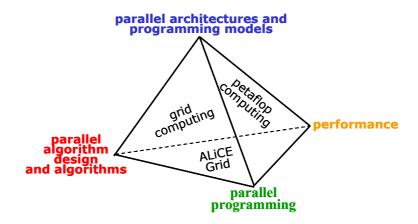
#### SINGAPORE-MIT ALLIANCE (COMPUTER SCIENCE)

# **SMA5505 / 6.338J/ 18.337J – Applied Parallel Computing**

Department of Computer Science, National University of Singapore (NUS) Spring 2004 (updated: 20 April 2004)



#### **Lecture Slides**

## <u>L0 – Course Admin</u>

## <u>L1 – Introduction</u>

- What, Why, How
- Classical (Modern) Science
- Definitions
- Evolution of Supercomputing
- Limits of Serial Computing
- Programming Parallel Computers
- Computing in the Internet Age
- Summary

## <u>L2 – Parallel Architectures and Programming Models</u>

- Architectures von Neumann, Flynn's taxonomy, memory model, interconnect
- Parallel Programming Models Shared, Distributed and Hybrid
- Designing Parallel Programs
- Overheads of Parallelism
- Summary

## L3 – Message Passing Computing

- Overview
- What is MPI?
  - Six Basic functions
  - Basic Program Structure
  - Basic Send and Receive
  - Types of Program
- Summary

#### L4 – Shared- Memory Programming

- OpenMP
- Data Parallelism
  - Shared memory Model
  - Parallel for Loops
  - Declaring Private Variables
  - Critical Sections
  - Reductions
  - Performance Improvements
  - More General Data Parallelism
- Functional Parallelism
- Summary

## <u>L5 – Parallel Algorithm Design</u>

- Motivation
- Task/Channel Model
- Algorithm Design Methodology
  - Partitioning
  - Communication
  - Agglomeration
  - Mapping
- Examples
  - Finding the Maximum
  - N-Body Problem
- Summary

## Lx – Parallel Algorithms (see Edelman's slides)

#### <u>L6 – Principles of Scalable Performance</u>

- Arguments against the Merit of Parallelism
- Performance Metrics
  - Average Program Parallelism
  - Harmonic Mean Performance
  - Efficiency, Utilization and Quality of Computation
- Applications / Algorithms
  - Application Models
  - Scalability of Parallel Algorithms
- Speedup Performance Laws
  - Fixed Workload Amdahl's Law (1967)
  - Scaled Problems Gustafson's Law (1987)
  - Memory-bounded Speedup Model Sun and Ni (1993)
- Scalability Analysis and Approaches
- Summary

## L7 – Grid Computing

- Internet 3 Generations
- The Grid Problem
- Why Grid and Why Now?
- What is Grid Computing?

- Types of Grid and Grid Computing Models
- Main Grid Computing Problems
  - Systems Problem
  - Programming Problem
- Where are we today?
  - Global Grid Forum
  - OGSA
  - OGSI
  - Globus Project, GT2, GT3
- GT3 Implementation & Terminology
- Summary

# L8 – Case Study of ALiCE Grid

- Cost of Idle Computing Cycles
- What and Why ALiCE?
- ALiCE
  - Design
  - Implementation
  - Grid Programming
  - Some Applications
- What's next?
  - Coping with System Complexities and Challenges
  - Desirable Properties of Large Distributed Systems
  - Ongoing Works
- Grid Computing Activities Worldwide and in Singapore
- References

#### <u>L9 – Conclusions</u>

- Supercomputing today
- Cost Comparison Supercomputer vs a Physical Cluster and a Virtual Grid of 100.000 PCs
- Distributed Computing Economics
- Petaflop Computing
  - Parallel Architectures
  - Application Requirements
- Predictions
- What have we covered?
- References

#### **Reference Texts**

- 1. Fundamentals of Parallel Processing, Harry Jordan, Gita Alaghband, Prentice-Hall, 2003.
- 2. Parallel Programming in C with MPI and OpenMP, Michael J. Quinn, Mc-Graw Hill. 2003.
- 3. Parallel Scientific Computing, Alan Edelman, Spring 2002 (draft).
- 4. Edelman's Notes