



Tribhuvan University
Institute of Science and Technology

On the Cyclic Sequences in Mixed Model Just-in-Time Production System

Dissertation

Submitted to

Central Department of Computer Science and Information Technology
Kirtipur, Kathmandu, Nepal

In partial fulfillment of the requirements
for the Master's Degree in Computer Science and Information Technology

by

Prem Raj Bhatta

January 2009



Tribhuvan University
Institute of Science and Technology

On the Cyclic Sequences in Mixed Model Just-in-Time Production System

Dissertation

Submitted to

Central Department of Computer Science and Information Technology
Kirtipur, Kathmandu, Nepal

In partial fulfillment of the requirements
for the Master's Degree in Computer Science and Information Technology

by

Prem Raj Bhatta

January 2009

Supervisor

Dr. Tanka Nath Dhamala



Tribhuvan University
Institute of Science and Technology
Central Department of Computer Science and Information Technology

Student's Declaration

I hereby declare that I am the only author of this work and that no sources other than that listed here have been used in this work.

.....

Prem Raj Bhatta

Date:

Date:



Tribhuvan University
Institute of Science and Technology
Central Department of Computer Science and Information Technology

Supervisor's Recommendation

I hereby recommend that this Dissertation prepared under my supervision by **Mr. Prem Raj Bhatta** entitled **On the Cyclic Sequences in Mixed Model Just-in-Time Production System** in partial fulfillment of the requirements for the degree of M. Sc. in Computer Science and Information Technology be processed for the evaluation.

.....

Dr. Tanka Nath Dhamala

Asst. Prof. Head, Central Department of Computer Science and Information Technology
Institute of Science and Technology
Tribhuvan University, Nepal

Date:



Tribhuvan University
Institute of Science and Technology
Central Department of Computer Science and Information Technology

LETTER OF APPROVAL

We certify that we have read this dissertation and in our opinion it is satisfactory in the scope and quality as a dissertation in the partial fulfillment for the requirement of Masters Degree in Computer Science and Information Technology.

Evaluation Committee

.....

Dr. Tanka Nath Dhamala
Head,
Center Department of Computer Science
and Information Technology,
Tribhuvan University, Nepal

.....

Dr. Tanka Nath Dhamala
Head,
Center Department of Computer Science
and Information Technology,
Tribhuvan University, Nepal

(Supervisor)

.....
(External Examiner)

.....
(Internal External)

Date:



Tribhuvan University
Institute of Science and Technology
Central Department of Computer Science and Information Technology

ACKNOWLEDGEMENT

It really gives me a great pleasure to write the acknowledgement on the completion of this dissertation at the Central Department of Computer Science and Information Technology, Tribhuvan University. I am deeply indebted to number of valuable guidance, constructive comments, encouragement and suggestion of my respected supervisor Dr. Tanka Nath Dhamala, Head, Central Department of Computer Science and Information Technology. His kindly help and scholarly guidance have become the greatest property of this dissertation, without his supervision, this would never have been appeared in the form. To whom I express my extreme gratitude. Meanwhile, I am very much grateful to the research committee members of Tribhuvan University who concluded positive decision on my proposal.

I express my appreciation to all my teachers, Dr. Onkar Prasad Sharma, Marist College, USA, Prof. Shashidhar Ram Joshi (IOE-TU), Asso. Prof. Dr. Subarna Sakaya (IOE-TU), Prof. Sudarsan Karanjit (NCIT), Asst. Prof. Min Bdr. Khatri (CDCSIT-TU), Mr. Samujjwal Bhandari (CDCSIT-TU), Mr. Hementa GC (CDCSIT-TU), Mr. Bishnu Gautam (CDCSIT-TU), Mr. Dinesh Bajracharya (CDCSIT-TU) and others for granting me broad knowledge and inspirations within the time period of two years.

I can not remain without admiring the efforts put by my senior Mr. Dipak Panday for his exceptional participation on this work. I extend my thanks to Mr. Chudamani Poudyal for providing necessary materials and guidance to complete this work. I specially thank Miss. Binita Pant who continuously helped me for preparing and improving this dissertation.

Finally, I want to express my love and appreciation to Miss. Puspa Pandey for her patience and encouragement throughout this research time. I would like to thank my family and my friends for their continuous help and encouragement. Likewise, I thank all those relatives and other who wish a success.

Date:
February, 2009 Prem Raj Bhatta



Tribhuvan University
Institute of Science and Technology
Central Department of Computer Science and Information Technology

ABSTRACT

On the Cyclic Sequences in Mixed Model Just-in-Time Production System

Mixed-model Just-in-Time production systems have been developed in recent years in order to reduce costs of diversified small-lot production, which involves producing only the necessary products in the necessary quantities at necessary times. This problem minimizes both the earliness and the tardiness penalties that respond to the customer demands for a variety of models without holding large inventories or incurring shortages. The problem of sequencing flexible transfer lines or mixed-model assembly lines according to the JIT philosophy can be formulated as a non-linear integer programming problem.

Minimization of the variation in demand rate for outputs of supplying processes is the output rate variation problem (ORVP) and minimization of the variation in the rate at which different products are produced on the line is the product rate variation problem (PRVP). The problem for minimizing of deviations between actual and desired production for PRVP can be solved efficiently in pseudo-polynomial time complexity. However, the ORVP with two or more levels is strongly NP-hard. But under the pegging assumption the ORVP can be solved efficiently.

In this dissertation, we implement different algorithms and heuristics to solve both ORVP and PRVP. The cyclic sequences are optimal for both sum-deviation and max-deviation PRVPs. The cyclic sequences to ORVP are presented with an example. Likewise, the existences of cyclic sequences to PRVP under different solution approaches are explored. Furthermore, several directions for further research are also explored including some emerged conjectures.

Date:



Tribhuvan University
Institute of Science and Technology
Central Department of Computer Science and Information Technology

DEDICATION

To My Mother Yashoda Bhatta

And

My Father Padam Raj Bhatta

Who spend their whole life

For

My Study

Date:



Tribhuvan University
Institute of Science and Technology
Central Department of Computer Science and Information Technology

LIST OF ABBREVIATIONS

AP	Assignment Problem
DP	Dynamic Programming
EDD	Earliest-Due-Date
FCFS	First Come First Serve
JIT	Just-in-Time
JITSP	Just-in-Time Sequencing Problem
MDJIT	Maximum Deviation Just-in-Time
MMJIT	Mixed-Model Just-in-Time
MMJITSP	Mixed-Model Just-in-Time Sequencing Problem
ORVP	Output Rate Variation Problem
OS	Operating System
PRVP	Product Rate Variation Problem
PRV-MD	Product Rate Variation Maximum Deviation
PRV-MM	Product Rate Variation Mixed-Model
SASJ	Scheduling Around the Shortest Job
SDJIT	Sum Deviation Just-in-Time
SJF	Shortest Job First
SRTN	Shortest Remaining Time Next

Date:



Tribhuvan University
Institute of Science and Technology
Central Department of Computer Science and Information Technology

Contents

1	<u>INTRODUCTION.....</u>	<u>1</u>
2	<u>FUNDAMENTAL BACKGROUND.....</u>	<u>4</u>
	<u>Functions</u>	<u>4</u>
	<u>Graph Theoretical Denotations</u>	<u>5</u>
	<u>Algorithms and Heuristics.....</u>	<u>6</u>
	<u>Complexity of Algorithms</u>	<u>7</u>
	<u>Dynamic Programming</u>	<u>9</u>
	<u>Combinatorial Optimization.....</u>	<u>10</u>
	<u>Integer Programming</u>	<u>11</u>
	<u>Bipartite Matching Problem.....</u>	<u>12</u>
	<u>Assignment Problem</u>	<u>14</u>
3	<u>SCHEDULING PROBLEMS</u>	<u>20</u>
	<u>Schedules and their Representations</u>	<u>20</u>
	<u>Three Field Notation</u>	<u>22</u>
	<u>Earliest Due Date (EDD) Algorithm.....</u>	<u>22</u>
	<u>Benefits of Just-in-Time Production Systems.....</u>	<u>23</u>
	<u>Applications of Just-in-Time Production System</u>	<u>24</u>
4	<u>MATHEMATICAL MODEL OF JIT PRODUCTION</u>	<u>26</u>
	Date:	



	Output Rate Variation Problem.....	26
	Product Rate Variation Problem.....	29
	Pegged ORV Problem.....	32
	Tribhuvan University	
5	SOLUTION PROCEDURE FOR PRV PROBLEM.....	33
	Central Department of Computer Science and Information Technology	33
	Earliest Due Date Algorithms	37
	Nearest Integer Point Problem	42
	Dynamic Programming Algorithm	47
	Min-max Absolute-chain Algorithm.....	52
	Cost Assignment Problem.....	54
6	SOLUTION PROCEDURE FOR ORV PROBLEM.....	57
	Toyota's Goal Chasing Method (GCM)	57
	Miltenburg and Sinnamon Heuristic Approach	59
	Dynamic Programming Algorithm	64
7	CONCLUSION.....	67
	REFERENCES.....	69

Date:



Tribhuvan University
Institute of Science and Technology
Central Department of Computer Science and Information Technology

List of Tables

Table 1: Schedule generated by EDD for max-abs	39
Table 2: Schedule generated by EDD for min-sum	42
Table 3: Schedule generated for demand vector $D = (2, 3, 5, 7)$ by nearest integer point	44
Table 4: Schedule generated for demand vector $D = (2, 3, 5, 1)$ by nearest integer point	44
Table 5: Schedule generated for demand vector $D = (2000, 3000, 5000, 1000)$ using heuristic nearest integer point	47
Table 6: Schedule generated by dynamic programming	50
Table 7: Calculation of window value	53
Table 8: Output of min-max absolute chain algorithm	54
Table 9: Excess inventory or shortage costs calculated	56
Table 10: Schedule generated by cost assignment problem	56
Table 11: Assembly and demand data for Example 6.2.1	62
Table 12: Detail Schedule of Example 6.2.1	64

Date:



Tribhuvan University
Institute of Science and Technology
Central Department of Computer Science and Information Technology

List of Figures

Figure 1: Graphical notation of $f(n) = O(g(n))$	8
Figure 2: The Bipartite Matching Algorithm	14
Figure 3: The Hungarian method... ..	19
Figure 4: Gantt chart.....	21
Figure 5: The ideal and actual commutative production quantities.....	28
Figure 6: Input data for min-max absolute-chain algorithm... ..	53
Figure 7: The Goal Chasing Algorithm.....	58
Figure 8: Miltenburg and Sinnamon heuristic approach... ..	61
Figure 9: Input demand for ORVP... ..	62

Date: