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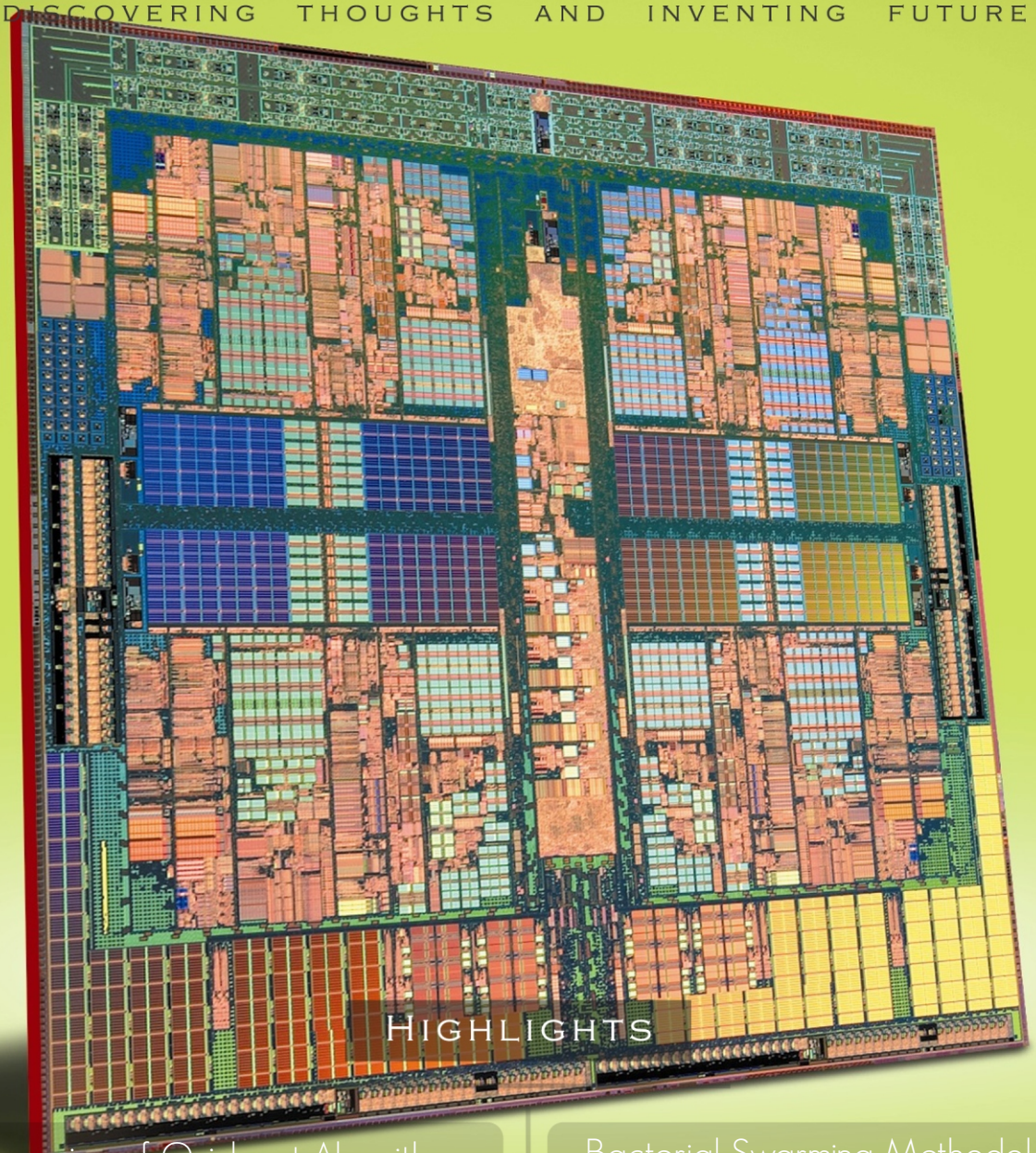
DISCOVERING THOUGHTS AND INVENTING FUTURE



HIGHLIGHTS

Improving of Quicksort Algorithm

Bacterial Swarming Methodology

Analytical Performance Comparison

Easily Accessible Telepresence

Hardware of AMD

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Hardware & Computation

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Improving of Quicksort Algorithm Performance by Sequential Thread or Parallel Algorithms

By Abdulrahman Hamed Almutairi & Abdulrahman Helal Alruwaili
King Saud University

Abstract - Quicksort is well-know algorithm used for sorting, making O(n log n) comparisons to sort a dataset of n items. Being a divide-and-conquer algorithm, it is easily modified to use parallel computing. The aim of this paper is to evaluate the performance of parallel quicksort algorithm and compare it with theoretical performance analysis. To achieve this we implement a tool to do both sequential and parallel quicksort on randomly generated arrays of different size in several runs to provide us with enough data to draw conclusions about the efficiency of using the capability of modern multicore processors together with algorithms designed to increase the speed of sorting large arrays.

Keywords : *Parallel computing, Parallel algorithms, Parallel Computing, Quicksort.*

GJCST-A Classification: *F.2.2*

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Improving of Quicksort Algorithm Performance by Sequential Thread or Parallel Algorithms

Abdulrahman Hamed Almutairi [α] & Abdulrahman Helal Alruwaili [α]

Abstract - Quicksort is well-know algorithm used for sorting, making O(n log n) comparisons to sort a dataset of n items. Being a divide-and-conquer algorithm, it is easily modified to use parallel computing. The aim of this paper is to evaluate the performance of parallel quicksort algorithm and compare it with theoretical performance analysis. To achieve this we implement a tool to do both sequential and parallel quicksort on randomly generated arrays of different size in several runs to provide us with enough data to draw conclusions about the efficiency of using the capability of modern multicore processors together with algorithms designed to increase the speed of sorting large arrays.

Keywords : Parallel computing, Parallel algorithms, Parallel Computing, Quicksort.

I. Introduction and Motivation

Sorting is among the fundamental problems of computer science. Sorting of different datasets is present in most applications, ranging from simple user applications to complex software. Today, in this modern age, the amount of data to be sorted is often so big, that even the most efficient sequential sorting algorithms become the bottleneck of the application. It may be a database or scientific data.

Today, it is said that the problem is not the lack of data but the need to sort and search in the huge amount of data available to us. To be able to do those tasks efficiently with the data available, the speed of sorting becomes critical. A lot of work was done to improve the speed of traditional sequential sorting algorithms, be it optimizing the pivot selection for quicksort or trying to come up with new, adapting sorting algorithms.

With the appearance of parallel computing, new possibilities have appeared to remove this bottleneck and improve the performance of known sorting algorithms by modifying them for parallel execution. At first, this was achieved using distributed computing, however with the hardware available today, it is possible to do this even on home computers thanks to their multicore processors.

In this paper, we present a parallel version of the well know quicksort algorithm and compare its performance to the performance of its simpler, sequential quicksort algorithm. Comparing their performance, we look for the threshold T, the size of the array, at which the parallel algorithm becomes actually slower than the sequential algorithm. By choosing a value that promises the best performance, we then test and compare the parallel and sequential versions of the quicksort algorithm, providing us with enough data to draw a conclusion about the increase in performance when using the parallel quicksort algorithm.

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II. Quicksort

Quicksort is a sorting algorithm developed by Tony Hoare that requires, on average, O(nlogn) comparisons to sort n items. In the worst case scenario, it makes O(n2) comparisons, even though this is a rare occurrence. In reality it is mostly faster than other O(nlogn) algorithms [1]. The implementation of a simple sequential Quicksort algorithm follows that we choose for our needs is:

- Choose a pivot element. We use the last element out of the sorting area
- Iterate through the sorting area, placing all numbers smaller then the pivot to a position on its left, while placing all other numbers to a position on its right. This is done by swapping elements.
- The pivot is now considered to be in its sorted position and we continue with the divide-and-conquer strategy, applying the same algorithm on the part to the left and the part to the right of the pivot.

This way, the whole, original dataset is sorted by recursively using the same algorithm on smaller and smaller parts. This is done sequentially. However, once the partitioning is done, the sorting of the new sorting areas can be performed in parallel as there is no collision.

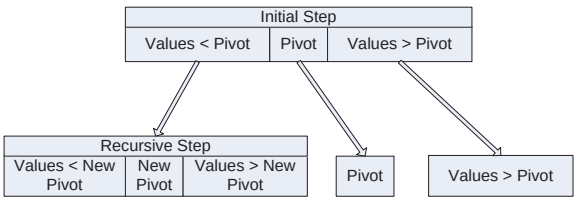

Figure 1: Simple graphical representation of the Quicksort algorithm

III. Related Work

Several works were done into parallel sorting algorithms. The first one, being restricted by hardware not providing multicore processors were using private

virtual [3]. This required the solutions to communicate between them using messaging witch not only complicated the process of implementation, but also increases the overhead of parallelism. The work presented a fine-tuned parallel quick sort. The algorithm used asynchronous multiprocessors with cache-coherent shared memory. They pick the pivot using the processor with the lowest ID. Afterwards, each processor picks a blok from the left and one block from the right side of the pivot, the size of the block chosen so it can fit into the L1 cache. This two block processed in a way so that one block contains values smaller then the pivot, and the other block contains values larger or equal, with again the CPU with lowest ID performing some after-cleanup operations. Then the input array is distributed between the processors and the recursion sorting of quicksort begins until each group of processors contains only one CPU or until the size of arrays are below a certain limit and insertion sort is performed. Here, we found especially the idea of a threshold to use a simpler, sequential sorting algorithm to save the computational cost when sorting small arrays, especially interesting.

However, in last few years, improvements in sorting have been made thanks to the works incorporating multi core and multiprocessor computer architecture [2].

IV. Theoretical Analysis

With the parallel algorithm, we have to remember that the cost of creating, monitoring and managing of the parallel tasks is added to the total computational cost. Let's assume the average case of quicksort with computational time O(nlogn).

When using parallel computing, the computational cost consists of these values:

- picking the pivot – O(1)
- moving the elements to the left and right side of pivot - O(n)
- creating new Tasks to sort the left and right part - O(1)

Based on Figure 1 it's easy to see, that the fully developed parallel quicksort algorithm will have the shape of a binary tree.

For each leaf node of this tree, we will be required to perform a sequential quicksort algorithm, the size of the leaf node depending on the threshold T we choose.

For each node, the creation of new Tasks for child nodes will add to the total computational cost.

The extreme condition would be where the last leaf node would be smaller then T in case N is not divisible by T. However, this has an minimal impact on the overall performance and therefore we decided to assume, which allows us to make our theoretical analysis using a complete binary tree.

For a dataset of N elements, the binary tree will have N/T leaf nodes. Therefore it can be easily seen, that the tree will have nodes.

The number of the leaf nodes will be N/T, each of it with the size of T. This means, the computational cost to sort the leaf nodes using sequential quicksort will be With this in mind, if we would ignore any overhead, parallel quicksort would be able to provide us with this increase in performance, as shown in Figure 2. In theory, lower threshold values would provide us with even better performance.

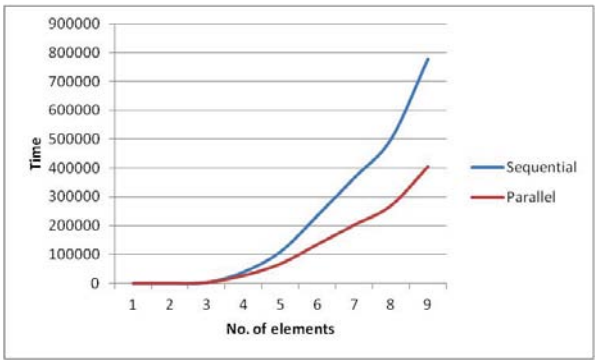

Figure 2 : Theoretical comparison between Sequential and Parallel quicksort, using threshold value of 500

However, given the binary tree, in each node we have to select a pivot, move the elements to the left and right side of the pivot and create the Tasks to do the parallel sorting.

The limitation to speed increase of a parallel algorithm as compared to a sequential algorithm are the overhead caused by the need to create new, parallel processes and their management.

V. Practical Analysis

For our practical analysis, we wrote a simple program to test and compare a sequential and parallel quicksort. This program first sorts a field of integers using sequential quicksort and then sorts the same field using parallel quicksort. To evaluate the overhead needed to create new tasks, we implemented a version of the quicksort algorithm, where for each recursive call, a new task is created, they are however executed not parallel but sequential.

Our solution was implemented in C# as a simple form application. The window can be seen in Figure 3.

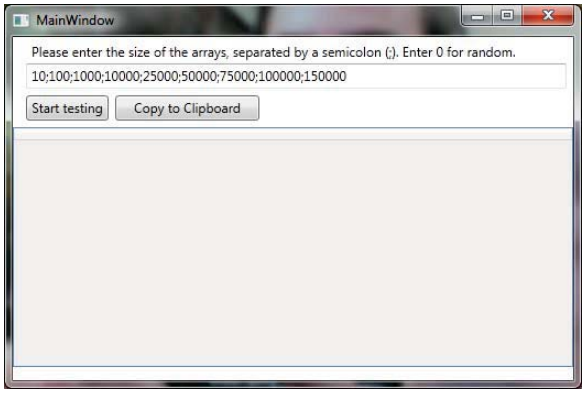

Figure 3 : The application used to compare the performance sequential and parallel quicksort

From the point of user interface, the application is very simple, providing 4 items for user interaction. The first one is a textfield where wecan define the size of arrays to be used for the testing. Next is the 'Start testing' button which begins the sorting process. The last button is the Copy to clipboard button which takes the aggregated results of the tests run so far and copies them into a table structure in the clipboard, which can be easily pasted into Excel for further processing.

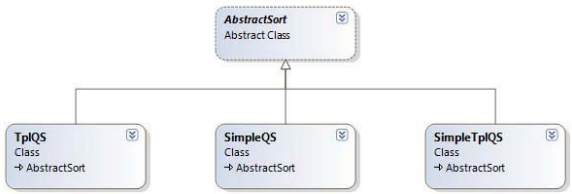

Figure 4 : The core class design of the benchmarking program

The base class is the AbstractSort, which contains the code for benchmarking the sorting. The derived classes override an abstract method called InnerSort and implement either the sequential or parallel version of quicksort.

This is the code for the public method Sort of the AbstractSort called.

```
int[] sorting=new int[array.Length];
Array.Copy(array, sorting, array.Length);
QSResult result=new QSResult();
DateTime start= System.DateTime.Now;
result.sorted = InnerSort(sorting);
result.time =
System.DateTime.Now.Subtract(start).Total
Milliseconds;
return result;
```

As can be seen, a copy of the array is created so that when the other sorting algorithm is to be benchmarked, it will be benchmarked on the same, unsorted array. Afterward the current time is stored and the sorting commences. When the sorting is finished, the result time is computed as current time minus the time stored before the sorting commenced.

The sequential quicksort is implemented in a simple manner as the following pseudo code shows:
qsort(array,left,right)

```
qsort(array,left,right)
{
  cur, last;
  if (left >= right) return;
swap(array,left,(left+right)/2);
last = left;
for(cur=left+1;cur<=right;++cur)
  {
    if(array[cur]<array[left])
    {
      ++last;
     swap(array,last,cur);
    }
  }
  swap(array,left,last);
qsort(array,left,last-1);
qsort(array,last+1,right);
}
```

Our parallel implementation is only slightly different. First, the size of the array to be sorted is checked against a threshold. If the size is smaller than the threshold, sequential quicksort is used as the overhead of creating new tasks would slow the sorting process too much. If the size of the array is bigger than the threshold, instead of calling the quicksort for each part directly, new Task is created for each of the call and let's them handle the sorting of each part of the array. This is show in the next code snippet:

```
if ((last - left) < SEQ_THRESHOLD)
{
       qsort(array, left, last - 1);
       qsort(array, last + 1, right);
}
else
{
       Task.WaitAll(
       Task.Factory.StartNew(()=>
       qsort(array,left,last-1)),
```

```
            Task.Factory.StartNew(()=>
            qsort(array, last + 1, right)));
        }
```

Last, to test the overhead caused by creating a new Task, we created a quicksort algorithm where new Task is created for the initial sorting. This is done by the following code when initializing he quicksort algorithm:

```
Thread thread=new Thread(delegate()
{
        qsort(array, 0, array.Length - 1);
});
thread.Start();
while (thread.IsAlive)
    Thread.Sleep(1);
```

These algorithms were tested on the same hardware, using a quad core processor.

To test we used 9 randomly generated arrays of following sizes: 10; 100; 1 000; 10 000; 25 000; 50 000; 75 000; 100 000; 150 000. We did 100 separated runs, algorithms in each run using the same data, but the data being randomly generated between runs to provide variability.

The hardware we run our test on was a Intel Core i5 processor running at 2.53GHz. This is a dual core processor capable of running four threads in parallel. The computer had 3.8GB of memory. During the test, no other program was running to provide a interference-free environment.

First, by using a trial and error approach, we established a suitable value for the SEQ_THRESHOLD value to be 1000. We ran a full scale test on arrays of 9 different sizes with three different SEQ_THRESHOLD values, 1000,5000 and 50 000. The resulting times can be seen in Table 1 and in Figure 5.

	T=1000	T=5000	T=50000
10	0.01	0	0.010001
100	0.01	0.020001	0.050004
1000	0.250016	0.270011	0.260018
10000	2.010118	2.880166	3.060169
25000	5.380318	6.120344	9.15052
50000	11.36065	11.320644	19.61112
75000	18.14103	18.251045	28.60164
100000	24.91142	22.591294	34.19196
150000	36.41208	34.551976	46.99269

Table 1: Average run times for different threshold and number of elements

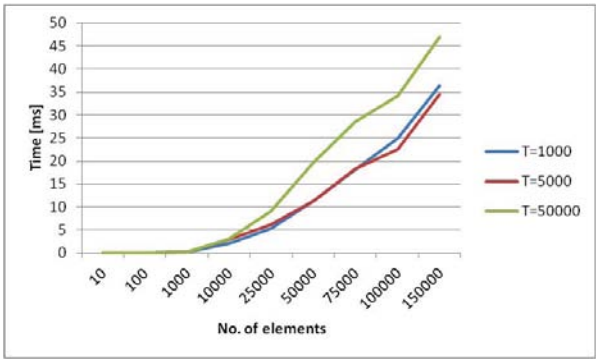

Figure 5 : Comparison of parallel quicksort run time with different thresholds

With the threshold set at 50000, the parallel algorithm is actually slower, as the computational cost of creating new tasks increases the total run time, but the parallelism is not utilized enough to offset this. In Figure 6 it can be clearly seen, that with the higher threshold of 50000, the additional computation cost of creating new threads cannot be compensated for by doing parallel computation as the algorithm returns to sequential quicksorting too soon.

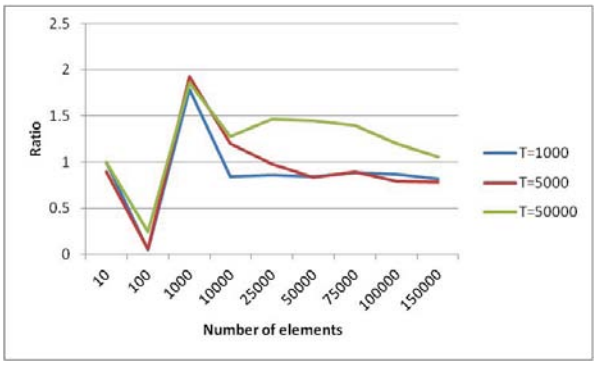

Figure 6 : Ratio of run time, Parallel to Sequential

We can see the comparison of a sequential and parallel quicksort in Figure 7.

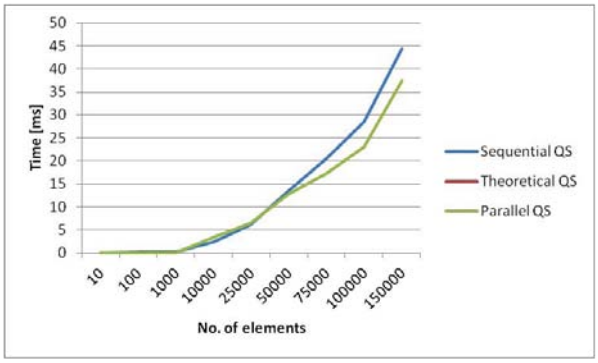

Figure 7 : Comparision of sequential and parallel quicksort, T=1000

To compare the speed gained by using parallel computing, we created a graph showing the speed up ratio for different data size as shown in Figure 8.

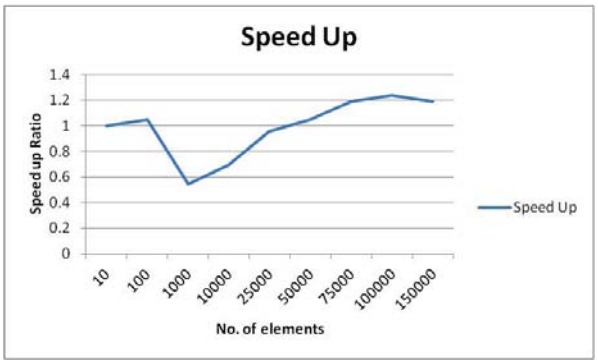

Figure 8 : Graph showing speed up ratio by using parallel quicksort

This graph was created by using the formula

$$Speedup = \frac{execution\ time\ of\ sequential\ algorithm}{execution\ time\ of\ parallel\ algorithm}$$

As can be seen here, at low number of elements no speed up is achieved. As the number of elements increases, the speed of sorting actually decreases. This is caused as stated before by the overhead needed for creating the parallel tasks and as there is not enough elements for the parallelism being able to compensate for this. After the number of elements increases enough, the overall speed and speed gain increases as well by about 20%.

VI. Conclusion

We successfully implemented a parallel version of quicksort algorithm. After choosing a appropriate threshold value to switch from parallel to sequential sorting, we observed the performance of the algorithm. The results are obviously in favor of the parallel quicksort algorithm. Using a reasonable threshold to return to sequential quicksort, we are able to circumvent the increased computational cost of creating new tasks for small datasets, while with the bigger datasets we take advantage of the parallelism possible by today's hardware. And thanks to simplicity of the parallel implementation of quicksort algorithm it is easy to achieve major, 20% increase of performance when sorting a larger dataset.

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A Hybrid Bacterial Swarming Methodology for Job Shop Scheduling Environment

By Shivakumar B L & Amudha T
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Abstract - Optimized utilization of resources is the need of the hour in any manufacturing system. A properly planned schedule is often required to facilitate optimization. This makes scheduling a significant phase in any manufacturing scenario. The Job Shop Scheduling Problem is an operation sequencing problem on multiple machines with some operation and machine precedence constraints, aimed to find the best sequence of operations on each machine in order to optimize a set of objectives. Bacterial Foraging algorithm is a relatively new biologically inspired optimization technique proposed based on the foraging behaviour of E.coli bacteria. Harmony Search is a phenomenon mimicking algorithm devised by the improvisation process of musicians. In this research paper, Harmony Search is hybridized with bacterial foraging to improve its scheduling strategies. A proposed Harmony Bacterial Swarming Algorithm is developed and tested with benchmark Job Shop instances. Computational results have clearly shown the competence of our method in obtaining the best schedule.

Keywords : *Harmony Search, BFO, Scheduling, Bioinspired systems, optimization.*

GJCST-A Classification: *D.4.1*

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I. Introduction

Nature Inspired Computing (NIC) is an upcoming area of research that aims at developing innovative computing techniques by observing how nature behaves in various situations to solve complex problems [2]. Based on the observation from nature a problem solving strategy can be formulated. The strategy can be used to design an initial model and remodeling it until a near perfect working model is obtained. The resulting model may also find certain new and unknown mechanisms. Principles such as survival of the fittest and law of jungle are used to develop the nature-inspired approaches [3]. NIC techniques are highly adaptable that they can be applied to wide range of problems and can be dealt with unseen data and even incomplete data. capable of learning, so robust that can handle. They have decentralized control of computational activities. Biological Inspired Computing (BIC) is a subdivision of Nature inspired computing (NIC). Bio- inspired algorithms are characterized byalgorithmic operators mimicking computationally useful aspects of various biological phenomena. Metaheuristic are algorithmic templates used to specify problem-independent optimization strategies, which can be instantiated in order to define problem-specific heuristics [24] [25].

In computer science, metaheuristics designates a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. Metaheuristics make few or no assumptions about the problem being optimized and can search very large spaces of candidate solutions. However, metaheuristics do not guarantee an optimal solution in most cases. Many metaheuristics implement some form of stochastic optimization. Metaheuristics have been most generally applied to problems classified as NP-Hard or NP-Complete by the theory of computational complexity. Some of the most successful metaheuristic [7] conceived in the last few years are Tabu Search, Simulated Annealing, Genetic Algorithms and Memetic Algorithms, Ant Colony Optimization (ACO) and Bacterial Foraging Optimization (BFO), Bee algorithms and Harmony Search (HS). They are population-based methods that make use of the global behavior that emerges from the local interaction of individuals with one another and with their environment.

Bacterial Foraging optimization algorithm is a novel biologically inspired computing technique proposed based on the foraging behavior of Escherichia coli (E. coli) bacteria living in human intestine [4]. The BFO Algorithm belongs tofield of Bacteria Optimization Algorithms and Swarm Optimization, and more broadly to thefields of Computational Intelligence and Metaheuristics. It is related to other Bacteria Optimization Algorithms such as the Bacteria Chemotaxis Algorithm and other Swarm Intelligence algorithms such as ACO and PSO. In specific, the BFO Algorithm is inspired by the chemotaxis behavior of bacteria that will perceive chemical gradients in the environment (such as nutrients) and move toward or away from specific signals.

Harmony Search is a phenomenon mimicking algorithm by the improvisation process of musicians. In the HS algorithm, each musician (= decision variable) plays (= generates) a note (= a value) for finding a best harmony (= global optimum) altogether [26]. HS algorithm was recently developed in an analogy with music improvisation process where music players improvise the pitches of their instruments to obtain

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better harmony. The working principle of HS algorithm is very different from classical optimization techniques. HS algorithm uses a random search, which is based on the harmony memory considering rate and the pitch adjusting rate. Compared to earlier meta-heuristic optimization algorithms, the HS algorithm imposes fewer mathematical requirements and can be easily adopted for various types of engineering optimization problems It has been successfully applied to various benchmark and real-world problems [1] [8] [13] [14].

ACO belongs to the class of metaheuristics, which are approximate algorithms used to obtain good enough solutions to hard combinatorial optimization problems in a reasonable amount of computation time [6] [10]. The inspiring source of ACO is the foraging behavior of real ants. The ant deposits a chemical pheromone trail on the ground when it forages. The quantity of pheromone deposited depends upon the quantity and quality of the food that will guide other ants to the food source [12]. The indirect communication between the ants via pheromone trails enables them to find shortest paths between their nest and food sources.

Scheduling problem is one of the most important problems in the field of combinatorial optimization [CO], and it finds its application in various engineering and manufacturing industries. It is generally NP-hard CO problem. The scheduling problem is a problem of deciding which job in which order to be done with which machine, when several jobs are processed with several machines. The Job Shop Scheduling Problem (JSSP) is one of the most difficult problems of these types. It is an operation sequencing problem on multiple machines subject to certain precedence constraints among the operations [5] [7] [28]. The JSSP has several machines of which each machine has each function, and each job is processed according to a specific order. The JSSP is to find the best sequence of operations on each machine in order to minimize or maximize a specific objective or a set of objectives. JSSP belongs to the class of NP-Complete problems and hence various heuristic approaches have been developed to solve these problems.

In this paper, BFO is improved by modifying the swarming behavior of the bacteria. Harmony search is used for improvising the search strategy of the bacteria which has remarkably resulted in a much better schedule. BFO and improved BFO using harmony search method, named as Harmony Bacterial Swarming Algorithm [HBSA] are applied to solve various benchmark instances of JSSP. JSSP benchmark instances were taken from the OR-Library. These instances are worth solving as they are considered as the most significant, classical and complex CO problems known to be NP-hard. The effectiveness of hybrid Bacterial swarming methodology is analyzed by comparing its performance with BFO and ACO. Experimental results on various benchmark instances have clearly shown the competence of the nature-inspired methods in solving complex combinatorial optimization problems and the improvement in optimal solutions when BFO was hybridized with HS.

II. Related Work

Zong Woo Geem et al., (2005) applied Harmony search (HS) to a TSP-like NP-hard Generalized Orienteering Problem (GOP) which is to find the utmost route under the total distance limit while satisfying multiple goals. The results of HS showed that the algorithm could find good solutions when compared to those of artificial neural network.

Sukayapong Ngonkham and Panhathai Buasri (2008) presented harmony search algorithm (HS) to solve economic dispatch (ED) problem in the power system integrating wind energy conversion system (WECS). Three optimization techniques, genetic algorithm (GA), interior point methods (ITP) and HS were applied to solve ED when system connecting and disconnecting to WECS. The results showed that HS can give the better solution than the others. In the comparison with GA, HS and ITP, HS had better than GA 3.2% and better than ITP 1.6%. Moreover total cost reduction when the system connected to WECS computed by HS was reduced to 8% per day.

Quan-Ke Pan et al., (2011) proposed a local-best harmony search (HS) algorithm with dynamic sub-harmony memories (HM), namely DLHS algorithm to minimize the total weighted earliness and tardiness penalties for a lot-streaming flow shop scheduling problem with equal-size sub-lots. Computational experiments and comparisons showed that the proposed DLHS algorithm generated better or competitive results than the existing hybrid genetic algorithm (HGA) and hybrid discrete particle swarm optimization (HDPSO) for the lot-streaming flow shop scheduling problem with total weighted earliness and tardiness criterion.

Mohammed Azmi Al-Betar and Ahamad Tajudin Khader (2010) applied a HS and a modified harmony search algorithm to university course timetabling against standard benchmarks. The results showed that the proposed methods were capable of providing viable solutions in comparison to previous works. The results of modified harmony search algorithm (MHSA) basically outperformed those obtained by basic harmony search algorithm (HSA) significantly. However, the computational time needed for MHSA is longer.

Christian Blum (2005) presented the Ant Colony Optimization algorithm introduction and its recent trends. In their paper, they explained how ant behavior exploited to search the approximate solutions for discrete and continuous optimization problems and to

important problem in telecommunication, such as routing &load balancing problems.

Jun Zhang, Xiaomin Hu, X.Tan, J.H Zhong and Q. Huang (2006) presented an investigation into the use of an Ant Colony Optimization (ACO) to optimize the JSSP. ACO is extensively used to solve NP-Hard Combinatorial Optimization problems. Its original model is based on the foraging behaviour of real ants who find an approximately shortest way to the food by detecting the density of pheromone deposited on the route. The main characteristics of ACO are positive feedback, distributed computation, robustness and the use of a constructive greedy heuristic.

James Montgomery, Cardc Fayad and Sarja Petrovic (2005) have discussed ACO for Job Shop Scheduling Problems and generated solutions by constructing a permutation of the operations, from which a deterministic algorithm can generate the actual schedule. They proposed a paper about Solution Representation for Job Shop Scheduling Problems in ACO. The result produces better solutions more quickly than the traditional approach.

W. J. Tang et al., (2006) studied a bacterial foraging algorithm (BFA) aiming for optimization in dynamic environments, called DBFA. A test bed proposed previously was adopted to evaluate the performance of DBFA. The simulation studies offered a range of changes in a dynamic environment. The simulation results showed that DBFA could adapt to various environmental changes which occurred in different probabilities, with both satisfactory accuracy and stability, in comparison with a recent work on bacterial foraging.

Sambarta Dasgupta et al., (2008) introduced a micro-bacterial foraging optimization algorithm, which evolved with a very small population compared to its classical version. In this modified bacterial foraging algorithm, the best bacterium was kept unaltered, whereas the other population members were reinitialized. This new small population μ-BFOA was tested over a number of numerical benchmark problems for high dimensions and found to outperform the normal bacterial foraging with a larger population as well as with a smaller population.

Wei Liu et al., (2011) presented a novel optimal scheduling method for Radio Frequency Identification (RFID) network using a Self-adaptive Bacterial Foraging Optimization (SABFO) Algorithm. The SABFO, which was based on the recently developed Bacterial Foraging Optimization (BFO) technique, could adjust the run-length unit parameter dynamically during evolution to balance the exploration/exploitation tradeoff. Simulation on an RFID reader network architecture was given to illustrate the effectiveness of the proposed SABFO based scheduling method. The simulation results, which compared to GA, PSO, and BFO, show that the SABFO obtained superior solutions than all the other methods.

According to S. Subramanian and S. Padma (2011), the selection behaviour of bacteria tends to eliminate poor foraging strategies and improve successful foraging strategies. The E.coli bacterium has a control system that enables it to search for food and try to avoid noxious substances. BFO was used to minimize cost and improve the efficiency simultaneously by using a multi objective based bacterial foraging algorithm.

E. Taillard [1989] has proposed a paper about Benchmarks' for Basic Scheduling Problems. In this paper he discussed about 260 scheduling problems whose size is greater than that of the rare examples published. Such sizes correspond to real dimensions of industrial problems. In this paper he solved the permutation Flow Shop, Job Shop and Open Shop Scheduling Problems.

III. Jssp Solution Representation Sing Hybrid Bacterial Swarming Algorithm [hbsa]

a) Bacterial Foraging Algorithm [BFA]

Bacterial foraging was proposed by Kevin M Passino in the year 2002 as a tool for distributed optimization and control which mimics the foraging behavior of E. coli bacteria. E. coli bacteria exist in intestines of most animals on the earth. E. coli bacterium has a control system, which directs its behaviors in food foraging. The foraging process consists of a series moves towards food sources [11]. The control system is in charge of evaluating changes from one state to the other states to provide reference information for E. coli bacterium's next state change. A change between two states is called as a move and the states include advancing direction and step length. E. coli bacteria gradually approach their food sources under the influence of its control system.

Biological studies have shown that the foraging process includes four steps: (1) search for a possible food region, (2) decide to whether or not enter into the possible food region, (3) perform a careful search if it enters into a new region, (4) decide to either keep stay in the current region or emigrate into a new and more ideal region, after they consume some food in the current region. In general, if the bacteria are trapped into a region in deficiency of food, they might draw a conclusion based on past experience that other regions must be in abundance of food. Due to this conclusion, bacteria would change their states [17][18][19]. Hence, each decision of state change is made under the physiological and environmental constraints with the final aim to maximize the obtained energy in unit time [81].

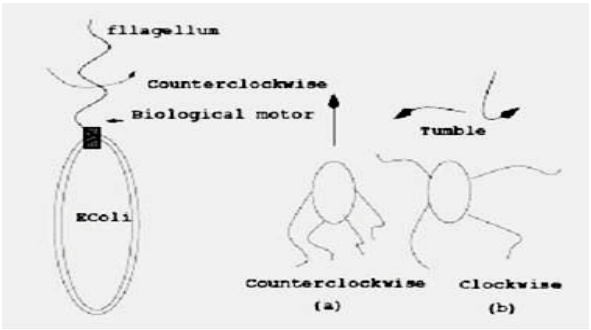

Fig. 1: Bacteria Swarming and Tumbling

The bacterial foraging system consists of three principal mechanisms, namely chemotaxis, reproduction and elimination-dispersal.

Chemotaxis : Biologically an E.coli bacterium can move in two different ways. It can swim for a period of time in the same direction or it may tumble, and alternate between these two modes of operation for the entire lifetime. Chemotaxis simulates the movement of an E.coli cell through swimming and tumbling via flagella. Depending upon the rotation of Flagella in each bacterium, it decides whether it should move in a predefined direction (swimming) or altogether in different directions (tumbling), in the entire lifetime. To represent a tumble, a unit length random direction, say ϕ (j), is generated; this will be used to define the direction of movement after a tumble. In particular

$$\theta^i (j+1, k, 1) = \theta^i (j, k, 1) + C(i)\phi(j) \quad (1)$$

where θi (j, k, l) represents the i-th bacterium at j-th chemotactic, k-th reproductive and i-th elimination and dispersal step. C (i) is the size of the step taken in the random direction specified by the tumble (run length unit).

Reproduction : The least healthy bacteria die and the other healthiest bacteria each split into two bacteria, which are placed in the same location. This makes the population of bacteria constant.

Elimination and Dispersal: It is possible that in the local environment the live of a population of bacteria changes either gradually (e.g., via consumption of nutrients) or suddenly due to some other influence. Events can occur such that all the bacteria in a region are killed or a group is dispersed into a new part of the environment. They have the effect of possibly destroying the chemotactic progress, but they also have the effect of assisting in chemotaxis, since dispersal may place bacteria near good food sources. From a broad perspective, elimination and dispersal are parts of the population- level long-distance motile behavior [58].

Pseudo code of Bacterial Foraging Algorithm

for *Elimination-dispersal loop* **do**
for *Reproduction loop* **do**
for *Chemotaxis loop* **do**
for *Bacterium i* **do**
Tumble: Generate a random vector $\varphi \in R^D$ *in* rand direction
Move: Let $\theta^{new} = \theta i + c\varphi$, compute J^{new}.
Let $J^{new}_{sw} = J^{new} + J_{cc}(\theta^{new}, \theta)$
Swim: Let m=0
while $m < N_s$ **do**
let m=m+1
if $J^{new}_{sw} < J_{sw}$ **then**
Let $\theta^i = \theta^{new}$, compute Ji and J^i_{sw}
Let $\theta^{new} = \theta^i + c\varphi$, *compute* $J(\theta^{new})$.
Let $J^{new}_{sw} = J^{new} + J_{cc}(\theta^{new}, \theta)$
Else
Let $m = N_s$
end
end
end
end
Sort bacteria ascending cost J_{sw}.
$S_r = S/2$ bacteria with the highest J value die & other S_r bacteria with the best value split
Update value of J and J_{sw} accordingly.
end
Eliminate and disperse the bacteria to random locations with probability p_{ed}.
Update corresponding J and J_{sw}.
End

Here C(i) is the Step size, i is the Bacterium number, j is the Counter for chemotactic step, J(i, j, k, l) is the Cost at the location of i^{th} bacterium, J_{cc} is the Swarm attractant cost , J^{i}_{health} is the Health of bacterium i, k is the Counter for reproduction step, l is the Counter for elimination- dispersal step, m is the Counter for swimming locomotion, N_c is the Maximum number chemotactic steps, N_{ed} is the Number of elimination-dispersal events, N_{re} is the Maximum number of reproduction steps, Ns is the Maximum number of swims, P is the Dimension of the optimization problem, P_{ed} is the Probability of occurrence of elimination-dispersal events, s is the Population of the E. coli bacteria, $\theta^i(j, k, l)$ is the Location of the i^{th} bacterium at j^{th} chemotactic step, k^{th} reproduction step, and l the elimination-dispersal step, $\omega_{attract}$ is the Width of attractant, $\omega_{repellant}$ is the Width of repellent, $h_{repellent}$ is the Height of repellent, $d_{attract}$ is the Depth of attractant.

The mathematical swarming (cell-cell signaling) function can be represented by:

$$J_{cc}(\theta^i,\theta)=\begin{cases}-M\left(\sum_{k=1}^{S}e^{-W_a\|\theta^i-\theta^k\|^2}-\sum_{k=1}^{S}e^{-W_r\|\theta^i-\theta^k\|^2}\right) & \text{With swarming}\\ 0 & \text{No swarming}\end{cases} \quad (2)$$

Where $\|.\|$ is the Euclidean norm, W_a and W_r are measures of the width of the attractant and repellent signals respectively; M measures the magnitude of the cell-cell signaling effect. These parameter values are chosen according to the nutrient profile used. During the lifetime of E. coli bacteria, they undergo different stages such as chemotactics, reproduction and elimination-dispersal.

b) Harmony Search [HS]

Harmony Search was first proposed by Zong Woo Geem et al. in 2001. This meta-heuristic algorithm was inspired by musical process of searching for a perfect state of harmony [23][27]. The harmony in music is analogous to the optimization solution vector, and the musician's improvisations are analogous to local and global search schemes in optimization techniques. In the HS algorithm, musical performances seek a perfect state of harmony determined by aesthetic estimation, as the optimization algorithms seek a best state (i.e., global optimum) determined by objective function value. It has been successfully applied to various optimization problems in computation and engineering fields including economic dispatch of electrical energy, multicast routing, clustering, optimum design, traveling salesman problem, parameter optimization of river flood model, design of pipeline network, and design of truss structures [15].

A musically pleasing harmony can be found based on three musical rules: (i) by playing a note from harmony memory (HM); (ii) by playing a note which is closer to another note stored in HM; and (iii) by playing an arbitrary note from the entire note range. Combination of these rules allows finding a musically pleasing harmony (best state). Adaptation of these rules to the optimization problems is as follows: (i) generate a new solution vector from HM (memory consideration); (ii) replace a decision variable with a new one which is close to the current one (pitch adjusting); and (iii) generate a solution vector from the possible random range (random selection). Combined utilization of these rules allows identification of the optimal or near optimal solutions [45].

Pseudo code of Harmony Search Algorithm

STEP1. Initialize the problem and HS parameters
Input data. *The data instance of the optimization problem and the HS parameters (HMCR, PAR, NI, HMS)*
STEP2. Initialize the harmony memory
Construct the vectors of the harmony memory
$HM = \{x^1, x^2, \ldots, x^{HMS}\}$
Recognize the worst vector in HM
$x^{worst} \in \{x^1, x^2, \ldots, x^{HMS}\}$
STEP3. Improvise a new harmony
$x' = \varphi$ // *new harmony vector*
for i = 1, . . . , N do // *N is the no. of decision variables.*
if (U(0, 1) ≤ HMCR) then // *U is uniform random no.gen*
begin
$x'_i \in \{x^1_i, x^2_i, \ldots, x^{HMS}_i\}$ {* *memory consideration* *}
if (U(0, 1) ≤ PAR) then
$x'_i = v_{i,k\pm m}$ // $x'_i = v_{i,k}$ {**pitch adjustment* *}
end
else
$x'_i \in X_i$ {* *random consideration* *}
end if
end for
STEP4. Update the harmony memory (HM)
if $(f(x^{new}) < f(x^{worst}))$ *then*
Include x^{new} *to the HM.*
Exclude x^{worst} *from HM.*
STEP5. Check the stop criterion
while (not termination criterion is specified by NI)
Repeat ***STEP3*** *and* ***STEP4***

where HMS is the Harmony Memory Size, HMCR is the Harmony Memory Considering Rate, PAR is the Pitch Adjusting Rate, NI is the no. of iterations.

After initializing the problem parameters, the Harmony Memory (HM) matrix is filled with as many randomly generated solution vectors as the size of the HM (HMS). A new harmony vector, $x' = (x_1', x_2' \ldots x_N')$ can be generated by following HM consideration, Pitch adjustment or totally random generation. The value of the decision variables for the new vector can be chosen from values stored in HM ($x_1^1 \sim x^{HMS}_1$). This method also permits to choose totally random values. HMCR parameter, which varies between 0 and 1, sets the rate whether a value stored in HM is chosen or a random value is chosen, as follows:

$$x'_i \leftarrow \begin{cases} x'_i \in \{x_i^1, x_i^2, \ldots, x_i^{HMS}\} & \text{w.p. } HMCR \\ x'_i \in X_i & \text{w.p. } (1\text{-}HMCR) \end{cases} \quad (3)$$

The HMCR is the rate of choosing one value from historical values stored in HM while (1-HMCR) is the rate of randomly choosing one value from the possible value range. On choosing a New Harmony vector $x' = (x_1', x_2' \ldots x_N')$, pitch-adjusting decision is examined for each component of the new vector.

$$x_i' \leftarrow \begin{cases} \text{Adjusting Pitch} & \text{w.p.} \quad PAR \\ \text{Doing Nothing} & \text{w.p.} \quad (1-PAR) \end{cases} \tag{4}$$

In the pitch adjusting process, a value moves to its neighboring value with probability of PAR, or just stays in its original value with probability (1-PAR). The HMCR and PAR parameters in Harmony Search help the algorithm find globally and locally improved solution, respectively.

c) Proposed Hybrid Method-HBSA

The problem solving efficiency of metaheuristics has paved way for the development of many hybrid approaches which combine the best features of more than one metaheuristic to improve the algorithmic performance [9][16]. In our proposed hybrid method HBSA, the best features of harmony search algorithm were incorporated into BFO to obtain improved swarming behavior. In BFO, chemotactic event is the primary and most significant component. It corresponds to the direction selection scheme which is the central step employed by a living creature to search food and in charge of the decisions that whether or not enter into a new region, how long does the individual stay in the current region, which direction should be selected in the next move. These decisions make chemotactic event highly influential in algorithm convergence [22]. The chemotactic event includes swarming as the key phenomena to decide the location in the search space where the bacteria moves next.

Swarming: An interesting group behavior has been observed for several motile species of bacteria including E.coli and S. typhimurium, where stable spatio-temporal patterns (swarms) are formed in semisolid nutrient medium. A group of E.coli cells arrange themselves in a traveling ring by moving up the nutrient gradient when placed amidst a semisolid matrix with a single nutrient chemo effecter[20]. The cells when stimulated by a high level of succinate, release an attractant aspirate, which helps them to aggregate into groups and thus move as concentric patterns of swarms with high bacterial density. The mathematical representation for swarming can be represented by

$$\begin{aligned} J_{cc}(\theta, P(j,k,1)) &= \sum_{i=1}^{s} J_{cc}^{i}(\theta, \theta^{i}(j,k,1)) \\ &= \sum_{i=1}^{s}\left[-d_{attract}\exp\left[-W_{attract}\sum_{m=1}^{p}(\theta_m - \theta_m^i)^2\right]\right] + \\ &\sum_{i=1}^{s}\left[h_{repelent}\exp\left[-W_{repelent}\sum_{m=1}^{p}(\theta_m - \theta_m^i)^2\right]\right] \end{aligned} \tag{5}$$

where *Jcc*(θ, *P*(*j*, *k*, *l*)) is the cost function value to be added to the actual cost function to be minimized to present a time varying cost function. "*S*" is the total number of bacteria and "*p*" the number of parameters to be optimized which are present in each bacterium. $d_{attract}$, $w_{attract}$, $h_{repellent}$, $w_{repellent}$ are different coefficients that are to be chosen properly.

To implement swarming, the improvisation technique of the HS algorithm is used in our proposed method. This procedure uses the PAR parameter to set the rate of pitch adjustment as follows:

$$\begin{bmatrix} x_1^1 & x_2^1 & \cdots & x_{N-1}^1 & x_N^1 \\ x_1^2 & x_2^2 & \cdots & x_{N-1}^2 & x_N^2 \\ \vdots & \cdots & \cdots & \cdots & \cdots \\ x_1^{HMS-1} & x_2^{HMS-1} & \cdots & x_{N-1}^{HMS-1} & x_N^{HMS-1} \\ x_1^{HMS} & x_2^{HMS} & \cdots & x_{N-1}^{HMS} & x_N^{HMS} \end{bmatrix} \begin{matrix} \Rightarrow f(x^1) \\ \Rightarrow f(x^2) \\ \Rightarrow \vdots \\ \Rightarrow f(x^{HMS-1}) \\ \Rightarrow f(x^{HMS}) \end{matrix} \tag{6}$$

Since HS does not require any initial values for the decision variables, the procedure to decide the swarming nature becomes highly flexible. In improvisation process, a value moves to its neighboring value with probability of pitch adjusting rate, or just stays in its original value with probability. The HMCR and PAR parameters in Harmony Search help the algorithm find globally and locally improved solution, respectively. Also, HS algorithm uses a stochastic random search that is based on the harmony memory considering rate and the pitch adjusting rate so that derivative information becomes irrelevant. Harmony search algorithm can deal with discrete variable problems as well as continuous variable problem and hence, it can also be applied for parameter optimization to identify the suitable set of parameter values for the optimization algorithms.

The job shop scheduling problem (JSSP) is the most popular scheduling model in practice and it has attracted many researchers due to its wide applicability and inherent difficulty. A Job Shop Scheduling Problem (JSSP) refers to the static problem where optimal schedules are searched for a given set of jobs. It is generally NP-hard [10][15][21]. In the real world, a JSSP becomes dynamic when jobs arrive continuously and it thus has an additional complexity. A JSP may be formulated as follows: given an $n \times m$ static JSP, in which n jobs must be processed exactly once on each of *m* machines, the set of *n* jobs can be defined as J= $\{J_1, \ldots\ldots, J_n\}$, while the set of *m* machines is M= $\{M_1, \ldots, M_m\}$. Each job is routed through the *m* machines in a pre-defined order, which is also known as operation precedence constraints. The processing of a job on one machine is called an operation, and the processing of job *i* on machine *j* is denoted by u_{ij}. So the set of operations can be defined as $O = \{ u_{ij} \mid i \in [1, n], j \in [1, m]\}$, in which *n* denotes the number of jobs and *m* denotes the number of machines. Once processing is initiated, an operation cannot be interrupted, and concurrency is not allowed. The value $C_{ij} = C_{ik} + p_{ij}$ is a completion time in operation u_{ij} in relation $u_{ik} \rightarrow u_{ij}$. p_{ij} is pre-set and the problem is only to find out the

completion time C_{ij} ($\forall$ u_{ij} $\in$O) which minimizes the objective function of JSSP as given below:

$$C_{\max} = \max_{all\ u_{ij} \in O}(C_{ij}) = \max_{u_{ik} \to u_{ij}}(C_{ik} + p_{ij}) \quad (7)$$

The JSP subjects to two constraints, known as the operation precedence constraint and machine processing constraint: The operation precedence constraint on the job is that the order of operations of job is fixed and the processing of an operation cannot be interrupted and concurrent, as given in Eqn.8.

$$C_{ij} \geq C_{kj} + p_{ij}, \quad \text{operation } u_{kj} \text{ is finished before } u_{ij} \quad (8)$$

The machine processing constraint is that only a single job can be processed at the same time on the same machine, as given in Eqn. 9.The operations must be assigned to the time intervals in such a way that once an operation is started it must be completed.

$$\neg \exists k(u_{ip} \to u_{ik} \vee u_{ik} \to u_{iq}), \text{ when } u_{ip} \to u_{iq},\ k \neq p \wedge k \neq q \quad (9)$$

Job Shop Scheduling benchmark problems from OR library are used in this paper to test the robustness of the proposed harmony BFO algorithm. In this research work, three algorithms, generic BFO framework, harmony search improvised BFO proposed by us termed as HBSA are implemented. In addition, the Ant Colony Optimization algorithm is also implemented to solve JSSP for the purpose of comparing the experimental results.

d) Implementation results

This section analyzes the result of the implementation of BFO, our proposed HBSA and ACO algorithms in solving JSSP benchmark instances . There are totally 82 test instances available in the OR library [7][28]. This study has chosen 22 problems of varying sizes from *abz and la* instances as listed in Table 1.

Table 1: JSSP instances used in this work

Instance	Size	Instance	Size
la 01	10 x 5	la 08	15 x 5
la 02	10 x 5	la 09	15 x 5
la 03	10 x 5	la 10	15 x 5
la 04	10 x 5	la 21	15 x10
la 05	10 x 5	la 24	15 x10
abz 5	10 x10	la 25	15 x10
abz 6	10 x10	la 27	20 x10
la 19	10 x10	la 29	20 x10
la 20	10 x10	abz 7	20 x15
la 06	15 x 5	abz 8	20 x 15
la 07	15 x 5	abz 9	20 x 15

The constant values initialized for the Harmony BSA are, ρ*=0.1,* β*=1.0,* α*=0.1, q0=0.8,* τ*=0.5,HMS=5, HMCR=0.9, PAR=0.4, NVAR=5, low=0, high=4 and BW=0.2.* Also the range of values chosen for harmony improvisation was *2.0-5.0, 3.0-6.0, 1.0-3.0, 2.0-3.0 and 1.0-4.0.*The result obtained by proposed Harmony BSA was compared with the results of BFO and ACO algorithms. It could be observed that our proposed method have achieved remarkably better optimization levels, almost equivalent to the best known optimal values obtained so far. The computational results are given below in table 2.

Table 2 : Optimality Comparison for benchmark JSSP instances

Instance	ACO	BFO	HBSA	Best-so-far
la 01	759	787	**666**	666
la 02	803	692	**668**	668
la 03	718	639	**624**	617
la 04	711	641	**614**	604
la 05	672	593	**593**	593
abz 5	1410	1323	**1246**	1234
abz 6	1046	1012	**956**	943
la 19	1033	926	**854**	842
la 20	1059	965	**959**	902
la 06	950	926	**926**	926
la 07	996	923	**903**	890
la 08	980	877	**873**	863
la 09	977	954	**951**	951
la 10	988	958	**958**	958
la 21	1324	1247	**1107**	1053
la 24	1241	1102	**942**	935
la 25	1242	1147	**978**	977
la 27	1610	1455	**1306**	1269
la 29	1481	1409	**1239**	1195
abz 7	837	787	**784**	668
abz 8	816	822	**792**	687
abz 9	921	856	**840**	707

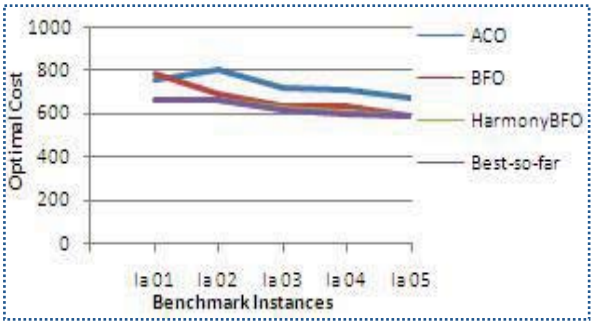

Fig. 2 : Optimal cost comparison of 10x5 size instances

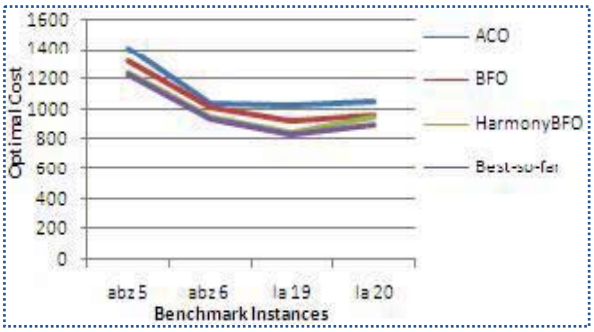

Fig. 3 : Optimal cost comparison of 10x10 size instances

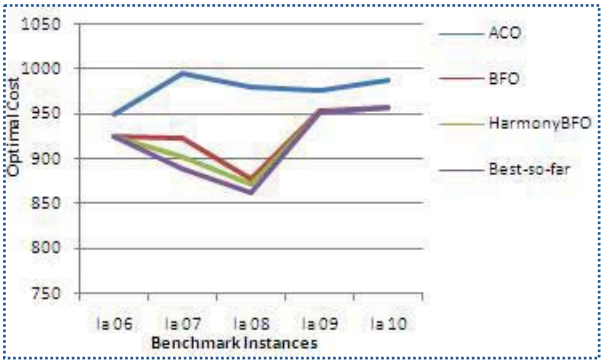

Fig. 4 : Optimal cost comparison of 15x5 size instances

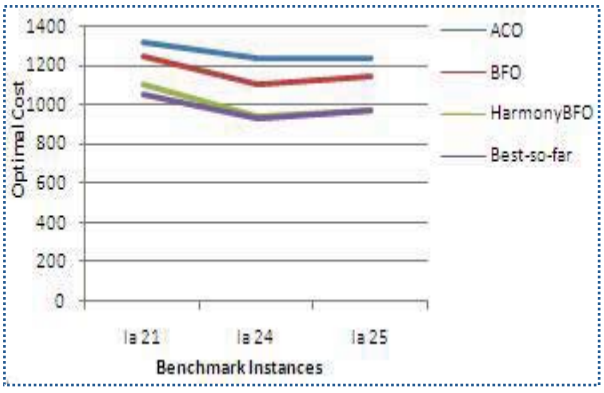

Fig. 5 : Optimal cost comparison of 15x10 size instances

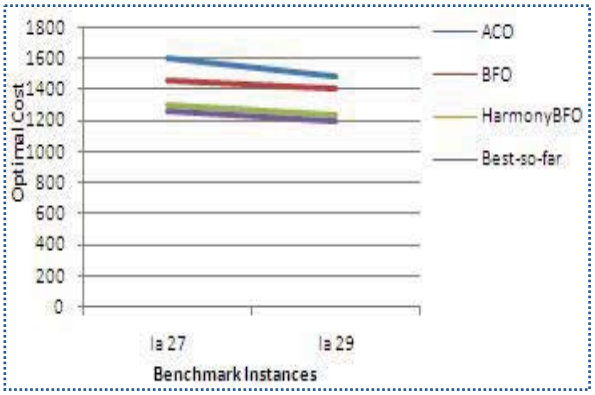

Fig. 6 : Optimal cost comparison of 20x10 size instances

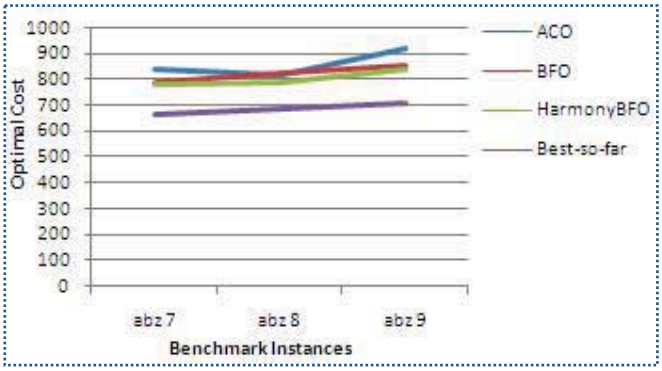

Fig. 7 : Optimal cost comparison of 20x15 size instances

From Fig.2, Fig.3, Fig.4, Fig.5, Fig.6 and Fig.7, it was clearly understandable that our proposed Harmony BSA algorithm gave the best optimal cost for all the chosen instances when compared with ACO and BFO algorithms. Also, it was observed that in most of the cases, our algorithm exactly matches the best known optimal values presented in the benchmark literature.

IV. Suggestions and Future Work

Scheduling Problems represent a rich domain in discrete optimization. Due to problem complexity many of these problems cannot be solved using traditional operations research techniques. In this paper, one of the most significant and complex classes of combinatorial optimization problems; the Job Shop Scheduling Problem was studied and implemented for analyzing the effectiveness of hybrid Harmony based Bacterial Swarming Algorithm. The JSSP determines a sequence for placing the jobs on the machines that optimizes a given evolution measure. The ability of the proposed Harmony BSA algorithm was investigated through the performance of several runs on 22 well-known test problems of different sizes, which were taken from OR library, which is the primary repository for such problems. The results obtained by the proposed HBSA for JSSP are much better than ACO and BFO algorithms

and highly comparable to the best-so-far results obtained for the benchmark instances.

The proposed Hybrid Harmony BSA method can be further improved to implement the same for still larger benchmark instances that are found in the OR library. The problem of efficiently scheduling jobs on several machines is an important consideration when attempting to make effective use of a multi-machines system such as a Flexible Job Shop Scheduling system, which can also be developed using this proposed technique. This method also has high scope for modification for solving other type of assignment problems such as Quadratic Assignment Problems (QAP), Frequency Assignment Problems (FAP) and other types of scheduling problems, both static and dynamic cases. This work can be extended by implementing other local search techniques and testing the features to solve combinatorial optimization problems such as Vehicle routing, Scheduling, Travelling Salesman Problem, Bin packing and so on.

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Analytical Performance Comparison of BNP Scheduling Algorithms

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Abstract - Parallel computing is related to the application of many computers running in parallel to solve computationally intensive problems. One of the biggest issues in parallel computing is efficient task scheduling. In this paper, we survey the algorithms that allocate a parallel program represented by an edge-directed acyclic graph (DAG) to a set of homogenous processors with the objective of minimizing the completion time. We examine several such classes of algorithms and then compare the performance of a class of scheduling algorithms known as the bounded number of processors (BNP) scheduling algorithms. Comparison is based on various scheduling parameters such as makespan, speed up, processor utilization and scheduled length ratio. The main focus is given on measuring the impact of increasing the number of tasks and processors on the performance of these four BNP scheduling algorithms.

Keywords : *Parallel computing, Scheduling, DAG, Homogeneous processors.*

GJCST-A Classification: *D.4.1*

Strictly as per the compliance and regulations of:

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Abstract - Parallel computing is related to the application of many computers running in parallel to solve computationally intensive problems. One of the biggest issues in parallel computing is efficient task scheduling. In this paper, we survey the algorithms that allocate a parallel program represented by an edge-directed acyclic graph (DAG) to a set of homogenous processors with the objective of minimizing the completion time. We examine several such classes of algorithms and then compare the performance of a class of scheduling algorithms known as the bounded number of processors (BNP) scheduling algorithms. Comparison is based on various scheduling parameters such as makespan, speed up, processor utilization and scheduled length ratio. The main focus is given on measuring the impact of increasing the number of tasks and processors on the performance of these four BNP scheduling algorithms.

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I. Introduction

Parallel computing is a technique of executing multiple tasks simultaneously on multiple processors. The main goal of parallel computing is to increase the speed of computation. Efficient task scheduling & mapping is one of the biggest issue in homogeneous parallel computing environment [1]. The objective of Scheduling is to manage the execution of tasks in such a way that certain optimality criterion is met. Most scheduling algorithms are based on list-scheduling technique [4][6][2][11]. There are two phases in List-scheduling technique: task prioritizing phase, where the priority is computed and assigned to each node in DAG, and a processor selection phase, where each task in is assigned to a processor in order of the priority of nodes that minimizes a suitable cost function. List scheduling algorithms are classified as static list scheduling if the processor selection phase starts after completion of the task prioritizing phase and dynamic list scheduling algorithm if the two phases are interleaved. A parallel program can be represented by a node-and edge-weighted directed acyclic graph (DAG) [2][3]. The Directed Acyclic Graph is a generic model of a parallel program consisting of a set of processes. The nodes represent the application process and the edges represent the data dependencies among these processes.

This paper surveys various scheduling algorithms that schedule an edge-weighted directed acyclic graph (DAG), which is also called a task graph, to a set of homogeneous processors. We examine four classes of algorithms: Bounded Number of Processors (BNP) scheduling algorithms, Unlimited Number of Clusters (UNC) scheduling algorithms, and Arbitrary Processor Network (APN) & Task Duplication Based (TDB) scheduling algorithms. Performance comparisons are made for the BNP algorithms. We provide qualitative analyses by measuring the performance of these four BNP scheduling algorithms under useful scheduling parameters: makespan, speed up, processor utilization, and scheduled length ratio.

The rest of this paper is organized as follows. In the next section, we describe the generic DAG model and discuss its variations & techniques. A classification of scheduling algorithms is presented in Section 3.The four BNP scheduling algorithms are discussed in Section 4.The performance results and comparisons are presented in Section 5, Section 6 concludes the paper. Section 7 suggest about future scope of research.

II. Task Scheduling Problem & Model Used

This section presents the application model used for task scheduling. The number of processors could be limited or unlimited. The homogeneous computing environment model is used for the surveyed algorithms. We first introduce the directed acyclic graph (DAG) model of a parallel program. This is followed by a discussion about some basic techniques used in most scheduling algorithms & homogeneous computing environment.

a) The DAG Model

The Directed Acyclic Graph [2][3] is a generic model of a parallel program consisting of a set of processes among which there are dependencies. The DAG model that we use within this analysis is presented below in Fig.1:

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A DAG - G = (V, E, w, c) - that represents the application to be scheduled

- V $\{v_i: i = 1,\ldots, N\}$ represents the set of tasks.
- E $\{e_{ij}$: data dependencies between node ni and node $n_j\}$
- $w(n_i)$ represents the node n_i's computation cost
- (e_{ij}) represents the communication cost between node n_i and node n_j .

Fig.1: Representation DAG

A task without any parent is called an entry task and a task without any child is called an exit task. A node cannot start execution before it gathers all of the messages from its parent nodes. The communication cost between two tasks assigned to the same processor is assumed to be zero. If node ni is scheduled to some processor, then ST(ni) and FT(ni)denote the start-time and finish-time of ni, respectively.After all the nodes have been scheduled, the schedule length is defined as maxi{FT(ni)}across all processors. The node- and edge-weights are usually obtained by estimation. Some variations in the generic DAG model are:-

Accurate model [2][3]— In an accurate model, the weight of a node includes the computation time, the time to receive messages before the computation, and the time to send messages after the computation. The weight of an edge is a function of the distance between the source and the destination nodes. It also depends on network topology and contention which can be difficult to model. When two nodes are assigned to a single processor, the edge weight becomes zero.

Approximate model 1 [2][3] — Here the edge weight is approximated by a constant. A completely connected network without contention fits this model.

Approximate model 2 [2][3]— In this model, the message receiving time and sending time are ignored in addition to approximating the edge weight by a constant.

An accurate model is useless when the weights of nodes and edges are not accurate. As the node and edge weights are obtained by estimation, which is hardly accurate, the approximate models are used. The approximate models can be used for medium to large granularity, since the larger the process grain-size, the less the communication, and consequently the network is not heavily loaded.

Preemptive scheduling: The preemptive scheduling is prioritized. The highest priority process should always be the process that is currently utilized.

Non-Preemptive scheduling: When a process enters the state of running, the state of that process is not deleted from the scheduler until it finishes its service time.

The homogeneous computing environment model is a set P of p identical processors connected in a fully connected graph [4]. It is also assumed that:

- Any processor can execute the task and communicate with other processors at the same time.
- Once a processor has started task execution, it continues without interruption, and on completing the execution it sends immediately the output data to all children tasks in parallel.

b) Basic Techniques in DAG Scheduling

Most scheduling algorithms are based on list scheduling. The basic idea of list scheduling is to assign priorities to the nodes of DAG, then place the nodes in a list called ready list according to the priority levels and then lastly map the nodes onto the processors in the order of priority. A higher priority node will be examined first for scheduling before a node with a lower priority. In case any two or more nodes have the same priority, then the ties are needed to be break using some useful method. There are various ways to determine the priorities of nodes such as HLF (Highest level First), LP (Longest Path), LPT (Longest Processing Time) and CP (Critical Path).Frequently used attributes for assigning priority are [2][4][5]:-

t-level: t-level(Top Level) of the node ni in DAG is the length of the longest path from entry node to ni (excluding ni) i.e. the sum of all the nodes computational costs and edges weights along the path.

b-level: The b-level (Bottom Level)of a node ni is the length of the longest path from node ni to an exit node . The b-level is computed recursively by traversing the DAG upward starting from the exit node.

Static level: Some scheduling algorithms do not consider the edge weights in computing the b-level known as static b-level. or static level.

ALAP time: The ALAP (As-Late-As-Possible) start time of a node is measure of how far the node's start time can be delayed without increasing the schedule length. It is also known as latest start time (LST).

CP (Critical Path):It is the length of the longest path from entry node to the exit node A DAG can have more than one CP. b-level of a node is bounded by the length of a critical path.

EST (Earliest Starting Time): Procedure for computing the t-levels can also be used to compute the EST of nodes. The other name for EST is ASAP (As-Soon-As-Possible) start-time.

DL (Dynamic Level): Dynamic level of a node is calculated by subtracting the EST from the ST.

III. A Classification of Dag Scheduling Algorithms

The DAG scheduling algorithms are basically classified into the following four groups:-

a) **Bounded Number of Processors (BNP) scheduling** [2][5][11]: BNP scheduling algorithms are non-task duplication based scheduling algorithms. These algorithms schedule the DAG to a bounded number of processors directly [2][5]. The processors are assumed to be fully-connected. No attention is paid to link contention or routing strategies used for communication. Most BNP scheduling algorithms are based on the list scheduling technique. Examples of BNP algorithms are: HLFET (Highest Level First with Estimated Times) algorithm, MCP (Modified Critical Path) algorithm, ISH (Insertion Scheduling Heuristic) algorithm, ETF (Earliest Time First) algorithm, DLS (Dynamic Level Scheduling) algorithm and LAST (Localized Allocation of Static Tasks).

b) **Unbounded Number of Clusters (UNC) scheduling** [5][11]: UNC scheduling algorithms are non-task duplication based scheduling algorithms. The processors are assumed to be fully-connected and no attention is paid to link contention or routing strategies used for communication. The basic technique employed by the UNC algorithms is called Clustering. These algorithms schedule the DAG to an unbounded number of clusters. At the beginning of the scheduling process, each node is considered as a cluster. In the subsequent steps, two clusters are merged if the merging reduces the completion time. This merging procedure continues until no cluster is left to be merged. UNC algorithms take advantage of using more processors to further reduce the schedule length. Examples of UNC algorithms are: The EZ (Edge-zeroing) algorithm, DSC (Dominant Sequence Clustering) algorithm, The MD (Mobility Directed) algorithm, The DCP (Dynamic Critical Path) algorithm.

c) **Task Duplication Based (TDB) scheduling** [5][11]: Scheduling with communication may be done using duplication. The rationale behind the task-duplication based (TDB) scheduling algorithms is to reduce the communication overhead by redundantly allocating some nodes to multiple processors. These algorithms schedule the DAG to an unbounded number of clusters. Different strategies can be employed to select ancestor nodes for duplication. Some of the algorithms duplicate only the direct predecessors whereas some other algorithms try to duplicate all possible ancestors. Examples TDB algorithms are: PY algorithm (named after Papadimitriou and Yannakakis[1990]), LWB (Lower Bound) algorithm, DSH (Duplication Scheduling Heuristic) algorithm, BTDH (Bottom-Up Top-Down Duplication Heuristic) algorithm, LCTD (Linear Clustering with Task Duplication) algorithm, CPFD (Critical Path Fast Duplication) algorithm.

d) **Arbitrary Processor Network (APN) scheduling** [5][11]: The APN scheduling algorithms perform scheduling and mapping on the target architectures in which the processors are connected via an arbitrary network topology. APN scheduling algorithms are non-task duplication based scheduling algorithms. The number of processors is assumed to be limited. A processor network is not necessarily fully-connected. Contention for communication channels need to be addressed. For communication channels message routing and scheduling must also be considered. Examples APN algorithms are: MH (Mapping Heuristic) algorithm, DLS (Dynamic Level Scheduling) algorithm, The BU (Bottom-Up) algorithm, BSA (Bubble Scheduling and Allocation) algorithm

IV. BNP Scheduling Algorithms

In this section, we discuss four basic BNP scheduling algorithms: HLFET, ISH, MCP, and ETF. All these algorithms are for a limited number of homogeneous processors. The major characteristics of these algorithms are summarized in Table 1[6]. In table, p denotes the number of processors given.

Table 1: Some of the BNP scheduling algorithms and their characteristics

Algorithm	Proposed by[year]	Priority	List Type	Greedy
HLFET	Adam *et al.* [1974]	SL	Static	Yes
ISH	Kruatrachue & Lewis [1987]	SL	Static	Yes
MCP	Wu & Gajski [1990]	ALAP	Static	Yes
ETF	Hwang *et al.* [1989]	SL	Static	Yes

a) The HLFET (Highest Level First with Estimated Times) Algorithm [12]: It is one of the simplest scheduling algorithms. The algorithm is briefly described below in Fig.2.

1) Calculate the static b-level of each node.
2) Make a ready list in a descending order of static b-level. Initially, the ready list contains only the entry nodes. Ties are broken randomly.

Repeat

3) Schedule the first node in the ready list to a processor that allows the earliest execution, using the non-insertion approach.
4) Update the ready list by inserting the nodes that are now ready.

Until all nodes are scheduled.

Fig. 2 : HLFET algorithm

b) The ISH (Insertion Scheduling Heuristic) Algorithm [12]: This algorithm uses the "scheduling holes "the idle time slots—in the partial schedules. The algorithm tries to fill the holes by scheduling other nodes into them. The algorithm is briefly described below in Fig.3.

1) Calculate the *static b-level of each node.*
2) Make a ready list in a descending order of *static b-level. Initially, the ready list* contains only the entry nodes. Ties are broken randomly.

Repeat

3) Schedule the first node in the ready list to the processor that allows the earliest execution, using the non-insertion algorithm.
4) If scheduling of this node causes an idle time slot, then find as many nodes as possible from the ready list that can be scheduled to the idle time slot but cannot be scheduled earlier on other processors.
5) Update the ready list by inserting the nodes that are now ready.

Until all nodes are scheduled

Fig. 3 : ISH algorithm

c) MCP (Modified Critical Path) Algorithm [12]: This algorithm uses the insertion approach but, this insertion approach is different from ISH algorithm. MCP looks for an idle time slot for a given node, while ISH looks for a hole for a node to fit in a given idle time slot. The algorithm is briefly described below in Fig.4

1) Compute the ALAP time of each node.
2) For each node, create a list which consists of the ALAP times of the node itself and all its children in a descending order.
3) Sort these lists in an ascending lexicographical order. Create a node list according to this order.

Repeat

4) Schedule the first node in the node list to a processor that allows the earliest execution, using the insertion approach.
5) Remove the node from the node list.

Until the node list is empty.

Fig. 4 : MCP algorithm

d) The ETF (Earliest Time First) Algorithm [12]: This algorithm schedules nodes based on b-level only. The ETF algorithm is briefly described below in Fig.5.

1) Compute the *static b-level of each node.*
2) Initially, the pool of ready nodes includes only the entry nodes.

Repeat

3) Calculate the earliest start-time on each processor for each node in the ready pool. Pick the node-processor pair that gives the earliest time using the non-insertion approach. Ties are broken by selecting the node with a higher *static b-level. Schedule* the node to the corresponding processor.
4) Add the newly ready nodes to the ready node pool.

Until all nodes are scheduled.

Fig. 5 : ETF algorithm

V. Performance Results and Comparison

In this section, we present the performance results and comparisons of the 4 BNP scheduling algorithms discussed above. The comparisons are based upon the following four comparison metrics [2][4]:

1. Makespan: Makespan is defined as the completion time of the algorithm. It is calculated by measuring the finishing time of the exit task by the algorithm.
2. Speed Up: The Speed Up value is computed by dividing the sequential execution time by the parallel execution time.

3. Scheduled length ratio (SLR): It is defined as the ratio of the Makespan of the algorithm to Critical path values of the DAG.
4. Processor Utilization: (total time taken of Scheduled tasks/Makespan)*100

The following parameters are used during simulation of BNP scheduling algorithms:

Table 2 : The simulation parameters used

Computing Environment	Homogeneous
Scheduling Algorithm	Bounded No. of Processors(BNP): ISH, HELFET, MCP, ETF
No. of Processors	Five (P1,P2,P3,P4,P5) with equal computational speeds
No. of Tasks	35 task nodes, 50 task nodes, 65 task nodes

The performance comparison of the four BNP scheduling algorithms (mentioned in Section IV.) are based upon the four comparison metrics and the simulation parameters discussed above and the results are shown graphically.

Case 1: 35 Task Nodes: From the graphs shown below it is observed that using 35 task nodes the MCP algorithm shows the least Makespan and SLR values with highest SpeedUp and Processor Utilization.

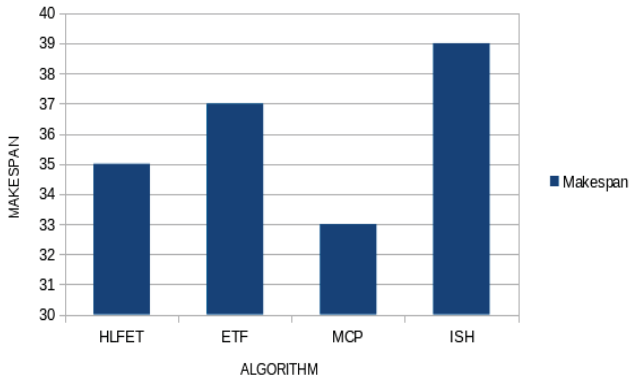

Fig. 6 : Makespan for 35 Nodes

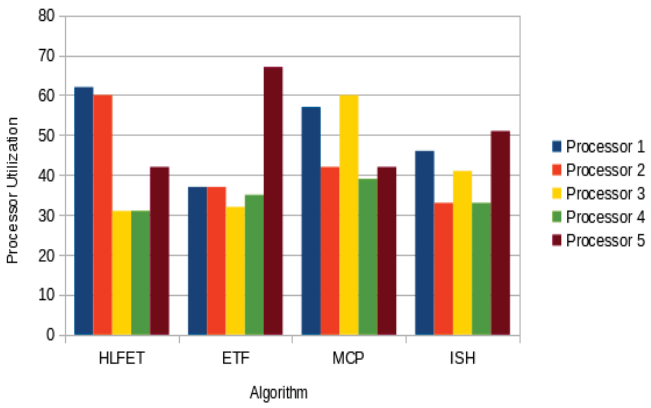

Fig. 7 : Processor Utilization for 35 Nodes

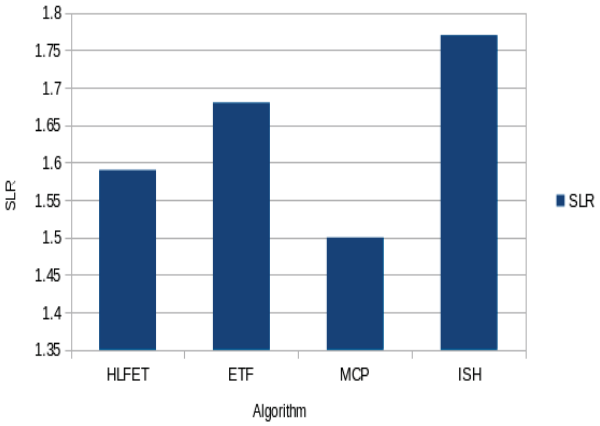

Fig. 8 : Scheduled Length Ratio for 35 Nodes

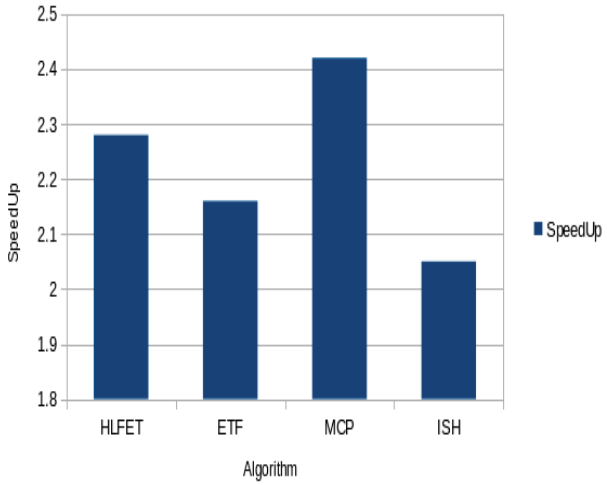

Fig. 9 : Speedup for 35 Nodes

Case2: 50 Task Nodes: From the graphs shown below we observed that using 50 task nodes ISH algorithm shows the least Makespan and SLR values with highest SpeedUp and Processor Utilization.

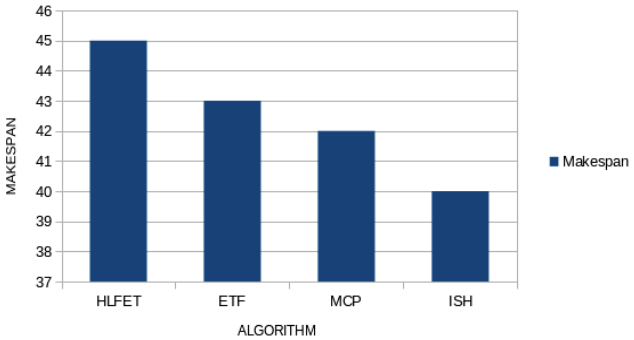

Fig. 10 : Makespan for 50 Nodes

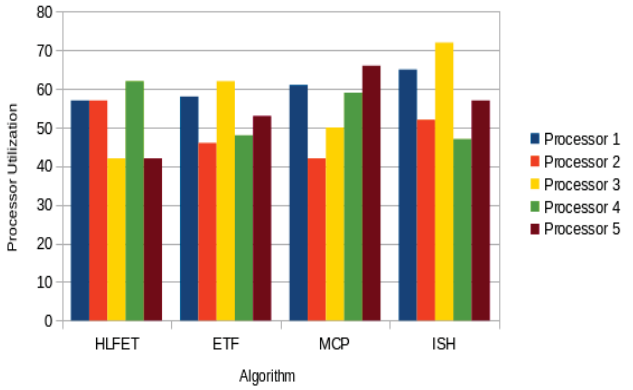

Fig. 11: Processor Utilization for 50 Nodes

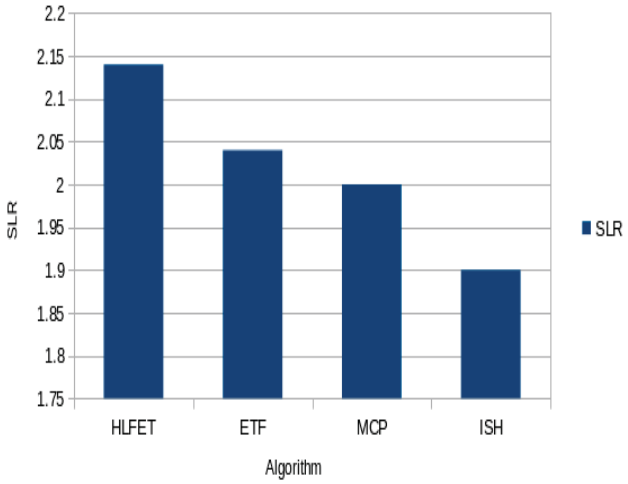

Fig. 12 : Scheduled Length Ratio for 50 Nodes

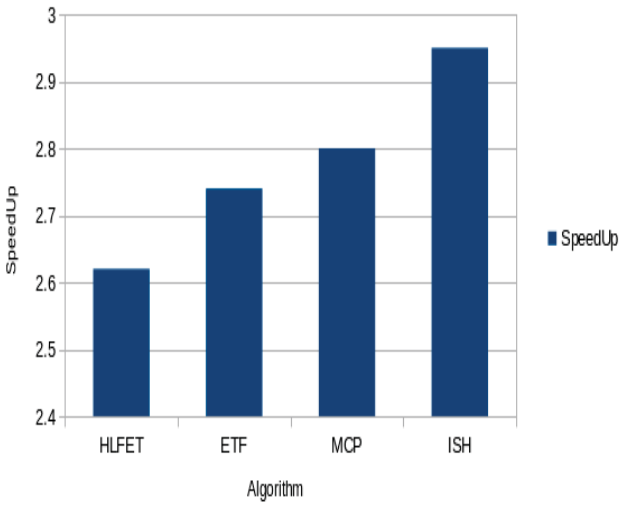

Fig. 13 : Speedup for 50 Nodes

Case3: 65 Task Nodes: Results obtained from all the algorithms using 65 task nodes are entirely different as observed with 35 and 50 task nodes.

- The ISH algorithm shows the least Makespan and SLR values with highest SpeedUp and processor utilization.
- The MCP and HLFET algorithms show throughout the same values for Makespan, SLR, SpeedUp and Processor Utilization.
- The ETF algorithm shows the highest Makespan and SLR values with lowest SpeedUp and processor utilization.

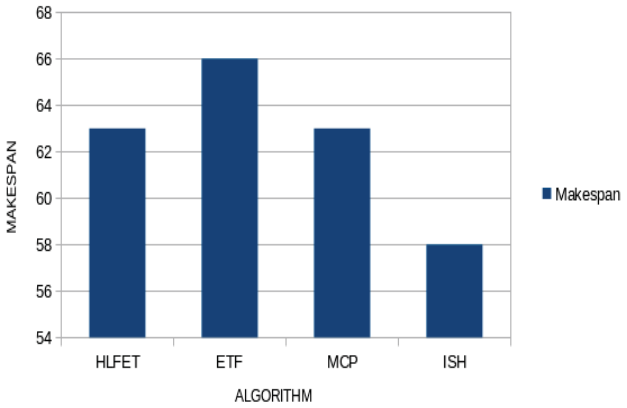

Fig. 14 : Makespan for 65 Nodes

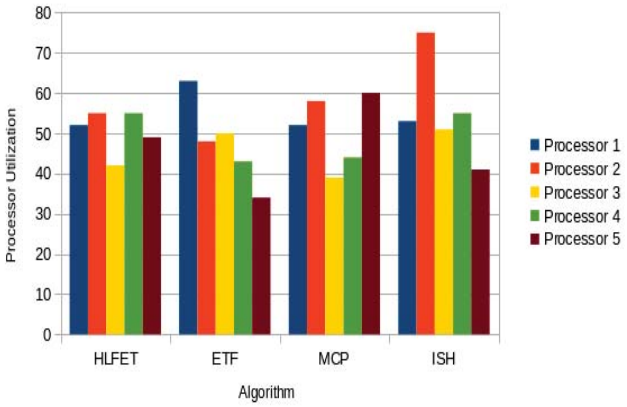

Fig. 15 : Processor Utilization for 65 Nodes

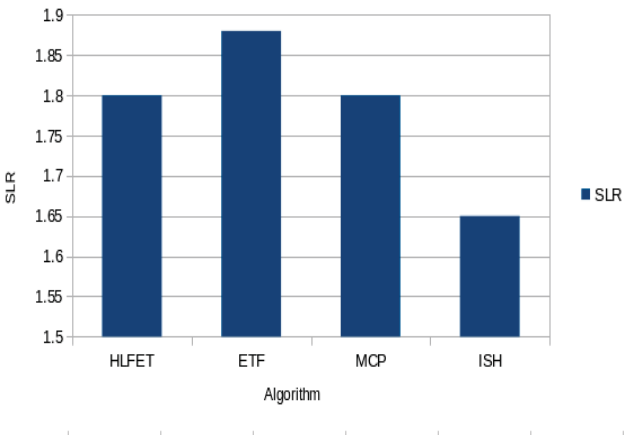

Fig. 16 : Scheduled Length Ratio for 65 Nodes

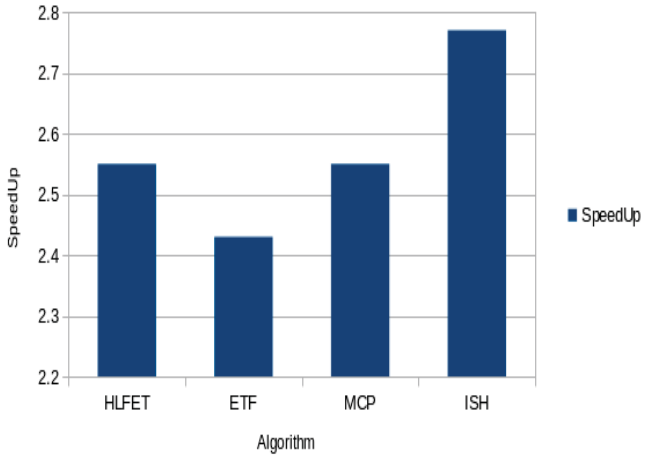

Fig. 17 : Speedup for 65 Nodes

➢ **Comparative Analysis:**

a) **Average Makespan:** Lesser the makespan, more efficient is the algorithm. Fig.18 shows the average Makespan of the all 4 algorithms with various nodes cases.

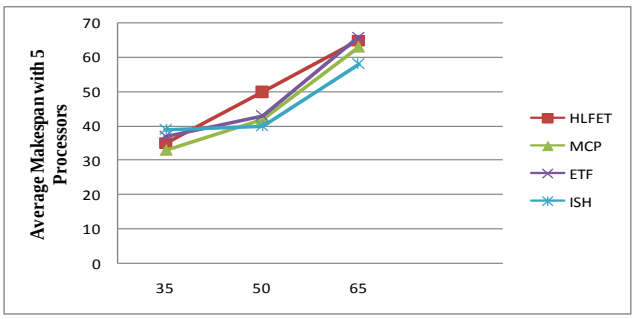

Fig.18 : Graph Representation of Average Makespan

It can be clearly observed that:

- With 35 task nodes, the MCP algorithm yields the best (lowest) average value for Makespan and ISH algorithm is the worst in this case with highest makespan value.
- With 50 task nodes, the ISH gives lowest makespan value and HLFET algorithm gives highest makespan value.
- With 65 task nodes, again the ISH appears to be more efficient with lowest makespan and ETF algorithm gives highest value in this case.

b) **Average Processor Utilization:** Greater the processor utilization the more efficient is the algorithms. Fig.19 shows the Average Processor Utilization of the all 4 algorithms with various nodes cases.

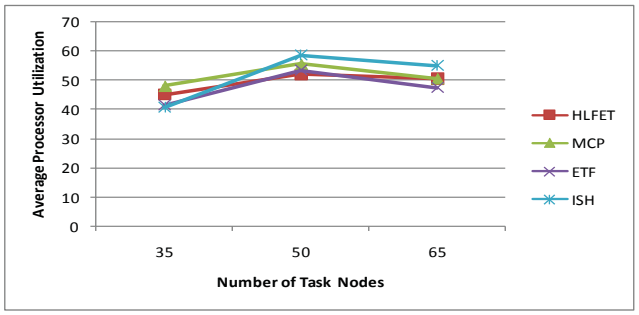

Fig.19 : Graph Representation of Average Processor Utilization

- With 35 tasks the processor utilization is efficient with MCP algorithm as it gives highest value and the ISH algorithm is the worst case with lowest processor utilization rate.
- With 50 tasks, the ISH algorithm tends to be more efficient than the other algorithms by giving highest usage value. The HLFET gives lowest value.
- With 65 tasks, the processor utilization is same for HLFET & MCP algorithm and again ISH is more efficient with giving highest processor utilization value. ETF gives lowest value here.

c) **Average Scheduled Length Ratio:** The lesser the value of SLR, the lesser is the time taken by the algorithm to execute the entire task and more efficient is the algorithm. Fig. 20 provides the details of SLR values for all the 3 tasks.

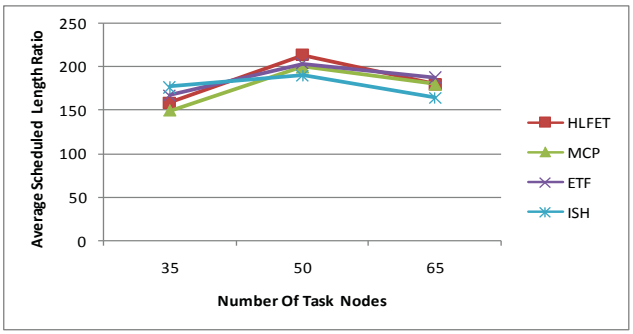

Fig. 20 : Graph representing SLR of algorithms

- With 35 task nodes, the MCP algorithm gives lowest SLR value with ISH algorithm giving highest SLR value.
- With 50 tasks, the ISH shows the lowest SLR value and HLFET gives highest SLR value.
- With 65 tasks, the ISH has the lesser SLR values and ETF gives highest value.

d) **Average Speedup:** Higher the value of Speedup, more efficient is the algorithm. Fig. 21 shows the Speedup of the all 4 algorithms with various nodes cases.

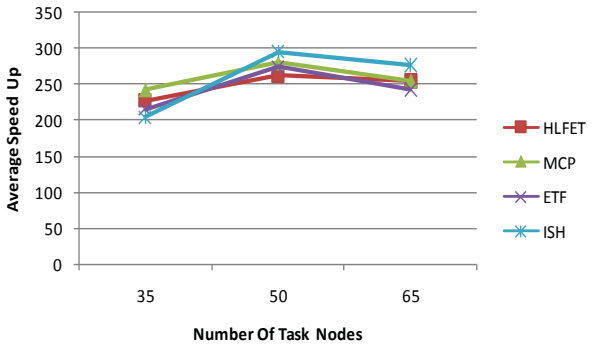

Fig. 21 : Graph representing Speedup of Algorithms

- When the tasks are 35, The MCP algorithm yields highest Speedup value and ISH gives lowest speedup.
- With 50 tasks the ISH yields highest Speedup value and HLFET gives lowest Speedup.
- With 65 tasks, the ISH again yields highest Speedup value and ETF gives lowest speedup. The Speedup of ISH leads others.

VI. Conclusion and Future Scope

After Comparative analysis following results were derived:

- ✓ Makespan of MCP algorithm is lowest for 35 task nodes as compare to others. With 50 and 65 tasks, ISH gives lowest makespan. HLFET and MCP remained same for 65 tasks, but ETF showed large increase.
- ✓ The average processor utilization of MCP is highest for 35 tasks. With 50 and 65 tasks, ISH algorithm proved to be better than other algorithms. MCP and HLFET gives similar values for 65 tasks and ETF showed large drop in utilization rate with 65 tasks.
- ✓ SLR for 35 tasks is lowest for MCP algorithm. With 50 and 65 tasks, the ISH was the one with lesser SLR. The SLR remained almost the same for MCP and HLFET with 50 and 65 tasks
- ✓ Same is the case with Speedup. With 35 tasks MCP algorithm gives highest value. With 50 and 65 tasks speedup of MCP and HLFET algorithms was same. With 50 and 65 tasks again ISH was the algorithm with higher SpeedUp.

So it can be concluded that for small number of tasks (35) MCP is the best algorithm but, with increasing number of tasks (50 & 65) ISH is one of the efficient algorithm, considering the data gathered using the scenarios and the performance calculated from them.

Future Scope: A lot of work can be done considering more case scenarios:

- The number of tasks can be changed to create test case scenarios.
- Heterogeneous environment can be considered.
- Both Homogenous and Heterogeneous can be considered.
- More algorithms can be considered and Their performance with other can be estimated.
- Further elaboration of various techniques like network topology and communication traffic can also be considered

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At Low Cost, Easily Accessible Telepresence Using Mobile Phone

By Dr. Amritpal Singh Brar & Raman Makhaik
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Abstract - The term telepresence was tossed by Marvin Minsky in an article in 1980, that focused on giving the remote participation a feeling of actually being present.

GJCST-A Classification: *B.m*

Strictly as per the compliance and regulations of:

At Low Cost, Easily Accessible Telepresence Using Mobile Phone

Dr. Amritpal Singh Brar [α] & Raman Makhaik [σ]

I. Introduction

a) What is Telepresence

The term telepresence was tossed by Marvin Minsky in an article in 1980, that focused on giving the remote participation a feeling of actually being present.[1]

This word brings a picture of video conferencing into our mind immediately, but it refers to the situation when a person is present at one place and it could communicate verbally and non verbally and could be able to stimulate his actions at other place too. We can well understand it by an example like:- a person is controlling a robot and that robot is driving a car. Or a doctor from a far away place is operating a patient, the technology of today demands more, so the researchers and developers of day today are trying to achieve each and every possibility of telepresence. [2]

Till now telepresence has got remarkable progress, it uses a remote access to a device i.e a robot usually.

Main achievements are like the use of telepresence in surgery, it has got high precision but it is for specific purpose only and is very costly and bulky.

b) Remote control: access a device from a distance

A remote control is an electronics device, most commonly used in television sets,car locks ,home appliances etc. The *remote control* is commonly called *remote*. Commonly, remote controls are Consumer IR devices used to issue commands from a distance to devices like tv , DVD players etc. Now a days remote controls don't just optimised to just few keys , the expectation of a user is huge , he wants to operate each and every thing from his position at rest and wants that the machinery should do all his work according to him via remote only.Most of the remotes communicate to their respective devices via infrared (IR) signals or via radio signals.

When we see around we can see a great change in our technology, in case of remote controls great changes are being there but the thing which makes the growth bounded is that it is "bounded", *yes talk about any of the remote control system it definitely have some boundations and limits but we propose a remote access which have greater coverage, one can access device from any corner of this world (having mobile network).*

c) What is DTMF (dual tone multi frequency)

When we press any button on a telephone's keypad, a specific signal is being generate which is produced by two different signals i.e one high signal and one low signal. The produced signal is a new frequency that generates a new tone , the resultant of the tones selected by perssing a button from a row and column respectively. The resultant frequency signal is "*Dual Tone Multiple Frequency*". These tones are very specific and unique. [3]

Hence A *DTMF* signal is the algebraic sum of two different audio frequencies, a low frequency and a high frequency selected according to the button pressed.

Each of the row i.e low frequency and the column i.e the high frequency groups comprise of four frequencies for the various keys present on the keypad. Two different frequencies, one from the high frequency group (column) and another from the low frequency groups (row) are used to produce a new discrete DTMF signal to represent the pressed key uniquely.

The amplitudes of the two sin waves should range in between:

$$(0.7 < (\text{Value of A/B}) < 0.9)V$$

The frequencies are chosen such that they are not harmonics of each other. The frequencies associated with various keys on the keypad are shown.

When we send DTMF signals to the telephone exchange through cables or wirelessly, the servers in the telephone exchange identifies those signals and makes the connection to the particular number that you are calling. The row and the column frequencies are:- [3]

1	2	3	697 Hz
4	5	6	770 Hz
7	8	9	852 Hz
*	0	#	941 Hz
1209 Hz	1336 Hz	1477 Hz	

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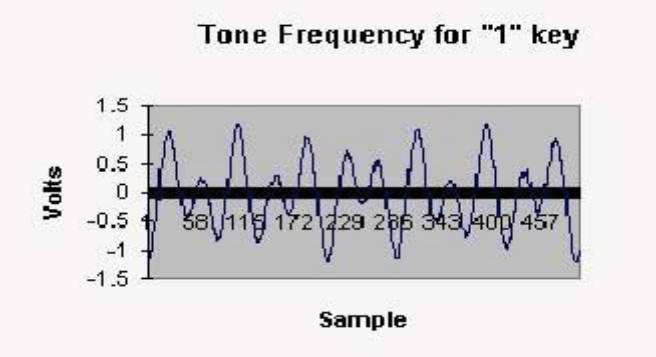
For example:-

If we press the digit 2 in the keypad it generates a resultant tone signal which is made up of frequencies 697Hz and 1336Hz.

If we press digit 9 it will produce the tone taken from tones 941Hz and 1477Hz.



In simple phones the matrix of numbers on the key pad is 3*4 but actually it is of 4*4 so there are some special characters: A, B, C, D. these are being used for special purposes but rarely.

II. Present Work

a) Objectives

Main objectives are:-

- To transmit and receive the DTMF signals.
- To control the device using those DTMF signals.
- To assign particular action or motion to device for each DTMF signal.
- To use a 3G enabled phone and a camera on the device and communicate via it.
- To do different tasks using the system.
- To optimize the resources and increase performance.
- To complete the above tasks within time and less cost.
- Achieve telepresence.

Some other ideas that might be tried:-

- Try to send video signal over 2G network.
- Make the device that we are operating itself intelligent and interactive.
- Make a console in mobile to operate device.

b) Methodology

To implement our idea we need:

- Two cell phones and 3g enabled connections
- Two units of camera.
- Gear motors 100rpm.
  - Resistance R1 = 102 KΩ
  - R2 = 71.5 KΩ
  - R3 = 390 KΩ
- Capacitance
  - C1,C2 = 100 nF
- Crystal Oscilator
  - X1 = 3.579545 MHz
- Robo chassis
- Battery 12 v.
- Integrated Circuits-(like CM8870,L298)
- Connecting wire
- Breadboard Etc.

We would prepare the whole system setup which depends on software, electronics and mechanical aspects.

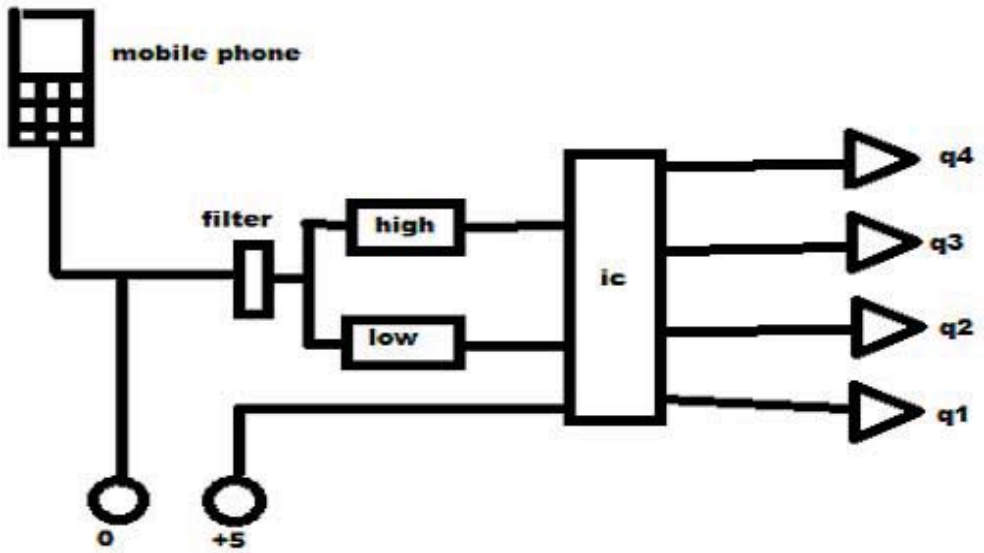
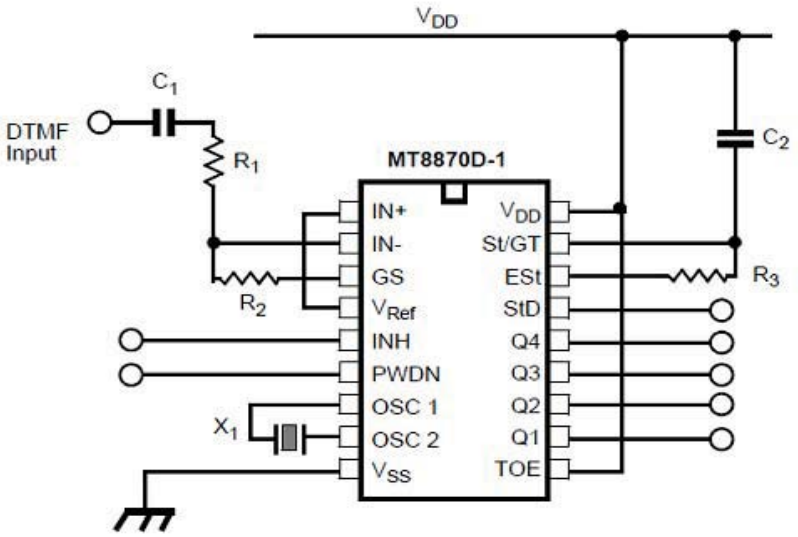


Diagram of DTMF receiver [3]

Let us assume that the signal is being transmitted from the mobile and now it reaches the cm8870;



CM8870

Pin #		Name	Description
18	20		
1	1	IN+	**Non-Inverting Op-Amp (Input).**
2	2	IN-	**Inverting Op-Amp (Input).**
3	3	GS	**Gain Select.** Gives access to output of front end differential amplifier for connection of feedback resistor.
4	4	V_{Ref}	**Reference Voltage (Output).** Nominally $V_{DD}/2$ is used to bias inputs at mid-rail
5	5	INH	**Inhibit (Input).** Logic high inhibits the detection of tones representing characters A, B, C and D. This pin input is internally pulled down.
6	6	PWDN	**Power Down (Input).** Active high. Powers down the device and inhibits the oscillator. This pin input is internally pulled down.
7	8	OSC1	**Clock (Input).**
8	9	OSC2	**Clock (Output).** A 3.579545 MHz crystal connected between pins OSC1 and OSC2 completes the internal oscillator circuit.
9	10	V_{SS}	**Ground (Input).** 0V typical.
10	11	TOE	**Three State Output Enable (Input).** Logic high enables the outputs Q1-Q4. This pin is pulled up internally.
11-14	12-15	Q1-Q4	**Three State Data (Output).** When enabled by TOE, provide the code corresponding to the last valid tone-pair received . When TOE is logic low, the data outputs are high impedance.
15	17	StD	**Delayed Steering (Output).**Presents a logic high when a received tone-pair has been registered and the output latch updated; returns to logic low when the voltage on St/GT falls below V_{TSt}.
16	18	ESt	**Early Steering (Output).** Presents a logic high once the digital algorithm has detected a valid tone pair (signal condition). Any momentary loss of signal condition will cause ESt to return to a logic low.
17	19	St/GT	**Steering Input/Guard time (Output) Bidirectional.** A voltage greater than V_{TSt} detected at St causes the device to register the detected tone pair and update the output latch. A voltage less than V_{TSt} frees the device to accept a new tone pair. The GT output acts to reset the external steering time-constant; its state is a function of ESt and the voltage on St.
18	20	V_{DD}	**Positive power supply (Input).** +5V typical.
	7, 16	NC	No Connection.

c) Significance

This idea if implemented would be a great add on to the field of telepresence as till now telepresence is possible using high speed internet using computers or connected cables etc and the setup is costly. But in the proposed idea the telepresence would be possible with the most common gadget of todays' life that is "a mobile phone" and using 3G we would be able to make telepresence a common phenomenon and people could do many tasks using it like:-

- Meeting people
- Driving a car(very enhanced)
- Defusing a bomb
- Look after your house from anywhere in this world.

The feature which makes it more significant is that it would have no limited area of access and you would be able to use it even from abroad, the condition is that your 3g mobile should work at that place from where you want to operate.

III. Result and Discussion

a) Digital Output of Dtmf Receiver [9]

No	LowFreq	HighFreq	Q4	Q3	Q2	Q1
1	697	1209	0	0	0	1
2	697	1336	0	0	1	0
3	697	1477	0	0	1	1
4	770	1209	0	1	0	0
5	770	1336	0	1	0	1
6	770	1477	0	1	1	0
7	852	1209	0	1	1	1
8	852	1336	1	0	0	0
9	852	1477	1	0	0	1
0	941	1336	1	0	1	0
*	941	1209	1	0	1	1
#	941	1477	1	1	0	0
A	697	1633	1	1	0	1
B	770	1633	1	1	1	0
C	852	1633	1	1	1	1
D	941	1633	0	0	0	0

According to these outputs the motors are operated.

The person who is operating is also be able to see the other end and communicate at other end and would be able to do some work also this is what is called telepresence.

It is ready to be used for:-

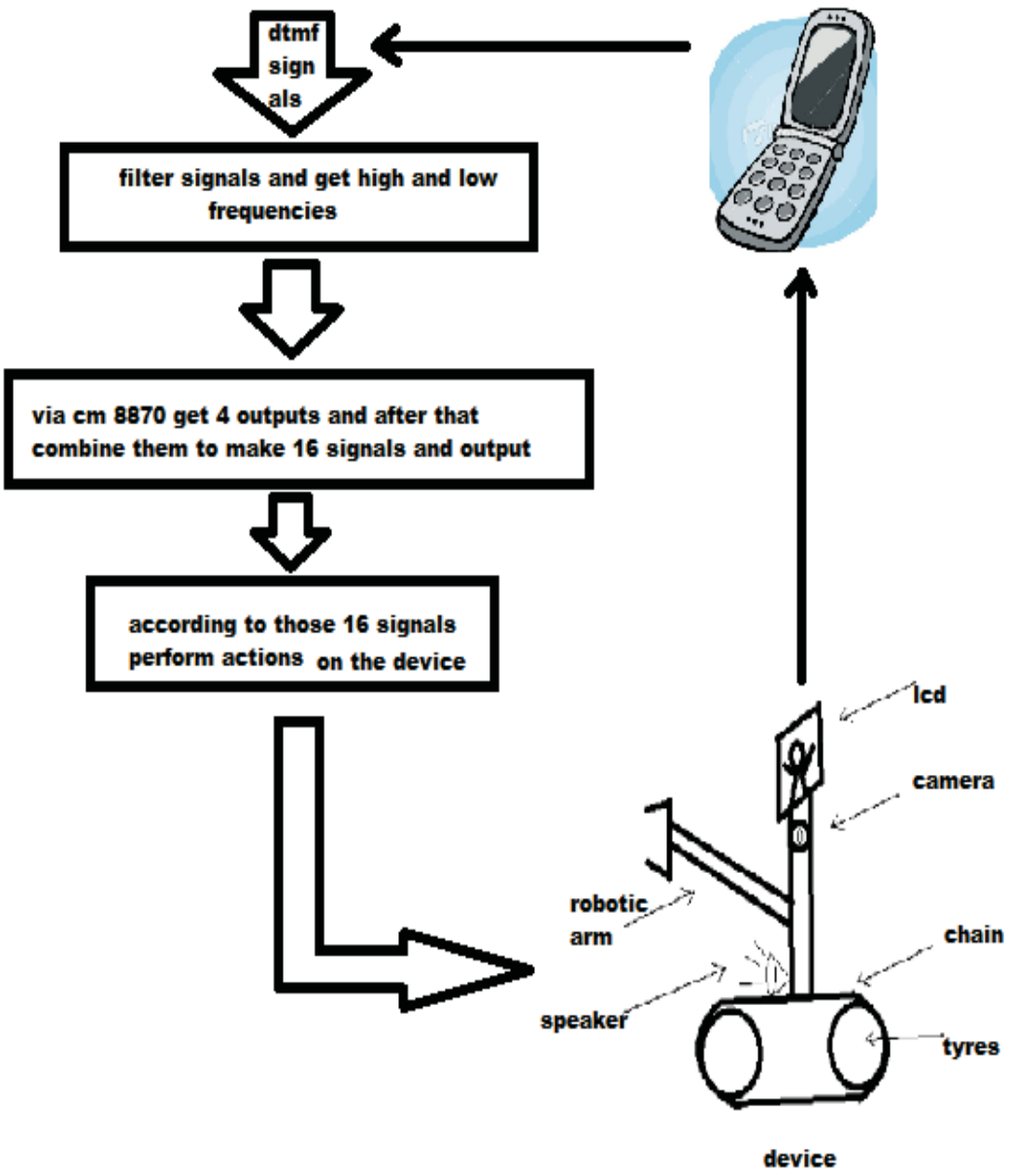
- Meeting people
- Move from one place to another
- Supervision
- Perform some action

b) How it works

In order to control the robot, you have to make a call to the cell phone attached to the robot from any phone. Now the phone is picked by the phone on the robot through auto answer mode.

When you press 2 the robot will move forward
When you press 4 the robot will move left
When you press 8 the robot will move backwards
When you press 6 the robot will move right
When you press 5 the robot will stop.

Diagram (How whole thing works)



IV. Conclusion and Future Scope

a) Future Scope

As the work done by us is only an initiation in this field so there is a big scope of work to be done in this field. As telepresence till now was not for common man and it was being achieved by bulky setups and machinery. We are proposing a new way of achieving telepresence.

In future our robot if modified accordingly would be able to:-

Functionality:-

- Drive car
- Operating machines in industry

- Bomb diffusing and many more.

Updation of technology:-

- Update device according to the mobile phone as 4g ,5g....
- Make it more effective and fast.
- Make a console in mobile to operate device.

b) Conclusion

We conclude that it can be said an initiation or a proposal of new way of telepresence by the use of which telepresence would become everybody's cup of tea. The cost is less and ease of access would make it more and more beneficial.

c) Questionnaire

Why only DTMF Signals?

- To make it easiest to access.
- To make it least costly.
- To have simplest setup for user.
- To make it such that everyone could use it.

Bottle necks?

- Hardware setup.
- Signal enhacement on receiver end.
- Cost effectiveness.
- Only 16 distinct signals.
- Time consuming concept.
- As the work is practical so difficult to make changes.

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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic

principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.

- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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