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授与した学位	博　士
専攻分野の名称	工　学
学位授与番号	博甲第　　６８４２　　号
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学位授与の要件	自然科学研究科　　産業創成工学専攻 （学位規則第４条第１項該当）
学位論文の題目	A Study of Job-Worker Assignment Algorithms Considering CPU Core Usage for User-PC Computing System （ユーザ PC コンピューティングシステムのための CPU コアを考慮したジョブのワーカ割当アルゴリズムに関する研究）
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学位論文内容の要旨

In this thesis, I study job-worker assignment algorithms considering CPU core usage for the *User-PC computing system*. The *User-PC computing system* is a low-cost and high-performance distributed computing system based on the *master-worker model* that offers computation capabilities to the members in an organization by using the idling computing resources of their PCs.

I first propose a *static job scheduling algorithm* for the UPC system. Given a set of independent jobs, this two-phase algorithm finds an assigned worker for each job such that the global makespan is minimized. In the first phase, workers and jobs are grouped into multiple classes according to the number of available cores and the number of required threads, in order to efficiently utilize worker PCs CPU cores. Then, the algorithm greedily finds job-worker assignments in each class independently. In the second phase, it improves job-worker assignments with a local search method that repeatedly reassigns jobs to different workers between classes.

Next, I introduce a *dynamic job scheduling algorithm* for the UPC system. It is obtained by modifying the previous *static job scheduling algorithm*. To deal with the dynamic job arrivals in the UPC system, I extend the static scheduling algorithm based on the following conditions:

- The proposed algorithm runs when a new job joins the system, or when a worker completes a job execution and returns the result to the master.
- The master sends the scheduled job to its assigned worker when the latter is idle.
- The algorithm finds an assigned worker to each queuing job.
- For each worker, the algorithm uses the estimated completion time of the currently running job as the starting time to run the next job assigned to the same worker.

Third, I extend the *dynamic job scheduling algorithm* by implementing the *job migration* concept. The basic idea is to migrate jobs that have already been assigned to workers, to faster or idling workers. Each preempted job must be assigned to a new worker based on specific criteria. Thanks to job migration, the global makespan could be further reduced by nearly 50%, compared to the first dynamic job-worker assignment algorithm.

Finally, I extend the *dynamic job-worker assignment algorithm* by considering *concurrent jobs execution* in the UPC system. It considers *assigning and processing several jobs at a time on each worker*. In the considered scenario, jobs join the system dynamically and the algorithm assigns queuing jobs to workers within their available computing resource limits when they become idling after having finished processing their assigned jobs.

This thesis is organized as follows: Chapter 2 reviews the design and implementation of the UPC system platform using Docker. Chapter 3 presents the static job-worker assignment algorithm for the UPC system and its evaluation through experiments. Chapter 4 presents the dynamic job-worker assignment algorithm for the UPC system and its evaluation through experiments. Chapter 5 extends the dynamic job-worker assignment algorithm based on dynamic job migration. This algorithm has been extensively assessed through several experiments. Chapter 6 extends the dynamic job-worker assignment algorithm with concurrent jobs execution. Its evaluation results have been presented as well. Chapter 7 reviews relevant works in the literature. Finally, Chapter 8 concludes this thesis with some future works.

論文審査結果の要旨

This thesis presented studies job-worker assignment algorithms considering CPU core usage for the User-PC computing system that is a low-cost and high-performance distributed system based on the master-worker model and offers computation capabilities to the members in an organization by using idling computing resources of their PCs.

The thesis first proposes a static job scheduling algorithm for the UPC system. Given a set of independent jobs, this two-phase algorithm finds an assigned worker for each job such that the global makespan is minimized. In the first phase, workers and jobs are grouped into multiple classes according to the number of available cores and the number of required threads, in order to efficiently utilize worker PCs CPU cores. Then, the algorithm greedily finds job-worker assignments in each class independently. In the second phase, it improves job-worker assignments with a local search method that repeatedly reassigns jobs to different workers between classes.

Next, the thesis introduces a dynamic job scheduling algorithm for the UPC system. It is obtained by modifying the previous static job scheduling algorithm. To deal with the dynamic job arrivals in the UPC system, it extends the static scheduling algorithm.

Third, the thesis extends the dynamic job scheduling algorithm by implementing the job migration concept. The basic idea is to migrate jobs that have already been assigned to workers, to faster or idling workers. Each preempted job must be assigned to a new worker based on specific criteria. Thanks to job migration, the global makespan could be further reduced by nearly 50%, compared to the first dynamic job-worker assignment algorithm.

Finally, the thesis extends the dynamic job-worker assignment algorithm by considering concurrent jobs execution in the UPC system. It considers assigning and processing several jobs at a time on each worker. In the considered scenario, jobs join the system dynamically and the algorithm assigns queuing jobs to workers within their available computing resource limits when they become idling after having finished processing their assigned jobs.

The applicant has published one journal paper and three international conference papers to present the contributions.

From the overall evaluation of this thesis, the applicant has satisfied the qualification condition for the doctor degree in Engineering from the Graduate School of Natural Science and Technology at Okayama University.