Hybrid Overloading and Fault Tolerant Task Scheduling in Multiprocessor systems Based on Primary and Backup Scheme

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Aim of research

With multiprocessor systems, redundant scheduling is a technique that trades processing power for increased reliability through redundancy. One approach, called primary-backup task scheduling, is often used in real-time multiprocessor systems to guarantee the deadlines of tasks in site of faults. Briefly, it consists in scheduling a secondary task conditionally in such a way that the secondary task is actually executed only if the primary task (or the processor executing it) fails to terminate properly. Doing so avoids wasting CPU resources in the failure-free case, but the difficulty comes from the fact that primary and secondary tasks must compete for resources in case of failure. To address this point, overloading strategies, such as primary and backup overloading (PB) and backup-backup overloading (BB), were developed to improve schedulability while retaining a certain degree of reliability. The aim of our research is to develop a good tradeoff between PB overloading and BB overloading. Then, we will use the new overloading technique to develop a new fault tolerance task scheduling approach.

Idea, approach, and progress

Real-time multiprocessor systems are defined as those systems in which the correctness of systems depends on not only the logical result of computation but also the time at which the results are produced. Thus, it is essential that tasks are completed before their deadlines even in the presence of processor failures. This makes fault tolerance an inherent requirement of real-time systems. In a multiprocessor system, fault tolerance can be provided by scheduling multiple copies of tasks on different processors. Primary-backup technique is one of fault tolerant scheduling techniques. In the PB-based task scheduling two versions of a task, primary version and backup version, are scheduled on two different processors and the acceptance test is used to check the correctness of the execution results. In order to improve the schedulability, overloading techniques are often used. PB overloading schedules the primary of a task onto the same or overlapping time slot with the backup of another task on a processor. BB overloading schedules the backups of multiple tasks onto the same or overlapping time slot on a processor. R. Al-Omari et al. drew a conclusion that the PB overloading is able to achieve better performance than BB overloading, and BB overloading strategy is better than non-overloading strategy.

We proposed a hybrid overloading technique, based on extended PB overloading [6]. In short, hybrid overloading is a new technique which combines the advantages of both PB and BB overloading. All three overloading strategies are compared through a stochastic analysis, as well as by simulating them under diverse system conditions. The performance analysis shows that hybrid overloading provides an excellent tradeoff between schedulability and reliability. We also proposed a dynamic PB-based task scheduling approach [2, 5], wherein an allocation parameter is used to search the available time slots for a newly arriving task, and the previously scheduled tasks can be rescheduled when there is no available time slot for the newly arriving task.

Our proposed task scheduling algorithm is compared with some existing scheduling algorithms in the literature through simulation studies. The results have shown that the task rejection ratio of our real-time task scheduling algorithm is lower than the compared algorithms.

Future Direction

The theoretical analysis can prove the advantage of hybrid overloading. In the future work, the detailed Markov model will be produced based on the results in 2007. Moreover, the analysis method in our publications and the Markov model can be used to evaluate more fault tolerance technologies. For example, a primary can have two or more backups to tolerate more faults. Thus, the overloading chain will be evolved to overloading tree.

Publications:

[1]**W. Sun** and Y. Inoguchi: “Time Constrained Job Admission and Scheduling in Service Oriented Grid,” J. Future Generation Computer Systems, submitted for the second review.

[2]**W. Sun,** C. Yu, X. Défago and Y. Inoguchi: “Dynamic Scheduling Real-time Task Using Primary-backup Overloading Strategy for Multiprocessor Systems," IEICE Trans. Information and Systems, Vol.E91-D, No.3, 2008.

[3]Y. Zhang, **W. Sun**, Y. Inoguchi: “Predicting Task Running Time in Grid Environment Based on CPU Load Predictions," J. Future Generation Computer Systems, pp.95-102, 2007.

[4]**W. Sun** and Y. Inoguchi: “Optimizing Average Response Time for Task Flow in Heterogeneous Systems," HPSRN 2008, accepted.

[5]**W. Sun**, C. Yu, X. Défago and Y. Inoguchi: “Real-time Task Scheduling Using Extended Overloading Technique for Multiprocessor Systems," 11th IEEE Int'l Symp. Distributed Simulation and Real Time Applications (DSRT), pp.95-102, 2007. Nominated for the best paper award.

[6]**W. Sun**, C. Yu, X. Défago and Y. Inoguchi: “Hybrid Overloading and Stochastic Analysis for Redundant Scheduling in Real-time Multiprocessor Systems," 26th IEEE Int'l Symp. Reliable Distributed Systems (SRDS), pp.265-274, 2007.