

## PRODUCT OVERVIEW

### STANDARDS ADHERENCE

C-DAC's HPCC software follows established standards to minimize learning time and maximize ease-of-use. Most commands use familiar UNIX syntax. HPCC software graphical user interfaces comply with Motif or Java style standards. HPCC's implementation of the MPI standard closely follows the published standard and allows programmers to write portable parallel applications which run on the PARAM systems and other cluster systems supporting the standard.

### HPCC SOFTWARE: PRODUCT COMPONENTS

KSHIPRA	Scalable Communication substrate layered over PARAMNet and Gigabit Ethernet for UNIX clusters.
C-MPI	Optimized implementation of MPI for Cluster of Multi Processors (CLUMPS). Both point-to-point and collective calls have been optimized. Effectively uses both shared and distributed memory of CLUMPS.
C-PFS	Parallel File System Provides MPI-IO file system interface to parallel applications
F90IDE	Integrated Development Environment for Fortran 77/90 that includes compiler, debugger, profiler, source code browser and Fortran 77 to F90 convertor.
PGF90	An automatic parallelizing compiler for Fortran for SMP based architecture.
DIVIA	Parallel program correctness and performance debugger. Detects communication bottlenecks and supports message debugging.
PARMON	Cluster monitoring tool. Monitors the cluster as a unified resource. Provides Web Interface for monitoring over internet.
RMS	Resource Management Software for effective load balancing and load scheduling on clusters.
PARCOM	Parallel Unix Commands. Provides parallel extensions to traditional UNIX commands.
Metric-Advisor	Software engineering tool for metrics. Evaluates Halstead, McCabe, Complexity Density, fan-in and Fan-out metrics.

### AVAILABILITY

Supported Hardware	:	Workstation Clusters
Supported Operating System	:	AIX, Solaris and Linux
User Interfaces	:	GUI
Supported Languages	:	Fortran 77/90, C
Prerequisite softwares	:	Java, X/Motif
Prerequisite hardware for base software	:	PARAMNet, Gigabit Ethernet



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# HPCC Software for Unix Clusters

## Flexible Parallel and Distributed Software Environment

Workstation clusters are a cost-effective solution for high performance computing. Programming the clusters to run efficiently and to provide a look and feel of conventional computers to maximise ease-of-use are major software challenges.

C-DAC's HPCC\* (High Performance Computing and Communication) software effectively addresses these performance and usability challenges through a high performance flexible software environment, which adheres to established and emerging standards in parallel and distributed computing.

The HPCC software supports the development and execution of sequential, message passing and data parallel programs and allows the ensemble of workstations to be viewed as independent workstations, cluster of workstations, or as a massively parallel processor system.

The HPCC software provides a complete solution for creating and executing parallel and distributed programs on UNIX clusters through high performance communication protocols and a rich set of program development, system management and software engineering tools.

### DESCRIPTION

The HPCC software suite of products includes high performance compilers, parallel debuggers, data visualisers and performance profilers. High performance communication protocols and efficient MPI implementation provide the correct framework to extract maximum performance.

A single system image at the system management level ensures easy administration and monitoring of large UNIX clusters.



CDAC HPCC Software Architecture

### KEY FEATURES

- ▶ Exploits hardware features for communication, providing a low latency and high bandwidth communication substrate
- ▶ Supports complete implementation of the MPI standard. Collective algorithms tuned to a Cluster of Multiprocessors (CLUMPS) architecture
- ▶ Provides scalable parallel IO for Unix clusters
- ▶ Full function development environment for parallel and distributed applications with support for parallel program debugging and profiling
- ▶ Provides an integrated Fortran 90 Development Environment
- ▶ Unified system management tool for cluster monitoring and administration
- ▶ Adheres to established and emerging standards in parallel and distributed computing

Centre for Development of Advanced Computing

The HPCC software consists of:

- ▶ Base software that includes a lightweight communication substrate, optimized MPI, and a parallel file system with MPI-IO interface
- ▶ A Program Development Environment, providing a rich set of FORTRAN 77 / Fortran 90 program development tools, and an integrated debugging environment for parallel programs.
- ▶ System Management tools for monitoring the effective utilization of the cluster resources and for administration of large UNIX clusters
- ▶ Software engineering tools for developing high quality programs.

**HPCC - BASE SOFTWARE**

Legacy protocols like TCP/IP having large overheads do not exploit hardware features nor allow experiments with new protocols and flow control mechanisms.

HPCC software's KSHIPRA communication substrate provides lightweight communication protocols based on AM conforming to the Active Messages II specifications of the University of California Berkeley and VIA conforming to Virtual Interface Architecture specifications jointly authored by Intel, Compaq and Microsoft. The implementation leverages on a mechanism, which decouples communication path from the operating system. This eliminates operating system overheads in frequent operations like send/receive. It provides a communication abstraction which allows the applications to exploit to the fullest the low latency and high bandwidth of the underlying high performance network. HPCC software also provides Message Passing Interface (MPI) application programming interface for parallel computing layered over the low-level communication substrate.

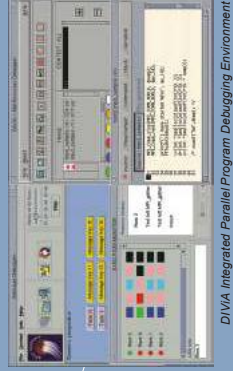
To facilitate simultaneous communication among many parallel processes, MPI provides collective communication functions. The performance of these functions can be enhanced by using appropriate algorithms for the architecture. C-MPI has tuned the MPI collective algorithms to a cluster of SMP nodes. In addition, C-MPI achieves enhanced performance by layering MPI over lightweight communication protocols.

Parallel applications, to scale also require an efficient file system that provides high throughput for executing parallel job. HPCC software addresses this issue by providing C-PFS\*, a high performance parallel file system exporting MPI-IO interface, an IO extension to the MPI 2 specification. Conventional distributed file systems optimize the aggregate IO throughput while the parallel applications require the full IO throughput to be delivered to a single application. C-PFS leverages on a mechanism that provides an end-to-end user level implementation to provide high performance. C-PFS also has features to provide high IO throughput for typical IO workloads of the parallel programs.

**HPCC - PROGRAM DEVELOPMENT**

HPCC software provides an integrated FORTRAN program development environment that includes the FORTRAN 90 compiler, parallelizing compiler for FORTRAN 77/90 for SMP and the integrated development environment (F90IDE). CDF90\* is a highly optimizing FORTRAN 90 and FORTRAN-77 compiler developed by C-DAC. It is fully ANSI X3.9:1978 and ISO/IEC 1539:1991 compliant. C-F77to90 is an extremely powerful tool for migrating FORTRAN 77 programs to Fortran 90.

PCF90 is an automatic parallelizing compiler for FORTRAN 77/90, which converts sequential FORTRAN programs to OpenMP based programs. These programs can be run parallelly on a SMP. The F90IDE is a complete integrated development environment for FORTRAN that includes a source level debugger, browser and profiler. For correctness and performance debugging of parallel applications, the HPCC software provides DIVIA



*DIVIA Integrated Parallel Program Debugging Environment*

integrated environment. DIVIA (Debugger with Integrated Visualizer and Analyzer) consists of a coherent set of tools that help programmers in both correctness and performance debugging. It works with MPI environment and debugs C or FORTRAN language parallel programs.

**Correctness Debugging Components**

- ▶ Multiprocess Debugger - Allows control of the execution of loosely synchronised, concurrently running multiple tasks as a related group of tasks with a source level debugging facility
- ▶ Message Debugger - Allows the user to inspect, modify, block and control the messages between the various tasks of a parallel application
- ▶ Visual Debugger - Provides visual feedback on the execution of a parallel program, filtering out all the unnecessary details and portraying the sequence of communication and the status of the participant tasks
- ▶ Execution Monitor displays the execution status of a parallel application by lighting software LEDs with different colors as specified by the user



*F90 Integrated Development Environment*

**Performance Debugging Components**

- ▶ Automatic Bottleneck Detector - Detects the communication bottlenecks and their sources automatically, to help the user fine-tune the parallel application.
- ▶ Profile Visualizer helps in analyzing the function profiles of a parallel application through different displays with respect to computation

**HPCC- SYSTEM MANAGEMENT**

The system management tool PARMON - allows the cluster user or administrator to monitor activities and resource utilization of various components of the cluster. It monitors the machine both at node level and at the entire system level, exhibiting a single system image. The PARMON, monitors system activities like process activities, system log activities, kernel activities; controls devices; and generates and analyses events. The cluster can be monitored from any workstation, PC or node of a cluster itself. PARMON also provides a web interface for cluster monitoring over the Internet.

A large cluster needs a software to do effective load scheduling and load balancing. The RMS allows the user to submit batch jobs and schedules them effectively to utilize all the nodes in the cluster. The Parallel Unix Commands PARCOM - is a tool for executing UNIX commands in a cluster environment where there is a frequent need to execute a given UNIX command on several processors in the cluster at the same time.

**HPCC-SOFTWARE ENGINEERING**

The HPCC software also provides programmers with tools for producing and maintaining quality code. The MetricAdvisor\* calculates a variety of source code metrics, which is essential for generating quality code. It evaluates the Halstead, McCabe and Complexity Density metrics. It also includes a static analyser that generates the call graph of C language source files.