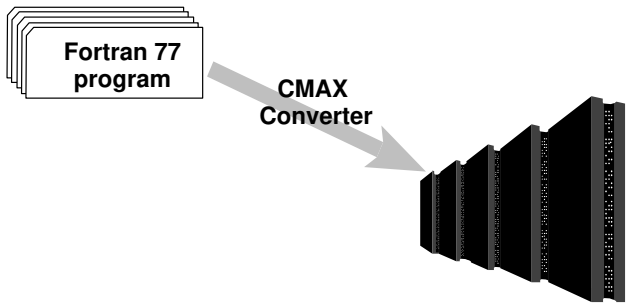
Chapter 8

The CMAX Converter

CMAX — the "CM Automated X–lator" — is a tool that converts standard Fortran 77 into CM Fortran. CMAX provides a convenient migration path for serial programs onto the massively parallel Connection Machine system, both for data parallel applications and for CM Fortran/CMMD message-passing applications.



In addition, CMAX gives users the option of maintaining their software in Fortran 77 for maximum portability to multiple platforms. Users in a heterogeneous computer environment and third-party software developers can use the converter as a "preprocessor" for routine Fortran compilation for CM systems. In this sense, CMAX provides a migration path onto and off of the Connection Machine system.

The major difference between serial and data parallel Fortran programs is the substitution of array operations for loop iterations, and the concomitant need to lay out some arrays across the processing nodes. These are the tasks performed by the CMAX converter.

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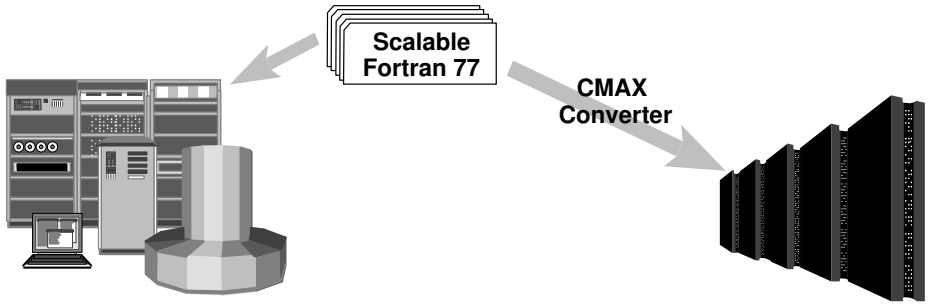
CMAX is a **DO** loop vectorizer; it analyzes loop constructs and translates them into CM Fortran array operations. For greatest efficacy, the converter performs an interprocedural dependence analysis of the whole program and applies vectorization techniques such as loop fissioning, scalar promotion, and loop pushing to the input code. CMAX also recognizes the intent of numerous programming idioms, such as structured data interactions and dynamic array allocation. When translating code, it makes full use of powerful Fortran 90 features such as array-processing intrinsic functions and dynamic allocation statements, as well as the **FORALL** statement defined by High Performance Fortran. CMAX thus provides entree both to the Connection Machine system and to the emerging HPF standard.

CMAX provides a convenient interface to the user. The Prism development environment provides facilities for examining CMAX output and comparing it line-by-line with the input program. CMAX command options and in-line directives allow the user to control the converter's actions and decision rules. The CMAX library provides canonical, portable — and translatable — Fortran 77 utilities for expressing common operations like dynamic array allocation and circular array element shifts. The converter generates detailed notes of a conversion, explaining all the changes it has made.

Although CMAX is designed primarily to assist in the creation of new applications, it accepts as input any program that is written in standard Fortran 77 and follows standard guidelines for scalability. These simple guidelines guarantee that a program runs efficiently on any size data set, large or small, and on any number of processors, from one to thousands. The combination of guidelines plus converter can assist substantially the task of upgrading "dusty deck" programs to take advantage of modern architectures and language features.



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The conventions of scalable Fortran programming express three basic objectives:

- Make it easy for a compiler to recognize how data and computations may be split up for independent or coordinated processing. For example: loop over as many array axes as possible in a single operation; use standard idioms to express common, well-structured data dependences.
- Avoid constructions that rely on a particular memory organization, such as linearizing multidimensional arrays or changing array size or shape across program boundaries.
- Use data layout directives and library procedures (with some conditionalizing convention) to take advantage of the specific performance characteristics of each target platform. For example, Fortran 77 programs targeted to the CM system can use compiler directives to fine-tune data layout and access the CM libraries for procedures that are specially tuned for performance on the CM system.

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