



PARADE

Parallel Development Environment for HPC

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PARAM SOFTWARE STACK

HPC Programming Tools	Performance Monitoring	HPCC	IMB/OSU	IOR	HPCG	C-DAC Tools IDE (APC)	
	Visualization Tools	Ferret	GrADS	ParaView	Visit/ VMD		
	Application Libraries	NetCDF/ HDF/ etc.	Math Libraries	Python Libraries	GNU Scientific Library		
	Development Tools	Intel Cluster Studio	GNU	CUDA Toolkit/ OpenACC			
	Communication Libraries	Intel MPI	MVAPICH2	Open MPI	PGAS		
Middleware Applications and Management	Cluster Monitoring/ Help Desk	Ganglia	C-DAC Tools	Nagios	XDMoD	osTicket	C-Chakshu
	Resource Management/ Scheduling/ Accounting	SLURM			SLURM Accounting		SuParikshan
	Provisioning	OpenHPC (xCAT)					SUM
	File System	NFS	Local FS (XFS)	Lustre	GPFS		HPC Tasks Automation Scripts
Operating Systems	Drivers	OFED	CUDA	Network & Storage Drivers		Cluster Checker Scripts	
	Operating System	Linux (CentOS 7.x)					



ParaDE URL on Pravega :: <https://parampravega.iisc.ac.in:8447/parade>

PARADE



Integrated Development Environment for HPC

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ParaDE
(Parallel Development Environment for HPC)

Login-Form

Username: deepika

Password:

Captcha: Xfzrlw

Submit

hit count:2115

- Browser based IDE
- No installation the client machine
- Single interface for application development



WORKING ENVIRONMENT IN HPC

Using Command-line !!



Login to the HPC Cluster

```
parade@login03:~  
login as: parade  
Using keyboard-interactive authentication.  
If you truly desire access to this host, then you must indulge me in a simple challenge.  
-----  
  
Observe the picture below and answer the question listed afterwards:  
  
  ^  ^  ^  ^  ^  ^  ^  ^  
 ( A | k | x | Q | E | f | o | n )  
  ^  ^  ^  ^  ^  ^  ^  ^  
  
Type the string above: AkxQEfOn  
Using keyboard-interactive authentication.  
Password:  
Last login: Wed Apr 20 17:43:58 2022 from deepika-workstation.blr.cdac.in  
[parade@login03 ~]$ vi pi-calculation.c
```

```
parade@login03:~  
[parade@login03 ~]$ module avail  
  
----- /opt/ohpc/pub/modulefiles -----  
EasyBuild/3.9.4  
apps/mom_6/intel_18.2  
apps/mpiblast/1.6.0/intel_18.2  
apps/roms/3.6/intel_18  
autotools  
charliecloud/0.11  
charliecloud/0.22 (D)  
clustershell/1.8.2  
cmake/3.15.4  
compiler/hpc_sdk/nvhpc/21.7  
compiler/intel/2017.7.259  
compiler/intel/2018.4.057  
compiler/intel/2019.5.281  
compiler/intel/2020.4.304 (D)  
cuda/7.5  
cuda/8.0  
cuda/9.0  
cuda/9.2  
cuda/10.0  
cuda/10.1  
cuda/10.2  
cuda/11.2 (D)  
gcc/8.2.0  
gnu8/8.3.0  
hwloc/.1.0  
intel/18.0.5.274  
lib/netcdf_c/4.3.3.1/intel_18  
lib/netcdf_fortran/4.4.0/intel_18  
lib/parallel_hdf5/1.8.21/intel_18  
oneapi/compiler32/2021.2.0  
oneapi/dal/2021.2.0  
oneapi/debugger/10.1.1  
oneapi/dev-utilities/2021.2.0  
oneapi/dnnl-cpu-gomp/2021.2.0  
oneapi/dnnl-cpu-iomp/2021.2.0  
oneapi/dnnl-cpu-tbb/2021.2.0  
oneapi/dnnl/2021.2.0  
oneapi/dpct/2021.2.0  
oneapi/dpl/2021.2.0  
oneapi/init_opencl/2021.2.0  
oneapi/inspector/2021.2.0  
oneapi/intel_ipp_ia32/2021.2.0  
oneapi/intel_ipp_intel64/2021.2.0  
oneapi/intel_ippcp_ia32/2021.2.0  
oneapi/intel_ippcp_intel64/2021.2.0  
oneapi/itac/latest  
oneapi/itac/2021.2.0 (D)  
oneapi/mkl/latest  
oneapi/mkl/2021.2.0 (D)  
oneapi/mkl32/2021.2.0  
oneapi/mpi/2021.2.0 (D)  
oneapi/oclfga/2021.2.0  
oneapi/tbb/2021.2.0  
oneapi/tbb32/2021.2.0  
oneapi/vp1/2021.2.2  
oneapi/vtune/2021.2.0  
openmpi/3.1.5  
openmpi/4.0.5
```

- Write code on editor or import existing code to the cluster
- Search for compatible compilers and libraries to compile
- Now compile and create executable

- Understand the submission process on the cluster
- Create a LRM based script to execute the application

```
parade@login03:~  
[parade@login03 ~]$ sinfo  
PARTITION AVAIL  TIMELIMIT  NODES  STATE NODELIST  
standard*   up 3-00:00:00    10 drain* cn[030-031,067-069],gpu010,hm[017,026,038-039]  
standard*   up 3-00:00:00   106 alloc  cn[001-028,033-060,070-072,074-101,105-110],hm[001,025,027-037]  
standard*   up 3-00:00:00    43  idle  cn[029,032,061-066,073,102-104],gpu[001-009],hm[002-016,018-024]  
gpu         up 3-00:00:00     1 drain* gpu010  
gpu         up 3-00:00:00     9  idle  gpu[001-009]  
hm         up 3-00:00:00     4 drain* hm[017,026,038-039]  
hm         up 3-00:00:00    13 alloc  hm[001,025,027-037]  
hm         up 3-00:00:00    22  idle  hm[002-016,018-024]  
cpu        up 3-00:00:00     5 drain* cn[030-031,067-069]  
cpu        up 3-00:00:00    93 alloc  cn[001-028,033-060,070-072,074-101,105-110]  
cpu        up 3-00:00:00    12  idle  cn[029,032,061-066,073,102-104]  
[parade@login03 ~]$ vi slurm_script
```



View the result and optimize if required

```
parade@login03:/scratch/parade/ParaDE/ExecutionDirectory/PI_Calculation
[parade@login03 PI_Calculation]$ cat output_19074.out
=====
SLURM_CLUSTER_NAME = paramutkarsh
SLURM_ARRAY_JOB_ID =
SLURM_ARRAY_TASK_ID =
SLURM_ARRAY_TASK_COUNT =
SLURM_ARRAY_TASK_MAX =
SLURM_ARRAY_TASK_MIN =
SLURM_JOB_ACCOUNT = cdac
SLURM_JOB_ID = 19074
SLURM_JOB_NAME = PI_Calculation
SLURM_JOB_NODELIST = cn[064-065]
SLURM_JOB_USER = parade
SLURM_JOB_UID = 21040
SLURM_JOB_PARTITION = standard
SLURM_TASK_PID = 348
SLURM_SUBMIT_DIR = /scratch/parade/ParaDE/ExecutionDirectory/PI_Calculation
SLURM_CPUS_ON_NODE = 2
SLURM_NTASKS =
SLURM_TASK_PID = 348
=====
Number of processes 2
Number of Threads 2
Pi Is Approximately 3.1415926535898993
[parade@login03 PI_Calculation]$
```

Debug code in case of errors

```
parade@login03:~  
ib64/qt-3.3/bin:/usr/local/bin:/usr/bin:/usr/local/sbin:/usr/sbin:/home/parade/.local/bin:/home/parade/bin  
[parade@login03 ~]$ module load compiler/intel/2020.4.304  
[parade@login03 ~]$ mpicc test_mpi.c -g -o test_mpi  
[parade@login03 ~]$ gdb ./test_mpi  
GNU gdb (GDB) Red Hat Enterprise Linux 7.6.1-120.e17  
Copyright (C) 2013 Free Software Foundation, Inc.  
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>  
This is free software: you are free to change and redistribute it.  
There is NO WARRANTY, to the extent permitted by law. Type "show copying"  
and "show warranty" for details.  
This GDB was configured as "x86_64-redhat-linux-gnu".  
For bug reporting instructions, please see:  
<http://www.gnu.org/software/gdb/bugs/>...  
Reading symbols from /home/parade/test_mpi...done.  
(gdb) b main  
Breakpoint 1 at 0x4008a5: file test_mpi.c, line 6.  
(gdb) r  
Starting program: /home/parade/./test_mpi  
[Thread debugging using libthread_db enabled]  
Using host libthread_db library "/lib64/libthread_db.so.1".  
  
Breakpoint 1, main (argc=1, argv=0x7fffffffcd18) at test_mpi.c:6  
6      MPI_Init(NULL, NULL);  
Missing separate debuginfos, use: debuginfo-install glibc-2.17-324.e17_9.x86_64 libgcc-4.8.5-44.e17.x86_64  
(gdb) n  
10     MPI_Comm_size(MPI_COMM_WORLD, &world_size);  
Missing separate debuginfos, use: debuginfo-install libibverbs-54mlnx1-1.54103.x86_64 libnl3-3.2.28-4.e17.x86_64 librdmacm-54mlnx1-1.54103.x86_64 numactl-libs-2.0.12-5.e17.x86_64 ucx-1.11.0-1.54103.x86_64 zlib-1.2.7-19.e17_9.x86_64  
(gdb)
```



o Profile the code to analyze the program for decreasing the execution time

```
[parade@login04 ~]$ gcc -pg mg_serial.c -o mg_serial -lm
[parade@login04 ~]$ ./mg_serial ^C
[parade@login04 ~]$ gprof -b mg_serial gmon.out >profile.log
[parade@login04 ~]$ cat profile.log
Flat profile:

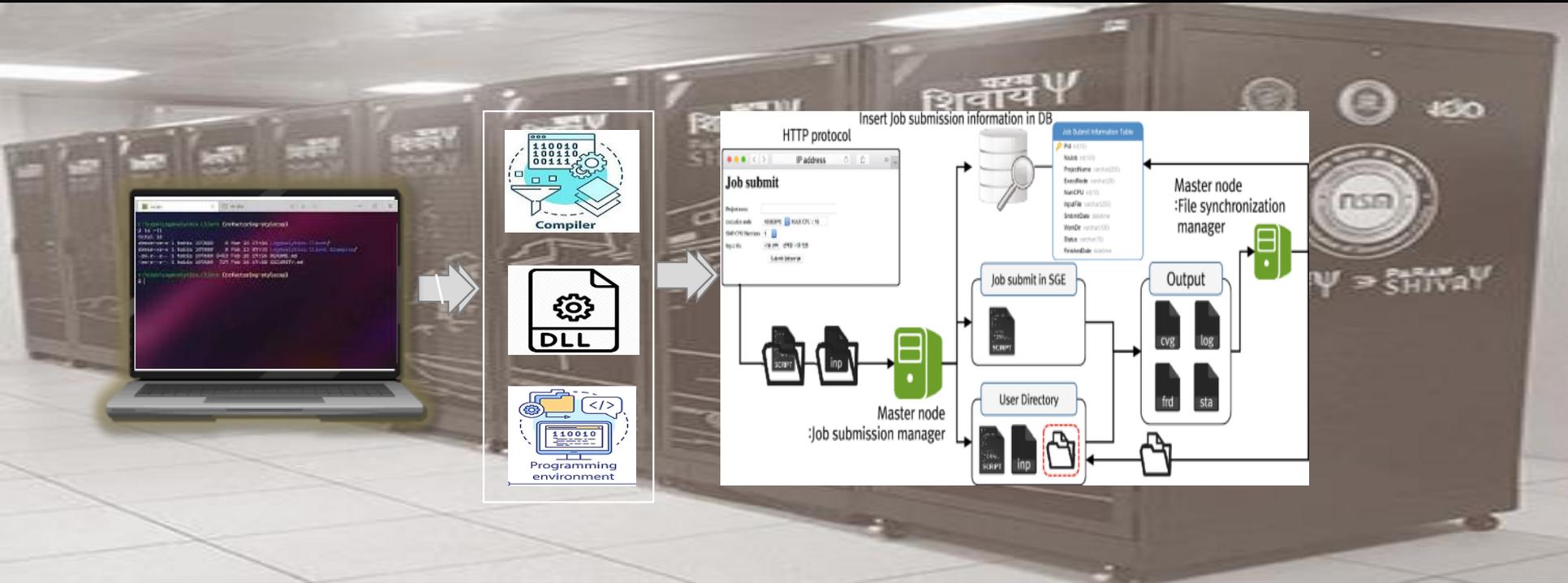
Each sample counts as 0.01 seconds.
%   cumulative   self           calls     self        total   name
time   seconds    seconds        us/call    us/call    us/call
100.19    0.01      0.01           101        99.20      99.20   compute
  0.00    0.01      0.00          999900     0.00      0.00   dist
  0.00    0.01      0.00           100        0.00      0.00   update
  0.00    0.01      0.00            2         0.00      0.00   cpu_time
  0.00    0.01      0.00            2         0.00      0.00   timestamp
  0.00    0.01      0.00            1         0.00      0.00   initialize
  0.00    0.01      0.00            1         0.00      0.00   r8mat_uniform_ab

Call graph

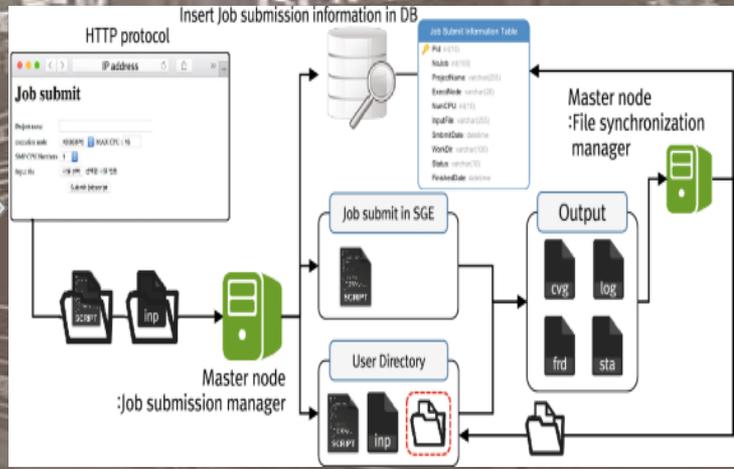
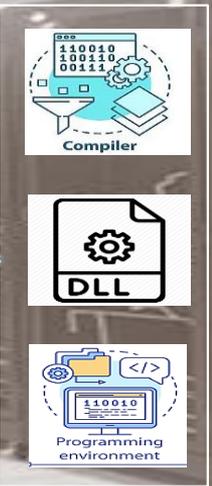
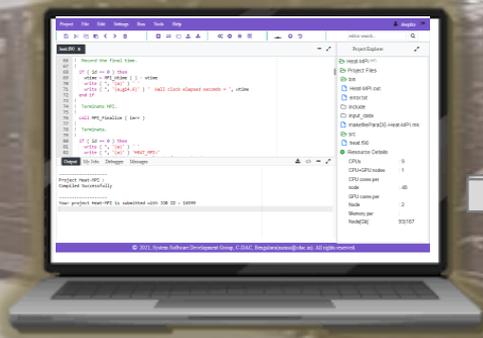
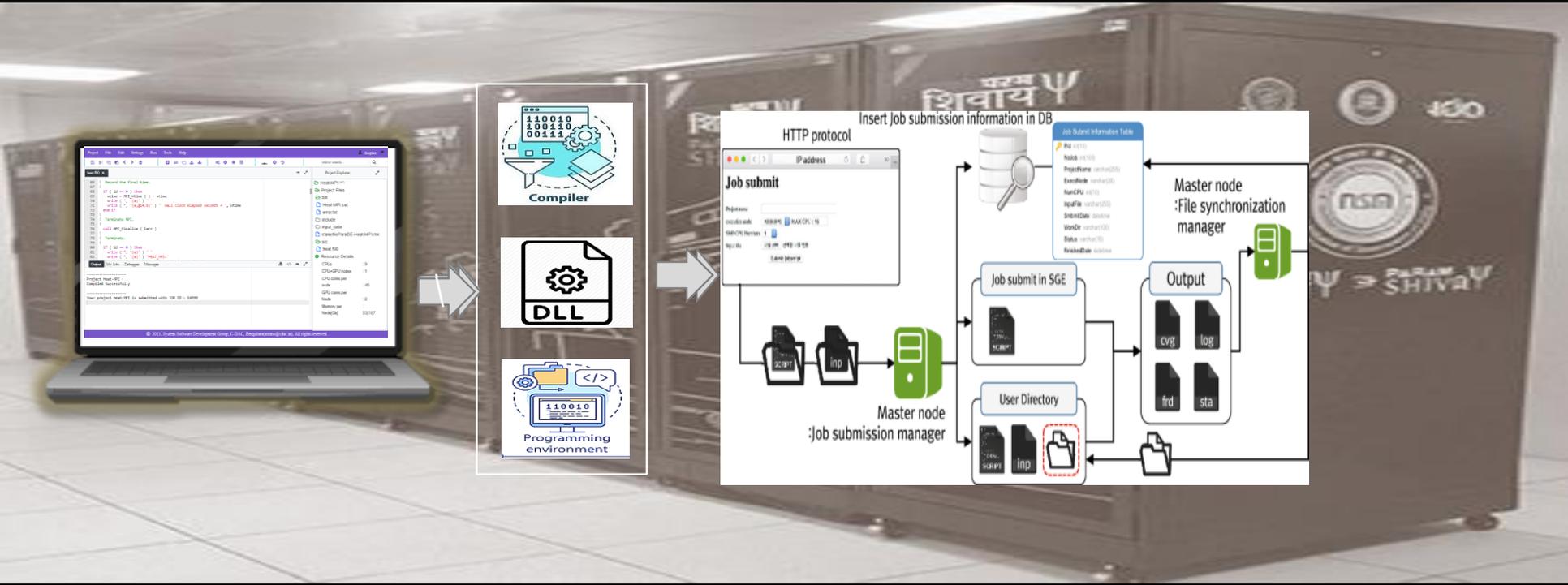
granularity: each sample hit covers 2 byte(s) for 99.81% of 0.01 seconds

index % time    self  children    called    name
-----
[1]   100.0    0.01   0.00    101/101    main [2]
      0.01   0.00     101      compute [1]
      0.00   0.00   999900/999900  dist [3]
-----
[2]   100.0    0.00   0.01     101/101    <spontaneous>
      0.01   0.00     101/101    main [2]
      0.00   0.00     100/100    compute [1]
      0.00   0.00      2/2       update [4]
      0.00   0.00      2/2       timestamp [6]
      0.00   0.00      2/2       cpu_time [5]
      0.00   0.00      1/1       initialize [7]
-----
[3]   0.0      0.00   0.00   999900/999900  compute [1]
      0.00   0.00   999900    dist [3]
-----
```

PROGRAMMING ON A SUPERCOMPUTER



PROGRAMMING ON A SUPERCOMPUTER USING PARADE





NSM

Login

About

Account

Contact



(Parallel Development Environment for HPC)



Login-Form

Username

deepika

Password

.....

Captcha



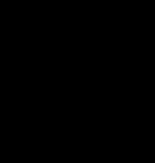
Enter

XFszJw

Captcha

Submit

hit count:2115





Editor

Auto
Compile

HPC Job
Submission

Debug

View Output

The screenshot displays an IDE interface with a purple header bar containing menu items: Project, File, Edit, Settings, Run, Tools, and Help. A toolbar with various icons is located below the header. The main workspace is divided into three panes:

- Code Editor:** Shows a C program for calculating Pi using OpenMP. The code includes headers for `stdlib.h`, `math.h`, `mpi.h`, and `omp.h`. It defines `NUMINTERVALS` as 1000000 and uses a `func` to calculate the value of Pi. The `main` function calls `omp_get_wtime` to measure execution time.
- Project Explorer:** Shows a project named "PI_Calculation-OpenMPwithMPI" with subfolders for `bin`, `include`, `input_data`, `lib`, and `src`. Source files include `PI.c`, `error.txt`, and `makefileParaDE-PI_Calculation-OpenMPwithMPI.mk`.
- Output Console:** Displays the compilation and execution results. It shows a successful compilation with warnings and a message that the project is submitted with JOB ID 18538. The output includes the number of processes (2), threads (8), and the calculated value of Pi: 3.1415926535899001.

```
1 #include <stdlib.h>
2 #include <stdlib.h>
3 #include <math.h>
4 #include <mpi.h>
5 #include <omp.h>
6
7 #define NUMINTERVALS 1000000
8
9 double
10 func(double x)
11 {
12     return (4.0 / (1.0 + x * x));
13 }
14
15 /* Main Program */
16
17 int
18 main(int argc, char *argv[])
19 {
20     double start, stop;
21     double pi = 0.0;
22     int i;
23     omp_set_num_threads(8);
24     start = omp_get_wtime();
25     for (i = 0; i < NUMINTERVALS; i++)
26         pi += func(i / (double) NUMINTERVALS);
27     stop = omp_get_wtime();
28     printf("Pi is approximately %f\n", pi);
29     printf("Time taken: %f\n", stop - start);
30     return 0;
31 }
```

Output MyJobs Debugger Messages

Compiled Successfully with warnings

Your project PI_Calculation-OpenMPwithMPI is submitted with JOB ID : 18538

[Job ID : 18538 Name : PI_Calculation-OpenMPwithMPI] :

Note : If project is generating any output files, to check that files go to cluster head node (/scratch_ib/)

Number of processes 2
Number of Threads 8
Pi Is Approximately 3.1415926535899001



DEMO

ParaDE URL :: <https://parampravega.iisc.ac.in:8447/parade>

FEATURES OF PARADE



Debuggers, Profiler,
Converter, Libraries,
etc

Auto
Compile

HPC Job
Submission

Context
Sensitive
Editor

Project
Management

Multiple
Parallel
Paradigms

Automatic
Makefile
Generation

Output/Error
Viewing

The screenshot displays the PARADE IDE interface. The main editor shows a C program named 'matrix_mul.c' with the following code:

```
1- /*  
2-  * Matrix (N*N) multiplication with a single thread.  
3-  */  
4- #include <stdio.h>  
5- #include <stdlib.h>  
6- #include <sys/time.h>  
7- #include "mpi.h"  
8- #include "omp.h"  
9-  
10- #define TAG 10  
11- #define DEBUG 0  
12-  
13- double ** allocate_matrix( int size )  
14- {  
15-     /* Allocate 'size' * 'size' doubles contiguously. */
```

The Project Explorer on the right shows the project structure:

- Matrix_MUL_Project [MC]
- Matrix_MUL
- bin
- Matrix_MUL.out
- error.txt
- include
- input_data
- makefileParaDE-Matrix_MUL.mk
- src
- matrix_mul.c
- Resource Details
 - CPU: 8
 - CPU+GPU nodes : 2
 - CPU cores per node : 44
 - GPU cores per Node : 2

The 'My Jobs' tab in the Output window shows the following table:

Job id	Job name	State	Allocated Nodes	Number of nodes	CPU	GPU	
12507	Matrix_MUL	COMPLETED	ssl_cn[01-02]	2	8	0	output_error
12499	pi_mpi	COMPLETED	ssl_cn[01-02]	2	8	0	output error
12498	vector_addition	COMPLETED	ssl_cn01	1	1	0	output error
12497	vector_add	COMPLETED	ssl_cn[01-02]	2	8	0	output error

IDE FOR HPC

- Anytime
- Anywhere
- Single interface for HPC programming





Make your life easy on HPC

Contact : nsmss@cdac.in

ParaDE URL :: <https://parampravega.iisc.ac.in:8447/parade>



THANK YOU
Email : nsmss@cdac.in

