Comparison between Double Stranded DNA with Restriction Enzymes and Single Stranded DNA with Primers for Solving Boolean Matrix Multiplication

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***Abstract*— Boolean matrix multiplication is the basis for most computing algorithms and is widely used in many fields. In this paper, we compare and discuss two methods to solve Boolean matrix multiplication with DNA computing. The first method utilizes double stranded DNA sequences with Restriction Enzymes meanwhile the second method utilizes single stranded DNA sequences with primers. We prove that while both methods are able to solve the Boolean matrix multiplication problem, these two methods differ in their performance and output results. We compare the advantages of the latter method in terms of easier sequence designs and more efficient analysis of results.**

***Index Terms*—DNA Computing; Bio-Inspired Computing; Boolean Matrix Multiplication; Graph Problem.**

I. INTRODUCTION

Matrix multiplication problem is a basic problem which is heavily utilized in areas such as signal processing, graph theory, parallel computing and digital control. In matrix multiplication problems, the zero-one data in matrices are widely applied in network fault identification, social networks, data mining, knowledge management and clustering analysis [1]. In computing, a number of approaches are proposed to implement matrix multiplication in parallel systems for higher performance. However, the current sequential computers have their limits in providing high performance computing due to the bottlenecking factor of Moore's Law. As an alternative to sequential computers, deoxyribonucleic acid (DNA) computing has emerged as a new computation medium. DNA computing attracts researches from various fields due to its massive parallel processing capabilities. The DNA computer is estimated to possess 104 faster computing prowess than the speed of supercomputers in a mix of mix of 1018 DNA strands [2]. Although the idea of using nature for computation is not exactly new, physical implementation of DNA computation was only proven by L. M Adleman in 1994 when he solved a seven-node Hamiltonian Path Problem. The computation was carried out by encoding the problem in double stranded DNA molecules and using bio-molecular tools to execute the computation [3]. Based on Adleman's architecture, many other proposals to compute Boolean operations using DNA have been published including a proposal to compute Boolean matrix multiplication by John S. Oliver in 1998, which also proposed using double stranded DNA oligonucleotides and restriction enzymes for executing the DNA computation [4]. In this paper, we compare two approaches to solve Boolean matrix multiplication with DNA computing. The first method utilizes double stranded DNA sequences with Restriction Enzymes and the second method utilizes single stranded DNA sequences and primers. We aim to compare these two methods and study the differences in the extraction outputs when using Restriction Enzymes as cutting reaction in DNA computing and primers as indicators for row and column in matrices.

II. BOOLEAN MATRIX MULTIPLICATION

Two matrices X and Y and their product matrix can be translated into a directed graph whereby the first column indicators in the first matrix X are denoted as initial vertices, the second column indicators in the matrix X and first column indicators in the matrix Y are the intermediate vertices, while the second column indicators in the matrix Y denoted as the terminal vertices. In such a way, the product matrix column indicators are consists of initial and terminal vertices and for each value of 1 indicators, an edge is created to link a vertex to the corresponding vertex, while no edge is created for the value 0. The values of the elements in the product matrix are later determined by the existence of path from an initial vertex to a terminal vertex by the connection of edges via the intermediate vertices. An example of such Boolean matrix multiplication is shown as in Figure 1 consisting of two matrices X and Y and their product matrix Z in (a) and its directed graph representation of initial vertices, intermediate vertices, terminal vertices and corresponding edges in (b) [4].

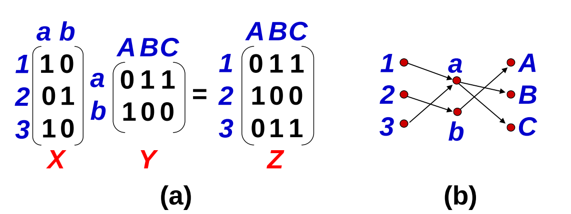

Figure 1: Boolean matrix multiplication and its directed graph representation