Partner Selection in Virtual Enterprises by Using Ant Colony Optimization in Combination with the Analytical Hierarchy Process

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1 Summary

Within the scope of the collaborative research centre "Non-hierarchical regional production networks" at Chemnitz University of Technology, a virtual enterprise model is developed. This is based on very small performance units - the competence cells (CCs). The precondition of the efficient and thereby competitive operation of those networks is a network controlling for objectively selecting the best suitable CCs for every order. This problem gains complexity because the manufacture of a product can be carried through in different ways.

The central task within the network consists in guaranteeing the best possible realization of an order. First of all, a customer offer has to be generated to the competence cell network and the necessary CCs for the processing of the several partial performances within an order have to be selected. Thereby, a difficult economical decision problem arises for the network management. An *elemen-*

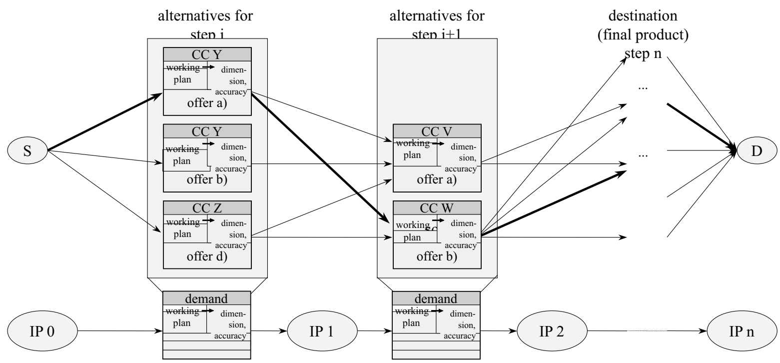

Fig. 1. Illustration of the Problem

tarized process variant plan are described exactly by the demand vectors (DV). Those define the necessary process plans in order to complete an intermediate product. According to the according DVs, the corresponding CCs are searched

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for all elements, which are potentially able to complete the performances. This means, the offer vectors (OVs) of the CCs have to be equal to the DVs to a special degree. The OV has to express the possibilities of a CC as exactly as possible and to make those comparable in order to make possible a machine evaluation.

For the optimization all manufacturing variants within the CC-offer network

begin
  $initialization(problem - structure);$
  $i = source;$
  while $not(exit - condition)$ **do**
    for $k := 0$ **to** m **step** 1 **do**
      while $(\mathcal{N}_{\mathrm{i}}^{\mathrm{k}} \neq \emptyset) \cap (\mathrm{i} \neq \mathrm{destination})$ **do**
        $random(z);$
        if $z \leq q$ **then** $p_{ij}^{k}(t) = [\tau_{ij}(t)]^{\alpha} \cdot [\eta_{ij}]^{\beta};$
          else $p_{ij}(t) = \frac{[\tau_{ij}(t)]^{\alpha} \cdot [\eta_{ij}]^{\beta}}{\sum_{l \in \mathcal{N}_{\mathrm{i}}^{\mathrm{k}}} [\tau_{il}(t)]^{\alpha} \cdot [\eta_{il}]^{\beta}};$
        fi
        $decide(j);\ \Psi_k = \Psi_k \cup CC(max(AHP(j)));$
        $/ * localPheromonupdate * /$
        $\tau_{ij}(t+1) = (1-\rho') \cdot \tau_{ij}(t) + \rho' \cdot \Delta\tau_{ij};\ i := j$
      od
    od
    $/ * globalPheromonupdate * /$
    $\tau_{ij}(t+1) \leftarrow (1-\rho) \cdot \tau_{ij}(t) + \Delta\tau_{ij}(t) \forall \tau_{ij};$
    $max - min - rule\ \ \tau_{ij};$
    $decide(L_k);$
  od
  $\Psi_k \in M: \ \forall\, \Psi_k\ \ mit\ \ L_k > \kappa \cdot L_k^* \quad 0 \leq \kappa \leq 1;$
  $compute(E_{\Psi_k, CC}\ \ \forall\ CC \in \Psi_k,\ \ K_{\Psi_k} \forall \Psi_k \in M);$
  $decide(\Psi_k^{max} : max(aggregation(MK_k, SK_k)))$
end

Fig. 2. Procedure of the Search for an optimal Manufacturing Variant

are illustrated in a *digraph*. Each manufacturing alternative includes a source, subsequently it disposes of CCs for carrying through the partial performances and finally it ends in a drain. The objective function of the algorithm is the maximization of the combined AHP-values of the CCs. The larger the value of a manufacturing variant, the more advantageous it is to realize that variant. Figure 1 illustrates the modelling as a digraph. For every step of processing along the way to the final product, several manufacturing variants exist, out of whom the best has to be selected by the help of an algorithm illustrated in Figure 2.

References

1. Teich, T., Fischer, M., Vogel, A., Fischer, J.: A new Ant Colony Algorithm for the Job Shop Scheduling Problem. In: Proceedings of the Genetic and Evolutionary Computation Conference, San Francisco, California (2001) 803