DNA Computing towards the Solution of Minimum Vertex Cover Problem

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Abstract--- *DNA computing is an unconventional method for parallel computation. It is a technique proposed for finding solution to intractable computational problems. Computational hard problem in which the time complexity can increase exponentially with problem size. This work develops a new DNA exploring model to solve a minimum vertex cover problem (MVCP). This DNA processing model solve the MVCP in polynomial time calculation.*

Keywords--- *Adleman-Lipton Model, Parallel Computing, MVCP, Watson-Crick Complementarity, NP-Complete Problem, DNA Computing.*

I. INTRODUCTION

NP complete problems [1] are computational issues which have exponential time complexity. It has challenging time complexity and no productive calculation found at this point. An energizing new research field DNA calculation has risen over the most recent twenty years as at the crossing point of engineering, science, mathematics, and biology. Two principle significant favorable circumstances of DNA calculation are huge storage capacity and massive parallelism. DNA model can execute billions of operations simultaneously in a single test tube. The huge parallelism of DNA computing originates from the huge number of molecules. These molecules synthetically interact in a little volume in a test tube.

DNA model provides an massive storage capacity since they encode the data on the sub-atomic scale. In 1994, the thought of performing sub-atomic calculation was figured it out. Adleman [2] displayed a thought of tackling the Hamiltonian path problem with n vertices in O (n) steps utilizing DNA particles. From that point forward the field has developed quickly, with huge hypothetical and test results being accounted for consistently. Lipton [3] showed that Adleman's test could be utilized to make sense of the arrangement of the NP-complete satisfiability issue. Many research papers have been published to solve the NP-Complete problem using DNA algorithm [4-9]. Parallel processing strategies are used in DNA processing model to take care of the computationally difficult issue. This exploration work develops a new processing model to solve the MVCP.

II. MINIMUM VERTEX COVER PROBLEM

Definition

The instance of the problem is an undirected graph $G = (V, E)$. The subset M of a graph is said to be a vertex cover of a graph if every edge $(s, t) \in E$ either $s \in M$ or $t \in M$ or both. Every edge is incident on one of the vertices in the vertex set M. Finding a set M which has minimum number of vertices of a graph G is a known as a minimum vertex cover for G.

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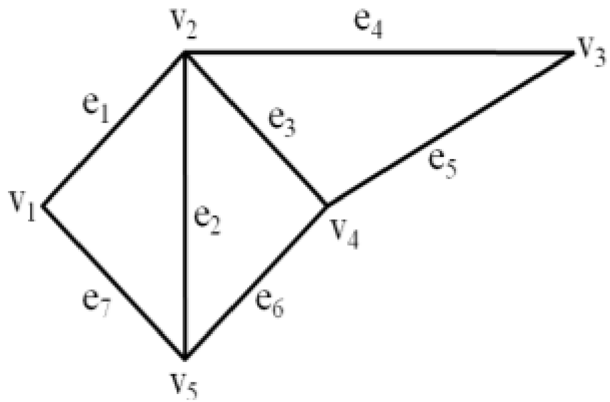
Problem Description

Consider a graph given below



This paper describes the computing model to solve the MVCP. Consider undirected graph G given in Fig 1. Let V be the vertex set and E be the edge set of the given graph G. The minimum vertex cover of G is defined as a set M with minimum number of vertices such that each edge in G is incident with at least one vertex in M. The given graph has 7 edges and 5 vertices. The cover sets of the Graph G are

$M_1 = \{ v_5, v_3, v_2\}$, $M_2 = \{v_4, v_2, v_1\}$, $M_3 = \{ v_5, v_4, v_3, v_1\}$, $M_4= \{ v_5, v_4, v_3, v_2\}$, $M_5 = \{ v_4, v_3, v_2, v_1\}$, $M_6= \{ v_5, v_4, v_2, v_1\}$, $M_7 = \{ v_5, v_3, v_2, v_1\}$, $M_8 = \{v_5, v_4, v_3, v_2, v_1\}$, … The cover set with minimum number of vertices are M_1 and M_2. The cardinality of the MVC of the graph is 3.

III. DNA CODING OF A GRAPH

Generate a test tube T which contains all possible solution of the graph G. The input is an undirected graph G = (V, E), where V is the set of vertices and E is the set of edges. |V | represents the number of vertices in V and |E| represents the number of edges in E. Let |V | = 5, |E| = 7

Encoding the Vertices

Consider a graph G and any vertex v in G, synthesize two DNA strands. Each DNA strand is of length 10 to represent the vertex which is either ON or OFF. The vertex which is ON represented by a 5 mer DNA sequence CCCGG and OFF represented by a 5mer DNA sequence ATATA. The following DNA strands are the encoding for a given problem. The DNA strands to encode the vertex v_i which is ON and v_i' which is OFF are as follows.

v_1	AATTACCCGG
v_2	ACTGCCCCGG
v_3	CAGTGCCCGG
v_4	CTGGTCCCGG
v_5	GGAATCCCGG

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v_1'	GTACGATATA
v_2'	TGCACATATA
v_3'	TTCCAATATA
v_4'	CCATCATATA
v_5'	GGTAGATATA

Encoding the Edges

For each undirected edge (v_i, v_j) is encoded by 8 DNA strands and each is of length 10 base consisting of 3' 5mer sequence of v_i and complementary of 5' 3mer sequence of v_j and vice-versa. The complementary seven edges are encoded as follows

Edge e_1: (v_1, v_2)	
GGGCCTGACG	TATATACGTG
GGGCCTTAAT	TATATCATGC
GGGCCACGTG	TATATTGACG
TATATTTAAT	GGGCCCATGC

Edge e_2: (v_2, v_5)	
GGGCCCCTTA	TATATCCATC
GGGCCTGACG	TATATACGTG
GGGCCCCATC	TATATCCTTA
TATATTGACG	GGGCCACGTG

Edge e_3: (v_2, v_4)	
GGGCCTGACG	TATATACGTG
GGGCCGACCA	TATATGGTAG
GGGCCGGTAG	TATATGACCA
TATATTGACG	GGGCCACGTG

Edge e_4: (v_2, v_3)	
GGGCCTGACG	TATATACGTG
GGGCCGTCAC	TATATAAGGT
GGGCCAAGGT	TATATGTCAC
TATATTGACG	GGGCCACGTG

Edge e_5: (v_3, v_4)	
GGGCCGTCAC	TATATAAGGT
GGGCCGACCA	TATATGGTAG
GGGCCGGTAG	TATATGACCA
TATATGTCAC	GGGCCAAGGT

Edge e_6: (v_4, v_5)	
GGGCCCCTTA	TATATGGTAG
GGGCCGACCA	TATATCCATC
GGGCCCCATC	TATATCCATC
TATATGACCA	GGGCCGGTAG

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Edge e_7: (v_1, v_5)	
GGGCCTTAAT	TATATCATGC
GGGCCCCTTA	TATATCCATC
GGGCCCCATC	TATATCCTTA
TATATTTAAT	GGGCCCATGC

IV. DNA ALGORITHM

The DNA model proposed in this paper creates a test tube which has all paths of a given graph G. Each DNA strand in a test tube has a number of sub strands. Each sub strand is a coding for a vertex and an edge of a given graph G. Using ligation reaction all paths of the graph is generated in a test tube T [10, 11].

DNA Algorithm for Minimum Vertes Cover of a Graph

This section describes the steps to filter the DNA strands which are the solution of MVCP. Consider the graph G in Fig 1. with 7 edges and 5 vertices.

Algorithm

Step 1: The input of the algorithm is a test tube T. T has all DNA sequence of possible paths of graph G. The paths represented have some vertices which are ON. The remaining Vertices are OFF

Step 2: For j = 1 to m

$T_1 \leftarrow + (T, e_j)$

End For

Step 3: If Detect (T_1) = yes then DNA strands in the test tube T_1 are the vertex cover of G.

Step 4: Weights of the DNA strands are determined by reading the length of the DNA sequence. The DNA strand which has minimum weight in T_1 Covers entire graph. The operation read is used to describe the DNA molecule which is the minimum vertex cover of the graph if it exists.

Computational Complexity

The graph G has 7 edges and 5 vertices. The proposed algorithm generates all possible paths of the given graph in step 1 by one step and step 2 collects all the DNA strands which have all the edges as the sub strand in m steps. Steps 3 needs one step to detect the DNA strand and step 4 needs one step to read out the solution if it exists. The algorithm runs up to m steps. The time complexity of the procedure of DNA model is O (m) in worst case.

V. CONCLUSION

This research work develops a DNA based computing model to solve the MVCP using Adleman-Lipton model. The suggested DNA model has two advantages. Firstly, the algorithm developed in this work generates all possible solution with a lesser error rate. Secondly, the time complexity of DNA model is O (m) steps for the MVCP of an undirected simple graph.

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