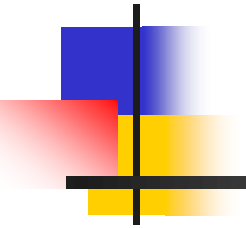


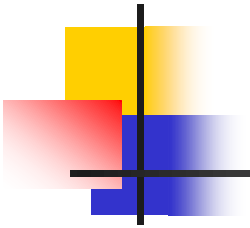
# Using Remote HPC Resources to Teach Local Courses

**Oklahoma Supercomputing Symposium**
**10/06/10**

**Larry F. Sells, Oklahoma City University**
**Clay B. Carley III, East Central University**
**Chao (Charlie) Zhao, Cameron University**

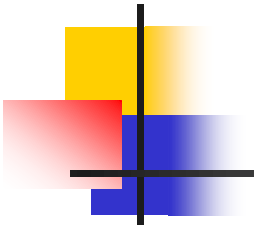
# The Impact of OSCER on Software Engineering at Oklahoma City University

**Larry F. Sells**
**Department of Computer Science**
**Oklahoma City University**



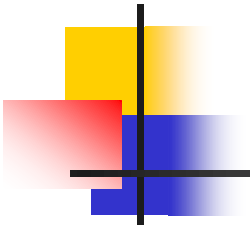
# Software Engineering at OCU

- Same instructor for many years
- SE concepts and team/project course
- The last 4 semesters project focus has been on MPI and OpenMP



# Instructor's Training

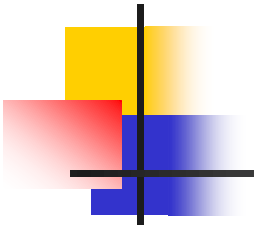
- OU Supercomputing Center for Education and Research (OSCER) resources
- National Computational Science Institute (NCSI)/SC07-09 HPC summer Parallel Computing workshops 2005, 2007, 2009, 2010
- Importance of NCSI summer 2010 Intermediate Parallel Computing workshop in pulling many things together



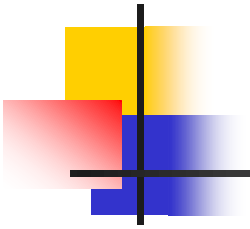
# Course Objectives

- Engage students in a first course in software engineering (Roger Pressman text)
- Help students work in a UNIX, C, MPI environment
- Help student teams create MPI project code along with SE documentation (requirements, design, test plan, user manual, final source code, executables, and report)

# Software Engineering Fall 2010 - Prerequisites



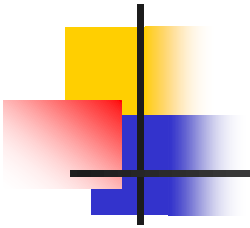
- 2 years experience in C, C++, or Java
- Knowledge of data structures
- Basic background in Linux (UNIX) helpful
- No previous study of parallel programming, HPC, or MPI
- No previous knowledge of cryptology



# Software Engineering Fall Project

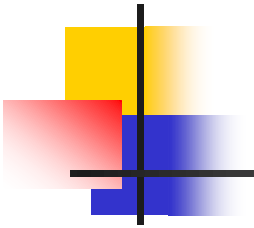
- Inspired by Simon Singh's "Cipher Challenge"
- Ciphers include:  homophonic, Vigenere, Playfair, ADFGVX, DES, and RSA
- Goal is to decipher Singh's ciphertexts using MPI and C or C++ and to develop appropriate SE documentation

# Dr. Henry Neeman, OSCER, and Sooner



- OSCER operations team created Sooner accounts for SE students
- Henry Neeman and Josh Alexander came to OCU to do an introduction to Sooner lab
- Importance of Neeman's 11 SiPE (Supercomputing in Plain English) presentations – especially #5 and #6
- We are working to set up an OU Sooner tour – gives gut understanding of a cluster.

# Relevant OSCER 2010 Workshop Ideas

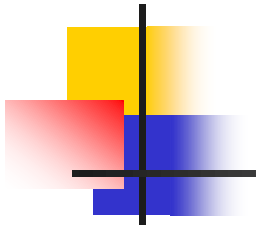


- Client/server, data parallelism, task parallelism, and pipeline parallel strategies
- Comparing MPI output on Sooner and Earlham cluster
- MPI debugging
- Introduction to CUDA
- Introduction to hybrid HPC – CUDA and MPI

# Sooner is Better

Clay B. Carley III
Department of Computer Science
East Central University

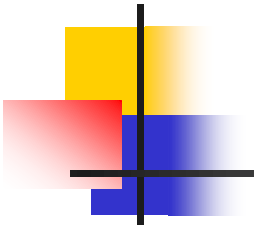
# Parallel Programming
# The Future



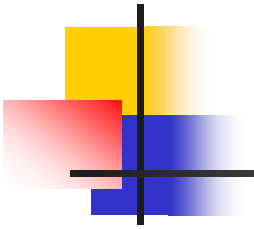
- High Performance Computing
- The Cloud
- Multicore Architectures

Equals => more pressure on future graduates to understand parallel programming

# Parallel Programming Spring 2010 - Prerequisites

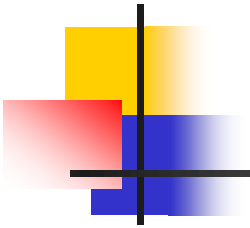


- Experience in C
- Linux (UNIX) experience
- No previous study of parallel programming, HPC (High Performance Computing) or MPI (Message Passing Interface) before
- No experience with batch processing



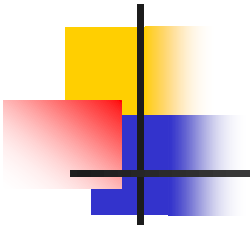
# Course Objectives

- Engage students in a first course in parallel programming ("Parallel Programming with MPI," Pacheco)
- Help students work in a C, MPI, batch environment
- Help students understand the different parallel computing architectures



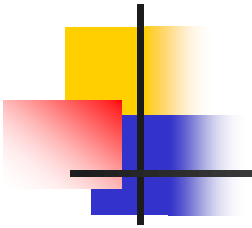
# OSCER Resources

- *Priming the Pump* with Dr. Henry Neeman's "Supercomputing in Plain English" slides
- Hardware and Memory Issues
- Workshop links
- MPI – examples are available in C and FORTRAN



# *Priming the Pump*

- Starting from scratch
- Getting an Instructor's account on Sooner
- Online Resources
  - Workshops
  - PowerPoint Slides
  - Exercises and Code Examples



# Course Kickoff

Visit by Dr. Neeman and Josh Alexander

- Connecting to Sooner for the first time
- Guidance for first exercises
- Q&A about supercomputing and supercomputers

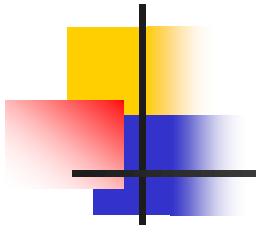
# The Sooner Linux Cluster

- 1,072 Intel Xeon CPU chips/**4288 cores**
- 8,768 GB RAM
- ~105 TB globally accessible disk
- QLogic Infiniband
- Force10 Networks Gigabit Ethernet
- Red Hat Enterprise Linux 5
- Peak speed: 34.45 TFLOPs*

*TFLOPs: trillion calculations per second

**sooner.oscer.ou.edu**

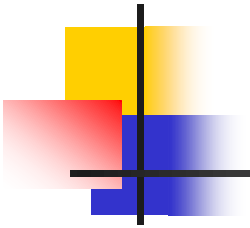
# Sooner Benefits for Course



- "real supercomputer environment"
- Ability to explore different options to see what impact they have on performance
  - Increasing/decreasing number of cores
  - Increasing/decreasing number of processes
  - Increasing/decreasing granularity of the problem

# Methods for Teaching Some Basic Concepts of Parallel Computing to Undergraduate CS Students at Cameron University

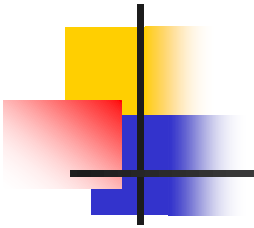
**Chao Zhao**
**Associate Professor**
**Computing and Technology Department**
**Cameron University**



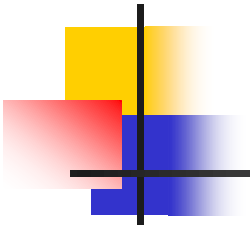
# Parallel Computing at Cameron

- Cameron is a five year regional public university.
- BS in Computer Science is offered in Computing and Technology Department.
- CS 3813 Parallel Computing is a required course in CS curriculum (ACM 2000).
- MPI is used as message passing library.
- OSCER has been used as significant teaching resources.

# Instructor's Training and Cooperation with OSCER

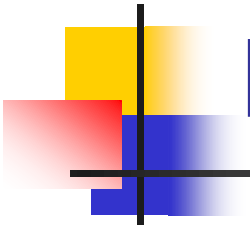


- OU HPC Summer Workshops (06, 07, 08, 09)
- Inviting supercomputing expert to deliver speech to students (Dr. Neeman: Basic Parallel concepts and Logics)
- Visiting OSCER Supercomputing Center
- Using OSCER's supercomputer to run students' parallel programs:
  - Dr. Neeman and Josh Alexander campus visits
  - Sooner account for each student



# Why Parallel Computing?

- Take advantage of multiple core machines
- Parallel approach may improve computing efficiency:
  - $Sp_{(n)} = Ts / Tp$
  - $Ep = Ts / (Tp \cdot n)$ or
  - $Ep = Sp / n$
- Solve some problems that CANNOT be solved by sequential approach
- No speed limit in theory



# Parallel Program Logical Structure

```
Main function
{
    common part (variables declaration and initialization);
    if ( myrank equal master)
    {
        code that will be executed by the master process;
    }
    else {
        code that will be executed by slave processes;
    }
    program termination part;
}
```

# Teaching Methods

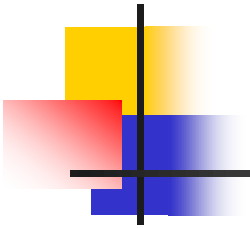
- Job Balance (Matrix Multiplication)
- A (m, n) * B (m', n') = C (n, m')

**Master process does the following in order**:

- Broadcasting matrix B to all slave processes;
- Sending a row of matrix A to each process.
- Receiving a row of matrix C from a slave process.
- Copying the received row into matrix C
- If the number of sent rows is less than the number of rows in matrix A, send a row to an idle process that completed its task. Repeat C, D, and E until the job is done.

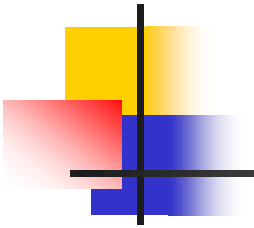
**A Slave process does**:

- Receiving matrix B;
- Receiving a row r of matrix A;
- Multiplying row r to matrix B to produce a row of matrix C
- Sending the resulted row back to the master process
- Repeating B, C, and D until the completion notice is received.



# Teaching Methods (continued)

- Communicator Creation
- Monte Carlo method to compute π
- Master process generates a set of random number repeatedly until it is noticed to terminated.
- Slave processes use the random numbers to generate points.
- Master process and slave process belong to different communicators.



# Conclusions

- Instructor training is essential to offer a sound teaching to our students in parallel computing and Software Engineering.
- OSCER is a very useful resource that can be used to improve teaching and learning quality.
- Proper teaching methods provide instructors with a efficient way to deliver their teaching materials.
- HPC has much to offer to the CS curriculum.
- Thanks to OSCER and its excellent staff!