A Novel Swarm Optimization Technique for Partner Selection in Virtual Enterprise

by

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Introduction

Globalization and customization of product greatly increase the competitiveness in the market place necessitating more demands for resources and capacity of the enterprises than ever before.

This directs the traditional enterprises to look for advanced and effective manufacturing processes and management modes. As a new manufacturing mode, network manufacturing is gaining popularity because it possesses basic features such as advantage of using resources scattered in different regions into a network alliance enterprise.

So that changes in market demand can be quickly responded and high-quality and low-cost products can be introduced in minimum response period.

Success of virtual enterprises (VE) largely depends on the cooperation among the channel partners.

Literature Review

Talluri and Baker have proposed a two-phase mathematical programming approach for partner selection considering important factors such as cost, time and distance without conisering precedence relations of subprojects and risk factors [1].

Noll has proposed a peer-to-peer architecture for deploying work flow in virtual enterprises engaged in knowledge-intensive activities [2].

Yang has proposed an instructor of remote manufacturing system supporting dynamic alliance for virtual enterprises with the multi-agent technology to solve the problem of partner enterprise selection [3].

Xiao-bo and Ting-ting have proposed a method based on ANP for partner selection and demonstrated its practical applicability with an example [4].

Wang et al. have developed a fuzzy decision making approach embedded with genetic algorithm (GA/FD) to obtain solution to a partner selection problem with due date constraint when subprojects of the project form a precedence network [5].

However, computationally elegant method like PSO which needs few parameters to be controlled in an optimization problem has not been adequately considered in the literature.

Objective

In this work, a novel technique is adopted to avoid the velocity of particles used in basic and discrete version of PSO without affecting exploration and maturation capability of PSO. By doing so, the number of control parameters has been reduced to a large extent. The superiority of the technique is demonstrated with exhaustive experimentation to partner selection problem in VE. The effect of number of processes, maximum number of partners in process, and population size on computational time, number of iterations and fitness value of the objective function is studied.

Algorithm

Step 1. Randomly initialize a swarm of particles of size N. Each particle is of n dimensions equal to number of processes in the project. Each particle is represented as $X_i = (X_{i1}, X_{i2}, ..., X_{in})$, i =1,2,...,N. Each particle contains attributes which are randomly generated.

Step 2. Evaluate each particle to obtain fitness value that considers running cost, reaction time and running risk.

Step 3. The personal best (P) of each particle and global best (G) of the swarm is stored.

Step 4. Set iteration number equal to 1.

Step 5. Update position vector of each particle comparing with its personal best. Again update each particle comparing with global best.

Step 6. Increase iteration number by one.

Step 7. Continue steps 5 to 6 until a termination criterion is met, usually a sufficiently good fitness value or a specified number of generations.

Particle Representation

In order to represent the combinatory problem in DPSO encoding of the particles is very important. Each attribute is identified by a unique positive integer number, or index. These numbers, indices, vary from 1 to n.

A particle is a subset of non-ordered indices without repetition. For example taking three processes {A,B,C} having two candidate for each process, the total candidates are {A1,A2,B1,B2,C1,C2}. Taking four particle the swarm can be presented like X (1)={2,1,1}, X (2)={1,2,1}, X (3)={1,1,1}, X (4)={1,2,2,}. Here, X (1) = {2, 1, 1} represent 2 corresponds to attribute A2, 1 to B1 and 1 to C1. That means the particle X (1) shows the solution taking A2, B1, and C1 candidate partners for three processes.

Velocity Updation

X_i=(1,2,1,1 ,2,2,1)

P_i=(1,3,2,1,2,1,2)

(X_i – P_i) = (1-1, 2-3,1-2,1-1,2-2,2-1,1-2) = (0,-1,-1,0,0,1,-1,)

The new vector B is generated, B = (2, 3, 6, 7).
Thus μ= 4
Suppose that β=2 and ψ = (0, 1, 0, 1)

That means that positions 3 and 7 will be replaced in X_i by the elements (in the same positions) of P_i.

New position vector = (1, 2, 2, 1, 2, 2, 2)

Result and discussions

Thirty problems having different processes and maximum number of partners in each process are generated randomly to test the efficiency of the algorithm.

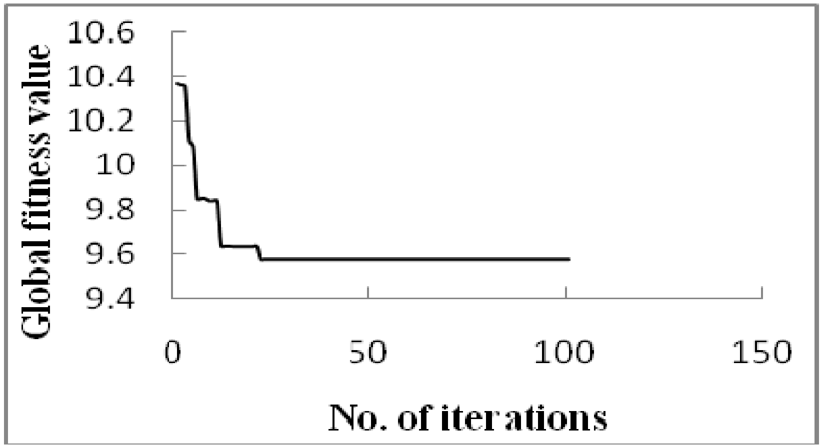
Candidates for each Process for the Example Problem

Processes	Maximum Number of Candidates for each Process
1	6
2	2
3	3
4	8
5	2

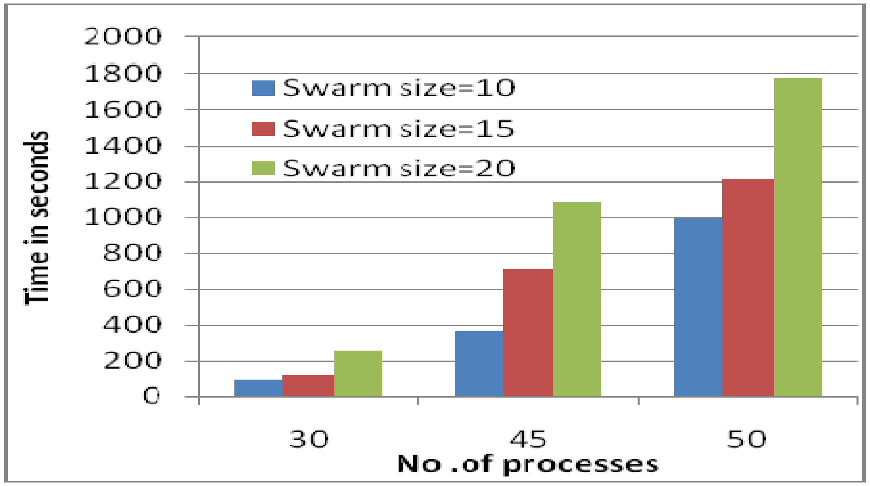
Internal cost, Internal time, and Risk for the Example Problem

Partners	Internal cost	Internal time	Risk
A1	66.85389	0.0750755	0.191180
A2	17.86250	33.815100	0.185144
A3	0.70040	11.598300	0.107871
A4	1.33671	48.524400	0.028468
A5	56.68200	35.100600	0.092416
A6	79.74940	28.792400	0.047066
B1	85.67770	21.017500	0.172448
B2	90.26460	53.757700	0.041920
C1	91.07490	49.370400	0.155931
C2	24.93510	44.796300	0.168731
C3	99.45680	10.446500	0.199359
D1	67.61830	51.536600	0.199939
D2	52.81840	42.630100	0.122300
D3	8.55586	30.81210	0.078488
D4	91.15270	18.23970	0.053243
D5	117.49800	0.899075	0.059456
D6	120.39100	5.484180	0.168029
D7	77.98240	21.867100	0.004749
D8	45.29250	8.838770	0.075173
E1	131.39600	9.953920	0.018525
E2	109.00100	59.311500	0.135441

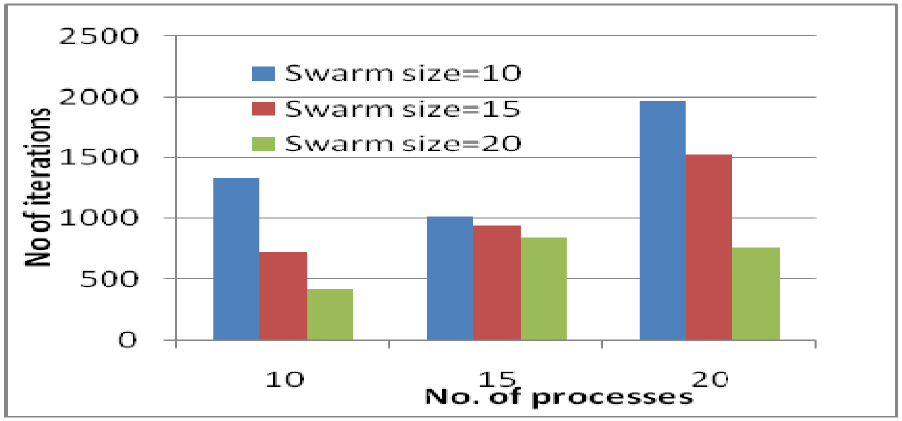
It is observed that fitness value is minimized at 22 iterations and it took um value 0.032 sec to converge. The optimum global fitness value is found to be 9.57367 and selected partners for five processes are {A2, B1, C3, D6, E1}.



A series of problems are randomly generated by changing the number of processes from 10 to 50 in the increment of 5. The number of candidates for each business process is varied from one to 15 candidates. The swarm sizes are taken as 10, 15 and 20. The fitness value, number of iterations and computational time needed for solution are calculated.



Computational time versus Number of Processes



Number of iterations versus Number of Processes

The required number of iterations is consistently more at small swarm size because solution diversity is not adequate enough at small swarm size. It is to be noted that comparison is made at the point when convergence of the solution is observed; not the best fitness value. The exhaustive experimentation reveals that best solution is obtained when the swarm size increases.

Conclusions

Partner selection for virtual enterprise is an important issue for improving operational effectiveness of supply chains.

The problem happens to be a combinatorial optimization problem and considered as NP-hard in nature.

There are many conflicting criteria influence at the time decision making for partner selection. Some important criteria such as link cost, link time and risk associated with partner selection are considered and solved using particle swarm optimization approach.

The encoding mechanism used in standard PSO needs modification to suit the combinatorial optimization problem so that computational time can be reduced. In this paper, a discrete version of PSO has been proposed avoiding particle velocity in standard PSO.

The particle representation and updating mechanism is explained with the help of example. Rigorous simulation studies reveal that the proposed PSO can be easily employed for solution of partner selection problem. The effect of swarm size and number of processes on solution quality has been reported.

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Thanks