

Searching Algorithm for Match Mapping in Kidney Exchange Program

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Abstract—Before kidney transplant is performed, the kidney donor and the kidney recipient must be a compatible pair. In reality, it's not uncommon that incompatibility occurs between the donor-recipient pair. To solve this problem, Kidney Exchange Program was created so that an incompatible pair can exchange the kidney to another incompatible pair, making cross donation easier. But to search for the optimal match map from incompatible pairs pool is not an easy task. Match map searching algorithm is an algorithm created for this task. Edmond's Algorithm, the existing algorithm, is suboptimal because it closes the possibility of three or more-way exchanges. Therefore, in this paper, by modifying existing two-way match map searching algorithms, N -way match map searching algorithm is implemented. Based on the test results, using 3000 incompatible pairs data, it is proven that N -way match map searching algorithm is superior in terms of matching efficiency compared to the two-way match map searching algorithm. The increase in matching efficiency obtained on average reaches 7.75% in comparison to the matching efficiency obtained by Edmond's Algorithm.

Index Terms—kidney transplantation, kidney exchange, match map searching algorithm

I. INTRODUCTION

Every year, in Indonesia alone, there are more than 100,000 patients with kidney needs. But among those patients, only about 20% can get a kidney transplantation [1]. There are many types of problems that leads to this condition, for example financial problems, public opinions, and the most common, kidney availability. This availability problem arises because many criteria must be met before kidney transplant can be performed [1]. The donor needs to have a healthy kidney, matching blood type, and no blood-borne diseases. Also, the patient's immune system must be able to accept the donor's kidney without killing it.

A. Kidney Transplant Prerequisites

TABLE I
BLOOD TYPE COMPATIBILITY BETWEEN PATIENT AND DONOR [2]

Donor \ Recipient	O	A	B	AB
O	1	0	0	0
A	1	1	0	0
B	1	0	1	0
AB	1	1	1	1

The blood type test, is performed to both the donor and the recipient. Donors can only make a donation if one's blood type is compatible with the recipient's blood type. In Table I, number 1 indicates compatibility and 0 indicates incompatibility. Donors with blood type O are considered Universal Donors because they can give donors to every patients regardless of the blood type. Recipients with blood type AB are considered a Universal Recipients because they can accept kidney donation from every donors regardless of the blood type [3]. The immune test is performed after the donor-recipient pair passes the blood type test [4]. The tests are cross match test and Human Leucocyte Antigen (HLA) test. In cross match test, donor's blood are met with recipient's blood to see whether there is a resistance reaction from recipient's immune system. The resistance reaction happens when the donor kidney is considered a foreign object that must be killed by recipient's immune system [5]. HLA test tests the same reaction as cross match test, but donor's and recipient's tissue cells are being used instead of blood [6]. Finally, to test whether the donor has any blood-borne diseases, serology is performed [5].

B. Kidney Exchange Program

Because of kidney transplant prerequisites, Kidney Exchange program named Kidney Paired Donation (KPD) was created [2] so that an incompatible donor-recipient pair can exchange their incompatible kidney to another incompatible pair, making cross-donation possible. The kidney exchange can be done two-way and can go up to N -way.

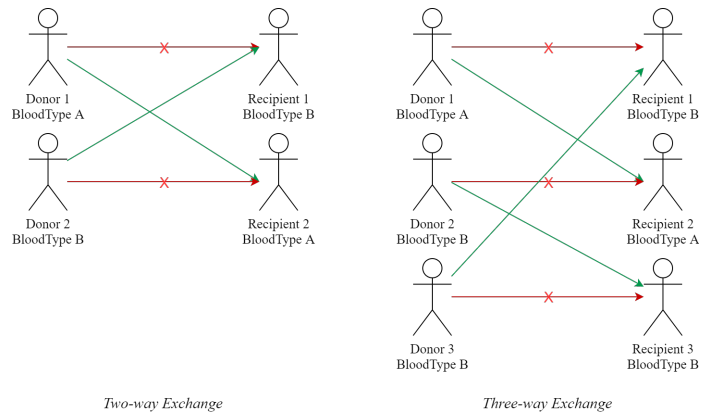


Fig. 1. Two-way(left) and Three-way(right) Exchange in KPD program

Unfortunately, because of the large number of incompatible pairs, hospitals cannot find the optimal matching solution for the pool of incompatible pairs. An algorithm that perform a mapping search is needed to address this issue. One of the most known algorithm to tackle this problem is Edmond’s Algorithm [2]. In Edmond’s Algorithm, the pool of incompatible pairs are represented as a graph with each node representing an incompatible pair and each edge representing a match between two incompatible pairs. The algorithm focuses on high priority pairs so that pairs who need a transplantation more can get an exchange first. Another algorithm regarding this problem is First Accept Heuristic Match [2] which focuses more on the heuristic if one registers first, then one gets an exchange first.

These algorithms are called Match Map Searching Algorithms. There are two performance metrics to evaluate these algorithms. The first one is Matching Efficiency, which measures the number of donor-patient pairs that matched another pair and were able to exchange divided by the total number of donor-patient pairs, represented in a percentage. The second metric is execution time, which measures how long does the algorithm run to get the optimal match map, usually measured in millisecond. The best match map searching algorithm is the algorithm that can produce high matching efficiency with low execution time. Meaning that many patients can be saved as fast as possible.

As good as it looks, Edmond’s Algorithm and First Accept Heuristic Match can only find two-way exchanges from the incompatible pairs pool. Meaning these algorithms are not able find a solution with three-way exchanges or more, closing the possibility.

II. METHODOLOGY

From the existing algorithms problems addressed in the previous section, match map searching algorithms that can find N -way exchanges from incompatible pairs pool are needed.

A. Maintaining the Integrity of the Specifications

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B. Units

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$$a + b = \gamma \quad (1)$$

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TABLE II
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Table Head	Table Column Head		
	Table column subhead	Subhead	Subhead
copy	More table copy ^a		

^aSample of a Table footnote.

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IV. RESULTS AND ANALYSIS

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V. RELATED WORK

this is still a template

VI. CONCLUSION

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ACKNOWLEDGMENT

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For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [?].

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