Bansilal Ramnath Agarwal Charitable Trust's

Vishwakarma Institute of Technology, Pune

Project on

"Job Scheduling in Networked Manufacturing using Game Theory"

Project Group No: C 16

Sponsor Company: Persistent Systems Limited, Pune

Internal Guide: Prof. A. S. Shingare

External Guide : Mr. Jigar Shah

Topics

- Introduction
- Problem Statement
- Motivation
- Objective
- Literature Survey
- Methodology
- Alternatives
- Limitation
- Conclusion

Introduction

- Globalization – a new trend for enterprise.

- Agile and rapid response

- Need of manufacturing models characterized by
  - globalization
  - digitalization,

Networked Manufacturing

- Traditional Job Scheduling Approach

- Networked Manufacturing Job Scheduling Approach
    - Customer-centric job scheduling
    - Geographically distributive machines

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Problem Statement

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“A series of jobs submitted by different customers competing with each other to occupy the corresponding machines according to their own respective objectives, e.g., minimal makespan”

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Motivation

- Decentralized jobs
- Job scheduling problem
  - optimization problem
  - NP-complete problem
  - complexity = $(n!)^m$
- Automation needed

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Objective

- The goal of the project is

    - to apply the sophisticated mathematical model

    - to find the optimal schedule of jobs

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Literature Survey

- Operations Research - By P.K. Gupta and D.S. Hira.
- Genetic Algorithms in Search, Optimization, and Machine Learning - David Edward Goldberg
- Guanghui Zhou, Pingyu Jiang, George Q. Huang(2009) A game-theory approach for job scheduling in networked manufacturing. Int J Adv Manuf Technol (2009) 41:972–985 (Springer Paper)

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Methodology

- To apply N-person non co-operative strategy to solve the game

- To find the NE point of game

- To design a genetic algorithm to reach the NE point of game

Nash's Equilibrium

- Characteristic :

- "An NE point is an N-tuple of strategies, one for each player, such that anyone who deviates from it unilaterally cannot possibly improve its expected payoff."

Mathematical Model

The solution profile

$$s^{Nash} = \left(s_0^{Nash},\ s_1^{Nash}, \cdots, s_{n-1}^{Nash}\right)$$

is characterized by

-

$$U_i\left(s_i^{Nash},\ s_{-i}^{Nash}\right) \leq U_i\left(s_i,\ s_{-1}^{Nash}\right),$$

for

$i = 0, 1, \cdots, n-1, \forall s_i \in S_i,$

where

$$s_{-1}^{Nash} = \left(s_0^{Nash},\ s_0^{Nash}, \ldots, s_{i-1}^{Nash},\ s_{i+1}^{Nash}, \ldots, s_{n-1}^{Nash}\right).$$

Genetic Algorithm

- GA is heuristic, which means it estimates a solution.
- Can solve every optimization problem which can be described with the chromosome encoding
- Solves problems with multiple solutions
- Can be easily transferred to existing simulations and models

Genetic Algorithm

- Emphasis on fitness function
- It should consider strategy of each player
- Those who are “fit” will be selected for “selection” “crossover ” and “mutation”
- It should check ability to reduce makespan of itself and to increase makespan of others

Problem Formulation

Job	Operation					
	O_0	O_1	O_2	O_3	O_4	O_5
J_0	(0, 2) [4, 6]	(1, 3, 5) [7, 5, 7]	(4, 0) [5, 4]	(1, 2) [7, 4]	(3, 4, 5) [3, 4, 5]	(1, 5) [5, 6]
J_1	(1) [4]	(0, 2) [2, 6]	(1, 3, 5) [4, 8, 5]	(2, 4) [7, 4]	(1,2, 3) [3, 4, 6]	(0, 5) [4, 5]
J_2	(1, 4) [8, 6]	(0) [5]	(2, 3, 5) [4, 6, 7]	(0, 5) [5, 5]	(4, 3) [6, 7]	(0, 1, 5) [8, 4, 6]
J_3	(0, 3, 4) [3, 5, 5]	(1) [4]	(2, 4) [5, 7]	(3, 1) [5, 6]	(1, 2, 5) [3, 4, 5]	(2, 4) [6, 7]
J_4	(2, 3) [4, 4]	(1, 3, 4) [3, 6, 3]	(0, 3, 5) [5, 6, 6]	(4) [7]	(2, 3) [6, 4]	(4, 5) [8, 7]
J_5	(1, 2, 5) [3, 6, 7]	(0, 2) [5, 6]	(1, 3, 4) [4, 6, 7]	(2, 4) [5, 3]	(0, 1) [5, 5]	(3, 5) [3, 4]

Table 3 Transportation time between two different machines

Machine	f_0	f_1	f_2	f_3	f_4	f_5
F_0	0	1	2	1	2	2
F_1	1	0	1	2	2	1
F_2	2	1	0	2	1	2
F_3	1	2	2	0	1	1
F_4	2	2	1	1	0	2
F_5	2	1	2	1	2	0

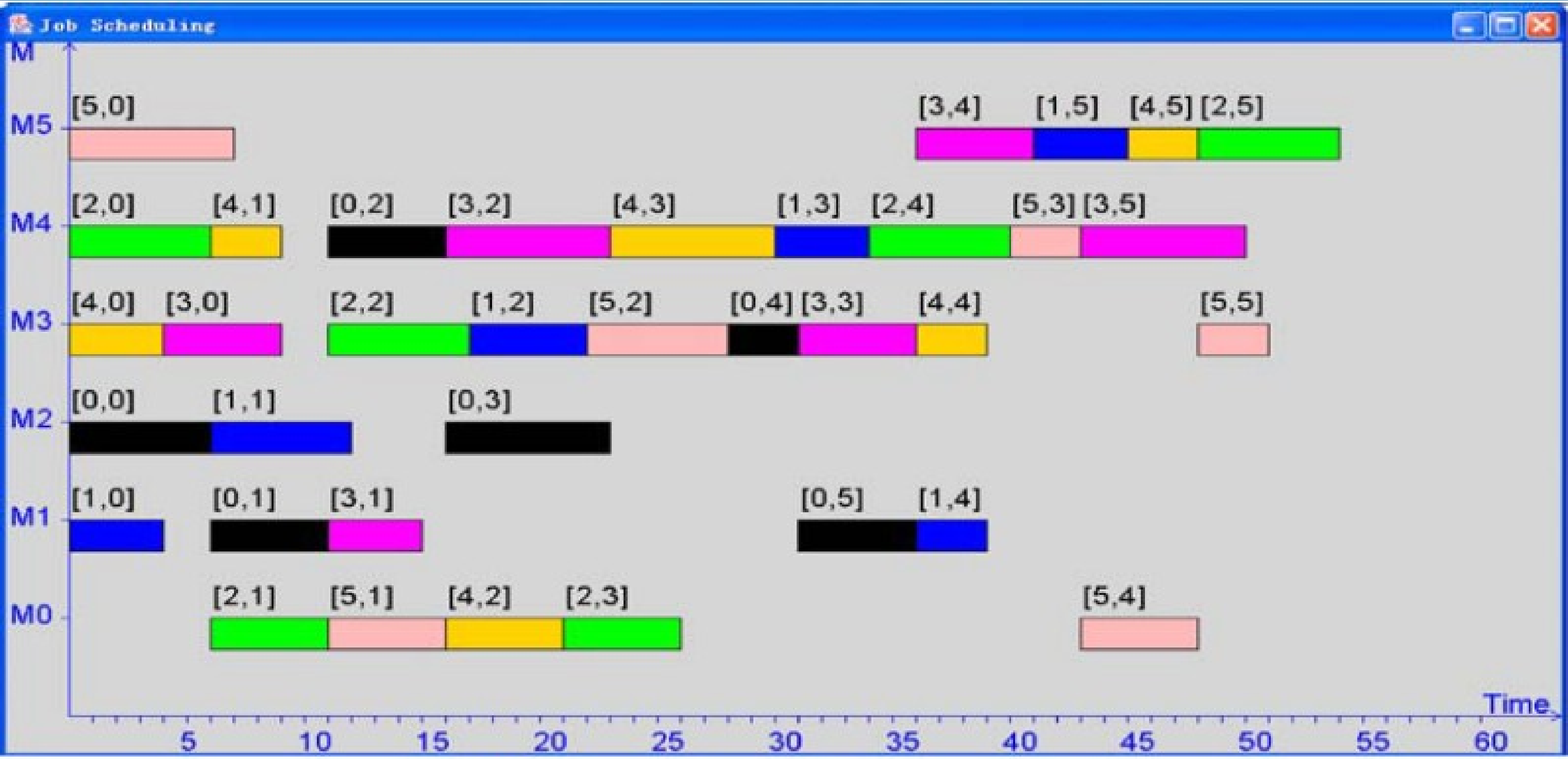
Experimental Result

Table 5 Feasible strategy profiles following FCFS rule

Generation	Strategy profile
1st	((2, 1, 4, 2, 3, 1), (1, 2, 3, 4, 1, 5), (4, 0, 3, 0, 4, 5), (3, 1, 4, 3, 5, 4), (3, 4, 0, 4, 3, 5), (5, 0, 3, 4, 0, 3))
120th	((0, 5, 4, 1, 3, 1), (1, 0, 5, 4, 1, 0), (4, 0, 3, 0, 4, 0), (3, 1, 4, 3, 5, 4), (2, 4, 0, 4, 2, 5), (5, 0, 1, 2, 1, 3))
200th	((0, 5, 4, 1, 3, 1), (1, 0, 5, 4, 1, 0), (4, 0, 3, 0, 4, 0), (3, 1, 4, 3, 5, 4), (2, 4, 0, 4, 2, 5), (5, 0, 1, 2, 1, 3))

1st Generation

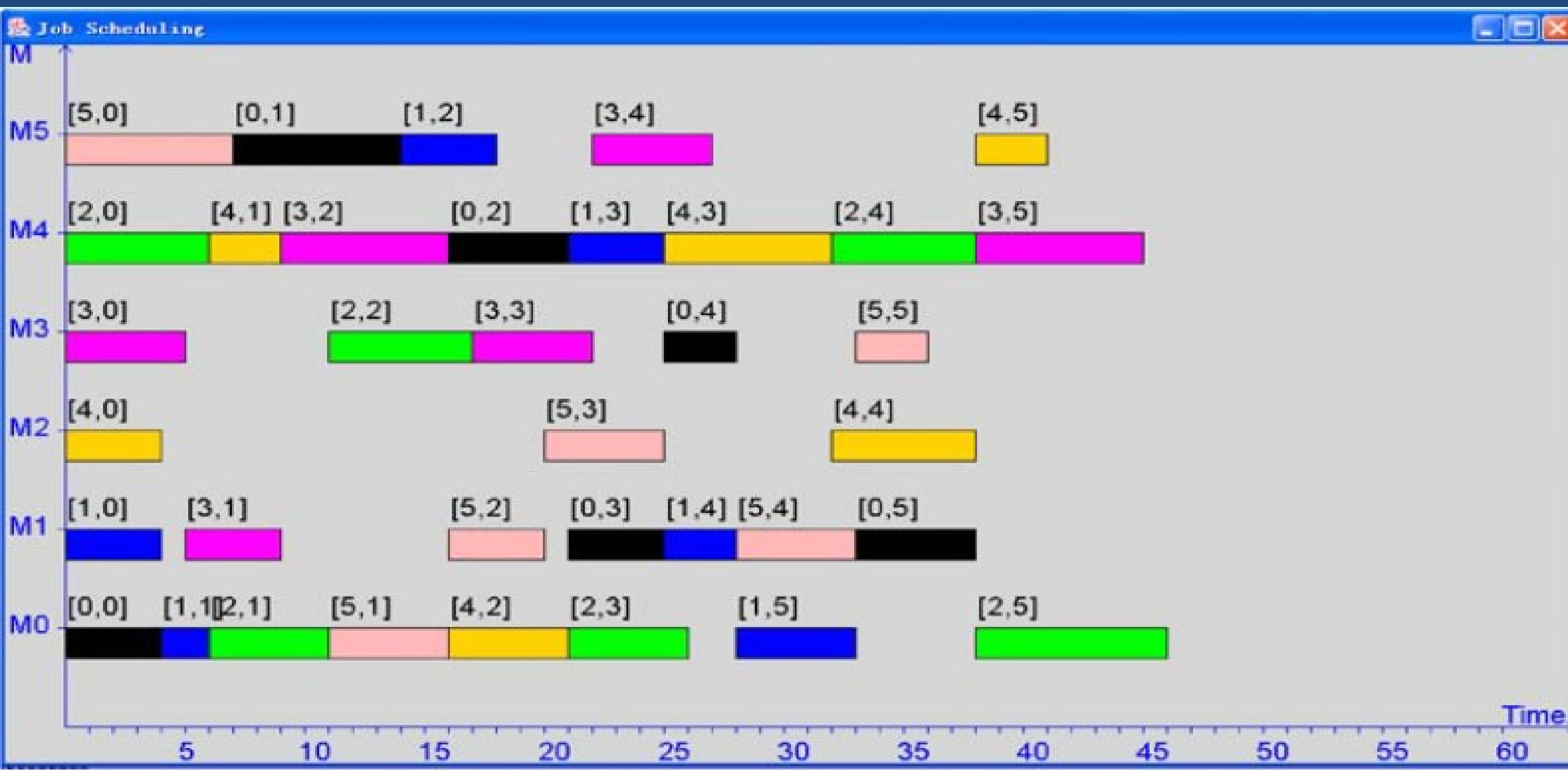
Generation	Strategy profile
1st	((2, 1, 4, 2, 3, 1), (1, 2, 3, 4, 1, 5), (4, 0, 3, 0, 4, 5), (3, 1, 4, 3, 5, 4), (3, 4, 0, 4, 3, 5), (5, 0, 3, 4, 0, 3))



(a) Gantt chart for 1th generation

200th Generation

Generation	Strategy profile
200th	((0, 5, 4, 1, 3, 1), (1, 0, 5, 4, 1, 0), (4, 0, 3, 0, 4, 0), (3, 1, 4, 3, 5, 4), (2, 4, 0, 4, 2, 5), (5, 0, 1, 2, 1, 3))



(c) Gantt chart for 200th generation

Comparision

Table 6 Payoff values (makespan) of jobs

Job	Payoff value (makespan)		
	1st generation	120th generation(NE point)	200th generation
J_0	36	38	38
J_1	45	33	33
J_2	54	46	46
J_3	50	45	45
J_4	48	41	41
J_5	51	36	36

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Alternatives

- A hierarchic approach for production planning and scheduling
- A holonics manufacturing scheduling architecture
- The branch-and-bound algorithm to deal with the scheduling problem in a flow shop
- An ant colony algorithm to model and deal with the permutation flowshop scheduling problems

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Limitations

- No job preemption
- No two jobs are scheduled on the same machine at the same time
- The transportation time exists
- Job availability at time zero

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Conclusion

- Defined of conceptual model for job scheduling
- Formulated a job scheduling model for optimally scheduling the jobs adopting game theory
- Proposed and developed the GA-based solution algorithm to solve our optimization problem

Thank You

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