COSMIC/NASTRAN® ON THE CRAY COMPUTER SYSTEMS

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SUMMARY

RPK Corporation has converted COSMIC/NASTRAN to the CRAY computer systems. The CRAY version is currently available and provides users with access to all of the machine-independent source code of COSMIC/NASTRAN. Future releases of COSMIC/NASTRAN will be made available on the CRAY by RPK soon after they are released by COSMIC.

INTRODUCTION

RPK Corporation has converted COSMIC/NASTRAN to the CRAY computers that operate under the CRAY operating system (COS). RPK believes that NASTRAN users with CRAY computers desire to have COSMIC/NASTRAN available to them. With RPK's CRAY version, users have access to all of the features in the current release of COSMIC/NASTRAN. These features include not only the analysis capabilities offered by NASTRAN, but also the availability of the machine-independent source code, thereby giving users the freedom and ability for incorporating in-house modifications and enhancements to NASTRAN. It is RPK's commitment to make available and maintain future releases of COSMIC/NASTRAN on the CRAY. RPK will ensure that the CRAY version will always have all of the capabilities available on the latest COSMIC-maintained versions of NASTRAN.

ADVANTAGES OF A CRAY COMPUTER

The CRAY computer is established as one of the fastest computers in the world. The CRAY computer employs a pipeline architecture with scalar and vector processing capabilities (Reference 1). It is capable of a peak computational speed of at least 100 million floating point operations per second and has a central-memory bandwidth of one word per 12.5 nanoseconds, or 80 million words per second. The CRAY computer is highly compact and, because of this, signals can be carried from point to point in it at the velocity attainable with ordinary copper wire: about three-tenths the speed of light. The CRAY also has a very fast scalar speed. This scalar speed is a very dominant factor for programs that are not optimized for vectorization or for programs that do not lend themselves for significant vector optimization.

Figure 1 shows a generalized block diagram of the architecture of a vector computer similar to the CRAY computer. In this diagram, the instruction registers are read and processed by the pipelined instruction processor and the scalar registers are used by the pipelined scalar arithmetic and logic unit. The vector processor performs all vector processes. On the CRAY computer, there are five groups of registers: 8 address registers, 64 intermediate address registers, 8 scalar registers, 64 intermediate scalar registers and 8 vector registers containing 64 words each. In addition, the CRAY has 4 sets of 16-word buffers used for storing instructions.

Figure 2 shows the vector processor of a CRAY computer. It includes seven special-purpose pipelined units for executing specific functions. Three are shared with the CRAY's scalar processor. Several of the units can work concurrently on different vector operations. Vector data stream from the eight vector registers, through the functional units and back to registers. The steering module switches operands from the registers to the functional units and back again to the registers. While some registers are serving as sources or destinations of vector operations, others can be transferring data to or from central memory. Because of the register-to-register streaming of vectors, pipelines are short and start-up overhead is small.

One consequence of the register-to-register streaming of vectors is that the curve of efficiency (megaflops or millions of floating point operations per second versus vector length) shows peaks at vector lengths that are multiples of 64. This is shown in Figure 3. The peaks at vector lengths of 64 and 128 are there because there are 64 words in each set of vector registers and the CRAY operates most efficiently when all of these words are used. The curve drops off after 64 because of the time it takes to reload the registers with the next data to be processed (Reference 2).

DESIGN OF THE CRAY VERSION

The design of the CRAY version of COSMIC/NASTRAN is similar to that of the DEC VAX version. There are fifteen programs that correspond to the fifteen standard NASTRAN links. None of these programs contains an overlay structure. The fifteen programs dynamically chain themselves through the use of conditional job control language (JCL) (Reference 3). The I/O is designed to automatically allow for logical file extensions to additional physical files if space is exhausted on any given external file. This will ensure that no jobs are lost due to space limitations on one file.

RPK has designed the CRAY version to allow for easy maintenance and growth. There is no need for a special linkage editor nor for any other special software utilities other than those provided by COS. Users can update and modify the CRAY version using such standard CRAY-supplied utilities as BUILD (Reference 3) and UPDATE (Reference 4). The design also readily lends itself to the use of the Fortran Flow Trace capability (Reference 5). This capability is of immense help in accurately evaluating the performance of the code and in determining the areas of the code where improvements can be made using optimization techniques that will obtain the most benefits.

OPTIMIZATION OF THE CRAY VERSION

Several important areas of code in RPK's CRAY version have been optimized by using the vectorization techniques available on the CRAY. These include the decomposition, forward/backward substitution and multiply/add routines, certain eigenvalue extraction routines and others. The reduction in CPU times resulting from optimization in these areas of code has ranged from a minimum of about 50% to as high as 99%. RPK is committed to optimizing the entire spectrum of capabilities in COSMIC/NASTRAN. However, RPK regards this work as an continuing activity and expects to optimize the bulk of NASTRAN code in the near future.

CONCLUDING REMARKS

In developing the CRAY version of COSMIC/NASTRAN, RPK hopes to satisfy the needs of CRAY users who desire to use COSMIC/NASTRAN on the CRAY and may desire to have access to the machine-independent source code. RPK is fully committed to maintaining the CRAY version in such a manner as to be fully compatible and equal in capability with the latest COSMIC-maintained versions of NASTRAN.

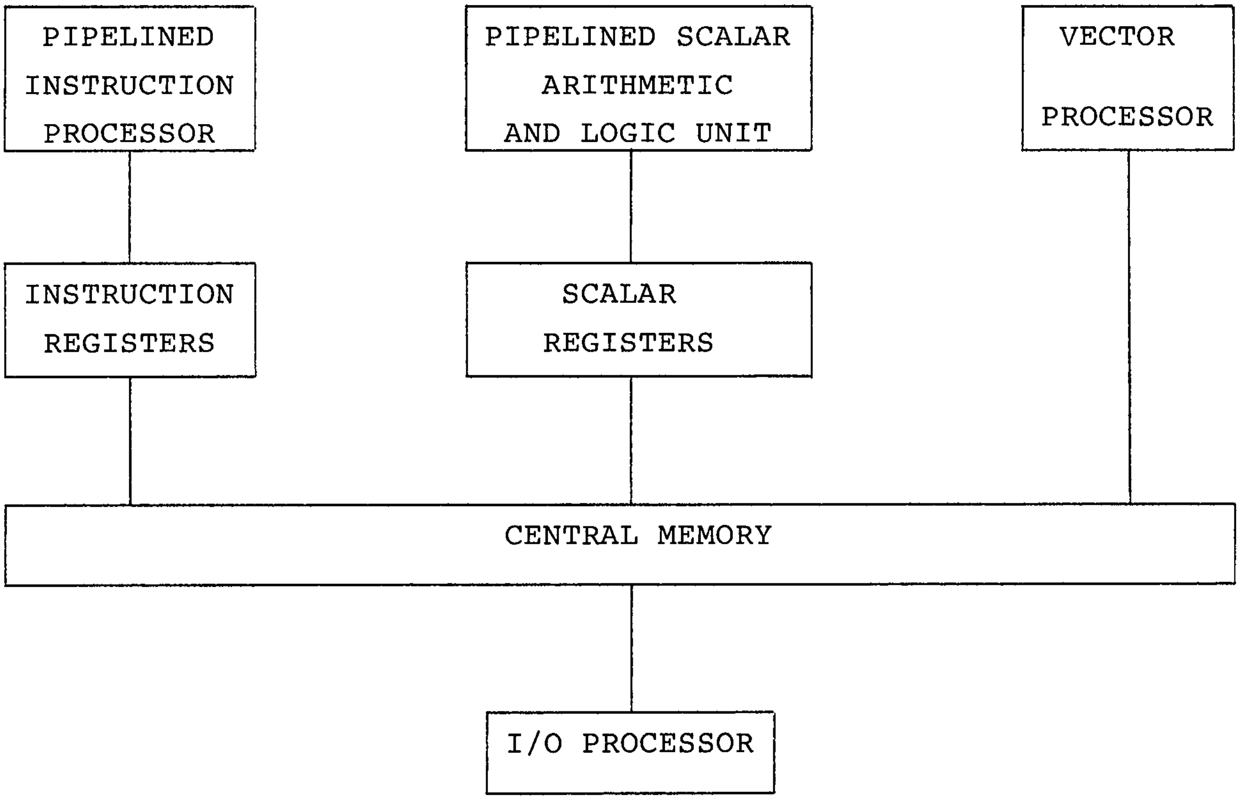

Figure 1. Generalized block diagram of a vector computer

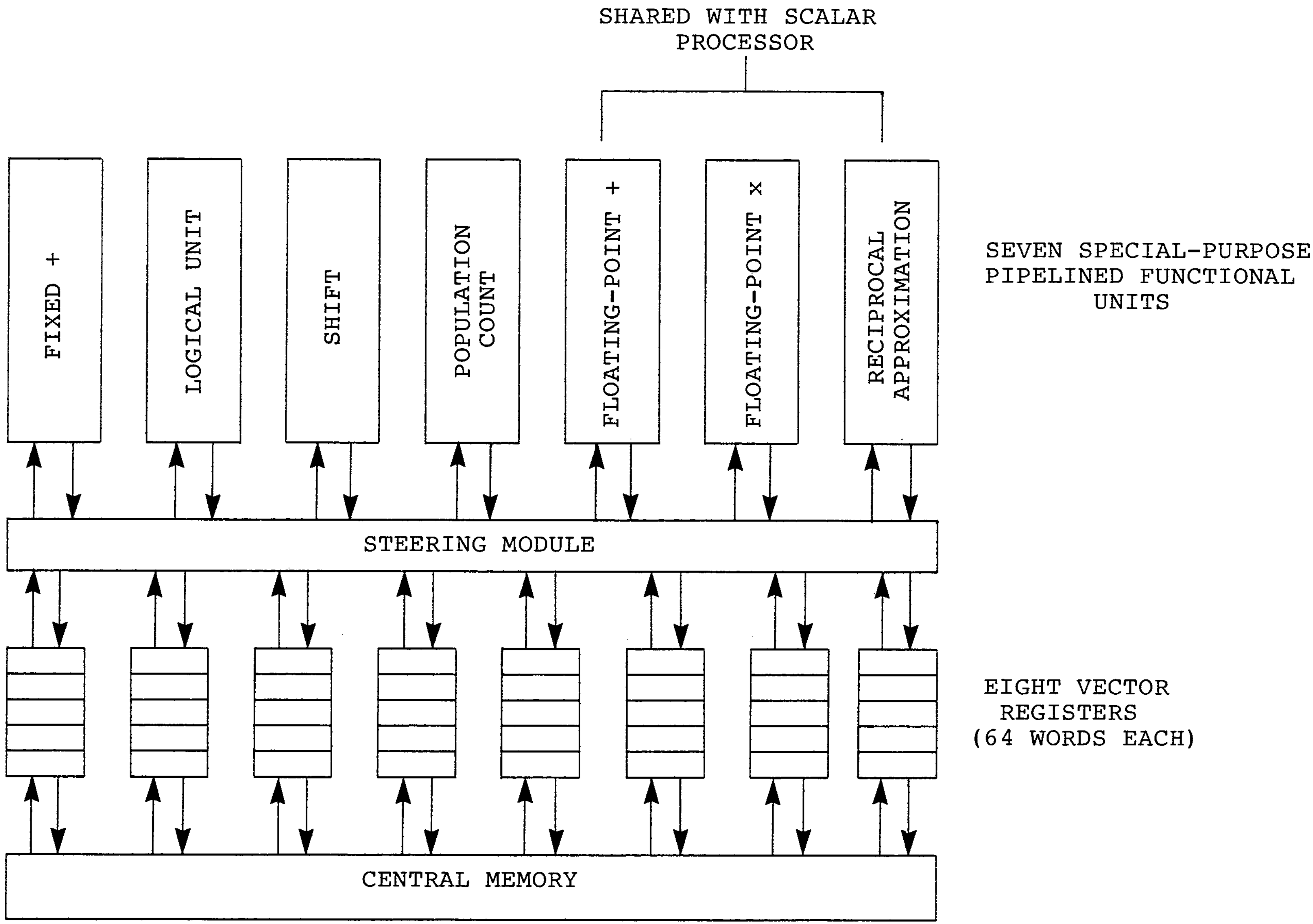

Figure 2. Vector processor of a CRAY computer

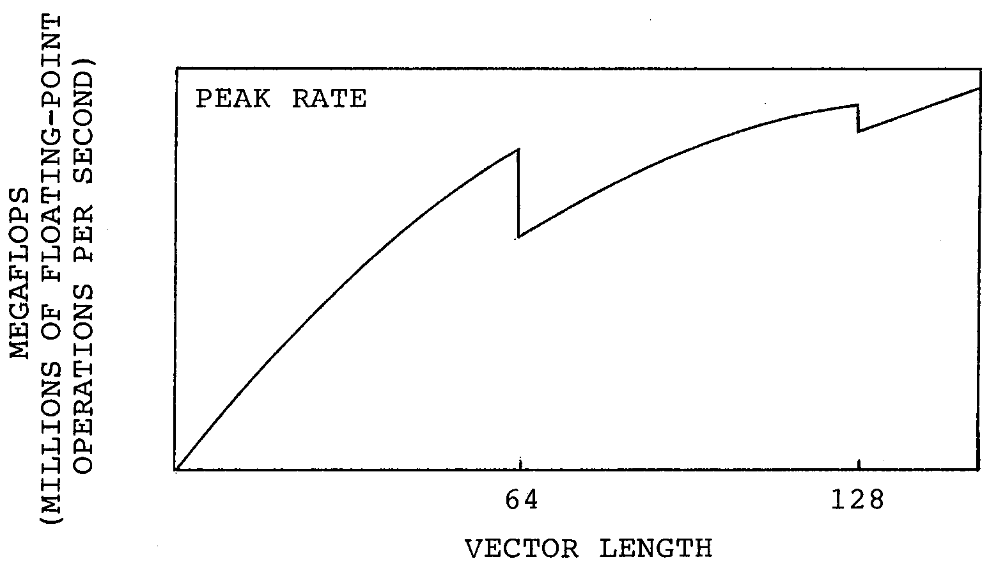

Figure 3. Vector processing on the CRAY

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3. Cray-OS Version 1 Reference Manual, CRAY-1 Computer Systems, Cray Research, Inc., Publication No. SR-0011.

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