Distributed Pipes Enforcement in Mobile Grid Environment - A Novel Approach for Task Scheduling

Aghila Rajagopal and M. A. Maluk Mohamed

***Abstract*—The Mobile Grid Environment has the dynamic structure in which the position and location of grid changes vigorously. It compounds the pervasive ingression methods of mobile computing and coalition of computational resources from multiple domains to attain a common task. Due to mobility, failure of nodes, disconnection and network partitioning in networks, resource allocation and scheduling is being the demanding problems. We endow with solutions to the above-mentioned problems by implementing pipes in the Mobile grid environment. It is conspicuous that pipes are the collection of segments or processes that are connected in a series which can execute its process concurrently with the other segments or processes in a successive manner. We contrive temporal clusters in our Distributed Pipes Enforcement (DPE) methodology with the determination of demand bound functions and induce master/slave conceits with that in order to augment the efficiency in task completion and abate the resource dissipation. With this, the chances to get erroneous result can be probably avoided. Our approach caters for performance optimization, flexible deployment and consistency.**

***Index Terms*—Deadline analysis, demand bound function, master/slave, mobile grid, pipes, scheduling.**

I. INTRODUCTION

In present scenario, the conventional network methodologies are redeemed with ad-hoc and resource apportioning network between heterogeneous devices. In our proposal, we described grid environment has been accessed through WAN using mobile nodes or mobile agents deployed widely. There defined two categories in grid platform implementations depending upon the distributed heterogeneous nodes or devices, namely agent-based implementations and message passing based implementations. Herewith, we implemented the distributed pipes processing with stream based computing in a mobile grid environment Apparently, Grid computing is the amalgamation of system resources from multiple decisive domains, which provide benefits for both service providers and users. It can also be termed as the type of distributed computing composed loosely coupled computers that work together to perform large tasks. In our conceit, we took mobile grid environment, in which the loosely coupled system in the network can dynamically change its position and location. Due to the mobility of heterogeneous network, there is a possibility for failure of nodes, network disconnection and network partitioning. Further it produces problem with resource allocation and scheduling on-demand. In order to afford solutions for these problems, we developed a novel method for Distributed pipe enforcement in mobile grid (DPE). In our proposal, we indulge the immense technologies such as stream-based computing with pipes processing and demand bound functions. The temporal clustering mechanism of our methodology plays a vital role in this overture.

Clustering is based on the temporal characteristics of the deployed nodes. Factually, we define the pipeline model with the implementation of flow-model that follows a sequence in which the I/O data streams are directly interconnected.

As in [7], mobile grid is an integration of the mobile computing and grid computing paradigm with the composition methodology. Hence, it shares the eminence of both the powerful grid computation capabilities and the ubiquitous ingression of distributed mobile system. The network of mobile grid comprises Static Hosts (SH) of grid and Mobile Hosts (MH) of mobile computing. The key proposal is to amalgamate the capabilities of prognosis, data and service grids to frame a novel mobile grid. The proposed mobile grid is formulated to, seamlessly and conspicuously, handle and bridge the requirements of the mobile and static abusers, and the authentic service providers. Thus, a MH from everyplace and at any time can consume large computing power, required resources and services. Concurrently, the Mobile Host could also be providing locality susceptible data to the grid. The mobility of the mobile hosts also formulates the hosts to interrelate with changing scenery of data resources and services. These resources are not only diverse but, also bear context-based information, depending on consumer, location, community and other attributes. Such services are considered to be value added services and embrace content provisioning.

With all the above-mentioned advancements of mobile grid, in this paper work, we are concerned with distributed pipe methodologies that process several modules of real-time responsibilities. There with each task actualizes on all stages in sequence and must complete the operations within a defined end-to-end latency bound. In accordance with distributed pipe methodologies, it constitutes clustering of deployed nodes and master/slave operations are induced within the framed clusters. Thus, the most prioritized jobs can be executed within a valid time and scrutinized through deadline analysis interval there by increases the scalability and makes the process of resource allocation and scheduling more accurate.

The rest of the paper is composed as follows: Section II describes the related work. Section III formulates our proposed system and the section IV deals with the experimental results.

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The conclusion remarks and future works are given in the terminal section.

II. Related Works

A proposal initiates a fair medium access protocol for pipelining in optical ring network [2]. They explained a global deadline scheduling mechanism for packet transmission. There mentioned that the network was best suited for Local Area Network (LAN) and System Area Network (SAN). The paper [8] described a mechanism for communication of parallel tasks in network workstation with programmability. The enhancement of this methodology could include the adaptive network explore and redistribution of parallel tasks.

Distributed mobile grid systems are typified by asymmetry in both network organization and computing control, mobility of hosts and their restraints. To address these affairs, existing methods endeavor to completely revamp distributed applications or concepts to make them work in a distributed mobile environment. The paper in [9] proposed an alternating mechanism called the surrogate object model to command the asymmetry dilemma in distributed mobile systems. The surrogate object was a delegate for a meticulous Mobile Host (MH) in the wired network that preserves application oriented data structures and methods.

A paper [19] had presented a portrayal model for grid networks. The model provided a synthetic examination of the network topology. The proposal includes the description of required information about the availability of the software in order to access a particular network topologies and prescription of network performance parameters. A delay composition rule for pipelined system was described in [5], which is independent of utilization. The rule established the processing time of higher priority jobs frame sub-additively for uniprocessor systems. There explained a meta-schedulability test for the declination of pipelined system to a single-stage system. The future study is based on the optimization of above said schedulability mechanisms. Effective ways for Managing and supporting context information in mobile grid environment was discussed in [13]. For that, they have used the dynamic virtual organization. In this paper, the effective mapping, expression and context measurement, had been left for future investigation.

A complete workflow for besetting representation, optimization and execution was specified for heterogeneous mobile grid environment in [18]. There defined a sequential stages that dissects the pipeline usability. The main motive of this paper was to reduce the execution time of the defined pipeline workflow. Another paper in [15], described the resource discovery methodologies in mobile grid environment. Mobile Grid computing environment, a kind of distributed computing environment due to the inadequacy in central organization and its capability to bond heterogeneous resources, had been obtained a matter of the extreme importance. As mentioned in this paper, Grid provided location independent access to distinctive computational resources in accordance with the machines services by user's on-demand resources. The decentralized resource delivery services were required, when there was an increase in number of users and resources.

Ade J. Fewings and Nigel W. John denoted that the cluster formation techniques related to the implementation of pipeline methodologies [4]. The velocity disparity in the simulation using jgviz and the changeable rate of graphics description produced a good situation for monitoring the pipeline performance. The pipeline was scheduled to provide the best recital in either a tiled-wall or readback-compositing configuration.

A paper explained the pipelined processing mechanism enforced by a set of flow-model in caravela platform, named as meta-pipeline and the additional functions are needed for the pipeline execution process [6]. There described that the execution is more secure with the conceit called meta-pipeline in remote server. The paper comprised a new processing style for stream-oriented computation on the distributed computing environment [11]. An architectural framework called Recycle was developed to reduce the pipeline imbalance by extensively applying the cycle-time plagiary to the pipeline.

A GRASP methodology stands for Grid-Adaptive Structure for Parallelism in [17], was prospered to integrate structural data at compile time into a parallel program that facilitates it to adapt mechanically to active variations in resource accomplishment. It was uncertain that the overall performance of the pipeline pattern progresses as long as discrepancies in the bottleneck stage were prohibited through continuous performance observation and process migration. The described pipeline in this paper reacted rapidly to the load variations. Thus, the approach prevented the growth of bottleneck for pipeline dispensation. Since the vast application of pipeline processing, involved in automatic visualizations for medical datasets [16]. The paper described the effectiveness of workload distribution between several machines and the service utilization. The future enhancement of this proposal was demonstrated as distribution of rendering process. The methodology discussed in [11] focused on polymorphic pipeline array (PPA) with multimedia applications. The PPA was designed with programmability and flexibility, as prior to the hardware requirements are dynamically customized to the applications. For dynamic partition of tasks, it required the virtualized modulo scheduling mechanism.

A distributed resource management for mobile learning (M-Learning) using mobile grid environment was studied in [20]. The methodology is so efficient since the gird is self-repairable and auto-management capabilities. It composed the Semantic information and context that made the learning process easier for the user. Searching semantically induces agents to illustrate the learner a sorted list of resources or data that are pertinent to the user concern. The paper work in [1] framed an algorithm for the demand bound function (DBF) that is being as one of the core of our affirmed methodology. The extended work bartered with the network scheduling functionalities by banding different scheduling methods at different nodes in the network. PipeProbe system presented for novel mobile sensor network for the determination of spatial topology [14].

An elegant group scheduling scheme termed as Maintenance Grouping Optimization (MGO) had been modeled in [3] for the maintenance of distributed pipeline assets. The model bargained with scalability over spatial networks by developing the judgment matrix with modified genetic algorithm, where the judgment matrix corresponded to distinct combinations of pipeline substitution schedules.

III. Proposed Work

Since the grid system is distributed, the network performance plays a vital role in job scheduling and dispatching. As is prevailing, mobile grid is an integration of the mobile computing and grid computing paradigm with the composition methodology. In mobile grid environment, mobility features of nodes tend to erects problems in resource allocation and scheduling for finishing some valuable task over the network. For elucidating these problems, we developed Distributed Pipe Enforcement in mobile grid (DPE). Applying this in the real time Mobile Grid environment involves a chain of tasks where each task is allocated to a processing node in the environment. The scheduling of tasks to the nodes can be done with the Master/Slave concept. The Master node monitors all the Slaves that are connected in the pipe series. The deadline information of each pipe is monitored by the Master node for which the deadline is calculated using the DA (Deadline Analysis) function. Subsequently, these pipe nodes are grouped to form a new pipe series according to the deadline. For grouping, Temporal-Clustering algorithm is used. The resource allocation and the scheduling for a particular task are made with the consideration of its priority. Our affirmed work also comprises demand bound function. Hence, our system increases the scalability and makes the process of resource allocation and scheduling more accurate.

A. Stream Based Computing

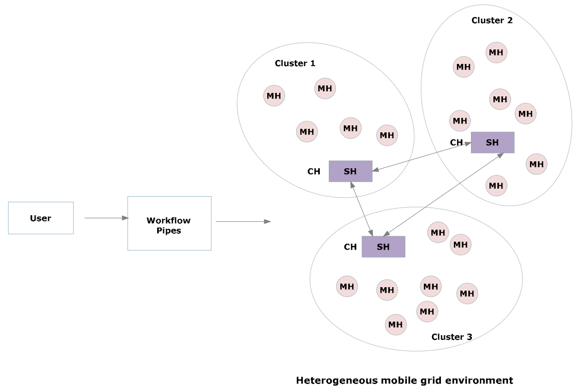

Fig. 1. Distributed pipes in heterogeneous grid

Regarding in our mobile grid environment, each node in the network may receive a set of data called stream, set of operations called kernel functions. The kernel functions are pipelined and the memory is reused for the optimal usage of external memory bandwidth. In the mobile grid, the nodes dependent on a workflow model composed I/O data streams, input parameters and programs to produce the output data streams.

As far as the pipes are considered in our methodology, the output produced by a node is given as the input for the next node in the network. The Fig. 1 shows that the workflow pipe processing in the heterogeneous grid network. It depicts the way a user may view the pipe processing. Our approach gratifies for flexible dispersal, charging, performance execution and consistency, which specifies the recognition and execution levels.

B. Invoking Pipe Model

The figure presented below shows the workflow model of stream based computing with recursive connections. A pipe-model may contain its own Input/output ports that can be processed with its own I/O data streams. Input data streams (1) in Fig. 2 are called as the ENTRANCE ports and output data streams (2) in Fig. 3 are known as the EXIT ports.

As we know, basically a distributed pipe model must satisfy the following conditions. 1) Must have one or more Exit points 2) Includes one or more flow models 3)all the flow model have connection at least with one I/O data stream. The represented pipe model is with recursive connections.

The invocation of the pipe-model is inevitably made by conveyance of input data to its Entrance ports, the operation is held on application side. When giving the input data at the first stage of a pipe-model it is computed and provides output data to the proceeding stage. This computation mechanism is proliferated until it reaches the Exit ports in a stage. The application is required to keep sending input data as long as Entrance ports are anticipating for input data. All stages are executed, during the data reception and when data reaches the Exit ports, it should be acquired by application. Because of the pipe execution mechanism, while the output data is not utterly received by the application stages with respect to the Exit ports will stall. Hence, as soon as the output data is prepared at the Exit ports, it will reach the application. The nodes in all heterogeneous grid networks may have a pipe workflow model to process the task in distributed computation manner and produce effective results. The pipe model focuses the adept resource allocation methods based on the requirements to complete a task in scheduling basis. Priority based resource allocation method is followed by the pipes.

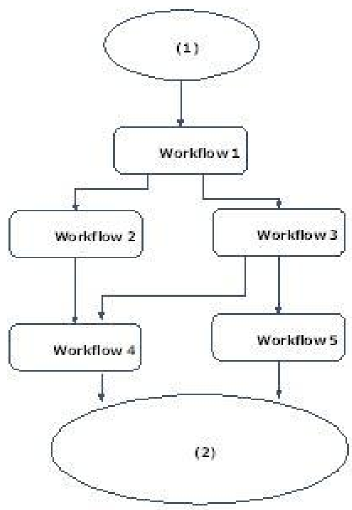

Fig. 2. Pipe model

C. Temporal Clustering

In our affirmed work, we follow the distributed pipe processing in mobile grid environment to reduce the problems of resource allocation and scheduling due to mobility of nodes. Temporal Clustering is the method of grouping up of mobile nodes in synchronous manner. While clustering is formed with the heterogeneous nodes of grid environment, Master/Slave concept is induced. In each cluster, a node will be commanding the other nodes called masters and the rest of the nodes are considered as slaves. Each master node monitors the performance of the slave node and commands the operations to be performed regarding network characteristics. With the clustered nodes, the resource allocation is made with pipes, when there is a need of requirements. The scheduling of tasks to the nodes can be done with the Master/Slave concept. The Master node monitors all the Slaves that are connected in the pipe series. The deadline information of each pipe is monitored by the Master node for which the deadline is calculated using the DA (Deadline Analysis) function. In pipe processing, specific time will be allotted for every process. The processes are supposed to finish its task within the specified time slice. The pipes split the bigger tasks into number of small parts. The part, having high priority gets processed and suits as an input for the next sub-task. A deadline is given for each sub-task in the pipe model to complete the task. In distributed computing environment the operation of the task is said to be failed, when task is not finished within the deadline, where the deadline is said to be relative to the event.

D. Demand Bound Function (DBF)

The temporal features of the nodes in mobile grid are abstracted by the set of demand bound functions. The demand bound function is defined as the computation time of all the occurrences of tasks in the subset T_k, where k represents the node, with activation time and deadline $[t_0, t_1]$. The DBF is represented by $d\,f_k(t_0, t_1)$. Let us assume T be the period, D be the end-end deadline, computation time is given with C and the nodes and their tasks are represented as N_1, N_2, ………, N_n. and T_1, T_2, ……….., T_n respectively.

The demand bound function is calculated as

$$df_k(t_0, t_1)=\sum_{Ti\in Tk}\left(\left[\frac{t1-Di}{T}\right]-\left[\frac{t0-\emptyset i}{T}\right]+1\right)C_i \qquad (1)$$

where *ti* presents the length of the interval and the node varies from i to k. In our approach, we include demand bound function to depict the temporal interface of a task pipe, one per each node, in which the pipe effects. We formulate an algorithm for computing the dbfs. It is glassy that the periodic activations are effectively done with pipes. By using demand bound function, we considerably reduce the computational time of our proposed methodology on pipes with reasonable size.

Pseudo code for DBF computation:

1) Interval Set ← $\emptyset$ initialize the set of intervals
2) STOREINTERVALS store intervals in intervalSet
3) sort interval Set by increasing $t1 - t0$
4) last DBFval ← 0
5) for each $[t0, t1] \in intervalSet$ do loop on all intervals
6) $\Gamma-, \Gamma+ \leftarrow \emptyset$ init sets of past and future patterns
7) SPANPATTERNS$(t0, t1)$ store patterns in $\Gamma-, \Gamma+$
8) Cur DBFval ← $dfk(t1, t0)$
9) if cur DBFval > last DBFval
10) store the point $(t1 - t0, curDBFval)$
11) else
12) do nothing
13) end if
14) end for

The algorithm commences with the initialization of the set of intervals. T_i value represents the length of the interval, which is stored in each level. The demand bound function of a particular node is termed as dfk. Iterations are made for the computation of current DBF value and storing that value. The below figure caters the layer representation of workflow pipe. The flow constitutes goal interpretation to workflow depiction. The goal interpretation is defined by the user about the task to be performed by the node. The interpretation may be in interface languages or the mathematical representations. The goal interpretation is mapped down to the conceptual workflow that describes what the operations to be performed are and not including how it is performed. The results are mapped to precise workflow, which defines the information and methods for performing the task. Then, it is mapped to the workflow depiction that instantiates the workflow in computational grid.

Then the execution of all the components is made by the pipelining process in the distributed environment. The workflow terminates with the collection and integration of results obtained by deployed nodes in the heterogeneous grid environment. The task of first pipe node in each group is initiated by the external events in a time sliced manner. Thus, the most prioritized jobs can be executed within a valid time interval there by increases the scalability and makes the process of resource allocation and scheduling more accurate.

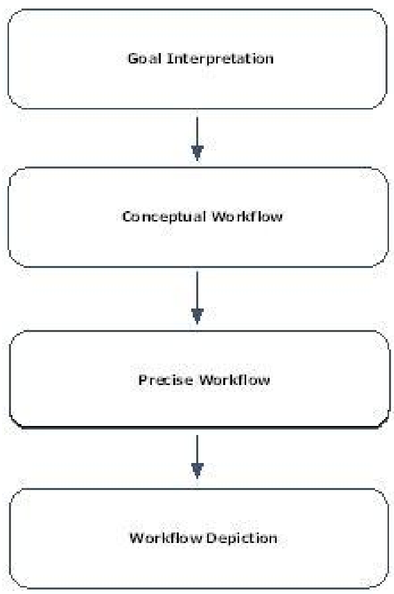

Fig. 3. Layers in work flow pipe

IV. Experimental Results

In order to test the results of our adduced work, we organized several executions on synthetic sequence of tasks. In each experiment, we vary the number of tasks, nodes and deadline/period ratio (D/T) for the determination of reduced computation time and memory usage with minimal synchronization delay. We proposed the methodology with the combination of stream based computing with pipes and the immense advantages of demand bound functions. Henceforth, our approach produces accurate results with minimum computational time, delay and memory usage. The results of our precise work are compared with the analysis of DBF approach, to provide evidence for our adept methodology. The Fig. 4 shows the execution time on 4 nodes related to the number of tasks of our proposed methodology. The numerical results are declared in Table I. In the following figure, we plotted the case with 4 nodes of grid environment. The pipe has a n number of tasks varies from 20, 40. . . 100, which are systematically distributed over the available nodes, we vary the value of *D* from 5 to 10. The Computation time *Ci*, relative deadlines *Di* is randomly generated.

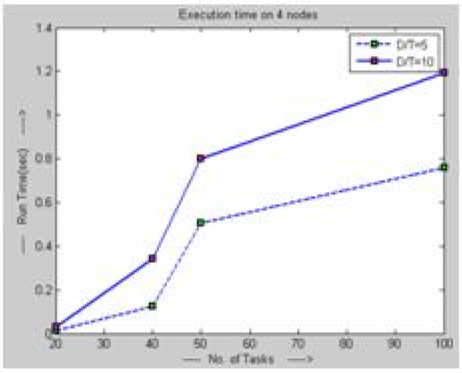

Fig. 4. Execution time on 4 nodes

The table given below shows the execution time taken for performing n number of tasks with varying ratio of deadline and period from 5 to 10. It is clearly stated that execution time is quite higher for *D*/*T*=10.

TABLE I: EXECUTION TIME ON 4 NODES

Nodes	N	D/T	Run-Time (sec)
4	20	5	0.0148
4	30	5	0.1237
4	40	5	0.5075
4	50	5	0.7577
4	20	10	0.0323
4	40	10	0.3420
4	60	10	0.7987
4	100	10	1.1929

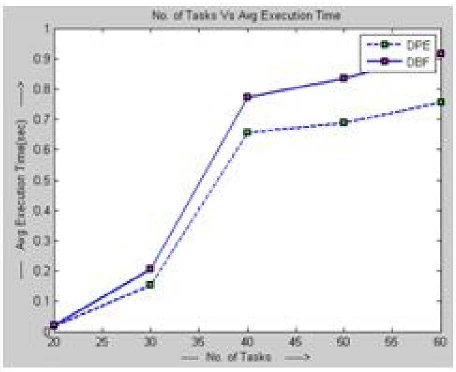

Fig. 5. No. of tasks Vs Avg execution time (sec)

The Fig. 5 exemplifies the correlation between number of tasks and average execution time. The comparison between the DBF methodology and our DPE is shown in above representation. Since we band the immense methodologies of stream based computing with pipes, scheduling mechanisms and demand bound function in our approach, it reduces the execution time of the task effectively.

With the persuasive pipelining methods, we considerably reduce the synchronization delay of the information transmitted from one node to another node. The above statement is pictorially represented in the following figure. The proposed methodology provides minimal average synchronization delay over the performance of the nodes in mobile grid environment.

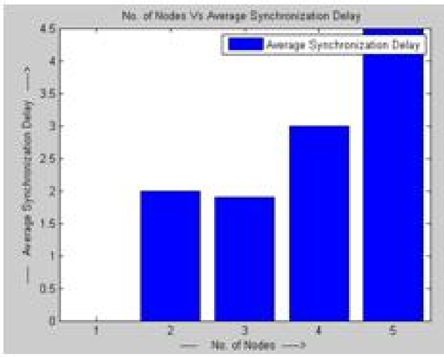

Fig. 6. No. of nodes Vs avg synchronization delay

The Fig. 7 represents the percentage of memory usage of DBF and our affirmed work. Since the nodes in our network are mobile nodes, there will be some memory and energy constraints. In order to optimize the memory usage, we framed temporal clustering, in which the distributed nodes are grouped to form clusters. Each cluster follows the Master/Slave method of communication, in which the master monitors and controls the slave nodes and it communicates the other cluster nodes.

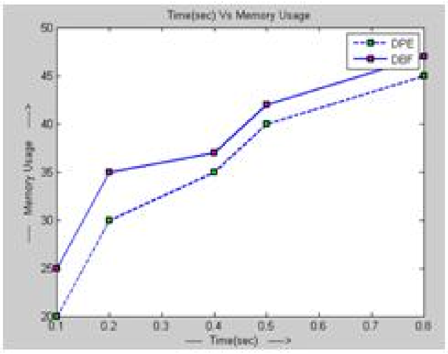

Fig. 7. Time (sec) Vs memory usage

Thus, the energy dissipation of the rest of the nodes other than master node in cluster is minimized, in such a way that the memory utilization is substantially low in our approach. Hence, our proposed methodology is more eminent, acquiring minimal execution time, synchronization delay and memory usage. The gratification of our affirmed methodology is ascertained by the above depictions.

V. CONCLUSION AND FUTURE WORK

In this paper, we derived an adept methodology for distributed pipe processing in mobile grid environment to elucidate the problems regarding mobility of nodes, resource allocation and scheduling. With stream based computing, we invoke pipelining process for each nodes in the mobile grid network, which are clustered by temporal clustering methods. The demand bound function is determined in our approach to reduce the computation time of nodes in executing a task, which is allotted to the nodes along with deadline function. The contingent methodology also affords parallelism and load balancing of nodes for efficient completion of tasks. With this paper, we work towards framing temporal clusters of mobile grid nodes and distributed pipe processing in accordance with demand bound functions to outperform the limitations of related works in an adept manner. Hence, our system increases the scalability and makes the process of resource allocation and scheduling more accurate. As for future work, we intend to extend our proposal with the consequence of combining disparate scheduling strategies on distinctive nodes and network scheduling. Analyzing distributed network with different precedence graph is also a worthwhile extension.

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