Proceedings of the International MultiConference of Engineers and Computer Scientists 2014 Vol II,
IMECS 2014, March 12 - 14, 2014, Hong Kong

Using Grey Relation to FPGA Multi-Objective Task Scheduling on Dynamic Reconfigurable System

Jan-Ou Wu, Yang-Hsin Fan, San-Fu Wang and Tsai-Hua Kang

Abstract—**Due to the FPGA technology evolution and market demand, the scheduling of the reconfigurable system has become an important part. From the past before run time the static schedule, with the evolution of technology, the dynamic scheduling is developed to reconfigurable computing. Only run in the execution order of the point in time, all tasks are decided. Thus fast and dynamically at runtime to change the order of tasks with in time execution, making the flexibility to improve. In this paper, we approach the grey relational algorithm for multi-objective tasking in dynamically reconfigurable scheduling to achieve the optimal performance of the overall system.**

***Index Terms—FPGA*, reconfigurable system, *grey relational*, *dynamic scheduling*, multi-objective tasking**

I. Introduction

THE FPGA reconfigurable computing is intended to fill the gap between hardware and software, achieving potentially much higher performance than software, while maintaining a higher level of flexibility than hardware [1]. Technology evolution and solving an important problem in reconfigurable systems, the scheduling methods has become an important part. Usually, scheduling methods can be classified into static and dynamic depending on when the scheduling is done. The static scheduling was scheduled before run-time. Static scheduling can be find an optimal schedule, but it is fixed and thus cannot be changed scheduling once the system is running, so it is quite inflexible. The dynamic scheduling is scheduled in run-time. Dynamic scheduling is faster and flexible, but the schedules might find a sub-optimal solution.

There have been extensive studies for static scheduling. Proposes a new method, when hardware task been executed, the task left in the surface of RPU as much as possible in Bassiri and Shahhoseini [2]. In [3], a heuristic run-time software/hardware scheduling is presented and implements the method in operating system for reconfigurable systems. For dynamic scheduling, the following methods have been proposed or used. Using priority-based scheduling was used in task schedulers and context schedulers [4-5]. In [6], the preemptive method with hardware tasks scheduling and placement for dynamic reconfigurable logic on SoC, such as Shortest-Remaining Processing Time (SRPT) and Least Laxity First (LLF). A novel Performance Aware Task Scheduler (PATS) is presented that decides the task schedule at runtime while considering the specific system state of the reconfigurable processor. The PATS considers the efficiency of a task to determine the scheduling decision and that are accelerated by reconfigurable Special Instructions (SIs) to improve system performance [7]. In [8], a simulation framework is proposed for application task distribution among different nodes of a reconfigurable computing grid.

From reference mentioned above, dynamic scheduling for FPGA or reconfigurable systems becomes more important. Dynamic scheduling is faster than static scheduling that could be reduce time of reconfiguration or scheduling in overall systems, and re-scheduled scheduling of task at runtime. In this paper, we propose grey relation of grey system to finish dynamic reconfiguration multi-objective task scheduling, and then to achieve the optimal performance of the overall system. Therefore we use grey relation analysis methods [9] to implement multi-objective task scheduling in dynamic reconfiguration systems. The remainder of this paper is organized as follows. Section II presents our proposed methodology. Experimental results are reported in section III. Finally, a conclusion and discussion of future research directions are given in section IV.

II. Propose Method

Grey theory was proposed by Deng (1989) [10], its contents include grey relational grade, grey programming, grey relational space, grey prediction and grey control, etc. The grey relation has been utilized for various applications, such as studies applied to VLSI in recent years [11-13]. This work is to do analysis of the relationship between tasks.

We have developed several features of task on the task model as important features of reconfigurable configuration as follows:

--Area *size*: The size of area is used by each task, and each task area is equal to the number of CLBs.

--*Overhead execution time*: when FPGA is executed configuration by tasks, there are also other tasks configurations. The configuration time will be affected and the execution time will cause overhead.

Jan-Ou Wu. Author is with the Department of Electronic Eng. De Lin Institute of Technology, Tu-Cheng, Taipei, Taiwan, ROC (e-mail: janou@ms42.hinet.net).

Yang-Hsin Fan. Author is with the Department of Computer Science and Information Eng. National Taitung University, Taitung, Taiwan, ROC (e-mail: yhfan@nttu.edu.tw).

San-Fu Wang. Author is with the Department of Electronic Eng. Ming Chi University of Technology Taipei, Taiwan, ROC (e-mail: sf_wang@mail.mcut.edu.tw)

Tsai-Hua Kang. Author is with the Department of Electronic Eng. De Lin Institute of Technology, Tu-Cheng, Taipei, Taiwan, ROC (e-mail: shakakang@yahoo.com.tw).

--*Locatability*: We assume that the FPGA can be allocated by tasks, so it hasn't to consider I/O.

--*Shape:* The initial shape of each task is rectangle. When logic resources of each task are implemented in FPGA, it's not that the shape of each task is rectangle. In order to simulate this case, we assume that the shape of the tasks is can be changed.

In this paper, we use the grey relation of dynamic reconfiguration multi-objective task scheduling. Every time FPGA is loaded the task, it can follow user's different demand and according to nature of task to determine the order of task scheduling. About of task and scheduling as follows, all of the task will be first stored into the module library. The task will be configured into FPGA until the demand for task. The corresponding task of module library will be configuration into FPGA after scheduler randomly decides. Placer is used to manage space while to find an optimal space to the loading task.

Task Graph for Free (TGFF) [14] was published in 1998 by Dick that is a task Graphs generator and it's an open source. The user just setup the parameter settings after execution TGFF, it can generate the task graph depending on user settings. The purpose is easily to generate standard random number scheduling and allocation, in order to provide a general synthesis of hardware and software for studies using. So we will verify grey relation of dynamic reconfiguration multi-objective task scheduling with Configuration Area (CA) size, Configuration Time (CT), Running Time (RT) by TGFF.

III. Experimental Result

The proposed the grey relation of dynamic reconfiguration multi-objective task scheduling was utilized TGFF construction in C# Builder to evaluate the performance. The measurement environments have been implemented on an Intel Core (TM) i-7-2600 3.4 GHz PC under the Windows 7 operating system. The examples are using events with relation of gray system and their corresponding relational and corresponds method to the target as following. The corresponds method adopts configuration area, configuration time, running time to evaluate various of task, and using TGFF to generate a set of task, such as a relation set of composed of Task1,Task 2,…,Task9,Task10. Therefore, if task scheduling considers more characteristics, then the corresponding relation sets will be more.

A. Result of the quantitative

According to the configuration area (CA), configuration time (CT) and running time (RT), we evaluate the effects of three kinds of quantitative as shown in Table I.

For the smaller-the-better type of criterion according to gray relational generation of configuration area, configuration time and running time, its reference value is the minimum lower limit associated with the said criterion as shown in Table II.

B. BResult of the dynamic multi-objective scheduling

In table II, we use 0.9, 0.05 and 0.05 expression of the weight value of CA, CT and RT status respectively. The integral effect of relational is configuration with the smallest CA size. The dynamic task scheduling with the smallest configuration area size is shown in figure 1.

TABLE I
QUANTITATIVE RESULT OF THE THREE EFFECTS TARGET

TGFF to generate 10 tasks	Result of the quantitative		
Task	CA	CT	RT
Task 1 (r_{1-1})	6	2	43
Task 2 (r_{1-2})	10	2	24
Task 3 (r_{1-3})	36	6	33
Task 4 (r_{1-4})	45	9	60
Task 5 (r_{1-5})	39	4	72
Task 6 (r_{1-6})	55	11	142
Task 7 (r_{1-7})	68	5	37
Task 8 (r_{1-8})	78	39	114
Task 9 (r_{1-9})	57	4	191
Task10 (r_{1-10})	69	23	86

TABLE II
RESULT OF THE SMALL-THE-BETTER OF THREE TARGETS

TGFF to generate 10 tasks	Result of the small-the–better		
Task	CA	CT	RT
Task 1 (r_{1-1})	1.000	1.000	0.558
Task 2 (r_{1-2})	0.600	1.000	1.000
Task 3 (r_{1-3})	0.167	0.333	0.727
Task 4 (r_{1-4})	0.133	0.222	0.400
Task 5 (r_{1-5})	0.154	0.500	0.333
Task 6 (r_{1-6})	0.109	0.182	0.169
Task 7 (r_{1-7})	0.088	0.400	0.649
Task 8 (r_{1-8})	0.077	0.051	0.211
Task 9 (r_{1-9})	0.105	0.500	0.126
Task10 (r_{1-10})	0.087	0.087	0.279

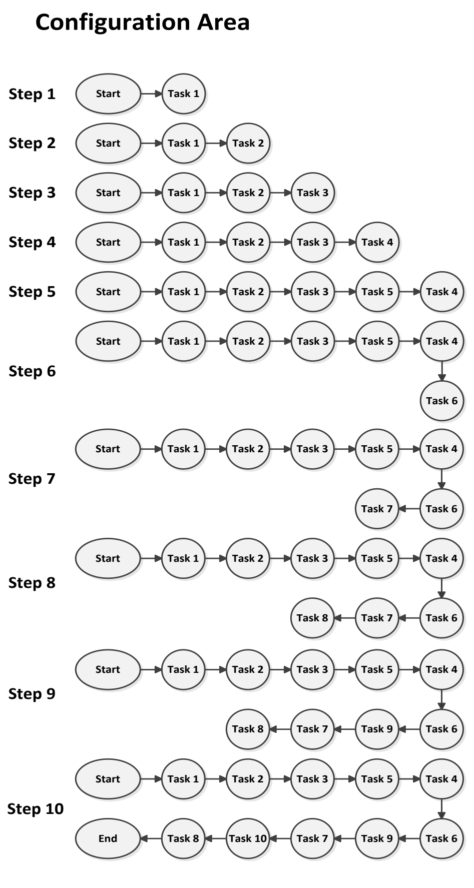

Fig. 1. The dynamic task scheduling with the smallest CA.

ISBN: 978-988-19253-3-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

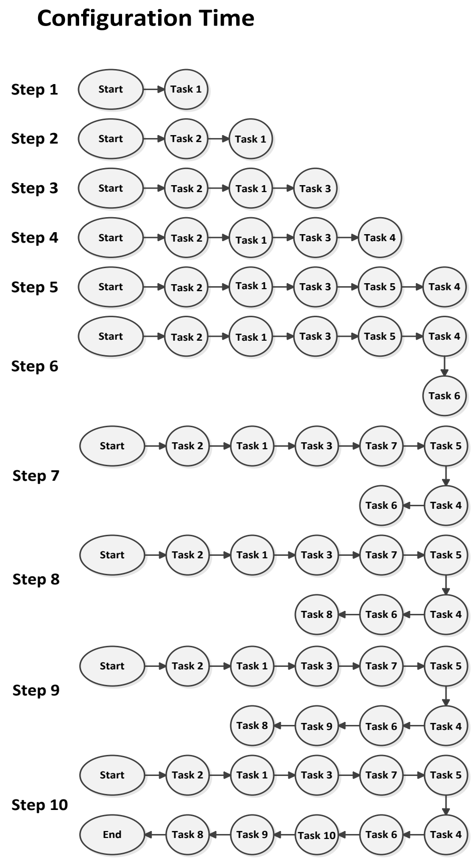

Fig. 2. The dynamic task scheduling with the smallest CT.

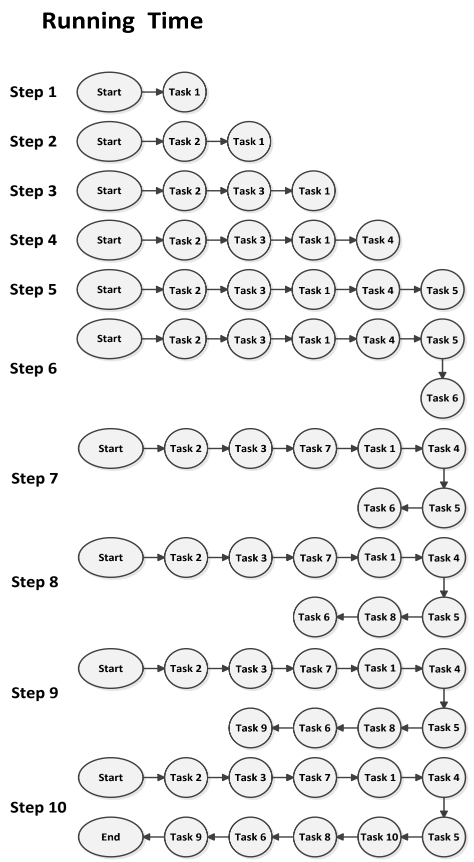

Fig. 3. The dynamic task scheduling with the smallest RT.

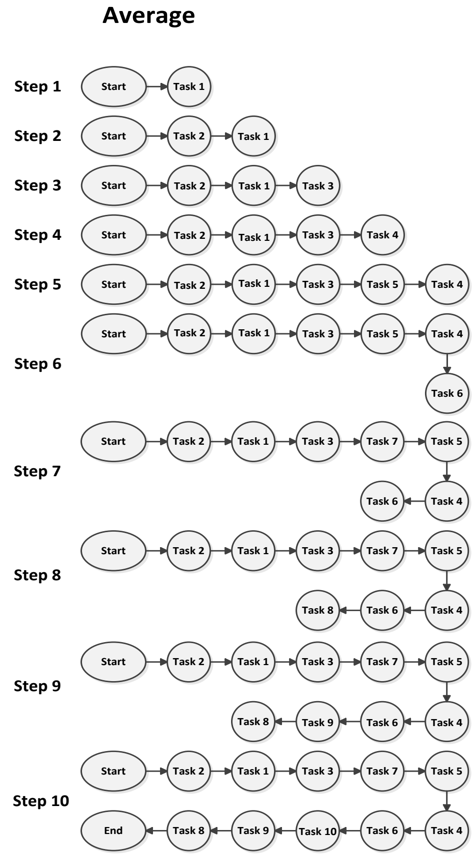

Fig. 4. The dynamic task scheduling with the multi-objective.

In table II, we use 0.05, 0.09 and 0.05 expression of the weight value of CA, CT and RT status respectively. The integral effect of relational is configuration with the smallest configuration time. The dynamic task scheduling with the smallest configuration time is shown in Figure 2.

The integral effect of relational is configuration with the smallest configuration time. The dynamic task scheduling with the smallest running time is shown in Figure 3.

GRDMTS obtains the integral effect of relational of multi-objective according to CA, CT and RT that mean value of average as shown in Table III. Figure 4 shows the optimal relation set of task scheduling with the multi-objective.

TABLE III
RESULT OF THE DYNAMIC MULTI-OBJECTIVE SCHEDULING

TGFF to generate 10 tasks	Result of the dynamic multi-objective scheduling				
Task	CA Time	CT Time	RT Time	AVG Time	AVG Seq.
Task 1 (r_{1-1})	0.990	0.990	0.833	0.938	2
Task 2 (r_{1-2})	0.958	0.997	0.997	0.984	1
Task 3 (r_{1-3})	0.755	0.940	0.896	0.864	3
Task 4 (r_{1-4})	0.694	0.899	0.709	0.767	6
Task 5 (r_{1-5})	0.725	0.946	0.656	0.776	5
Task 6 (r_{1-6})	0.633	0.864	0.449	0.649	7
Task 7 (r_{1-7})	0.608	0.940	0.855	0.801	4
Task 8 (r_{1-8})	0.542	0.674	0.494	0.570	10
Task 9 (r_{1-9})	0.624	0.926	0.379	0.643	9
Task10 (r_{1-10})	0.581	0.776	0.584	0.647	8

IV. Conclusion

In this paper, we propose Grey relational method for multi-objective problems to improve task scheduling in FPGA reconfigurable system. We conclude from the experimental results demonstrate that the proposed method use TGFF to generate benchmark tasks and give in different objective. The results can be found out the multi-objective optional scheduling.

References

[1] K. Compton, "Reconfigurable computing: a survey of systems and software," *ACM Computing Surveys*, vol. 34, no. 2, pp. 171–210, 2002.

[2] Bassiri, M.M., Shahhoseini, H.S, "Mitigating reconfiguration overhead in on-line Task scheduling for reconfigurable computing systems," in: *Proc. of 2nd International Conference on Computer Engineering and Technology (ICCET)*, pp. 397–402, 2010.

[3] Ghaffari, F., Miramond, B., Verdier, F., "Dynamic adaptation of hardware-software scheduling for reconfigurable system-on-chip," in: *Proc. of the 19th IEEE/IFIP International Symposium on Rapid Prototyping*, pp. 112–118, 2008.

[4] J. Noguera and R.M. Badia, "Dynamic run-time hardware-software scheduling techniques for reconfigurable architectures," in: *Proc. of the 17th International Conference on Hard-ware Software Co-design (CODES)*, pp. 205–210 , May 2002.

[5] J. Noguera and R.M. Badia, "System-level power-performance trade-offs in Task scheduling for dynamically reconfigurable architectures," in: *Proc. of the 2003 International Conference on Compilers, Architectures and Synthesis for Embedded Systems*, ACM Press, pp. 73–83 Oct. 2003,.

[6] Pao-Ann Hsiung, Chun-Hsian Huang, Yuan-Hsiu Chen, "Hardware task scheduling and placement in operating systems for dynamically reconfigurable SoC," *Journal of Embedded Computing - Selected papers of EUC 2005*, pp. 53-62, 2009.

[7] L. Bauer, A. Grudnitsky, M. Shafique, J. Henkel, "PATS- a performance aware task scheduler for runtime reconfigurable processors," in: *Proc. of IEEE 20th Annual International Symposium on Field-Programmable Custom Computing Machines (FCCM)*, pp. 208-215, 2012.

[8] M. Faisal Nadeem, S. Arash Ostadzadeh, Stephan Wong, and Koen Bertels, "Task Scheduling Strategies for Dynamic Reconfigurable Processors in Distributed Systems," in: *Proc. of International Conference on High Performance Computing and Simulation (HPCS)*, pp. 90-97, 2011.

[9] JWK Chan and TKL Tong, "Multi-criteria material selections and end-of-life product strategy: Grey relational analysis approach," *Materials & Design*, vol. 28, no. 5, pp. 1539-1546, 2007.

[10] J. L. Deng, "Introduction to grey system theory," The Journal of Grey System, vol. 1, pp.1-24, 1989.

[11] Jan-Ou Wu, Chyun-Shin Cheng, and Chia-Chun Tsai, "The application of Grey multi-objective decision making in data structure of VLSI layout," *Journal of National Taipei University of Technology*, vol. 34-1, pp. 99-107, 2001.

[12] Jan-Ou Wu, Chyun-Shin Cheng, and Chia-Chun Tsai, "Application of Grey relational analysis to minimal clock skew routing in SoC," *The Journal of Grey System*, vol. 16, no. 3, pp. 221-234, 2004.

[13] Chia-Chun Tsai, Jan-Ou Wu, and Trong-Yen Lee, "GDME: Grey Relational Clustering Applied to a Clock Tree Construction with Zero Skew and Minimal Delay," *IEICE Trans. on Fundamentals of Electronics, Communications and Computer Sciences*, vol. E91-A, no.1, pp.365-374, Jan. 2008.

[14] R. P. Dick, D. L. Rhodes and W. Wolf, "TGFF: task graphs for free," in *Proceedings of the Sixth International Workshop Hardware/Software Codesign*, Washington, USA, pp. 97-101, Mar.1998.