parallel tools platform

http://eclipse.org/ptp

A New and Improved

# Eclipse Parallel Tools Platform

## Advancing the Development of Scientific Applications

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Based on slides by
Greg Watson, Beth Tibbitts, and others

# Tutorial Outline

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

# About the Tutorial Installation

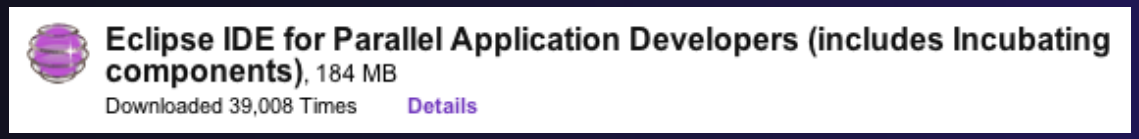
- This tutorial assumes you have Eclipse and PTP pre-installed on your laptop
- If you already have Eclipse installed, go directly to "Starting Eclipse", slide 5
- If you don't have Eclipse installed, you will need to follow the handouts so that you can catch up with the rest of the class
- Note: up-to-date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

# System Prerequisites

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

# Eclipse Packages

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




“Parallel Package”

- Can also add PTP to an existing Eclipse installation

# Eclipse Installation

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

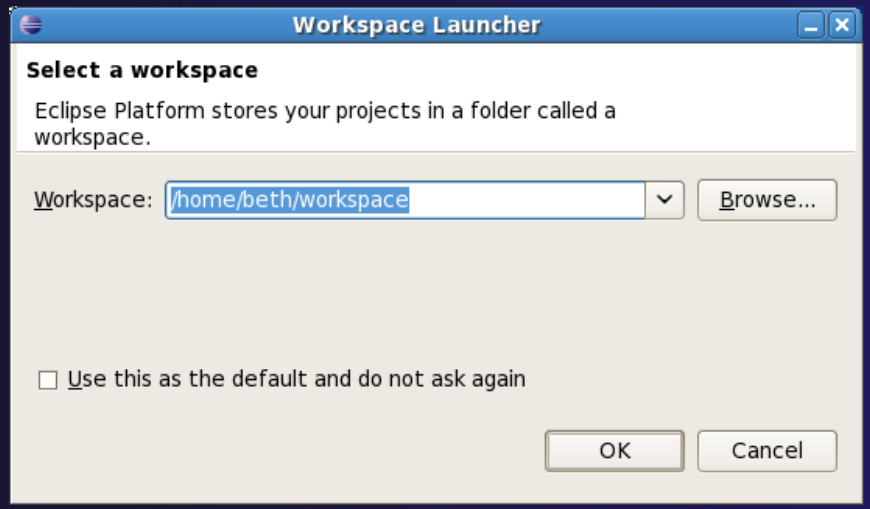
# Starting Eclipse

- **Linux**
  - From a terminal window, enter "<eclipse_installation_path>/eclipse/eclipse &"
- **Mac OS X**
  - From finder, open the **eclipse** folder where you installed
  - Double-click on the **Eclipse** application
  - Or launch from a terminal window instead (like Linux)
- **Windows**
  - Open the **eclipse** folder
  - Double-click on the **eclipse** executable

# Specifying A Workspace

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

The prompt can be turned off



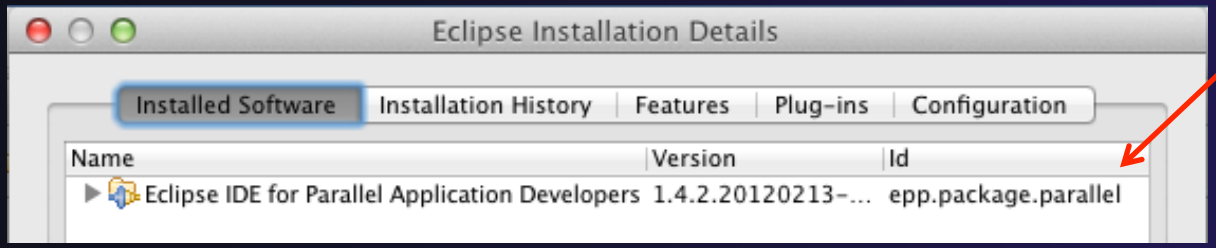
# Eclipse Welcome Page

- Displayed when Eclipse is run for the first time

Select “Go to the workbench”

# Check Installation Details

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




Differs depending on base download

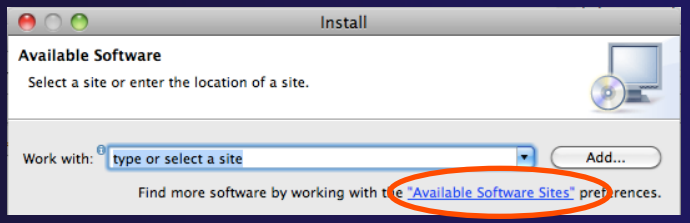
- Close the dialog: **Close, OK**

# Checking for PTP Updates

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

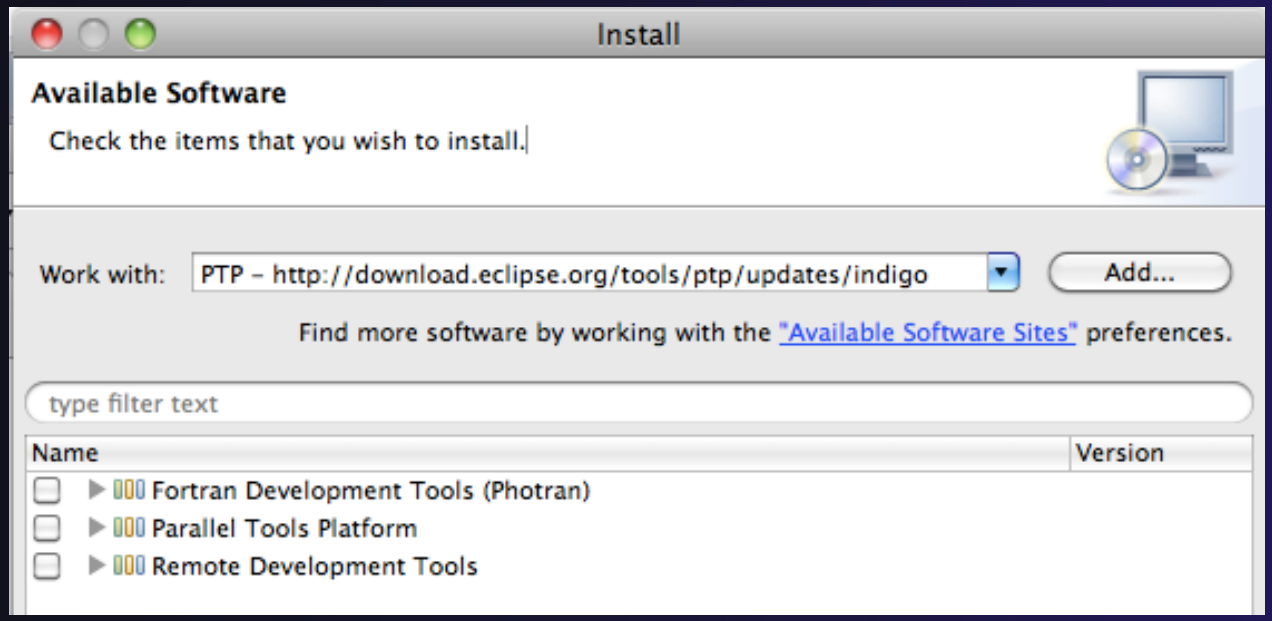
# Updating PTP

- Enable PTP-specific update site
  - **Help>Install New Software…**
  - Click **Available Software Sites** link
  - Ensure this checkbox is selected for the PTP site:
    http://download.eclipse.org/tools/ptp/updates/indigo
  - Choose **OK**
  - Choose **Cancel** (to return to Eclipse workbench)
- Now select **Help>Check for updates**
  - If you see "No updates were found"…
  - It's only because there are no updates in the "Eclipse IDE for Parallel Application Developers"
    - We will update the PTP within it



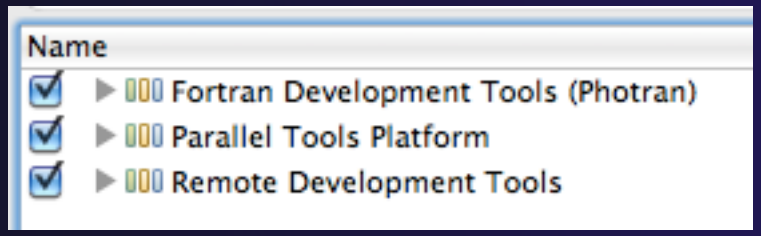
# Updating PTP (2)

- We will get the PTP release that is more recent than what is currently (Nov. 2011) within the parallel package
- Now select **Help>Install New Software...**
  - In the **Work With:** dropdown box, select the PTP update site you confirmed already:

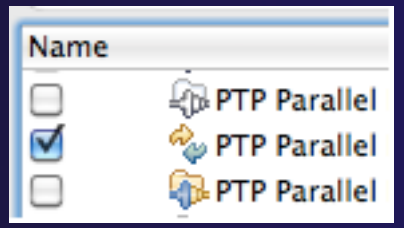


# Updating PTP (3)

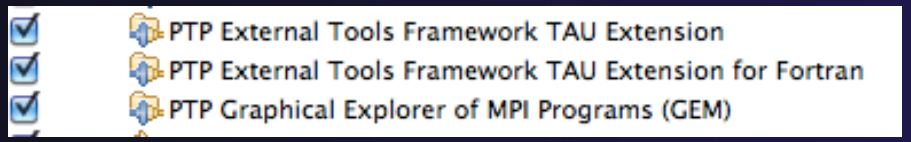
- Quick and dirty:
  - Check everything - which updates existing features and adds a few more



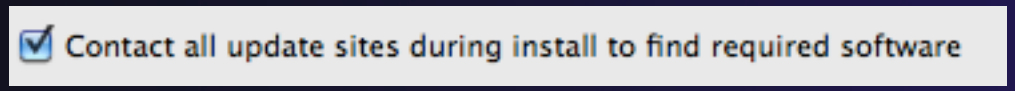

- Detailed:
  - Open each feature and check the ones you want to update
  - Icons indicate: Grey plug: already installed and up to date
    Double arrow: can be updated
    Color plug: Not installed yet




Note: For this tutorial, install GEM and TAU

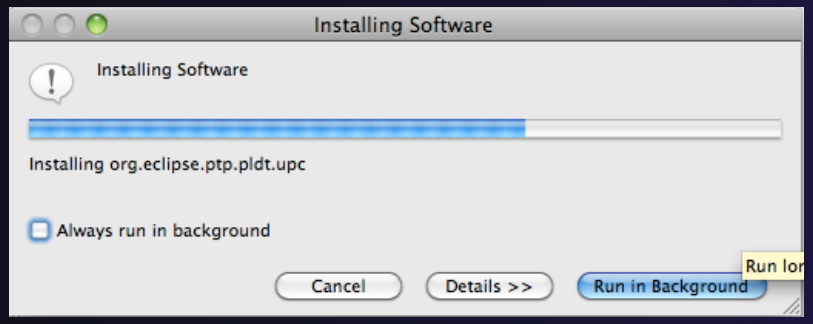



Note: if conference network is slow, consider unchecking:

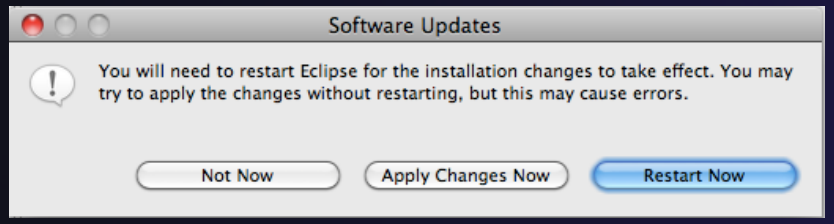


# Updating PTP (4)

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




- Select **Restart Now** when prompted



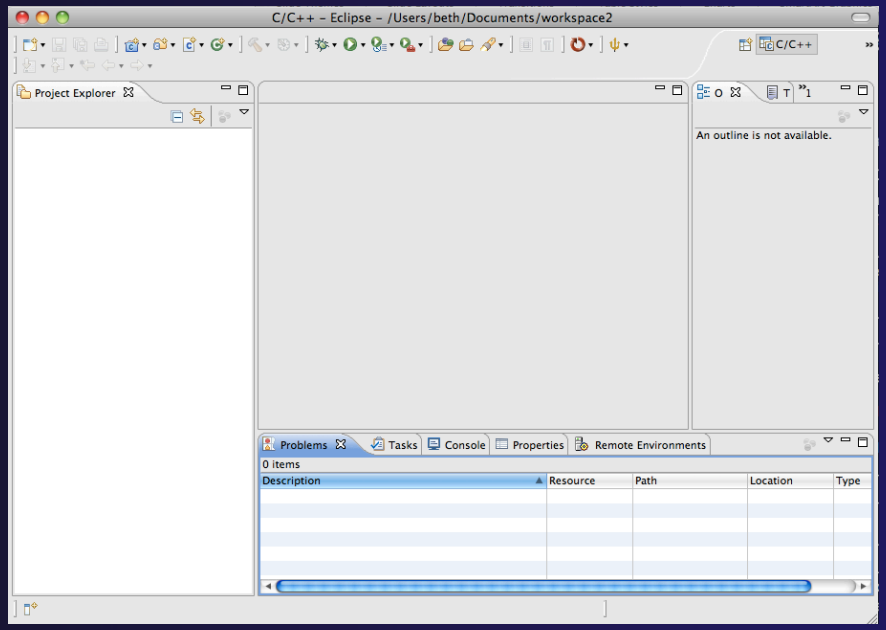

Wait for installation to finish

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

# Restart after Install

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

  … Ready to go!




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

# New and Improved Features

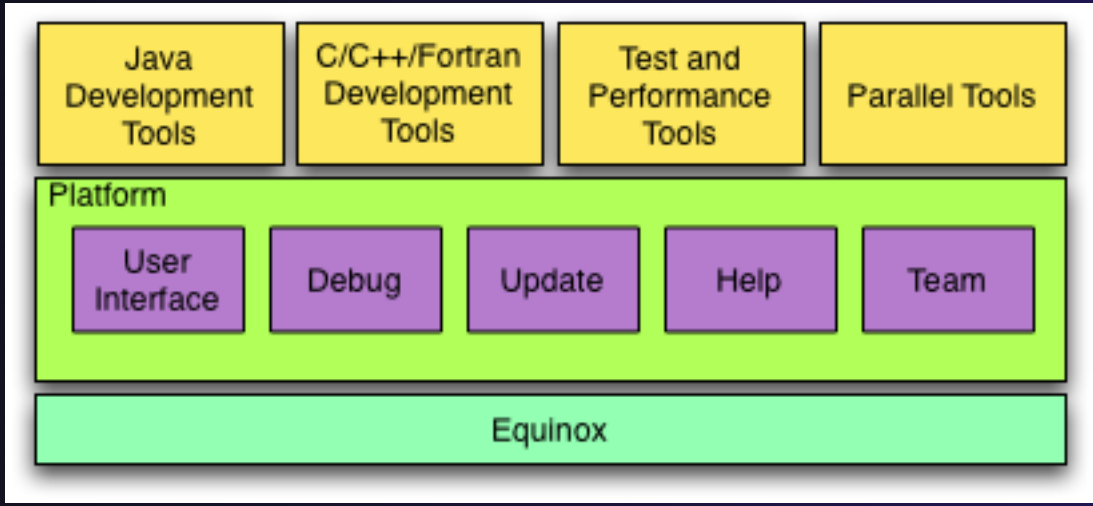
- More flexible projects
  - Synchronized projects overcome many problems of remote projects
  - Allows development when “off-line”
  - Works with non-C/C++ projects
- More customizable resource managers
  - Resource managers can now be added by users
  - Able to have site-specific configurations
  -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

# New and Improved Features (2)

- Scalable system/job monitoring
  - New perspective allows monitoring of systems of virtually any size
  - View shows location of jobs on cluster
  - Active and inactive jobs views
- Remote support for performance tools
  - External Tools Framework has been extended to support remote systems
  - Performance tools such as TAU can now launch and collect data from remote systems

# What is Eclipse?

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

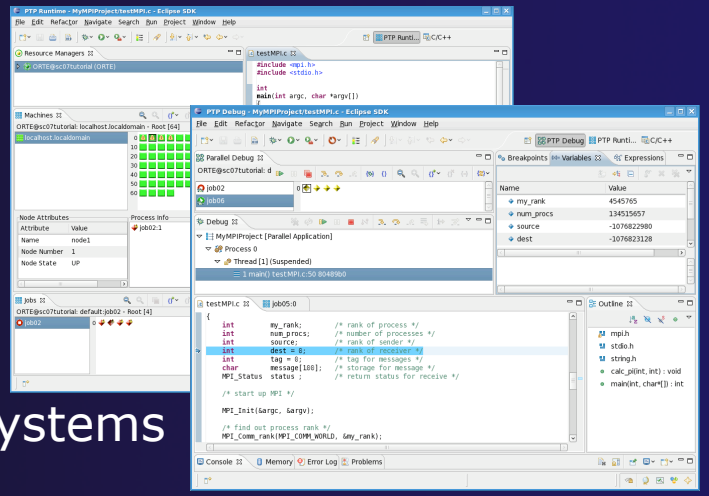


# Eclipse Features

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

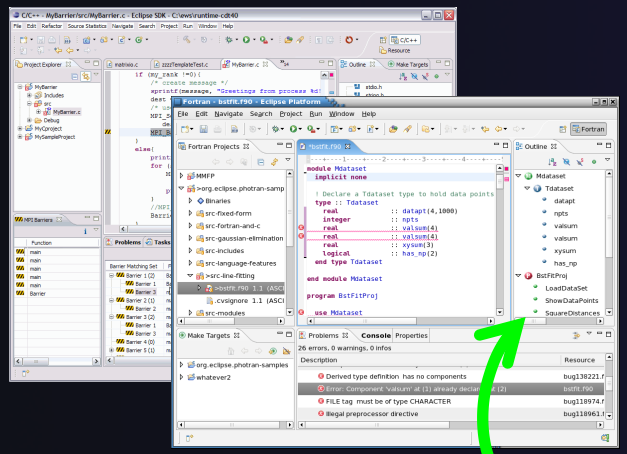
# Parallel Tools Platform (PTP)

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

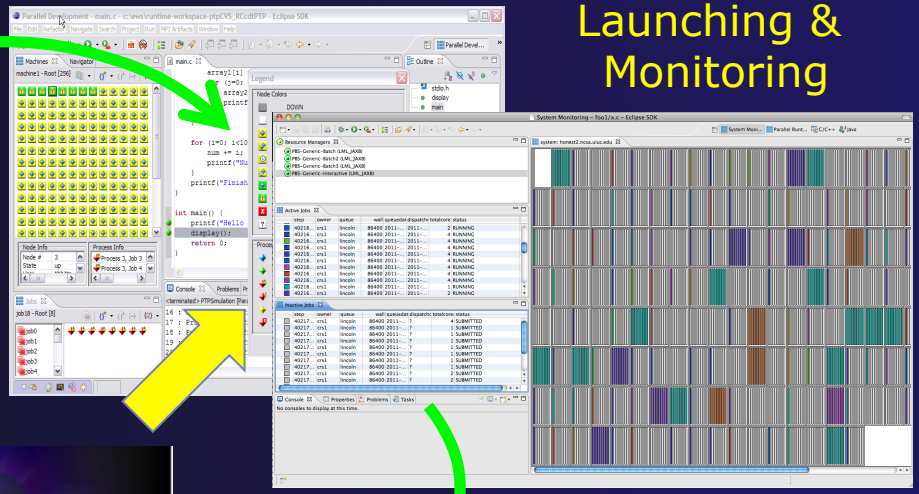


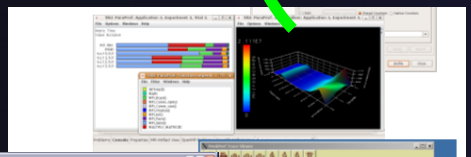
# Eclipse PTP Family of Tools

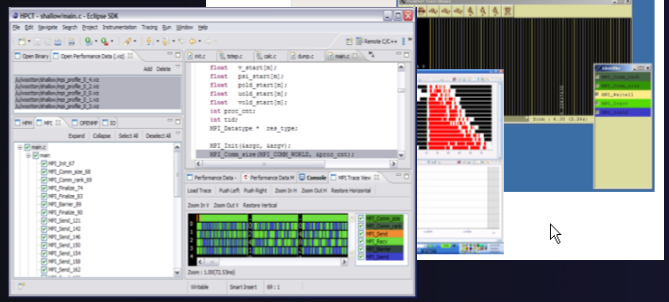
Coding & Analysis
(C, C++, Fortran)



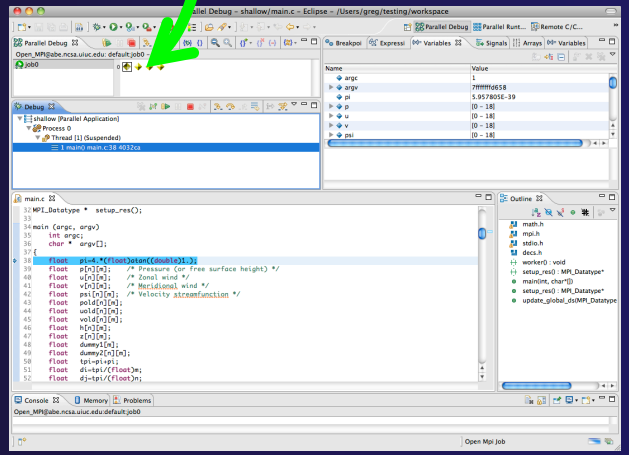
Launching & Monitoring







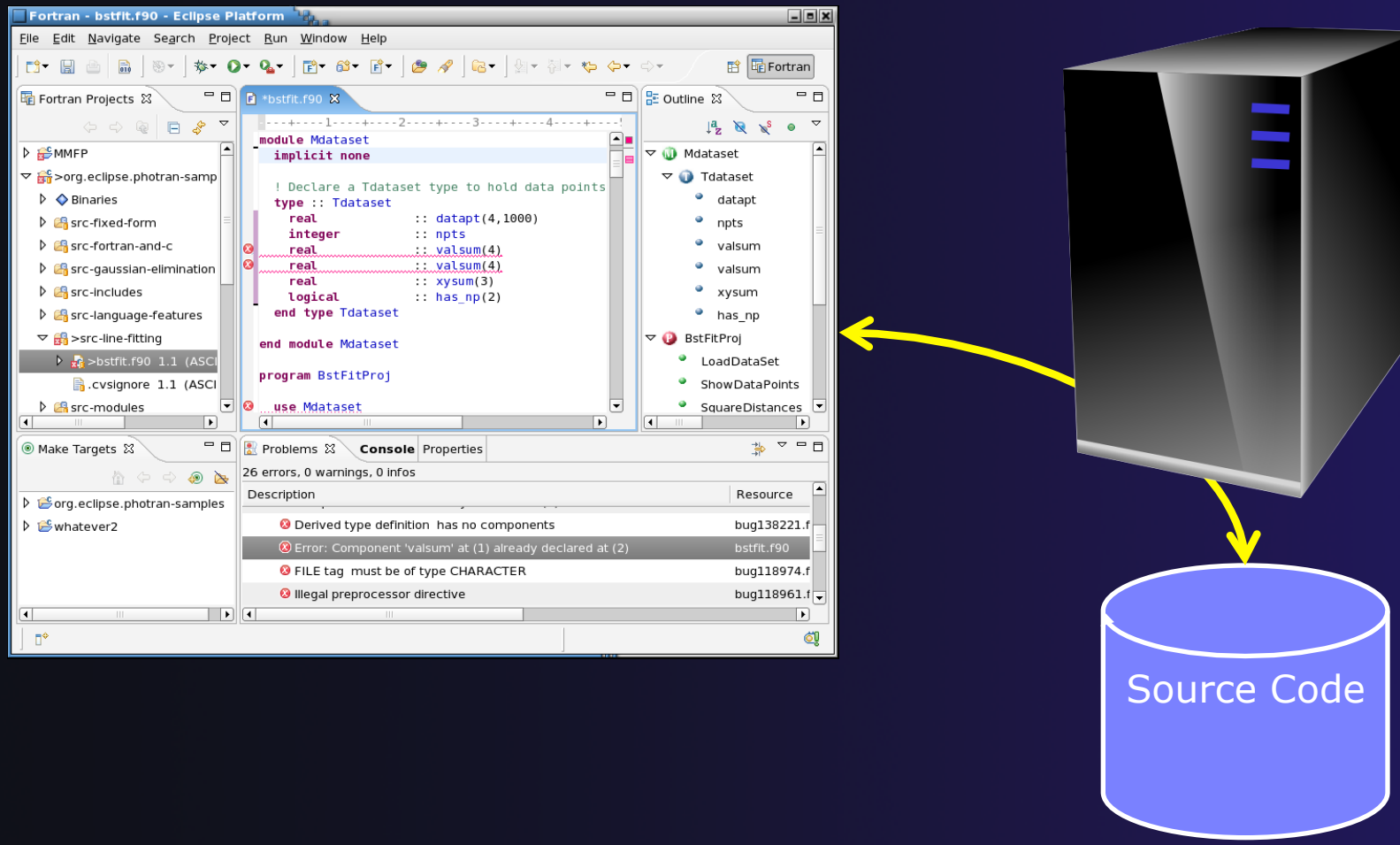
Performance Tuning
(TAU, PPW, …)



Parallel Debugging

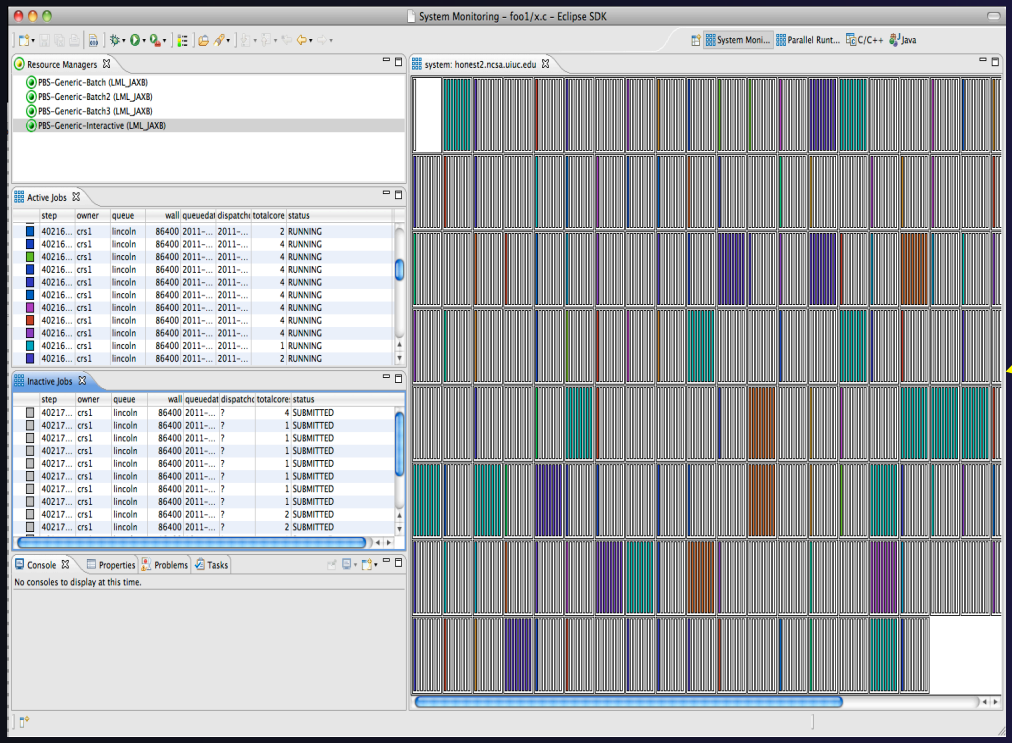
# How Eclipse is Used

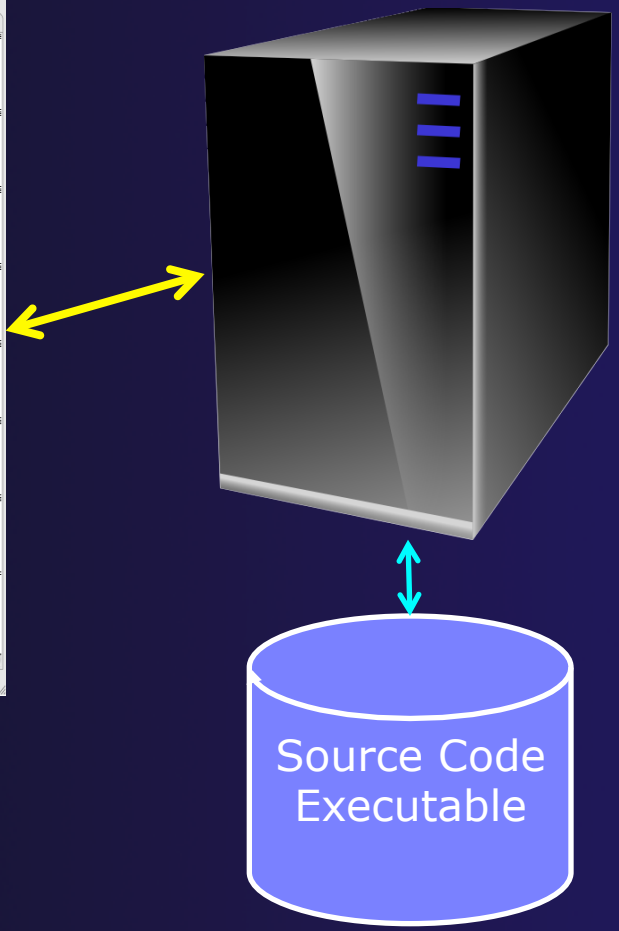
## Editing/Compiling



# How Eclipse is Used

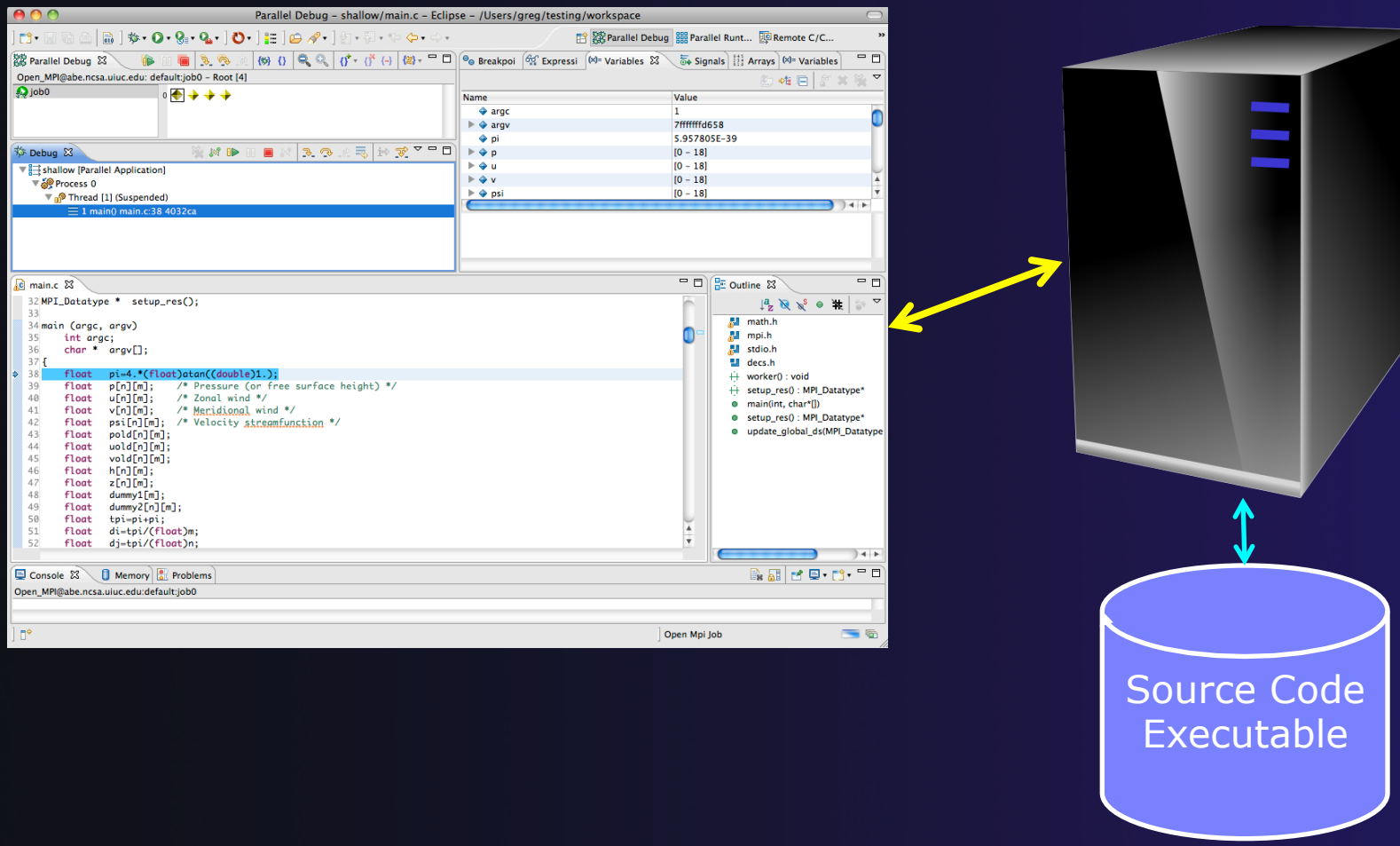
## Launching/Monitoring



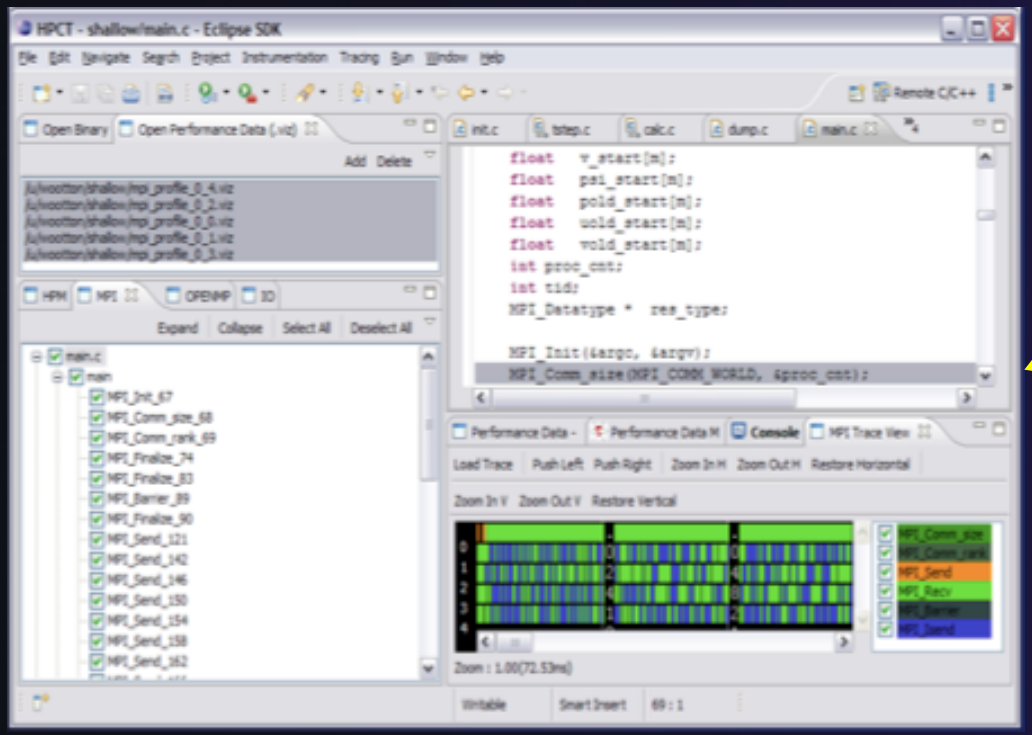
# How Eclipse is Used

## Debugging



# How Eclipse is Used

## Performance Tuning

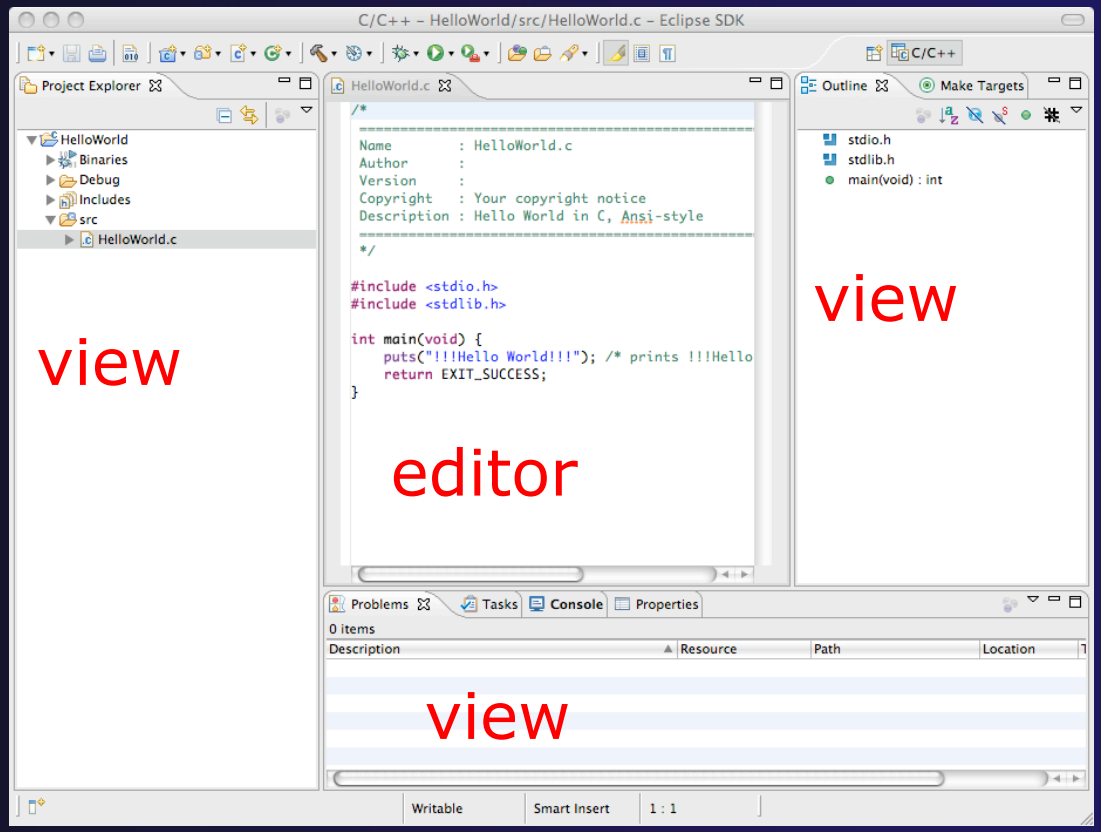


# Contents

# Basic Eclipse Features

# Eclipse Basics

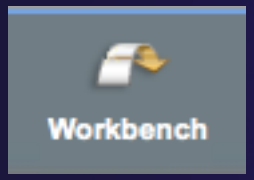
- A *workbench* contains the menus, toolbars, editors and views that make up the main Eclipse window
- The workbench represents the desktop development environment
  - Contains a set of tools for resource mgmt
  - Provides a common way of navigating through the resources
- Multiple workbenches can be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



# Perspectives

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

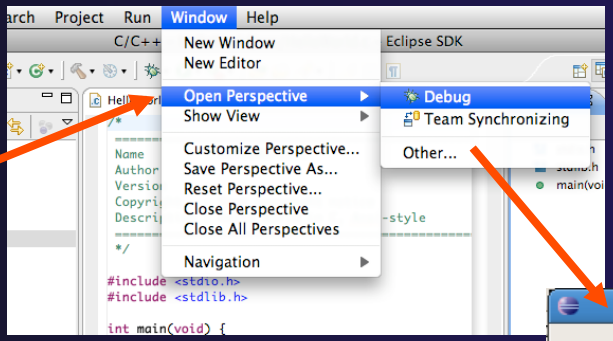
- If you are on the Welcome screen now, select "Go to Workbench" now



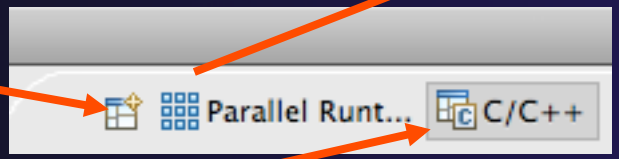
# Switching Perspectives

- Three ways of changing perspectives

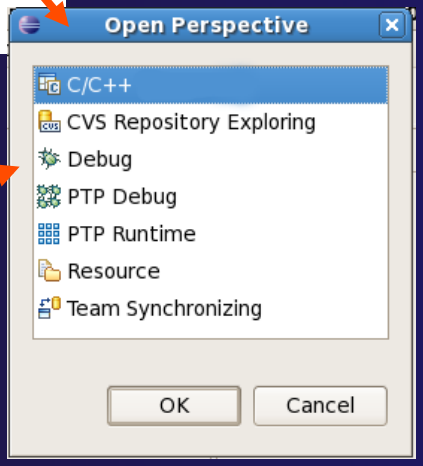
1. Choose the **Window>Open Perspective** menu option Then choose **Other...**




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



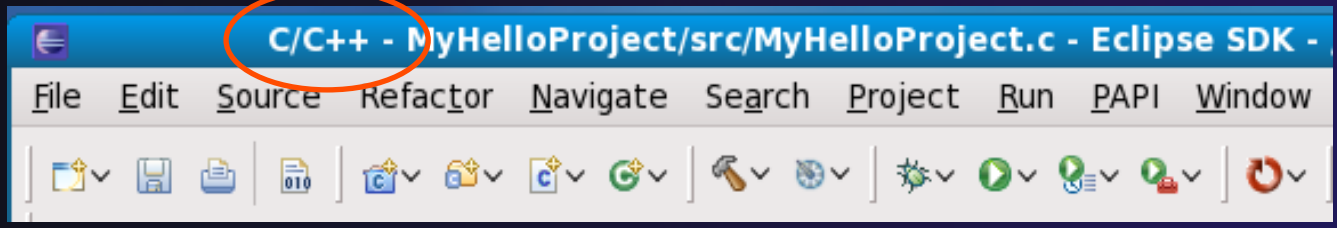

3. Click on a perspective shortcut button



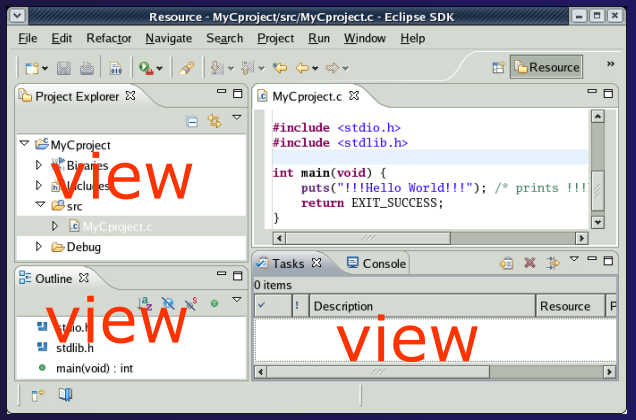

- Switch to the C/C++ Perspective

# Which Perspective?

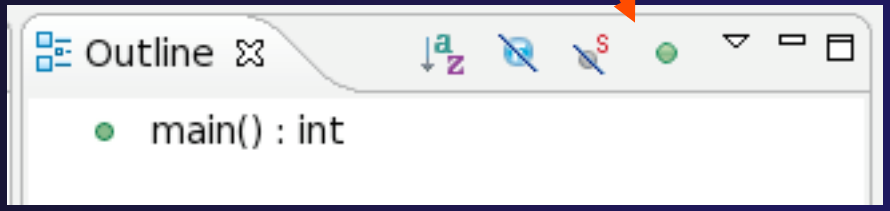
- Which Perspective am in in?
  See Title Bar



# Views

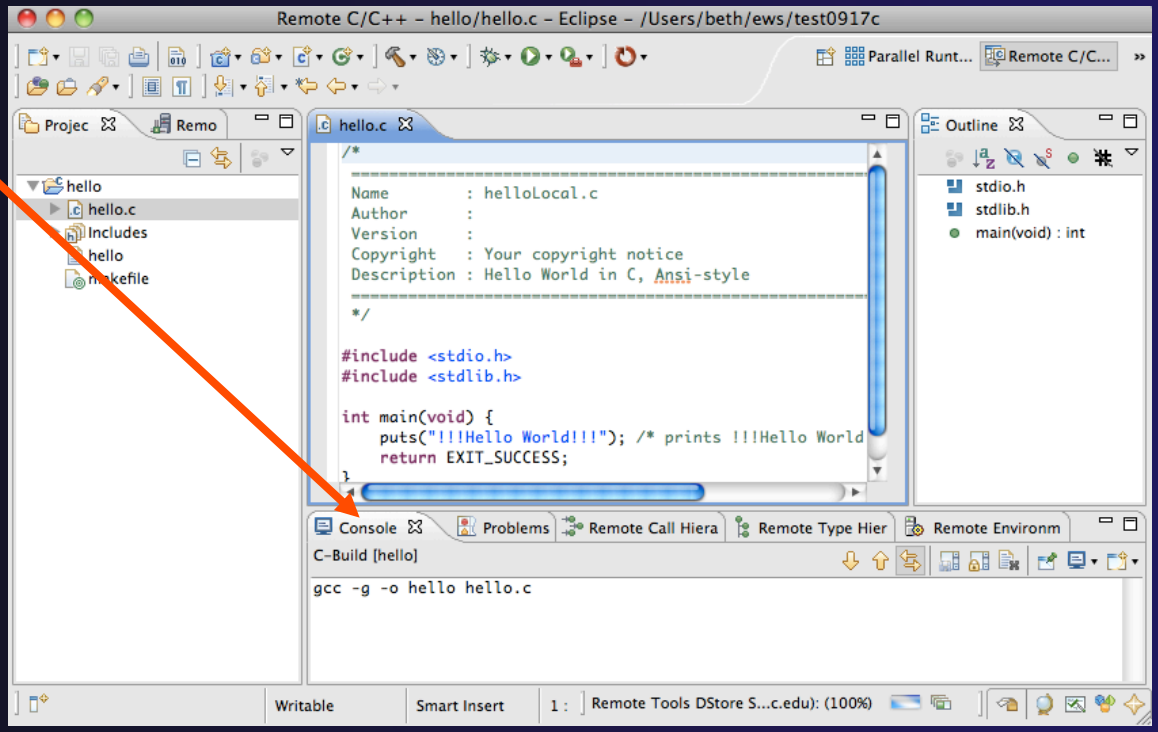



- The workbench window is divided up into Views
- The main purpose of a view is:
  - To provide alternative ways of presenting information
  - For navigation
  - For editing and modifying information
- Views can have their own menus and toolbars
  - Items available in menus and toolbars are available only in that view
  - Menu actions only apply to the view
- Views can be resized



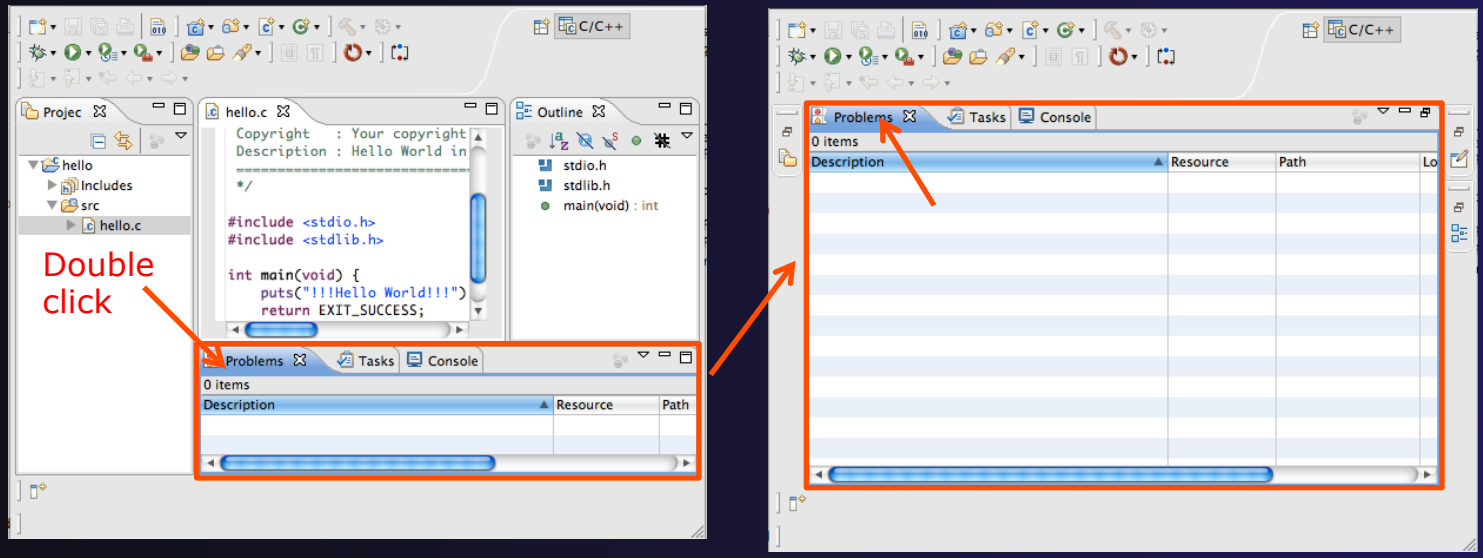
# Stacked Views

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



# Expand a View

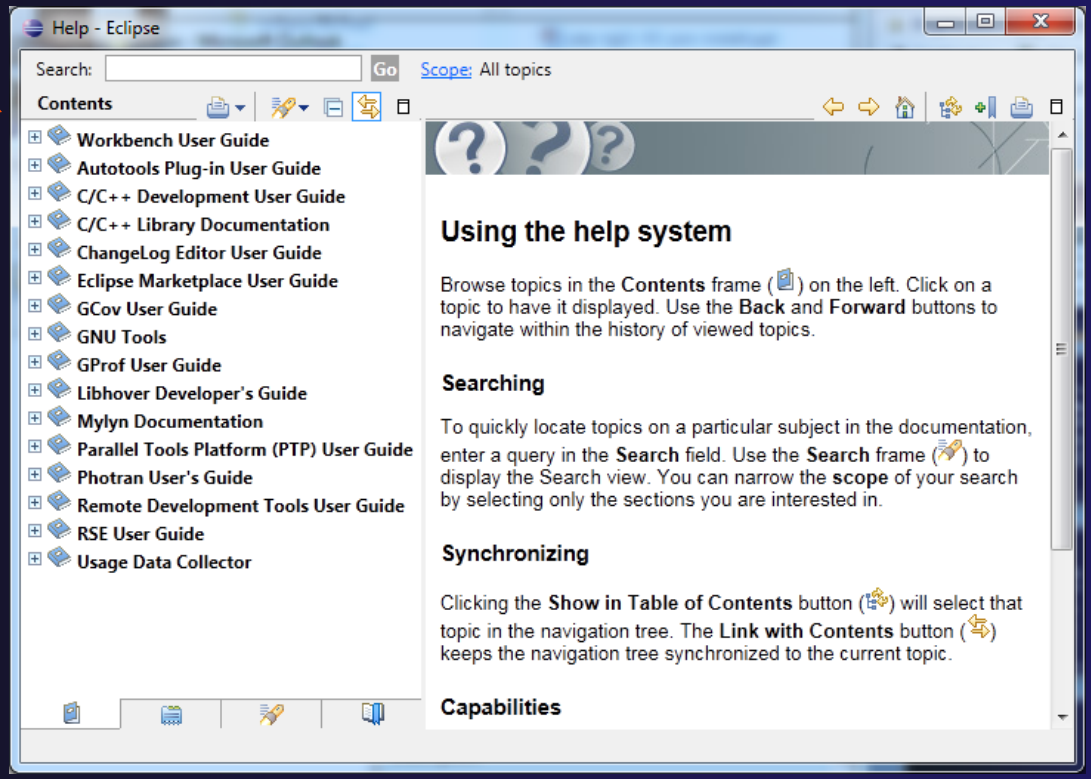
- Double-click on a view/editor's tab to fill the workbench with its content;
- Repeat to return to original size



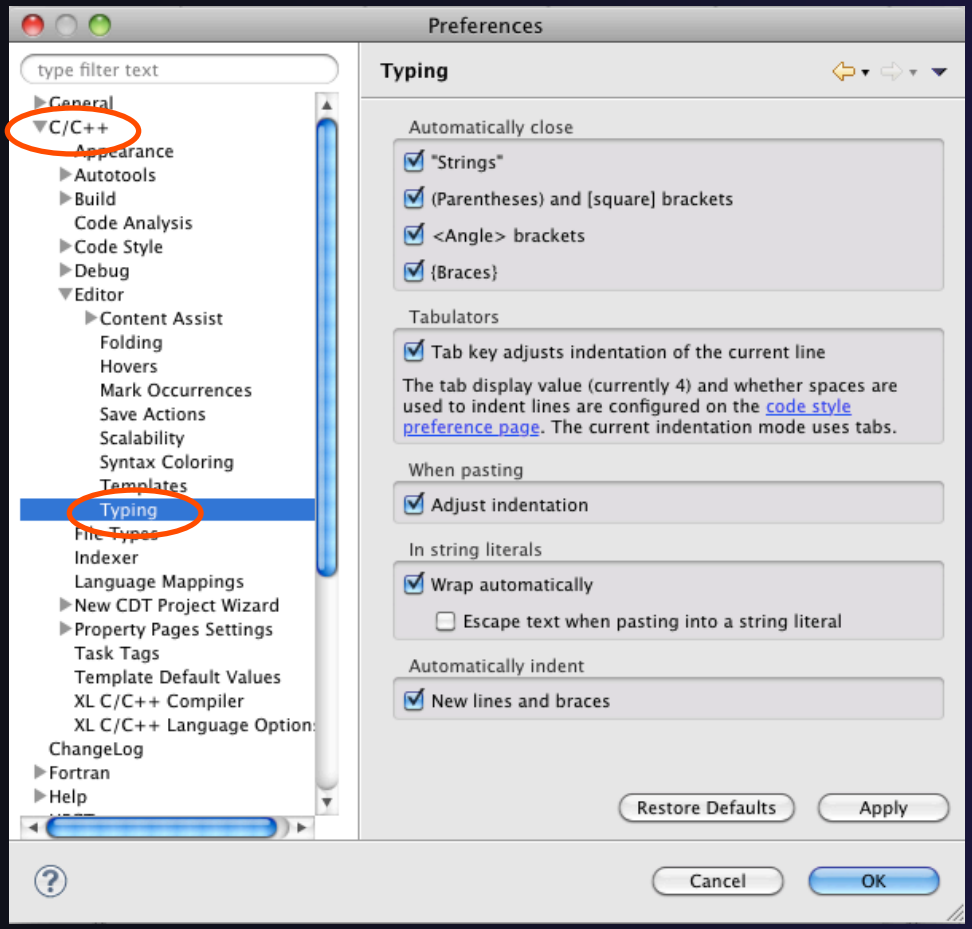

- Window > Reset Perspective returns everything to original positions

# 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.)

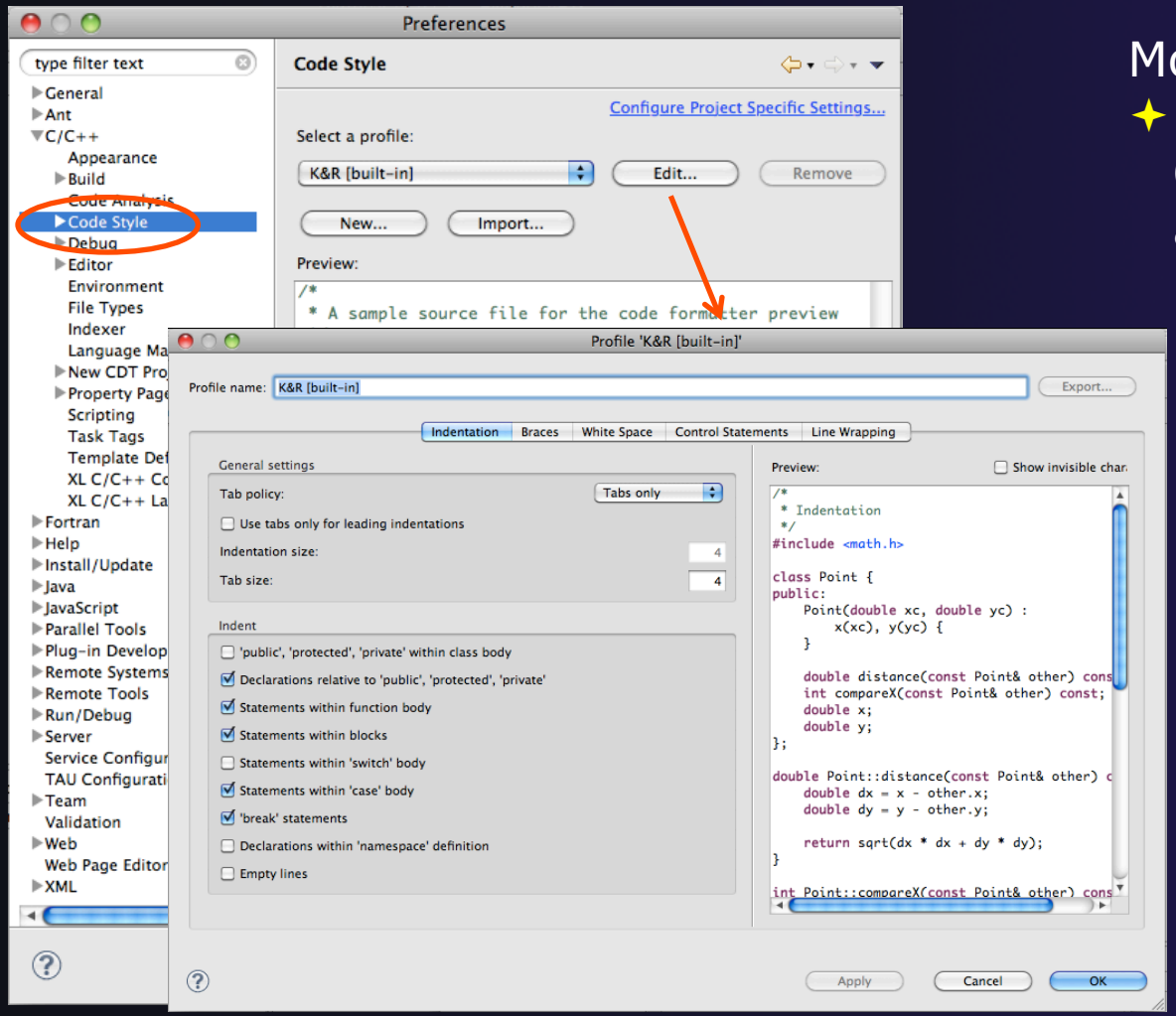


# Eclipse Preferences




- 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:

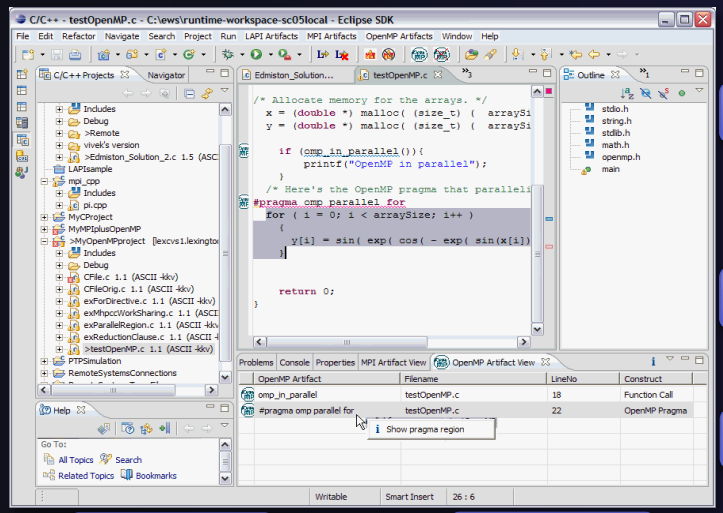
- In this example the Code Style preferences are shown
  - These allow code to be automatically formatted in different ways

# Projects In Eclipse

# Project Types

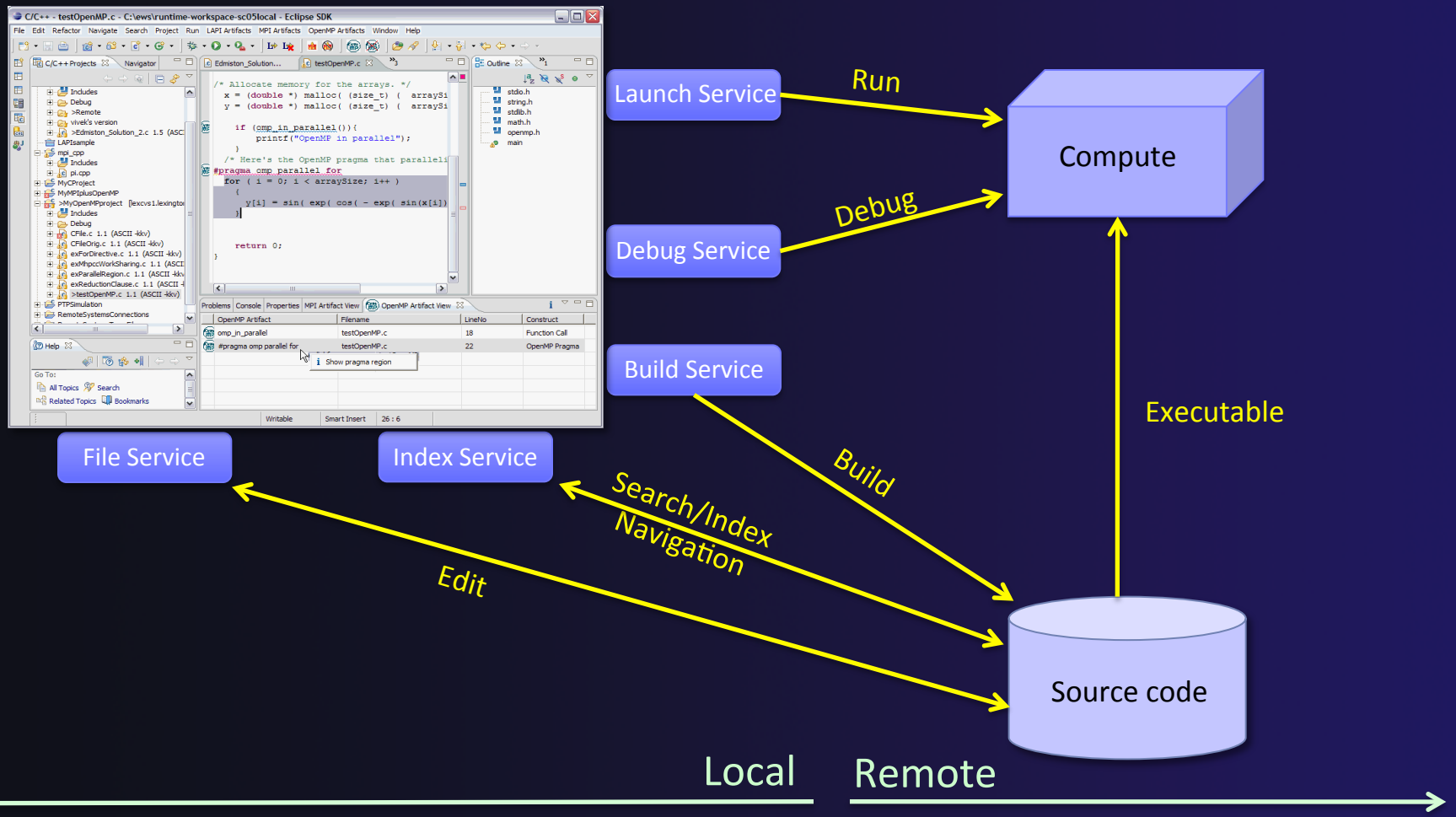
- Local
  - Source is located on local machine, builds happen locally
- Synchronized
  - Source is local, then synchronized with remote machine(s)
  - Building and launching happens remotely (can also happen locally)
- Remote
  - Source is located on remote machine(s), build and launch takes place on remote machine(s)

# Synchronized Projects



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

# Remote Projects



# C, C++, and Fortran Projects

## Build types

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

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

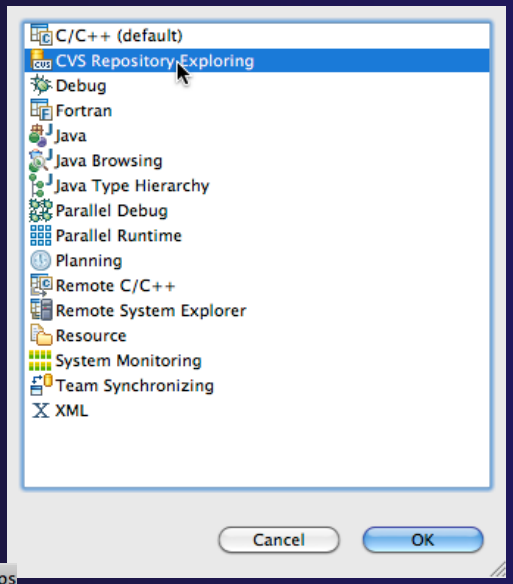
- MPI (or other runtime) needs to be installed
- An application built locally probably can't be run on a remote machine unless their architectures are the same

# Checking out the project

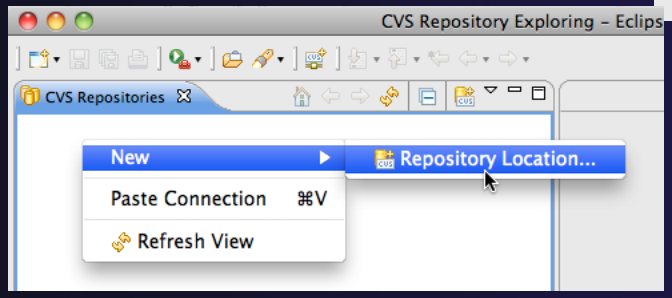
# Using a Source Code Repository Introduction to Team Features

# Importing a Project from CVS

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

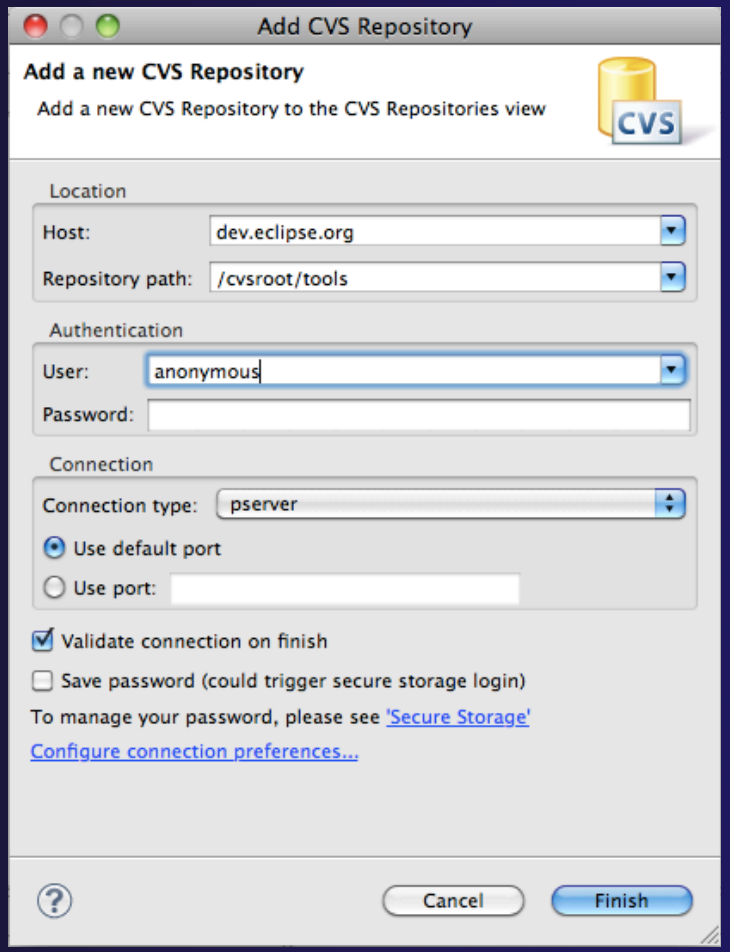



- Right click in **CVS Repositories** view and select **New>Repository Location…**



# Add CVS Repository

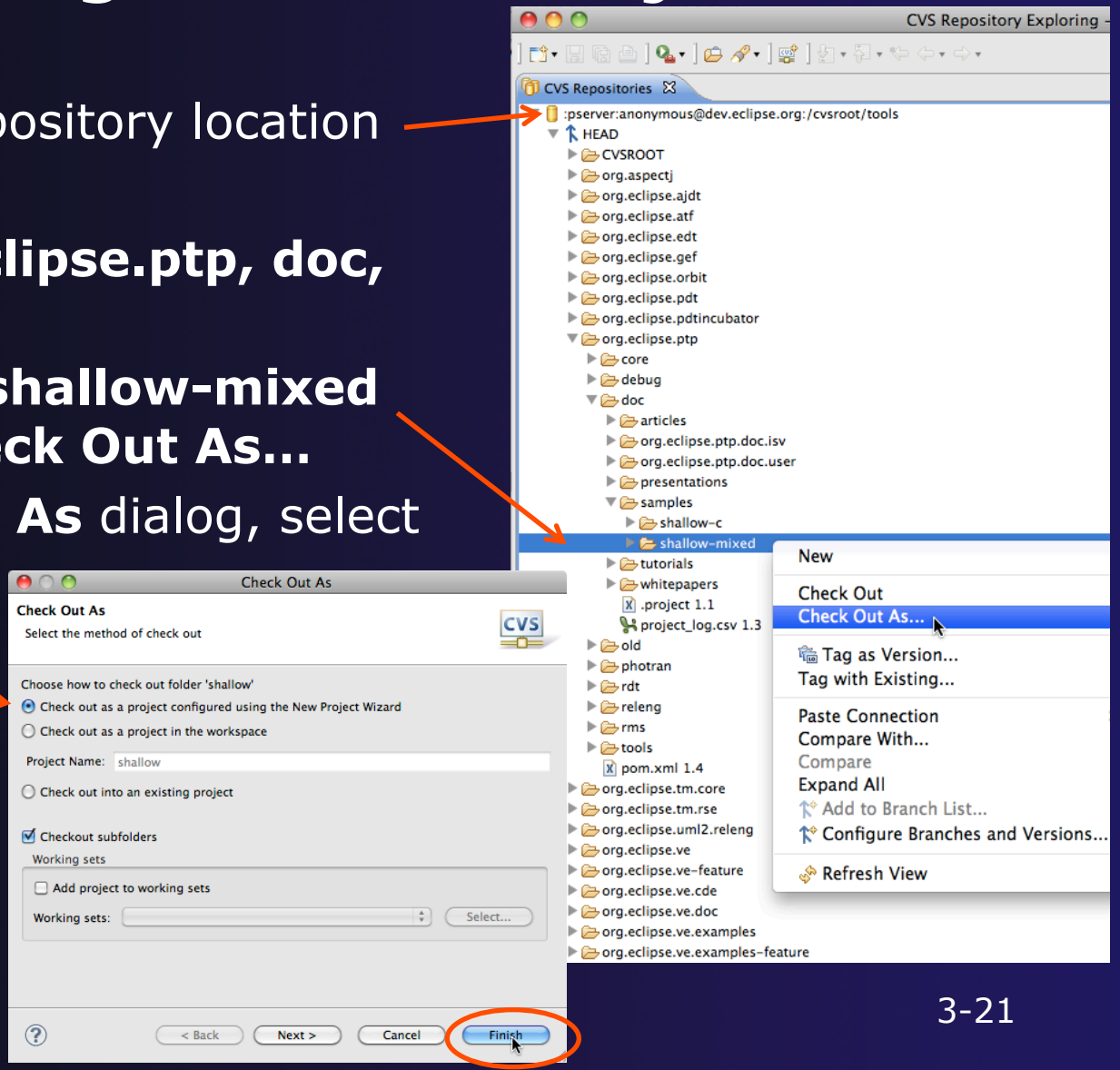
- Enter **Host:** dev.eclipse.org
- **Repository path:** /cvsroot/tools
- For anonymous access:
  - **User**: anonymous
  - No password is required
  - **Connection type:** pserver (default)
- For authorized access:
  - **User**: your userid
  - **Password**: your password
  - **Connection type:** change to **extssh**
- Select **Finish**



# Checking out the Project

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

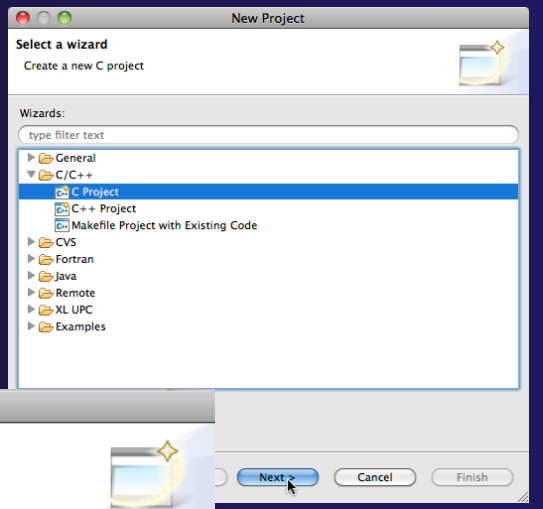
The default of "Check out as a project configured using the New Project Wizard" is what we want

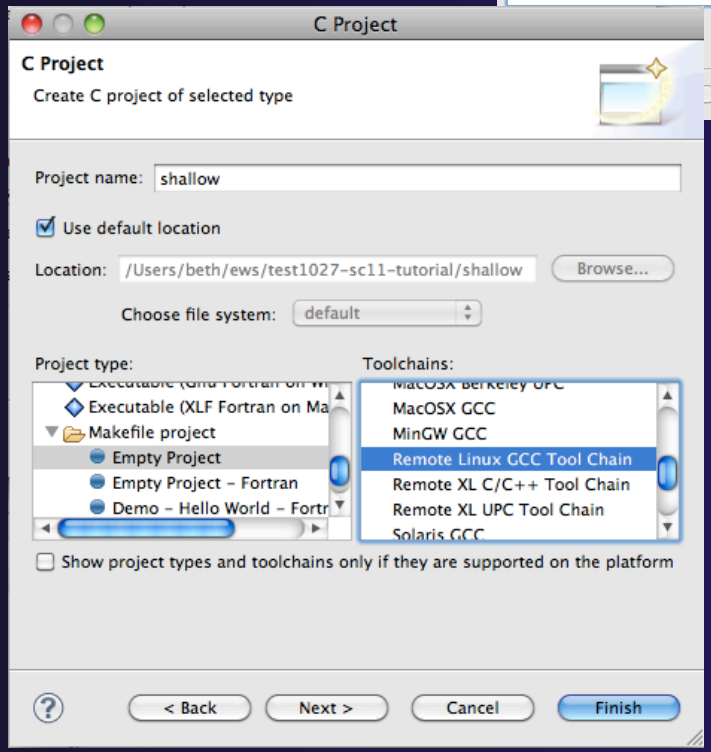


# New Project Wizard

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

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

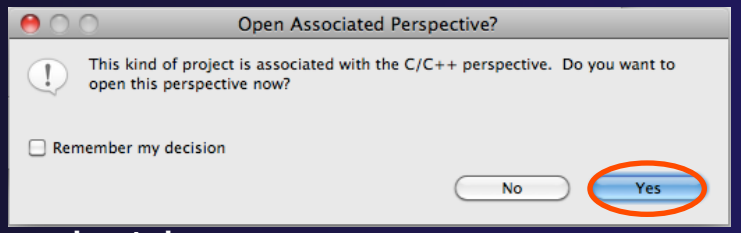


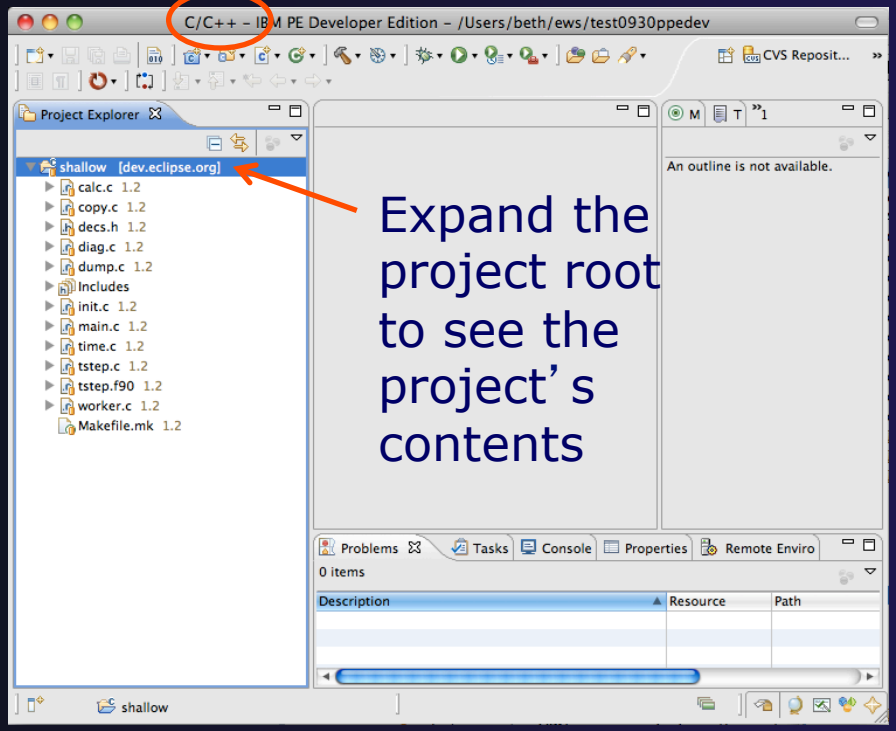

For SC tutorial Choose Remote Linux GCC Tool Chain

# C/C++ Perspective

- Switch to the C/C++ Perspective when Prompted



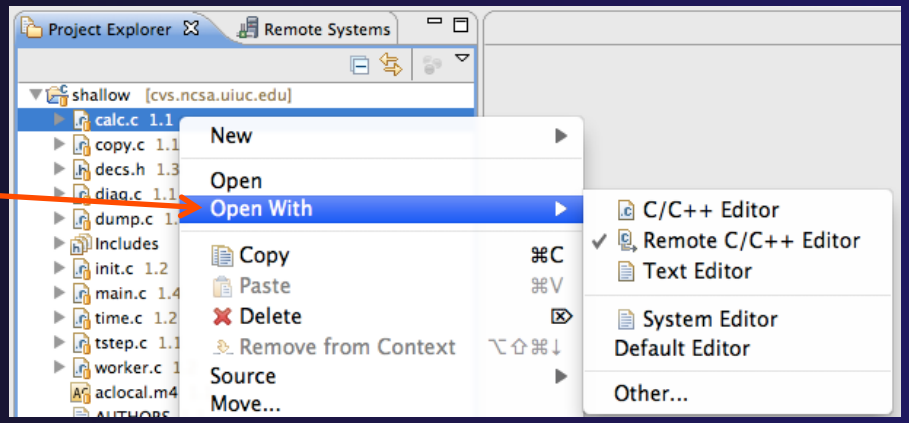

- You should now see the “shallow” project in your workspace



# Editor Features

# Editors

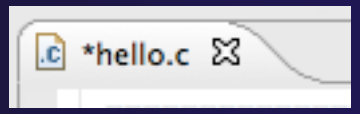
- An editor for a resource (e.g. a file) opens when you double-click on a resource
- The type of editor depends on the type of the resource
  - .c files are opened with the C/C++ editor by default
  - You can use **Open With** to use another editor
  - In this case the default editor is fine (double-click)




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

# Saving File in Editor

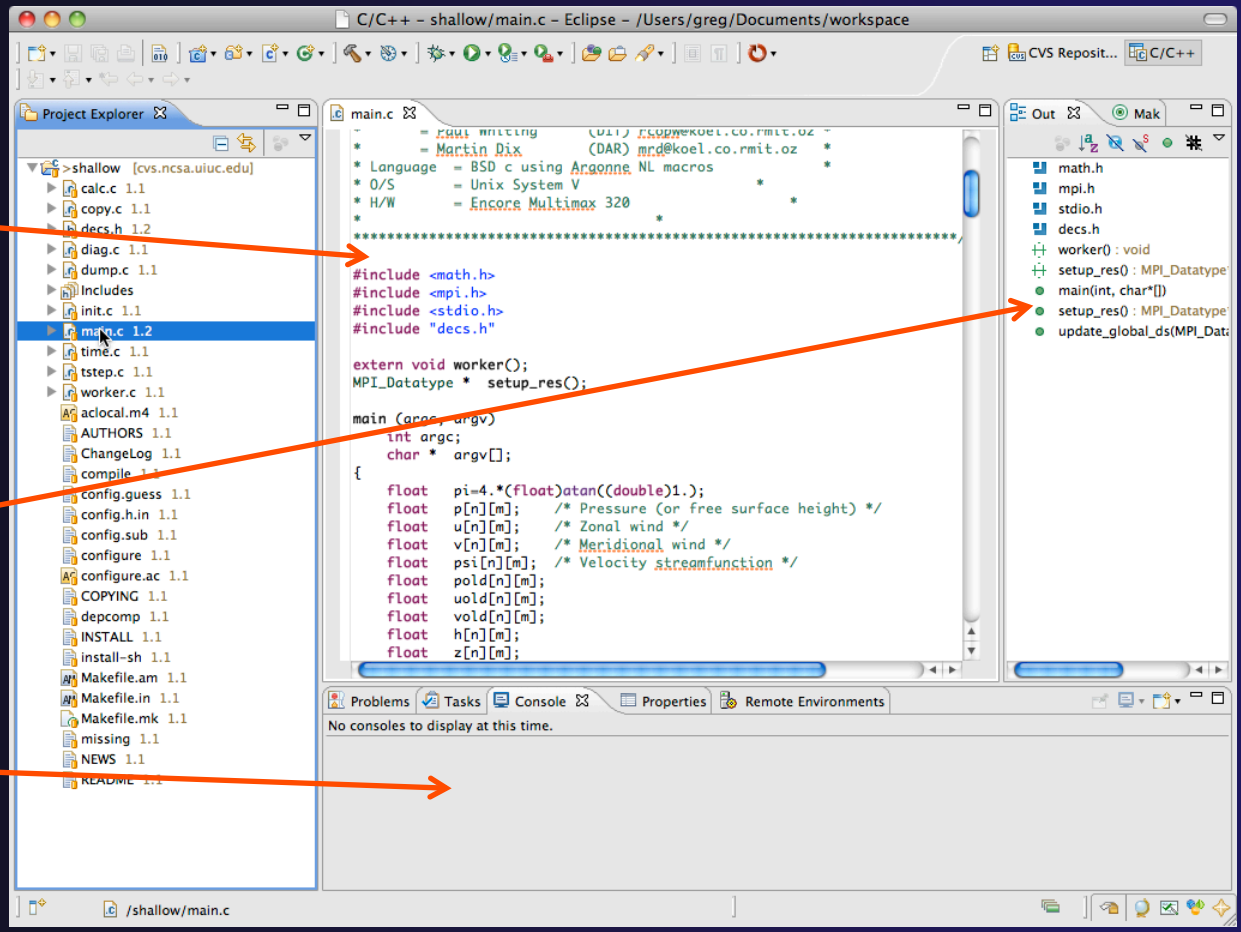
- When you change a file in the editor, an asterisk on the editor's title bar indicates unsaved changes




- Save the changes by using Command/Ctrl-S or **File>Save**
- Undo last change using **Command/Ctrl Z**

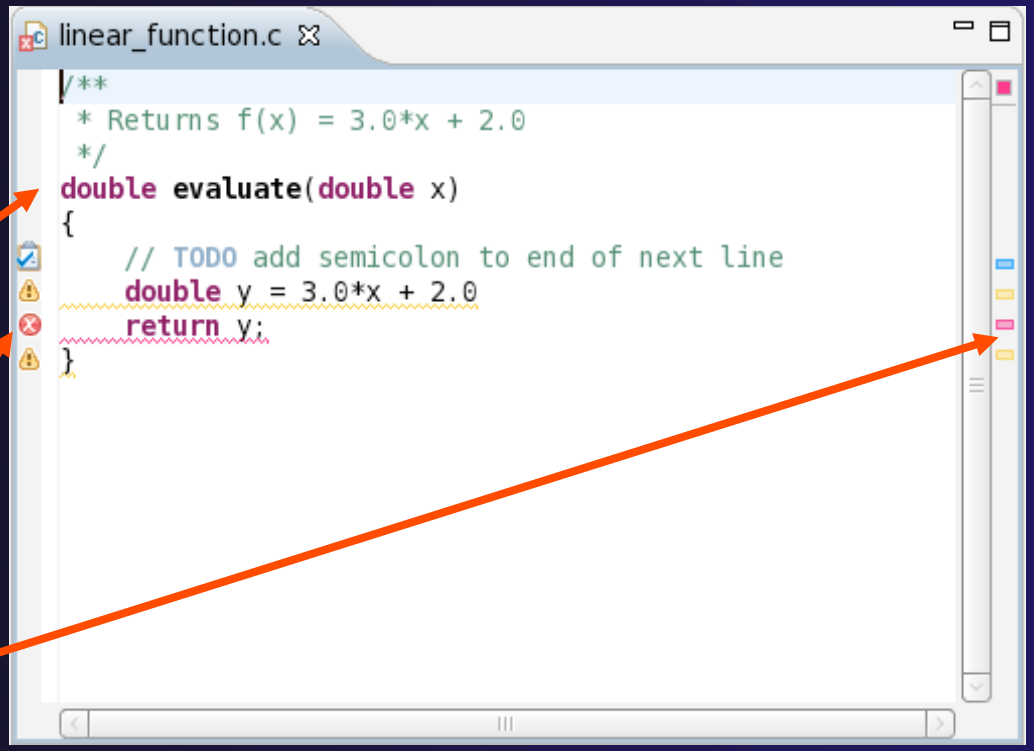
# Editor and Outline View

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



# Source Code Editors & Markers

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




Icons:

# Code Analysis (Codan)

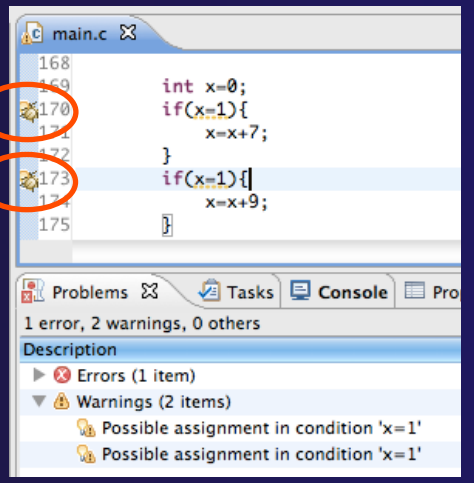
- If you see bug icons in the editor marker bar, they are likely suggestions from Codan
- Code checkers can flag possible errors, even if code is technically correct
- To turn them off, use Preferences

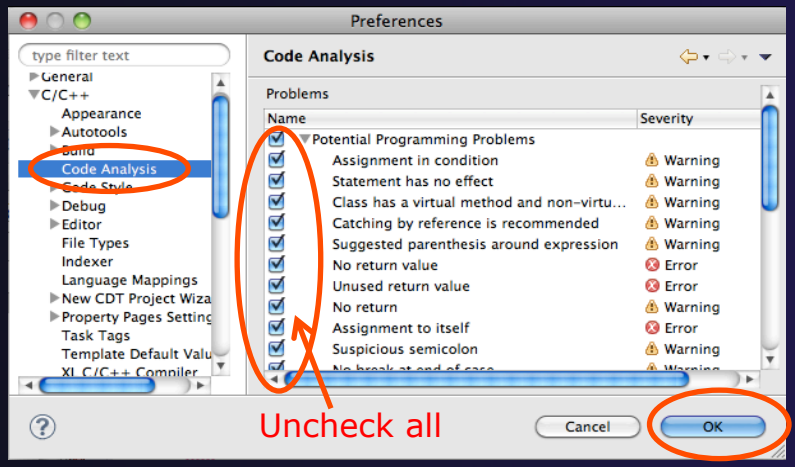
  Window > Preferences or Mac: Eclipse > Preferences

  **C/C++ > Code Analysis**

  and uncheck all problems
- Select OK to close Preferences

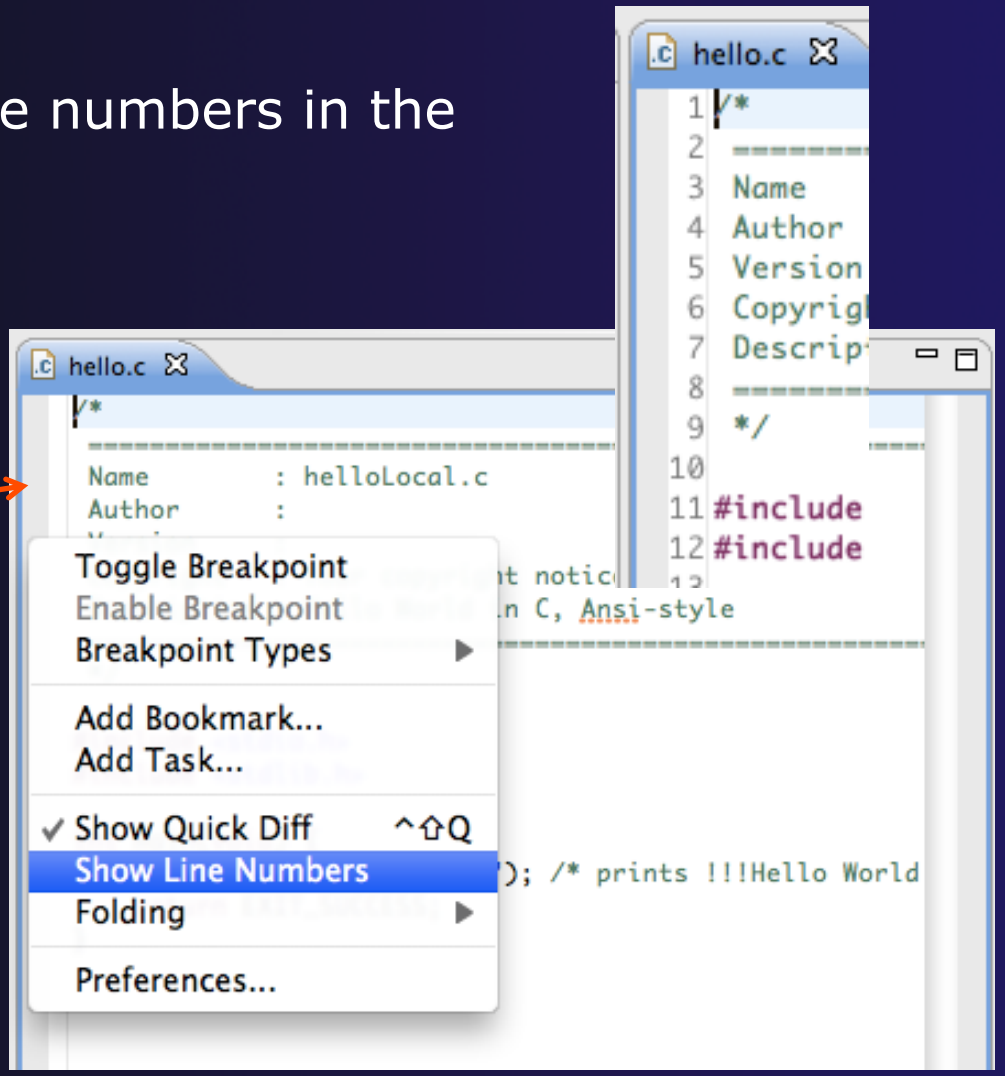
- To remove icons: Rightmouse on Project > Run C/C++ Code Analysis



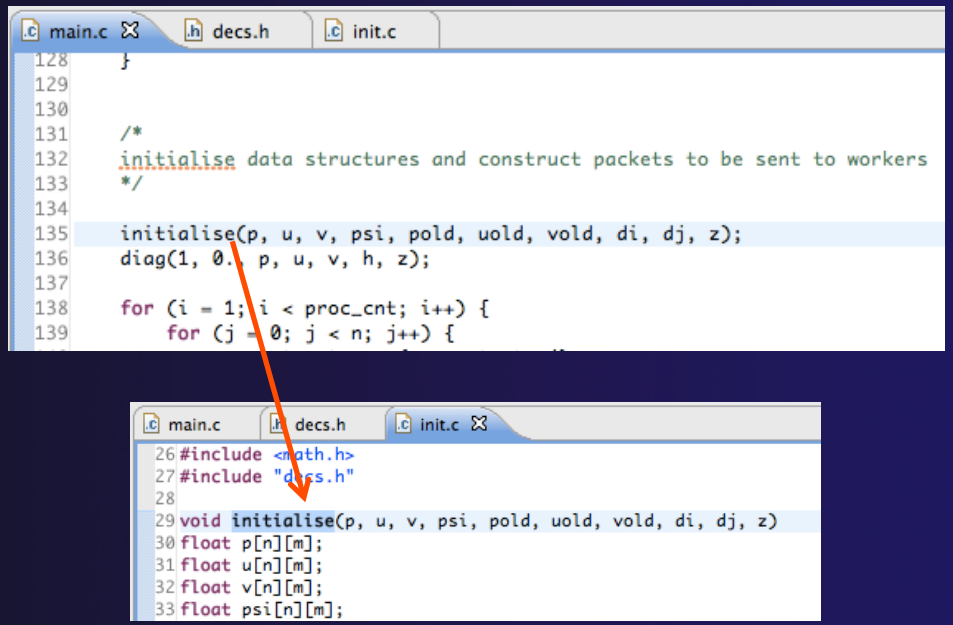
# Line Numbers

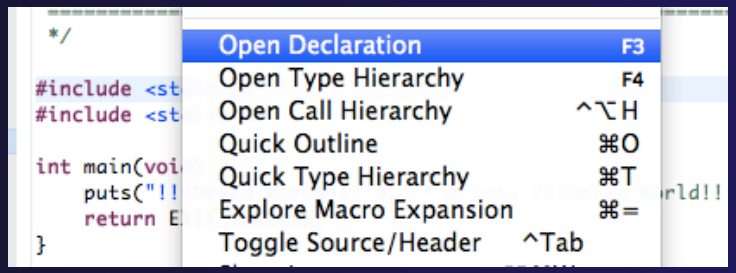
- Text editors can show line numbers in the left column
- To turn on line numbering:
  - Right-mouse click in the editor marker bar
  - Click on **Show Line Numbers**



# Navigating to Other Files

- On demand hyperlink
  - In main.c line 135:
  - Hold down Command/Ctrl key e.g. on call to `initialise`
  - Click on `initialise` to navigate to its definition in the header file (Exact key combination depends on your OS)
  - E.g. Command/Ctrl and click on initialise
- Open declaration
  - Right-click and select **Open Declaration** will also open the file in which the element is declared
  - E.g. in main.c line 29 right-click on decs.h and select **Open Declaration**

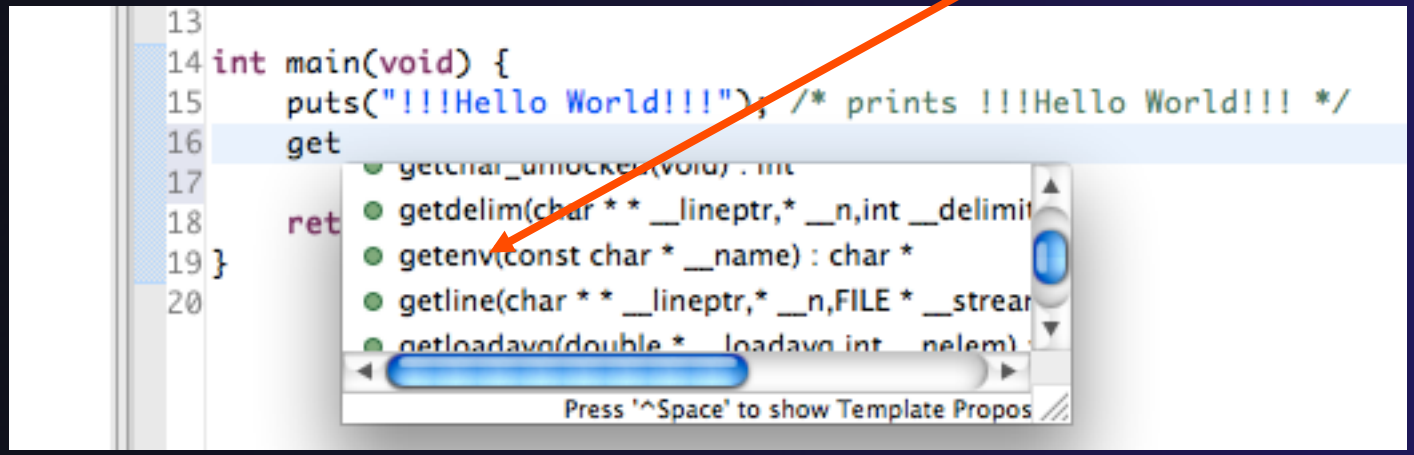



Note: may need to left-click before right-click works

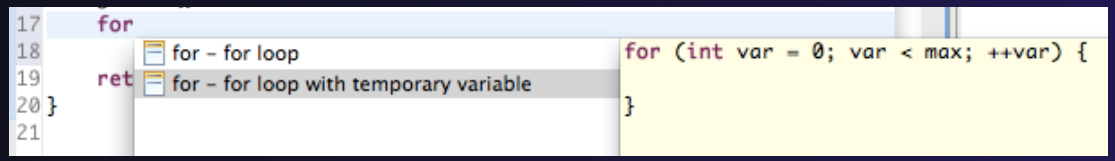
# Content Assist & Templates

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




- Code Templates: type ‘for’ and Ctrl-space

Hit ctrl-space again for code templates




More info on code templates later

# 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
```

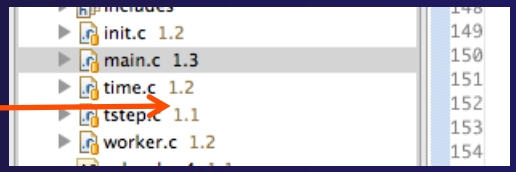
# Team Features

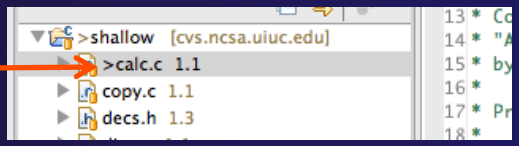
# "Team" Features

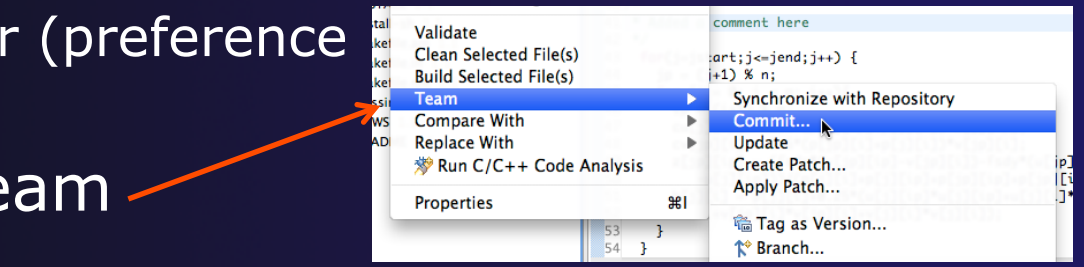
- Eclipse supports integration with multiple version control systems (VCS)
  - CVS, SVN, Git, and others
  - Collectively known as "Team" services
- Many features are common across VCS
  - Compare/merge
  - History
  - Check-in/check-out
- Some differences
  - Version numbers
  - Branching

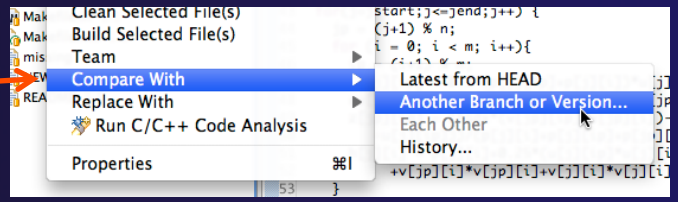
# CVS Features

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



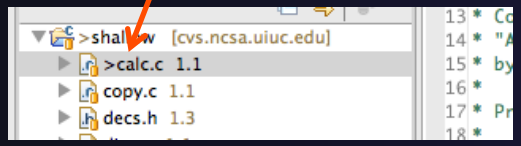



# File Modification

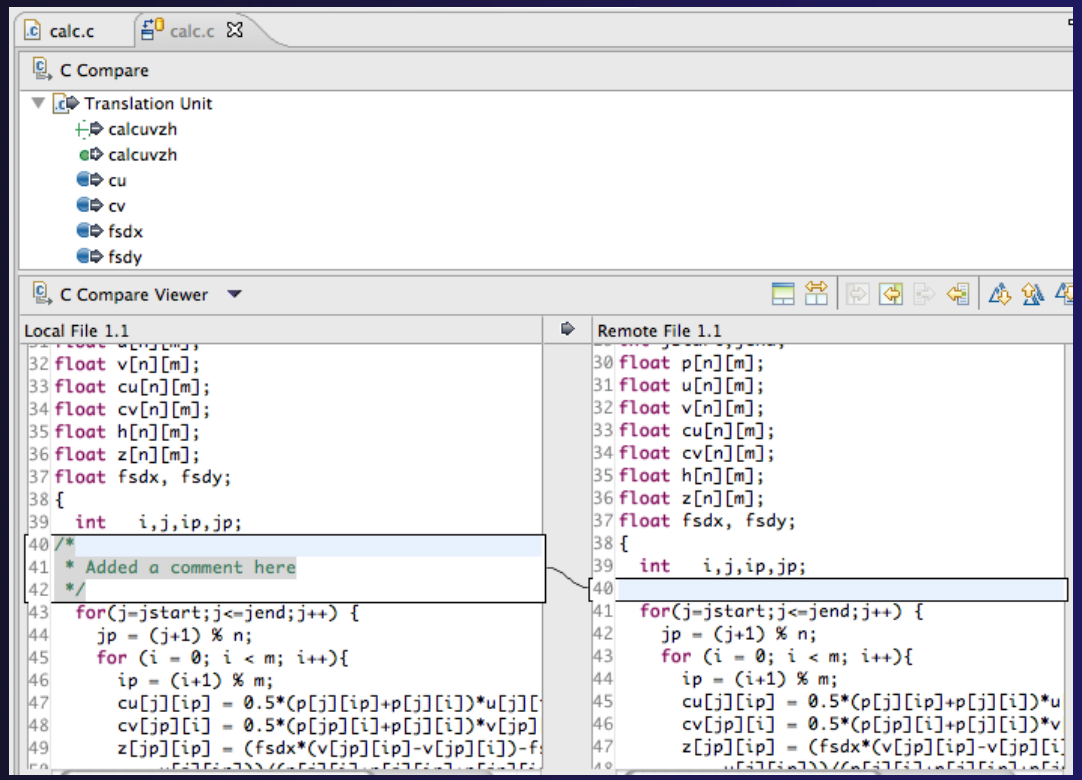
- Open “calc.c”
- Add comment at line 40
- Save file
- File will be marked to indicate that is has been modified

```
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     }
```



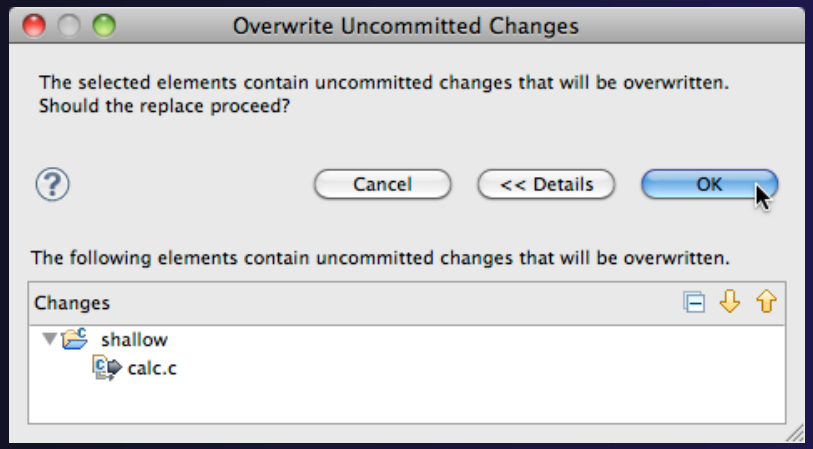
# View Changes

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



# Revert To The Latest Version

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



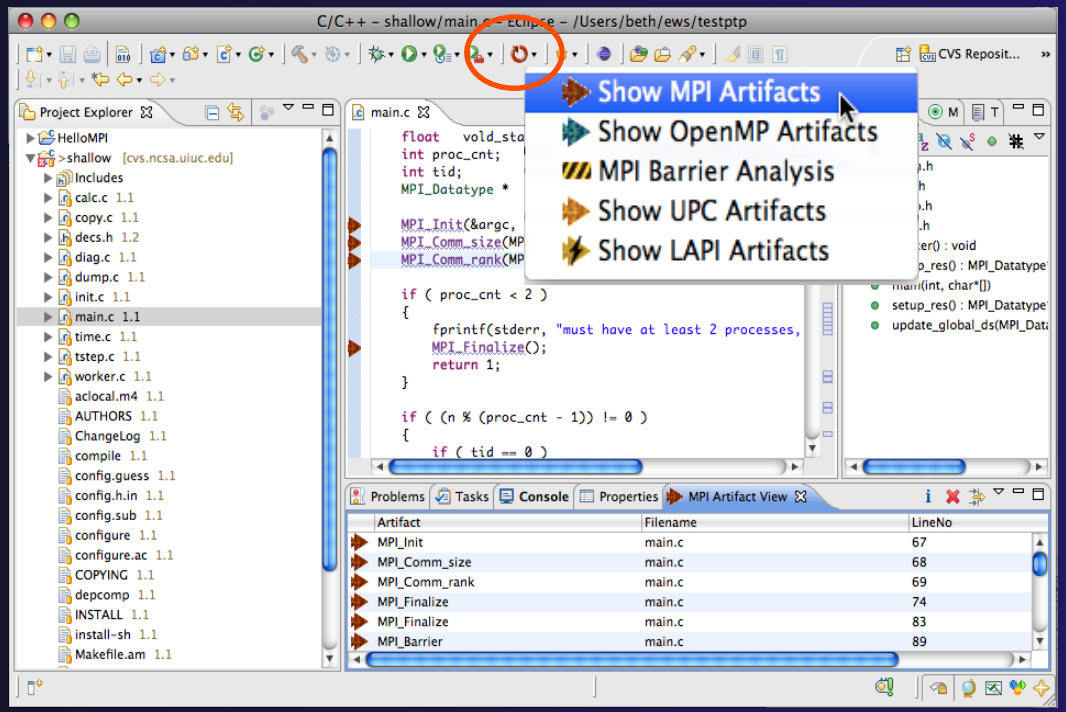
# MPI Features

# MPI-Specific Features

- PTP's Parallel Language Development Tools (PLDT) has several features specifically for developing MPI code
  - Show MPI Artifacts
  - Code completion
  - Context Sensitive Help for MPI
  - Hover Help
  - MPI Templates in the editor
  - MPI Barrier Analysis

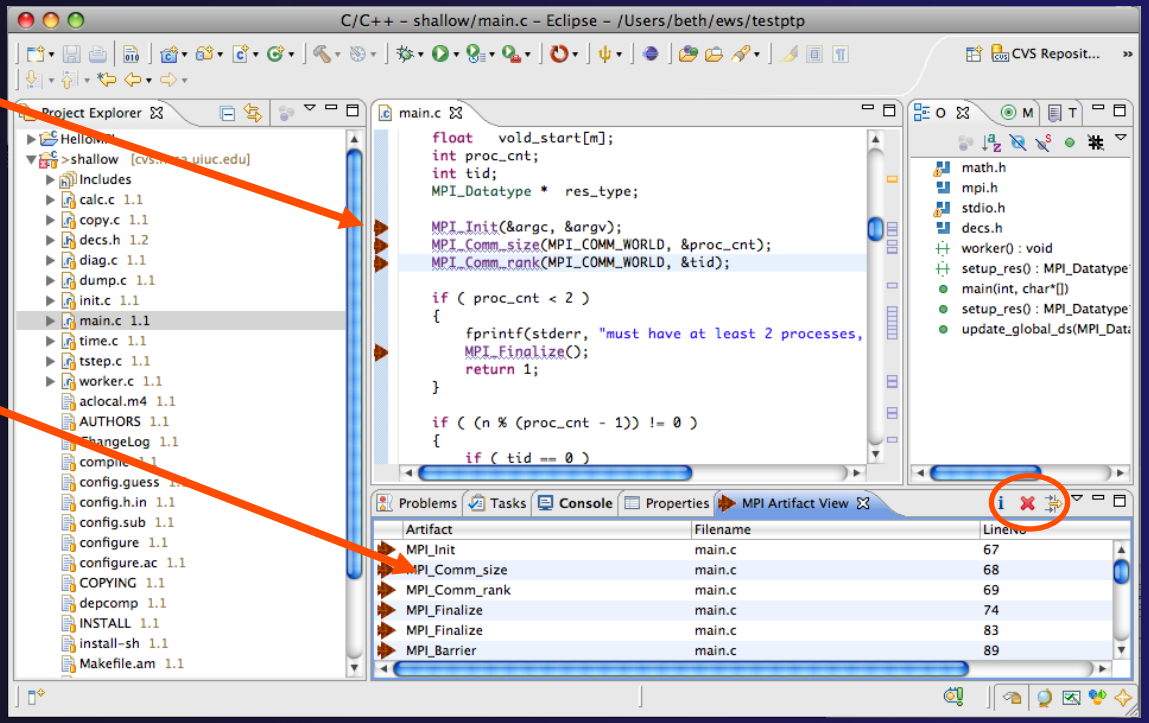
# Show MPI Artifacts

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

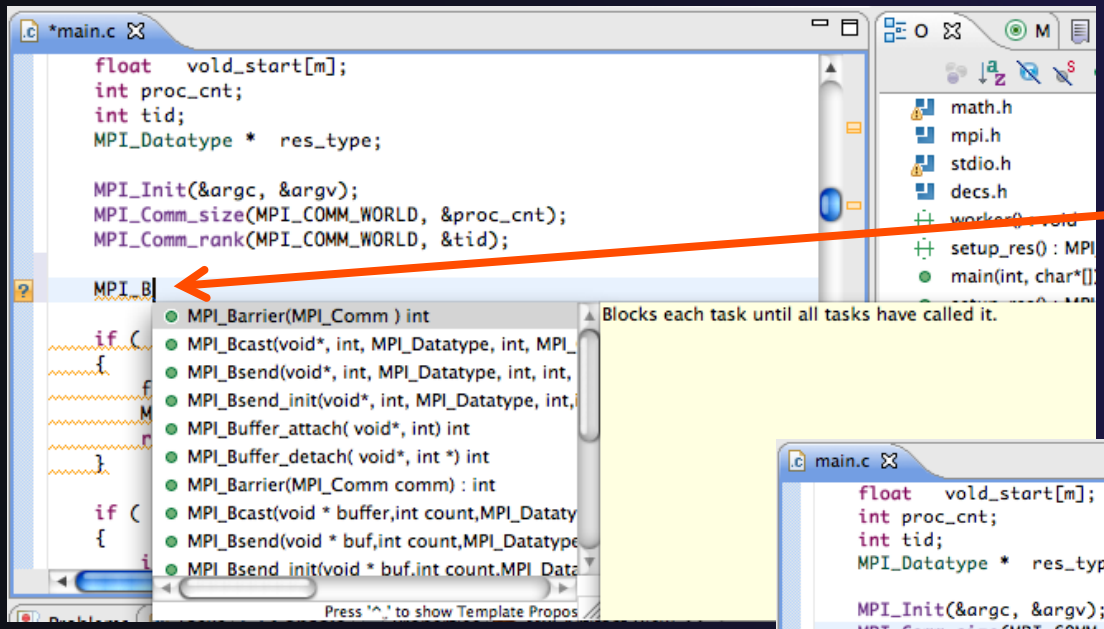


# MPI Artifact View

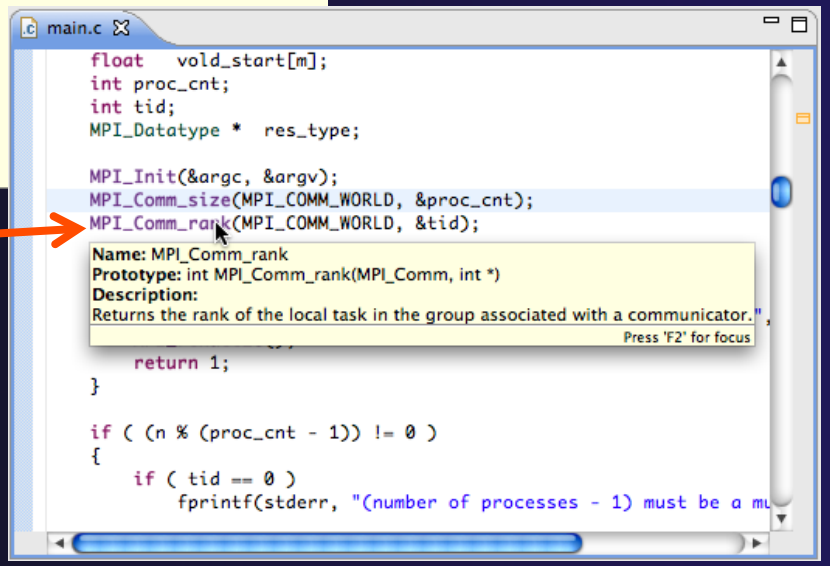
- Markers indicate the location of artifacts in editor
- The **MPI Artifact View** lists the type and location of each artifact
- Navigate to source code line by double-clicking on the artifact
- Run the analysis on another file (or entire project!) and its markers will be added to the view
- Click on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



# MPI Editor Features



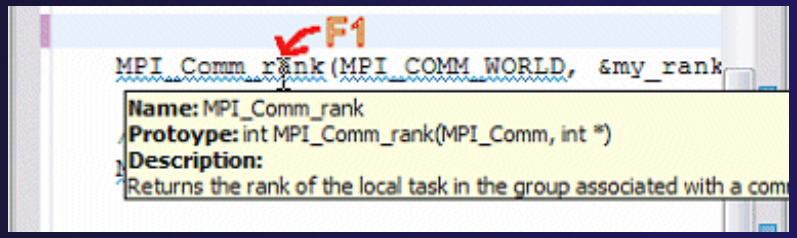

- Code completion will show all the possible MPI keyword completions
- Enter the start of a keyword then press <ctrl-space>

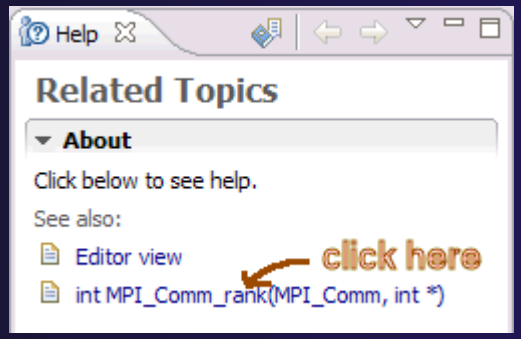



- Hover over MPI API
- Displays the function prototype and a description

# 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



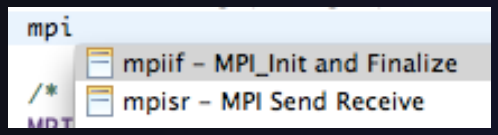




Some special info has been added for MPI APIs

# 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

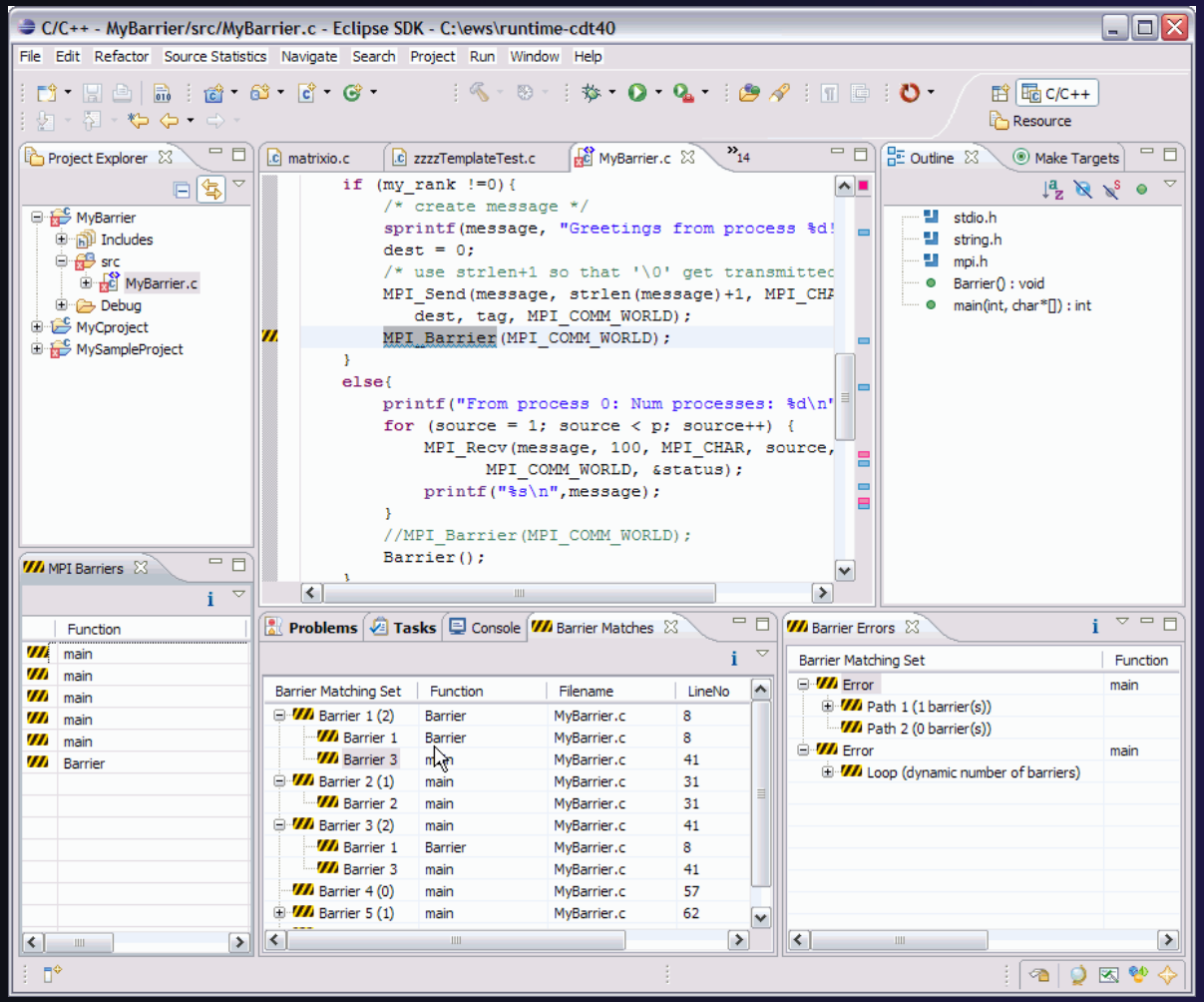



```
MPI_Comm_rank(MPI_COMM_WORLD, &rank);
MPI_Comm_size(MPI_COMM_WORLD, &p);
if (rank == 0){ //master task
        printf("Hello  From process 0: Num processes: %d\n",p);
        for (source = 1; source < p; source++) {
            MPI_Recv(message, 100, MPI_CHAR, source, tag,
                    MPI_COMM_WORLD, &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

*Local files only*




**Verify barrier synchronization in C/ MPI programs**

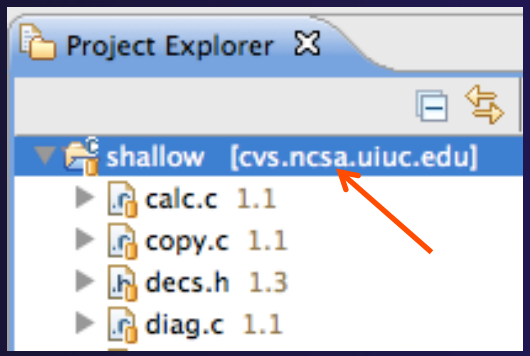
Interprocedural static analysis outputs:

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

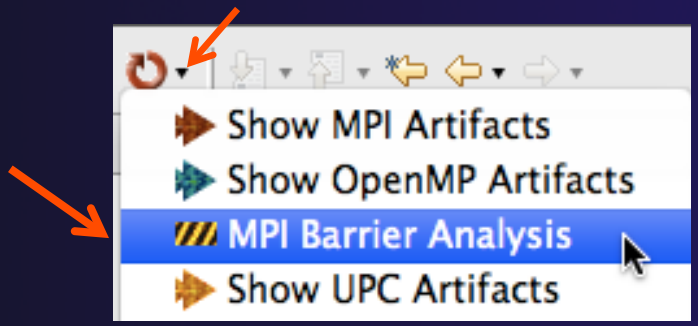
# MPI Barrier Analysis – Try it

Run the Analysis:

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

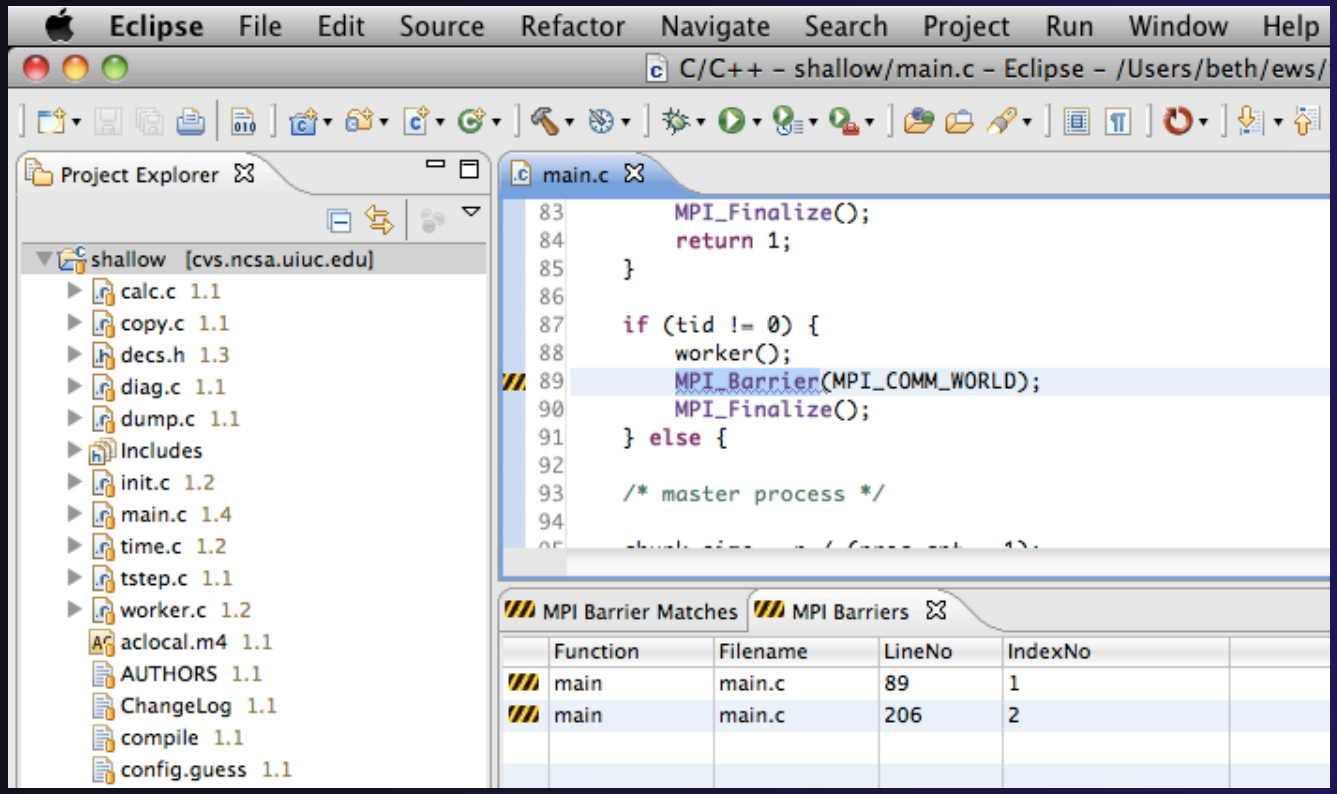



- Select the MPI Barrier Analysis action in the pull-down menu

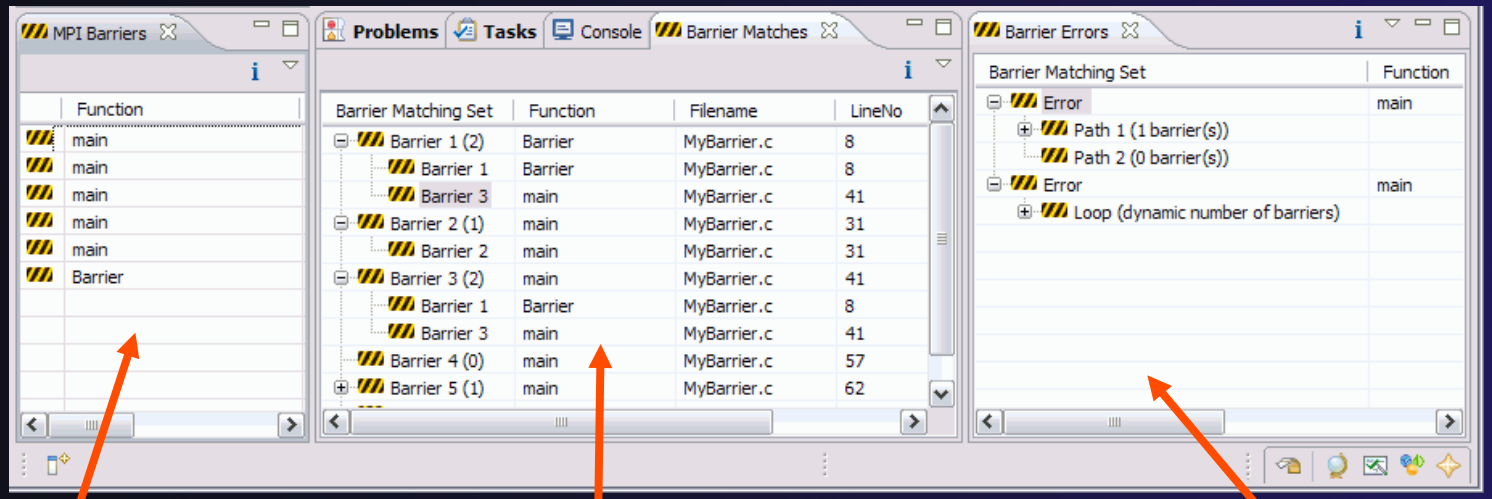


# MPI Barrier Analysis – Try It (2)

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



# MPI Barrier Analysis - views




## MPI Barriers view

Simply lists the barriers

Like MPI Artifacts view, double-click to navigate to source code line (all 3 views)

## Barrier Matches view

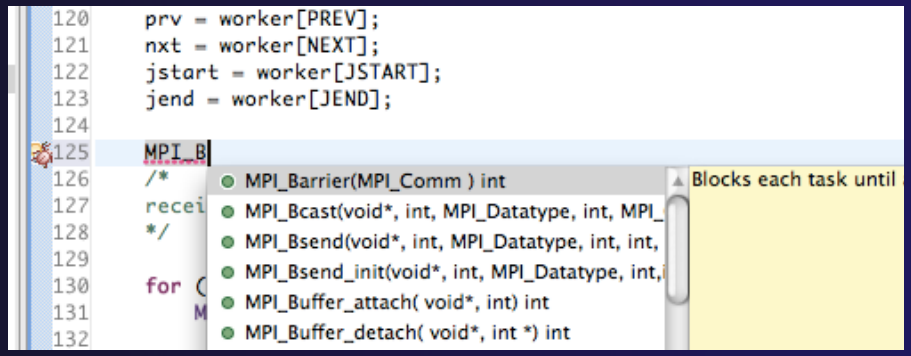
Groups barriers that match together in a barrier set – all processes must go through a barrier in the set to prevent a deadlock

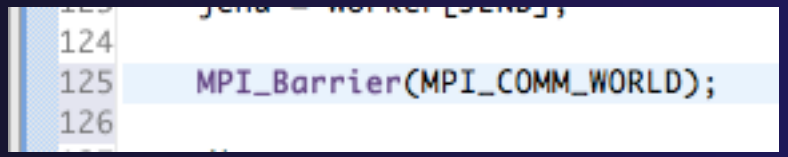
## Barrier Errors view

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

# 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

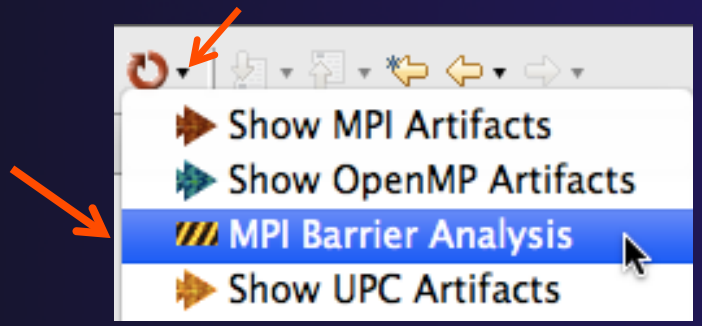


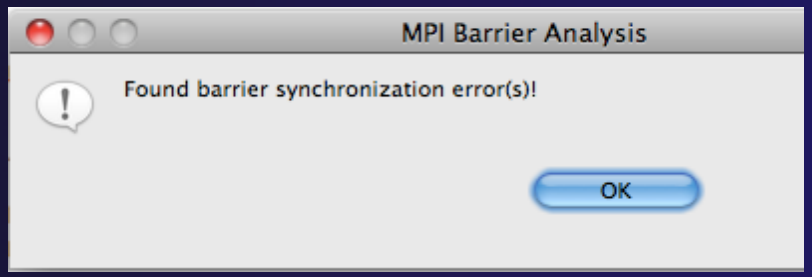
# Barrier Errors (2)

- 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

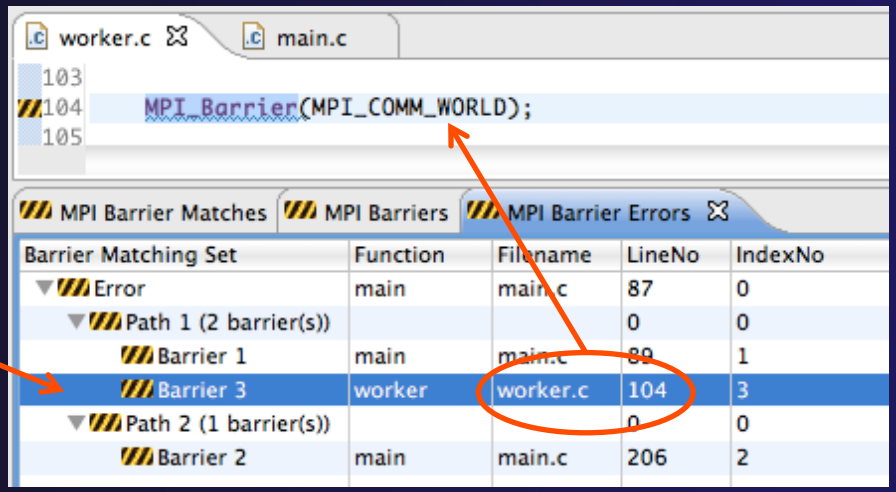
MPI Barrier Matches | MPI Barriers | MPI Barrier Errors

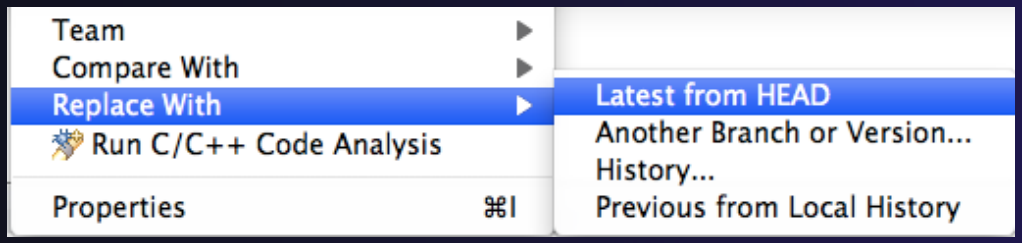
| Barrier Matching Set | Function | Filename | LineNo | IndexNo |
|---|---|---|---|---|
| Error | main | main.c | 87 | 0 |
| Path 1 (2 barrier(s)) | | | 0 | 0 |
| Barrier 1 | main | main.c | 89 | 1 |
| Barrier 3 | worker | worker.c | 125 | 3 |
| Path 2 (1 barrier(s)) | | | 0 | 0 |
| Barrier 2 | main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

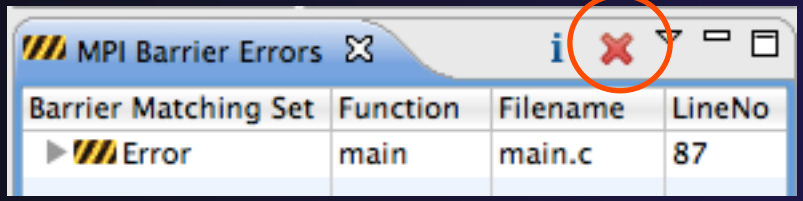
- Fix the Barrier Error before continuing
- Double-click on the barrier in worker.c to quickly navigate to it
- Remove the line and save the file
  -or-
  Right mouse on worker.c in Project Explorer and do **Replace With > Latest from HEAD**



# Remove Barrier Markers

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



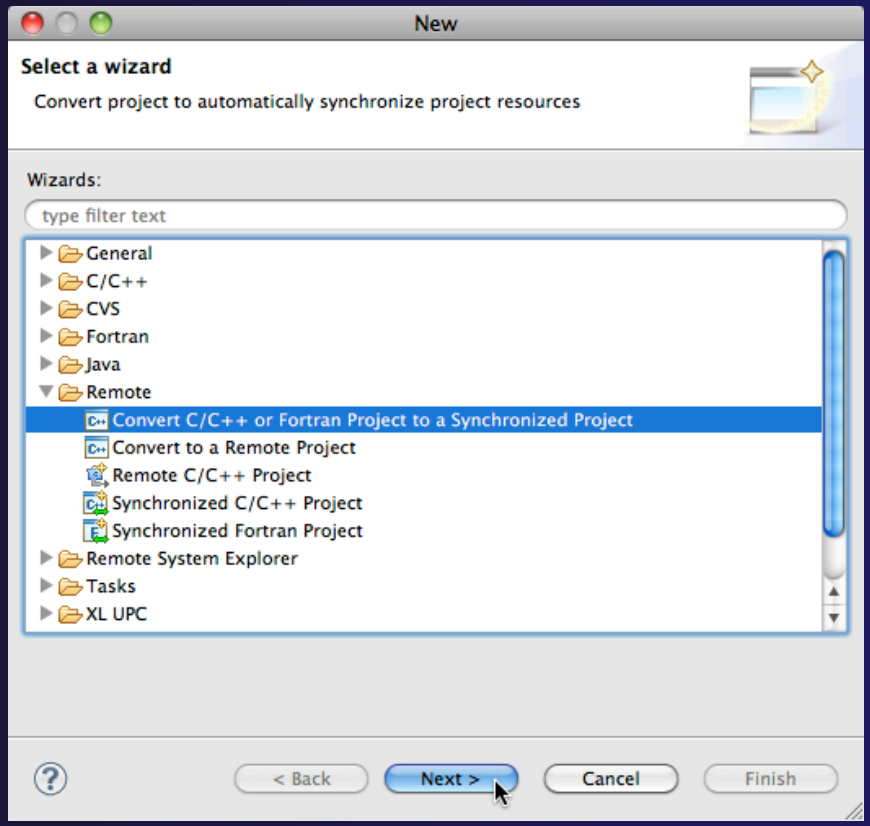
# Synchronizing the Project

# Synchronizing the Project

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

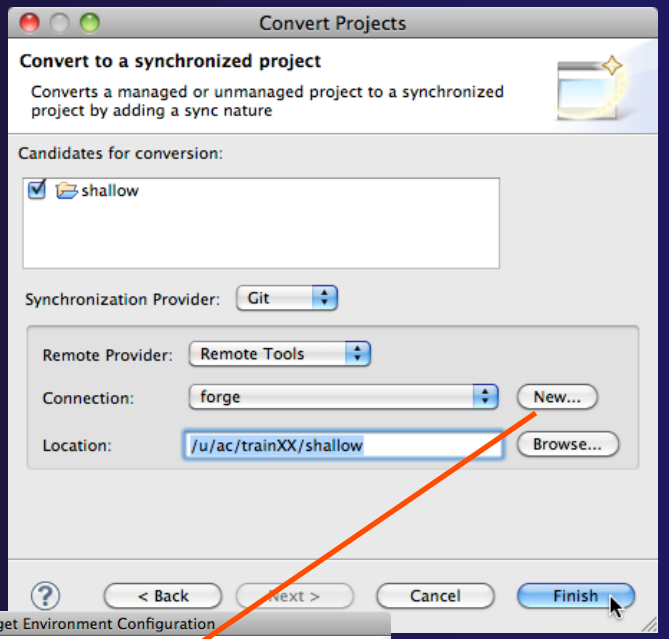
# Converting To Synchronized

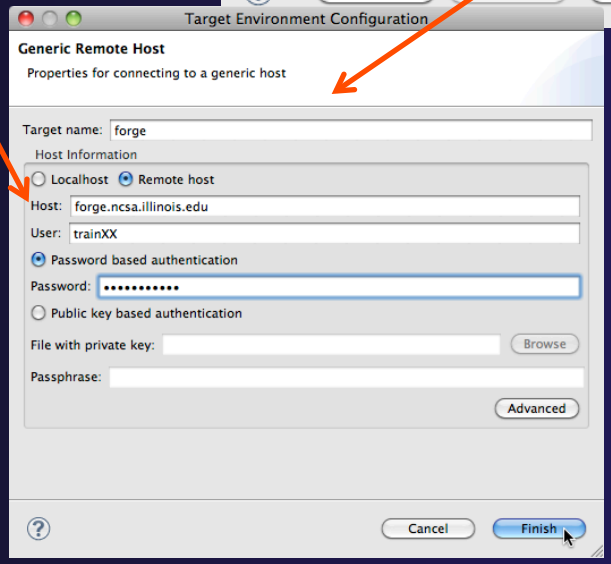
- Select **File>New>Other…**
- Open the Remote folder
- Select **Convert C/C++ or Fortran Project to a Synchronized Project**
- Click **Next>**



# Convert Projects Wizard

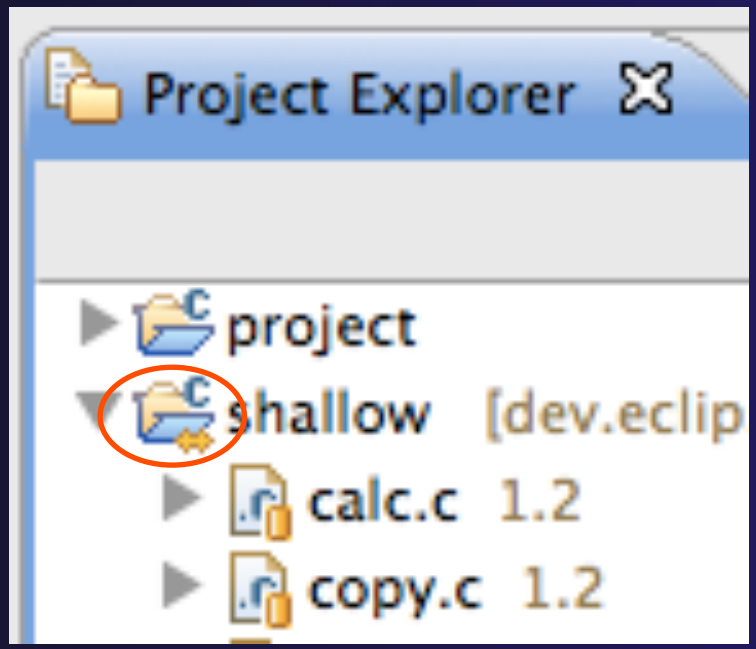
- Select checkbox next to “shallow”
- For **Connection:**, click on **New…** Enter as directed:
  - **Target name**
  - **Host** name of remote system
  - **User** id and **Password**
- Click **Finish** to close it
- Back in the **Convert Projects** dialog,
- Enter a directory name in the **Location**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



# Synchronized Project

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

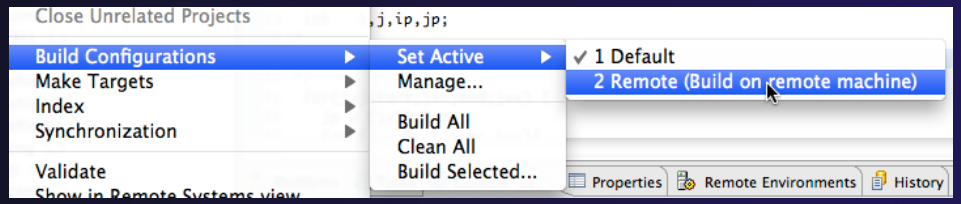



- Before sync

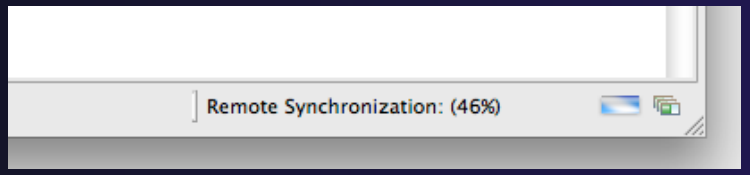

- After sync

# Set Active Build Configuration

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



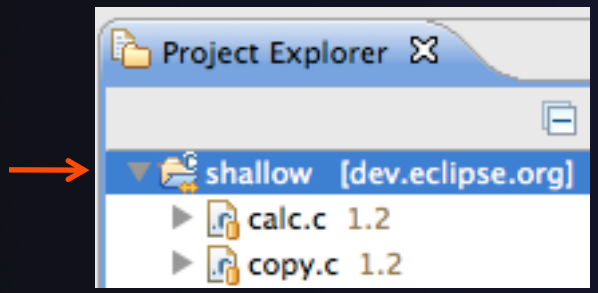

- The project should synchronize immediately

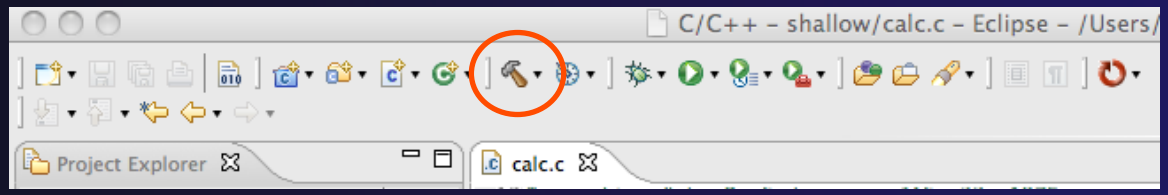


# Building the Project

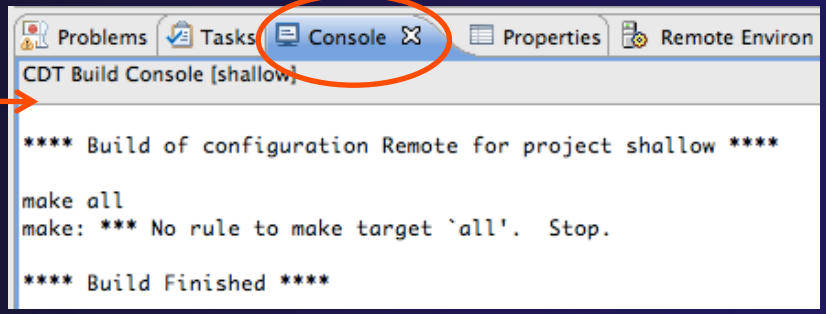
# Building the Project

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



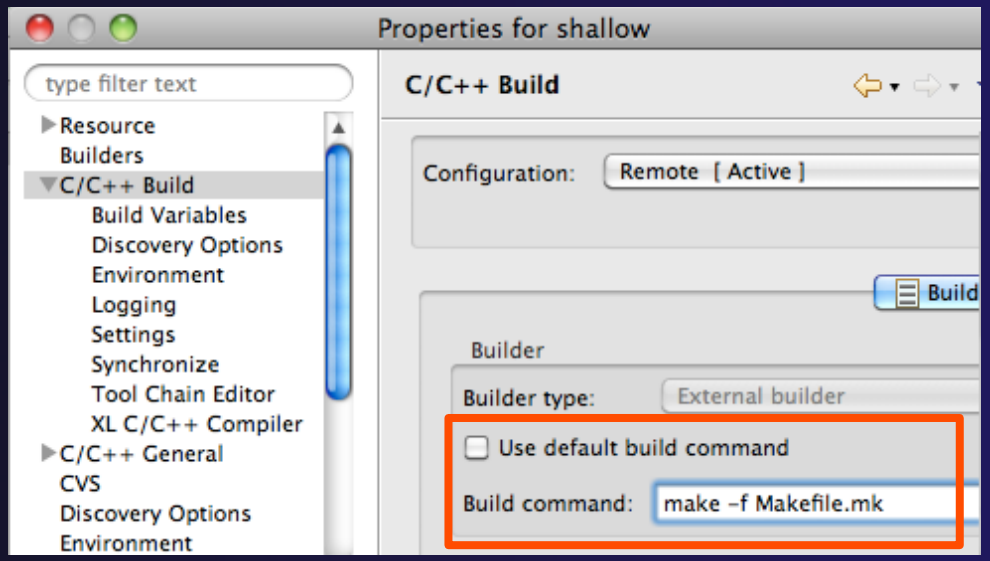




- By default, the Build Configuration assumes there is a Makefile (or makefile) for the project
- In this case, there is no Makefile, so the build will fail. See Console:
  - We'll see how to change it if the build command is different from 'make –f Makefile'



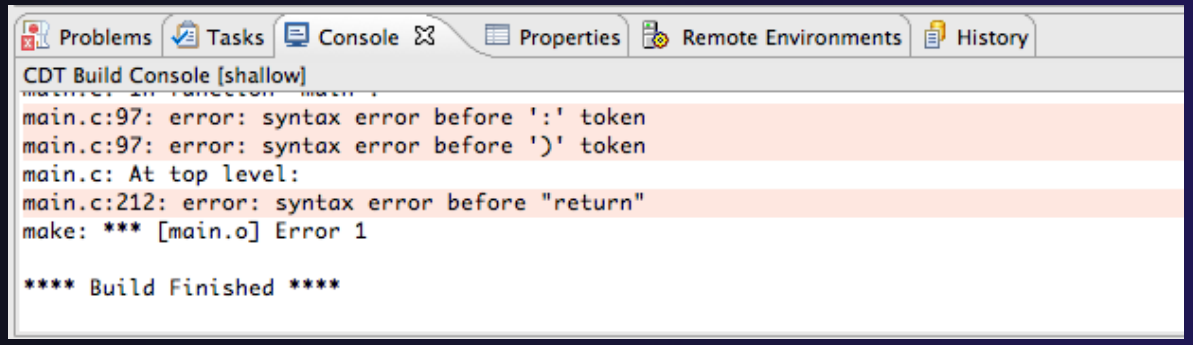
# Fixing the Build Command: Editing Project Properties

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



# Re-Building the Project

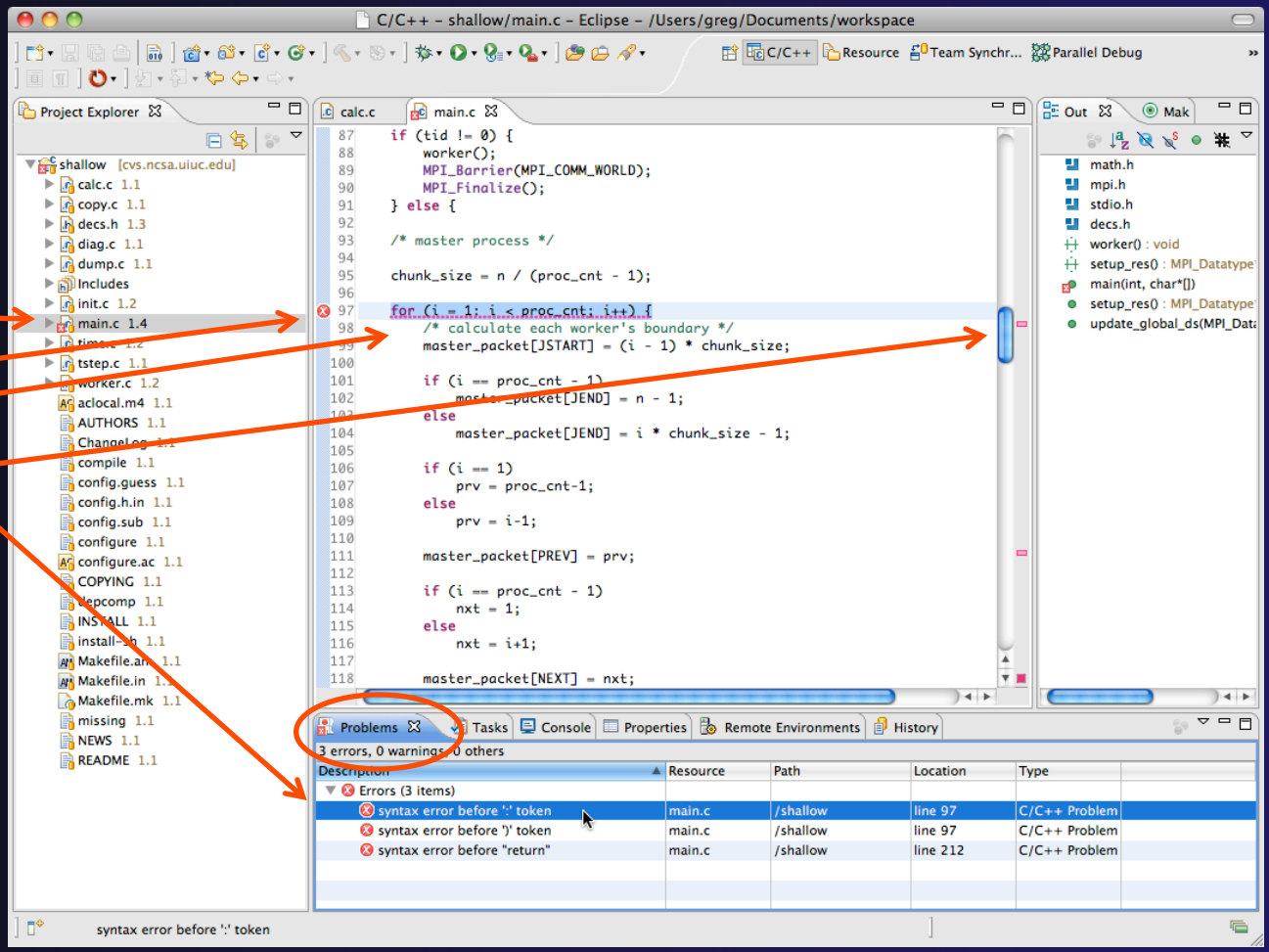
- Click on the  button again to run the build
- Build output will be shown in the **Console** view




- Exact output depends on your compiler

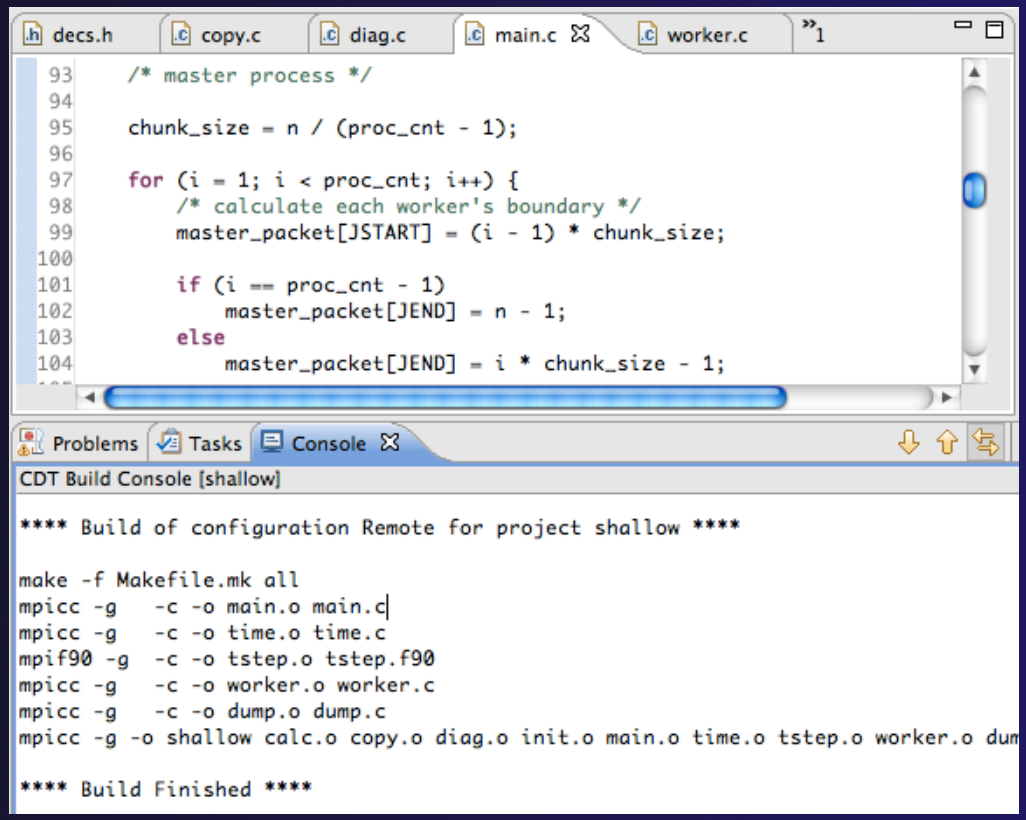
# Build Problems

- Build problems will be shown in a variety of ways
  - Marker on file
  - Marker on editor line
  - Line is highlighted
  - Marker on overview ruler
  - Listed in the **Problems view**
- Double-click on line in **Problems view** to go to location of error in the editor



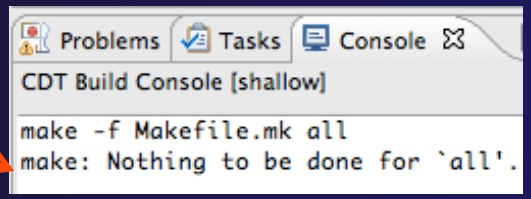
# Fix Build Problems

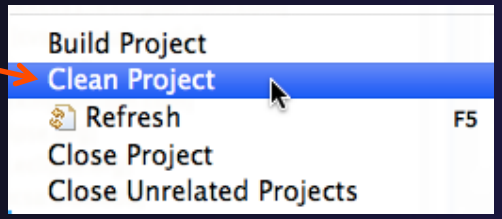
- Fix errors by changing ':' to ';' on line 97
- Save the file
- Rebuild by pressing build button 
- Error markers have been removed
- Check console for correct build output

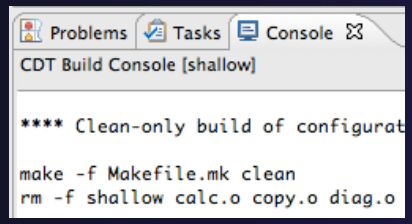


# Forcing a Rebuild

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



# Running the Program

# Resource Managers

# Running the Program

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

Do this once

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

# Resource Managers

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

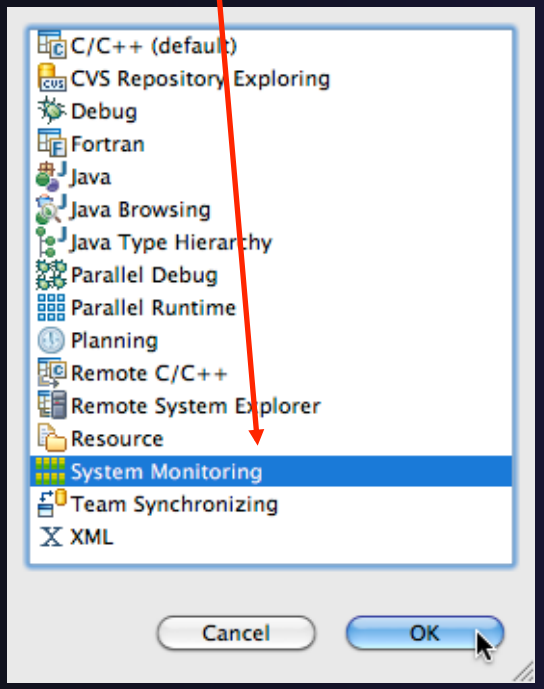
# Monitoring/Runtime Perspectives

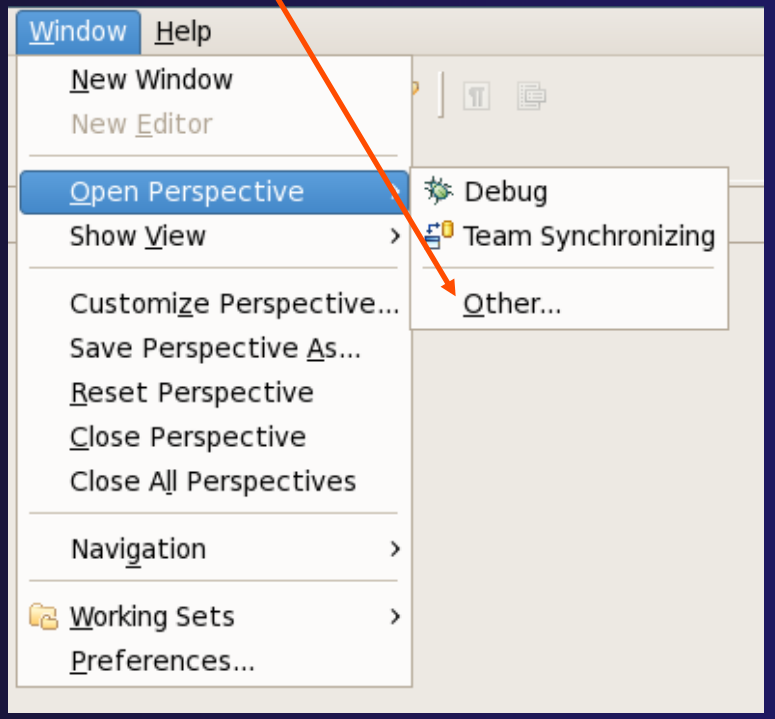
- Parallel Runtime Perspective
  - Used for legacy PTP Resource Managers
- System Monitoring Perspective
  - Used for newer Configurable Resource Managers (since PTP 5.0)
- Which one is used?

| Resource Manager | System Monitoring | Parallel Runtime |
|---|---|---|
| IBM LoadLeveler | | ✔ |
| IBM Parallel Env | | ✔ |
| MPICH2 | | ✔ |
| Open MPI | | ✔ |
| PBS-Batch-Generic | ✔ | |
| PBS-Batch-Interactive | ✔ | |
| Remote Launch | | ✔ |
| SLURM | | ✔ |

# Preparing to Launch

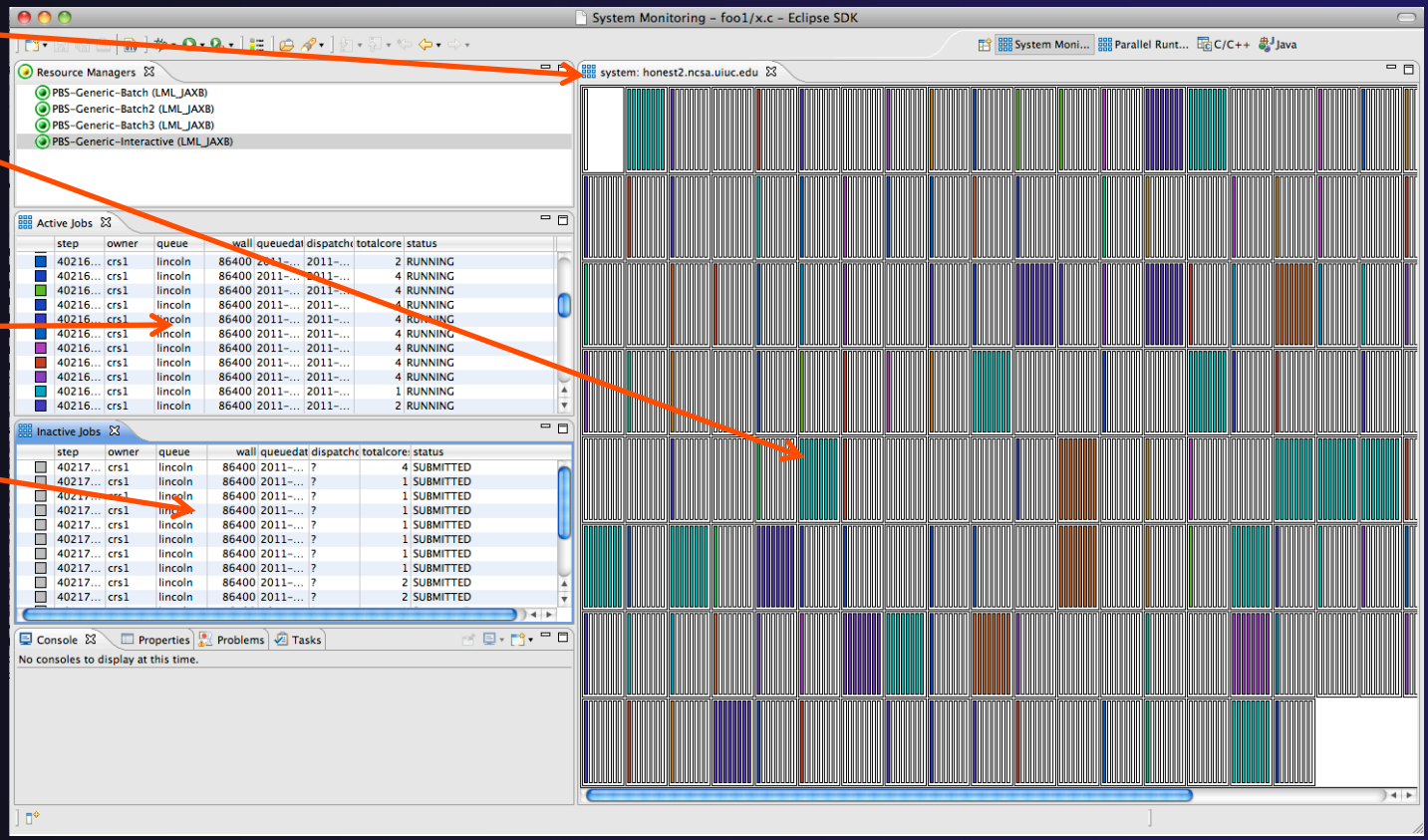
- Setting up a resource manager is done in the System Monitoring perspective
  - (For PTP 5.0, this applies to PBS)
- Select **Window>Open Perspective>Other...**
- Choose **System Monitoring** and click **OK**



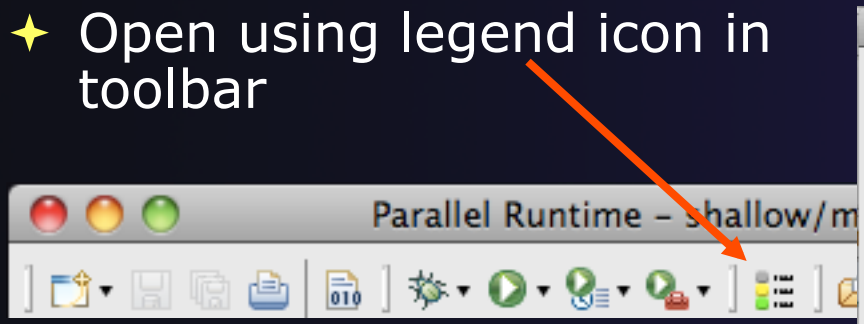
# System Monitoring Perspective

- System view
- Jobs running on system
- Active jobs
- Inactive jobs



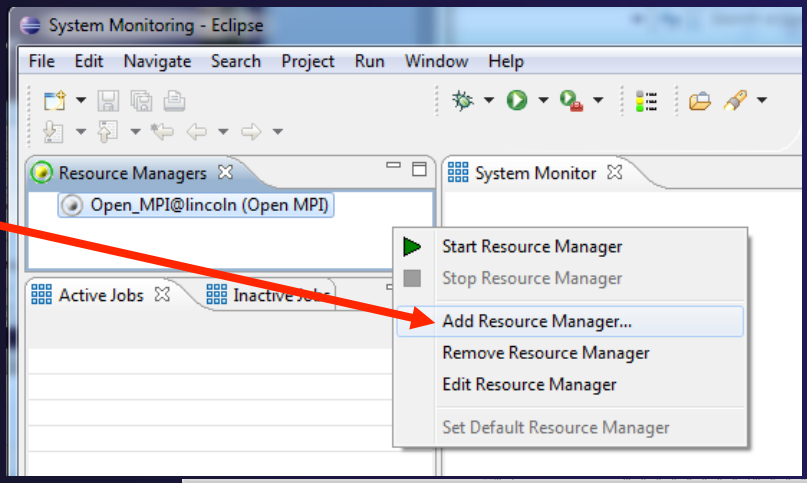
# About PTP Icons

- Open using legend icon in toolbar



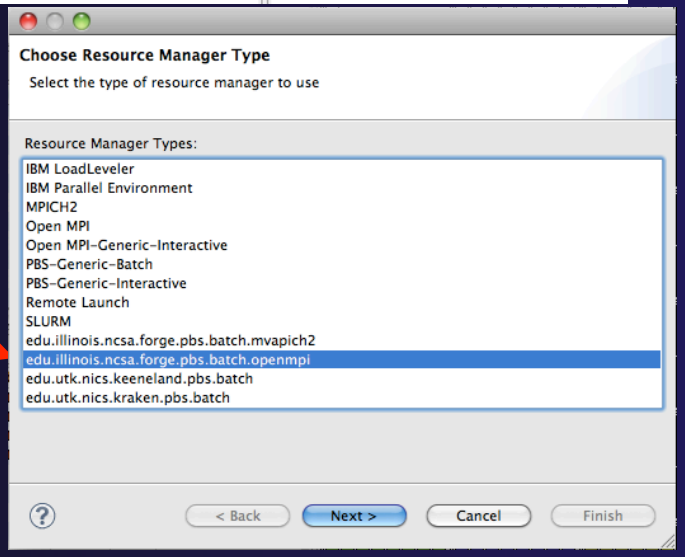

# Configuring Job Scheduler

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




Do this once

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

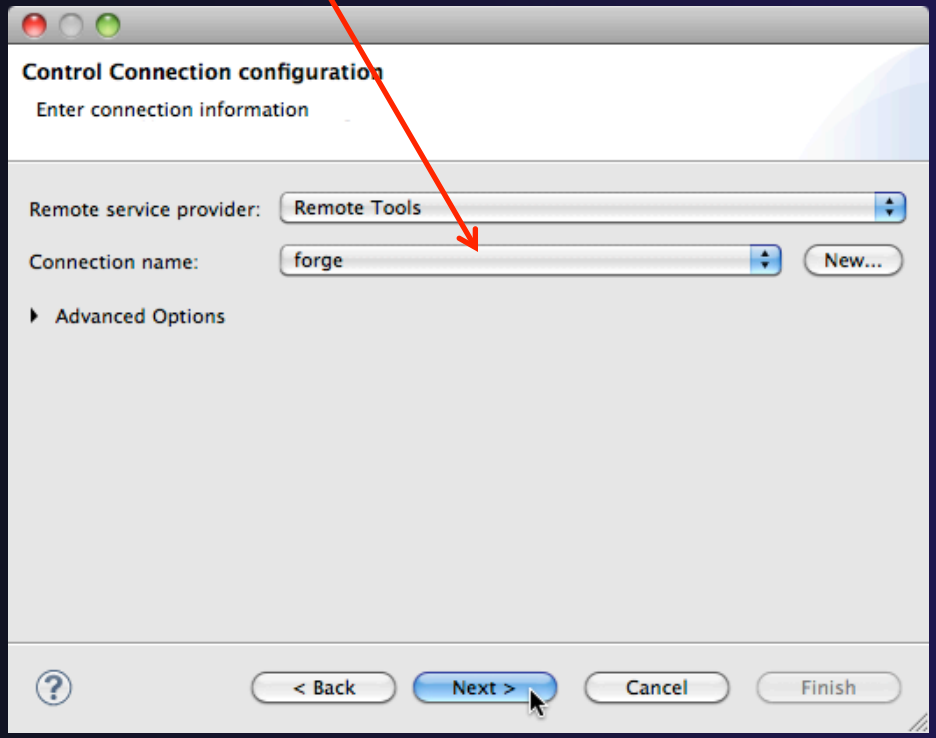



- Select **Next>**

# Configure Control Connection

Do this once

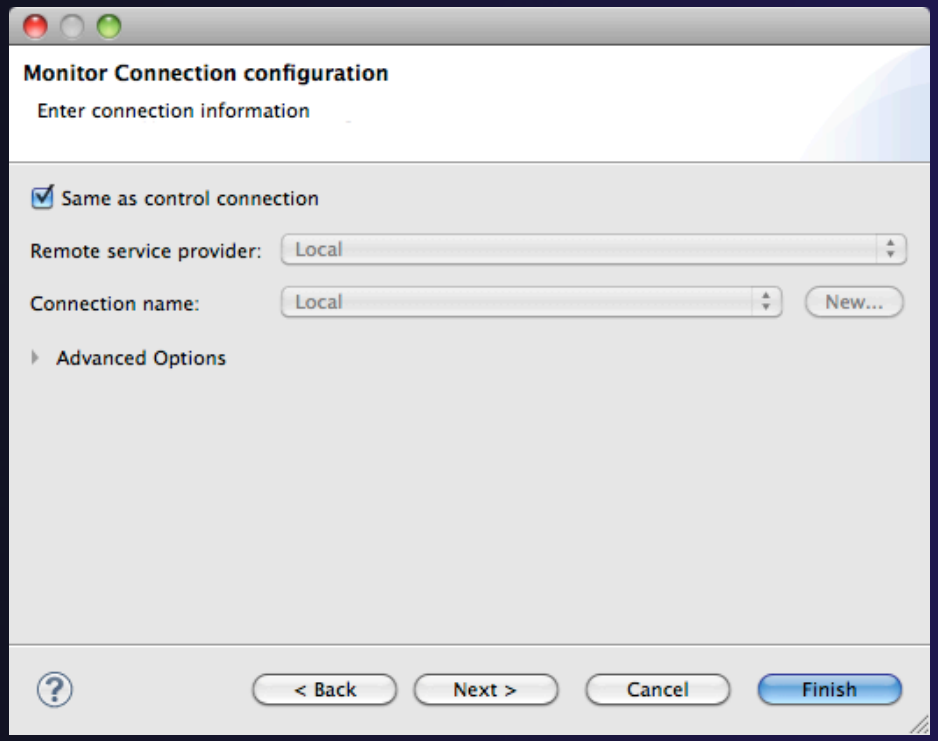
- Choose **Remote Tools** for **Remote service provider**
- Choose the remote connection you made previously
- Click **Next>**



# Configure Monitor Connection

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

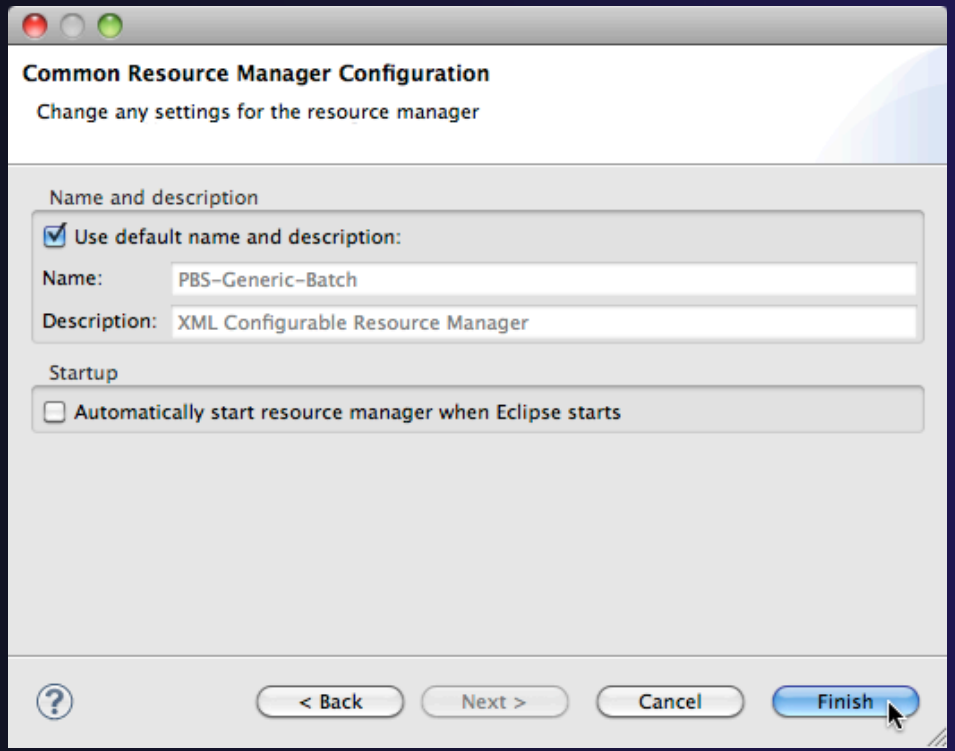
Do this once



# Common Configuration

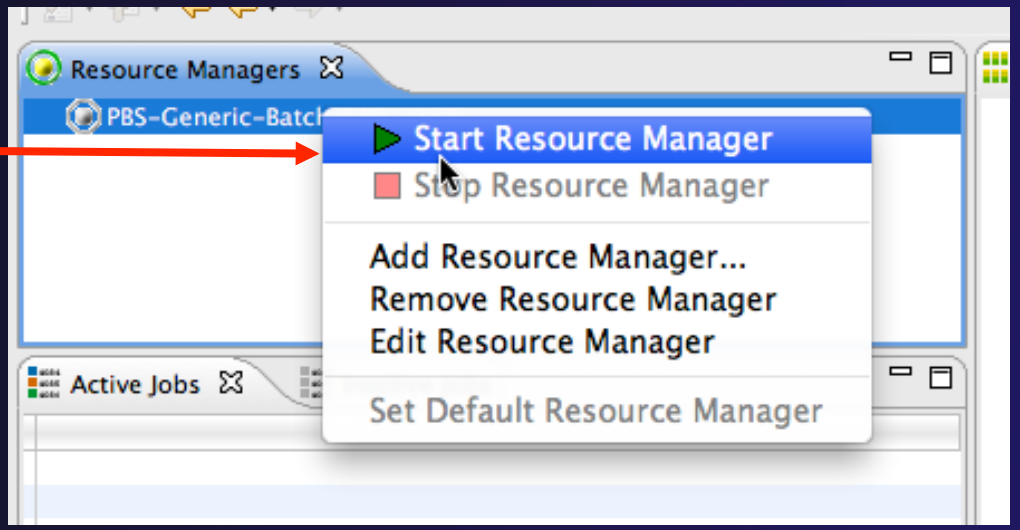
- Keep default name
- Can automatically start Resource Manager (leave unselected today)
- Click **Finish**

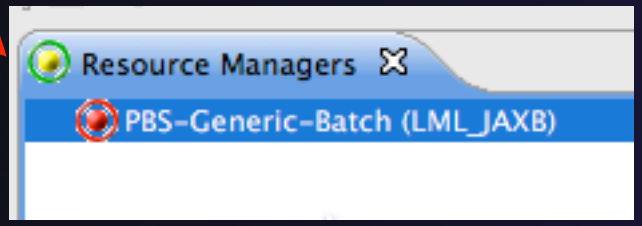
Do this once

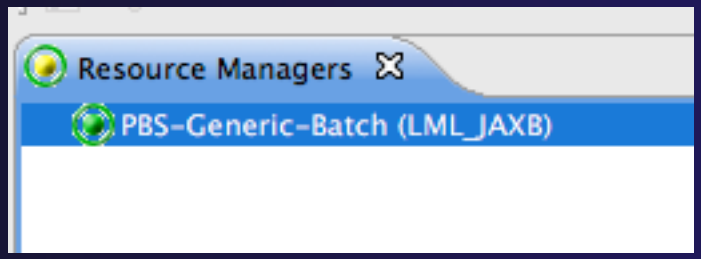


# Starting the Resource Manager

- Right click on new resource manager and select **Start resource manager**
- If everything is ok, you should see the resource manager change to green
- If something goes wrong, it will change to red



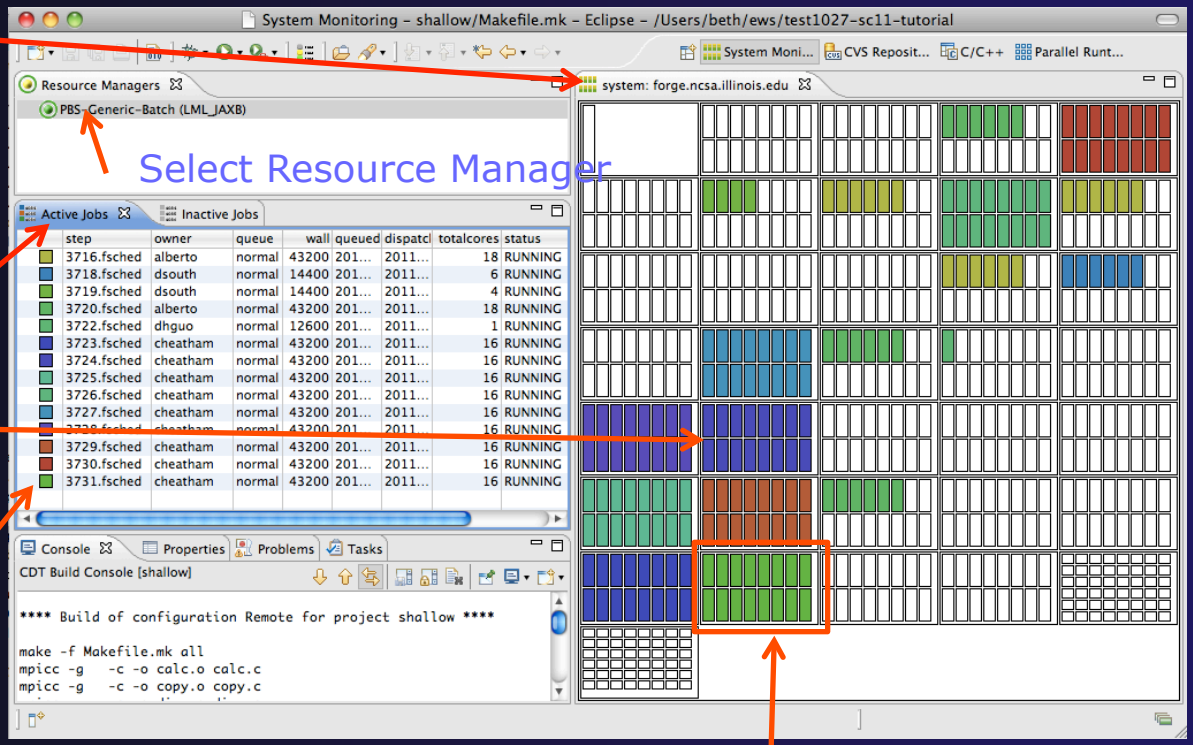



# System Monitoring

forge.ncsa.illinois.edu

- **System** view, with abstraction of nodes for selected Resource Manager
- Active and inactive jobs
- Hover over node in **System** view to see job running on node in **Active Jobs** view
- Hold mouse button down on a job in **Active Jobs** view to see where it is running in **System** view



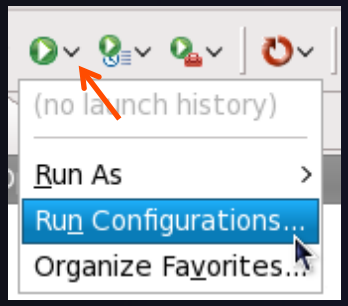

One node with 16 cores

# Running the Program

# (Launching a Job)

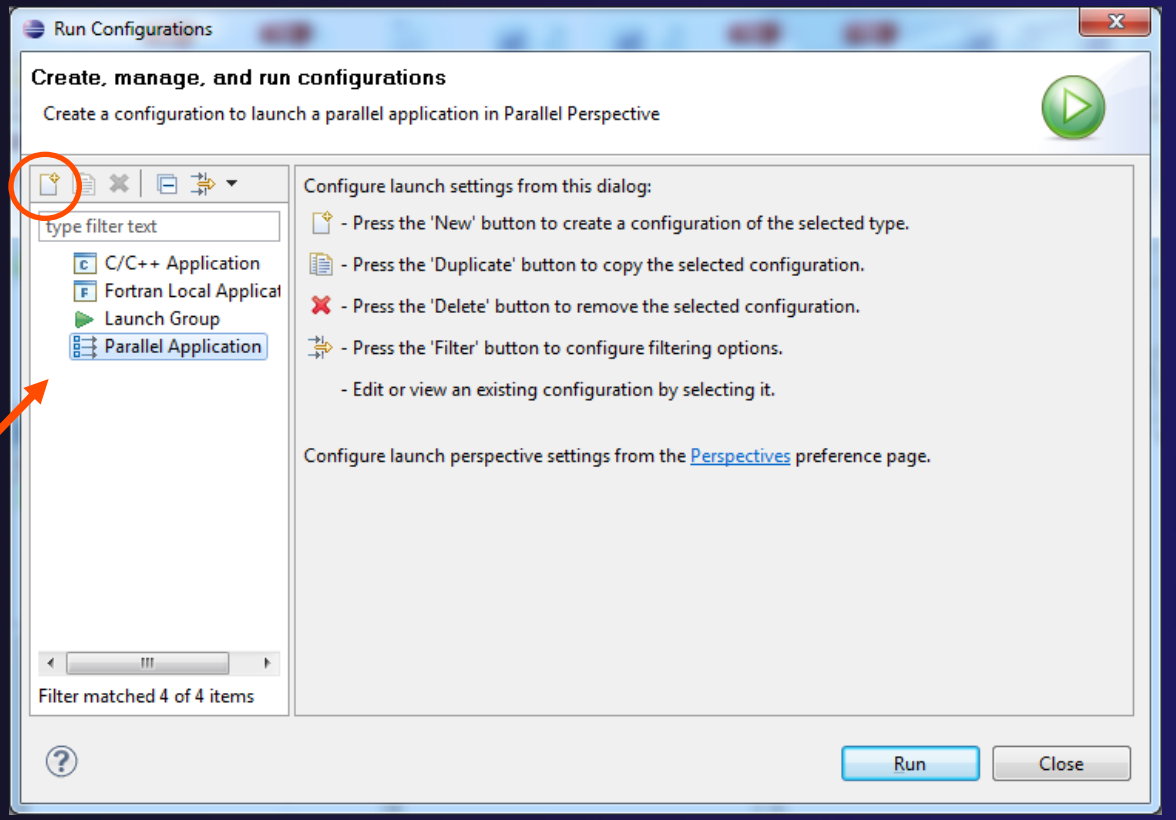
# Create a Run Configuration


Do this once




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

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



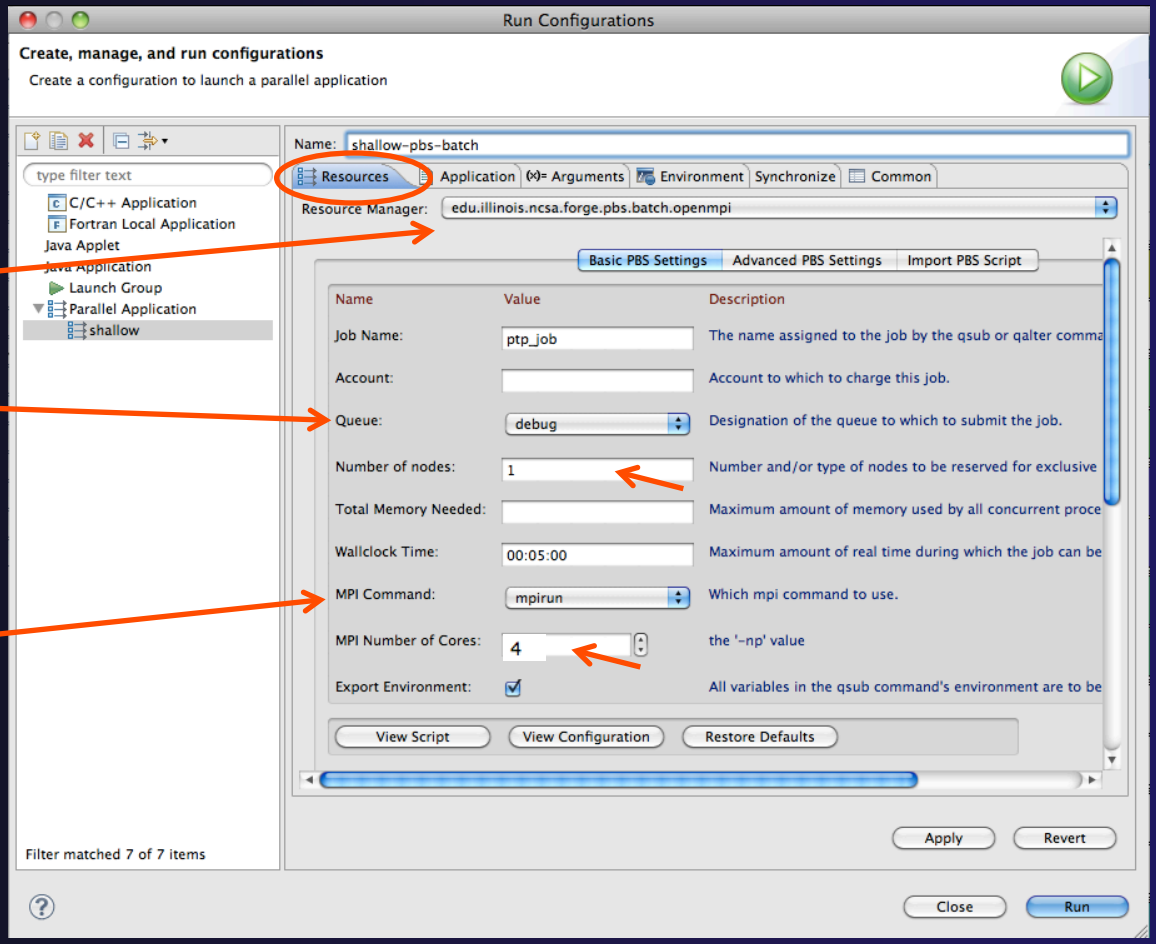

Depending on which flavor of Eclipse you installed, you might have more choices in Application types

*Note: we sometimes interchange the terms "Run Configuration" and "Launch Configuration"*

# Complete the Resources Tab


Do this once

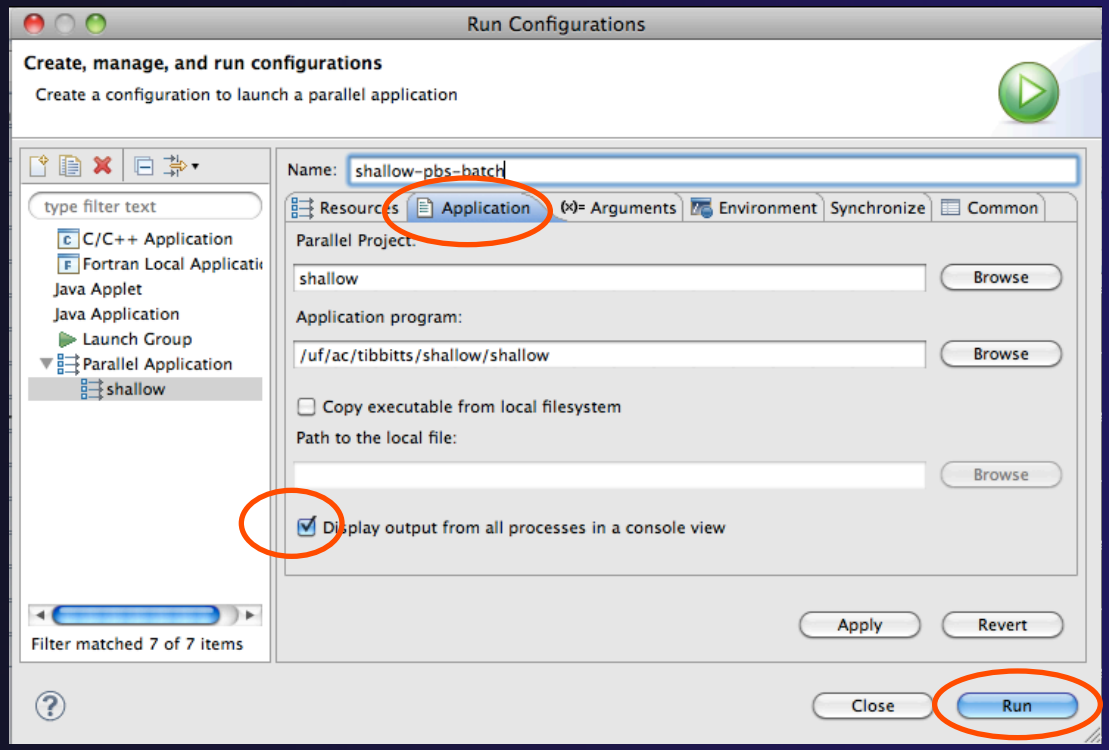
- Enter a name for this run configuration, e.g. “shallow-pbs-batch”
- In **Resources** tab, select the PBS resource manager you just created (edu.illinois.ncsa.forge….)
- Select the destination queue – **debug**
- The **MPI Command** field allows this job to be run as an MPI job
  - Choose **mpirun**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



# Complete the Application Tab

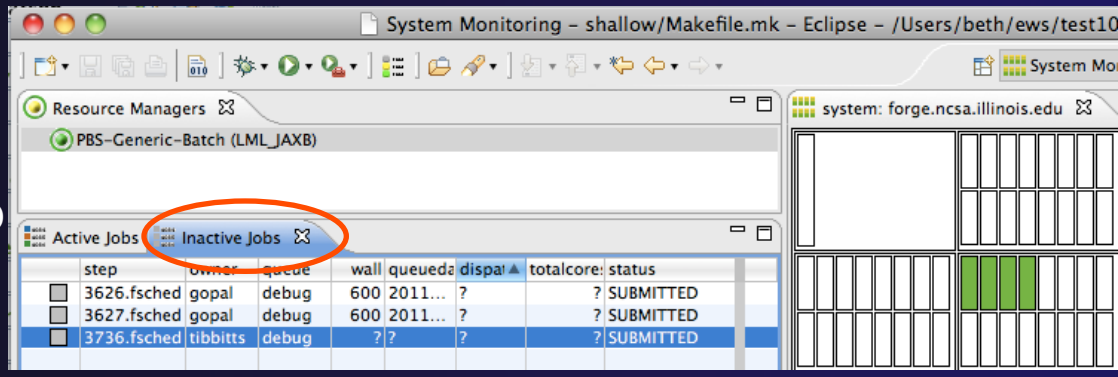
Do this once

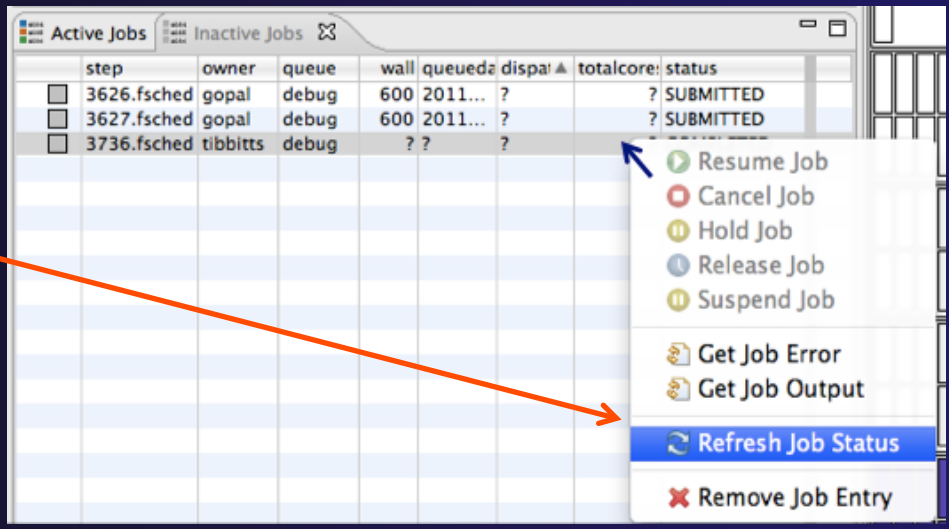
- Select the **Application** tab
- Choose the **Application program** by clicking the **Browse** button and locating the executable on the remote machine
  - Use the same “shallow” executable
- Select **Display output from all processes in a console view**
- Click **Run** to submit the application to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



# Job Monitoring

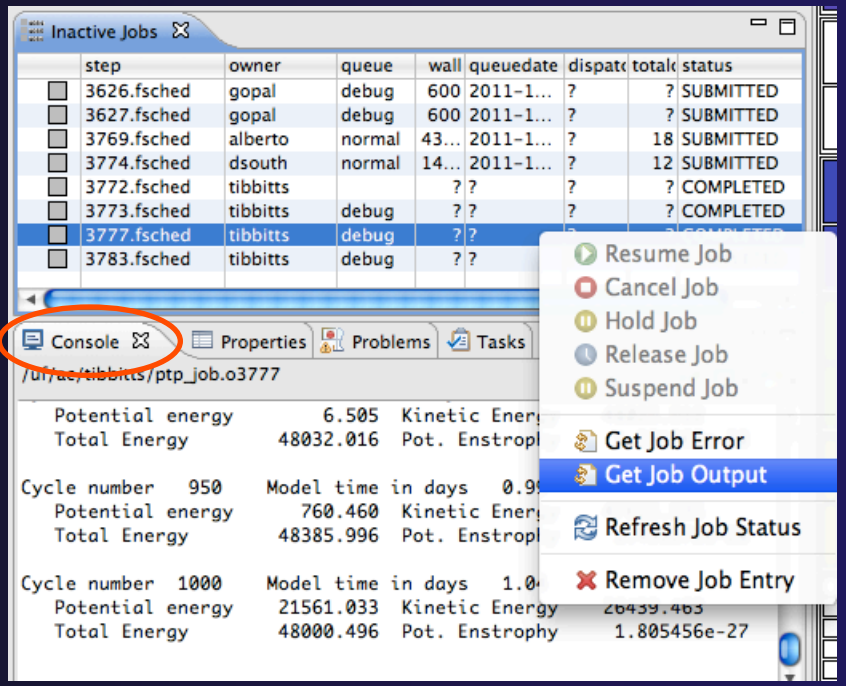
- Job initially appears in “Inactive Jobs”, then in “Active Jobs”, then returns to Inactive on completion
- This short-running program may not run long enough to appear in “Active Jobs”
- Status refreshes automatically every 60 sec Or force refresh with menu
- After status = COMPLETED, Can view output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



# Job Output

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

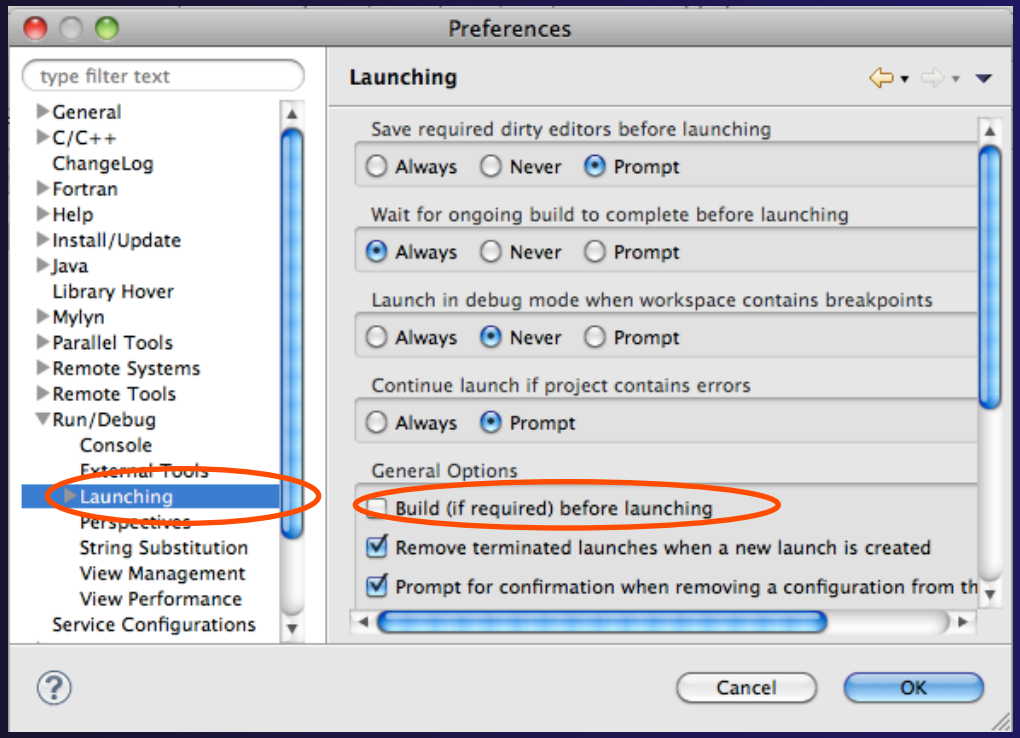


# Building before Run

Do this once

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

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



# Exercise

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

# Advanced Features

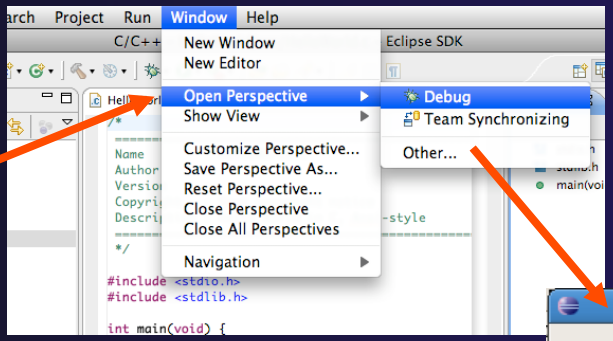
Searching
Fortran
Refactoring

# Searching

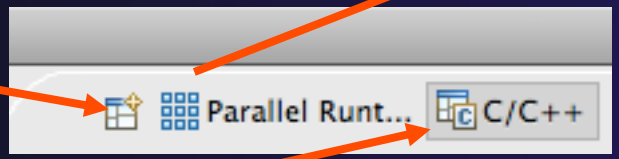
# Switching Perspectives

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

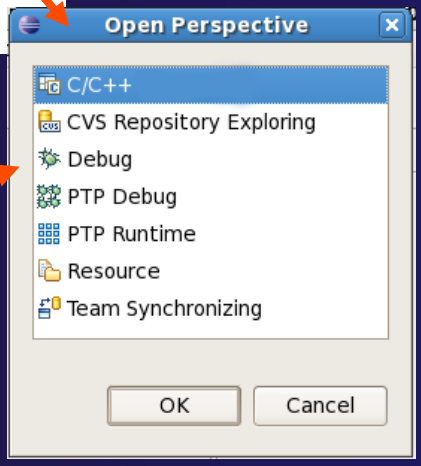
1. Choose the **Window>Open Perspective** menu option Then choose **Other...**




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

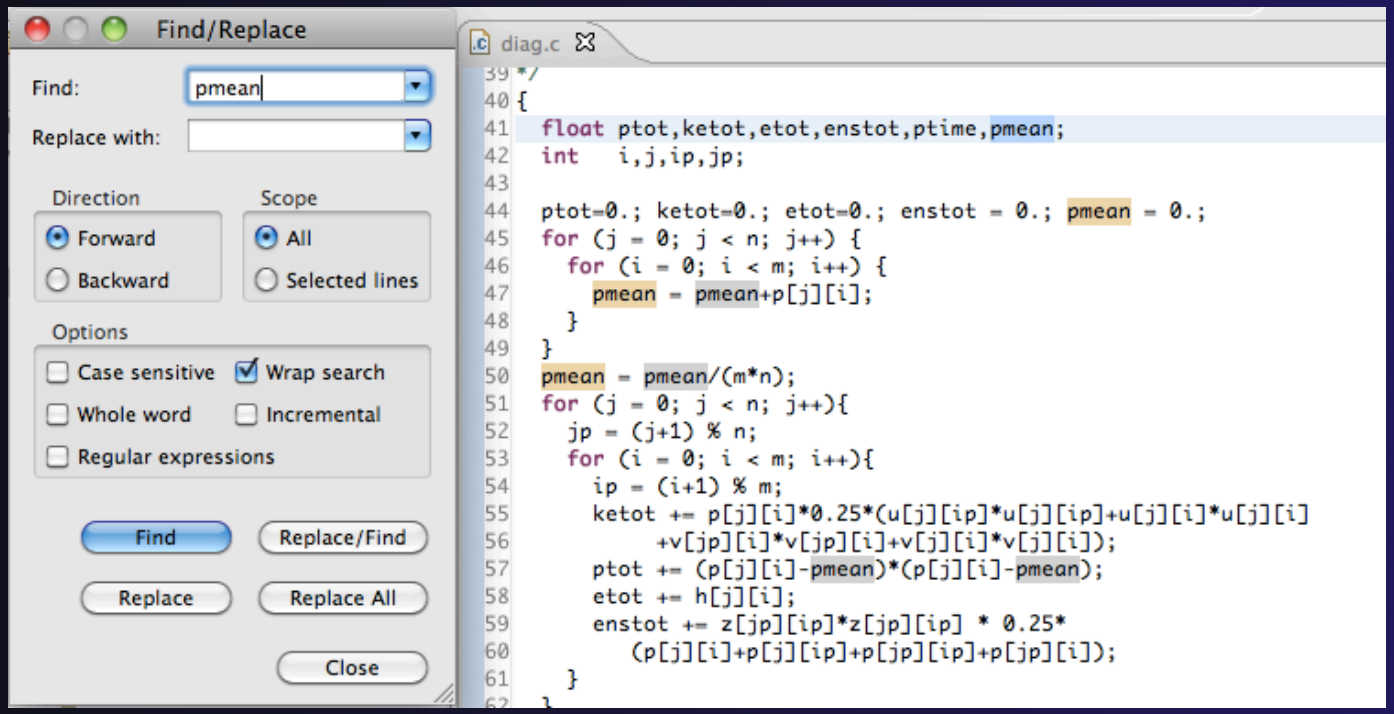



3. Click on a perspective shortcut button



# Find/Replace within Editor

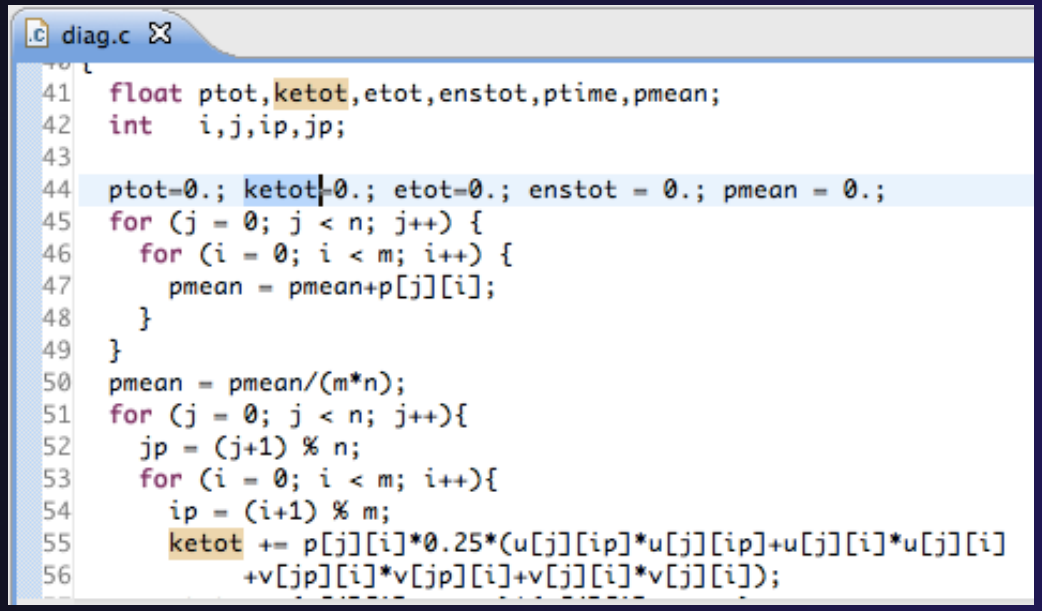
- Simple Find within editor buffer
- Ctrl-F (Mac: Command-F)



# Mark Occurrences

(C/C++ Only)

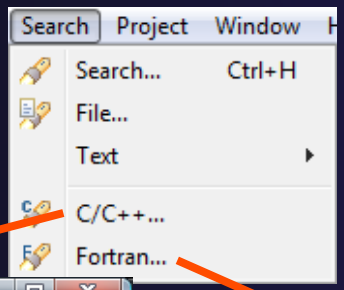
- Double-click on a variable in the CDT editor
- All occurrences in the source file are highlighted to make locating the variable easier
- Alt-shift-O to turn off (Mac: Alt-Cmd-O)



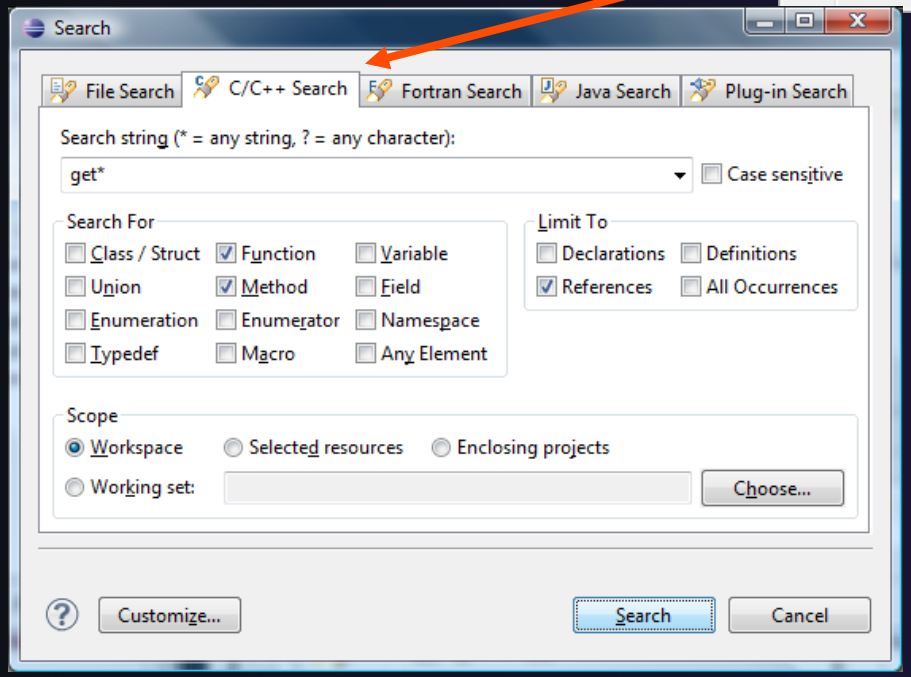
# Language-Based Searching

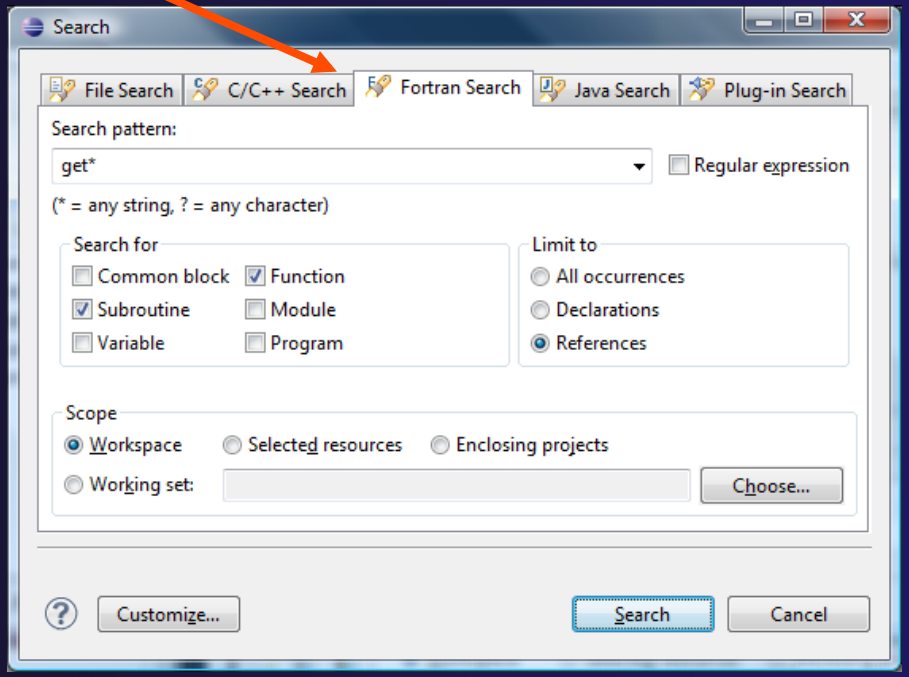
(C/C++ and Fortran)

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




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

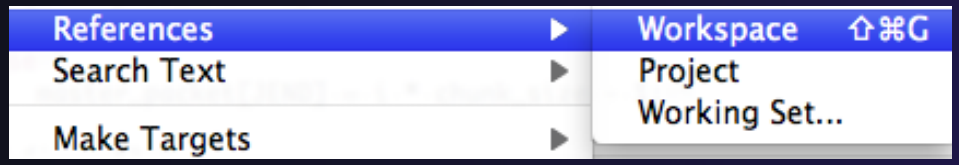


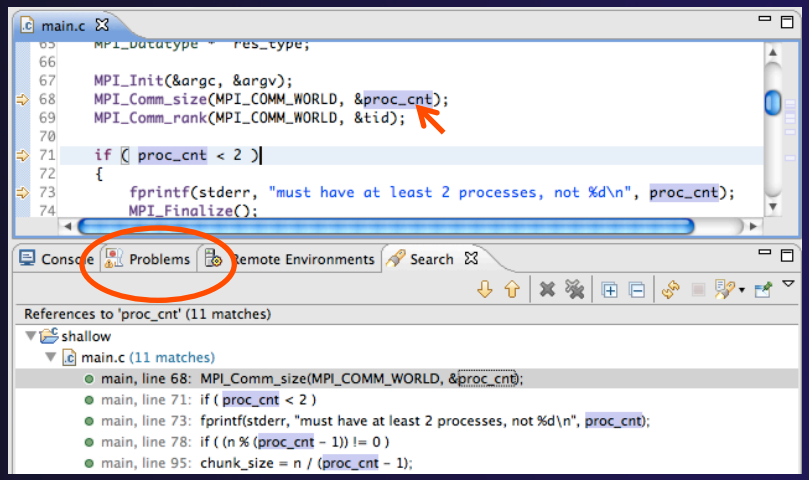
# Find References

(C/C++ and Fortran)

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



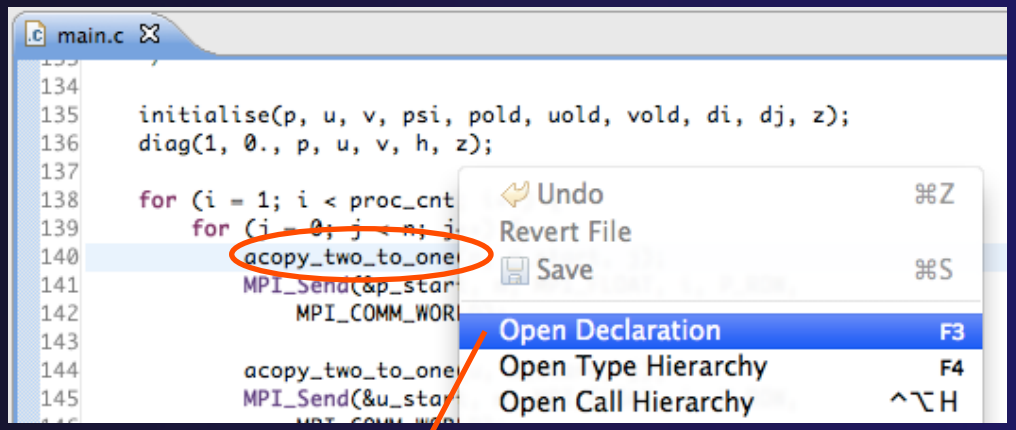

  - **Search** view shows matches



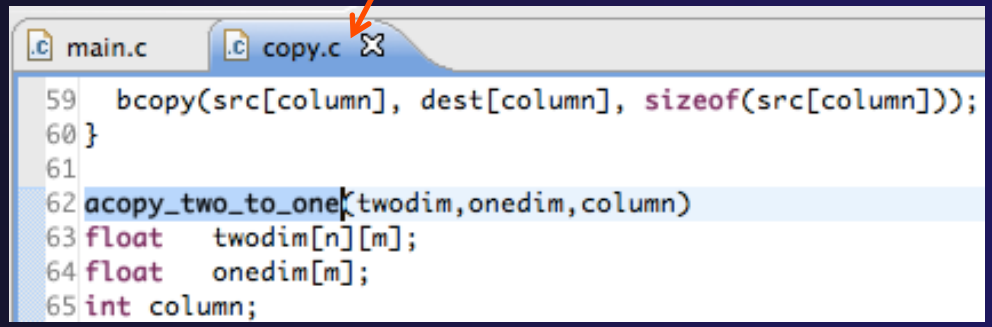
# Open Declaration

(C/C++ and Fortran)

- Jumps to the declaration of a variable, function, etc., even if it's in a different file
- Left-click to select identifier
- Right-click on identifier
- Click **Open Declaration**
- C/C++ only:
  Can also Ctrl-click (Mac: Cmd-click) on an identifier to "hyperlink" to its declaration




Goes to its declaration in copy.c



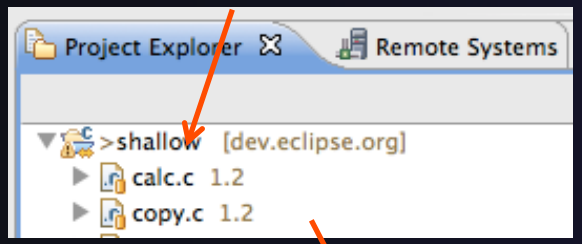
# Search – Try It!

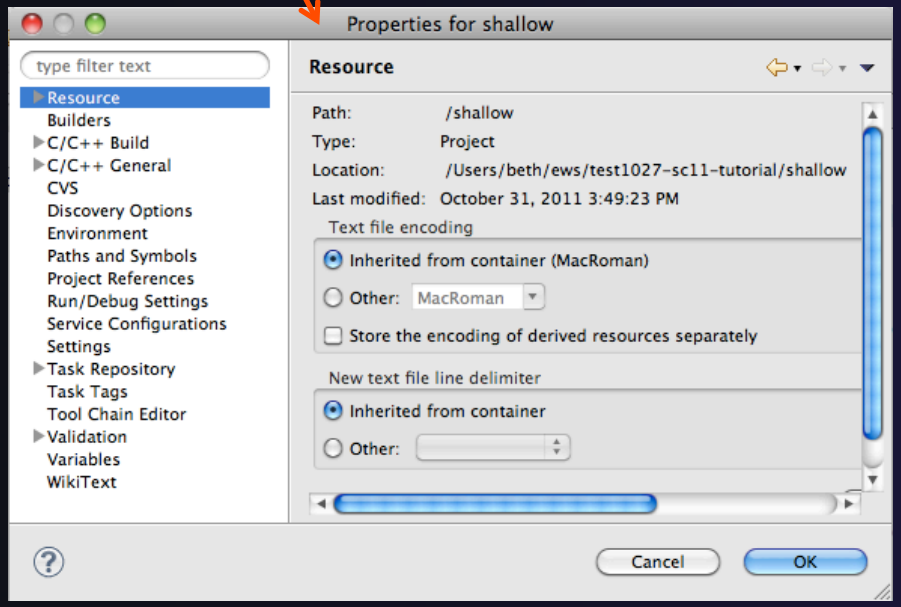
1. Find every call to `MPI_Recv` in Shallow.
2. In worker.c, on line 42, there is a declaration `float p[n][m]`.
   a) What is `m` (local? global? function parameter?)
   b) Where is `m` defined?
   c) How many times is `m` used in the project?
3. Find every function whose name contains the word `time`

# Fortran Specifics

# Project Properties

- Right-click Project
- Select **Properties**…



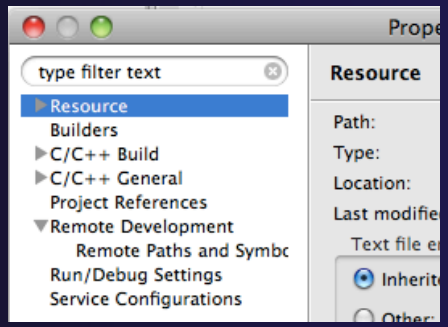




- *Project properties* are settings that can be changed for each project
  - Contrast with *workspace preferences*, which are the same regardless of what project is being edited
    - e.g., editor colors
    - Set in **Window ▸ Preferences** (on Mac, **Eclipse ▸ Preferences**)
    - Careful! Dialog is very similar

# Converting to a Fortran Project

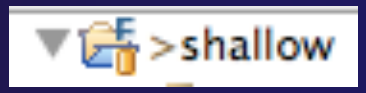
- Are there categories labeled **Fortran General** and **Fortran Build** in the project properties?

No Fortran categories →




Do this once

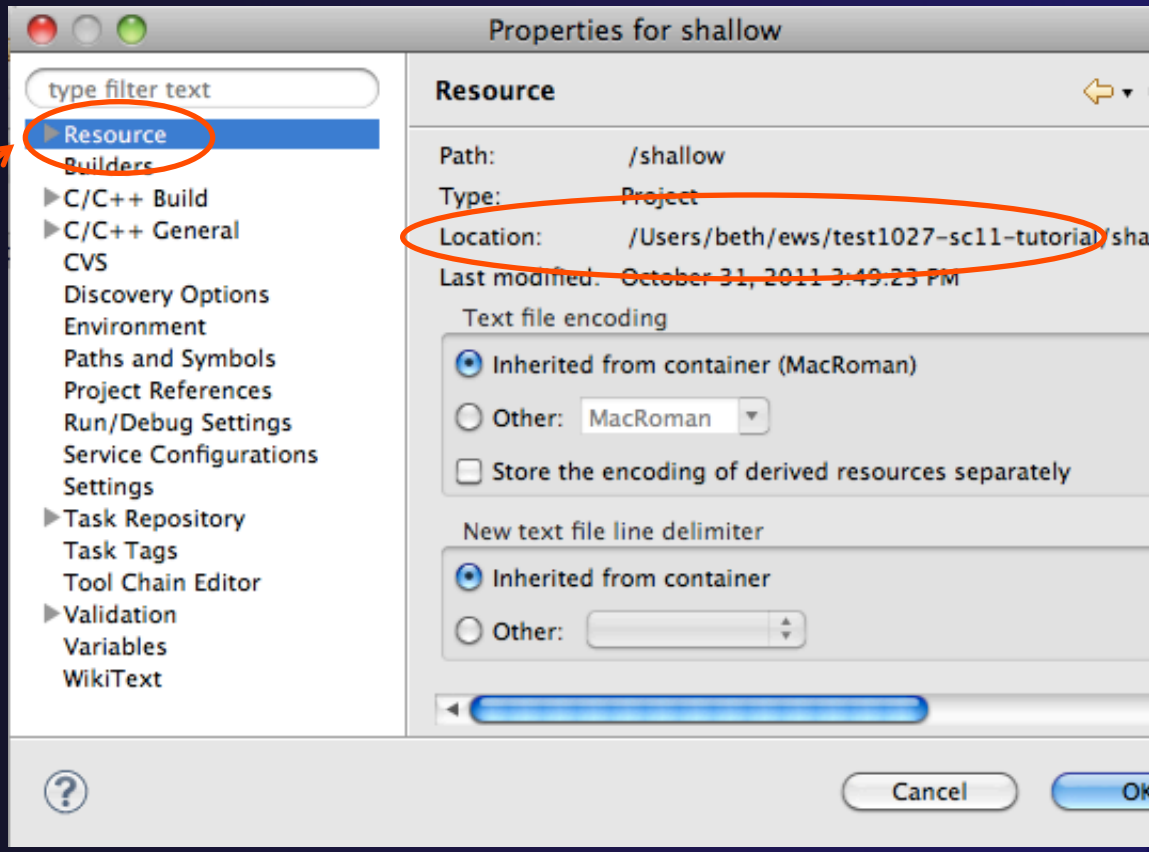
- If not, the project is not a Fortran Project
  - Switch to the Fortran Perspective
  - In the Project Explorer view, right-click on the project, and click **Convert to Fortran Project**
  - Don't worry; it's still a C/C++ project, too




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

# Project Location

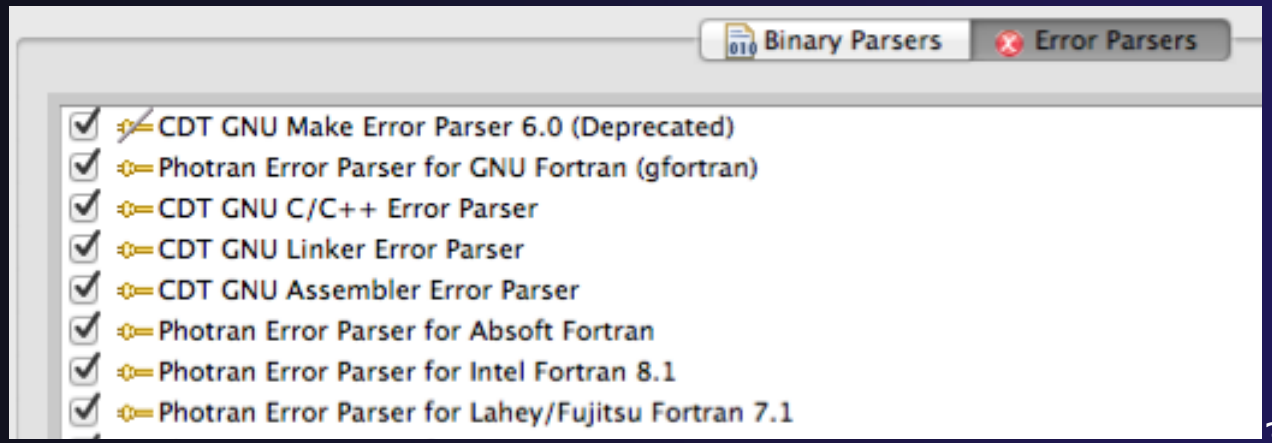
- How to tell where a project resides?
- In the project properties dialog, select the **Resource** category



# Error Parsers

Do this once

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



# Fortran Source Form Settings

- Fortran files are either *free form* or *fixed form;* some Fortran files are *preprocessed* (#define, #ifdef, etc.)
  - Source form determined by filename extension
  - Defaults are similar to most Fortran compilers:

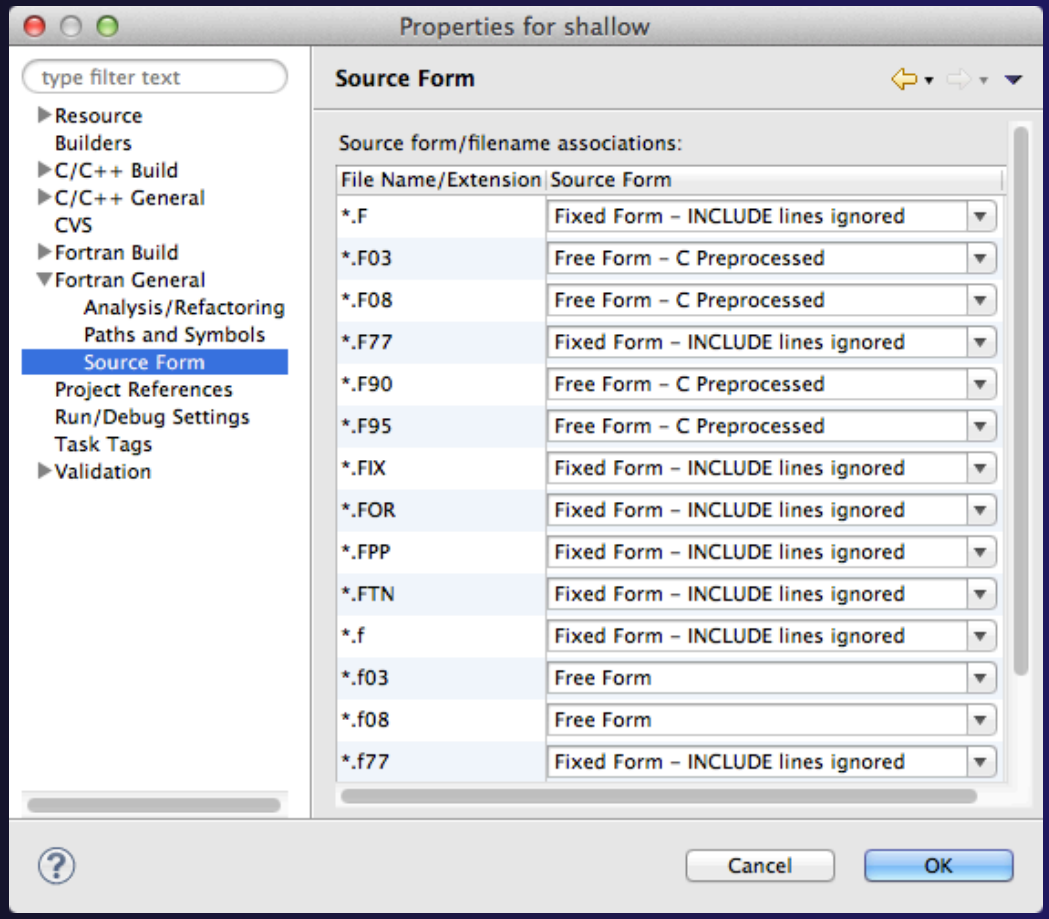
| | | | | | | |
|---|---|---|---|---|---|---|
| Fixed form: | .f | .fix | .for | .fpp | .ftn | .f77 |
| Free form: | .f08 | .f03 | .f95 | .f90 | | < unpreprocessed |
| | .F08 | .F03 | .F95 | .F90 | | < preprocessed |

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

# Fortran Source Form Settings

Do this once

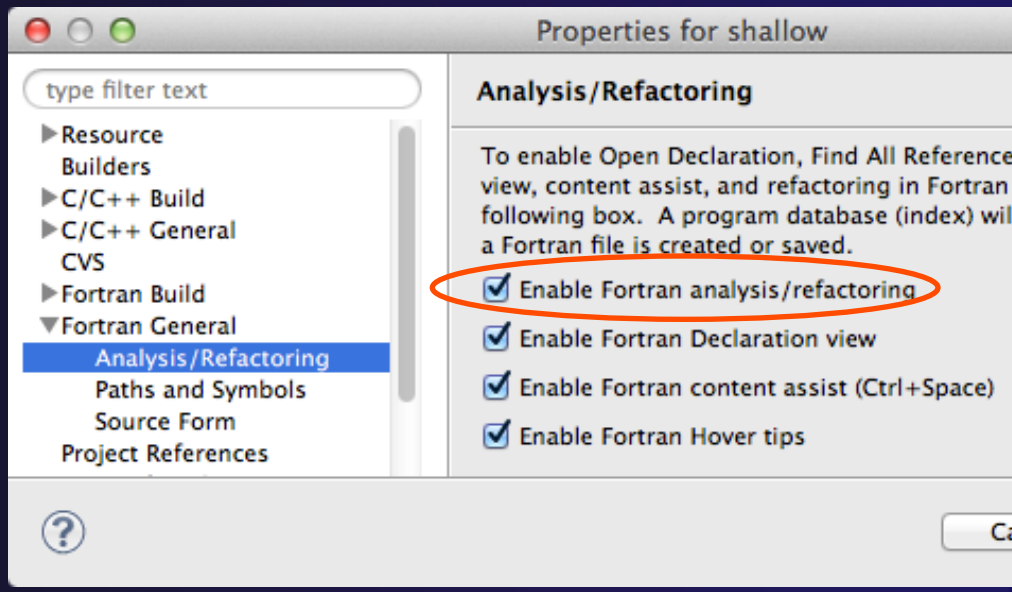
- In the project properties, select **Fortran General ▸ Source Form**
- Select source form for each filename extension
- Click **OK**



# Enabling Fortran Advanced Features

Do this once

- Some Fortran features are *disabled* by default
- Must be explicitly enabled
  - In the project properties dialog, select **Fortran General ▸ Analysis/Refactoring**
  - Click **Enable Analysis/ Refactoring**
  - Close and re-open any Fortran editors
- This turns on the "Photran Indexer"
  - Turn it off if it's slow



# Project Properties – Try It!

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

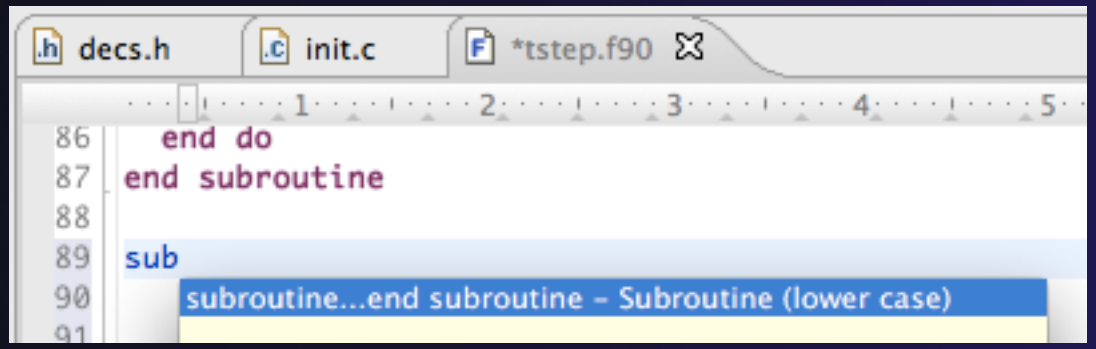
# Advanced Editing

# Code Templates

# Code Templates

(C/C++ and Fortran)

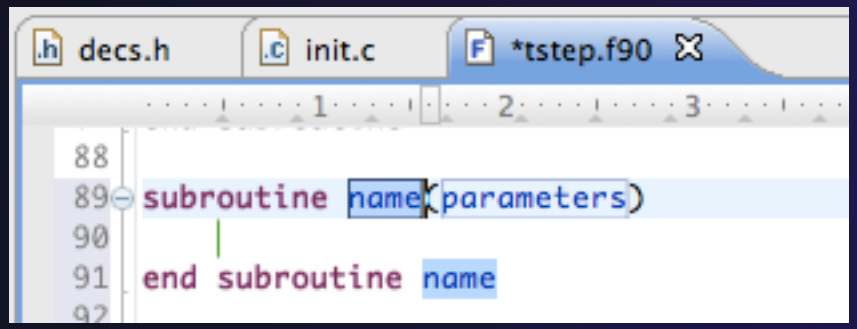
- Auto-complete common code patterns
  - For loops/do loops, if constructs, etc.
  - Also MPI code templates
- Included with content assist proposals (when **Ctrl-Space** is pressed)
  - E.g., after the last line in tstep.f90, type “sub” and press **Ctrl-Space**
  - Press **Enter** to insert the template



# Code Templates (2)

(C/C++ and Fortran)

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




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

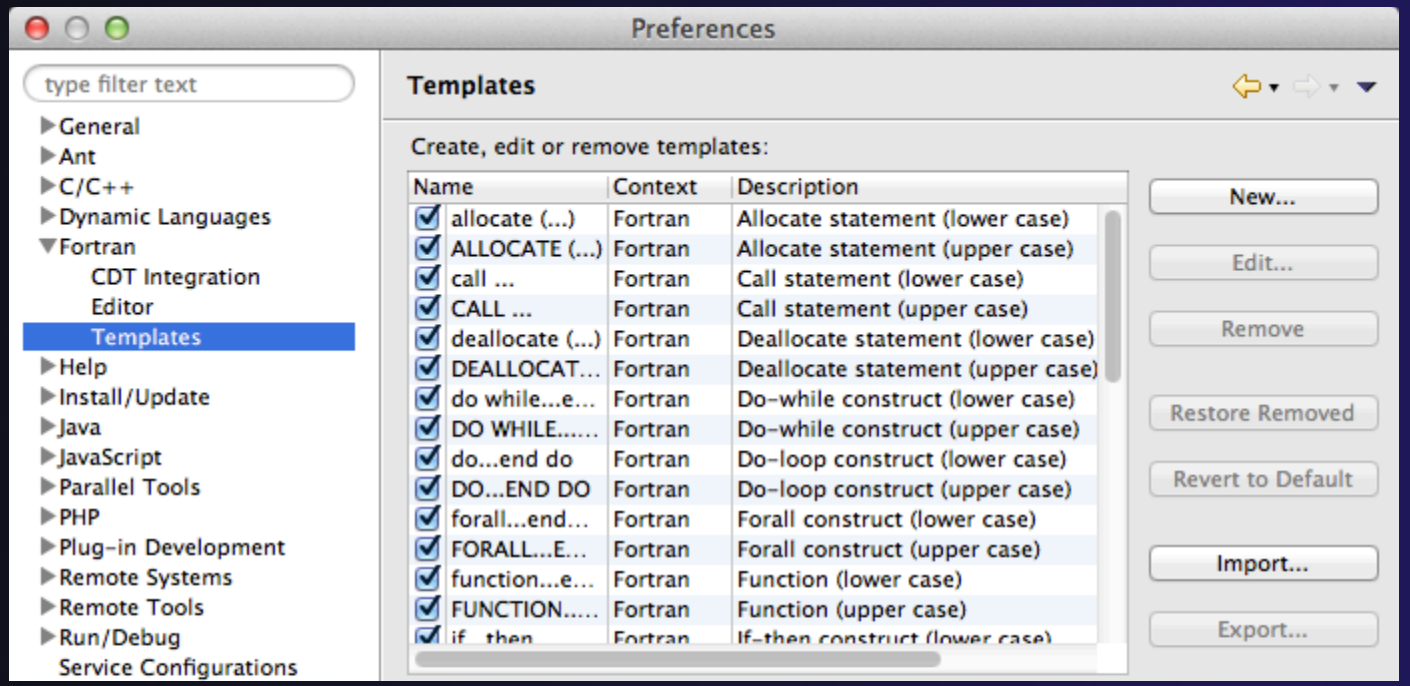
# Advanced Editing – Try It!

- Open tstep.f90 and retype the last loop nest
  - Use the code template to complete the do-loops
  - Use content assist to complete variable names

# Custom Code Templates

(Fortran)

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

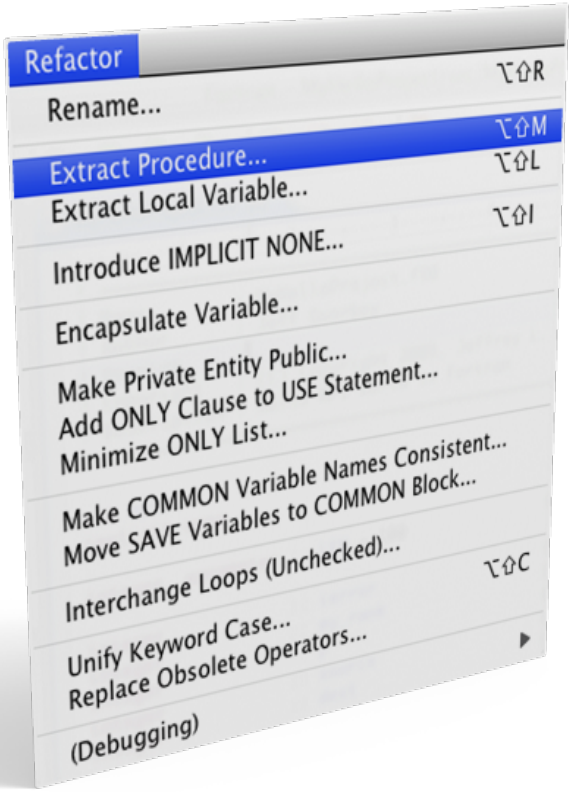



- Can import/export templates to XML files

# Refactoring and Transformation

# Refactoring

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




- Refactoring is the research motivation for Photran @ Illinois
  - Illinois is a leader in refactoring research
  - "Refactoring" was coined in our group (Opdyke & Johnson, 1990)
  - We had the first dissertation… (Opdyke, 1992)
  - …and built the first refactoring tool… (Roberts, Brant, & Johnson, 1997)
  - …and first supported the C preprocessor (Garrido, 2005)
  - Photran's agenda: refactorings for HPC, language evolution, refactoring framework
- Photran 7.0: 31 refactorings

# Refactoring Caveats

- Photran can only refactor free form code that is *not* preprocessed
  - Determined by Source Form settings
    (recall from earlier that these are configured in
    **Project Properties: Fortran General▸Source Form**)

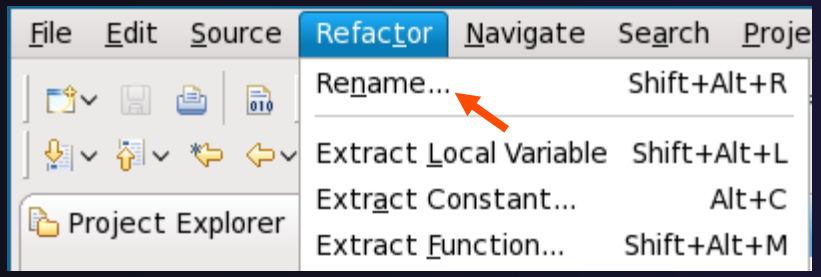
| | | | | | | |
|---|---|---|---|---|---|---|
| ✔ | **Free Form, Unpreprocessed:** | | .f08 | .f03 | .f95 | .f90 |
| ✖ | **Free Form, Preprocessed:** | | .F08 | .F03 | .F95 | .F90 |
| ✖ | **Fixed Form:** | .f | .fix | .for | .fpp | .ftn | .f77 |

- 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):

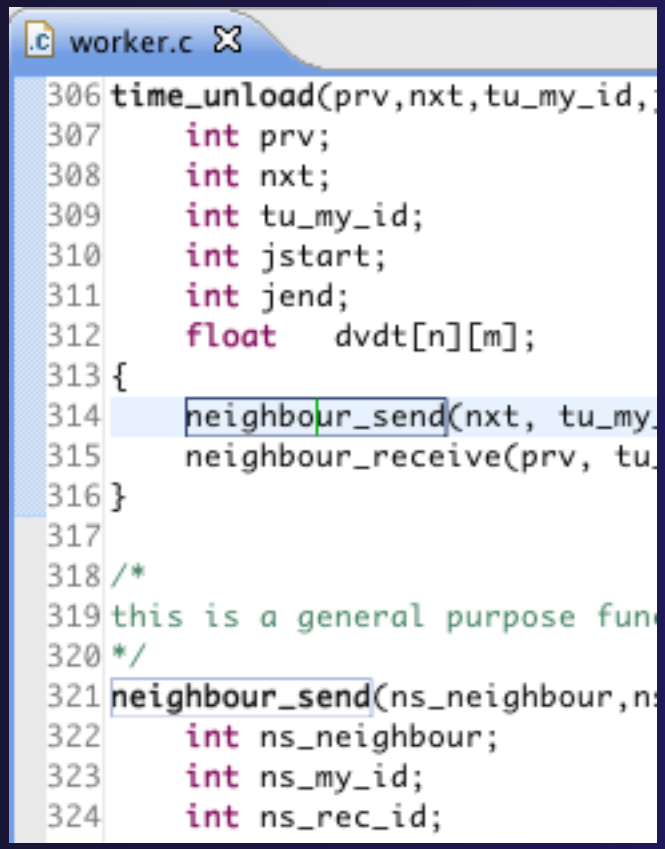
| Refactoring | Uses | Percentage |
|---|---|---|
| Rename | 179,871 | 74.8% |
| Extract Local Variable | 13,523 | 5.6% |
| Move | 13,208 | 5.5% |
| Extract Method | 10,581 | 4.4% |
| Change Method Signature | 4,764 | 2.0% |
| Inline | 4,102 | 1.7% |
| Extract Constant | 3,363 | 1.4% |
| (16 Other Refactorings)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

- 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

# Rename in File

(C/C++ Only)

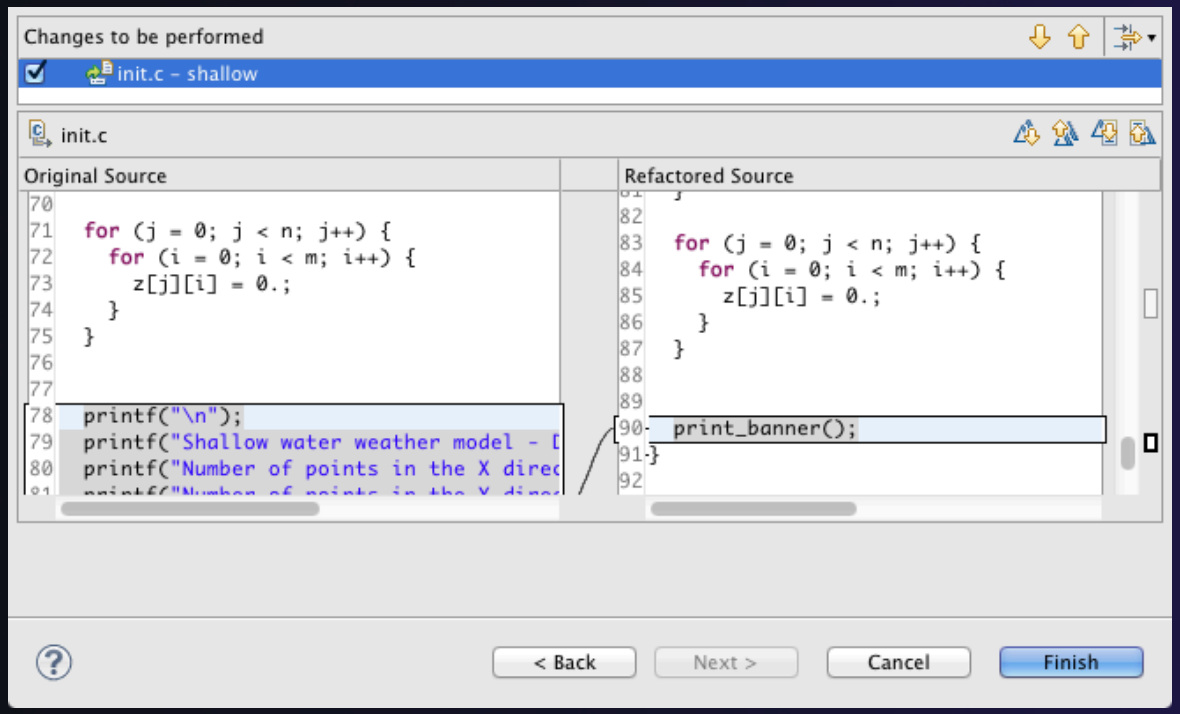
- Position the caret over an identifier.
- Press **Ctrl-1** (**Command-1** on Mac).
- Enter a new name. Changes are propagated within the file as you type.



# Extract Function Refactoring

(also available in Fortran - “Extract Procedure”)

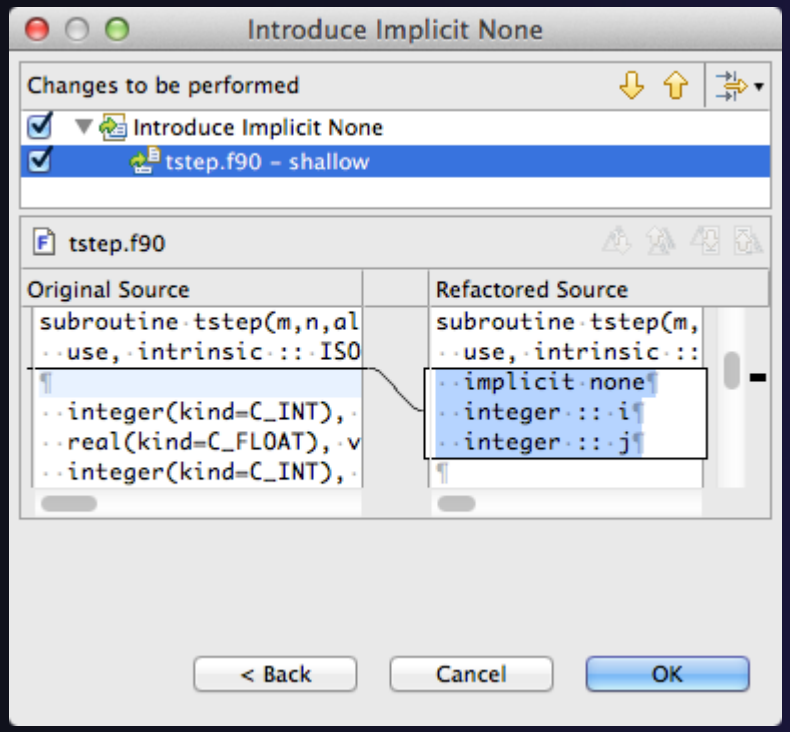
- Moves statements into a new function, replacing the statements with a call to that function
- Local variables are passed as arguments




- Select a sequence of statements
- Select menu item **Refactor ▸ Extract Function...**
- Enter new name

# Introduce IMPLICIT NONE Refactoring

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

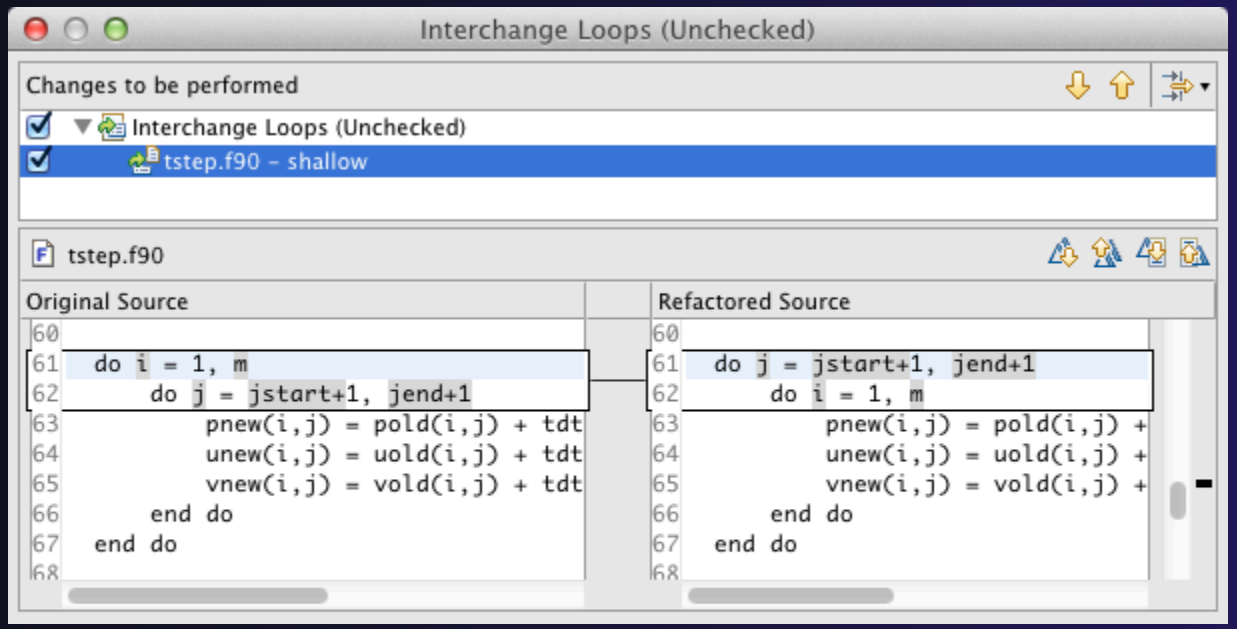



- Introduce in a single file by opening the file and selecting **Refactor▸Coding Style▸ Introduce IMPLICIT NONE...**
- Introduce in multiple files by selecting them in the Project Explorer view, right-clicking on the selection, and choosing **Refactor▸Coding Style▸Introduce IMPLICIT NONE...**

# Loop Transformations

(Fortran only)

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




Old version traverses matrices in row-major order

New version traverses in column-major order (better cache performance)

# Loop Transformations

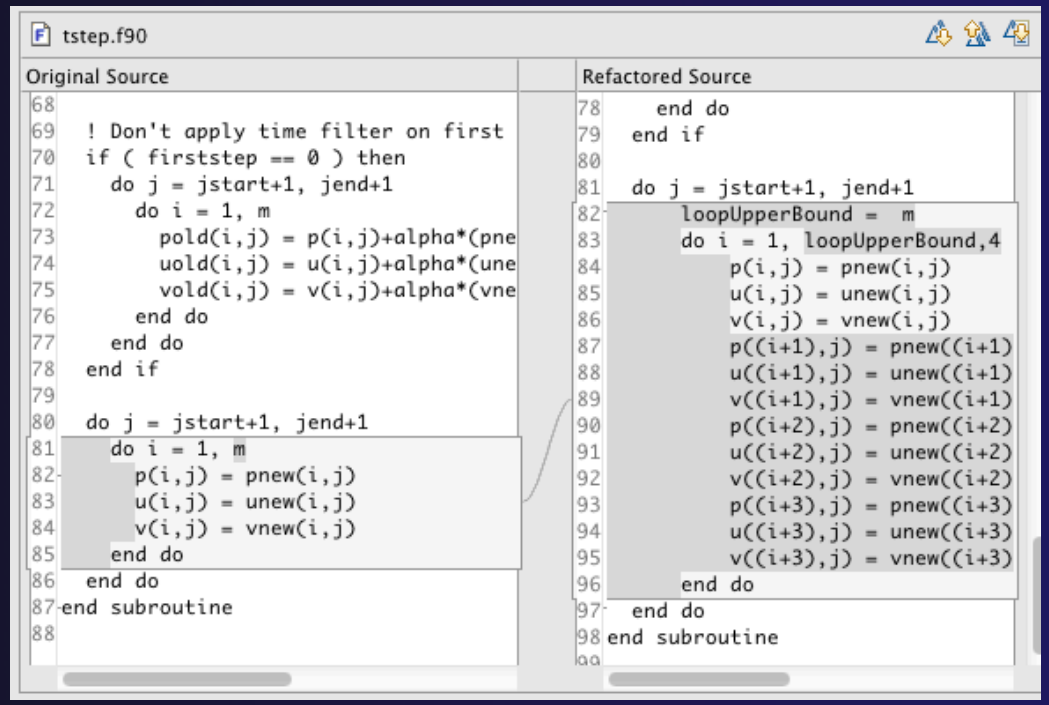
(Fortran only)

- **Unroll Loop**
- Select a loop, click **Refactor ▸ Do Loop ▸ Unroll Loop...**

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

Unroll 4×

```
do i = 1, 12, 4
  print *, 10*i
  print *, 10*(i+1)
  print *, 10*(i+2)
  print *, 10*(i+3)
end do
```



# Refactoring & Transformation – Try It!

In tstep.f90…

1. In init.c, extract the `printf` statements at the bottom of the file into a new function called `print_banner`
2. In worker.c, change the spellings of `neighbour_send` and `neighbour_receive` to American English
3. In tstep.f90, make the (Fortran) `tstep` subroutine IMPLICIT NONE


# NCSA Blue Waters HPC Workbench

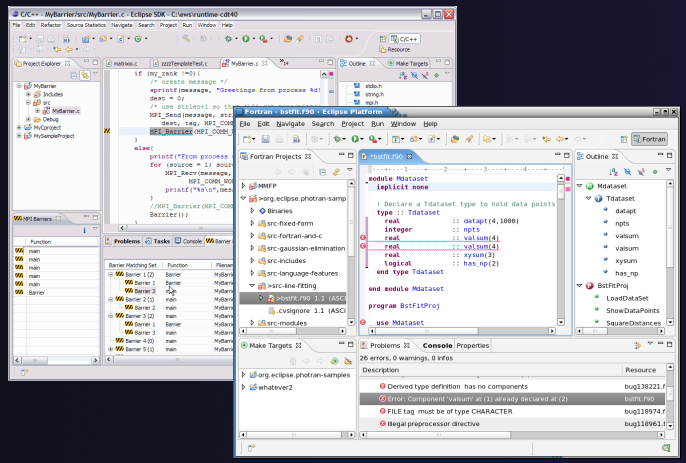
- Tools for NCSA Blue Waters
  - http://www.ncsa.illinois.edu/BlueWaters/
  - Sustained Petaflop system
- Based on Eclipse and PTP
- Includes some related tools
  - Performance tools
  - Workflow tools (https://wiki.ncsa.uiuc.edu/display/MRDPUB/MRD+Public+Space+Home+Page)
- Part of the enhanced computational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

# NSF SI2 Workbench for High Performance Computing

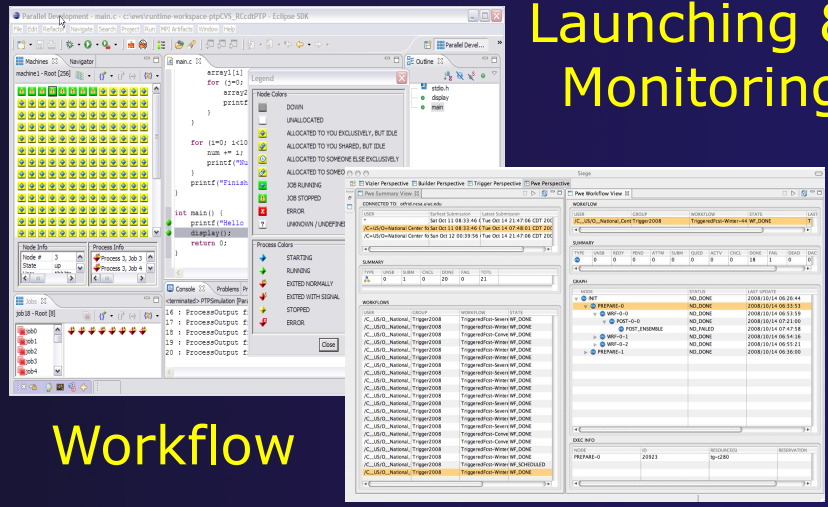
- "SI2-SSI Productive and Accessible Development Workbench for HPC Applications", which is supported by the National Science Foundation under award number OCI 1047956
- Produce a productive and accessible development workbench using Eclipse PTP
- Key Components
  - Determining Requirements, Ensuring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

# NCSA HPC Workbench

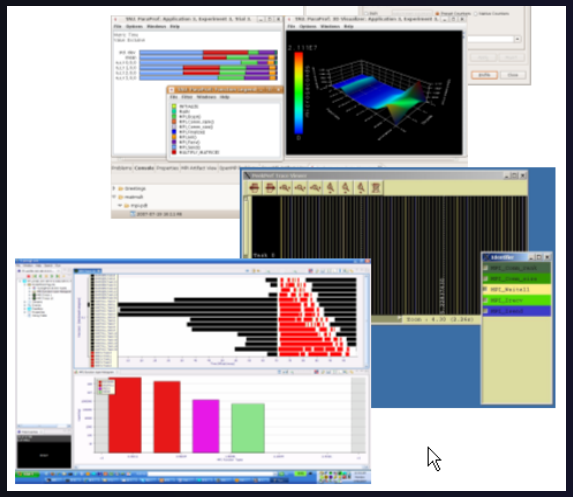
Coding & Analysis (C/C++, Fortran)



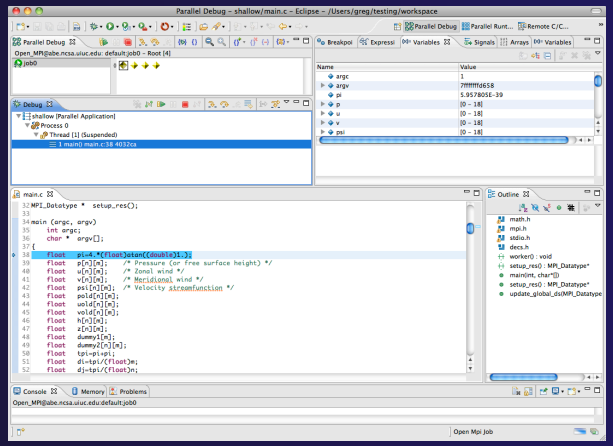
PTP Launching & Monitoring



Workflow



Performance Tuning



Parallel Debugger

# Planned PTP Future Work

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

# Useful Eclipse Tools

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

# Online Information

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

# Mailing Lists

- PTP Mailing lists
  - Major announcements (new releases, etc.) - low volume
    - http://dev.eclipse.org/mailman/listinfo/ptp-announce
  - User discussion and queries - medium volume
    - http://dev.eclipse.org/mailman/listinfo/ptp-user
  - Developer discussions - high volume
    - http://dev.eclipse.org/mailman/listinfo/ptp-dev
- Photran Mailing lists
  - User discussion and queries
    - http://dev.eclipse.org/mailman/listinfo/photran
  - Developer discussions –
    - Also on ptp-dev list (see above)

# Getting Involved

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

PTP will only succeed with your participation!