SCHEDULING TO MINIMIZE FLOW-TIME AND OTHER ON-LINE PROBLEMS

by

Muralidhara V N

Department of Computer Science and Engineering

Submitted

in fulfillment of the requirements of the degree of

Doctor of Philosophy

to the

Indian Institute of Technology Delhi

January 2009

Certificate

This is to certify that the thesis titled "SCHEDULING TO MINIMIZE FLOW-TIME AND OTHER ON-LINE PROBLEMS" being submitted by Muralidhara V N to the Indian Institute of Technology Delhi, for the award of the degree of Doctor of Philosophy, is a record of bona-fide research work carried out by him under my supervision. In my opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted to any other university or institute for the award of any degree or diploma.

Sandeep Sen
Professor
Department of Computer Science and Engineering
Indian Institute of Technology Delhi, New Delhi 110 016

Naveen Garg
Professor
Department of Computer Science and Engineering
Indian Institute of Technology Delhi, New Delhi 110 016

Acknowledgments

I feel great pleasure in expressing my gratitude towards Prof. Sandeep Sen, under whose supervision and guidance I had the privilege to initiate my research work. I am deeply indebted to him for his kind help, lasting encouragement and valuable suggestions rendered to me through the entire period of my research work. I am thankful to him for his tolerance and having continues faith in my research capabilities for several years.

I am very fortunate and privileged to work with Prof. Naveen Grag and Dr. Amit Kumar. I am thankful to them for being very generous and immensively patient with me. Most of the results presented in this thesis originated from them. I am grateful to them for allowing me to include the results obtained in the joint work with them into this thesis.

I am thankful to all people at the Dept. of CSE, for providing good environment for research. Special thanks to Ayesha, Vaishali, Uma, Smruti, Taposh, Parag, Subhajit, Vikram, Anant, Nagaraju, Sahu, Neeraj and others for their time and encouragement. Thanks to my friends Ranga Rao, Sudhakar, Raghavendra, Navneeth Pande for their help and making my stay in the campus easy.

I am thankful to Department of Science and Technology, New Delhi, for their financial support through SERC fast track proposal for young scientist scheme during my research work and also for the international travel grant provided to attend ISAAC 2008.

It has been several years that I stayed away from home for studies. I am thankful to my brother and mother for their love, understanding and infinite patience for years.

January 2009 — Muralidhara V N

Abstract

We study the problem of scheduling jobs on multiple machines in different models so as to minimize the total flow-time. We prove the following results.

1. We improve the lower bound on the approximability for the problem of minimizing flow-time on parallel machines in the off-line case from $\Omega(\sqrt{\log P / \log\log P})$ to $\Omega(\log^{1-\varepsilon} P)$ for any $\varepsilon > 0$. Here, P is the ratio of the largest to the smallest processing requirement.

2. We define a notion of (α, β)-*variability* for the processing time of the jobs. We say that processing times have an (α, β)-*variability* if the processing time of job j on machine i can be expressed as $p_{ij} = a_j \cdot b_{ij} \cdot s_i$ where $b_{ij} \in B, |B| = \beta$ and $1 \leq a_j \leq \alpha$. We give an $O(\beta \log \alpha)$ approximation for this setting in the off-line case. As special cases, we get

   (a) an $O(k)$ approximation when there are only k different processing times.

   (b) an $O(\log P)$-approximation if each job can go on a specified subset of machines only, but has the same processing requirement on each such machine. Further, the machines can have different speeds. Here, P is the ratio of the largest to the smallest processing requirement.

3. We show that the above algorithm can be modified to get an $O(\frac{1}{\varepsilon} \log \frac{1}{\varepsilon})$- approximation off-line algorithm for unrelated machines if we assume that our algorithm has machines which are an ε-factor faster than the optimum algorithm's machines.

4. We give an $O(1/\varepsilon^2)$- approximation on-line algorithm for unrelated machines to minimize the average weighted flow-time, if we assume that our algorithm has machines which are an ε-factor faster than the optimum algorithm's machines.

Another problem we consider in this thesis is the network discovery problem. The network discovery problem involves certifying all the edges and non-edges of an unknown graph based on queries from minimal number of vertices. We will develop an on-line algorithm for approximating the optimal set cover through hitting set queries. Using this algorithm we get an $O(\log^2 n)$-competitive Monte Carlo randomized algorithm for the on-line version of network discovery problem.

Contents