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TM No. 841181

NAVAL UNDERWATER SYSTEMS CENTER  
NEW LONDON LABORATORY  
NEW LONDON, CONNECTICUT 06320

Technical Memorandum

THE COMPUTATIONAL SPEED OF A  
CRAY-XMP COMPUTER

DATE: 10 October 1984

Prepared by:

Abraham Y. Shigematsu  
Engineering Mechanics Division  
Engineering & Technical Support  
Department

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# Report Documentation Page

Form Approved  
OMB No. 0704-0188

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1. REPORT DATE <b>10 OCT 1984</b>		2. REPORT TYPE <b>Technical Memo</b>		3. DATES COVERED <b>10-10-1984 to 10-10-1984</b>	
4. TITLE AND SUBTITLE <b>The Computational Speed of a Cray-XMP Computer</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) <b>Abraham Shigematsu</b>				5d. PROJECT NUMBER <b>633Y00</b>	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Naval Underwater Systems Center, New London, CT, 06320</b>				8. PERFORMING ORGANIZATION REPORT NUMBER <b>TM No. 841181</b>	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>NUWC2015</b>					
14. ABSTRACT <b>Seven major production programs currently being used at NUSC were selected to be run on the NASA-Ames CRAY-XMP computer. The results of this study will be described herein.</b>					
15. SUBJECT TERMS <b>Cray; Cray-XMP</b>					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

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ABSTRACT

Seven major production programs currently being used at NUSC were selected to be run on the NASA-Ames CRAY-XMP computer. The results of this study will be described herein.

ADMINISTRATIVE INFORMATION

This memorandum was prepared under Project 644Y00, Special Projects and Studies, Principal Investigator, A. D. Carlson, Code 44. The author of this memorandum, A. Y. Shigematsu, is located at the Naval Underwater Systems Center, New London Laboratory, Code 44, New London, CT 06320.

## INTRODUCTION

In order to study the computational speed of a CRAY-XMP computer, seven major NUSC production programs were selected to be run on the NASA-Ames CRAY-XMP computer. Three of these programs were successfully converted and run on the CRAY-XMP computer. The remaining four programs were found to require many changes in order to convert them to run on the CRAY-XMP computer, and it was decided not to pursue the conversion. The results of the three successful conversions and the difficulties encountered in converting the other four programs will be discussed herein.

## DISCUSSION

The first program converted was "SIM2" a combat simulation program used by Code 61. "SIM2" is a logic intensive program. It is a FORTRAN program with 70-80% of its code consisting of "IF" statements or "IF--THEN--ELSE" blocks. Because "IF" statements inhibit vectorization on CRAY computers and logical statements execute more slowly than floating point instructions on CRAY computers; it was not possible to realize the full computational power of the CRAY-XMP for "SIM2". It was found that the CRAY-XMP executes "SIM2" 18 times faster than the UNIVAC 1100/80 computers.

The second program converted was "TIGER" a life-cycle simulation program from Code 434. "TIGER" was also a logic intensive program with 70-80% of the code consisting of "IF" statements and "IF--THEN--ELSE" blocks. It took 21.4 minutes of CPU-time on the CRAY-XMP to run 500 missions compared with 300 minutes (5 hours) on a VAX 11/780 computer. Hence, the CRAY-XMP was 14 times faster.

The third program converted was "IFD" an IMPLICIT FINITE-DIFFERENCE program which computes propagation loss. "IFD" was written by Ding Lee and George Botseas of Code 3342. This program performs intensive floating point computation. About 80-90% of its code consists of floating point operations. Also it has many "DO-Loops" that CFT (CRAY FORTRAN) is able to vectorize. When "IFD" is executed a section of the code known as the "MAIN PROGRAM LOOP" is executed thousands of times. The problem being solved determines the number of passes. Most of the smaller "DO"-loops in the "MAIN PROGRAM LOOP" were vectorized by CRAY FORTRAN (CFT). However, there are conditional calls to subroutine "DIAG". The subroutine "DIAG" is not vectorizable. Hence, the problems which required thousands of calls to "DIAG" ran a lot slower than those problems that make only a few or no calls to "DIAG". Those problems that did not call "DIAG" many times ran an average of 115 times faster than on a VAX 11/780 computer. Those problems that called "DIAG" many times ran about 60 times faster than the VAX 11/780.

For all three programs, that have been discussed above, little effort was made to optimize the code. Many techniques are known that would increase the speed of programs run on a CRAY-XMP computer. The type of program that would run most efficiently on the CRAY-XMP are programs that require intensive double precision computations (i.e. 64 bits per floating point word). Because on the CRAY-XMP the single precision word size is 64-bits long.

The following programs were not converted to run on the CRAY-XMP due to the large number of changes required to the codes to make them CRAY FORTRAN compatible:

- 1) "MINIMAX" from Code 3292
- 2) "RASTER" from Code 3251
- 3) "OPENJAVA" from Code 3511
- 4) "RSUBA1" from Code 3511

Most of the FORTRAN incompatibilities in these programs fell into the following general classes:

- 1) Conversion of Double Precision VAX programs into single precision CRAY single precision programs. Because CRAY FORTRAN uses 64-bit single precision. Also all "INTEGER\*2" declarations must be changed to "INTEGER" (64-bit integers).
- 2) Removal of ASCII control characters from the VAX source code is required. Control characters which must be removed are:
  - a) "FORM-FEED" (<FF> or (CTRL-L))
  - b) TAB-CHARACTERS (CTRL-I)
  - c) SOS--editor "page marks"
- 3) Variable names must be limited to 8 characters and the underscore character is not permitted.
- 4) All "OPEN" & "CLOSE" statements must be modified.
- 5) All "INCLUDE" statements must be removed and replaced with appropriate labeled common statements.
- 6) CRAY FORTRAN requires the subprogram with the longest occurrence of a labeled common block to occur first.

After these general rules are satisfied there may still be specific differences which have to be resolved. In general, a program which conforms to ANSI-FORTRAN-77 will compile on CRAY FORTRAN.

Implementation of conversion from VAX Double Precision to CRAY Single Precision is not always straight forward. For example, the MINIMAX program requires detailed knowledge of the algorithm to successfully convert from Double to single precision. It is not possible to convert MINIMAX in an automatic (syntactical) way.

## CONCLUSION

Most FORTRAN programs can be converted to run on the CRAY-XMP computer. It is easier to convert a program written in ANSI FORTRAN-77. The performance of the converted program depends on the type of algorithm being solved. However, it was found that a minimum improvement in speed of 14x was observed, and in some cases a 115x improvement in speed was observed. In programs not discussed in this memorandum, speed improvements of 300x or better have been experienced.

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10 October 1984  
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