

# Looking at MPI source code



## Initial conditions/prerequisites:

- Have a running Bootable Cluster CD on your system with a graphical interface
- Basic knowledge on the use of a text editor, preferably vi

## Goals:

- Understanding how MPI is used within a source code
- Obtain knowledge on each of the MPI functions used and understand the role of each function.

*This lab is designed to give the student a closer look on how MPI is used within a source code that displays the name of the student. The code printing the name of the student is written in C, no previous knowledge of programming is required.*

| Procedure                                                                                                                                                                                                                                                   | Explanation / Background                                                                                                                                             |
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| <p>Boot from the Bootable Cluster CD (BCCD) if you have not already done so. Also start the graphical interface by typing the following in the command line (if you have not already done so) :</p> <p>→ <code>startx</code> <code>&lt;enter&gt;</code></p> | <ul style="list-style-type: none"><li>• The startx command starts the X graphical interface.</li></ul>                                                               |
| <p>You will now open two terminals to work on. The first terminal would be for executing command on the command line, and the second is to write the code within the vi editor.</p>                                                                         | <ul style="list-style-type: none"><li>• To open a new terminal right click your mouse on the desktop and select terminals then aterm for the new terminal.</li></ul> |
| <p>Choose one of the terminals and type the following to create a new file:</p> <p>→ <code>touch mpilab.c</code> <code>&lt;enter&gt;</code></p>                                                                                                             | <ul style="list-style-type: none"><li>• The touch command allows you to create a new file, in this case the name of the new file is mpilab.</li></ul>                |
| <p>On the second terminal you created use the ls command to ensure the file mpilab is created:</p> <p>→ <code>ls</code> <code>&lt;enter&gt;</code></p>                                                                                                      | <ul style="list-style-type: none"><li>• A display of files (Gal, Life, Param_space, hello.c ...) should include the new C file you created mpilab.c .</li></ul>      |

| Procedure                                                                                                                                                                                                                                                                                                                                                                                                                    | Explanation / Background                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
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| <p>You will now open your newly created file for editing using vi (use the terminal you opened for editing files):</p> <p>→ <code>vi mpilab.c</code> <code>&lt;enter&gt;</code></p>                                                                                                                                                                                                                                          | <ul style="list-style-type: none"> <li>Opening the file for editing you should see the file name in the bottom left corner.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <p>To become in insert mode type i. Copy the code below to your file.</p> <pre><code>#include &lt;stdio.h&gt; // For standard input and output int main() { // starting the main program     printf(" Your Name \n ");     // Prints your name to the screen. }</code></pre> <p>After the code is completed transferred type the following after hitty the Esc key:</p> <p>→ <code>.wq</code> <code>&lt;enter&gt;</code></p> | <ul style="list-style-type: none"> <li>Now you are capable of inserting the code that will display your name on the screen.</li> </ul> <p><code>#include &lt;stdio.h&gt;</code> allows standard input and output to be sent into the program and out of program.</p> <p>The <code>//</code> represent comments made within the code.</p> <p><code>Int main()</code> is the function that gets the “ dice rolling “ for the rest of the code to execute.</p> <p><code>Printf()</code> does exactly that, prints to the screen your name. <code>/n</code> wihtin the print function skips to the next line.</p> <p>The <code>{</code> symbol represents the starting of a function . <code>}</code> symbolizes closing of the function.</p> |
| <p>Now compiling the code you just saved to be able to execute afterwards (Have your code on one terminal and the second terminal you may use to compile and execute your code) :</p> <p>→ <code>gcc -o NAME mpilab.c</code> <code>&lt;enter&gt;</code></p>                                                                                                                                                                  | <ul style="list-style-type: none"> <li>The <code>gcc</code> command is the C compiler that will create the executable (NAME) from the C code <code>mpilab.c</code> .</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <p>Now you will make sure that your compiling of the code created an executable (NAME).</p> <p>→ <code>ls</code> <code>&lt;enter&gt;</code></p>                                                                                                                                                                                                                                                                              | <ul style="list-style-type: none"> <li>An executable (NAME) should appear green in color. Green text usually means the file is an executable.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <p>Running the executable is done by typing the foloowing:</p> <p>→ <code>./NAME</code> <code>&lt;enter&gt;</code></p>                                                                                                                                                                                                                                                                                                       | <ul style="list-style-type: none"> <li>Your name should output to the screen when you hit the enter key to run the exectuable.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

*You have completed your training compiling and running a C program, and will now start the process of using MPI within the C program that displays your name. Then you will compile and run the program using MPI on a different number of processors on the cluster in your lab.*

| Procedure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Explanation / Background                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
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| <p>Now you are ready to have MPI functions written to your code, but before you do so you must first declare that you will be using MPI. Open your old mpilab.c file and add the following changes seen in the code:</p> <pre> #include &lt;stdio.h&gt; // standard input output #include "mpi.h" // enables use of MPI  int main(int argc, char ** argv) {      MPI_Init(&amp;argc, &amp;argv);     /*     MPI_init takes in two arguments     // &amp;argc and &amp;argv     // argc is the number of arguments to     // the program including the     // program name. Argv holds the names     // of these arguments.     */     printf(" Your Name \n ");     // Prints your name to the screen.     MPI_Finalize(); //finalizes use of MPI } </pre> <p>When you have completed writing all the changes to your code type the following after you hit the Esc key to save and exit:</p> <pre> → :wq &lt;enter&gt; </pre> | <p>The additions do the following:</p> <ul style="list-style-type: none"> <li>• #include "mpi.h" allows the use of MPI functions within the code.</li> <li>• Int argc and char ** argv represent two things: argc is an integer holding the number of arguments passed into the program. Argv is an array of size argc holding the names of those arguments.</li> <li>• MPI_Init() initializes MPI functions to be used within the code.</li> <li>• /* symbolizes the start of a comment, and */ symbolizes the end of the comments.</li> <li>• MPI_Finalize() signals the end of using MPI functions within the code.</li> <li>• All the code uses with MPI is MPI initialization and MPI Finalization.</li> </ul> |
| <p>You will now recompile the code but notice what changes in the compiling process:</p> <pre> → mpicc -o MPINAME mpilab.c &lt;enter&gt; </pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <ul style="list-style-type: none"> <li>• The change should appear to you with the compiler. It is no longer a regular C compiler. The mpicc is our new command that is used to compile C code containing MPI command.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <p>Similarly you will now run the executable, but slight changes occur in running the executable, type the following:</p> <pre> → mpirun -np 3 MPINAME &lt;enter&gt; </pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <ul style="list-style-type: none"> <li>• You again notice the change in the executing command, where mpirun is now used in place of the ./ command. The -np 3 argument allows you to enter the number of processes to run the executable, as an output you should have three prints of your name on the screen when you hit the enter key to run the executable.</li> </ul>                                                                                                                                                                                                                                                                                                                                       |

| Procedure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Explanation / Background                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
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| <p>Open the mpilab.c file once again to make some changes. Now you will add the functions that receive the size of the cluster and assign a rank to each node :</p> <pre> #include &lt;stdio.h&gt; // standard input output  #include "mpi.h" // enables use of MPI  int main(int argc, char ** argv) {      int rank, size;     /* definition of rank which will hold     the rank of each processor.     Size will hold the number of     processor.     */     MPI_Init(&amp;argc, &amp;argv);      /* MPI_init takes in two arguments     &amp;argc and &amp;argv     argc is the number of arguments to     the program including the     program name. Argv holds the     names of these arguments.     */     MPI_Comm_rank(MPI_COMM_WORLD,&amp;rank);     MPI_Comm_size(MPI_COMM_WORLD,&amp;size);      // The following printf() is one line ends after size);     printf(" Your Name is on node %d of %d total nodes \n", rank, size);     // Prints your name to the screen.      MPI_Finalize (); //ending use of MPI } </pre> | <ul style="list-style-type: none"> <li>• The changes done to the code are highlighter below, where int rank and size are defined and the MPI_comm_rank and MPI_comm_size are called.</li> <li>• MPI_comm_rank assigns a rank to each node that is part of the cluster.</li> <li>• MPI_comm_size stores the size of the number of nodes that are part of the cluster.</li> <li>• Printf() will print your name and the rank of the node that ran the executable.</li> </ul> |
| <p>When you have finished making the changes type the following after you hit the Esc key.</p> <p>→ <code>.wq &lt;enter&gt;</code></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <p>Following a similar procedure you will compile and run the file you have just changed, type:</p> <p>→ <code>mpicc -o MPINAME mpilab.c &lt;enter&gt;</code></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

| Procedure                                                                                                                            | Explanation / Background                                                                                                                                                                                                                                                                                                 |
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| <p>Now that you have compiled the program run the executable by typing:</p> <p>→ <code>mpirun -np 3 MPINAME &lt;enter&gt;</code></p> | <ul style="list-style-type: none"> <li>An output with your name and the node it was executed on should print to the screen. The output should look like the following:<br/> Your name is on node 0 of 3 total nodes<br/> Your name is on node 1 of 3 total nodes<br/> Your name is on node 2 of 3 total nodes</li> </ul> |
| <p>You can now practice with a different number of processors, or copy the code and modify it to do a different task.</p>            |                                                                                                                                                                                                                                                                                                                          |

## Stuff to do when you're done with the lab

*Here are some things to try if you finish early.*

1. Search for MPI and understand how it works ( You can start with google and see where that takes you ).
2. How about writing your own program that does something else besides writing your name to the screen? Perhaps calculating the circumference of a circle given its radius ( or something of that sort).

**Date:** \_\_\_\_\_

What command did you use to create a new file of name mpilab.c ?

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Write down the command that is used to compile a normal C code followed by a command that is used to compile a C code containing MPI functions:

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Make a copy of the mpilab.c file using the cp command. Open the copy and remove the header #include "mpi.h" and try recompiling the code, what kind of errors do you receive?

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What are the functions of MPI\_Comm\_rank and MPI\_Comm\_size within the code ? :

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When you are running the mpirun command, what does -np represent ?

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What is the difference between the executing command of a regular C program and one containing MPI functions ? (write down both commands)

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