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Improved Fault Tolerant Elastic Scheduling Algorithm (IFESTAL)

Sukhbir Singh and Raman Kumar

***Abstract*—** The existing fault tolerant models focus on the failure of host. If a host fails, the copies of tasks on this host will fail to finish. At one time instant, at most one host may encounter a failure, that is to say, if the primaries of tasks fail, the backups can always finish successfully before another host fails. Failures can be either transient or permanent, and are independent, affecting only a single host. In this paper, an attempt will be made to propose an improved algorithm to tolerate multiple host failures which will be tested using guarantee ratio, hosts active time, ratio of task over host time.

Keywords—fault tolerance, Guarantee Ratio, Hosts Active Time, primary backup model and Ratio of Task Time over Host Time

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1 INTRODUCTION

Cloud computing is a paradigm where services are provided across the Internet using different models and layers of abstraction. It refers to the applications delivered as services to the mass, ranging from the end-users hosting their personal documents on the Internet to enterprises outsourcing their entire IT infrastructure to external data centers. A simple example of cloud computing service is Yahoo email or Gmail etc.

Although cloud computing has been widely adopted by the industry, still there are many research issues to be fully addressed like fault tolerance, workflow scheduling, workflow management, security etc. Fault tolerance is one of the key issues amongst all.

1.1 Cloud computing aspects

Cloud computing is a large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted virtualized, dynamically scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet.

"Cloud computing"- came into view as a new paradigm of large scale distributed computing, embraces cyber infrastructure and builds upon the concept in virtualization, autonomic computing, grid computing, utility computing, networking, web services and software services to carry out a service oriented architecture for diminishing information technology overhead for the end-user to provide great flexibility and decrease total cost of ownership and all above on-demand services to a shared pool of computing resources. It has the capacity to yoke the internet and wide area network to use the resources that are available remotely there by to provide cost efficient solution on pay per use basis.

Adapted from Voas and Zhang (2009), Figure 1, shows six phases of computing paradigms, from dummy terminals/mainframes, to PCs, networking computing, to grid and cloud computing. In phase 1, many users shared powerful mainframes using dummy terminals. In phase 2, stand-alone PCs became powerful enough to meet the majority of users' needs. In phase 3, PCs, laptops, and servers were connected together through local networks to share resources and increase performance. In phase 4, local networks were connected to other local networks forming a global network such as the Internet to utilize remote applications and resources. In phase 5, grid computing provided shared computing power and storage through a distributed computing system. In phase 6, cloud computing further provides shared resources on the Internet in a scalable and simple way.

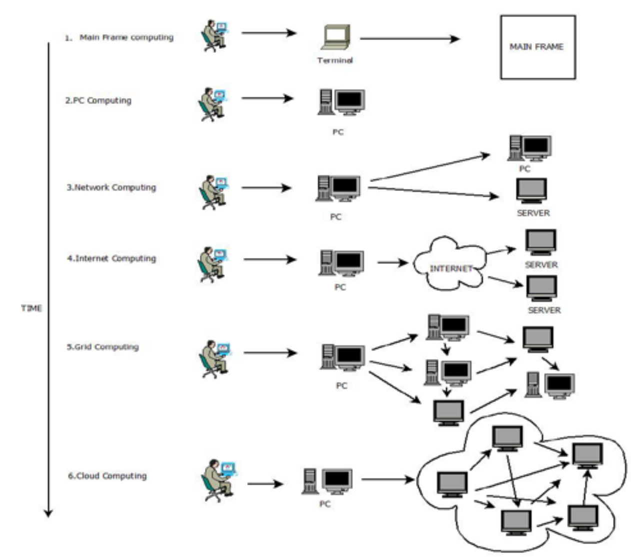

Figure 1: Six computing paradigms – from mainframe computing to Internet computing, to grid computing and cloud computing.

Autonomic-computing — Computer systems capable of self-management. The system makes decisions on its own, using high-level policies; it will constantly check and

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optimize its status and automatically adapt itself to changing conditions. An autonomic computing framework is composed of autonomic components (AC) interacting with each other.

Client–server model — Client–server computing refers broadly to any distributed application that distinguishes between service providers (servers) and service requesters (clients). A server is a computer system that selectively shares its resources; a client is a computer or computer program that initiates contact with a server in order to make use of a resource. Data, CPUs, printers, and data storage devices are some examples of resources.

Grid computing — "A form of distributed and parallel computing, whereby a 'super and virtual computer' is composed of a cluster of networked, loosely coupled computers acting in concert to perform very large tasks."

Mainframe computer — Powerful computers used mainly by large organizations for critical applications, typically bulk data processing such as census, industry and consumer statistics, police and secret intelligence services, enterprise resource planning, and financial transaction processing. The term originally referred to the large cabinets that housed the central processing unit and main memory of early computers.

Utility computing — The "packaging of computing resources, such as computation and storage, as a metered service similar to a traditional public utility, such as electricity." This model has the advantage of a low or no initial cost to acquire computer resources; instead, computational resources are essentially rented.

Peer-to-peer- means distributed architecture without the need for central coordination. Participants are both suppliers and consumers of resources (in contrast to the traditional client–server model).

1.1.1 Cloud components

A cloud computing is made up of several elements. Each element has a purpose which plays specific roles which can be classified as clients, Distributed servers, data centers.

Clients: These are typically the computers which are used by the end users i.e. the devices which can be used by the end user to manage the information on the cloud (laptops, mobile phones, PADs etc.)

Data center: These are collection of servers where the service is hosted. Virtualization is used in data center to create number of virtual server on one physical server.

Distributed servers: These are servers which are located in different geographical place .It provides better accessibility, security to the use.

Due to the rapid exponential growth of cloud computing the need of fault tolerance in cloud is a key factor for concern.

1.1.2 Fault tolerance in aspect of cloud computing

Fault-tolerance bear-on with all the inevitable techniques to enable robustness and dependability. Robustness leads to the property to providing of a correct service in an adverse situation arising due to an uncertain system environment. Dependability is related to some QOS aspects provided by the system, it includes the attributes like reliability and availability.

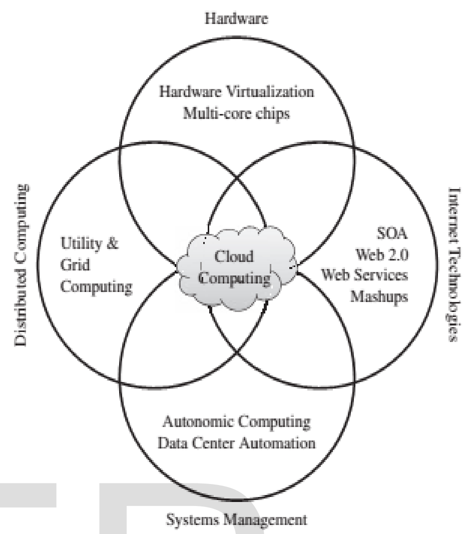

Figure 2: Convergence of various advances leading to the advent of cloud computing.

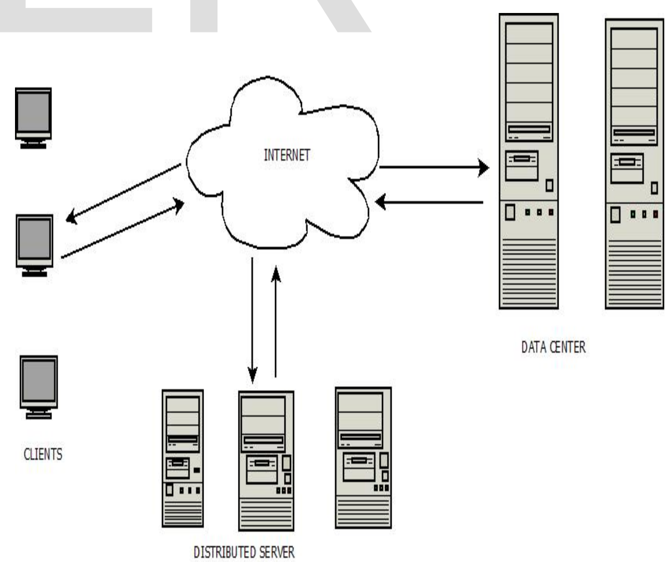

Figure 3: Cloud computing components.

The ability of a system to respond gracefully to an unexpected hardware or software failure is known as fault tolerance The main benefits of implementing fault tolerance in cloud computing includes failure recovery, lower cost for infrastructure, improved performance metrics. There are many levels of fault tolerance, the lowest being the ability to continue operation in the event of a power failure. Many fault-

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tolerant computer systems mirror all operations in order to increase reliability by doing the same work on two or more duplicate systems, so if one fails the other can take over. So theoretically fault tolerance techniques are used to predict these failures and take an appropriate action before failures actually occur.

2 Previous Schemes

Ji Wang [1] described that clouds have been deployed widely in various fields; the reliability and availability of clouds become the major concern of cloud service providers and users. Thereby, fault tolerance in clouds receives a great deal of attention in both industry and academia, especially for real-time applications due to their safety critical nature. Large amounts of researches have been conducted to realize fault tolerance in distributed systems, among which fault-tolerant scheduling plays a significant role. However, few researches on the fault-tolerant scheduling study the virtualization and the elasticity, two key features of clouds, sufficiently. To address this issue, this paper presents a fault-tolerant mechanism which extends the primary-backup model.

M. Armbrust [2] cloud computing, the long-held dream of computing as a utility, has the potential to transform a large part of the industry, making software even more attractive as a service and shaping the way it's hardware is designed and purchased. Developers with innovative ideas for new internet services no longer require the large capital outlays in hardware to deploy their service or the human expense to operate it. They need not be concerned about over-provisioning for a service whose popularity does not meet their predictions, thus wasting costly resources, or under-provisioning for one that becomes wildly popular, thus missing potential customers and revenue. Moreover, companies with large batch-oriented tasks can get results as quickly as their programs can scale, since using 1,000 servers for one hour costs no more than using one server for 1,000 hours. This elasticity of resources, without paying a premium for large scale, is unprecedented in the history of it.

B. Nicolae [3] Infrastructure-as-a-service (iaas) cloud computing is gaining significant interest in industry and academia as an alternative platform for running hpc applications. Given the need to provide fault tolerance, support for suspend-resume and offline migration, an efficient checkpoint-restart mechanism becomes paramount in this context.

X. Qin [4] Fault tolerance is an essential requirement for real-time systems, due to the potentially catastrophic consequences of faults; they investigated an efficient off-line scheduling algorithm in which real-time tasks with precedence constraints can tolerate one processor's permanent failure in a heterogeneous system with fully connected network. The tasks are assumed to be non-preemptable, and each task has two copies that are scheduled on different processors and mutually excluded in time. In the literature in recent years, the quality of a schedule has been previously improved by allowing a backup copy to overlap with other backup copies on the same processor. However, this approach assumes that tasks are independent of one other. To meet the needs of real-time systems where tasks have precedence constraints, a new overlapping scheme is proposed. They showed that, given two tasks, the necessary conditions for their backup copies to safely overlap in time with each other are (1) their corresponding primary copies are scheduled on two different processors (2) they are independent tasks (3) the execution of their backup copies implies the failures of the processors on which their primary copies are scheduled. For tasks with precedence constraints, the new overlapping scheme allows the backup copy of a task to overlap with its successors' primary copies, thereby further reducing schedule length. Based on a proposed reliability model, tasks are judiciously allocated to processors so as to maximize the reliability of heterogeneous systems. Additionally, times for detecting and handling of a permanent fault are incorporated into the scheduling scheme. They have performed experiments using synthetic workloads as well as a real world application. simulation results show that compared with existing scheduling algorithms in the literature, their scheduling algorithm improves the reliability by up to 22.4% (with an average of 16.4%) and achieves an improvement in per formability, a measure that combines reliability and schedulability, by up to 421.9% (with an average of 49.3%).

G. Manimaran [5] many time-critical applications require dynamic scheduling with predictable performance. Tasks corresponding to these applications have deadlines to be met despite the presence of faults. In this paper, they proposed an algorithm to dynamically schedule arriving real-time tasks with resource and fault-tolerant requirements on to multiprocessor systems. The tasks are assumed to be non-preemptable and each task has two copies (versions) which are mutually excluded in space, as well as in time in the schedule, to handle permanent processor failures and to obtain better performance, respectively. Their algorithm can tolerate more than one fault at a time, and employs performance improving techniques such as 1) distance concept which decides the relative position of the two copies of a task in the task queue 2) flexible backup overloading which introduces a trade-off between degree of fault tolerance and performance 3) resource reclaiming, which reclaims resources both from de-allocated backups and early completing tasks. They quantify, through simulation studies, the effectiveness of each of these techniques in improving the guarantee ratio, which is defined as the percentage of total tasks, arrived in the system, whose deadlines are met. Also, they compared through simulation studies the performance their algorithm with a best known algorithm for the problem and showed analytically the importance of distance parameter in fault-tolerant dynamic scheduling in multiprocessor real-time systems.

R. Al-omari [6] in real-time systems, tasks have deadlines to be met despite the presence of faults. Primary-backup (PB) scheme is one of the most important schemes that has been employed for fault-tolerant scheduling of real-time tasks wherein each task has two versions and the versions are scheduled on two different processors with time exclusion. There have been techniques proposed for improving schedulability of the pb-based scheduling, of which backup–backup (bb) overloading is among the most popular ones. In this technique two or more backups can share/overlap in time on a processor. They proposed two new techniques that accommodate more tasks and/or tolerate faults effectively. In the first technique, called dynamic grouping, the processors are dynamically grouped into logical groups in order to achieve efficient overloading of tasks on resources, thereby improving the schedulability and the reliability of the system. In the second technique, called overloading, the primary of a task can share/ overlap in time with the backup of another task on a processor. The intuition is that, for a primary (or backup), the pb-overloading can assign an earlier start time than that of the bb-overloading, thereby increasing the schedulability. They conducted schedulability and reliability analysis of the proposed techniques through simulation and analytical studies. Their studies show that dynamic grouping improves the schedulability more than static grouping, and offers graceful degradation with increasing faults. Also, pb-overloading improves the schedulability more than bb-overloading, and offers reliability comparable to that of bb-overloading. The proposed techniques are generic that they can be incorporated into many fault-tolerant non-preemptive scheduling algorithms.

Q. Zheng [7] in this paper, they first identified two cases that may happen when scheduling dependent tasks with primary-backup approach. For one of the cases, they derived two important constraints that must be satisfied. Further, they showed that these two constraints play a crucial role in limiting the schedulability and overloading efficiency of backups of dependent tasks. They then proposed two strategies to improve schedulability and overloading efficiency, respectively. They proposed two algorithms called the minimum replication cost with early completion time (mrc-ect) algorithm and the minimum completion time with less replication cost (mct-lrc) algorithm, to schedule backups of independent jobs and dependent jobs respectively. Algorithm mrc-ect is shown to guarantee an optimal backup schedule in terms of replication cost for an independent task while mct-lrc can schedule a backup of a dependent task with minimum completion time and less replication cost. They conducted extensive simulation experiments to quantify the performance of the proposed algorithms and strategies.

X. Zhu [8] Fault-tolerant scheduling plays a significant role in improving system reliability of clusters. Although extensive fault-tolerant scheduling algorithms have been proposed for real-time tasks in parallel and distributed systems, quality of service (QoS) requirements of tasks have not been taken into account.

J. Balasangameshwara [9] Computational grids provide a massive source of processing power, providing the means to support processor intensive applications. The strong burstiness and unpredictability of the available resources raise the need to make applications robust against the dynamics of grid environment. The two main techniques that are most suitable to cope with the dynamic nature of the grid are load balancing and job replication. In this work, they developed a load-balancing algorithm by just points of neighbor-based and cluster-based load-balancing methods.

K. Plankensteiner [10] this paper introduces the current state of the art in fault tolerance techniques for grid work flow systems. The examined categories and the summary of current solutions reveal future directions in this area and help to guide research towards open issues of the current designations.

3 Proposed Scheme

The main objective in this study is to accommodate as many tasks as possible, and enhance the system resource utilization. As a result, the first scheduling objective is to maximize the number of accepted tasks under timing constraints. The existing fault model focus on the failure of a single host. If a host fails, the copies of tasks on this host will fail to finish. At one time instant, at most one host may encounter a failure, that is to say, if the primaries of tasks fail, the backups can always finish successfully before another host fails. Failures can be either transient or permanent, and are independent, affecting only a single host. Attempt will be made to propose an improved algorithm to tolerate multiple host failures which will be tested using guarantee ratio, hosts active time, ratio of task over host time.

Table 1: - Research Gaps

Author	Research Gaps
Ji Wang	They have designed FESTAL only for single host failure
M. Armburst	They have reviewed a few services of cloud computing
B. Nichoae	They have given some fault tolerance for offline migration
X. Qin	They have only investigated offline scheduling algorithms
G. manimaran	They have proposed algorithm

	only for dynamic scheduling
R Al-Omari	They proposed only generic technique for the fault tolerance
Q. Zheng	They have only worked for schedulability and overloading efficiency
Raman Kumar	We will provide all facilities in IFESTAL

4 Results and Discussions

The analysis is based on three performance evaluation matrices:

1) GR - Guarantee Ratio
2) HAT – Hosts Active Time
3) RTH – Ratio of total execution of all the jobs/tasks over total active time of all the hosts

Guarantee Ratio:-

It is defined to be the percentage of tasks that are guaranteed to finish successfully among all the submitted tasks.

Hosts Active Time:-

It is defined to be the total active time of all the hosts in the cloud, reflecting the resource consumption of the system.

Ratio of Task Time to Hosts Active Time:-

It is defined to be the total tasks execution time over the total active time of all the hosts in the cloud, reflecting the resource utilization of the system.

By optimizing these three parameters we may improve the Fault Tolerant Elastic Scheduling Algorithm

5 Conclusion

As the clouds have been deployed widely in various fields, the reliability and availability of clouds become the major concern of cloud service providers (CSP) and users. Meanwhile, for the first time, we propose an elastic resource provisioning mechanism in the fault-tolerant context to improve the resource utilization on the basis of the fault-tolerant mechanism and the elastic resource provisioning mechanism. In this paper, an attempt is made to propose an improved algorithm to tolerate multiple host failures which will be tested using guarantee ratio, hosts active time, ratio of task over host time.

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