Chapter 1

Introduction

This manual provides information on compiling and executing CM Fortran programs on CM-5 systems with or without vector units.

It also describes tools and utilities that assist program development, and notes some miscellaneous details of the implementation.

This chapter introduces the execution environment for CM Fortran programs running on the Connection Machine model CM-5 and its CMOST operating system. For more information, refer to the *CM-5 User's Guide*.

The chapters that follow describe the compiler, the development tools and utilities, and various features of the CM Fortran implementation on the CM-5.

CM Fortran programmers may wish to consult the *CM-5 User's Guide* for information about development tools, file systems, and libraries available on the CM-5 system.

1.1 Introducing the CM-5 Supercomputer

A CM-5 system is a massively parallel, scalable supercomputer containing a few or thousands of processors. These processors may be divided into two categories, computational processors and control processors.

- *Computational processors* make up the vast majority of processors inside the CM-5 system. They do the actual computations on data in parallel, communicating with each other to share data as necessary.

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- *Control processors* manage the CM-5's computational processors and I/O devices. They provide major OS services for the system, handling the system's user interface, its I/O and network interfaces, and its system administration and diagnostic interfaces.

A group of computational processors under the control of a single control processor is called a *partition*, and the control processor is called the *partition manager*.

Interprocessor communication networks connect all processors, of both types, to provide rapid, high-bandwidth communication within and between user processes.

The CM-5 operating system provides for both spacesharing and timesharing among user processes.

- Spacesharing occurs when the system administrator partitions the CM-5, allotting so many processors to one partition, so many to another. The system administrator also decides which users have access to a given partition. Administrators can change partition sizes or access rules as needed to suit the needs of their sites.

- All partitions run CMOST: the CM Operating System — Timeshared. Therefore, timesharing is the natural state on all partitions.

CMOST is an enhanced version of the UNIX operating system. Users of the CM-5 thus have access to all standard UNIX facilities, as well as to the special tools and utilities provided by CM software to facilitate parallel programming.

1.1.1 The User's View of the System

Figure 1 diagrams a sample CM-5 system as it appears to a user. This particular system has two partition managers, named Mars and Venus. Each of them is currently managing a partition of 256 *processing nodes* (SPARC nodes). Since this system has the optional vector unit hardware, each SPARC node in turn manages 4 vector units.

The system also has control processors managing some I/O peripherals and one that is dedicated as a system console.

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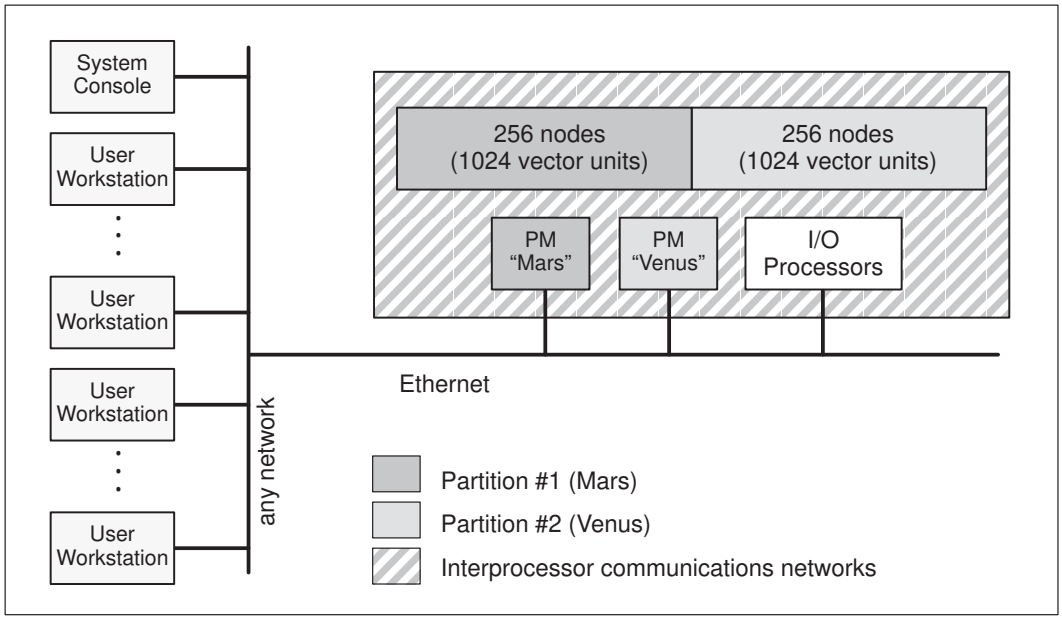

Figure 1. A sample CM-5 system.

1.1.2 Gaining Access

You gain access to a CM-5 system through one or more of its partition managers. The CM-5 is usually accessed across a network, either by logging in remotely (via the UNIX **`rlogin`** command) or by running a remote shell (via the **`rsh`** command).

For example, the users in Figure 1 (shown at workstations "somewhere on the network") can log in remotely or use remote shells to run programs on either partition. Typical command sequences might be

```
% rlogin mars
  [ login sequence ]
% a.out

% rsh venus my_program
```


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Once you have logged in or established your shell, you are operating in the CMOST timesharing environment, with the following resources available to you:

- A partition manager (equivalent to a UNIX workstation). You initiate program execution on this processor, which utilizes computational processors and I/O devices as needed.
- All the parallel processors in the partition. Under the CMOST timesharing environment, all the nodes (and vector units) are available to, and all are used by, every parallel program running on that partition.
- All the I/O devices on the CM-5 (assuming you have been granted access to the appropriate file systems).

Execution and debugging of CM Fortran programs are initiated on one of the CM-5's partition managers, either from the CMOST shell or from the Prism development environment. Compilation can be done either on a CM-5 partition manager or on a separate workstation that has CMOST and the CM Fortran compiler installed.

1.1.3 Executing Programs

Programs executing on the CM-5 begin their execution on the partition manager, which downloads program blocks to the nodes. You begin execution on CMOST in the same way as on the UNIX operating system:

```
% a.out
```

You can submit interactive jobs directly, or, if your site is using DJM, you can use the **jrun** command.

To submit a batch job, you can use the UNIX **at** and **batch** commands, the commands of the NQS system, or the DJM **jsub** command. (See the documentation for NQS for the CM system or for DJM.)

The partition manager runs the full CMOST operating system; it initiates program execution on the computational processors, performs I/O, and handles timesharing and other OS tasks for the partition. Each SPARC node runs a stripped-down version of the operating system, which enables it to

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fetch instructions, to manage the processing of its local data, and to communicate with the partition manager and with the other nodes in the partition.

If a program needs access outside the partition — to read from an I/O device, for example, or to pass data to a process running on another partition — it goes through the partition manager to do so. (The partition manager, running in supervisor mode, can access any address in the system.) The partition manager passes a request to read data from a disk file to the processor controlling that disk; data from the disk is, however, read directly into the processing nodes rather than passed through the partition manager, thus allowing a much more rapid transfer.

1.1.4 Checking System Status

Partitions are not permanent. They are defined by the system administrator to meet the site's needs, and they can be changed by the administrator as needed. The system shown in Figure 1, for example, could be reconfigured as a single partition, with Venus controlling all the nodes and Mars either inactive or acting as a stand-alone compile server. Similarly, if some nodes needed to be taken out of service temporarily, the partition could be reconfigured around them.

The most common questions about system status on a CM-5, therefore, are,

- How large is this partition at this time?
- How many user processes are running on it?
- How much time and memory has been allocated to each process?

You can use the **cmps** command to answer these questions; **cmps** tells you how many vector units or nodes the partition manager currently controls and gives information about the jobs it is running. The UNIX **ps** command (on which **cmps** is modeled) provides similar information on workload for the partition manager itself.

Note that the **cmps** command provides information only about the partition on which the command runs. If you are logged into Mars, **cmps** provides information only about the partition controlled by Mars. To find out about conditions on Venus, you would use a remote shell, and type

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```
% rsh venus cmps
```

1.2 CM Fortran and Other CM-5 Software

The CM-5 provides a complete environment for developing, compiling, and executing CM Fortran programs. This environment includes:

- A run-time system that optimizes parallel execution, with functionality available to users through the CM Fortran language and libraries.
- Data parallel CM libraries, including the visualization libraries CM/AVS, CMX11, and CMHFB, the scientific software library CMSSL, and the CM file system libraries SFS (for Scalable Disk Array) and CMFS (for DataVault and devices such as CM-HIPPI).
- The message-passing library CMMD, which permits node-level programming in CM Fortran and other languages.
- Prism, a programming environment that integrates debugging, performance analysis, and data visualization tools. Prism is available as a windowed environment on terminals and workstations that run the X Window System. It can also be used in command mode from the CMOST shell.
- A variety of development tools and facilities, described later in this manual, accessible from CMOST.

1.3 CM Fortran and System Terminology

Some of the terminology used for the CM-5 had its origins in CM-2 system terminology. Thus, terms such as *front-end array* and *CM array* continue to be used. On the CM-5, a *front-end array* is an array that is stored and processed on the partition manager (except in the case of the nodal execution model, in which front-end arrays are on the nodes), and a *CM array* is an array that is stored and processed on the parallel processing

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elements (vector units or SPARCs). The term *CM* includes both the control processors and the computational processors.

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