BLUE WATERS

SUSTAINED PETASCALE COMPUTING

May 1, 2012

The Eclipse Parallel Tools Platform

Toward an Integrated Development Environment for Improved Software Engineering on Crays

NCSA

NSF

GREAT LAKES CONSORTIUM FOR PETASCALE COMPUTATION

CRAY

Agenda

1. What is the Eclipse Parallel Tools Platform (PTP)
2. Tour of features available in Eclipse/PTP
   - Features added to support Blue Waters
3. How could Cray-PTP integration be improved

What is the Eclipse Parallel Tools Platform?

- **Eclipse**
  - Multi-platform integrated development environment
  - Extremely popular as a Java IDE
  - Excellent support for C/C++, UPC, Fortran, Python
  - Extensible via third-party plug-ins
    - Actually, *everything* is a plug-in!
    - Java, C/C++, Fortran support are all plugged in
    - CVS, Subversion, Git support are plugged in
    - What about plug-ins to support HPC?

What is the Eclipse Parallel Tools Platform?

- **Parallel Tools Platform (PTP)**
  - Set of Eclipse plug-ins
  - Adds support for HPC development to Eclipse
    - Write code on your laptop; compile on an HPC resource
    - Submit jobs to a batch scheduler; monitor jobs
    - Debug remote MPI applications (parallel debugger)
    - Get assistance with MPI, OpenMP development
  - Current release: about 50,000 downloads

Supporting Blue Waters

- **Blue Waters:** Cray XE6/XK6 at NCSA
- PTP did not work with Crays "out of the box"
  - Could not submit jobs with appropriate aprun options
  - Could not monitor status of compute nodes
  - Could not set environment modules for build
  - Did not recognize Cray, PGI compilers' errors messages
  - Did not support OpenACC
  - …
- Less than 6 months to fix these for PTP 6.0 (!)

Fortran - homme/src/Homme.F90 - Eclipse

File Edit Refactor Navigate Search Project Run Window Help

Fortran Projects

- homme [k2-zone.ucar.edu]
  - .ptp-sync
  - .settings
  - benchmark NSF
  - doc NSF
  - libs
  - physics NSF
  - src NSF
    - advance_mod.F90 2.9
    - advance_si.F90 2.12
    - aquaplanet.F90 2.31
    - baroclinic_inst_mod.F90 2.10
    - bndry_mod.F90 2.8
    - cg_mod.F90 2.15
    - checksum_mod.F90 2.11

Homme.F90

```
  type(ESMF_VM) :: vm
! Components
  type(ESMF_GridComp) :: compGridded

! Return codes for error checks
  integer :: rc
  type(ESMF_Clock) :: localclock

!-----------------------------------------
!-----------------------------------------
!    Create section
!-----------------------------------------
!-----------------------------------------
!



   ! Initialize the ESMF Framework and
```

Outl

<Free Form - C Preproces

Homme

0 MPI Artifacts found

File Navigation

Syntax-aware Editing

Code Outline

Call Hierarchy

Calls from main(int, char * *) - /proxy/org.eclipse.ptp.debug.sdm_5.0.4.201111121445/src/ma

- main(int, char * *) : int
  - shortopts : char *
  - longopts : option []
  - opt_type : int
  - find_dbg_backend(char *, dbg_backend * *) : int
    - dbg_backends : dbg_backend [] (2 matches)
    - dbg_backend::db_name : char *
  - backend_set_path(dbg_backend *, char *) : void
  - find_proxy(char *, proxy * *) : int
  - sdm_init(int, char * *) : int
  - sdm_route_get_id() : sdm_id (2 matches)
  - SDM_MASTER : int
  - master(char *, char *, int) : void
    - sdm_route_get_size() : int
    - DbgMasterInit(int, int, char *, proxy_svr_helper_funcs *, proxy_commands *) : int
    - sdm_route_get_id() : sdm_id
    - helper_funcs : proxy_svr_helper_funcs
    - command_tab : proxy_commands
    - DbgMasterCreateSession(int, char *, int) : int
    - DbgGetErrorStr() : char *
    - DbgMasterQuit(int, int, char * *) : int
    - DbgMasterProgress() : int (2 matches)
    - DbgMasterIsShutdown() : int

Static analyses built in, available in real time while coding

< Static call hierarchy

Integrated OpenACC documentation

(added for BW)

test1.f90

```
!$acc parallel loop
  do i = 1, 1000
    c(:,:) = (a(:,:) + b(:,:)) / 2.d0
    a(:,:) = (a(:,:) + c(:,:)) / 2.d0
    b(:,:) = (b(:,:) + c(:,:)) / 2.d0
  end do
!$acc end parallel loop
```

Problems | Fortran Declaration

OpenACC™ parallel directive

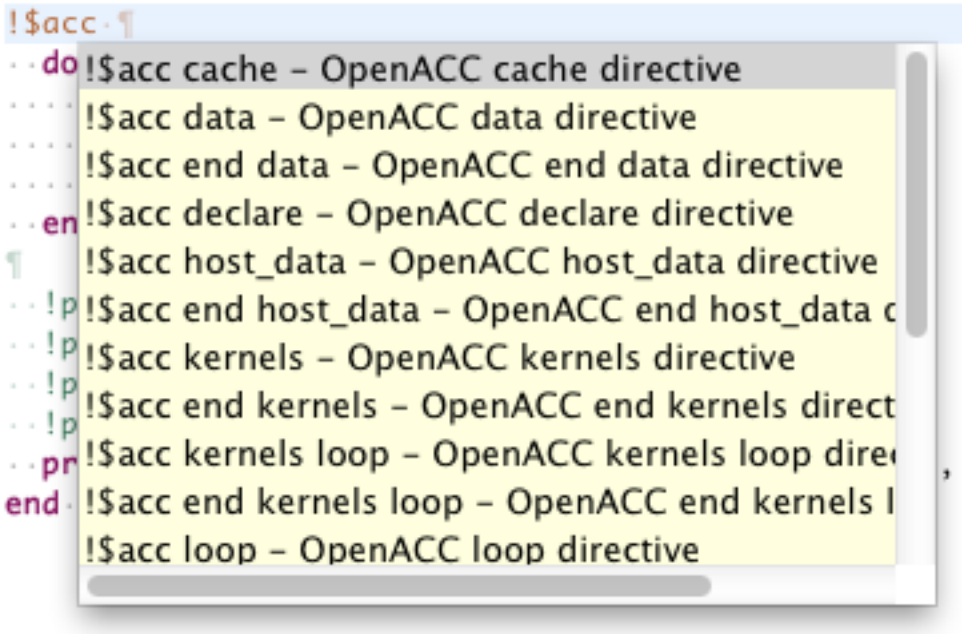
Delineates a block of code that will be executed on an accelerator device.

```
!$acc parallel [clause [, clause ...]]
  block
!$acc end parallel
```

```
#pragma acc parallel [clause [, clause ...]]
  block
```

Supported clauses are **if, async, num_gangs, num_workers, vector_length, reduction, copy, copyin, copyout, create, present, present_or_copy, present_or_copyin, present_or_copyout, present_or_create, deviceptr, private, firstprivate.**

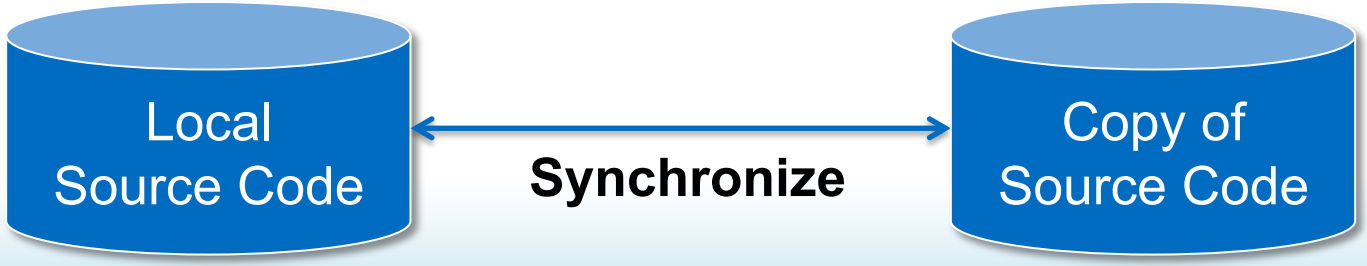
Documentation also available for MPI, OpenMP



Code completion for OpenACC directives (added for BW)

- Source code editing
- Code search/navigation
- Static analysis

- Compilation
- Running and debugging
- Performance tuning



Properties for HelloESS

type filter text

- Resource
- Builders
- C/C++ Build
  - Build Variables
  - Discovery Options
  - Environment
  - Environment Manage
  - Logging
  - Settings
  - Synchronize
  - Tool Chain Editor
  - XL C/C++ Compiler
- C/C++ General
- Fortran Build
  - Discovery Options
  - Environment
  - Settings
  - Tool Chain Editor
  - Variables
- Fortran General
- Project References
- Run/Debug Settings
- Service Configurations
- Task Tags
- Validation

Environment Management

Configuration: Default [Active] Manage Configurations...

☑ Use an environment management system to customize the remote build environment

☐ Manually specify environment configuration commands

Modules 3.2.6.6 on h2ologin1.ncsa.illinois.edu

Select modules to be loaded. Environment variables configured on the Environments page of this dialog are set beforehand and may be overwritten.

Filter list (* = any string, ? = any character):

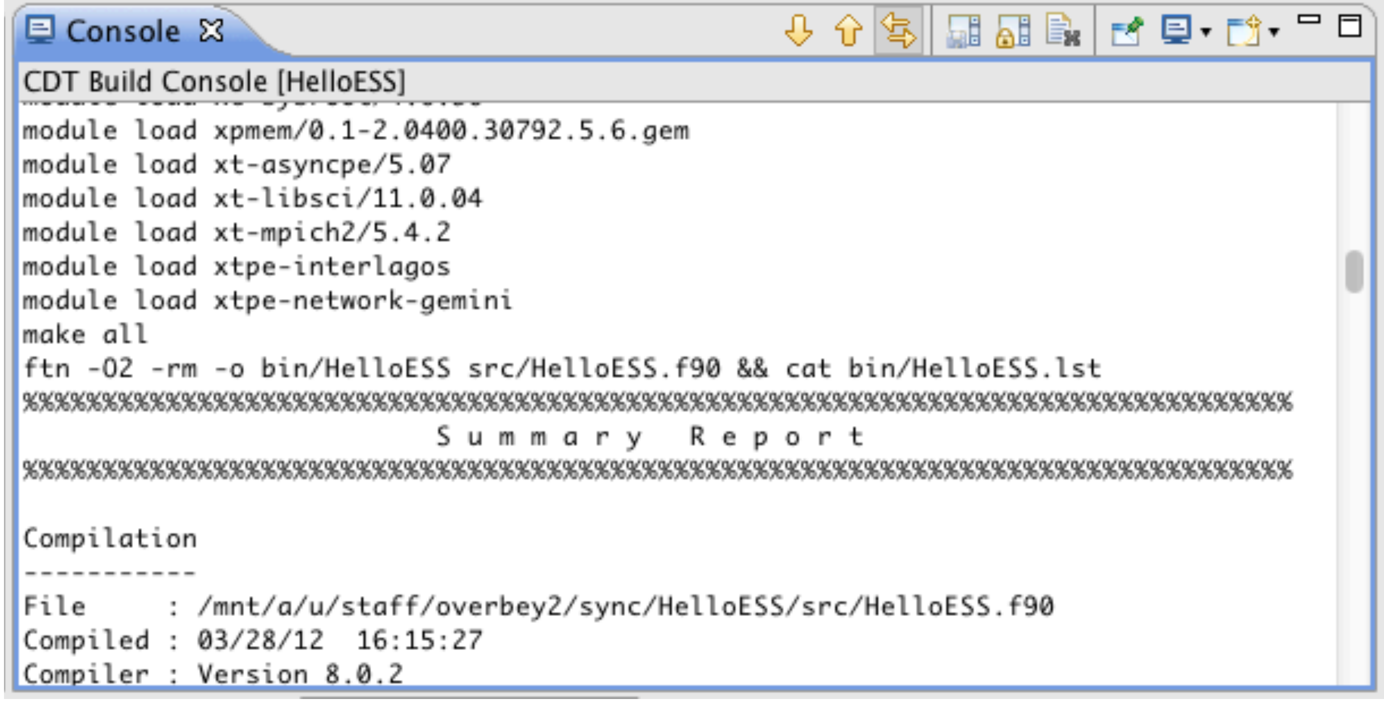
Name
☑ pmi/3.0.0-1.0000.8661.28.2807.gem
☐ PrgEnv-cray
☑ PrgEnv-cray/4.0.36
☐ PrgEnv-cray/4.0.46
☐ PrgEnv-gnu
☐ PrgEnv-gnu/4.0.36
☐ PrgEnv-gnu/4.0.46
☐ PrgEnv-pgi
☐ PrgEnv-pgi/4.0.36
☐ PrgEnv-pgi/4.0.46
☐ rca

Clear Selection Select Defaults

Restore Defaults Apply

Cancel OK

Configuring environment modules for build (added for BW)



```
module load xpmem/0.1-2.0400.30792.5.6.gem
module load xt-asyncpe/5.07
module load xt-libsci/11.0.04
module load xt-mpich2/5.4.2
module load xtpe-interlagos
module load xtpe-network-gemini
make all
ftn -O2 -rm -o bin/HelloESS src/HelloESS.f90 && cat bin/HelloESS.lst
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
                          S u m m a r y   R e p o r t
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

Compilation
-----------
File     : /mnt/a/u/staff/overbey2/sync/HelloESS/src/HelloESS.f90
Compiled : 03/28/12  16:15:27
Compiler : Version 8.0.2
```

Build is performed on remote machine (via SSH)

```
5   double precision :: a(SIZE, SIZE), b(SIZE, SIZE), c(SIZE, SIZE)
6
7   a(:) = 0.  ! This will raise a warning
8
9   do i = 1, SIZE
10    do j = 1, SIZE
11      a(i,j) = i*10.d0+j
12      b(i,j) = j*10.d0+i
13    end do
14  end do
15
!$acc parallel loop
17  do i = 1, 1000
18    c(:,:) = (a(:,:) + b(:,:)) / 2.d0
19    a(:,:) = (a(:,:) + c(:,:)) / 2.d0
20    b(:,:) = (b(:,:) + c(:,:)) / 2.d0
21  end do
22 !$acc end parallel loop
23
24  !print *, "Averages:"
25  !print *, sum(a(:,:)/(SIZE*SIZE))
26  !print *, sum(b(:,:)/(SIZE*SIZE))
27  !print *, sum(c(:,:)/(SIZE*SIZE))
28  print *, "Minimums:", minval(a(:,:)), minval(b(:,:)), minval(c(:,:))
```

Problems | Console | Fortran Declaration | Fortran Analysis/Refactoring Problems

1 error, 1 warning, 17 others

Description	Resource
Warnings (1 item)	
The number of subscripts is smaller than the number of declared dimensions.	test1.f90
Infos (17 items)	
A divide was turned into a multiply by a reciprocal	test1.f90
A divide was turned into a multiply by a reciprocal	test1.f90
A divide was turned into a multiply by a reciprocal	test1.f90
A floating point expression involving an induction variable was strength reduced b...	test1.f90
A loop nest at line 18 collapsed to a single loop.	test1.f90
A loop starting at line 10 was not vectorized because a better candidate was found...	test1.f90
A loop starting at line 17 was blocked with block size 512	test1.f90

After the build, compiler errors, warnings, and loopmark information are shown in the Problems view and source code editor

(Cray, PGI support added for BW)

Resources | Application | Arguments | Environment | Synchronize | Common

Resource Manager: ESS – Batch (XE)

Basic PBS Settings | Import PBS Script

Name	Value	Description
Total MPI Tasks:	32	Each XE6 node has two AMD Interlagos CPUs for a total of 32 integer cores and 16 floating point units per node. Therefore, the product of the number of MPI tasks per node and the number of OpenMP threads per task must be less than or equal to 32 (or 16 if running in single-stream mode). The number of MPI tasks per node must not exceed the total number of MPI tasks.
MPI Tasks per Node:	32	
OpenMP Threads per Process:		
Run in Dual-Stream Mode:	☑	XE6 nodes are normally run in "dual-stream mode," where every integer core is allocated one task (i.e., one MPI task or one OpenMP thread). However, this means that every two tasks share a floating point unit. Some floating-point-intensive computations may need to run in "single-stream mode," where every other integer core is idle but every task has exclusive access to a floating point unit.
Job Name:	ptp_job	The name assigned to the job by the qsub or qalter command.
Account:		Account to which to charge this job.
Queue:		Designation of the queue to which to submit the job.
Total Memory Needed:		Maximum amount of memory used by all concurrent processes in the job.
Wallclock Time:	00:30:00	Maximum amount of real time during which the job can be in the running state.
When to Send E-mail:		Whether e-mail should be sent when the job (b)egins, (e)nds, or (a)borts.

Graphical interface for launching a job (customized for BW)

System Monitoring – Eclipse SDK

Resource Managers

- edu.illinois.ncsa.bluewaters.pbs.batch.xe (LML_JAXB)
- edu.illinois.ncsa.forge.pbs.batch.mvapich2 (LML_JAXB)

Active Jobs

step	owner	queue	wall	quei	disp	t	status
78713.sdb	yanxinl	xe_medium	28...	2...	2...	?	RUNNING
78718.sdb	yanxinl	xe_medium	28...	2...	2...	?	RUNNING
78733.sdb	yanxinl	xe_medium	28...	2...	2...	?	RUNNING
78751.sdb	yanxinl	xe_medium	28...	2...	2...	?	RUNNING
78772.sdb	yanxinl	xe_medium	28...	2...	2...	?	RUNNING
78776.sdb	yanxinl	xe_medium	28...	2...	2...	?	RUNNING
79149.sdb	jperilla	xe_medium	28...	2...	2...	?	RUNNING
79151.sdb	jperilla	xe_medium	28...	2...	2...	?	RUNNING
79206.sdb	yanxinl	xe_medium	28...	2...	2...	?	RUNNING
79215.sdb	yanxinl	xe_medium	28...	2...	2...	?	RUNNING
79262.sdb	cdetar	xe_medium	5400	2...	2...	?	RUNNING
79263.sdb	cdetar	xe_medium	5400	2...	2...	?	RUNNING
79264.sdb	cdetar	xe_medium	5400	2...	2...	?	RUNNING
79272.sdb	bjoo	xe_large	28...	2...	2...	?	RUNNING
79273.sdb	kychan	xe_medium	28...	2...	2...	?	RUNNING
79274.sdb	cdetar	xe_medium	5400	2...	2...	?	RUNNING

Inactive Jobs

step	owner	queue	wall	q	dispat	t	status
77694.sdb	yanxinl	xe_medium	28...	2	20...	?	SUBMITTED
78650.sdb	rgamini	xe_medium	28...	2	20...	?	SUBMITTED
78652.sdb	rgamini	xe_medium	28...	2	20...	?	SUBMITTED
78654.sdb	rgamini	xe_medium	28...	2	20...	?	SUBMITTED
78705.sdb	yanxinl	xe_medium	28...	2	20...	?	SUBMITTED
78714.sdb	yanxinl	xe_medium	28...	2	20...	?	SUBMITTED
78715.sdb	yanxinl	xe_medium	28...	2	20...	?	SUBMITTED
78719.sdb	yanxinl	xe_medium	28...	2	20...	?	SUBMITTED
78734.sdb	yanxinl	xe_medium	28...	2	20...	?	SUBMITTED
78735.sdb	yanxinl	xe_medium	28...	2	20...	?	SUBMITTED
78736.sdb	yanxinl	xe_medium	28...	2	20...	?	SUBMITTED
78737.sdb	yanxinl	xe_medium	28...	2	20...	?	SUBMITTED
78738.sdb	yanxinl	xe_medium	28...	2	20...	?	SUBMITTED
78739.sdb	yanxinl	xe_medium	28...	2	20...	?	SUBMITTED
78740.sdb	yanxinl	xe_medium	28...	2	20...	?	SUBMITTED
78741.sdb	yanxinl	xe_medium	28...	2	20...	?	SUBMITTED

system: h2ologin2

c0- c1- c2- c3- c4- c5- c6- c7- c8- c9- c10-
c0-0 c1-0 c2-0 c3-0 c4-0 c5-0 c6-0 c7-0 c8-0 c9-0 c10-0
c0-1 c1-1 c2-1 c3-1 c4-1 c5-1 c6-1 c7-1 c8-1 c9-1 c10-1
c0-2 c1-2 c2-2 c3-2 c4-2 c5-2 c6-2 c7-2 c8-2 c9-2 c10-2
c0-3 c1-3 c2-3 c3-3 c4-3 c5-3 c6-3 c7-3 c8-3 c9-3 c10-3

Graphical interface for system monitoring

Enabling Better Software Engineering

- Integrated static analyses, available in real time
- Language-aware code completion
- Language-aware code searching and navigation
- Automated refactoring
- Integrated documentation, available in real time
- Easy-to-use, graphical interfaces for
  - Version control (CVS, Subversion, Git)
  - Issue tracking (Bugzilla, Jira)

Toward Better Cray Support

- PTP parallel debugger does not yet work
  - DDT does not have Eclipse integration, either
- Craypat could be integrated with PTP
  - TAU integrated using PTP's *External Tools Framework (ETFw)*
- Refactorings could be built for OpenACC
- Loopmark information could be better integrated
  - E.g., used to suggest automated refactorings
  - ETFw *Feedback View* is designed to make this possible

Building a Cray-PTP Community

- Try PTP
  - See **www.eclipse.org/ptp**
  - Tutorials given at Supercomputing, XSEDE
    - Slides online: see wiki.eclipse.org/PTP/tutorials
- Ask questions and give feedback
  - Join the ptp-user mailing list
- Join the open source developer community
  - Join the ptp-dev mailing list
- How could PTP benefit your organization?