MATLAB® + Star-P™ = interactive development of custom HPC codes.

Use MATLAB to develop HPC code. Accelerate time-to-solution. Increase the return on your HPC investment.
The best of both worlds — the interactive desktop tool you want; the supercomputing power you need.

Engineers, Scientists, Analysts

Enjoy a quick learning curve thanks to:
- Familiar MATLAB environment
- Automatic and transparent parallelization
- Leverage existing MATLAB code
- Work interactively for rapid iteration & refinement

Harness powerful new capabilities such as:
- Global parallelism ("data parallel")
- Coarse-grained parallelism ("embarrassingly-parallel")
- Scale to Terabyte-sized data sets and hundreds of CPUs
- World-class parallel computing libraries

Introduction

Background: The pressure for quick turnaround. Across commercial, government, and research sectors, engineers and scientists are under increasing pressure for dramatic reductions in time-to-solution for critical problems. Simulation is replacing physical prototyping, and models and algorithms are expanding to include multi-domain phenomena and reflect whole products rather than subsystems. As a result, high-performance computers are increasingly used to solve the large and complex problems that can no longer be solved productively on the desktop.

The Challenge: A time-consuming and flawed programming model. However, the current workflow is fundamentally flawed. Because interactive desktop science and engineering tools do not run on HPCs, more than half of the time-to-solution is typically spent reprogramming the models and algorithms for use on HPCs, rather than developing and refining them. As a result, an interactive discovery process has not been possible to date. Furthermore, the batch nature of today’s HPC software means that it takes hours, days, and even weeks to get one iteration of the computation done.

The Solution: Star-P accelerates custom HPC code development. Star-P is an interactive parallel computing platform that allows existing desktop simulation tools to operate interactively and automatically on high-performance computers. Through a client-server model, the Star-P software acts as a bridge between popular scientific and engineering desktop computing tools, like MATLAB by MathWorks, and the parallel computing capability of HPC servers. Star-P fundamentally transforms the workflow, substantially shortening the “time to solution,” and delivers the “best of both worlds” — the interactive and familiar use of their desktop application, coupled with the computing power of HPCs.
Fine- & Coarse-grained Algorithms

Leveraging both fine- and coarse-grained parallelization is necessary in the vast majority of production-level HPC applications. Star-P enables users to work in both a global format, and a distributed format, and to interoperate between the two.

Star-P’s fine-grained parallelization enables algorithms requiring large-scale memory access and inter-processor communication, such as those found in matrix manipulation and signal processing applications. Star-P’s coarse-grained mode is ideally suited for parallelization of algorithms often called “embarrassingly parallel,” where computations can be naturally broken up into largely independent processes such as Monte Carlo simulation, or parallelization of FOR loops.

Leverage Existing Codes & Libraries

A broad array of libraries and application packages — commercial, public, or customer-proprietary — can be integrated into Star-P and accessed via MATLAB. The Star-P platform allows you to reuse existing serial & parallel codes via the Star-P A.P.I. Existing commercial and community batch codes can take advantage of Star-P to add interactive capabilities. And, desktop software vendors interested in porting their computationally-intensive codes to parallel computers can use Star-P to reduce porting and maintenance costs.

Tap Into the Power of The Star-P™ Platform

A key benefit of high-performance computers is that many calculations can take place in parallel, leveraging multiple processors and access to expanded memory. These benefits come with a price — numerous technical challenges must be overcome in programming parallel computers. Challenges that represent a critical bottleneck in:

- The time-to-solution for key problems
- The adoption of HPCs in science and engineering
- The availability of commercial software tools running on high-performance computers

The Star-P interactive parallel computing platform will help desktop tool vendors leverage HPCs without having to solve the significant challenges associated with parallel programming and supporting multiple HPC platforms. Star-P eliminates user HPC programming and delivers interactive performance by automatically:

- Sending computations to the HPC
- Splitting up the work across multiple servers
- Providing access to world-class parallel computing libraries
- Managing inter-processor communication
- Managing the flow and memory storage of large data sets
Maintain Your Familiar Desktop Environment

The expressive and interactive power of MATLAB can now be brought to bear on the largest, complex, and most important scientific and engineering problems an organization faces. Star-P enables faster algorithm development and new science by using simple extensions to the MATLAB language to address large memories and multiple processors, while preserving the core strengths of MATLAB, such as the visual interface, high level language, and interactivity. Star-P is accessed through the familiar features of MATLAB — the file editor, profiler, debugger, array editor, etc. In short, “It’s still MATLAB!”

Standard MATLAB commands and functions are available and perform in a parallel manner transparently to the user. Existing MATLAB scripts can be reused to run larger problems in parallel with minimal modification. No programming needs to be done beyond standard MATLAB programming, with a very few minor modifications.

Because MATLAB’s high-level scripts are typically at least an order of magnitude shorter than comparable C, Fortran, and MPI programs, they are much easier to develop, debug, and extend. And although designed for the non-expert desktop user, Star-P also features the controls often demanded by users familiar with parallel computing.

% explicitly parallel with *p
n=10000*p

% implicitly parallel
A = randn(n, n);

% implicitly parallel
x = randn(n, 1);

% implicitly parallel
y = zeros(size(x));

while norm(x-y) / norm (x) > 1e-11
    y = x;
    x = A*x;
    x = x / norm(x);
end;

Simple MATLAB script for finding the eigenvector of a random matrix. Adding the *p construct makes variables parallel. Through propagation, related variables also become parallel. Functions on parallel variables are transparently “overloaded” and outsourced to the HPC.

Star-P leverages MATLAB’s core strengths, such as the visual interface, high level language, and interactivity. In this example, Star-P extends a computationally-intensive image processing application to an HPC.
The Need for Interactive High-Performance Computing

When reducing time-to-solution is the goal, it is the engineers’ and scientists’ time that is typically the gating factor, not computing resources. During the model/algorithm development phase, interactivity is critical. Yet although interactive use can be taken for granted with desktop science and engineering tools, to date it has simply not been available in high-performance computing, which remains firmly in the batch world.

The emergence of the Star-P interactive parallel computing platform — one that bridges interactive desktop applications and high-performance computers — is about to change the paradigm. There is now an opportunity to bring the power of HPCs to today’s and tomorrow’s users, by eliminating the last hurdle: the need to manually reprogram models initially prototyped using desktop tools.

With Star-P, the recoding is eliminated, so scientists and engineers can use the same desktop tools they know and love. They can now work with the large data sets, live in memory. They can prototype and scale in a tightly coupled process, in real time, with fine-grained control of both algorithms and data, transparently harnessing the HPC’s computing resources.

“Our molecular models involve computations with 10,000x10,000 matrices, so we quickly reached the limits of desktop memory and computing power. We are looking to Star-P to let us continue working interactively within our MATLAB environment, extending our computations to larger and more complicated models.”

— Bryan Wong, Researcher
M.I.T. — Earth, Atmospheric & Planetary Sciences
M.I.T./N.C.S.A. Joint Project

Project Leadership

- Reduce the time-to-solution
- Accelerate your time-to-market
- Make better decisions, products
- Eliminate HPC reprogramming in C, Fortran, MPI
- Lower project labor costs

Infrastructure Leadership

- Increase return on your HPC investment
- Reuse existing HPC codes
- Expand access to HPC resources across organization
- Leverage the powerful, secure, and easy to use HPC management environment
Industries & Applications

- **Aerospace**: Space vehicle design optimization, Airframe optimization
- **Defense**: Control systems, Synthetic aperture radar, Signal processing
- **Intelligence**: Cryptography, Image processing, Face recognition
- **Life Sciences**: Drug discovery, Image processing, Molecular simulation, Neuroscience, Computational biology
- **Earth Sciences**: Air & water current analysis, Weather geophysics, Earthquakes
- **Energy**: Oil exploration, Reservoir modeling
- **Finance**: Risk modeling, Neural networks, Energy trends
- **Manufacturing**: Control systems, Post-processing of CAE analyses, FPGA design

Connecting Desktop MATLAB to High-Performance Computers

Star-P is used by scientists, engineers and analysts to solve large and complex problems using MATLAB. Star-P transparently connects your desktop computer and MATLAB application to a high-performance computer, to greatly speed up computations and allow larger problems to be handled, scaling to hundreds of processors and Terabytes of memory. As a result, your algorithm prototyping and model development are dramatically accelerated, shortening the time-to-solution. The fundamental concepts of Star-P are to:

- Implement high-performance parallel versions of the computational libraries on the parallel processor server
- Intercept desktop calls and ship them to the server for high performance execution
- Manage memory for the very large objects to be allocated on the server
- Provide the complete software infrastructure on HPCs to support the interactive process

With these concepts, intensive computations can be transparently off-loaded from a desktop to a parallel processor server without reprogramming.
Interactive Workflow Shrinks Time-to-Solution

During the model/algorithm development phase, interactivity is critical. In many cases, the correct algorithm, approach, or key to the problem, may not be known up front, and may typically be discovered only by running the code on the HPC, with the actual input data.

Star-P eliminates the need to re-code MATLAB algorithms in C, Fortran, and MPI to take advantage of parallel computing power. Now, you can work in an interactive, high-level environment all the way from prototyping to production.

Through fine-grained control, Star-P revolutionizes model development and refinement. No longer must compiled programs run start-to-finish in overnight batch runs. Instead, just the portion of the code in question can be run, dramatically speeding up response time, and enabling rapid iterations.

“In computing with humans, response time is everything...One’s likelihood of getting the science right falls quickly as one loses the ability to steer the computation on a human time scale.”

– Prof. Nick Trefethen, Oxford University

Turning a 6-hour job into a 10-second batch job: With fine-grained control, just a few percent of the code can be easily isolated, enabling rapid parameter studies. In this example, a 6-hour computation on a desktop computer turns into nearly-real-time response with an HPC.
About Interactive Supercomputing

Interactive Supercomputing, Inc. develops Star-P, a software platform supporting automatic parallelization and interactive execution of desktop-developed technical applications on HPC servers.

The Star-P interactive parallel computing platform allows existing desktop simulation tools to operate interactively and automatically on high-performance computers. The Star-P software acts as a bridge between popular scientific and engineering desktop computing tools, such as MATLAB by MathWorks, and the parallel computing capability of high-performance computers.

Star-P fundamentally transforms the typical HPC workflow by eliminating the reprogramming associated with porting desktop application code to HPCs, and delivers the “best of both worlds” — the interactive and familiar use of their desktop application, coupled with the computing power of HPCs. Star-P was originally developed at the Massachusetts Institute of Technology, and has been jointly commercialized by SGI and Interactive Supercomputing.