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15 -17 December 2005
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Edited by Nyoman Pujawan
Iwan Vanany

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Welcome Address

It is an honor to us to welcome you to the First International Conference on Operations and Supply Chain Management. The theme of the conference is “The role of OM/SCM in promoting smarter use of global resources”. We have chosen this theme to reflect our concern with the long term sustainability of business and industry operations given the constantly depleting availability of resources in many sectors.

The response to our call for papers had been overwhelming. We received over 300 abstracts submission at the beginning, but due to various reasons, including the recent tragic bombings in Bali, only about 130 papers are scheduled to be presented. We are glad to see the international nature of the conference. We are glad to welcome participants from Australia, Canada, China, Cyprus, Finland, France, Germany, Hong Kong, India, Indonesia, Iran, Japan, Korea, Malaysia, Netherlands, New Zealand, Norway, Philippines, Singapore, Sweden, Switzerland, Taiwan, Thailand, Turkey, UK, USA. We are also glad to see many attendants from industries, which then makes this conference an excellent opportunity to create networking, not only between academics, but also between academics and practitioners.

This conference would not have been possible without contributions of many individuals and organizations. The supports from advisory and review committee have played fundamental roles in making sure the conference, in particular the accepted papers, are of high quality. We would also like to thanks the plenary speakers, Professor Kai Mertins from IPK Germany and Professor Luk Van Wassenhove from INSEAD for their willingness to address the audience in the plenary sessions. Thanks also to Professor M. Nuh, Rector of the Sepuluh Nopember Institute of Technology for his supports and encouragement. All members of the local committee have been instrumental in bringing this conference to a success. We are also indebted to a number of supporting organizations, including IPOMS, EUROMA, MSORMS, AIT and our sponsors for the endorsement, financial and other supports.

Finally, I wish you have an effective conference and enjoyable days here in Bali.

Conference co-chairs

Dr. Nyoman Pujawan
Sepuluh Nopember Institute of Technology (ITS), Surabaya – Indonesia

Dr. Saibal Ray
McGill University, Canada

CONFERENCE PROGRAM
INTERNATIONAL CONFERENCE ON OPERATIONS AND SUPPLY CHAIN MANAGEMENT
BALI INTERNATIONAL CONVENTION CENTER, THE WESTIN RESORT, NUSA DUA – BALI

WEDNESDAY, 14 DECEMBER 2005

17.00 – 20.00	**Registration**

THURSDAY, 15 DECEMBER 2005

08.00 – 09.00	**Registration**
09.00 – 09.30	**Opening ceremony** Welcome address from conference co-chairs Welcome address by Rector of Sepuluh Nopember Institute of Technology (ITS)
09.30 – 10.30	**Plenary Speech I** ***Model Driven Management for Networked Enterprises*** **Prof. Dr.-Ing. Kai Mertins, FhG-IPK Berlin, Germany**
10.30 – 11.00	**Break**
11.00 – 12.00	**Plenary Speech II** ***Closed-loop supply chains: practice and potential*** **Prof. Luk Van Wassenhove, INSEAD**
12.00 – 13.00	**Lunch Break**
13.00 – 14.45	**Parallel Sessions I**
14.45 – 15.15	**Break**
15.15 – 17.00	**Parallel Sessions II**
18.30 – 21.00	**Gala Dinner**

FRIDAY, 16 DECEMBER 2005

08.00 – 09.45 **Parallel Sessions III**

09.45 – 10.15 **Break**

10.15 – 11.15 **Panel: ISO and Supply Chain Management**

Panelist I: Prof. Charles Corbett, University of California, Los Angeles
Diffusion of ISO 9000 and ISO 14000 through global supply chains

Panelist II: Dr. Pavel Castka, University of Canterbury, NZ
ISO 26000 and Supply Chains - on the diffusion of the social responsibility standard

10.15 – 13.00 **BREAK**

13.00 - 14.45 **Parallel Sessions IV**

14.45 – 15.15 **Break**

15.15 – 17.00 **Parallel Sessions V**

17.00 – 17.15 **Closing Remarks**

SATURDAY, 17 DECEMBER 2005

CONFERENCE TOUR
(Time estimate: 06.30 – 17.00)

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A MODEL TO EVALUATE CAPACITY SHARING IN A MANUFACTURING NETWORK

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ABSTRACT

One of successful keys of a supply chain activity is about how to make harmony in supplying goods along the chain. Related to customer needs, the important factors are not only about the technical capabilities to attain right product specifications but also the capacity to satisfy due-date or market share. This paper tries to evaluate capacity sharing in a network of factories. Some of the factories may have same technical capabilities but different capacities. A factory is not seen as an individual object that has many competitors to fight but as a social object that has companions to share and collaborate. Each factory has its own contribution to the network's goals. Allowing only high capacity factories to do all orders without permitting low capacity factories to take part may mean allowing the network goes slower than it should do. The problem is how to assign each factory to make the network work properly. The analysis begins with a heuristic assignment model developed from several previous researches. The simulation study then is performed to evaluate the model workability in a dynamic probabilistic system. The result shows that the proposed model could give higher network throughput in most cases evaluated.

Keywords: manufacturing network, factory assignment, capacity sharing.

1. INTRODUCTION

1.1. Background

The objective of every supply chain is to maximize the overall value generated. Focusing on profitability at individual stages may lead to a reduction in overall supply chain profits (Chopra and Meindl, 2004). One of successful keys of manufacturing activities in a supply chain is about how to make harmony in supplying goods along the chain. This harmony is dedicated to satisfy customer needs that are related to appropriate product specifications and desirable delivery or available time. Appropriate product specifications are supported by the technical capabilities of manufacturing facilities, while desirable delivery or available time is supported by the capacity. This paper concerns with the second.

In the real industrial system, most manufacturing facilities are not independent. The performance of a factory for example, is influenced by its customers' and suppliers' performance. Several factories depending on each other will form a manufacturing network having one goal, living together by satisfying the customers.

Inspired by an Indonesian's original value of life namely '*gotong-royong*' that means 'collaborative actions among a group of people to achieve a goal' and stand on supposition that a factory could be seen as a social object like a human that has companions to share and collaborate, the research presented here tries to find the rule to utilize the manufacturing network capacity to maximize the network performance. The role does not only belong to the factories having highest capacities. All the factories in the network have their own contribution to the network's goals.

1.2. Problem

When many orders consisting of many types of product have to produce in a kind of manufacturing network as mentioned above, these orders belong to the network, not to the factories individually. Then, the problem is how to assign each factory to make the network able to complete the orders properly. The initial hypotheses is 'allowing only high capacity factories to do all orders without permitting low capacity factories to take part means allowing the network goes slower than it should do'.

1.3. State of the Art

Chopra (2003) said that performing flexible network among several manufacturers, distributors, and retailers instead of performing a single line manufacturer-distributor-retailer will reduce the overall supply chain cost. Many other researches related to collaboration among supply chain elements are carried out yet, but most of them discussed about collaboration among different level of supply chain elements. The researches subsequently explained are related to collaboration among several same level supply chain elements as needed for this research. Suharyanti and Wigati (2003) proposed a model of capacity sharing in a manufacturing network when several network elements are under load comparing to the others. The model called KBDEJ (*Kapasitas Bersama antara Dua Elemen dalam Jaringan Manufaktur*; means capacity sharing between two elements in a manufacturing network) was used to evaluate how to assign two non-identical machines to process a number of single type parts coming dynamically and randomly. Meanwhile, Suharyanti et al (2005) developed a model called MLAWP-AR (Modified Least Average Weighted Process time with Alternative Routing) to allocate a number of jobs to a number of identical machines, improving the previous model called LAP (Least Average Process time) proposed by Subramaniam et al (2000). MLAWP-AR is built based on minimum cumulative load sharing in order to achieve low average flow time and low work in process. Together with the supposition mentioned in Sub-section 1.1, the logic of KBDEJ and MLAWP-AR are adopted here to develop a new assignment model for a manufacturing network.

1.4. Objectives

The purpose of this research is to develop an assignment model for a manufacturing network as explained in Section 2. The principles of splitting an order to several manufacturing facilities proposed by KBDEJ model and the principles of distributing a number of orders to several manufacturing facilities from MLAWP-AR model will be adopted. Average flow time of order in the network is used as parameter to represent delivery time to customer.

2. SCOPE

2.1. System Configuration

Manufacturing system evaluated here is a manufacturing network which consists of several factories as shown in Figure 1. The factories are classified to several groups representing stages of a process chain. All factories in a group have same technical capabilities but different capacities and will be called as parallel factories. A coming order will proceed through all the stages to make it complete. Number of order types may be less or more than number of parallel factories in each group. At each stage, an order will allocate to one or more factories according to the assignment model proposed in this research. The order arrives in unit of transportation lot. The order arrivals are probabilistic as well as transportation time between two factories and production lead time of each factory. Transportation time is presented in hours per unit of transportation lot and production lead time is presented in days per unit of transportation lot. Lead time is all the time needed to process a lot of order in a factory, from preparation to time before delivery.

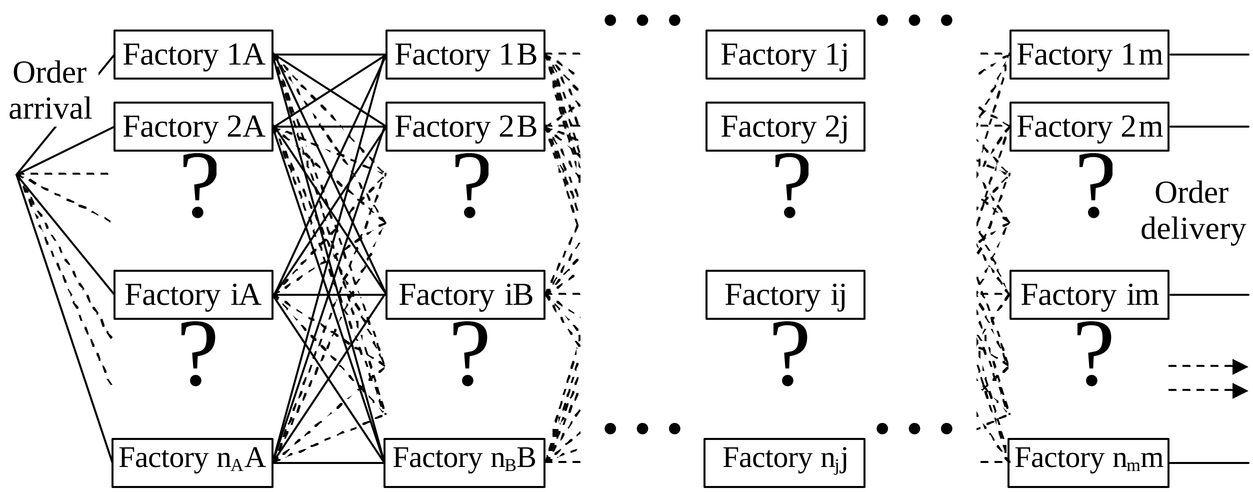

Figure 1. System configuration of m stages with n_j factories in group j.

2.2. Assumptions

These are some assumptions used here to simplify the problem:

(1) No due-date restriction is considered.
(2) All the factories are always in normal condition.
(3) Number of transportation devices between any two factories are not limited.
(4) Information management in the network is suitable.
(5) Inter-arrival time distribution of orders are exponentially distributed.
(6) Transportation time and production lead time is uniformly distributed.
(7) Order lot splitting is not permitted.
(8) No cost aspect is discussed.

3. METHOD

The proposed assignment model is a heuristic model. It is developed based on KBDEJ and MLAWP-AR models. A number of hypothetical cases are generated and are classified to 3 categories: cases with number of jobs less than number of parallel factories, cases with number of jobs equal to parallel factories, and cases with number of jobs larger than number of parallel factories. The proposed model then applied to all these cases. To evaluate model workability in a dynamic probabilistic system, a simulation study is performed using Arena Software version 7.01.

4. THEORETICAL REVIEW

4.1. KBDEJ Model

KBDEJ model proposed by Suharyanti and Wigati (2003) is a mathematical model representing a load queue length of a constraint resource that is used as limit point to switch load allocation to a non-constraint resource. By using a simulation study of a number of hypothetical cases, the KBDEJ model as written in Equation (1) provided network capacity enhancing for capacity sharing between two serial directly connected resources or between two parallel resources. The KBDEJ model did not work for capacity sharing between two serial non-directly connected resources.

$$N_{cmax}' = N_{cmax} - \frac{\overline{N_c}\,\overline{L_c}}{\overline{L_{cn}}\left(\frac{1-\overline{U_C}}{1-\overline{U_n}}\right)+\overline{L_c}} \tag{1}$$

where N_{cmax}' = maximum limit of load queue length at constraint resource

N_{cmax} = maximum value of load queue length at constraint resource in initial system

$\overline{N_c}$ = mean load queue length at constraint resource

$\overline{L_{cn}}$ = mean lead time of constraint resource load at non-constraint resource

$\overline{L_c}$ = mean lead time at constraint resource

$\overline{U_n}$ = mean utilization of non-constraint resource in initial system

$\overline{U_c}$ = mean utilization of constraint resource in initial system

The KBDEJ model application showed that moving a part of load from a constraint manufacturing facilities to another non-constraint manufacturing facilities in a manufacturing network will enhance the network capacity.

4.2. MLAWP-AR Model

Starting from LAP model proposed by Subramaniam et al (2000), Suharyanti et al (2005) developed an assignment model called MLAWP-AR to allocate a number of operations of a number of jobs to a number of identical machines. The assignment rule was based on the parameter shown in Equation (2).

$$t_{pm} = \sum_{i=1}^{N} \alpha_i t_{ipm} \quad , \quad p = 1,2,3,\ldots,P; m = 1,2,3,\ldots,M \tag{2}$$

The MLAWP-AR model is a heuristic model represented by this algorithm (for N jobs with maximum P operations each, allocated to M identical machines):

(1) Calculate t_{pm} using Equation (2).
(2) Start from non-allocated p with min(t_{pm}).
(3) Calculate $t_{pm(cum)}$ for all p and m (defined as cumulative t_{pm} of operations have allocated to machine m plus operation p).
(4) Determine m_p* that is defined as m for operation p related to min($t_{pm(cum)}$).
(5) If all p have allocated, go to step (6), otherwise back to step (2).
(6) Find operation p* that is defined as an operation allocated in m_{max} (machine with maximum load) that will alternatively move to m_{min} (machine with minimum load) when number in queue at m_{max} are larger than number in queue at m_{min}.
(7) End.

where t_{ipm} = processing time of operation p of job i at machine m
t_{pm} = weighted average processing time of operation p of all job at machine m
$t_{pm(kum)}$ = cumulative t_{pm} of all allocated operation at machine m plus operation p
m = index for machine
m_p* = assigned machine for operation p
i = index for job
p = index for operation
α_i = proportion of job i

The principle of MLAWP-AR model is allocating an operation to a machine one by one so that the weighted average of allocated operation time at every machine is minimum. Using a simulation study, the application of MLAWP-AR model resulted shorter flow time than LAP in 68% of all the hypothetical cases evaluated.

5. THE PROPOSED MODEL: LEAST BALANCE LOAD ASSIGNMENT

5.1. Model Development

Based on:

(1) supposition that the factories in the manufacturing network discussed here are social objects so that all the factories have to be involved in processing the orders,
(2) capacity sharing among all the factories in a group to process a number of order when the number of order less than the number of factories as what the KBDEJ model did,
(3) balance order distribution among the factories when the number of orders larger than or equal with the number of factories as what the MLAWP-AR model proposed,

a model of capacity sharing among the factories in a manufacturing network will develop in order to achieve minimum average flow time of orders in the network. That is why this proposed model focuses in these principles:

(1) All the factories in the network should be involved in processing orders.
(2) Each order should be completed as soon as possible.
(3) The load should be allocated as evenly as possible to the factories.

These are the steps of the assignment algorithm of the proposed assignment model called LBLA (Least Balance Load Assignment):

(0) Initialize S = {A, B, …, m}, S' = {∅}, O_j = {1, 2, …, K}, O_j' = {∅}, F_j = {1, 2, …, n_j}, F_j' = {∅} for all j ∈ S.
(1) Start from j = A.
(2) Find t_{ijk}* = min{t_{ijk}} for all i ∈ O_j and k ∈ F_j, break tie arbitrary
(3) Allocate order k arg(min{t_{ijk}*}) to f_{ij}, revise O_j, O_j', F_j, and F_j'.
(4) If K = n_j go to Step (5), if K < n_j go to Step (7), otherwise go to Step (13)
(5) If O_j = {∅} go to Step (6), otherwise back to Step (2)
(6) If S = {∅} go to Step (19) , otherwise move to next j and back to Step (2)
(7) For all k ∈ O_j' define t_k* = t_{ijk}*
(8) Find order k* = order k arg(max{t_k*}), k ∈ O'
(9) For all i ∈ F_j, calculate t_k* using Equation (3)
(10) Assign f_{ij} arg(min{t_k*}) to process k*, revise F_j and F_j'
(11) If F_j = {∅} go to Step (12), otherwise back to Step (8)
(12) If S = {∅} go to Step (19) , otherwise move to next j and back to Step (2)
(13) If F_j = {∅} go to Step (14), otherwise back to Step (2)
(14) For all i ∈ F_j' define t_i* = t_{ijk}*

(15) For all $k \in O_j$ calculate t_i^* using Equation (4)
(16) Allocate order k to f_{ij} arg(min{t_i^*}), revise O_j and O_j'
(17) If $O_j = \{\varnothing\}$ go to Step (18), otherwise back to Step (15)
(18) If $S = \{\varnothing\}$ go to Step (10), otherwise move to next j and back to Step (2)
(19) End.

where i = index for parallel factories, i = 1, 2, ..., n_j
- j = index for stages, j = A, B, ..., m
- f_{ij} = factory i in stage j
- k = index for order, k = 1, 2, ..., K
- t_{ijk} = production lead time of order k in factory i of stage j
- O_j = {non-allocated orders at stage j}
- O_j' = {allocated orders at stage j}
- F_j = {non-assigned factories at stage j}
- F_j' = {assigned factories at stage j}
- S = {non-evaluated stages}
- S' = {evaluated stages}
- s_{jk} = number of factories assigned to process order k at stage j

The equations required to run the algorithm are as follow.

$$t_k^* = \frac{t_k^* . s_{fk}^2 + t_{ijk}^*}{(s_{fk}+1)^2} \tag{3}$$

$$t_i^* = t_i^* + t_{ijk}^* \tag{4}$$

5.2. Application Examples

The following 3 examples represent the 3 case categories: cases with number of jobs less than number of parallel factories, cases with number of jobs equal to number of parallel factories, and cases with number of jobs larger than number of parallel factories. Table 1, Table 2, and Table 3 show the production lead time data. Shaded cells show the assignment decisions. The transportation time data are not shown here because they do not significantly affect the flow time (on average only 1/24 of production lead time).

As shown in Table 1, Order 1 and Order 2 are allocated to more than one factory in both stages because number of orders is less than number of parallel factories. In stage A Order 2 is allocated to only one factory with short production lead time, while Order 1 is allocated to 4 factories because the production lead time are relatively long.

In Case 2, since number of orders is equal to number of parallel factories, each order is allocated to one factory and each factory only assigned to process one order. Table 2 shows that in order to involve all the factories, an order is not always allocated to a factory that have shortest production lead time. The allocation of Order 2 to Factory 3B is an example.

Table 1. Production lead time (days) data and assignment decisions
for Case 1: 2 orders, 2 stages, 5 factories in each stage

Order	Stage A					Stage B				
	f_{1A}	f_{2A}	f_{3A}	f_{4A}	f_{5A}	f_{1B}	f_{2B}	f_{3B}	f_{4B}	f_{5B}
1	9	10	9	4	9	7	5	9	2	2
2	8	4	2	3	9	1	3	6	4	3

Table 2. Production lead time (days) data and assignment decisions for Case 2: 5 orders, 2 stages, 5 factories in each stage

Order	Stage A					Stage B				
	f_{1A}	f_{2A}	f_{3A}	f_{4A}	f_{5A}	f_{1B}	f_{2B}	f_{3B}	f_{4B}	f_{5B}
1	3	3	5	4	10	1	7	5	3	4
2	3	7	2	9	10	5	10	7	9	4
3	6	3	5	6	6	10	8	9	4	3
4	2	9	8	7	1	10	9	7	1	8
5	6	10	10	4	4	7	2	3	1	10

Table 3 shows an example of Case 3. Here number of orders is larger than number of parallel factories, so that each factory is assigned to process more than one orders. In order to evenly distribute the orders to the factories, an order is allocated to a factory that have minimum cumulative production lead time, rather than to a factory that have shortest production lead time. The allocation of Order 1 to Factory 1A, not to Factory 1B, is an example.

Table 3. Production lead time (days) data and assignment decisions for Case 3: 5 orders, 2 stages, 2 factories in each stage

Order	Stage A		Stage B	
	f_{1A}	f_{2A}	f_{1B}	f_{2B}
1	4	3	2	3
2	9	7	4	9
3	2	4	4	10
4	9	2	3	1
5	5	3	10	9

6. SIMULATION STUDY

To evaluate workability of the proposed LBLA model in the dynamic probabilistic system, a simulation study using Arena Software version 7.01 was performed. Sixty cases were hypothetically generated. Fifteen of these are cases with number of jobs less than number of parallel factories, 20 are cases with number of jobs equal to parallel factories, and the other 25 are cases with number of jobs larger than number of parallel factories.

In this simulation study, the proposed LBLA model application is compared to shortest processing time assignment. In the shortest processing time assignment, orders are allocated to factories that have shortest processing time. Consequently, not all the factories in the network are assigned, violating the 'gotong-royong' philosophy of the proposed LBLA model.

Technical evaluation of the simulation result is based on the theories and methods presented by Law and Kelton (1991).

7. CONCLUSION

The simulation result shows that the application of LBLA model gives better average flow time than shortest processing time assignment in 58.33% of the cases, 10% of the cases shows no differences, while the other 31.67% of the cases fails to show the advantage of LBLA model. Evaluation on the 31.67% failed cases shows that the significant difference between the lowest assigned production lead time and the highest one is the reason for unsuccessful application of LBLA model. In the real system, it means that capacity sharing between a very high capacity factory and a very low capacity factory will lead to network capacity reduction.

Although 31.67% of cases shows the unsuccessful application of LBLA model, it does not mean that the model is unsuitable for any cases. For short time running, involving the very low capacity factories in the network activities may lead to profit reduction, but for long time improvement planning, it might be useful to push improvement action acceleration of the very low capacity factories. If the very low capacity factories are never involved in the network activities, they will be never encouraged to improve themselves and may go down.

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I Nyoman Pujawan, Ph.D