The Working Operation Problem Based on Probe Machine Model

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Abstract. The working operation problem is an old problem that it is difficult to effectively solve the combinatorial mathematics. So far this problem has not been completely effectively solved, and it is an non-deterministic polynomial (NP)-complete problem. This paper mainly uses the probe machine model and combines the advantages of the nanometer-material to design a computing model for the working operation problem. It structures a database of the vertex and edge, then encodes as a probe library. Using computing platforms to get the solution to be tested, and finding all vertices of the directed Hamilton path which is the solution of the problem. The probe machine is a parallel computing model starting from the bottom; thereby it can improve the effectiveness of the calculation in theory.

Keywords: Probe machine · NP-complete problem · Working operation problem

1 Introduction

In 2016, Xu [1] and his research team reported major breakthrough article "Probe Machine" at the IEEE transactions on neural networks and learned system journal in computer science. This paper presents the first computing model beyond Turing machine [2] that is called the probe machine. It is computing model from the underlying whole of parallel. It is just one probe operation to find all solutions of problems for the NP-complete problem, while the computer can not handle today, such as Hamilton Problems, Vertex graph coloring problem, and so on. All NP-complete problems based on the Turing machine are equivalent in polynomial time, which means that it has no NP-completely problem puzzled mankind in the probe model. Some peering works on DNA computing can be found in [6–8].

The probe machine is divided into two types of transfer and connection. The probe machine is composed by the database, the probe libraries, data controller, the controller probe, probe computing, computing platform, the detector, the true solution, and residual memory support recycling. In order to composite nano-particles and DNA molecules as data and make use of the DNA molecule

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as probe, the probe machine of connection type will be introduced. So it is the nanometer DNA computer. The difference with the Turing machine is: the data of the probe machine is free on placement pattern space, and it can be directly processed information between any pair of data, which indicates a powerful parallelism with the increase of the size of the data, with the increasing size of data, and the information processing capabilities dramatically.

The working operation problem for the production process is an important problem for the organization. It is a variety of parts, and how to arrange the appropriate equipment and decided on their order processing should be firstly considered. To enhance efficiency, it is beneficial for full using the equipment and shortening the production cycle. Here, we introduce a variety of jobs on a single machine production working operation problem.

We can suppose machine that it must manufacture a variety of parts J_1, J_2,...,J_n. For example, in a factory, each job J_i is a type of mold. In order to manufacture next job, machine must be adjusted after a job. If the adjustment time is t_{ij} from J_i to J_j parts, we seek a machining order that the entire machinery of the adjustment period is least. In fact, this problem seeks for the smallest weight to the directed Hamilton path in a weighted directed graph. At present, there is no known effective method. First we have to translate the problem into the directed graph G:

(1) The job $J_i, i = 1, 2, \cdots, n$ is represented vertex v_i of the directed graph G.
(2) A is an arc set of the directed graph G, and $(v_i, v_j) \in A$ if and only if $t_{ij} \leq t_{ji}$.
(3) Empowering t_{ij} to arc (v_i, v_j).

Thus, a working operation problem is corresponding with a directed Hamilton path of the minimum weights sum of directed weighted graph. The vertex order of the directed Hamilton path is corresponding to processing the order of the job.

This paper attempts to use the connection type probe computing model for working operation problem. Since the underlying model is an efficient full parallel resistance, it can be more effective for working operation problem.

2 The Probe Computing Principles

The probe machine includes nine sections, which are $X, Y, \sigma_1, \sigma_2, \tau, \lambda, \eta, Q, C$, respectively. The database X includes n data pool $X_1, X_2, X_3 ... X_n$. Each data pool X_i stores huge element x_i. Each cell consists of data and data fiber. And data cell has only one, but the data types of fibers has p_i, as shown in Fig. 1.

The probe of biological computing is used to detect a nucleotide sequence, wherein the molecular beacon has been widely used and developed as a new type of fluorescent probe in recent years [3–5]. The probe machine is similar to an existing probe meaning, but it is an abstract concept. If x_i^l and x_t^a can be the probe, it can be connected with the data elements x_i^l and x_t^a by connected probe

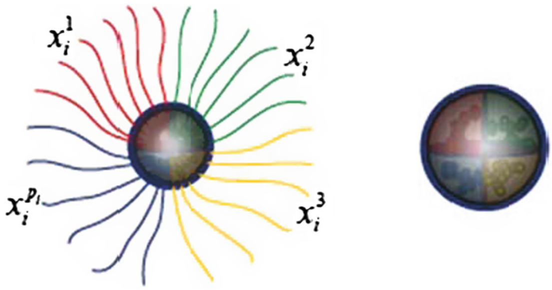


Fig. 1. The structure of data cell

$\tau^{x_i^l x_t^a}$. It is named operator connection, denoted by $\tau^{x_i^l x_t^a}$. Its direction is from x_i to x_j. According to the data types of fiber, we structure the probe pool Y_{it}, and different probe pools constitute a probe library Y (Fig. 2).

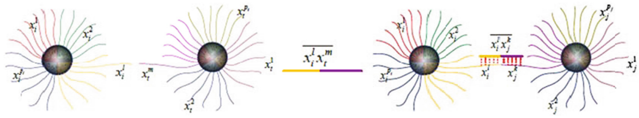


Fig. 2. The diagram of the connect operator process

The data controller σ_1 and the probe controller σ_2 respectively take the required number of data and probes into the computing platform λ. Be probe operation, and then through the detector η. Will be the result, respectively, in the true solution storage Q or residual limb collector C.

3 The Working Operation Problem Description

The paper uses a specific example to illustrate the molecular processes operating methods of the problem. Assuming that a machine can product 5 jobs $J_1, J_2, \cdots, J_5$. End processing needs change after J_i in order to process J_j. We know that the time required when we change from the mold of J_i to J_j are shown in the adjust matrix. First of all, we make the working operating problem matching to the graph G. For the encoding operation and convenience, we consider a simple working operating problem. Even to the DNA computing, the problem is still difficult. Although the figure can easily see that the best sort of work, but with our approach, the more complex plans can also be calculated, and it is almost difficult. If the degree of difficulty on the difference, it is only in the encoding and molecular aspects of the operation of the pilot in a little more trouble. We introduce the above-mentioned algorithm corresponding to the molecular steps.

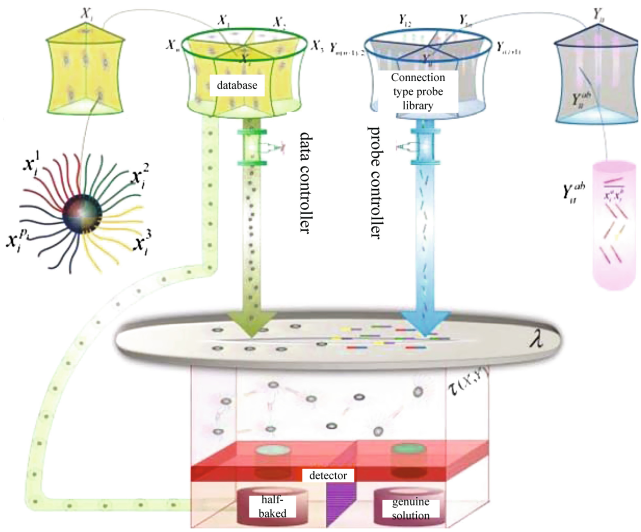
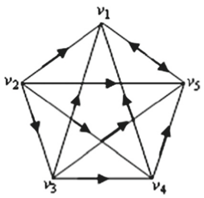


Fig. 3. A structure model for the connection type of probe machine



	J_1	J_2	J_3	J_4	J_5
J_1	0	6	4	5	1
J_2	2	0	1	3	2
J_3	3	4	0	1	2
J_4	1	5	6	0	1
J_5	1	3	4	3	0

Fig. 4. The graph of working operation problem and its adjust matrix

Algorithm
Step1 Structure database X.

$$X = \bigcup_{i=1}^{n} E^2(v_i)$$

Among them $E^2(v_i)$ is a set of directed two long that v_i is the center. Any directed two long $(v_l v_i v_j, i \neq l, j, l \neq j)$ is named x_{ilj}, and every x_{ilj} has two data fibers, be named x_{ilj}^{l}, x_{ilj}^{j}. Its direction is from v_l through v_i to v_j. In this example, database is:

$$X = \bigcup_{i=1}^{n} E^2(v_i), i = 1, 2, 3, 4, 5$$

$$E^2(v_1) = \{x_{125}, x_{135}, x_{145}\}$$
$$E^2(v_3) = \{x_{324}, x_{321}, x_{325}\}$$

$$E^2(v_4) = \{x_{431}, x_{421}, x_{435}, x_{425}\}$$
$$E^2(v_5) = \{x_{541}, x_{531}, x_{521}\}$$

Structure database according to Fig. 3. There have 13 types data, and 13 types data fibers, among that the length of data fiber is directly proportional to the weight in the examples.

Structure of 13 types of nanometer particles (2.5 nm) as 13 types data cell. Code DNA sequence for 13 type data fibers, and then synthesize corresponding DNA strands. Thus, DNA strands (data fibers) embed in the corresponding nanometer particles (data cell).

$$\Im(x_{125}) = x_{125}^5, \Im(x_{135}) = x_{135}^5, \Im(x_{145}) = x_{145}^5, \Im(x_{324}) = x_{324}^4, \Im(x_{321}) = x_{321}^1$$
$$\Im(x_{325}) = x_{325}^5, \Im(x_{431}) = x_{431}^1, \Im(x_{421}) = x_{421}^1, \Im(x_{435}) = x_{435}^5, \Im(x_{425}) = x_{425}^5$$
$$\Im(x_{541}) = x_{541}^1, \Im(x_{531}) = x_{531}^1, \Im(x_{521}) = x_{521}^1$$

Step2 Structure probe library based on the conditions of the probe.

In the example, to avoid small elements gathered by the probe after the operation, and affect the calculation, design of probe conditions between two elements is:

Between data x_{ilj}, x_{tab}, the probe need to meet and only meet one of the following conditions

$$(1)\ |\{i, l, j\} \bigcap \{t, a, b\}| = |\{l.j\} \bigcap \{a, b\}| = 1$$

$$(2)\ t \in \{l, j\}, i \in \{a, b\}, and |\{l, j\} \bigcap \{a, b\}| = 0$$

Structure the corresponding probe pool for the different data fibers, and structure a probe library. The structure of the probe is on the basis of the Xu Jin's probe principle [1].

These probe libraries include 31 probes.

$$Y_{13} = \{\overline{x_{321}^1 x_{125}^5}, \overline{x_{321}^1 x_{135}^5}, \overline{x_{321}^1 x_{145}^5}$$

$$Y_{14} = \{\overline{x_{431}^1 x_{125}^5}, \overline{x_{431}^1 x_{135}^5}, \overline{x_{431}^1 x_{145}^5}, \overline{x_{421}^1 x_{125}^5}, \overline{x_{421}^1 x_{135}^5}, \overline{x_{421}^1 x_{145}^5}$$

$$\begin{aligned} Y_{15} = \{&\overline{x_{541}^1 x_{125}^5}, \overline{x_{541}^1 x_{135}^5}, \overline{x_{541}^1 x_{145}^5}, \overline{x_{531}^1 x_{125}^5}, \overline{x_{531}^1 x_{135}^5}, \overline{x_{531}^1 x_{145}^5}, \\ &\overline{x_{521}^1 x_{125}^5}, \overline{x_{521}^1 x_{135}^5}, \overline{x_{521}^1 x_{145}^5}, \overline{x_{125}^5 x_{541}^1}, \overline{x_{135}^5 x_{541}^1}, \overline{x_{145}^5 x_{541}^1}, \\ &\overline{x_{125}^5 x_{531}^1}, \overline{x_{135}^5 x_{531}^1}, \overline{x_{145}^5 x_{531}^1}, \overline{x_{125}^5 x_{521}^1}, \overline{x_{135}^5 x_{521}^1}, \overline{x_{145}^5 x_{521}^1}\} \end{aligned}$$

$$Y_{34} = \{\overline{x_{324}^4 x_{431}^1}, \overline{x_{324}^4 x_{435}^5}, \overline{x_{324}^4 x_{421}^1}, \overline{x_{324}^4 x_{425}^5}\}$$

$$Y_{35} = \{\overline{x_{325}^5 x_{531}^1}, \overline{x_{325}^5 x_{541}^1}, \overline{x_{325}^5 x_{521}^1}\}$$

$$Y_{45} = \{\overline{x_{435}^5 x_{541}^1}, \overline{x_{435}^5 x_{531}^1}, \overline{x_{435}^5 x_{521}^1}, \overline{x_{425}^5 x_{541}^1}, \overline{x_{425}^5 x_{531}^1}, \overline{x_{425}^5 x_{521}^1}\}$$

Step3 Perform the operation and obtain the feasible solution. After testing platform, we get all the solution of a problem.

The probe machine takes the required number of data, the probe from the probe pool in the database, the probe library for the quantity of data using the data controller σ_1, and the probe controller σ_2, and putting into the computing platform, respectively. Then performing the operation. Through the specific hybridization reaction between DNA molecules, under the effect of computing platform, a variety of types of data aggregations are formatted. Get all of the possible solutions.

Step4 Test solution. Detector puts polymers into the memory of the true solution, and puts the rest of the polymer in the remnants of collector. Due to the design of the data fiber, making its length is proportional to the weight of sample, finally formed by detecting the order of working operation problem (Fig. 4).

$$J_2 \rightarrow J_3 \rightarrow J_4 \rightarrow J_5 \rightarrow J_1$$

4 Conclusion

The probe machine model is a mathematical model, and its data storage form make it has strong parallelism. To deal with the problem of the working operation problem, after a probe operation we can obtain all possible solutions. Compared with other models, the model greatly reduces the complexity of the operation process. Probe machine model expands the traditional notions of calculation as a new research direction, and owns a profound meaning relative to the computer and other subjects. However, we still face so many challenging problems in the question of what kind of material in this model.

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