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Study of Photon Based Computing for the Improvement of the Performance of Computation Process

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ABSTRACT

Moor's law almost accurately predicted growth of computing capacity of a processor and it is not questioned till today. As per recent research results, silicon chips may come to its maximum capacity as reducing the size of its transistors further may be practically impossible. But the globe demands more computing power to manage its huge needs like processing bigdata, mobility, processor intensive cloud solutions, super computers, etc. So the world is seeking for alternatives and researchers focusing on new methodologies like quantum computing. Here, we are trying to propose a method for computing using laser beams with different wavelengths. Multiple laser beams will not mix together if it is passing through the vacuum or normal mediums, but it will mix and produce a different wavelength when it is passing through some special mediums, and we consider it as a computation.
Keywords: Computing, Photon Computing, Laser Based Computing

I. INTRODUCTION

Modern digital computers are achieving huge growth in computational capacity at a rapid rate. As personal computing devices are evolving as mobile/handheld devices, there is high demand for powerful, less in size, and energy efficient processors. Standalone, Mission critical, dedicated super computers etc are also demand processors with higher processing capacity. There is an immense amount of research happening in the field in many universities, private companies, and research organizations. Many types of research are focusing on replacing copper/metal cables and circuits with an optical alternative to achieve high transmission rate. Light fleet and some other technologies succeeded on their research, and communication between micro processors and internal components are achieving huge data transfer rate. When we are using such technologies for communication between components, data processing is being a bottle neck. Even the data is reached in the components, the time taken to process it will slow down the entire system. So we have to achieve high processing capacity.

Many types of research are happening to increase the processing capacity of a silicon/Metal chip. Optimizing it for more micro components, increasing the clock speed, implementing multiple cores on a single chip, etc are the focus areas. But many types of research are happening to find a complete game changer which will be using different concepts and technologies for computing. Quantum computer is a classic example of such research and scientists achieved to develop few quantum computers which are under experimental use. As quantum computing gives more possibilities in solving problems in a different way unlike normal computers, scientists are experimenting it with a special set of problems which may be difficult to solve in conventional methods.

This work proposes using light/laser beams with different wavelengths for computing. Here, we assume a value for each band of wavelength of the visible light spectrum. By mixing two or more different bands of the wavelength, we assume that it will produce a different band, and we assume it as a processing done. Here, we consider two or more bands as input and the produced band as output. By measuring the wavelength of the produced band, we can decide the output value. We can use multiple inputs and can create a nested structure for using one output as the next input. So we assume that processing will be done at the speed of light. Here, we assume a fresh computational logic as digital computing logic may not be suitable for the system. We may need to develop a new level of computational logic, algorithms, architecture, and Turing machine etc for the proposed method. Co working with existing digital devices may be possible but converting the input to the new system and converting the output back is needed.

We assume that we can achieve the nearby speed of light in processing theoretically, Clocking architecture, capacity, and speed of sensors, the speed of intermediate storage etc have to be considered when calculating speed. Research advancements in the field of optical flip-flops, optical computing etc are giving more confidence for the proposed model.

II. CURRENT TECHNOLOGIES

Most of the optical technologies are focused on the interconnection between micro components inside digital systems. each digital components produce signals to be transferred in between and normally metal wires or printed board are used. Electrons from each component flow through the cables or printed boards and it gives very low cost and simple solution. But as the industry demands more processing capacity, researchers were focused on improving processing capacity. The industry is growing as per Moore's Law predictions and we are achieving huge processing capacity, But as intercommunication between processors is through metal wires, it is being a bottleneck. So many researches are going on for solving this issue. As a result industry leaders like Intel, IBM etc came up with cutting edge technologies for inter connection using optical alternatives. Optical communication was used for data communication but it was unable to use it directly inside a Machine as it needs huge infrastructures and machinery. But new findings are capable of managing inter-processor communication effectively as it needs very small components and less energy. IBM Holy OptoChip is an example for such a solution. It uses Silicon photonics to work with both electron and photon, and claim to transfer 1 TB/second Image. There will be a converter connected to each processor, and the converter converts electrical signals to optical signals to transmit through optical channels. The optical signals again converted to electrical signals in another end to make use of the transferred data by second processor/component.

III. LIMITATIONS

IBM Holy OptoChip and other optical interconnection methods make high bandwidths between processors a reality but we need huge processing capacity to process the transferred data. Even though we achieve huge data transfer speed, we have to increase the speed of processing too to avoid the bottle neck. Optical inter connectors can only increase the speed of communication, but to increase the speed of overall processing, we have to increase the processing capacity. Each time, data need to be converted into optical signals and it should be converted again to its previous format for processing in a microprocessor as it can only deal with electrons.

IV. PROPOSED SOLUTION

We are proposing a fresh processing concept with the help of mixing/ making alterations on laser waves. Laser waves can be ”mixed” together or can make alterations when it passes through some special mediums. That changes can be considered as a logical operation and it can be used for computation. As it s a fresh concept, it's hard to implement it with the existing software, tools or simulators. We are planning to design a simple arithmetic calculator by using a set of Light sources and light detectors. We can use lasers to get the more accurate result in such a design. Light sources emit different colored (wavelength) light beams and optical components are used to focus beams, position beams, 'mix' beams or separate beams according to the logical needs of the operations. Here, we are considering each beam with a wavelength as a pre defined value and different beams represent different values. We can use sensors and light sources in all surface of the box, as light beams will not mix in normal conditions, light beams with different wavelength can pass through same physical space.

We have to use highly flexible light sources, sensors, color mixers, prisms and other optical tools to mix, guide, reflect and use the light beam according to the instructions from a stored program.

We have to design a new computational logic for the proposed system. Suppose we are splitting the spectrum A in to a1, a2, ...a10 and assigning 0toa1, 1toa2, 2toa3....9toa10, and if we are implementing the arithmetic logic addition, we have to check the possibility of finding the spectrum such a way that a1+a2 results a3, a1+a3 results a4 etc. We may need to develop a Turing machine to implement the computational logic. As the output of each combination of light beams is complex, we have to map it into a logical method and to implement it into computation logic.

V. COLORBOX

ColorBox is a small box with few color beam generators and color sensors to demonstrate the concept. It's only for the demonstration purpose of the concept and it is not a POC as it assumes mixing of colors which is impossible in normal conditions. The box is having 3 holes on the top side with 3 different color beam generators. The bottom side of the box, a color sensor is fixed and its connected to a Digital display through an electronic circuitry. here, three colors c1, c2, c3 are having different values assigned v1,v2, v3 respectively. Each of the color beams can be turned on/ off by separate switches. if we turn on c1, the sensor will sense the color and the digital display will display v1, the same will happen for c2,c3 as v2,v3 respectively. this is happening because we already assigned a value for each color and the value will be displayed on the screen as the sensor detects the colors. Now, if we turn on any two colors, we will get a different color as that two beams ”mix” together. if we turn on c1 and c2, the beams together form a different color and the sensor detect a different value d1 which we assume d4=v1+v2 where + is the operation we intended to perform with v1 and v2. If we turn on c1 and c3, it will give a different color and the sensor detect a different value d5 where d5=v1+v3, where + is the operation we intended to perform with v1 and v3. such as we can find other combinations too which are d6=v2+v3 d7=v1+v2+v3. so we are having 8 states for the system where as d0 is the absence of all light beams, d1=v1, d2=v2, d3=v3, d4= v1+v2, d5=v1+v3, d6=v2+v3, d7=v1+v2+v3. It is evident that mixing of two visible light beams is impossible in normal conditions. So this demonstration cannot be considered as a Proof of concept, but it can give a clear idea about the concept and can be used for study purpose. The color sensor is a normal color sensor which will output value of RGB to the circuit and based on the RGB values, the circuit decided which value to be displayed on the digital display. value for each color is pre defined and the electronic circuitry is only selecting the values to be displayed from the pre defined table based on the color identified by the color sensor so that we can argue that processing is already done by ”mixing” color beams inside the box and not by the electronic circuitry.

VI. MATERIALS IDENTIFIED

There are many materials identified which will show non-linear properties. We can select materials already developed for dealing with laser beams according to our needs and situations. There are a lot of materials that will be resisting laser beams to a particular intensity and it will transmit the beams if it reached the intensity. There are materials which will act as a medium and combine two different laser beams into a single beam.

VII. PRACTICALITY

As we already have many kinds of research in the field of lasers, nonlinear materials, changes to the laser beams when passing through different mediums, etc, the concept is a workable one. But there are many practical difficulties and need huge advancements in the supporting technologies and environments to make it for commercial purpose. As per the previous research findings, it is possible to add wavelength of two laser beams with different wavelength when it is passing through a special medium. So it's clear that we can achieve a computation by using the process. If we consider a1 as the first laser beam with a wavelength w1 and a2 as the second laser beam with wavelength w2, and both beams are passing through a special medium, will get a different laser beam with w3, which is w3= w1+w2. So we can consider it as a computation, if we are able to design a computation logic based on it, we can use laser beams with different wavelengths for different computation purpose. We need to identify laser beams with different wavelength and to assign each one to a value or logic. Mapping of laser beams for each value is a very important task as each beam should be easily distinguishable from another one. Mixing of two or making an alteration on a beam should result in a identified beam to make the system simple and practical. The system may not be possible to use for a general purpose computing in near future, but it can be used to design a processor for a special kind of logic which will solve a limited no of problems in a very effective way.

VIII. BENEFITS

As silicon based computing has the above-said limitations, new methods are necessary. We can assume several benefits for the proposed system like high speed in processing, Low energy consumption, easy management of different lasers in the same chamber, low temperature, etc.

IX. THREATS

There are many threats for the proposed concept as its still in a conceptual stage. We are not even aware of unexpected practical complexities and problems may arise at the time of practical implementation of a complete general purpose system. But we are certain with the practicality of the special purpose systems on the basis of already proven concepts based on the researches in the field of lasers and nonlinear materials. Mapping of values into the laser beams is a difficult task as it should be picked based on its consistency, easiness to handle, detection of property changes when it is passing through special mediums or mixing with other beams, etc. Preparation of a new computational logic is another threat. If we are creating a fresh computational logic, it will be hard to co-work with existing systems. So that we have to find a way to map it into the existing computational logic if possible. Environment and components to co work with the proposed model have to be developed and it may take time. If we are dealing with electronic circuitry with the proposed model, we have to do conversion between the electronic signal to optical signal to process the data and to optical signal to electronic signal after processing it. It will complex system and may affect the performance. So the proposed method will be practical for a general purpose computer only if we can achieve an environment where the components co-working with the processor will manage optical data. Optical flip flops, optical switching, and other micro components are developed already and many other components are under research. The success of the proposed system for general purpose computing depends on the advancements of research in components in optical technology.

X. CONCLUSION

There is a huge demand for computation power after the invention of the first computer and industry is supplying computation power for the thirsty applications. Moors low accurately predicted the growth of computation power related to the growth of the number of transistors used for the purpose. Even we have a huge supply of computation power, there are many problems remain unsolved or taking the time to be solved as the algorithms are very complex and it needed a huge amount of computation power. Here the proposed system may not be able to use for general purpose computing in near future but it can be used to design special purpose processors to solve some particular problems. We wish to propose the idea to bring the attention of researchers to this area and to happen more researches on this.

XI. REFERENCES

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