AD-A230 282

TECHNICAL ABSTRACT (Subline Item 0001AA)

for

DIGITAL OPTICAL COMPUTER GLOBAL INTERCONNECT ALGORITHM STUDY

SPONSORED BY:	Scientific Officer Office of Naval Research 800 North Quincy Street Arlington, VA. 22217-5000 Attn.: WM, Code 12613 ref.: N00014-89-C-0225
TECHNICAL CONTRACT MONITOR:	William Miceli
CONTRACT NO.	N00014-89-C-0225
TOPIC NO.	89-011
EFFECTIVE DATE OF CONTRACT:	15 Sept. 1989
CONTRACT EXPIRATION DATE:	February 28, 1991
NAME OF CONTRACTOR:	OPTICOMP Corporation Inc. P. O. Box 10779 215 Elks Point Road Zephyr Cove, NV. 89448
PRINCIPAL INVESTIGATOR:	Peter Guilfoyle
SHORT TITLE OF WORK:	Digital Optical Computer Global Interconnect Study
PERIOD OF WORK COVERED:	October 1989 through November 1990

(Format: Investigator Prepared Abstract for SDIO/IST Reporting)

Digital Optical Computer Global Interconnect Algorithm Study

SBIR Contract No. N00014-89-C-0225 Phase I Report: Sub-line Item 0001AA

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Abstract

Optical computer technology has demonstrated the potential to offer extremely high computational rates at significant power savings over conventional semi-conductor electronics technology. The leverage over power requirement is extended by the use of global interconnect geometries which allow a larger fan-in per photon than the parallel architectures under study at the time of project inception. The purpose of this project is to study and formulate candidate digital computation primitives to be applied to optical global interconnect geometries to recommend a Global Digital Optical Computer architecture. This project is directed at expanding and enhancing the work completed in a parallel digital optical computer project that is currently underway. The goal is to implement a digital optical computer that surpasses the performance offered by strictly parallel interconnect geometries.

This study will revolve about two architectural concerns: optical and computational. The current parallel approaches can be extended to global in discrete steps of complexity. The central principle applied to achieving global interconnects is the Fourrier transform properties of any optical system. The interconnect geometries will utilize the auto-coherence properties of the laser array emitters; however, all of the emitters will be specified to be mutually incoherent to frustrate different channels from interferometrically coupling at the detector. Optical interconnect geometries increase in complexity at a geometric rate. The first problem is to identify all likely global interconnect geometries and preliminarily assess their relative difficulty to implement. This will require assessing optical design difficulty (f/.1 optics, etc.), technical risks, packaging difficulty, size, component risks (128 channels Bragg cells, etc.) and digital electronics input/output (I/O) requirements for each interconnect geometry considered. Technical problems to be addressed for evaluating trades include two dimensional high power laser diode emitter arrays, modulation of individual emitters in an array, two dimensional detector arrays, and holographic optical elements for optimized global broad-casting. These assays will be compiled from technical expertise of industry experts and experience gained from implementing the parallel interconnect computer. As the complexity of the optical interconnect grows, the generality and through-put capacity of the computational primitives realized increase as well. The computational concerns of this project are related to identifying and evaluating the computational primitives that can be realized on any interconnect geometry. While we wish to implement a general purpose computer, we feel that some of the primitives identified will prove promising for specific applications (such as image processing) and will tag those architectures for additional projects. We have found that desirable computer primitives suggest interconnect geometries and vice versa. This study intends to resolve the trade-off between the technical risk of increased complexity with the advantages of increased through-put capacity and lower power requirements. The thrust of this approach is to significantly increase system through-put by utilizing larger (approximately three orders of magnitude) fan-in at the optical gate. This approach is different than other optical computer developments that are limited in fan-in and seek to increase through-put by increasing the number of gates. We realize that the power required will scale roughly proportionally to the number of gates and are optimistic that we can realize greater through-put as measured by Gate Interconnect Bandwidth Product (GIBP) with out increasing power requirements. This project's goal is to extend the parallel computer being implemented will by necessity use very similar technology components and design techniques. The potential in additional through-put volume that can be realized with little additional power required is clearly desirable to missions requiring high speed computation on space platforms.

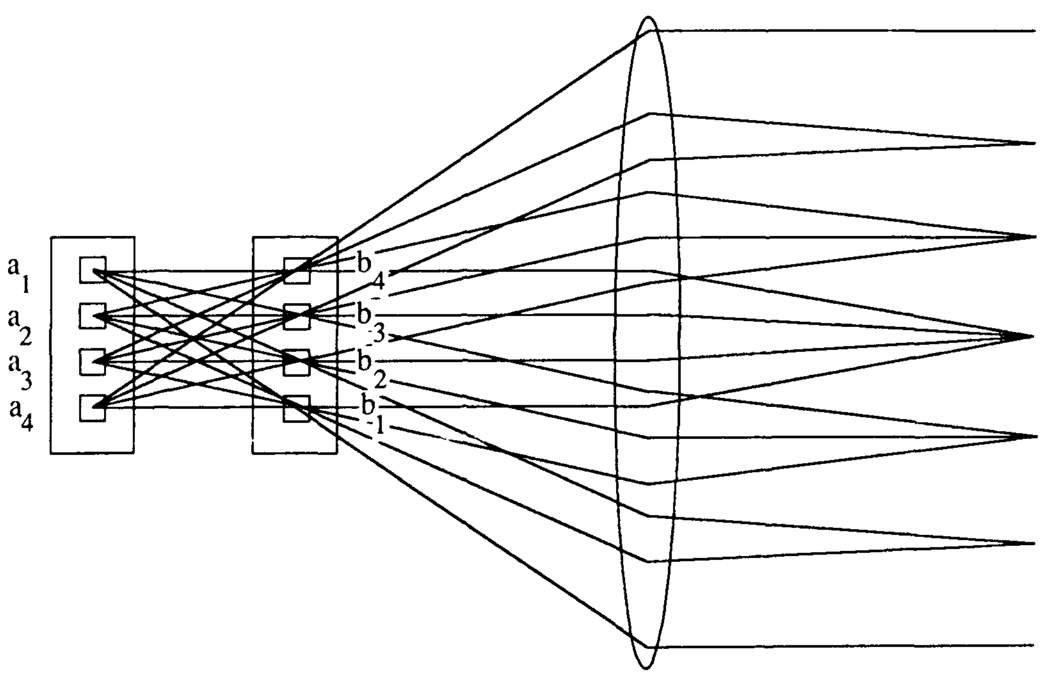
OptiComp is in the process of demonstrating a general purpose digital optical computer. As this technology becomes thoroughly understood, its evolution to higher performance will proceed as it further demonstrates its advantage over electron interconnects. Identification of optimal architectures will motivated device technology development and the development of optically addressed optical read/write memories. Anticipated is subsequent commercialization of this new computer technology for not only governmental use, but also the private sector. Projected commercial fall-out applications includes seismic geophysical signal and data processing, structural and aerodynamic simulation and very large data base manipulation.

CORRELATION FUNCTION

$$X(n) = A(n) \oplus B(n)$$

$$X(p) = \sum_{m=-n}^{n} B(m)\, A(m-p)$$

Let $\vec{A} \equiv \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ \cdot \\ \cdot \\ a_n \end{bmatrix}$ and $\vec{B} \equiv \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ \cdot \\ \cdot \\ b_n \end{bmatrix}$; $\vec{A} \oplus \vec{B} = \vec{X} = \begin{bmatrix} a_1 b_1 \\ a_1 b_2 + a_2 b_1 \\ a_1 b_3 + a_2 b_2 + a_3 b_1 \\ \cdot \\ \cdot \\ a_1 b_{n-1} + a_2 b_{n-2} + \ldots + a_{n-2} b_2 + a_{n-1} b_1 \\ a_1 b_n + a_2 b_{n-1} + \ldots + a_{n-1} b_2 + a_n b_1 \\ a_2 b_n + a_3 b_{n-1} + \ldots + a_{n-1} b_3 + a_n b_2 \\ \cdot \\ \cdot \\ a_{n-2} b_n + a_{n-1} b_{n-1} + a_n b_{n-2} \\ a_{n-1} b_n + a_n b_{n-1} \\ a_n b_n \end{bmatrix}$



$x_1 = a_4 b_4$

$x_2 = a_4 b_3 + a_3 b_4$

$x_3 = a_4 b_2 + a_3 b_3 + a_2 b_4$

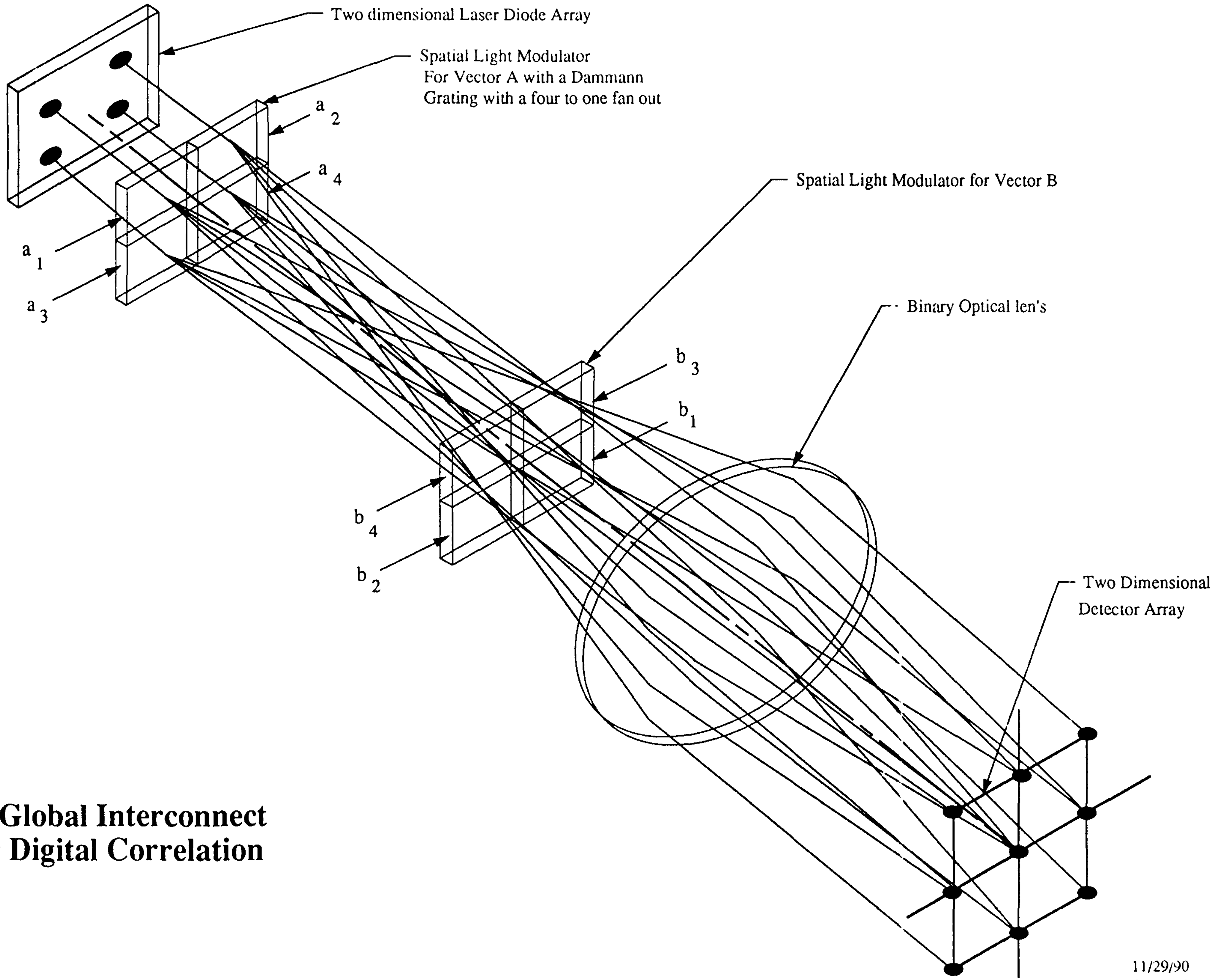
$x_4 = a_1 b_4 + a_2 b_3 + a_3 b_2 + a_4 b_1$

$x_5 = a_1 b_3 + a_2 b_2 + a_3 b_1$

$x_6 = a_2 b_1 + a_1 b_2$

$x_7 = a_1 b_1$

11/29/90
Global Graph



3D Global Interconnect For Digital Correlation

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