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E-mail: jzus@zju.edu.cn

# Supplementary materials for

Yuexia FU, Jing WANG, Lu LU, Qinqin TANG, Sheng ZHANG, 2024. Reputation-based joint optimization of user satisfaction and resource utilization in computing force network. *Front Inform Technol Electron Eng*, 25(5):685-700. https://doi.org/10.1631/FITEE.2300156

## 1 Reputation-based joint optimization of user satisfaction and resource utilization

### 1.1 Proof of Eq. (1)

Generally, the Bayes theorem is given by

$$\begin{aligned} P(\frac{Belief}{Observation}) &= \frac{P(\frac{Observation}{Belief})*P(Belief)}{Normalization} \\ &= \frac{P(\frac{Observation}{Belief})*P(Belief)}{P(Observation)} \\ &= \frac{P(\frac{Observation}{Belief})*P(Belief)}{\sum P(\frac{Observation}{Belief})*P(Belief)} \end{aligned} . \tag{S1}$$

### 1.2 Proof of Eq. (4)

With the binary rating model, the posterior distribution of CNRP *j*'s reputation *z* can be derived as

$$\begin{aligned} P(z) &= \frac{Bin(p+q,p)Beta(1,1)}{Normalization} \\ &= \frac{Bin(p+q,p)Beta(1,1)}{p+q+1} . \\ &= Beta(p+1,q+1) \end{aligned} \tag{S2}$$

## 2 Problem solution based on NSGA-II

**Algorithm S1** NSGA-II

**Input:** the population size PS, the probability of mutation PM, the probability of crossover CR, and the maximum number of iterations G.

**Output:**

1 Initialize the parameters for NSGA-II.
2 Generate an initial population by random means.
3 Calculate the function value of each chromosome in the population.
4 Rank the population using a fast non-dominated sorting approach.
5 Compute the crowding distance.
6 Population is sorted based on its ranks and crowding distance.
7 Produce new offspring by selection, crossover, and mutation operations.
8 Calculate the function value of offspring.
9 Combining the parent population and offspring population into a new population.
10 Rank the new population by fast non-dominated sorting approach.
11 Compute the crowding distance of the new population.
12 Create a new parent population according to the sorted result.
13 If the termination condition is not accomplished, return line 4.
14 Return Pareto optimal set.

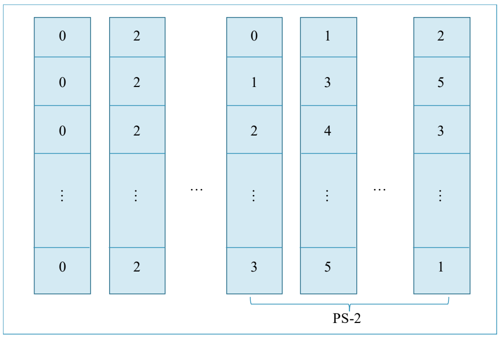


**Fig. S1 Initial population**

## 2.1 Fast non-dominated sorting approach

Pareto Constraint-Dominance: a solution $x_1$ dominates another solution $x_2$ if any of the following conditions can be satisfied:

1) $x_1$ is a feasible solution and $x_2$ is a feasible solution.

2) $x_1$ and $x_2$ are feasible solutions, and $x_1 <= x_2$.

3) $x_1$ and $x_2$ are infeasible solutions, and $CV(x_1) < CV(x_2)$.

First, we look for all non-dominated solutions in the entire population to form the first front. Then, we find the non-dominated solutions in the remaining solutions to form the second front. Repeat this process until all solutions are placed at the right front. The Pareto front denotes the set of Pareto solutions. We believe that the smaller the value of the rank, the more powerful the solution.

## 2.2 Crowding distance calculation

The CD of solution $x_i$ is the average side length of this rectangle.

$$CD_i = \begin{cases} \infty & if\ i = 1\ or\ \mathrm{h} \\ \sum_{k=1}^{Q} \frac{f_k(x_i+1) - f_k(x_i-1)}{f_k^{\max} - f_k^{\min}} & otherise \end{cases}, \quad \text{(S3)}$$

where $h$ is the number of solutions in the same front and $Q$ is the number of objection functions. $f_k^{max}$ and $f_k^{mim}$ are the maximum and minimum values of the $kth$ objection function, respectively. With larger CD, the distribution is more uniform, which can maintain the diversity of the solutions as much as possible.

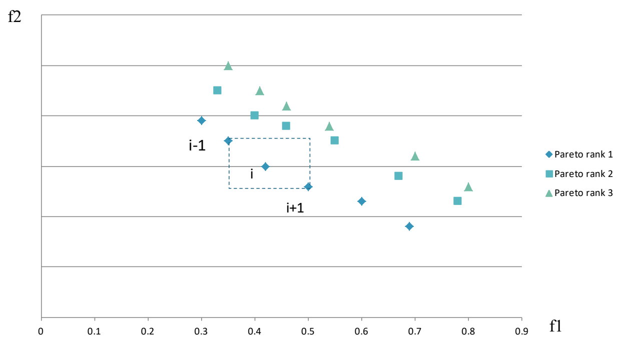


**Fig. S2 Schematic of the Pareto rank of the solution space**

## 2.3 Crossover and mutation operators

The crossover operation is performed as follows:

$$\beta = \begin{cases} \left(\frac{1}{2-2u}\right)^{\frac{1}{n+1}} & if\ u > 0.5 \\ (2u)^{\frac{1}{n+1}} & if\ u \le 0.5 \end{cases} \quad \text{(S4)}$$

$$\begin{cases} x_1^* = \frac{1}{2}(x_1 + x_2) - \frac{1}{2}\beta(x_2 - x_1) \\ x_2^* = \frac{1}{2}(x_1 + x_2) + \frac{1}{2}\beta(x_2 - x_1) \end{cases}, \quad \text{(S5)}$$

where $n$ is the spread factor distribution index and $u$ is a uniform distribution random number in range [0, 1).