IMPLEMENTING OPTICAL COMPUTATION WITH PROTEIN-BACTERIORHODOPSIN

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To my beloved parents, sisters, brother and friends

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ABSTRACT

The aim of this project is to implement a feasibility study of bacteriorhodopsin in optical computation. Bacteriorhodopsin (bR) is very unique because it can store data or information like silicon chip. Both chips are different from each other in the way they process and store data. Silicon chip use electrons flow to read a binary state, 1 or 0. Meanwhile, bacteriorhodopsin use photons to read the binary. Therefore the intent of this paper is to know the unique, the process and the advantages of using of bacteriorhodopsin for the future.

ABSTRAK

Tujuan utama kajian ini ialah untuk melaksanakan kebolehan bacteriorhodopsin di dalam pengkomputeran optik. Bacterirhodopsin (bR) mempunyai keistimewaannya untuk menyimpan data seperti juga chip silicon yang biasa digunakan pada masa ini. Kedua-dua cip tersebut berbeza dari segi pemprosesan dan penyimpanan data. Cip silicon menggunakan cas electron untuk membaca binari, 1 atau 0. Manakala cip bacteriorhodopsin menggunakan photon untuk membaca binari tersebut. Oleh sebab itu matlamat utama penulisan kertas kajian ini adalah untuk mengetahui ciri-ciri istimewa, proses-proses yang terlibat dan kebaikan menggunakan bacteriorhodopsin ini pada masa akan datang.

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GLOSSARY OF ABBREVIATIONS

3D	Three-dimensional
AG	aluminium gamet[6]
bR	bacteriorhodopsin
CID	charge-injection device
CPU	Central Processing Unit
EPROM	Erasable Programmable Read Only Memory
GB	Gigabytes
IC	Integrated Circuit
LA	light adapted
LCD	liquid crystal displays
Nd	neodymium
PDAs	Personal Digital Assistants
PM	purple membrane
RAM	Random Access Memory
RAMAC	Random Access Method of Accounting and Control
ROM	Read Only Memory
SLM	Spatial Light Modulators
WORM	Write Once, Read Many

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Now days, the electronics industry is continuing to move in the direction of miniaturization. Features on silicon chips are becoming so small that they are dwarfed by human hair, and miniaturization can be carried further still. The new generation of chips would have features that are less than a micrometer across; miltons of transistors would be packed into a scrap of silicon or some other semiconductor material.

Recent work at the University of Illinois will probably accelerate the pace of hybrid-chip research. Continuous lasers and optical interconnects have been developed. The use of materials that respond to light suggests the potential for major shift in technology from computing and communications devices based on the movement of electrons to device based on the transmission of light.

Optical computation and communications are not yet a major commercial technology although the communications part is becoming important. One major interest of researcher is develop classes of materials that enable one to manipulate light with the speeds and characteristics that are required of new generations.

Computing technologies have consistently high rates of change and transformation. Since the IC was developed, the number of transistors that engineers can pack on a chip has increased at a phenomenal rate.

The computationally intensive problems requiring tremendous computing speed and volume (storage capacity) motivated a new field of optical computing.

1.2 PROBLEMS

The demands made upon computers and computing devices are increasing each year. Processor speeds are increasing at tremendously fast clip. As several years ago, researchers used the same type of memory and now the limits of making RAM (Random Access Memory) more dense are being reached. The problem is it is quite economical because the decrease by a factor of two in size will increase the cost of manufacturing of semiconductor pieces by a factor of 5.

Currently, RAM is available in modules called SIMMs or DIMMs. These modules can be bought in various capacities from a few hundred kilobytes of RAM to about 64 megabytes. Anything more is both expensive and rare. These modules are generally 70ns, however 60ns and 100ns modules are available. The lower the nanosecond rating, the more the module will cost. Currently, a 64MB DIMM costs over $400. All DIMMs are 12cm X 3cm X 1cm or about 36 cubic centimetres.

Response to the demand far faster, more compact, and more affordable memory storage devices, several viable alternatives have appeared in recent years. Among the most promising approaches include memory storage using protein-based memory. (*Brown, el. at.*, 1996)

The challenges in scaling another factor of 1000 shouldn't be minimised. Developing millimetre scale electronic and micrometer scale integrated circuits wasn't easy. (*Walker, 1996)*

In designing an ideal computer memory, a number of functionally contradictory factors must be optimised, e.g. cost, capacity, speed, persistence, robustness, portability, replicability, size, energy utilization, and operating environment.

1.3 OBJECTIVES

The objective of this research is to determine the feasibility study of such on implementing optical computing with the Bacteriorhodopsin. The other objectives are:

i) To survey the applications of this protein in optical computing.

ii) To understand the unique of Bacteriorhodopsin in optical computing.

iii) To compare the performance of protein chip over Semiconductor chip.

iv) Advantages of protein-based memory.

1.4 SCOPE OF WORKS

i) Study the background of Bacteriorhodopsin.

ii) Find the results of the implementation and feasibility study.

iii) Gaining the information regarding the applications of Bacteriorhodopsin in Optical Computation.

CHAPTER 2

LITERACTURE REVIEW

2.1. BACKGROUND

In mid twentieth century have gone through theirs own evolution in storage media. Everyone who took a computer course at that time have to used punched cards to give the computer information and store data. In 1956, researchers at IBM developed the first disk storage system, which was called RAMAC (Random Access Method of Accounting and Control). (*Brown, et al.,* 1996)

Today, companies constantly push the limits of these technologies to improve their speed and reliability while reducing cost because the fastest and most expensive storage technology today is based on electronic storage in a circuit such as a solid state "disk drive" or flash RAM. (*Brown, et al.,* 1996) And since the days of punch cards, computer manufactures have strived to squeeze more data into smaller spaces but there are many issues that we have to look at.

The main issue is that the size. Since 1960s, the computer industry has been compelled to make the individual components on semiconductor chips smaller and smaller in order to manufacture larger memories and more powerful processors economically. These chips consist of arrays of switches, that flip between two states-designated as 0 and 1 in response to changes in the electric current passing through them. According to Birge, director of the W.M. Keek Center for Molecular Electronics at Syracuse University, "the size of a single logic gate with approach the size of a molecule by about the year 2030".

2.2. SIZE

Whatever the size or speed of computer, all of the control and management of the computer is now done through "chips" of various materials and not all of them are made of silicon. The chips that are the CPU (Central Processing Unit) and the memory chips are made of switches, assembled from very transistors. Millions and soon billions of these transistors can be replaced on fingernail size chips. These switches are also known as bits, which can be thought of as switches that are on or off.

Computers have gone from requiring the space of a small building, to the size of a room, to the size of an item to fitting on a desk, to a lap and then to hand-held devices increasing called PDAs or Personal Digital Assistants. This trend towards downsizing the computer is far from over. The time will come when the "form factor" or size and shape of the computer will become a major design issue.

2.3. SPEED

The original approach to computer speed was to produce a single chip, the CPU that could process data faster than the last design. The world's very fastest computers were referred to as supercomputers. Future revolutions in size and speed are likely to come from bio computing, optical computing and quantum mechanics.

The speed at which a computer can carryout its operations is referred to as its megahertz rate. A CPU that runs at one megahertz would complete one million operations per second. Most of the computers that we use are the 60 to 400 megahertz rate.

In spite of their rapid growth in capacity, today's computers based on electrons will one day become the dinosaurs of the early history of computer technology. The next generation of computers will be based on photons (light beams) and run hundreds of times faster than today's fastest computers.

Computer chips contain many small switches, which represent a condition of on (1) and off (0). Many different techniques and chemical structures are used to make these chips work. Silicon is one common substance used to create computer memory, but it was not the first, and is certainly not the last. For example, serious work is being done on protein memory.

2.4. COMMON TYPES OF COMPUTER MEMORY CHIPS

Through RAM and ROM are the most common forms of computer memory chips there are other forms of which EPROM is one example.

i) RAM – is Random Access Memory. This memory (setting of the switches) is emptied or last when the electrical power to the computer stops.

ii) ROM - is Read Only Memory. These transistors are placed in specific settings during their manufacture and cannot be erased once they are programmed or loaded with specific instructions. These chips enable our computer to start up or carry specific directions that leave in a state that we can tell it what software to run.

iii) EPROM – is Erasable Programmable Read Only Memory. These chips allow the user to store data that will not be lost when electrical power to the computer stops, but through various techniques can be quickly erased to start over again.

CHAPTER 3

GENERAL BACKGROUND

3.1 INTRODUCTION

A team of researchers has derived a scheme to use a light-sensitive protein made by a saltwater bacterium as the basic component of an optical computer. In an optical computer, information zips around as photons of light rather than as electrons. (Science News Online, 1997) The use of biological molecules as the active components in computer circuitry may offer an alternative approach that is more economical and settle the size issue.

Molecules can potentially serve as computer switches because their atoms are mobile and change position in a predictable way. If we can direct that atomic motion and thereby consistently generate at least two discrete states in a molecule, we can use each state to represent either 1 or 0. Such switches offer reductions in the size of hardware because they are themselves small – about one thousandth the size of the semiconductor transistors used today as gates (which measure about one micron, or a millionth of a meter, across). Indeed, a bio molecular computer could in principle be one fifty the size of a present-day semiconductor computer composed of a similar