



parallel tools platform

<http://eclipse.org/ptp>

Developing and Tuning Parallel Scientific Applications in Eclipse

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Tutorial Outline

Time (Tentative!)	Module	Topics	Presenter
8:30-9:00	1. Eclipse and PTP Installation	✦ Installation of Eclipse and PTP (can start early as people arrive)	Greg/Beth
9:00-9:30	2. Introduction & Overview	✦ Eclipse architecture & organization overview	Greg
9:30-10:00	3. Developing with Eclipse	✦ Eclipse basics; Creating a new project from CVS; Local, remote, and synchronized projects	Beth
10:00-10:30	BREAK		
10:30-12:00	3. Developing with Eclipse (continued)	Continue from before the break... ✦ Editing C files; MPI Features; Building w/Makefile ✦ Resource Managers and launching a parallel app ✦ Fortran, Refactoring, other Advanced Features	Beth, Jay, Jeff
12:00 - 1:30	Lunch		
1:30-2:15	4. Debugging	✦ Debugging an MPI program	Greg
2:15-3:00	5a. Performance Tuning & Analysis Tools	✦ 1. TAU (Tuning and Analysis Utilities) ETFw (External Tools Framework)	Wyatt
3:00-3:30	BREAK		
3:30-4:45	5b. Performance Tuning & Analysis Tools	✦ 2. GEM (Graphical Explorer for MPI programs) ✦ 3. gprof/gcov from Linuxtools	Alan Galen
4:45-5:00	6. Other Tools, Wrapup	✦ Other Tools, website, mailing lists, future features	Beth/Jay

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PTP Tutorial – Slide Topics	PDF page #	Slide page # prefix
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Adding a remote shell in Eclipse	43	Shell-
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Final Slides, Installation Instructions

- ★ Please go to <http://wiki.eclipse.org/PTP/tutorials/SC12> for slides and installation instructions

Installation

✦ Objective

- ✦ To learn how to install Eclipse and PTP

✦ Contents

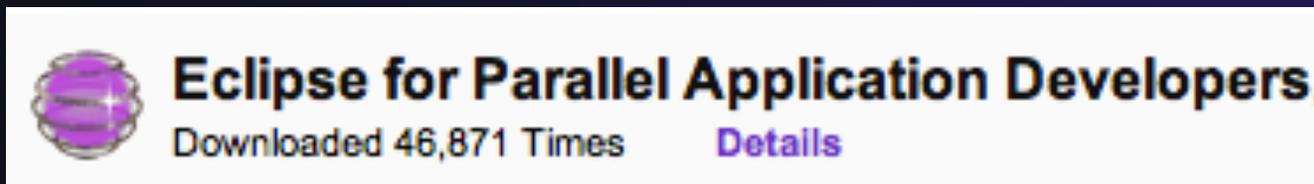
- ✦ System Prerequisites
- ✦ Eclipse Download and Installation of “Eclipse for Parallel Application Developers”
- ✦ Installation Confirmation
- ✦ Updating the PTP within your Eclipse to the latest release

System Prerequisites

- ★ Local system (running Eclipse)
 - ★ Linux (just about any version)
 - ★ MacOSX (10.5 Leopard or higher)
 - ★ Windows (XP on)
- ★ 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 JRE 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 (4.2) is also known as "Juno"
- ★ Eclipse is available in a number of different packages for different kinds of development
 - ★ <http://eclipse.org/downloads>
- ★ For PTP, we recommend the all-in-one download:
 - ★ Eclipse for Parallel Application Developers



We often call this the "Parallel Package"



Exercise

1. Download the “Eclipse for Parallel Application Developers” package to your laptop
 - ★ Your tutorial instructions will provide the location of the package
 - ★ Make sure you match the architecture with that of your laptop
2. If your machine is Linux or Mac OS X, untar the file
 - ★ On Mac OS X you can just double-click in the Finder
3. If your machine is Windows, unzip the file
4. This creates an **eclipse** folder containing the executable as well as other support files and folders

Starting Eclipse

★ Linux

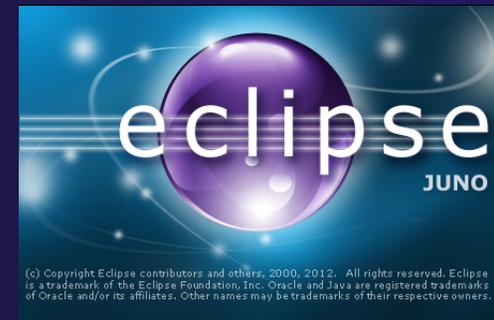
- ★ From a terminal window, enter
“<eclipse_installation_path>/eclipse/eclipse &”

★ Mac OS X

- ★ From finder, open the **eclipse** folder where you installed
- ★ Double-click on the **Eclipse** application
- ★ Or from a terminal window

★ Windows

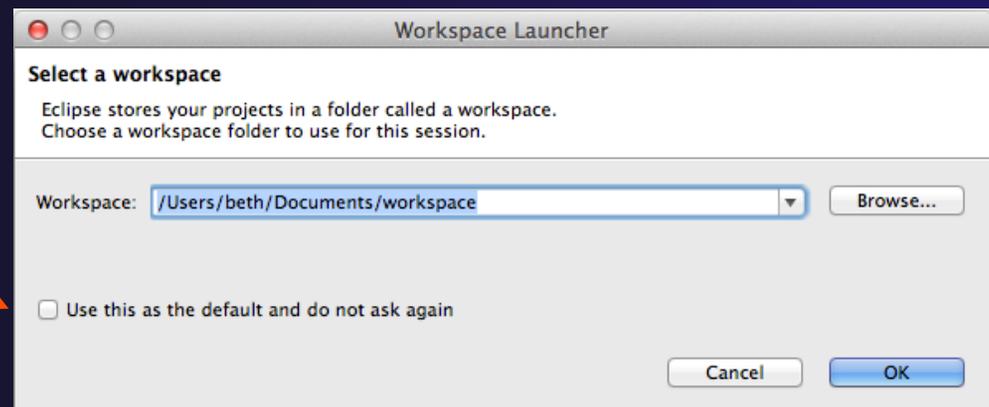
- ★ Open the **eclipse** folder
- ★ Double-click on the **eclipse** executable



Specifying A Workspace

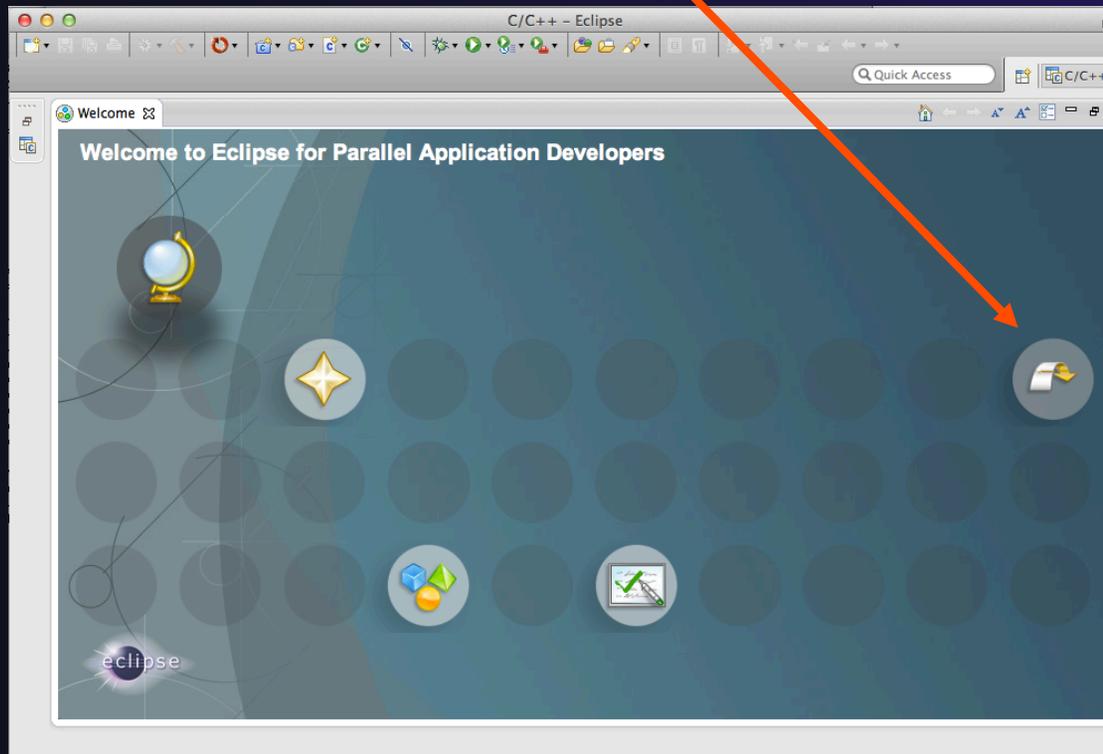
- ✦ Eclipse prompts for a workspace location at startup time
- ✦ The workspace contains all user-defined data
 - ✦ Projects and resources such as folders and files
 - ✦ The default workspace location is fine for this tutorial

The prompt can be turned off



Eclipse Welcome Page

- ★ Displayed when Eclipse is run for the first time
Select "Go to the workbench"

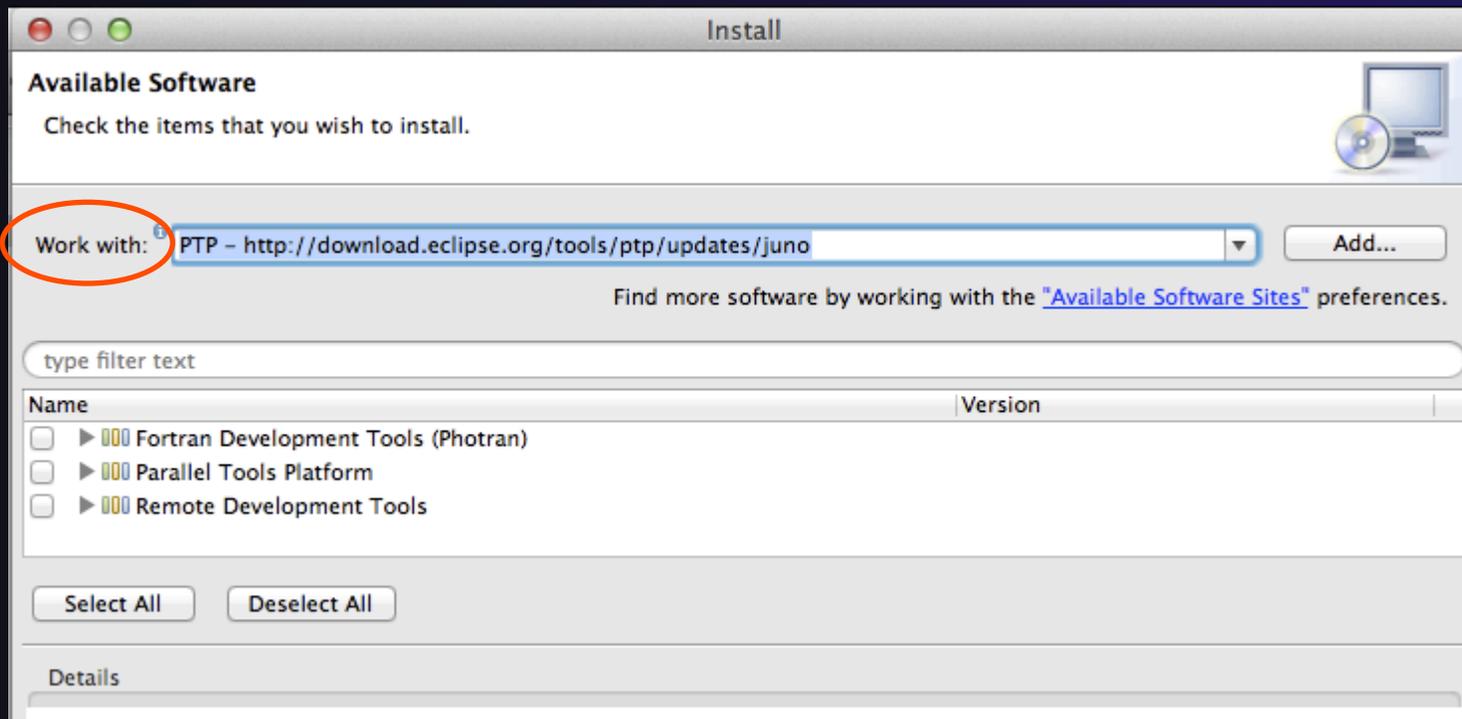


Checking for PTP Updates

- ✦ From time-to-time there may be newer PTP releases than the Juno release
 - ✦ Juno and "Parallel package" updates are released only in September and February
- ✦ PTP maintains its own update site with the most recent release
 - ✦ Bug fix releases can be more frequent than base Eclipse (e.g. Juno), and what is within the parallel package
- ✦ You must enable (and install from) the PTP-specific update site before the updates will be found

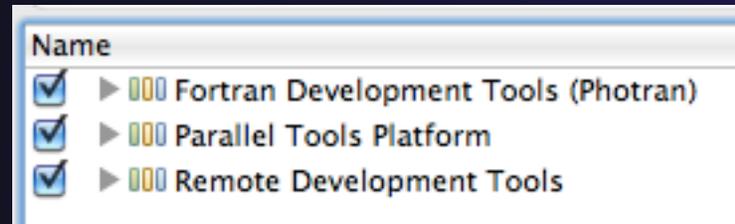
Updating PTP

- ★ Now select **Help>Install New Software...**
 - ★ In the **Work With:** dropdown box, select this update site, or enter it:
<http://download.eclipse.org/tools/ptp/updates/juno>



Updating PTP (2)

- ★ Easiest option is to check everything - which updates existing features and adds a few more

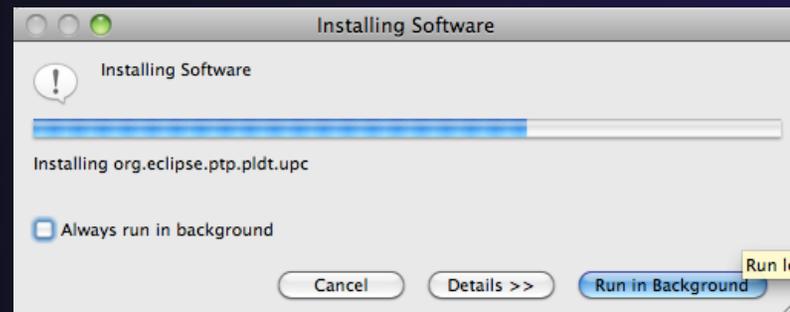


Note: for SC tutorial, this installs extra features you'll need later anyway (GEM, TAU)

- ★ Select **Next** to continue updating PTP
- ★ Select **Next** to confirm features to install

Updating PTP (3)

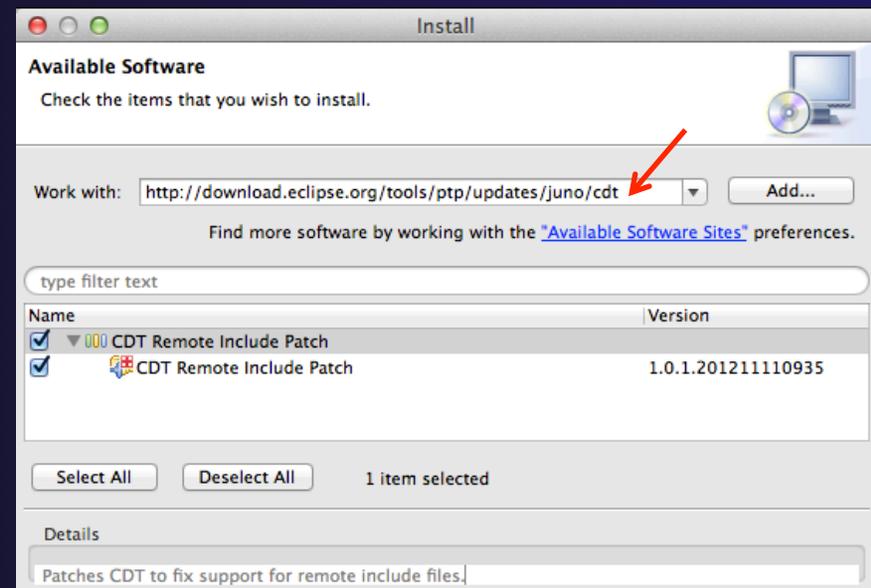
- ★ Accept the License agreement and select **Finish**



- ★ Don't restart Eclipse yet!
 - ★ ... see next slide (for one more update) before accepting to restart Eclipse
 - ★ ... or you can restart eclipse and do it then

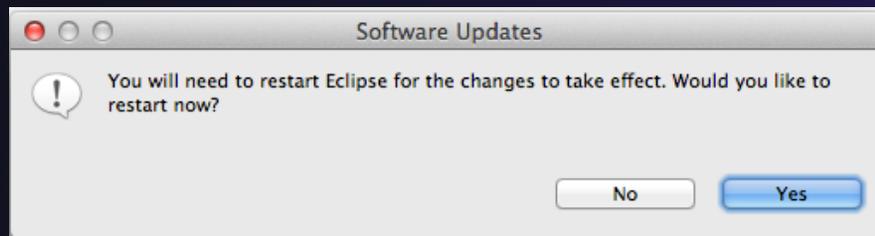
Updating PTP –CDT fix

- ✦ Currently CDT (C/C++ Development Tools) needs a fix for remote includes
- ✦ We'll install from another update site to fix this:
- ✦ In the **Work With:** dropdown box, add:
`http://download.eclipse.org/tools/ptp/updates/juno/cdt`
- ✦ Select All
- ✦ Next, Next, accept license, Finish – to complete the install



Updating PTP - restart

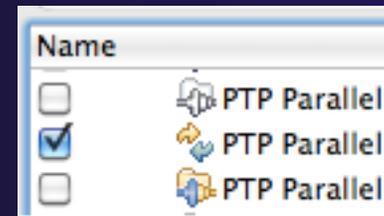
- ★ Select **Yes** when prompted to restart Eclipse



Updating Individual Features

- ★ It's also possible (but a bit tedious) to update features without adding any new features
 - ★ Open each feature and check the ones you want to update

- ★ Icons indicate: Grey plug: already installed
Double arrow: can be updated
Color plug: Not installed yet

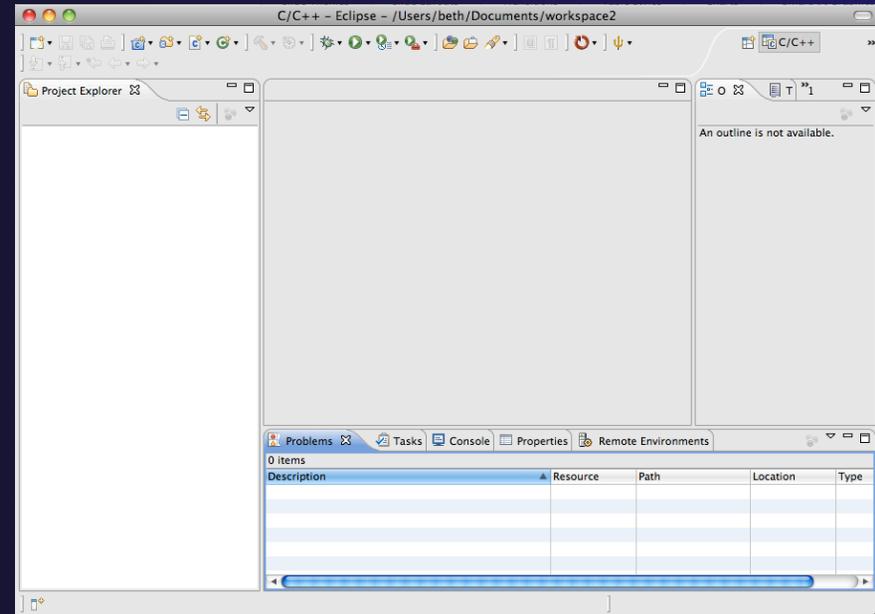


- ★ Note: if network is slow, consider unchecking:

Contact all update sites during install to find required software

Restart after Install

- ★ If any new top-level features are installed, they will be shown on the welcome screen
- ★ We only updated PTP, so we land back at C/C++ Perspective



- ★ **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



Exercise

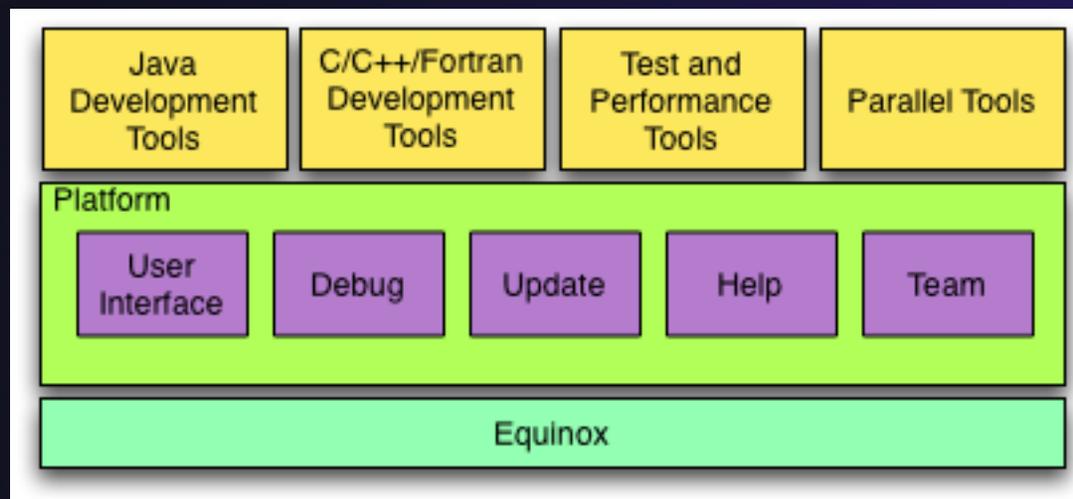
1. Launch Eclipse and select the default workspace
2. Configure Eclipse to check for PTP updates
3. Update all PTP features to the latest level
4. Install the optional features of PTP, including TAU and GEM
 - ✦ Selecting *all* features accomplishes 3. and 4.
5. Install the CDT fix
6. Restart Eclipse once the installation is completed

Introduction

- ✦ Objective
 - ✦ To introduce the Eclipse platform and PTP
- ✦ Contents
 - ✦ New and Improved Features
 - ✦ What is Eclipse?
 - ✦ What is PTP?

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

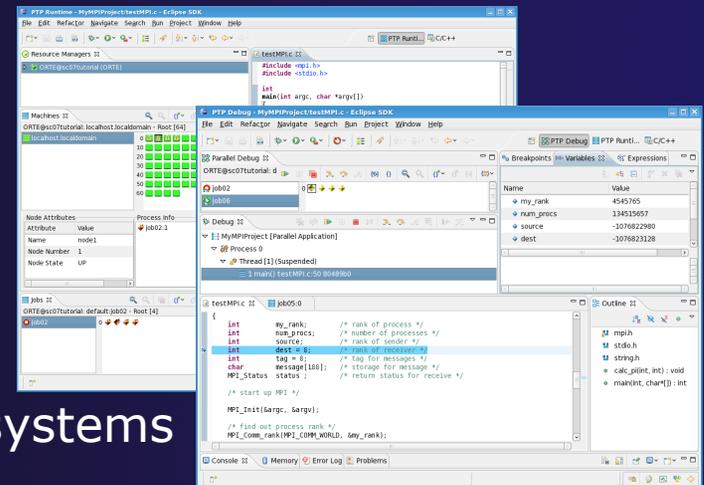


Eclipse Features

- ✦ 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)

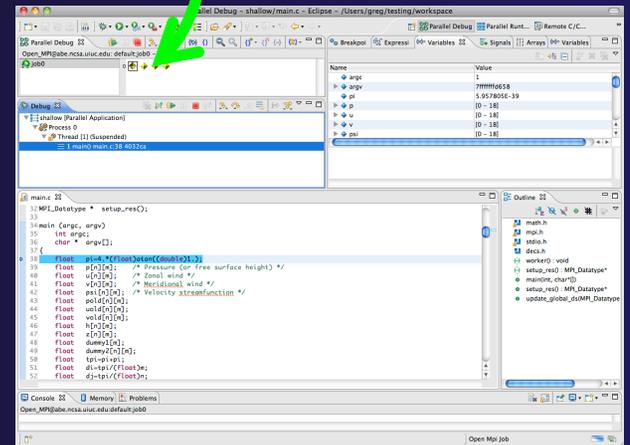
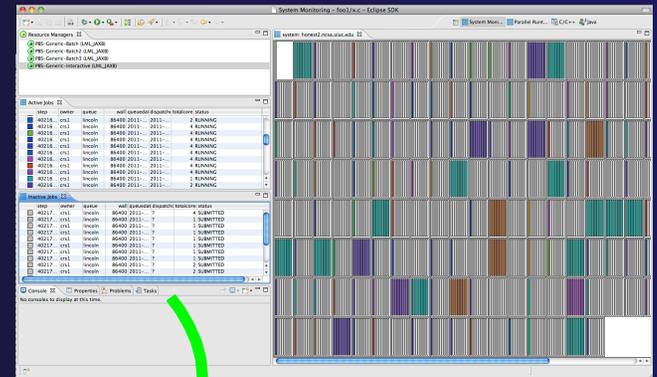
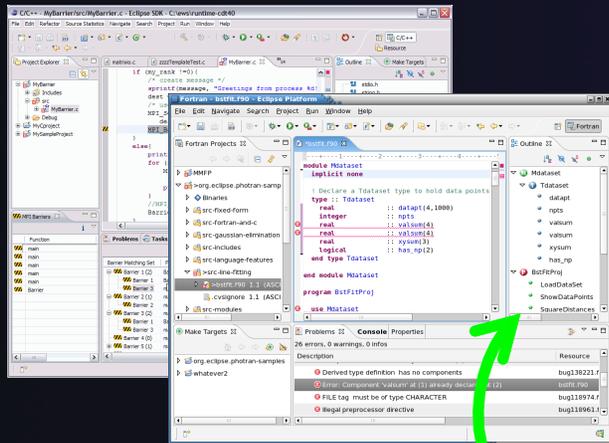
- ★ The Parallel Tools Platform aims to provide a highly integrated environment specifically designed for parallel application development
- ★ Features include:
 - ★ An integrated development environment (IDE) that supports a wide range of parallel architectures and runtime systems
 - ★ A scalable parallel 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

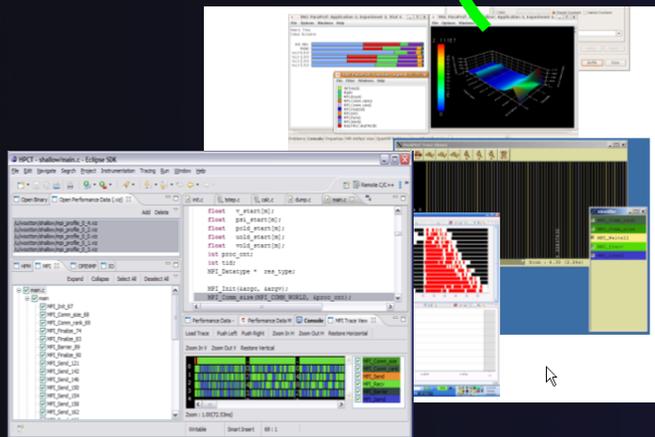


Performance Tuning
(TAU, PPW, ...)

Parallel Debugging

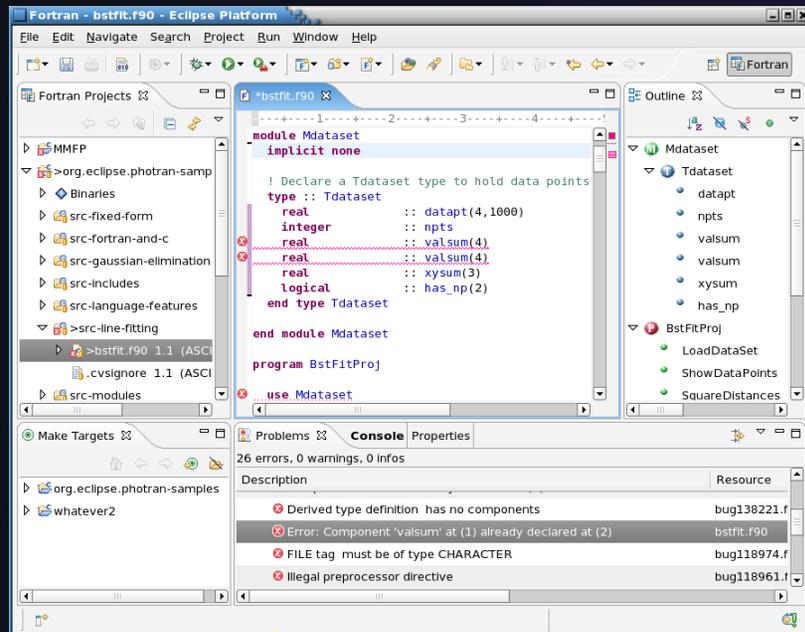
Introduction

Intro-4

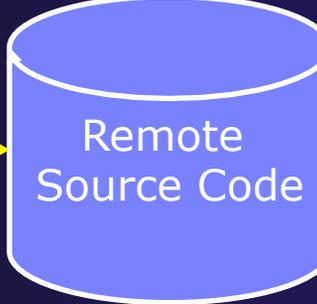


How Eclipse is Used

Editing/Compiling



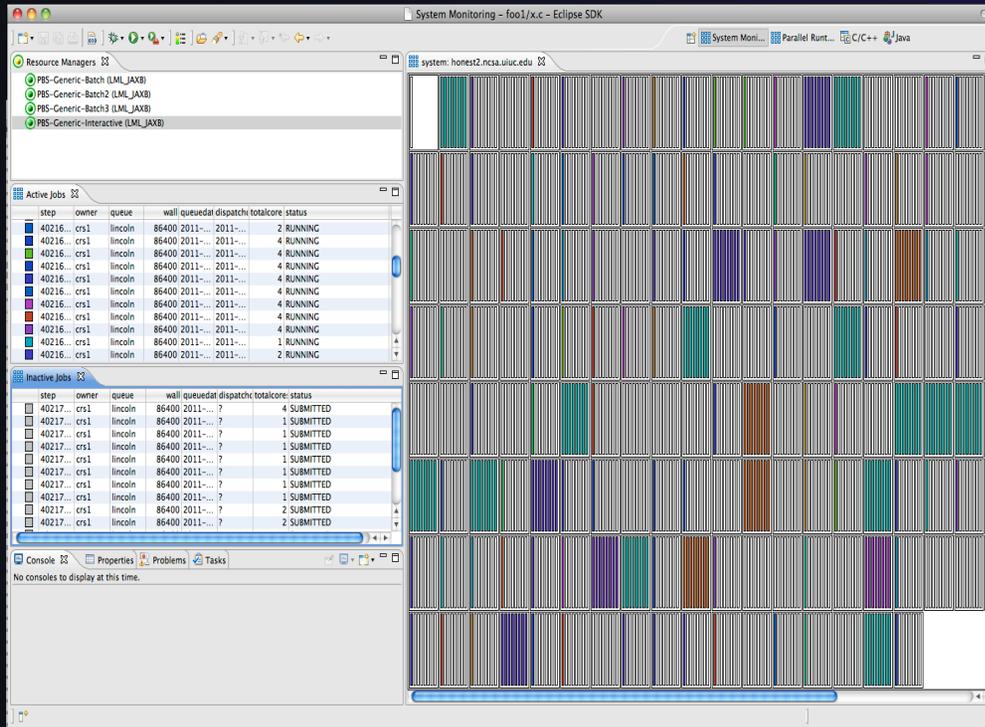
Introduction



Intro-5

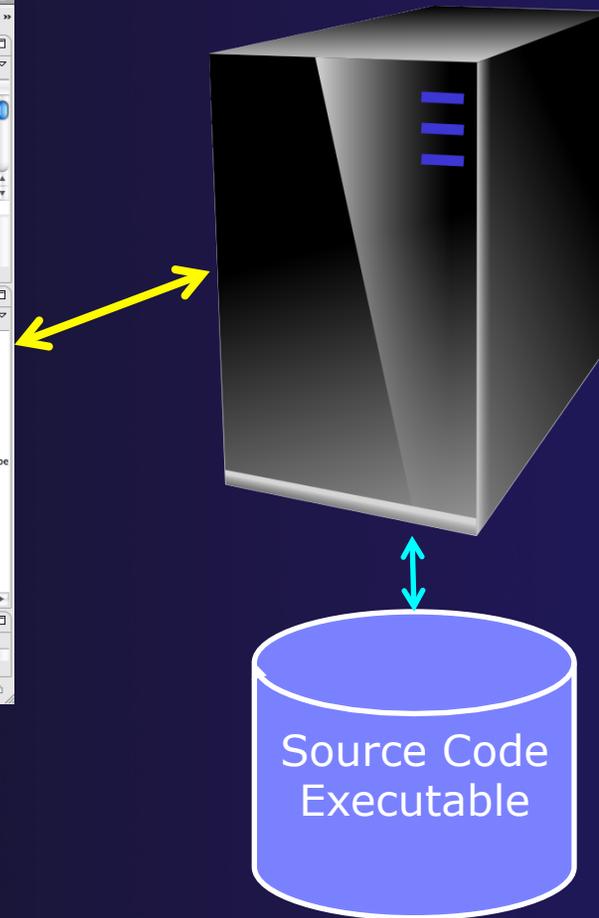
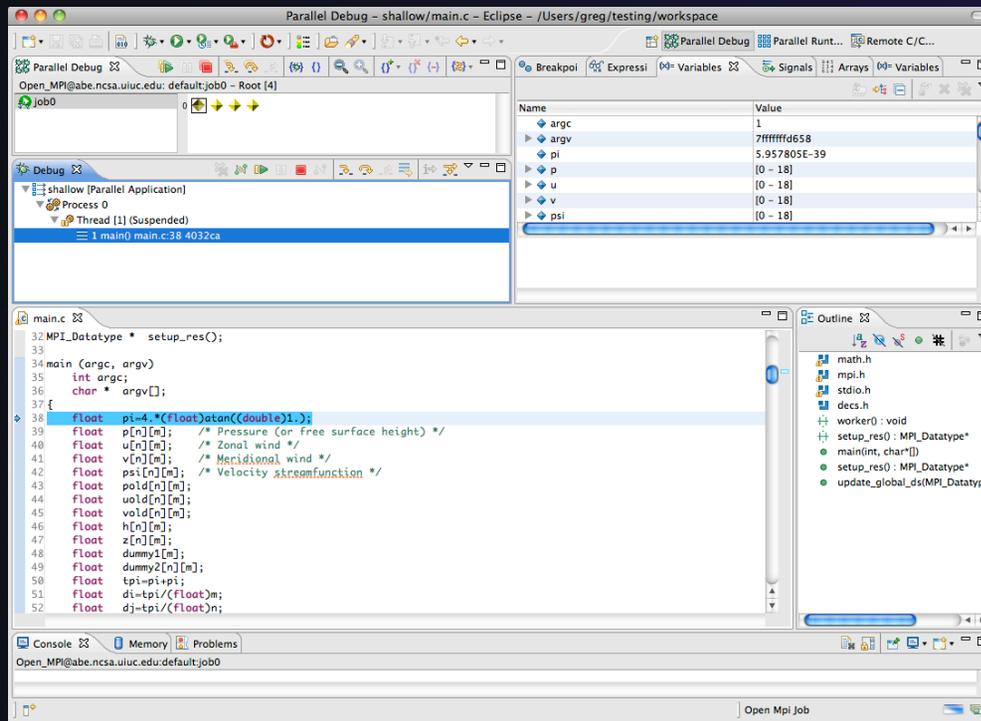


How Eclipse is Used Launching/Monitoring



Source Code
Executable

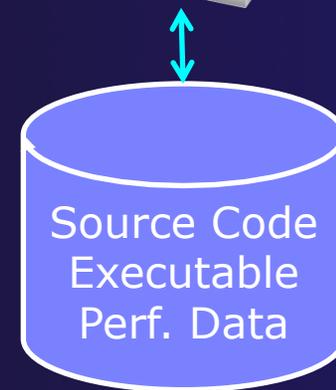
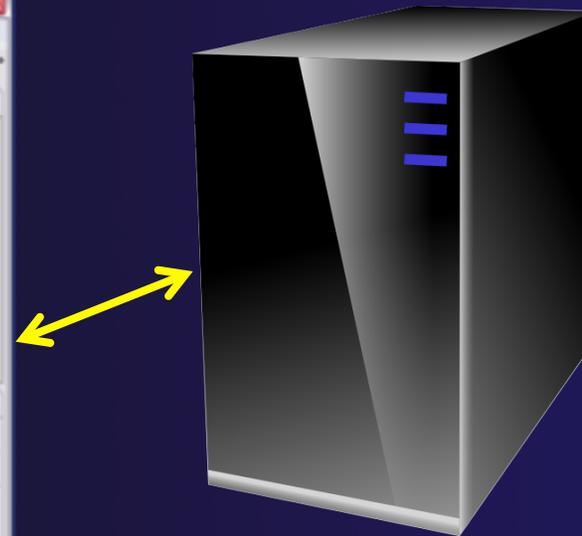
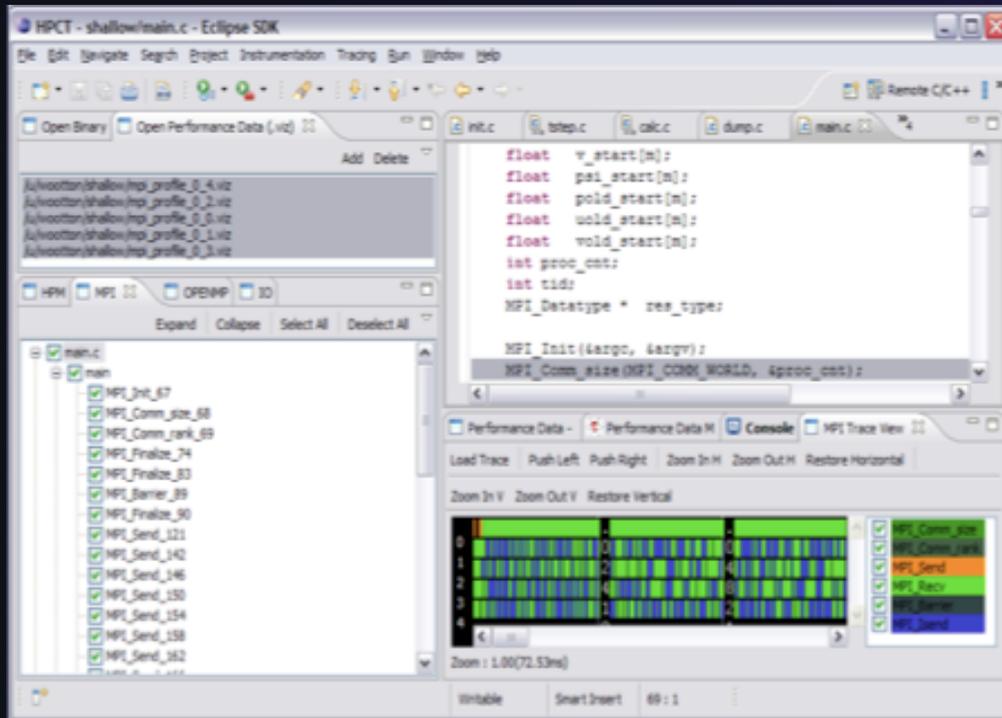
How Eclipse is Used Debugging



Source Code
Executable

How Eclipse is Used

Performance Tuning



Eclipse Basics

★ Objective

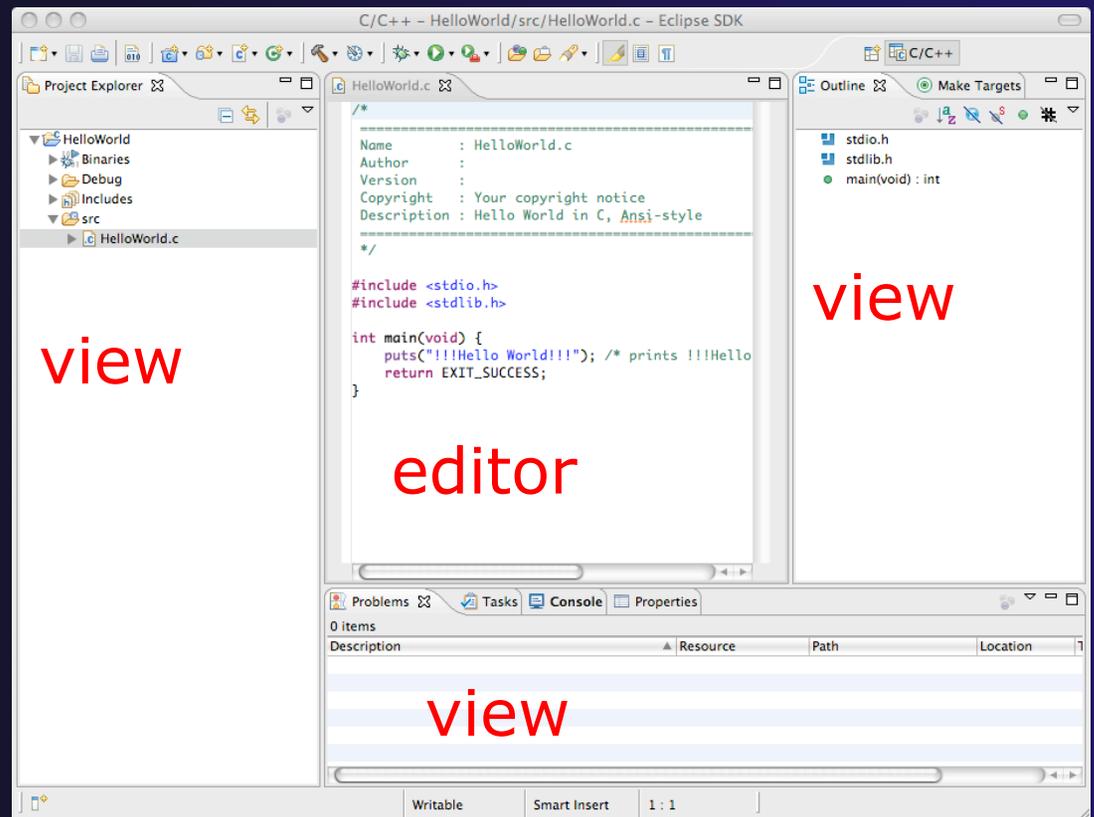
- ★ Learn about basic Eclipse workbench concepts: projects,
- ★ Learn about projects: local, synchronized, remote

★ Contents

- ★ Workbench components: Perspectives, Views, Editors
- ★ Local, remote, and synchronized projects
- ★ Learn how to create and manage a C project
- ★ Learn about Eclipse editing features

Eclipse Basics

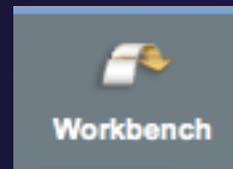
- ★ A *workbench* contains the menus, toolbars, editors and views that make up the main Eclipse window
- ★ The workbench represents the desktop development environment
 - ★ Contains a set of tools for resource mgmt
 - ★ Provides a common way of navigating through the resources
- ★ Multiple workbenches can be opened at the same time
- ★ Only one workbench can be open on a *workspace* at a time



perspective

Perspectives

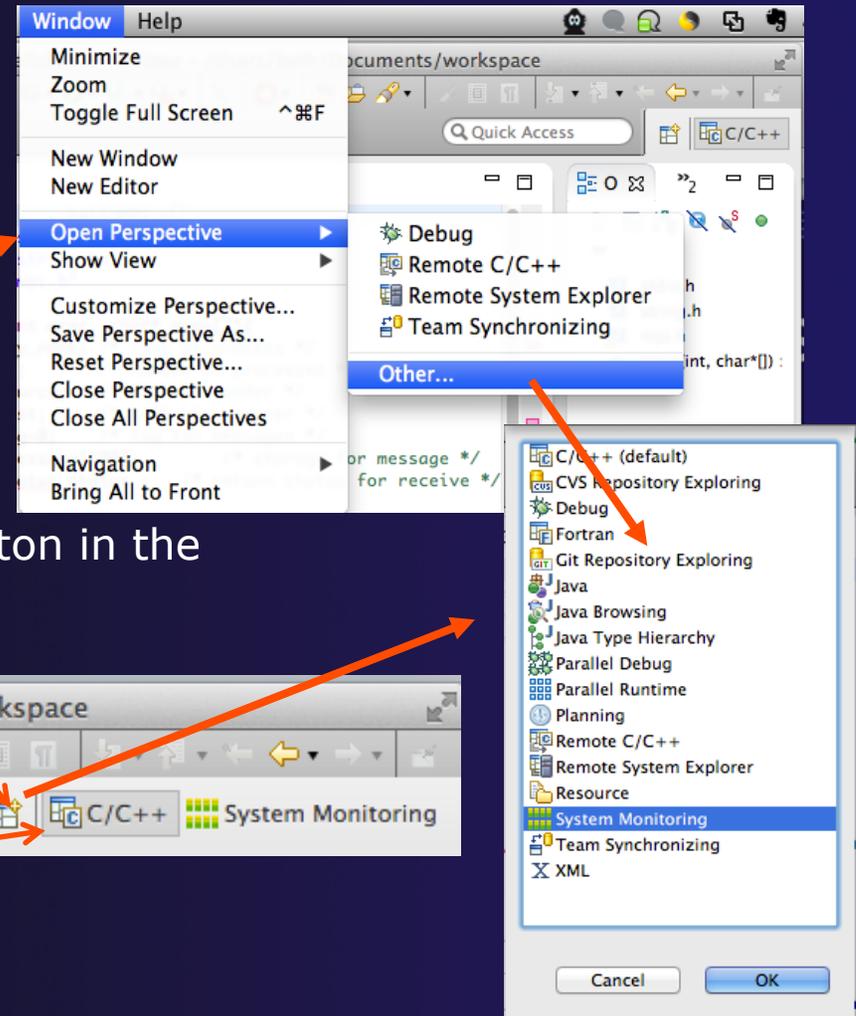
- ✦ Perspectives define the layout of views and editors in the workbench
- ✦ They are *task oriented*, i.e. they contain specific views for doing certain tasks:
 - ✦ **C/C++ Perspective** for manipulating compiled code
 - ✦ **Debug Perspective** for debugging applications
 - ✦ **System Monitoring Perspective** for monitoring jobs
- ✦ You can easily switch between perspectives
- ✦ If you are on the Welcome screen now, select “Go to Workbench” now



Switching Perspectives

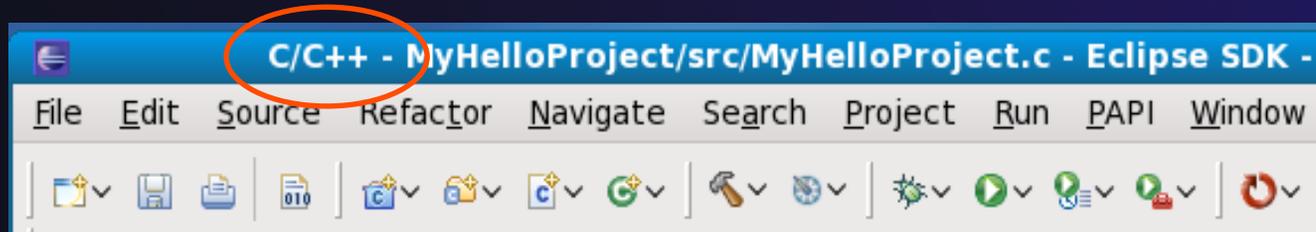
★ Three ways of changing perspectives

1. Choose the **Window>Open Perspective** menu option
Then choose **Other...**
2. Click on the **Open Perspective** button in the upper right corner of screen (hover over it to see names)
3. Click on a perspective shortcut button



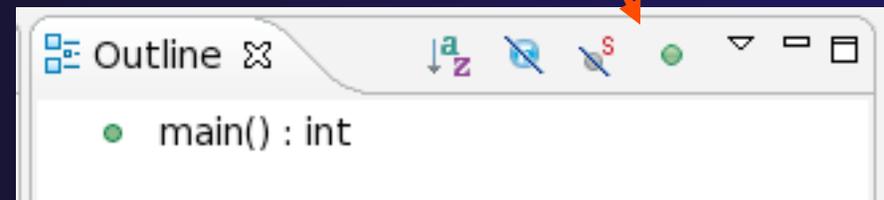
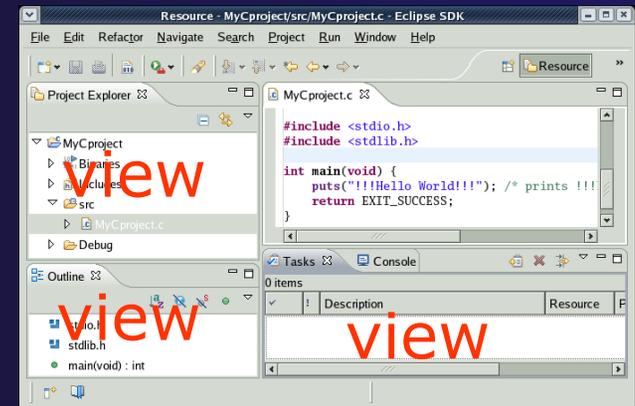
Which Perspective?

- ★ The current perspective is displayed in the title bar



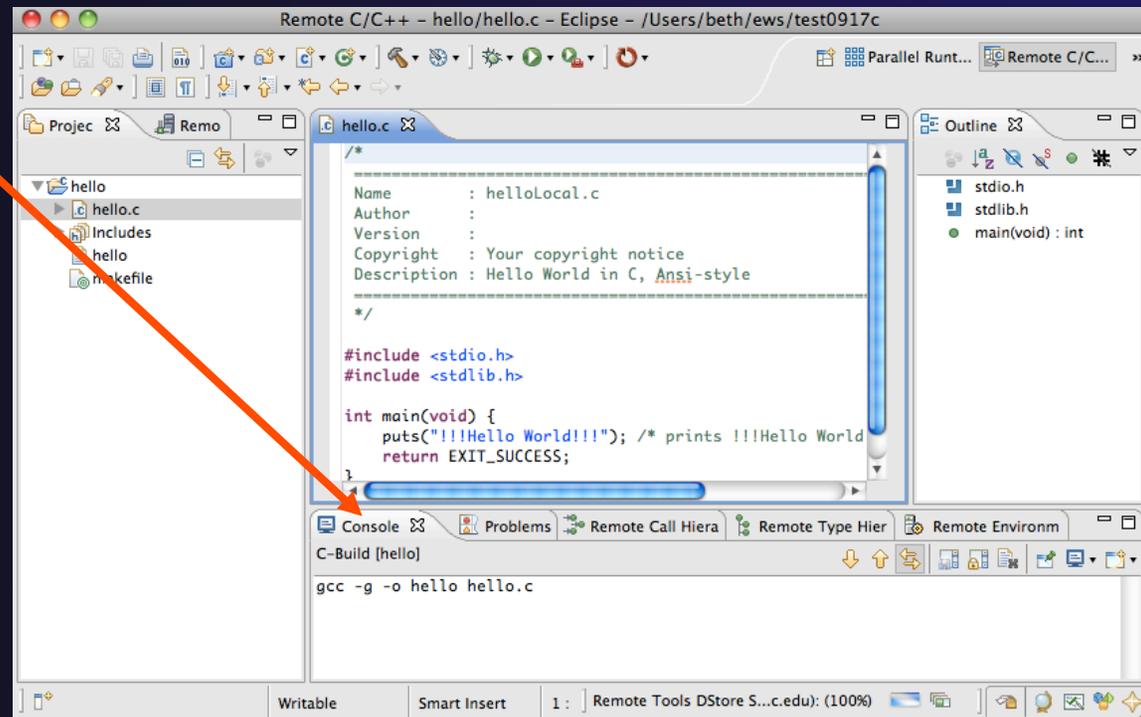
Views

- ★ 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



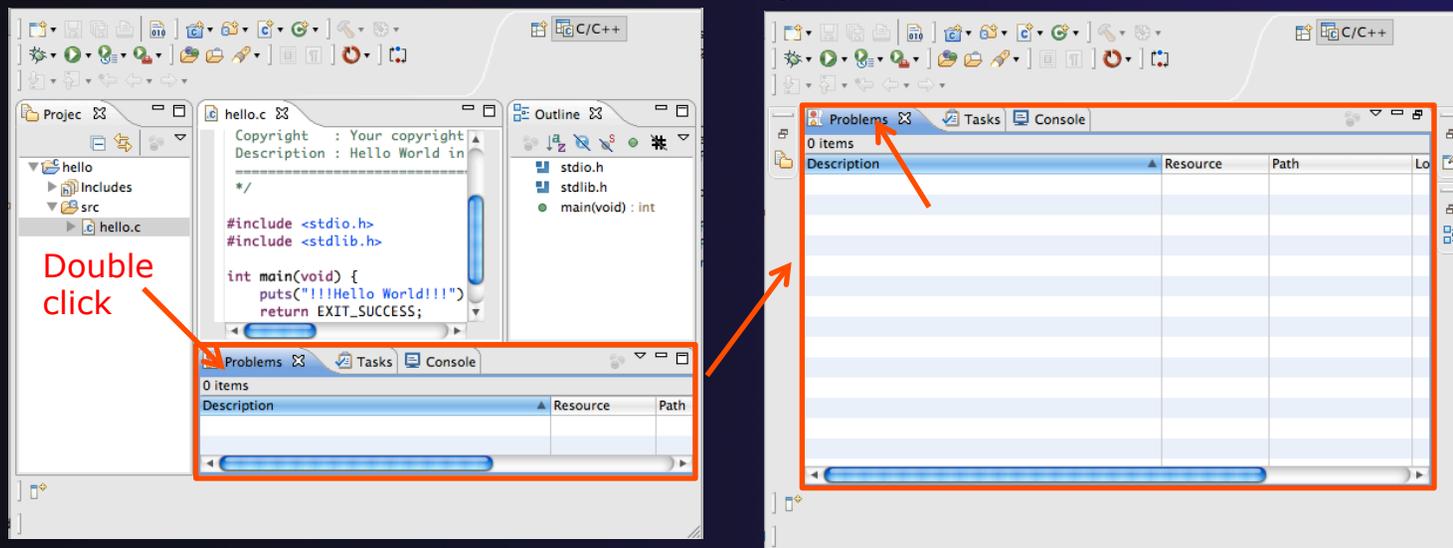
Stacked Views

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



Expand a View

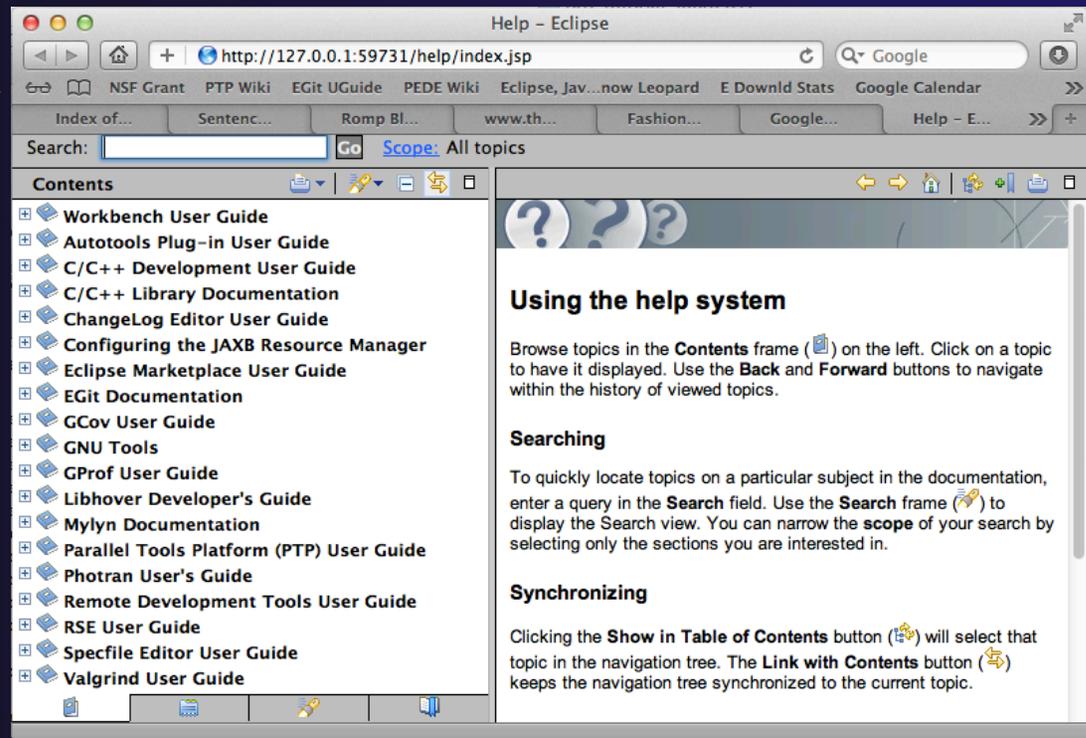
- ★ Double-click on a view/editor's tab to fill the workbench with its content;
- ★ Repeat to return to original size



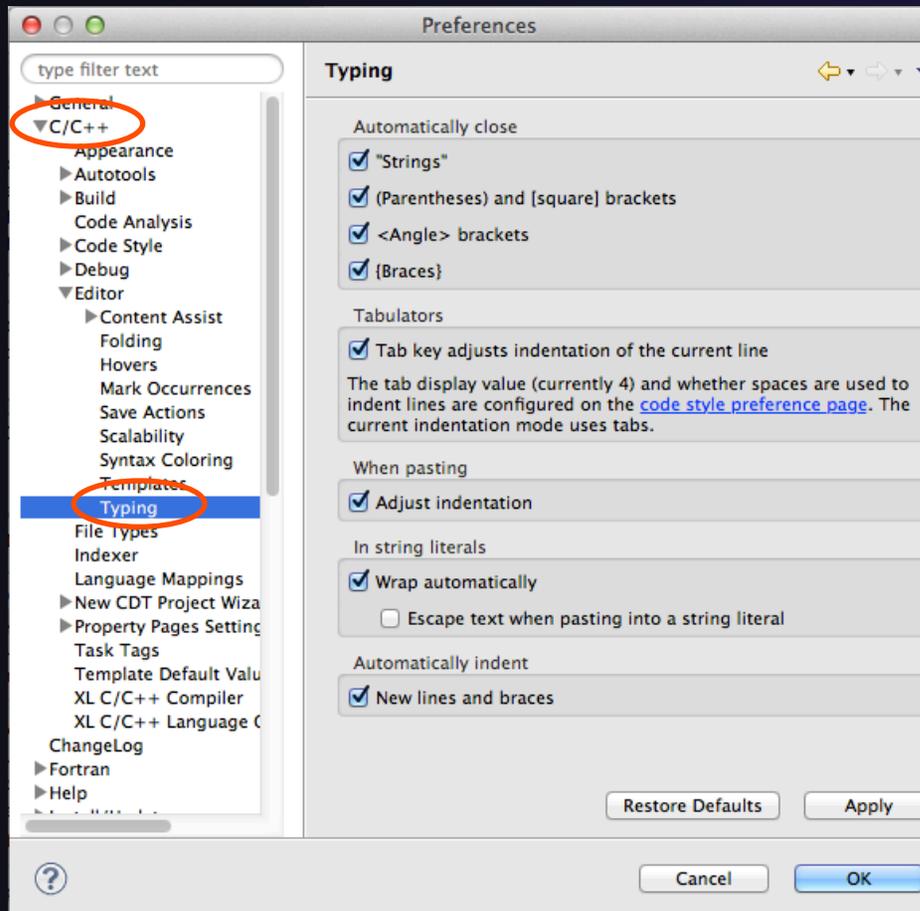
- ★ Window > Reset Perspective returns everything to original positions

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.)

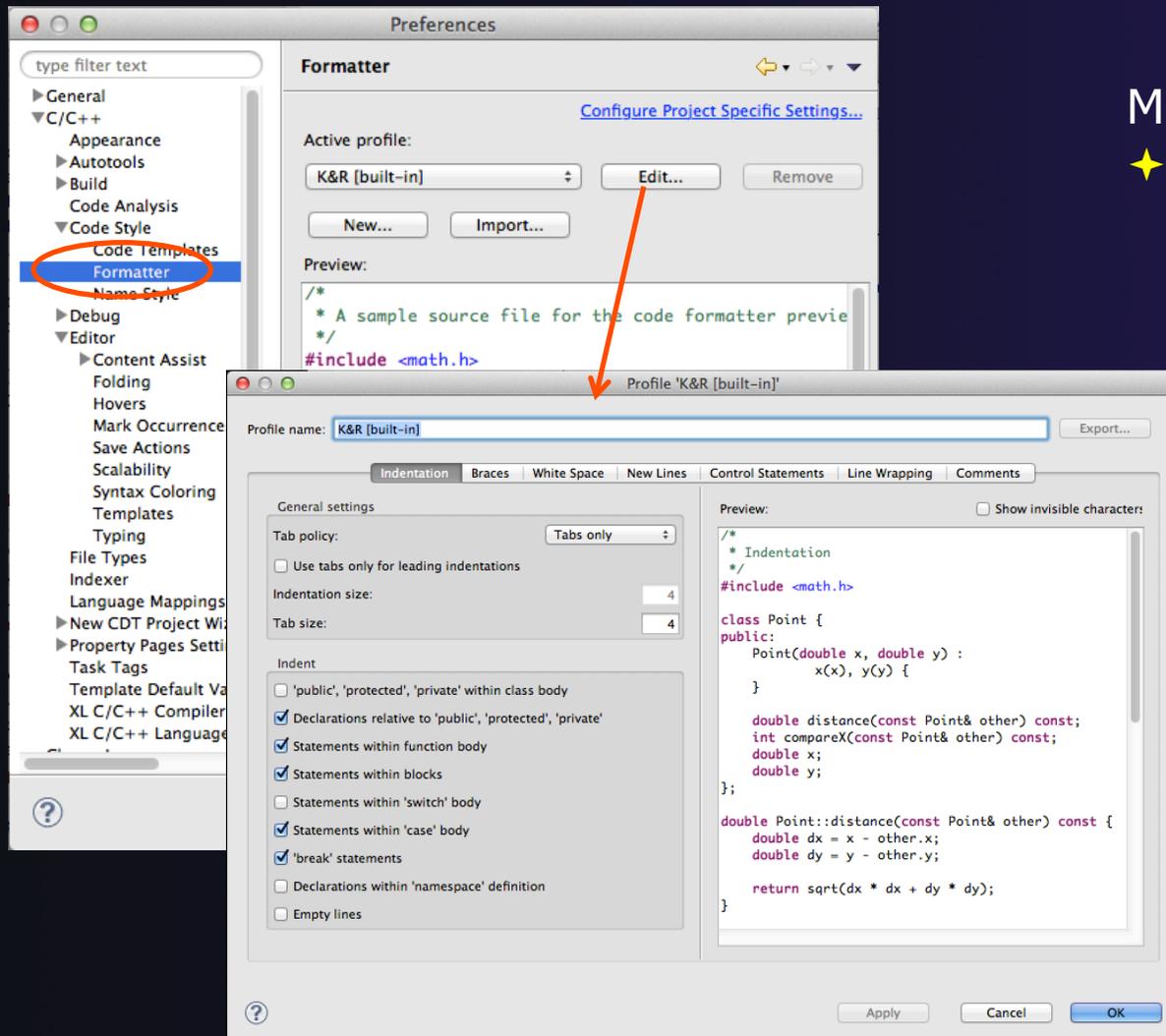


Eclipse Preferences



- ✦ 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



Exercise

1. Change to a different perspective
2. Experiment with moving and resizing views
 - ✦ Move a view from a stack to beside another view
 - ✦ Expand a view to maximize it; return to original size
3. Save the perspective
4. Reset the perspective
5. Open Eclipse preferences
6. Search for "Launching"
7. Make sure the "Build (if required) before launching" setting is *disabled*



Optional Exercise

Best performed *after* learning about projects, CVS, and editors

1. Use source code formatting to format a source file, or a region of a source file
 - ✦ Use Source>Format menu
2. In Eclipse Preferences, change the C/C++ source code style formatter, e.g.
 - ✦ Change the indentation from 4 to 6
 - ✦ Make line wrapping not take effect until a line has a maximum line width of 120, instead of the default 80
 - ✦ Save a (new) profile with these settings
 - ✦ Format a source file with these settings
3. Revert the file back to the original – experiment with
 - ✦ Replace with HEAD, replace with previous from local history, or reformat using original style

Adding a Remote Shell

★ Objective

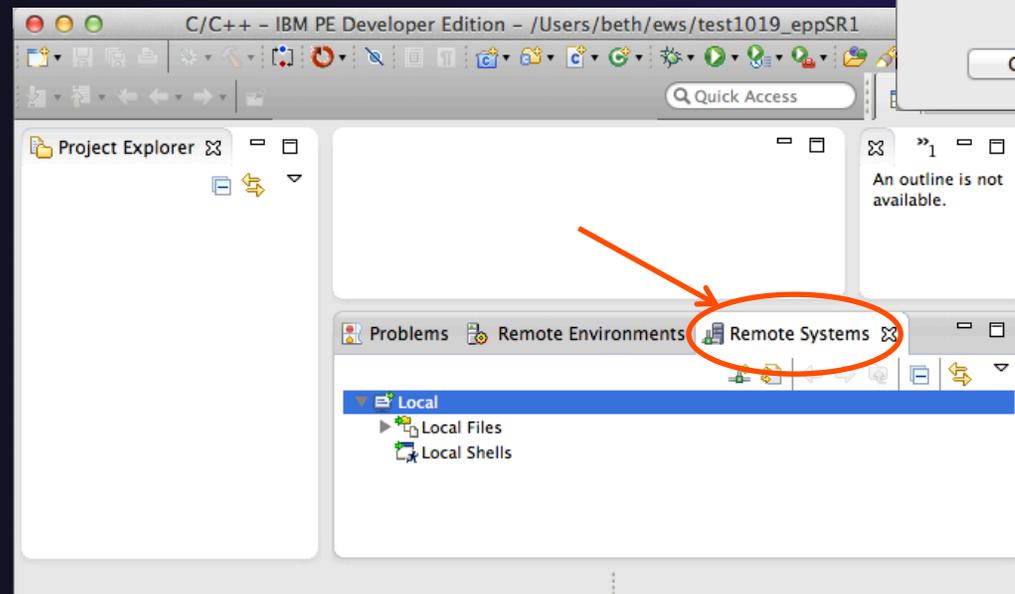
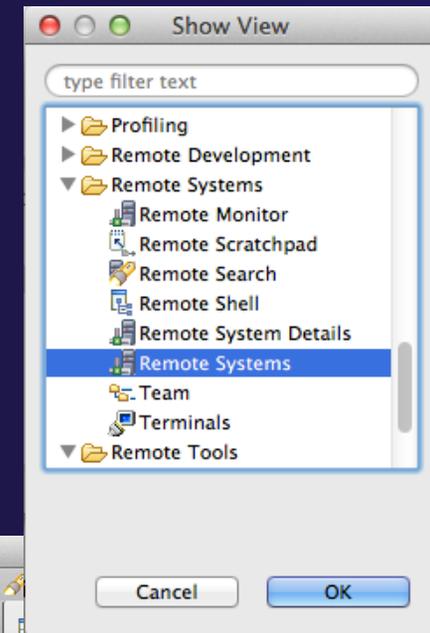
- ★ Learn how to add an additional Eclipse View with a shell to a remote system
- ★ Learn how to do command line interaction with the remote system right from Eclipse

★ Contents

- ★ Set up Remote Systems Explorer (RSE) connection
- ★ Add Remote Shell view
- ★ Connect to remote system
- ★ Allow opportunity to inspect remote system, copy file, etc as needed

Add the Remote Systems View

- ★ Open the **Remote Systems** view
 - ★ Open it via Window>Show View>Other...
Under **Remote Systems**, select **Remote Systems**
 - ★ Or ... it can be found in the Remote C/C++ perspective
- ★ Probably gets added at the bottom



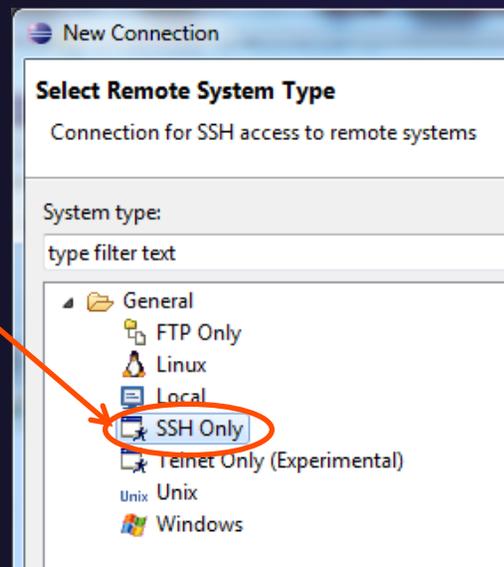
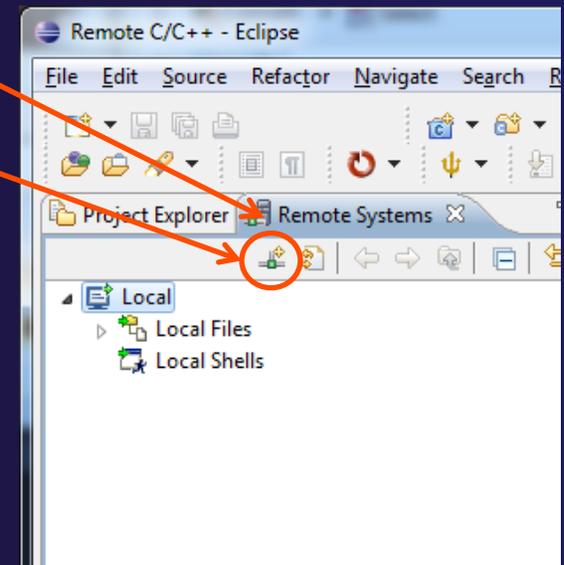
Shell in a View

Shell-1



Define a new RSE connection

- ★ Select the Remote Systems view
 - ★ Define a new connection (buttons may be on the far right side of the toolbar)
 - ★ In the **New Connection** dialog, Select "SSH Only"
 - ★ Then **Next**



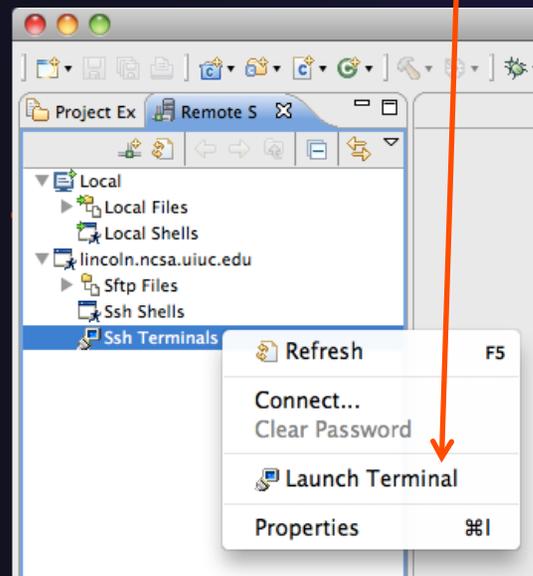
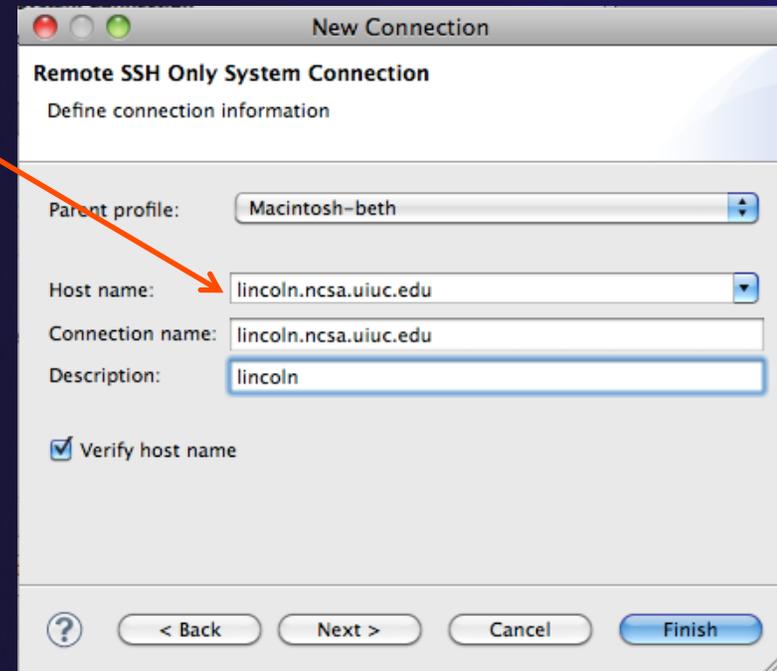
Shell in a View

Shell-2

Define a new RSE connection (2)



- ★ Add system's host info
 - ★ Then **Finish**
- ★ Right click on **Ssh terminals**, under your new connection
- ★ Select **Launch Terminal**



Shell in a View

Shell-3

Define a new RSE connection (3)



- ✦ Add your userid and password
- ✦ Click through any RSA messages
- ✦ And now you have a terminal to the remote system

Enter Password

System type: SSH Only

Host name: LINCOLN.NCSA.UIUC.EDU

User ID: tibbits

Password (optional): *****

Save user ID

Save password

Cancel OK

lincoln.ncsa.uiuc.edu

If you require assistance in migrating your codes or data, please contact the NCSA Consulting Office at 217-244-1144 or consult@ncsa.illinois.edu. For allocations questions or questions about requesting a transfer, contact allocations@teragrid.org or 217-244-0635.

[tibbits@honest1 ~]\$



Notes

★ **Why did we do this?**

To show you can gain “traditional” access to a remote host through Eclipse

★ **Why did I have to specify the connection information again?**

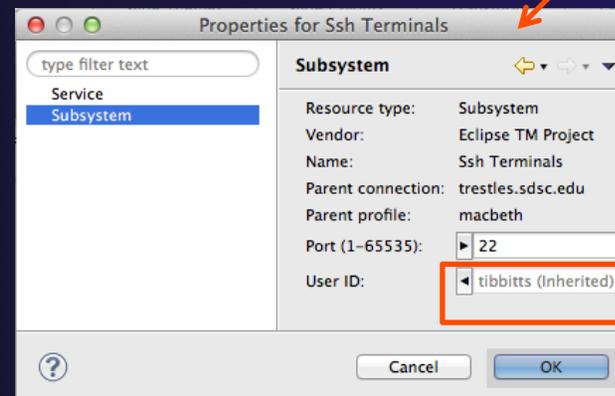
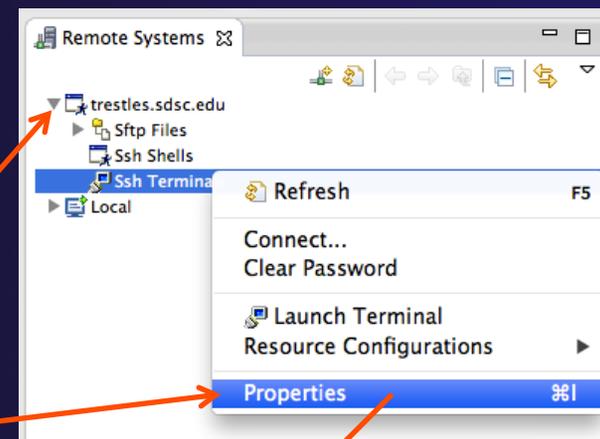
Note: RSE “Connection” information is not shared with PTP Synchronized projects.

PTP will allow using existing connections with terminal consoles in a future release.

RSE Connection Properties

★ To alter the properties e.g. of the remote Terminal, such as the userid used for the login...

- ★ Open/select the **Remote Systems** view
- ★ Expand your connection
- ★ Right mouse on **Ssh Terminals** and select **Properties**
- ★ In **Properties** dialog, select **Subsystem**





Exercise

1. Add the **Remote Systems** view to your workbench
2. Connect to the remote machine and open an ssh terminal
3. Inspect home directory

Creating a Synchronized Project

★ Objective

- ★ Learn how to create and use synchronized projects
- ★ Learn how to create a sync project directly from source that already exists on a remote machine

★ Contents

- ★ Eclipse project types
- ★ Creating a synchronized project
- ★ Using synchronize filters
- ★ Converting an existing project to synchronized

★ Project Creation Alternative #1

In this scenario, we will use code existing on a remote host, and create a synchronized project which copies it to the local machine

- ★ (Project Creation Alternative #1 is to check out code from a CVS source code repository and then convert to a Sync project)

Project Types

★ Local

- ★ Source is located on local machine, builds happen locally

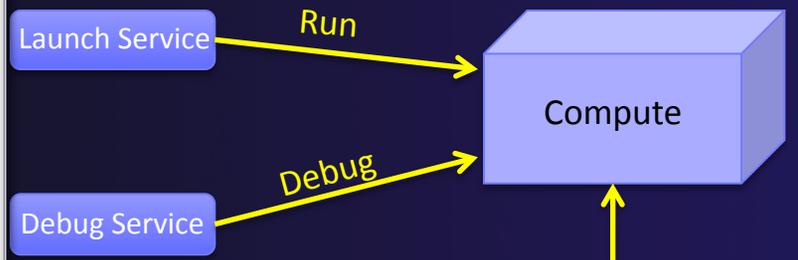
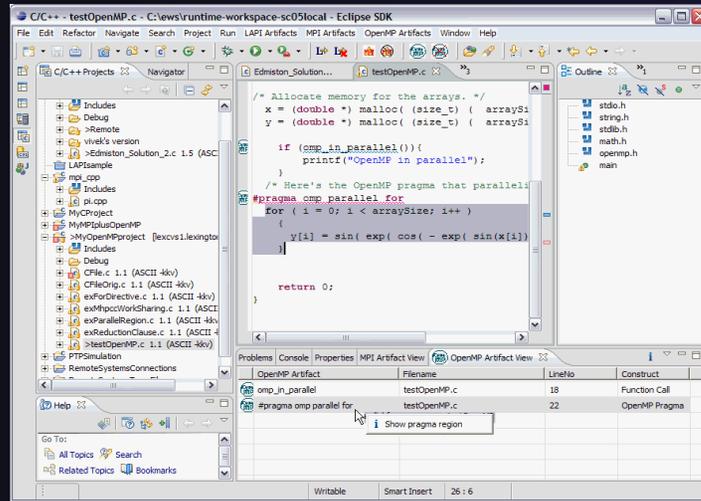
★ Remote

- ★ Source is located on remote machine(s), build and launch takes place on remote machine(s)

★ Synchronized

- ★ Source is local, then synchronized with remote machine(s) (or vice-versa)
- ★ Building and launching happens remotely (can also happen locally)

Remote Projects



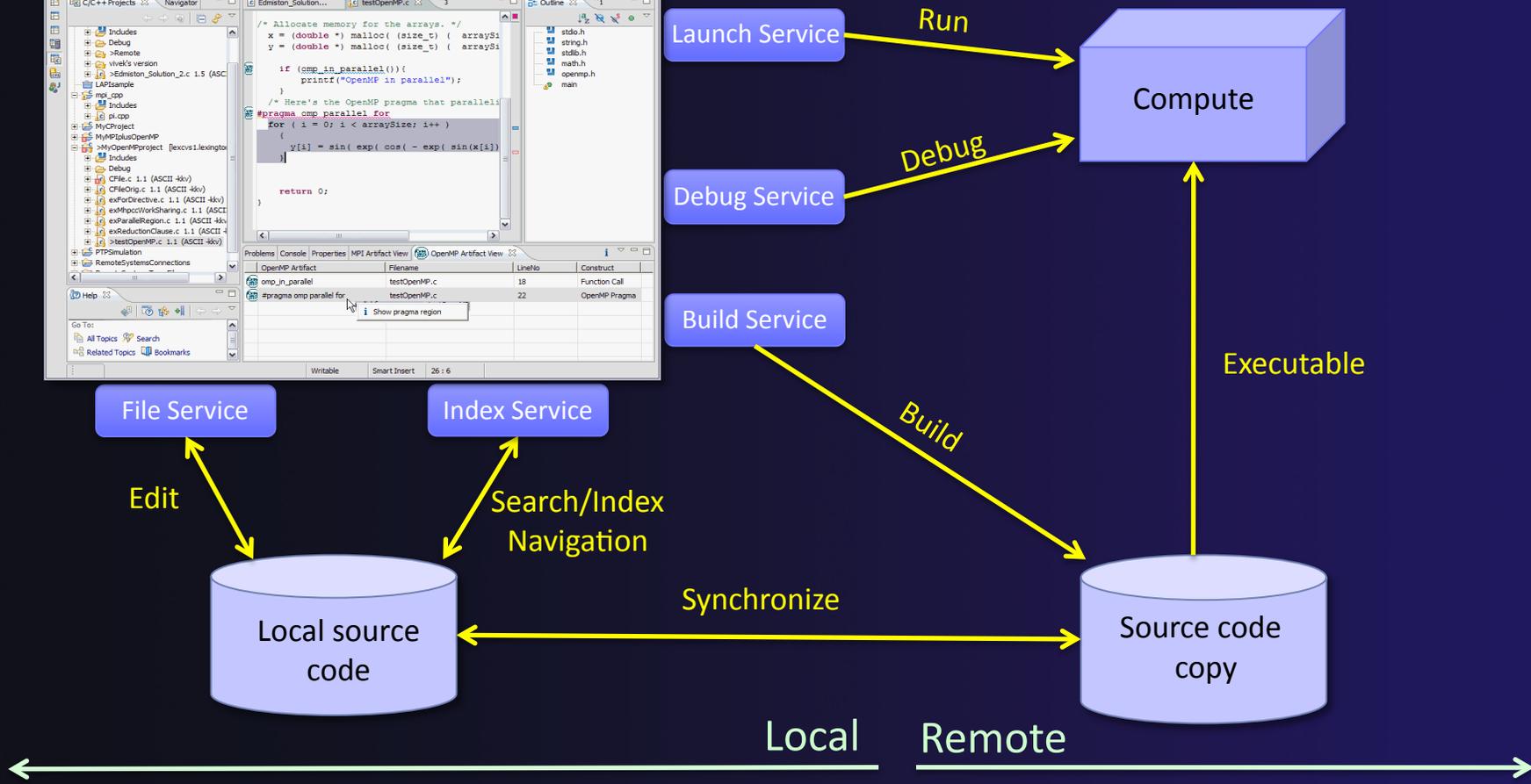
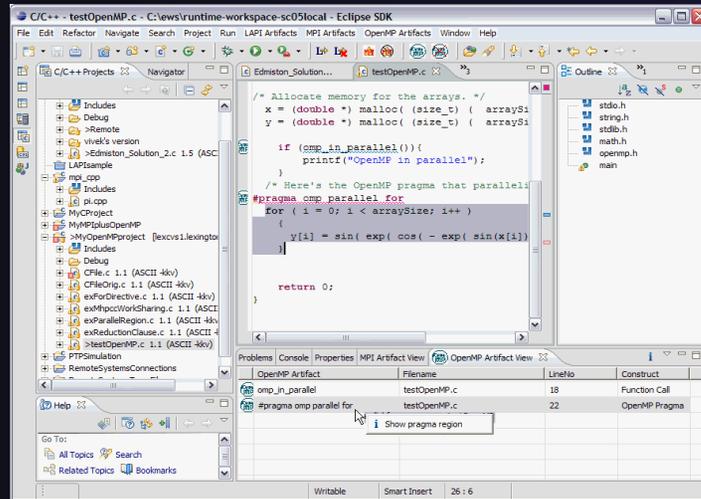
Local Remote



Synchronized Projects

Sync-2

Synchronized Projects



C, C++, and Fortran Projects

Build types

- ★ Makefile-based
 - ★ Project contains its own makefile (or makefiles) for building the application – or other build command
- ★ Managed
 - ★ Eclipse manages the build process, no makefile required

Create Project

- ★ This module creates a Synchronized project from source code already existing on the remote system

- or -

- ★ The CVS module creates a Synchronized project from a CVS source code repository

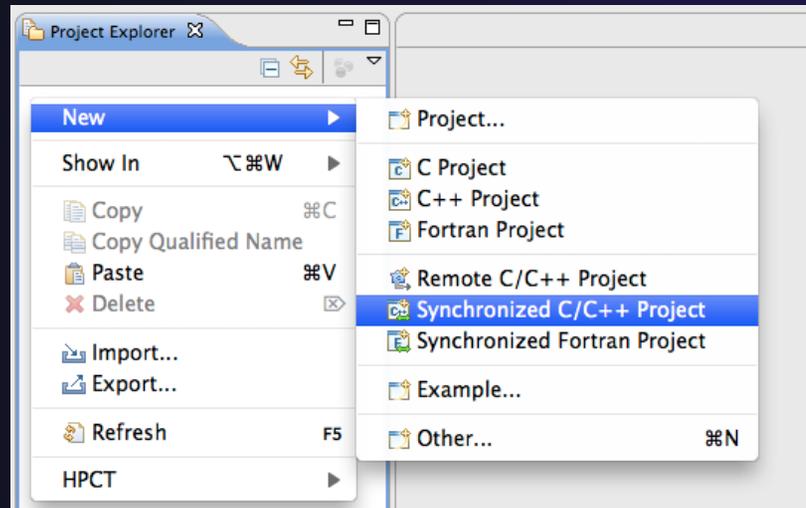
Source Code for project

- ★ Source code exists on remote target

```
$ pwd
/gpfs/ibmu/tibbitts/shallow
$ ls -la
total 2880
drwxr-xr-x 2 tibbitts users 32768 Mar 16 15:53 .
drwxr-xr-x 7 tibbitts users 32768 Mar 15 18:38 ..
-rw-r--r-- 1 tibbitts users 1741 Feb 11 16:25 calc.c
-rw-r--r-- 1 tibbitts users 2193 Feb 11 16:25 copy.c
-rw-r--r-- 1 tibbitts users 2873 Jan 25 08:52 decs.h
-rw-r--r-- 1 tibbitts users 2306 Feb 11 16:25 diag.c
-rw-r--r-- 1 tibbitts users 2380 Feb 11 16:25 dump.c
-rw-r--r-- 1 tibbitts users 2512 Feb 11 16:25 init.c
-rw-r--r-- 1 tibbitts users 6161 Mar 15 19:27 main.c
-rw-r--r-- 1 tibbitts users 718 Mar 15 18:34 Makefile
-rw-r--r-- 1 tibbitts users 1839 Feb 11 16:25 time.c
-rw-r--r-- 1 tibbitts users 2194 Feb 11 16:25 tstep.c
-rw-r--r-- 1 tibbitts users 8505 Feb 11 16:25 worker.c
$ █
```

Create Synchronized Project

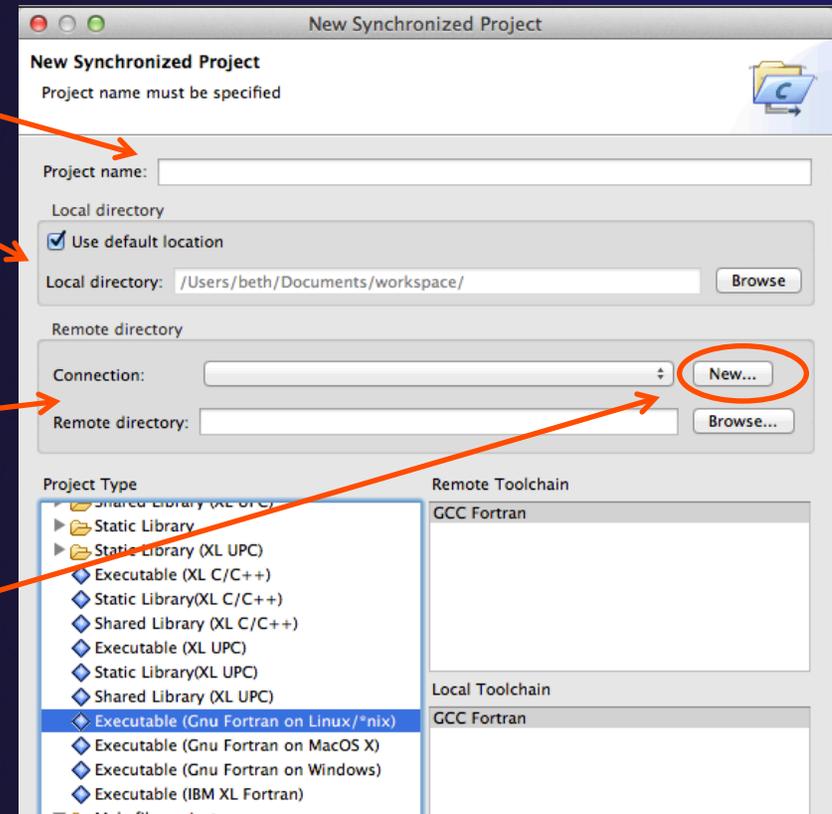
- ★ In the Project Explorer, right click then choose
 - ★ **New>Synchronized C/C++ Project** if your project is C/C++ only



- ★ **New>Synchronized Fortran Project** if your project contains Fortran files
- ★ This adds a Fortran nature so you can access Fortran properties, etc.

New Synchronized Project Wizard

- ★ Enter the **Project Name**
 - ★ E.g. "shallow"
- ★ The **Local Directory** specifies where the local files are located
 - ★ Leave as default
- ★ The **Remote Directory** specifies where the remote files are located
 - ★ Select a connection to the remote machine, or click on **New...** to create a new one
(See next slide)
 - ★ Browse for the directory on the remote machine



Creating a Connection

- ★ In the **Target Environment Configuration** dialog
 - ★ Enter a **Target name** for the remote host
 - ★ Enter host name, user name, and user password or other credentials
 - ★ Select **Finish**

*If your machine access requires ssh access through a frontend/intermediate node, **use localhost and port** – see **alternate instructions***

The screenshot shows a window titled "Target Environment Configuration" with a subtitle "Generic Remote Host" and the text "Properties for connecting to a generic host". The "Target name" field contains "forge". Under "Host Information", the "Remote host" radio button is selected. The "Host" field contains "forge.ncsa.illinois.edu", the "User" field contains "tibbitts", and the "Password" field is filled with dots. The "Password based authentication" radio button is selected. There are fields for "File with private key" (with a "Browse" button) and "Passphrase". At the bottom right, there are "Cancel" and "Finish" buttons, and a "Advanced" button is also visible.

Project Type & Toolchain

★ Choose the **Project Type**

- ★ If you are synchronizing with an existing project, use **Makefile Project** > **Empty Project**
- ★ Otherwise, choose the type of project you want to create

★ Choose the toolchain for the remote build

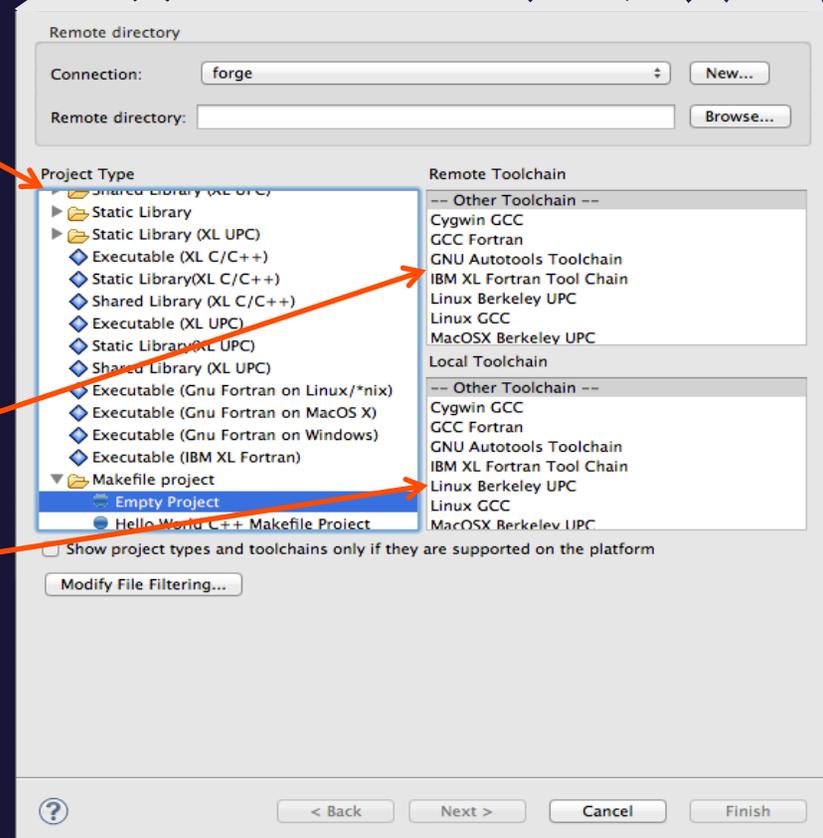
- ★ Use a toolchain that most closely matches the remote system

★ Choose a toolchain for the local build

- ★ This is used for advanced editing/searching

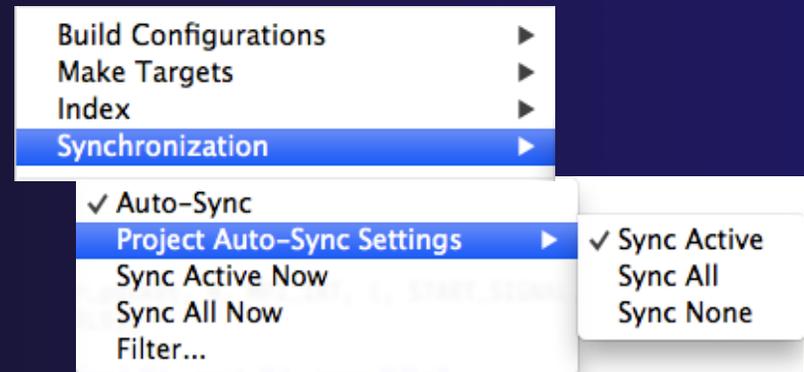
★ Use **Modify File Filtering...** if required (see later slide)

★ Click **Finish** to create the project



Synchronized Project

- ★ Synchronized projects are indicated with a "synchronized" icon
- ★ Right click on project to access **Synchronization** menu
 - ★ Select **Auto-Sync** to enable/disable automatic syncing
 - ★ **Project Auto-Sync Settings** are used to determine which configurations are synchronized (**Active** only, **All** or **None**)
 - ★ **Sync Active/All Now** to manually synchronize
 - ★ **Filter...** to manage synchronization filters

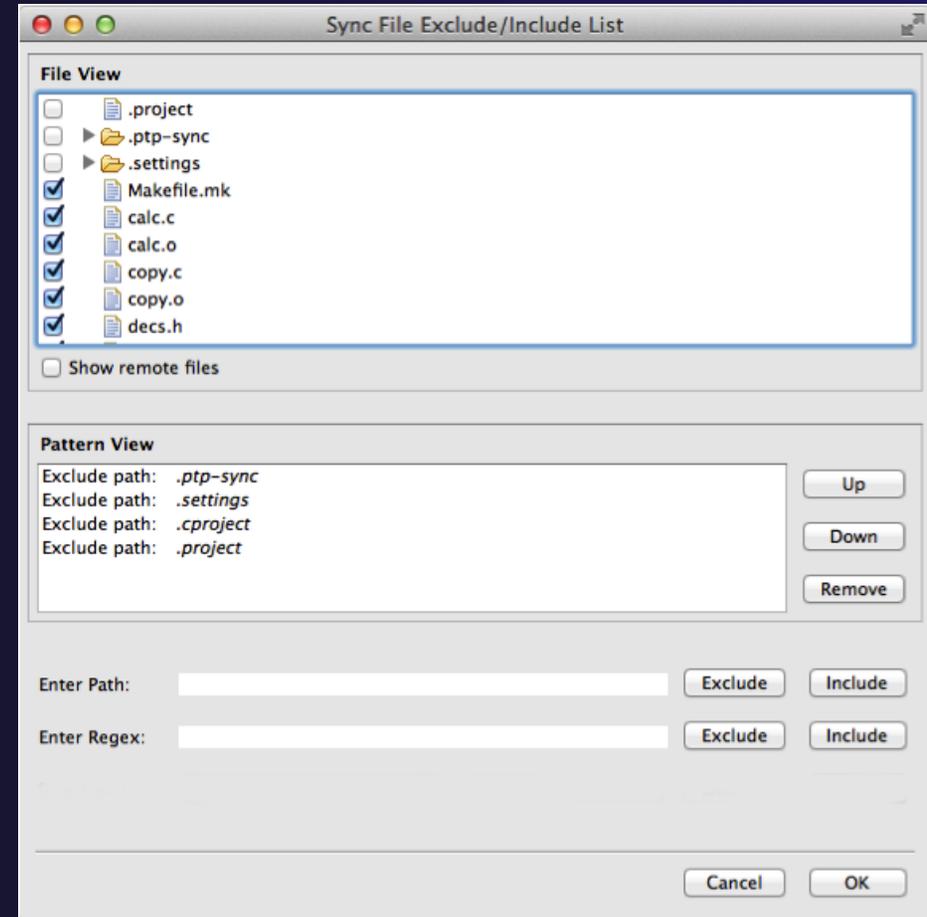


Synchronize Filters

- ✦ If not all files in the remote project should be synchronized, a filter can be set up
 - ✦ For example, it may not be desirable to synchronize binary files, or large data files
- ✦ Filters can be created at the same time as the project is created
 - ✦ Click on the **Modify File Filtering...** button in the New Project wizard
- ✦ Filters can be added later
 - ✦ Right click on the project and select **Synchronization>Filter...**

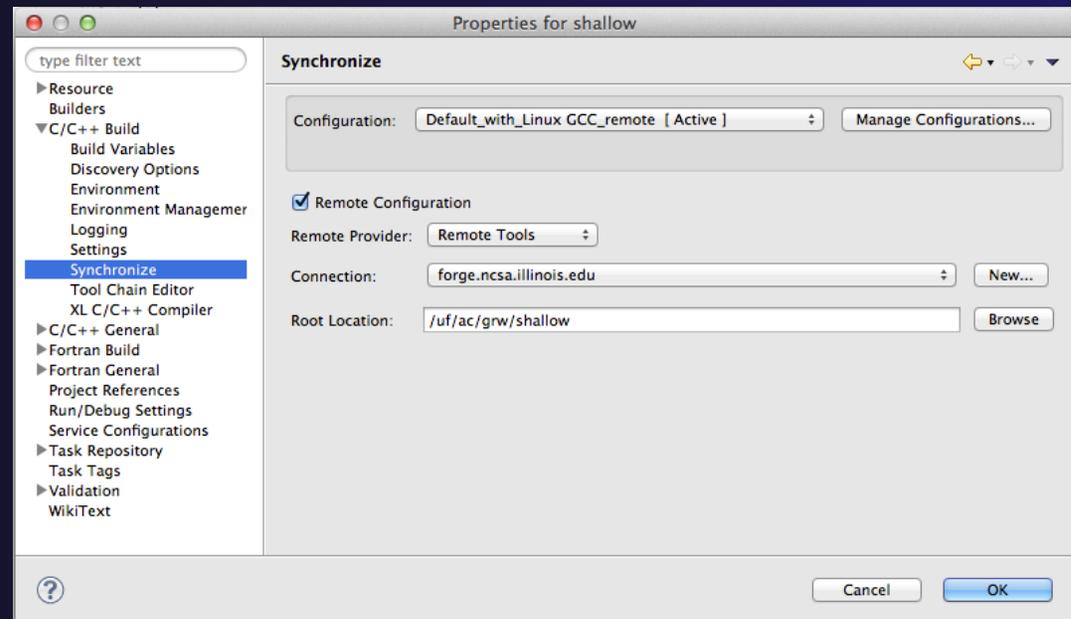
Synchronize Filter Dialog

- ★ Files can be filtered individually by selecting/unselecting them in the **File View**
- ★ Include or exclude files based on paths
- ★ Include or exclude files based on regular expressions



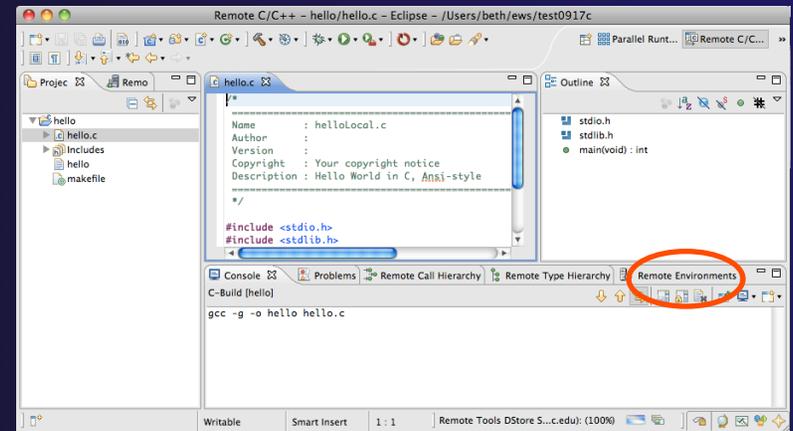
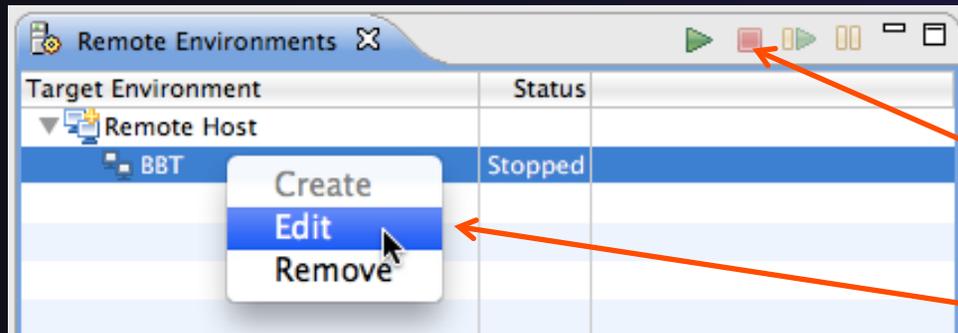
Synchronized Project Properties

- ★ Synchronized project properties can be configured manually
- ★ Open the project properties, then select **C/C++ Build>Synchronize**
- ★ Each configuration is associated with a remote connection and a root directory
- ★ Can be changed manually, but only if you know what you are doing!



Changing Remote Connection Information

- ★ If you need to change remote connection information (such as username or password), use the **Remote Environments** view



- ★ Stop the remote connection first
- ★ Right-click and select **Edit**

- ★ Note: Remote Host may be stopped
 - ★ Any remote interaction starts it
 - ★ No need to restart it explicitly

Converting a Local C/C++/Fortran Project to a Synchronized Project

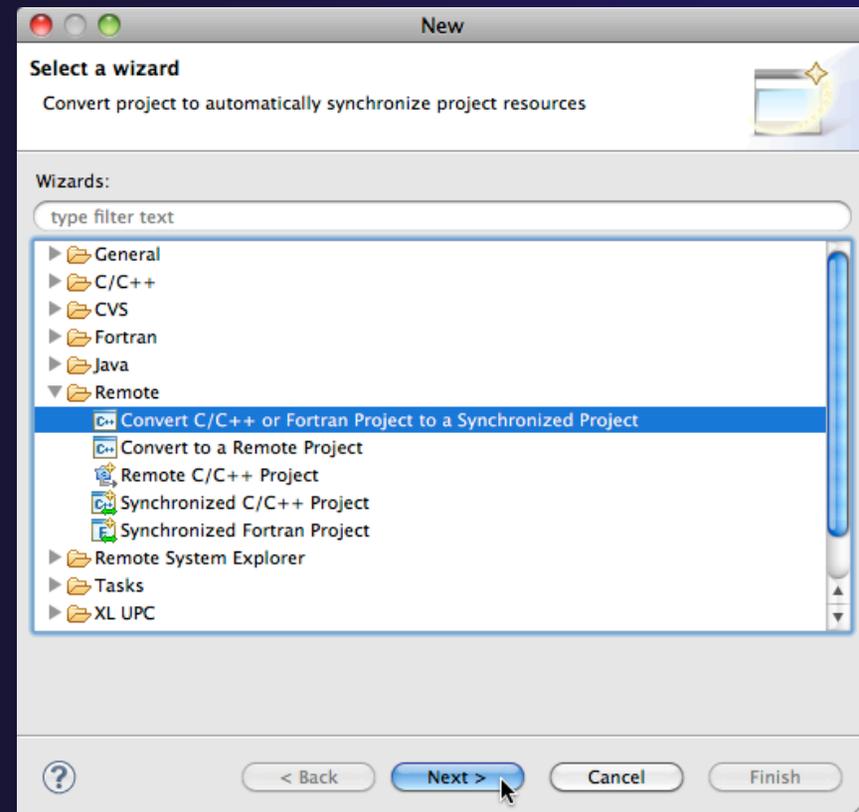
The following slides are for reference.
Our project is already a Synchronized Project.

Converting To Synchronized



If source files exist on the local machine and you wish to convert it to a Synchronized Project on a remote system...

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

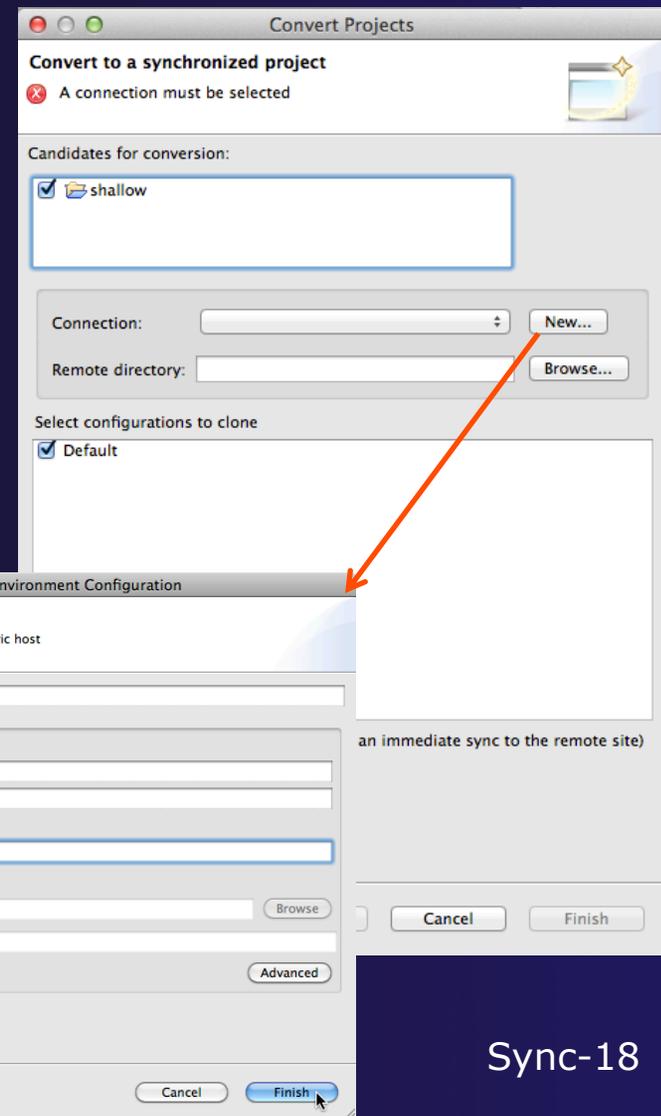


Convert Projects Wizard



- ✦ Select checkbox next to “shallow”
 - ✦ Only C/C++/Fortran projects will be in the list of candidates for conversion to Sync project
- ✦ For **Connection:**, click on **New...**
 - ✦ Unless you already have a connection
- ✦ The tutorial instructor will indicate what to enter for:
 - ✦ **Target name**
 - ✦ **Host** name of remote system
 - ✦ **User ID**
 - ✦ **Password**
- ✦ Click **Finish** to close it
- ✦ The connection name will appear in the **Convert Projects** wizard for **Connection**

Synchronized Projects



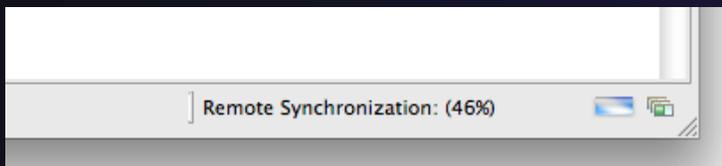
Sync-18

Convert Projects Wizard (2)

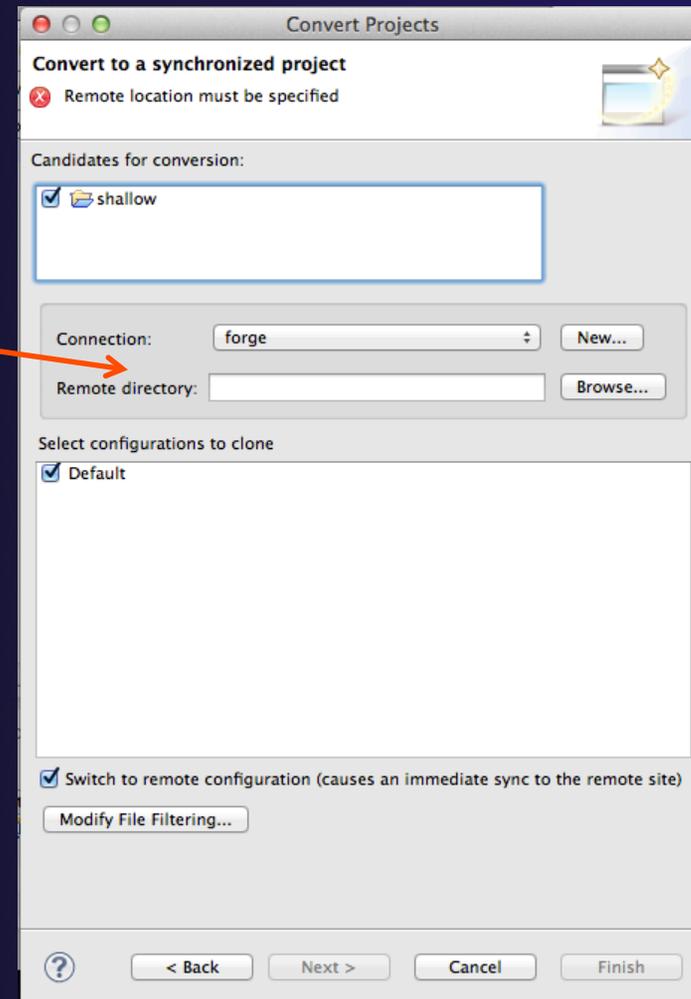


Back in the **Convert Projects** dialog, we specify where the remote files will be stored

- ✦ Enter a directory name in the **Remote Directory** field: select **Browse...**
 - ✦ Sample: /u/ac/trainXX/shallow
Typing a new directory name creates it
 - ✦ This should normally be an empty directory – since local files will be copied there
 - ✦ Project files will be copied under this directory
- ✦ Click **Finish**
- ✦ The project should synchronize automatically



Synchronized Projects



Sync-19



Exercise

1. Create a synchronized project
 - ✦ Your login information and source directory will be provided by the tutorial instructor
2. Observe that the project files are copied to your workspace
3. Open a file in an editor, add a comment, and save the file
4. Observe that the file is synchronized when you save the file
 - ✦ Watch lower-right status area; confirm on host system



Optional Exercise

1. Modify Sync filters to not bring the *.o files and your executable back from the remote host
 - ★ Rebuild and confirm the files don't get copied

Eclipse CVS – “Team” Features

★ Objective

- ★ Learn how to use a source code repository with Eclipse
- ★ Learn how to create a Synchronized project

★ Contents

- ★ Checking out project in CVS
- ★ Setting up a Connection for a Synchronized Project
- ★ Handling changes; Comparing files (diffs)

★ Project Creation Alternative #2

In this scenario, we will check out code from a CVS source code repository, setting it up as a synchronized project on a remote host.

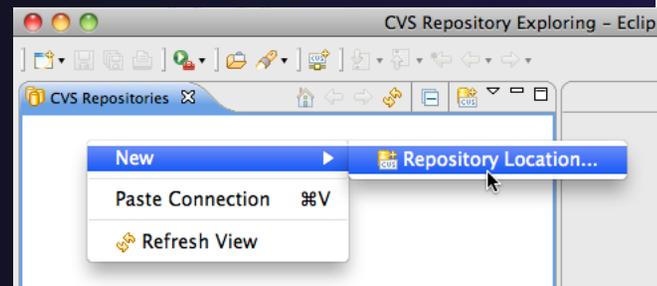
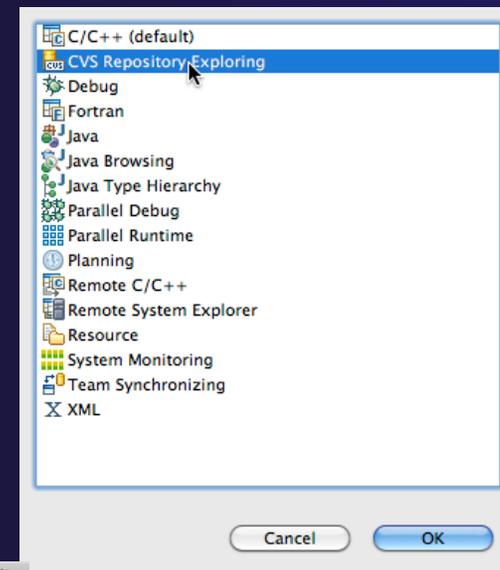
- ★ (Project Creation Alternative #1 in this PTP tutorial is to create a Synchronized project directly from code existing on a remote host)



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:** cvs.ncsa.uiuc.edu
- ★ **Repository path:** /CVS/ptp-samples



- ★ 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**

Add a new CVS Repository

Add a new CVS Repository to the CVS Repositories view

Location

Host: cvs.ncsa.uiuc.edu

Repository path: /CVS/ptp-samples

Authentication

User: anonymous

Password:

Connection

Connection type: pserver

Use default port

Use port:

Validate connection on finish

Save password (could trigger secure storage login)

To manage your password, please see '[Secure Storage](#)'

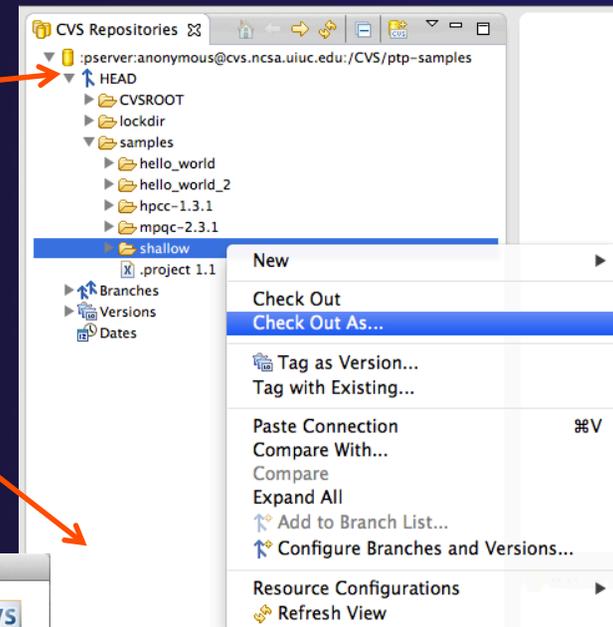
[Configure connection preferences...](#)

Cancel Finish

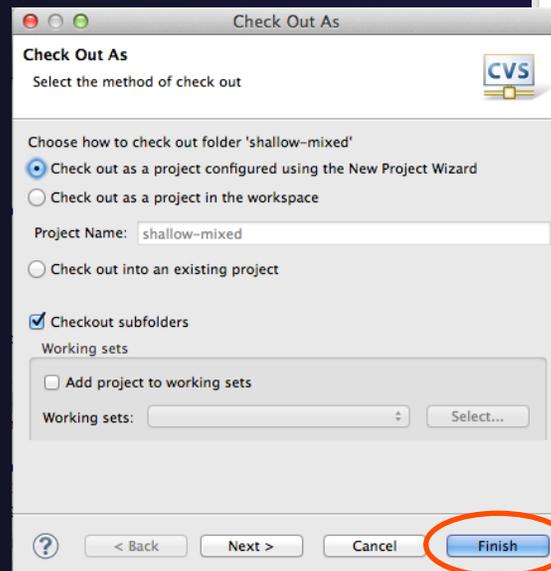
Checking out the Project



- ★ Expand the repository location
- ★ Expand **HEAD**
- ★ Expand **samples**
- ★ Right click on **shallow** 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

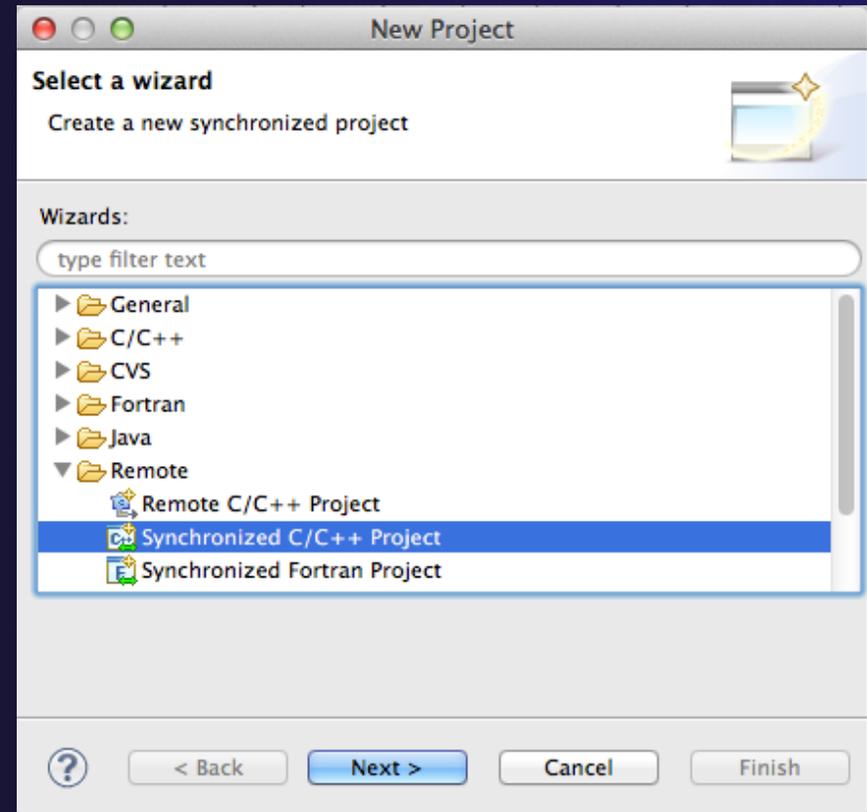


New Project Wizard



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

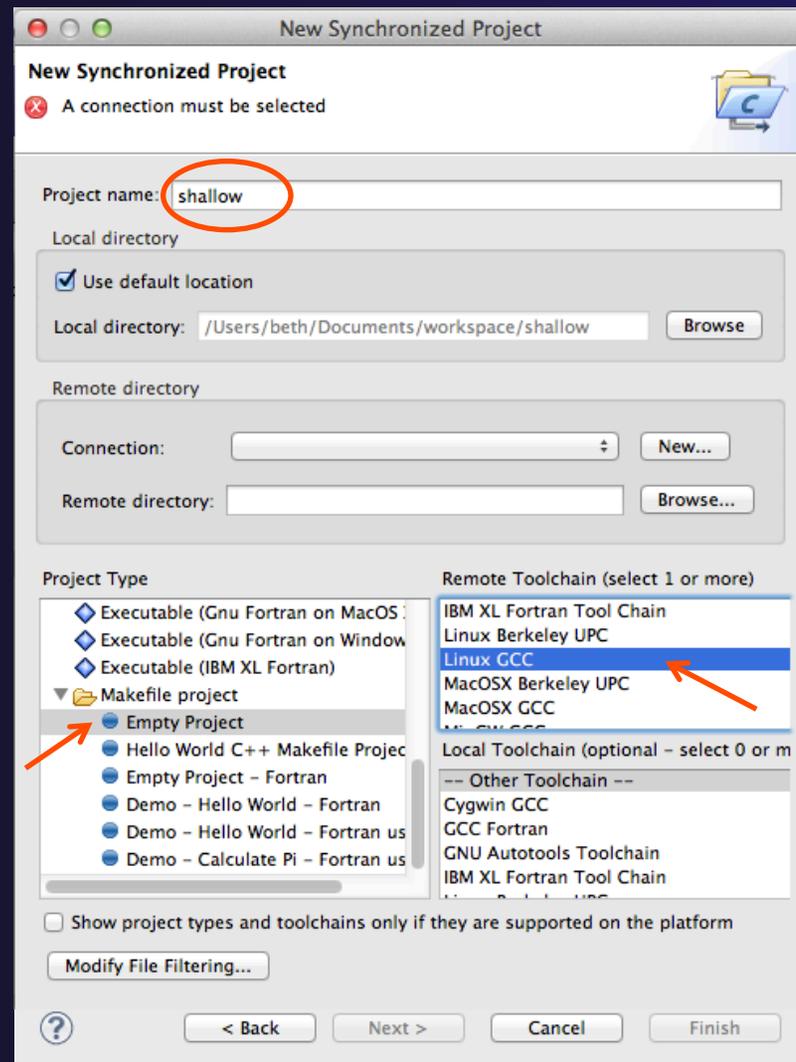
- ✦ Expand **Remote**
- ✦ Select **Synchronized C/C++ Project** and click on **Next>**



New Project Wizard (2)



- ★ Enter 'shallow' as **project name**
- ★ Under **Project type**, expand **Makefile project**
 - scroll to the bottom
- ★ Select **Empty Project**
- ★ For **Remote Toolchain**,
Select **Linux GCC**
 - ★ In general, choose a toolchain that matches the compiler you intend to use on the remote system
- ★ For **Local Toolchain**
 - ★ If you intend to build on the local machine, select this; it is optional
- ★ Next slide ... connection



Select Remote Connection

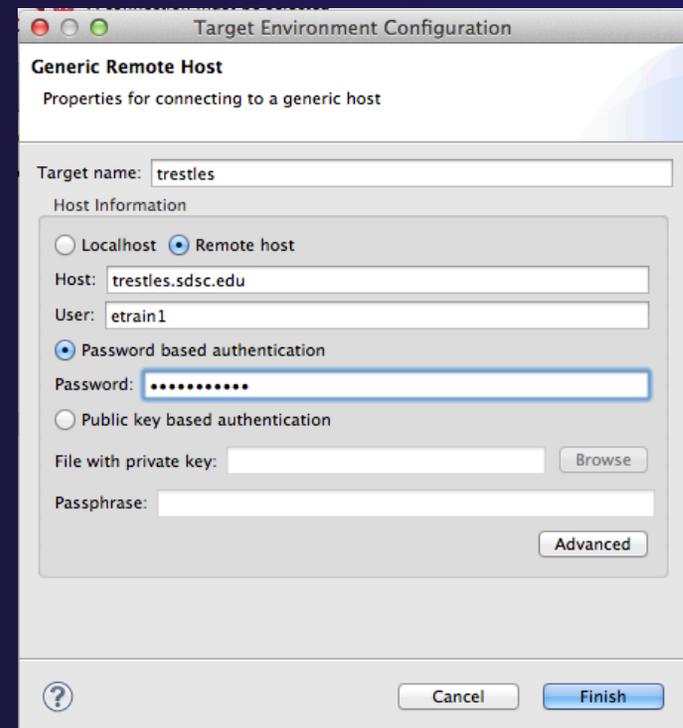
- ★ For **Connection:**, click on **New...**
 - ★ Unless you already have a connection

- ★ The tutorial instructor will indicate what to enter in **Target Environment Configuration** for:

- ★ Target name
- ★ Host name of remote system
- ★ User ID
- ★ Password

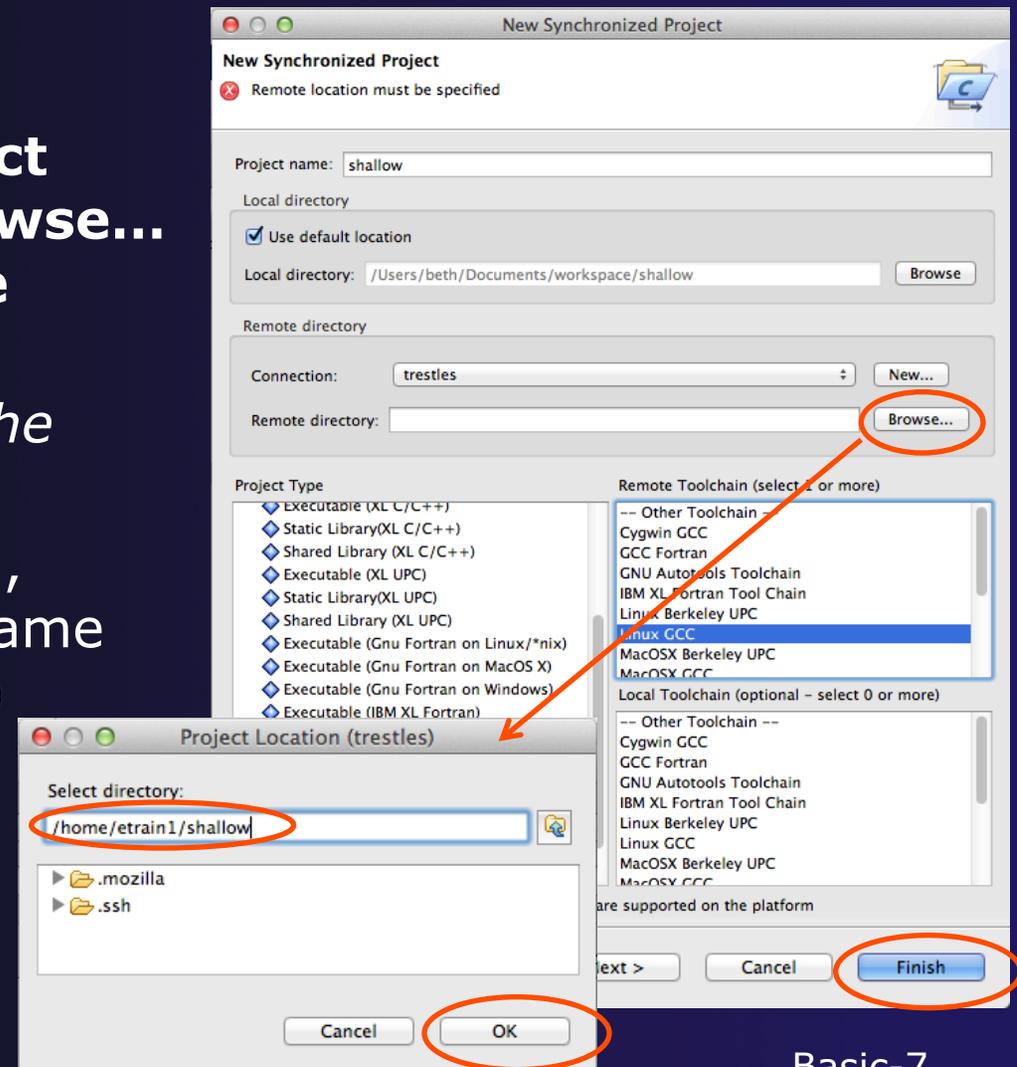
Note: if you need to use ssh tunneling, use **Localhost**; the **Advanced** button lets you enter the port #*

- ★ Select **Finish**



Select Remote Directory

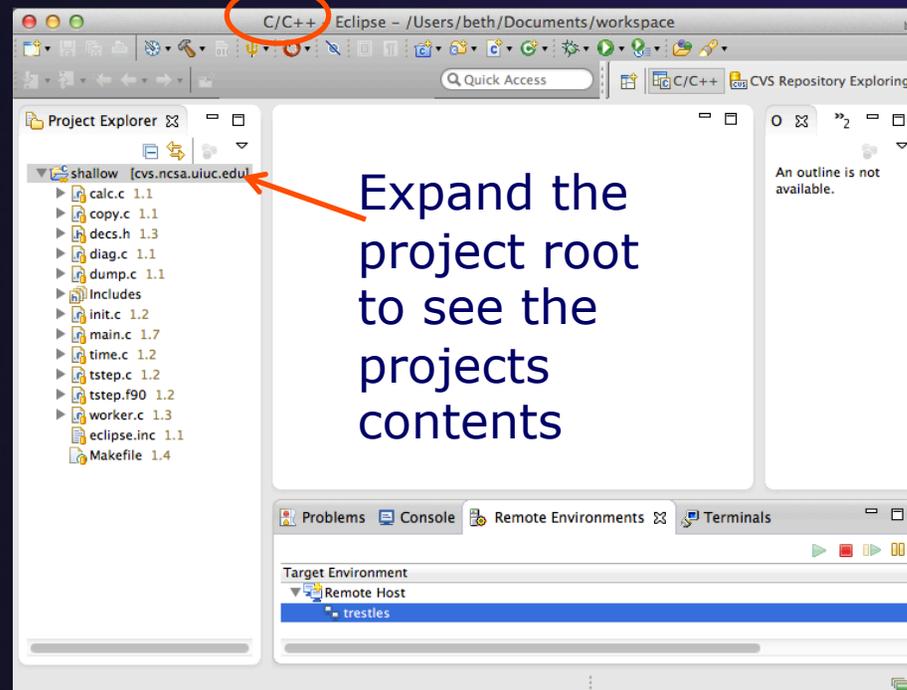
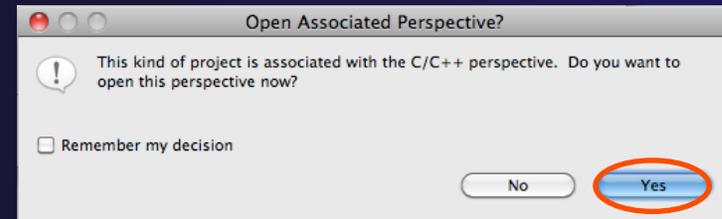
- ★ Back in the **New Synchronized Project** dialog, select the **Browse...** button under **Remote Directory**
- ★ *This is the first time the connection is used*
- ★ For **Project Location**, enter new directory name (or select existing dir)
- ★ Hit **OK**, then **Finish**



Project successfully checked out



- ★ Switch to the C/C++ Perspective when prompted after checking out the code
- ★ You should now see the “shallow” project in your workspace
- ★ Project is synchronized with remote host



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
- ✦ The synchronized project does this
- ✦ Files are synchronized automatically when they are saved
- ✦ A full synchronize is also performed prior to a build



Synchronized Project

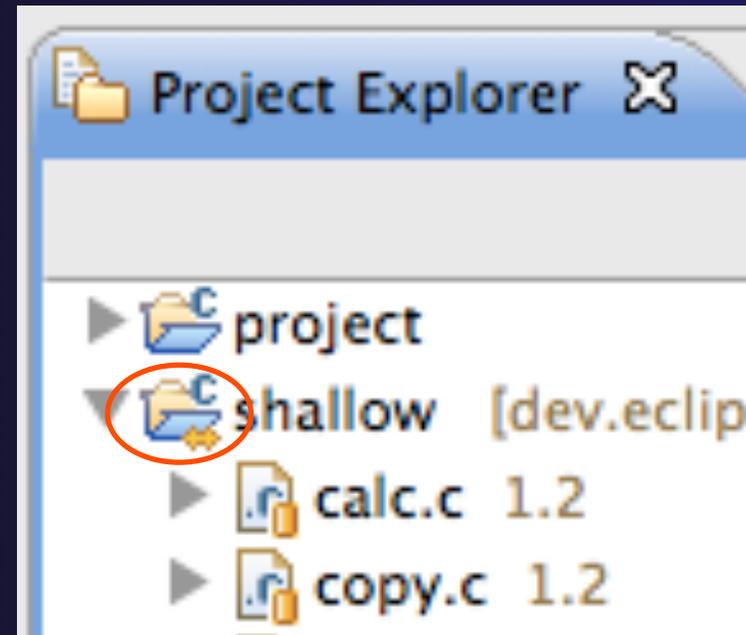
- ★ Back in the Project Explorer, decorator on project icon indicates synchronized project
- ★ Double-+ icon

- ★ C Project w/o Sync

▼  shallow [dev.eclipse.org]

- ★ Synchronized Project

▼  shallow [dev.eclipse.org]



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

Two meanings for 'Synchronize'

- ✦ PTP's *synchronize*

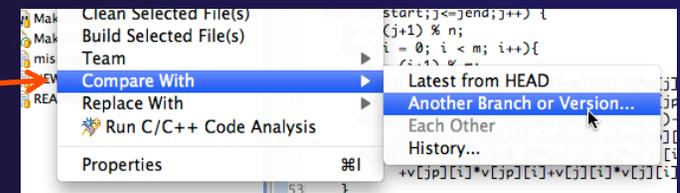
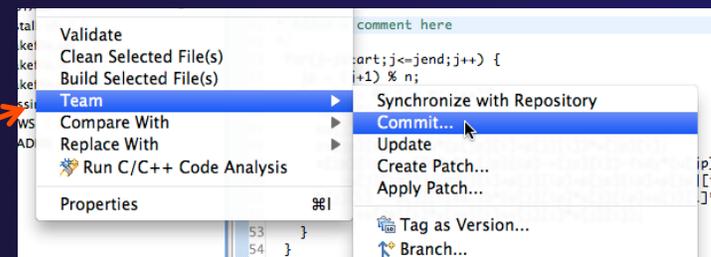
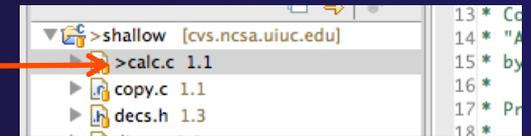
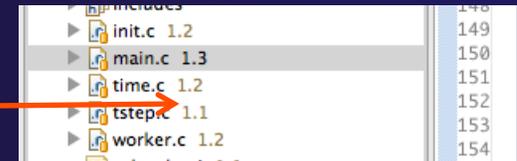
- ✦ *Copy files in synchronized projects between local and remote to mirror them*

- ✦ Team *synchronize*

- ✦ *Show differences between local project and source code repository versions*

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)



* Team synchronize

How to tell that you've changed something

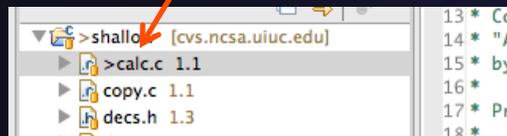


- ✦ Open "calc.c"
- ✦ Add comment at line 40
- ✦ Save file
- ✦ File will be marked ">" to indicate that it has been modified

```

27
28 void calcuvzh(jstart, jend, p, u, v, cu, cv, h, z, fsdx, fsdy)
29 int jstart, jend;
30 float p[n][m];
31 float u[n][m];
32 float v[n][m];
33 float cu[n][m];
34 float cv[n][m];
35 float h[n][m];
36 float z[n][m];
37 float fsdx, fsdy;
38 {
39     int i, j, ip, jp;
40     /*
41      * Added a comment here
42      */
43     for(j=jstart; j<=jend; j++) {
44         jp = (j+1) % n;
45         for (i = 0; i < m; i++){
46             ip = (i+1) % m;
47             cu[j][ip] = 0.5*(p[j][ip]+p[j][i])*u[j][ip];
48             cv[jp][i] = 0.5*(p[jp][i]+p[j][i])*v[jp][i];
49             z[jp][ip] = (fsdx*(v[jp][ip]-v[jp][i])-fsdy*(u[jp][ip]
50             -u[j][ip]))/(p[j][i]+p[j][ip]+p[jp][ip]+p[jp][i]);
51             h[j][i] = p[j][i]+0.25*(u[j][ip]*u[j][ip]+u[j][i]*u[j][i]
52             +v[jp][i]*v[jp][i]+v[j][i]*v[j][i]);
53         }

```



Comparing *single file* with what's in the repository



- ★ Right-click on “calc.c” and select **Compare With>Latest from HEAD**
 - ★ Even if you didn't create project from CVS, you can try **Compare With>Local History...**
- ★ 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

The screenshot shows the 'C Compare Viewer' window with two panes: 'Local File 1.1' and 'Remote File 1.1'. The local file has a comment added at line 41: `/* Added a comment here */`. The remote file does not have this comment. The code in both panes is C code for a matrix multiplication algorithm.

```

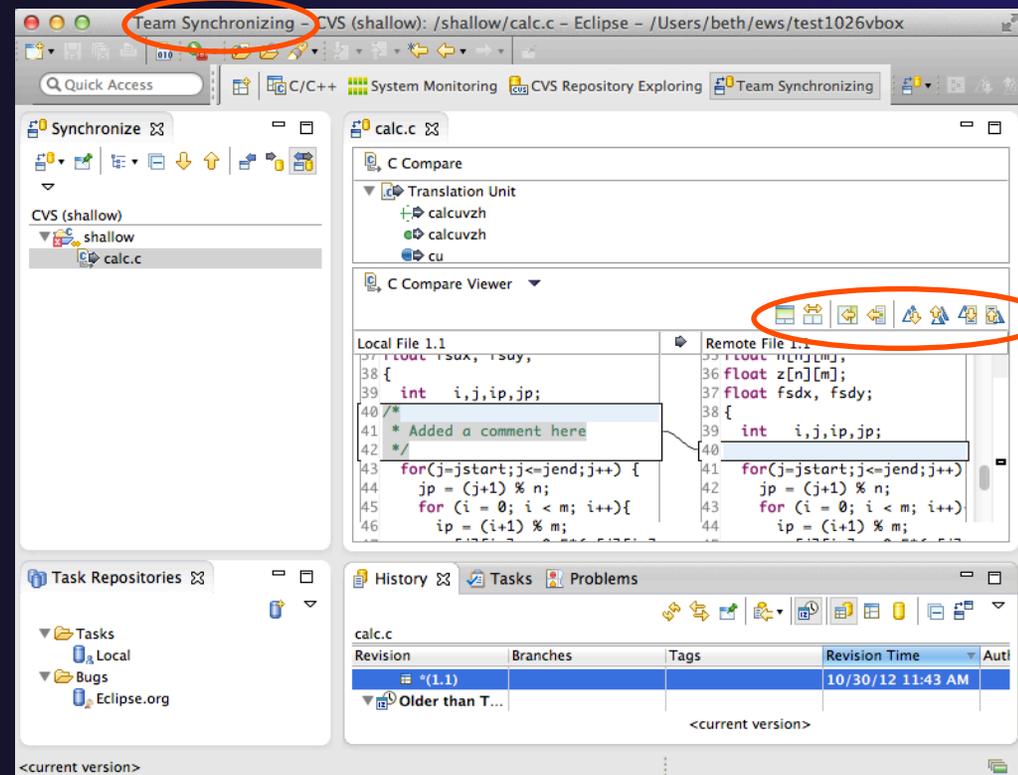
Local File 1.1
32 float v[n][m];
33 float cu[n][m];
34 float cv[n][m];
35 float h[n][m];
36 float z[n][m];
37 float fsdx, fsdy;
38 {
39     int i,j,ip,jp;
40     /*
41     * Added a comment here
42     */
43     for(j=jstart;j<=jend;j++) {
44         jp = (j+1) % n;
45         for (i = 0; i < m; i++){
46             ip = (i+1) % m;
47             cu[j][ip] = 0.5*(p[j][ip]+p[j][i])*u[j][i];
48             cv[jp][i] = 0.5*(p[jp][i]+p[j][i])*v[jp][i];
49             z[jp][ip] = (fsdx*(v[jp][ip]-v[jp][i])-f
Remote File 1.1
30 float p[n][m];
31 float u[n][m];
32 float v[n][m];
33 float cu[n][m];
34 float cv[n][m];
35 float h[n][m];
36 float z[n][m];
37 float fsdx, fsdy;
38 {
39     int i,j,ip,jp;
40
41     for(j=jstart;j<=jend;j++) {
42         jp = (j+1) % n;
43         for (i = 0; i < m; i++){
44             ip = (i+1) % m;
45             cu[j][ip] = 0.5*(p[j][ip]+p[j][i])*u
46             cv[jp][i] = 0.5*(p[jp][i]+p[j][i])*v
47             z[jp][ip] = (fsdx*(v[jp][ip]-v[jp][i]

```

Comparing *your project* with what's in the repository



- ✦ Right-click on project name (or any subset) and select **Team>Synchronize with Repository**
- ✦ **Team Synchronizing** perspective will open
- ✦ List of changed files appears
- ✦ Double-click on a file to see the diff viewer
- ✦ Buttons allow changes to be merged from right to left
- ✦ Can also navigate between changes using buttons

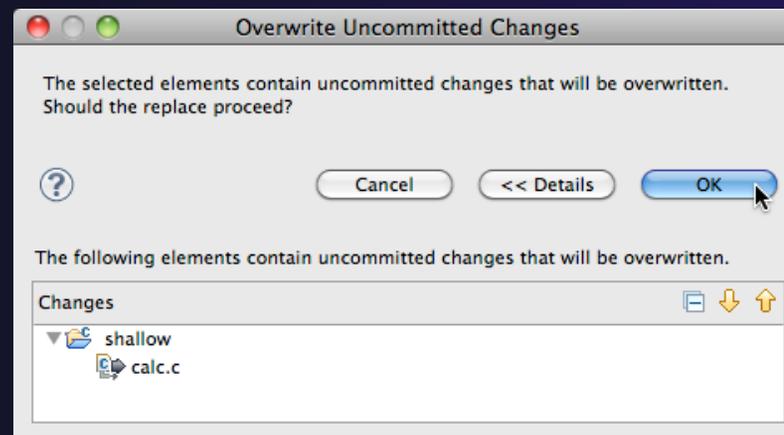




Revert To The Latest Version

To replace your project contents to the current contents of the project in the src code repo,

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





Exercise

- ★ Check out the *shallow* project from CVS as a synchronized project - as described in this module

Optional Exercise

1. Name every person who modified the Makefile
2. Identify which parts of the Makefile changed since revision 1.3

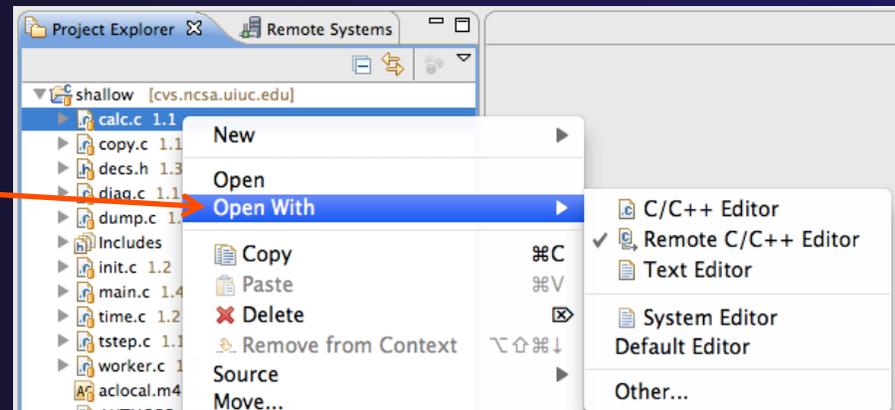
***Hint:** Right-click the Makefile and select **Team > Show History**. Both of these can be done from the History view.*

Editor Features

- ★ Objective
 - ★ Learn about Eclipse editor features
- ★ Contents
 - ★ Saving
 - ★ Editor markers
 - ★ Setting up include paths
 - ★ Code analysis
 - ★ Content assistance and templates

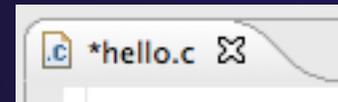
Editors

- ★ 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

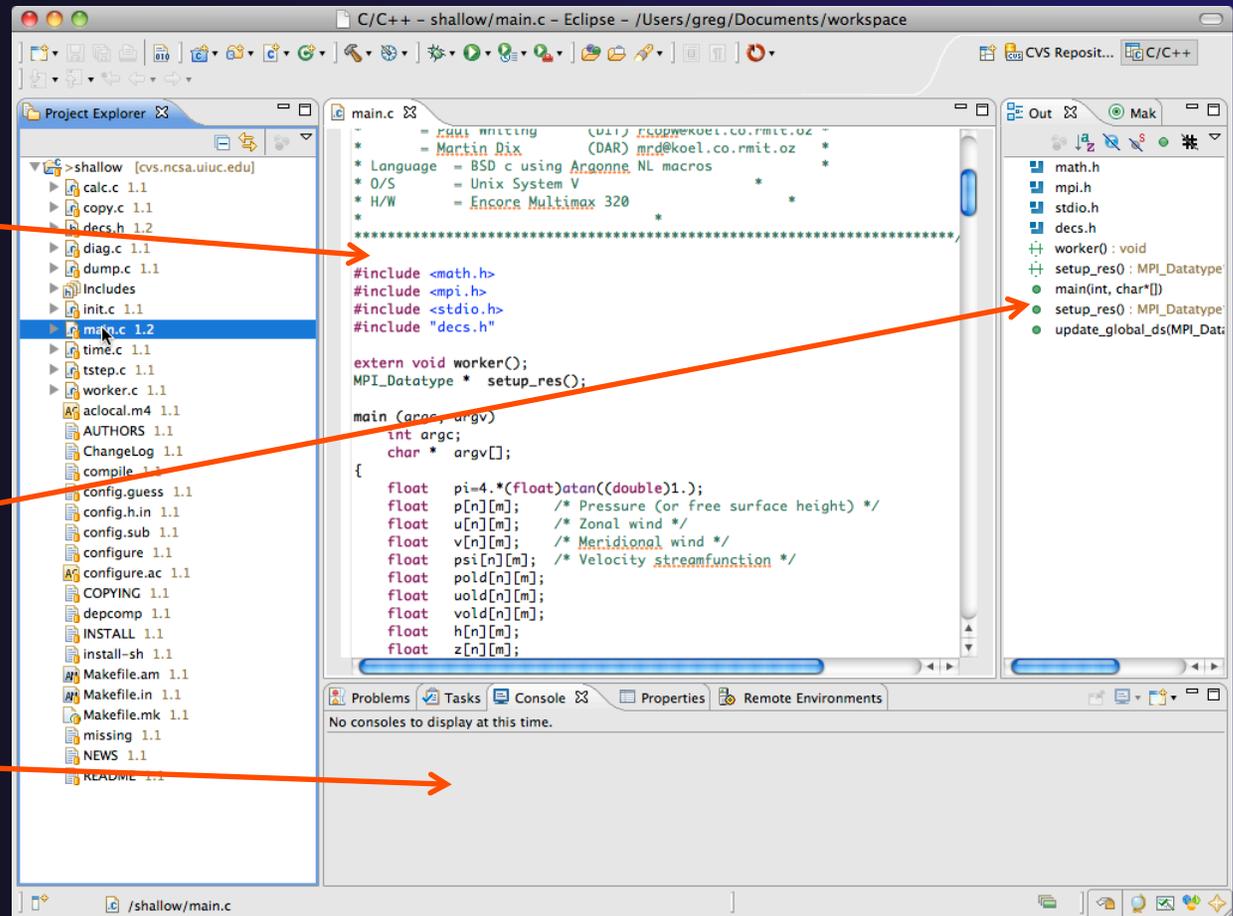
- ★ When you change a file in the editor, an asterisk on the editor's title bar indicates unsaved changes



- ★ 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.

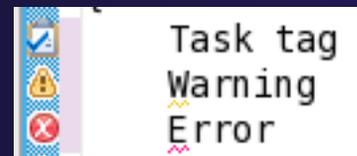


Source Code Editors & Markers

- ★ 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

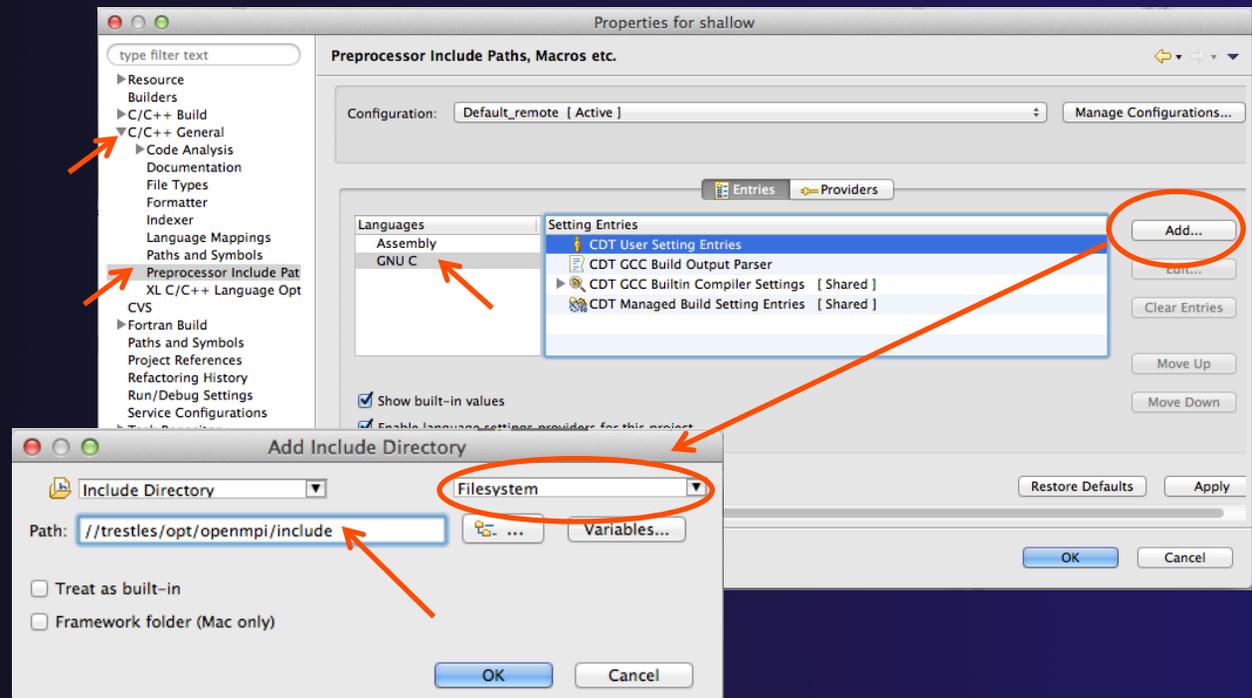
```
linear_function.c
/**
 * Returns f(x) = 3.0*x + 2.0
 */
double evaluate(double x)
{
    // TODO add semicolon to end of next line
    double y = 3.0*x + 2.0
    return y;
}
```

Icons:



Include Paths (1)

- ★ In order for editor and build features to work properly, Eclipse needs to know where your include files are located
- ★ The build environment on the remote host knows your include files etc., but we must tell Eclipse so that indexing, search, completion, etc. will know where things are
- ★ Open Project Properties
- ★ Expand C/C++ General
- ★ Select **Preprocessor Include Paths**
- ★ Click **GNU C**, then **CDT User Setting Entries**, then click **Add...**
- ★ In upper right, select **Filesystem** in pulldown
- ★ A UNC-style path specifies `//<connection>/<path>`
- ★ Enter Path `//trestles/opt/openmpi/include`
- ★ Select **OK**



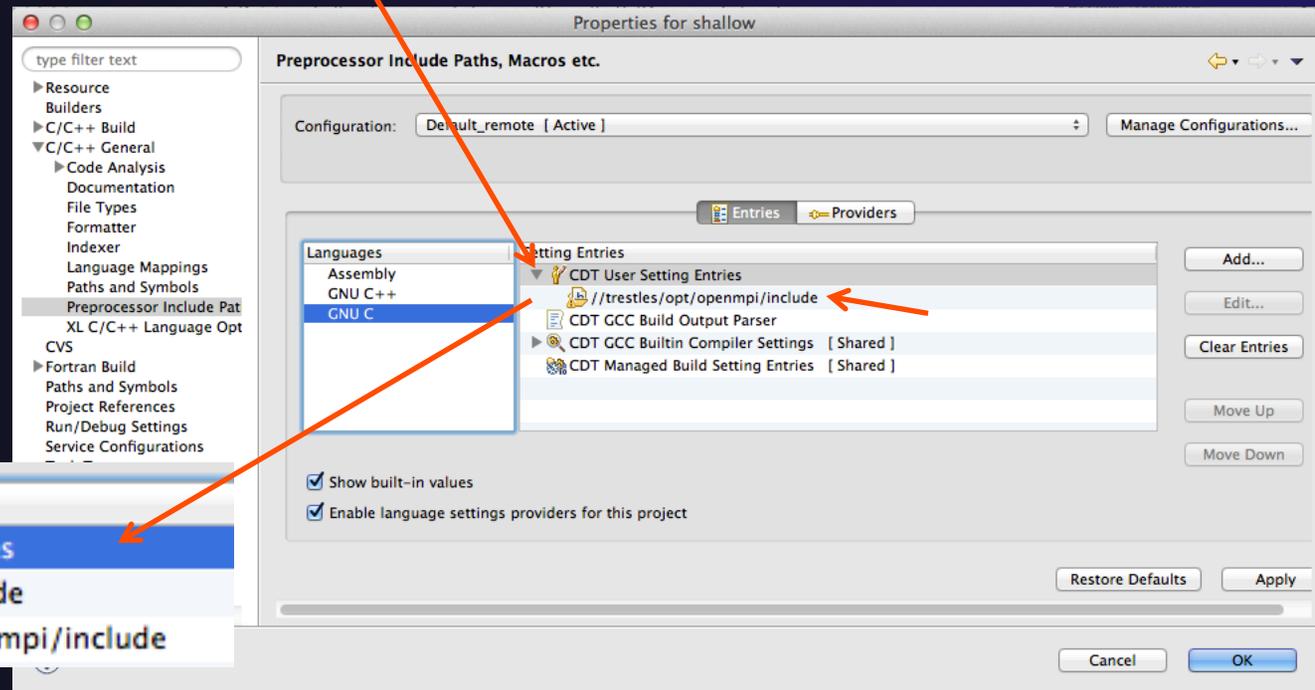
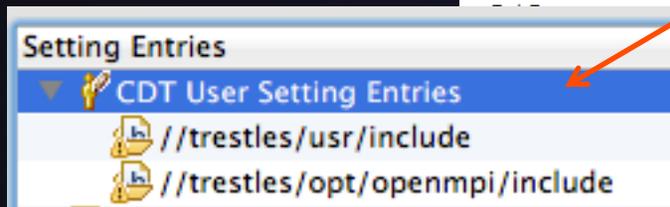
Include Paths (2)

- ★ After adding include directory, it should appear in the list
- ★ Bug: on Mac, it appears as blank. Close and re-open the twisty to see the correct value.

- ★ Add second value:

`//trestles/usr/include`
... the same way

You should have two entries:



Include Paths (3)

- ★ Select **OK**
- ★ The C/C++ Indexer should run
 - ★ Lower right status area indicates it



- ★ If not force it via Project Properties>Index>Rebuild

Code Analysis (Codan)

★ If you see bug icons in the editor marker bar, they are likely suggestions from Codan

★ If include files are set correctly, they *should* not appear.

★ Code checkers can flag possible errors, even if code is technically correct

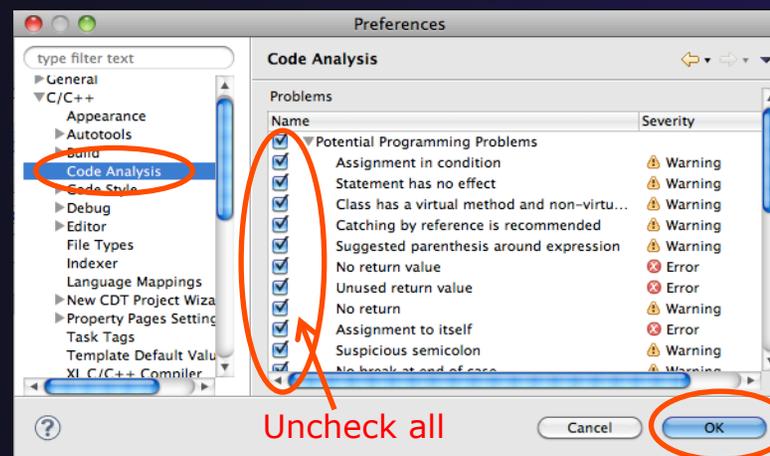
★ To turn them off, use Preferences

Window > Preferences or Mac: Eclipse > Preferences

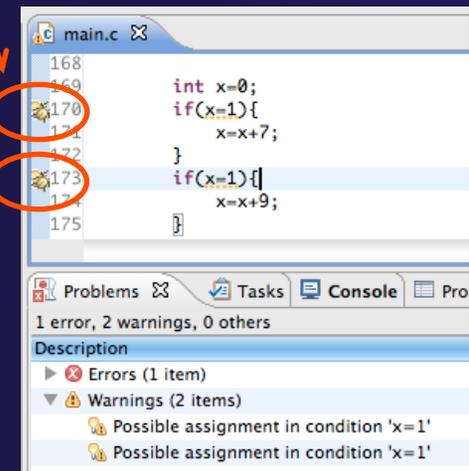
C/C++ > Code Analysis

and uncheck
all problems

★ Select OK to
close
Preferences



Editor Features

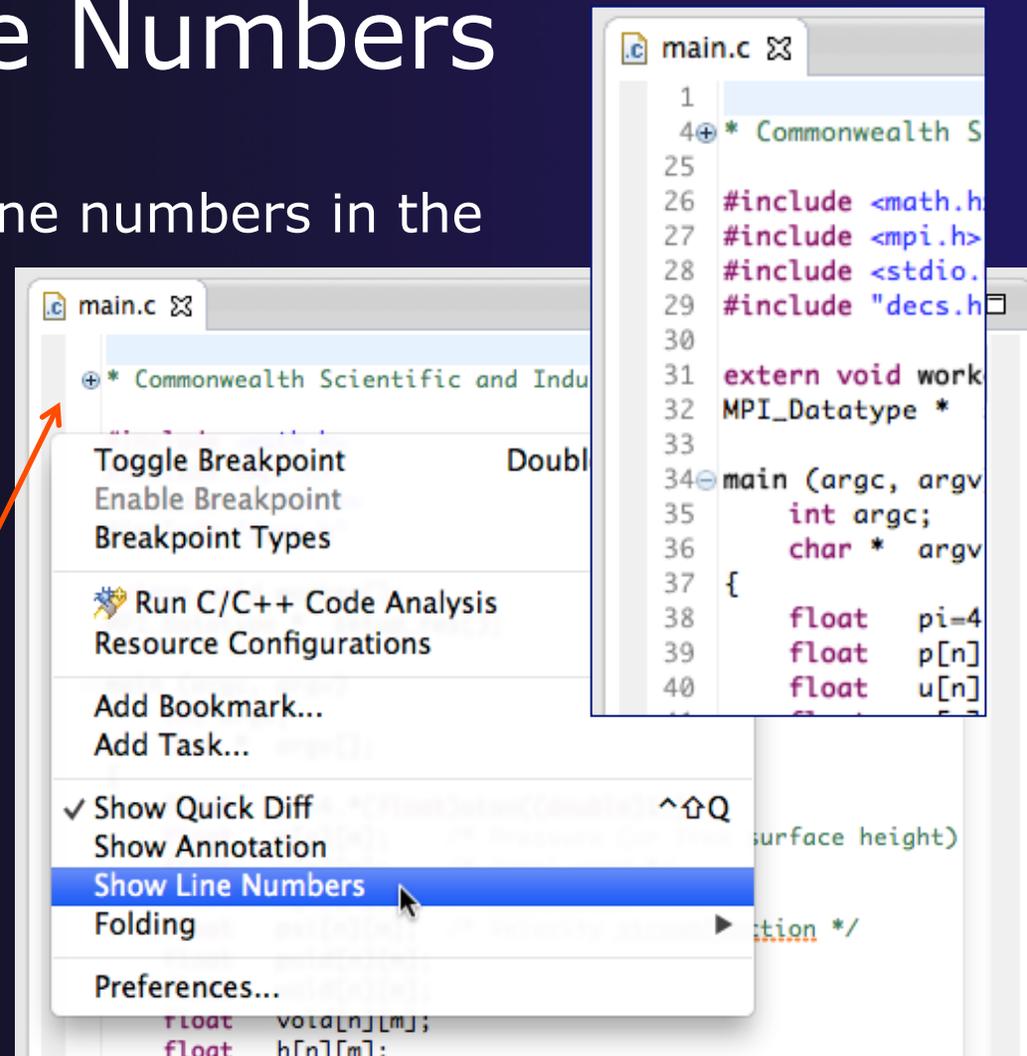


★ If icons don't disappear:
Right mouse on Project >
Run C/C++ Code Analysis
★ You can also enable/disable
this per project in Project
Properties

Editor-8

Line Numbers

- ★ Text editors can show line numbers in the left column
- ★ To turn on line numbering:
 - ★ Right-mouse click in the editor marker bar (at editor left edge)
 - ★ 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`

```

128 }
129
130
131 /*
132 initialise data structures and construct packets to be sent to workers
133 */
134
135 initialise(p, u, v, psi, pold, uold, vold, di, dj, z);
136 diag(1, 0, p, u, v, h, z);
137
138 for (i = 1; i < proc_cnt; i++) {
139     for (j = 0; j < n; j++) {

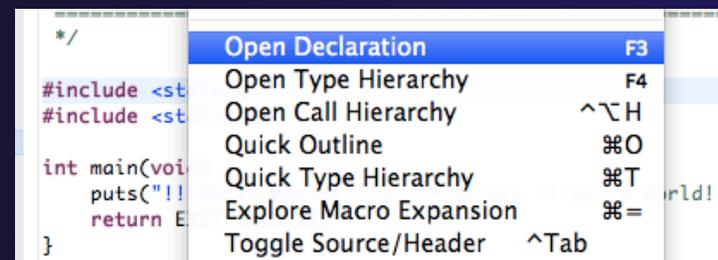
```

```

26 #include <math.h>
27 #include "dss.h"
28
29 void initialise(p, u, v, psi, pold, uold, vold, di, dj, z)
30 float p[n][m];
31 float u[n][m];
32 float v[n][m];
33 float psi[n][m];

```

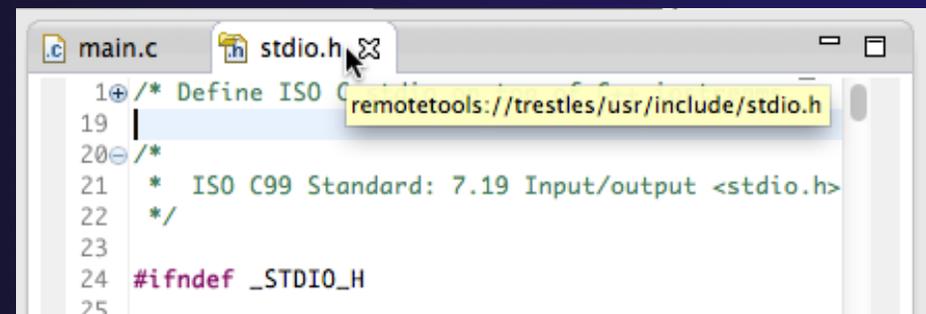
- ★ Open declaration
 - ★ Right-click and select **Open Declaration** will also open the file in which the element is declared
 - ★ E.g. in main.c line 29 right-click on `decs.h` and select **Open Declaration**



Note: may need to left-click before right-click works

Navigating to Remote Files

- ★ Note: remote includes must be set up correctly for this to work
- ★ On demand hyperlink
 - ★ In main.c line 73:
 - ★ Ctrl-click on fprintf
 - ★ stdio.h on remote system opens
- ★ Open declaration (or F3)
 - ★ In main.c, right-click and select **Open Declaration** e.g on <stdio.h>
 - ★ File from remote system is opened.
- ★ Hover over editor name tab to see remote location.



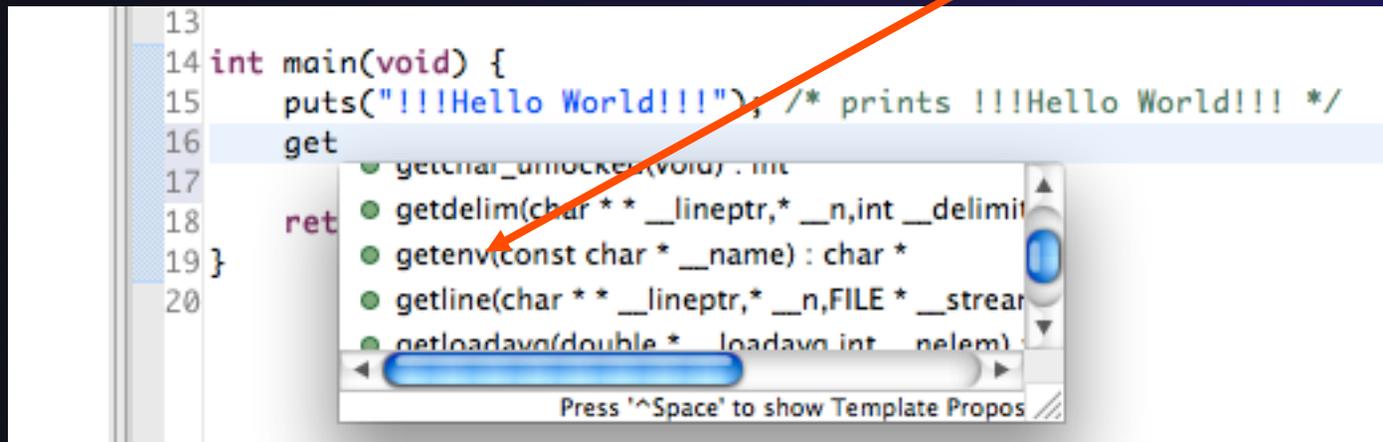
The screenshot shows an IDE window with two tabs: 'main.c' and 'stdio.h'. The 'stdio.h' tab is active and shows the following code:

```
19 |
20 | /*
21 |  * ISO C99 Standard: 7.19 Input/output <stdio.h>
22 |  */
23 |
24 | #ifndef _STDIO_H
25 |
```

A tooltip is visible over the 'stdio.h' tab, displaying the remote file path: `remotetools://trestles/usr/include/stdio.h`.

Content Assist & Templates

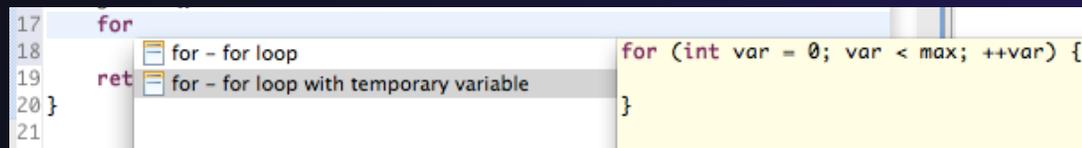
- ✦ Type an incomplete function name e.g. "get" into the editor, and hit **ctrl-space**
- ✦ Select desired completion value with cursor or mouse



A screenshot of a code editor showing a completion list for the word "get". The list includes functions like `getchar_unlocked`, `getdelim`, `getenv`, `getline`, and `getloadavg`. An orange arrow points to the `getenv` entry. The editor background shows a C program with a `main` function that prints "Hello World".

- ✦ Code Templates: type 'for' and Ctrl-space

Hit ctrl-space again
for code templates

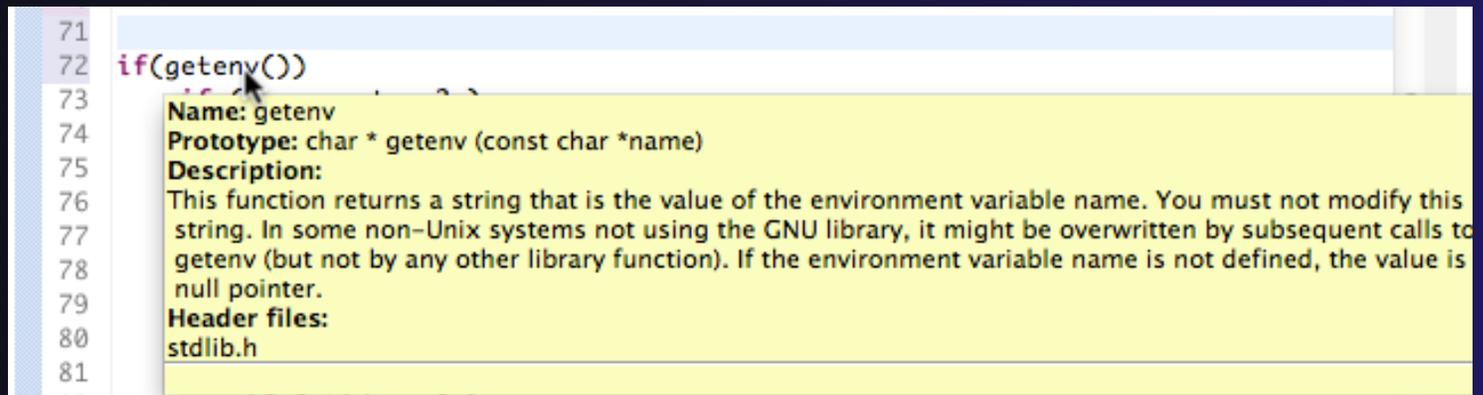


A screenshot of a code editor showing a completion list for the word "for". The list includes templates like "for - for loop" and "for - for loop with temporary variable". The editor background shows a C program with a `main` function that prints "Hello World".

More info on code templates later

Hover Help

- ★ Hover the mouse over a program element in the source file to see additional information



The screenshot shows a code editor with a yellow tooltip displayed over the `getenv()` function call on line 72. The tooltip contains the following information:

```
71  
72 if(getenv())  
73  
74  
75  
76  
77  
78  
79  
80  
81
```

Name: getenv
Prototype: char * getenv (const char *name)
Description:
This function returns a string that is the value of the environment variable name. You must not modify this string. In some non-Unix systems not using the GNU library, it might be overwritten by subsequent calls to getenv (but not by any other library function). If the environment variable name is not defined, the value is null pointer.
Header files:
stdlib.h

Inactive code

- ★ Inactive code will appear grayed out in the CDT editor

```
260 #define VAL
261 #ifdef VAL
262     acopy_one_to_two(VAL, ds, res.indx);
263 #else
264     acopy_one_to_two(res.row, ds, res.indx);
265 #endif
```

```
260 //#define VAL
261 #ifdef VAL
262     acopy_one_to_two(VAL, ds, res.indx);
263 #else
264     acopy_one_to_two(res.row, ds, res.indx);
265 #endif
```



Exercise

1. Open an editor by double clicking on a source file in the **Project Explorer**
2. Use the **Outline View** to navigate to a different line in the editor
3. Back in main.c, turn on line numbering
4. In main.c, ctrl-click on line 99, master_packet, should navigate to its definition in the file
5. In worker.c, line 132, hover over variable p to see info



Optional Exercise

1. Type "for", then activate content assist
 - ✦ Select the **for loop with temporary variable** template, insert it, then modify the template variable
 - ✦ Surround the code you just inserted with "#if 0" and "#endif" and observe that it is marked as inactive
 - ✦ Save the file
2. What do these keys do in the editor?
 - ✦ Ctrl+L; Ctrl+Shift+P (do it near some brackets)
 - ✦ Ctrl+Shift+;/
 - ✦ Ctrl+Shift+Y and Ctrl+Shift+X (do it on a word or variable name e.g.)
 - ✦ Alt+Down; Alt+Up
3. To make sure you didn't do any damage,
 - ✦ Select any source files you changed and do rightmouse > replace with ..
 - ✦ (if you made project from CVS) ...Latest from HEAD
 - ✦ (If you made project from remote files) ... Local History ...
 - ✦ Observe that your changes are gone.

MPI Programming

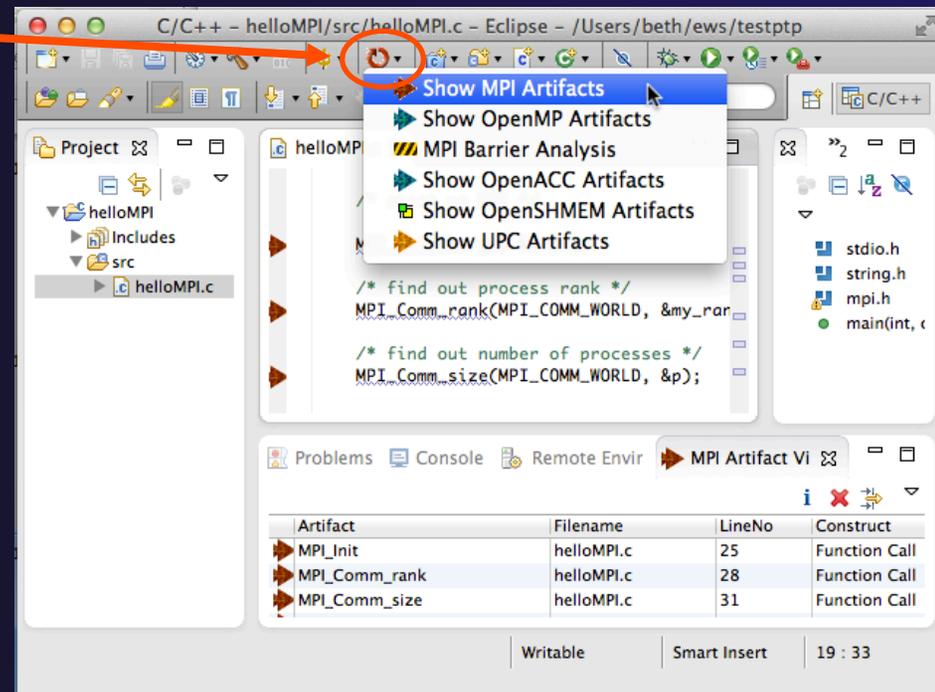
- ★ Objective
 - ★ Learn about MPI features for your source files
- ★ Contents
 - ★ Using Editor features for MPI
 - ★ MPI Help features
 - ★ Finding MPI Artifacts
 - ★ MPI New Project Wizards
 - ★ MPI Barrier Analysis

MPI-Specific Features

- ★ PTP's Parallel Language Development Tools (PLDT) has several features specifically for developing MPI code
 - ★ Show MPI Artifacts
 - ★ Code completion / Content Assist
 - ★ Context Sensitive Help for MPI
 - ★ Hover Help
 - ★ MPI Templates in the editor
 - ★ MPI Barrier Analysis
- ★ PLDT has similar features for OpenMP, UPC, OpenSHMEM, OpenACC

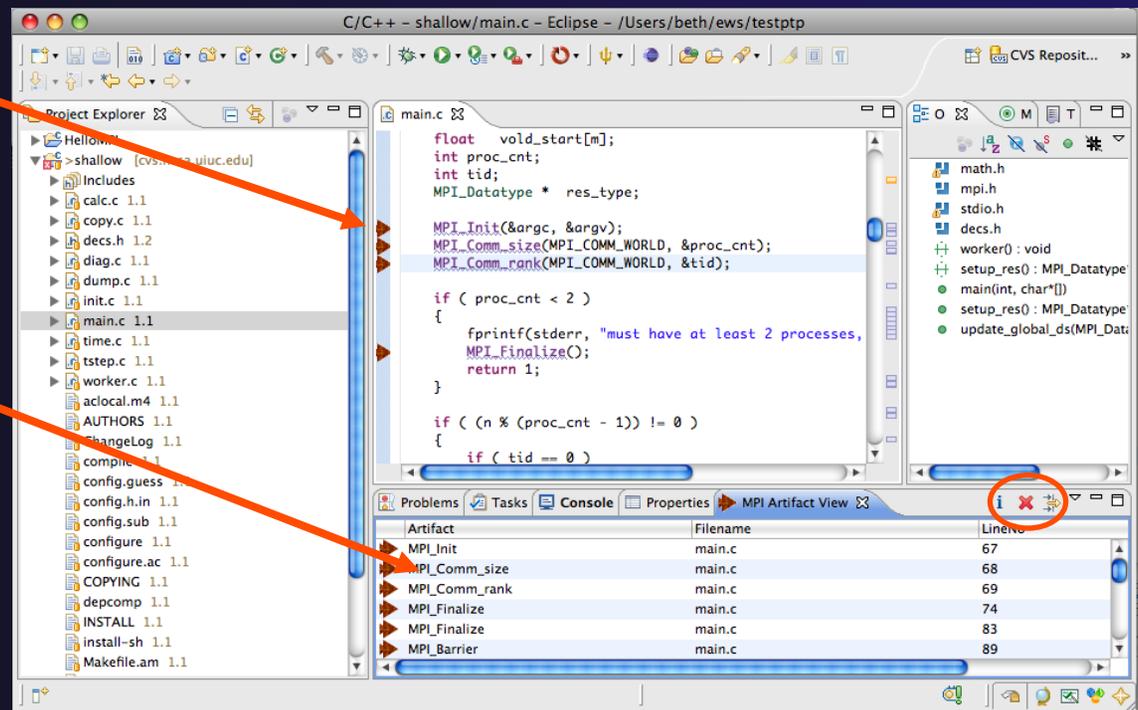
Show MPI Artifacts

- ★ In Project Explorer, select a project, folder, or a single source file
 - ★ The analysis will be run on the selected resources
- ★ Run the analysis by clicking on drop-down menu next to the analysis button
- ★ Select **Show MPI Artifacts**
- ★ 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

A screenshot of an MPI editor window titled '*main.c'. The code includes MPI initialization and communication functions. The cursor is positioned at the start of a new line with 'MPI_B'. A dropdown menu shows a list of MPI functions starting with 'MPI_B', such as MPI_Barrier, MPI_Bcast, MPI_Bsend, MPI_Buffer_attach, MPI_Buffer_detach, MPI_Barrier, MPI_Bcast, MPI_Bsend, and MPI_Bsend_init. A yellow tooltip is visible over the list, stating 'Blocks each task until all tasks have called it.'

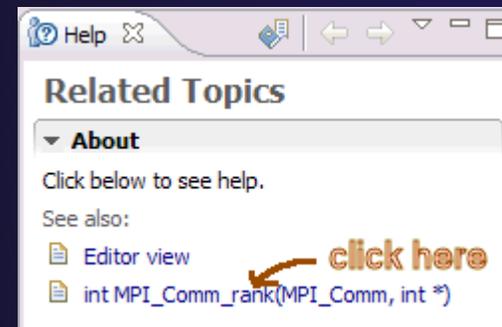
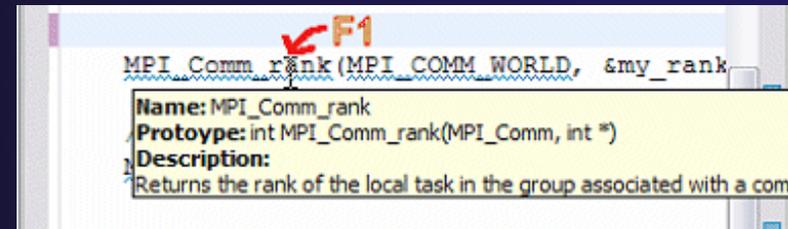
- ★ Code completion will show all the possible MPI keyword completions
- ★ Enter the start of a keyword then press <ctrl-space>

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

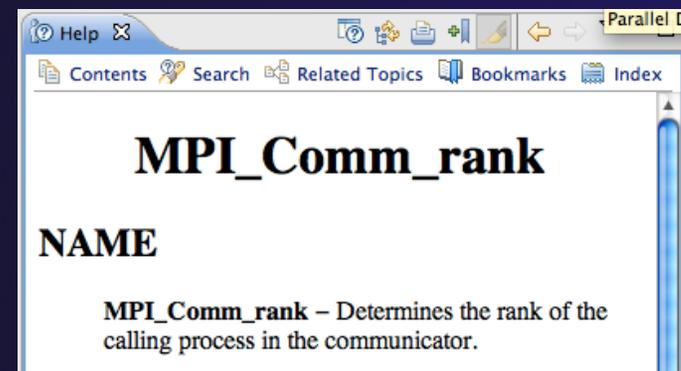
A screenshot of the same MPI editor window. The cursor is now over the 'MPI_Comm_rank' function call. A tooltip is displayed, showing the function's name, prototype, and description. The tooltip text is: 'Name: MPI_Comm_rank', 'Prototype: int MPI_Comm_rank(MPI_Comm, int *)', and 'Description: Returns the rank of the local task in the group associated with a communicator.' Below the description, it says 'Press 'F2' for focus'.

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



Some special info has been added for MPI APIs



MPI Templates

✦ Allows quick entry of common patterns in MPI programming

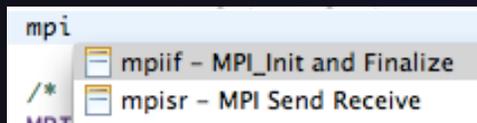
✦ Example:
MPI send-receive

✦ 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



```

MPI_Comm_rank(MPI_COMM_WORLD, &rank);
MPI_Comm_size(MPI_COMM_WORLD, &p);
if (rank == 0){ //master task
    printf("Hello From process 0: Num processes: %d\n",p);
    for (source = 1; source < p; source++) {
        MPI_Recv(message, 100, MPI_CHAR, source, tag,
                MPI_COMM_WORLD, &status);
        printf("%s\n",message);
    }
}
else{ // worker tasks
    /* create message */
    sprintf(message, "Hello from process %d!", my_rank);
    dest = 0;
    /* use strlen+1 so that '\0' get transmitted */
    MPI_Send(message, strlen(message)+1, MPI_CHAR,
             dest, tag, MPI_COMM_WORLD);
}

```

Add more templates using Eclipse preferences!
C/C++>Editor>Templates
 Extend to other common patterns

MPI Barrier Analysis

The screenshot shows the Eclipse IDE interface for a C++ project named 'MyBarrier'. The main editor displays the source code for 'MyBarrier.c'. The code includes a function that sends a message to process 0 and then calls MPI_Barrier. Below the editor, the 'Barrier Matches' panel shows a table of barrier matching sets, and the 'Barrier Errors' panel shows a table of errors.

Barrier Matching Set	Function	Filename	LineNo
Barrier 1 (2)	Barrier	MyBarrier.c	8
Barrier 1	Barrier	MyBarrier.c	8
Barrier 3	main	MyBarrier.c	41
Barrier 2 (1)	main	MyBarrier.c	31
Barrier 2	main	MyBarrier.c	31
Barrier 3 (2)	main	MyBarrier.c	41
Barrier 1	Barrier	MyBarrier.c	8
Barrier 3	main	MyBarrier.c	41
Barrier 4 (0)	main	MyBarrier.c	57
Barrier 5 (1)	main	MyBarrier.c	62

Barrier Errors Set	Function
Error	main
Path 1 (1 barrier(s))	
Path 2 (0 barrier(s))	
Error	main
Loop (dynamic number of barriers)	

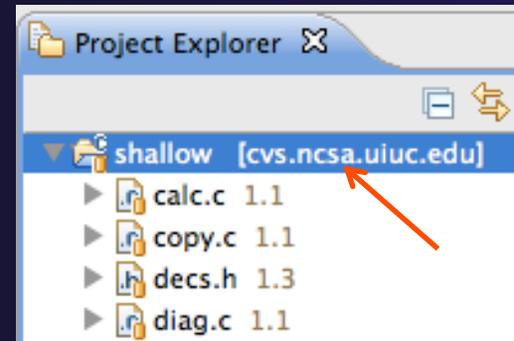
- ★ Verify barrier synchronization in C/MPI programs
- ★ For verified programs, lists barrier statements that synchronize together (match)
- ★ For synchronization errors, reports counter example that illustrates and explains the error

Local files only

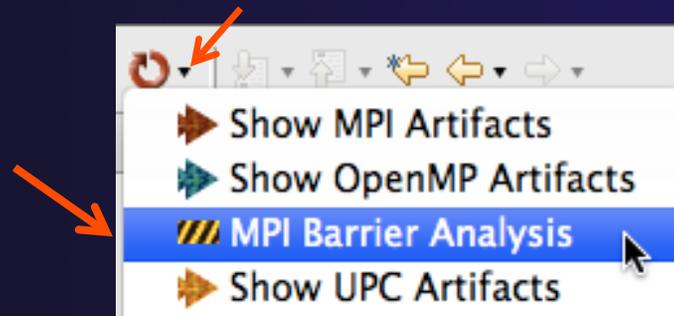
MPI Barrier Analysis (2)

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



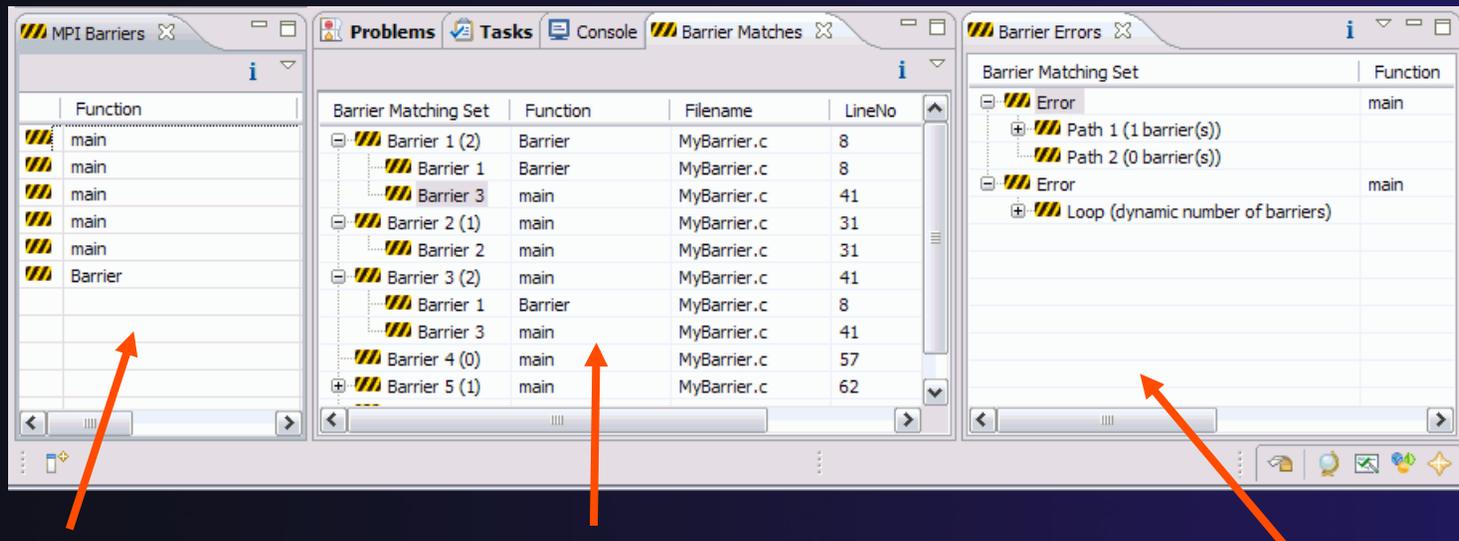
MPI Barrier Analysis (3)

- ★ No Barrier Errors are found (no pop-up indicating error)
- ★ Two barriers are found

The screenshot shows the Eclipse IDE interface. The Project Explorer on the left displays a project named 'shallow' with various source files. The main editor window shows the code for 'main.c', with line 89 highlighted: `MPI_Barrier(MPI_COMM_WORLD);`. Below the code editor, the 'MPI Barrier Matches' and 'MPI Barriers' tabs are active, showing a table of results.

Function	Filename	LineNo	IndexNo
main	main.c	89	1
main	main.c	206	2

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

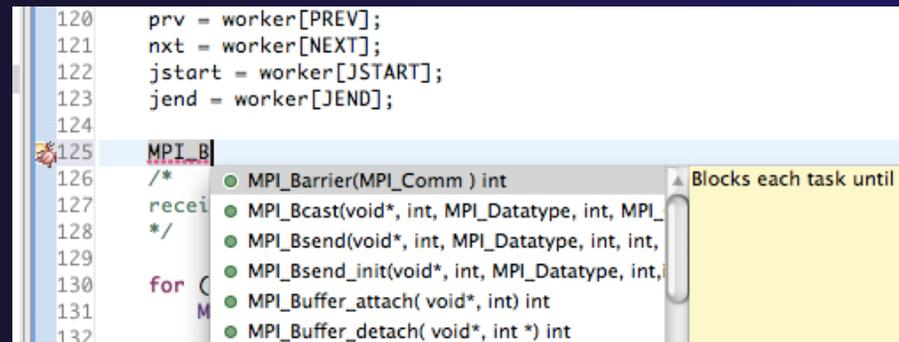
Groups barriers that match together in a barrier set – all processes must go through a barrier in the set to prevent a deadlock

Barrier Errors view

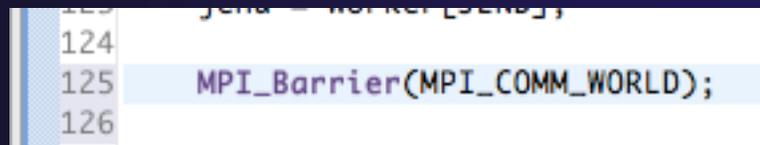
If there are errors, a counter-example shows paths with mismatched number of barriers

Barrier Errors

- ✦ 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 Ctl-space
 - ✦ Select MPI_Barrier
 - ✦ Add communicator arg MPI_COMM_WORLD and closing semicolon



A screenshot of an IDE showing a code completion menu for the text 'MPI_B' at line 125. The menu lists several MPI functions: MPI_Barrier(MPI_Comm) int, MPI_Bcast(void*, int, MPI_Datatype, int, MPI_Recv_status) int, MPI_Bsend(void*, int, MPI_Datatype, int, int, MPI_Recv_status) int, MPI_Bsend_init(void*, int, MPI_Datatype, int, MPI_Recv_status) int, MPI_Buffer_attach(void*, int) int, and MPI_Buffer_detach(void*, int*) int. A tooltip for MPI_Barrier is visible on the right, stating 'Blocks each task until'.



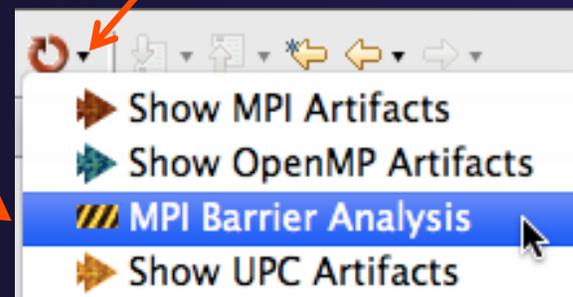
A screenshot of an IDE showing the final code line for the barrier: `MPI_Barrier(MPI_COMM_WORLD);` at line 125. The line is highlighted in blue.

Barrier Errors (2)

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

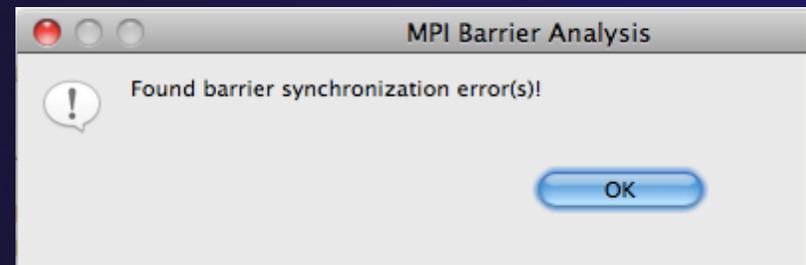


- ★ Run barrier analysis on shallow project again
 - ★ Select shallow project in Project Explorer first



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



Barrier Matching Set	Function	Filename	LineNo	IndexNo
▼ Error	main	main.c	87	0
▼ Path 1 (2 barrier(s))			0	0
Barrier 1	main	main.c	89	1
Barrier 3	worker	worker.c	125	3
▼ Path 2 (1 barrier(s))			0	0
Barrier 2	main	main.c	206	2

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
- ★ Re-run the barrier analysis to check that it has been fixed

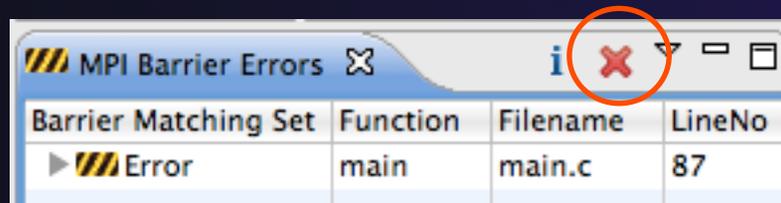
The screenshot shows an IDE with two tabs: worker.c and main.c. The worker.c tab is active, showing line 104 with the code `MPI_Barrier(MPI_COMM_WORLD);`. Below the code editor is a table titled 'MPI Barrier Errors' with columns: Barrier Matching Set, Function, Filename, LineNo, and IndexNo. The table contains the following data:

Barrier Matching Set	Function	Filename	LineNo	IndexNo
▼ Error	main	main.c	87	0
▼ Path 1 (2 barrier(s))			0	0
Barrier 1	main	main.c	89	1
Barrier 3	worker	worker.c	104	3
▼ Path 2 (1 barrier(s))			0	0
Barrier 2	main	main.c	206	2

Red arrows indicate the flow of information: one arrow points from the 'Barrier 3' row in the table to the corresponding line in the code editor, and another arrow points from the code editor back to the 'Barrier 3' row in the table.

Remove Barrier Markers

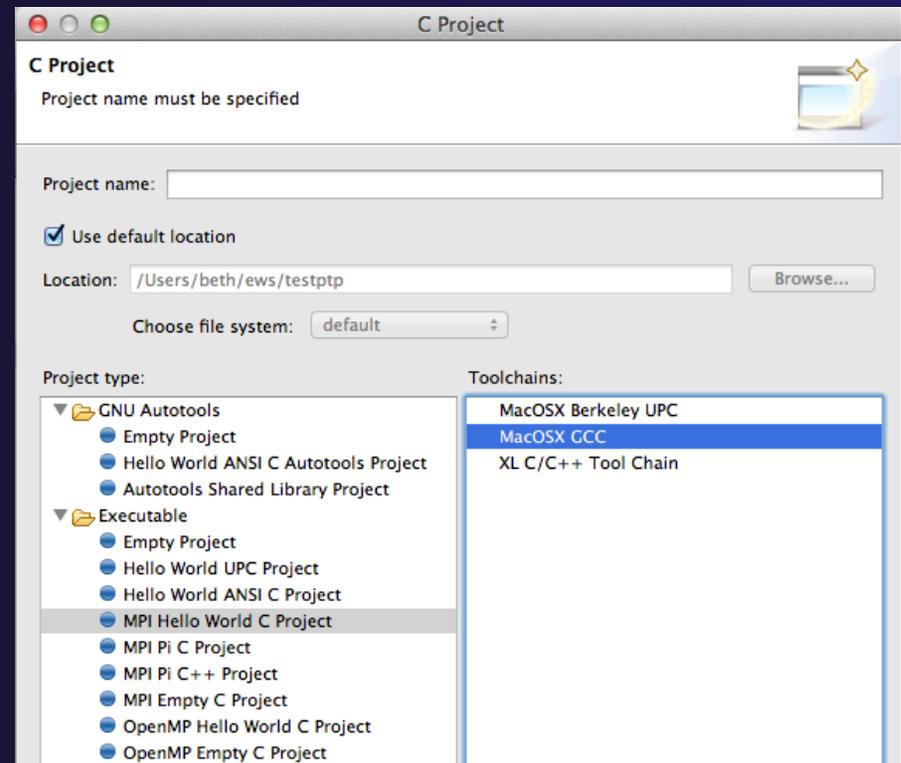
- ★ Run Barrier Analysis again to remove the error
- ★ Remove the Barrier Markers via the "X" in one of the MPI Barrier views



Barrier Matching Set	Function	Filename	LineNo
▶ Error	main	main.c	87

MPI New Project Wizards

- ★ Quick way to make a simple MPI project
- ★ File > New > C Project
- ★ “MPI Hello World”
is good for trying out
Eclipse for MPI



MPI New Project Wizards (2)

★ Next> and fill in (optional) Basic Settings

Basic Settings
Basic properties of a project

Author: Polly Parallel

Copyright notice: Your copyright notice

Hello world greeting: Hello MPI World

Source: src

< Back Next > Cancel Finish

★ Next> and fill in MPI Project Settings

★ Include path set in MPI Preferences can be added to project

MPI Project Settings
Select the MPI include path, lib name, library search path, and build command information to be automatically added to the new project.

Add MPI project settings to this project

Use default information

Include path: Browse...

Library name:

Library search path: Browse...

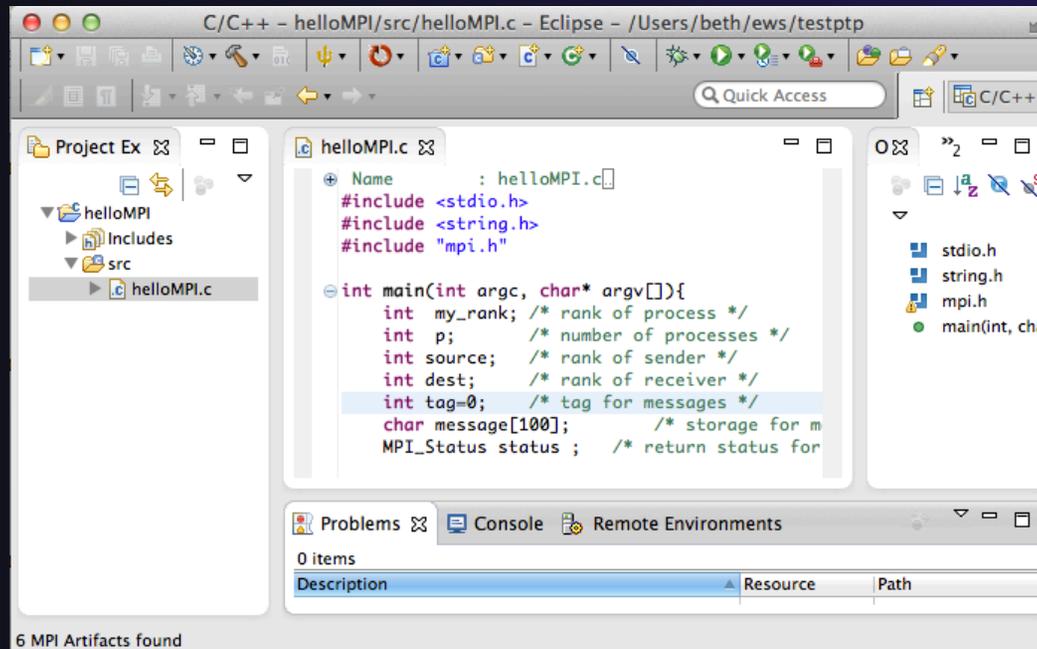
MPI compile command: mpicc

MPI link command: mpicc

< Back Next > Cancel Finish

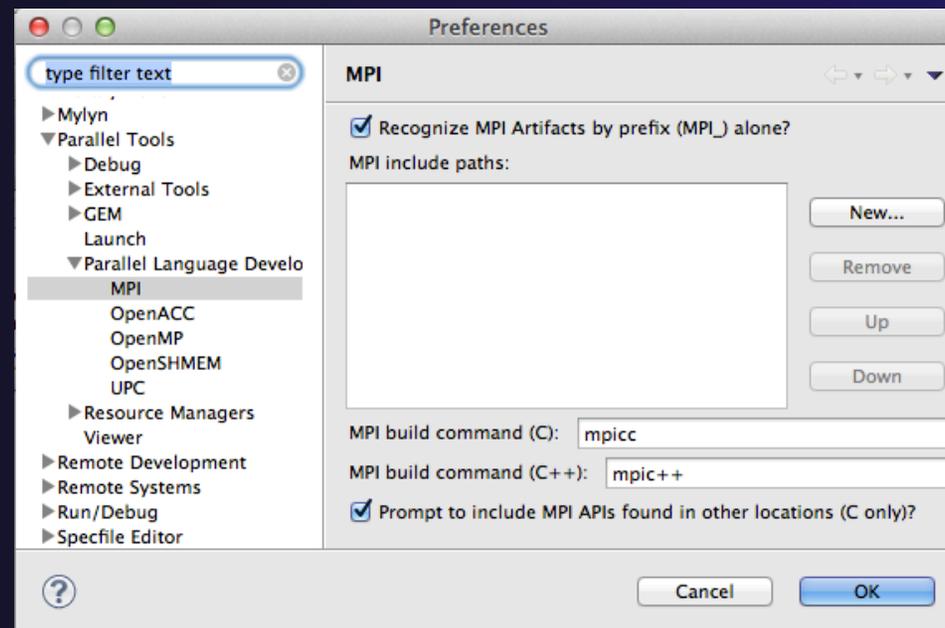
MPI New Project Wizards (3)

- ★ Select **Finish** and “MPI Hello World” project is created



MPI Preferences

- ✦ Settings for MPI New Project wizards
- ✦ MPI Include paths, if set in MPI Preferences, are added in MPI New Project Wizard





Exercise

1. Find MPI artifacts in 'shallow' project
 - ✦ Locate all the MPI communication (send/receive) calls
2. Use content assist to add an api call
 - ✦ E.g., Type MPI_S, hit ctrl-space
3. Use hover help
4. Use a template to add an MPI code template
 - ✦ On a new line, type mpisr and ctrl-space...



Optional Exercise

1. Insert an `MPI_Barrier` function call into one of your source files using content assist
 - ✦ E.g. Line 125 of `worker.c`
2. Save the file
3. Run Barrier Analysis on the project
4. Locate the source of the barrier error and remove the statement
5. Re-run barrier analysis to observe that the problem has been fixed

Configuring SSH Tunnel

SSH Tunnel

Tunnel-0

Configure the Synchronized Project - SSH tunnel (1)

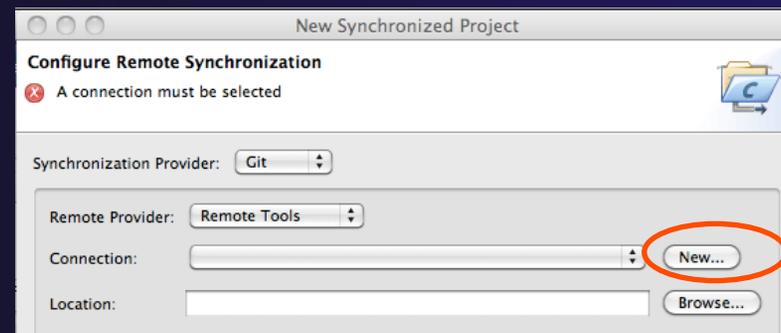


- ★ If your machine access requires ssh access through a frontend/intermediate node, set up an ssh tunnel before configuring the project - from command line or e.g. Windows PuTTY, e.g.
`ssh -L <port>:<target-host> <userid>@<frontend-host>`
(For details see <http://wiki.eclipse.org/PTP/FAQ>)

- ★ When you configure the connection for the project

- ★ **Connection: New...**

- ★ The connection will use the port for the ssh tunnel (details on next slide)



Configure connection to remote host – SSH Tunnel (2)



- ★ In Target Environment Configuration dialog, enter target name, and host information
 - ★ 1. Specify **Target name**
 - ★ 2. If using a tunnel, select **Localhost** and enter userid and password for remote system
 - ★ For direct access, just select **Remote Host**, enter hostname, userid, password
 - ★ 3. select the **Advanced** button to specify the port
- ★ Select **Finish**

The screenshot shows two overlapping dialog boxes. The top one is 'Configure Remote Synchronization' with fields for Synchronization Provider (Git), Remote Provider (Remote Tools), Connection, and Location. The bottom one is 'Target Environment Configuration' for a 'Generic Remote Host'. It has a 'Target name' field containing 'BBC' (annotated with a red '1.'). Below it are 'Host Information' options: 'Localhost' (selected, annotated with a red '2.') and 'Remote host'. There are fields for 'Host:', 'User:', and 'Password:'. Authentication options include 'Password based authentication' (selected) and 'Public key based authentication'. There are also fields for 'File with private key:' and 'Passphrase:'. At the bottom of this dialog are 'Simplified' and 'Advanced' buttons (the 'Advanced' button is circled in red and annotated with a red '3.'). A separate dialog box in the foreground shows 'Port: 7373' (circled in red) and 'Timeout(sec): 5'. A red arrow points from the 'Advanced' button to this dialog, with the text 'Specify port for tunnel' below it.

Building a Project

✦ Objective

- ✦ Learn how to build an MPI program on a remote system

✦ Contents

- ✦ How to change build settings
- ✦ How to start a build and view build output
- ✦ How to clean and rebuild a project
- ✦ How to create build targets

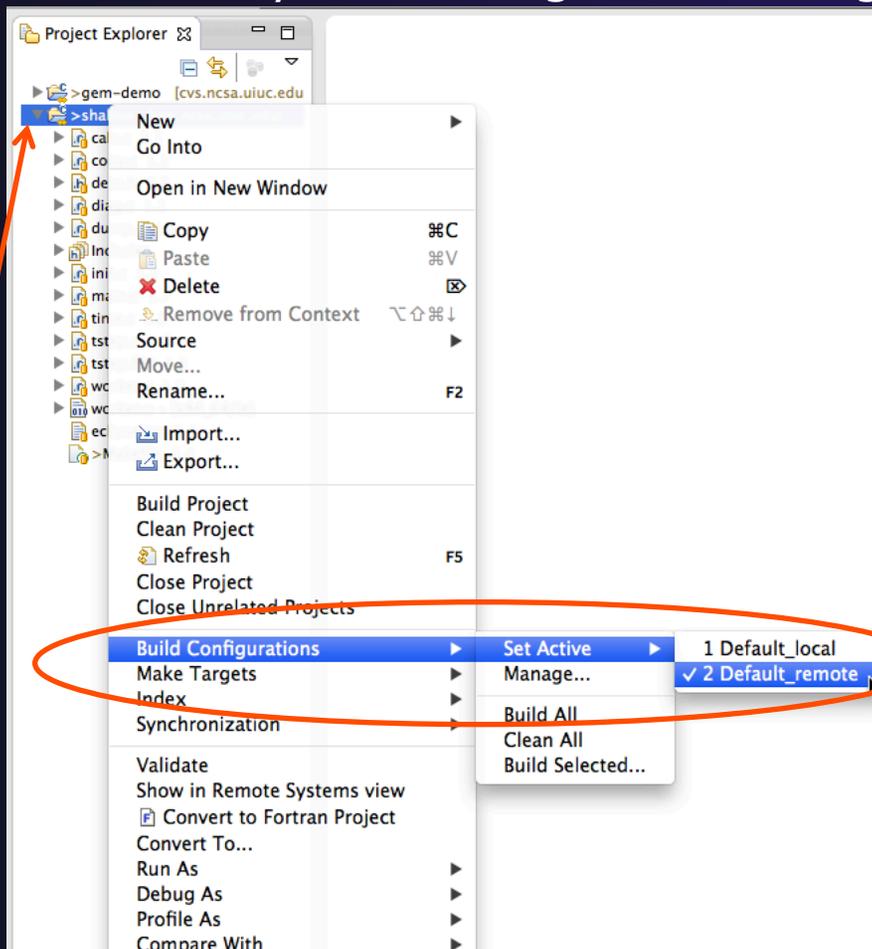
Synchronizing the Project Prior to Build

- ✦ Because we will be running on a remote system, we must also build on that system
- ✦ Source files must be available to build
- ✦ We have already created a synchronized project to do this
- ✦ Files are synchronized automatically when they are saved
- ✦ A full synchronize is also performed prior to a build



Active Build Configuration

- ★ The “Active” build configuration determines which system will be used for both synchronizing and building
- ★ Since this is a Synchronized Project, the remote target will be the Active Build Configuration by default
- ★ Right mouse on Project
- ★ Next slide confirms where this is....



Build

Build-2

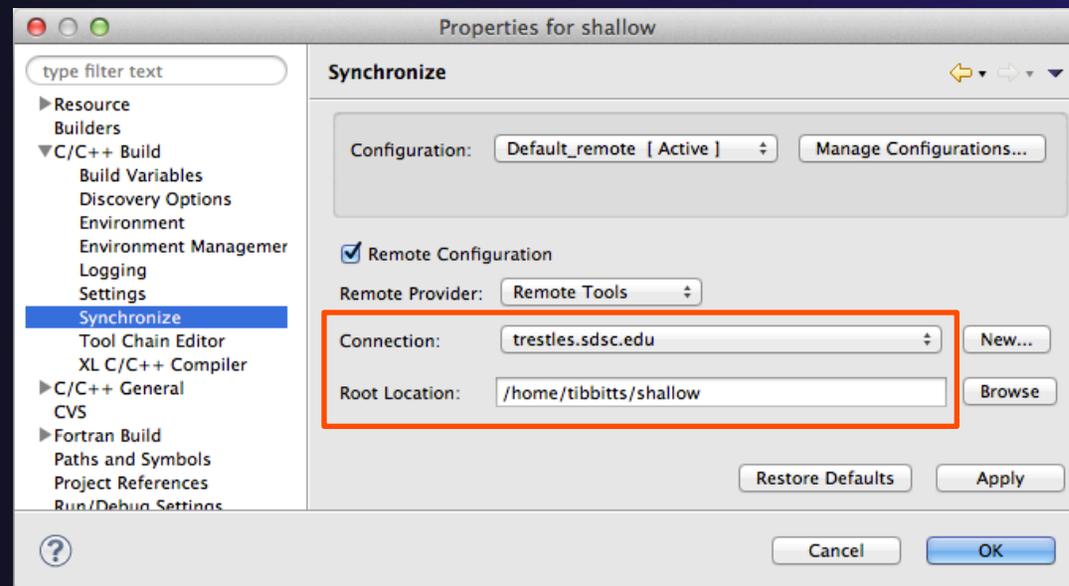
Confirm Active Build Configuration



- ★ “Where is my project going to build?”

To confirm where each build configuration is located:

- ★ In **Project Properties***, under C/C++ Build, select **Synchronize**. You should see the remote connection and file location



* To see Project Properties: in Project Explorer view, right mouse on project and select **Properties...** at the bottom of the context menu

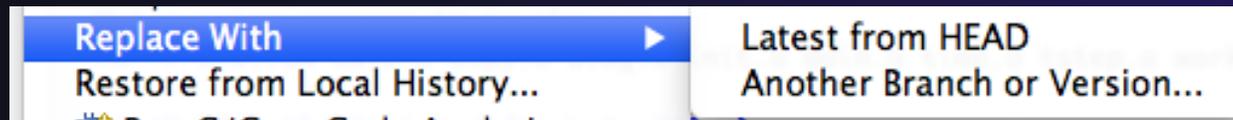
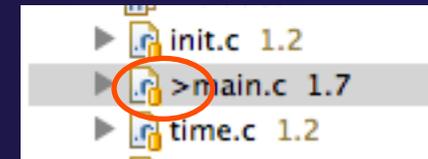
Start with clean 'shallow'

- ★ Start with original 'shallow' code:

- ★ Project checked out from CVS:

- ★ Right mouse on project,
Replace with > Latest from HEAD

Changed file:



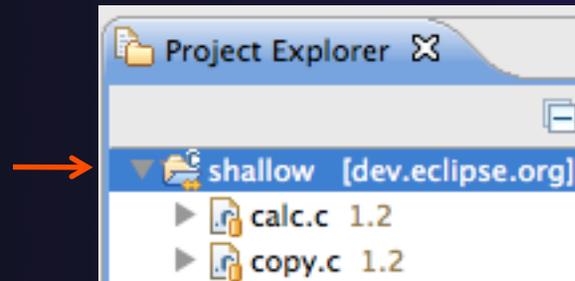
Also see Compare With ...

- ★ Other project:

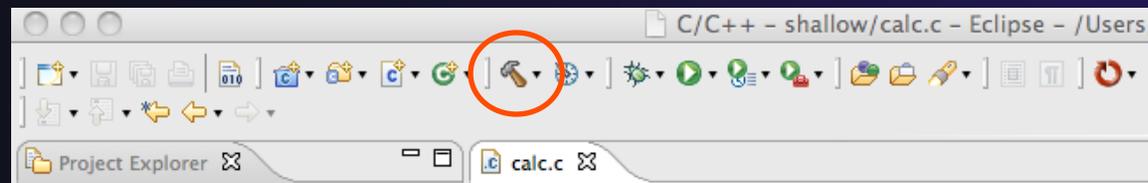
- ★ Right mouse on project,
Restore from local history – finds deleted files
 - ★ Right mouse on file, **Compare With**
or **Replace With**

Starting the Build

- ★ Select the project in Project Explorer



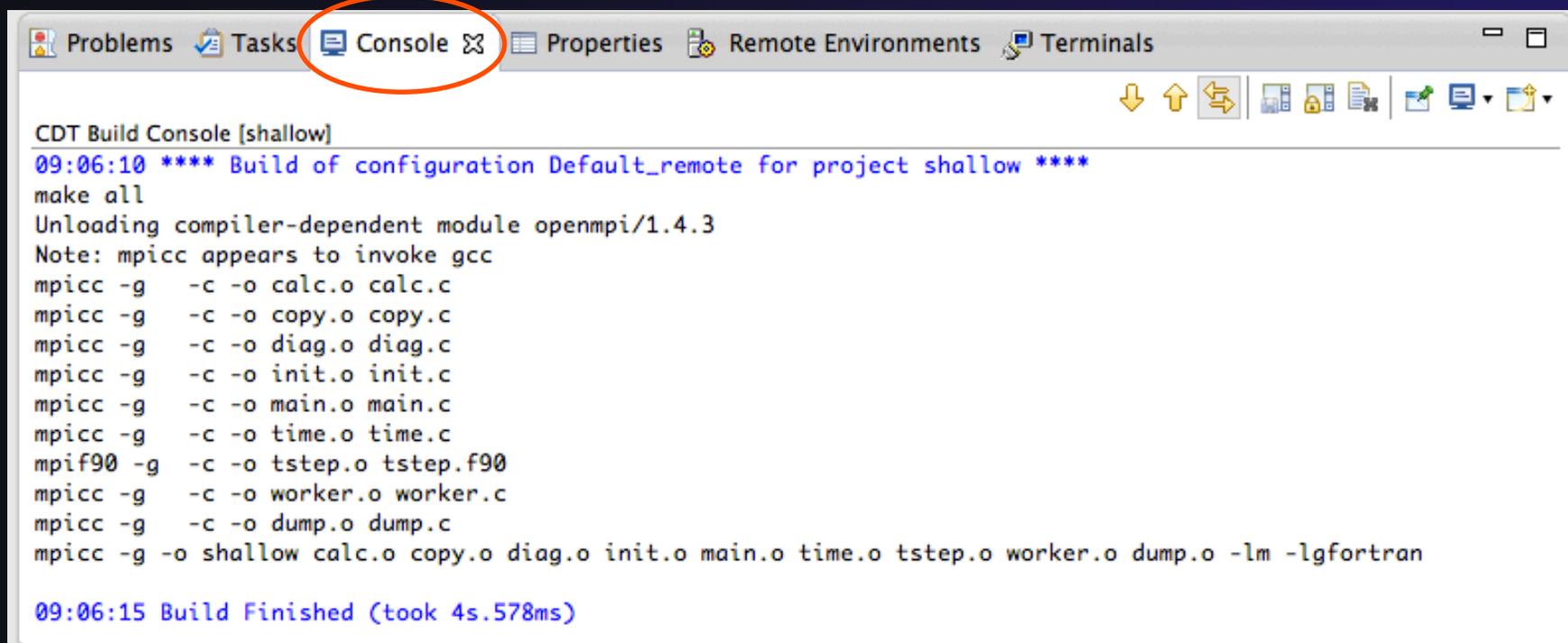
- ★ Click on the  hammer button in toolbar to run a build using the active build configuration



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

Viewing the Build Output

- ✦ Build output will be visible in console

A screenshot of an IDE's console window. The window title bar shows tabs for 'Problems', 'Tasks', 'Console', 'Properties', 'Remote Environments', and 'Terminals'. The 'Console' tab is selected and circled in orange. The console output shows the following text:

```
CDT Build Console [shallow]
09:06:10 **** Build of configuration Default_remote for project shallow ****
make all
Unloading compiler-dependent module openmpi/1.4.3
Note: mpicc appears to invoke gcc
mpicc -g -c -o calc.o calc.c
mpicc -g -c -o copy.o copy.c
mpicc -g -c -o diag.o diag.c
mpicc -g -c -o init.o init.c
mpicc -g -c -o main.o main.c
mpicc -g -c -o time.o time.c
mpif90 -g -c -o tstep.o tstep.f90
mpicc -g -c -o worker.o worker.c
mpicc -g -c -o dump.o dump.c
mpicc -g -o shallow calc.o copy.o diag.o init.o main.o time.o tstep.o worker.o dump.o -lm -lgfortran

09:06:15 Build Finished (took 4s.578ms)
```

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**

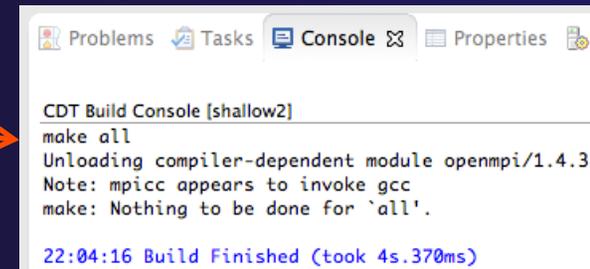
★ Double-click on line in **Problems view** to go to location of error in the editor

The screenshot shows the Eclipse IDE interface. The Project Explorer on the left shows a project named 'shallow' with various source files. The main editor window displays the code in 'main.c'. A syntax error is highlighted on line 97: 'for (i = 1; i < proc_cnt; i++) {'. The Problems view at the bottom shows three error messages: 'syntax error before '' token' at line 97, 'syntax error before ')' token' at line 97, and 'syntax error before "return"' at line 212. Red arrows from the text on the left point to the file 'main.c' in the Project Explorer, the error marker on line 97 in the editor, the error message in the Problems view, and the double-click action on the error message.

Description	Resource	Path	Location	Type
✘ syntax error before '' token	main.c	/shallow	line 97	C/C++ Problem
✘ syntax error before ')' token	main.c	/shallow	line 97	C/C++ Problem
✘ syntax error before "return"	main.c	/shallow	line 212	C/C++ Problem

Forcing a Rebuild

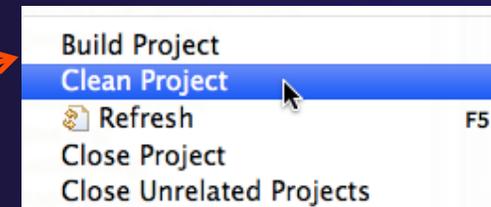
- ★ If no changes have been made, make doesn't think a build is needed e.g. if you only change the Makefile



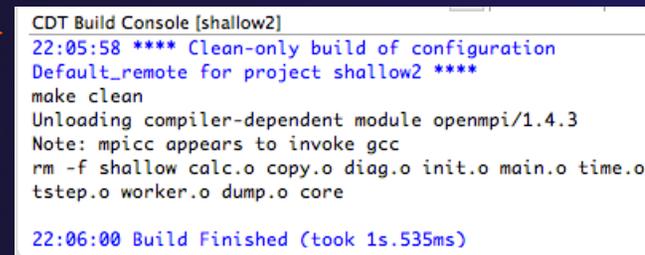
```
CDT Build Console [shallow2]
make all
Unloading compiler-dependent module openmpi/1.4.3
Note: mpicc appears to invoke gcc
make: Nothing to be done for 'all'.

22:04:16 Build Finished (took 4s.370ms)
```

- ★ In **Project Explorer**, right click on project; Select **Clean Project**



- ★ Build console will display results



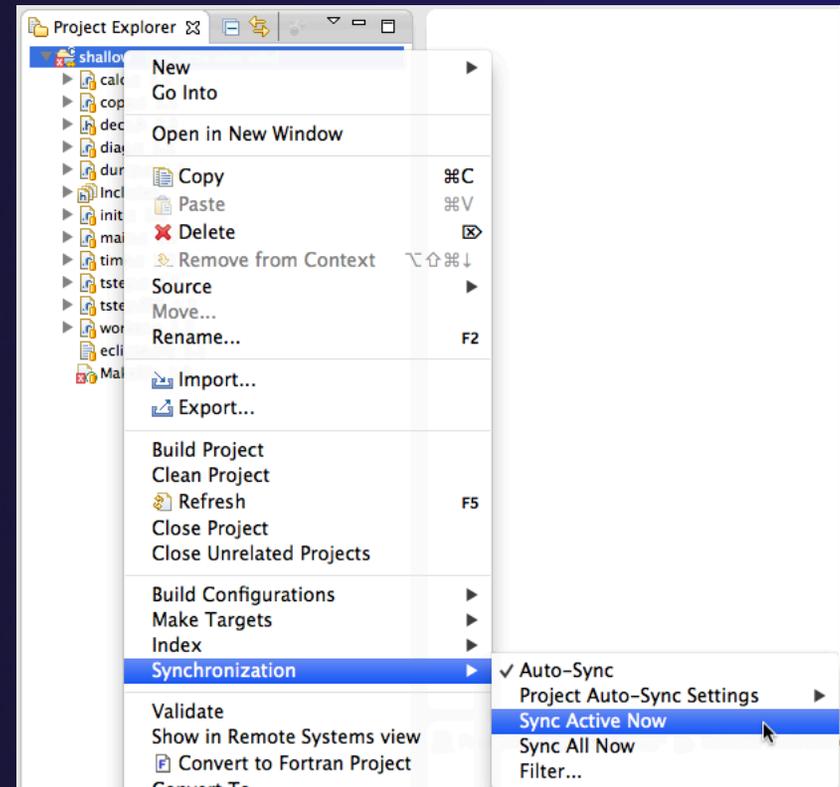
```
CDT Build Console [shallow2]
22:05:58 **** Clean-only build of configuration
Default_remote for project shallow2 ****
make clean
Unloading compiler-dependent module openmpi/1.4.3
Note: mpicc appears to invoke gcc
rm -f shallow calc.o copy.o diag.o init.o main.o time.o
tstep.o worker.o dump.o core

22:06:00 Build Finished (took 1s.535ms)
```

- ★ Rebuild project by clicking on build button again 

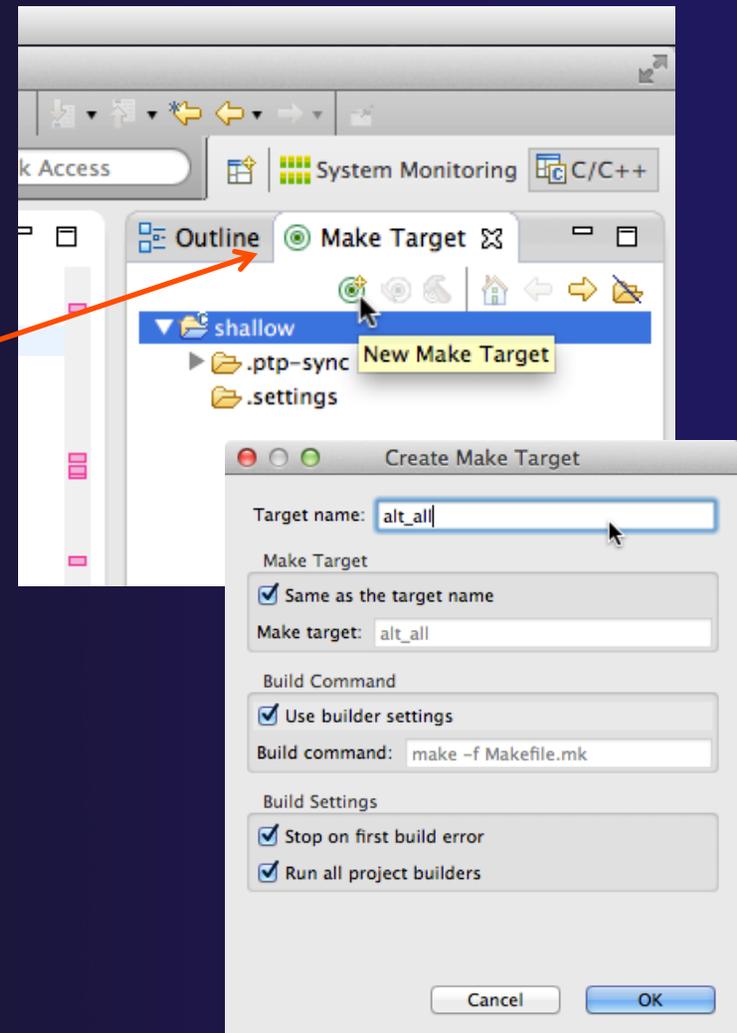
Forcing a Resync

- ★ Project should resync with remote system when things change
- ★ Sometimes you may need to do it explicitly
- ★ Right mouse on project, Synchronization>Sync Active Now
- ★ Status area in lower right shows when Synchronization occurs



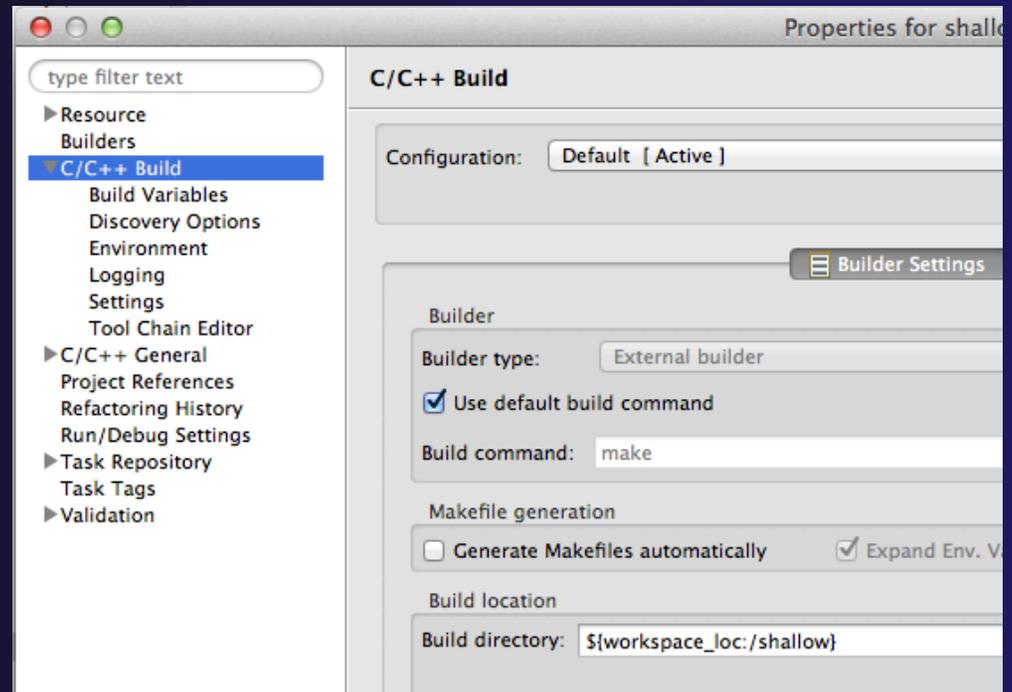
Creating Make Targets

- ✦ By default
 - ✦ The build button will run “make all”
 - ✦ Cleaning a project will run “make clean”
- ✦ Sometimes, other build targets are required
- ✦ Open **Make Target** view
- ✦ Select project and click on **New Make Target** button
- ✦ Enter new target name
- ✦ Modify build command if desired
- ✦ New target will appear in view
- ✦ Double click on target to activate



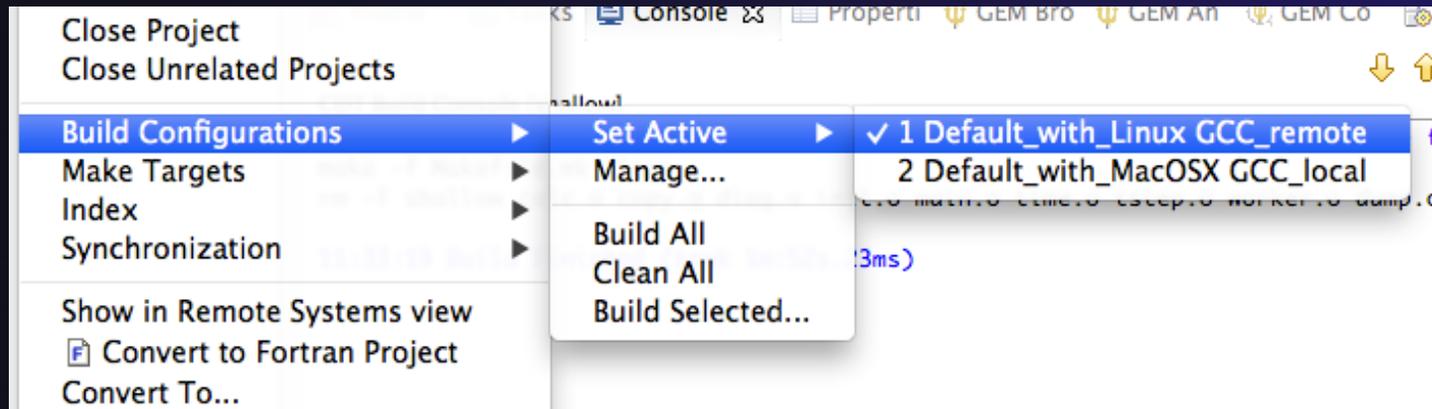
Build Configuration

- ★ The build configuration is specified in the project properties
- ★ Open the properties by right-clicking on the project name in the **Project Explorer** view and selecting **Properties** (bottom of the context menu list)
- ★ **C/C++ Build**
 - ★ Configure the build command
 - ★ Default is “make” but this can be changed to anything
- ★ **C/C++ Build > Settings**
 - ★ Binary and Error parser selection
 - ★ Tool Chain settings (managed projects only)
- ★ **C/C++ Build > Environment**
 - ★ Modify/add environment variables passed to build
- ★ **C/C++ Build > Logging**
 - ★ Enable/disable build logging



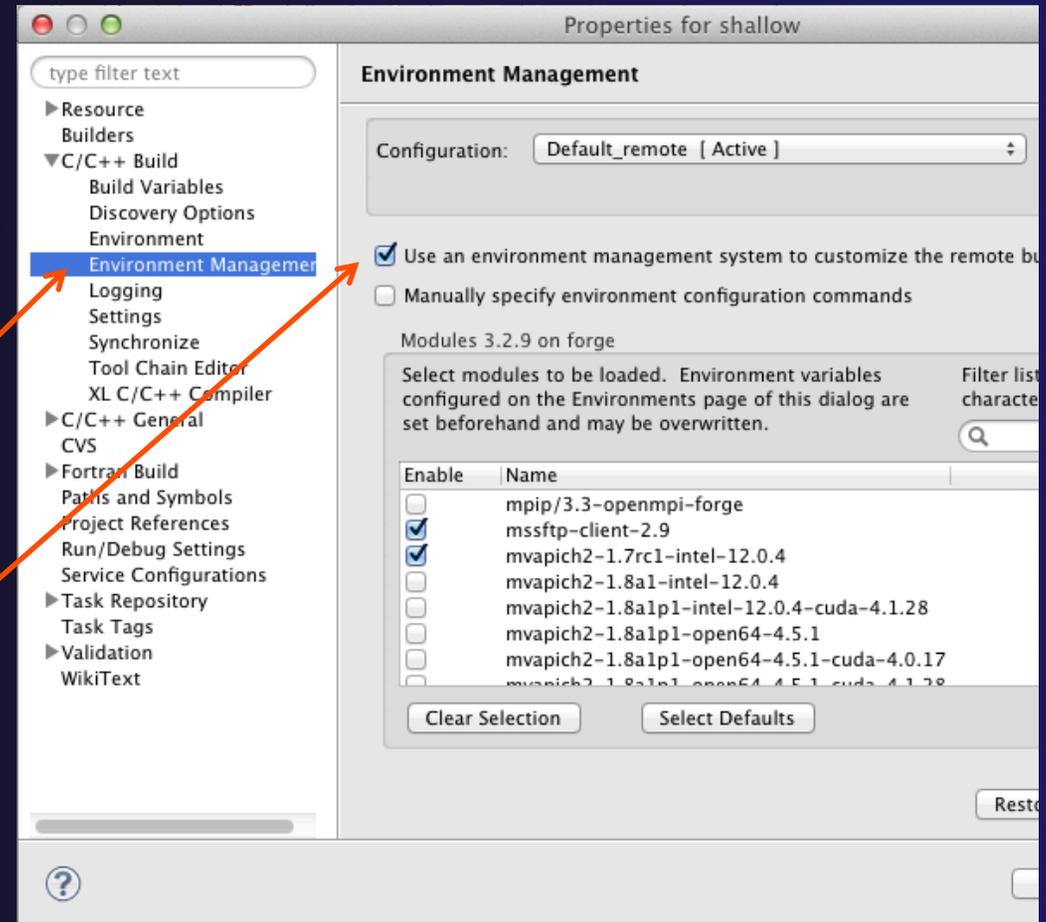
Selecting Build Configuration

- ★ Multiple build configurations may be available
 - ★ Remote and local build configuration
 - ★ Build configurations for different architectures
- ★ The active build configuration is set from the **Build Configurations** project context menu
 - ★ Right click on project, then select the build configuration from the **Build Configurations > Set Active** menu



Configuring Build Modules

- ★ If the remote system has Modules installed, a custom set of modules can be configured for building C/C++ projects
- ★ In the project properties, navigate to **C/C++ Build > Environment Management**
- ★ Check **Use an environment management system to customize the remote build environment**



Configuring Build Modules (2)

★ Select modules from the list

★ Use the **Filter list** field to quickly find modules with a given name

Use an environment management system to customize the remote build environment
 Manually specify environment configuration commands

Modules 3.2.9 on forge

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):

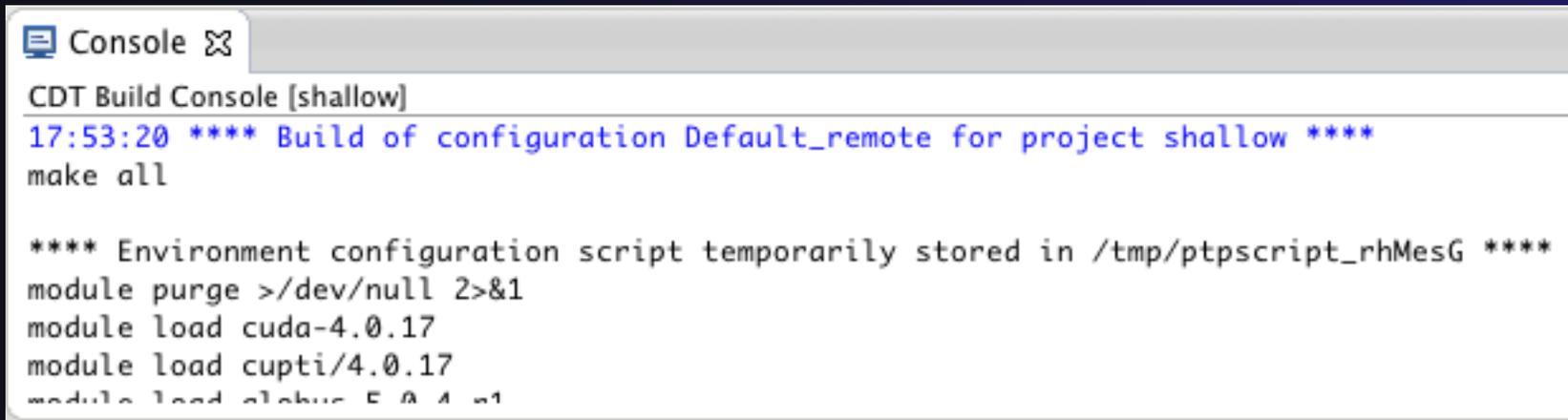
Enable	Name
<input type="checkbox"/>	mpip/3.3-openmpi-forge
<input checked="" type="checkbox"/>	mssftp-client-2.9
<input checked="" type="checkbox"/>	mvapich2-1.7rc1-intel-12.0.4
<input type="checkbox"/>	mvapich2-1.8a1-intel-12.0.4
<input type="checkbox"/>	mvapich2-1.8a1p1-intel-12.0.4-cuda-4.1.28
<input type="checkbox"/>	mvapich2-1.8a1p1-open64-4.5.1
<input type="checkbox"/>	mvapich2-1.8a1p1-open64-4.5.1-cuda-4.0.17
<input type="checkbox"/>	mvapich2-1.8a1p1-open64-4.5.1-cuda-4.1.28

Clear Selection Select Defaults Reload List

★ Click **Select Defaults** to check only those modules that are present in a new Bash login shell

Configuring Build Modules (3)

- ✦ To build the project, Eclipse will
 - ✦ Open a new Bash login shell
 - ✦ Execute *module purge*
 - ✦ Execute *module load* for each selected module
 - ✦ Run *make*
- ✦ Module commands are displayed in the Console view during build
- ✦ Beware of modules that must be loaded in a particular order, or that contain common paths like */bin* or */usr/bin*



```
Console [X]
CDT Build Console [shallow]
17:53:20 **** Build of configuration Default_remote for project shallow ****
make all

**** Environment configuration script temporarily stored in /tmp/ptpscript_rhMesG ****
module purge >/dev/null 2>&1
module load cuda-4.0.17
module load cupti/4.0.17
module load ctkub 5.0.4.01
```



Exercise

1. Start with your 'shallow' project
2. Build the project
3. Edit a source file and introduce a compile error
 - ✦ In main.c, line 97, change ';' to ':'
 - ✦ Save, rebuild, and watch the Console view
 - ✦ Use the Problems view to locate the error
 - ✦ Locate the error in the source code by double clicking on the error in the **Problems** view
 - ✦ Fix the error
4. Rebuild the project and verify there are no build errors



Optional Exercise

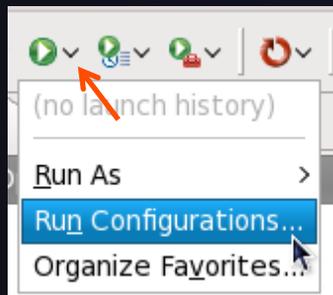
1. Open the Makefile in Eclipse. Note the line starting with "tags:" – this defines a make target named **tags**.
2. Open the Outline view while the Makefile is open. What icon is used to denote make targets in the Outline?
3. Right-click the **tags** entry in the Outline view. Add a Make Target for **tags**.
4. Open the Make Targets view, and build the **tags** target.

5. Rename Makefile to Makefile.mk
6. Attempt to build the project; it will fail
7. In the project properties (under the C/C++ Build category), change the build command to: `make -f Makefile.mk`
8. Build the project; it should succeed

Running an Application

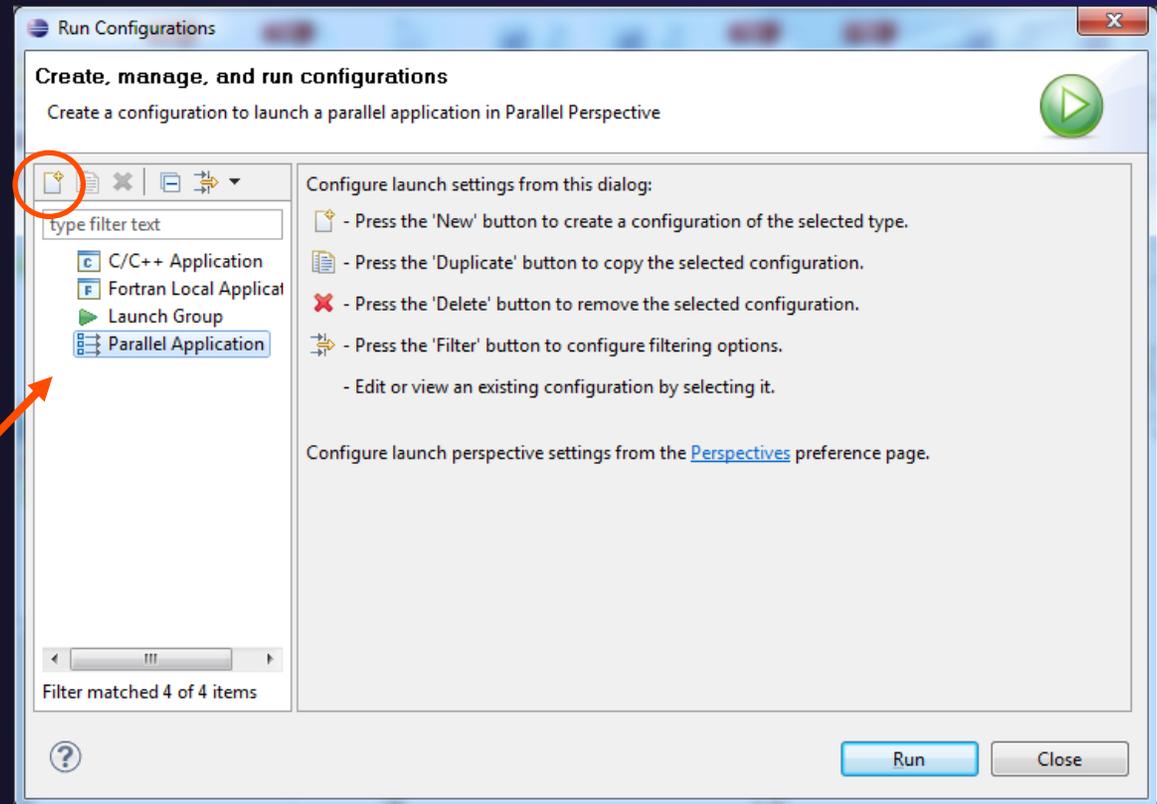
- ★ Objective
 - ★ Learn how to run an MPI program on a remote system
- ★ Contents
 - ★ Creating a run configuration
 - ★ Configuring the application run
 - ★ Monitoring the system and jobs
 - ★ Controlling jobs
 - ★ Obtaining job output

Creating a Run Configuration



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

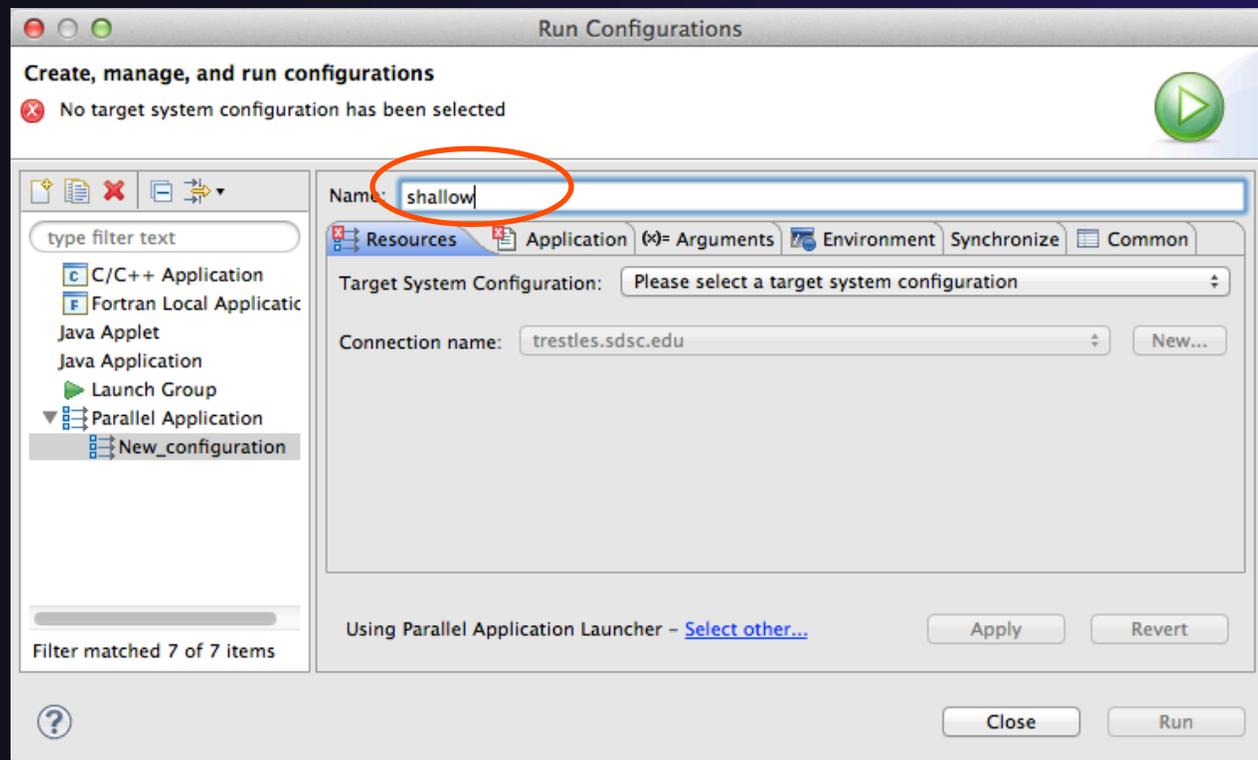
Or, just double-click on **Parallel Application** to create a new one



Note: We use “Launch Configuration” as a generic term to refer to either a “Run Configuration” or a “Debug Configuration”, which is used for debugging.

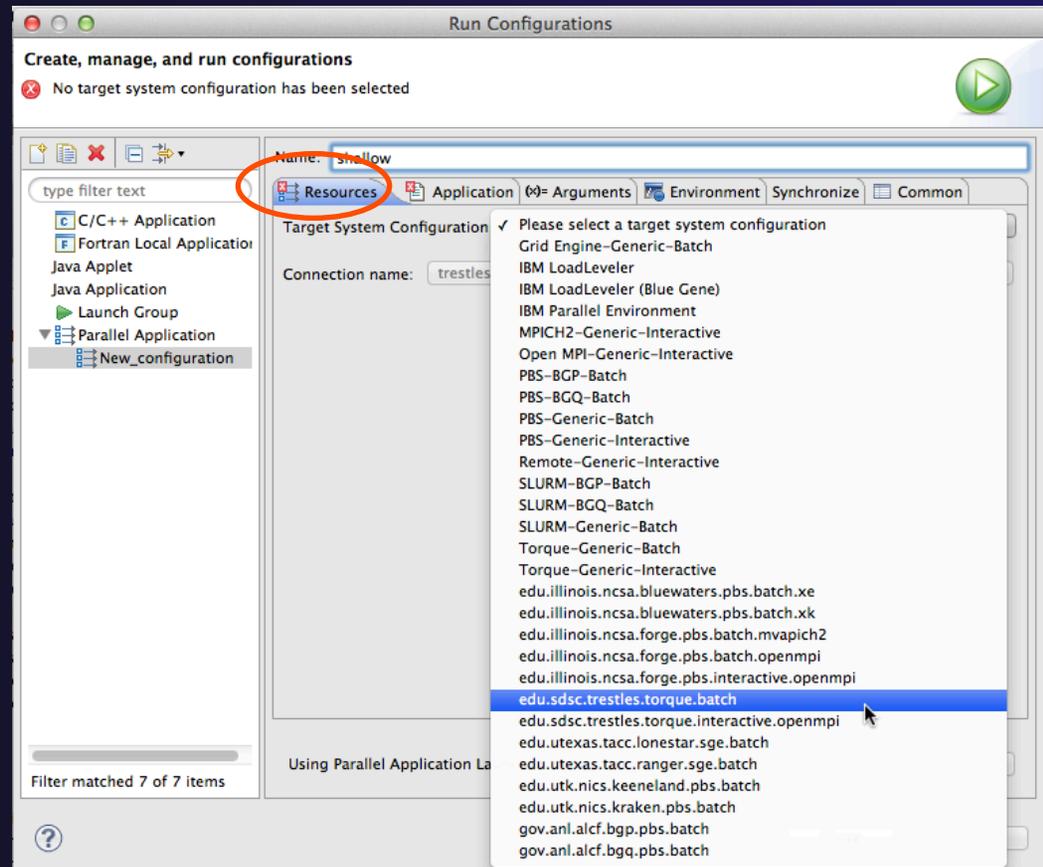
Set Run Configuration Name

- ✦ Enter a name for this run configuration
 - ✦ E.g. “shallow”
- ✦ This allows you to easily re-run the same application



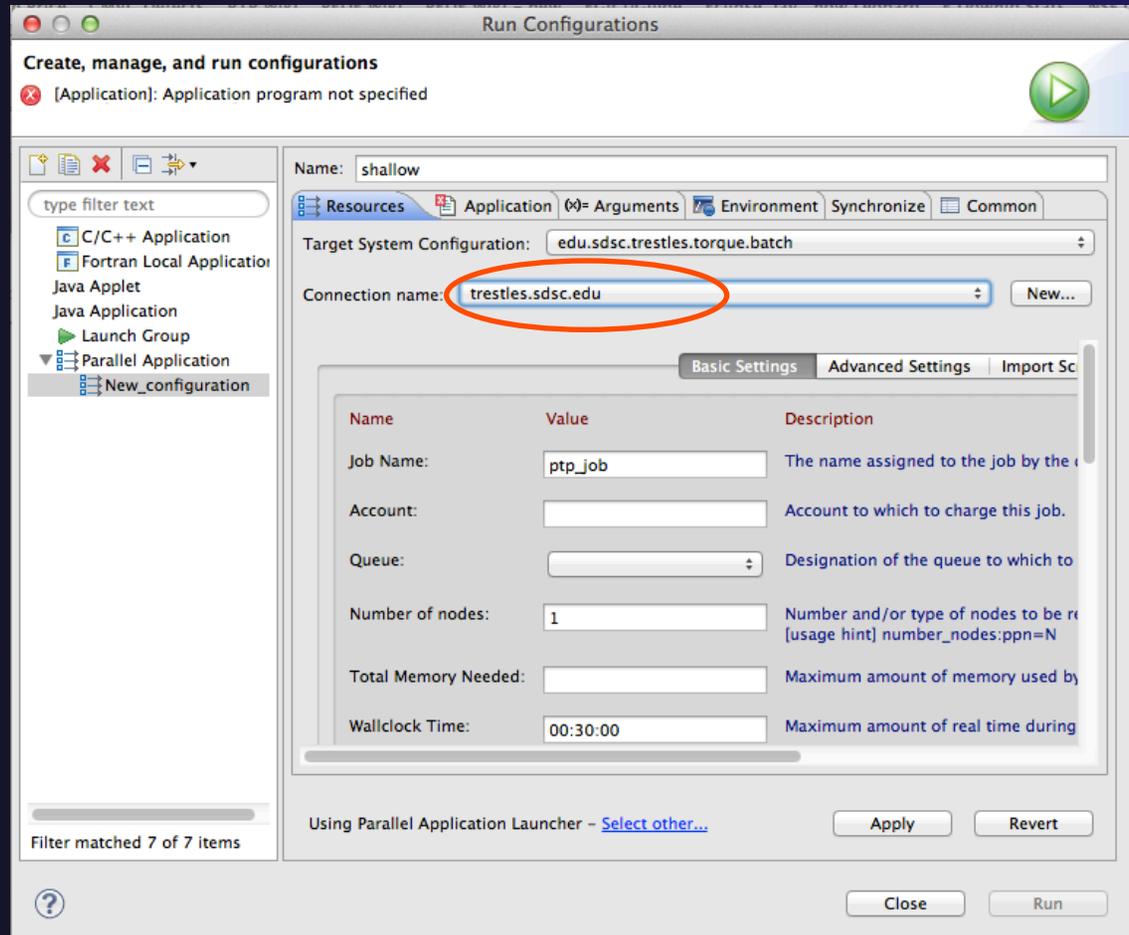
Configuring the Target System

- ★ In **Resources** tab, select a **Target System Configuration** that corresponds to your target system
 - ★ The tutorial instructor will indicate what Target System Configuration to select
 - ★ SC12: use `edu.sdsc.trestles.torque.batch`
- ★ Target system configurations can be *generic* or can be specific to a particular system
- ★ Use the specific configuration if available, or the generic configuration that most closely matches your system



Configure the Connection

- ★ Choose a connection to use to communicate with the target system
- ★ If no connection has been configured, click on the **New** button to create a new one
 - ★ Fill in connection information, then click ok
- ★ The new connection should appear in the dropdown list
- ★ SC12: Select the connection you already have to trestles.sdsc.edu



Resources Tab

- ★ The content of the **Resources** tab will vary depending on the target system configuration selected
- ★ This example shows the TORQUE configuration
- ★ For TORQUE, you will normally need to select the *Queue* and the *Number of nodes*
- ★ For parallel jobs, choose the *MPI Command* and the *MPI Number of Processes*

Name	Value	Description
Job Name:	ptp_job	The name assigned to the job by the qsub or qalter c
Account:		Account to which to charge this job.
Queue:	shared	Designation of the queue to which to submit the job.
Number of nodes:	1:ppn=5	Number and/or type of nodes to be reserved for excl [usage hint] number_nodes:ppn=N
Total Memory Needed:		Maximum amount of memory used by all concurrent
Wallclock Time:	00:30:00	Maximum amount of real time during which the job c
MPI Command:	mpirun	Which mpi command to use.
MPI Number of Processes:	5	the '-np' value [usually equals Nodes*ppn]
Export Environment:	<input checked="" type="checkbox"/>	All variables in the qsub command's environment are

Buttons: View Script, View Configuration, Restore Defaults

Viewing the Job Script

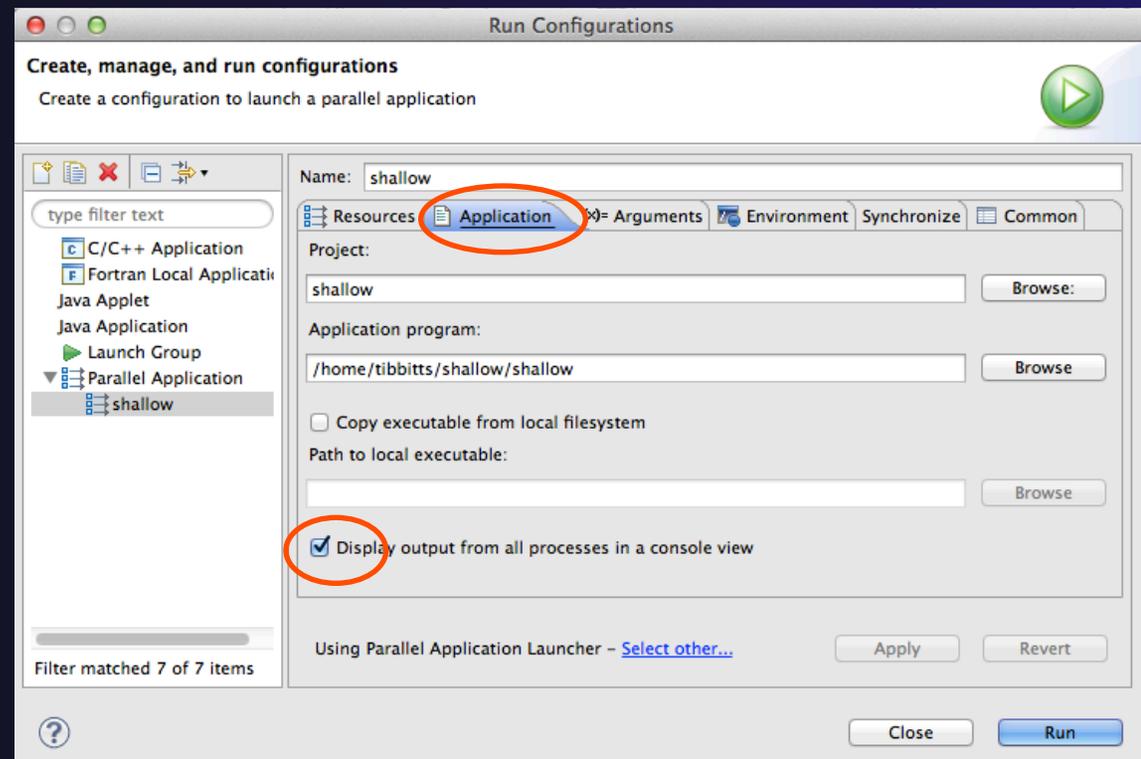
- ★ Some target configurations will provide a **View Script** button
- ★ Click on this to view the job script that will be submitted to the job scheduler
- ★ Batch scheduler configurations should also provide a means of importing a batch script

The screenshot shows a web-based job configuration interface. The 'View Script' button is highlighted with an orange arrow. A window titled 'Script with current values' is open, displaying the following job script:

```
#!/bin/bash --login
#PBS -q shared
#PBS -N ptp_job
#PBS -l nodes=1:ppn=5
#PBS -l walltime=00:30:00
#PBS -V
MPI_ARGS="-np 5"
if [ "-np" == "${MPI_ARGS}" ]; then
  MPI_ARGS=
fi
cd /oasis/scratch/trestles/$USER/$PBS_JOBID
cp /home/tibbitts/shallow/shallow .
MYSCREXE=`basename /home/tibbitts/shallow/shallow`
COMMAND=mpirun
if [ -n "$COMMAND" ]; then
  COMMAND="$COMMAND" ${MPI_ARGS} -hostfile ${PBS_NODEFILE} ${MYSCREXE} "
else
  COMMAND="${MYSCREXE} "
fi
${COMMAND}
```

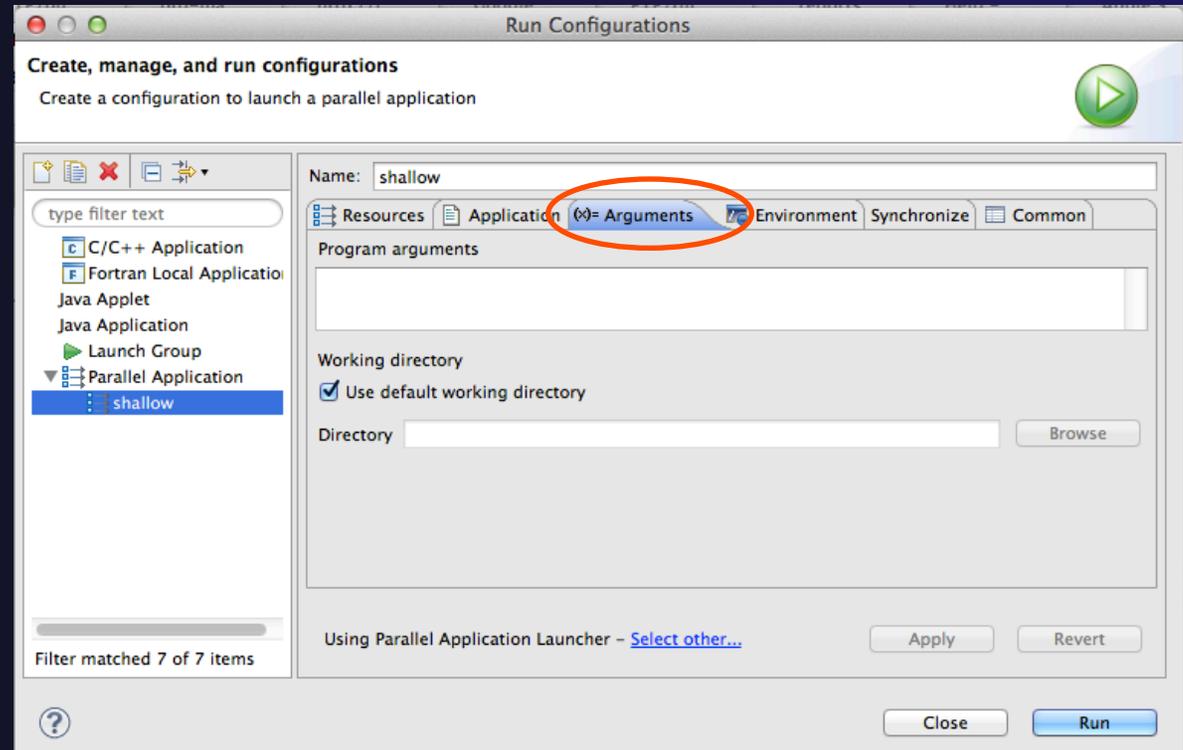
Application Tab

- ★ 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**



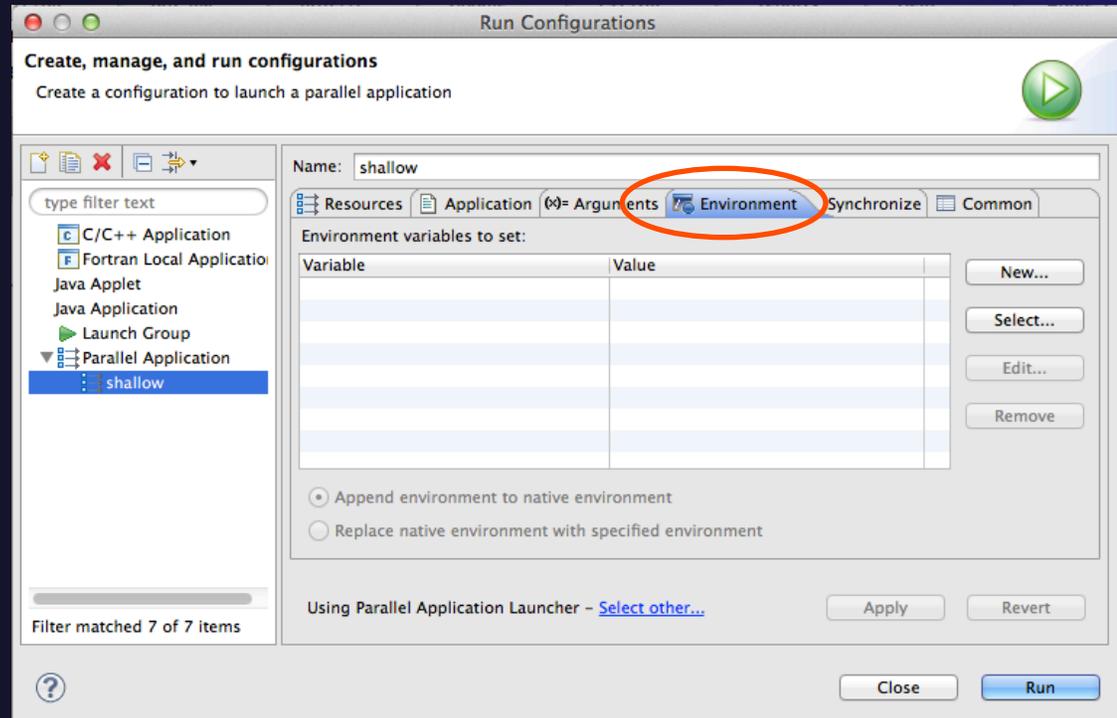
Arguments Tab (Optional)

- ★ The **Arguments** tab lets you supply command-line arguments to the application
- ★ You can also change the default working directory when the application executes



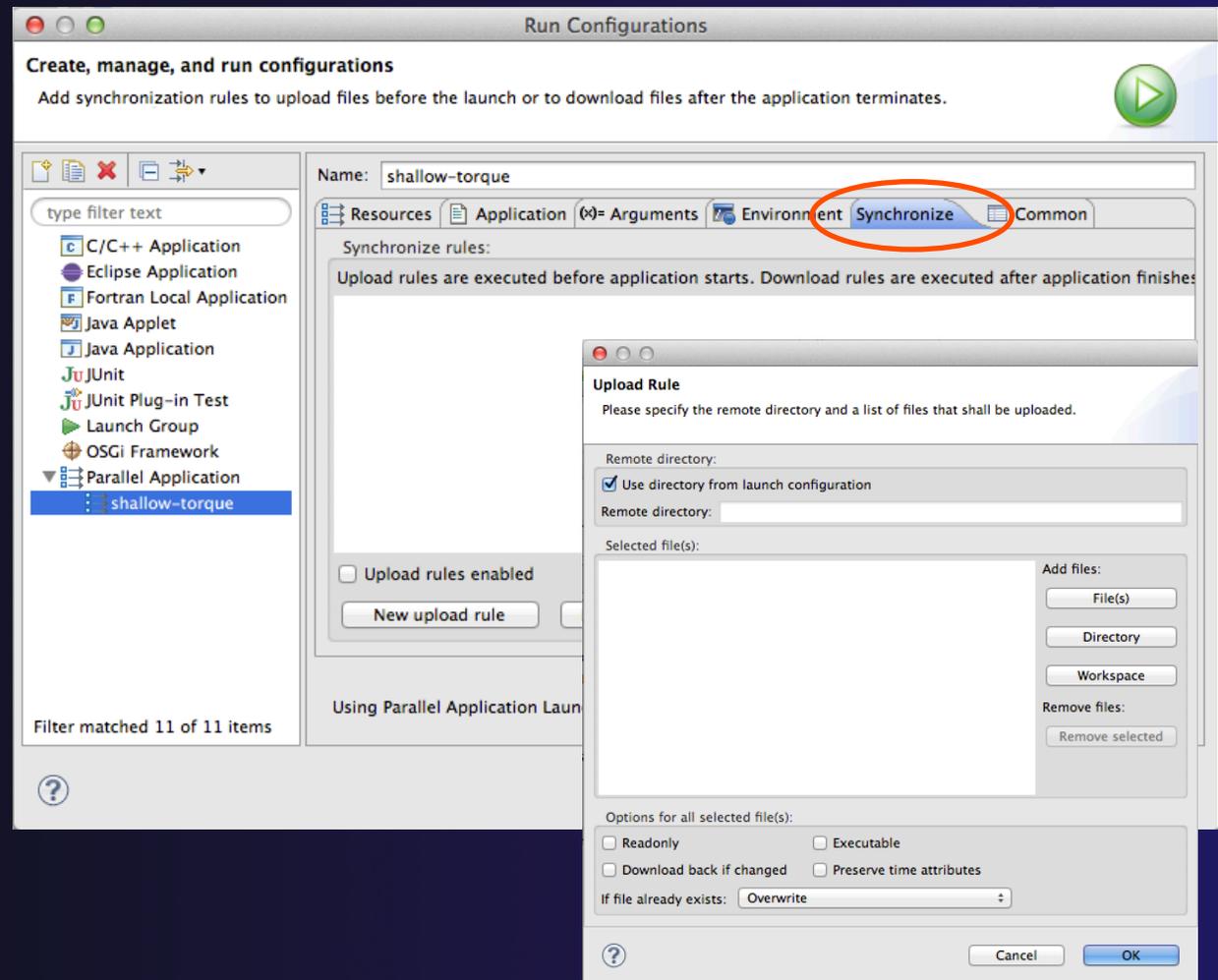
Environment Tab (Optional)

- ★ The **Environment** tab lets you set environment variables that are passed to the job submission command
- ★ This is independent of the Environment Management (module/softenv) support described in a separate module



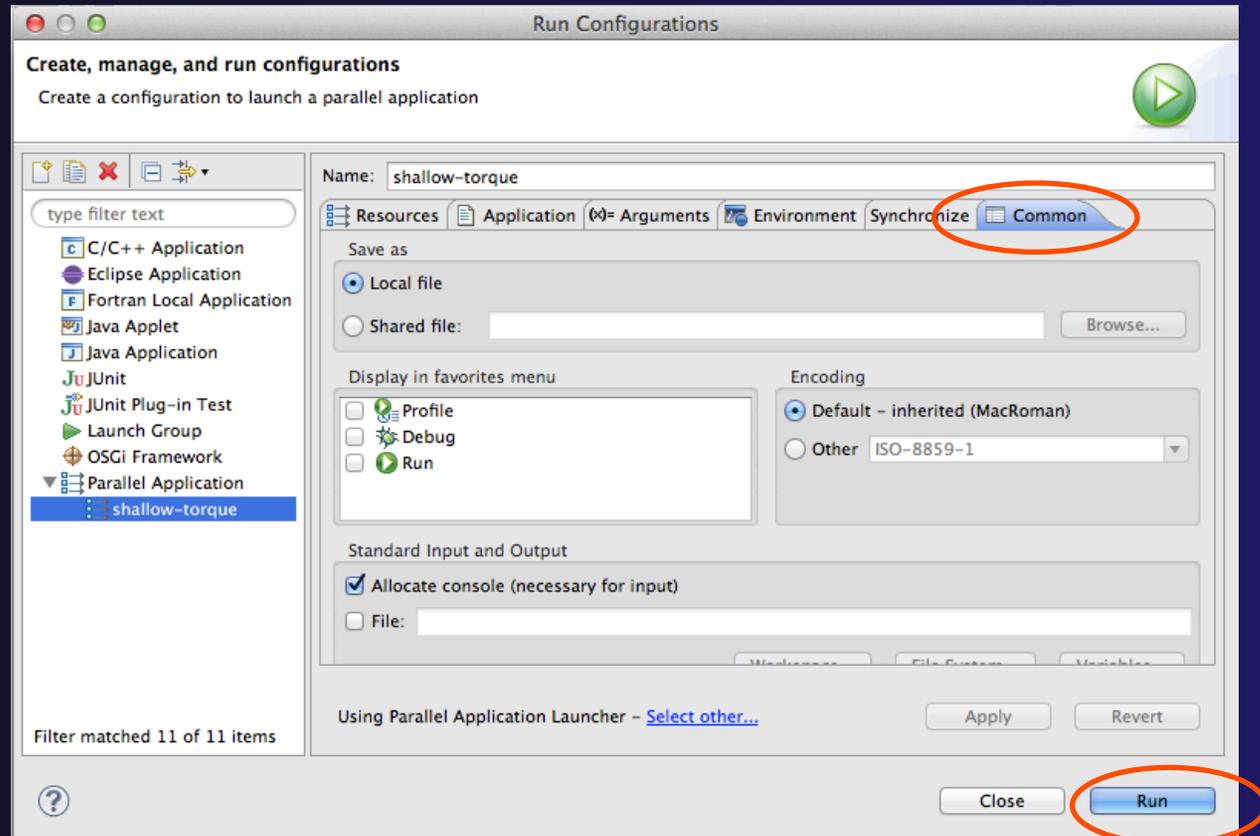
Synchronize Tab (Optional)

- ★ The **Synchronize** tab lets you specify upload/download rules that are executed prior to, and after the job execution
- ★ Click on the **New upload/download rule** buttons to define rules
- ★ The rule defines which file will be uploaded/downloaded and where it will be put
- ★ Can be used in conjunction with program arguments to supply input data to the application



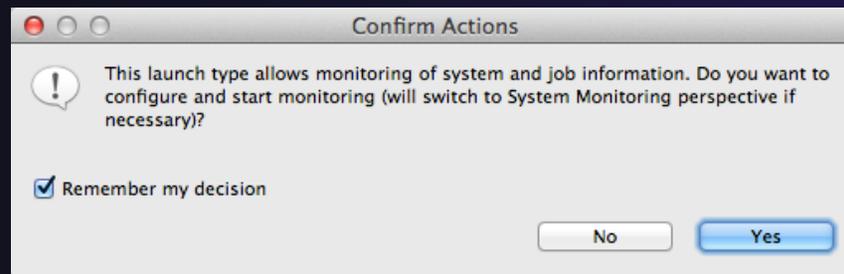
Common Tab (Optional)

- ★ The **Common** tab is available for most launch configuration types (not just Parallel Application)
- ★ Allows the launch configuration to be exported to an external file
- ★ Can add the launch configuration to the favorites menu, which is available on the main Eclipse toolbar
- ★ Select **Run** to launch the job



Run

- ✦ Select **Run** to launch the job
- ✦ You may be asked to switch to the System Monitoring Perspective



- ✦ Select **Remember my decision** so you won't be asked again
- ✦ Select **Yes** to switch and launch the job

System Monitoring Perspective

★ System view

★ Jobs running on system

★ Active jobs

★ Inactive jobs

★ Messages

★ Console

The screenshot shows the Eclipse IDE interface with the System Monitoring perspective. The top toolbar includes icons for System Monitoring and Parallel Debug. The main area is divided into several views:

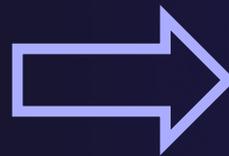
- Monitors:** Shows the connection name 'trestles.sdsc.edu' and system type 'TORQUE Resource Manager'.
- Active Jobs:** A table with columns: step, owner, queue, wall, queued, dispatched, total. It lists four active jobs with step ID 10553, owner 'jmondal', and queue 'normal'.
- Inactive Jobs:** A table with columns: step, owner, queue, wall, queued, dispatched, total. It lists three inactive jobs with step IDs 1056...
- Messages:** Shows a message: '<terminated> shallow [Parallel Application] Runtime process 1'.
- Console:** Shows the same message as the Messages view.
- Job Status Grid:** A large grid of small colored squares representing the status of individual jobs or processes across the system.

Scroll to see more

Moving views

- ★ The System Monitoring Perspective overlaps the **Active Jobs** and **Inactive Jobs** views
- ★ To split them apart and see both at once, *drag* the tab for the **Inactive Jobs** view to the lower half of its area, and let go of mouse

step	owner	queue	wall	queue	dispat	totalcc	status
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	179...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED



step	owner	queue	wall	queue	dispat	totalcc	status
509...	alb...	eight	172...	20...	20...	24	RUNNING
509...	alb...	eight	172...	20...	20...	24	RUNNING
509...	rde...	nor...	172...	20...	20...	4	RUNNING
509...	rde...	nor...	172...	20...	20...	4	RUNNING

step	owner	queue	wall	queue	dispat	totalcc	status
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED
510...	llev...	nor...	129...	20...	?	16	SUBMITTED

System Monitoring

- ★ **System** view, with abstraction of system configuration
- ★ Hold mouse button down on a job in **Active Jobs** view to see where it is running in **System** view
- ★ Hover over node in **System** view to see job running on node in **Active Jobs** view

Monitors

Status	Connection Name	System Type
z25c2s2	ompi_host	IBM LoadLeveler
forge.ncsa.illinois.edu	TORQUE Resource Manager	

system: forge.ncsa.illinois.edu

Active Jobs

step	owner	queue	wall	queuec	dispatc	totalco	status
495...	rarijit	normal	172...	201...	201...	12	RUNNING
500...	rarijit	eight	50400	201...	201...	6	RUNNING
500...	rarijit	eight	43200	201...	201...	6	RUNNING
500...	rarijit	eight	43200	201...	201...	6	RUNNING
500...	rarijit	eight	43200	201...	201...	6	RUNNING
500...	rarijit	eight	43200	201...	201...	6	RUNNING
500...	rarijit	eight	82800	201...	201...	6	RUNNING
501...	mkb72	normal	172...	201...	201...	6	RUNNING
501...	mkb72	normal	172...	201...	201...	6	RUNNING

Inactive Jobs

step	owner	queue	wall	queuec	dispatc	totalco	status
390...	sgot...	normal	3300	201...	?	?	SUBMITTED
500...	rarijit	eight	86400	201...	?	6	SUBMITTED
500...	rarijit	eight	82800	201...	?	6	SUBMITTED
501...	alberto	eight	172...	201...	?	16	SUBMITTED
501...	rarijit	eight	79200	201...	?	6	SUBMITTED
501...	rarijit	eight	79200	201...	?	6	SUBMITTED
501...	rarijit	eight	79200	201...	?	6	SUBMITTED
501...	rarijit	eight	43200	201...	?	6	SUBMITTED
501...	rarijit	eight	79200	201...	?	6	SUBMITTED
501...	rarijit	eight	79200	201...	?	6	SUBMITTED
501...	rarijit	eight	79200	201...	?	6	SUBMITTED
501...	rarijit	eight	79200	201...	?	6	SUBMITTED
501...	rarijit	eight	79200	201...	?	6	SUBMITTED
501...	rarijit	eight	79200	201...	?	6	SUBMITTED

Messages Console Remote Environments

Welcome to Forge NCSA's DELL login node running RedHat 6 and has NVIDIA Tesla M2070's

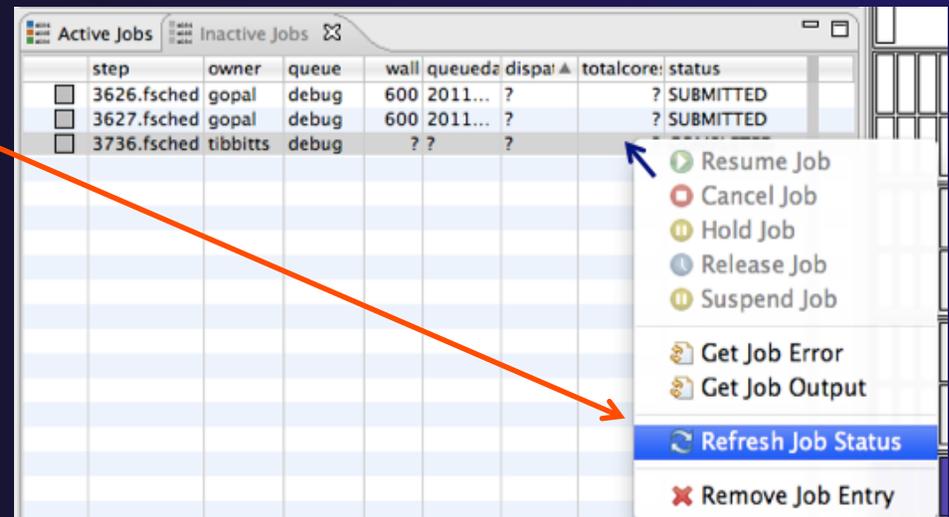
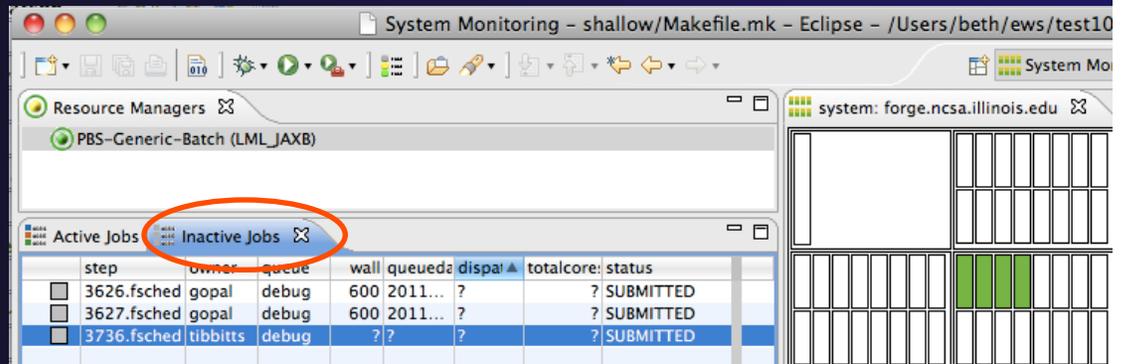
See for more detailed information about this system.
<http://www.ncsa.illinois.edu/UserInfo/Resources/Hardware/DellINVIDIACluster/>

LML DA Driver (forge...inois.edu): (90%)

One node with
16 cores

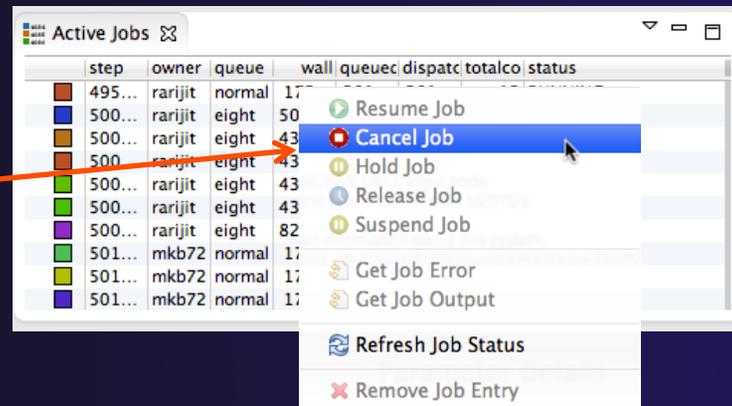
Job Monitoring

- ✦ Job initially appears in **Inactive Jobs** view
- ✦ Moves to the **Active Jobs** view when execution begins
- ✦ Returns to **Inactive Jobs** view on completion
- ✦ Status refreshes automatically every 60 sec
- ✦ Can force refresh with menu



Controlling Jobs

- ★ Right click on a job to open context menu
- ★ Actions will be enabled IFF
 - ★ The job belongs to you
 - ★ The action is available on the target system
 - ★ The job is in the correct state for the action
- ★ When job has COMPLETED, it will remain in the **Inactive Jobs** view



step	owner	queue	wall	queuenc	dispatc	totalco	status
501...	rarijit	eight	79200	201...	?	6	SUBMITTED
501...	rarijit	eight	79200	201...	?	6	SUBMITTED
501...	rarijit	eight	79200	201...	?	6	SUBMITTED
501...	rarijit	eight	79200	201...	?	6	SUBMITTED
502...	nvellor	normal	86400	201...	?	6	SUBMITTED
503...	boxu	normal	28800	201...	?	64	SUBMITTED
503...	boxu	normal	18000	201...	?	64	SUBMITTED
503...	boxu	normal	18000	201...	?	64	SUBMITTED
503...	boxu	normal	28800	201...	?	64	SUBMITTED
504...	alberto	eight	172...	201...	?	24	SUBMITTED
504...	alberto	eight	172...	201...	?	24	SUBMITTED
504...	inca	normal	300	201...	?	4	SUBMITTED
501...	grw		?	?	?	?	COMPLETED

Obtaining Job Output

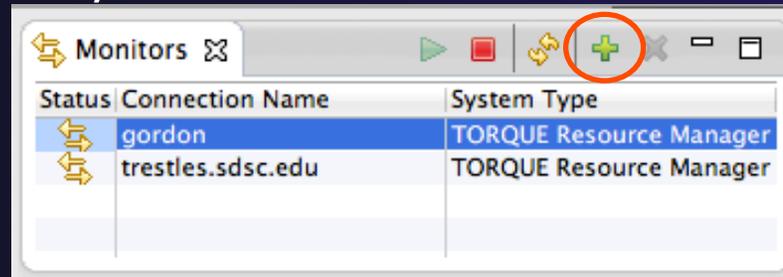
- ✦ After status changes to **COMPLETED**, the output is available
 - ✦ Right-click on the job
 - ✦ Select **Get Job Output** to display output sent to standard output
 - ✦ Select **Get Job Error** to retrieve output sent to standard error
- ✦ Output/Error info shows in **Console View**
- ✦ Jobs can be removed by selecting **Remove Job Entry**

The screenshot shows a window titled "Inactive Jobs" with a table of job entries. The table has columns: step, owner, queue, wall, queuedate, dispatch, total, and status. The job 3777.fsched is selected. A context menu is open over this job, listing actions: Resume Job, Cancel Job, Hold Job, Release Job, Suspend Job, Get Job Error, Get Job Output (highlighted), Refresh Job Status, and Remove Job Entry. Below the table, the "Console" view is visible, showing output for job 3777.fsched, including energy and cycle information. Red arrows indicate the flow from the text instructions to the corresponding UI elements.

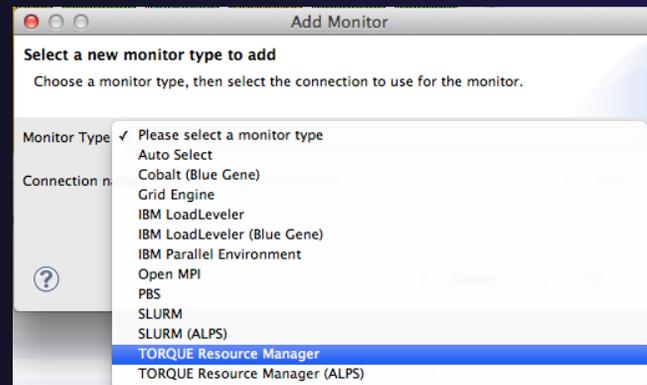
step	owner	queue	wall	queuedate	dispatch	total	status
3626.fsched	gopal	debug	600	2011-1...	?	?	SUBMITTED
3627.fsched	gopal	debug	600	2011-1...	?	?	SUBMITTED
3769.fsched	alberto	normal	43...	2011-1...	?	18	SUBMITTED
3774.fsched	dsouth	normal	14...	2011-1...	?	12	SUBMITTED
3772.fsched	tibbitts		??		?	?	COMPLETED
3773.fsched	tibbitts	debug	??		?	?	COMPLETED
3777.fsched	tibbitts	debug	??		?	?	COMPLETED
3783.fsched	tibbitts	debug	??		?	?	COMPLETED

Add a Monitor

- ★ You can monitor other systems too
- ★ In **Monitors** view, select the '+' button to add a monitor



- ★ Choose monitor type and connection;
create a new connection if necessary



Double click
new monitor
to start



Exercise

1. Start with your 'shallow' project
2. Create a run configuration
3. Complete the Resources tab
4. Select the executable in the Application tab
5. Submit the job
6. Check the job is visible in the Inactive Jobs view, moves to the Active Jobs view when it starts running (although it may be too quick to show up there), then moves back to the Inactive Jobs view when completed
7. View the job output
8. Remove the job from the Inactive Jobs view

Fortran

★ Objectives

- ★ Learn how to create and convert Fortran projects
- ★ Learn to use Fortran-specific editing features
- ★ Learn about Fortran-specific properties/preferences

★ Contents

- ★ Fortran projects
- ★ Using the Fortran editor
- ★ Fortran project properties and workbench preferences

★ Prerequisites

- ★ Basics (for exercises)



Ralph Johnson's research group at UIUC used to meet at Pho-Tran...

PHOTRAN

eclipse

IDE for Fortran

eclipse

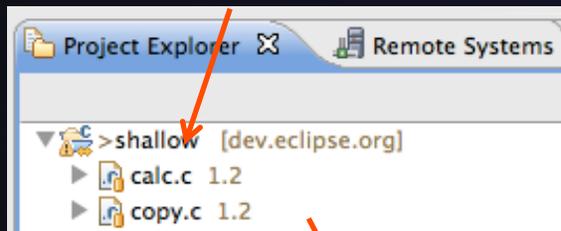
TAKE OUT 365-0051

...which became the name of their Fortran IDE.

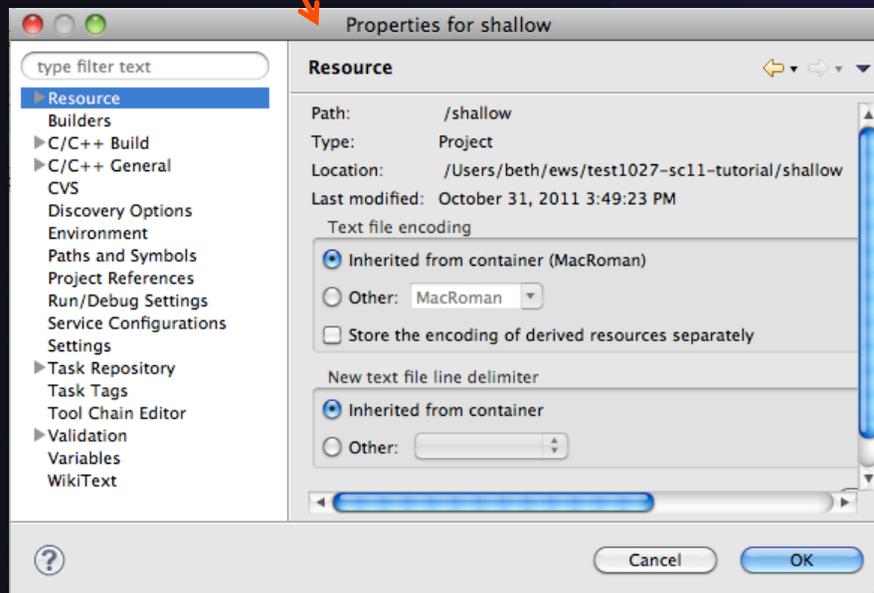
Configuring Fortran Projects

Project Properties

- ★ Right-click Project
- ★ Select **Properties...**



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



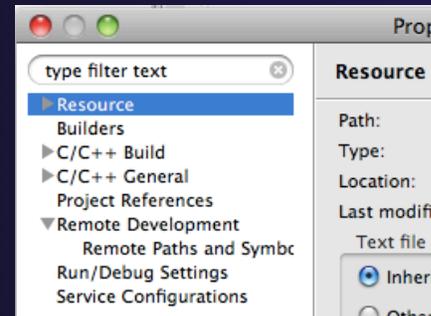
- ★ Contrast with *workspace preferences*, which are the same regardless of what project is being edited

- ★ e.g., editor colors
- ★ Set in **Window ► Preferences** (on Mac, **Eclipse ► Preferences**)
- ★ Careful! Dialog is very similar

Converting to a Fortran Project

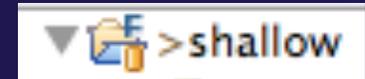
- ★ Are there categories labeled **Fortran General** and **Fortran Build** in the project properties?

No Fortran categories →



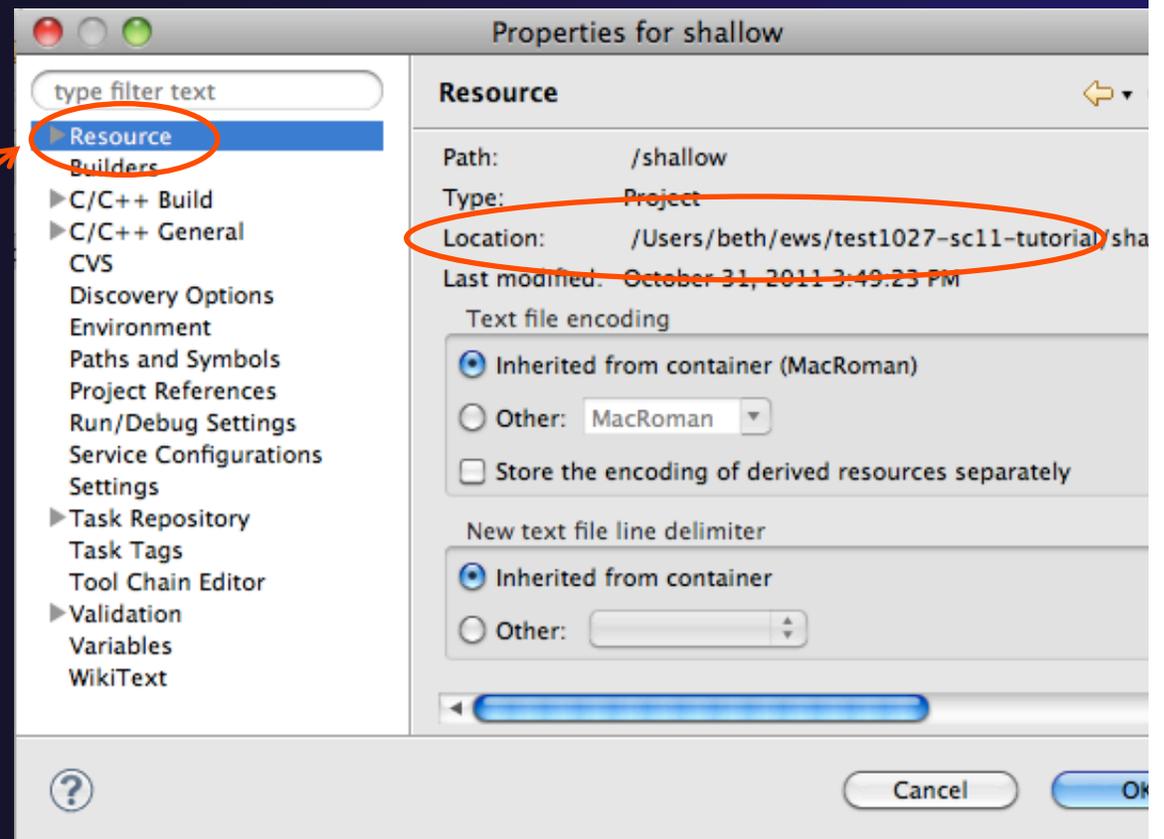
Do this once

- ★ If not, the project is not a Fortran Project
 - ★ Switch to the Fortran Perspective
 - ★ In the Fortran Projects 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

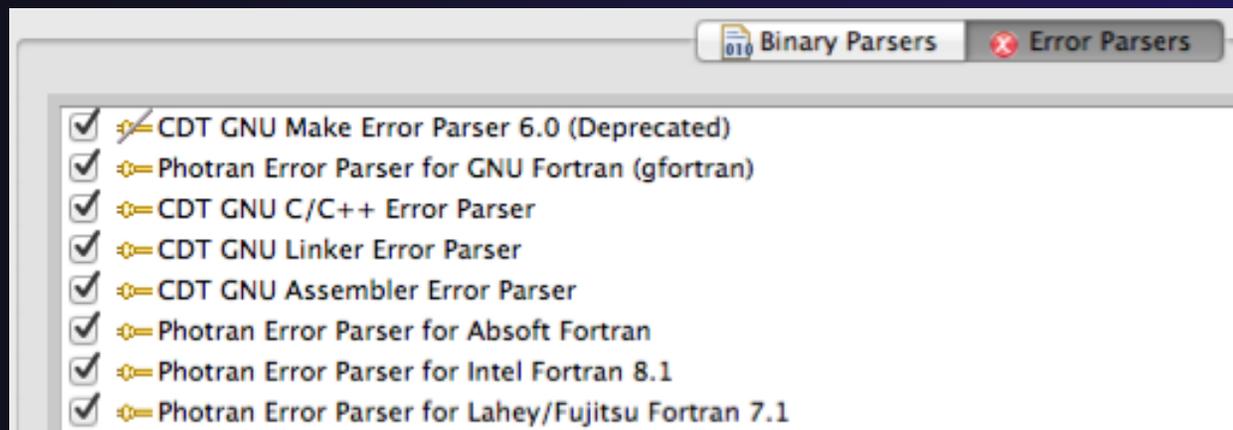


Error Parsers

- ★ 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)



Do this once



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

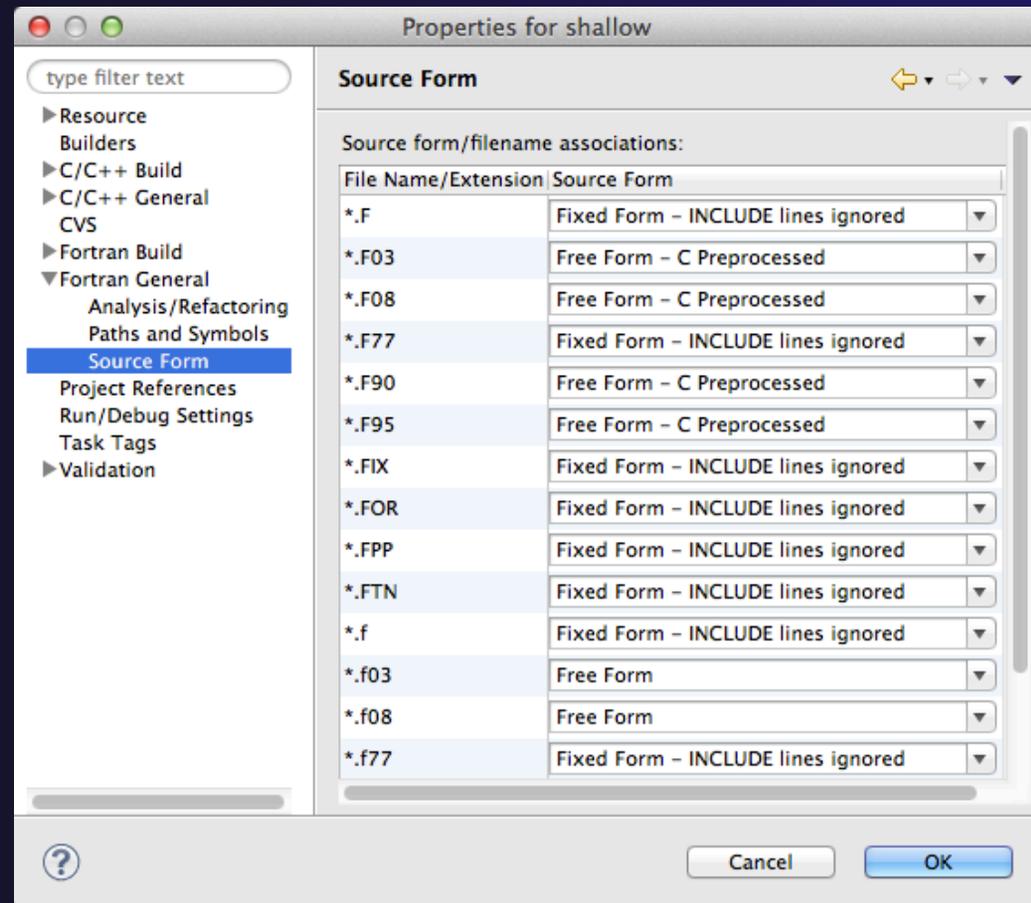
- ★ Many features *will not work* if filename extensions are associated with the wrong source form (outline view, content assist, search, refactorings, etc.)

Fortran Source Form Settings



Do this
once

- ★ In the project properties, select **Fortran General** ▶ **Source Form**
- ★ Select source form for each filename extension
- ★ Click **OK**

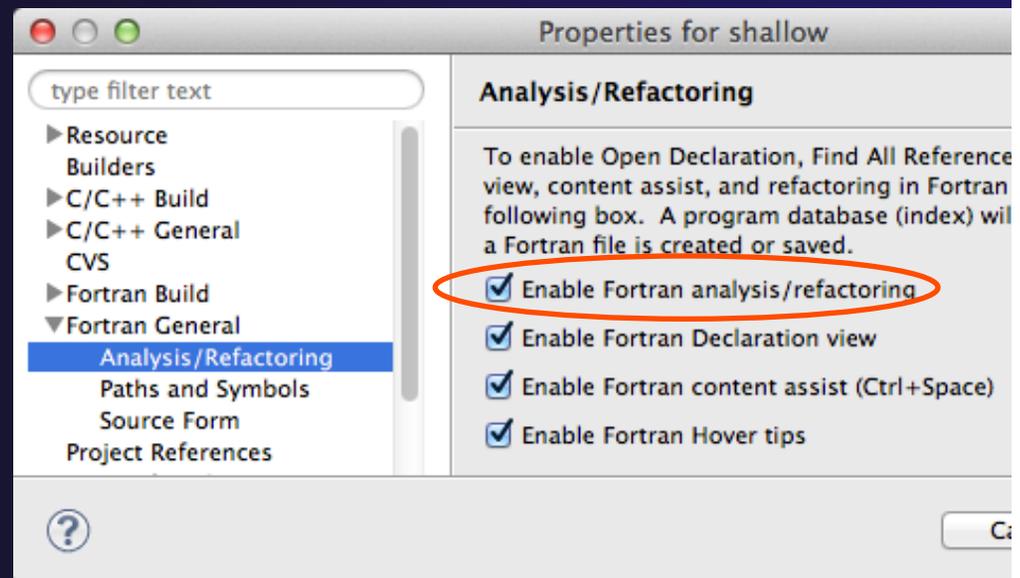


Enabling Fortran Advanced Features

- ★ 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



Do this once





Exercise

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

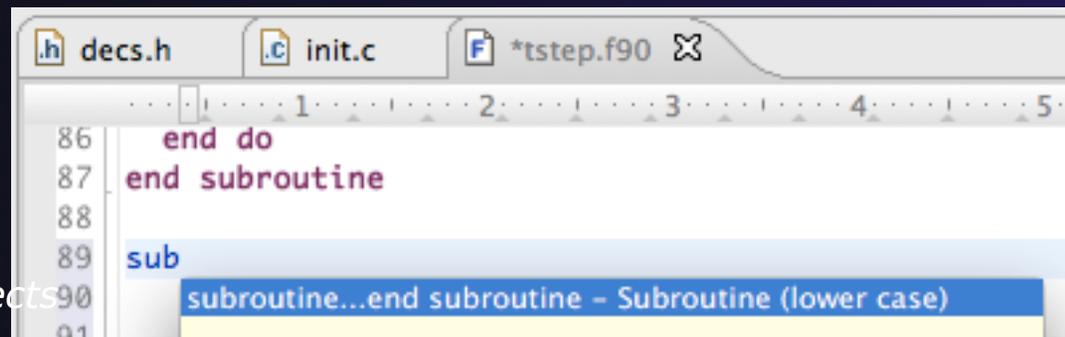
Advanced Editing

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



The screenshot shows an IDE window with three tabs: 'decs.h', 'init.c', and '*tstep.f90'. The active file is '*tstep.f90'. The code in the editor is as follows:

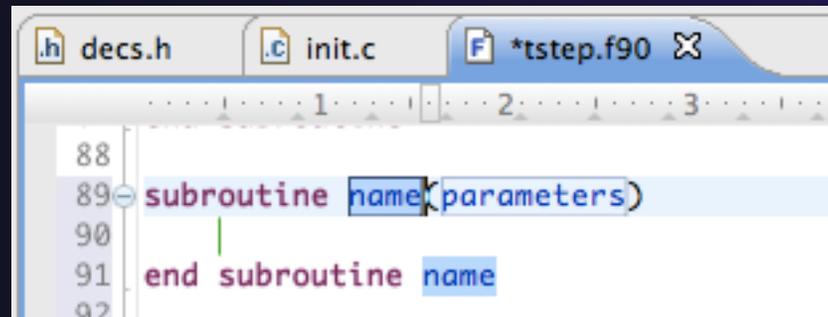
```
86   end do
87   end subroutine
88
89   sub
90   subroutine...end subroutine - Subroutine (lower case)
91
```

A code completion popup is visible at line 90, showing the suggestion 'subroutine...end subroutine - Subroutine (lower case)'. The popup is highlighted in blue.

Code Templates (2)

(C/C++ and Fortran)

- ✦ After pressing enter to insert the code template, completion fields are highlighted



The screenshot shows an IDE window with three tabs: 'decs.h', 'init.c', and '*tstep.f90'. The active window is '*tstep.f90'. The code is as follows:

```
88  
89 subroutine name(parameters)  
90  
91 end subroutine name  
92
```

The word 'name' in line 89 is highlighted in blue, and a vertical line is positioned at the end of the word. The word 'name' in line 91 is also highlighted in blue. The word 'parameters' in line 89 is highlighted in blue, and a vertical line is positioned at the end of the word.

- ✦ Press **Tab** to move between completion fields
- ✦ Changing one instance of a field changes all occurrences



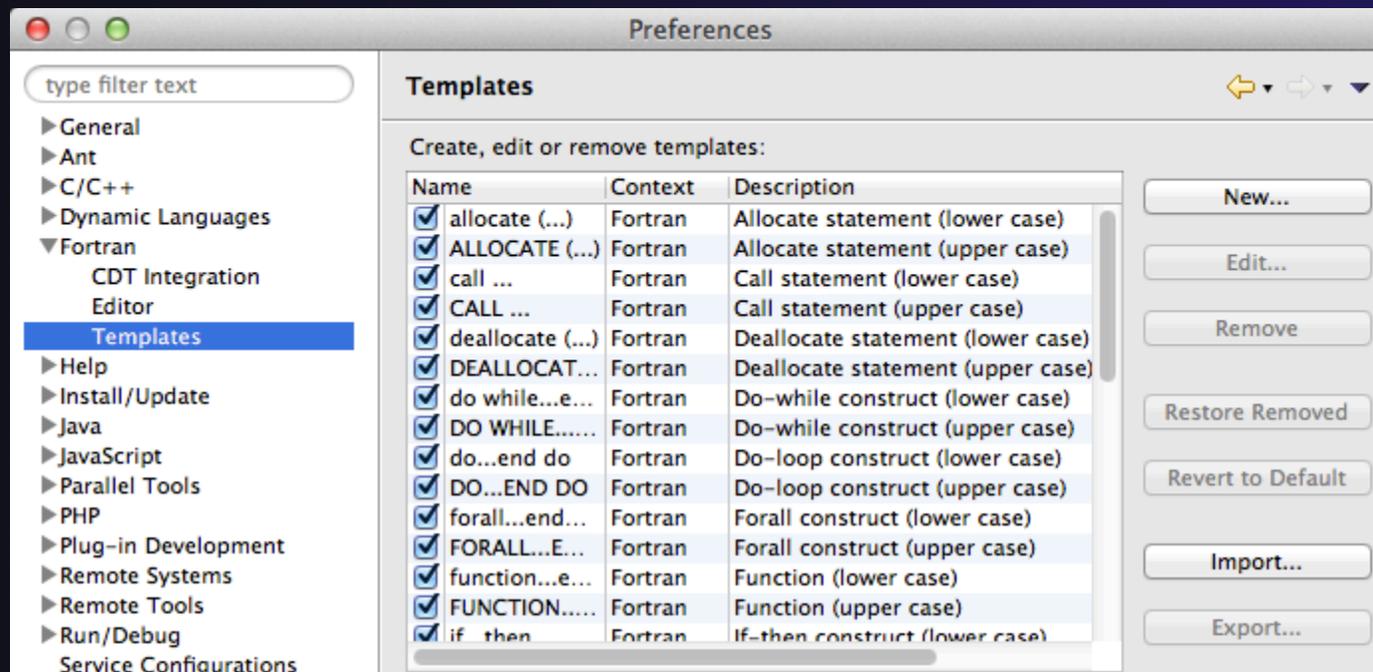
Exercise

- ✦ 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

Search & Refactoring

★ Objectives

- ★ Develop proficiency using Eclipse's textual and language-based search and navigation capabilities
- ★ Introduce common automated refactorings

★ Contents

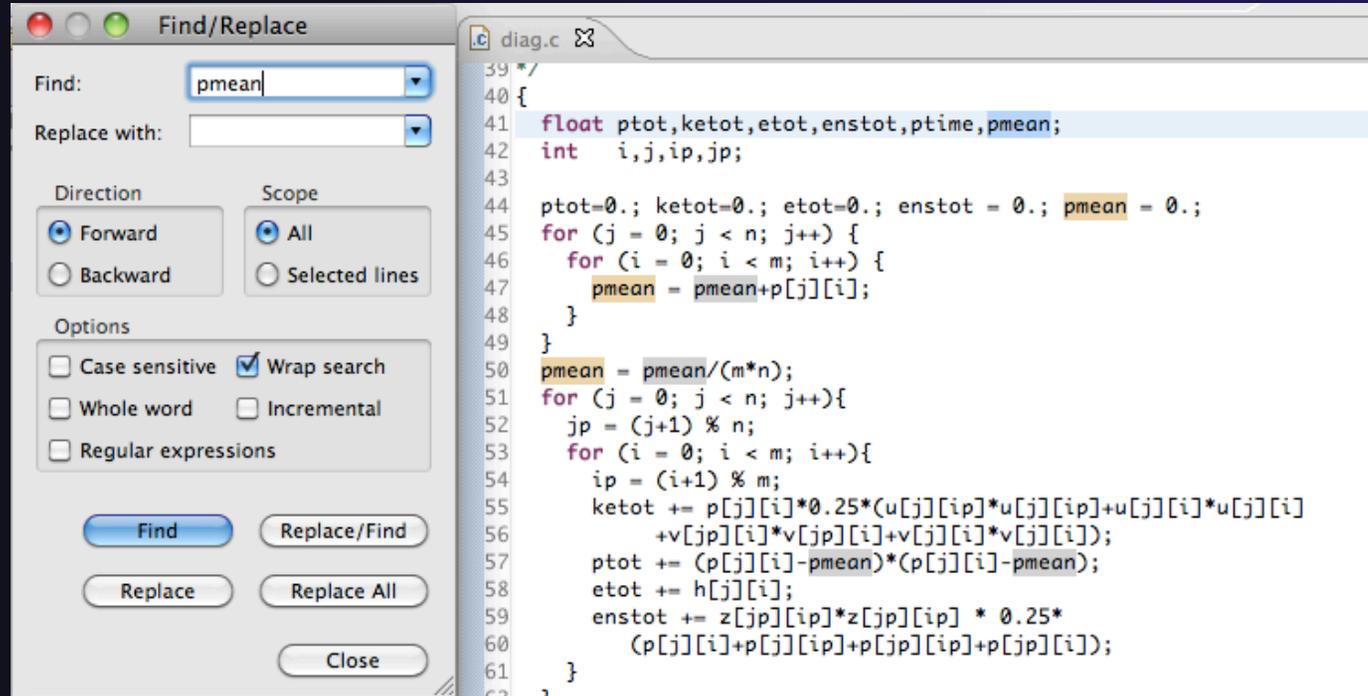
- ★ Searching
- ★ Refactoring and Transformation

★ Prerequisites

- ★ Basics
- ★ Fortran

Find/Replace within Editor

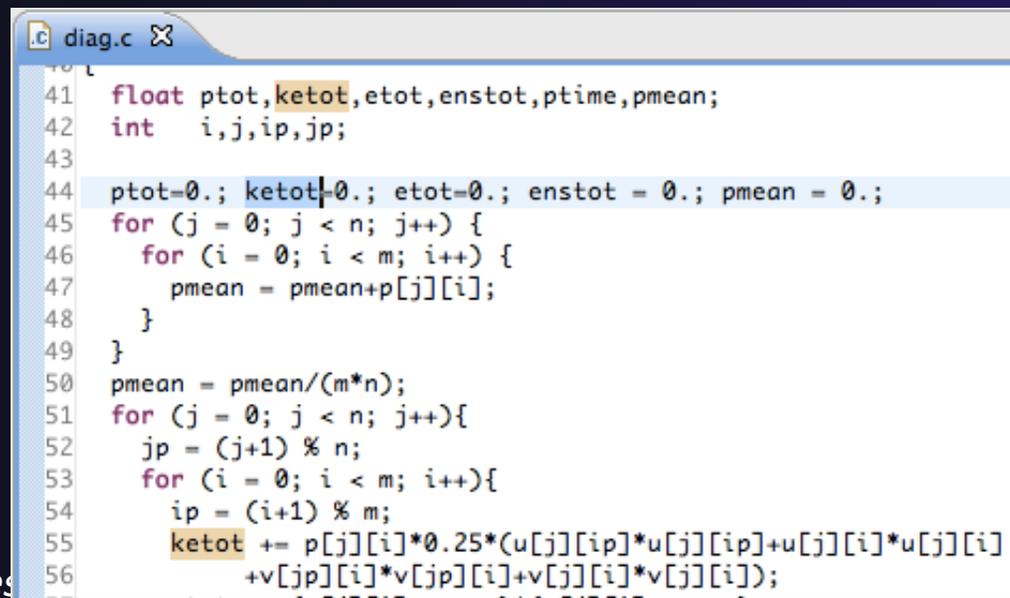
- ✦ Simple Find within editor buffer
- ✦ Ctrl-F (Mac: Command-F)



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-Command-O)



The screenshot shows a code editor window titled 'diag.c'. The code is as follows:

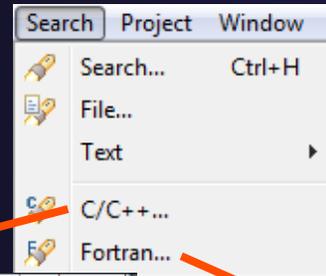
```
41 float ptot, ketot, etot, enstot, ptime, pmean;  
42 int i, j, ip, jp;  
43  
44 ptot=0.; ketot=0.; etot=0.; enstot = 0.; pmean = 0.;  
45 for (j = 0; j < n; j++) {  
46     for (i = 0; i < m; i++) {  
47         pmean = pmean+p[j][i];  
48     }  
49 }  
50 pmean = pmean/(m*n);  
51 for (j = 0; j < n; j++){  
52     jp = (j+1) % n;  
53     for (i = 0; i < m; i++){  
54         ip = (i+1) % m;  
55         ketot += p[j][i]*0.25*(u[j][ip]*u[j][ip]+u[j][i]*u[j][i]  
56             +v[jp][i]*v[jp][i]+v[j][i]*v[j][i]);
```

In the screenshot, the variable 'ketot' is highlighted in yellow in lines 41, 44, and 55. The entire line 44 is highlighted in light blue.

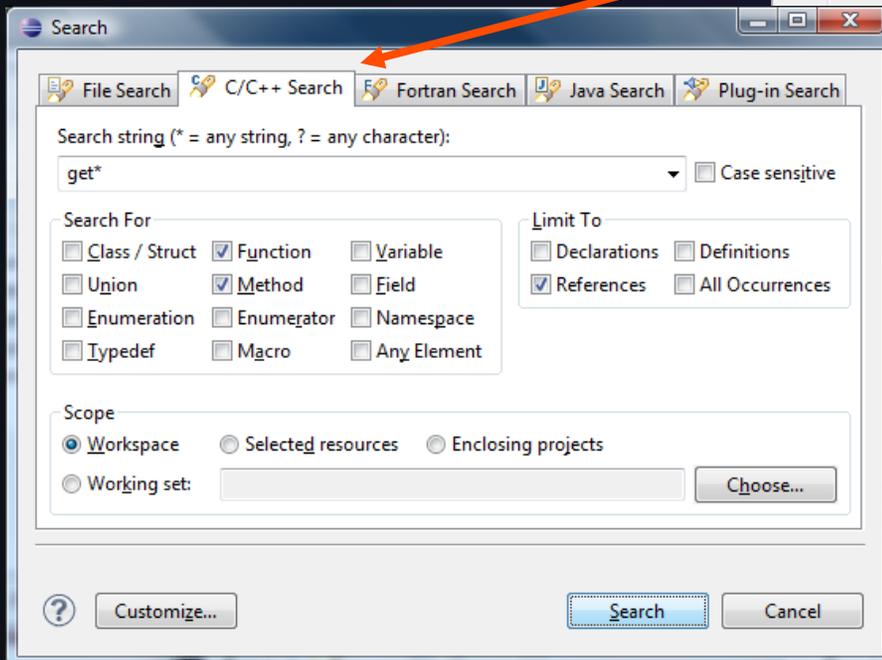
Language-Based Searching

(C/C++ and Fortran)

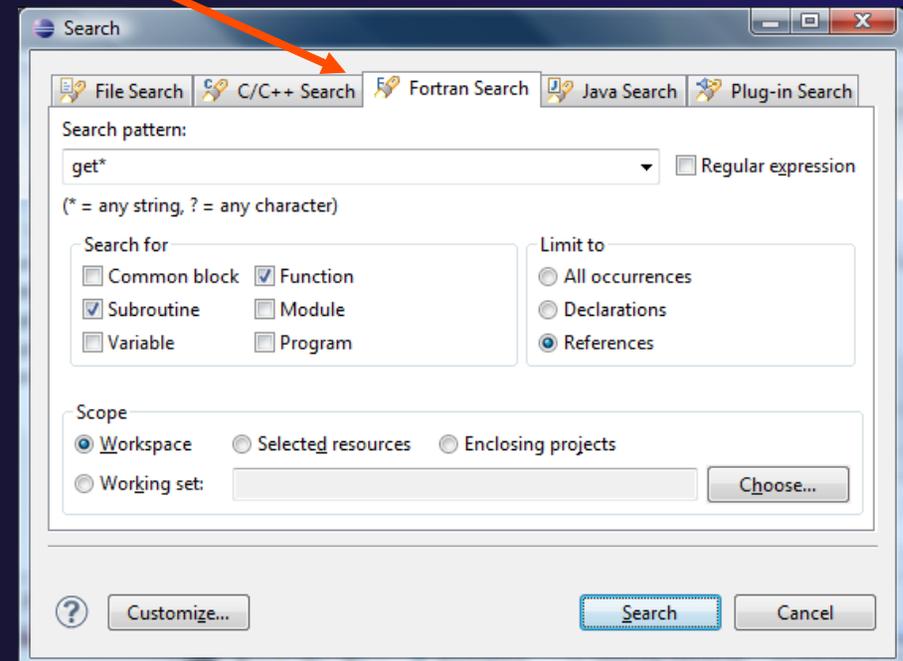
- ★ “Knows” what things can be declared in each language (functions, variables, classes, modules, etc.)



- ★ E.g., search for every call to a function whose name starts with “get”
- ★ Search can be project- or workspace-wide



Advanced Features

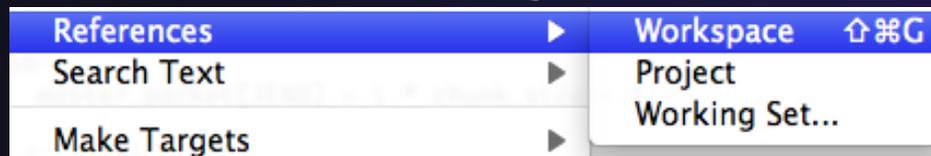


Advanced-3

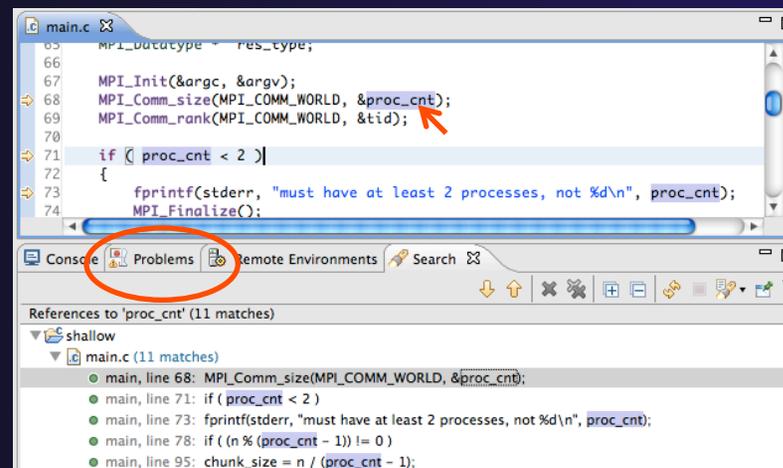
Find References

(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

```

134
135 initialise(p, u, v, psi, pold, uold, vold, di, dj, z);
136 diag(1, 0., p, u, v, h, z);
137
138 for (i = 1; i < proc_cnt; i++)
139     for (j = 0; j < n; j++)
140         acopy_two_to_one(i, j, column);
141     MPI_Send(&star, 1, MPI_COMM_WORLD, j, 0);
142
143
144     acopy_two_to_one(i, j, column);
145     MPI_Send(&star, 1, MPI_COMM_WORLD, j, 0);
  
```

Goes to its declaration in copy.c

```

59 bcopy(src[column], dest[column], sizeof(src[column]));
60 }
61
62 acopy_two_to_one(twodim, onedim, column)
63 float twodim[n][m];
64 float onedim[m];
65 int column;
  
```



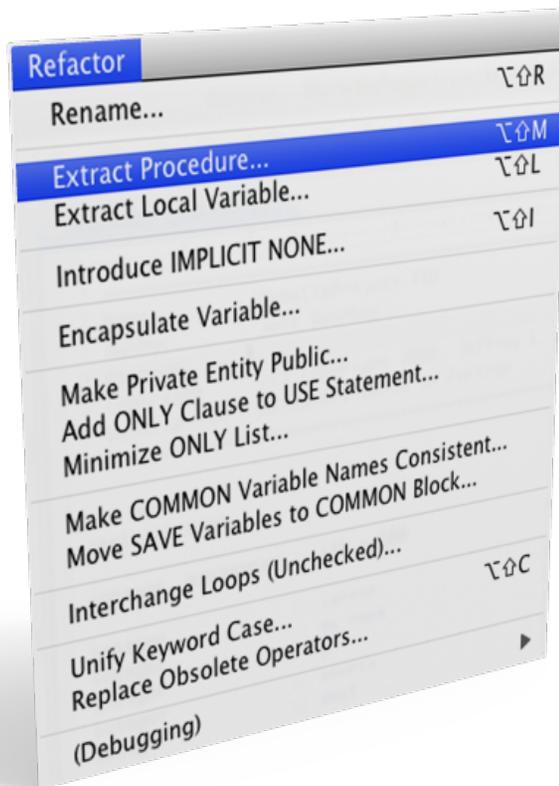
Search – Try It!

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 C function in Shallow whose name contains the word `time`

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)

✓	Free Form, Unpreprocessed:	.f08	.f03	.f95	.f90		
✗	Free Form, Preprocessed:	.F08	.F03	.F95	.F90		
✗	Fixed Form:	.f	.fix	.for	.fpp	.ftn	.f77

- ★ 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)

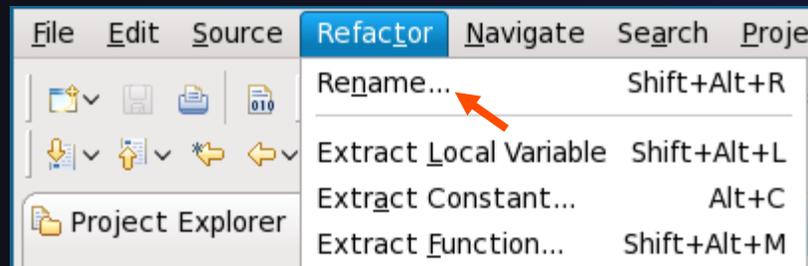
- ★ The file in the active editor is fixed form

- ★ 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.)



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

Refactoring	Uses	Percentage
Rename	179,871	74.8%
Extract Local Variable	13,523	5.6%
Move	13,208	5.5%
Extract Method	10,581	4.4%
Change Method Signature	4,764	2.0%
Inline	4,102	1.7%
Extract Constant	3,363	1.4%
(16 Other Refactorings)	10,924	4.5%

Advanced

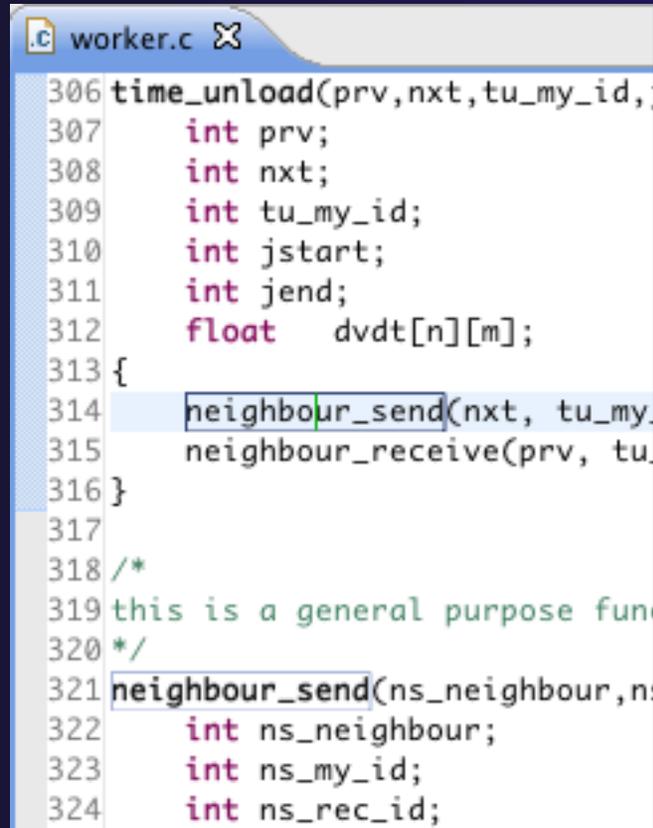
- ✦ Switch to C/C++ Perspective
- ✦ Open a source file
- ✦ In the editor, click on a variable or function name
- ✦ Select menu item **Refactor ▶ Rename**
 - ✦ Or use context menu
- ✦ Enter new name

Advanced-10

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.

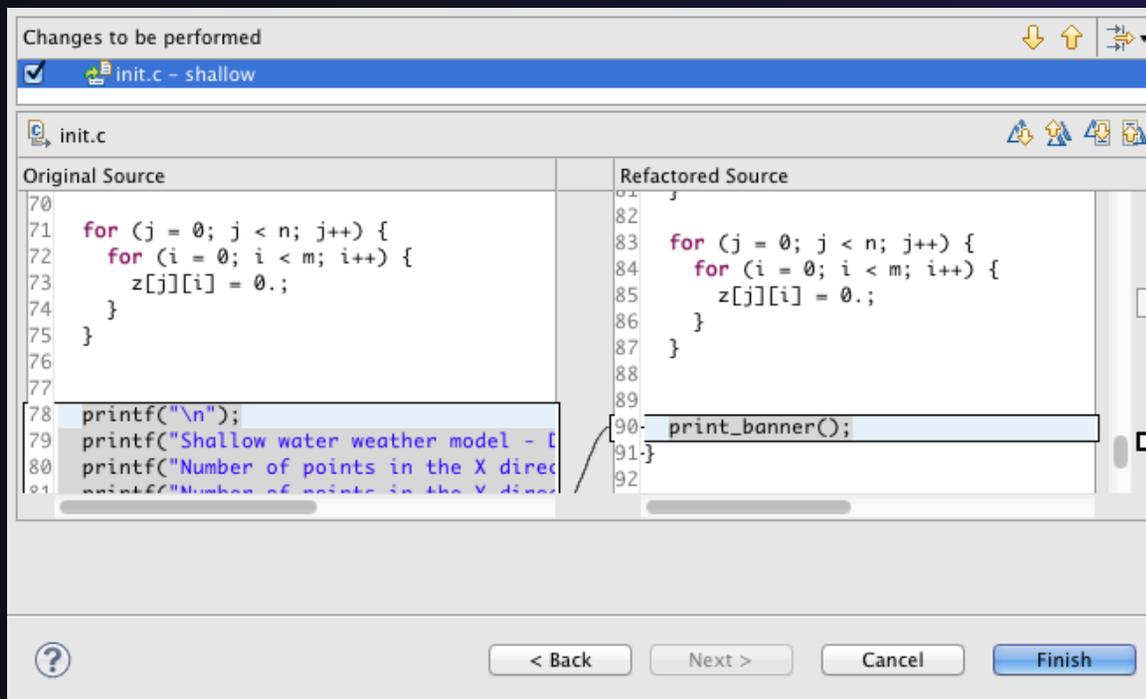


```
worker.c X
306 time_unload(prv,nxt,tu_my_id,
307     int prv;
308     int nxt;
309     int tu_my_id;
310     int jstart;
311     int jend;
312     float  dvdt[n][m];
313 {
314     neighbour_send(nxt, tu_my.
315     neighbour_receive(prv, tu.
316 }
317
318 /*
319 this is a general purpose fun
320 */
321 neighbour_send(ns_neighbour,n
322     int ns_neighbour;
323     int ns_my_id;
324     int ns_rec_id;
```

Extract Function Refactoring

(also available in Fortran - "Extract Procedure")

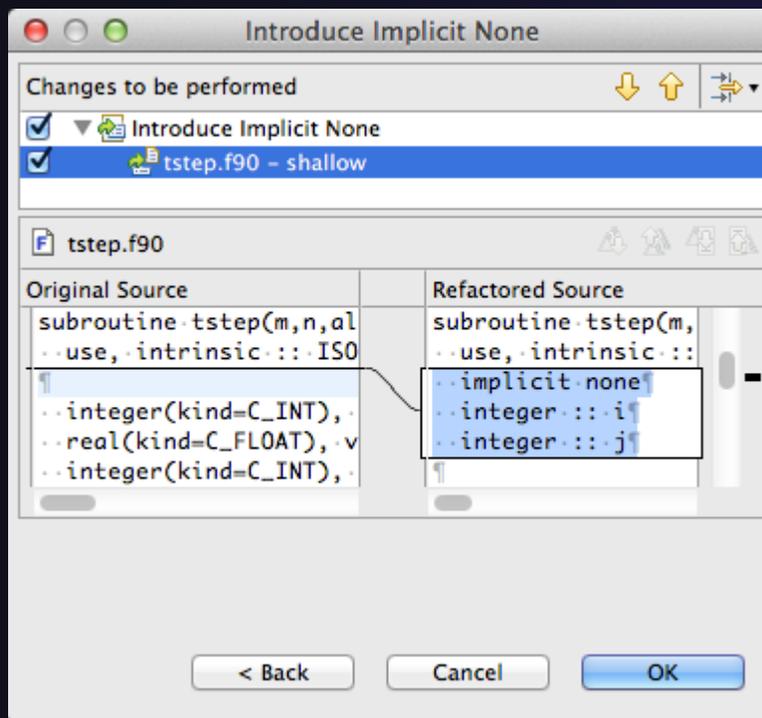
- ✦ Moves statements into a new function, replacing the statements with a call to that function
- ✦ Local variables are passed as arguments



- ✦ 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

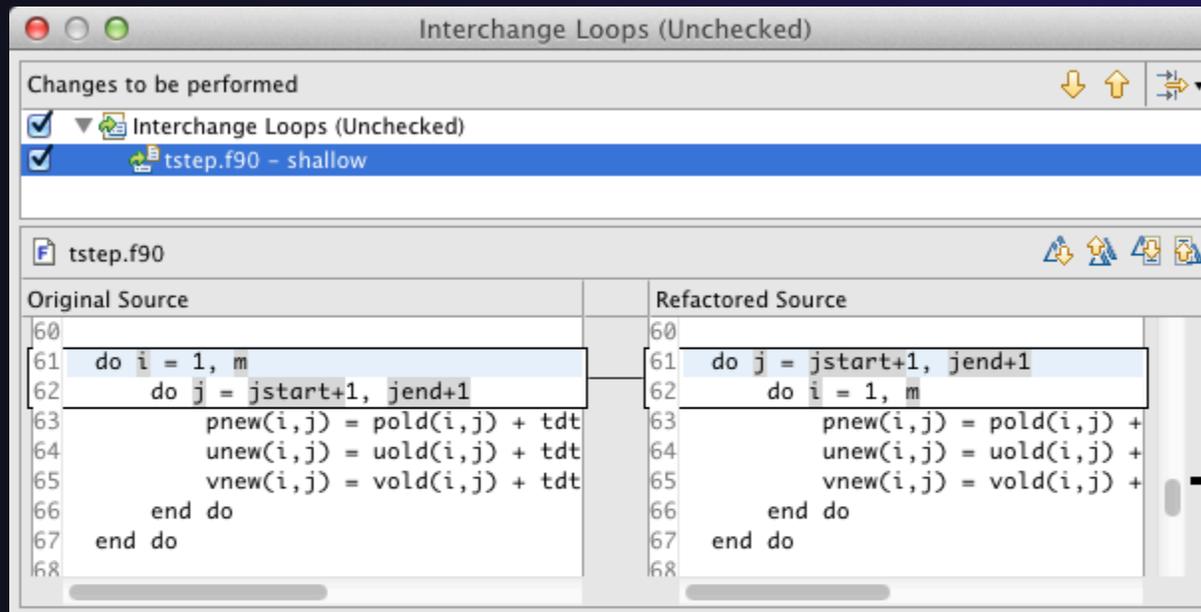


- ★ Introduce in a single file by opening the file and selecting **Refactor ▶ Coding Style ▶ Introduce IMPLICIT NONE...**
- ★ Introduce in multiple files by selecting them in the Fortran Projects view, right-clicking on the selection, and choosing **Refactor ▶ Coding Style ▶ Introduce IMPLICIT NONE...**

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)

Advanced Features

Advanced-14

Loop Transformations

(Fortran only)

★ Unroll Loop

★ Select a loop, click **Refactor** ▶ **Do Loop** ▶ **Unroll Loop...**

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



Unroll 4x

```
do i = 1, 10, 4
  print *, 10*i
  print *, 10*(i+1)
  print *, 10*(i+2)
  print *, 10*(i+3)
end do
```

Original Source	Refactored Source
68	78
69 ! Don't apply time filter on first	79 end if
70 if (firststep == 0) then	80
71 do j = jstart+1, jend+1	81 do j = jstart+1, jend+1
72 do i = 1, m	82 LoopUpperBound = m
73 pold(i,j) = p(i,j)+alpha*(pne	83 do i = 1, LoopUpperBound,4
74 uold(i,j) = u(i,j)+alpha*(une	84 p(i,j) = pnew(i,j)
75 vold(i,j) = v(i,j)+alpha*(vne	85 u(i,j) = unew(i,j)
76 end do	86 v(i,j) = vnew(i,j)
77 end do	87 p((i+1),j) = pnew((i+1)
78 end if	88 u((i+1),j) = unew((i+1)
79	89 v((i+1),j) = vnew((i+1)
80 do j = jstart+1, jend+1	90 p((i+2),j) = pnew((i+2)
81 do i = 1, m	91 u((i+2),j) = unew((i+2)
82 p(i,j) = pnew(i,j)	92 v((i+2),j) = vnew((i+2)
83 u(i,j) = unew(i,j)	93 p((i+3),j) = pnew((i+3)
84 v(i,j) = vnew(i,j)	94 u((i+3),j) = unew((i+3)
85 end do	95 v((i+3),j) = vnew((i+3)
86 end do	96 end do
87 end subroutine	97 end do
88	98 end subroutine
	99
	00

Refactoring & Transformation – Exercises



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/XSEDE Features

★ Objectives

- ★ Install NCSA's GSI auth and XSEDE support plug-ins
- ★ Become familiar with the System menu

★ Contents

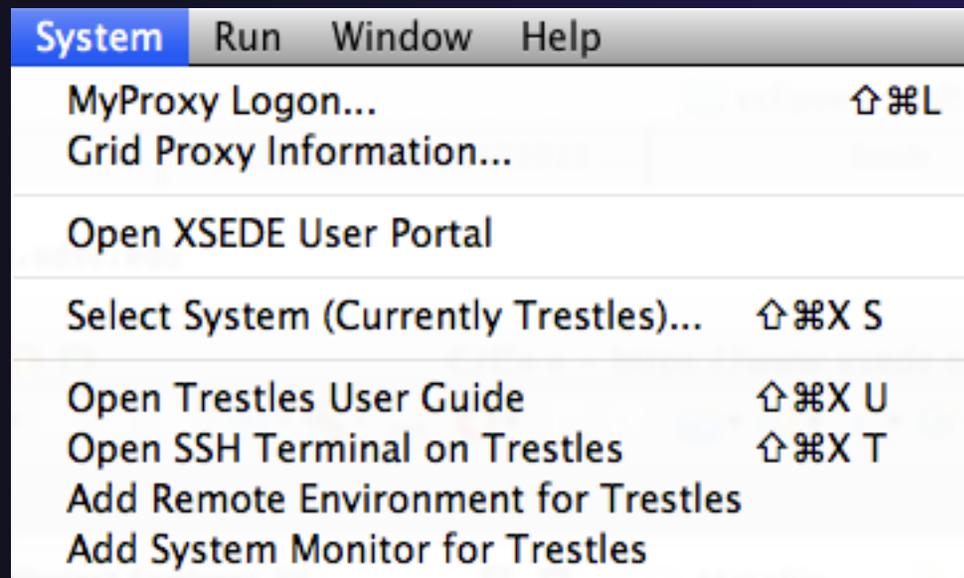
- ★ Capabilities
- ★ Installation

★ Prerequisites

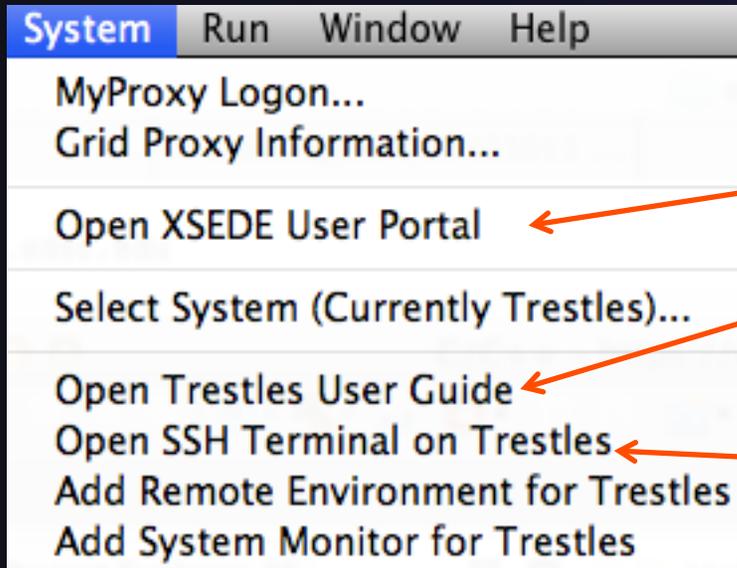
- ★ (none)

Additional Plug-ins from NCSA

- ★ NCSA publishes additional plug-ins can be added onto an existing PTP installation
- ★ Contribute a **System** menu to the menu bar with XSEDE- and NCSA-specific commands



System Menu



✦ Open Web content in Eclipse:

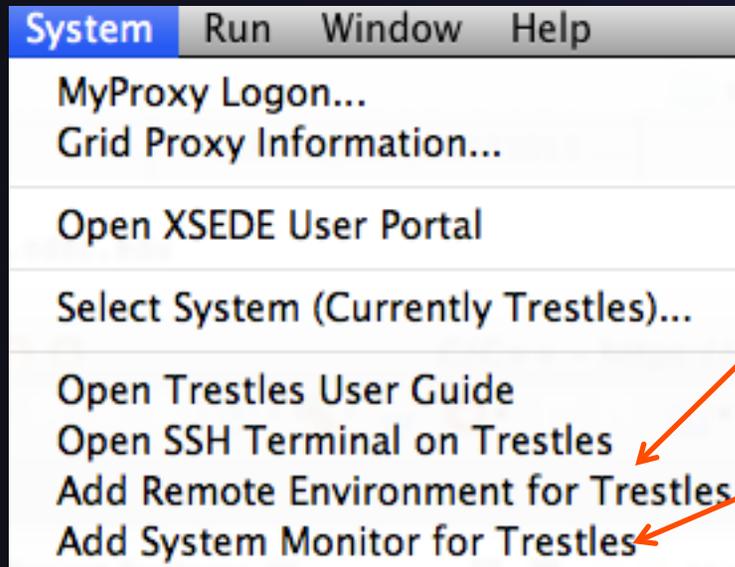
✦ **Open XSEDE User Portal**

✦ **Open User Guide** for a machine

✦ Open an SSH terminal
(as an Eclipse view)

Eclipse-integrated SSH terminals are provided by the Remote System Explorer (RSE), one of the features that is included in the Eclipse for Parallel Application Developers package.

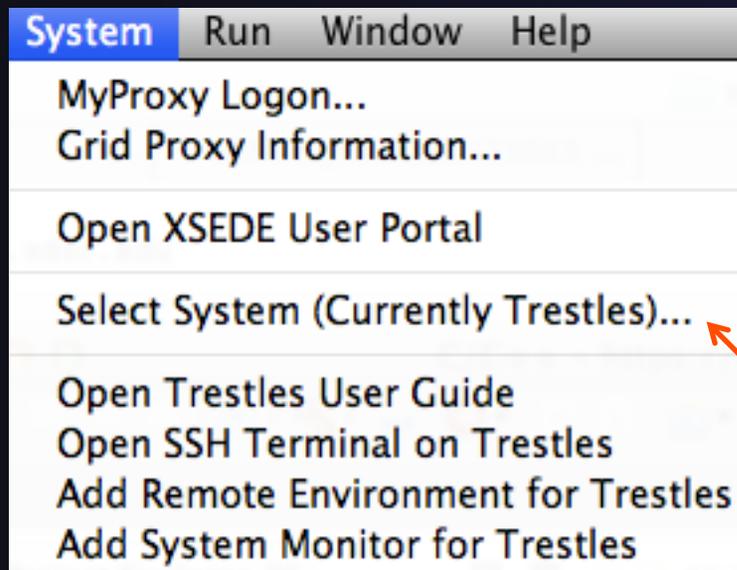
System Menu



★ Shortcuts for common PTP tasks:

- ★ **Add Remote Environment** adds a Remote Tools connection for a particular machine
- ★ **Add System Monitor** opens the System Monitoring perspective and begins monitoring a particular machine

System Menu



- ✦ The plug-in is preconfigured with information about XSEDE and NCSA resources
- ✦ The bottom four commands generally prompt for a system
- ✦ **Select System** can be used to eliminate this prompt, so these commands always act on a particular system

MyProxy Logon



- ✦ **MyProxy Logon** allows you to authenticate with a MyProxy server
 - ✦ Often **myproxy.teragrid.org**
- ✦ It stores a “credential,” which is usually valid for 12 hours
- ✦ During these 12 hours, SSH connections to XSEDE resources will not require a password; they can use the stored credential
 - ✦ However, you **must** enter the correct username for that machine!

Installation

1. Click **Help > Install New Software**
2. Click **Add** to open the Add Repository dialog
3. In the **Location** field, enter
`http://forecaster.ncsa.uiuc.edu/updates/juno`
and then click **OK** to close the Add dialog.
 - Or, if you copied ncsa-update-size.zip from a USB drive, click **Archive**, select that file, and click **OK**.
4. Select the following:
 - ✦ GSI Authentication and MyProxy Logon Support
 - ✦ NCSA and XSEDE System Support
5. Click **Next** and complete the installation

Parallel Debugging

- ★ Objective

- ★ Learn the basics of debugging parallel programs

- ★ Contents

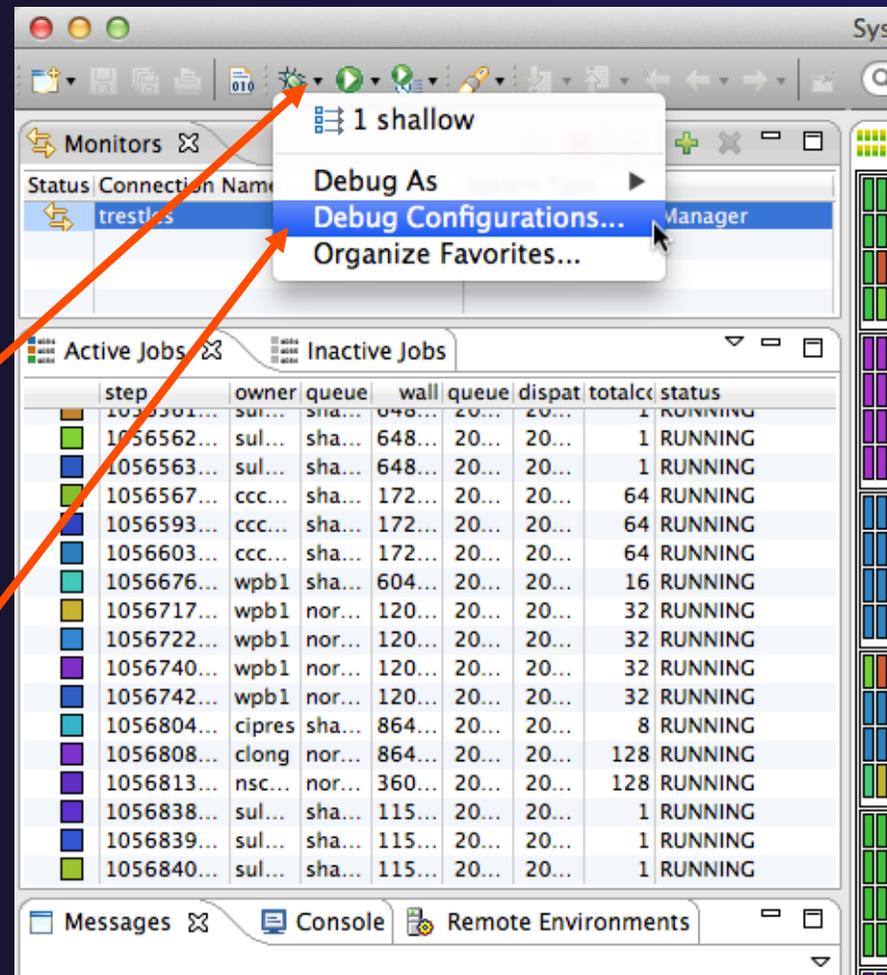
- ★ Launching a debug session
- ★ The Parallel Debug Perspective
- ★ Controlling sets of processes
- ★ Controlling individual processes
- ★ Parallel Breakpoints
- ★ Terminating processes

Debugging Setup

- ★ Debugging requires interactive access to the application
- ★ Can use any of the *-Interactive* target configurations
 - ★ *Torque-Generic-Interactive*
 - ★ *PBS-Generic-Interactive*
 - ★ *OpenMPI-Generic-Interactive*

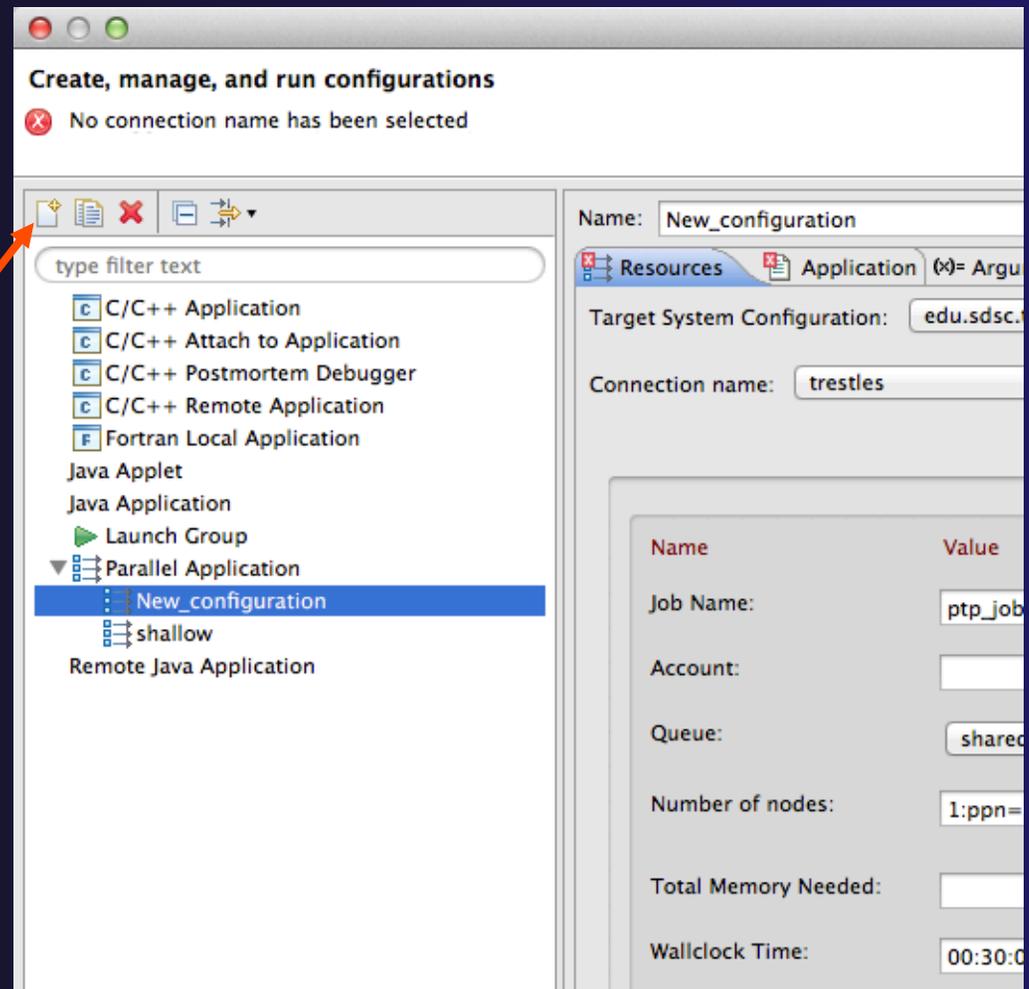
Create a Debug Configuration

- ★ A debug configuration is essentially the same as a run configuration (like we used in the *Running an Application* module)
- ★ It is possible to re-use an existing configuration and add debug information
- ★ Use the drop-down next to the debug button (bug icon) instead of run button
- ★ Select **Debug Configurations...** to open the **Debug Configurations** dialog



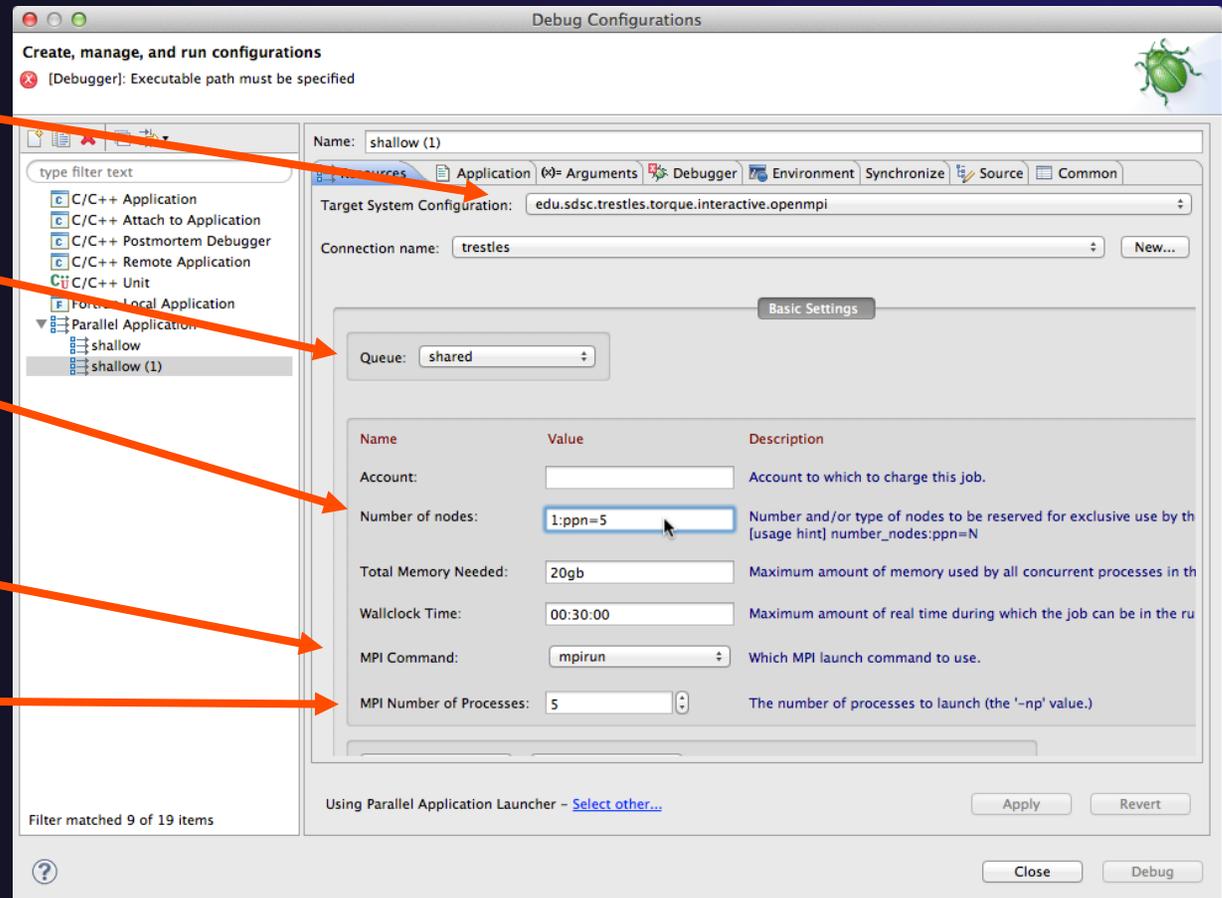
Create a New Configuration

- ★ Select the existing configuration
- ★ Click on the **new** button to create a new configuration



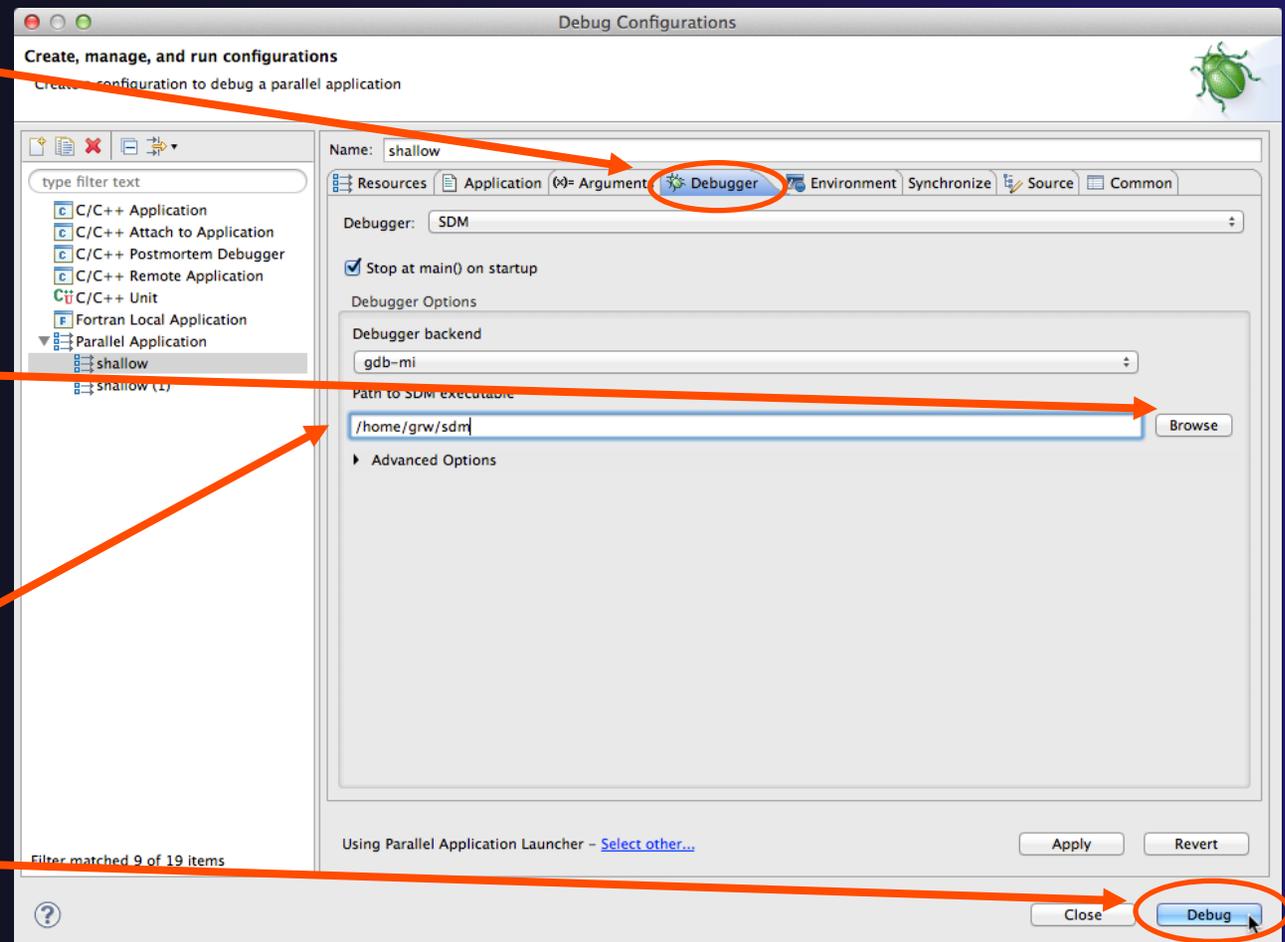
Configure the Resources Tab

- ★ Select the new target system configuration
- ★ Choose the queue
- ★ Make sure number of nodes is correct
- ★ Make sure the **mpirun** command is selected
- ★ Select the number of processes (in this case use 5)



Configure the Debug Tab

- ★ Select **Debugger** tab
- ★ Choose "gdb-mi" for the **Debugger backend**
- ★ Click **Browse** and select "sdm" in your home directory
- ★ Click **Ok**
- ★ Make sure the debugger path is correct
- ★ Click on **Debug** to launch the program





Exercise

1. Open the debug configuration dialog
2. Create a new configuration
3. Select the *edu.sdsc.trestles.torque.interactive.openmpi* target configuration
4. Configure the **Debug** tab
 - ✦ Queue: *shared*
 - ✦ Number of nodes: *1:ppn=5*
 - ✦ MPI Command: *mpirun*
 - ✦ MPI Number of Processes: *5*
5. Launch the debugger

The Parallel Debug Perspective (1)

- ★ **Parallel Debug view** shows job and processes being debugged
- ★ **Debug view** shows threads and call stack for individual processes
- ★ **Source view** shows a **current line marker** for all processes

The screenshot displays the Eclipse IDE in the Parallel Debug perspective. The top toolbar shows various debugging tools. The main interface is divided into several panes:

- Parallel Debug:** Shows a tree view with 'job0' and its sub-processes.
- Debug:** Shows the current thread and call stack for 'Process 0', specifically 'Thread [1] (Suspended)' at 'main() main.c:38 4032ca'.
- Variables:** A table showing the values of variables:

Name	Value
argc	1
argv	7fffffff658
pi	5.957805E-39
p	[0 - 18]
u	[0 - 18]
v	[0 - 18]
psi	[0 - 18]
- Source:** Shows the C code for 'main.c'. Line 38 is highlighted with a blue background, indicating the current execution point:


```
38 float pi=4.*((float)atan((double)1.));
```
- Outline:** Shows a list of files and functions, including 'math.h', 'mpi.h', 'stdio.h', 'decs.h', and 'worker(): void'.
- Console:** Shows the output of the program, including the path 'Open_MPI@abe.ncsa.uiuc.edu:default:job0'.

The Parallel Debug Perspective (2)

- ★ **Breakpoints** view shows breakpoints that have been set (more on this later)
- ★ **Variables** view shows the current values of variables for the currently selected process in the **Debug** view
- ★ **Outline** view (from CDT) of source code

The screenshot displays the Eclipse IDE in the Parallel Debug perspective. The interface is divided into several panes:

- Breakpoints:** Located at the top, it shows a list of breakpoints. An orange arrow points to the Breakpoints view.
- Variables:** Located on the right, it displays a table of current variable values for the selected process. An orange arrow points to this view.
- Debug:** Located in the middle-left, it shows the execution stack and the current thread. An orange arrow points to the Debug view.
- Outline:** Located on the right, it shows the source code structure. An orange arrow points to the Outline view.
- Source Code:** The main editor shows the source code of `main.c`. The current line of execution is highlighted in blue.

Name	Value
argc	1
argv	7fffffff658
pi	5.957805E-39
p	[0 - 18]
u	[0 - 18]
v	[0 - 18]
psi	[0 - 18]

```

32 MPI_Datatype * setup_res();
33
34 main (argc, argv)
35     int argc;
36     char * argv[];
37 {
38     float pi=4.*((float)atan((double)1.));
39     float p[n][m]; /* Pressure (or free surface height) */
40     float u[n][m]; /* Zonal wind */
41     float v[n][m]; /* Meridional wind */
42     float psi[n][m]; /* Velocity streamfunction */
43     float pold[n][m];
44     float uold[n][m];
45     float vold[n][m];
46     float h[n][m];
47     float dummy1[n][m];
48     float dummy2[n][m];
49     float tpi=pi+pi;
50     float di=tpi/(float)m;
51     float dj=tpi/(float)n;
52

```

Stepping All Processes

- ★ The buttons in the **Parallel Debug View** control groups of processes
- ★ Click on the **Step Over** button
- ★ Observe that all process icons change to green, then back to yellow
- ★ Notice that the current line marker has moved to the next source line

```

Parallel Debug - shallow/main.c - Eclipse - /Users/greg/testing/workspa
Parallel Debug
Open_MPI@abe.ncsa.uiuc.edu: default:job0 Root [4]
job0
shallow [Parallel Application]
  Process 0 (Suspended)
    Thread [1] (Suspended)
      1 main() main.c:50 4032f6
main.c
38 float pi=4.*(float)atan((double)1.);
39 float p[n][m]; /* Pressure (or free surface height) */
40 float u[n][m]; /* Zonal wind */
41 float v[n][m]; /* Meridional wind */
42 float psi[n][m]; /* Velocity streamfunction */
43 float pold[n][m];
44 float uold[n][m];
45 float vold[n][m];
46 float h[n][m];
47 float z[n][m];
48 float dummy1[m];
49 float dummy2[n][m];
50 float tpi=pi+pi;
51 float di=tpi/(float)m;
52 float dj=tpi/(float)n;
53 int i, j, chunk_size, nxt, prv;
54
55 int master_packet[4];
56 float p_start[m];
57 float u_start[m];
58 float v_start[m];
  
```

Stepping An Individual Process

- ★ The buttons in the **Debug view** are used to control an individual process, in this case process 0
- ★ Click the **Step Over** button
- ★ You will now see two current line markers, the first shows the position of process 0, the second shows the positions of processes 1-3

Parallel Debug - shallow/main.c - Eclipse - /Users/greg/testing/works

Parallel Debug

Open_MPI@abe.ncsa.uiuc.edu: default:job0 - Root [4]

Job0 0

Debug

shallow [Parallel Application]

Process 0 (Suspended)

Thread [1] (Suspended)

1 main() main.c:51 403309

Name

- argc
- argv
- pi
- p
- u
- v
- psi

main.c

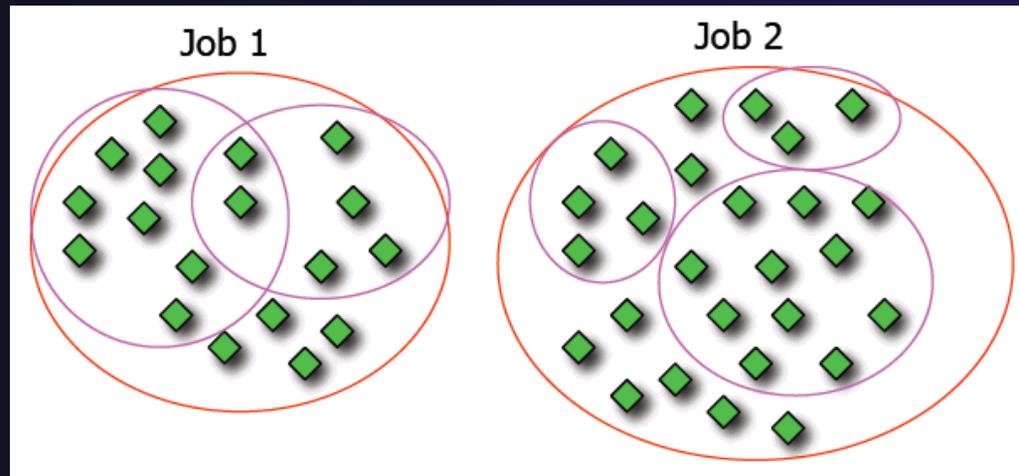
```

38 float pi=4.*(float)atan((double)1.);
39 float p[n][m]; /* Pressure (or free surface height) */
40 float u[n][m]; /* Zonal wind */
41 float v[n][m]; /* Meridional wind */
42 float psi[n][m]; /* Velocity streamfunction */
43 float pold[n][m];
44 float uold[n][m];
45 float vold[n][m];
46 float h[n][m];
47 float z[n][m];
48 float dummy1[n][m];
49 float dummy2[n][m];
50 float tpi=pi+pi;
51 float di=tpi/(float)m;
52 float dj=tpi/(float)n;
53 int i, j, chunk_size, nxt, prv;
54
55 int master_packet[4];
56 float p_start[m];
57 float u_start[m];

```

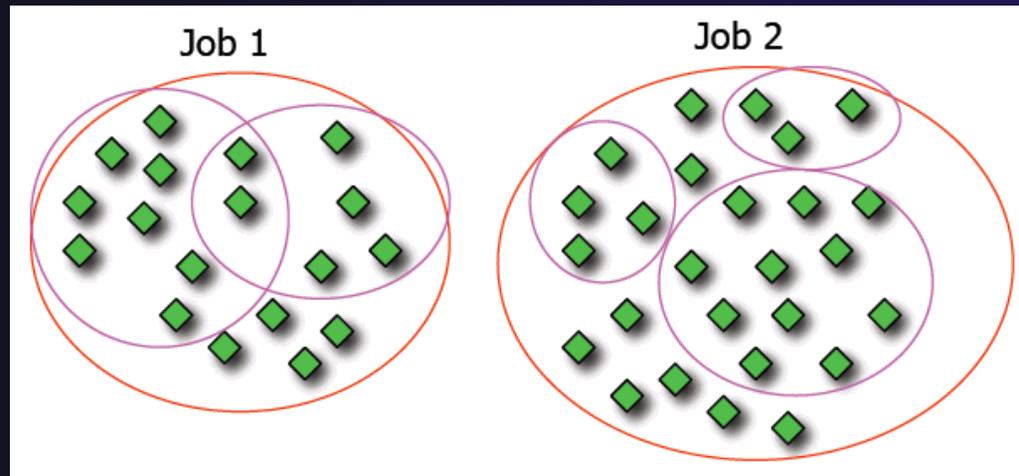
Process Sets (1)

- ★ Traditional debuggers apply operations to a single process
- ★ Parallel debugging operations apply to a single process or to arbitrary collections of processes
- ★ A process set is a means of simultaneously referring to one or more processes



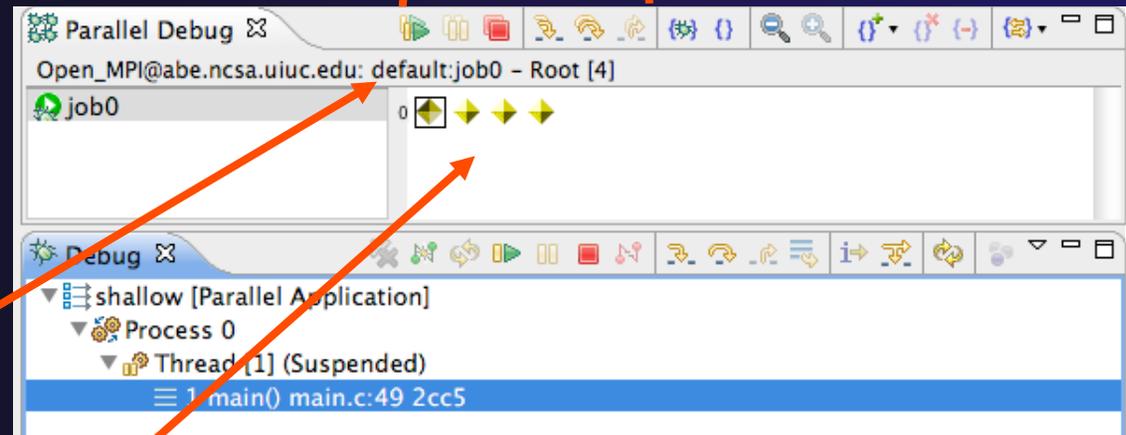
Process Sets (2)

- ★ When a parallel debug session is first started, all processes are placed in a set, called the **Root** set
- ★ Sets are always associated with a single job
- ★ A job can have any number of process sets
- ★ A set can contain from 1 to the number of processes in a job



Operations On Process Sets

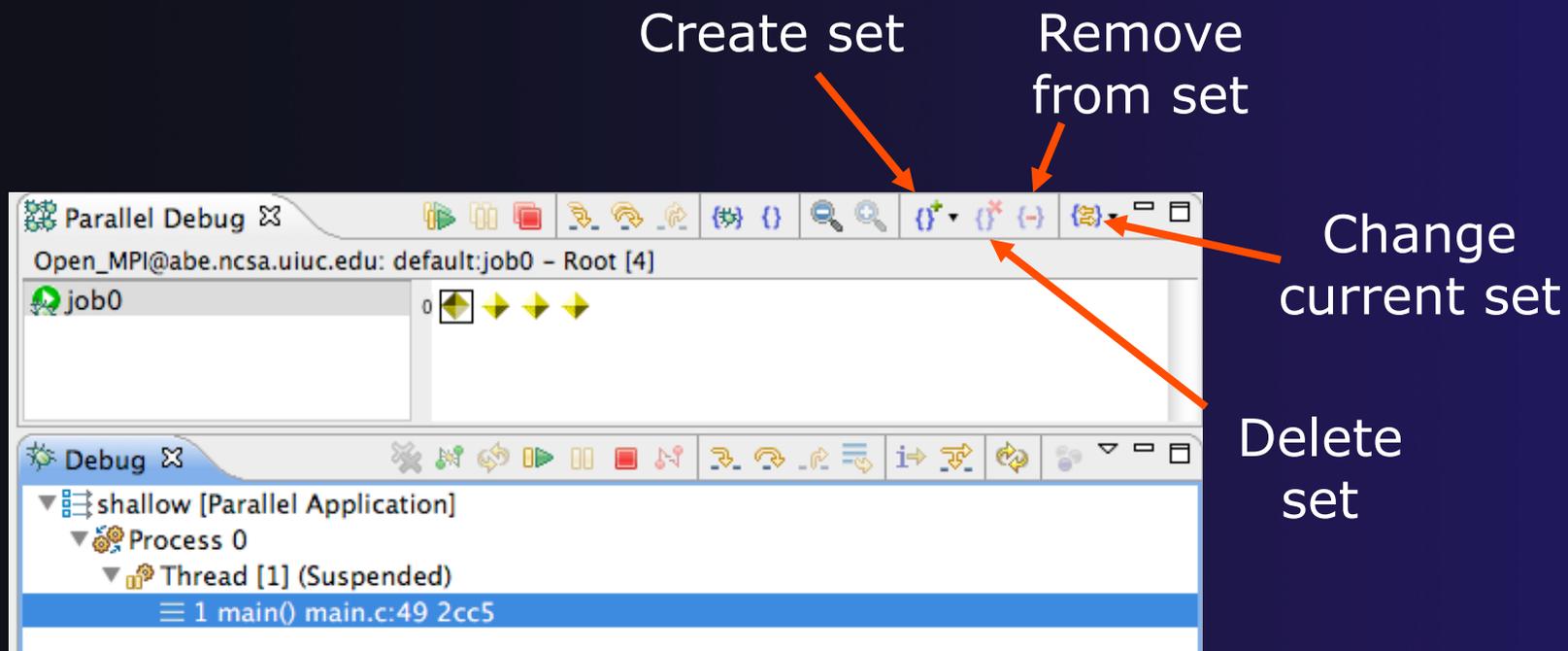
- ★ Debug operations on the **Parallel Debug view** toolbar always apply to the current set:
 - ★ Resume, suspend, stop, step into, step over, step return
- ★ The current process set is listed next to job name along with number of processes in the set
- ★ The processes in process set are visible in right hand part of the view



Root set = all processes

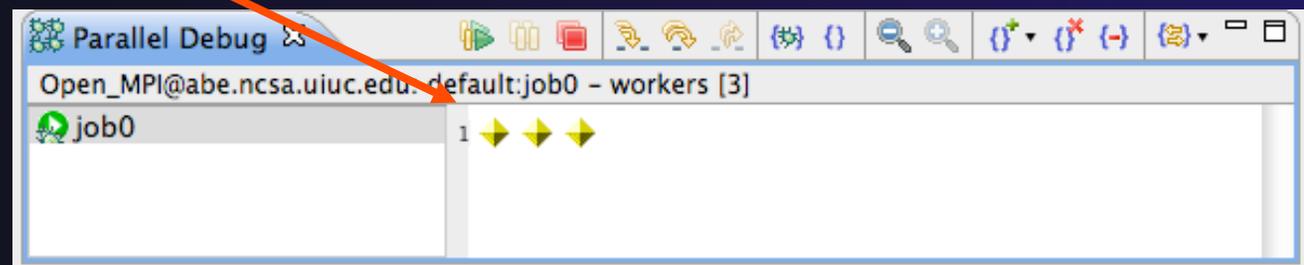
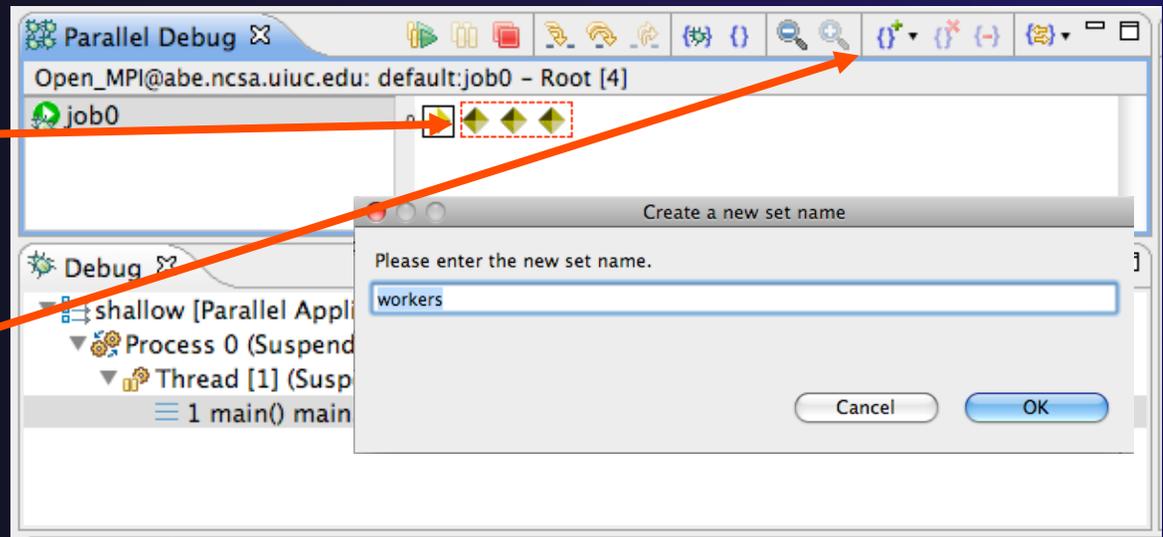
Managing Process Sets

- ★ The remaining icons in the toolbar of the **Parallel Debug view** allow you to create, modify, and delete process sets, and to change the current process set



Creating A New Process Set

- ★ Select the processes you want in the set by clicking and dragging, in this case, the last three
- ★ Click on the **Create Set** button
- ★ Enter a name for the set, in this case **workers**, and click **OK**
- ★ You will see the view change to display only the selected processes



Stepping Using New Process Set

- ★ With the **workers** set active, click the **Step Over** button
- ★ You will see only the first current line marker move
- ★ Step a couple more times
- ★ You should see two line markers, one for the single master process, and one for the 3 worker processes

```

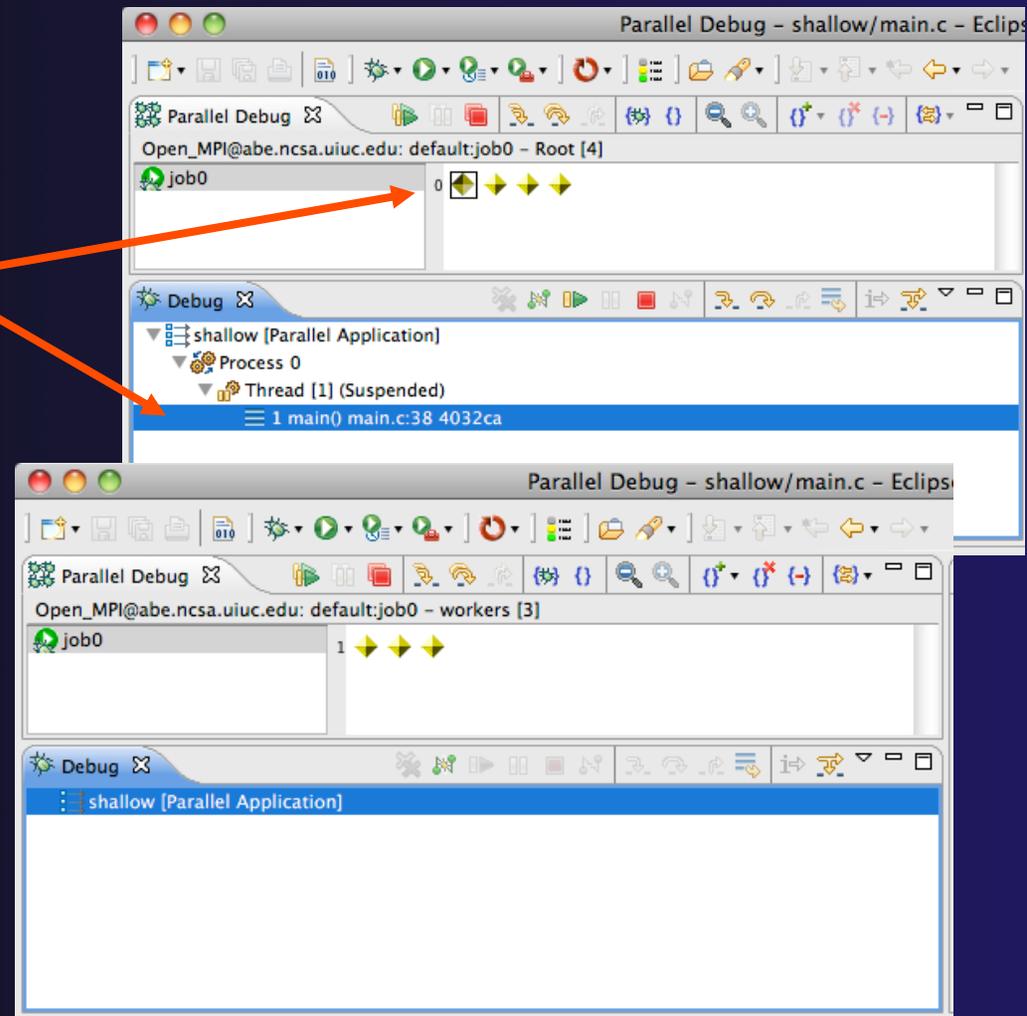
49 float dummyc[n][m];
50 float tpi=pi*pi;
51 float di=tpi/(float)m;
52 float dj=tpi/(float)n;
53 int i, j, chunk_size, nxt, prv;
54
55 int master_packet[4];
56 float p_start[m];
57 float u_start[m];
58 float v_start[m];
59 float psi_start[m];
60 float pold_start[m];
61 float uold_start[m];
62 float vold_start[m];
63 int proc_cnt;
64 int tid;
65 MPI_Datatype * res_type;
66
67 MPI_Init(&argc, &argv);
68 MPI_Comm_size(MPI_COMM_WORLD, &proc_cnt);//hello
69 MPI_Comm_rank(MPI_COMM_WORLD, &tid);
  
```

Process Registration

- ✦ Process set commands apply to groups of processes
- ✦ For finer control and more detailed information, a process can be registered and isolated in the **Debug view**
- ✦ Registered processes, including their stack traces and threads, appear in the **Debug view**
- ✦ Any number of processes can be registered, and processes can be registered or un-registered at any time

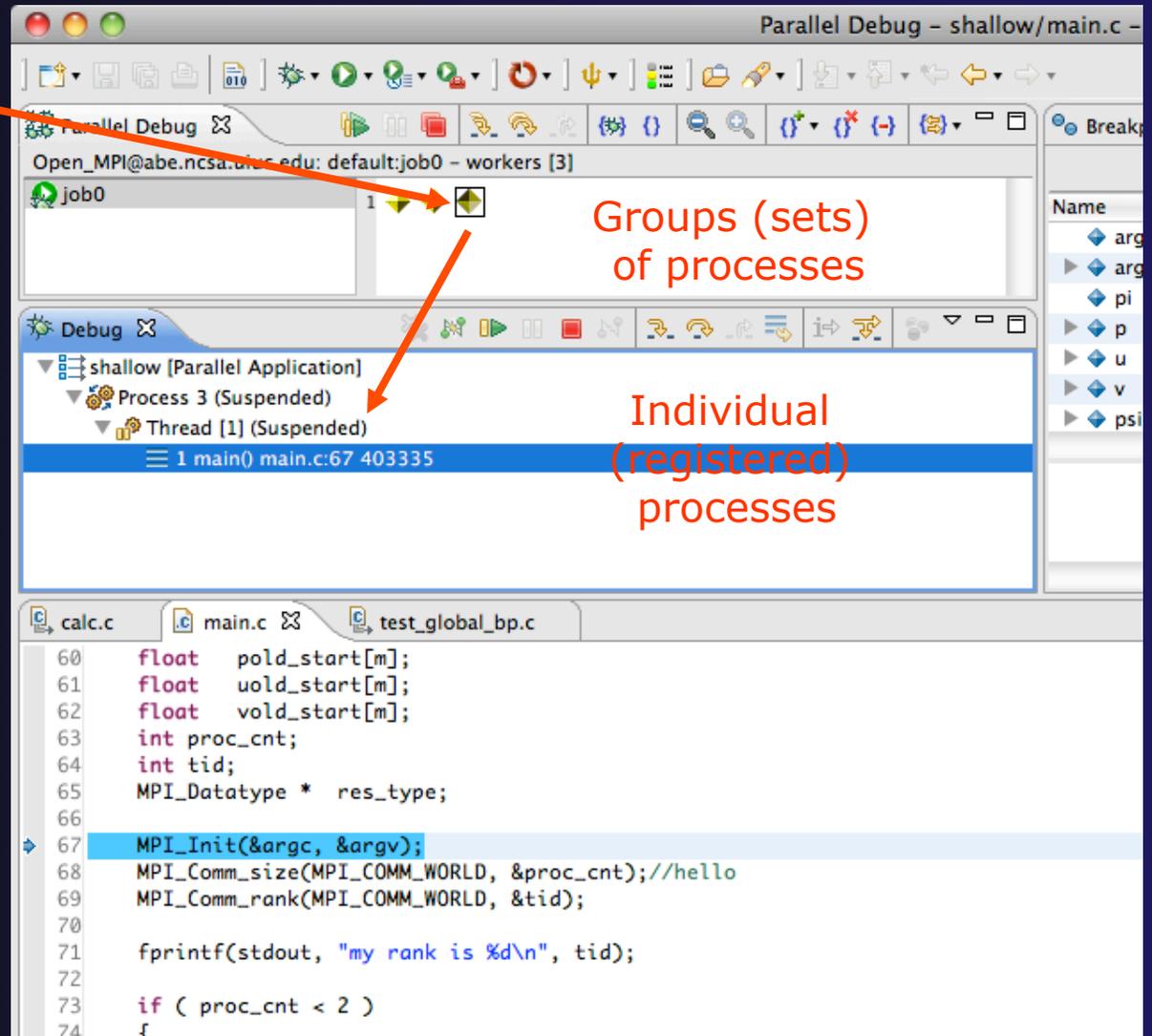
Process Registration (2)

- ✦ By default, process 0 was registered when the debug session was launched
- ✦ Registered processes are surrounded by a box and shown in the Debug view
- ✦ The Debug view only shows registered processes in the current set
- ✦ Since the “workers” set doesn’t include process 0, it is no longer displayed in the Debug view



Registering A Process

- ★ To register a process, double-click its process icon in the **Parallel Debug view** or select a number of processes and click on the **register** button
- ★ To un-register a process, double-click on the process icon or select a number of processes and click on the **unregister** button



Current Line Marker

- ✦ The current line marker is used to show the current location of suspended processes
- ✦ In traditional programs, there is a single current line marker (the exception to this is multi-threaded programs)
- ✦ In parallel programs, there is a current line marker for every process
- ✦ The PTP debugger shows one current line marker for every group of processes at the same location

Colors And Markers

- ★ The highlight color depends on the processes suspended at that line:
 - ★ **Blue:** All registered process(es)
 - ★ **Orange:** All unregistered process(es)
 - ★ **Green:** Registered or unregistered process with no source line (e.g. suspended in a library routine)
- ★ The marker depends on the type of process stopped at that location
- ★ Hover over marker for more details about the processes suspend at that location

```

main.c
int proc_cnt;
int tid;
MPI_Datatype * res_type;

MPI_Init(&argc, &argv);
MPI_Comm_size(MPI_COMM_WORLD, &proc_cnt);
MPI_Comm_rank(MPI_COMM_WORLD, &tid);

if ( proc_cnt < 2 )
{
    fprintf(stderr, "must have at least 2 processes, not %d\n", proc_cnt);
    MPI_Finalize();
    return 1;
}
  
```



Multiple processes marker



Registered process marker



Un-registered process marker



Multiple markers at this line
 -Suspended on unregistered process: 2
 -Suspended on registered process: 1

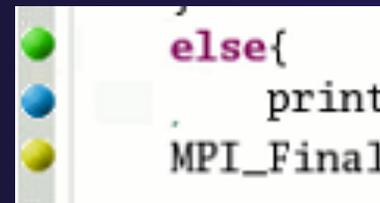


Exercise

1. From the initial debugger session, step all processes until the current line is just after MPI_Init (line 68)
2. Create a process set called "workers" containing processes 1-4
3. Step the "worker" processes twice, observe two line markers
4. Hover over markers to see properties
5. Switch to the "root" set
6. Step only process 0 twice so that all processes are now at line 71 (hint – use the debug view)

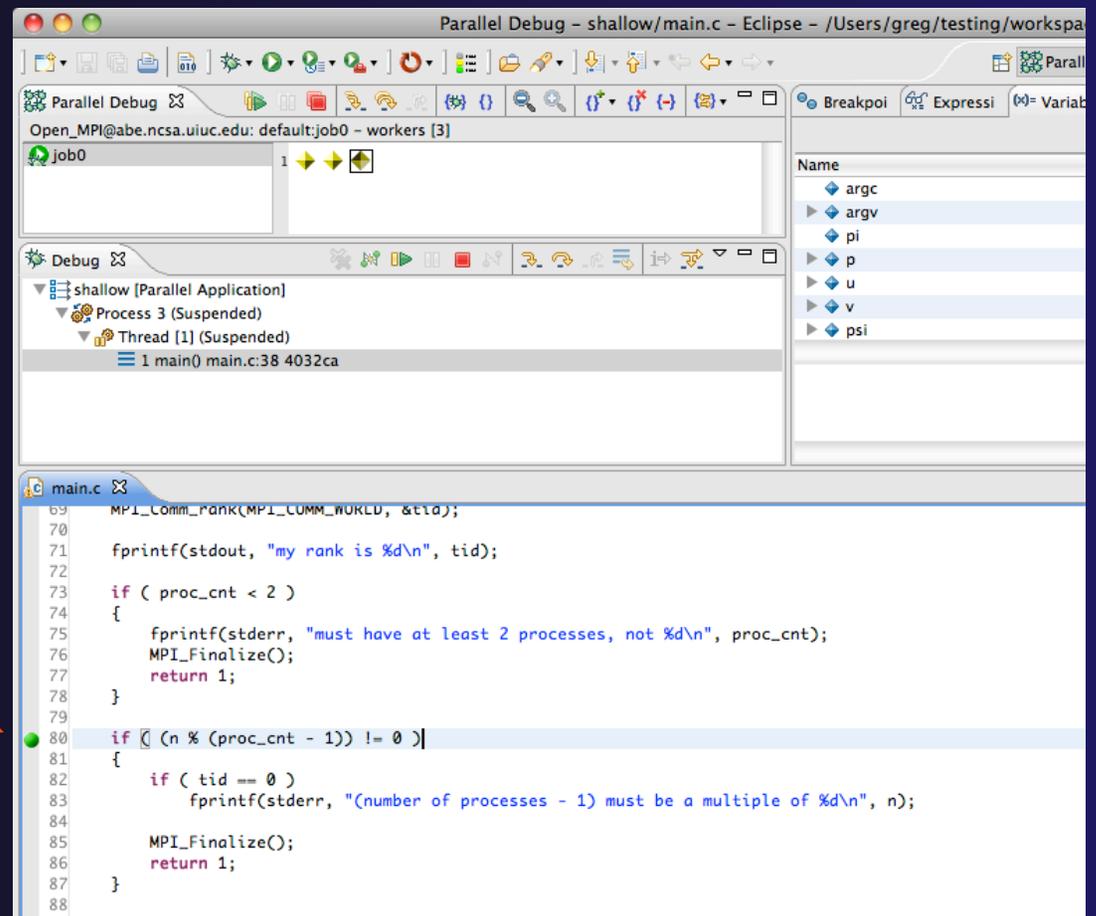
Breakpoints

- ★ Apply only to processes in the particular set that is active in the **Parallel Debug view** when the breakpoint is created
- ★ Breakpoints are colored depending on the active process set and the set the breakpoint applies to:
 - ★ **Green** indicates the breakpoint set is the same as the active set.
 - ★ **Blue** indicates some processes in the breakpoint set are also in the active set (i.e. the process sets overlap)
 - ★ **Yellow** indicates the breakpoint set is different from the active set (i.e. the process sets are disjoint)
- ★ When the job completes, the breakpoints are automatically removed



Creating A Breakpoint

- ★ Select the process set that the breakpoint should apply to, in this case, the **workers** set
- ★ Double-click on the left edge of an editor window, at the line on which you want to set the breakpoint, or right click and use the **Parallel Breakpoint ► Toggle Breakpoint** context menu
- ★ The breakpoint is displayed on the marker bar

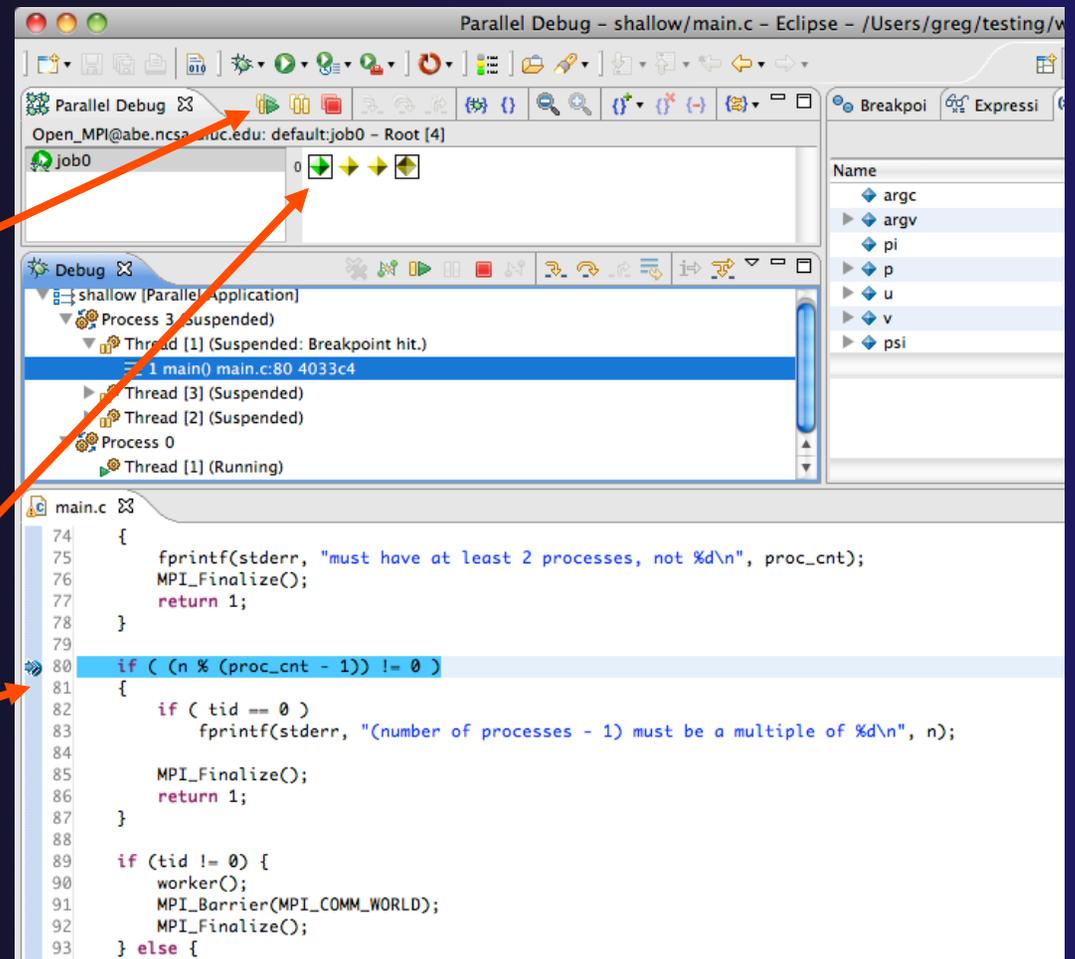


The screenshot shows the Eclipse IDE interface for a parallel application. The top toolbar includes a 'Parallel Breakpoint' icon. The 'Parallel Debug' window shows a job named 'job0' with a marker bar containing a green dot representing a breakpoint. The 'Debug' window shows the application structure: 'shallow [Parallel Application]' containing 'Process 3 (Suspended)' and 'Thread 1 (Suspended)'. The 'main.c' editor window shows the source code with a breakpoint set on line 80. An orange arrow points from the text 'The breakpoint is displayed on the marker bar' to the green dot on the marker bar.

```
69 MPI_Comm_rank(MPI_COMM_WORLD, &tid);
70
71 fprintf(stdout, "my rank is %d\n", tid);
72
73 if ( proc_cnt < 2 )
74 {
75     fprintf(stderr, "must have at least 2 processes, not %d\n", proc_cnt);
76     MPI_Finalize();
77     return 1;
78 }
79
80 if ( (n % (proc_cnt - 1)) != 0 )
81 {
82     if ( tid == 0 )
83         fprintf(stderr, "(number of processes - 1) must be a multiple of %d\n", n);
84
85     MPI_Finalize();
86     return 1;
87 }
88
```

Hitting the Breakpoint

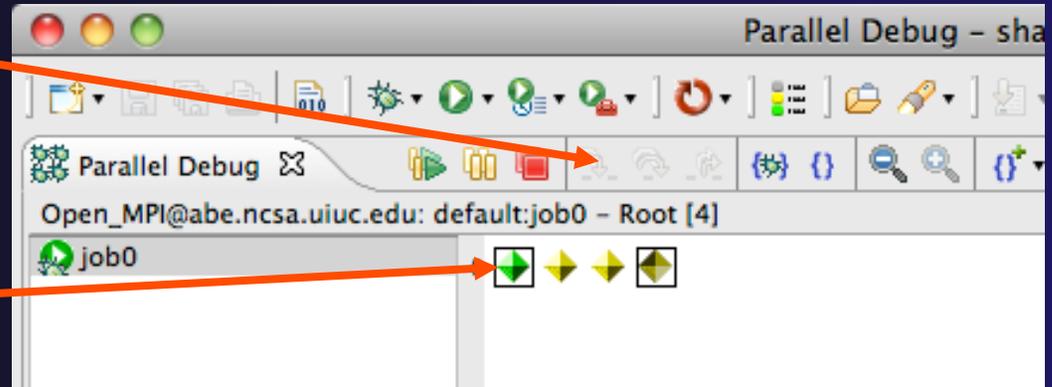
- ✦ Switch back to the **Root** set by clicking on the **Change Set** button
- ✦ Click on the **Resume** button in the **Parallel Debug view**
- ✦ In this example, the three worker processes have hit the breakpoint, as indicated by the yellow process icons and the current line marker
- ✦ Process 0 is still running as its icon is green
- ✦ Processes 1-3 are suspended on the breakpoint



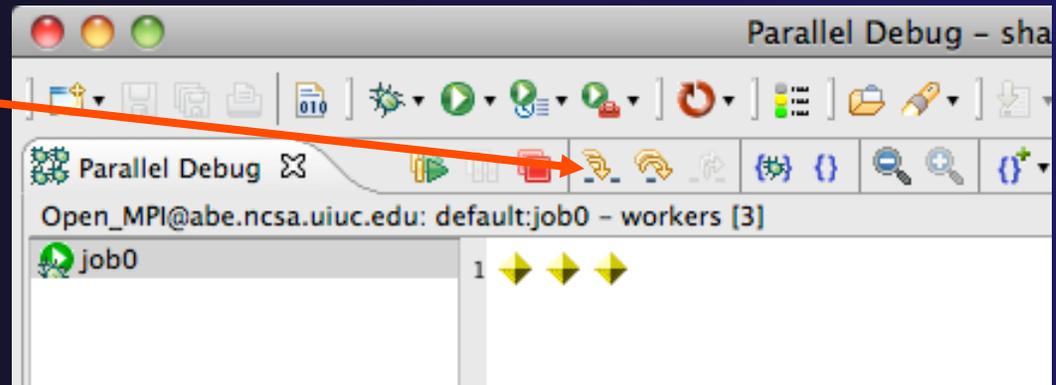
```
74 {
75     fprintf(stderr, "must have at least 2 processes, not %d\n", proc_cnt);
76     MPI_Finalize();
77     return 1;
78 }
79
80 if ( n % (proc_cnt - 1) != 0 )
81 {
82     if ( tid == 0 )
83         fprintf(stderr, "(number of processes - 1) must be a multiple of %d\n", n);
84
85     MPI_Finalize();
86     return 1;
87 }
88
89 if (tid != 0) {
90     worker();
91     MPI_Barrier(MPI_COMM_WORLD);
92     MPI_Finalize();
93 } else {
```

More On Stepping

- ★ The **Step** buttons are only enabled when all processes in the active set are **suspended** (yellow icon)
- ★ In this case, process 0 is still running

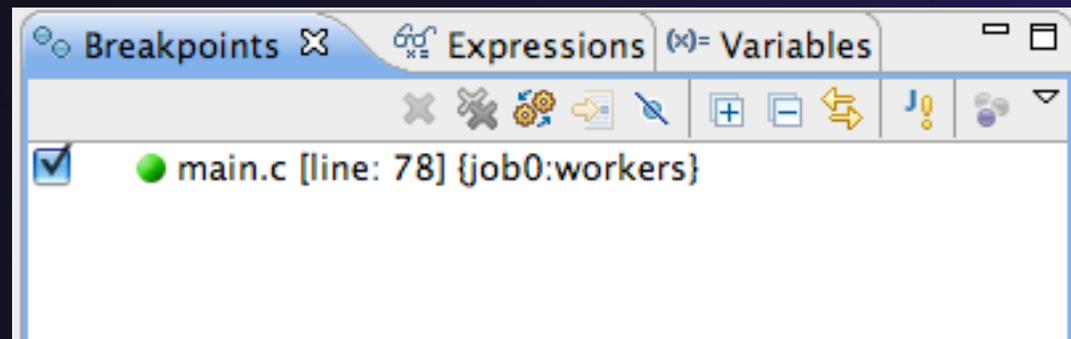


- ★ Switch to the set of suspended processes (the **workers** set)
- ★ You will now see the **Step** buttons become enabled



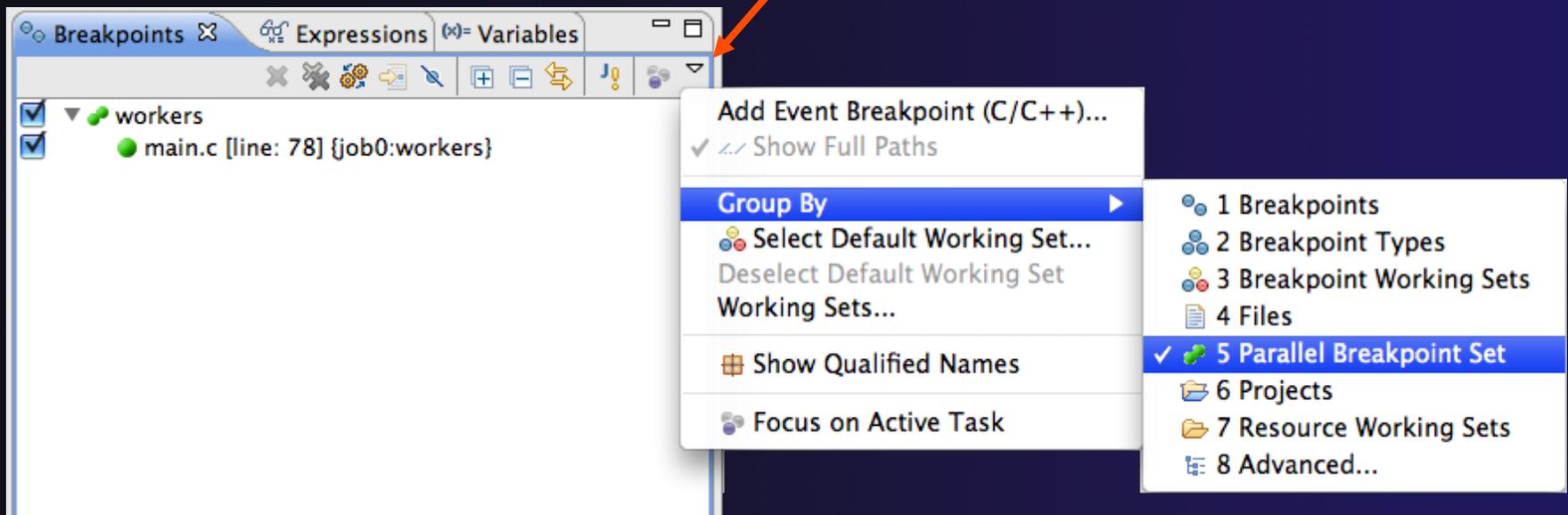
Breakpoint Information

- ✦ Hover over breakpoint icon
 - ✦ Will show the sets this breakpoint applies to
- ✦ Select **Breakpoints** view
 - ✦ Will show all breakpoints in all projects



Breakpoints View

- ★ Use the menu in the breakpoints view to group breakpoints by type
- ★ Breakpoints sorted by breakpoint set (process set)



Global Breakpoints

- ✦ Apply to all processes and all jobs
- ✦ Used for gaining control at debugger startup
- ✦ To create a global breakpoint
 - ✦ First make sure that no jobs are selected (click in white part of jobs view if necessary)
 - ✦ Double-click on the left edge of an editor window
 - ✦ Note that if a job is selected, the breakpoint will apply to the current set

```
if (my_rank != 0) {  
    /* create message */  
    sprintf(message, "Greetin
```

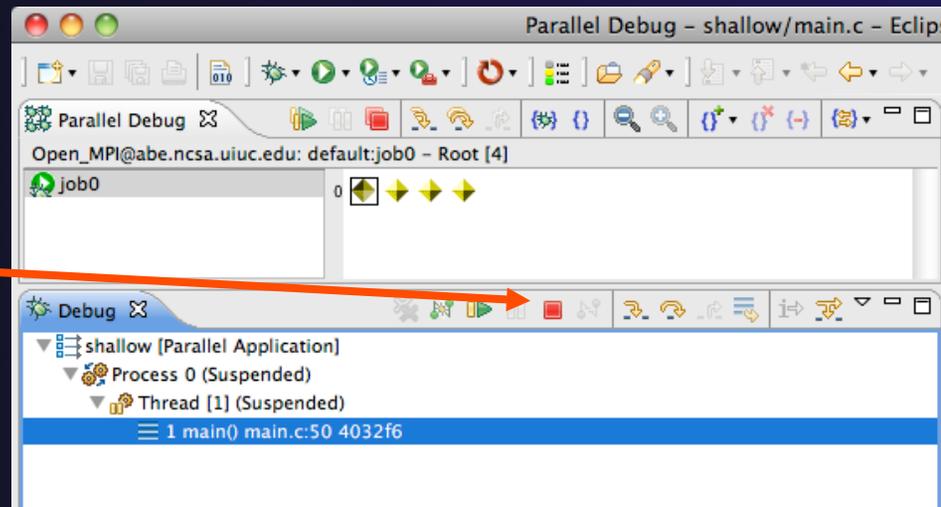
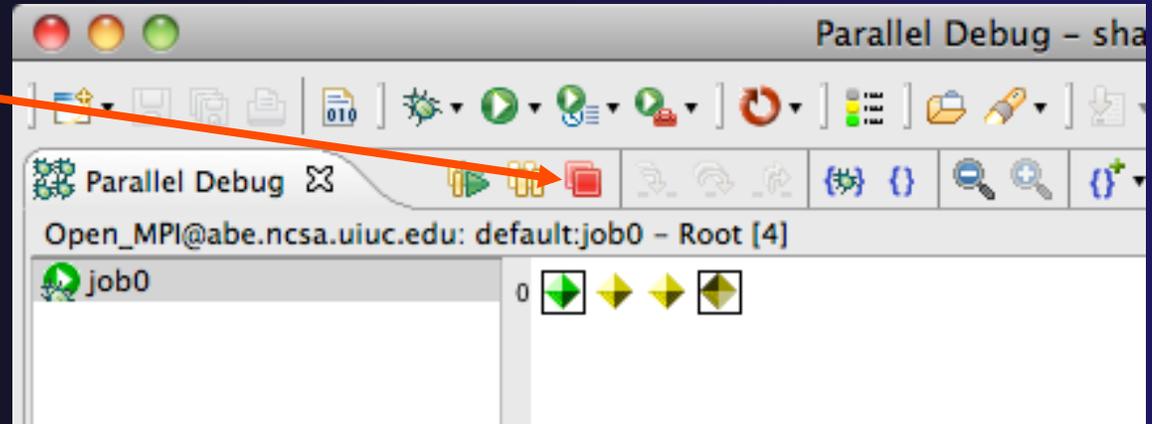


Exercise

1. Select the "worker" process set
2. Create a breakpoint by double-clicking on right hand bar at line 88 (worker function)
3. Hover over breakpoint to see properties
4. Switch to "root" process set
5. Observer breakpoint color changes to blue
6. Resume all processes
7. Observe "worker" processes at breakpoint, and process 0 still running (green icon)
8. Switch to "worker" process set
9. Step "worker" processes over worker() function
10. Observe output from program

Terminating A Debug Session

- ★ Click on the **Terminate** icon in the **Parallel Debug view** to terminate all processes in the active set
- ★ Make sure the **Root** set is active if you want to terminate all processes
- ★ You can also use the terminate icon in the **Debug view** to terminate the currently selected process



Cancelling The Job

- ✦ Interactive jobs will continue until the reservation time has expired
- ✦ You can cancel the job once the debug session is finished
- ✦ Locate the job in the **Active Jobs** view
 - ✦ Use the view menu to filter for only your jobs if there are too many
- ✦ Right click on the job and select **Cancel Job**

The screenshot shows the 'System Monitoring - shallow/main' window. The 'Active Jobs' view is selected, displaying a table of jobs. The job with ID 1059599 is highlighted in blue. A right-click context menu is open over this job, showing options: Resume Job, Cancel Job (highlighted), Hold Job, Release Job, Suspend Job, Get Job Error, Get Job Output, Refresh Job Status, and Remove Job Entry. An orange arrow points from the text 'select Cancel Job' in the list to the 'Cancel Job' option in the menu.

step	owner	queue	wall	queue	dispat	totalcc	status
1059550...	cipres	sha...	720...	20...	20...	8	RUNNING
1059552...	cipres	sha...	259...	20...	20...	8	RUNNING
1059553...	cipres	sha...	604...	20...	20...	8	RUNNING
1059565...	gha...	sha...	180...	20...	20...	1	RUNNING
1059569...	cipres	sha...	126...	20...	20...	8	RUNNING
1059572...	cipres	sha...	126...	20...	20...	8	RUNNING
1059573...	tib...	sha...	1800	20...	20...	5	RUNNING
1059578...	arm...	sha...	432...	20...	20...	6	RUNNING
1059579...	arm...	sha...	432...	20...	20...	6	RUNNING
1059588...	ccole	sha...	864...	20...	20...	8	RUNNING
1059590...	cipres	sha...	108...	20...	20...	8	RUNNING
1059592...	cipres	sha...	108...	20...	20...	8	RUNNING
1059594...	ram...	sha...	306...	20...	20...	16	RUNNING
1059595...	cipres	nor...	604...	20...	20...	10	RUNNING
1059599...	grw	sha...	180...	20...	20...	8	RUNNING
1059600...	cipres	nor...	720...	20...	20...	8	RUNNING



Exercise

1. Switch to the "root" set
2. Terminate all processes
3. Switch to the System Monitoring perspective
4. Right-click on your running job and select **Cancel**



Optional Exercise

1. Launch another debug job
2. Create a breakpoint at line 71 in main.c
3. Resume all processes
4. Select the Variables view tab if not already selected
5. Observe value of the "tid" variable
6. Register one of the worker processes
7. Select stack frame of worker process in Debug view
8. Observe value of the "tid" variable matches worker process
9. Switch to the breakpoints view, change grouping
10. Terminate all processes
11. Switch to the System Monitoring perspective and cancel the job

Performance Tuning and Analysis Tools

★ Objective

- ★ Become familiar with tools integrated with PTP, to help enhance performance of parallel applications

★ Contents

- ★ Overview of ETFw and Performance Tools

PTP/External Tools Framework

formerly "Performance Tools Framework"

Goal:

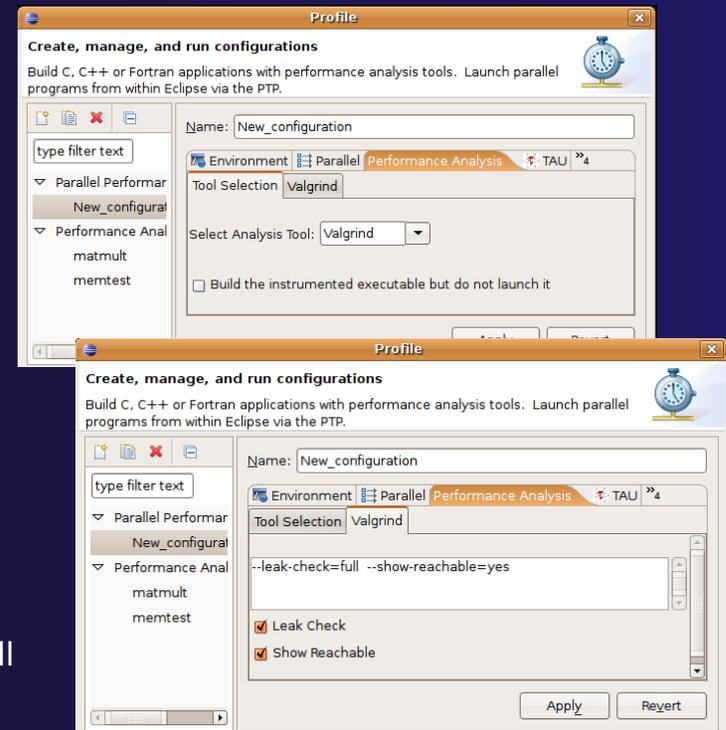
- ★ Reduce the "eclipse plumbing" necessary to integrate tools
- ★ Provide integration for instrumentation, measurement, and analysis for a variety of performance tools

- ★ Dynamic Tool Definitions: Workflows & UI
- ★ Tools and tool workflows are specified in an XML file
- ★ Tools are selected and configured in the launch configuration window
- ★ Output is generated, managed and analyzed as specified in the workflow
- ★ One-click 'launch' functionality
- ★ Support for development tools such as TAU, PPW and others.
- ★ Adding new tools is much easier than developing a full Eclipse plug-in

```

-<tool name="Valgrind">
-<execute>
  <utility command="bash" group="inbin"/>
  -<utility command="valgrind" group="valgrind">
    -<optionpane title="Valgrind" seperatewith=" ">
      <togoption label="Leak Check" optname="--leak-check=full" tooltip="">
      <togoption label="Show Reachable" optname="--show-reachable=yes" tooltip="">
    </optionpane>
  </utility>
</execute>
</tool>

```



Performance Tuning and Analysis Tools - TAU

★ Objective

- ★ Become familiar with tools integrated with PTP, to help enhance performance of parallel applications

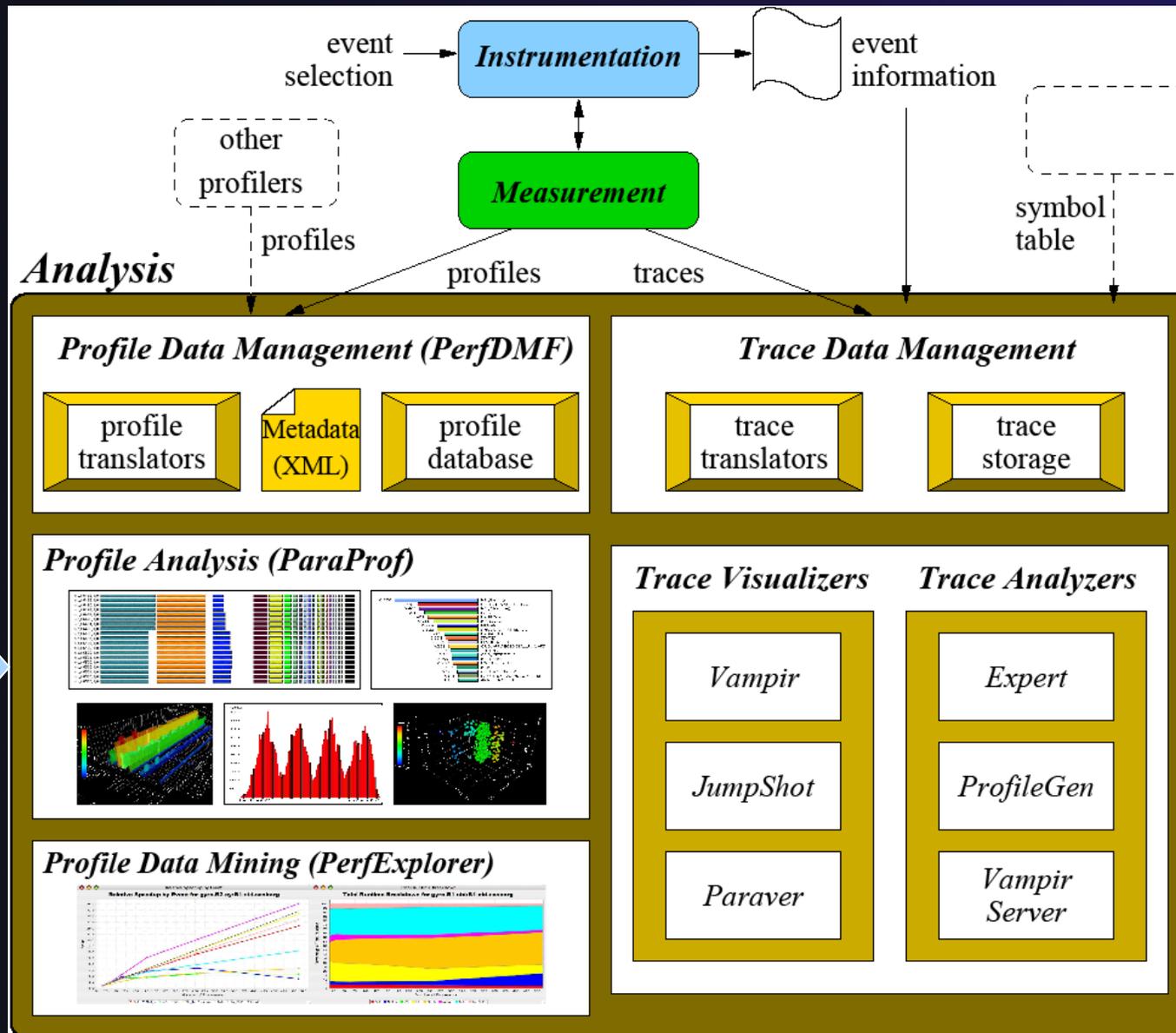
★ Contents

- ★ Performance Tuning and external tools:
 - ★ PTP External Tools Framework (ETFw), TAU
 - Hands-on exercise using TAU with PTP

TAU: Tuning and Analysis Utilities

- ★ TAU is a performance evaluation tool
- ★ It supports parallel profiling and tracing
 - ★ Profiling shows you how much (total) time was spent in each routine
 - ★ Tracing shows you *when* the events take place in each process along a timeline
- ★ TAU uses a package called PDT (Performance Database Toolkit) for automatic instrumentation of the source code
- ★ Profiling and tracing can measure time as well as hardware performance counters from your CPU (or GPU!)
- ★ TAU can automatically instrument your source code (routines, loops, I/O, memory, phases, etc.)
- ★ TAU runs on all HPC platforms and it is free (BSD style license)
- ★ TAU has instrumentation, measurement and analysis tools
 - ★ **paraprof** is TAU's 3D profile browser

TAU Performance System Architecture

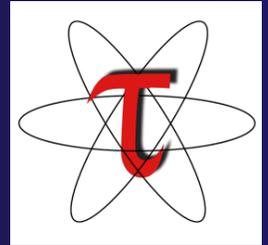


TAU

TAU-3

PTP TAU plug-ins

<http://www.cs.uoregon.edu/research/tau>



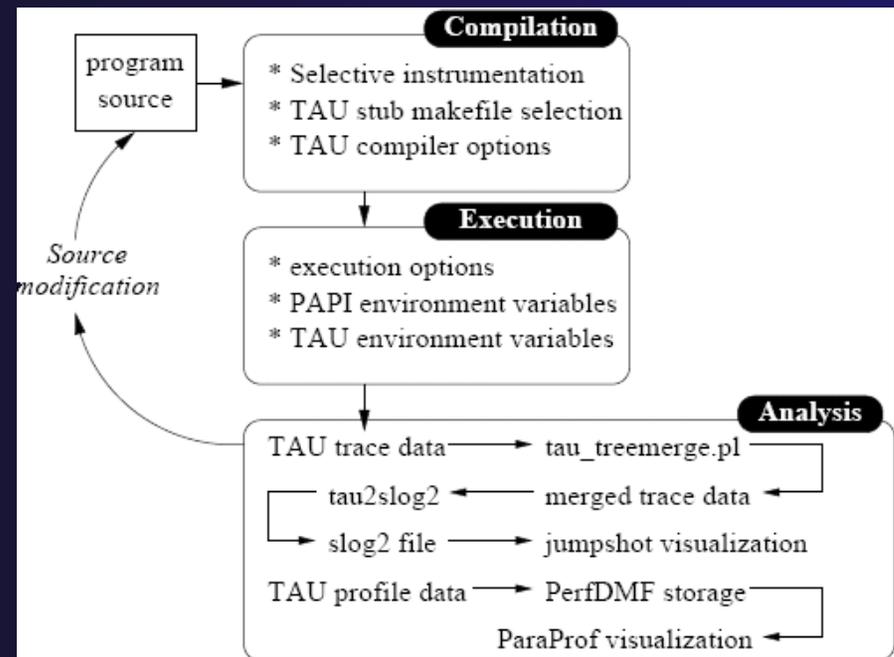
- ★ TAU (Tuning and Analysis Utilities)
- ★ First implementation of External Tools Framework (ETFw)
- ★ Eclipse plug-ins wrap TAU functions, make them available from Eclipse
- ★ Full GUI support for the TAU command line interface
- ★ Performance analysis integrated with development environment

TAU

TAU-4

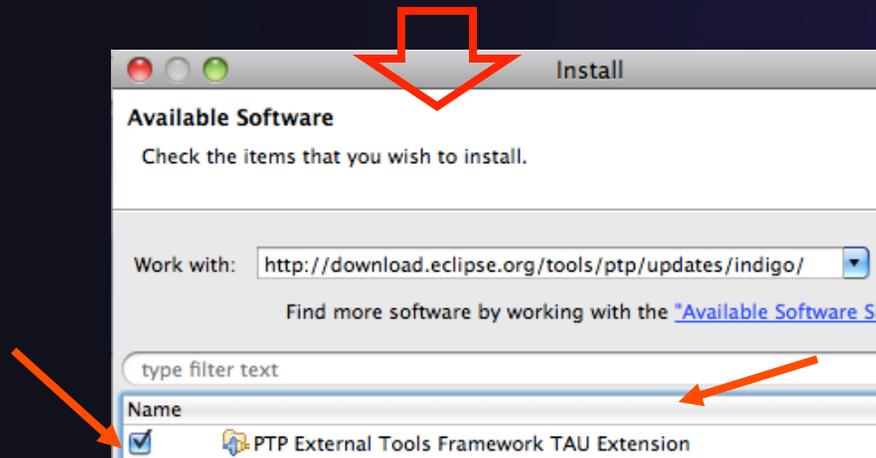
TAU Integration with PTP

- ★ TAU: Tuning and Analysis Utilities
 - ★ Performance data collection and analysis for HPC codes
 - ★ Numerous features
 - ★ Command line interface
- ★ The TAU Workflow:
 - ★ Instrumentation
 - ★ Execution
 - ★ Analysis



TAU PTP Installation

- ✦ This tutorial assumes that the TAU extensions for PTP are installed – they are not included in the “Eclipse for Parallel Application Developers”
- ✦ The installation section (Module 1) shows how to install TAU and other features from the PTP update site – be sure TAU was selected



To confirm:

- ✦ Help>Install New Software...
- ✦ Select the link “What is already installed” at the bottom of the dialog
- ✦ You should see the TAU Extension

Installing TAU Analysis Tools

- ★ The TAU plugin can use ParaProf for visual analysis and TauDB for organization of profiles
- ★ To install these utilities on Mac or Linux platforms:
 - ★ Download (browser, curl or wget) tau.uoregon.edu/tautools.tgz
 - ★ `tar -zxf tautools.tgz`
 - ★ `cd tautools-2.22b`
 - ★ `./configure`
 - ★ Set path as shown (launch eclipse from this environment)
 - ★ Run `taudb_configure` and follow the instructions
- ★ Java WebStart: tau.uoregon.edu/paraprof
- ★ TAU Installation, downloads and instructions: tau.uoregon.edu

Assumptions

- ★ Obtain and install TAU*
 - ★ Download at tau.uoregon.edu
 - ★ The website includes setup and user guides
- ★ Set up the \$PATH on the remote machine*
 - ★ For TAU you should be able to run 'which pprof' on a remote login and see a result from your TAU bin directory
 - ★ On trestles.sdsc.edu this is accomplished by loading the tau module in the module configuration interface
- ★ Include 'eclipse.inc' in the makefile*
 - ★ Create an empty eclipse.inc file in the same directory as the makefile
 - ★ Place 'include eclipse.inc' in the makefile after regular compiler definitions
 - ★ ETFw will modify eclipse.inc to set CC/CXX/FC variables

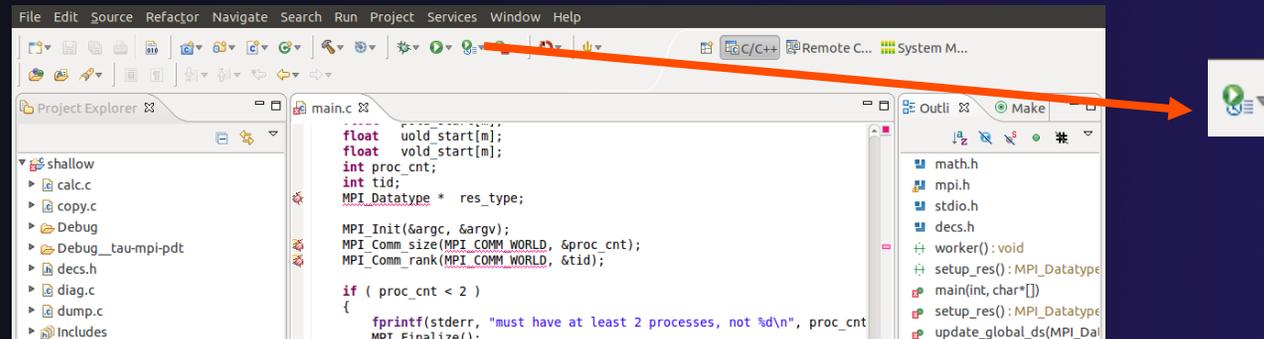
Selective Instrumentation

- ★ By default tau provides timing data for each subroutine of your application
- ★ Selective instrumentation allows you to include/exclude code from analysis and control additional analysis features
 - ★ Include/exclude source files or routines
 - ★ Add timers and phases around routines or arbitrary code
 - ★ Instrument loops
 - ★ Note that some instrumentation features require the PDT
- ★ Right click on calc.c, init.c, diag.c go to the Selective Instrumentation option and select Instrument Loops
- ★ Note the creation of tau.selective (refresh if needed)

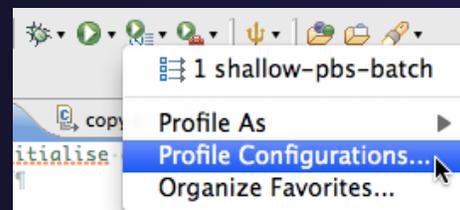


Begin Profile Configuration

- ★ The ETFw uses the same run configurations and resource managers as debugging/launching
- ★ Click on the 'Run' menu or the right side of the Profile button



- ★ From the dropdown menu select 'Profile configurations...'

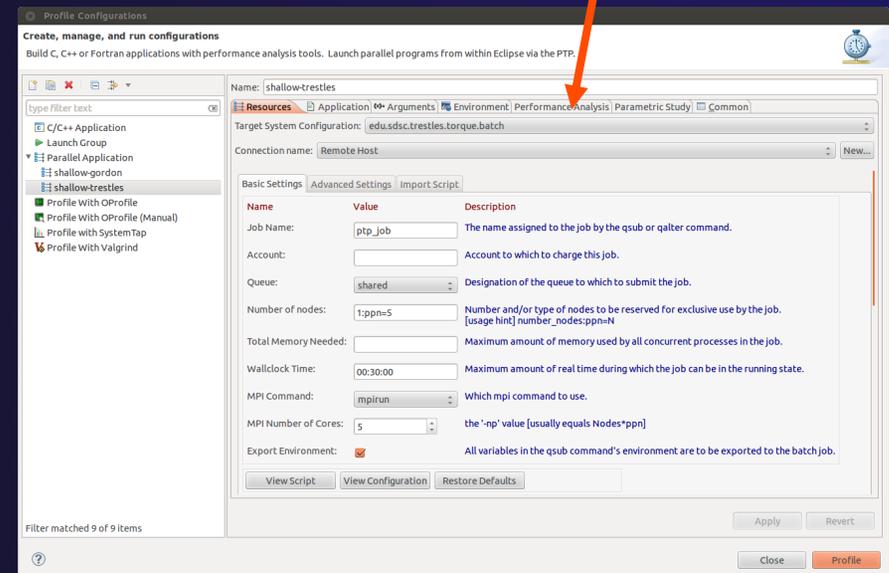


Select Configuration



- ★ Select the shallow configuration prepared earlier
- ★ The Resource and Application configuration tabs require little or no modification
 - ★ We are using the same resource manager and Torque settings
 - ★ Since we are using a makefile project the application will be rebuilt in and run from the previously selected location

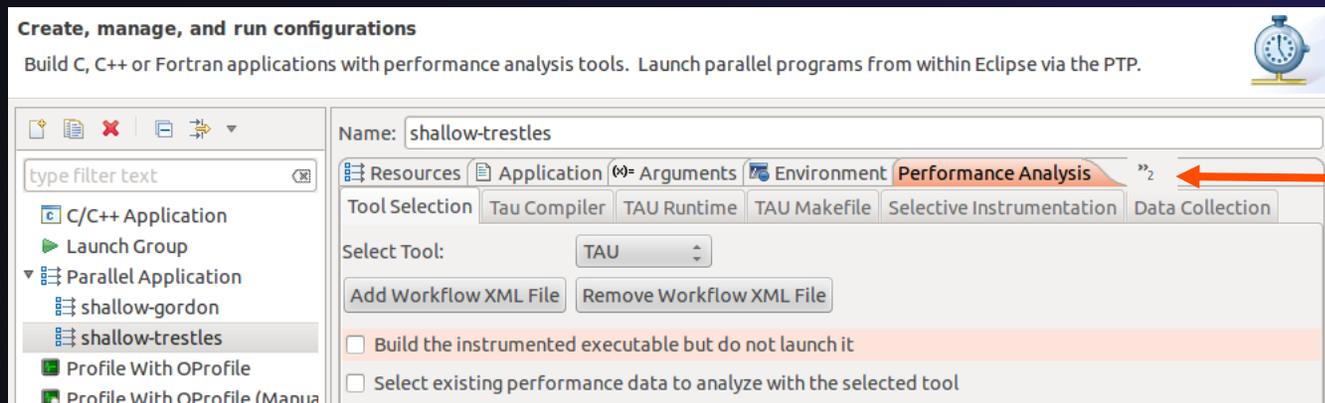
Performance Analysis tab is present in the **Profile Configurations** dialog





Select Tool/Workflow

- ★ Select the **Performance Analysis** tab and choose the TAU tool set in the 'Select Tool' dropdown box
 - ★ Other tools may be available, either installed as plug-ins or loaded from workflow definition XML files
 - ★ Configuration sub-panes appear depending on the selected tool

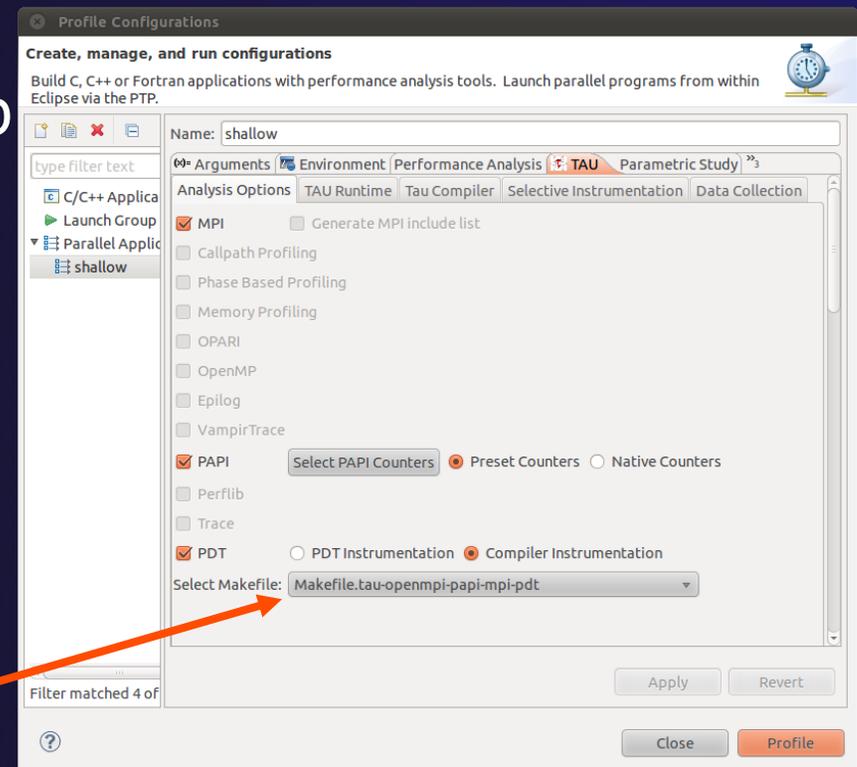


Tabs may be hidden if the window is too small



Select TAU Configuration

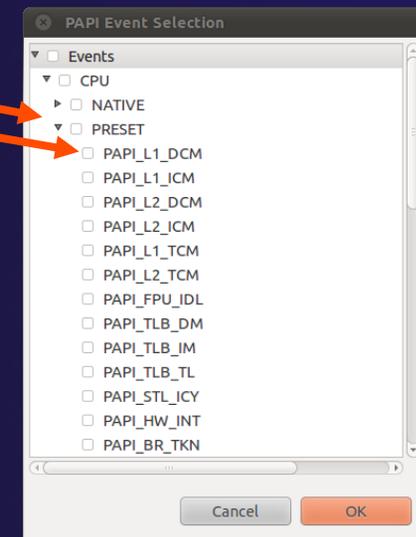
- ★ Choose the TAU Makefile tab
 - ★ All TAU configurations in remote installation are available
 - ★ Check MPI and PDT checkboxes to filter listed makefiles
 - ★ Make your selection in the **Select Makefile:** dropdown box
 - ★ Select Makefile.tau-mpi-pdt





Choose PAPI Hardware Counters

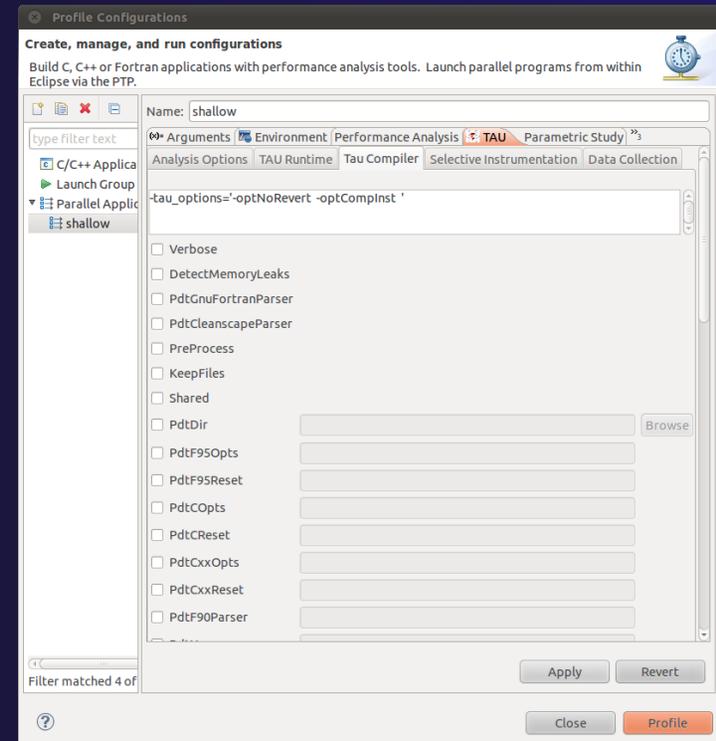
- ★ When a PAPI-enabled TAU configuration is selected the PAPI Counter tool becomes available
 - ★ Select the 'Select PAPI Counters' button to open the tool
 - ★ Open the PRESET subtree
 - ★ Select PAPI_L1_DCM (Data cache misses)
 - ★ Scroll down to select PAPI_FP_INS (Floating point instructions)
 - ★ Invalid selections are automatically excluded
 - ★ Select **OK**
 - ★ **Not available on trestles.sdsc.edu**





Compiler Options

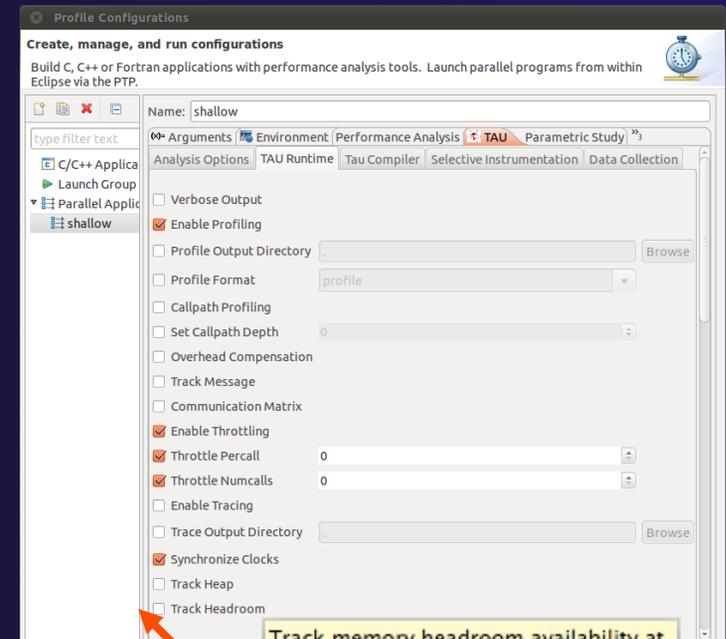
- ✦ TAU Compiler Options
 - ✦ Set arguments to TAU compiler scripts
 - ✦ Control instrumentation and compilation behavior
 - ✦ Verbose shows activity of compiler wrapper
 - ✦ KeepFiles retains instrumented source
 - ✦ PreProcess handles C type ifdefs in fortran
- ✦ In the Selective Instrumentation tab select Internal then hit Apply
- ✦ Scroll to bottom of the Tau Compiler tab and activate TauSelectFile to use tau.selective





Runtime Options

- ✦ TAU Runtime options
 - ✦ Set environment variables used by TAU
 - ✦ Control data collection behavior
 - ✦ Verbose provides debugging info
 - ✦ Callpath shows call stack placement of events
 - ✦ Throttling reduces overhead
 - ✦ Tracing generates execution timelines
- ✦ Set Profile Format to merged

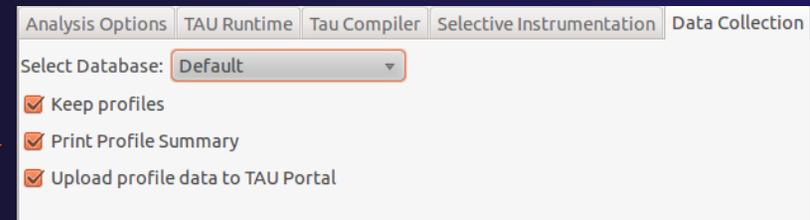


Hover help



Working with Profiles

- ★ Profiles are uploaded to selected database
- ★ A text summary may be printed to the console
- ★ Profiles may be uploaded to the TAU Portal for viewing online
 - ★ tau.nic.uoregon.edu
- ★ Profiles may be copied to your workspace and loaded in ParaProf from the command line. Select Keep Profiles



TAU Profile Output

MULTI_GET_TIME_OF_DAYReading Profile files in profile.*

FUNCTION SUMMARY (total):

%Time	Exclusive msec	Inclusive total msec	#Call	#Subrs	Inclusive Name usec/call
100.0	196	16,797	9	9	1866428 .TAU application
98.8	56	16,601	9	3662	1844640 main
68.7	11,538	11,538	9	0	1282002 MPI_Init()
26.0	204	4,360	8	59684	545009 worker
9.5	803	1,602	80000	160000	20 neighbour_receive
8.3	789	1,402	80000	160000	18 neighbour_send
8.3	234	1,398	8000	64000	175 time_load
7.1	1,188	1,188	81968	0	14 MPI_Recv()
6.5	182	1,085	8000	48000	136 calc_load

TAU Portal URL:

TAU Portal Username:

TAU Portal Password:

Select a workspace

Select Workspace:

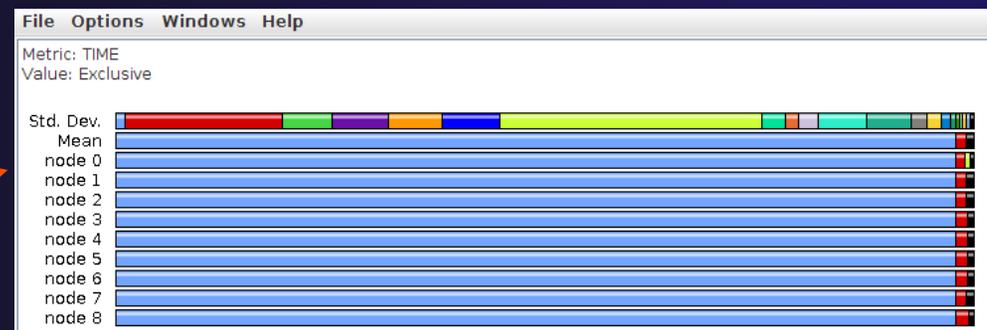


Launch TAU Analysis

- ★ Once your TAU launch is configured select 'Profile'
- ★ Notice that the project rebuilds with TAU compiler commands
- ★ The project will execute normally but TAU profiles will be generated
- ★ TAU profiles will be processed as specified in the launch configuration.
- ★ If you have a local profile database the run will show up in the Performance Data Management view
 - ★ Double click the new entry to view in ParaProf
 - ★ Right click on a function bar and select **Show Source Code** for source callback to Eclipse



TAU

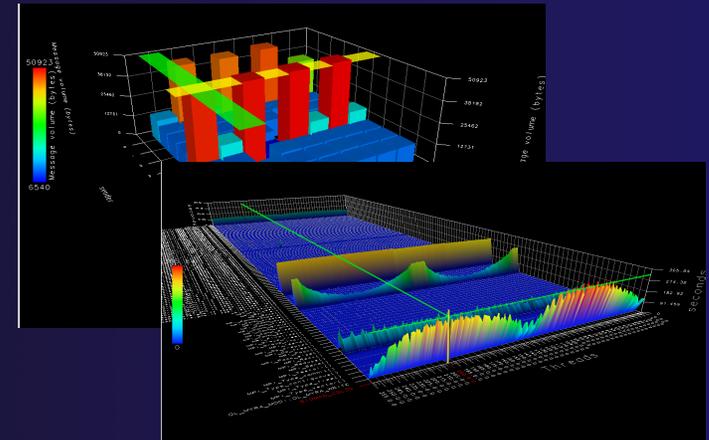


TAU-18



Paraprof

- ★ Use ParaProf for profile visualization to identify performance hotspots
 - ★ Inefficient sequential computation
 - ★ Communication overhead
 - ★ IO/Memory bottlenecks
 - ★ Load imbalance
 - ★ Suboptimal cache performance
- ★ Compare multiple trials in PerfExplorer to identify performance regressions and scaling issues
- ★ To use ParaProf, install TAU from tau.uoregon.edu or use Java webstart from tau.uoregon.edu/paraprof





Exercise

- ★ Multi-Trial profile comparison
 1. Edit the shallow Makefile, adding -O3 to CFLAGS and FFLAGS
 2. Rerun the analysis (Run->Profile Configurations. Hit Profile)
 3. A second trial, distinguished by a new timestamp, will be generated
 - ★ It will appear in your Performance Data Manager view if a profile database is available
 - ★ Also present in the Profile subdirectory of your project directory
 - ★ If you do not see a Profile directory right click on your project and go to Synchronization->'Sync All Now'
 4. Load the two trials in paraprof (on the command line: paraprof / path/to/tauprofile.xml)
 5. Open Windows->ParaProf Manager
 6. Expand your database down to reveal all trials
 7. Right click on each trial and click 'Add Mean to Comparison Window' to visualize the two trials side by side

GEM

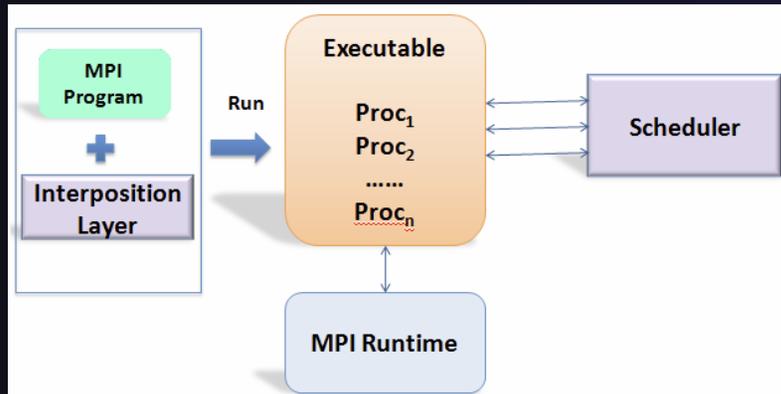
Graphical Explorer of MPI Programs

GEM

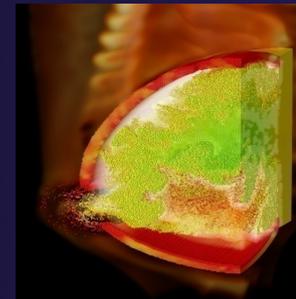
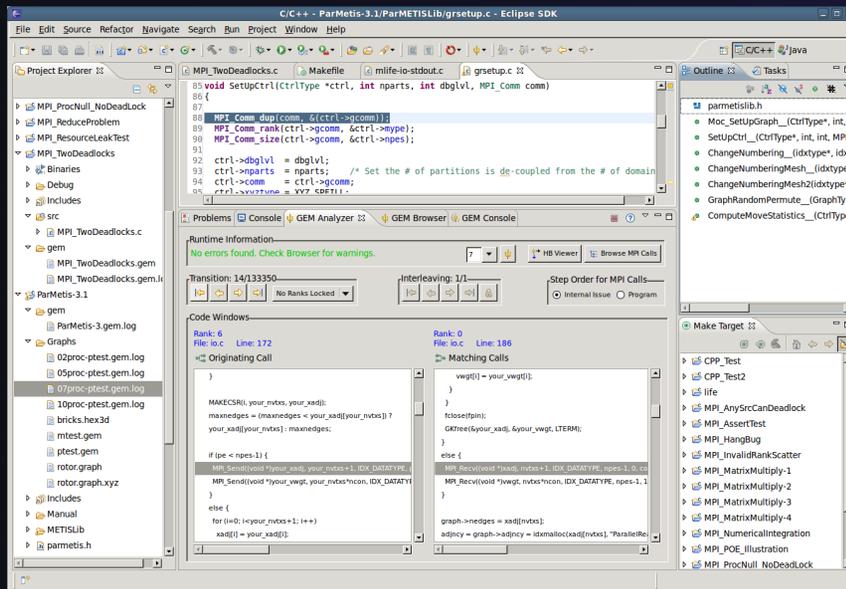
Graphical Explorer of MPI Programs

- ★ Dynamic verification for MPI C/C++ that detects:
 - ★ Deadlocks
 - ★ MPI object leaks (e.g. communicators, requests, datatypes)
 - ★ Functionally irrelevant barriers
 - ★ Local assertion violations
 - ★ MPI Send/Recv Type Mismatches
- ★ Offers rigorous coverage guarantees
 - ★ Complete nondeterministic coverage for MPI (MPI_ANY_SOURCE)
 - ★ Determines relevant interleavings, replaying as necessary
- ★ Examines communication / synchronization behaviors

GEM - Overview



- ★ Front-end for In-situ Partial Order (ISP) developed at University of Utah
- ★ Contributes “push-button” C/C++ MPI verification and analysis to the development cycle
- ★ Automatically instruments and runs user code, displaying post verification results
- ★ Variety of views & tools to facilitate debugging and MPI runtime understanding

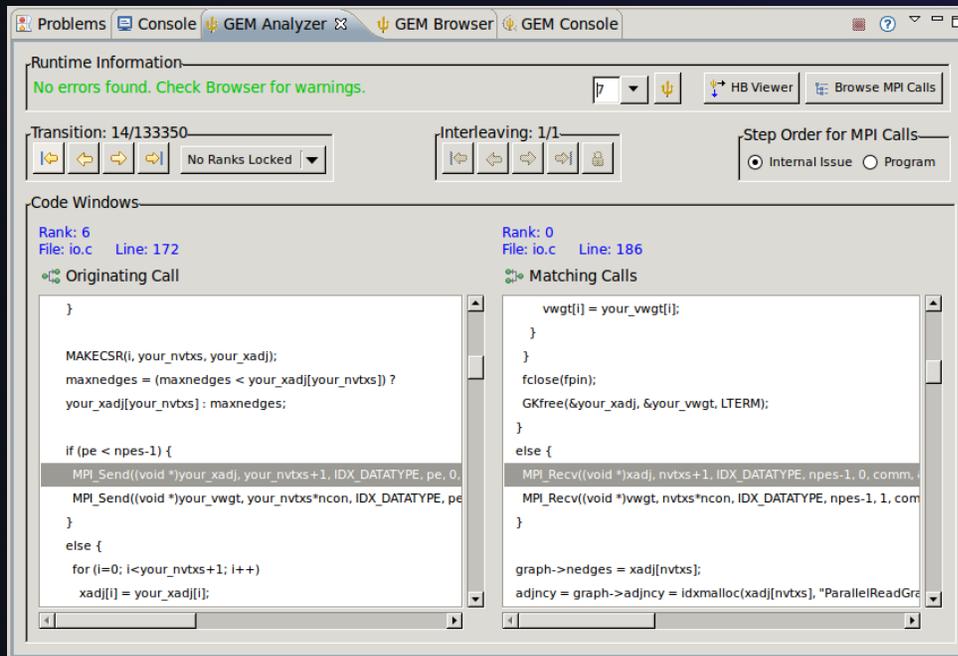


(Image courtesy of Steve Parker, U of Utah)

GEM – Views & Tools

Analyzer View

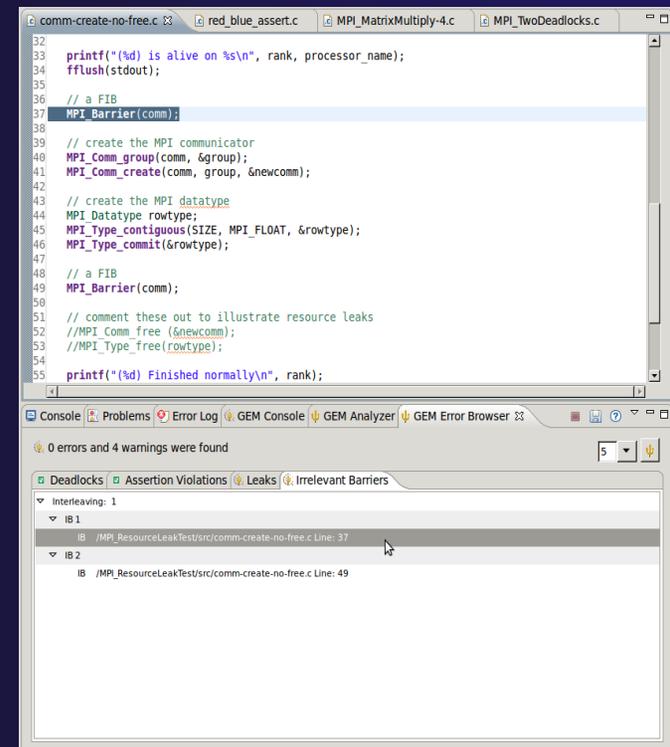
Highlights bugs, and facilitates post-verification review / debugging



GEM

Browser View

Groups and localizes MPI problems. Maps errors to source code in Eclipse editor

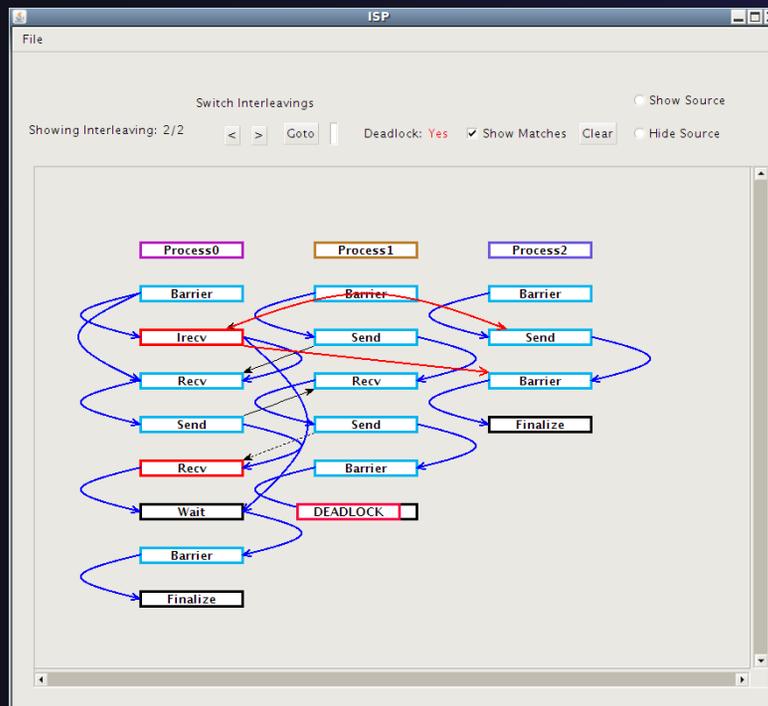


GEM-3

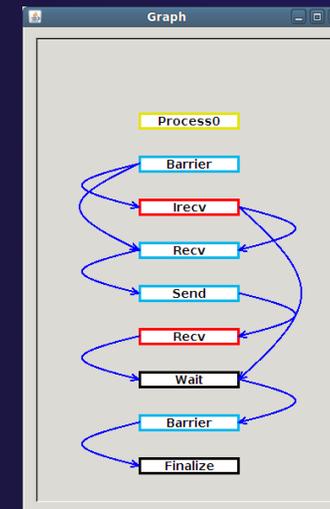
GEM – Views & Tools (cont.)

Happens-Before Viewer

Shows required orderings and communication matches
(currently an external tool - not supported in remote and
synchronized projects)



GEM



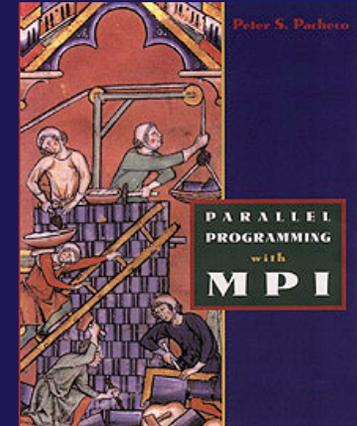
GEM-4

Plugins for GEM

GEM can be extended to import and analyze MPI projects from the popular MPI programming book:

“Parallel Programming with MPI”

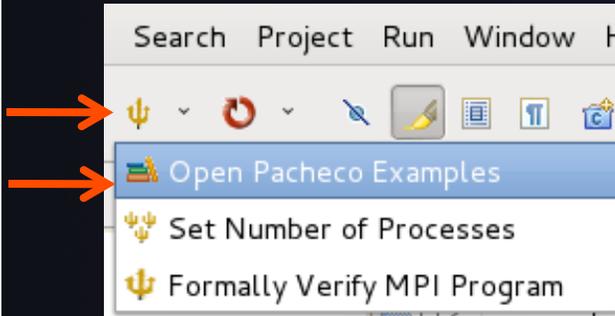
by Peter Pacheco



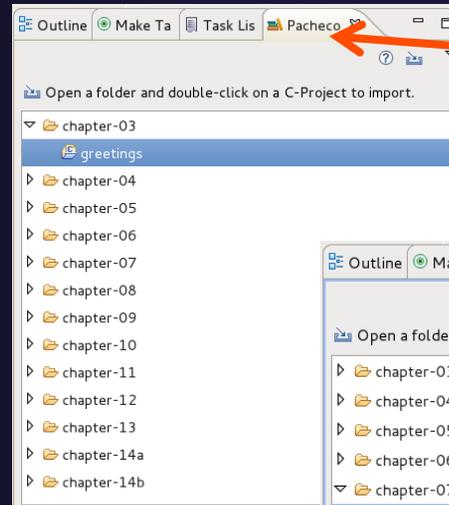
- ✦ Pacheco plugin was developed at University of Utah (not part of PTP) with full permission by the book's author
- ✦ **An excellent way to learn MPI using PTP/GEM**
- ✦ Update Site: http://www.cs.utah.edu/formal_verification/Pacheco/
- ✦ **Prerequisite**: PTP 6.0 with GEM installed

Pacheco Plugin

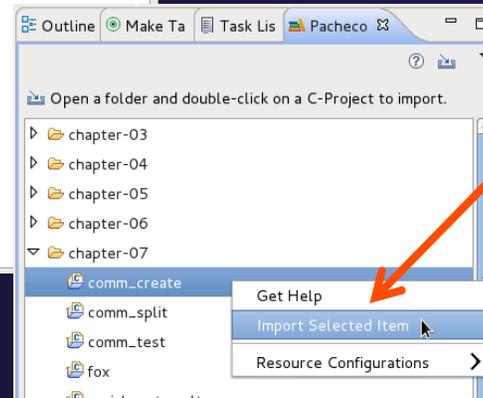
Ties in to GEM toolbar button



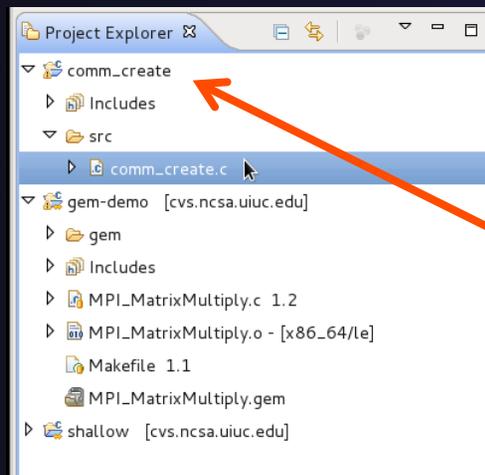
Provides a New Eclipse View with programming examples from book



Automatically import examples into workspace as Eclipse C projects

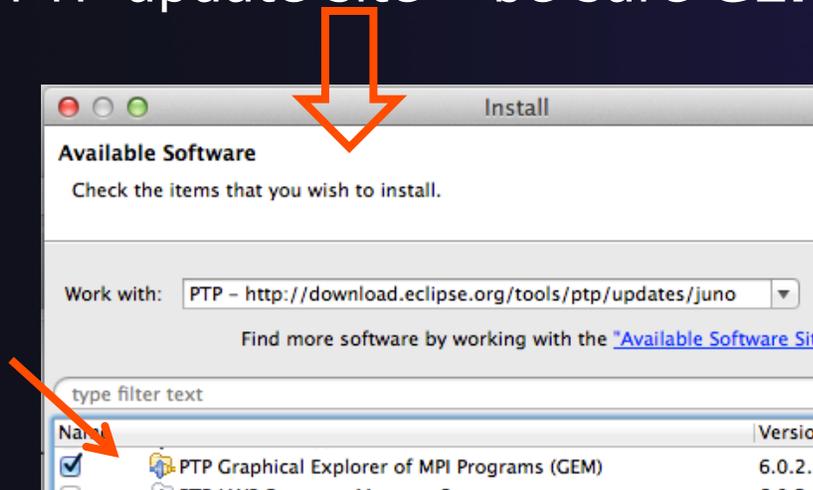


Build, work with and do analysis on any of these example projects using PTP and GEM



GEM PTP Installation

- ✦ This tutorial assumes that the GEM plugin for PTP is installed – they are not included by default in the “Eclipse for Parallel Application Developers” package
- ✦ GEM should already be installed for the tutorial, but the installation section shows how to install GEM from the PTP update site – be sure **GEM** was selected



To confirm:

- ✦ Help>Install New Software...
- ✦ Select the link: “What is already installed” at the bottom of the dialog
- ✦ You should see the GEM there

GEM

Hands-on Section

GEM Hands-on (0) Checkout GEM Project



★ (1) Check out GEM project "gem-demo" from CVS repo. This is the same repository as the **shallow** project.

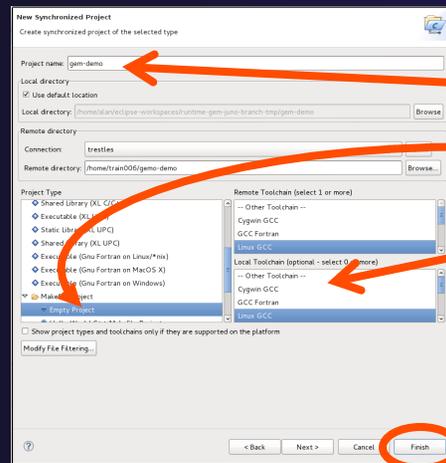
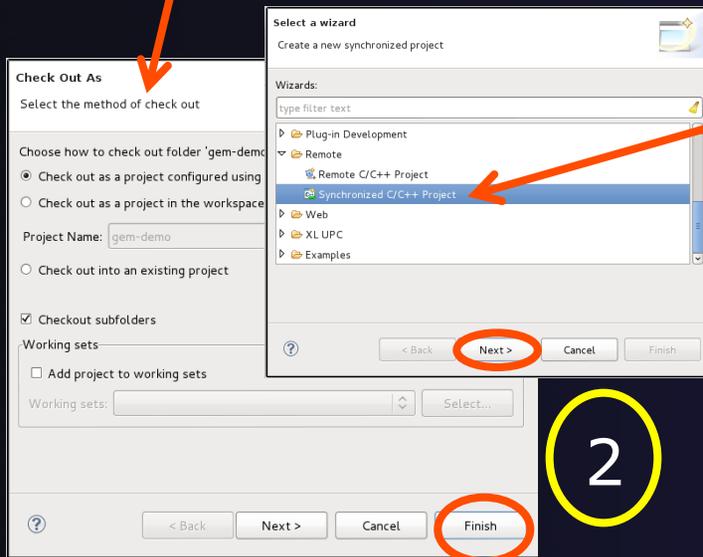
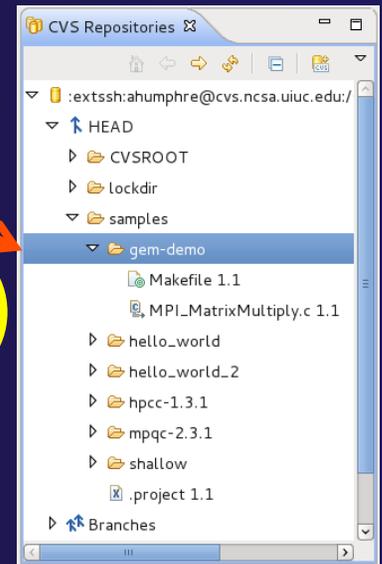
★ (2) Check out using New Project Wizard

★ Create a new Synchronized C Project

★ (3) Name the project: "gem-demo"

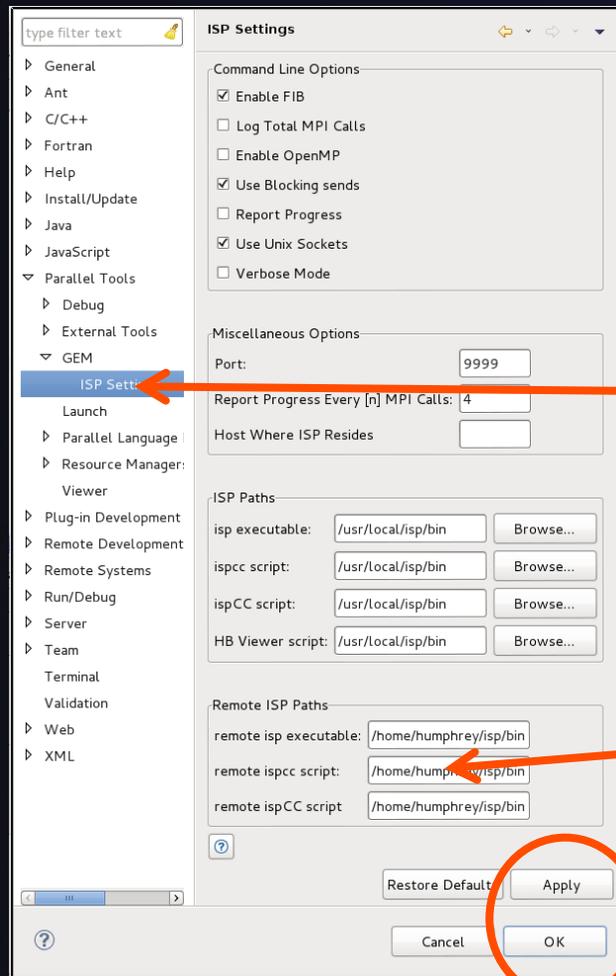
★ Empty Makefile Project

★ Linux GCC toolchain for both remote and local



GEM Hands-on (1)

Configure GEM Preferences



- ★ For the tutorial, you will only need to set:

"Remote ISP Paths"

- ★ Window → Preferences → Parallel Tools → GEM → ...

- ★ Use the following for all remote paths (ignore local):

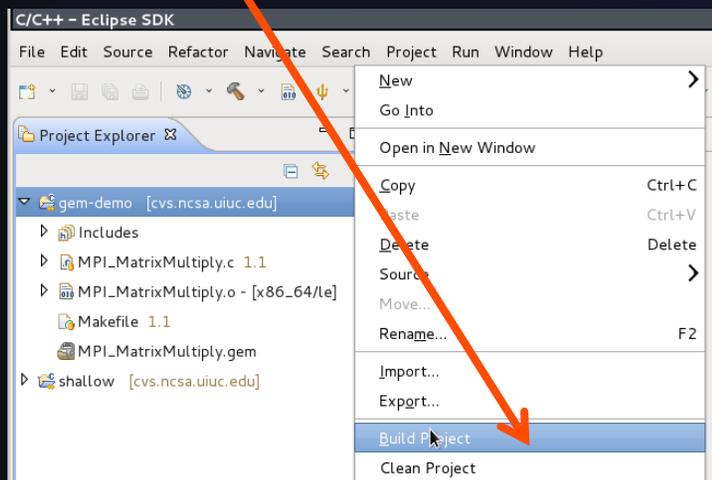
/home/humphrey/isp/bin

- ★ Leave everything else at defaults
- ★ Click Apply and OK

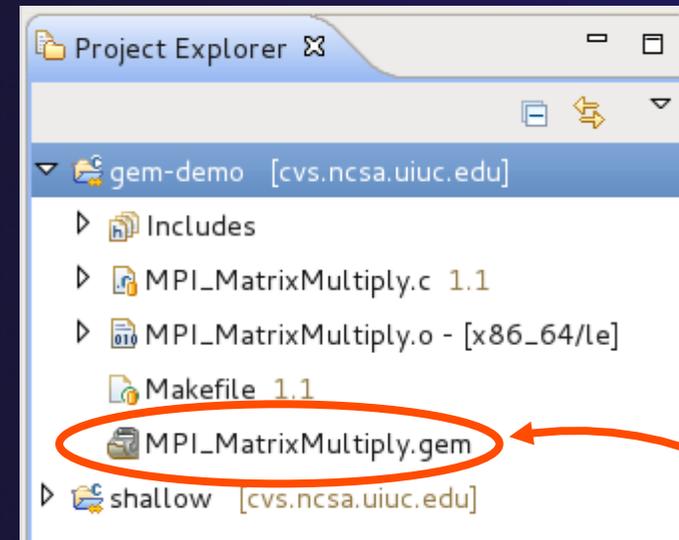
GEM Hands-on (2)

Build GEM Project

- ★ Right click on **gem-demo**
- ★ Select **“Build Project”**



NOTE: The build automatically works here because the GEM compiler wrapper path is in the Makefile for the gem-demo project



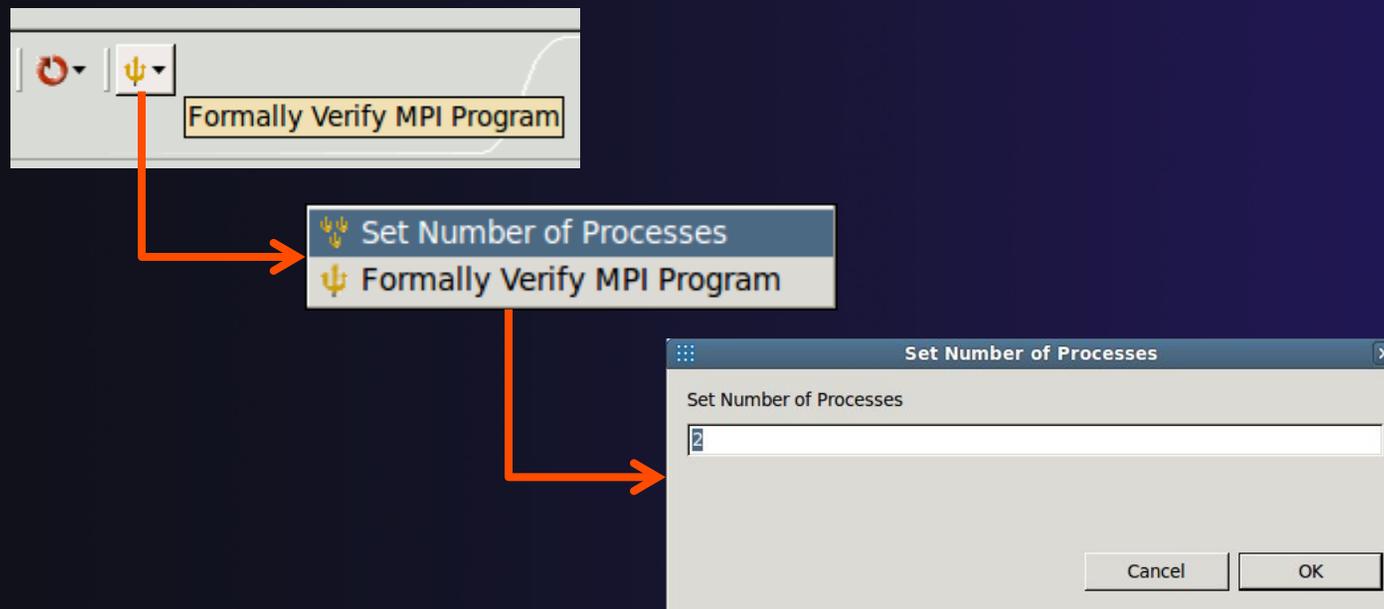
- ★ Instrumented executable (**.gem** extension) is visible after build (output in console)
- ★ Force a project sync if this is not visible

GEM Hands-on (3)

Set Number of Processes



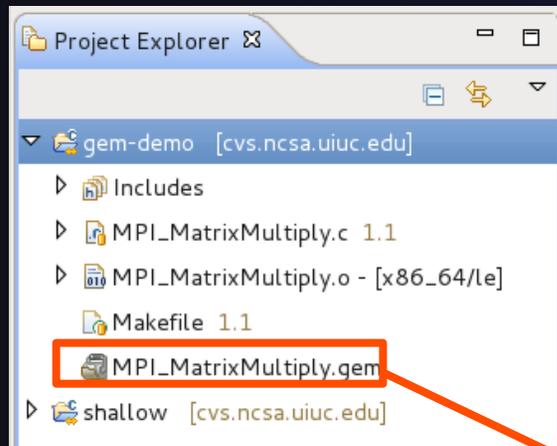
- ✦ Locate the trident  Icon on the Eclipse toolbar
- ✦ From pull-down menu, set number of processes to **2**



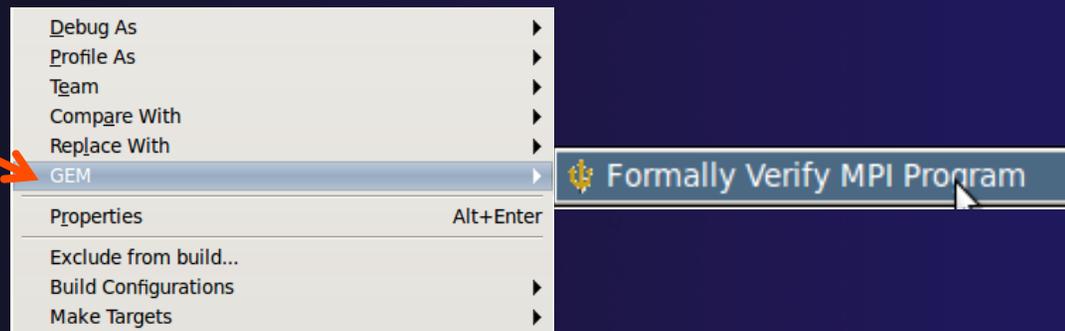


GEM Hands-on (4)

- ★ Locate file the profiled binary **MPI_MatrixMultiply.gem** in the Project Explorer view



- ★ Right click on: **MPI_MatrixMultiply.gem**
- ★ Select:
 - ★ GEM -> Formally Verify Profiled MPI Program



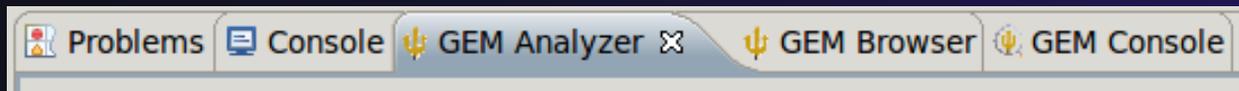
Finally, wait for analysis. This may take several seconds and you will see output in the

GEM Console View

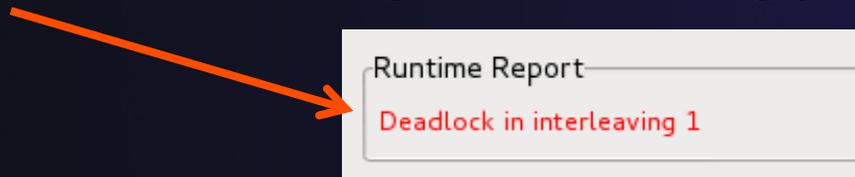


GEM Hands-on (5)

- ★ Notice that three new Eclipse views have opened:
 - ★ *See next slide if your views are not positioned correctly*



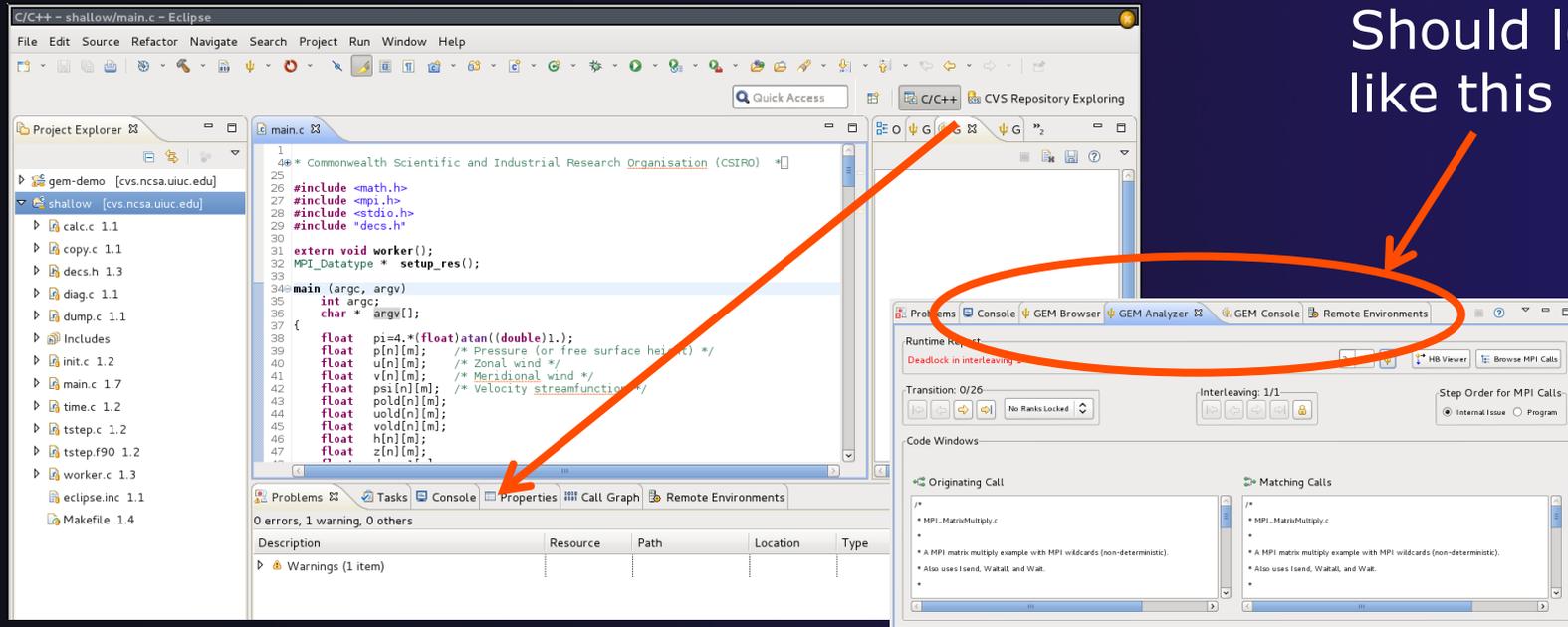
- ★ In the **GEM Analyzer View** (in focus by default), notice there was a deadlock detected. No subsequent errors or warning will be flagged until this is fixed



- ★ We can localize and fix this issue using:
 - ★ **GEM Analyzer View** or the **GEM Browser View**
 - ★ In this example, we will use the **Analyzer View** and the transition navigation buttons

* *FIX GEM VIEWS* *

(NOTE: you may not need to do this)



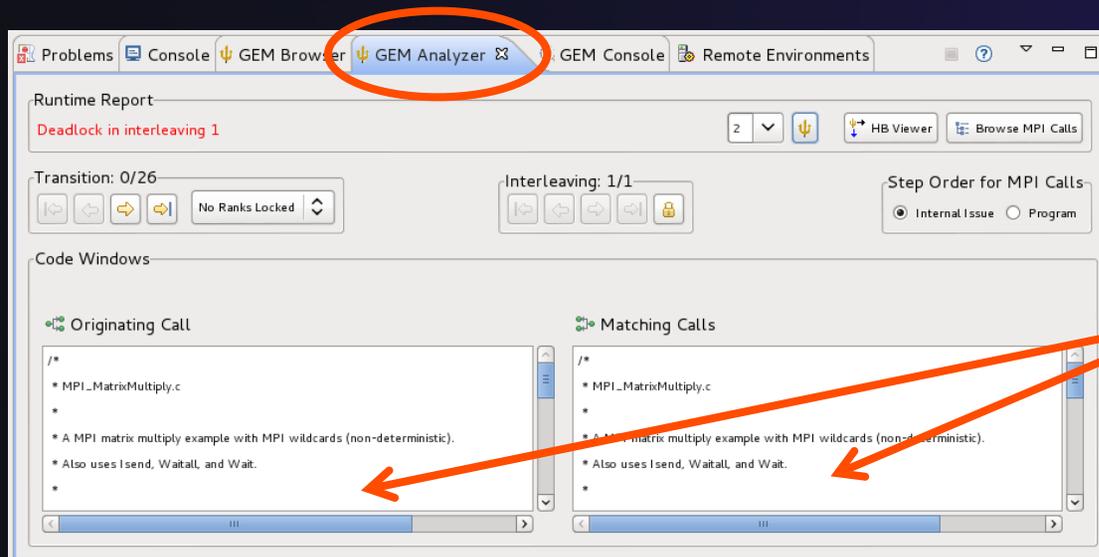
Should look like this now

Simply drag GEM views to position them underneath the Eclipse Editor



GEM Hands-on (6)

- ★ Double Click on the Gem Analyzer View tab
 - ★ This makes the view fill the workbench window
- ★ Fix the deadlock using the GEM Analyzer View



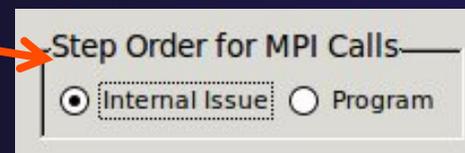
- ★ The GEM Analyzer View should look similar to this figure

- ★ MPI_MatrixMultiply.c is open in both code view windows. This is where we will trace execution as and MPI calls (P2P and collective matches) can be examined as they happened at runtime

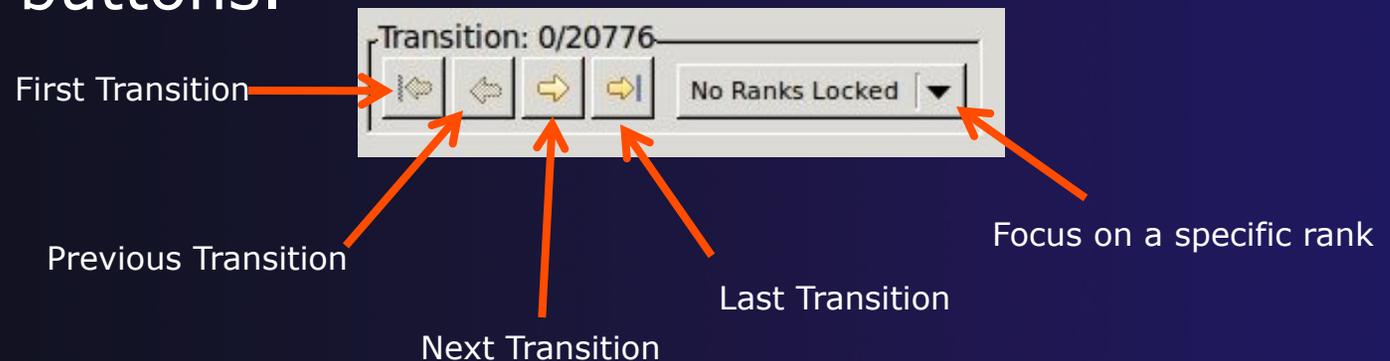


GEM Hands-on (7)

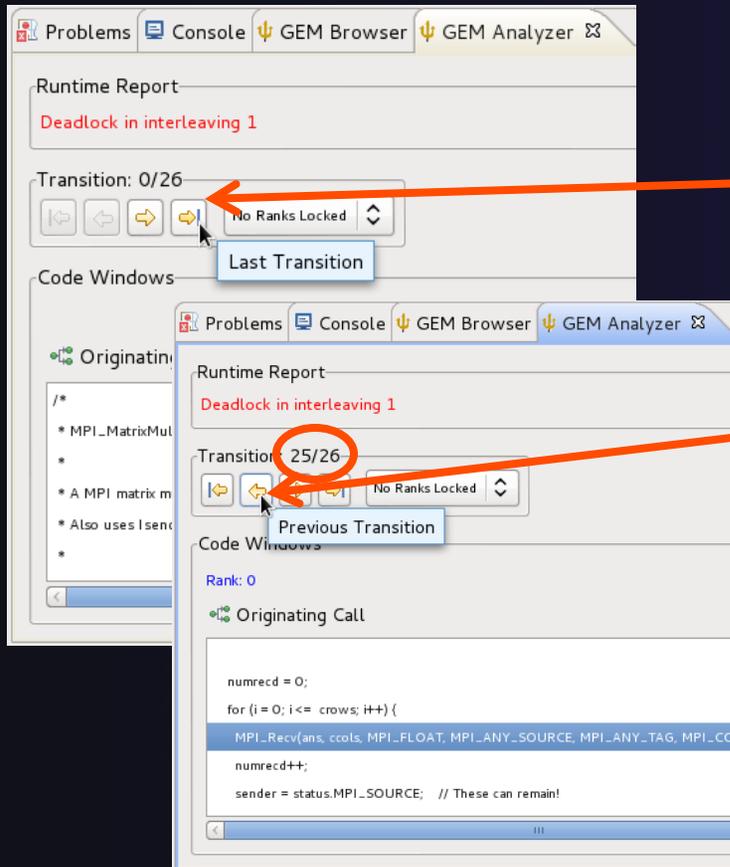
- ★ Under **Step Order for MPI Calls**, select **Internal Issue Order**. This is the order in which GEM issues the intercepted MPI calls to the MPI runtime



- ★ Using the **Transition Group**, we will step through the single interleaving discovered by GEM using the navigation buttons.



GEM Hands-on (8)



- ✦ *Using navigation buttons:*
- ✦ Navigate to last transition using last transition button
- ✦ Then single step backward to transition 25/26 using previous transition button
- ✦ Looking at **24/25**, we see it's the last call to actually complete before deadlocking, so **25/26** is the problem

We are essentially looking at calls as issued to the MPI runtime and reverse debugging to point of deadlock

GEM Hands-on (9)

```
78 //
79
80 MPI_Bcast(b, brows * bcols, MPI_FLOAT, master, MPI_COMM_WORLD);
81 for (i = 0; i < numprocs - 1; i++) {
82     for (j = 0; j < acols; j++) {
83         buffer[j] = a[i * acols + j];
84     }
85     MPI_Isend(buffer, acols, MPI_FLOAT, i + 1, i + 1, MPI_COMM_WORLD, &reqs[i]);
86     numsent++;
87 }
88
89 MPI_Waitall(numsent, reqs, statuses); // Ignore the status codes for now
90
91 numrcvd = 0;
92 // Loop condition should be strictly "less than", this creates an
93 // extra rcv with no corresponding send.
94 // SOLUTION: Change the loop check to "i < crows"
95 for (i = 0; i <= crows; i++) {
96     MPI_Recv(ans, ccols, MPI_FLOAT, MPI_ANY_SOURCE, MPI_ANY_TAG, MPI_COMM_WORLD, &status);
97     numrcvd++;
98     sender = status.MPI_SOURCE; // These can remain!
99     anstype = status.MPI_TAG - 1; // These can remain!
100     for (j = 0; j < ccols; j++) {
101         c[anstype * ccols + j] = ans[j];
102     }
103     if (numsent < arows) {
104         for (j = 0; j < acols; j++) {
105             buffer[j] = a[numsent * acols + j];
106         }
107     }
108 }
```

Runtime Report
Deadlock in interleaving 1

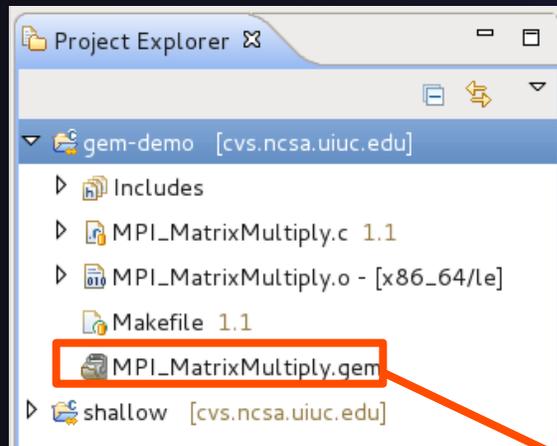
Transition: 25/26
Interleaving: 1/1

Code Windows
Rank: 0
File: MPI_MatrixMultiply.c Line: 96
Originating Call
// SOLUTION: Change the loop check to "i < crows"
for (i = 0; i <= crows; i++) {
MPI_Recv(ans, ccols, MPI_FLOAT, MPI_ANY_SOURCE, MPI_ANY_TAG, MPI_COMM_WORLD, &status);
numrcvd++;
sender = status.MPI_SOURCE; // These can remain!
anstype = status.MPI_TAG - 1; // These can remain!

- ★ Double click on the highlighted rcv (25/26).
- ★ This takes you to line in the Eclipse editor
- ★ Notice the comment: this loop creates an extra rcv that will never have a matching send
- ★ Fix as suggested in the comments

GEM Hands-on (10)

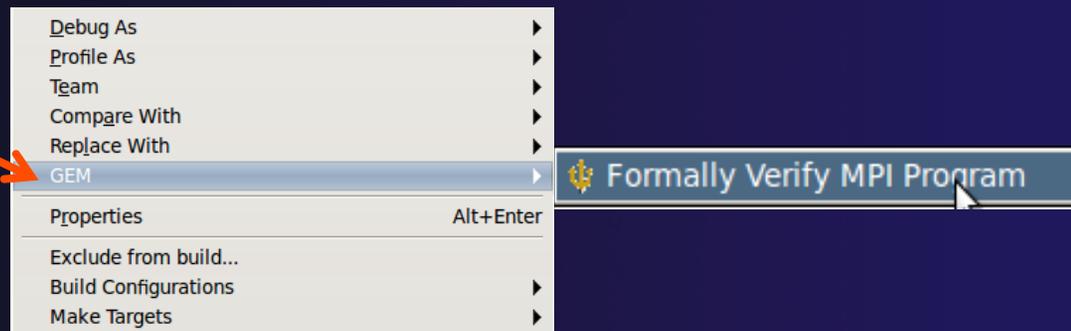
★ Rebuild the gem-demo project



★ Right click on:
MPI_MatrixMultiply.gem

★ Select:

★ GEM -> Formally Verify Profiled MPI Program



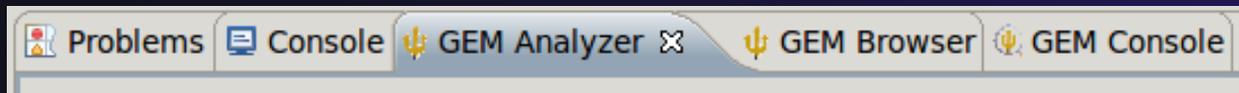
Finally, wait for analysis. This may take several seconds and you will see output in the

GEM Console View



GEM Hands-on (11)

- ★ Notice again, the three GEM views:
 - ★ GEM Analyzer, GEM Browser, GEM Console



- ★ In the **GEM Analyzer View** (in focus by default), notice there were no MPI errors, e.g. deadlock, assertion violation, but warnings were issued

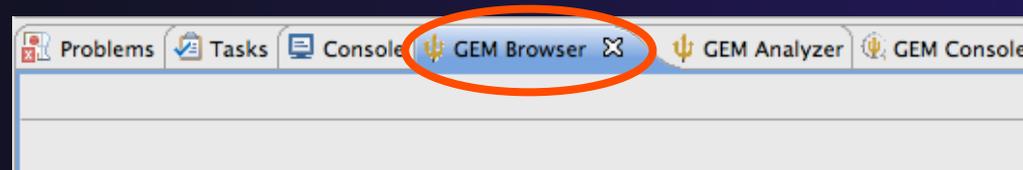


- ★ Examine these warnings in the **GEM Browser View**

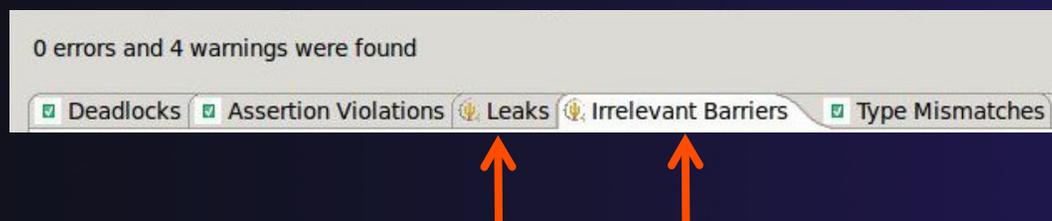
GEM Hands-on (12)



- ★ Click on the tab for the **GEM Browser View**



- ★ Notice GEM has found two types of warnings:
 - ★ **Functionally Irrelevant Barriers** (unnecessary synchronization)
 - ★ **Resource Leaks** (allocated MPI data types and communicators not freed)



- ★ GEM maps these warnings (and errors) to the offending line of source code within the Eclipse editor



GEM Hands-on (13)

- ★ Click on **Irrelevant Barriers** tab
- ★ Expand the **Interleaving 1** tree
- ★ Click on the **FIB** line

```

123 printf("%f\t", c[i * MAX_COLS + j]);
124 printf("\n");
125 }
126 }
127 }
128 } else {
129 MPI_Bcast(b, brows * bcols, MPI_FLOAT, master, MPI_COMM_WORLD);
130 while (1) {
131 MPI_Recv(buffer, acols, MPI_FLOAT, master, MPI_ANY_TAG, MPI_COMM_WORLD, &status);
132 if (status.MPI_TAG == 0) {
133 break;
134 }
135 row = status.MPI_TAG - 1;
136 for (i = 0; i < bcols; i++) {
137 ans[i] = 0.0;
138 for (j = 0; j < acols; j++) {
139 ans[i] += buffer[j] * b[j] * bcols + i;
140 }
141 }
142 // row+1 Used as tag
143 MPI_Send(ans, bcols, MPI_FLOAT, master, row + 1, MPI_COMM_WORLD);
144 }
145 }
146 }
147 MPI_Barrier(MPI_COMM_WORLD);
148 // uncomment these to illustrate elimination of resource leaks
149 MPI_Comm_free (&newcomm);
150 // MPI_Comm_free (&newcomm);
151 // MPI_Tune_free(&...);
152 // MPI_Tune_free(&...);

```

- ★ Notice you are taken to the corresponding line in the Eclipse Editor
- ★ This **MPI_Barrier()** call is “functionally irrelevant” and can be safely removed without changing program behavior
- ★ We’ll investigate this further in the **exercise section** at the end of this section

GEM Hands-on (14)



NOTE

*Fixing these warnings is left as an exercise
at the end of this section*

GEM Hands-on (15)



- ✦ Briefly examine the GEM help plugin
- ✦ GEM Help also walks through the Managed-Build, PI-C example created by the new MPI project wizard
 - ✦ Help -> Help Contents -> PTP -> GEM

The screenshot shows the Eclipse IDE Help window. The left sidebar contains a 'Contents' tree with the following structure:

- Workbench User Guide
- Java development user guide
- Plug-in Development Environment Guide
- C/C++ Development User Guide
- Eclipse Marketplace User Guide
- EGit Documentation
- JavaScript Development Guide
- Mylyn Documentation
- Parallel Tools Platform (PTP) User Guide
 - Contents
 - Overview
 - PTP Prerequisites
 - Local vs. Remote Projects
 - Creating an MPI Project
 - Synchronized Projects
 - Resource Managers
 - Running Parallel Programs
 - Monitoring Jobs and Systems
 - Parallel Debugging
 - PTP Preferences
 - Parallel Language Development Tools (PLDT)
 - External Tools Framework (ETFW)
 - Graphical Explorer of MPI Programs (GEM)
 - Contents
 - GEM Overview
 - Prerequisites
 - Getting Started
 - Setting the Number of Processes
 - Analyzer View
 - Browser View
 - Console View
 - Understanding Console Output
 - Happens Before (HB) Viewer
 - Makefile Project Support
 - Remote Projects
 - Preferences
 - Troubleshooting GEM

The main content area displays the 'Getting Started' page for GEM. The page title is 'Getting Started'. The text reads:

This page serves to get the new GEM user up and running.

To help get the new GEM user started, this page will walk through examples of how to use GEM to formally verify a MPI Managed-Build project as well as a larger MPI Makefile project. Please note that when we say "formally verify", we mean "check the correctness" of your MPI application.

For Example - GEM will check your MPI application for the presence of:

- Deadlocks
- Functionally Irrelevant Barriers
- MPI Object Leaks
- Local Assertion Violations
- MPI Type Mismatches

Some of these errors and problems are **extremely difficult** to detect and find with traditional debugging tools and practices.

Remember that no code instrumentation is necessary. At compile time, GEM will link in its profiler library which takes care of everything for you automatically (using the PMPI mechanism). GEM offers push-button formal verification for MPI C/C++ applications. Fortran support is planned in the future.

The main idea here is to illustrate just how easy it is to do verification on your MPI application **throughout** your project's life-cycle. A developer can create, edit, compile, verify, parallel debug (for standard logic errors) and launch your MPI apps all from the comfort of the Eclipse IDE.

Verifying a MPI Managed Build Project

STEP - 1: Make Sure all Prerequisites are Satisfied
Please see the [GEM Prerequisites Page](#). Particularly important, is the installation of [In-situ Partial Order \(ISP\)](#), the underlying formal verification engine GEM serves as a front-end for.

STEP - 2: Set ISP Command Line Options
You'll need to tell GEM where ISP and its scripts (both local and remote) are installed and which of its command line options you would like to use. Please see the [ISP Preference Page](#) for detailed instructions (image below).

STEP - 3: Set the Number of Processes to Verify With
(the same number of processes that you would run your MPI application with normally)
To do this, please consult the help page detailing [Setting the number of processes](#)

STEP - 4: Set Preference for Command Line Arguments Prompt
Depending on whether or not this preference is set, a dialog (figure 1 below) may be opened prior to verification (e.g. when GEM is run) to collect this information. Please see the [GEM Preference Page](#) for this (figure 2 below).

Reference Slides

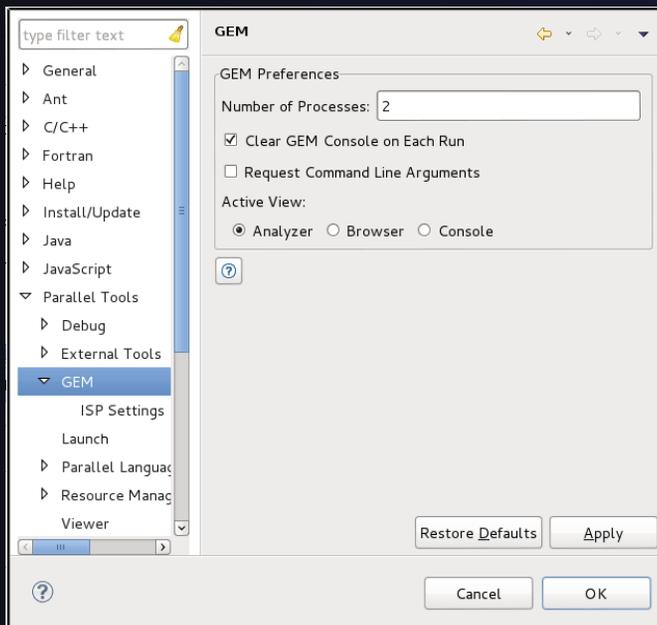
- ★ **NOTE:** The following slides are not part of the presentation or hands-on section
- ★ They are meant to be used as further reference and to provide more detailed information on:
 - ★ GEM setup, configuration and preference pages
 - ★ Using GEM views
 - ★ Help contribution
 - ★ Troubleshooting
 - ★ GEM Success stories

ISP Installation

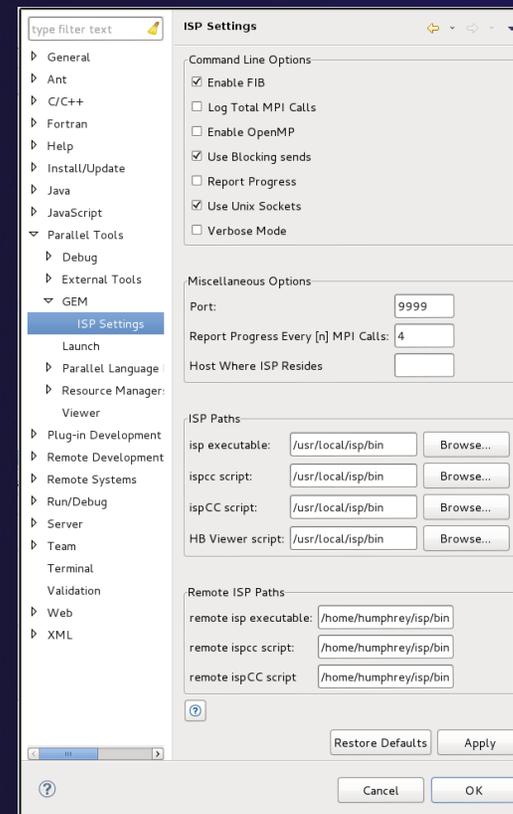
- ★ **ISP itself must be installed prior to using GEM**
- ★ Download ISP at <http://www.cs.utah.edu/fv/ISP>
- ★ Make sure libtool, automake and autoconf are installed.
- ★ Just untar `isp-0.3.1.tar.gz` into a tmp directory:
 - ★ Configure and install
 - ★ `./configure -prefix=/my/preferred/install/location`
 - ★ `make`
 - ★ `make install`
 - ★ This installs binaries and necessary scripts

GEM Preferences

Set preferences for GEM and its underlying verification tool, ISP



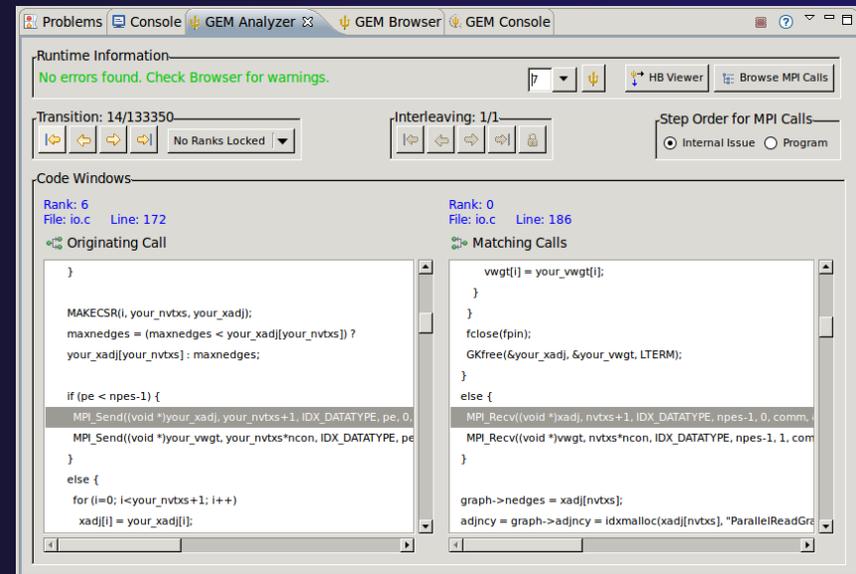
GEM



GEM-28

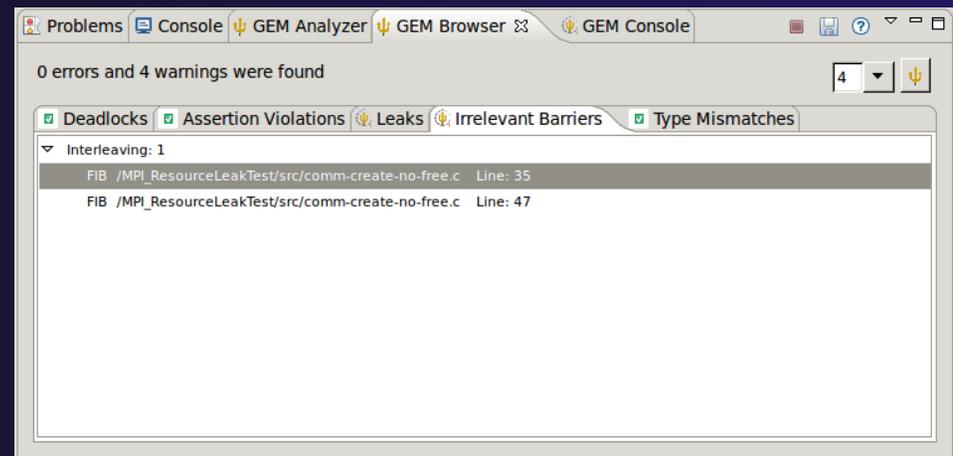
GEM Analyzer View

- ★ Reports program errors, and runtime statistics
- ★ Debug-style source code stepping of interleavings
 - ★ Point-to-point / Collective Operation matches
 - ★ Internal Issue Order / Program Order views
 - ★ Rank Lock feature – focus on a particular process
- ★ Also controls:
 - ★ Call Browser
 - ★ Happens Before Viewer launch
 - ★ Re-launching of GEM



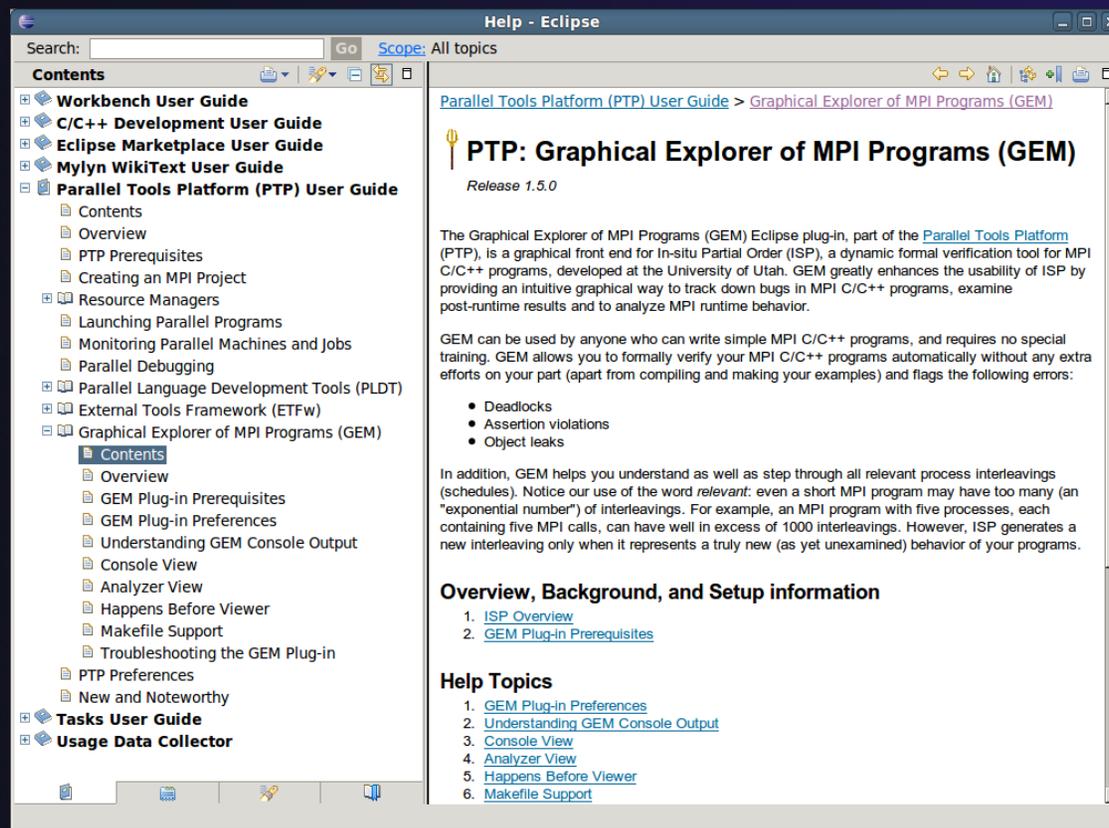
GEM Browser View

- ★ Tabbed browsing for each type of MPI error/warning
- ★ Each error/warning mapped to offending line of source code in Eclipse editor
- ★ One click to visit the Eclipse editor, to examine:
 - ★ Calls involved in deadlock
 - ★ Irrelevant barriers
 - ★ MPI Object Leaks sites
 - ★ MPI type mismatches
 - ★ Local Assertion Violations



GEM – Help Plugin

Extensive how-to sections, graphical aids and trouble shooting section



GEM/ISP Success Stories

★ Umpire Tests

- ★ <http://www.cs.utah.edu/fv/ISP-Tests>
- ★ Documents bugs missed by tests, caught by ISP

★ MADRE (EuroPVM/MPI 2007)

- ★ Previously documented deadlock detected

★ N-Body Simulation Code

- ★ Previously unknown resource leak caught during EuroPVM/MPI 2009 tutorial !

★ Large Case Studies

- ★ ParMETIS, MPI-BLAST, IRS (Sequoia Benchmark), and a few SPEC-MPI benchmarks could be handled

★ Full Tutorial including LiveDVD ISO available

- ★ Visit <http://www.cs.utah.edu/fv/GEM>



Exercise (1) – Fix MPI Warnings

1. Comment out the `MPI_Barrier` call on line 152 of **`MPI_MatrixMultiply.c`**
2. Uncomment lines 155 & 156 of the same source file. These last two lines are the corresponding “free” for the MPI communicator that was created and also the MPI datatype that was committed
3. Build the GEM project again to incorporate these changes into the profiled executable
4. Re-run GEM and check that there are in fact no errors or warnings

Exercise (2) – Multiple Interleavings

1. Re-run GEM on the gem-demo project using “3” processes
2. How many Interleavings does GEM report?
3. Use the Interleaving navigation buttons to explore this. You can reference GEM help for the documentation on Interleaving navigation buttons, or simply click the help icon in the **GEM Analyzer View** to quickly navigate to specific help with the **GEMAnalyzer View**

Gcov and gprof support in linux tools

★ Objective

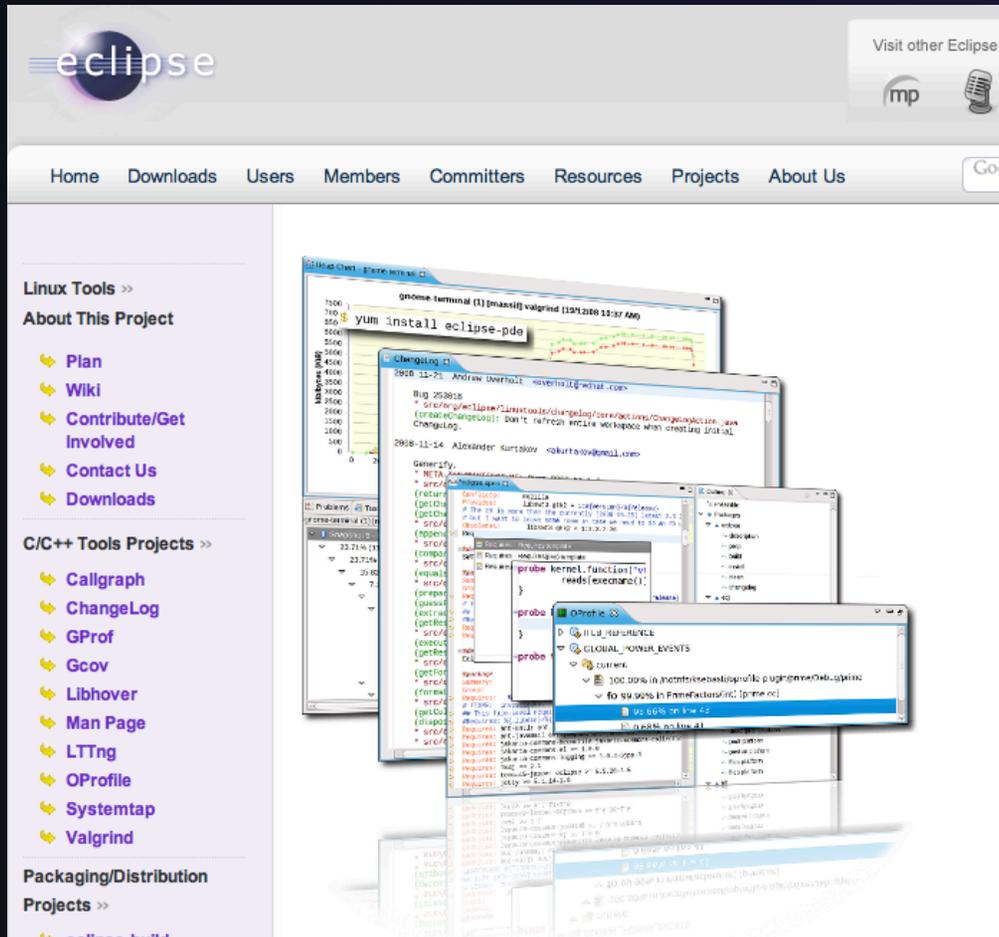
- ★ Learn how to use Eclipse-based interfaces to GNU tools Gcov and Gprof

★ Contents

- ★ Build with “-pg” for gprof profiling
- ★ Build with “-ftest-coverage -fprofile-arcs” for gcov
- ★ Run gcov to determine code coverage – which parts of your program are logically getting exercised
- ★ Run gprof to determined which parts of your program are taking most of the execution time

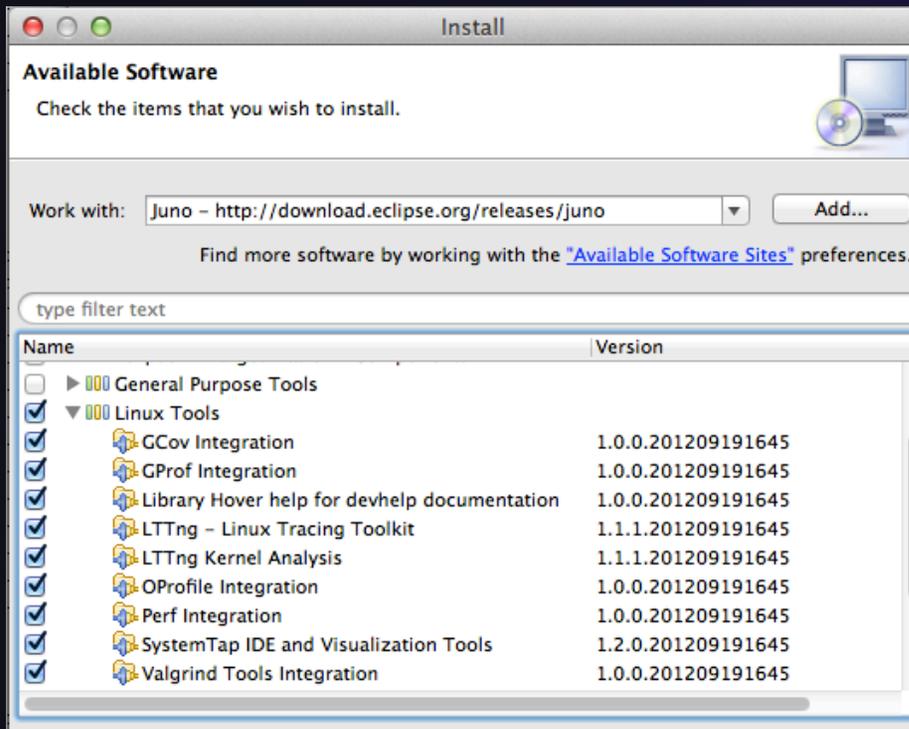
Linux Tools

<http://eclipse.org/linuxtools>



- ✦ What is Linux Tools?
- ✦ <http://eclipse.org/linuxtools/>
- ✦ Builds on CDT for C/C++
- ✦ Integrates popular native development tools such as Valgrind, OProfile, RPM, SystemTap, GCov, GProf, LTTng, etc. – into Eclipse

Linux Tools - Installation



Linux Tools

- ★ Some of the Linux Tools are included with **Eclipse for Parallel Application Developers** package
- ★ Everything you need for this tutorial is in the package
- ★ To install manually:
 - ★ Help > Install New Software
 - ★ In **Work With:** Select Juno update site
 - ★ Under **Linux Tools**, Select the tools you want or just select all of them
 - ★ Some cannot be installed on all non-Linux platforms
 - ★ Click Next> ... and continue to end of installation and restart Eclipse when prompted

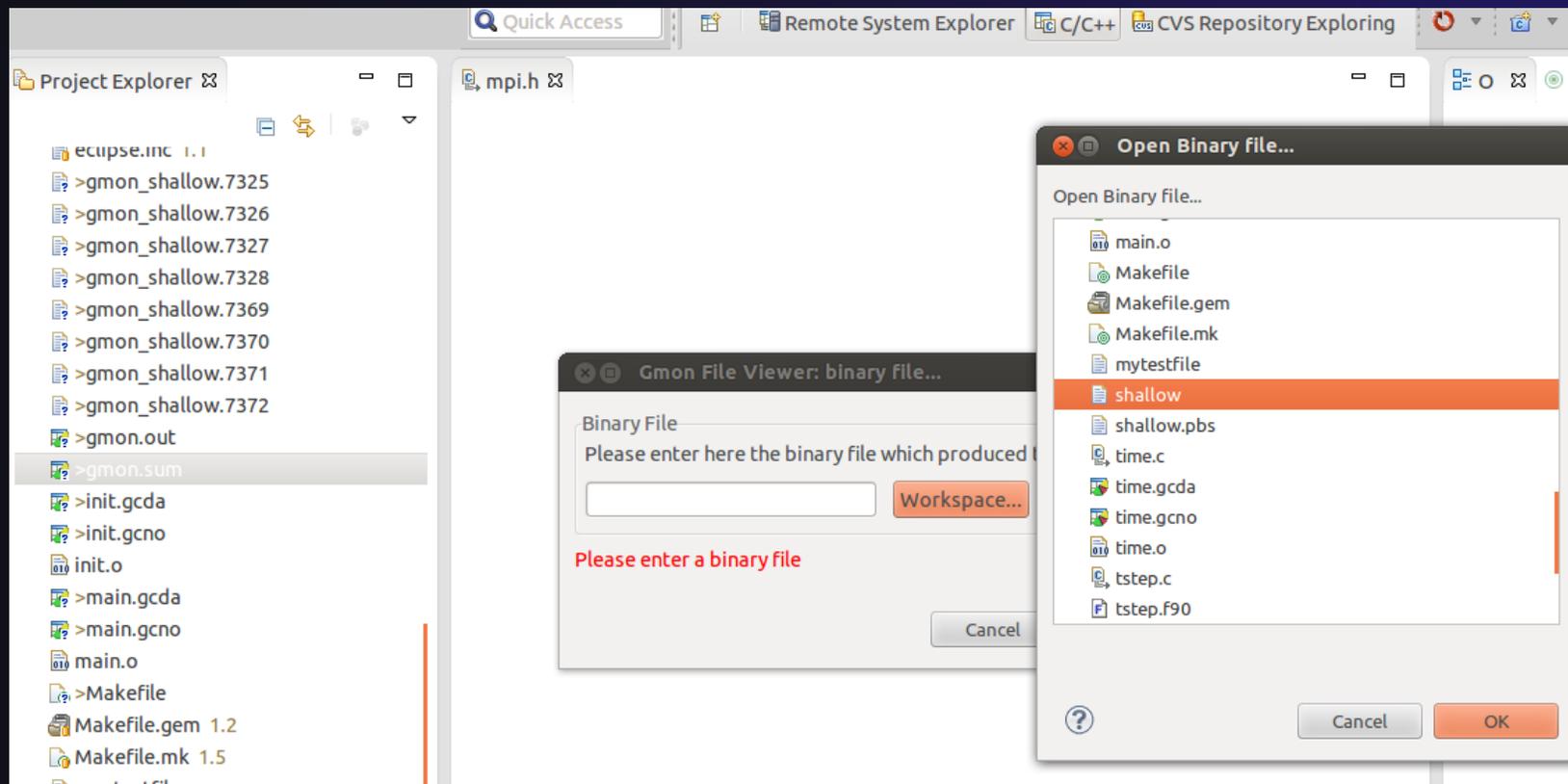
Linux-2

Linux Tools - usage

- ★ With a synchronized project, you only need linuxtools available on the remote system. (Even the Windows client can view the gprof and gcov output files.)
- ★ Compiler flags
 - ★ `-pg` to profile with gprof for the GNU compilers
 - ★ `-ftest-coverage -fprofile-arcs` for gcov support
 - ★ It's ok to use both at the same time at low optimization settings
- ★ Re-run the application
- ★ With synchronized projects, remember to re-sync to retrieve the resultant files
- ★ `gprof -s shallow gmon_shallow.*` : creates a summary profile (`gmon.sum`) from MPI programs with a profile per rank

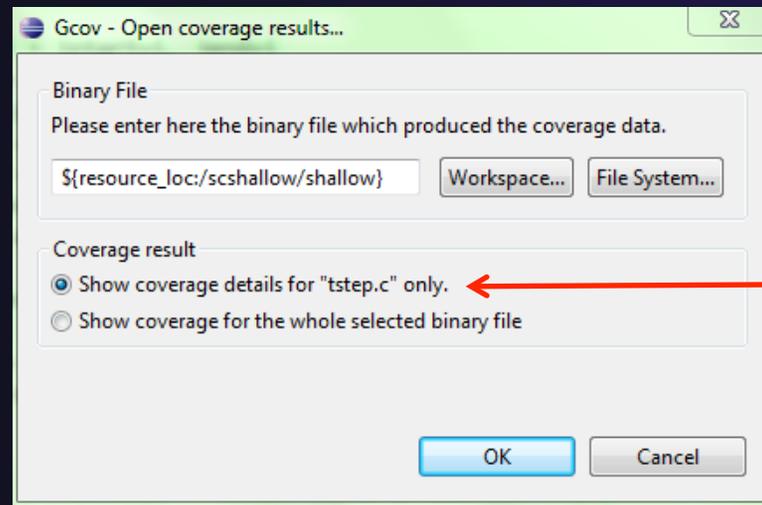
Linux Tools – click to view

- ✦ Double-click gmon.* for gprof view
- ✦ Double-click *.gcno or *.gcda for gcov view



Linux Tools – click to view

- ✦ Double-click gmon.* for gprof view
- ✦ Double-click *.gcno or *.gcda for gcov view,
 - ✦ It will ask for binary file location
 - ✦ Coverage Result: for Windows, select src file only (do not select the whole binary file in the radio button of the dialog box)



Windows only.
Mac/Linux can show
coverage for whole
file

Opening a profile with gprof viewer

Note: since we've changed filename from 'gmon.out' to gmon_shallow.xxx we will force the gprof editor to be invoked for the files.

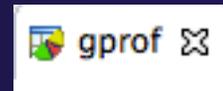
Use Right mouse > Open With... > Other ... and choose Gprof Editor

gmon file: /home/galen/workspace/scshallowL/gmon_shallow.26551
program file: /home/galen/workspace/scshallowL/shallow
4 bytes per bucket, each sample counts as 10.000ms

Name (location)	Samples	Calls	Time/Call	% Time
▼ Summary	6			100.0%
▶ calc.c	2			33.33%

Gprof tab

Double-click on gmon.out file to open gprof viewer

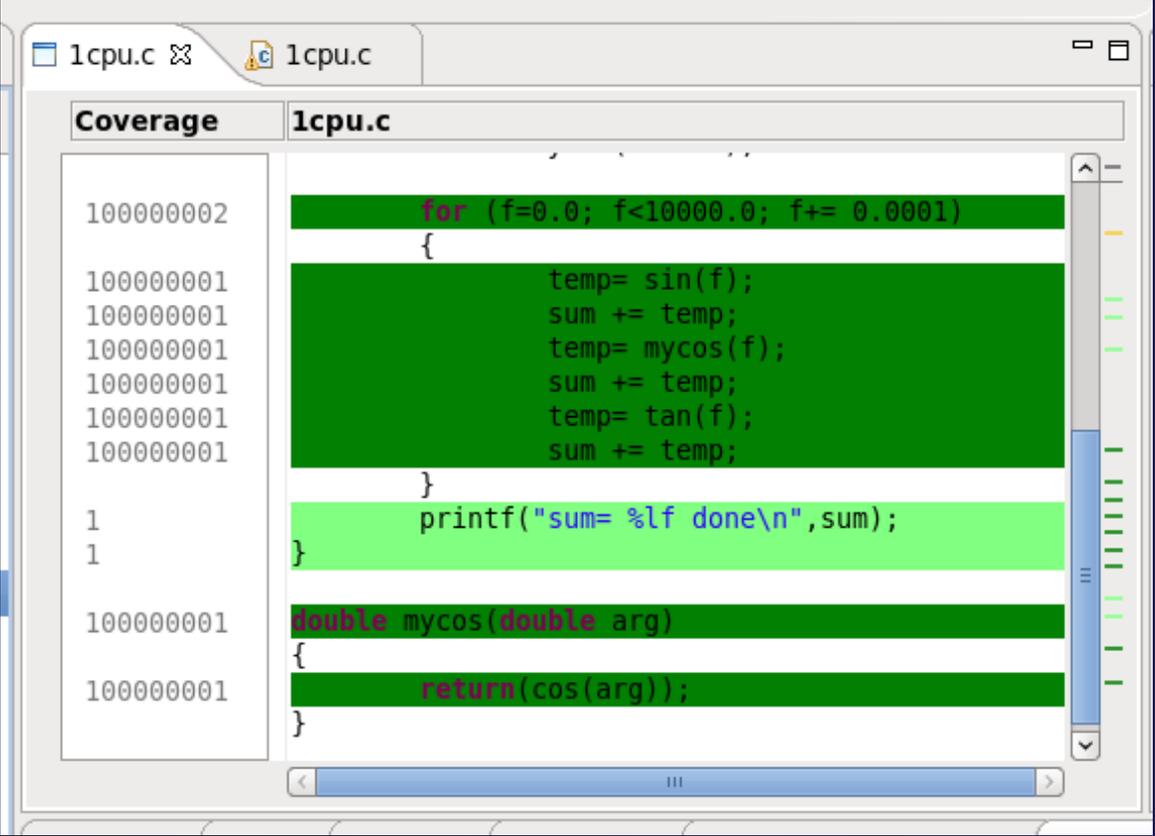


gmon file: /home/arnoldg/workspace/linux_tools_demo/gmon.out
 program file: /home/arnoldg/workspace/linux_tools_demo/1cpu
 4 bytes per bucket, each sample counts as 10.000ms

Name (location)	^	Samples	Calls	Time/Call	%Time
Summary		131			100.0%
1cpu.c		131			100.0%
main		0	0		0.0%
mycos		19	100000001	1ns	14.5%
mycos (1cpu.c:140)		5			3.82%
0x40094c		5			3.82%
mycos (1cpu.c:30)		14			10.69%
0x400930		7			5.34%
0x400938		6			4.58%
0x40093c		1			0.76%
work		112	1	1.120s	85.5%
work (1cpu.c:17)		4			3.05%
work (1cpu.c:19)		9			6.87%
work (1cpu.c:20)		36			27.48%
work (1cpu.c:21)		7			5.34%

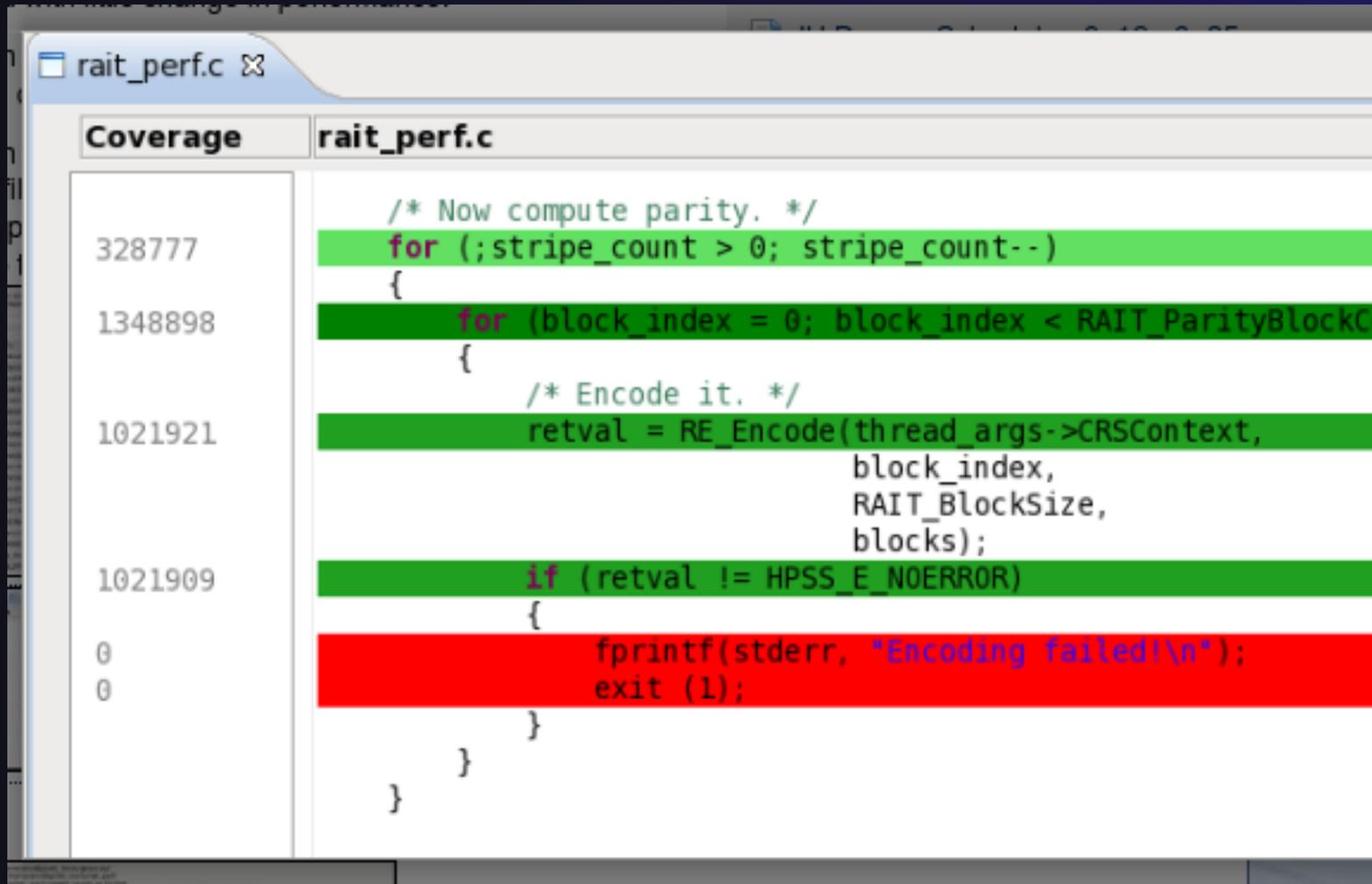
Run code, inspect gcov display

Double-click on a source file in gcov view to see code coverage highlighted in source file



Coverage	1cpu.c
1000000002	for (f=0.0; f<10000.0; f+= 0.0001)
	{
1000000001	temp= sin(f);
1000000001	sum += temp;
1000000001	temp= mycos(f);
1000000001	sum += temp;
1000000001	temp= tan(f);
1000000001	sum += temp;
	}
1	printf("sum= %lf done\n",sum);
1	}
1000000001	double mycos(double arg)
	{
1000000001	return(cos(arg));
	}

Gcov with a production code, unexecuted region



The screenshot shows a code coverage tool window for the file `rait_perf.c`. The window is divided into two columns: **Coverage** and **rait_perf.c**. The **Coverage** column shows line numbers, and the **rait_perf.c** column shows the corresponding source code. The code is color-coded to indicate execution status: green for executed lines and red for unexecuted lines. The unexecuted region is highlighted in red and contains the following code:

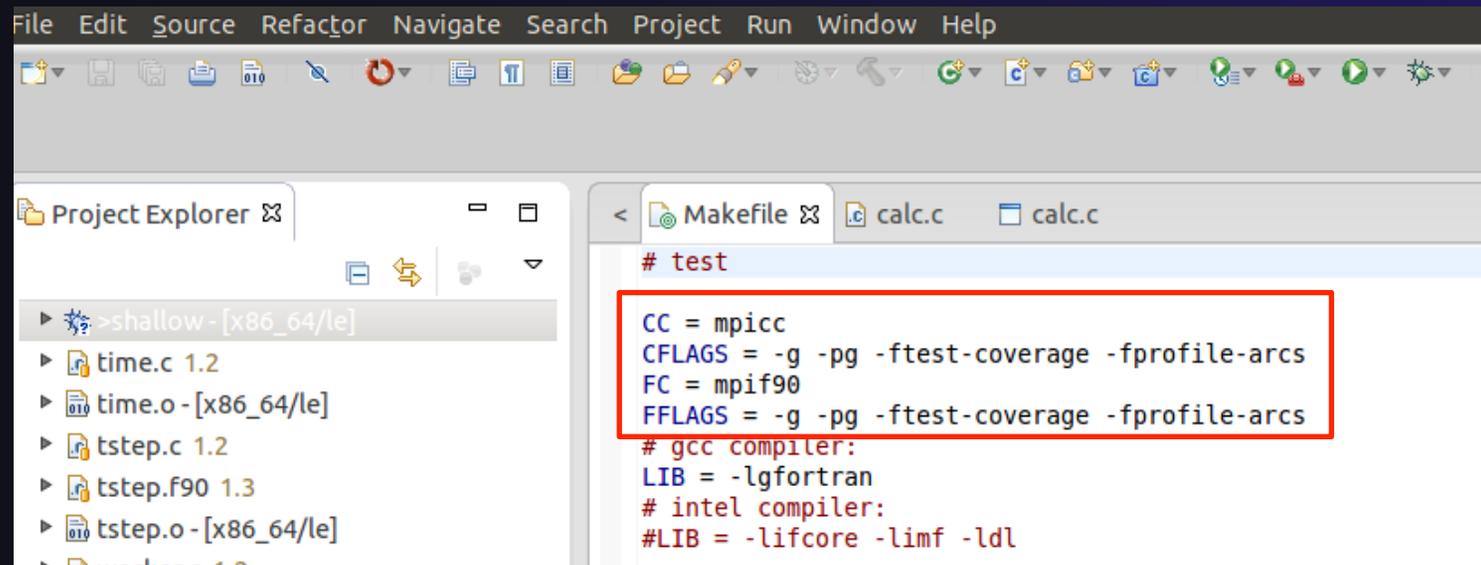
```
0          fprintf(stderr, "Encoding failed!\n");
0          exit (1);
```

The rest of the code, including the `for` loops and the `if` statement, is highlighted in green, indicating it was executed.



gprof with shallow project, MPI

Add compiler flags to Makefile



```
File Edit Source Refactor Navigate Search Project Run Window Help
Project Explorer
>shallow -[x86_64/le]
time.c 1.2
time.o -[x86_64/le]
tstep.c 1.2
tstep.f90 1.3
tstep.o -[x86_64/le]
worker.c 1.2
Makefile
calc.c
calc.c
# test
CC = mpicc
CFLAGS = -g -pg -ftest-coverage -fprofile-arcs
FC = mpif90
FFLAGS = -g -pg -ftest-coverage -fprofile-arcs
# gcc compiler:
LIB = -lgfortran
# intel compiler:
#LIB = -lifcore -limf -ldl
```

The Makefile CFLAGS and FFLAGS are modified as shown to support profiling and coverage at the same time. We have created the Makefile so you should just be able to uncomment these lines.



gprof with shallow project, MPI (2)

Modify Run Configuration

Run > Run Configurations ... to modify existing Run Configuration

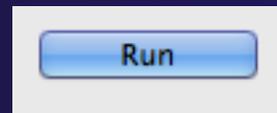
Make this the fully qualified path+prefix for gmon output. E.g.
/home/userid/shallow/gmon_shallow
(Otherwise they end up in a scratch dir)

Setup the MPI run configuration with the Environment variable `GMON_OUT_PREFIX` defined with a /full/path/name for your individual MPI rank gmon outputs. By default `gmon.out` is used but MPI doesn't do that well and you end up with a profile that's missing most of the information, so by using `GMON_OUT_PREFIX`, each MPI rank adds its process id to its gmon output filename.



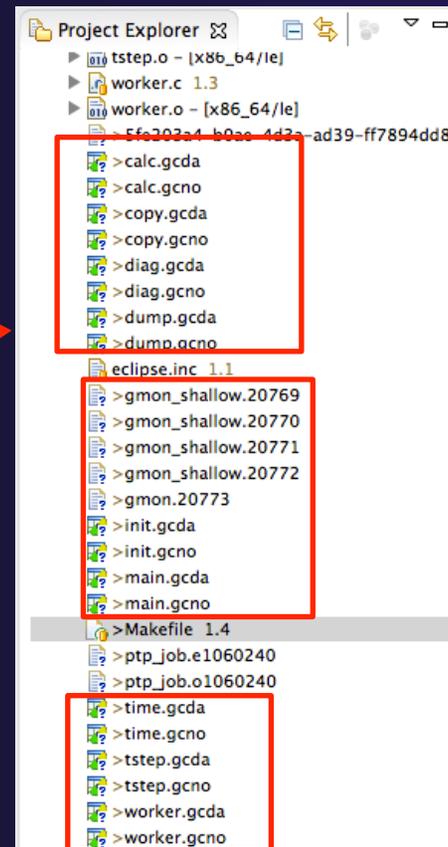
gprof with shallow project, MPI (3)

✦ Run from Run Configuration dialog



✦ See build results in Console

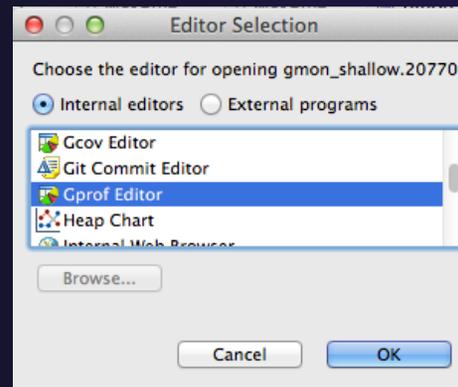
✦ See new files in Project Explorer (You may need to force a Sync)





gprof with shallow project, 1 rank

- ✦ Open gmon file with gprof viewer
- ✦ Double-click on gmon.out file
 - or- since gmon_shallow.xxx has non-standard file types ...
- ✦ Right click on gmon_shallow.xxx file and select Rightmouse >Open With... Other... and select **Gprof Editor**





gprof with shallow project, 1 rank (2)

View gmon data with gprof viewer

It's interesting to compare the summary gmon output to that from one of the ranks.

This view shows a gmon.out file (you have a gmon_shallow.xxx file) from a single rank.

Name (location)	Samples	Calls	Time/Call	%Time
Summary	8			100.0%
calc.c	0			0.0%
calcuvzh	0	1000	0ns	0.0%
copy.c	0			0.0%
diag.c	1			12.5%
main.c	0			0.0%
time.c	4			50.0%
tstep.F90	3			37.5%
tstep	3	1000	30.000us	37.5%
tstep (tstep.f90:64)	1			12.5%
tstep (tstep.f90:73)	1			12.5%
tstep (tstep.f90:75)	1			12.5%
worker.c	0			0.0%

Gprof with shallow project, summary



Aggregate the gmon output – invoke from a terminal:

```
gprof -s shallow gmon_shallow.*
```

This creates a gmon.sum file

Force a sync to
see the file in
Project Explorer

Double-click to
open the gmon.sum
File with the
gprof viewer

Name (location)	Samples	Calls	Time/Call	%Time
Summary	23			100.0%
calc.c	3			13.04%
calcuvzh	3	3000	10.000us	13.04%
calcuvzh (calc.c:47)	1			4.35%
0x401d00	1			4.35%
calcuvzh (calc.c:49)	2			8.7%
0x401f54	1			4.35%
0x401f64	1			4.35%
copy.c	0			0.0%
diag.c	1			4.35%
init.c	0			0.0%
main.c	0			0.0%
main	0	0		0.0%
setup_res	0	4	0ns	0.0%
update_global_ds	0	5	0ns	0.0%
time.c	5			21.74%
timetend	5	3000	16.666us	21.74%
tstep.f90	14			60.87%
tstep	14	3000	46.666us	60.87%
worker.c	0			0.0%

Gprof viewer does not currently work well on Windows



Windows: gprof with shallow project, summary, use a terminal window to create text file

- Invoke cmd line gprof
- Sync to see file
- Double-click to view txt file

The linuxtools team knows about the issue with Juno and they're working on it.

Linux Tools

```

Remote System Details  Tasks  Terminals  X
trestles.sdsc.edu  X
calc.o      diag.o      gmon_shallow.27090  main.gcda
copy.c      dump.c      gmon_shallow.27091  main.gcno
copy.gcda   dump.gcda   gmon.sum            main.o
copy.gcno   dump.gcno   gmon.sum.txt        Makefile
copy.o      dump.o      init.c              ptp_job.e
decs.h      eclipse.inc init.gcda           ptp_job.e
-bash-3.2$ gprof -A shallow gmon.sum > gmon.sum.txt
-bash-3.2$

```

```

gmon.sum.txt  X
402          !
403          ! Programmers   = David Abramson   (DIT) rcoda@koel
404          !           = Paul Whiting    (DIT) rcopw@koel.co.rmi
405          !           = Martin Dix      (DAR) mrd@koel.co.rmit.
406          ! Language    = BSD c using Argonne NL macros
407          ! O/S        = Unix System V
408          ! H/W        = Encore Multimax 320
409          !
410          !*****
411
412          4000 -> subroutine tstep(m,n,alpha,jstart,jend,cpold,cuold,
413                   use, intrinsic :: ISO_C_BINDING
414                   implicit none
415
416                   integer(kind=C_INT), value :: m, n
417                   real(kind=C_FLOAT), value :: alpha
418                   integer(kind=C_INT), value :: jstart,jend
419                   type(C_PTR), value :: cpold; real(kind=C_FLOAT),

```



Gcov with shallow project

The gcov view is similar to the gprof view but keep in mind that you're looking at code coverage and not necessarily performance or timing information (though there is a relationship...code not executed is performing quite well !). Also note that multiple executions will accumulate values in the gcov output files until they are removed or truncated to zero-length (2nd run to demonstrate this).

Double-click on any of the *.gcda or *.gcno to open this gcov viewer

Name	Total Lines	Instrumented	Executed Line	Coverage %
▼ Summary	1166	351	298	84.9%
▼ calc.c	54	12	12	100.0%
calcuvzh		12	12	100.0%
▶ copy.c	92	13	6	46.15%
▶ diag.c	76	25	25	100.0%
▶ dump.c	91	38	0	0.0%
▶ init.c	87	30	30	100.0%
▼ main.c	262	83	75	90.36%
main		67	60	89.55%
setup_res		11	10	90.91%
update_global_ds		5	5	100.0%
▶ time.c	57	14	14	100.0%
▶ tstep.f90	88	42	42	100.0%
▶ worker.c	359	94	94	100.0%

Gcov with shallow project, integration with CDT editor



Selecting (double click) a source code line from either the gcov or gprof view and you'll see the file and routine highlighted in the editor. Also notice the support for the .f90 file and its routines.

The screenshot shows an IDE window with the following components:

- Project Explorer:** Lists project files including 'time.c', 'tstep.c', 'worker.c', 'calc.gcda', 'copy.gcda', 'diag.gcda', 'dump.gcda', 'gmon_shallow.9885', 'gmon_shallow.9886', 'gmon_shallow.9887', 'gmon_shallow.9888', 'gmon.out', 'gmon.sum', 'init.gcda', 'init.gcno', 'main.gcda', 'main.gcno', 'Makefile', 'Makefile.gem 1.2', 'Makefile.mk 1.5', 'time.gcda', 'time.gcno', 'tstep.gcda', and 'tstep.gcno'.
- Main Editor:** Displays the source code of 'calc.c'. A function call `void calcuvzh(jstart, jend, p, u, v, cu, cv, h, z, fsdx, fsdy)` is highlighted in green. The code includes a header `#include "decs.h"` and a function definition for `calcuvzh`.
- Console:** Shows the Gprof output for the program file `/home/galen/workspace/shallow/gmon.sum`. The output is as follows:

Name (location)	Samples	Calls	Time/Call	%Time
calcuvzh (calc.c:47)	1			4.35%
0x401d00	1			4.35%

Exercise

Follow directions in previous slides to

1. Add the compiler flags to Makefile
2. Modify run configuration as described (add gmon prefix), and Run
3. View gmon and gcov files with gprof and gcov viewers

Optional Exercise

- 1) Run the shallow application with gcov compiler flags enabled.
 - a) Re-sync with Sync Active Now under Synchronization
 - b) View the tstep.gcno file and note the count, then repeat 1)a-b , have the counts changed?

- 2) Compare the tstep.f90 loops at lines 61, 70, 80 in the gprof and gcov displays .
 - a) Change the Makefile to use `-O3` with `FFLAGS` and clean/rebuild/re-run
 - b) `gprof -s shallow gmon_shallow.273*` [your most recent gmon_ files from the run you just finished]
 - c) Re-sync the project
 - d) Does the gprof view of gmon.sum still exactly match up with the gcov display? If not, what happened to the missing loop(s)?

Tutorial Wrap-up

★ Objective

- ★ How to find more information on PTP
- ★ Learn about other tools related to PTP
- ★ See PTP upcoming features

★ Contents

- ★ Links to other tools, including performance tools
- ★ Planned features for new versions of PTP
- ★ Additional documentation
- ★ How to get involved

Useful Eclipse Tools

- ✦ Linux Tools (autotools, valgrind, Oprofile, Gprof)
 - ✦ <http://eclipse.org/linuxtools> (part of Parallel package)
- ✦ Python
 - ✦ <http://pydev.org>
- ✦ Ruby
 - ✦ <http://www.apтана.com/products/radrails>
- ✦ Perl
 - ✦ <http://www.epic-ide.org>
- ✦ VI bindings
 - ✦ Vrapper (open source) - <http://vrapper.sourceforge.net>
 - ✦ viPlugin (commercial) - <http://www.viplugin.com>

Online Information

- ★ Information about PTP
 - ★ PTP online help
 - ★ <http://help.eclipse.org>
 - ★ Main web site for downloads, documentation, etc.
 - ★ <http://eclipse.org/ptp>
 - ★ Wiki for designs, planning, meetings, etc.
 - ★ <http://wiki.eclipse.org/PTP>

- ★ Information about Photran
 - ★ Main web site for downloads, documentation, etc.
 - ★ <http://eclipse.org/photran>

Mailing Lists

★ User Mailing Lists

★ PTP

★ <http://dev.eclipse.org/mailman/listinfo/ptp-user>

★ Photran

★ <http://dev.eclipse.org/mailman/listinfo/photran>

★ Major announcements (new releases, etc.) - low volume

★ <http://dev.eclipse.org/mailman/listinfo/ptp-announce>

★ Developer Mailing Lists

★ Developer discussions - higher volume

★ <http://dev.eclipse.org/mailman/listinfo/ptp-dev>

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 Tutorial Wrap-Up

- ★ PTP BOF @ SC12
 - ★ Tuesday Nov 13 5:30-7:00 pm
 - ★ Room 250-C
- ★ Please complete feedback forms
 - ★ Our paper feedback form
 - ★ SC12 online feedback form
- ★ Your feedback is valuable!

Thanks for attending
We hope you found it useful