Module 4: Working with MPI

Objective

 Learn how to develop, build and launch a parallel (MPI) program on a remote parallel machine

+ Contents

- Remote project setup
- Building with Makefiles
- MPI assistance features
- Working with resource managers
- Launching a parallel application

Local vs. Remote

- PTP allows the program to be run locally if you have MPI installed
 - However we want to run the program on a remote machine
- We will now show you how to run a parallel program on a remote machine
 - Interactively
 - Through a batch system
- We have provided the source code to an MPI program on the remote machine
- The project will be created using this source code



Creating a Remote MPI Project

- Like the previous module, create a new Remote C/C++ project
- Enter "shallow" for the Project
 Name
- Use the same Connection as before
- Click the Browse... button and choose the directory "shallow" in in your home directory
- Select a Remote Makefile Project as before
- Click Finish

You may be prompted to open the Remote C/C++ Perspective

Eclipse	File	Edit	Source	Refactor	Navigate	e Search	Project	Run	Wind
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00	New Remote Project			
New Remote Project Existing project settings will be overridden				
Project name: sha	llow			
Remote Provider:	Remote Tools	•		
Connection:	n: abe.ncsa.uiuc.edu 🗘 New			
Location:	on: /u/ac/etrain1/shallow Browse			
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Changing the Project Build Properties

- The project makefile has a non-standard name Makefile.mk
- We need to change the build properties so that the project will build
 - By default, the project is built by running "make"
- Right-click on project
 "shallow" in the Project
 Explorer
- Select Properties

Project Explorer	3 🕞 🔄 🐨 🍟 🗖 🔂 hello.c
✓ Shallow Calc.c Calc.c Copy.c In decs.h Calc.c In decs.h	New Go Into Open in New Window
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Changing the Build Command

- Select C/C++ Build
- Uncheck Use default build command
- Change the Build command to:
 - + make –f Makefile.mk

$\bigcirc \bigcirc \bigcirc$	Properties for shallow	
type filter text	C/C++ Build	
type filter text Resource Builders C/C++ Build Build Variables Discovery Options Environment Logging Settings Tool Chain Editor C/C++ General Project References Remote Development Run/Debug Settings Service Configurations Task Repository WikiText	C/C++ Build Configuration: Default [Active] Builder Settings Builder Settings Builder type: External builder Ue default build command Build command: make -f Makefile.mk Makefile generation Concernent Makefile automation for proceeding to the back in Makefile	
	Build location	
	Build directory: /u/ac/etrain1/shallow	=

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Building the Project

- Click OK to save project properties after changing build command
- Select project and hit the build button
- The project can be built at any time by hitting this button





Include File Locations

- Like the previous example, Eclipse content assist and navigation require knowledge of include file locations on the remote system
 - Since the build will be running remotely, the compiler knows how to find include files
 - But Eclipse does not
- In Project Explorer, right-click on project
- Select Properties





Remote Paths and Symbols

In Project Properties,

- Expand Remote Development
- Select

Remote Paths and Symbols

- Select Languages>GNU C
 - + This is compiler on abe
- + Click Add...
 - Enter /usr/local/openmpi-1.4.2-intel-11.1/include
- Click OK, then Add... again
 - Enter /usr/include
- Click OK
- Click OK to close preferences
- When prompted to rebuild index, click OK

	10-	Properties for shallow	
(type filter text (3)	Remote Paths and Symbols		, , , , , , , , , , , , , , , , , , ,
 ▶ Resource Builders ▶ C/C++ Build ▶ C/C++ General 	Configuration: Default [Active	e]	Manage Configurations)
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?			Restore Defaults Apply OK Cancel

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Include directories

- 📙 /usr/local/openmpi-1.4.2-intel-11.1/include
- / usr/include

MPI-Specific Features

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- 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

More MPI features covered in Module 7: Advanced Features

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
- Selecting Show MPI Artifacts



MPI Artifact View

- Markers indicate the location of artifacts in editor
- The MPI Artifact View list 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
- 🔸 Remove markers via 🗴
- Click on column headings to sort





Context Sensitive Help

- Click mouse, then press help key when the cursor is within a function name
 - Windows: F1 key
 - + Linux: ctrl-F1 key
 - MacOS X: Help key or Help►Dynamic Help
- A help view appears (Related Topics) which shows additional information (You may need to click on MPI API in editor again, to populate)
- Click on the function name to see more information
- Move the help view within your Eclipse workbench, if you like, by dragging its title tab



MPI Templates

Allows quick entry of common patterns in MPI programming



C/C++>Editor>Templates Extend to other common patterns

Running the Program

Creating a resource manager
Starting the resource manager
Creating a launch configuration
Launching the application
Viewing the application run

Terminology

- The Parallel Runtime perspective is provided for monitoring and controlling applications
- Some terminology
 - Resource manager Corresponds to an instance of a resource management system (e.g. a job scheduler). You can have multiple resource managers connected to different machines.
 - + Queue A queue of pending jobs
 - Job A single run of a parallel application
 - Machine A parallel computer system
 - + Node Some form of computational resource
 - Process An execution unit (may be multiple threads of execution)

Resource Managers

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 PTP uses the term "resource manager" to refer to any subsystem that controls the resources required for launching a parallel job.

+ Examples:

Job 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

Preparing to Launch

- Setting up a resource manager is done in the Parallel Runtime perspective
- Select Window>Open Perspective>Other
- Choose Parallel Runtime and click OK





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About PTP Icons





Running Jobs Interactively

- Interactive resource managers will run the parallel application immediately
- They are also used for debugging the application
- Right-click in Resource Managers view and select
 Add Resource Manager
- Choose the Open MPI
 Resource Manager Type
- Select Next>





Configure the Remote Location

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A Back A	Next > Finish	Cancel				

- Choose Remote Tools for Remote service provider
- Choose the remote connection you made previously
- Configure Tunneling
 Options to use SSH Port
 Forwarding
- Click Next>



Configure the Resource Manager

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Installation Location	Comment Resource Manager Configuration						
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	Name: Open_MPI@abe.ncsa.uiuc.edu						
	Description: Open MPI Resource Manager						
0	Startup						
Module 4	(<u>Back</u> <u>Next</u> > <u>Finish</u> Cancel)						

- The Open MPI resource manager will auto detect the version and use the appropriate commands
 - Change only if you're an expert
- Set the location of the "mpirun" command if it is not in your path
- Click Next>
- Change the Name or
 Description of the resource manager if you wish
- You can also set the resource manager to automatically start
- + Click Finish



Starting the Resource Manager

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

🔊 Resource Managers 🔀



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System Monitoring

- Machine status shown in Machines view
- Node status also shown Machines view
- Hover over node to see node name
- Double-click on node to show attributes

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Create a Launch Configuration



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

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	Create, manage, and run Create a configuration to laun	configurations ch a parallel application in Parallel Perspective	
n on	Image: Second system Image: Second system	 Configure launch settings from this dialog: Press the 'New' button to create a configuration of the selected type. Press the 'Duplicate' button to copy the selected configuration. Press the 'Delete' button to remove the selected configuration. Press the 'Filter' button to configure filtering options. Edit or view an existing configuration by selecting it. Configure launch perspective settings from the <u>Perspectives</u> preference page.	
	0	Run	Close

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

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Complete the Resources Tab

- Enter a name for the launch configuration, e.g. "shallow"
- In Resources tab, select the resource manager you want to use to launch this job
- Enter a value in the Number of processes field
- Other fields can be used to specify resource manager-specific information
 - E.g. specify
 By node to allocate
 each process to a
 different node

Run Configurations		X
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Filter matched 5 of 5 items	Apply	Re <u>v</u> ert
?	Run	Close



Complete the Application Tab

- Select the Application tab
- Choose the Application program by clicking the Browse button and locating the executable on the remote machine
 - There should be a "shallow" executable in the "shallow" directory
- Select Display output from all processes in a console view
- Click Run to run the application

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?	Run	Close

Viewing The Run

- Double-click a node in machines view to see which processes ran on the node
- Hover over a process for tooltip popup
- Job status and information

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parallel tools platform Viewing Program Output - O X Parallel Runtime - shallow/main.c - Eclipse File Edit Navigate Search Run Project Window Help 🎄 • 🜔 • 🤬 • 💁 • 🜔 • 🗀 🔗 👻 ॑॑॑॑॑ - ऄ॑ - ♠ ↔ ↔ 1 - 김 명 수 🗟 Parallel Runti... 📮 Console 🖾 📀 Resource Managers 🖾 🗟 🚮 📑 🖃 🕶 📬 👻 Console displays Open_MPI@abe.ncsa.uiuc.edu (Open MPI) Open_MPI@abe.ncsa.uiuc.edu:default:job0 combined output Cvcle number 850 Model time in days 0.89 Potential energy nan Kinetic Energy from all processes Total Energy nan Pot. Enstrophy 🔍 🔍 🛛 🖍 🕶 🖓 🕶 🗖 Machines 🔀 Open MPI@abe.ncsa.uiuc.edu: abe.ncsa.uiuc.edu - Root [32] Cycle number 900 Model time in days 0.94 abe.ncsa.uiuc.edu 0 Potential energy nan Kinetic Energy Total Energy nan Pot. Enstrophy 9 18 Cycle number 950 Model time in days 0.99 27 🗾 🎒 🎒 🎒 Potential energy nan Kinetic Energy Total Energy nan Pot. Enstrophy Process Info Node Attributes 🐳 job0:job0.0 Attribute Value Cycle number 1000 Model time in days 1.04 honest1 Name Potential energy nan Kinetic Energy Node Number 28 Total Energy nan Pot. Enstrophy Properties view Open MPI number of nodes 1 shows job details <. 111 111 🖹 Problems 🖉 Tasks 🐻 Remote Enviro Properties 🖾 - -Jobs List 23 \bigtriangledown **7 ₿** Executable Name Status User Ar S., Name Xecon . Value Property Ο job0 NORMAL shallow /u/ac/etrain7/shal... 11 = Name honest1.ncsa.uiuc.edu Node Number 28 ٠. 111 ÷ Open MPI number of no 1 ∎≎ Remote Tools DStore S...c.edu): (100%) 6

Using a Job Scheduler

- Right-click in Resource Managers view and select Add Resource Manager
- Choose the PBS
 Resource Manager
 Type
- Select Next>







Configure the Remote Location

	🔶					
PBS Proxy Configuration						
Enter information to connect to an PBS proxy server	+					
Remote service provider: Remote Tools						
Connection name: abe.ncsa.uiuc.edu						
Proxy Options	+					
Tunneling Options	_					
© None						
Local address for proxy connection: localhest						
SSH port forwarding						
Launch server manually						
(?) < Back Next > Finish Cancel						

- Choose Remote Tools for Remote service provider
 - Choose the remote connection you made previously
- Configure Tunneling
 Options to use SSH Port
 Forwarding
- Click Next>



Configure the Resource Manager

PBS Batch Script Configuration								
Enter information to configure PBS Batch Script Templates								
Default Template: default_	template 👻							
Edit Template Delet	e Template							
	eremplate							
Attribute Placeholders								
Name	Default Value	Tool Tip						
Account_Name		Format: string						
Error_Path		Format: "[hostname:]r ≡						
Job_Name		Format: string up to 15						
Output_Path		Format: "[hostname:]p						
Resource_List.nodes		The value is one or mc						
Resource_List.walltime	00:30:00	Format: [[hours:]minu						
destination		Format: queuel@serve						
•	III	4						

- The PBS resource manager allows customization to match the local site options for the PBS installation
- By default, all known PBS options will be displayed
- Templates can be used to customize the options for each installation
- We will not change this, just click Finish to complete the configuration

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

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Resource Managers 🔀

Open_MPI@abe.ncsa.uiuc.edu (Open MPI



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System Monitoring

- Machine status shown in Machines view
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- Hover over node to see node name
- Double-click on node to show attributes

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Create a Launch Configuration

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

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Create, manage, and run configurations Create a configuration to launch a parallel application in Parallel Perspective									
Image: Second system Type filter text C C/C++ Application Fortran Local Application Data Parallel Application Shallow	 Configure launch settings from this dialog: Press the 'New' button to create a configuration of the selected type. Press the 'Duplicate' button to copy the selected configuration. Press the 'Delete' button to remove the selected configuration. Press the 'Filter' button to configure filtering options. Edit or view an existing configuration by selecting it. 								
?	Run	Close							



Complete the Resources Tab

- Enter a name for this launch configuration, e.g. "shallow (PBS)"
- In Resources tab, select the PBS resource manager you just created
- The MPI Command field allows this job to be run as an MPI job
 - + Choose mpirun
- Enter account name "dvd" -
- Enter the number of nodes to reserve in the Resource_List.nodes field
 Use 4 nodes
 - Use 4 hodes
- Select the destination queue -- nomss

Run Configurations			
Create, manage, and run config Create a configuration to launch a para	urations Ilel application in Parallel Persp	ective	
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	Attribute Account_Name Error_Path Job_Name Output_Path Resource_List.nodes Resource_List.walltime destination	Value dvd 4 00:30:00 nomss ~	Description Account to which to charge this job. The final path name for the file containing the job's standard error str The name assigned to the job by the qsub or qalter command. The final path name for the file containing the job's standard output Number and/or type of nodes to be reserved for exclusive use by the Maximum amount of real time during which the job can be in the rur Designation of the queue to which to submit the job.
Filter matched 7 of 7 items			Apply Reyert <u>R</u> un Close



Complete the Application Tab

- Select the Application tab
- Choose the Application program by clicking the Browse button and locating the executable on the remote machine
 - Use the same "shallow" executable
- Select Display output from all processes in a console view
- If Debugger tab has error, select Debugger: SDM
- Click Run to submit the application to the job scheduler



Job Monitoring

- Job status is tracked here, successful jobs disappear from list
- To cancel, select
 job and select
 Red button in
 Jobs List



Parallel Runtime - Eclipse												
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