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OPTICAL COMPUTING : AN EMGERING DIMENSION

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ABSTRACT

Performing computations, operations , storage and transmission of information using light is defined as optical computing . It is a device that plays all the computations carried out inside the computer using optical fibers, photons, thin films etc. which is produce by way of lasers in preference to using thin electrical wires, electrons, silicon chips and transistors. Optical computing is the technological know how computing work better is in optics.

Given paper talks approximately the need for optical computing, its structure over modern computational systems, Computing with light is great deal tons simpler than computing with electricity. 30cm lenghthy wire produces 1ns delay to negelct optical technology must be used .A calculation suggests that electron is moving approx. 2200km/s while light travels at the speed of 300000Km/s which is less than 1% speed of light. With the increase of computing generation the need of high over all performance of PC has appreciably improved. One of the theoretical limits on how speedy a computer can characteristic is given by Einstein's Principle that "Signal cannot propagate faster than the velocity of Light". Optical computing has opened up new possibilities in several fields associated with excessive overall performance computing, high speed communications. For optical computing VCSEL, WDM, SLM, smart pixel technology are used in optical computer, there may be no short circuit and no dissipation. Also light beams can travel in parallel which is not always possible in electronic computing. It will be more compact and it will have faster speed, huge bandwidth than electronic computers. It has potential to carry the whole words internet traffic simultaneously over a single optical cable. Optical computers will someday eliminate the need for the enormous triangles of wire using electronics computer today.

Keywords: *optical fiber, photons, VCSEL, WDM, SLM, smart pixel technology.*

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1. INTRODUCTION

Optical computing is the science of making computing work higher the use of optics and associated technologies. Optical computing is lifeless simplest if we foolishly outline it because the try to supplant electronics. The hope for optics lies in doing things which are provably impossible for electronics. Optics has the potential to resolve traumatic issues in computing hardware. With the boom of computing technology the need of high performance computers (HPC) has notably extended. The increase demand for excessive performance information processing and scientific computations suggest the need for large parallel computing systems. Numerous statics processing systems and ideas in space and time have been studied for the duration of past many years. Yet, optical computing and processing in space and time has to this point did not pass out of the lab. The free-space and guided-wave gadgets are highly priced, bulky, and fragile in their alignment. The construction of optical subsystems immediately on-chip, with the equal lithographic tools as the surrounding electronics has been made possible by the advances in these tools, that can now create features significantly smaller than the optical wavelength; Professionals predict lithographic decision as exceptional as 16nm by way of year 2020 [1]. Optical computation is the maximum viable technology which can alternate electronics, and promises impressive speeds that could beautify processing power and data rate transmission. Main gain of optics lies in its interconnection technology which is reflected in the overall performances of the computing and processing machines [2, 3].

2.BASCIS OF OPTICAL INFORMATION PROCESSING

Optical information processing is primarily based at the idea of processing the facts at high-data rate using all the properties of speed and parallelism of the light. The data can be inside the shape of an optical signal. One of the maximum highlighted blessing of optical processing in comparison with electronic processing computers was inherent parallel processing. For this reason , optics has an important ability for processing big quantity of information in real time. The basis of optical computing is the Fourier transform of a lens. When the use of coherent light, the Fourier trans- form of a 2D transparency is placed in the front focal plane of a lens, is achieved in its returned focal plane.

3. NEED FOR OPTICAL COMPUTING

The imgerging need for optical technology stems from the truth that now a days computers are restrained by the point response of digital circuits. A solid transmission medium limits both the speed and volume of signals. One of the theoretical limits on howspeedy a computer can characteristics is given by Einstein's principle that signal cannot propagate quicker than speed of light. So to build up computers faster, their components must be smaller and there by decrease the distance between them. This has resulted inside the improvement of very large scale integration (VLSI) technology, with smaller tool dimensions and greater complexity. The smallest dimensions of VLSI these days are about 0.08mm.notwithstanding the major progress in the development and refinement of the basic technologies over the past decade, there is growing concern that these technologies may not be capable of solving the computing problems of even the current millennium. The speed of computers was achieved by miniaturizing electronic. components to a very small micron-size scale, but they are limited not only by the speed of electrons in matter but also by the increasing density of interconnections necessary to link the electronic gates on microchips. The optical computer comes as a solution of miniaturization problem. Optical data processing can perform several operations in parallel tons quicker and less difficult than electrons. This parallelism facilitates in superb computational power.

4. BACKGROUND

The expertise of some recirds of sciences is beneficial for know how the evolution of a research domain, its successes and disasters. Optical computing is an interesting candidate for a historic overview. This research subject is also named optical facts processing, and now the terms of information optics or information photonics are regularly used, reflecting the evolution of the domain. Optical computing is approximately 60 years old and its far a nicely defined area with its own specialized conferences, sections in the scientific journals. It turened into additionally very active international and therefore it is not possible in the frame of a paper to describe all the research results. Numerous books have been written on the subject, for example, the following books describe the state of the art of optical computing at the time of their publication in 1972 [1], in 1981-82[2,3],in1989[4].

Due to fact that optical computing is the sort of nicely described decipline over these lenthy period of time, it is interesting to study its evolution and this study can be helpful to understand why some research domains were very successful during only a limited period of time while other have generated numerous applications that are still in use. From the beginning there was a lot of questioning about the potential of optics for computing whereas there was no doubt about the potential and the future of electronics. Caulfield wrote in 1998 an interesting and enlightening paper on the perspectives in optical computing [6] where he discusses this competition between optics and electronics and shows that there were three phases, first “ignorance and underestimation” of electronics then “awakening and fear inferiority” and now “realistic acceptance that optical computing and electronics are eternal partners”.

5.ARCHITECTURE OF OPTICAL COMPUTING

Figure 1 depicts a block diagram of the basic com ponents of the optical architecture. Not like conventional computers that manipulate individual O’s and l’s as basic computational objects, the optical architecture manipulates bit planes as basic com- putational entities. Each bit plane i corresponds to a weight factor 2i in the binary representation. Up to 3 bit planes can be processed simultaneously. For images of n x n elements, it follows that up to $3n^2$ operations are carried out concurrently. Domestically , this array can be considered as a bit-serial or a bit-slice processor, since it performs one logical operation, on one, two or three single-bit operands.

Globally, it can be viewed as a plane-parallel pro- cessor, since it simultaneously performs the same operation on a large set of operands encoded as bit planes. This bit-serial processing allows flexible data formats and almost unlimited precision. Optical interconnects are used to move the images around the system. The architecture is conceived to be built with optical hardware that manipulates entire images simultaneously both at I/O and pro- cessing, so that the 2-D parallelism is sustained throughout various stages of the computation.

5.1 The Processing Array:

The processing array operates inside the SIMD (single instruction multiple data) mode of computation, wherein the exact operation is applied to all the data entries. Within the proposed system, processing is based on the optical symbolic substitution logic(SSL).The processing unit is ready with 3 fundamental operators: a logical NOT which inverts all the entries of an input plane, a logical AND , denoted by & that performs the logical and of the overlapping bits of two bit planes, and a full ADD, denoted by l+J, that performs the full addition of the overlapping bits of the three input planes.Via overlapping bits, it is meant bits with the same Cartesian coordinates (i, j) in the input planes. These operators constitute a complete arithmetic and logic set capable of computing any arithmetic or logic function.

5.2 Input/output Data Routing:

The data represented as bit planes is fed to the system through three input planes, namely A-, B-, and C-plane as shown in Fig.1.Relaying on the essential operator wanted at a given computational step, the input combiner performs three data movement functions: for the logical NOT, it simply latches the relevant input plane to the processing unit. For the logical AND, the data movement re- quired is called the 2-O perfect shufie. This func- tion performs the shuffling of the row position, i, of the data such that the overlapping bits from the two planes become spatially adjacent. This func- tion does not affect the column position, j. The data movement required for the full ADD operator is called the 2-O 3-sftufsle. This function is similar to the 2-D shuffle function except that it performs a 3-way shuffling of the rows of the three input planes.

The output router is responsible for directing the processed data to its appropriate destination. It also performs three data movement functions, namely, feeding back to the input combiner, a par- tial result such as a carry bit plane resulting from a full ADD operation, sending a final result to the data memory for storage, and shifting the output either in the X or Y direction by a variable num- ber of pixels. This shift enables communication between pixels in the plane. By means of this spa- tial shifting, data can be moved among widely and at arbitrarily separated locations in the plane.

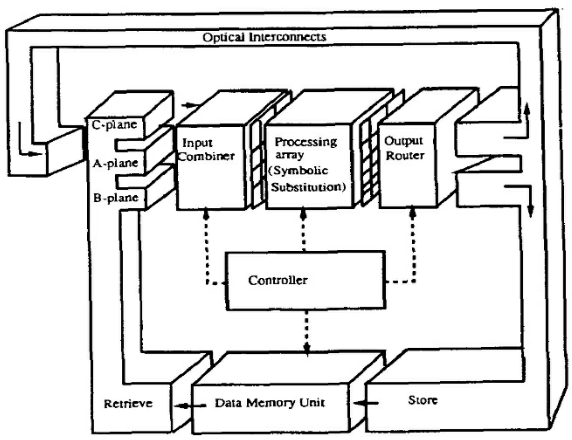

Figure 1: Optical processing architecture in 3d way

Input-output is generally performed by the CPU or by a system closely coupled to the CPU. The CPU accesses the memory through a binary addressing unit and memory contents are returned to the CPU through a single or small number of lines. This multiplexing scheme reduces the communications requirements and minimizes the number of lines. This serial addressing of memory results in a tradeoff of time for interconnection complexity. The eventual limitation on computing speed is known as the vonNeumann bottleneck.

SOME KEY OPTICAL COMPONENTS FOR COMPUTING

The formost breakthroughs on optical computing have been centered on the development of micro-optic devices for data input. **A. VCSEL (Vertical Cavity Surface Emitting Laser):** VCSEL (pronounced 'vixel') is a semiconductor vertical cavity surface emitting laser diode which emits light in a cylindrical beam vertically from the surface of a fabricated wafer, and offers significant benefits when compared to the edge-emitting lasers currently used in the majority of fiber optic communications devices. The principle included in the operation of a VCSEL is very similar to those of regular lasers. There are two special semiconductor materials sandwiching an active layer where all the action going on. But instead of reflective ends, in a VCSEL there are several layers of partially reflective mirrors above and below the active layer. Layers of semiconductors with differing compositions create these mirrors, and each mirror reflects a narrow range of wavelengths back in to the cavity in order to cause light emission at just one wavelength. VCSEL convert the electrical signal to optical signal when the light beams are passed through a pair of lenses and micromirrors. Micromirrors are used to direct the light beams and this light rays is passed through a polymer waveguide which serves as the path for transmitting data rather than copper wires in electronic computers. Then those optical beams are once more handed through a pair of lenses and sent to a photodiode. This photodiode convert the optical signal back to the electrical signal.

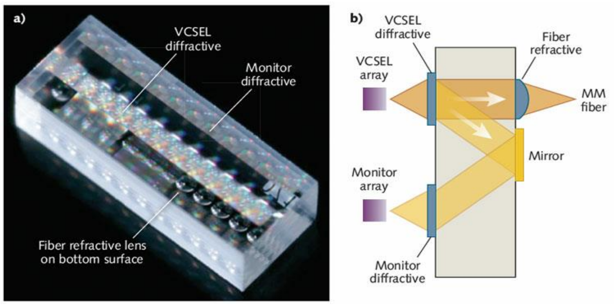

Fig.2

B. SLM (Spatial Light Modulators)

SLM play an crucial role in several technical areas in which manage of light on a pixel-by-pixel basis is a key element, which includes optical processing and displays. 1) SLM For show purposes the preference is to have as many pixels as feasible in as small and cheap a device as possible. For such purposes designing silicon chips for use as spatial light modulators has been effective. The in general idea is to have a set of memory cells laid out on a regular grid. These cells are electrically connected to metal mirrors, like the voltage on the mirror depends on the value stored in the memory cell. A layer of optically active liquid crystal is sandwiched between this array of mirrors and a piece of glass with a conductive coating. The voltage between individual mirrors and the front electrode affects the optical activity of liquid crystal in that neighborhood.So by being able to individually program the memory locations one can set up a pattern of optical activity in the liquid crystal layer

Fig.3

C. Smart Pixel Technology

Smart pixel technology is a significantly new approach for integrating electronic circuitry and optoelectronic devices. The main idea behind is to leverage the advantages of each individual technology and provide improved performance for specific applications. Here, the electronic circuitry gives critical functionality and programmability while the optoelectronic devices gives high-speed switching with existing optical media. Arrays of these smart pixels leverage the parallelism of optics for computation. A smart pixel device, a light emitting diode under the control of a FET can now be made solely out of organic materials on the same substrate for the first time. In general, the advantage of organic over conventional semiconductor electronics is that they should lead to cheaper, lighter, circuitry that can be printed.

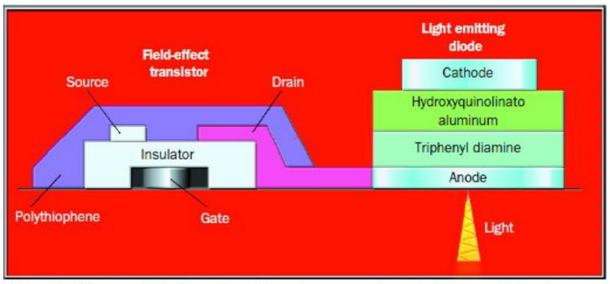

Figure 2. This smart pixel, made entirely from organic materials, consists of a light-emitting diode controlled by a field-effect transistor. As well as being bright (important for use in flat-panel displays), it can be printed rather than etched.

Fig.4

D. WDM (Wavelength Division Multiplexing)

Wavelength division multiplexing is a method of sending maximum various wavelengths down the same optical fiber. Using this technology, modern networks in which individual lasers can transmit at 10 gigabits per second through the same fiber at the same time. WDM can transmit up to 32 wavelengths through a single fiber, even though it transmit high range wavelength it can't fullfill the bandwidth requirements of today's communication systems. So nowadays DWDM (Dense wavelength division multiplexing) is used. This can transmit up to 1000 wavelengths through a single fiber. So by using this we can improve the bandwidth efficiency.

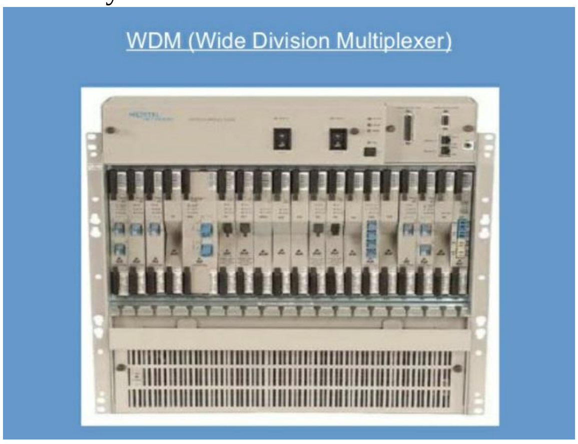

Fig.5

6.CONCLUSION

In this paper we have added architecture, need of optical computing as well as few key necessities of optical computing.

Now a days, we see that optics is too much successful in information systems along with communications and memories in comparison with its relative failure in computing. This could have alternate, if, in the seventies when the electronic computers had been gradual and with a confined strength, now a day components like efficient laser diodes or high speed and high resolution detectors would have been available. So, all the research outcomes the need of optical computing. The digital optical computers were not able to compete with the electronic due to the dearth of appropriate optical components. It shows truely that the solution is to accomplished with optics and electronics and to use optics only when it can bring something that electronics cannot do. Optical processing is useful when the information is optical and that no electronics to optics transducers are needed.

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