International Journal of Innovative Computing, Information and Control
Volume **6**, Number **9**, September **2010**
ICIC International ©2010 ISSN 1349-4198
pp. 3911–3928

A MOLECULAR ALGORITHMIC SOLUTION FOR THE NOT-ALL-EQUAL AND ONE-IN-THREE 3-SAT PROBLEMS IN DNA-BASED SUPERCOMPUTING

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Received March 2009; revised August 2009

Abstract. *The satisfiability problem is given as a Boolean formula for which is determined whether a satisfying truth assignment exists.* $(\overline{x_{12}} \vee x_5) \wedge (\overline{x_{24}} \vee x_3 \vee \overline{x_{13}} \vee x_9) \wedge \ldots \wedge (x_{12}) \wedge (x_{17} \vee x_8 \vee \overline{x_{18}})$ *is an example of Boolean formula. A k-SAT problem indicates that each clause has exactly k literals. The Not-All-Equal (NAE) 3-SAT problem and One-In-Three (1IN3) 3-SAT problem are both NP-complete problems. In this paper, we present molecular solutions to determine all true assignments (for the 3-SAT problem), and furthermore to determine Not-All-Equal (NAE) solutions and One-In-Three (1IN3) solutions in DNA-based supercomputing.*

The complexity of the presented DNA-based algorithm is also discussed. We describe the time complexity and volume complexity of Algorithms 3-1 and 4-1, numbers of test tubes used, and the longest library strand in the solution spaces of Algorithms 3-1 and 4-1.

Finally, the simulated experiment is applied to verify correction of the proposed DNA-based algorithm for solving the One-In-Three 3-SAT problem.

Keywords: Satisfiability problem, 3-SAT problem, NP-complete problem, Not-All-Equal 3-SAT problem, One-In-Three 3-SAT problem, Molecular solution, DNA-based supercomputing

1. Introduction.

1.1. Research motivation.

This paper seeks to illustrate the current state-of-the-art of DNA computing achievements; especially of new approaches to solving theoretical 3-SAT problems. Beginning with Adleman's breakthrough, which is a molecular algorithm for the solution of a NP-complete combinatorial problem (the directed Hamiltonian path problem (HPP)), many researchers all over the world have been proposing new methods to solve engineering or application problems using a DNA computing approach [33-35].

DNA is the basic medium of inheritance for all living cells. The main idea underlying DNA computing is to encode data in a DNA-like strand form; and to use bio-operation to manipulate DNA strands in a test tube to simulate arithmetical and logical operations. It is estimated that approximately 1018 DNA strands can operate 10^4 times faster than the speed of today's advanced supercomputers [30]. While modern supercomputers perform 10^{12} operations per second, Adleman estimates 10^{20} operations per second for molecular instructions can be acheived.

Energy consumption and memory capacity are similarly impressive: A supercomputer requires one joule for 10^9 operations, while the same amount of energy is sufficient to perform $2 * 10^{19}$ ligation operations [31,32]. On a video tape, every bit needs 10^{12} cubic