A New and Improved

Eclipse Parallel Tools Platform

Advancing the Development of Scientific Applications

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Based on slides by
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## Tutorial Outline

<table>
<thead>
<tr>
<th>Time (Tentative)</th>
<th>Module</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30-9:00</td>
<td>1. Eclipse &amp; PTP Installation</td>
<td>✤ Installation of Eclipse and PTP (can start early as people arrive)</td>
</tr>
<tr>
<td>9:00-9:30</td>
<td>2. Introduction &amp; Overview</td>
<td>✤ Eclipse architecture &amp; organization overview</td>
</tr>
<tr>
<td>9:30-10:30</td>
<td>3. Developing with Eclipse</td>
<td>✤ Eclipse basics; Creating a new project from CVS; Local, remote, and synchronized projects ✤ Editing C files; MPI Features; Building w/ Makefile</td>
</tr>
<tr>
<td>10:30-10:45</td>
<td>BREAK</td>
<td></td>
</tr>
<tr>
<td>10:45-11:45</td>
<td>3. Developing with Eclipse (continued)</td>
<td>Continue from before the break... ✤ Resource Managers and launching a parallel app ✤ Fortran, Refactoring, other Advanced Features</td>
</tr>
<tr>
<td>11:45-12:00</td>
<td>4. Wrap-up</td>
<td>✤ NCSA HPC Workbench, Other Tools, website, mailing lists, future features</td>
</tr>
</tbody>
</table>
About the Tutorial Installation

- This tutorial assumes you have Eclipse and PTP pre-installed on your laptop
- If you already have Eclipse installed, go directly to “Starting Eclipse”, slide 5
- If you don’t have Eclipse installed, you will need to follow the handouts so that you can catch up with the rest of the class
- Note: up-to-date info on installing PTP and its pre-reqs is available from the release notes:
  - http://wiki.eclipse.org/PTP/release_notes/5.0
  - This information may supersede these slides
System Prerequisites

- Local system (running Eclipse)
  - Linux (just about any version)
  - Mac OS X (10.5/Leopard or later)
  - Windows (XP or later)
- Java: Eclipse requires Sun or IBM Java
  - Only need Java runtime environment (JRE)
  - Java 1.6 or higher
    - Java 1.6 is the same as Java SE 6.0
  - The GNU Java Compiler (GCJ), which comes standard on Linux, will not work!
  - OpenJDK, distributed with some Linux distributions, has not been tested by us but should work.
  - See http://wiki.eclipse.org/PTP/installjava
Eclipse Packages

- The current version of Eclipse (3.7) is also known as “Indigo”
- Eclipse is available in a number of different packages for different kinds of development
  - http://eclipse.org/downloads
- With Indigo, there is a new package directly relevant for HPC:
  - Eclipse IDE for Parallel Application Developers
  - This is recommended for all new installs
- Can also add PTP to an existing Eclipse installation
Eclipse Installation

- Download the “Eclipse IDE for Parallel Application Developers” package
  - http://download.eclipse.org
- Make sure you match the architecture with that of your laptop
- If your machine is Linux or Mac OS X, untar the file
  - On Mac OS X you can just double-click in the Finder
- If your machine is Windows, unzip the file
- This creates an **eclipse** folder containing the executable as well as other support files and folders
Starting Eclipse

**Linux**
- From a terminal window, enter
  “<eclipse_installation_path>/eclipse/eclipse &”

**Mac OS X**
- From finder, open the **eclipse** folder where you installed
- Double-click on the **Eclipse** application
- Or launch from a terminal window instead (like Linux)

**Windows**
- Open the **eclipse** folder
- Double-click on the **eclipse** executable
Specifying A Workspace

- Eclipse prompts for a workspace location at startup time
- The workspace contains all user-defined data
  - Projects and resources such as folders and files
  - The default workspace location is fine for this tutorial

The prompt can be turned off

Module 1
Eclipse Welcome Page

- Displayed when Eclipse is run for the first time
- Select “Go to the workbench”
Check Installation Details

- To confirm you have installed OK
  - Mac: **Eclipse> About Eclipse**
  - Others: **Help> About**
- Choose **Installation Details**
- Confirm you have the following installed software

- Close the dialog: **Close, OK**
Checking for PTP Updates

- From time-to-time there may be newer PTP releases than the Indigo release
  - Indigo and “Parallel package” updates are released only in Sept and February
- PTP maintains its own update site with the most recent release
  - Bug fix releases can be more frequent than Indigo’s and what is within the parallel package
- You must enable the PTP-specific update site before the updates will be found
Updating PTP

- Enable PTP-specific update site
  - Help>Install New Software...
  - Click Available Software Sites link
  - Ensure this checkbox is selected for the PTP site: http://download.eclipse.org/tools/ptp/updates/indigo
  - Choose OK
  - Choose Cancel (to return to Eclipse workbench)

- Now select Help>Check for updates
  - If you see "No updates were found"...
  - It’s only because there are no updates in the “Eclipse IDE for Parallel Application Developers”
    - We will update the PTP within it
We will get the PTP release that is more recent than what is currently (Nov. 2011) within the parallel package.

Now select **Help > Install New Software...**

In the **Work With:** dropdown box, select the PTP update site you confirmed already:
Updating PTP (3)

- **Quick and dirty:**
  - Check everything - which updates existing features and adds a few more

- **Detailed:**
  - Open each feature and check the ones you want to update
  - Icons indicate: Grey plug: already installed and up to date
  - Double arrow: can be updated
  - Color plug: Not installed yet

Note: For this tutorial, install GEM and TAU

Note: if conference network is slow, consider unchecking:

Module 1
Updating PTP (4)

- Select **Next** to continue updating PTP
- Select **Next** to confirm features to install
- Accept the License agreement and select **Finish**

Wait for installation to finish

If conference network is too slow, we have this cached on USB

- Select **Restart Now** when prompted
Restart after Install

- If any top-level features are installed... Welcome page informs you of new features installed
- We only updated PTP, so we land back at C/C++ Perspective

... Ready to go!

- **Help> About** or **Eclipse > About Eclipse** ... will indicate the release of PTP installed
- Further **Help> Check for Updates** will find future updates on the PTP Update site
New and Improved Features

- More flexible projects
  - Synchronized projects overcome many problems of remote projects
  - Allows development when “off-line”
  - Works with non-C/C++ projects
- More customizable resource managers
  - Resource managers can now be added by users
  - Able to have site-specific configurations
  - Interactive launch using job schedulers now supported
New and Improved Features (2)

- Scalable system/job monitoring
  - New perspective allows monitoring of systems of virtually any size
  - View shows location of jobs on cluster
  - Active and inactive jobs views

- Remote support for performance tools
  - External Tools Framework has been extended to support remote systems
  - Performance tools such as TAU can now launch and collect data from remote systems
What is Eclipse?

- A vendor-neutral open-source workbench for multi-language development
- A extensible platform for tool integration
- Plug-in based framework to create, integrate and utilize software tools
Eclipse Features

- Full development lifecycle support
- Revision control integration (CVS, SVN, Git)
- Project dependency management
- Incremental building
- Content assistance
- Context sensitive help
- Language sensitive searching
- Multi-language support
- Debugging
Parallel Tools Platform (PTP)

- The Parallel Tools Platform aims to provide a highly integrated environment specifically designed for parallel application development.
- Features include:
  - An integrated development environment (IDE) that supports a wide range of parallel architectures and runtime systems.
  - A scalable parallel debugger.
  - Parallel programming tools (MPI, OpenMP, UPC, etc.).
  - Support for the integration of parallel tools.
  - An environment that simplifies the end-user interaction with parallel systems.
- http://www.eclipse.org/ptp
Eclipse PTP Family of Tools

Coding & Analysis (C, C++, Fortran)

Launching & Monitoring

Performance Tuning (TAU, PPW, ...)

Parallel Debugging

Module 2
How Eclipse is Used
Editing/Compiling
How Eclipse is Used
Launching/Monitoring
How Eclipse is Used

Debugging
How Eclipse is Used

Performance Tuning

Module 2
Contents

- Basic Eclipse Features (3-2)
- Projects In Eclipse (3-13)
- Editor Features (3-24)
- Team Features (3-34)
- MPI Features (3-40)
- Synchronizing the Project (3-56)
- Building the Project (3-62)
- Running: Resource Manager Configuration (3-69)
- Running: Launching a Job (3-82)
- Advanced Features: Searching (3-90)
- Fortran Specifics (3-99)
- Advanced editing: Code Templates (3-108)
- Refactoring and Transformation (3-113)
Basic Eclipse Features
A workbench contains the menus, toolbars, editors and views that make up the main Eclipse window.

The workbench represents the desktop development environment:
- Contains a set of tools for resource management.
- Provides a common way of navigating through the resources.
- Multiple workbenches can be opened at the same time.
- Only one workbench can be open on a workspace at a time.

Module 3
Perspectives

- Perspectives define the layout of views and editors in the workbench
- They are *task oriented*, i.e. they contain specific views for doing certain tasks:
  - There is a **Resource Perspective** for manipulating resources
  - **C/C++ Perspective** for manipulating compiled code
  - **Debug Perspective** for debugging applications
- You can easily switch between perspectives

- If you are on the Welcome screen now, select “Go to Workbench” now
Switching Perspectives

Three ways of changing perspectives

1. Choose the **Window** > **Open Perspective** menu option. Then choose **Other**...

2. Click on the **Open Perspective** button in the upper right corner of the screen (hover over it to see names).

3. Click on a perspective shortcut button.

Switch to the C/C++ Perspective

Module 3
Which Perspective?

- Which Perspective am in in?
  See Title Bar
The workbench window is divided up into Views

The main purpose of a view is:
- To provide alternative ways of presenting information
- For navigation
- For editing and modifying information

Views can have their own menus and toolbars
- Items available in menus and toolbars are available only in that view
- Menu actions only apply to the view

Views can be resized
Stacked Views

- Stacked views appear as tabs
- Selecting a tab brings that view to the foreground
Expand a View

- Double-click on a view/editor’s tab to fill the workbench with its content;
- Repeat to return to original size

- Window > Reset Perspective returns everything to original positions
Help

- To access help
  - Help > Help Contents
  - Help > Search
  - Help > Dynamic Help

- **Help Contents** provides detailed help on different Eclipse features *in a browser*
- **Search** allows you to search for help locally, or using Google or the Eclipse web site
- **Dynamic Help** shows help related to the current context (perspective, view, etc.)
Eclipse Preferences

- Eclipse Preferences allow customization of almost everything
- To open use
  - Mac: Eclipse>Preferences…
  - Others: Window>Preferences…
- The C/C++ preferences allow many options to be altered
- In this example you can adjust what happens in the editor as you type.
Preferences Example

More C/C++ preferences:

- In this example the Code Style preferences are shown.
- These allow code to be automatically formatted in different ways.
Projects In Eclipse
Project Types

- **Local**
  - Source is located on local machine, builds happen locally

- **Synchronized**
  - Source is local, then synchronized with remote machine(s)
  - Building and launching happens remotely (can also happen locally)

- **Remote**
  - Source is located on remote machine(s), build and launch takes place on remote machine(s)
Synchronized Projects

Projects types can be:

- Module 3
- File Service
- Index Service
- Launch Service
- Build Service
- Debug Service
- Local source code
- Source code copy
- Edit
- Search/Index
- Navigation
- Compute
- Run
- Debug
- Executable
- Build
- Synchronize
- Local
- Remote
Remote Projects

Projects types can be:
- File Service
- Index Service
- Launch Service
- Build Service
- Debug Service
- Source code
- Run
- Debug
- Compute
- Edit
- Executable
- Search/Index Navigation
- Build
- Local
- Remote
C, C++, and Fortran Projects

Build types

- **Makefile-based**
  - Project contains its own makefile (or makefiles) for building the application

- **Managed**
  - Eclipse manages the build process, no makefile required

Parallel programs can be run on local machine or on a remote system

- MPI (or other runtime) needs to be installed
- An application built locally probably can’t be run on a remote machine unless their architectures are the same
Checking out the project

Using a Source Code Repository

Introduction to Team Features
Importing a Project from CVS

- Switch to **CVS Repository Exploring** perspective
  - Window > Open Perspective > Other...
  - Select **CVS Repository Exploring**
  - Select OK

- Right click in **CVS Repositories** view and select **New>Repository Location...**
Add CVS Repository

- Enter **Host:** dev.eclipse.org
- **Repository path:** /cvsroot/tools

- For anonymous access:
  - **User:** anonymous
  - No password is required
  - **Connection type:** pserver (default)

- For authorized access:
  - **User:** your userid
  - **Password:** your password
  - **Connection type:** change to extssh

- Select **Finish**
Checking out the Project

- Expand the repository location
- Expand HEAD
- Expand `org.eclipse.ptp, doc, and samples`
- Right click on `shallow-mixed` and select **Check Out As**...
- On **Check Out As** dialog, select **Finish**

The default of “Check out as a project configured using the New Project Wizard” is what we want.
New Project Wizard

As project is checked out from CVS, the **New Project** Wizard helps you configure the Eclipse information to be added to the project:

- Expand **C/C++**
- Select **C Project** and click on **Next>**
- Enter ‘shallow’ as **Project Name**
- Under **Project type**, expand **Makefile project** - scroll to the bottom
- Select **Empty Project**
- Select a toolchain that matches your system from **Toolchains**
  - Since we will build/run this on the remote system, choose an appropriate toolchain
  - You may need to uncheck “Show project types and toolchains only if they are supported on the platform”
- Click on **Finish**

*Module 3*
C/C++ Perspective

- Switch to the C/C++ Perspective when Prompted
- You should now see the “shallow” project in your workspace

Expand the project root to see the project’s contents
Editor Features
Editors

- An editor for a resource (e.g. a file) opens when you double-click on a resource.
- The type of editor depends on the type of the resource.
  - .c files are opened with the C/C++ editor by default.
  - You can use **Open With** to use another editor.
  - In this case the default editor is fine (double-click).

- Some editors do not just edit raw text.
- When an editor opens on a resource, it stays open across different perspectives.
- An active editor contains menus and toolbars specific to that editor.
Saving File in Editor

- When you change a file in the editor, an asterisk on the editor’s title bar indicates unsaved changes.

- Save the changes by using Command/Ctrl-S or File>Save.

- Undo last change using Command/Ctrl Z.
Editor and Outline View

- Double-click on source file
- Editor will open in main view
- Outline view is shown for file in editor
- Console shows results of build, local runs, etc.
Source Code Editors & Markers

- A source code editor is a special type of editor for manipulating source code
- Language features are highlighted
- Marker bars for showing:
  - Breakpoints
  - Errors/warnings
  - Task Tags, Bookmarks
- Location bar for navigating to interesting features in the entire file

Icons:
Code Analysis (Codan)

- If you see bug icons in the editor marker bar, they are likely suggestions from Codan.
- Code checkers can flag possible errors, even if code is technically correct.
- To turn them off, use Preferences Window > Preferences or Mac: Eclipse > Preferences C/C++ > Code Analysis and uncheck all problems.
- Select OK to close Preferences.
- To remove icons: Rightmouse on Project > Run C/C++ Code Analysis.

Uncheck all.
Text editors can show line numbers in the left column.

To turn on line numbering:
- Right-click in the editor marker bar.
- Click on **Show Line Numbers**.
Navigating to Other Files

✦ On demand hyperlink
  ✦ In main.c line 135:
  ✦ Hold down Command/Ctrl key e.g. on call to initialise
  ✦ Click on initialise to navigate to its definition in the header file (Exact key combination depends on your OS)
  ✦ E.g. Command/Ctrl and click on initialise

✦ Open declaration
  ✦ Right-click and select **Open Declaration** will also open the file in which the element is declared
  ✦ E.g. in main.c line 29 right-click on decs.h and select **Open Declaration**

Note: may need to left-click before right-click works
Content Assist & Templates

- Type an incomplete function name e.g. “get” into the editor, and hit ctrl-space
- Select desired completion value with cursor or mouse

Code Templates: type ‘for’ and Ctrl-space

More info on code templates later
Inactive code

- Inactive code will appear grayed out in the CDT editor

```c
#define VAL
#ifdef VAL
    acopy_one_to_two(VAL, ds, res.indx);
#else
    acopy_one_to_two(res.row, ds, res.indx);
#endif
```

```c
//#define VAL
#ifdef VAL
    acopy_one_to_two(VAL, ds, res.indx);
#else
    acopy_one_to_two(res.row, ds, res.indx);
#endif
```
Team Features
“Team” Features

✚ Eclipse supports integration with multiple version control systems (VCS)
  ✧ CVS, SVN, Git, and others
  ✧ Collectively known as “Team” services

✚ Many features are common across VCS
  ✧ Compare/merge
  ✧ History
  ✧ Check-in/check-out

✚ Some differences
  ✧ Version numbers
  ✧ Branching
CVS Features

- Shows version numbers next to each resource
- Marks resources that have changed
  - Can also change color (preference option)
- Context menu for Team operations
- Compare to latest, another branch, or history
- Synchronize whole project (or any selected resources)
File Modification

- Open “calc.c”
- Add comment at line 40
- Save file
- File will be marked to indicate that it has been modified
View Changes

- Right-click on “calc.c” and select **Compare With>Latest from HEAD**
- Compare editor will open showing differences between local (changed) file and the original
- Buttons allow changes to be merged from right to left
- Can also navigate between changes using buttons
Revert To The Latest Version

- Right-click on the “shallow” project and select **Replace With > Latest from HEAD**
- Review the resources that will be replaced, then click **OK**
MPI Features
MPI-Specific Features

- PTP’s Parallel Language Development Tools (PLDT) has several features specifically for developing MPI code
  - Show MPI Artifacts
  - Code completion
  - Context Sensitive Help for MPI
  - Hover Help
  - MPI Templates in the editor
  - MPI Barrier Analysis
In Project Explorer, select a project, folder, or a single source file
- The analysis will be run on the selected resources

Select **Show MPI Artifacts**

Run the analysis by clicking on drop-down menu next to the analysis button

Works on local and remote files
MPI Artifact View

- Markers indicate the location of artifacts in editor
- The **MPI Artifact View** lists the type and location of each artifact
- Navigate to source code line by double-clicking on the artifact
- Run the analysis on another file (or entire project!) and its markers will be added to the view
- Click on column headings to sort
- Remove markers via
MPI Editor Features

- Code completion will show all the possible MPI keyword completions
- Enter the start of a keyword then press <ctrl-space>

- Hover over MPI API
- Displays the function prototype and a description

Module 3
Context Sensitive Help

- Click mouse, then press help key when the cursor is within a function name
  - Windows: F1 key
  - Linux: ctrl-F1 key
  - MacOS X: Help key or Help ➤ Dynamic Help

- A help view appears (Related Topics) which shows additional information (You may need to click on MPI API in editor again, to populate)

- Click on the function name to see more information
- Move the help view within your Eclipse workbench, if you like, by dragging its title tab
MPI Templates

- Allows quick entry of common patterns in MPI programming

- Example: MPI send-receive
  - Enter: `mpisr <ctrl-space>`
  - Expands to a send-receive pattern
  - Highlighted variable names can all be changed at once
  - Type `mpi <ctrl-space> <ctrl-space>` to see all templates

Add more templates using Eclipse preferences!

C/C++ > Editor > Templates
Extend to other common patterns
MPI Barrier Analysis

Verify barrier synchronization in C/ MPI programs

Interprocedural static analysis outputs:

- For verified programs, lists barrier statements that synchronize together (match)
- For synchronization errors, reports counter example that illustrates and explains the error

Local files only
MPI Barrier Analysis – Try it

Run the Analysis:

✧ In the Project Explorer, select the project (or directory, or file) to analyze

✧ Select the MPI Barrier Analysis action in the pull-down menu
MPI Barrier Analysis – Try It (2)

- No Barrier Errors are found (no pop-up indicating error); Two barriers are found
MPI Barrier Analysis - views

MPI Barriers view
Simply lists the barriers
Like MPI Artifacts view, double-click to navigate to source code line (all 3 views)

Barrier Matches view
Groups barriers that match together in a barrier set – all processes must go through a barrier in the set to prevent a deadlock

Barrier Errors view
If there are errors, a counter-example shows paths with mismatched number of barriers
Let’s cause a barrier mismatch error
Open worker.c in the editor by double-clicking on it in Project Explorer
At about line 125, enter a barrier:
- Type MPI_B
- Hit Ctrl-space
- Select MPI_Barrier
- Add communicator arg MPI_COMM_WORLD and closing semicolon

```c
prv = worker[PREV];
nxt = worker[NEXT];
jstart = worker[JSTART];
jend = worker[JEND];

MPI_Barrier(MPI_COMM_WORLD);
```
Barrier Errors (2)

✦ Save the file
  ✦ Ctrl-S (Mac Command-S) or File > Save
  ✦ Tab should lose asterisk indicating file saved

✦ Run barrier analysis on shallow project again
  ✦ Select shallow project in Project Explorer first
Barrier Errors (3)

- Barrier Error is found
- Hit OK to dismiss dialog

- Code diverges on line 87
  - One path has 2 barriers, other has 1

Double-click on a row in Barrier Errors view to find the line it references in the code
Fix Barrier Error

- Fix the Barrier Error before continuing
- Double-click on the barrier in worker.c to quickly navigate to it
- Remove the line and save the file
  - or -
  Right mouse on worker.c in Project Explorer and do **Replace With > Latest from HEAD**
Remove Barrier Markers

- Run Barrier Analysis again to remove the error - and/or -
- Remove the Barrier Markers via the “X” in one of the MPI Barrier views
Synchronizing the Project
Synchronizing the Project

- Because we will be running on a remote system, we must also build on that system
- Source files must be available to build
- We will use a synchronized project to do this
  - Only needs to be done once for each project
  - A synchronized project could have been created initially
- Files are synchronized automatically when they are saved
- A full synchronize is also performed prior to a build
Converting To Synchronized

- Select **File > New > Other**...
- Open the Remote folder
- Select **Convert C/C++ or Fortran Project to a Synchronized Project**
- Click **Next >**
Convert Projects Wizard

- Select checkbox next to “shallow”
- For **Connection:** click on **New...** Enter as directed:
  - **Target name**
  - **Host** name of remote system
  - **User id** and **Password**
- Click **Finish** to close it
- Back in the **Convert Projects** dialog,
- Enter a directory name in the **Location** field; select **Browse...**
  - Sample: /u/ac/trainXX/shallow
  - Project files will be copied under this directory
- Click **Finish**
Synchronized Project

- Back in the Project Explorer, decorator on project icon indicates synchronized project
- Double-+ icon

- Before sync
- After sync
Set Active Build Configuration

- The “Active” build configuration determines which system will be used for both synchronizing and building.
- Right-click on the project and select Build Configurations > Set Active > Remote (Build on remote machine).
- The project should synchronize immediately.
Building the Project
Building the Project

- Select the project in Project Explorer, click on the hammer button to run the build.

- By default, the Build Configuration assumes there is a Makefile (or makefile) for the project.

- In this case, there is no Makefile, so the build will fail.

See Console:

- We’ll see how to change it if the build command is different from ‘make –f Makefile’.
Fixing the Build Command: Editing Project Properties

- The build command is specified in the project properties
- Open the properties by right-clicking on “shallow” and selecting **Properties** (bottom of the context menu list)
- Click on **C/C++ Build**
- Uncheck **Use default build command**
- Enter “make –f Makefile.mk” in the **Build Command** field
- Click **OK** to close project properties dialog
Re-Building the Project

✧ Click on the button again to run the build
✧ Build output will be shown in the Console view

✧ Exact output depends on your compiler
Build Problems

- Build problems will be shown in a variety of ways:
  - Marker on file
  - Marker on editor line
  - Line is highlighted
  - Marker on overview ruler
  - Listed in the Problems view

- Double-click on line in Problems view to go to location of error in the editor
Fix Build Problems

- Fix errors by changing ‘:’ to ‘;’ on line 97
- Save the file
- Rebuild by pressing build button
- Error markers have been removed
- Check console for correct build output
Forcing a Rebuild

- If no changes have been made, make doesn’t think a build is needed
- In Project Explorer, Rightmouse on project, select **Clean Project**
- See console
- Then rebuild
Running the Program

Resource Managers
Running the Program

- Creating a resource manager
- Starting the resource manager
- Creating a run configuration
- Running (launching) the application
- Viewing the application run

Much of the following setup is configuration that you only need to do once: This icon will remind you.
Resource Managers

- PTP uses the term “resource manager” to refer to any subsystem that controls the resources required for launching a parallel job.
- Examples:
  - Batch scheduler (e.g. LoadLeveler, PBS, SLURM)
  - Interactive execution (e.g. Open MPI, MPICH2, etc.)
- Each resource manager controls one target system
- Resource Managers can be local or remote
Monitoring/Runtime Perspectives

- **Parallel Runtime Perspective**
  - Used for legacy PTP Resource Managers
- **System Monitoring Perspective**
  - Used for newer Configurable Resource Managers (since PTP 5.0)

Which one is used?

<table>
<thead>
<tr>
<th>Resource Manager</th>
<th>System Monitoring</th>
<th>Parallel Runtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM LoadLeveler</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>IBM Parallel Env</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>MPICH2</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Open MPI</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>PBS-Batch-Generic</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>PBS-Batch-Interactive</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Remote Launch</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>SLURM</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
Preparing to Launch

- Setting up a resource manager is done in the System Monitoring perspective
  - (For PTP 5.0, this applies to PBS)
- Select **Windows > Open Perspective > Other...**
- Choose **System Monitoring** and click **OK**
System Monitoring Perspective

- System view
- Jobs running on system
- Active jobs
- Inactive jobs
About PTP Icons

- Open using legend icon in toolbar
Configuring Job Scheduler

- Right-click in Resource Managers view and select **Add Resource Manager**

- Choose Resource Manager Type: `edu.illinois.ncsa.forge.pbs.batch.openmpi`

- Select **Next**

*Module 3*
Configure Control Connection

- Choose **Remote Tools** for **Remote service provider**
- Choose the remote connection you made previously
- Click **Next**

![Control Connection configuration](image)
Configure Monitor Connection

- Keep default Monitor Connection (same as Control Connection), click **Next**
Common Configuration

- Keep default name
- Can automatically start Resource Manager (leave unselected today)
- Click **Finish**
Starting the Resource Manager

- Right click on new resource manager and select **Start resource manager**
- If everything is ok, you should see the resource manager change to **green**
- If something goes wrong, it will change to **red**
_system view, with abstraction of nodes for selected Resource Manager

- Active and inactive jobs

- Hover over node in **System** view to see job running on node in **Active Jobs** view

- Hold mouse button down on a job in **Active Jobs** view to see where it is running in **System** view

forge.ncsa.illinois.edu

One node with 16 cores
Running the Program

(Launching a Job)
Create a Run Configuration

- Open the run configuration dialog **Run > Run Configurations**...
- Select **Parallel Application**
- Select the **New** button

Or, just double-click on **Parallel Application** to create a new one

Depending on which flavor of Eclipse you installed, you might have more choices in Application types

*Module 3*
Complete the Resources Tab

- Enter a name for this run configuration, e.g. "shallow-pbs-batch"
- In Resources tab, select the PBS resource manager you just created (edu.illinois.ncsa.forge....)
- Select the destination queue – debug
- The MPI Command field allows this job to be run as an MPI job
  - Choose mpirun
- Enter the resources needed to run this job
  - Use 1 nodes, 4 cores (MPI tasks)
Complete the Application Tab

- Select the **Application** tab
- Choose the **Application program** by clicking the **Browse** button and locating the executable on the remote machine
  - Use the same “shallow” executable
- Select **Display output from all processes in a console view**
- Click **Run** to submit the application to the job scheduler
Job Monitoring

- Job initially appears in “Inactive Jobs”, then in “Active Jobs”, then returns to Inactive on completion
- This short-running program may not run long enough to appear in “Active Jobs”
- Status refreshes automatically every 60 sec
- Or force refresh with menu
- After status = COMPLETED, Can view output or error by right clicking on job, selecting appropriate output
Job Output

- After status = COMPLETED, Can view output or error by right clicking on job, selecting appropriate output
- Output/Error info shows in Console View
Building before Run

- If projects build prior to launch, you can turn it off.
  - Go into Preferences>Run/Debug and click on Launching.
  - Uncheck "Build (if required) before launching"

- Should be set by default now

To bring up Preferences dialog, use Window>Preferences or Mac: Eclipse>Preferences
Exercise

- Start with your ‘shallow’ project
- Create and start Resource Manager
- Build; Run shallow
- See results
- Change something
  - Change m and n in decs.h
- Rebuild and re-run
Advanced Features

Searching
Fortran
Refactoring
Searching
Switching Perspectives

Switch to C/C++ Perspective one of three ways:

1. Choose the **Window>Open Perspective** menu option
   Then choose **Other**...

2. Click on the **Open Perspective** button in the upper right corner of screen (hover over it to see names)

3. Click on a perspective shortcut button
Find/Replace within Editor

- Simple Find within editor buffer
- Ctrl-F (Mac: Command-F)
Mark Occurrences
(C/C++ Only)

- Double-click on a variable in the CDT editor
- All occurrences in the source file are highlighted to make locating the variable easier
- Alt-shift-O to turn off (Mac: Alt-Cmd-O)
Language-Based Searching
(C/C++ and Fortran)

- “Knows” what things can be declared in each language (functions, variables, classes, modules, etc.)
- E.g., search for every call to a function whose name starts with “get”
- Search can be project- or workspace-wide

Module 3
Find References
(C/C++ and Fortran)

✦ Finds all of the places where a variable, function, etc., is used
  ✦ Right-click on an identifier in the editor
  ✦ Click References►Workspace
    or References►Project

✦ Search view shows matches
Open Declaration
(C/C++ and Fortran)

- Jumps to the declaration of a variable, function, etc., even if it’s in a different file
- Left-click to select identifier
- Right-click on identifier
- Click **Open Declaration**

- C/C++ only: Can also Ctrl-click (Mac: Cmd-click) on an identifier to “hyperlink” to its declaration

Goes to its declaration in copy.c
Search – Try It!

1. Find every call to MPI_Recv in Shallow.

2. In worker.c, on line 42, there is a declaration
   float p[n][m].
   a) What is m (local? global? function parameter?)
   b) Where is m defined?
   c) How many times is m used in the project?

3. Find every function whose name contains the word time
Fortran Specifics
Project Properties

- Right-click Project
- Select Properties...

*Project properties* are settings that can be changed for each project

- Contrast with *workspace preferences*, which are the same regardless of what project is being edited
  - e.g., editor colors
  - Set in *Window > Preferences* (on Mac, *Eclipse > Preferences*)
- Careful! Dialog is very similar
Converting to a Fortran Project

Are there categories labeled **Fortran General** and **Fortran Build** in the project properties?

If not, the project is not a Fortran Project

- Switch to the Fortran Perspective
- In the Project Explorer view, right-click on the project, and click **Convert to Fortran Project**
- Don’t worry; it’s still a C/C++ project, too

*Every* Fortran project is also a C/C++ Project
Project Location

- How to tell where a project resides?
- In the project properties dialog, select the **Resource** category.
Error Parsers

✨ Are compiler errors not appearing in the Problems view?
- Make sure the correct error parser is enabled
- In the project properties, navigate to C++ Build ► Settings or Fortran Build ► Settings
- Switch to the Error Parsers tab
- Check the error parser(s) for your compiler(s)
Fortran Source Form Settings

- Fortran files are either *free form* or *fixed form*; some Fortran files are *preprocessed* (#define, #ifdef, etc.)

- Source form determined by filename extension
- Defaults are similar to most Fortran compilers:
  
  **Fixed form:** .f .fix .for .fpp .ftn .f77
  
  **Free form:** .f08 .f03 .f95 .f90
  
  < unpreprocessed
  
  .F08 .F03 .F95 .F90
  
  < preprocessed

- Many features *will not work* if filename extensions are associated with the wrong source form (outline view, content assist, search, refactorings, etc.)
In the project properties, select **Fortran General**. Select source form for each filename extension. Click **OK**.
Enabling Fortran Advanced Features

- Some Fortran features are *disabled* by default
- Must be explicitly enabled
  - In the project properties dialog, select **Fortran General ▶ Analysis/Refactoring**
  - Click **Enable Analysis/Refactoring**
  - Close and re-open any Fortran editors
- This turns on the “Photran Indexer”
  - Turn it off if it’s slow
Project Properties – Try It!

1. Convert shallow to a Fortran project
2. Make sure errors from the GNU Fortran compiler will be recognized
3. Make sure *.f90 files are treated as “Free Form” which is unpreprocessed
4. Make sure search and refactoring will work in Fortran
Advanced Editing

Code Templates
Code Templates
(C/C++ and Fortran)

- Auto-complete common code patterns
  - For loops/do loops, if constructs, etc.
  - Also MPI code templates

- Included with content assist proposals (when Ctrl-Space is pressed)
  - E.g., after the last line in tstep.f90, type “sub” and press Ctrl-Space
  - Press Enter to insert the template
After pressing enter to insert the code template, completion fields are highlighted.

Press **Tab** to move between completion fields.

Changing one instance of a field changes all occurrences.
Advanced Editing – Try It!

- Open tstep.f90 and retype the last loop nest
- Use the code template to complete the do-loops
- Use content assist to complete variable names
Custom Code Templates (Fortran)

- Customize code templates in **Window ▶ Preferences ▶ Fortran ▶ Templates**

- Can import/export templates to XML files
Refactoring and Transformation
Refactoring

(making changes to source code that don’t affect the behavior of the program)

Refactoring is the research motivation for Photran @ Illinois

- Illinois is a leader in refactoring research
- “Refactoring” was coined in our group
  (Opdyke & Johnson, 1990)
- We had the first dissertation...
  (Opdyke, 1992)
- ...and built the first refactoring tool...
  (Roberts, Brant, & Johnson, 1997)
- ...and first supported the C preprocessor
  (Garrido, 2005)
- Photran’s agenda: refactorings for HPC, language evolution, refactoring framework

Photran 7.0: 31 refactorings
Refactoring Caveats

✦ Photran can only refactor free form code that is not preprocessed

✦ Determined by Source Form settings
  (recall from earlier that these are configured in
  Project Properties: Fortran General ▶ Source Form)

<table>
<thead>
<tr>
<th></th>
<th>.f08</th>
<th>.f03</th>
<th>.f95</th>
<th>.f90</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔ Free Form, Unpreprocessed:</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>✗ Free Form, Preprocessed:</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>✗ Fixed Form:</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>

✦ Refactor menu will be empty if

✦ Refactoring not enabled in project properties
  (recall from earlier that it is enabled in
  Project Properties: Fortran General ▶ Analysis/Refactoring)

✦ The file in the active editor is fixed form

✦ The file in the active editor is preprocessed
Rename Refactoring
(also available in Fortran)

- Changes the name of a variable, function, etc., including every use
  (change is semantic, not textual, and can be workspace-wide)

- Only proceeds if the new name will be legal
  (aware of scoping rules, namespaces, etc.)

Switch to C/C++ Perspective
Open a source file
In the editor, click on a variable or function name
Select menu item **Refactor ▶ Rename**
Or use context menu
Enter new name

In Java (Murphy-Hill et al., ICSE 2008):

<table>
<thead>
<tr>
<th>Refactoring</th>
<th>Uses</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rename</td>
<td>179,871</td>
<td>74.8%</td>
</tr>
<tr>
<td>Extract Local Variable</td>
<td>13,523</td>
<td>5.6%</td>
</tr>
<tr>
<td>Move</td>
<td>13,208</td>
<td>5.5%</td>
</tr>
<tr>
<td>Extract Method</td>
<td>10,581</td>
<td>4.4%</td>
</tr>
<tr>
<td>Change Method Signature</td>
<td>4,764</td>
<td>2.0%</td>
</tr>
<tr>
<td>Inline</td>
<td>4,102</td>
<td>1.7%</td>
</tr>
<tr>
<td>Extract Constant</td>
<td>3,363</td>
<td>1.4%</td>
</tr>
<tr>
<td>(16 Other Refactorings)</td>
<td>10,924</td>
<td>4.5%</td>
</tr>
</tbody>
</table>
Rename in File
(C/C++ Only)

- Position the caret over an identifier.
- Press **Ctrl-1** (**Command-1** on Mac).
- Enter a new name. Changes are propagated within the file as you type.
Extract Function Refactoring
(also available in Fortran - “Extract Procedure”)

- Moves statements into a new function, replacing the statements with a call to that function
- Local variables are passed as arguments

Select a sequence of statements
Select menu item **Refactor**
**Extract Function**
Enter new name
Introduce **IMPLICIT NONE** Refactoring

- Fortran does not require variable declarations (by default, names starting with I-N are integer variables; others are reals)
- This adds an **IMPLICIT NONE** statement and adds explicit variable declarations for all implicitly declared variables

- Introduce in a single file by opening the file and selecting **Refactor** ➤ **Coding Style** ➤ **Introduce IMPLICIT NONE**...

- Introduce in multiple files by selecting them in the Project Explorer view, right-clicking on the selection, and choosing **Refactor** ➤ **Coding Style** ➤ **Introduce IMPLICIT NONE**...
Loop Transformations
(Fortran only)

- **Interchange Loops**  **CAUTION**: No check for behavior preservation
  - Swaps the loop headers in a two-loop nest
  - Select the loop nest, click menu item **Refactor -> Do Loop**

Interchange Loops (Unchecked)...

Old version traverses matrices in row-major order
New version traverses in column-major order (better cache performance)
Loop Transformations

(Fortran only)

- **Unroll Loop**
- Select a loop, click **Refactor ▶ Do Loop ▶ Unroll Loop…**

```fortran
do i = 1, 12
    print *, 10*i
end do
```

Unroll 4×

```fortran
do i = 1, 12, 4
    print *, 10*i
    print *, 10*(i+1)
    print *, 10*(i+2)
    print *, 10*(i+3)
end do
```
Refactoring & Transformation – Try It!

In *tstep.f90*...

1. In *init.c*, extract the `printf` statements at the bottom of the file into a new function called `print_banner`

2. In *worker.c*, change the spellings of `neighbour_send` and `neighbour_receive` to American English

3. In *tstep.f90*, make the (Fortran) `tstep` subroutine `IMPLICIT NONE`
NCSA Blue Waters
HPC Workbench

- Tools for NCSA Blue Waters
  - [http://www.ncsa.illinois.edu/BlueWaters/](http://www.ncsa.illinois.edu/BlueWaters/)
  - Sustained Petaflop system
  - Based on Eclipse and PTP
  - Includes some related tools
    - Performance tools
    - Workflow tools (https://wiki.ncsa.uiuc.edu/display/MRDPUB/MRD+Public+Space+Home+Page)
- Part of the enhanced computational environment described at:
  - [http://www.ncsa.illinois.edu/BlueWaters/ece.html](http://www.ncsa.illinois.edu/BlueWaters/ece.html)
NSF SI2 Workbench for High Performance Computing

- “SI2-SSI Productive and Accessible Development Workbench for HPC Applications”, which is supported by the National Science Foundation under award number OCI 1047956
- Produce a productive and accessible development workbench using Eclipse PTP
- Key Components
  - Determining Requirements, Ensuring Impact
  - Make improvements to Eclipse PTP
  - Engineering Process
  - Metrics
  - Outreach/Training/Education

Module 4
NCSA HPC Workbench

Coding & Analysis (C/C++, Fortran)

PTP Launching & Monitoring

Workflow

Performance Tuning

Parallel Debugger
Planned PTP Future Work

- Scalability improvements
  - UI to support 1M processes
  - Very large application support
- Usability improvements
  - New wizard to improve setup experience
  - Ability to share configuration information
- Resource Managers
  - More implementations of configurable resource managers
- Synchronized project improvements
  - Conversion wizard
  - Resolving merge conflicts
Useful Eclipse Tools

- Linux Tools (autotools, valgrind, Oprofile, Gprof)
  - http://eclipse.org/linuxtools
- Python
  - http://pydev.org
- Ruby
  - http://www.aptana.com/products/radrails
- Perl
  - http://www.epic-ide.org
- Git
  - http://www.eclipse.org/egit
- VI bindings
  - Vrapper (open source) - http://vwrapper.sourceforge.net
  - viPlugin (commercial) - http://www.viplugin.com
Online Information

- Information about PTP
  - Main web site for downloads, documentation, etc.
    - http://eclipse.org/ptp
  - Wiki for designs, planning, meetings, etc.
    - http://wiki.eclipse.org/PTP
  - Articles and other documents
    - http://wiki.eclipse.org/PTP/articles

- Information about Photran
  - Main web site for downloads, documentation, etc.
    - http://eclipse.org/photran
  - User’s manuals
Mailing Lists

- **PTP Mailing lists**
  - Major announcements (new releases, etc.) - low volume
    - [http://dev.eclipse.org/mailman/listinfo/ptp-announce](http://dev.eclipse.org/mailman/listinfo/ptp-announce)
  - User discussion and queries - medium volume
    - [http://dev.eclipse.org/mailman/listinfo/ptp-user](http://dev.eclipse.org/mailman/listinfo/ptp-user)
  - Developer discussions - high volume
    - [http://dev.eclipse.org/mailman/listinfo/ptp-dev](http://dev.eclipse.org/mailman/listinfo/ptp-dev)

- **Photran Mailing lists**
  - User discussion and queries
    - [http://dev.eclipse.org/mailman/listinfo/photran](http://dev.eclipse.org/mailman/listinfo/photran)
  - Developer discussions –
    - Also on ptp-dev list (see above)
Getting Involved

✦ See http://eclipse.org/ptp
✦ Read the developer documentation on the wiki
  ✦ http://wiki.eclipse.org/PTP
✦ Join the mailing lists
✦ Attend the monthly developer meetings
  ✦ Conf Call Monthly: Second Tuesday, 1:00 pm ET
  ✦ Details on the PTP wiki
✦ Attend the monthly user meetings
  ✦ Teleconf Monthly: 4th Wednesday, 1:00 pm ET
  ✦ Details on the PTP wiki

PTP will only succeed with your participation!