International Journal of
Science and Engineering Investigations vol. 1, issue 8, September 2012
ISSN: 2251-8843

Nephron Algorithm: A New Solution to the 0-1 Linear Programming Problem

Reza Behmanesh
Dept. Accounting, Khorasgan (Isfahan) Branch, Islamic Azad University, Isfahan, Iran
(rezaehs@yahoo.com)

Abstract- Many optimization problems are assumed as NP-complete and on the other hand, some researchers are to find the fast algorithms to solve these. Moreover, algorithms such as DNA, GA are the most usable in solving NP-complete problems because of their high density computation. Besides, there exist several proposed approaches to resolve this problem. However, a different methodology is proposed due to its powerful discriminatory performance, in this paper. For this purpose, the nephron algorithm (NA) as a biological computation was inspired based of nephron performance because of its intelligent screening. It can be applied as data mining technique in order to excrete infeasible as well as non optimized solutions. Therefore, optimized solution will be figured out after these cyclic and repeated operations. To illustrate the proposed model, the example of 0-1 linear programming (LP) was taken into account. Consequently, applied model is supposed to solve 0-1 LP precisely and accurately according to intellectual logic of nephron.

Keywords- *Nephron algorithm; 0-1 linear programming; and Knapsack problem.*

I. Introduction

Recently, many combinatorial optimization problems were considered very important. It must be pointed out that these problems are playing key role to other sub problems both of industrial and academic institutes. However, these are known as NP-complete problems. On the other hand, several theorists as well as practitioners are to seek fast approaches and methodologies so as to solve optimization problems. Although, there are various algorithms for solving such problems, but now days data mining (DM) algorithms such as decision tree (DT), artificial neural network (ANN), and some biology methods like genetic algorithm (GA), and deoxyribonucleic acid (DNA) were applied to solve linear programming as well as non linear programming because of their high density computation in solution. In the first time, DNA was applied to solve an instance of directed Hamiltonian path problem as molecular biology (Adleman, 1994). Besides, nephron algorithm (NA) was used to solve supplier selection problem as biological computation, for the first time (Behmanesh & Rahimi, 2012). In this study, NA is applied as new approach to solve 0-1 LP.

II. Literatures

A. *Binary knapsakc (BKP) problem*

In recent decade, knapsack problems have been studied drastically. These problems attract practitioners as well as researchers. From view point of a researcher, this theory allows us to exploit a number of combinatorial properties, besides, more complex optimization problems to be solved throughout a series of knapsack-type problems. On the other hand, according to practitioner's opinion, these problems can model not only industrial cases such as cargo loading, cutting stock, and capital budgeting, but also most classical applications. Assuming that we want to fill up a knapsack problem by selecting some objects among various objects (generally called items). There are n several items available and each item j has a weight of w_j and a profit of p_j. The knapsack can hold a weight of at most W. The problem is to find an optimal subset of items in order to maximize the total profits subject to the knapsack's weight capacity. The profits, weights, and capacities are positive integers. Let x_j be binary variables given as follows:

$$x_j = \begin{cases} 1 & \text{if item } j \text{ is selected,} \\ 0 & \text{otherwise.} \end{cases}$$

The knapsack problem is formulated mathematically as below.

$$\begin{aligned} \max \quad & \sum_{j=1}^{n} p_j x_j, \\ s.t. \quad & \sum_{j=1}^{n} w_j x_j \le W, \\ & x_j = 1 \ \ or \ \ 0, \qquad j = 1,2,\dots,n. \end{aligned}$$

This equation is known as 0-1 knapsack problem that constitutes a one of the most important class of integer programming (Darehmiraki & Mishmast, 2007).

B. Nephron

A nephron (from Greek νεφρός (nephros) meaning "kidney") is defined as the principal structural and functional unit of every kidney. Its basic function is to regulate water and soluble substances by filtering the blood, reabsorbing what is needed and excreting the rest as urine. Nephrons eliminate wastes from the body. As it is indicated, its function is vital to life (Maton et al., 1993). Each nephron is composed of an initial filtering component (the "renal corpuscle") and a tubule specialized for reabsorption and secretion (the "renal tubule", which is the portion of the nephron containing the tubular fluid filtered through the glomerulus). The renal corpuscle filters out large solutes from the blood, delivering water and small solutes to the renal tubule for modification. About 20% of the blood plasma is forced out of glomerulus (specialized capillaries) and across the membrane Bowman's capsule. It applies to filter some of the substances that are located in blood plasma from others (University of Colorado, 2007).

The components of the renal tubule are (Fig1.):

- Proximal convoluted tubule (PCT)
- Loop of Henle (hair-pin like i.e. U-shaped and lies in medulla)
- The ascending limb of loop of Henle is divided into 2 segments: Lower end of ascending limb is very thin and is lined by simple squamous epithelium. The distal portion of ascending limb is thick and is lined by simple cuboidal epithelium.
- Thin ascending limb of loop of Henle
- Thick ascending limb of loop of Henle (enters cortex and becomes DCT-distal convoluted tubule.)
- Distal convoluted tubule (DCT) (Behmanesh & Rahimi, 2012)

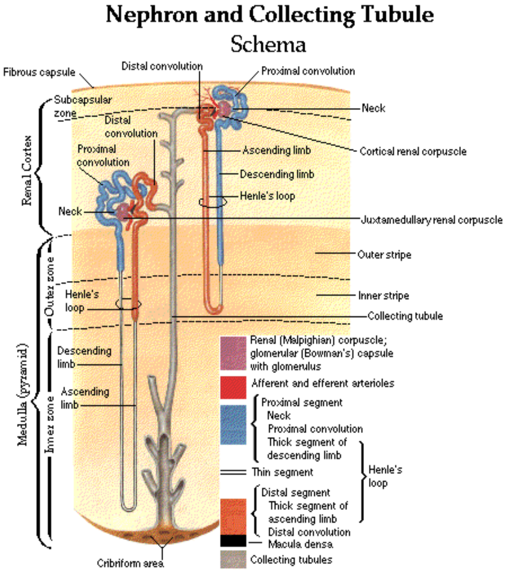

Figure 1. Nephron anatomy

Also, in one study (Mishmast & Hamidi, 2012; 2007), one counterexample was provided to illustrate applying DNA algorithm not only for 0-1 knapsack but also for quadratic assignment problems (QAP). It was demonstrated that DM algorithms such as DNA, GA are the most usable in solving NP-complete problems because of their high density computation. As it was indicated, several biological computations of the solution were presented to aforementioned problems. In one research conducted (Behmanesh & Rahimi, 2012), nephron algorithm as a biological computation was applied to resolve supplier selection problem by clustering as well as prioritizing suppliers according their attributes and scores respectively. Nephron algorithm, which was inspired of nephron performance, made valid results of classification with accuracy of 0.79.

III. Methodology

Several s, data mining methods are suitable because of their well-known accuracy rate.

In this paper, nephron algorithm is proposed in order to resolve the 0-1 knapsack problem. Aforementioned algorithm was inspired based on natural nephron performance so that infeasible solutions are separated and excreted step by step. Role of nephron in separating and screening of solution series is important; this algorithm can aid us to separate bad stuffs (infeasible & non optimized solutions) from good stuffs (optimized solutions) among whole solutions, correspondent with principals of nephron performance. The rules of nephron are able to discriminate bad and good stuffs step by step so that finally, the best stuffs will be deposited out of nephron and the rest will exited as infeasible and non optimized solutions cluster by cluster in each stage.

In order to conduct the research, four-step methodology is proposed:

1. *Filtration*: according to rule of filtration in nephron, 20 percent of whole solutions must be input of it, so for this purpose, 20% of whole series was considered as filtrating criteria of this part. Therefore, solution series, which have more 0, will enter to nephron, whereas, the other not be filtrated and will be deposited in vein.
2. *Reabsorption*: this operation is done in PCT part of nephron, some existing solution series in nephron must be entered to vein based on this rule. So, data will be transferred to vein so as to belong to feasible solutions or to produce optimizing.
3. *Secretion*: this operation is carried out in DCT part of nephron, some existing solution series in vein must be entered to nephron based on this rule. So, data will be transferred to nephron so as to belong to in feasible solutions or to produce none optimizing.
4. *Excreting and repeating*: according to this step, existing data of nephron must be excreted as bad data and the rest data of vein must be passed 3 previous steps till the best data is deposited in vein as optimized solution.

5. *Termination condition*: if stopping criteria are met, then stop, else go to filtration step.
   - Assuming that solution was reabsorbed more than twice.
   - Provided that the filtration step can not be fulfilled based on mathematical rules (20% of the rest data in vein can not be calculated), as a result, there is no solution to enter to nephron.

The algorithm includes of filtration, reabsorption, secretion, and excretion is presented in Fig2. That is inspired by performance of natural nephron.

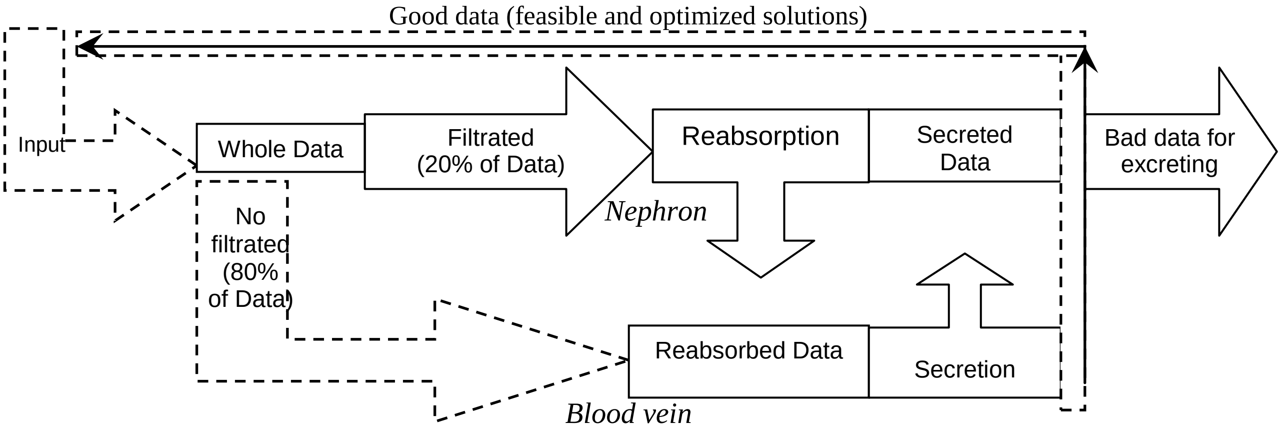

Figure 2. Theoretical (conceptual) framework

IV. Numerical illustration and results

A. Algorithm

In this part, the algorithm procedure of nephron for solving the 0-1 linear programming problem is in accordance with following manner (it is pointed out that each step is introduced as one function in programming):

Step 1: Define objective function and constraints.

- Define z as objective function.
- Define c_1 to c_i as m constraints.

Step 2: Define strand.

- Define j as number of decision variables.
- Define x = 0 or 1 as content of strand.
- Define c=1 as counter.

Step 3: Come up with solution space.

- Define $n = 2^j$ as number of all solutions.
- Generate n solutions with content of (0 or 1) in j number, according to array s_k[] (s_1, s_2, ..., s_n).

Step 4: Sorting.

- Sort (s_1, s_2, ..., s_n) according to 2 criteria : the sum of contents of s, and priority the 0 to 1.

Step 5: Filtration.

- Define c_f = 0.2 as filtration criterion.
- Define $n_f = c_f \times n$ as filtration solution numbers.
- Select n_f out of n sorted solutions as input to nephron.
- Select (n - n_f) out of n solutions (rest) as input to vein (n_r).

Step 6: Reabsorption.

- For (k=1; k <= n_f ; k++)
- {For (i=1; i <=m ; i++)
- {If (c_i is FALSE)
- Break;
- Else{if (i ==m){Reabsorb (s_k) , n_r ++}}}}
- if ($n_{r==}$ n) {For (k=1; k <= n_f ; k++)
- {Compare (z (s_k)) , select (z_{max}), Reabsorb (s_k)}}
- Else{Verify (Reabsorb (s_k))
- if (c=>2) go to step 9}
- If (p==k){c++}else {p=k}

Step 7: Secretion.

- For (k=1; k <= n_r ; k++)
- {For (i=1; i <=m ; i++)
- {If (c_i is TRUE)
- Continue;
- {Secrete (s_k) , n_r -- , break;}}}

Step 8: Excreting and repeating.

- $n = n_r$, Go to step 5 and repeat steps 6 & 7

Step 9: Termination.

- If(n==0 or c=>2)
- {Compute z (s_k) as optimized}

B. Data

The numerical example was taken into account for illustration of the nephron algorithm application in solving 0-1 knapsack problem. Therefore, zero one linear programming example was considered and it is indicated as follows:

$$\begin{aligned}
&Max \quad z = 3x_1 + 2x_2 - 5x_3 - 2x_4 + 3x_5 \\
&s.t. \\
&x_1 + x_2 + x_3 + 2x_4 + x_5 \le 4 \\
&7x_1 \qquad + 3x_3 - 4x_4 + 3x_5 \le 8 \\
&11x_1 - 6x_2 \qquad - 3x_4 - 3x_5 \ge 3 \\
&x_j \in \{0,1\} \quad , j = 1,2,...,5
\end{aligned}$$

C. Implementation and computation

In the first place, before applying the algorithm, the set of solution strands must be simulated in memory space, according to item *j* (number of decision variables) as below:

$$\{00000, 00001, 00010, 00100, ..., 11110, 11111\}$$

Next, solution series are sorted ascending and are tagged according their sorter number. All solution series were considered as data, which are selected as input to nephron, and then 20% of data based of their descending tag number is filtrated as filtration solution series.
For example: Let j=5, so n as number of solutions $=2^5=32$;
Then, 20% of 32 (as n_f) is $6.4 \cong 6$;

Filtrated strands					Tag No.
0	0	0	0	0	1
0	0	0	0	1	2
0	0	0	1	0	3
0	0	1	0	0	4
0	1	0	0	0	5
1	0	0	0	0	6

In reabsorption phase, the feasible solutions among filtrated are reabsorbed, in the event that least two filtrated data were feasible, the optimized solution among them must be considered as reabsorbed solution and thereby, others are remained in nephron.

In secretion step, some data (solution sets) of vein must be secreted into nephron for eliminating infeasible solutions as well as non optimized solutions. For this aim, a criterion for secretion data by nephron is correspondent with infeasible solution.

As it is shown, after the 3rd step, worst data based on their infeasibility and non optimized solutions were separated from whole data, and then these are ready to excrete by nephron. In addition to excreting in last phase, the rest from vein must be processed again in algorithm and previous steps are repeated for them. One of the nephron algorithms cycle (repeating) is indicated in Fig 3. These processes (1st three steps) are repeated 2 times and solution with tag no. of 16 (11000) is reabsorbed more than twice and hence according to rule of termination, the optimized solution is acquired. So, optimized dependent variable will be (z = 5) based of solution set (x_1=1, x_2=1, x_3=0, x_4=0, x_5=0).

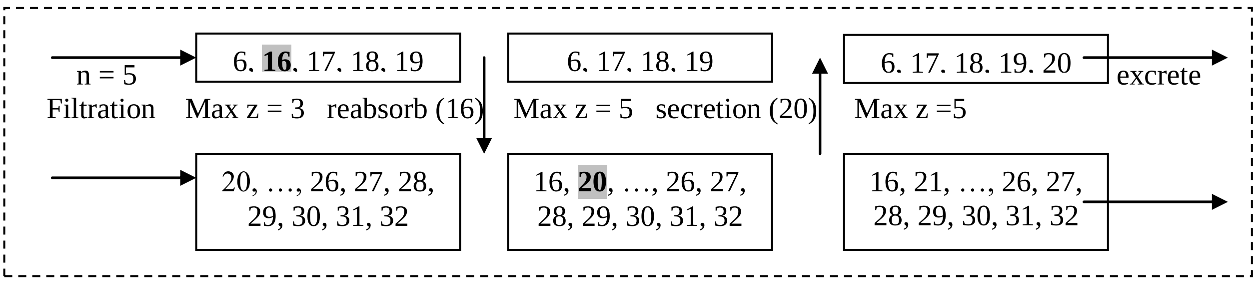

Figure 3. Figuring the 2th cycle

Advantage of this methodology in comparison with other techniques is to prioritize the data as well as to categorize homogenous data step by step. This algorithm aids us to discriminate data from each other along with ranking the data accurately. Innovation of this paper is to apply the simulated NA not only to eliminate infeasible data but also to rank them by NA learning as a data mining approach as well as a screening algorithm.

V. CONCLUSION

In this paper, we studied on solving 0-1 linear programming problem. There are various parametric and non-parametric methodologies, which were applied to this solution. Several researches were conducted on this issue in order to model industrial cases and classical applications. In this study, the methodology was employed in order to achieve optimized solution by deleting or eliminating some infeasible randomly, and then accepting optimized feasible solution step by step. The proposed algorithm was presented based upon natural nephron performance in kidney as a meta-heuristic so as to improve solution data step by step because of its discriminatory power and its excreting power for bad stuffs. The nephron algorithm was employed in order to separate the best data (solutions) from the worst data (solutions) according to their feasibility as well as their optimizing role for the first time. Optimization and feasibility are two issues, which are taken into account in researches simultaneously, thus nephron is able to play key role in screening, discriminating, and identifying data in order to make optimized solution. Consequently, the nephron computed the 0-1 problem according to its special algorithm accurately. It is pointed out the nephron algorithm is applied in order to resolve 0-1 linear programming as innovative application, and thereby, this proposed model with capabilities such as reabsorption and secretion functions can be improved in next researches in order to enhance accuracy in computation.

Aim of this paper is to introduce nephron meta-heuristic technique as a biological computer for optimization and to solve the 0-1 linear programming problem. Furthermore, it can be applied as optimization technique to resolve other LP and also NLP. Therefore, it is suggest applying optimized nephron algorithm with design of experiments (DOE) in resolving 0-1 LP problems for future researches.

REFERENCES

[1] Adleman, L., (1994). Molecular computation of solution to combinatorial problems. Science, vol. 266, pp. 1021‑1024.

[2] Darehmiraki, M., Mishtmast N., H., (2007). Molecular solution to the 0-1 knapsack problem based on DNA computing. Applied Mathematic and Copmputation, vol.187, pp.1033-1037.

[3] Darehmiraki, M., Mishtmast N., H., (2007). A surface-based DNA algorithm for solving binary knapsack problem. Applied Mathematic and Copmputation, vol.188, pp.1991-1994.

[4] Mishtmast N., H., Hamidi, F., (2012). A comment on biological computation of the solution to the quadratic assignment problem. Applied Mathematic and Copmputation, vol.218, pp.10759-10761.

[5] Behmanesh, R., Rahimi, I., (2012). Nephron algorithm: a new approach for rank-oriented clustering case study supplier selection of multinational company. IJSEI, vol. 1, No. 7, pp. 29-35.

[6] Ecology & Evolutionary Biology - University of Colorado at Boulder. "The Kidney Tubule I: Urine Production. Retrieved March 6, 2007, from http://www.colorado.edu/eeb/web_resources/cartoons/nephrexl.html.

[7] Maton, Anthea; Jean Hopkins, Charles William McLaughlin, Susan Johnson, Maryanna Quon Warner, David LaHart, Jill D. Wright (1993). Human Biology and Health. Englewood Cliffs, New Jersey, USA: Prentice Hall. Retrieved august 7, 2012, from http://en.wikipedia.org/wiki/Nephron.

R. Behmanesh from Iran, with birth date of 3/2/1979. B.A. degree of mining engineering from Isfahan University of technology, Isfahan, Iran graduated in 30/8/2001. M.A. degree of Industrial engineering from Yazd University, Yazd, Iran graduated in 30/8/2010. He is currently PHD student of industrial engineering in Universiti putra Malaysia (UPM), Malaysia. The author’s major field of study is supply chain management (SCM), Quality control (QC), and data mining techniques include Neural Networks (NNs), Decision tree (DT), DNA, and technique of Data Envelopment Analysis (DEA).

He has 3 years job experience in EORC as a planner in maintenance workshop, he has accompanied with 6sigma team in the course of 6 month in order to decline response time of maintenance process. His first publications pertain to prioritizing the improvable HRM process in EORC which has been published in IEEE. His next is about same issue extensively, but it was published in the journal of operation and product management. His current research interest is to predict supplier's performance using new data mining methods.