

High Performance Computing Modernization Program (HPCMP) Summer 2011 Puerto Rico Workshop on Intermediate Parallel Programming & Cluster Computing

**in conjunction with
the National Computational Science Institute (NCSI)/
SC11 Conference**



**Jointly hosted at
Polytechnic U of Puerto Rico
and U Oklahoma**
**and available live via videoconferencing
(streaming video recordings coming soon)**



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Intermediate Parallel Programming & Cluster Computing

Strategies for Debugging Parallel Programs



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Jeff Rufinus, Widener University
Luis Vicente, Polytechnic University of Puerto Rico
Aaron Weeden, Earlham College
Sunday July 31 – Saturday August 6 2011





This is an experiment!

It's the nature of these kinds of videoconferences that **FAILURES ARE GUARANTEED TO HAPPEN! NO PROMISES!**

So, please bear with us. Hopefully everything will work out well enough.

If you lose your connection, you can retry the same kind of connection, or try connecting another way.

Remember, if all else fails, you always have the toll free phone bridge to fall back on.



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H.323 (Polycom etc)

If you want to use H.323 videoconferencing – for example, Polycom – then:

- If you ARE already registered with the OneNet gatekeeper, dial 2500409.
- If you AREN'T registered with the OneNet gatekeeper (which is probably the case), then:
 - Dial **164.58.250.47**
 - When asked for the conference ID, enter:
#0409#

Many thanks to Roger Holder and OneNet for providing this.



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H.323 from Internet Explorer

From a Windows PC running Internet Explorer:

1. You **MUST** have the ability to install software on the PC (or have someone install it for you).
2. Download and install the latest Java Runtime Environment (JRE) from here (click on the Java Download icon, because that install package includes both the JRE and other components).
3. Download and install this video decoder.
4. Start Internet Explorer.
5. Copy-and-paste this URL into your IE window:
http://164.58.250.47/
6. When that webpage loads, in the upper left, click on "Streaming".
7. In the textbox labeled Sign-in Name, type your name.
8. In the textbox labeled Conference ID, type this:
0409
9. Click on "Stream this conference".
10. When that webpage loads, you may see, at the very top, a bar offering you options. If so, click on it and choose "Install this add-on."



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EVO

There's a quick description of how to use EVO on the workshop logistics webpage.



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Phone Bridge

If all else fails, you can call into our toll free phone bridge:

1-800-832-0736

* 623 2874 #

Please mute yourself and use the phone to listen.

Don't worry, we'll call out slide numbers as we go.

Please use the phone bridge **ONLY** if you cannot connect any other way: the phone bridge is charged per connection per minute, so our preference is to minimize the number of connections.

Many thanks to OU Information Technology for providing the toll free phone bridge.



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Please Mute Yourself

No matter how you connect, please mute yourself, so that we cannot hear you.

At ISU and UW, we will turn off the sound on all conferencing technologies.

That way, we won't have problems with echo cancellation.

Of course, that means we cannot hear questions.

So for questions, you'll need to send some kind of text.



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Questions via Text: Piazza

Ask questions via:

<http://www.piazza.com/>

All questions will be read out loud and then answered out loud.

NOTE: Because of image-and-likeness rules, people attending remotely offsite via videoconferencing **CANNOT** ask questions via voice.



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Thanks for helping!

- OSCER operations staff (Brandon George, Dave Akin, Brett Zimmerman, Josh Alexander, Patrick Calhoun)
- Debi Gentis, OU
- Kevin Blake, OU IT (videographer)
- James Deaton and Roger Holder, OneNet
- Alfredo Cruz, Polytechnic U Puerto Rico
- Omar Padron, Kean U
- Scott Lathrop, SC11 General Chair
- Donna Cappelletti, ACM
- Bob Panoff, Jack Parkin and Joyce South, Shodor Education Foundation Inc



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Strategies for Debugging Parallel Algorithms



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Strategies for Debugging Parallel Algorithms

- Preventing Bugs Through Good Software Engineering
- Finding Bugs
- Fixing Bugs



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Preventing Bugs Through Good Software Engineering

- “Days of debugging can save you from hours of design and planning” - Charlie Peck.



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Preventing Bugs Through Good Software Engineering

- Read and write lots of documentation.
 - man pages
 - MPI standard, OpenMP standard
 - GIYF (Google Is Your Friend)
 - comments
 - READMEs
 - man pages



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Preventing Bugs Through Good Software Engineering

- Adopt test-driven development.

```
my_area = total_area / number_of_processes;  
#ifdef TESTING  
    if(my_area != 2.0)  
        printf("Area calculation incorrect:  area is  
            %d\n", my_area);  
#endif
```

\$./area

Area calculation incorrect: area is 1.6666667



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Preventing Bugs Through Good Software Engineering

- Automate the process.

\$./tests

Test 1 (same send and recv message #1) ... passed!

Test 2 (good area calculation) ... passed!

Test 3 (same send and recv message #2) ... **FAILED:**

Received message of length 12 instead of 2.

Test 4 (good area aggregation) ... passed!

Test 5 (cleanup) ... passed!

PASSED 4 of 5 TESTS



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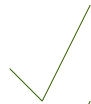




Preventing Bugs Through Good Software Engineering

- Develop incrementally.

Change



Change



Change



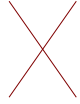
Change



Change



Compile/Run/Test



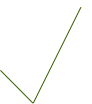
Change



Compile/Run/Test



Change



Compile/Run/Test



Change



Compile/Run/Test



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Preventing Bugs Through Good Software Engineering

- Choose meaningful variable names.

```
my_nSs = nSs / m_R;
```

VS

```
my_number_of_stars = number_of_stars /  
my_region;
```



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Preventing Bugs Through Good Software Engineering

- Keep MPI collective calls outside of conditional branches.

```
if(my_rank != 0)
{
    MPI_Allgather(...);
}
```



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Finding Bugs

- Make it easy to turn off the parallelism.

```
#ifdef MPI
    MPI_Send( ... );
#endif
```

```
$ gcc -DMPI=0 area.c -o area
```



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Finding Bugs

- Let the compiler help you.

```
$ gcc -Wall --pedantic -O0 -Wuninitialized file.c -o file
```

```
const double AREA = 10.0;
```

```
#define AREA 10.0
```



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Finding Bugs

- Examine error codes.

```
return_value = MPI_Recv(message, 10,  
MPI_CHAR, 0, TAG, MPI_COMM_WORLD,  
&status);
```

```
if(return_value != MPI_SUCCESS)  
{...}
```



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Finding Bugs

- Use print statements, report the MPI rank and OpenMP thread number in each, and keep them in your code for later.

```
MPI_Recv(message, 10, MPI_CHAR, 0,  
TAG, MPI_COMM_WORLD, &status);  
  
printf("Rank %d: Thread %d: Message  
after receive: %s\n", my_rank,  
omp_get_thread_num(), &message);
```



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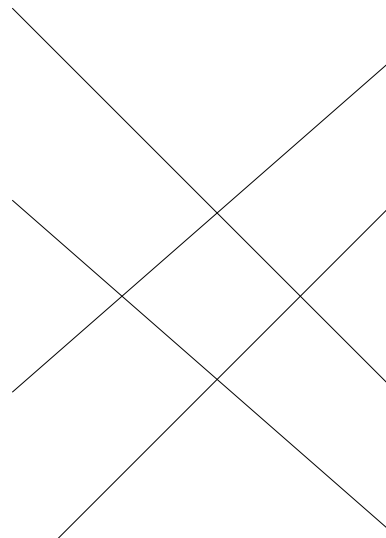




Finding Bugs

- Match MPI Sends and Receives.

```
/* 0th Send */  
MPI_Send(...);  
/* 1st Recv */  
MPI_Recv(...);  
...  
/* 0th Recv */  
MPI_Recv(...);  
/* 1st Send */  
MPI_Send(...);
```



```
/* 0th Send */  
MPI_Send(...);  
/* 1st Recv */  
MPI_Recv(...);  
...  
/* 0th Recv */  
MPI_Recv(...);  
/* 1st Send */  
MPI_Send(...);
```



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Finding Bugs

- Try your code under different MPI bindings.



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Fixing Bugs

- Take advantage of the other OpenMP pragmas.
 - critical
 - private
 - firstprivate
 - master
 - single



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Fixing Bugs

- Use a debugger and take advantage of its parallel debugging features.

- The “attach” command in gdb:

```
$ mpirun -np 2 program &
```

```
$ ps | grep program
```

```
$ gdb
```

```
gdb> attach the_PID_returned_by_the_ps_command
```



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Fixing Bugs

- Only fix one error at a time, but fix it everywhere.



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Fixing Bugs

- Get a “second set of eyeballs” to look at your code.



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Fixing Bugs

- “Code deleted is code debugged” - Steve Olson.



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Fixing Bugs

- Walk away for awhile.



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Thanks for your attention!

Questions?



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