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Deciding on the Ideal Channel Coefficients in Multi-Channel Manufacturing

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Abstract. **This paper provides a methodology to determine ideal channel coefficients in Multi-Channel Manufacturing (MCM). MCM enhances the advantages of cellular manufacturing by expanding the capabilities of the cells to handle multiple products. The ideal channel coefficients are needed as input for MCM design techniques. While determining ideal channel coefficients (so channel coefficients), we want to assign more profitable parts to more channels. In some cases, this may require additional investment (as extra machines) for some of the channels. These two conflicted goals must be compromised. To do this, the Analytic Network Process (ANP) approach, which is one of the systematic decision-aid tools, is used. The developed model is solved by Super Decisions software. Results showed that ANP is a powerful methodology to determine ideal channel coefficients in MCM design.**

I. INTRODUCTION

Multi-Channel Manufacturing is based on the simple observation that in an effective manufacturing system multiple channels (or paths) are provided for each manufactured product as it flows through the manufacturing system; that is, instead of having one channel through the manufacturing system for each product (as many traditional manufacturing systems are often designed), multiple channels are provided. This allows the product to flow through the facility by choosing the channel that allows for the greatest manufacturing system efficiency at that time [1]. If a certain line is busy or a machine in the line is out of order or in maintenance, the product can be produced at another channel. This is impossible in a flow shop or in classical cellular manufacturing environment [2].

MCM designs are characterized by the number of manufacturing channels for each product and can be captured in a statistic termed the channel coefficient. The number of manufacturing channels provided for a product is known as its channel coefficient. Channel coefficient of a certain component is proportional to the importance of the part. The importance of the part is determined by using Pareto Principle (ABC analysis). Pareto principle advises us to concentrate on the vital few sources of problems and not be distracted by those of lesser importance. Thus after determining the part importance (A-B-C) by Pareto Principle, we must determine the ideal channel coefficients for each group (A-B-C). MCM design techniques require the ideal channel coefficients as input. While determining ideal channel coefficients (so channel coefficients), we want to assign more profitable parts to more channels. Ideal channel coefficients are the target values of channel coefficients and restrict the solution space. If you use more than needed ideal channel coefficients, you will find a solution with high investment, low machine utilization. On the contrary, if you use low than needed ideal channel coefficients, you will not produce as much as demand so the solution will be unfeasible. For that reason, determining ideal channel coefficients exactly is very important.

Meller [3] regards the balance between efficiency due to higher channel coefficients and burden of extra investment as the core decision of MCM system design. These two conflicted goals must be compromised. To do this, systematic decision-aid tools are needed which consider a multitude of factors affecting the channel coefficient determining decision and explicitly consider tradeoffs among them. Such decision-aid tools may include various multi-objective programming techniques and scoring methods such as Analytic Hierarchy Process (AHP) or Analytic Network Process (ANP) [4].

Like Meller and DeShazo [1], Ozcelik and Islier [2] determined ideal channel coefficients arbitrarily. In this study, an ANP model is developed to determine ideal channel coefficients. This model implemented in the Super Decisions software.

In the following section of this paper, the basics of the ANP are described. In Section 3, the ANP decision model is introduced. Section 4 presents the results. These results are used as an input of Genetic Algorithm (GA) presented in Section 5 and then, the effect of the determined coefficients to the solution is examined. Finally, the conclusions and the application areas for this research are described.

II. THE ANALYTIC NETWORK PROCESS

The ANP generalizes a widely used multi-criteria decision-making tool, the AHP, by replacing hierarchies with networks. The AHP is a well-known technique that decomposes a problem into several levels in such a way that they form a hierarchy [5]. Each element in the hierarchy is supposed to be independent, and a relative ratio scale of measurement is derived from pairwise comparisons of the elements in a level of the hierarchy with respect to an element of the preceding level. However, in many cases, there is interdependence among criteria and alternatives. The ANP can be used as an effective tool in those cases where the interactions among the elements of a system form a network structure [6].

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While AHP employs a unidirectional hierarchical relationship among decision levels, ANP enables interrelationships among the decision levels and attributes to be taken into consideration in a more general form. ANP uses ratio scale measurements based on pairwise comparisons; however, it does not impose a strict hierarchical structure as in AHP, and models a decision problem using a systems-with-feedback approach. Figure 1a and b shows the structural difference between the hierarchy and network. Nodes of the network represent components of the system, and arcs denote interactions between them. The directions of the arcs represent dependence, whereas loops signify inner dependence of the elements in a cluster. As we can observe, a hierarchy is a simple and special case of a network [7].

The ANP consists of two stages: the first one is the construction of the network, and the second one is the calculation of the priorities of the elements. While constructing the structure of the problem, all of the interactions among the elements should be considered.

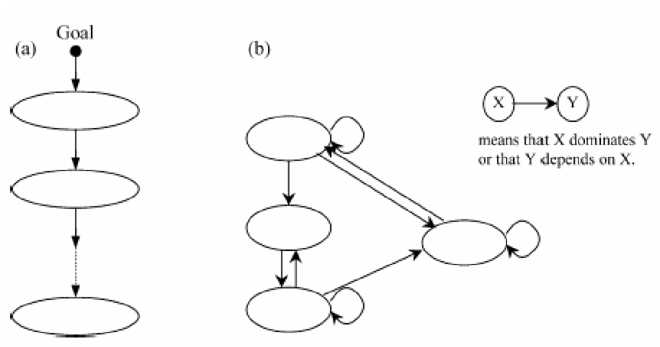


Fig. 1. (a) A hierarchy (b) A nonlinear network [7].

III. THE ANP DECISION MODEL

An ANP model is developed to determine the ideal channel coefficients. A decision problem that is analyzed with either the ANP is often studied through a control hierarchy or network for benefits, costs, opportunities and risks. In this model, there are two networks one for advantages and one for disadvantages (Table 1). These are called the merits of the decision. If there is only advantage and disadvantage of doing something, generally advantage and disadvantage are equally important for decision maker. For that reason weighting for merits is neglected.

A. Benefits Network

Each network has clusters, elements and links. A cluster is a collection of relevant elements within a network or sub-network. In benefits network (Figure 2) there are three clusters: advantages to costumers, advantages to company and alternatives. All interactions and feedbacks within the clusters are called inner dependencies whereas interactions and feedbacks between the clusters are called outer dependencies. Inner and outer dependencies are the best way decision-makers can capture and represent the concepts of influencing or being influenced, between clusters and between elements with respect to a criterion [8]. Here advantages to customer and advantages to company cluster inner dependent and all clusters influencing and influenced from the others.

TABLE I
CLUSTERS IN THE DECISION NETWORKS AND ELEMENTS IN THE CLUSTERS

BOCR	Clusters	Elements
Benefits	Advantages to customers	Product variety Faster delivery Customer satisfaction
	Advantages to company	Work-in-process level To meet the demand Machine utilization Production rate Competition advantage Stoppage Dynamism Increasing benefit
	Alternatives	A-1 channel A-2 channel A-3 channel A-4 channel B-1 channel B-2 channel B-3 channel B-4 channel C-1 channel C-2 channel C-3 channel C-4 channel
Costs	Costs	Additional machine cost Monitoring device cost Arrangement cost Additional labor cost
	Alternatives	A-1 channel A-2 channel A-3 channel A-4 channel B-1 channel B-2 channel B-3 channel B-4 channel C-1 channel C-2 channel C-3 channel C-4 channel

Elements of advantages to customers cluster are:

- Product variety: Adding new channels in system increase the production volume. Thus a wide variety of products could be produced.
- Faster delivery: Since allowing the product to be produced in alternative channels prevents the stoppage, unexpected increase in the throughput time should be seen.
- Customer satisfaction: The customers whose demand is satisfied and delivered on time will be pleased.

Advantages to company cluster's elements are as follows:

- Work-in-process (WIP) level: If a certain line is busy or a machine in the line is out of order or in maintenance, WIP level increases, the parts will be delayed. In this case the part whose channel coefficient is high can be produced at alternative channel. Thus WIP levels decrease.

- Machine utilization: If more than one type of part is produced in a channel, utilization of a machine in this channel will be increased.
- Dynamism: The product whose channel coefficient is more than one can be produced at another channel, if a certain line is busy or a machine in the line is out of order or in maintenance. Thus the unexpected demands should be answered easily.
- Production rate: Dynamism allows the decision maker to pull the part as fast as possible. This has an direct effect on production rate.
- Stoppage: Multi-channel manufacturing prevents the stoppage that occurs when a machine is out of order or in maintenance with alternative channels. Higher channel coefficient is better.
- To meet the demand: Due to increase in production rate (decreased cycle time), prevented stoppage and decreased work-in-process level, planned amount of part can be produced in planned time.
- Competition advantage: Company becomes a strong competitor in the market by dynamism, increased production rate, product variety.
- Increasing benefit: Dynamism, increased production rate and product variety allows the company to produce variable products in high volumes. So the profit of the company increases.

Alternatives cluster shows ideal channel coefficient alternatives for a four-channel manufacturing system. Because all part must be assigned at least one channel, ideal channel coefficient for all part groups such as A, B and C can be from 1 to 4. So there are 12 alternatives:

- A-1 channel: Ideal channel coefficient of A-parts is one.
- A-2 channel: Ideal channel coefficient of A-parts is two.
- A-3 channel: Ideal channel coefficient of A-parts is three.
- A-4 channel: Ideal channel coefficient of A-parts is four.
- B-1 channel: Ideal channel coefficient of B-parts is one.
- B-2 channel: Ideal channel coefficient of B-parts is two.
- B-3 channel: Ideal channel coefficient of B-parts is three.
- B-4 channel: Ideal channel coefficient of B-parts is four.
- C-1 channel: Ideal channel coefficient of C-parts is one.
- C-2 channel: Ideal channel coefficient of C-parts is two.
- C-3 channel: Ideal channel coefficient of C-parts is three.
- C-4 channel: Ideal channel coefficient of C-parts is four.

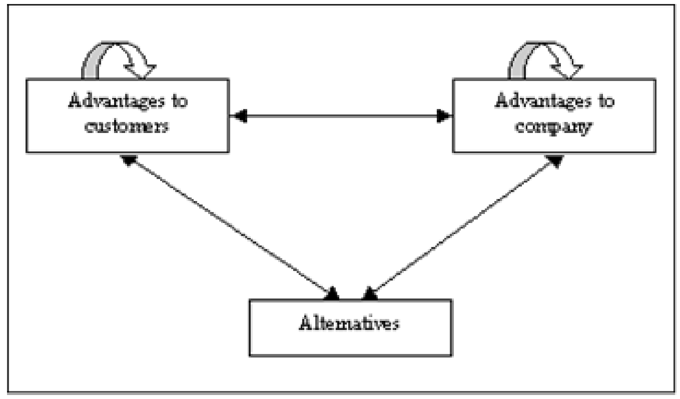


Fig. 2. Structure of the benefits network.

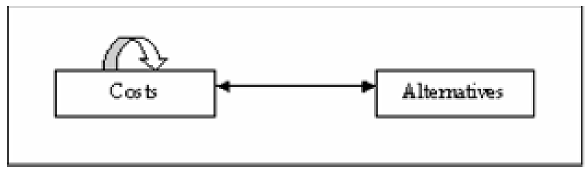


Fig. 3. Structure of the benefits network.

B. Costs Network

Costs network (Figure 3) has two clusters: costs and alternatives. Costs network's elements are as following:

- Additional machine cost: Increasing the channel coefficients of products requires additional machines for some of the channels.
- Monitoring device cost: To take advantage of MCM, the status of the manufacturing channels needed to be monitored in real-time. A central decision-maker uses available information to decide which channel to use for a current production order. If downstream processes in one channel are being utilized, then the decision-maker may select another channel. In this way, the decision-maker can avoid assigning an order to a channel with current congestion or upcoming scheduled maintenance. Such flexibility allows the decision-maker to pull product through the facility as rapidly as possible, which has a direct impact on throughput time, inventory levels, and facility throughput. Although conceptually the decision-maker sits in the middle of the system, physically the conductor can reside elsewhere through the appropriate use of information technology. However, either physically or with monitoring devices, it is imperative that the decision-maker be able to assess current manufacturing system states instantaneously and without great effort. In some cases this will mean the use of on-the-floor cameras in addition to computer support when the decision-maker is a human remotely located [3].
- Arrangement cost: Arrangement cost includes labor cost that is occurred to locate the new machines and devices, transportation cost that is occurred while

changing the locations of machines and production loses occurred while arranging the system.

- Additional labor cost: When new machines added to the manufacturing channel to increase the channel coefficient of a product, additional labor is also needed to work with the new machines.

Alternatives are same as the benefits network's alternatives.

C. Pairwise Comparisons

After clusters, elements and links are determined, pairwise comparisons are made systematically including all the combinations of element/cluster relationships. In ANP, the relative importance values are determined similar to AHP using pairwise comparisons with a scale of 1–9. Here a score of 1 indicates equal importance between the two elements and 9 represents the extreme importance of one element compared to the other one.

In a hierarchy, we ask the question for making a comparison, which of two elements is more dominant or has more influence (or is influenced more) with respect to a certain element in the level above? [6]. In the network we ask the following questions:

1. Given a criterion, which of two elements has greater influence (is more dominant) with respect to that criterion?
2. Given an alternative, which of two criteria or properties is more dominant in that alternative?
3. Given a criterion and given an element X in any cluster, which of two elements in the same cluster or in a different cluster has greater influence on X with respect to that criterion?

The entire decision uses the idea of something "influencing" another. An example of pairwise comparison is shown in Table 2. All pairwise comparisons are made like this.

D. Constructing supermatrix

In ANP, the analysis is made by using three types of matrices such as unweighted matrix, weighted matrix and limit matrix. The unweighted matrix is the outcome of the pairwise comparisons process and its columns contain the priorities derived from the pairwise comparisons of the elements. The weighted matrix is the new matrix that is achieved by multiplying the blocks of the unweighted supermatrix by the corresponding cluster priority. Raising a matrix to powers gives the long-term relative influences of the elements on each other. The limit matrix is achieved by raising the weighted matrix to powers. The limit matrix has the same form as the weighted matrix, but all the columns of the limit matrix are the same. As an example, Tables 4–6 illustrate some parts of unweighted, weighted and limit matrices of the factors within the benefits network. Table 4 shows the pairwise comparisons of the factors. The weighted matrix (Table 5) is obtained by weighting the blocks in the unweighted matrix by the corresponding priority from the cluster matrix shown in Table 3. The entries of the weighted matrix itself give the direct influence of any one factor on any other factor. The weighted matrix has some zeros indicating no interaction.

TABLE III
CLUSTER MATRIX FOR BENEFITS NETWORK

Clusters	Advantages to company	Advantages to customers	Alternatives
Advantages to company	0.444444	0.546931	0.750000
Advantages to customers	0.444444	0.344544	0.250000
Alternatives	0.111111	0.108525	0.000000

IV. SYNTHESIS

Following all pairwise comparisons, the synthesized results would come up. The benefits, opportunities, costs and risks are rated separately and then the synthesized results of the four control systems are combined to determine the best outcome by using these ratings. The result is a set of priorities of the alternatives [9].

The benefits and costs are rated separately and then the synthesized results of the two control systems are combined to determine the best outcome by using these ratings. There are various formulas to combine control systems. For this problem multiplicative formula is used. The alternative values coming from the subnets for benefits and opportunities are multiplied and result is divided by the product of the alternative values coming up from the subnets for costs and risks. The result is a set of priorities of the alternatives (Table 7). For each part group we must choose alternative that has max priority in this group. So for A group parts ideal channel coefficient is 4, for B group parts 2 and 1 for C-parts. A-parts can be considered as if they were furnishing 80% of the profit while consisting 20% of the part types. So for A group parts maximum 4 channel is an expected result.

TABLE II
PAIRWISE COMPARISON

Which criteria have greater influence on advantages to company with respect to machine utilization?																		
	9:1	8:1	7:1	6:1	5:1	4:1	3:1	2:1	1:1	1:2	1:3	1:4	1:5	1:6	1:7	1:8	1:9	
Stoppage							X											WIP

TABLE IV
UNWEIGHTED MATRIX FOR BENEFITS NETWORK

	Advantages to company								Advantages to customers			
	Competi~	Dynamism	Increas~	Machine~	Product~	Stoppage	To meet~	Work-in~	Custome~	Faster ~	Product~	. . .
Advantages to company												
Competi~	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	. . .
Dynamism	0.33333	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
Increas~	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
Machine~	0.00000	0.00000	0.14286	0.00000	0.00000	0.00000	0.13965	0.00000	0.00000	0.00000	0.00000	
Product~	0.00000	1.00000	0.42857	0.00000	0.00000	0.00000	0.33252	0.25000	0.00000	0.66667	0.00000	
Stoppage	0.00000	0.00000	0.42857	0.75000	0.75000	0.00000	0.52784	0.75000	0.00000	0.33333	0.00000	
To meet~	0.66667	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	1.00000	0.00000	0.00000	
Work-in~	0.00000	0.00000	0.00000	0.25000	0.25000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
Advantages to customers												
Custome~	0.42857	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	. . .
Faster ~	0.14286	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.66667	0.00000	0.00000	
Product~	0.42857	1.00000	1.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.33333	0.00000	0.00000	
Alternatives												
A-1 cha~	0.07201	0.06805	0.04907	0.06502	0.05704	0.03515	0.06796	0.07214	0.08325	0.03485	0.03843	. . .
A-2 cha~	0.12161	0.08358	0.08679	0.08952	0.11463	0.09009	0.09975	0.11879	0.13280	0.07848	0.07235	
A-3 cha~	0.15596	0.16408	0.14873	0.15073	0.17263	0.14392	0.14635	0.18743	0.15248	0.16293	0.13334	
A-4 cha~	0.23672	0.18029	0.18887	0.20792	0.21966	0.20646	0.21605	0.24254	0.20892	0.23558	0.20514	
. . .	. . .								. . .			

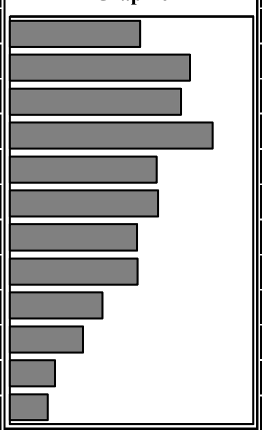
TABLE V
WEIGHTED MATRIX FOR BENEFITS NETWORK

	Advantages to company								Advantages to customers			
	Competi~	Dynamism	Increas~	Machine~	Product~	Stoppage	To meet~	Work-in~	Custome~	Faster ~	Product~	. . .
Advantages to company												
Competi~	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	. . .
Dynamism	0.14815	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
Increas~	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
Machine~	0.00000	0.00000	0.06349	0.00000	0.00000	0.00000	0.11172	0.00000	0.00000	0.00000	0.00000	
Product~	0.00000	0.44444	0.19048	0.00000	0.00000	0.00000	0.26601	0.20000	0.00000	0.55629	0.00000	
Stoppage	0.00000	0.00000	0.19048	0.60000	0.60000	0.00000	0.42227	0.60000	0.00000	0.27814	0.00000	
To meet~	0.29630	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.54693	0.00000	0.00000	
Work-in~	0.00000	0.00000	0.00000	0.20000	0.20000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
Advantages to customers												
Custome~	0.19048	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	. . .
Faster ~	0.06349	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.22970	0.00000	0.00000	
Product~	0.19048	0.44444	0.44444	0.00000	0.00000	0.00000	0.00000	0.00000	0.11485	0.00000	0.00000	
Alternatives												
A-1 cha~	0.00800	0.00756	0.00545	0.01300	0.01141	0.03515	0.01359	0.01443	0.00903	0.00577	0.03843	. . .
A-2 cha~	0.01351	0.00929	0.00964	0.01791	0.02293	0.09009	0.01995	0.02376	0.01441	0.01299	0.07235	
A-3 cha~	0.01733	0.01823	0.01653	0.03015	0.03453	0.14392	0.02927	0.03749	0.01655	0.02698	0.13334	
A-4 cha~	0.02630	0.02003	0.02099	0.04158	0.04393	0.20646	0.04321	0.04851	0.02267	0.03900	0.20514	
. . .	. . .								. . .			

TABLE VI
LIMIT MATRIX FOR BENEFITS NETWORK

	Advantages to company								Advantages to customers			
	Competi~	Dynamism	Increas~	Machine~	Product~	Stoppage	To meet~	Work-in~	Custome~	Faster ~	Product~	. . .
Advantages to company												
Competi~	0.03081	0.03081	0.03081	0.03081	0.03081	0.03081	0.03081	0.03081	0.03081	0.03081	0.03081	. . .
Dynamism	0.05274	0.05274	0.05274	0.05274	0.05274	0.05274	0.05274	0.05274	0.05274	0.05274	0.05274	
Increas~	0.01884	0.01884	0.01884	0.01884	0.01884	0.01884	0.01884	0.01884	0.01884	0.01884	0.01884	
Machine~	0.02372	0.02372	0.02372	0.02372	0.02372	0.02372	0.02372	0.02372	0.02372	0.02372	0.02372	
Product~	0.10213	0.10213	0.10213	0.10213	0.10213	0.10213	0.10213	0.10213	0.10213	0.10213	0.10213	
Stoppage	0.19574	0.19574	0.19574	0.19574	0.19574	0.19574	0.19574	0.19574	0.19574	0.19574	0.19574	
To meet~	0.06084	0.06084	0.06084	0.06084	0.06084	0.06084	0.06084	0.06084	0.06084	0.06084	0.06084	
Work-in~	0.05228	0.05228	0.05228	0.05228	0.05228	0.05228	0.05228	0.05228	0.05228	0.05228	0.05228	
Advantages to customers												
Custome~	0.03637	0.03637	0.03637	0.03637	0.03637	0.03637	0.03637	0.03637	0.03637	0.03637	0.03637	. . .
Faster ~	0.04509	0.04509	0.04509	0.04509	0.04509	0.04509	0.04509	0.04509	0.04509	0.04509	0.04509	
Product~	0.05754	0.05754	0.05754	0.05754	0.05754	0.05754	0.05754	0.05754	0.05754	0.05754	0.05754	
Alternatives												
A-1 cha~	0.01348	0.01348	0.01348	0.01348	0.01348	0.01348	0.01348	0.01348	0.01348	0.01348	0.01348	. . .
A-2 cha~	0.02922	0.02922	0.02922	0.02922	0.02922	0.02922	0.02922	0.02922	0.02922	0.02922	0.02922	
A-3 cha~	0.04745	0.04745	0.04745	0.04745	0.04745	0.04745	0.04745	0.04745	0.04745	0.04745	0.04745	
A-4 cha~	0.06770	0.06770	0.06770	0.06770	0.06770	0.06770	0.06770	0.06770	0.06770	0.06770	0.06770	
.	.								.			
.	.								.			
.	.								.			

TABLE VII
SYNTHESIZED PRIORITIES FOR THE ALTERNATIVES (OUTPUT OF SUPER DECISIONS SOFTWARE)

Name	Graphic	Ideals	Normals	Totals
A-1 channel		0,643064	0,087925	0,703554
A-2 channel		0,887794	0,121387	0,971304
A-3 channel		0,842326	0,11517	0,92156
A-4 channel		1	0,136729	1.094
B-1 channel		0,724369	0,099042	0,792507
B-2 channel		0,731023	0,099952	0,799787
B-3 channel		0,628123	0,085883	0,687208
B-4 channel		0,629765	0,086107	0,689003
C-1 channel		0,456039	0,062354	0,498937
C-2 channel		0,361759	0,049463	0,395788
C-3 channel		0,223313	0,030533	0,244318
C-4 channel		0,186165	0,025454	0,203676

V. COMPARISON

The ideal channel coefficients that are identified by using ANP is used as input of the genetic algorithm (GA) that is developed by Ozcelik and Islier [2] to solve channel formation problem in MCM systems. The structure of the algorithm is summarized in this section.

A. Chromose representation

Each channel is depicted as a certain length of sub strings to represent the layout. The internal ordering of these sub strings resembled the sequence of the machines within channels in turn. Matching consecutive machines with fixed positions prevents infeasible solutions, that is, positions in these sub strings do not change after mutation and crossover operations. Thus, dealing with the problem will be rather easy. Chromosome representation of a three-channel system is given in Fig. 4.

The capacities of these channels are 15, 10 and 10, respectively (totally 35). Bold numbers in boxes denote the machine types (small numbers beneath, state the positions). There is a type 4 machine (say lathe) in the first position of the first channel. Position 27, for example, is for the second machine on channel 3 (it is a type 2 machine, say drill). A zero means there is no machine in that position of the chromosome. In the evaluation phase, zeros are removed; machines are squeezed to the leading edge of the channels before calculating the handling distances.

4	**1**	**6**	**0**	**3**	**5**	**…**	**2**	**6**	**1**	**4**	**3**	**4**	**5**	**6**	**2**	**4**	**4**	**0**	**2**	**0**	**0**	**0**	**1**	**5**	**6**	**4**	**0**
1	*2*	*3*	*4*	*5*	*6*	*…*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*

Fig. 4. Modeling of the machine-channel relations in a chromosome

B. Initialization, evaluation and selection

An initial population of strings up to the specified population size is generated at random. The objective function of the model developed by Ozcelik and Islier [2] is adopted as the fitness function of the proposed GA. They modeled the MCM system design problem with four objectives: maximizing the channel coefficients, minimizing the transportation load, minimizing the unused capacity and minimizing the exceeded capacity. A modified roulette wheel method where individuals are selected by randomized fitness value is used as a selection algorithm.

C. Crossover and mutation

In this study a two-point crossover operator is used. If the difference between fitness value of the best parent and the worst parent in a population is less than or equal to mutation threshold (constant value), a mutation would be performed. Then a random number is generated to determine the gene that is been mutated.

D. Convergence policy

The GA iterates as the process proceeds, the generation includes chromosomes with higher fitness values. If the best performing chromosomes remain unchanged with 100 generations, the population converges. At this stage, since the chance for further improvement is very small, the process is terminated.

E. Results

The genetic algorithm is applied for identified ideal channel coefficients with data set for stove factory. The same problem was solved by Ozcelik and Islier [2] with arbitrary coefficients (determined as decision maker wish, not by a method). The results (Table 8) showed that a solution with lower investment, lower transportation load and lower unused capacity than arbitrary coefficients is found with ANP coefficients. Investment decreased %20, transportation load (so transportation cost) decreased %13.26 and unused capacity decreased %13. In each case, there is not any exceeded capacity.

TABLE VIII
COMPARISONS OF ARBITRARY AND ANP SOLUTIONS.

	Arbitrary	**ANP**
Ideal channel coefficient	4-3-2	4-2-1
Investment ($)	634 625	509 183
Transportation load	1.82377	1.58188
Unused capacity	3.115	2.7108
Exceeded capacity	0	0

VI. CONCLUSIONS

An ANP model is developed to determine ideal channel coefficients for a manufacturing system. Before this study, ideal channel coefficients are being determined arbitrary. This study suggests a methodology. By using a methodology to determine ideal channel coefficients, solution time will decrease and quality of solution will increase.

Ideal channel coefficient for A-group parts is determined as 4, for B-group parts as 2 and for C-group parts as 1. Because we consider pareto principle to determine part groups or weights this is an expected and applicable result.

By this study, a more consistent way is developed to determine ideal channel coefficients. Genetic algorithm results showed that these coefficients are more realistic than arbitrary coefficients. Using more than needed ideal channel coefficients as input results with more than needed machines (this increases the investment costs). So machines used in low capacity. Determining ideal channel coefficients with a methodology (here ANP) deals with this problem. The following study will compare both coefficient sets by using a simulation model.

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