies on data mining applications in various fields use the variety of data types i.e., text, image audio and video in a variety of databases. Different methods of data mining are used to extract the hidden patterns and knowledge discovery. For this purpose knowledge of the domain is very necessary. The variety of data should be collected to create the database in the specific problem domain. The next steps in this process are selection of specific data for data mining, cleaning and transformation of data, extracting patterns for knowledge generation and final interpretation of the patterns and knowledge generation described in [3].

In this paper, the estimation of this primary representation is based on a compilation of state-of-the-art research in this area, enumerated in this section. Different studies and research works have been conducted on feature selection and audio classification by employing different features and methods.

A new feature selection algorithm FCBF is implemented and evaluated through experiments comparing with three feature selection algorithm introduced in [4]. The method also focuses on efficiency and effectiveness of feature selection in supervised learning where data content irrelevant or redundant features. George Forman [5] described a comparative study of feature selection metrics for the high dimensional domain of text classification which is focused on support vector machines and 2-class problems. It also focuses on the method for selecting one or two metrics that have the best chances of obtaining the best performance for a *dataset*. A multiclass classification strategy for the use of SVMs to solve the audio classification problem and achieve lower error rates is presented in [6]. For content based audio retrieval, it proposes a new metric, called distance-from-boundary (DFB). An SVM based approach to classification and segmentation of audio streams which achieves high accuracy described in [7]. It proposed a set of features for the representation of audio streams, including band periodicity and spectrum flux.

Various audio files, i.e., music, background sound and speeches were analyzed and classified with respect to various features extracted in a different perspective. Mainly KNN and SVM method are used for this purpose. S. Pfeiffer *et al.* [8] presented a theoretical framework and application of automatic audio content analysis using some perceptual features. Saunders [9] described a speech/music classifier based on simple features such as zero-crossing rate. Scheirer *et al.* [10] introduced features for audio classification and performed experiments with different classification models. An efficient method [11] presented for effective feature subset selection, which builds upon known strengths of the tree ensembles from large, dirty, and complex data sets (in 2009). Research work [12] to evaluate feature selection algorithms for financial credit-risk evaluation decisions and the selected features are used to develop a predictive model for financial credit-risk classification using a neural network (in 2010). S. Maldonado et al. [13] presented an embedded method that simultaneously selects relevant features during classifier construction by penalizing each feature's use in the dual formulation of SVM (in 2011). Unifying framework mentioned in [14] for feature selection based on dependence maximization between the selected features and the labels of an estimation problem, using the Hilbert-Schmidt Independence Criterion proposed in 2012. In 2013, Mauricio Schiezaro and Helio Pedrini introduces feature selection method based on the Artificial Bee Colony approach [15], that can be used in several knowledge domains through the wrapper and forward strategies and the method has been widely used for solving optimization problems. Many other works have been conducted to enhance audio classification algorithms. The basic objectives of research works are to increase the efficiency of the classification process and reduce the rate of error.

The current open issues of data mining are based on (a) development of unifying theory, (b) information network analysis, (c) process-related, biological and environmental problems, and (d) dealing with complex, non-static, unbalanced, high dimensional and cost-sensitive data. Handling of historical and real-time data simultaneously is very difficult for analytics system found in [16]. The significance of the statistical result is very important in comparing to random output. In future we have to concentrate on more research work with practical and theoretical analysis to provide new methods and technique in the field of distributed data mining. Representation of large data set and space required for storing the data these two are very important factors. In case of compression less space is required but there is no loss of information. The 2012 IDC study on Big Data [17] mentioned that in 2012, 23% of the digital universe would be useful for Big Data if tagged and analyzed. But at present only 3% of the potentially useful data is tagged, and even less is analyzed.

3. SYSTEM DESIGN

The Figure 1 depicted various stages of the whole process starting from database creation to classification phase. At first we have created a training database of classified and non-classified audio files. Classified audio file database is consisting of various .wav files of different music genre. In the second phase various features of an audio file are identified. Then numerical values of each feature are extracted from individual audio files for creating feature vector in the third step of system design. The next phase deals with the data analysis part. After that range of each feature for every music class is identified for further processing. In fifth step gain ratio is calculated with respect to pulse clarity to identify the splitting attribute. Three splitting attributes with maximum gain ratio is already selected and then in sixth phase, a threshold value of each feature is calculated. The next phase describes classification of audio files from testing database. In the last step we concentrate on result analysis and calculation of successful classification and rate of error.

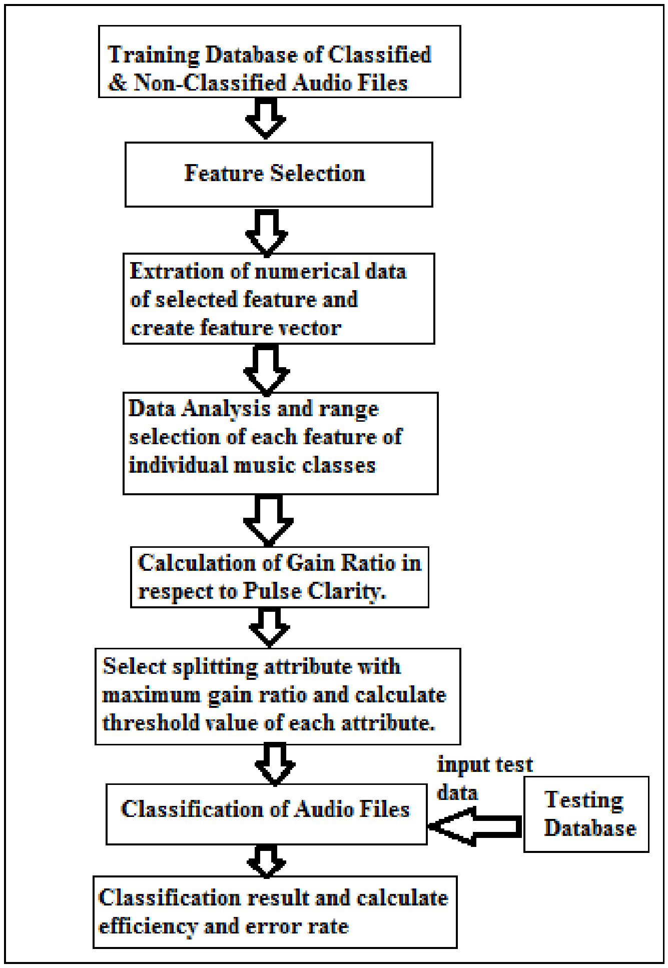

Figure 1. System Design

4. FEATURE SELECTION

The development of internet technology is widely increasing the use of multimedia data i.e., image, audio and video. In this paper our focus is on audio and music. Data mining techniques can be used to discover relevant similarities between music for the purpose of classifying it in a more objective manner. The backbone of most music information retrieval systems is the features extracted from audio file. The effectiveness of this recording is dependent on the ability to classify and retrieve the audio files in terms of their sound properties. Audio files basically of three types i.e. speech, music and background sound. Male and female speech files are available in .wav file format. Music files are classified into two categories - classical and non-classical music. According to genre of the track the classical music is subdivided into the chamber and orchestral. Rock, Pop, Jazz and Blues are various genres of non-classical music. Rock and Pop music is sub classified to hard rock, soft rock, techno and hip-hop music. For these work totals 11 genres of music are identified. An important phase of audio classification is feature selection. In order to obtain high accuracy for classification and segmentation, it is very important to select good features of audio files. Generally audio file analysis is based on the nature of the waveform. So the features have been selected on the basis of their numerical values. Before feature extraction, an audio signal is converted into a general format, which is .wav format. Selected features of an audio file are sampling rate (in Hz.), temporal length (seconds/sample), rms energy, low energy, tempo (in bpm), pulse clarity, zero crossing rate (per second), roll off (in Hz.), Spectral irregularity, Pitch (in Hz.) and inharmonicity. The numerical value of each feature is computed using MIRToolBox for further analysis. RMS Energy of an audio file is represented in the Figure 2.

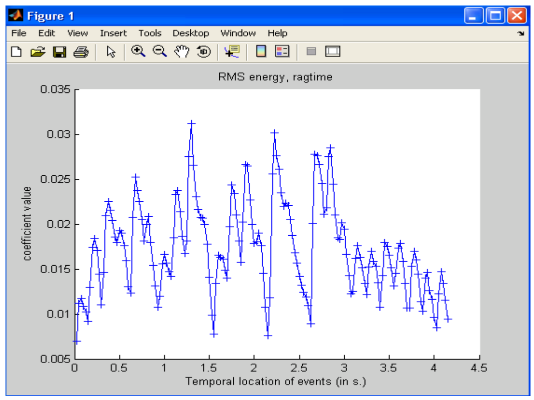

Figure 2. RMS Energy

5. Gain Ratio

Information Gain and Gain Ratio are used in this work as attribute selection measures. Node N holds the tuples of partition D. The expected information needed to classify a tuple in D is as follows:

$$Info(D) = -\sum_{i=1}^{m} P_i \log_2(P_i)$$

where P_i is the nonzero probability that an arbitrary tuple in D belongs to class C_i and is estimated by $|C_{i,D}|/|D|$.

To partition the tuple in D on some attribute A having v distinct values $\{a_1, a_2, \ldots a_v\}$. Attribute A can be used to split D into v partitions $\{D_1, D_2, \ldots D_v\}$, where D_j contains those tuples in D that have outcome a_j of A. The expected information required to classify is,

$$Info_A(D) = \sum_{j=1}^{v} |D_j|/|D| \times Info(D_j)$$

where $|D_j|/|D|$ = weight of jth partition.

Information Gain is, $Gain(A) = Info(D) - Info_A(D)$

By splitting the training data set D into v partitions on attribute A Splitting Information is calculated as follows:

$$\text{SplitInfo}_A(D) = -\sum_{j=1}^{v} |D_j|/|D| \times \log_2 (|D_j|/|D|)$$

and the Gain Ratio is, GainRatio(A) = Gain(A) / $\text{SplitInfo}_A(D)$.

6. DATA ANALYSIS AND EXPERIMENTAL EVALUATION

The audio files of training database are already classified and the numerical values of each feature of a specific audio file are extracted using MIRToolBox. MIRToolbox is a Matlab toolbox dedicated to the extraction of musically related features from audio recordings. It has been designed in particular with the objective of enabling the computation of a large range of features from databases of audio files, which can be applied to statistical analyses described in [18]. MIRToolBox application is used with MATLAB 2012 to compute the numerical values of selected features. The files of testing database are processed and input to the application to identify the music genre of that specific audio file. The following commands are executed in a MIRToolBox application to calculate the numerical values of individual features for all files:

```
miraudio('b1.wav')
mirlength('b1', 'Unit', 'Second')
mirrms('ragtime')
r1 = mirrms('b1', 'Frame')
mirlowenergy(r1)
mirtempo('b1', 'Autocor')
mirpulseclarity('b1', 'MaxAutocor')
mirzerocross('b1', 'Per', 'Second')
mirrolloff('b1', 'Threshold', .85)
mirregularity('b1', 'Jensen')
mirpitch('b1', 'Autocor')
mirinharmonicity('b1', 'f0', 450.8155)
```

6.1 Non-Classified Audio File Database

Total 52 .wav files are collected for creating non-classified Database. Extracted numerical values of this feature of non-classified audio files are stored in a dataset. The data values of individual features of non-classified audio files are plotted and analyzed in a waveform and linear values are identified. Temporal Length of non-classified audio files is represented in Figure 3. Then the data values of individual features are subdivided into three groups- high, medium and low on the basis of their range of values. Pulse clarity is considered as a high-level musical dimension that conveys how easily in a given musical piece, listeners can perceive the underlying rhythmic or metrical pulsation. This Characterization of music plays an important role in musical genre recognition described in [19] which allows discrimination between genres

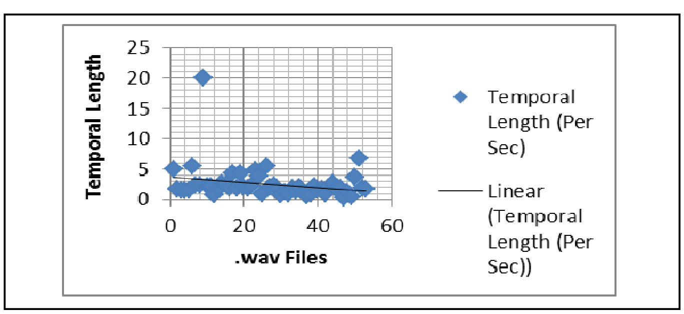

Figure 3. Temporal Length

but that differ in the degree of emergence of the main pulsation over the rhythmic texture. The notion of pulse clarity is considered in this study as a subjective measure and it is used to calculate the gain of features of all audio files. Roll Off has the highest information gain among features, so it is selected as the splitting attribute. The gain ratio of each feature is calculated for audio file analysis in respect to the feature pulse clarity. Table 1 consists of gain ratio of each feature in respect of various music classes. The Roll Off feature with the maximum gain ratio is selected as the splitting attribute in case of non-classified audio files.

Table 1. Gain_Ratio of Non-Classified Audio Files

Feature	**Gain**	**Gain Ratio**
Sampling Rate	.2923	.164
Temporal Length	.0048	.00687
RMS Energy	.0412	.0513
Low energy	.0214	.0198
Tempo	.1022	.1228
Zero Crossing Rate	.1562	.0996
Roll Off	.3037	.2428
Spectral Irregularity	.1392	.0981
Pitch	.0412	.0262
Inharmonicity	.0445	.1159

6.2 Classified Audio File Database

The Classified Database is consisting of 110 audio files which is based on some basic classes i.e., Blues, Classical, Chamber, Orchestral, Jazz, Pop, Hip Hop, Techno, Rock, Hard rock and Soft rock music. 10 .mp3 files for each class are collected for the creation of the database. Then the files are converted into .wav format for processing. The sampling rate of all files is fixed to 44100 Hz. These extracted values are saved in a database for further analysis. The data values of individual features are plotted and analysed for all classes. From the graph layout we can get the minimum and maximum range of a specific feature for a particular music class. Figure 4 shows the data ranges of various features. Based on different ranges the data sets are divided into three groups – low, medium and high.

Types	Temporal Length	RMS Energy	Low Energy	Tempo(bpm)	Pulse Clarity	Zero crossing rate	Rolloff(Hz)	ectral Irregular	Pitch(Hz)	Inharmonicity
Blues	67.030-218.044	.039-.066	.473-.601	104.547-167.276	.021-.594	721.237-1900.420	2522.161-7131.948	.005-.641	110.631-986.892	.468-.515
Classical	62.537-200.112	.034-.057	.504-.637	70.926-160.200	.030-.547	470.025-837.309	1118.381-5676.943	.181-.835	83.007-355.879	.401-.482
Chamber	133.251-223.622	.037-.073	.466-.629	91.508-172.097	.041-.653	583.278-2395.851	1846.220-6689.256	.141-.543	154.685-506.055	.419-.496
Orchestral	63.817-183.249	.046-.07	.506-.592	106.047-190.455	.060-.861	443.363-1699.553	2318.941-5467.835	.176-.985	195.730-853.233	.458-.550
Jazz	125.350-236.266	.050-.069	.454-.645	96.695-183.722	.150-.691	613.763-1894.917	1804.752-5890.593	.071-.882	116.615-1017.057	.469-.508
Pop	63.387-221.780	.043-.078	.484-.582	99.969-182.133	.141-.736	515.761-2735.099	3571.568-6644.087	.049-.769	157.633-945.820	.400-.514
HipHop	99.892-221.951	.039-.066	.465-.572	77.101-193.077	.237-.672	1015.925-3284.513	5211.119-8124.579	.075-.890	114.463-1006.787	.476-.503
Techno	80.106-220.435	.039-.095	.462-.672	114.681-189.943	.529-.878	816.616-2548.420	3221.569-8289.526	.094-.609	118.570-1067.258	.436-.524
Rock	113.293-236.931	.055-.070	.468-.568	87.217-157.269	.123-.521	1278.300-3066.453	3898.015-6736.528	.081-.395	78.623-903.383	.474-.508
Hard Rock	104.635-224.484	.055-.070	.494-.564	100.221-189.410	.274-.643	929.503-2250.428	4023.429-6179.104	.110-.307	116.642-1080.453	.473-.507
Soft Rock	47.479-205.546	.057-.086	.492-.570	104.660-176.061	.082-0.676	1122.605-1994.774	3626.326-7124.883	.092-.436	198.253-1032.027	.473-.508

Fig4. Feature_DataRange

Figure 4. Feature_DataRange

After that information gain and gain ratio are calculated in respect to pulse clarity of each feature corresponding to a particular music class. Maximum and average values of gain ratio are calculated as Max_{Gain} and Avg_{Gain} respectively for individual feature. Then threshold value is calculated from the average value of Max_{Gain} and Avg_{Gain}. Figure 5 Shows that, Roll off, Zero

Crossing rate and Tempo have maximum threshold value. So these three features are selected as the main criterion to classify an audio file.

Gain Ratio in respect to Pulse Clarity									
Music Type	**Temporal Length**	**RMS Energy**	**Low Energy**	**Tempo**	**ZeroCrossing Rate**	**RollOff**	**Spectral Irregularity**	**Pitch**	**Inharmonicity**
Blues	0.5236	0.3077	0.5368	0.0982	0.3244	0.7073	0.0876	0.2258	0.2437
Classical	0.3012	0.2367	0.3508	0.4343	0.3997	0.1092	0.1379	0.2097	0.1413
Chamber	0.3044	0.2347	0.5459	0.3045	0.3797	0.3567	0.0876	0.3567	0.2437
Orchestral	0.3897	0.2652	0.2157	0.1614	0.2897	0.3168	0.1414	0.1092	0.4223
Jazz	0.4654	0.4039	0.4375	0.4999	0.2876	0.3189	0.3428	0.5324	0.153
Pop	0.1317	0.4849	0.3101	0.4462	0.5698	0.2024	0.3543	0.0505	0.4126
HipHop	0.4106	0.1605	0.1543	0.5591	0.3543	0.0905	0.2252	0.446	0.1543
Techno	0.5146	0.3242	0.5146	0.1127	0.362	0.3972	0.3927	0.2252	0.2076
Rock	0.3508	0.2437	0.14	0.2432	0.3242	0.2098	0.1123	0.4265	0.3598
Hard Rock	0.362	0.1127	0.2933	0.5519	0.4276	0.1054	0.1123	0.0984	0.3466
Soft Rock	0.3925	0.3492	0.2863	0.3762	0.3429	0.3268	0.0801	0.1011	0.266
Max	0.5236	0.4849	0.5459	0.5591	0.5698	0.7073	0.3927	0.5324	0.4223
Avg	0.3770	0.2839	0.3441	0.3443	0.3693	0.2855	0.1886	0.2529	0.2683
Threshold	0.4503	0.3844	0.4450	0.4517	0.4695	0.4964	0.2906	0.3926	0.3453

Figure 5. GainRatio_PulseClarity

We've developed an application in PHP to implement the different functionalities i.e., feature extraction and classification. Training databases of classified and non-classified audio files and testing database are also created using MySQL. At first, an audio file from testing database is entered into the application for feature extraction and the numerical values of each feature of the audio file are displayed. From this data value system can identify the class of that music file. In this method, three splitting attributes which have a maximum gain ratio can be easily calculated from the gain_ratio table. For classification phase, the values of Roll of, Zero Crossing rate and Tempo are fixed to threshold value which is already calculated and selected as the basic criterion of classification. The threshold value of each feature is calculated as follows:

$$\text{Threshold}_{Fi} = [\{(\text{Max}_{Fi} + \text{Avg}_{Fi})/2\} + \{(\text{Max}_{Fi} - \text{Avg}_{Fi})/4\}]$$

During the classification phase of an audio file (from testing database) the system compares the values with threshold values. If the values are less than or equal to threshold value then it is successfully classified and music class is identified. Out of 110 music files 9 files are not classified as the value exceeds the threshold limit.

Total	**Successful (91.82%)**	**Unsuccessful (8.18%)**						
		Jazz	**Orchestral**	**Pop**	**Hip Hop**	**Techno**	**Rock**	**Hard Rock**
110	101	2	1	1	1	2	1	1

Figure 6. Classification Result

Figure 6 represents the classification result on testing database. All test music files of classes Blues, Classical, Chamber and Soft rock are classified successfully and no error occurs. For improvement of efficiency of classification and to get the optimal solution threshold value plays an important role. 91.82% files of testing database are correctly classified and the error rate of unsuccessful classification is 8.18%. So, our approach is effective with respect to music genre classification accuracy in [20]. By dimensionality reduction top three features have been selected which are used for classification. The classification result is not affected by this method and we can improve the percentage of successful classification above 90%, which can further improve in the future on the basis of performance of the system and the result of success and error in classification.

7. CONCLUSIONS

This approach includes the method to consistently and precisely identify the features that take part in the classification of an audio file. We have described in detail an audio classification scheme that uses Gain Ratio to select splitting attribute for classification into various music genres. This research work presented here is based on feature selection, extraction, analysis of data, feature selection using gain ratio and finally a classification stage using splitting criterion. For calculation of gain ratio we have included Pulse Clarity feature which has high discrimination power among different features and it ensures that the system can achieve high accuracy. All audio files are of .wav format and the sampling rates are fixed. The audio files belonging to any particular music genre share a similarity in a range of values of their features and hence make it possible to discover the pattern and then classify the audio file accordingly. This work emphasizes both the theoretical concept as well as gives insight into the practical application program. Experimental results showed that the scheme is very effective and the total accuracy rate is over 90%. There are many interesting directions that can be explored in the future. To achieve this, we need to concentrate on the selection of more audio features that can be used to characterize the audio content. In the future, our audio classification scheme will be improved to discriminate more audio classes, speeches, background music or any other sound. We will also focus on developing an effective scheme to apply data mining techniques to improve the efficiency of the classification process. The future scope of the work is to improve the quality of the audio file by improving the quality of sound by reducing the noise.

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STUDY ON PERFORMANCE IMPROVEMENT OF OIL PAINT IMAGE FILTER ALGORITHM USING PARALLEL PATTERN LIBRARY

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ABSTRACT

This paper gives a detailed study on the performance of oil paint image filter algorithm with various parameters applied on an image of RGB model. Oil Paint image processing, being very performance hungry, current research tries to find improvement using parallel pattern library. With increasing kernel-size, the processing time of oil paint image filter algorithm increases exponentially.

KEYWORDS

Image Processing, Image Filters, Linear Image Filters, Colour Image Processing, Paint algorithm, Oil Paint algorithm.

1. INTRODUCTION

This document provides an analytical study on the performance of Oil Paint Image Filter Algorithm. There are various popular linear image filters are available. One of them is Oil Paint image effect. This algorithm, being heavy in terms of processing it is investigated in this study. There related studies are detailed in the Section 7.

2. BACKGROUND

Modern days, hands are flooded with digital companions, like Digital Camera, Smart Phones and so on. Most of the devices are having built-in camera. People now more keen on using the built-in camera. The computation power of this class of devices is also increasing day by day. The usage of this handheld devices as camera, overshoot the usage of traditional camera in huge number.
The usage of these cameras has become a common fashion of modern life. This has started a new stream of applications. Applications include various categories e.g. image editing, image enhancement, camera extension application and so on. A large group of these applications include applying different kinds of image filters.

Image filters are of different kinds, with respect their nature of processing or mathematical model. Some of the image filters are good in execution-time in comparison with others. The execution

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time is a very important data, for this category of application development. Oil Paint is one of the very popular linear image filters, which is very heavy in terms of execution.

3. INVESTIGATION METHOD

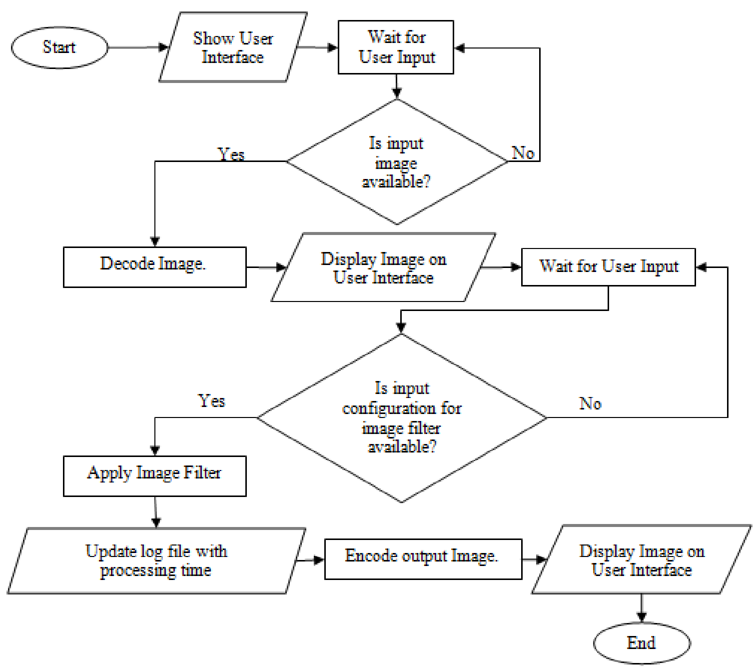
A simple windows application is developed to analyse different types of image filters. The purpose of this windows application is to accept different JPG image files as an input, and apply different kinds of image filters on to it. In the process of applying image filters the application will log the processing time. The overall operation of the application is explained here.

3.1. Operational Overview

The application is realised with two primary requirements: input jpg image files and configuration of image filter parameters. To cater requirements, the application is designed with three major components: a user interface, a jpeg image encoder-decoder and image filter algorithm.

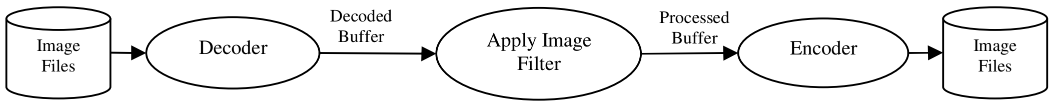
The user interface is developed with Microsoft's Win32 programing. The image encoder and decoder component is designed with Windows Imaging Component, provided by Microsoft on windows desktop.

The following flowchart diagram shows the operational overview of the test environment. During this process of testing, the processing time is logged and analysed for the study.



3.2. Implementation Overview

Considering the above workflow diagram, main focus of the current study is done with the application of image filter (marked as "Apply Image Filter" operation). Other operations are considered to be well known and do not affect the study. The code snippet below will provide the clear view of implementation. The user interface can be designed in various ways; even this experiment can be performed without a GUI also. That is why the main operational point of interests can be realized with the following way.



Decoder

The interface for decoding is exposed as shown here.

```
/* ********************************************************************************
 * Function Name : Decode
 * Description : The function decodes an image file and gets the decoded buffer.
 *
 * ********************************************************************************/
HRESULT Decode(LPCWSTR imageFilename, PUINT pWidth, PUINT pHeight, PBYTE* ppDecodedBuffer, PUINT
pStride, PUINT pBufferSize, WICPixelFormatGUID*         pWicPixelFormatGUID);
```

One of the possible ways of implementing the decode interface is provided here

```
HRESULT Decode(LPCWSTR imageFilename, PUINT pWidth, PUINT pHeight, PBYTE* ppDecodedBuffer, PUINT
pStride, PUINT pBufferSize, WICPixelFormatGUID* pWicPixelFormatGUID)
{
        HRESULT                              hr = S_OK;
        UINT                                 frameCount = 0;
        IWICImagingFactory                   *pFactory = NULL;
        IWICBitmapDecoder                    *pBitmapJpgDecoder = NULL;
        IWICBitmapFrameDecode                *pBitmapFrameDecode = NULL;

        do
        {
                /* Create Imaging Factory  */
                BREAK_IF_FAILED(CoCreateInstance( CLSID_WICImagingFactory, NULL,
CLSCTX_INPROC_SERVER,
                                   IID_IWICImagingFactory, (LPVOID*)&pFactory))

                /*  Create Imaging Decoder for JPG File */
                BREAK_IF_FAILED(pFactory->CreateDecoderFromFilename(imageFilename, NULL,
GENERIC_READ,                                                    WICDecodeMetadataCacheOnDemand,
&pBitmapJpgDecoder))

                /* Get decoded frame & its related information from Imaging Decoder for JPG File */
                BREAK_IF_FAILED(pBitmapJpgDecoder->GetFrameCount(&frameCount))

                BREAK_IF_FAILED(pBitmapJpgDecoder->GetFrame(0, &pBitmapFrameDecode))

                /* Get Width and Height of the Frame */
                BREAK_IF_FAILED(pBitmapFrameDecode->GetSize(pWidth, pHeight))

                /* Get Pixel format and accordingly allocate memory for decoded frame */
                BREAK_IF_FAILED(pBitmapFrameDecode->GetPixelFormat(pWicPixelFormatGUID))

                *ppDecodedBuffer = allocateBuffer(pWicPixelFormatGUID, *pWidth, *pHeight,
                                        pBufferSize, pStride))
                if(*ppDecodedBuffer == NULL) break;

                /* Get decoded frame  */
                BREAK_IF_FAILED(pBitmapFrameDecode->CopyPixels(NULL, *pStride,
                                                     *pBufferSize, *ppDecodedBuffer))

        }while(false);

        if(NULL != pBitmapFrameDecode)       pBitmapFrameDecode->Release();
        if(NULL != pBitmapJpgDecoder)        pBitmapJpgDecoder->Release();
        if(NULL != pFactory)                 pFactory->Release();

        return hr;
}
```

Encoder

The interface for encoding is exposed as shown here.

```
/* ********************************************************************************
 * Function Name : Encode
 *
           * Description : The function encodes an deocoded buffer into an image file.
 *
 * ********************************************************************************/
HRESULT Encode(LPCWSTR outFilename, UINT imageWidth, UINT imageHeight, PBYTE pDecodedBuffer, UINT
cbStride, UINT cbBbufferSize, WICPixelFormatGUID*       pWicPixelFormatGUID);
```

One of the possible ways of implementing the encode interface is provided here.

```
HRESULT Encode(LPCWSTR outFilename, UINT imageWidth, UINT imageHeight, PBYTE pDecodedBuffer, UINT
cbStride, UINT
                  cbBbufferSize, WICPixelFormatGUID*    pWicPixelFormatGUID)
{
         HRESULT                              hr = S_OK;
         UINT                                 frameCount = 0;
         IWICImagingFactory                   *pFactory = NULL;
         IWICBitmapEncoder                    *pBitmapJpgEncoder = NULL;
         IWICBitmapFrameEncode                *pBitmapFrameEncode = NULL;
         IWICStream                           *pJpgFileStream = NULL;

         do
         {
                  /* Create Imaging Factory  */
                  BREAK_IF_FAILED(CoCreateInstance(CLSID_WICImagingFactory, NULL,
CLSCTX_INPROC_SERVER,
IID_IWICImagingFactory, (LPVOID*)&pFactory))

                  /* Create & Initialize Stream for an output JPG file */
                  BREAK_IF_FAILED(pFactory->CreateStream(&pJpgFileStream))

                  BREAK_IF_FAILED(pJpgFileStream->InitializeFromFilename(outFilename,
GENERIC_WRITE))

                  /* Create & Initialize Imaging Encoder  */
                  BREAK_IF_FAILED(pFactory->CreateEncoder(GUID_ContainerFormatJpeg,
                                                          &GUID_VendorMicrosoft,
                                                                            &pBitmapJpgEncoder))

                  /* Initialize a JPG Encoder */
                  BREAK_IF_FAILED(pBitmapJpgEncoder->Initialize(pJpgFileStream,
WICBitmapEncoderNoCache))

                  /* Create & initialize a JPG Encoded frame */
                  BREAK_IF_FAILED(pBitmapJpgEncoder->CreateNewFrame(&pBitmapFrameEncode, NULL))
                  BREAK_IF_FAILED(pBitmapFrameEncode->Initialize(NULL))

                  /* Update the pixel information */
                  BREAK_IF_FAILED(pBitmapFrameEncode->SetPixelFormat(pWicPixelFormatGUID))
                  BREAK_IF_FAILED(pBitmapFrameEncode->SetSize(imageWidth, imageHeight))
                  BREAK_IF_FAILED(pBitmapFrameEncode->WritePixels(imageHeight, cbStride,
                                                                  cbBbufferSize, pDecodedBuffer))

                  BREAK_IF_FAILED(pBitmapFrameEncode->Commit())
                  BREAK_IF_FAILED(pBitmapJpgEncoder->Commit())


         }while(false);

         if(NULL != pJpgFileStream)           pJpgFileStream->Release();
         if(NULL != pBitmapFrameEncode)       pBitmapFrameEncode->Release();
         if(NULL != pBitmapJpgEncoder)        pBitmapJpgEncoder->Release();
         if(NULL != pFactory)                 pFactory->Release();

         return hr;
```

```
/* ********************************************************************************
 * Utility Macros
 * ********************************************************************************/
#define BREAK_IF_FAILED(X)  hr = X; \
                            if(FAILED(hr)) { break; } \
```

Application of Image Filter

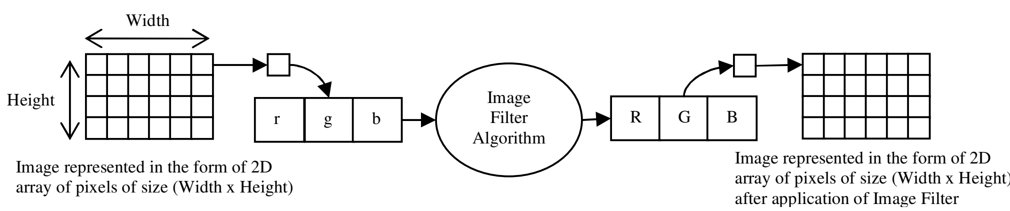
The image processing algorithm is the subject of study in current experiment. Details of the algorithms are explained later sections. Following code snippet will explain how the performances for any simple filter (e.g. oil paint) captured for study. Similar approach is followed all image filters.

```
HRESULT ApplyOilPaintOnFile (LPCWSTR inImageFile, LPCWSTR outImageFile)
{

        HRESULT                     hr = S_OK;
        PBYTE                       pDecodedBuffer = NULL;
        PBYTE                       pOutputBuffer = NULL;
        UINT                        decodedBufferLen = 0;
        UINT                        inImageWidth = 0;
        UINT                        inImageHeight = 0;
        UINT                        cbStride = 0;
        WICPixelFormatGUID          wicPixelFormatGUID;
        DWORD                       dTimeStart = 0;
        DWORD                       dTimeDecode = 0;
        DWORD                       dTimeProcess = 0;
        DWORD                       dTimeEncode = 0;
        char                        sMessage[256] = {0};

        do
        {
                /* --------- Decode. --------- */
                dTimeStart = GetTickCount();

                BREAK_IF_FAILED(Decode( inImageFile, &inImageWidth,
&inImageHeight, &pDecodedBuffer,
                                               &cbStride, &decodedBufferLen,
&wicPixelFormatGUID))

                dTimeDecode = GetTickCount() - dTimeStart;

                /* Allocate Memory for output. */
                pOutputBuffer = (PBYTE)calloc(sizeof(BYTE), decodedBufferLen);
                if(NULL == pOutputBuffer)
                        break;

                /* ------------  Process Image Filter ------------ */
                dTimeStart = GetTickCount();

                BREAK_IF_FAILED(ApplyOilPaintOnBuffer(pDecodedBuffer,
                                                          inImageWidth,
                                               inImageHeight, pOutputBuffer))

                dTimeProcess = GetTickCount() - dTimeStart;

                /* --------- Encode ---------  */
                dTimeStart = GetTickCount();

                BREAK_IF_FAILED(Encode( outImageFile, inImageWidth,
inImageHeight, pOutputBuffer,
                                           cbStride, decodedBufferLen,
&wicPixelFormatGUID))

                dTimeEncode = GetTickCount() - dTimeStart;

                sprintf(sMessage,
                "Grey Scale : Width=%d, Height=%d, Time(Decode)=%lu
        Time(Process)=%lu Time(Encode)=%lu\r\n",
                 inImageWidth, inImageHeight, dTimeDecode, dTimeProcess,
```

For measuring the time taken for processing, well known standard windows API GetTickCount is used. GetTickCount retrieves the number of milliseconds that have elapsed since the system was started.

4. OIL PAINT IMAGE FILTER IN RGB COLOUR MODEL

During this study, the input images are considered to be in RGB model. In this model, an image consists of two dimensional arrays of pixels. Each pixel of a 2D array contains data of red, green and blue colour channel respectively.



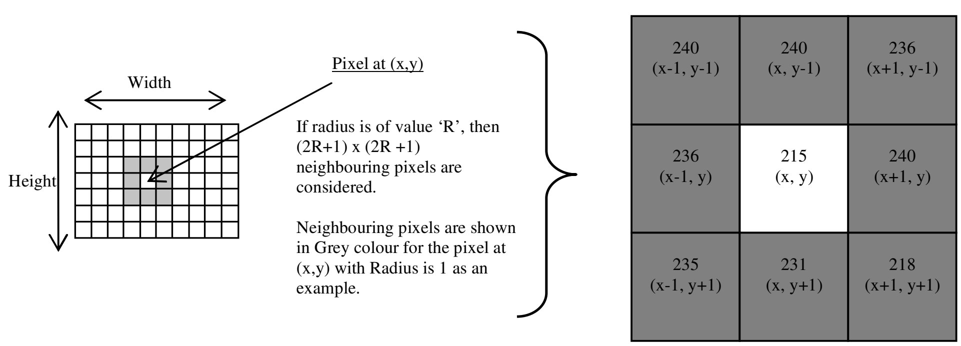
The Image Filters are basically algorithm for changing the values of Red, Green and Blue component of a pixel to a certain value.

There are various kinds of Image Filters, available. One of the categories of image filter is linear image filters. For processing one pixel its neighbouring pixels is accessed, in linear image filter. Depending upon the amount of access to neighbouring pixels, the performance of linear filters is affected.

As a part of our analysis we have considered Oil Paint image filter, which is popular but process hungry.

Histogram based algorithm for Oil Paint

For each pixel, it is done in this way: for pixel at position (x, y), find the most frequently occurring intensity value in its neighbourhood. And set it as the new colour value at position (x, y).



1) The right side provides the larger and clear picture of the neighbouring pixels or Radius 1, with respect to pixel at (x, y). The intensities of the respective pixels are also provided (as an example).
2) The pixels at (x-1, y-1), (x, y-1), (x+1, y) have the maximum occurring intensity i.e. 240.
3) The each colour channel of the pixel at (x, y) is set with an average of each colour channel of 3 pixels [(x-1, y-1), (x, y-1), (x+1, y)].

The interface for the oil paint algorithm is exposed as follows.

```
/* ***********************************************************************************
 * Function Name : ApplyOilPaintOnBuffer
 * Description : Apply oil paint effect on decoded buffer.
 *
 * ***********************************************************************************/
HRESULT ApplyOilPaintOnBuffer(PBYTE pInBuffer, UINT width, UINT height, const UINT intensity_level, const int
radius, PBYTE pOutBuffer);
```

Generally bigger images will be captured with higher resolution cameras. Here the radius also needs to be of higher value to create better oil paint image effect. And this creates more performance bottleneck.

One of the possible ways of implementing the interface is as follows.

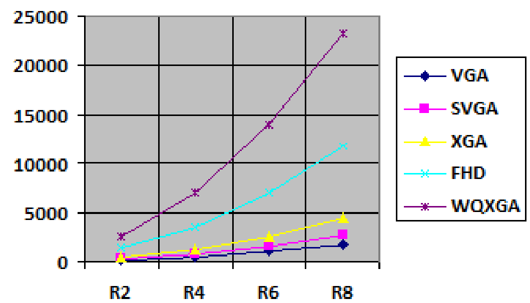
```
HRESULT ApplyOilPaintOnBuffer(PBYTE pInBuffer, UINT width, UINT height, const UINT
intensity_level,
const int radius, PBYTE pOutBuffer)
{
        int                                     index = 0;
        int                                     intensity_count[255] = {0};
        int                                     sumR[255] = {0};
        int                                     sumG[255] = {0};
        int                                     sumB[255] = {0};
        int                                     current_intensity = 0;
        int                                     row,col, x,y;
        BYTE                                    r,g,b;
        int                                     curMax = 0;
        int                                     maxIndex = 0;

        if(NULL == pInBuffer || NULL == pOutBuffer)
                return E_FAIL;

        for(col = radius; col < (height - radius); col++) {
                for(row = radius; row < (width - radius); row++) {
                        memset(&intensity_count[0], 0, ARRAYSIZE(intensity_count));
                        memset(&sumR[0], 0, ARRAYSIZE(sumR));
                        memset(&sumG[0], 0, ARRAYSIZE(sumG));
                        memset(&sumB[0], 0, ARRAYSIZE(sumB));

                        /* Calculate the highest intensity Neighbouring Pixels. */
                        for(y = -radius; y <= radius; y++) {
                                for(x = -radius; x <= radius; x++) {
                                  index = ((col + y) * width * 3) + ((row + x) * 3);

                                  r = pInBuffer[index + 0];
                                  g = pInBuffer[index + 1];
                                  b = pInBuffer[index + 2];

                                  current_intensity = ((r + g + b) *
intensity_level/3.0)/255;

                                  intensity_count[current_intensity]++;

                                  sumR[current_intensity] += r;
                                  sumG[current_intensity] += g;
                                  sumB[current_intensity] += b;
                                }
                        }

                        index = (col * width * 3) + (row * 3);

              /* The highest intensity neighbouring pixels are averaged out to get the
exact color. */
              maxIndex = 0;
              curMax = intensity_count[maxIndex];

              for( int i = 0; i < intensity_level; i++ )   {
```

Experimental Results

The experimental is conducted with images of different size and application of oil paint with different radius. The following data shows the time of execution with different parameters.

Size	Radius	Time
VGA(640x480)	2	218
VGA(640x480)	4	531
VGA(640x480)	6	1046
VGA(640x480)	8	1685
SVGA(800x600)	2	297
SVGA(800x600)	4	826
SVGA(800x600)	6	1606
SVGA(800x600)	8	2652
XGA(1024x768)	2	499
XGA(1024x768)	4	1326
XGA(1024x768)	6	2621
XGA(1024x768)	8	4383
FHD(1920x1080)	2	1466
FHD(1920x1080)	4	3526
FHD(1920x1080)	6	7020
FHD(1920x1080)	8	11716
WQXGA(2560x1600)	2	2559
WQXGA(2560x1600)	4	6973
WQXGA(2560x1600)	6	14008
WQXGA(2560x1600)	8	23229

System	Details
Processor	Intel® Core™ i7-3630QM CPU @ 2.40 GHz, 2.40 GHz
Operating System	Windows 7 Enterprise, 64 bit Operating System.
RAM	8.00GB



After application of
Oil Paint Image Filter

In due course of our investigation, we have observed that the performance of oil paint image filter increases in greater degree with increasing width, height and radius (i.e. usage of neighbouring pixel).

More importantly, we have observed most of the high resolution images are captured by more and more and power camera (i.e. either in high end digital camera or high end handheld devices). For these kinds of higher resolution photos, as the resolution of the image increases, the radius parameter needs to be increased to generate Oil Paint effect of an acceptable quality.

5. Oil Paint Image Filter by Microsoft Parallel Patterns Library

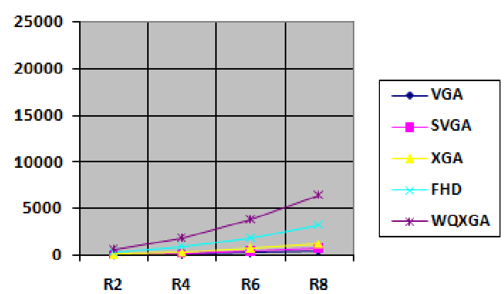
We have observed, in our previous section of investigation, which time increases with higher degree with increasing width, height and radius. So we tried to improve the oil paint algorithm by using Microsoft Parallel Patterns Library. We have kept the same interface for Oil Paint algorithm; only we differentiated in the implementation. Following code snippet will provide clear picture of the implementation using Microsoft PPL.

```
HRESULT ApplyOilPaintOnBuffer(PBYTE pInBuffer, UINT width, UINT height, const UINT intensity_level,
const int radius, PBYTE pOutBuffer)
{
        int tStart = radius;
        int tEnd =(height - radius);

        if(NULL == pInBuffer || NULL == pOutBuffer)
                        return E_FAIL;

        parallel_for(tStart, tEnd, [&pInBuffer, &width, &height, &intensity_level, &radius,
&pOutBuffer]
        (int col){
                int                     index = 0;
                int                     intensity_count[255] = {0};
                int                     sumR[255] = {0};
                int                     sumG[255] = {0};
                int                     sumB[255] = {0};
                int                     current_intensity = 0;
                int                     row,x,y;
                BYTE                    r,g,b;
                int                     curMax = 0;
                int                     maxIndex = 0;

                for(row = radius; row < (width - radius); row++)
                {
                   /* This portion of the code remains same, as mentioned above */
                }

        });

        return S_OK;
}
```

Experimental Results

The experiment is conducted with same set of images, used for the experiment, mentioned in the section above. We have also obtained same quality of output with and better performance.

Size	Radius	Time
VGA(640x480)	2	94
VGA(640x480)	4	156
VGA(640x480)	6	281
VGA(640x480)	8	483
SVGA(800x600)	2	78
SVGA(800x600)	4	234
SVGA(800x600)	6	452
SVGA(800x600)	8	734
XGA(1024x768)	2	140
XGA(1024x768)	4	375
XGA(1024x768)	6	733
XGA(1024x768)	8	1248
FHD(1920x1080)	2	343
FHD(1920x1080)	4	967
FHD(1920x1080)	6	1935
FHD(1920x1080)	8	3261
WQXGA(2560x1600)	2	686
WQXGA(2560x1600)	4	1872
WQXGA(2560x1600)	6	3915
WQXGA(2560x1600)	8	6490



System	Details
Processor	Intel® Core™ i7-3630QM CPU @ 2.40 GHz, 2.40 GHz
Operating System	Windows 7 Enterprise, 64 bit Operating System.
RAM	8.00GB

6. COMPARATIVE ANALYSIS OF BOTH APPROACHES

The improvement of the performance in terms of percentage is deduced as [100 * (T1 – T2)/ t1], where T1 is time required for processing by 1st approach and T2 is the time required for processing time by latest approach.

Size	Radius	T1	T2	Improvement (%)
VGA(640x480)	2	218	94	56.88073394
VGA(640x480)	4	531	156	70.62146893
VGA(640x480)	6	1046	281	73.13575526
VGA(640x480)	8	1685	483	71.33531157
SVGA(800x600)	2	297	78	73.73737374
SVGA(800x600)	4	826	234	71.67070218
SVGA(800x600)	6	1606	452	71.85554172
SVGA(800x600)	8	2652	734	72.32277526
XGA(1024x768)	2	499	140	71.94388778
XGA(1024x768)	4	1326	375	71.71945701
XGA(1024x768)	6	2621	733	72.03357497
XGA(1024x768)	8	4383	1248	71.52635181
FHD(1920x1080)	2	1466	343	76.60300136
FHD(1920x1080)	4	3526	967	72.57515598
FHD(1920x1080)	6	7020	1935	72.43589744
FHD(1920x1080)	8	11716	3261	72.16626835
WQXGA(2560x1600)	2	2559	686	73.19265338
WQXGA(2560x1600)	4	6973	1872	73.15359243
WQXGA(2560x1600)	6	14008	3915	72.05168475
WQXGA(2560x1600)	8	23229	6490	72.06078609

7. REFERENCES

From reference [3] the histogram based analysis has been studied. The reference [3] provides the algorithm for the implementation of oil pain image filter algorithm. The algorithm (mentioned in reference [3], section 'Oil-paint Effect') is implemented, as explained in the section 4 of this paper. The achieved performance of the algorithm is examined and captured in the section 4 (sub-section: Experimental Result) here. The result shows high growth of the processing time with respect to kernel-size. Reference [4] is another reference, where algorithm similar reference [3] is proposed for implementation. The reference [1] and [2] are used for way of analysis and follow the broadened scope in this arena of image processing. Reference [5] also proposes algorithm which are similar in nature with reference [3]. So we can clearly depict algorithms similar to reference [3] and [5], will face similar performance problem.

8. CONCLUSIONS

As mentioned in section 4 & 7, I have obtained result, which depicts huge growth in processing time with respect to the increase in kernel size of oil paint image filter. There are various approaches have been proposed for the betterment of processing performance of the image filter algorithms. The parallel pattern library is a Microsoft library designed for the use by native C++ developers, which provides features of multicore programming. The current paper conducts study on improving oil paint image filter algorithm using the Microsoft technology.

By comparing results, as shown in section 6 I conclude that by using Microsoft Parallel Pattern library 71.6% (average) performance improvement can be achieved for Oil Paint Algorithm. This study is applicable for similar class of image filter algorithms as well.

There are various similar image filter algorithm, where processing of a single pixel depends on the values of its neighbouring pixels. In this respect, if the larger neighbouring pixels are accessed, there are performance issues. The approach mentioned in this paper can be referred for similar issues.

In future, more well-known or new techniques in conjunction with the current idea can be used for betterment. Not only in image processing in other dimensions of signal processing as well similar approach can be tried.

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HIGH LEVEL VIEW OF CLOUD SECURITY: ISSUES AND SOLUTIONS

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ABSTRACT

In this paper, we discuss security issues for cloud computing, Map Reduce and Hadoop environment. We also discuss various possible solutions for the issues in cloud computing security and Hadoop. Today, Cloud computing security is developing at a rapid pace which includes computer security, network security and information security. Cloud computing plays a very vital role in protecting data, applications and the related infrastructure with the help of policies, technologies and controls.

KEYWORDS

Cloud Computing, Big Data, Hadoop, Map Reduce, HDFS (Hadoop Distributed File System)

1. INTRODUCTION

In order to analyze complex data and to identify patterns it is very important to securely store, manage and share large amounts of complex data. Cloud comes with an explicit security challenge, i.e. the data owner might not have any control of where the data is placed. The reason behind this control issue is that if one wants to get the benefits of cloud computing, he/she must also utilize the allocation of resources and also the scheduling given by the controls. Hence it is required to protect the data in the midst of untrustworthy processes. Since cloud involves extensive complexity, we believe that rather than providing a holistic solution to securing the cloud, it would be ideal to make noteworthy enhancements in securing the cloud that will ultimately provide us with a secure cloud.

Google has introduced MapReduce [1] framework for processing large amounts of data on commodity hardware. Apache's Hadoop distributed file system (HDFS) is evolving as a superior software component for cloud computing combined along with integrated parts such as MapReduce. Hadoop, which is an open-source implementation of Google MapReduce, including a distributed file system, provides to the application programmer the abstraction of the map and the reduce. With Hadoop it is easier for organizations to get a grip on the large volumes of data

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being generated each day, but at the same time can also create problems related to security, data access, monitoring, high availability and business continuity.

In this paper, we come up with some approaches in providing security. We ought a system that can scale to handle a large number of sites and also be able to process large and massive amounts of data. However, state of the art systems utilizing HDFS and MapReduce are not quite enough/sufficient because of the fact that they do not provide required security measures to protect sensitive data. Moreover, Hadoop framework is used to solve problems and manage data conveniently by using different techniques such as combining the k-means with data mining technology [3].

1.1 Cloud Computing

Cloud Computing is a technology which depends on sharing of computing resources than having local servers or personal devices to handle the applications. In Cloud Computing, the word “Cloud” means “The Internet”, so Cloud Computing means a type of computing in which services are delivered through the Internet. The goal of Cloud Computing is to make use of increasing computing power to execute millions of instructions per second. Cloud Computing uses networks of a large group of servers with specialized connections to distribute data processing among the servers. Instead of installing a software suite for each computer, this technology requires to install a single software in each computer that allows users to log into a Web-based service and which also hosts all the programs required by the user. There's a significant workload shift, in a cloud computing system.

Local computers no longer have to take the entire burden when it comes to running applications. Cloud computing technology is being used to minimize the usage cost of computing resources [4]. The cloud network, consisting of a network of computers, handles the load instead. The cost of software and hardware on the user end decreases. The only thing that must be done at the user's end is to run the cloud interface software to connect to the cloud. Cloud Computing consists of a front end and back end. The front end includes the user's computer and software required to access the cloud network. Back end consists of various computers, servers and database systems that create the cloud. The user can access applications in the cloud network from anywhere by connecting to the cloud using the Internet. Some of the real time applications which use Cloud Computing are Gmail, Google Calendar, Google Docs and Dropbox etc.,

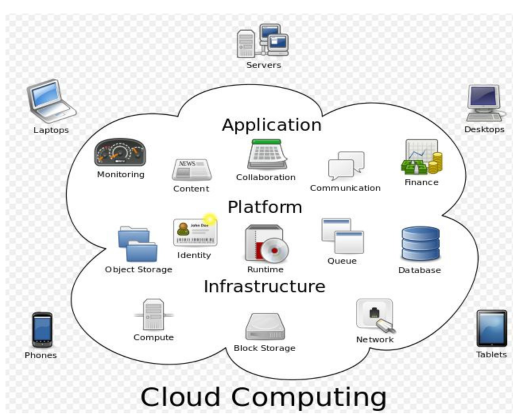

Fig1. Cloud Computing

1.2 Big Data

Big Data is the word used to describe massive volumes of structured and unstructured data that are so large that it is very difficult to process this data using traditional databases and software technologies. The term "Big Data [5]" is believed to be originated from the Web search companies who had to query loosely structured very large distributed data. The three main terms that signify Big Data have the following properties:

a) Volume: Many factors contribute towards increasing Volume - storing transaction data, live streaming data and data collected from sensors etc.,

b) Variety: Today data comes in all types of formats – from traditional databases, text documents, emails, video, audio, transactions etc.,

c) Velocity: This means how fast the data is being produced and how fast the data needs to be processed to meet the demand.

The other two dimensions that need to consider with respect to Big Data are Variability and Complexity [5].

d) Variability: Along with the Velocity, the data flows can be highly inconsistent with periodic peaks.

e) Complexity: Complexity of the data also needs to be considered when the data is coming from multiple sources. The data must be linked, matched, cleansed and transformed into required formats before actual processing.

Technologies today not only support the collection of large amounts of data but also help in utilizing such data effectively. Some of the real time examples of Big Data are Credit card transactions made all over the world with respect to a Bank, Walmart customer transactions, and Facebook users generating social interaction data.

Fig2. Big Data

When making an attempt to understand the concept of Big Data, the words such as "Map Reduce" and "Hadoop" cannot be avoided.

1.3 Hadoop

Hadoop, which is a free, Java-based programming framework supports the processing of large sets of data in a distributed computing environment. It is a part of the Apache project sponsored by the Apache Software Foundation. Hadoop cluster uses a Master/Slave structure [6]. Using Hadoop, large data sets can be processed across a cluster of servers and applications can be run on systems with thousands of nodes involving thousands of terabytes. Distributed file system in Hadoop helps in rapid data transfer rates and allows the system to continue its normal operation even in the case of some node failures. This approach lowers the risk of an entire system failure, even in the case of a significant number of node failures. Hadoop enables a computing solution that is scalable, cost effective, flexible and fault tolerant. Hadoop Framework is used by popular companies like Google, Yahoo, Amazon and IBM etc., to support their applications involving huge amounts of data. Hadoop has two main sub projects – Map Reduce and Hadoop Distributed File System (HDFS).

1.4 Map Reduce

Hadoop Map Reduce is a framework [7] used to write applications that process large amounts of data in parallel on clusters of commodity hardware resources in a reliable, fault-tolerant manner. A Map Reduce job first divides the data into individual chunks which are processed by Map jobs in parallel. The outputs of the maps sorted by the framework are then input to the reduce tasks. Generally the input and the output of the job are both stored in a file-system. Scheduling, Monitoring and re-executing failed tasks are taken care by the framework.

1.5 Hadoop Distributed File System (HDFS)

HDFS [8] is a file system that spans all the nodes in a Hadoop cluster for data storage. It links together file systems on local nodes to make it into one large file system. HDFS improves reliability by replicating data across multiple sources to overcome node failures.

2. Motivation and Related Work

2.1. Motivation

Along with the increasing popularity of the Could Computing environments, the security issues introduced through adaptation of this technology are also increasing. Though Cloud Computing offers many benefits, it is vulnerable to attacks. Attackers are consistently trying to find loopholes to attack the cloud computing environment. The traditional security mechanisms which are used are reconsidered because of these cloud computing deployments. Ability to visualize, control and inspect the network links and ports is required to ensure security. Hence there is a need to invest in understanding the challenges, loop holes and components prone to attacks with respect to cloud computing, and come up with a platform and infrastructure which is less vulnerable to attacks.

2.2. Related Work

Hadoop (a cloud computing framework), a Java based distributed system, is a new framework in the market. Since Hadoop is new and still being developed to add more features, there are many security issues which need to be addressed. Researchers have identified some of the issues and started working on this. Some of the notable outcomes, which is related to our domain and helped us to explore, are presented below.

The World Wide Web consortium has identified the importance of SPARQL which can be used in diverse data sources. Later on, the idea of secured query was proposed in order to increase privacy in privacy/utility tradeoff. Here, Jelena, of the USC Information Science Institute, has explained that the queries can be processed according to the policy of the provider, rather than all query processing. Bertino et al published a paper on access control for XML Documents [9]. In the paper, cryptography and digital signature technique are explained, and techniques of access control to XML data document is stressed for secured environment. Later on, he published another paper on authentic third party XML document distribution [10] which imposed another trusted layer of security to the paradigm. Moreover, Kevin Hamlen and et al proposed that data can be stored in a database encrypted rather than plain text. The advantage of storing data encrypted is that even though intruder can get into the database, he or she can't get the actual data. But, the disadvantage is that encryption requires a lot of overhead. Instead of processing the plain text, most of the operation will take place in cryptographic form. Hence the approach of processing in cryptographic form added extra to security layer.

IBM researchers also explained that the query processing should take place in a secured environment. Then, the use of Kerberos has been highly effective. Kerberos is nothing but a system of authentication that has been developed at MIT. Kerberos uses an encryption technology along with a trusted third party, an arbitrator, to be able to perform a secure authentication on an open network. To be more specific, Kerberos uses cryptographic tickets to avoid transmitting plain text passwords over the wire. Kerberos is based upon Needham-Schroeder protocol. Airavat [11] has shown us some significant advancement security in the Map Reduce environment. In the paper, Roy and et al have used the access control mechanism along with differential privacy. They have worked upon mathematical bound potential privacy violation which prevents information leak beyond data provider's policy.

The above works have influenced us, and we are analyzing various approaches to make the cloud environment more secure for data transfer and computation.

3. Issues and Challenges

Cloud computing comes with numerous security issues because it encompasses many technologies including networks, databases, operating systems, virtualization, resource scheduling, transaction management, load balancing, concurrency control and memory management. Hence, security issues of these systems and technologies are applicable to cloud computing. For example, it is very important for the network which interconnects the systems in a cloud to be secure. Also, virtualization paradigm in cloud computing results in several security concerns. For example, mapping of the virtual machines to the physical machines has to be performed very securely. Data security not only involves the encryption of the data, but also ensures that appropriate policies are enforced for data sharing. In addition, resource allocation and memory management algorithms also have to be secure. Finally, data mining techniques may also be used in the malware detection in clouds.

The challenges of security in cloud computing environments are discussed below.

3.1 Distributed Nodes

Distributed nodes [12] are an architectural issue. The computation is done in any set of nodes. Basically, data is processed in those nodes which have the necessary resources. Since it can happen anywhere across the clusters, it is very difficult to find the exact location of computation. Because of this it is very difficult to ensure the security of the place where computation is done.

3.2 Distributed Data

In order to alleviate parallel computation, a large data set can be stored in many pieces across many machines. Also, redundant copies of data are made to ensure data reliability. In case a particular chunk is corrupted, the data can be retrieved from its copies. In the cloud environment, it is extremely difficult to find exactly where pieces of a file are stored. Also, these pieces of data are copied to another node/machines based on availability and maintenance operations. In traditional centralized data security system, critical data is wrapped around various security tools. This cannot be applied to cloud environments since all related data are not presented in one place and it changes.

3.3 Internode Communication

Much Hadoop distributions use RPC over TCP/IP for user data/operational data transfer between nodes. This happens over a network, distributed around globe consisting of wireless and wired networks. Therefore, anyone can tap and modify the inter node communication[12] for breaking into systems.

3.4 Data Protection

Many cloud environments like Hadoop store the data as it is without encryption to improve efficiency. If a hacker can access a set of machines, there is no way to stop him to steal the critical data present in those machines.

3.5 Administrative Rights for Nodes

A node has administrative rights [12] and can access any data. This uncontrolled access to any data is very dangerous as a malicious node can steal or manipulate critical user data.

3.6 Authentication of Applications and Nodes

Nodes can join clusters to increase the parallel operations. In case of no authentication, third part nodes can join clusters to steal user data or disrupt the operations of the cluster.

3.7 Logging

In the absence of logging in a cloud environment, no activity is recorded which modify or delete user data. No information is stored like which nodes have joined cluster, which Map Reduce jobs have run, what changes are made because of these jobs. In the absence of these logs, it is very difficult to find if someone has breached the cluster if any, malicious altering of data is done which needs to be reverted. Also, in the absence of logs, internal users can do malicious data manipulations without getting caught.

3.8 Traditional Security Tools

Traditional security tools are designed for traditional systems where scalability is not huge as cloud environment. Because of this, traditional security tools which are developed over years cannot be directly applied to this distributed form of cloud computing and these tools do not scale as well as the cloud scales.

3.9 Use of Different Technologies

Cloud consists of various technologies which has many interacting complex components. Components include database, computing power, network, and many other stuff. Because of the wide use of technologies, a small security weakness in one component can bring down the whole system. Because of this diversity, maintaining security in the cloud is very challenging.

4. THE PROPOSED APPROACHES

We present various security measures which would improve the security of cloud computing environment. Since the cloud environment is a mixture of many different technologies, we propose various solutions which collectively will make the environment secure. The proposed solutions encourage the use of multiple technologies/ tools to mitigate the security problem specified in previous sections. Security recommendations are designed such that they do not decrease the efficiency and scaling of cloud systems.

Following security measures should be taken to ensure the security in a cloud environment.

4.1 File Encryption

Since the data is present in the machines in a cluster, a hacker can steal all the critical information. Therefore, all the data stored should be encrypted. Different encryption keys should be used on different machines and the key information should be stored centrally behind strong firewalls. This way, even if a hacker is able to get the data, he cannot extract meaningful information from it and misuse it. User data will be stored securely in an encrypted manner.

4.2 Network Encryption

All the network communication should be encrypted as per industry standards. The RPC procedure calls which take place should happen over SSL so that even if a hacker can tap into network communication packets, he cannot extract useful information or manipulate packets.

4.3 Logging

All the map reduce jobs which modify the data should be logged. Also, the information of users, which are responsible for those jobs should be logged. These logs should be audited regularly to find if any, malicious operations are performed or any malicious user is manipulating the data in the nodes.

4.4 Software Format and Node Maintenance

Nodes which run the software should be formatted regularly to eliminate any virus present. All the application softwares and Hadoop software should be updated to make the system more secure.

4.5 Nodes Authentication

Whenever a node joins a cluster, it should be authenticated. In case of a malicious node, it should not be allowed to join the cluster. Authentication techniques like Kerberos can be used to validate the authorized nodes from malicious ones.

4.6 Rigorous System Testing of Map Reduce Jobs

After a developer writes a map reduce job, it should be thoroughly tested in a distributed environment instead of a single machine to ensure the robustness and stability of the job.

4.7 Honeypot Nodes

Honey pot nodes should be present in the cluster, which appear like a regular node but is a trap. These honeypots trap the hackers and necessary actions would be taken to eliminate hackers.

4.8 Layered Framework for Assuring Cloud

A layered framework for assuring cloud computing [13] as shown in Figure (1) consists of the secure virtual machine layer, secure cloud storage layer, secure cloud data layer, and the secure virtual network monitor layer. Cross cutting services are rendered by the policy layer, the cloud monitoring layer, the reliability layer and the risk analysis layer.

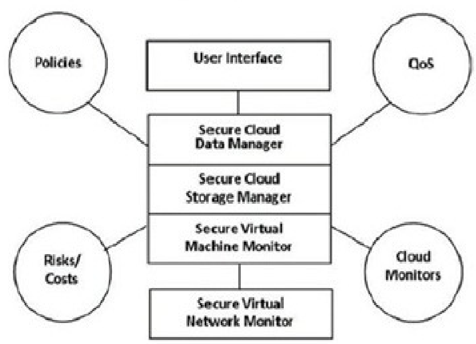

Fig3: Layered framework for assuring cloud [13]

4.9 Third Party Secure Data Publication to Cloud

Cloud computing helps in storing of data at a remote site in order to maximize resource utilization. Therefore, it is very important for this data to be protected and access should be given only to authorized individuals. Hence this fundamentally amounts to secure third party publication of data that is required for data outsourcing, as well as for external publications. In the cloud environment, the machine serves the role of a third party publisher, which stores the sensitive data in the cloud. This data needs to be protected, and the above discussed techniques have to be applied to ensure the maintenance of authenticity and completeness.

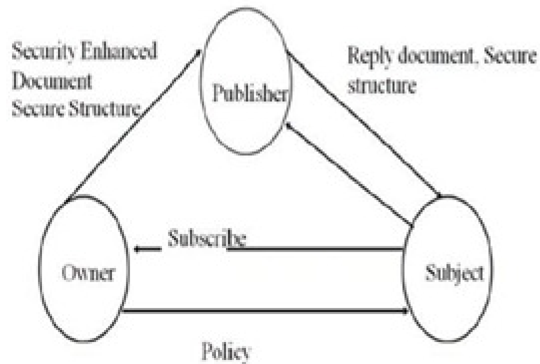

Fig4: Third party secure data publication applied to cloud [13].

4.10 Access Control

Integration of mandatory access control and differential privacy in distributed environment will be a good security measure. Data providers will control the security policy of their sensitive data. They will also control the mathematical bound on privacy violation that could take place. In the above approach, users can perform data computation without any leakage of data. To prevent information leak, SELinux [14] will be used. SELinux is nothing but Security-Enhanced Linux, which is a feature that provides the mechanism for supporting access control security policy through the use of Linux Security Modules (LSM) in the Linux Kernel. Enforcement of differential privacy will be done using modification to Java Virtual Machine and the Map Reduce framework. It will have inbuilt applications which store the user identity pool for the whole cloud service. So the cloud service will not have to maintain each user's identity for each application. In addition to the above methodologies, cloud service will support third party authentication. The third party will be trusted by both the cloud service and accessing user. Third party authentication will add an additional security layer to the cloud service.

Real time access control will be a good security measure in the cloud environment. In addition to access control to the cloud environment, operational control within a database in the cloud can be used to prevent configuration drift and unauthorized application changes. Multiple factors such as IP address, time of the day, and authentication method can be used in a flexible way to employ above measures. For example, access can be restricted to specific middle tier, creating a trusted path to the data. Keeping a security administrator separate from the database administrator will be a good idea. The label security method will be implemented to protect sensitive data by assigning data label or classifying data.

Data can be classified as public, confidential and sensitive. If the user label matches with the label of the data, then access is provided to the user. Examination of numerous data breaches has shown that auditing could have helped in early detection of problems and avoids them. Auditing of events and tracking of logs taking place in the cloud environment will enable possible attack. Fine grain auditing just like Oracle 9i enables conditional auditing on the specific application column.

5. CONCLUSION

Cloud environment is widely used in industry; therefore security is an important aspect for businesses running on these cloud environments. Using proposed approaches, cloud environments can be secured for complex business operations.

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MULTIPLE DAG APPLICATIONS SCHEDULING ON A CLUSTER OF PROCESSORS

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ABSTRACT

Many computational solutions can be expressed as Directed Acyclic Graph (DAG), in which nodes represent tasks to be executed and edges represent precedence constraints among tasks. A Cluster of processors is a shared resource among several users and hence the need for a scheduler which deals with multi-user jobs presented as DAGs. The scheduler must find the number of processors to be allotted for each DAG and schedule tasks on allotted processors. In this work, a new method to find optimal and maximum number of processors that can be allotted for a DAG is proposed. Regression analysis is used to find the best possible way to share available processors, among suitable number of submitted DAGs. An instance of a scheduler for each DAG, schedules tasks on the allotted processors. Towards this end, a new framework to receive online submission of DAGs, allot processors to each DAG and schedule tasks, is proposed and experimented using a simulator. This space-sharing of processors among multiple DAGs shows better performance than the other methods found in literature. Because of space-sharing, an online scheduler can be used for each DAG within the allotted processors. The use of online scheduler overcomes the drawbacks of static scheduling which relies on inaccurate estimated computation and communication costs. Thus the proposed framework is a promising solution to perform online scheduling of tasks using static information of DAG, a kind of hybrid scheduling.

KEYWORDS

Task scheduling, DAG, workflow, PTG

1. INTRODUCTION

Many business, industrial and scientific areas, such as high-energy physics, bioinformatics, astronomy, epigenomics, stock market and others involve applications consisting of numerous components(tasks) that process data sets and perform scientific computations. These tasks communicate and interact with each other. The tasks are often precedence-related. The problem of scheduling jobs with precedence constraints is an important problem in scheduling theory and has been shown to be NP-hard [1]. Data files generated by one task are needed by other tasks. The requirement of large amount of computations and data storage of these applications can be provided by a cluster. Because of huge technological changes in the area of parallel and

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distributed computing, powerful machines are now available at low prices. This is visible in large spreading of cluster with hundreds of homogeneous/heterogeneous processors connected by high speed interconnection network [2]. This democratization of cluster calls for new practical administration tools.

The task scheduling problem is to allocate resources (processors) to the tasks and to establish an order for the tasks to be executed by resources. There are two different types of task scheduling: static and dynamic. Static strategies define a schedule at compile time based on estimated time required to execute tasks and to communicate data. Static schedule can be generated only when the application behaviour is fully deterministic and this has the advantage of being more efficient and a small overhead during runtime. The full global knowledge of application in the form of DAG will help to generate a better schedule. Dynamic strategies, on the other hand are applied when tasks are generated during runtime. Tasks are assumed to be non-preemptive.

Workflows have recently emerged as a paradigm for representing complex scientific computations [26]. Few widely used example workflows are Montage (Fig. 2), cybershake, LIGO, SIPHT. Workflows represented by one of many workflow programming languages can be translated into DAG, in general. Thus workflow scheduling is essentially a problem of scheduling DAG. Although much work has been done in scheduling single workflow [3], multiple workflow scheduling is not receiving deserved attention. Few initial studies are found in the literature [4, 5]. Because of huge computing power of a cluster and the inability of a single DAG to utilize all processors on cluster, multiple DAG applications need to be executed concurrently. Thus a scheduler to deal with multi-user jobs with the objectives of maximizing resource utilization and minimizing overall DAG completion time is essential. The contributions of this paper are 1) a new method to find minimum, optimal and maximum number of processors that can be allotted for a DAG and this information is used to find one best way to share available processors among multiple DAGs 2) a framework to receive submission of DAGs, find the allotment for each submitted DAG and schedule tasks on allotted processors, with the objectives of maximizing resource utilization and minimizing overall completion time.

1.1. Application Model

The data flow model is gaining popularity as a programming paradigm for parallel processors. When the characteristics of an application is fully deterministic, including task's execution time, size of data communication between tasks, and task dependencies, the application can be represented by directed acyclic graph (DAG) as shown in Fig.1. Each node in DAG represents a task to be performed and the edges indicate inter-task dependencies. Node weight stands for the computation cost of the corresponding task and the edge cost represents the volume of data to be communicated between the corresponding nodes. The node and edge weights are usually obtained by estimation or profiling. Communication-to-Computation (CCR) is the ratio of average communication cost to the average computation cost of a DAG. This characterizes the nature of DAG. The objective of scheduling is to map tasks onto processors and order their execution so that task dependencies are satisfied and minimum overall completion time is achieved. Makespan is the total time required to complete a DAG.

1.2. Platform

A cluster with 'P' homogeneous processors, each of which is a schedulable resource is considered. Processors are interconnected by a high speed and low latency network. A processor can communicate with several other processors simultaneously with multi-port model.

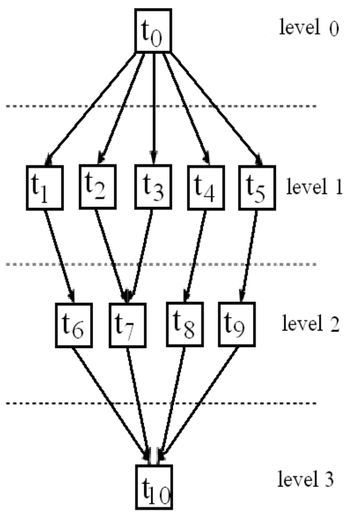

Figure 1. A Typical DAG

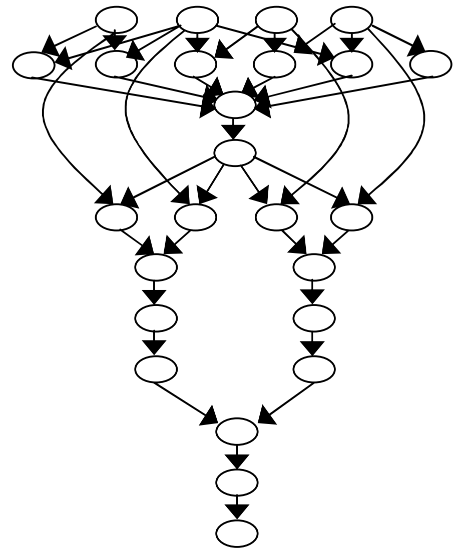

Figure 2. Montage – a Workflow

2. RELATED WORK

Extensive work has been done on scheduling a single DAG [6, 7, 8]. Zhao et al.[4] have proposed few methods to schedule multiple DAGs. One approach is to combine several DAGs into one by making the entry nodes of all DAGs, immediate successors of new entry node and then use standard methods to schedule the combined DAG. Another way is to consider tasks from each DAG in round robin manner for scheduling. They have proposed other policies to optimize both makespan and fairness. The key idea is to evaluate, after scheduling a task, the slowdown value of each DAG against other DAGs and make a decision on which DAG must be considered next for scheduling.

A list scheduling method to schedule multi-user jobs is developed by Barbosa et al. [9] with an aim to maximize the resource usage by allowing a floating mapping of processors to a given job, instead of the common mapping approach that assigns a fixed set of processors to a user job for a period of time. A master DAG where each node is a user job and each edge representing a priority of one job over another is constructed using all submitted DAGs. A list scheduling algorithm [6] is used to schedule all tasks of Master DAG. The master DAG is created based on job priorities and deadlines

Bittencourt et al. [10] have used Path Clustering Heuristic (PCH) to cluster tasks and the entire cluster is assigned to a single machine. They have proposed four heuristics which differ in the order tasks of multiple DAGs are considered for scheduling. The methods are sequential, Gap search method, Interleave algorithm and Group DAGs method. A meta-scheduler for multiple DAGs [11] merges multiple DAGs into one to improve the overall parallelism and optimize idle time of resources. The efforts are limited to the static case and they do not deal with dynamic workloads.

Duan et al. [12] have proposed a scheduling algorithm based on the adoption of game theory and idea of sequential cooperative game. They provide two novel algorithms to schedule multiple DAGs which work properly for applications that can be formulated as a typical solvable game. Zhifeng et al. [13] addresses the problem of dynamic scheduling multiple DAGs from different users. They expose a similar approach from Zhao et al. [4] without merging DAGs. Their algorithm is similar to G-heft algorithm.

An application which can exploit both task and data parallelism can be structured as Parallel Data Graph (PTG) in which task can be either sequential or data parallel. Data parallelism means parallel execution of the same code segment but on different sections of data, distributed over several processors in a network. A DAG is a special case of PTG where task can only be sequential task. Thus PTG scheduling is quite similar to DAG scheduling. Not much work is carried out in Multiple PTG scheduling. Tapke et al. [5] have proposed an approach where each PTG is given a maximum constraint on number of processors it can use and tasks are scheduled using a known PTG scheduling algorithm. The size of each processor subset is determined statically according to various criteria pertaining to the characteristics of PTG like maximum width, total absolute work to be done and proportional work to be carried out.

Sueter et al. [14] have focused on developing strategies that provide a fair distribution of resources among Parallel Task Graphs (PTG), with the objectives of achieving fairness and makespan minimization. Constraints are defined according to four general resource sharing policies: unbounded Share(S), Equal Share (ES), Proportional Share (PS), and Weighted Proportional Share (WPS). S policy uses all available resources. ES policy uses equal resources for each PTG. PS and WPS use resources proportional to the work of each PTG, where the work is considered as critical path cost by width of PTG.

A study of algorithms to schedule multiple PTGs on a single homogeneous cluster is carried out by Casanova et al. [15]. Therein it is shown that best algorithms in terms of performance and fairness all use the same principle of allocating a subset of processors to each PTG and that this subset remains fixed throughout the execution of the whole batch of PTGs. The basic idea in job schedulers [19] is to queue jobs and to schedule them one after the other using some simple rules like FCFS (First Come First Served) with priorities. Jackson et al. [20] extended this model with additional features like fairness and backfilling.

Online scheduling of multiple DAGs is addressed in [16]. Authors have proposed two strategies based on aggregating DAGs into a single DAG. A modified FCFS and Service-On-Time (SOT) scheduling are applied. FCFS appends arriving DAGs to an exit node of the single DAG, while SOT appends arriving DAGs to a task whose predecessors have not completed execution. Once the single DAG has been built, scheduling is carried out by HEFT.

An Online Workflow Management (OWM) strategy [18] for scheduling multiple mix-parallel workflows is proposed. DAG tasks are labelled, sorted, and stored into independent buffers. Labelling is based on the upward rank strategy. The sorting arranges tasks in descendent order of the task rank. Task scheduling referred to as a rank hybrid phase determines the task execution order. Tasks are sorted in descending order when all tasks in the queue belong to the same workflow. Otherwise, they are sorted in ascending order. Allocation assigns idle processors to tasks from the waiting queue.

Raphael et al. [23] have addressed online scheduling of several applications modelled as work-flows. They have extended a well-known list scheduling heuristic (HEFT) and adapted it to the multi-workflow context. Six different heuristics based on HEFT key ideas are proposed. These heuristics have been designed to improve the slowdown of different applications sent from multiple users.

Much work has not been done on scheduling multiple DAG applications. A common approach is to schedule a single DAG on fixed number of processors [6] but methods to find the number of processors to be used for a DAG, are not found in literature. Tapke et al. [5] have proposed methods to find maximum resource constraint for each PTG, while scheduling multiple PTGs. But they have not restricted scheduling of a PTG to the fixed set of processors. A method proposed by Barbosa et al. allows floating number of processors to a given job, instead of fixed number of processors. Many existing workflow scheduling methods do not use fixed set of processors for each DAG. Instead a task based on some heuristic is picked among tasks of all DAGs and is scheduled on a processor where it can start earliest based on some heuristic. The work proposed in this paper is similar to Barbosa [9] method, in the sense that a fixed set of processor is allocated for each DAG which later can be varied during runtime with the objective of maximizing resource usage. Their work does not address several issues like - how initial processor allotment for each DAG is made, a method to decide number of DAGs to be scheduled concurrently among several submitted DAGs, to deal with online submission of DAGs. This work addresses all the above mentioned issues.

3. PROCESSOR ALLOTMENT FOR A DAG

A schedule for a DAG can be obtained with varied number of processors. By increasing the number of processors allotted for a DAG, its makespan decreases. The gain in terms of reduction in makespan, reduces as more number of processors are allotted to a DAG. This is due to communication overhead and limited parallelism present in DAG. The optimal and maximum number of processors for a DAG will help in finding processor allotment while scheduling multiple DAGs concurrently on a cluster.

3.1. Maximum Number of Processor for a DAG

The maximum number of processors a DAG can utilize depends on its nature and degree of parallelism present in it. The number of allotted processors, beyond which DAG's makespan does not decrease with any more additional processors, is the maximum number of processors that can be utilized by a DAG. A brute force method can be used to find this, by making several calls to scheduling method and recording the makespan for each case. But an efficient binary search based method [24] is used in this work and its time complexity is O(log n) against O(n) of the brute force method.

3.2. Optimal Number of Processor for a DAG

Optimal number of processors for a DAG is that number up to which every added processor is utilized well and beyond it, they are underutilized. With increase in number of allotted processors, DAG's makespan decreases and average processor utilization decreases due to communication overhead and limited parallelism. Average processor utilization can best be measured using computing area, which is the product of makespan and the number of processors used. In this work, computing area is used to find the optimal number of processors for a DAG. As processor allotment to a DAG is increased, makespan decreases and computing area increases. Initially decrease in makespan is more than increase in computing area, justifying the worthiness of increase in processor allotment. After the processor allotment reaches a certain value, the increase in computing area is more than the decrease in makespan for every added processor, indicating that any further increase in processors allotment is not of significant use.

By successively increasing number of processors allotted for a DAG, makespan and computing area are recorded. The number of processors for which decrease in makespan becomes less than the increase in computing area, fixes the optimal number of processors for a DAG.

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4. MULTIPLE DAGS SHARING CLUSTER

It is advantageous to schedule multiple DAGs simultaneously on a cluster instead of dedicating the entire cluster to a single DAG, due to communication overhead. Furthermore, it is beneficial to schedule more number of DAGs each with relatively less number of processors than scheduling less number of DAGs each with large number of processors, because of communication overhead. The returns, in terms of decrease in makespan, for each additional processor differs for each DAG depending on its nature and number of processors already allotted to it. Hence additional processors must be allotted to those DAGs which will be benefitted most by means of reduction in makespan. To find the most benefitting DAGs, reduction in makespan for the next added processor must be known for each DAG. Reduction in makespan for every added processor can be best captured as an equation using regression analysis and are provided to scheduler along with DAG. During regression analysis of large number of DAGs, it is observed that for any DAG, makespan reduction follows either exponential or power curve. Thus for each DAG, makespan reduction for each added processor is recorded and curve fitting is done. The type of equation and its constants are stored along with each DAG, which then is used by the scheduler while finding processor allotment for each DAG, while scheduling multiple DAGs. The scheduler is invoked when a DAG arrives or a DAG completes execution. The minimum number of processors to be allotted for each DAG is assumed to be four, by conducting the experiments large number of times. The algorithm for the proposed scheduler is given below.

```
Algorithm multi_dag_scheduler()

// information submitted along each DAG – opt_proc, max_proc, eqn_type, eqn_const
//avail_proc – currently available number of free processors
// let min_core = 4
Input : submitted DAGs
Output : processor allotment and calling an instance of scheduler for each DAG

Step 1:  if (arrival)  then     // DAG has arrived
Step 2:         if (avail_proc < min_core ) then
Step 3:            append to waiting queue
Step 4:        else
Step 5 :          allot (min_proc or max_proc or opt_proc) whichever best fits avail_proc
Step 6 :          create an instance of scheduler for a DAG on allotted processors
Step 7 :        endif
Step 8:   else        //DAG has completed
Step 9:         if ( waiting queue is not empty) then
Step 10 :           do_allot()
Step 11 :       endif
Step 12 : end_algorithm
```

```
Algorithm do_allot()

Step 1:  remove those many number of DAGs from queue beginning, whose sum of their
           min_proc is less than avail_proc
Step 2 : if (sum of opt_proc of all removed DAGs is less than available processors) then
Step 3 :        allot opt_proc to each removed DAG
Step 4 :  else
Step 5 :      for each removed DAG allot their min_proc number of processors
Step 6 : endif
```

Step 7 : if (free processors are left) then
Step 8 : distribute those free processors among DAGs, in such a way that each processor is added to that DAG for which it yields maximum reduction in makespan, using equations types and their constants
Step 9 : endif
Step 10 : end_algorithm

5. EXPERIMENTAL SETUP AND RESULTS

5.1. Experiment Setup

A discrete-event based simulator is developed to simulate the arrival, scheduling, execution and completion of DAGs. Simulation allows performing statistically significant number of experiments for a wide range of application configurations. Poisson distribution is used to simulate the arrival time of DAGs. Several kinds of benchmark DAGs from several sources are used to experiment the proposed scheduler for different types of DAGs. Series-parallel DAGs from Task Graphs For Free [22], random DAGs from Standard Task Graph Set [21], DAGs of linear algebra applications like FFT, LU decomposition, Gauss-elimination, Laplace transform and workflows like LIGO, cybershake, Montage, SIPHT[25]. DAGs with CCR values of 0.1, 0.4, 1 and 5 are used in experiments.

5.2. Results and Analysis

5.2.1. Optimal and Maximum Number of Processors for a DAG

An efficient binary search based method [24] with time complexity of O(log(n)) is used to find the maximum number of processors a DAG can utilize. The decrease in makespan and increase in computing area (decrease in average processor utilization) for every added processor is used to fix the optimal number of processors for a DAG. The plot of decrease in makespan and increase in computing area for different number of processors, for a DAG is given in Fig.3. The crossover point gives the optimal number of processors for that DAG. The method can be used for any kind of DAG.

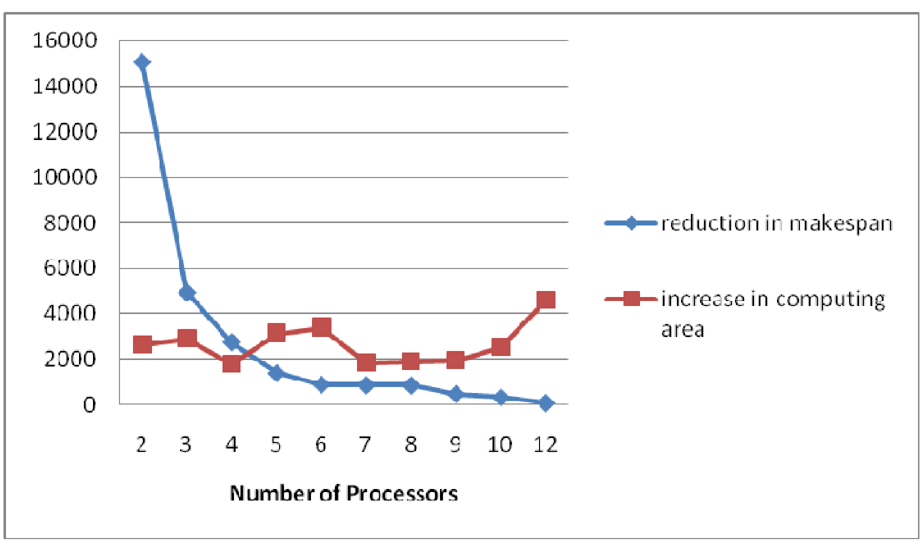

Figure 3. To find Optimal Number of Processors for a DAG

5.2.1. Multiple DAGs Scheduling

Recent works on multiple DAG scheduling [4, 5, 9, 10, 11, 12, 14] have not considered allotment of fixed set of processors to a DAG. Instead, tasks from all DAGs are scheduled on any processor on which they can start earliest, using some heuristic. Hence initially, it is proved experimentally that space partitioning of processors among multiple DAGs, delivers improvement in performance compared to combined DAGs scheduling. To experiment this, a set of DAGs of all kinds, were scheduled on a cluster with 100 numbers of processors. The metric used is the sum of computing area of all scheduled DAGs. To study the effect on both computation intensive and communication intensive applications, DAGs with both low and high CCR are considered. Two sets of DAGs each with 8 and 16 number of DAGs, under each category are considered. Thus the four categories of DAGs are labelled as ccrl_8, ccrl_16, ccrh_8 and ccrh_16. Since the behaviour depends on the nature of DAG, 50 sets of DAGs are considered for each category. Care is taken to consider all different types of DAGs in the sets of DAGs. The results obtained from 50 sets are averaged and the same is shown in Fig. 4. The performance of the proposed method is better than combined DAGs scheduling for all four categories of DAGs. For the category ccrh_8, proposed method shows maximum improvement of 12%, since DAGs are communication intensive and thus scheduling tasks on fixed set of processors reduces time to complete the DAG. Performance improvement is only 9% for the category ccrh_18, as there is less scope for further improvement due to large number of DAGs being scheduled together.

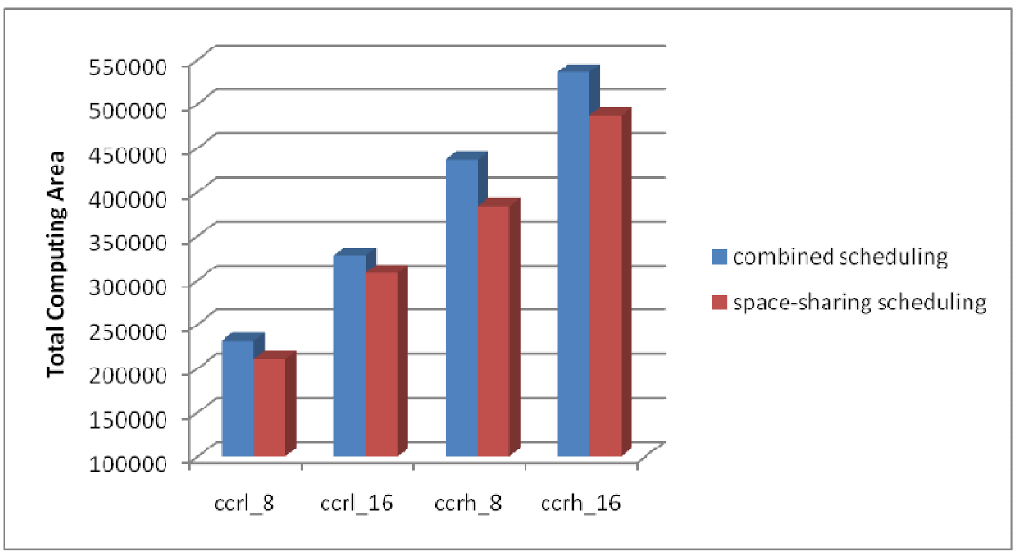

Figure 4. Combined DAGs scheduling vs Proposed Space-sharing Schedule

The benefits of space partitioning processors which cannot be measured for DAGs with dummy tasks are 1) as tasks of a DAG are scheduled on the same set of processors, they will be benefitted from cache-warm and secondary memory warm. 2) an online scheduler can be used for each DAG, after allotting a set of processors to it. 3) processor allotment for a DAG can be varied depending on availability of processor, with the objectives of maximizing resource utilization.

A highlight of this work is to find one best way to share available processors among multiple DAGs, using regression analysis. The proposed work is compared against policies proposed by Tapke et al. [14] - unbounded Share(S), Equal Share (ES), Proportional Share (PS), and Weighted Proportional Share (WPS). The strategy S which is a selfish allocations and tasks of different DAGs are not differentiated is used as a baseline performer for other strategies as it gives an indication of performance of heuristics originally designed for single DAG. Values obtained are normalized with the value of S strategy, to help in comparison. Performance metric used is average makespan and resource utilization which is measured as the sum of computing area of all DAGs scheduled together. Five categories of DAGs each with 4, 8, 12, 16 and 20 number of DAGs are considered. Random, series-parallel, linear algebra DAGs and various workflows like montage, SIPHT, epigenemics, LIGO are considered. 100 sets of DAGs are considered for each category and the results obtained are averaged. The result is shown in Fig. 5 and Fig. 6. The proposed method is better than all policies found in literature.

For less number of DAGs, performance of all methods is almost the same, as there will not be much conflict for resources. With more number of DAGs, resource conflicts increase and the proposed method shows considerable good performance over previous methods.

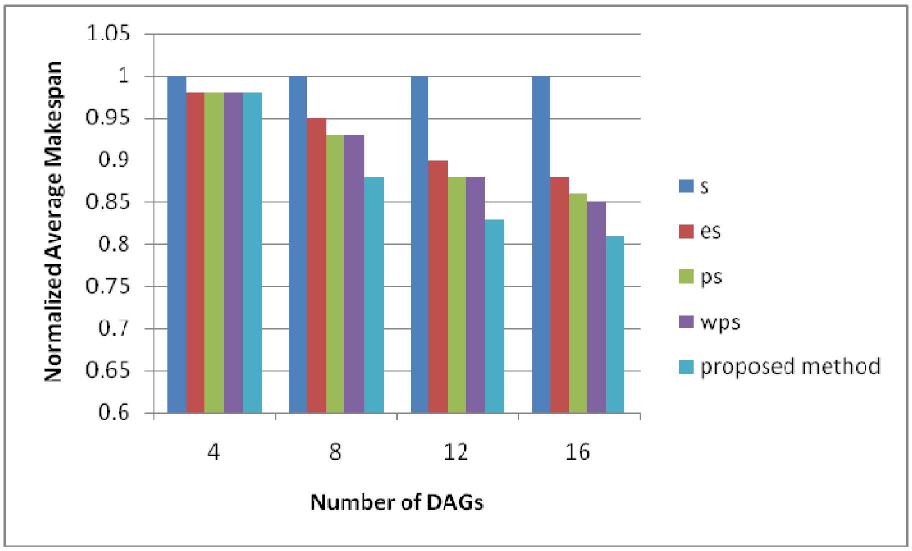

Figure 5. Normalized Average Makespan of Set of DAGs

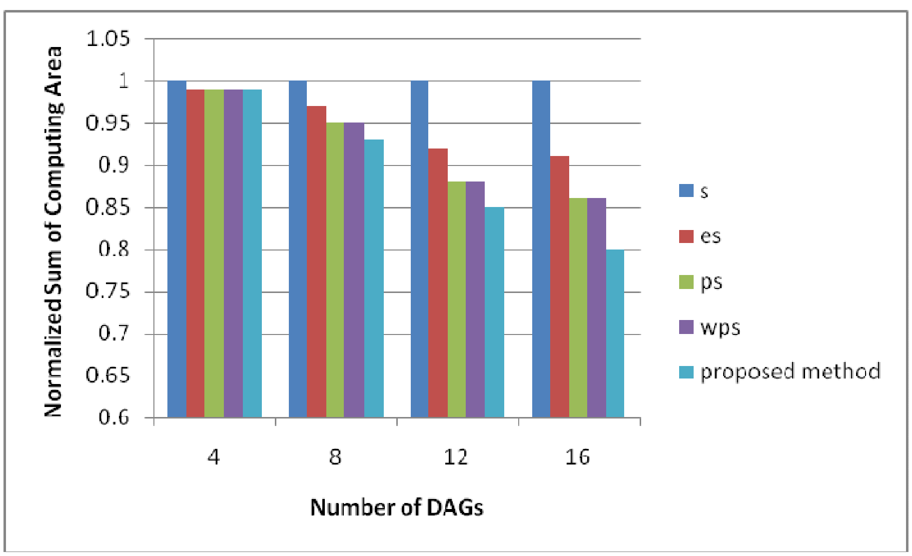

Figure 6. Normalized Sum of Computing Area of Set of DAGs

6. CONCLUSIONS

Multiple DAGs scheduling on a cluster is not receiving the deserved attention. Few methods found in literature performing combined DAGs scheduling. But in this work, it is proposed to allot a fixed number of processors to each DAG and an instance of local DAG scheduler to schedule DAG's tasks only on the allotted fixed set of processors. A method to find the maximum and optimal number of processors that can be allotted to a DAG is given, which will be used to find the processor allotment for each DAG while scheduling multiple DAGs. A new framework to schedule multiple DAGs with the objectives of maximizing resource utilization and minimizing DAGs completion time is proposed. Regression analysis is used to find the number of processors to be allotted to each DAG while scheduling multiple DAGs. This method is proved to outperform other methods found in literature by around 10-15%.

The other big advantage of the proposed approach is that instead of static schedule, an online scheduler for each DAG can be used to schedule tasks, as they are generated, onto the allotted processor. An Online scheduler overcomes drawbacks of static schedule and is more advantageous. Also static DAG information can be used during online scheduling to further improve performance. Because of space sharing of processors, the number of processors allotted to each DAG can be varied during runtime, depending on the availability of free processors. This will improve resource utilization, hence performance of the scheduler. In future work, the idea of online scheduler and varied processor allotment for each DAG will be experimented.

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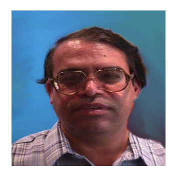

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TASK & RESOURCE SELF-ADAPTIVE EMBEDDED REAL-TIME OPERATING SYSTEM MICROKERNEL FOR WIRELESS SENSOR NODES

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ABSTRACT

Wireless Sensor Networks (WSNs) are used in many application fields, such as military, healthcare, environment surveillance, etc. The WSN OS based on event-driven model doesn't support real-time and multi-task application types and the OSs based on thread-driven model consume much energy because of frequent context switch. Due to the high-dense and large-scale deployment of sensor nodes, it is very difficult to collect sensor nodes to update their software. Furthermore, the sensor nodes are vulnerable to security attacks because of the characteristics of broadcast communication and unattended application. This paper presents a task and resource self-adaptive embedded real-time microkernel, which proposes hybrid programming model and offers a two-level scheduling strategy to support real-time multi-task correspondingly. A communication scheme, which takes the "tuple" space and "IN/OUT" primitives from "LINDA", is proposed to support some collaborative and distributed tasks. In addition, this kernel implements a run-time over-the-air updating mechanism and provides a security policy to avoid the attacks and ensure the reliable operation of nodes. The performance evaluation is proposed and the experiential results show this kernel is task-oriented and resource-aware and can be used for the applications of event-driven and real-time multi-task.

KEYWORDS

WSN, event-driven, thread-driven, scheduling strategy, over-the-air, security

1. INTRODUCTION

Wireless sensor networks (WSN) have gained a great development in recent years. Many WSN applications are emerging rapidly and being applied in different scenarios. Unlike traditional embedded devices, the sensor nodes have many resource constraints, such as limited energy, short communication range, low bandwidth, and limited processing memory. In addition, sensor nodes are generally deployed large-scaly and far from human access. Thus, the characteristics of WSN applications bring some challenges for designing an OS on sensor nodes, described as follows:

1. To reduce power consumption and memory requirements for resource-constrained nodes.
2. To support Multi-task in view of diversity of WSN applications.

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3. To update codes remotely and dynamically.
4. To provide security services in resource-constrained nodes

This paper presents a novel task and resource self-adaptive real-time microkernel for wireless sensor nodes. The kernel provides a hybrid programming model, which combines the benefits of Event-driven and Thread-driven model. Correspondingly, the kernel adopts event & thread 2 level strategies aimed at supporting real-time multi-task. Moreover, to make the nodes capable of coping with new tasks and then adjusting their behaviours in different environments, the kernel provides an over-the-air reprogramming mechanism to update the code of the OS dynamically. The kernel also provides a security service to avoid the attacks and ensure the normal operation of nodes.

The rest of this paper is organized as follows: Section 2 discusses the related work on WSN OS design. Section 3 describes the kernel in detail, including its architecture, hybrid programming model, scheduling strategy, the run-time updating mechanism and its security policy. In Section 4, we evaluate the performance and overheads, and draw the conclusions. Finally, we will give a brief conclusion in Section 5.

2. RELATED WORK

At present, there are two different research methodologies for WSN OS: one is to streamline the general RTOS(such as the μC/OS-II[1], VxWorks[2], Windows CE[3]) but they are not suitable for resource-constrained nodes. Another is to develop a dedicated OS according to the characteristic of WSN, such as TinyOS[4], SOS[5], MantisOS[6], and Contiki[7]. But most of dedicated WSN OS are built on network protocols without supporting multi-task and event-driven at the same time.

2.1. Architecture

The kernel architecture has an influence on the size of the OS kernel as well as on the way it provides services to the application programs. For resource-constrained sensor nodes, we must take the performance and flexibility into consideration at same time.

A WSN OS should have an architecture that results in a small kernel size, hence small memory footprint. The architecture must be flexible, that is, only application-required services get loaded onto the system [8].The followings are the feature analyses of three mainstream architectures [9], as described in Table 1.

Table 1. Features of 3 mainstream architectures.

Architectures	Features
Monolithic	• a single image for the node • not suitable for frequent changes
Modular	• Organized as independent module • fits well in reconfiguration • extra overhead of loading and unloading modules
Virtual machine	• whole network of nodes is a single entity • gives flexibility in developing applications

2.2. Programming Model

An appropriate programming model not only facilitates software development but also promotes good programming practices [10]. The issue between event-driven mode and thread-driven model has been discussed in the WSN field for years. Table 2 shows the advantages and disadvantages of event-driven and thread-driven model with its corresponding OSs [11].

Table 2. Event-driven vs.Thread-driven

Model	advantages	disadvantages	OS
Event-driven	• Concurrency with low resources • Inexpensive scheduling • Complements the way networking protocols work • Highly portable	• Event-loop is in control • Can't be preempted and do not support multi-task • Bounded buffer producer consumer problem	Tiny OS, SOS, Contik
Thread-driven	• Eliminates bounded buffer problem • Automatic scheduling • Real-time performance • Simulates parallel execution	• Complex shared memory • Expensive context switches • Complex stack analyze	Contiki Mantis OS

2.3. Run-time Remote-updating

Due to the dense and large-scale deployment of the sensor nodes, we should provide a mechanism to update nodes over-the-air: collecting nodes to apply updates is often tedious or even dangerous [12]. Remote code-update schemes for sensor nodes meet two key challenges: (1) resource consumption and (2) integration into the system architecture. Existing approaches can be classified into three main categories.

Full-Image Replacement: These techniques such as XNP [14] or Deluge [15] operate by disseminating a new binary image of an application and the OS in the network. However, frequent full image replacements result in huge energy consumption and short-life of sensor node.

Virtual Machines (VM): VMs can reduce the energy-cost of disseminating new functionality in the network as VM code is commonly more compact than native code [16]. However, as mentioned in architecture, it is hard to be realized on a resource-constrained sensor node.

Dynamic Module Loading: It is also called the incremental update. Unlike the full image replacement, the kernel will not be modified and just add e new or remove modules, such as Contiki, SOS and TinyOS. This mechanism can reduce the updating code size and energy-consumption.

2.4. Security Guarantee

WSNs suffer from many constraints, including low computation capability, small memory, limited energy resources, susceptibility to physical capture, and the use of insecure wireless communication channels. These constraints make security in WSNs a challenge.

At present, the researches on security are classified into five categories: cryptography, key-management, secure routing, secure data aggregation, and intrusion detection. Among them, cryptography and key-management are regarded as the core issues in WSN security.

3. TASK & RESOURCE SELF-ADAPTIVE OPERATING SYSTEM DESIGN

3.1. Microkernel Design

3.1.1. Architecture

As the kernel is task and resource self-adaptive, we must take the performance and the flexibility into consideration at the same time. So the kernel takes the modular structure based on its requirement as illustrated.

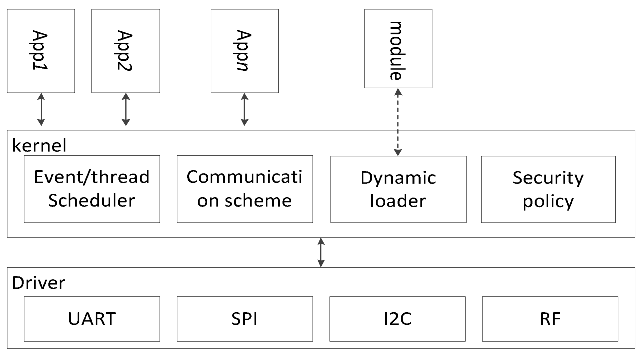

Figure 1. Architecture of task-oriented and resource-aware operating system

Figure 1 shows the kernel structure of task and resource self-adaptive WSN OS. The hardware driver is isolated from the kernel. Applications can also access kernel function by API and system call. Moreover, Applications are loaded as modules for processing the specific task. By this way, the node can adapt to the environment automatically.

3.1.2. Hybrid programming model

As mentioned in section 2, the event can't be preempted and doesn't support real-time multi-task. And thread-driven model consumes much energy on context switching .The kernel integrates advantages of the event-driven and thread-driven model and proposes a hybrid programming model. The kernel is defined as a set of events, and an event is then defined as a set of threads, as shown in Equation 1 and 2

$$K=\{E_{i:}i=1,2,\cdots,n;\ E_1\rightarrow E_2\cdots\rightarrow E_n\} \tag{1}$$

$$E_i=\{T_{i,j}:\ j=1,2,\ \cdots,n;T_{i,1}//T_{i,2}//\cdots//T_{i,n}\} \tag{2}$$

The K is an instance of the kernel, E represents an event and T is a thread. The symbol '→' indicates the precedence operation and '//' indicates the concurrent operation.

The feature of the hybrid programming model is that the node can easily switch operation mode between two typical programming models according to the kind of task. If we set the event number equal 1, the kernel runs in the manner of multi-thread model, shown in Figure 2**.** While if event contains a single thread, the kernel runs in the manner of event-driven model.

The kernel is task self-adaptive automatically to work in different modes, thus the scopes of applications will be greatly extended.

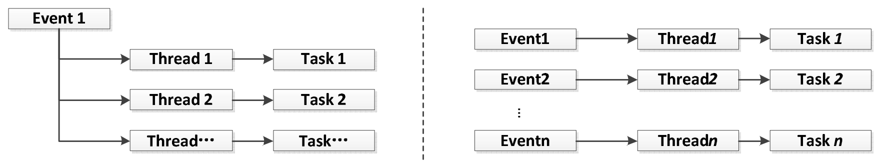

Figure 2. Switch to the thread-driven mode &Switch to Event-driven mode

3.1.3. Communication Scheme

From the view of operating system, the communication refers to two parts: internal communication in single node and the communication between nodes. In addition, most of WSN OS is designed for a single node without supporting communication in distributed network.

Therefore, the kernel proposes a scheme to unify the inter-process communication and communication between nodes. This scheme is based on "tuple space", a thought from a parallel programming language "Linda" [17], through "In / Out" system primitives to achieve the communication of inter-event, inter-thread, event/thread-peripherals and inter-CPU, as shown in Figure 3. Each "tuple" is identified by one numeric identifier, which can be assigned to the local or distributed buffer. And user can customize it automatically.

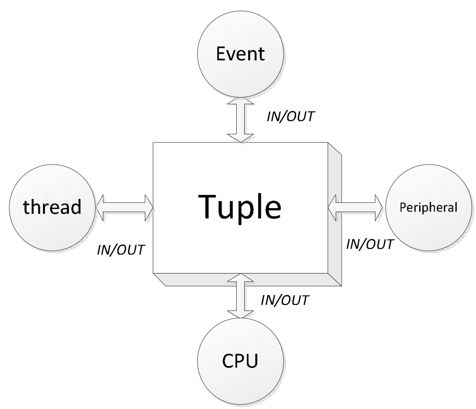

Figure 3. Tuple-based unified communication scheme

3.1.4. Scheduling strategy.

Based on hybrid programming model and tuple space, the kernel offers a two-level scheduling strategy: 'event-driven' (scheduling for events) and 'priority-based preemptive' (scheduling for threads).

Event management

Each event is associated with a unique tuple identified by a numeric identifier. A tuple has its private buffer space which is used for storing messages or signals received from hardware or software interrupts. Each event has also a priority level which is adapted automatically to the message number of the event tuple according to the event priority. The priority of the event can be pre-defined by programmer, as shown in (3)

$$Event\_next = select\_event(\ tuple\_msg\_num,\ priority) \qquad (3)$$

The strategy is sensitive to the memory consumption and proved a solution for the problem that event cant' be preempted. Thus, the kernel can make a rapid response to emergent tasks.

Thread scheduler

In comparison with events, threads have one more state named ‘Suspend’. If the operating condition is not met, this thread is blocked and its state changes to ‘Suspend’. Whereas, if the operating condition is satisfied, the suspended thread is activated to resume running and its state changes to ‘Ready’. Each thread is allocated with a unique priority level. Thread can be preempted by other threads in a same event. The kernel adopts a ‘priority-based preemptive’ scheduling scheme and the scheduler will decide next-run thread through look up the value of *thread_priority* and *thread_timeslice*, as shown in Equation (4)

$$thread\_next=select\_thread(priotity,time\_slice) \tag{4}$$

Through switching the threads, the system can process multiple tasks concurrently. For some periodic tasks such as data collections, sampling and interval routing, the kernel can be customized to thread-driven mode and process them at the same time. However, if the system is used to detect some events, the kernel can be switched to the event-driven mode to make a rapid response.

3.2. Run-time over-the-air updating mechanism

As the kernel is task-oriented, it is necessary for nodes to provide a run-time over-the-air updating mechanism, which is described from three levels according to granularity of updating code size.

Global variable modification

In the kernel, there exist many global variables pre-defined by developers, which can determine the operating routines. Through modifying the global variable in the ram, the node can be switched to another operation mode. So the kernel will maintain a variable table which keeps the information of the global variables, including the variable name and the physical address. After rebooting the nodes, the new mode is activated. Meanwhile, a set of remote-commands is designed to inform the node to update the global variables. The method relatively consumes little power because only several bytes are transmitted and modified.

Dynamically loading Module

In the modular architecture, the kernel can load new module or unload the existing module at run time without rebooting the node. Thus, just the necessary modules need to be transmitted, that is an efficient way to reduce the update code size and optimize the power usage. The procedure can be divided into the following steps [18]:

1. *Meta-Data Generation:* The meta-data consists of information about the whole program, component specific information, symbol information, and the relocation table.
2. *Code Distribution*: during this step, the new modules together with their meta-data are transmitted from the base station or the sink node.
3. *Data Storage on the Node*: Once modules with meta-data are received at the radio interface of the node, they are stored in the external FLASH memory.
4. *Register module*: the kernel merges information of the new module’s meta-data with the old symbol table in order to access to the new module and invoke the new functions.
5. *Relocation Table Substitution*: the kernel will substitute the old relocation table with the new one.
6. *Update Reference*s: through the new relocation table, the kernel can update the references of the global variable in the data segment or the function address in the code segment.

Full image replacement

This level is designed for updating the whole kernel image. Namely, when the new version of the kernel differs from the old one greatly, the node should erase the whole image and program the new version into the flash. For resource-constrained nodes, it is unlikely to modify the kernel frequently. So full image replacement is relatively rarely used.

3.3. Security policy

Due to the nature of wireless connection and unattended mode, the sensor node is prone to security attack. The kernel provides a security policy for sensor nodes, in order to guarantee the normal operation of the nodes and support reliable and efficient code distribution.

3.3.1. Cryptography

The traditional encryption algorithm is divided in two categories: symmetric cryptography (such as RC4, RC5, SHA-1 and MD5) and asymmetric cryptography (such as RSA and ECC). Therefore, the kernel adopts a tow-level cryptography mechanism, as shown in Figure 4. In symmetric cryptography, hashing algorithms (MD5 and SHA-11) incurred almost an order of a magnitude higher overhead than encryption algorithms (RC4, RC5). Thus, RC5 is adopted for communication between resource-constrained nodes. Meanwhile, the RSA algorithm, a typical asymmetric cryptography is applied for communication between nodes and sink node or base station which has adequate resource.

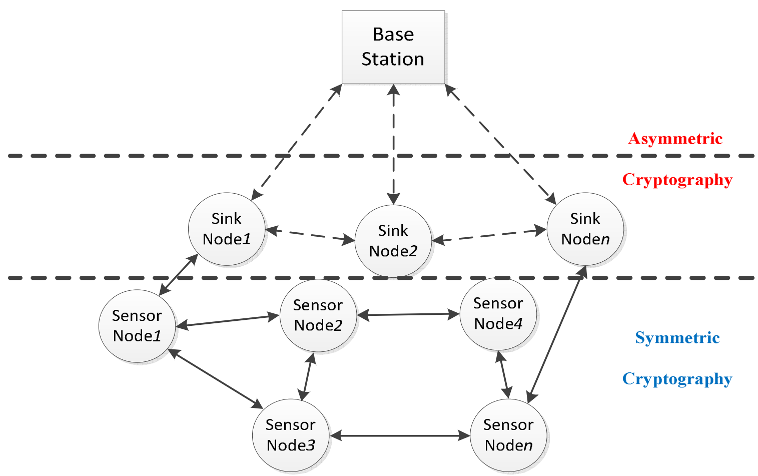

Figure 4. The two-level cryptography mechanism

3.3.2. Key Management.

In Sensor networks end-to-end encryption is impractical because of large number of communicating nodes and each node is incapable of storing large number of encryption keys. We assume that the number of sensor nodes in WSN is *N*. Storing the keys of other *N-1* nodes will occupy large memory of the limited memory nodes.

In order to reduce the memory the keys occupied, the kernel takes the hop-by-hop encryption mechanism, in which each sensor node stores encryption keys shared with its immediate neighbours. Thus the keys stored in nodes can be divided into 2 parts: the keys *Kn*, which is shared with its neighbours and the key *Ks, which* is shared with the base station or sink node. This mechanism reduces the memory the keys occupied and the power consumption of transmitting keys.

4. EVALUATION

4.1. Sensor platform

The kernel has been tested on the AT91SAM7S evaluation board which include AT91SAM7S256 processor core (based on arm7),256Kbytes Flash, 64Kbytes SRAM, and peripherals such as UART, SPI, and I2C etc. The RF module is XBEE-PRO [21] (based on Zigbee) which communicates with the processor core through UART (RS-232 protocol).

4.2. Performance analysis

4.2.1. Memory usage

Table 3 shows the storage usage of the kernel. It occupies no more than 5KB and is suitable for resource-constrained sensor node. The code size of whole image which includes kernel, hard drivers and applications is less than 30KB. Thus, the kernel is flexible and portable to heterogeneous sensor nodes.

Table 3. Code size and data size of the kernel and whole system

	Code size(bytes)	Data size(bytes)
Kernel	3572	1272
Kernel+Driver+Applications	16988	11929

4.2.2. Power analysis

To reduce energy consumption, the main energy-aware module of the sensor node (microprocessor, wireless RF module) support low power mode, as shown in Table 4.

Table 4. Power consumption evaluation

Chips		Power consumption	
		Normal mode	Low power mode
AT91SAM7S256(48MHz)		<50mA	<60µA
Xbee-pro	Transmit Mode	<250mA	
	Receive Mode	<50mA	
	Sleep Mode	<50µA	

When the system is in idle state (no data transmission or no running components), the kernel can customize the node configuration to make it run at low power mode to reduce the consumption and prolong the lifetime of the node. Thus, it demonstrated that the kernel is task and resource self-adaptive for sensor node.

4.2.3. Overhead of scheduling strategy

The kernel adopts event/thread 2 level scheduling strategies to support real-time multi-task. This paper evaluates the overhead of scheduling strategy from 3 aspects: Interrupt response time, Event switch time and Thread switch time.

Table 5. Overhead of scheduling strategy

	Overhead (instruction cycle)			Time (μS)(48Mhz)		
	min	avg	max	min	avg	max
Event switch time	164	168	516	3.4	3.5	10.7
Thread switch time	176	93	798	3.6	1.9	16.6
Interrupt response time	157	194	395	3.2	4	8.2

Table 5 shows the overhead of the scheduling strategy through testing the average time mentioned above.

4.2.4. Overhead of run-time updating mechanism

As mentioned in chapter 3, the paper proposes a run-time remote-updating scheme from 3 levels according to the granularity of the updating code size. Obviously, the overhead and power consumption is determined by the code size disseminated to a great extent. The paper evaluates the overhead from two aspects, dynamic loading of modules and full image replacement.

Table 6. Comparison of energy-consumption of dynamic loading and full image replacement

step	Dynamic loading (mJ)	Full image replacement(mJ)
Code size	160bytes	28917bytes
Receive data	17mJ	330mJ
Store data	1.1mJ	22mJ
Reloc&ref updating	14.mJ	0mJ

As the meta-data generation is executed in sink node or base station, the paper evaluate the energy-consumption of the rest of steps, which are executed in sensor node. The table 6 shows the Comparison of energy-consumption of dynamic loading and full image replacement.

5. CONCLUSION

This paper presents a novel task and resource self-adaptive real-time microkernel for wireless sensor nodes. Based on the modular architecture, the kernel integrates the benefits of Event-driven and Thread-driven model to make the kernel capable of processing real-time tasks and multi-task. Moreover, in order to adapt to the complex environment, the sensor nodes are enabled to be customized and configured dynamically through the run-time over-the-air updating mechanism. A two level Cryptography mechanism and key management is also proposed for resource-constrained node to guarantee the reliable and efficient communication and code distribution.

Through analysis of the evaluation results, the kernel has good performance in communication throughout, supporting real-time task, and over-the-air updating mechanism. Compared with other dedicated WSN OSs, the kernel consumes more energy and memory. The verification of the updating code integrity should also be taken into account in over-the-air updating mechanism. In addition, there is still much room for optimizing the cryptography algorithm and managing the keys more efficiently.

Finally, the kernel extends the range of WSN application and provides the reliability and robustness for the complex application.

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ANALYSIS OF SIGNAL TRANSITION ACTIVITY IN FIR FILTERS IMPLEMENTED BY PARALLEL MULTIPLIER ACCUMULATOR BASED ON MODIFIED BOOTH ALGORITHM

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ABSTRACT

The MAC architecture is used in real time digital signal processing and multimedia information processing which requires high throughput. A novel method to estimate the transition activity at the nodes of a multiplier accumulator architecture based on modified booth algorithm implementing finite impulse response filter is proposed in this paper. The input signals are described by a stationary Gaussian process and the transition activity per bit of a signal word is modeled according to the dual bit type (DBT) model. This estimation is based on the mathematical formulation by multiplexing mechanism on the breakpoints of the DBT model.

KEYWORDS

Digital Signal Processing (DSP), MAC, dual-bit type (DBT), multiplexing mechanism, signal transition activity, word level activity

1. INTRODUCTION

Multiplier and multiplier-and-accumulator (MAC) [1] are the important elements of the digital signal processors. For example, many filters and channel estimators require FIR or FFT/IFFT computations that MAC units can accelerate efficiently. The Booth multiplier has the highest operational speed and less hardware count.

To increase the speed of MAC, the modified radix-4 Booth's algorithm (MBA) [2] is usually used. The power dissipation in very large scale integration (VLSI) is the major concern. The dynamic power consumed during charging and discharging the load and parasitic capacitances, depends on the number of transitions occurring at the capacitive nodes, estimation of the average

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number of bit level signal transitions is a most requirement of the power estimation techniques. Estimation of the data path power consumption at the architectural level based on the dual –bit-type (DBT) model has been explained in [3]. In DBT model, the LSB's of a word behaves as random sequences and the MSB's exhibits nonrandom behavior. The bit level activity is explained in [4]. The DBT model and high level signal statistics for the estimation of the bit level transition activity on filters has been proposed in [5]. This paper deals with the accurate calculation of transition activity at the nodes of a MAC which is used in FIR filter, is discussed. The DBT model is followed to calculate required word-level signal statistics at the nodes of the MAC, with known statistics.

2. MULTIPLIER ARCHITECHTURE

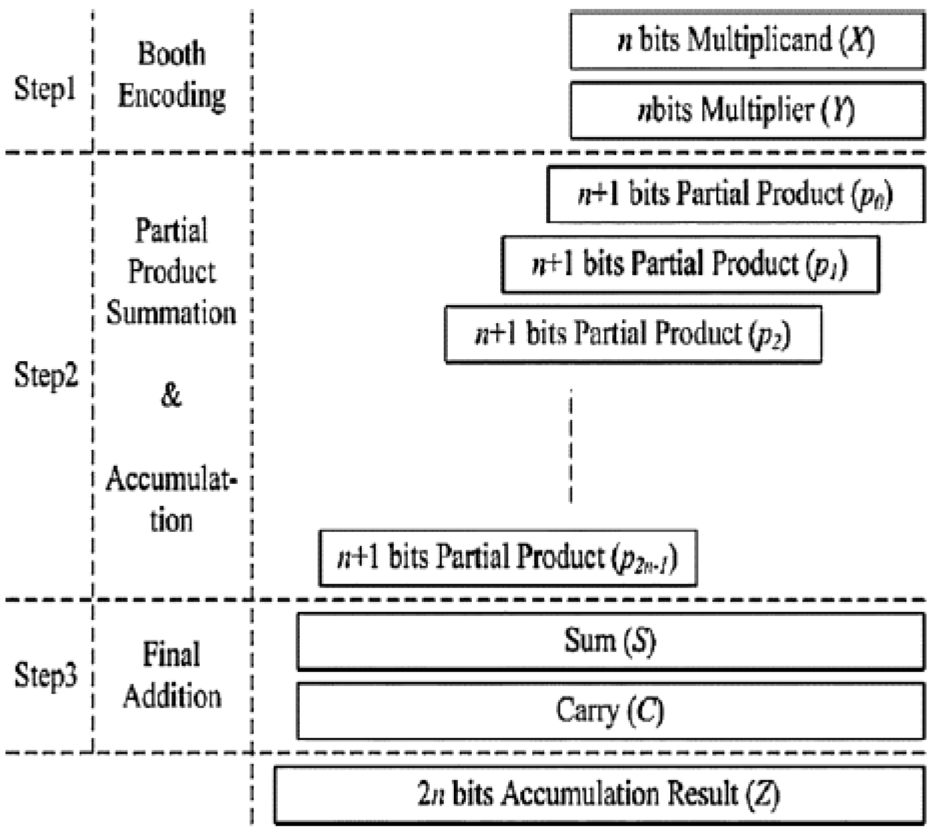

Fig.1. Basic arithmetic operation of multiplication and accumulation

The Multipliers has two parts. The first part is to generate the partial products, and the second one is to collect and add them. The multiplier accumulator composed of three blocks: the booth encoder, partial product summer and accumulator, and final adder. The partial product can be generated by using any one of the multiplication algorithm which uses bit serial, serial-parallel, or full parallel techniques. The booth algorithm or the modified booth algorithm is used for the generation of partial products. The basic arithmetic operation of multiplication and accumulation is shown in fig.1. The signed multiplication based on 2's complement is possible. If N-bit data are multiplied the number of partial product also equal to N. the Modified Booth encoding is used to reduce the number of partial products [7].

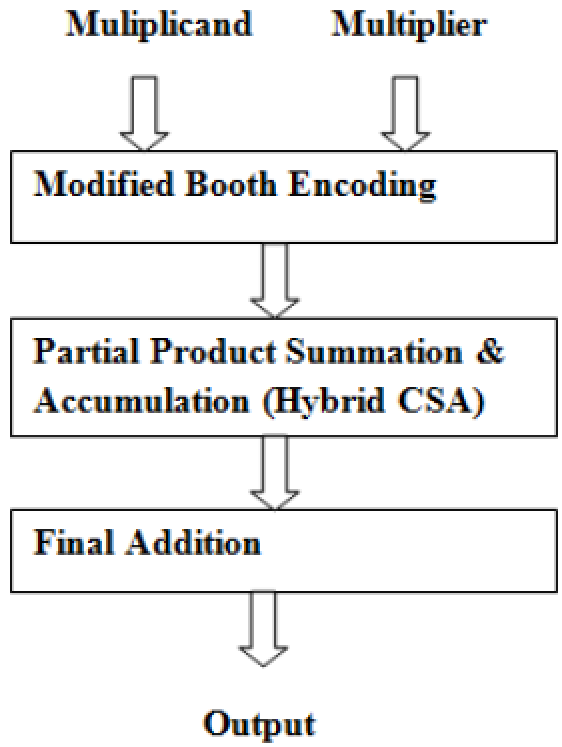

Fig.2. Multiplication process by Modified Booth Encoding.

3. Word Level Statistics and Transition Activity

The input sequence of a DSP system bex(n) and can be modeled by stationary Gaussian process with mean value μ variance σ^2 , and correlation factor ρ. Let $b_{<i>}(n)$, be the ith bit of the binary word representing x(n). The probability of $b_{<i>}(n)$ be one or zero and is denoted by p_1^i and p_0^i respectively, the conditional probability of $b_{<i>}(n)$ be in state *l*is given by $b_{<i>}(n-1)$, in state k is denoted by p_{kl}^i , where k, *l* = 0,1. The transition probability tp_{kl}^i is the probability of $b_{<i>}(n) = 1$ and $b_{<i>}(n) = k$. Therefore $p_{kl}^i = p_k^i\ p_{kl}^i$. Thus, the transition activity t_i of $b_{<i>}(n)$ is

$$t_i = tp_{01}^i + tp_{10}^i = p_0^i p_{01}^i + p_1^i p_{10}^i$$

It is observed that for $p_0^i = p_1^i = 0.5, p_{01}^i = p_{10}^i$ and therefore $t_i = p_{01}^i$

The transition activity is a function of bit level correlation factor $\rho_{<i>}$ [5].

$$t_i = 2p_1^i p_0^i(1 - \rho_{<i>})$$

4. BIT LEVEL STATISTICS

The bit level correlation factor is modeled by DBT model [5],[3]. A signal word is divided into three regions of continuous bits as the LSB, linear and MSB regions. The breakpoints BP_0 and BP_1 which defines the linear regions given by

$$BP_0 = log_2^{\sigma} + log_2^{[\sqrt{1-\rho^2}+\frac{|\rho|}{8}]}$$

$$BP_0 = log_2^{3\sigma}$$

The MSB's are highly correlated signals which have low transition activity while anticorrelated ones possess high activity. The transition activity can be expressed as

$$t_i = \begin{cases} 2p_1^i p_0^i, & i < BP_0 \\ \frac{t_{msb}(i-BP_0)-2p_1^i p_0^i(i-BP_1)}{BP_1 - BP_0}, & BP_0 \le i \le BP_1 \\ t_{msb}, & i \ge BP_1 \end{cases}$$

Where t_{msb} is the activity of the MSB. For zero mean Gaussian signals, the word level correlation factor for t_{msb} is given by

$$t_{msb} = (1/\pi)cos^{-1}(\rho)$$

5. SIGNAL STATISTICS IN FIR FILTER

The signal statistics at the output of the *l* th tap of an FIR filter is the function of the input statistics and the filter coefficients are expressed as

$$\mu_{f-l} = \mu \sum_{i=0}^{l} c_i$$

$$\sigma_{f-l}^2 = \sigma^2 \sum_{i=0}^{l} c_i^2 + 2 \sum_{i=0}^{l-1} \sum_{i=0}^{l} \rho(j-i) c_i c_j$$

$$\rho_{f-l} = \frac{\sigma^2}{\sigma_{f-l}^2} \left(\sum_{i=0}^{l-1} c_i c_{i+1} + \sum_{i=0}^{l} \sum_{j=0}^{l} c_i c_j \rho(j-i+1) + \sum_{i=0}^{l-2} \sum_{j=i+2}^{l} c_i c_j \rho(j-i-1) \right)$$

The structure of FIR filter is shown in fig.3.

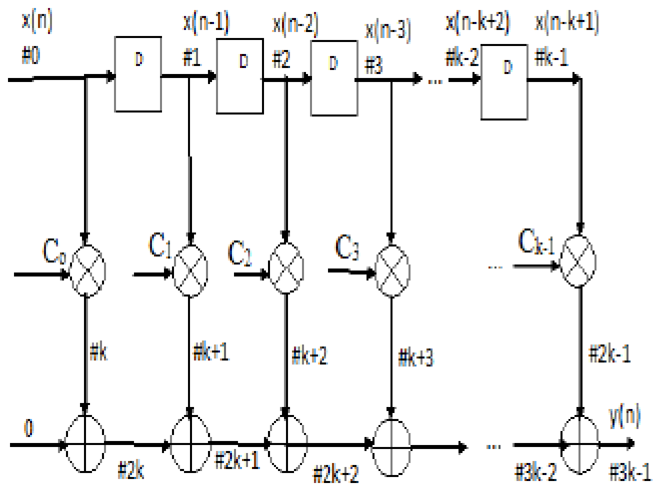

Fig.3.FIR filter structure

6. MAPPING THE FIR FILTER STRUCTURE ON A MAC BASED ON MODIFIED BOOTH ALGORITHM

The architecture of FIR filter implemented by MAC using modified Booth algorithm is shown in Fig.4. Registers are inserted at the input and output of the MAC unit to increase the data throughput rate. The sampling period of the input signal at the nodes of the filter structure is a sequence in the time domain at the corresponding nodes of the MAC architecture. During the n^{th} input signal sampling period, the sequence [x(n), x(n-1), x(n-2)….x(n-k+1)] appears at the input node #1 of the MAC. The control signal is given at node #2, is a increasing integer in the interval [0, k-1], returning back to zero at every new sample. A mathematical approach to find the statistics of its input sequence is mixing method [8]. The output distribution is a linear combination of the inputs. When all the inputs show identical normal distribution the output distribution remains Gaussian. When all the input sequences have equal mean values and different variances the output distribution is symmetric around the mean value, but not normal. When the input sequences have different mean values, the output distribution is nonsymmetric.

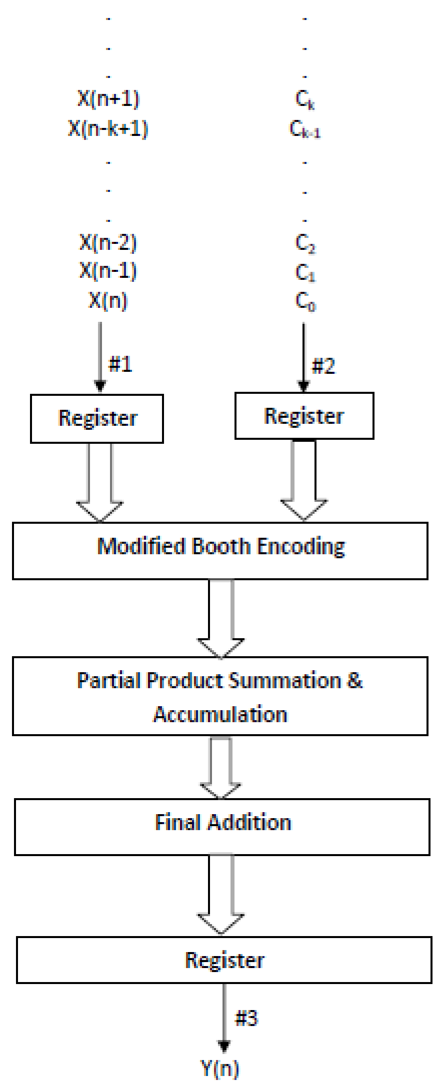

Fig.4.Signal activity at the nodes of MAC unit with Modified Booth Algorithm

7. SIGNAL ACTIVITY AT THE NODES OF MAC

The input signals at the nodes of the MAC unit are the output from the multiplexers. The multiplexing mechanism is used for the signal statistics. The input signal x(n) is described by a stationary Gaussian process with signal statistics μ, σ^2 and ρ. The statistics of the input signal at node#1 are given by

$$\mu_1 = \mu$$

$$\sigma_1^2 = \sigma^2$$

$$\rho_1 = (E[y_1(n)y_1(n-1)] - \mu_1^2/\sigma_1^2$$

Where

$$E[y_1(n)y_1(n-1)]$$

$$= \frac{1}{k}\left(\sum_{i=2}^{k} E[x(n-i+1)x(n-i+2)] + E[x(n+1)x(n-k+1)]\right)$$

Since the input sequence is assumed to be stationary

$$\begin{aligned} E[x(n-1)x(n)] &= \cdots \\ &= E[x(n-k+1)x(n-k+2)] \\ &= \rho\sigma^2 + \mu^2 \end{aligned}$$

$$\begin{aligned} E[x(n+1)x(n-k+1)] &= \rho(k)\sigma^2 + \mu^2 \\ &\approx \rho^k\sigma^2 + \mu^2 \end{aligned}$$

The correlation coefficient of $y_1(n)$ is $\rho_1 = \frac{\left((k-1)\rho + \rho^k\right)}{k}$

Since ρ < 1, for higher order filter the correlation coefficient at node#1 approximates the correlation of the input signal.

The statistics of the sequence of the coefficients at node#2 is

$$\mu_2 = \frac{1}{k}\sum_{i=0}^{k-1} c_i$$

$$\sigma_2^2 = \frac{1}{k}\sum_{i=0}^{k-1} c_i^2 - \mu_2^2$$

$$\rho_2 = \frac{1}{k\sigma_2^2}\left(\left(\sum_{i=0}^{k-2} c_{i+1}c_i\right) + c_0c_{k-1} - k\mu_2^2\right)$$

The statistics of the signal sequence at the output of the multiplier at node#3 is

$$\mu_3 = \mu_2\mu_1$$

$$\sigma_3^2 = (\sigma_2^2 + \mu_2^2)(\sigma_1^2 + \mu_1^2) - \mu_3^2$$

$$\rho_3 = \left((\rho_2\sigma_2^2 + \mu_2^2)(\rho_1\sigma_1^2 + \mu_1^2) - \mu_3^2\right)/\sigma_3^2$$

The sequence at the output nodes #2k - #(3k-1) of the filter are given by

$$\mu_4 = \frac{\mu}{k}\sum_{j=0}^{k-1}\sum_{i=0}^{j} c_i$$

$$\sigma_4^2 = \frac{1}{k}\sum_{i=0}^{k-1}[\sigma_{f-i}^2 + \mu_{f-i}^2] - \mu_4^2$$

$$\rho_4 = \frac{1}{k\sigma_4^2}\left(\sum_{i=0}^{k-2}[\sigma_{f-i}^2 + \mu_{f-i}^2] + \sum_{i=1}^{k-1}\sum_{j=0}^{i-1} c_i c_j[\rho^{|j-i|}\sigma^2 + \mu^2] + c_0\left[\sigma^2\sum_{i=0}^{k-1} c_i\rho^{i+1} + \mu^2\sum_{i=0}^{k-1} c_i\right] - k\mu_4^2\right)$$

Where μ_{f-i} and σ_{f-i}^2 are given by (6). To verify real life signals like music and speech signals the proposed models can be used.

8. CONCLUSION

In this paper the method of estimating the Signal Transition Activity in FIR Filters implemented by parallel Multiplier Accumulator based on Modified Booth Algorithm has been proposed. The DBT model is used to analyze the signal transition activity by means of the signal statistics. The mathematical formulation of the multiplexing mechanism is developed for the signal statistics. The mapping of FIR filter structure on a MAC based on modified booth algorithm increases the data throughput rate. The proposed multiplexing mechanism is used for the signal transition activity at the nodes.

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BIG DATA: PAVING THE ROAD TO IMPROVED CUSTOMER SUPPORT EFFICIENCY

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ABSTRACT

The organizational adage 'customer is king' is not new. With a significant number of organizational resources devoted to understanding the 'king's' needs and responding to them, this phrase, in today's competitive business arena, is an understatement. With the increasing customer touch points and avenues for customers to provide formal/informal feedback, the modern day customer support ecosystem is a complex environment. There is a need to fuse the different components of support ecosystem to create a coherent system and Big Data platform is just the right catalyst that a flat-world organization today needs to re-energize its customer service effort and venture out to capture newer horizons. This white paper looks at the different components that make up the current customer support service environment and the challenges they pose to a uniform integration strategy. Finally it highlights how Big Data can be leveraged to achieve this strategy.

KEYWORDS

Big Data, Text Analytics ,Speech Analytic, Customer Support.

1. INTRODUCTION

Steam engines triggered the beginning of the Industrial Age, and Henry Ford's Assembly Line kick-started a mechanical revolution that is still as dynamic as it was 100 years ago. In comparison, the IT revolution that can be pegged to start coinciding with Y2K boom is still in its infancy. Though we can communicate across the world in real-time, share photographs on our social networks instantly and receive comments on them even faster, an organization needs to cover several miles before it can develop a truly 360-degree understanding of the customer. Merely having a presence on social networks does not warrant a 360 degree customer understanding. These social networks need to be integrated with enterprise systems where the data received will besynthesized, processed and converted to meaningful insights that can help product design and development, or sales and marketing.

Organizations worldwide understand and acknowledge the fact that to be successful and remain competitive, it is important to have a healthy customer support ecosystem in place. While the

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customer may develop a preference for a company on account of the superior product quality initially, it is equally important to maintain an efficient customer support ecosystem to sustain the customer relationship in the long run and create a positive brand image. This support ecosystem is not merely limited to CRM systems, but should include every touch-point a customer can use to interact with the organization. Although organizations may have multiple IT systems managing customer information, it is rare to find them working in synergy. Even the capacity to indirectly influence sentiments is part of the broader customer service support ecosystem. An effective customer service ecosystem must clearly identify these disparate systems and get them to interact with each other in real-time. For example, if a call center executive has access to a sales representative's information sheet on a successful sale while addressing a customer enquiry, they may be able to tailor the response according to the problems reported to the Level 1/Level 2/Level 3 support desk for that particular model.

For HiTech industry characterized by a high rate of innovation, and hence, a high rate of obsolescence, it is imperative to have a very robust and fine-tuned support ecosystem in order to retain customers. A good example of this is the way the personal computer operating system space has evolved. It is not that Windows had a free run always; several equally competent operating systems came up from time to time like Linux. However, what kept customers linked with Windows as OS of choice, had a lot to do with the support ecosystem Microsoft was able to create behind it. They not only listened to the customer complaints and rectified them, but also from time to time kept evolving the OS to best address the increasing demand from perspective of a personal computer operating system, something that others could not do as effectively.

The situation that Microsoft faced and reacted to was not an isolated case, but a typical scenario that exists for all the participants of HiTech Industry segment. If we look across length and breadth of HiTech segment (be it a semiconductor manufacturers like Intel, Micron or Amat, or personal printer manufacturers like HP, Lexmark or Xerox) it is equally important for all to have a very robust support ecosystem to not only launch a successful product, but do it over and over without losing sight of customer expectation and reaction. Integrating the different components of the customer ecosystem such as marketing, sales, Level 1/Level 2 support desks, product research and development divisions is challenging due to their distinct purposes and the variety of data they generate. Big Data has the ability to handle and process variety of data, be it structured data from enterprise applications, unstructured text data from social media or semi-structured data from devices, under one platform. By enabling easy data integration, Big Data is slowly emerging as a key technology ingredient to overhaul customer support services.

2. ALL ROADS LEAD TO CUSTOMER SUPPORT INTEGRATION

For any organization, the product or services they offer go through a cycle of ideation, design, prototype, development, support, upgrade, and finally obsolescence. Similarly, from an organization's perspective, customer relationships go through a lifecycle involving identification, prospect development, prospect conversion, marketing approach, servicing, support, up-selling, cross-selling, retention and so on covered as part of Customer Life Cycle Management (CLM) process.

While this white paper references CLM to draw a high-level architecture of the customer service ecosystem, the focus here is largely on data and how data coming from different layers of CLM can be integrated to improve the efficiency of the entire customer support process. Figure 1 presents the different stages of CLM that are of interest from the customer support perspective.

Figure 1: Customer Support stages

For a HiTech organization looking at selling enterprise software, the pre-sales stage will focus on identifying target organizations that may be interested in the enterprise solution to tailor marketing campaigns and promotional activities.

These different stages act in a way to support customers either by enabling them to make a decision or providing support post the decision process. There are several technology platforms that support the various customer support processes: tools to generate Web mail campaigns, enterprise level CRM suite, Interactive Voice Response (IVR) systems, tools to track customer-reported issues, or systems to capture daily salesperson logs. Organizations, therefore, use a complicated set of systems - technologies and platforms, to provide seamless service to customers. However, integration between these systems is usually missing.

In the modern day ecosystem, social media has emerged as an important influence in the customers' decision making process. Before making a purchase, customers go through numerous reviews available on social channels, connect with friends and peers to seek opinions and carry out a comparative analysis between different products/services on offer. Therefore, an organization's success at converting a customer depends not only on the quality of the product/service it offers or the marketing campaign launched, but also on how the organization and its products are perceived by the wider community. This is where it is important for the organization to integrate its customer support ecosystem to develop a better understanding of customers and also provide them with unique post-sales support experiences.

The key to achievethis seamless integration lies in capturing, integrating, and analyzing the data generated at different customer touch-points, and making it available to the last line of customer support service. For example, in the current customer support landscape, it is almost impossible for a support engineer to establish a link between a customer support request, the advertisement campaign that triggered the buying process, and any product features highlighted by a sales representative that helped close the deal.

3. ROADBLOCKS TO DATA INTEGRATION

Integration of systems that constitute the customer support ecosystem is encumbered by a multitude of factors that weigh against any effort made towards this integration. The primary impediments towards this integration are:

- Variety of data
- Variety of applications
- Information silos

Data: The biggest challenge that prevents organizations from integrating the different layers of customer engagement is the variety of data. Each layer of customer engagement has its own characteristics and generates data that is specific to that layer. For example, a front desk deals mainly with voice data while the Level 2/Level 3 support deals mostly with textual data with some attributes attached to it. Although data generated from pre-sales activities is structured, it does require further processing to be of use to the sales and post-sales layer.

Applications: The second challenge is the technology used to capture data across different layers. Typically, different applications are used for different layers of customer engagement and these applications work in isolation. In an organization, the marketing team makes use of digital marketing campaigns such asemail, social media channels or postal mails; the sales team uses enterprise planning systems for posting and tacking their orders; the customer support desk uses its own set of applications to interact with customers, monitor their service requests and raise tickets for issues that require more deeper analysis by the development team. Each of thesesystems supports a key organizational function or process. However, unified view of data residing in these isolated systems is lacking. Getting all these application systems to share data to create a truly integrated view is a difficult proposition from the conventional data management layer perspective.

Information silos: Today, organizations operate in multiple geographies and use different systems and tools depending on regional requirements. It is rare to find a single implementation of a CRM system across North America, Europe, Asia, and Africa. Regional factors, not restricted to language alone, play a crucial part in defining and creating an IT system that supports operations in a specific geography. One can debate endlessly on the futility of cross-geography information integration, but experience shows that cross-leveraging factors that support growth in one region may work equally well in other areas too.

Organizations realize the need to bring these information silos under one head and enable healthy collaboration, knowledge management, and uniform customer experience.

4. DEFINING THE ROADMAP TO INTEGRATION

In order to align itself with the changing market dynamics brought in by the increasing penetration of social channels in decision making process, it is important for organizations to create an environment that integrates the different customer touch points into a continuous flow of information that captures and transmits insights about a customer uniformly across the entire customer support ecosystem.

Driving efficiency improvement through integration withthe application or the system level may not be cost-effective today, considering the varied mix of technologies used under customer support, as well as the geographic spread. Further, integrating applications that are custom built or from different vendors might not be a viable option. A data-centric approach then proves to be an effective mechanism for integration. The challenges posed by the variety of data components are effectively mitigated through proper utilization of newer technology elements that constitute the Big Data ecosystem. The right mix and proper orchestration of these newer technology elements provide a far more cost-effective mechanism to integrate the different layers of customer support services under a unified fabric.

A few technology paradigms that come under the spotlight include:

a) **Textual data processing**: Organizations, over a period of time, have collected huge amounts of pure text data such as entries in the 'Remarks' column of a feedback form, or the comments left by support executives in CRM systems. Earlier, due to technology constraints, it was difficult to process this data and convert it into actionable insights. However, today there are tools that work on the principles of Natural Language Processing (NLP) and efficiently churn out insights from this data. Presently, NLP is emerging as a front runner among the Big Data ecosystem technologies. Textual data can now be mined to understand the customer sentiment associated with a particular product family, the key features discussed by customers, and the changes over a period of time. Organizations can further integrate this information with data of their marketing campaigns carried out from time to time to understand how the campaign affected customer sentiment as well as the features highlighted through the campaign; an effective way to capture the return on investment (ROI) on the marketing campaign. There are several such instances where the capability to mine information from textual data has transformed relatively obscure data into an information goldmine.

b) **Voice processing**: The voice-based service/call center is a mainstay in the customer support strategy of any organization. It not only acts as the first point of contact between a customer and the organization, but also goes a long way in shaping an organization's brand perception. While organizations have invested heavily in setting up customer support desks or call centers, very little has been done to process the data captured from calls. Most organizations only rely on the efficiency of the support person to decipher the data and convert it into information.

   Converting voice data into text whichcan be stored and analyzed further is a challenge that the technology world is experiencing today. There are several factors contributing to the challenges faced while deriving the right information from voice data. The tone of the caller, the accent, and the language used are among the most common ones. Voice processing or speech recognition is an area that is evolving rapidly. IBM's Watson participation and winning of the Jeopardy Quiz represents a step in the right direction to achieve complete speech capture, conversion, and usage. There are many more solutions like those from Dragon Naturally Speaking, TalkTyper, VoxSigma and others that are targeting the area of speech to text conversion and analysis.

c) **Web Analytics**: While aspects like voice to text conversion, text analytics and others have been the subject of research and used for some time now, Web analytics has gained traction only over the past few years. Albeit it is relatively new, the science of analyzing users' Web behavior has evolved tremendously. From using keywords on Web pages to render a more meaningful Web search which resultsincapturing every user activity on a Website, Web analytics has come a long way and found favor across organizations.

d) **Structured enterprise data and unstructured data integration**: Processing unstructured data (text or voice) on its own is not very significant unless the processed outcome is given as inputto the structured enterprise data to derive meaningful inferences. For example, an insightful picture of the sales performance will emerge only when the processed social media data is linked backed to the sales figures, and further enriched with information emerging from call center data.

Trying to integrate varied data sources on conventional relational database management platforms may not work due to their inherent inability to process data that does not fit into a structured, relational schema. Processing of text, voice, or data originating from devices (such as log files) requires an approach that is completely different from the number crunching approach that the relational databases are suited for. Platforms leveraging Big Data are emerging as platforms of choice for these kinds of operations. The recent global Big Data trend study survey conducted by TCS identifies customer support services as among the top three areas where companies worldwide are focusing their Big Data investments.

5. CONCLUSION

A well-tuned and integrated customer support and service infrastructure brings in additional benefits that add value to the organization. For instance, it brings greater transparency, better insights, and delivery of tailored services, leading to a prolonged and profitable engagement for both sides.

A comprehensive, integrated approach to customer support service can leverage Big Data to not only drive more efficient customer support, but also other areas within an organization such as product design. It is time to make the big move to Big Data!

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CLOUD-BASED MULTI-TENANCY MODEL FOR SELF-SERVICE PORTAL

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ABSTRACT

A multi-tenant portal implementation extends the capabilities of an enterprise by enabling several customers to run independently on the same portal infrastructure hosted by a service provider. However, building multi-tenant solutions requires addressing several technical challenges, but service providers/solution developers can build and deploy scalable, customizable, manageable, and cost-effective multi-tenant solutions. Addressing multi-tenancy is a key consideration in implementing Cloud enabled enterprise portal solutions which are becoming an international phenomenon, driven by both local demand as well as global reach by medium or large enterprises that are in need of reducing cost of infrastructure/ hosting.

The paper enlighten the focus on the core of multi-tenant portal infrastructure along with key design elements that need to be considered in providing Cloud- enabled multi-tenant portal solutions. The paper would not focus on any specific vendor or their product suites but it acts as a synopsis for developer and architect community to strategize their thinking towards right portal architecture by gaining insights on multi-tenant portal features, key benefits and portal landscape.

KEYWORDS

Multi-tenancy, Portal Infrastructure, Cloud-based Model, Enterprise Portal, Self-service Portal

1. INTRODUCTION

Cost savings and increase in revenue are always the key business challenge to face in today's competitive market place. However, increase in revenue is directly impacted by various factors like –continuously adding new customers, retain customer by offering new innovative services. Each enterprise, Medium or large, needed an enterprise-proven on-Demand business portal solution fulfilling the demand of their employees, customers and partners.

The very basic goal of multi-tenant portal infrastructure is to improve productivity, enhance communication, collaboration and performance by shortening the decision cycles at different levels and also to bring people, resources and processes together to create an exponential economic value to the customer. Today, Software service providers are continuously challenged in architecting standards based portal solutions that can manage lots of customers on a single code base but in a more coordinated way than the standard multi-site installation.

The most critical features when evaluating or considering multi-tenant enterprise portals include a cost-effective deployment, a secure solution, an enterprise proven system (scalability) and the ability to integrate with all major technology platforms. However, multi-tenancy is ultimately

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about cost efficiency because its goal is to reduce the number of instances, and to align everyone's schemas, it becomes cheaper and easier to manage. Basically, different levels of multitenancy are just different trade-off points on the cost curve.

Customer specific branding and corporate identify are clearly the winning streak for multitenant portal infrastructure. Multi-tenant portal even bring more flexibility by allowing administrators (both Global and Tenant) to divide a portal into logical partitions, each with its own parallel entry points and dedicated content and navigation for exclusive use of each customer. A shared portal infrastructure (multi-tenant portal) unifies portal administration in a single interface and simplifies management of customer intranets, websites and self-service customer portals.

2. OVERVIEW OF MULTI-TENANT SELF SERVICE PORTAL

Multi-tenant Portal is a single physical portal divided into several logical Portals. A multitenant portal environment allows parallel entry points into the portal, and each entry point is referenced by a unique URL that is assigned to the end User.

In a multi-tenant portal environment, each customer instance is known as Portal Tenant. Each portal tenant comprises a set of secure portal objects and set of services that are highly customized for the respective customer, business users, administrators and the service provider. In addition, the content presented to business users through a tenant is customized and branded by designers to suit the corporate identity of the customer. Within a single portal infrastructure, enterprise can provide content which is unique to different user groups and apply access controls and permissions to customized content on a per user, group, or role basis. There are basically two types of administrator roles in a multi-tenant portal infrastructure –

- Tenant administrator and
- Global administrator

Tenant administrator is a specialized tenant user who manages tenant specific users or content in the design time environment of a multitenant portal. Global administrator is one who has access to cross tenant users or content and this role is normally defined by super user of the portal. The core of the multi-tenant portal infrastructure is shown in the diagram below:-

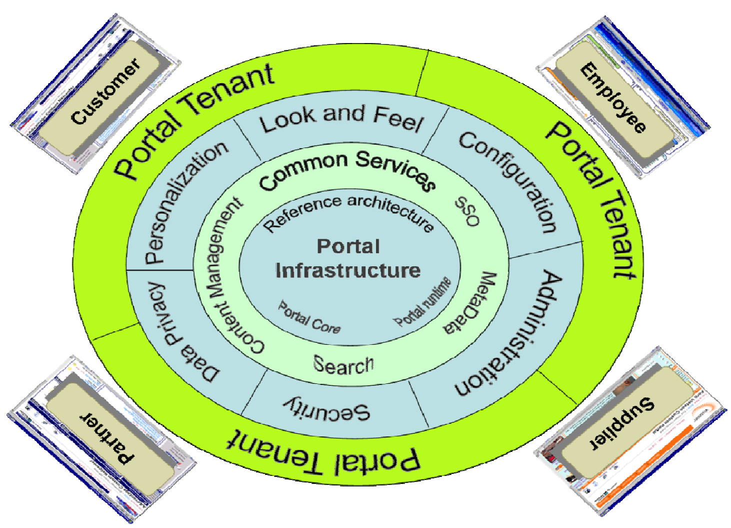

Fig.1. Multi-tenant Portal Infrastructure

3. KEY DESIGN CONSIDERATIONS IN MULTI-TENANT PORTAL

Multi-tenancy efficient architecture is an important requirement for Web-delivered solutions as well as enterprise proven on-Demand business portals accessed by customers, employees and trade partners.

In case of multi-tenancy, single instance of the portal serves multiple tenants (i.e. Client organizations) but in case of multi-instance architecture, separate portal instances e.g. Virtual portals are setup for different client organizations. With a multi-tenant architecture, a portal application is designed to virtually partition its data and configuration so that each client organization works with a customized virtual portal instance. The multi-tenancy support is the key decision in designing enterprise portal solutions.

The below points describe the key design elements that need to be considered for Cloud enabled multi-tenant Portal.

- Addressing variations in tenant requirements -
  - User Interface/Look and feel
  - Workflows
  - Service orchestration and implementation
  - Entities and Database extensions
  - Authentication and Authorization
- Customization i.e. One time setup requirement for different customers
- Degree of Configurability
- Collect, Collate & Configure meta-data at each level
- Data security and Isolation
- Fine grained role based access
- Unique user experience through personalized look and feel
- Tenant provisioning through provisioning Virtual portal instance
- Keeping Customer/vendor data separated and secured
- SOA based architecture & Web services based messaging/event model for middle-tier
- Data center economics

A typical portal implementation offers a lot of features (out of box or available on customization) which can be leveraged by service providers to provide a customized look and feel in offering branding services to their customers. Another advantage of taking portal solution path is the rich out-of-box feature support based on open standards and portlets, the power engine for Portal framework are modeled against portlet specification standards like JSR 168 or JSR 286. Each portlet can be made configurable for each service vendor or customer based on their needs.

3.1 Virtual Portal Implementation – Clone and Configure Approach

Most of the open source/traditional portal vendors provide a clone-and-configure approach to the implementation & deployment of the portal for multi-tenant applications i.e. the ability to clone a base portal and configure it as per end-user/vendor/partner needs. Several Open Source portal vendors support the concept of a virtual portal which is basically a logical copy of an existing base portal utilizing the same hardware and software resources.

3.1.1 Degree of Configurability and Customization

To enable a high level of reuse, the degree of configurability in the portlet design is achieved by supporting customer and/or vendor-specific settings through name and-value pair configurations such as Customer IDs or customer's service endpoints, to offer each customer specific look-and-feel thereby offering a highly scalable, configurable and multi-tenant efficient solutions.

Following are the recommendations for portal environment based multi-tenant applications:

- Each portlet must be configurable for each customer, since a service provider shares portlets across individual vendors.
- To enable a high level of reuse, the degree of configurability in portlets must support subscriber or vendor specific settings, such as vendor's service endpoints, to provide vendor or subscriber-specific look-and-feel, with specific settings to indicate which form fields or action buttons should be rendered to end-users/administrators based on role based access.

In addition to configuration at the customer level, the individual vendors/channel partners must be able to perform the configuration without the support from the customer or service providers.

3.1.2 Security Isolation

Each virtual portal supports isolation of user populations for each tenant through a multi-tenant LDAP tree structure in a single instance of a directory Server. Through dynamic profiles, an application developer can define variables in a common ‘profile set’ that can be configured by each tenant’s administrator at runtime thereby, enabling the unique branding for different tenants.
Tenant specific customizations are created by applying those configured profiles to their portlets at runtime to change the appearance, content and behavior of the portlet.A sample scenario as outlined below:

- Create a multi-tenant user directory structure in LDAP by:
  - Create a realm for each vendor or customer i.e. a separate tree hierarchy starting at dn [dc=vendor1, dc=com]
  - And, for each security realm, a security context entry must be created, configured and mapped to user population of each service provider or end customer organization.
- Collaboration and Knowledge Management
- Extended Collaboration
- Social Business Extensions

3.1.3 Unique User Experience

Rich and unique user experience, at very high level, consists of:

- Look and feel for users or groups (belonging to either customer or end user organization) and
- Structure and scope of user role

Most portal vendors provide out-of-box features which can be utilized and customized in a unique manner to create a distinct look and feel that will go consistent with the customer branding needs. Also it provides flexibility to the vendors to customize the look and feel based on their specific business requirements to serve their end-customer effectively and efficiently.

4. Multi-Tenant Portal Implementation

A multi-tenant portal extends the capabilities of self-service portal by enabling a single service provider to offer granular services based on SAP technology and applications to multiple customers from a single portal infrastructure.

The service provider partitions a single portal installation into several logical units. Each partition is a portal with its own dedicated content and navigation for the exclusive use of a customer. The term tenant is used to describe each logical partition. The service provider sets up parallel entry points into the portal—one entry point per tenant. Each entry point is referenced by a unique URL gateway, also referred to as a portal alias. The users of a tenant can access only the information of their tenant.

The following figure shows a layered multi-tenant portal architecture with three tenants:

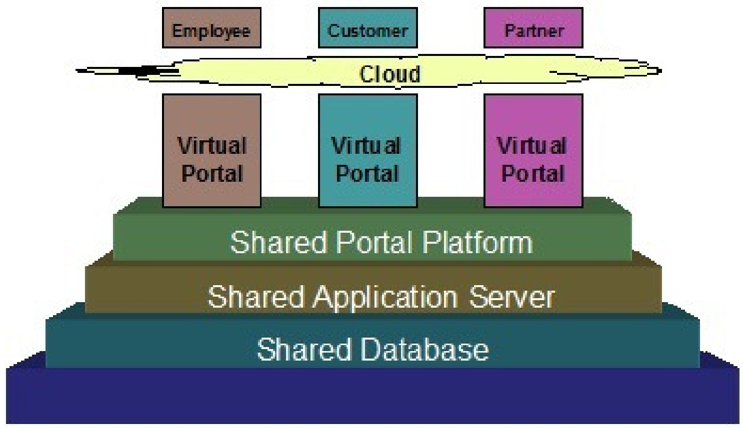

Fig.1. Layered Multi-tenant Portal Architecture

The overall strategy for enterprise portal implementation should consider the following fundamental requirements for multi-tenant efficient applications:

- Describes the multi-tenant portal environment
- Explains how to configure a single portal landscape to support multiple tenants
- Outlines how to secure the multi-tenant portal environment to make sure that content belonging to one enterprise is not delivered to members of other enterprises.
- Discusses administration tasks, such as initial preparation, configuration, and daily maintenance
- Details how to manage the customized portal content of individual enterprises within a single portal landscape
- Details how to manage the users in a multi-tenant portal environment
- Details how to customize the look and feel of each portal tenant to incorporate the customers' corporate identity

5. KEY FEATURES SUPPORTED IN MULTI-TENANT PORTAL

The following features support the multi-tenant portal environment:

- Customer-specific branding and corporate identity
- Per user/group/role permission infrastructure for controlling access to portal content
- Delegated administration for setting up different customized content
- Mass customization and configuration operations
- User management filtering mechanism for controlling access to users, groups, and roles per tenant
- Multi-language user interface support

Within a single portal infrastructure, the service provider can:-

- Provide content which is unique to different user groups
- Isolate the content of a group
- Apply access controls and permissions to customized content on a per user, group, or role basis

6. MULTI-TENANT PORTAL LANDSCAPE

The following figure provides an example of a multi-tenant portal system landscape:

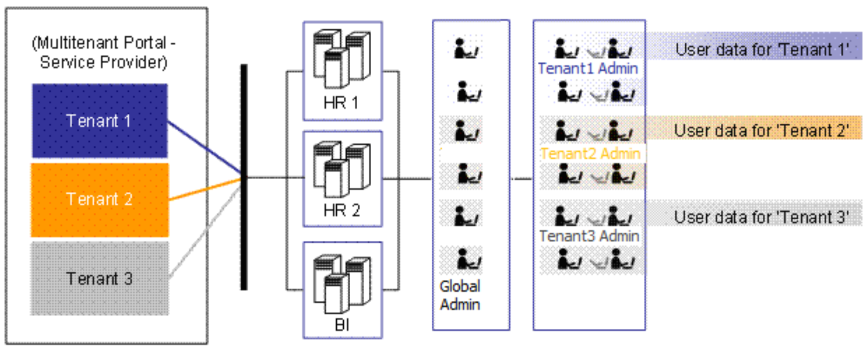

Fig.3. Multi-tenant Portal Landscape

The Portal system landscape in the figure above comprises two Human Resources (HR) systems, one Business Intelligence (BI) system, and a central user administration, which are all connected to the multi-tenant portal. These systems present information to the following tenants: Tenant 1, Tenant 2, and Tenant 3.

Users of the different tenants are defined in separate clients either in one or several systems. For example, when a user from Tenant 1 makes a request in the portal, that user is authenticated in the central user administration, which also checks the authorization level of the user for the requested data.

After the request is authenticated and the user has permission for the requested data, the information is presented in the portal based on branding and corporate identity of respective Tenant.

7. KEY TAKEAWAYS

There are several benefits of using a multi-tenant portal landscape. Some of the key takeaways as below: -

- Single portal infrastructure would deliver services to multiple customers. There is a definite cost reduction through lower ongoing total costs for operating a multitenant environment rather than multiple portals.
- Global administrators provide centralized control by defining various tenants that are hosted in the portal infrastructure. Besides this, administrator defines the portal alias, the path to the company logo as well as other tenant specific information.
- System landscape is less complex; thereby reducing overall risk to businesses. It also helps to achieve system landscape optimization.
- Standardization and best practices across single portal infrastructure improves the quality standards.

- The cost for the service and the cost per user is drastically reduced by standardization and reuse of services by different portal tenants.
- Each tenant specific configuration becomes easy through metadata associated with each tenant. It does not require making changes in codebase each time a new portal tenant is instantiated.

However, besides above benefits, multi-tenant portal solutions can also be used to structure the portal for different business units, as well as subsidiaries within the same organization. Several service providers leverages its rich experience in providing Portal solution offerings across its global customer base to help companies achieve their objective of a state-of-the-art self-service multi-tenant portal.

8. CONCLUSION

The multi-tenancy is the most significant paradigm shifts in portal application design extensively dependent on metadata at each level to configure the way the application appear/behave for the users. However, the multitenant enterprise portal is a vital component to businesses in reducing the cost and also empowers customer to identify the solutions to their problems quickly.

From my experience, I strongly recommend multi-tenant architecture when creating enterprise portal solutions as it allows vendors to provide self-service capabilities to customers and prospects for key marketing, sales and support activities and branding services for their partners/channels.

In summary, the multi-tenant architecture is an important design decision when working with potential business solutions that have similar core functionality but fundamentally differ in various aspects such as UI, Layout and workflows. The basic concepts explained here are the foundations for the Multi-Tenant Architecture. Depending on your organization needs, there may be extra steps to utilize the design in an effective manner.

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DESIGN ARCHITECTURE-BASED ON WEB SERVER AND APPLICATION CLUSTER IN CLOUD ENVIRONMENT

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ABSTRACT

Cloud has been a computational and storage solution for many data centric organizations. The problem today those organizations are facing from the cloud is in data searching in an efficient manner. A framework is required to distribute the work of searching and fetching from thousands of computers. The data in HDFS is scattered and needs lots of time to retrieve. The major idea is to design a web server in the map phase using the jetty web server which will give a fast and efficient way of searching data in MapReduce paradigm. For real time processing on Hadoop, a searchable mechanism is implemented in HDFS by creating a multilevel index in web server with multi-level index keys. The web server uses to handle traffic throughput. By web clustering technology we can improve the application performance. To keep the work down, the load balancer should automatically be able to distribute load to the newly added nodes in the server.

KEYWORDS

Compute Cloud, Hadoop, MapReduce, load balancing, Web server.

1. INTRODUCTION

Cloud is emerging as a cost effective solution in the computing world. The data capacity of the cloud has gone up to a zettabyte from gigabyte. Cloud Computing are the virtual pool of computing resources that provides an online pool of resources for computing, where the computing is performed by efficient sharing of resources, which we call as load balancing/ resource sharing. Cloud relies on its resources for handling the application in the local and personal devices.

MapReduce [2] is the heartbeat of Hadoop framework. It is a programming paradigm that allows for huge scalability across hundreds or thousands of servers in a cluster. It is a programming model that is associated with the implementation of processing and generating large data sets. The term MapReduce basically refers to two separate and distinct tasks that Hadoop programs perform [6]. MapReduce also plays an important factor in Cloud computing environment, because it decreases the complexity of the distributed programming and is easy to be developing on large clusters of common machine [12]. The data flow architecture of MapReduce shows the techniques to analyze and produce the search index [12] as shown in figure1.

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The main purpose of this work is to develop a technique for a fast and efficient way of searching data in the MapReduce paradigm of the Hadoop Distributed File System. Hadoop is a framework which is specifically designed to process and handle vast amounts of data [10]. It is based on the principle of moving computation to the place of data which is cheaper than moving large data blocks to the place of computation.

The Hadoop [1] MapReduce framework is a master - slave architecture, which has a single master server called *a job tracker* and several slave servers called *task trackers*, one per node in the cluster. The job tracker is the point of interaction between users and the framework. The user submits map and reduce jobs to the job tracker, which puts them in a queue of pending jobs and executes them on a first-come-first-served basis.

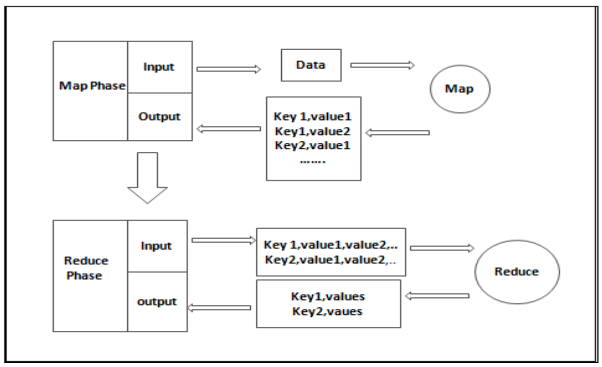

Figure 1. MapReduce data flow

In this paper the schematic view of the design architecture is given, with effective scenario to investigate the performance of Hadoop in high speed retrieval of data in the cloud environment by replacing the map phase of the MapReduce paradigm with a web server. For real time processing on Hadoop, a searchable mechanism is implemented in HDFS by creating multilevel index in web server with multi-level index keys in NameNode.

The rest of the paper is structured as follows. Module 2 & 3 highlights the related works and Hadoop Distributed File System implementation. Module 4 describes the web application in a cloud and architecture design. Module 5 describes the implementation details followed by the results & analysis. Finally work done is concluding, with future work in module 6.

2. RELATED WORK

Hadoop [10] is an open source Java-based programming framework which is a part of the Apache project which was sponsored by the Apache Software Foundation. MapReduce is a part of Hadoop framework. It is a programming concept and Hadoop is a framework to run MapReduce program. In February 2003 first MapReduce library was introduced @Google. In 2004 MapReduce was simplified for data processing on large cluster [4]. Google introduced MapReduce in 2004 to support large distributed computing, on large clusters of computers to implement huge amounts of data set [3]. MapReduce is a framework that processed parallel problems of huge data set using a large number of computers or nodes that is collectively referred to as a cluster or a grid [7]. A distributed file system (DFS) facilitates rapid data transfer rates among nodes and allows the system to continue operating uninterrupted in case of a node failure. It was originally developed to support distribution for the Nutch search engine project. In January 2008 Hadoop made apache as a top level project center.

In July 2009 new Hadoop subproject was found where Hadoop core is renamed as Hadoop Common. In this subproject MapReduce and Hadoop distributed file system (HDFS) get separated for doing separate work. HDFS is designed to store very large data sets [10]. In 2010 web application based process is used to handle high throughput traffic [6]. Facebook has claimed that they had the largest Hadoop cluster in the world with 21 PB of storage and on July 27th, 2011 they have announced that the data had grown up to 30PB.

In 2012 the load rebalancing problem in cloud DFSs is illustrated by Hsueh-Yi Chung Che-Wei Chang Hung Chang Hsiao, Yu-Change Chao. The file system in cloud shall incorporate decentralized load rebalancing algorithm to eliminate the performance [17]. In May 2013 a fully distributed load rebalancing algorithm is presented to cope with the load imbalance problem by Hung-Chang, Haiying Shen. This algorithm is a centralized approached in a production system and a competing system [18].

3. HADOOP DISTRIBUTED FILE SYSTEM

Recent trends in the analysis of big data sets from scientific applications show adoption of the Google style programming infrastructure, MapReduce [2]. Hadoop, which is a collection of open-source projects originated by “Doug Cutting in 2006” to apply the Google MapReduce programming framework across a distributed system [8]. It provides an easily obtained framework for distributed processing, and a number of open-source projects quickly emerged which leveraged this to solve very specific problems. Hadoop in a cloud computing environment supports the processing of large data sets in a distributed computing environment, primarily in data warehouse systems and plays an important role in support of big data analytics to understand the user behavior and their needs in web services [9].

HDFS stores file system and application data separately. HDFS also provides high throughput access to the application of data and it is suitable for the application that has large data sets. HDFS is highly fault-tolerant, which provides high throughput access to the application data and is a perfect application that has large data sets. It adopts the master and slave architecture.

HDFS cluster consists of DataNode and NameNode shown in Figure 2. NameNode which is a central server, also called as a Master server, is responsible for managing the file system namespace and client access to files and DataNode in the cluster node are responsible for files storage. In HDFS, a file is divided into one or more number of blocks for storing data [13].

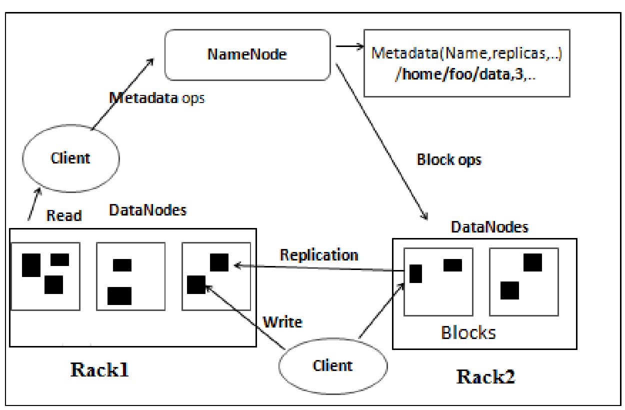

Figure 2. HDFS Architecture

4. WEB APPLICATION IN A CLOUD AND ARCHITECTURE DESIGN

In the following module, the schematic design of the architecture for a scaling structure and the dynamic scaling for a web application in cloud is designed. The structure is based on using a front-end load balancer to dynamically route user requests to backend, Master web servers that host the web application. The number of web servers should automatically scale according to the threshold on the number of current active sessions in each web server instance to maintain service quality requirements.

High speed data retrieval from cloud storage has been an active area of research. The Apache Hadoop project design, architecture which is based on the web server and application cluster in cloud environment was started with this as one aim in mind. We review here the basic details of the design architecture, apache load balancer and the details of the Master web server with the multi-level indexing. In the following module, the schematic design of the architecture for a scaling scenario and the dynamic scaling web application for the web in a Cloud is clustered.

4.1. Architecture Design

The data in Hadoop Distributed File System is scattered, searching and data retrieval is one of the most challenging tasks, so to overcome these tasks a searchable mechanism in HDFS has been implemented. A web server has been designed in the Map phase of MapReduce. The jetty web server is considered as a web interface. Web applications are generated in the HDFS and a web server is started in the form of Hadoop job by submitting our keys to URL Hadoop url/file/key. The Apache load balancer is used in between the client and server to balance the work load of the localhost because if one level is not sufficient, then the system will automatically expand to the second level of indexing.

For real time processing on Hadoop, a searchable mechanism is implemented in HDFS by creating a multilevel index in web server with multi-level index keys. To keep the work down, the load balancer should automatically be able to distribute load to the newly added nodes in the server. The load balancer is used to balance the workload across servers to improve its availability, performance and scalability. To be able to exploit the elasticity of a cloud infrastructure, the applications usually need to be able to scale horizontally, i.e. it must be possible to add and remove nodes offering the same capabilities as the existing ones. In such scenarios, a load balancer is usually used.

NameNode is divided into Master and Slave server. Master server contains multi - level index and slave have data and key index. In the server at the time of the data request, the key is being passed on multi level indexes. Indexing all the process is done by Master server and all retrieval process are done by slave serve. The overall view of the design architecture has been shown in the figure 3.

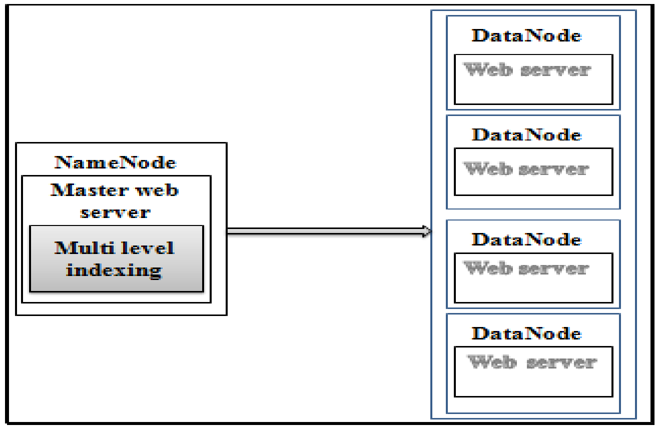

Figure 3. Schematic view of design architecture

4.2. Load Balancer

It is used to balance the workload across servers to improve its availability, performance and scalability. Its purpose is to improve the performance of the distributed system through an appropriate distribution of the application [17]. In a distributed system, it is possible for some computers to be heavily loaded while others are lightly loaded. In this situation system can lead to poor system. The goal of load balancing is to improve the performance by balancing the loads among computers.

The Apache load balancer will give better performance of the workload. These can be configured to know a certain number of workers and their host names, but no workers can be added automatically during runtime [14]. It is implemented in between clients and servers to balance the work load of the web server. These servers run on each NameNode and DataNode of which web application package is deployed on the HDFS [13].

4.3. Load Balancing With The Master Web Server

A common approach is used in combination of the Apache module mod proxy [15] and mod proxy balancer [16]. After adding these modules to the Apache Web Server 2, a virtual host configuration has to be created that configures the load balancer and its balance members. By using the directive ProxySet, the load balancing method can be set to balance either by the number requests, by counting the bytes of the traffic, or by pending requests. By using the Balancer Member directive, a worker with the given URL can be introduced to the load balancer, including how much load it should receive.

The Master server runs on each NameNode and DataNode (Figure 4), web server application package is deployed on the HDFS. The web server in NameNode is divided into Master/slave architecture, according to HDFS storage features, it will store all the keys in the indexing form.

All client requests are first sent to the NameNode through URL Hadoop url/file/key, and Master server in NameNode will decide which the Master server either master/slave on DataNode to respond to the request according to the location information of web files stored in the multi-level indexing on NameNode, and then redirected URL to the node and request the same Uri, finally, a connection can be established between the current Master web server and the browser, and sending files and data between them. To be able to exploit the elasticity of a cloud infrastructure, the applications usually need to be able to scale horizontally, i.e. it must be possible to add and remove nodes offering the same capabilities as the existing ones. In such scenarios, a load balancer is usually used.

It is possible to add the new workers directly to the Master server configuration and starting the load balancer, a large number of virtual folders can be defined in the virtual host configuration. Then, whenever a worker registers at the load balancer, the htaccess rewriter writes a forward rule to the. htaccess file located in htdocs/virtual a request sent to, the URL path route/1 is redirected to the first URL specified in the htaccess file, a request sent to, the URL path route/2 to the second, and so on. Since then htaccess file is evaluated for each request, changing it at runtime allows additions as well as removal of workers. With these measures, it is possible to allow workers to register at the load balancer automatically upon their startup and shutdown, thus bypass the need to manually add or remove workers. Even the rules allow for the changes take effect during runtime. Further modifications of the load factor are possible by collecting monitoring data [11].

A starting load factor can be determined by a performance test. Load balancer knows the potential workload of all workers; it can calculate a load factor for each worker proportional to each worker's potential or monitored workload [5].

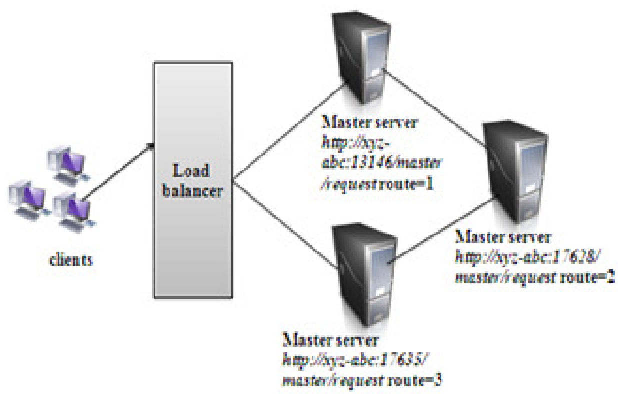

Figure 4. Master web servers based on cluster architecture

The features of load balancer are

- If a server dies connection will be directed to the nearest server.
- Once the server comes back online it rejoins the cluster.
- It can be controlled to take into account machine difference.
- It supports complex topologies and failover configuration
- It distributes the client request across the server, redirect to the localhost.

5. RESULT & ANALYSIS

In this module, for the implementation, we configured Hadoop with 6 DataNodes and one NameNode, 6 Task trackers and one job tracker. With each of the nodes we install the jetty server and connect it with Hadoop using eclipse. Jetty server is running on each of DataNode of Master server. Each jetty server works on specific key. Master server contains a list of keys which correspond to jetty server information. When a read request come from the clients via Master server then it does look up to find the jetty server for corresponding keys and then forward it to the corresponding server. For our experiments we use all systems with Core i7 2.93 GHz CPU, 8 GB DDR3 RAM, 1 TB hard drive. All systems are connected over a 1 Gbps switch.

Web applications are generated in the HDFS and a web server is started in the form of Hadoop job by submitting our keys to the URL of Hadoop i.e. Hadoop url/file/key. The key and value are submitted to the local host of a Hadoop URL in the file system of Master web server and read operations can be performed in the same URL. The read operation performed in Hadoop is done by Master web server through Uniform Resource Locator. To keep the work down, the load balancer should automatically be able to distribute load to the newly added nodes in the server.

When one Master Server (jetty server) is running and read operation is carried out from HDFS, it has been seen that the average time (seconds) keeps on increasing when data input is increased in HDFS. The average time taken for retrieving data in HDFS is shown in the figure 6 and is 4.2 seconds for 100MB data size, 6.8seconds for 1000MB, 17.3seconds for 10000MB and 24.7second for 100000MB data size.

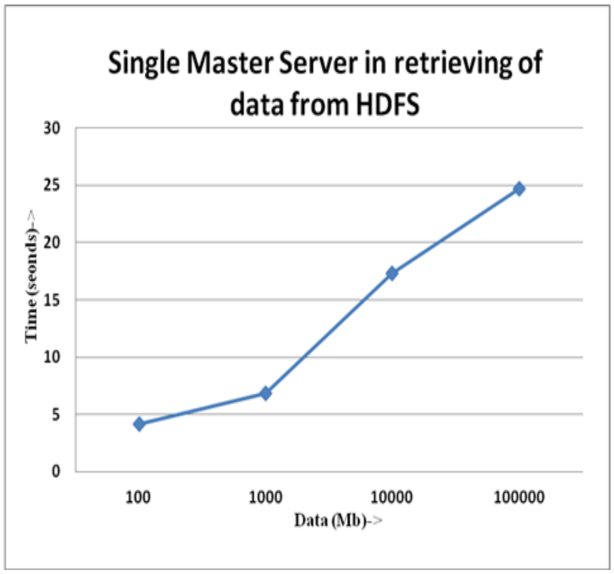

Figure 5. Time taken for single Master server (jetty server) in the retrieval of data from HDFS**.**

Increased of Master Server (jetty server) will give better performance for retrieving data through the Hadoop url / file/key. It has been seen that the average time (retrieving data) keeps on decreasing when data input is constant or increasing in HDFS. The Master web server (Jetty server) takes seconds to read a particular or text data from 100000 MB size of data which has been stored in the HDFS where the data are kept constant (100000MB). We have increased the number of servers from 1 to 6 servers for better performance in retrieving of text data from HDFS. The average time taken for retrieval of text data in HDFS by Master server is shown in Figure 7 and is 22.7 seconds, 17.8seconds, and 14.7seconds, 8.3seconds, 7.6seconds and 4.8seconds form 100000MB data size where data are kept constant and web servers are increasing.

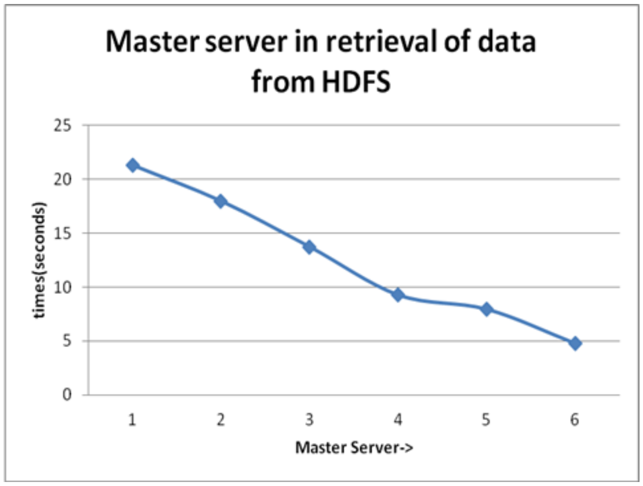

Figure 6. Master Server in retrieval of data from HDFS

6. CONCLUSION & FUTURE WORK

In this paper, we have given the schematic view of the designed architecture with effective structure to investigate the performance of Hadoop in high speed retrieval of data in a cloud environment. Apache Web Server a dynamic cloud-ready load balancer was presented as well. It was shown that the Master web server is a static load balancer when using one of the common load balancing modules. To avoid having to manually add workers to the load balancer configuration, we have also added a benchmarking and registration component to the workers.

The results shows that using this architecture in the Hadoop and making map phase as a web server, faster read operation for MapReduce programs can be achieved through URL. For large databases of data warehouse applications in cloud, searching process takes a very long time as the data is scattered. High sped retrieval of data can be particularly useful for real-time applications based on Hadoop where quick fetching and storage of data is necessary.

In future, experiments can be carried out on large datasets and some real-time applications to measure the usefulness of the proposed approach. This web server can conceptually be extended to provide dynamic load balancing capabilities. Apache Web Server cans also be used as a load balancer in combination with Apache Tomcat workers.

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RICH INTERNET APPLICATIONS, PLATFORMS AND TOOLS - A PARADIGM SHIFT IN WEB USER EXPERIENCE

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ABSTRACT

There has been a paradigm shift in the way how organizations are moving towards enterprise-level adoption of Rich Internet Applications and Platforms with the evolution of internet. Earlier the webpages were more of static content and involved lot of traversing through pages to complete a transaction, now the web applications are very much dynamic, interactive and help the user complete the same transaction in a few clicks. In the near term, such adoption will favor The deployment of Rich Internet Applications and technologies added more twist to these changing terrains by providing desktop like features, sandbox security and many more capabilities there by creating an integrated rich user experience where most of the business users want to access their RIA applications on Mobile and tablet devices.

This paper also presents key trends to understand the evolution of different RIA technologies and also harness the power of RIA in creating an interactive and converging user experience across domains and industries.

KEYWORDS

Rich Internet Applications, RIA Security, RIA Frameworks, Content delivery Network, Flex, Ajax

1. INTRODUCTION

The focus of internet competition is rapidly progressing beyond mere delivery of products and services to address the quality of the end user experience. It altogether brings a paradigm shift in the way the business applications are developed, delivered and consumed. The continuous change in user expectations has been brought about due to the new frontiers explored by the technology.
Gone are the days of static HTML pages with poor or no interaction. However, in the past, technology was playing a crucial role in deciding how and where to access information, but today, the business is playing a crucial role in deciding the channels of information management and want to gain the operational and cost advantages of deploying rich interactive applications over the Internet, but worries surround with the limitations that Web browsers impose on user interfaces. RichInternetapplications(RIAs)maybecomethenewnormforapplicationsusedbydecision-makersandtask-orientedworkers. The Key Characteristics of RIA-based Solutions as below –

- Accessibility
- Advanced communications
- Complexity

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- Consistency
- Installation and Maintenance
- Offline
- Security
- Performance
- Richness

However, meeting the demand for information through innovative and rich interactive applications will continue to gain more prominence in the enterprises.

2. CHALLENGES FOR ADOPTING RIA

Most organizations need to factor-in various challenges in adopting RIA technologies –

- **Accessibility and integration –** Most of the RIA applications are developed using Ajax/JSON and JavaScript technologies. Prevailing issues with Ajax implementation and JavaScript models are not new**.** Apart from the look and feel of RIA applications, most of the organizations are concerned about the integration and communication protocols.

- **RIA Security** - Security is a key concern for RIA deployments across enterprises. Several client-side frameworks open up new avenues of compromising critical information. The lack of security aspects in RIA application is the major concern for its adoption across enterprises.

- **Lack of standards** – There is a lack of standards in RIA technologies. There is a lot of confusion on using AJAX or Flex or a combination of both while each of them have their own advantages and issues, say for example, some of the Ajax tools have cross-browser and cross-platform problems. There is a need to identify and consolidate best practices and provide reference implementation for tools interoperability and decide on right programming models.

- **Lack of Rich, Interactive Use Experience** – Organizations are looking a rich user experience that engages business users more effectively and personalize their web experience based on their preferences and needs so that they can make better informed decisions in real-time which is only possible through an intuitive and easy-to-navigate RIA.

3. POTENTIAL OF A NEW RIA PARADIGM

A rich Internet application (RIA) is the converging point between both desktop-based and browser-based applications. RIA's are generally lightweight applications which provide the features of a desktop based application and is executed and displayed via a browser.RIA based applications have evolved over the time to deal with the challenges and limitations of development and delivery of both web and desktop applications.

Some of the RIA benefitsfor enterprises are given below –

- The same application can accessed within desktop, browser and mobile platforms
- Rich user experience meeting the consumer demands along with the ones of business users
- Multiple types of content can be served using a single user interface than having to build and maintain multiple applications
- Enables an engaging, interactive user experience without page reloads or refreshes
- Real-time data and cross platform support
- Increased customer and partner productivity and reduce operational cost

There are several recurring problems that need to be addressed by considering right design principles in RIA applications. With the same context, enterprises need to look at a few fundamental questions –

- What are the business benefits of adopting RIA and what are the challenges?
- Will RIA implementation lead to increased end user productivity?
- How to design a RIA application with fast response time?
- How secured is the RIA Application architecture?
- When to use RIA frameworks? Which technology to choose?
- How RIA fits into SOA-based Enterprise Architecture Stack?
- What is the Role of RIA in Cloud delivery model?
- Is RIA solution based on open standards?
- When to use Ajax?
- Is RIA Mash-up required?

While significant attention has recently been placed on emerging RIA technologies such as Asynchronous JavaScript and XML (Ajax) style solutions to Cloud-based mash-up deployments, but their success, mainly depends on the user-centered design which offers desktop-like experience by combining real-time user interaction with rich user interfaces. Moreover, enterprises need to align their technology practices and to instill the right composition of technology, platforms and disciplines in order to consistently execute ahead of others.

4. Rich Internet Applications (RIA) Emerging Trends

Rich Internet Application platforms are moving from an early adoption phase to enterprise level adoption and are emerging as next generation vehicles more suited to decision makers and business end users who need seamless, high quality visual user experience. This leads to the key RIA trends that we see across the industry. To name a few:

4.1. Improve Customer Experience Through RIA

No matter how customers interact with an enterprise, whether it through an online store, net banking portal, or a mobile application designed to indicate the latest products or services available where each interaction builds on the top of the last one. There are a few important factorsto consider while delivering an intuitive customer experience –

4.1.1. Consistent Experience Across Channels

In the recent past, there have been remarkable changes in the mobility space with technology advancements and new innovations meeting the need of accessing information through intuitive and rich applications on smartphones and tablets. Ubiquity of information on all form factors of mobile and tablet devices changes the user perception on how they ought to get what they need in whatever form and wherever they need it.

A common theme that has emerged across customers, RIA exist as part of an overall Web experience where a collection of Web technologies such as Ajax, Flex, JavaFx are looked as the subset of RIA each flourishing in its own right, coming together in powerful new ways but they complement each other when used in the context of Service oriented architecture (SOA).

Without a concrete focus on Mobility strategy or long-term roadmap, enterprises today misses out an opportunity to acquire new customer and leverage many different channels across their line of business and it is even more important to ensure that user has a consistent and rich experience across all such channels. To this effect, enterprises generate powerful positive word of mouth and convert their customer base from satisfied customers to loyal advocates.

4.1.2. Empowering Customers

It is in the best interest of organizations to invest in technologies to enable and empower their customers by provide in their applications, across channels, the right number of options and automation capabilities to allow end users to customize their experience, and let them manage their information. Not only does this empower business users to customize the information presented to them, it also greatly increases the adoption of the applications as well as the likelihood of them sticking with it and recommending it to others.

4.1.3. Intuitive, User Friendly Interfaces For Enterprise Processes

Enterprise Processes are most critical for day to day operations of global businesses and systems. It is imperative to enhance all customer touch points with enterprise processes, by building user interfaces that are intuitive and interactive and guide them to provide all essential data, required by the enterprise as well as regulatory and compliance processes.This data can then be plugged into enterprise processes and used to generate all manner of documentation, legal or otherwise, in whatever layout or format desired.

There is a need of having an RIA developed capability to provide a consolidated view of information from all relevant systems and processes at one place at the same time. More and more companies are moving towards such a consolidated dashboard, that they can build around key activities and strategic analysis, leveraging not only information within the company firewall but also relevant information outside it. Such a consolidation of information is going to be key in future, for companies to squeeze out productivity out of their employees and save on time, as well as being nimble when it comes to looking at the bigger picture across systems.

4.2 RIA Security

One of the most important assets on which an enterprise stands is data and the security of the data is of vital importance for the enterprise. Technology selection depends significantly on its compliance to core security model. The criticality of the data governs the choice of technology where security needs to be one of the prime features. The sand box modelintroduced by Java applets in the early 2000 can be considered as a benchmark in this area where in the client cannot access any local resources except that the ones from where it originated. Sandbox security is an important trend to provide a security-rich user experience from RIA-based architectures. This idea is being implemented by several RIA technologies like Adobe Flex providing a secure environment for the data to be used by the intended application only.

4.3 RIA on the Cloud

Most of the enterprises are moving their platforms and services to the cloud where RIA applications are deployed on the cloud and clients access their services on pay-per use model without much marrying about deployment and scalability. In social media space, enterprises are leveraging RIA mash-ups to provide their users a unified view of various information hubs.

4.4 RIA Applications - Server-side Components

The USP of RIA based applications is the way they abstract the server side capabilities from the user by providing a desktop based application kind of look and feel. The earlier technologies failed to create this wave as they relied heavily on HTTP and web services based communication with the components located in the server and these often would get clogged due to the increased data transfer. The current technologies have gone a step ahead and started using a new protocol – Binary protocol. Action Script Messaging Format (AMF) used by GWT, JavaFx, Adobe Flex etc., is an example of this protocol.

A recent trend observed is that several RIA frameworks comes bundled with support for integration with server-side technologies which essentially ease the work of system integrators to ensure that all integrate and communicate with each other seamlessly.

5. Web User Experience Adoption

The behavior of the web users has changed over the times with the ad-vent of new business opportunities and how soon they grab those to stay current in the market. The earlier web technologies use to pose challenges to the users like:

- Traversing through multiple pages to accomplish as set of tasks which takes a lot of time and being less intuitive to new users.
- The data visualization was more monotonous and less interactive in providing visually appealing and interactive data display, which is very much needed by the current day user as data plays a vital role in their data to day activities.
- The users were unable to customize the look and feel as needed and perceived by them for their usage needs. The web pages were less interactive and had a bigger learning curve to get acquainted with the application to cater to their activities.

The behavior based programing has brought in a paradigm shift in the thought process of both the users and developers as it allows in creating views that simulate desktop application components like menus, but-tons, trees, etc. for the developers and the applications are more intuitive and interactive and also considerably decreasing the learning curve and thus changing the overall experience of the users.

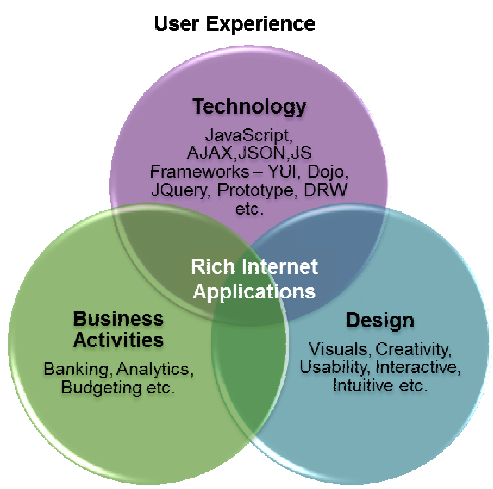

Fig. 1.User-centered Design

The RIA's unlike traditional web applications use the client environment to provide a desktop like look and feel by using plug-in like features and thus offloading some load from the servers. This helps in providing a desktop like look and feel and in some cases offline usage capabilities. The offline usage capabilities might be needed in some scenarios where in the users might be working from a remote location or a place of less connectivity, they can still continue to work and the application gets synced with the server once the connectivity is available, thus preventing from the loss of productivity, time and data.

5.1. RIA – Impact on Web User Experience

The evolving RIA technologies are creating a lot of impact in the way the applications and developed and experienced by the users. The traditional web applications rely a lot on the servers as the browser is used as a mere rendering layer/engine to the user. All the validations, computations etc. are performed at the server side and the browser just renders this aggregated response to the user and while doing this it might make a lot of trips back and forth to the server to compile a chunk of displayable content. This increases the response time to the user and creating a negative impact on the user experience.

On the contrary the RIA's have created an impact by involving the client tier of not just display but for some of the validating and processing activities, thus reducing the load on the server and decreasing the response time. Only the required and requested data is brought back from the server. Using some of the latest design methodologies and technologies the user's next action can predicted and the data needed for that action can be pre-fetched from the server. This has improved the user experience manifolds. There is a downside for this design approach, if the user does not perform the expected action, even then the application needs to cater to the current user action and this might impact the user experience. Although the latest RIA technologies up to some extent help the designers in this aspect, utmost care needs to be taken other-wise it might ruin the user experience.

5.2. Key RIA Technologies and Platforms

There has been a significant focus on various RIA platforms such as Adobe Flex/Flash, Microsoft Silverlight and IBM Lotus Expeditor in a belief that these enterprise-oriented vendors offer feature rich RIA tools and platforms that go beyond basic Ajax capabilities. Moreover, their market adoption is seen to be increasing as the technology matures and the market broadens over time.

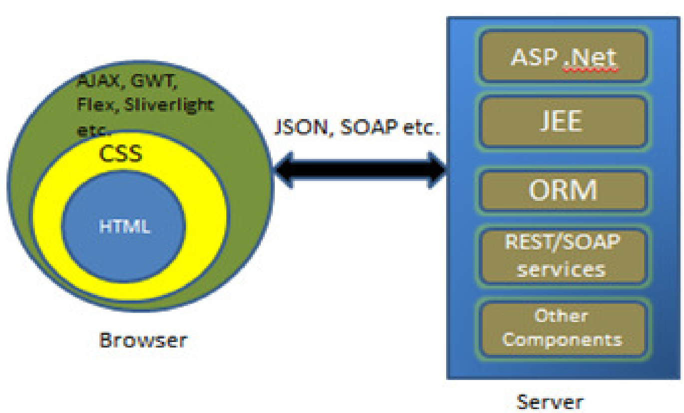

Fig.2. RIA – Key Technologies

The emerging trends are portraying a picture that enterprise RIA ad-dresses the enhancements in existing web applications, next-generation enterprise portals, event-driven applications, BI and mash-up oriented solutions. From software development perspective, RIA follows a standard model with rich controls that include powerful data and multimedia capability allowing end users to present a rich set of information in more attractive interface. From design perspective, RIA delivers highly customizable output with a CSS (Cascading Style Sheet) based model.

As far as, an expressive, secure and cross platform user experience is concerned, there is a necessity to bridge the gap between user experience design and programming logic. Rich Web technology like JavaFx addresses such gap by featuring a high-performance declarative scripting language with a suite of tools and authoring solutions that helps building and delivering the next generation of rich Internet applications for desktop, mobile, TV, and other consumer platforms.
Apart from the Java language itself, there are several well-known JVM languages available in the market such as – JavaFx Script, JRuby (an implementation of Ruby), Jython (an implementation of Python), Rhino (an implementation of JavaScript), but Groovy, an agile and dynamic language for JVM, is getting popular and started taking shape in customer technology landscape to improve productivity by accelerated deployment cycles. Dynamically typed languages are much more expressive and easier to code with than statically typed languages. With this perspective one the areas to be explored is the flexibility of Groovy over Grails as Grails currently supports all popular frameworks like Prototype, Dojo, script.aculo.us and Yahoo User Interface (YUI).

6. KEY TAKEAWAYS

Due to the availability of feature rich technologies in the RIA space enterprises are investing in building and deploying rich and dynamic content based applications to improve their user experience. However as every coin have two sides there are some challenges that the enterprises are facing along with the features. RIA can have a significant and transformative impact on businesses and a few learnings on the same line as given below –

- **RIA project strategy to be developed**in-line with organization business goals that improve the brand value by bringing company's web presence in the market

- **Organization to consider adding RIA components** to existing sites and micro-sites to reduce cost in long run

- **Next stage of Internet** – RIA to support mobility initiatives and integrate with cloud based delivery model and services (PaaS/SaaS)

- **A new generation of RIA tools** to use standards-based technologies and industry specific programming models and patterns to create solutions that deliver secure, scalable and high performance solutions

- **Leverage a lightweight fully featured UI framework** for RIA development that closely matches the look and feel of a native desktop application GUI.

- **Dynamic Content delivery-**As long as the application has static content and data that does not change frequently; they can be cached to deliver faster experience to the users. Content Delivery Network (CDN's) like Amazon Cloud Front, Akamai can be leveraged for this. These CDN's have a wide network of Edge location across the globe and can cache the static content in those servers and can deliver it to the users swiftly. As the dynamic data increases it becomes difficult to cache and thus takes a long response time and affects the user experience. In this situation new technologies like Akamai's Dynamic Site Accelerator (DSA) can be leveraged. The DSA ensures that all site elements including the static ones and dynamic are delivered with an improved response time.

- **Usability-**Although the RIA based applications are meant to improve the user experience with interactive and simple look and feel, if the design is too complicated then it may confuse the users and in turn hits their experience. It is always suggested to keep the design simple and more intuitive so that the user has a pleasant experience while using the application.

- **RIA application to be designed addressing key enterprise issues** like security, integration, authentication and authorization.

7. CONCLUDING NOTES

The rich internet application space is replete with software products, and witnesses launches every day. It is obvious that with the emergence of RIA technologies, customer immediate focus has shifted towards those tools, technologies or platforms that deliver rich user experience that is visibly different than what's delivered by traditional server-centric platforms.

With its proven market convergence RIA based applications flaunt their ability to combine the strengths and advantages of browser and desktop applications. The web applications focus on accessibility, contextual interaction, ease of use and quick deployment to deliver a more relevant, aggregated and social experience to the user.

The potential of RIA is not fully realized by enterprises yet. As the RIA adoption is catching up, the bar regarding the basic requirements like security, availability, reliability and similar features is getting raised. The RIA technologies are coping up with the raised bar and evolving to bridge the gap with the requirements.

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