SGI Message-Passing Status and Plans

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ABSTRACT: SGI message-passing software has been enhanced in the past year to support additional interconnect fabrics, improve NUMA-awareness, increase MPI-2 content, and provide other improvements. This paper describes the recent enhancements to MPI and SHMEM software and also outlines our roadmap of planned future enhancements.

Introduction

This paper will describe enhancements to SGI's message-passing software. *Message-passing* is a style of parallel programming that uses fast library calls to provide communication between cooperating parallel processes typically engaged in CPU-intensive work. SGI-supported message-passing application programming interfaces (APIs) include MPI, SHMEM, and PVM. All three APIs are packaged with the SGI Message-Passing Toolkit (MPT) on IRIX systems. See the SGI MPT web page at http://www.sgi.com/software/mpt/ for more background and description of SGI message-passing software.

Recent SGI MPT releases were 1.4.0.2 in August 2000, 1.4.0.3 in November 2000, and 1.5 in March 2001. MPT update release 1.5.1 is planned for June 2001 release. In this paper we will highlight some features of the MPT software thematically. For more detailed information about features, consult the MPT release documentation on the above-listed MPT web page or in the *relnotes* included with each MPT release.

MPT Feature Themes

The goals we have for SGI message-passing software include delivering communication performance, supporting all SGI high performance computing (HPC) hardware platforms, and providing increasing conformance to the MPI-2 standard. Performance features deliver favorable point-to-point communication microbenchmark performance, but more importantly they deliver performance to actual user programs. For example, fast message queuing and tuning of message headers help with high message contention, and runtime-tunable buffer management and single-copy data transfer help out with bandwidth-limited communication. Hardware platform support involves new generations of MIPS-based servers, early work with Intel-based servers, and a number of new and enhanced interconnects. The final feature theme, standards, acknowledges the gradually increasing customer interest in various MPI-2 capabilities and also involves a transition away from our support of PVM.

Performance

Message-passing software at SGI provides a number of performance-oriented features.

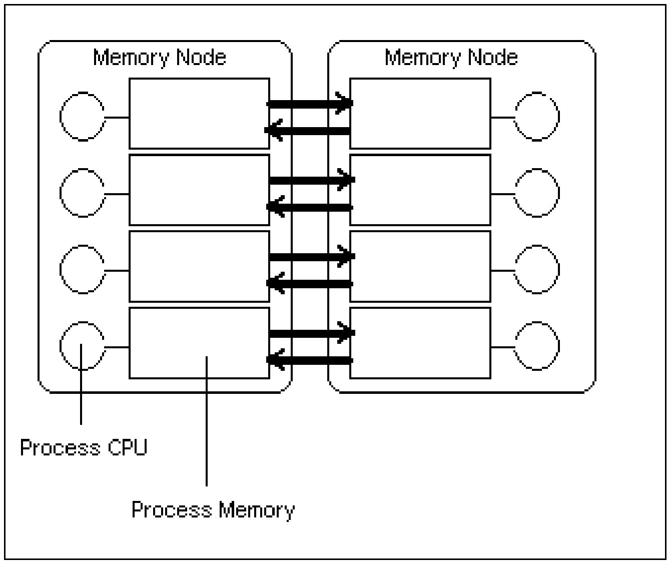
Low latency

For message-passing communication over NUMAlink on Origin 3000 servers, send-receive exchange of an 8-byte datum is performed in 5.5 microseconds. A put or get operation incurs a latency of less than 1 microsecond.

High bandwidth

The peak NUMAlink bandwidth for send-receive on Origin 3000 systems is 600 MB/sec when MPI uses the Block Transfer Engine (BTE). The capability to use BTE is planned for upcoming MPT release 1.5.1. When BTE is not being used, bcopy-based bandwidth achieves 280 MB/sec. Messaging bandwidth is also important in situations where all processes are communicating concurrently, as during data exchanges with logical nearest neighbors in a domain-decomposed application. MPT currently delivers up to 170 MB/sec per transfer on Origin 3000 with NUMAlink in all-communicate scenarios involving two memory nodes and the eight associated processors.

All-communicate Scenario



One-sided Communication

One-sided communication or *put/get* communication is provided in MPT via the SHMEM and the MPI-2 APIs. This style of communication can provide the lowest possible latency and the highest possible bandwidth for some communication patterns. SGI continues to support the SHMEM API because of its ease of use. The MPI-2 syntax for put/get communication is slightly more complicated to program, but is seeing increased use. The SHMEM API is more flexible and intuitive in some ways. It allows for the use of flag words to signal data delivery with user-written spin-waits. However, both APIs are easy to program when the common (barrier, communicate, barrier, compute) pattern is used in an application. Both APIs for put/get and the associated barrier synchronization routines (shmem_barrier_all and MPI_Win_fence) perform comparably on Origin 3000 systems with the NUMAlink interconnect.

Fast Barriers

Barrier synchronization times on Origin 3000 systems have accelerated proportionately with the reduced memory latency. Using the fetchop tree barrier, which is selected by setting the MPI_BAR_DISSEM environment variable, barrier synchronization times for 494 processes is 26 microseconds on Origin 2000 systems and 14 microseconds on Origin 3000 systems.

Physical CPU Selection

The MPT 1.5.1 will provide a new capability, which should prove helpful for those who wish to optimize and closely study the performance of parallel applications on dedicated Origin 2000 and Origin 3000 systems. The new MPI_DSM_CPULIST and SMA_DSM_CPULIST environment variables provide an easy way to specify the physical CPUs from **`/hw/cpunum`** that the ranks of the message-passing program are to be mapped to. For example, setting MPI_DSM_CPULIST to "4-7,12-15" specifies that ranks 0 through 7 are mapped respectively to CPUs 4, 5, 6, 7, 12,13, 14 and 15.

Single-Copy Send/Receive

In MPT 1.4.0.1 and later it is possible for MPI to deliver messages using a single data copy. In the typical and default send/receive pathway, MPI will copy the sender's data into a temporary buffer from which the receiver then copies the data. This type of algorithm can lead to contention for MPI message buffers and bandwidth bottlenecks when large messages are being sent, often by many processes concurrently. The single-copy send/receive pathway can avoid this contention and improve performance in some cases.

To select the single-copy messaging pathway, the user needs to set the MPI_BUFFER_MAX environment variable to some single-copy threshold value. We recommend setting MPI_BUFFER_MAX to 2000, to activate single-copy only for the larger messages. Because of the way that MPI maps memory, the single-copy send/receive pathway will not be taken unless the buffer passed by the sender is remotely accessible. Remotely accessible memory includes common blocks and symmetric heap. It excludes stack and private heap variables. We have seen performance gains realized in user codes that do large broadcasts and message exchanges similar to the MPI_Alltoallv collective communication. Speed-ups can be by more than a factor of two because of the combined effects of reduced bandwidth requirement and reduced message buffer contention.

The improvements from single-copy can be dramatic, but there are some caveats. Some MPI programs are written with the assumption that MPI_Send buffers its data. This is not conformant with the standard, but nevertheless some programs have this assumption. The single-copy pathway requires that MPI_Send not buffer its data. Performance in many of these data exchanges will not optimize well unless the user is calling the non-blocking MPI_Isend variant on the sending side.

Reducing Runtime Variability

On single-kernel Origin 3000 systems, MPI and SHMEM programs are cpuset-friendly. That is to say that when message-passing programs are launched within a cpuset, they will be scheduled optimally within the cpuset. A number of third party vendors' batch workload schedulers take advantage of this. The result is a dramatic reduction in the interference between two different parallel jobs scheduled to run concurrently. MPT 1.5.1 has further enhanced the interoperability of MPI with cpusets that contain partial memory nodes or nodes with downed CPUs.

Platforms and Interconnects

The MPI, SHMEM, and PVM APIs are available on differing sets of platform and interconnect configurations. The following chart shows SGI's status and plans for support of these APIs. Note that these are plans, and do not constitute commitments by SGI.

Platform	MPI	SHMEM	PVM
MIPS: single kernel NUMAlink	Supported	Supported	PVM will be retired after MPT 1.6
MIPS: partitioned NUMAlink	Supported in MPT 1.5.1	Planned late 2001	
MIPS: GSN	Beta GSN library supported. Libst 2.0 support planned July 2001.		
MIPS: Myrinet	Supported in MPT 1.5.1		
MIPS: HIPPI	Supported		
MIPS: Sockets	Supported		

Platform	MPI	SHMEM	PVM
SNIA: single kernel NUMAlink	Prototype working	Prototype planned in 2001	PVM will not be supported by SGI on SNIA systems.
SNIA: partitioned NUMAlink	Prototype planned in 2001	Prototype planned in 2001	
SNIA: Myrinet	Prototype working on IA64 (non-SNIA)		
SNIA: Sockets	Prototype working		

MPI Standards

SGI's strategy towards the implementation of MPI-2 functionality is to focus on customer needs and prioritize the work on a feature-by-feature basis. Over time, MPI-2 content in MPT will increase. As of MPT 1.5, significant MPI-2 functionality exists in MPT in the following areas:

- One-sided communication
- MPI I/O
- Thread Safety
- Fortran 90 bindings (USE MPI)
- C++ bindings

MPI-2 functionality planned in upcoming releases includes:

- MPI I/O integration with MPI_Wait
- MPI-2 datatypes that replace deprecated MPI-1 Fortran datatypes
- Expanded one-sided communication: lock, unlock, and accumulate
- MPI Process Spawn

Reading More about MPT Software

A number of references exist for SGI message-passing software information.

MPT Relnotes

The "relnotes mpt" command provides information about new features and bugfixes, as well as administration information to help with software installation.

Man Pages

The "man mpi" command will display a reference page containing general topics about using MPI. This page lists all runtime environment variables used for runtime tuning of MPI.

The "man shmem" command describes the SHMEM API and also lists environment variables used for runtime tuning of SHMEM.

Web Pages

The MPI Programmers Reference Manual is viewable with the "insight" command and also on the web at http://techpubs.sgi.com.

The SGI MPT product web page is http://www.sgi.com/software/mpt/.