Study on Static Task Scheduling Based on Heterogeneous Multi-Core Processor

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***Abstract*—Aiming at the situation of priority scheduling algorithm of chaos, later redundant processing in the task scheduling on current multi-core heterogeneous processors, this paper proposes a task scheduling algorithm with weighted priority algorithm-- WPTS. It is related to three attribute values of the main reference tasks, which can be obtained by weighted comparison that can overcome the confusion and redundancy of task selection to a certain extent. And it can maintain the priority processing of priority scheduling processor in the processor task allocation process to improve the computational efficiency, reduce idle memory accounted rate. In addition, redundant task processing is introduced in order to achieve a better recovery of the processor’s time period and the effect of time reduction. Compared with the HCPED algorithm and HDEFT algorithm, the WPTS algorithm has a better performance.**

Keywords-Heterogeneous multi-core platform; Static task scheduling; Weighted finite assessment; Time control; Redundant task

I. INTRODUCTION

Because of the high chip utilization rate and the low power consumption, the heterogeneous multi-core processor becomes the important direction of the system in support and development for the multi application platform. But it also brings new challenges to the whole era of computing processor’s development, which means how multi-core processor threads scheduling optimization makes the execution time, execution period or power consumption of processor performance significantly improved. Therefore, as the most important index affecting the integrated performance of the entire multi-core processor, heterogeneous task scheduling becomes a hot research topic in current time. The following is the analysis of three different types of task scheduling algorithm--CPFD/HCPFD/HDEFT, summarizes the evaluation index, and combined with the operating characteristics of heterogeneous multi-core processor, implementing organic combination of three algorithms, weighted parameter values make priority system which realize service mapping in order. This kind of task scheduling algorithm can make up for the deficiency of multi application performance, and has important reference value to the development of the static task scheduling and the technology promotion.

II. ARCHITECTURE OF WPTS ALGORITHM

A. Analysis of Three Kinds of Algorithms

The current general-purpose heterogeneous multi-core processor scheduling algorithm includes CPFD/HDEFT/HCPFD algorithms. Among them, standard of priority classification of the HCPFD algorithm is key work and starting time of the work, one by one to assign the task to processor mapping time, integrated with idle time of system processor to distribute allocate tasks. CPFD algorithm adopts the method of calculating the entrance node to divide the priority, which means the thread distance of the hierarchical from the task node to the entry node that will be scheduled to the corresponding completion time on the processors in batches completing the task in time. With “O”referring data mixed degree in time axis, “V”referring task node inventory. The HDEFT algorithm uses a SUM type priority evaluation mechanism in the algorithm task allocation stage, and in the stage of processor and task link mapping start the complex moment and insert of task.

Comparison of the three algorithms tells adaptive scheduling of CPFD/HCPFD is not very ideal, analysis the reason knows that taking only priority evaluation reference from the algorithm, and does not take into account the existence of the multi constraint in task mapping and influence on scheduling performance of the whole communication overhead for mapping produced. The HDEFT algorithm has no high degree of complexity in time, so the time thread is small. But there is a lack of task after the complex moment of the overflow of redundant processing, but also to extend the overall task scheduling time spent, while taking up more of resources the processor. The following is the summary of the pros and cons of the above algorithm, designing the WPTS algorithm with validation for scheduling algorithm.

B. Execution of WPTS Algorithm

Generally speaking, the WPTS algorithm has two stages of the implementation of the priority decision and the bridge mapping between the task and the multi-core processors.

Among them, as the core of the first stage, the task layer and the weight evaluation are related to the length of the thread of the algorithm, which determines the performance level of the algorithm. In the second stage, the multi task and multi processor allocation is implemented, and the process of the optimization of task scheduling results is derived.

C. Achievement of Principle in WPTS Algorithm

1) Design of Priority Evaluation

First of all, to carry out the combination for task. Follow the same merger rules. It need to optimize the task of independent task, the communication overhead task and task which mapping a longer period of time. Followed by the implementation of DAG depth tree priority search, when the task V only has separate successor nodes, the corresponding only has a precursor node. At the same time, the communication overhead between the two tasks must be greater than the task execution overhead of average processor. After the combined, task is denoted as V*, the sum of the combined expenses is calculated, and the operation and the processing are carried out as a whole in the following task scheduling.

Then, the task layer is implemented. First with the “level” as independent markers for the number of layer in DAG, setting the entrance node of the initial value as 0, the global DAG stratified by stripping down in the order, seperating the maximum number of communication of task nodes and the entrance node , the nominal task named as Level value, so the hierarchical can avoid the omission of global search, and determine the weights for subsequent analysis and calculation of scheduling. The calculation method of Level value follows the following formula:

$$\text{level}(v_i) = \text{Max}(\text{level}(v_j)) + 1,\ v_j \in \text{pred}(v_i)$$

Next, Starting the weight evaluation, calculation process needs to consider the the priority level’s influence of three attributes on task finishing the degree of ranking. WPTS selects the average communication overhead and the mapping time as the task priority evaluation parameters. Through the weight difference, the computation cost of the global server means ACC, the formula refers (a). Communication overhead includes two layer which includes data transfer ADTC and ADRC. Calculation formula refers(b) and (C). X is the successor node parameter, and Y is the precursor node parameter.

$$ACC(v_i) = \sum w_{i,j}/m \qquad (\alpha)$$

$$ADTC(v_i) = \frac{1}{x}\sum_{j=1}^{x} C(v_i, v_j) \qquad (\beta)$$

$$ADRC(v_i) = \frac{1}{y}\sum_{k=1}^{y} C(v_k, v_i) \qquad (\chi)$$

At the same time, weight is defined as the value of the task V, which means the sum of the three tasks (ADTC/ADRC/ACC) that is calculated as follows:

$$\text{weight}(v_i) = \text{ADTC}(v_i) + \text{ADRC}(v_i) + \text{ACC}(v_i)$$

2) Task mapping processing

Process from task to mapping processor includes task mapping and processor redundancy processing

In the process of mapping the entire task, through all the core processors, and the task assigned to the earliest completed idle processor, the job completion time is recorded as EFT1. V allocation and idle period processor task complex moment to complete the node named EFT2. From the moment of the re-engraved precursor node to all processors assigned and in the free time becomes EFT3. Compared with the three aspects, the optimal processing distribution path is selected. The corresponding calculation formula is as follows:

$$\text{EFT1} = \min_{0 \leqslant n < |p|} \{\text{AST}(v_i, p_n) + w(v_i, p_n)\}$$

$$\text{EFT2} = \min_{0 \leqslant n < |p|} \left\{ \text{Max}\left\{ \begin{array}{l} \text{Avail}(p_n), \\ \text{AFT}(v_i, p_k) + c(v_{par}, v_i) \end{array} \right\} + w(v_i, p_n) \right\}$$

$$\text{EFT3} = \min_{0 \leqslant n < |p|} \left\{ \text{Max}\left\{ \begin{array}{l} \text{Avail}(p_n) + w(v_{par}, p_n), \\ \text{AFT}(v_i, p_k) + c(v_{par}, v_i) \end{array} \right\} + w(v_i, p_n) \right\}$$

Through the in-depth study of the DAG map, the redundant task processing is the best after the first layer mapping, which means the most close to the original value of the redundant decision after the completion of the adjacent task layer scheduling, and it is easier to accurate correction. Therefore, the step type colloid redundant processing is adopted to carry out correction layer by layer until the redundant item is empty.

III. TIME ANALYSIS OF WPTS ALGORITHM

In the process of task merging, a global DAG layer’s deep analysis is needed to obtain the time complexity O (v+e), which are the number of layers and the number of edges in the graph. Calculating task hierarchical node level value needs to comply with the complexity of the function O (n+e). And in the corresponding task weight evaluation, it needs to make bread search for DAG graph firstly to get the node weight initial value and the entrance node in connection of the key path, the complexity function is O (n2).

The above mentioned functions of time complexity together with the time complexity determines the time length of the task to the processor mapping stage. Therefore, to enhance the processing performance of multi core processor for static multiple task scheduling, it is needed to optimize the DAG layer from the time complexity O. The WPTS algorithm uses O (V + e) + O (n + e) + O (n2) + O (kpm + k2m), which means O (V3) combined with algorithm in suppressing DAG layer complexity at the same time, in order to solve engraved redundancy with reducing redundant scheduling processing time to avoid occupation of processor resource and waste of time.

IV. RESEARCH ON EXPERIMENTAL SCHEDULING MEASUREMENT AND DATA

A. Evaluation of Performance Parameter

In the static task scheduling, the resources and data traffic of overall scheduling is small, so in addition to the total length of the practice of a scheduling algorithm, it needs to add performance indicators. Specific evaluation and reference formulas are as follows

1)Setting "makespan" as the maximum scheduling length index on the global processor.

2)The minimum time for all the critical path tasks seemed as the ratio denominator of scheduling length. SLR looks as algorithm scheduling performance referring association, its value is close to 1, the overall performance of the better.

3) "Efficiency" is set to evaluate the efficiency of the algorithm parameters. The speedup of task scheduling is named as the molecule, and the higher of the value means the higher efficiency of the task scheduling.

The above parameters are calculated as follows:

$$SLR = \frac{makespan}{\sum_{t_i \in cp} \min_{p_j \in P}\{W(t_i, p_j)\}}$$

$$Efficiency = \frac{Speedup}{|P|}$$

$$Speedup = \frac{\min_{p_j \in P}\{\sum_{t_i \in DAG} W(t_i, p_j)\}}{makesapn}$$

B. Data Analysis of Experimental Results

The scheduling performance of the two group WPTS algorithm is tested by simulation experiment in the test group of the same scheduling task.

1)Then a series of task graph happen, according to the DAG task to determine the parameters respectively, then get {30, 40, 50, 60, 70, 80, 90,100}, a (the value of size of DAG is {0.5, 1.0, 2.0}, β (node values {1, 2, 3, 4, 5)}, γ (the value of node{1, 2, 3, 4, 5}), CCR (communication and computation time rate, the value is {0.1, 0.5, 1.0, 5.0, 10.0} generating a total of more than 3000 sets of DAG type, each set has at least 20 different nodes weight type.

2)The task then from the entrance to the global parameters input node processor algorithm, system restores present multi-core processor work by Tesco configuration simulation environment. Join program C to the algorithm to achieve mutual communication, simulation the information interaction and mapping operations of multi-core algorithms. Processing performance is determined by processing efficiency of the same task graph and the length of the processor.

Table I. is detailed program structure and evaluation analysis method referred.

TABLE I . COMPARISON OF ALGORITHM SCHEDULING PERFORMANCE

Algorithm 1	Algorithm 2	Result	Comprehensive
WPTS	HDEFT	Worse:6751 Equal:16523 Better:36726	Ratio:9.47% Worse:17052
	HCPFD	Worse:6884 Equal:11667 Better:41449	Ratio:19.00% Equal:34202
	CPFD	Worse:3417 Equal:6012 Better:50571	Ratio:71.53% Better:128746

It can be seen that in the real simulation environment of random experiment, the three algorithms are in integrated operation, the optimal scheduling ratio of WPTS is the highest, and it is much better than the other three algorithms. With the complexity of scheduling nodes and types of task graphs, the performance advantages of WPTS algorithm and redundant processing rate will become more and more prominent.

V. CONCLUSION

Through the analysis of common task scheduling algorithm for the heterogeneous multi-core processor platform, this paper refers problems and shortcomings to realize the structure optimization and algorithm coordination, and put forward the WPTS scheduling algorithm. The weighted value is used to make the priority of the nominal method, which makes up for the assessment of the single selection of parameter which can be used to accurately reflect the location and attributes of the cluster in the DAG diagram. At the same time, it can bring the task with the shorter thread-the processor mapping, and the elimination of redundant tasks. The optimal scheduling ratio of the new algorithm is as high as 70%, which has a very high and stable processing scheduling performance.

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