An Introduction to Parallel Programming
Solutions, Chapter 1

Jinyoung Choi and Peter Pacheco

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1.
```
quotient = n / p;
remainder = n % p;
if (my_rank < remainder) {
    my_n_count = quotient + 1;
    my_first_i = my_rank * my_n_count;
} else {
    my_n_count = quotient;
    my_first_i = my_rank * my_n_count + remainder;
}
my_last_i = my_first_i + my_n_count;
```

2. We are assigning blocks of elements to cores in order (the first n/p elements to core 0, the next n/p elements to core 1, so on). So, for example, if $n = 12$ and $p = 4$, core 0 spends 12 milliseconds in the call to Compute_next_value ($i = 0, 1, 2$), core 1 spends 30 milliseconds ($i = 3, 4, 5$), core 2 spends 48 milliseconds ($i = 6, 7, 8$), and core 3 spends 66 milliseconds ($i = 9, 10, 11$). So clearly this assignment will do a very poor job of load balancing.

   A better approach uses a *cyclic* assignment of the work to the cores:

```
/* assign[c][j] is the jth value of i assigned to core c   */
/* work[c] is the total amount of work assigned to core c */
c = j = 0;
for (i = 0; i < n; i++) {
    work[c] += 2*(i+1);
    assign[c][j] = i;
    c = (c + 1) % p;
    if (c == 0) j++;
}
```

1

Introduction To Parallel Programming Peter Pacheco Solutions

Kyoji Sassa,Kazuo Konagai,Binod Tiwari,Željko Arbanas,Shinji Sassa

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   An Introduction to Parallel Programming Peter Pacheco,Matthew Malensek,2021-08-27 An Introduction to Parallel Programming Second Edition presents a tried and true tutorial approach that shows students how to develop effective parallel programs with MPI Pthreads and OpenMP As the first undergraduate text to directly address compiling and running parallel programs on multi core and cluster architecture this second edition carries forward its clear explanations for designing debugging and evaluating the performance of distributed and shared memory programs while adding coverage of accelerators via new content on GPU programming and heterogeneous programming New and improved user friendly exercises teach students how to compile run and modify example programs Takes a tutorial approach starting with small programming examples and building progressively to more challenging examples Explains how to develop parallel programs using MPI Pthreads and OpenMP programming models A robust package of online ancillaries for instructors and students includes lecture slides solutions manual downloadable source code and an image bank New to this edition New chapters on GPU programming and heterogeneous programming New examples and exercises related to parallel algorithms

   Introduction to Parallel Programming Subodh Kumar,2023-01-05 In modern computer science there exists no truly sequential computing system and most advanced programming is parallel programming This is particularly evident in modern application domains like scientific computation data science machine intelligence etc This lucid introductory textbook will be invaluable to students of computer science and technology acting as a self contained primer to parallel programming It takes the reader from introduction to expertise addressing a broad gamut of issues It covers different parallel programming styles describes parallel architecture includes parallel programming frameworks and techniques presents algorithmic and analysis techniques and discusses parallel design and performance issues With its broad coverage the book can be useful in a wide range of courses and can also prove useful as a ready reckoner for professionals in the field

   An Introduction to Parallel Programming Scott L. Hamilton,2013-12-31 An introduction to parallel programming with openmpi using C It is written so that someone with even a basic understanding of programming can begin to write mpi based parallel programs   Parallel Programming with MPI Peter Pacheco,1997 Mathematics of Computing Parallelism

   Introduction to Parallel Computing Wesley P. Petersen,Peter Arbenz,2004 This is a practical student guide to scientific computing on parallel computers working up from a hardware instruction level to shared memory machines and finally to distributed memory machines   **Progress in Landslide Research and Technology, Volume 1 Issue 1, 2022** Kyoji Sassa,Kazuo Konagai,Binod Tiwari,Željko Arbanas,Shinji Sassa,2023-01-10 This open access book provides an overview of the progress in landslide research and technology and is part of a book series of the International Consortium on Landslides ICL The book provides a common platform for the publication of recent progress in landslide research and technology for practical applications and the benefit for the society contributing to the Kyoto Landslide Commitment 2020

which is expected to continue up to 2030 and even beyond to globally promote the understanding and reduction of landslide disaster risk as well as to address the 2030 Agenda Sustainable Development Goals **Forthcoming Books** Rose Arny,1996 **Applied Parallel Computing: Advanced Scientific Computing** Juha Fagerholm,Juha Haataja,Jari Järvinen,Mikko Lyly,Peter Raback,Ville Savolainen,2003-08-03 This book constitutes the refereed proceedings of the 6th International Conference on Applied Parallel Computing PARA 2002 held in Espoo Finland in June 2002 The 50 revised full papers presented together with nine keynote lectures were carefully reviewed and selected for inclusion in the proceedings The papers are organized in topical sections on data mining and knowledge discovery parallel program development practical experience in parallel computing computer science numerical algorithms with hierarchical memory optimization numerical methods and algorithms cluster computing grid and network technologies and physics and applications *Books In Print 2004-2005* Ed Bowker Staff,Staff Bowker, Ed,2004 **Books in Print Supplement** ,2002 *Mathematical Reviews* ,2005 **Python Parallel Programming Solutions** ,2017 This course gets you started programming in Python using parallel computing methods Learn how to work with parallel processes organize memory synchronize threads distribute tasks and more **Parallel Programming with MPI** Peter S. Pacheco,1997 **Python Parallel Programming Solutions** Giancarlo Zaccone,2017 Patterns for Parallel Programming Timothy G. Mattson,Beverly Sanders,Berna Massingill,2004-09-15 The Parallel Programming Guide for Every Software Developer From grids and clusters to next generation game consoles parallel computing is going mainstream Innovations such as Hyper Threading Technology HyperTransport Technology and multicore microprocessors from IBM Intel and Sun are accelerating the movement s growth Only one thing is missing programmers with the skills to meet the soaring demand for parallel software That s where Patterns for Parallel Programming comes in It s the first parallel programming guide written specifically to serve working software developers not just computer scientists The authors introduce a complete highly accessible pattern language that will help any experienced developer think parallel and start writing effective parallel code almost immediately Instead of formal theory they deliver proven solutions to the challenges faced by parallel programmers and pragmatic guidance for using today s parallel APIs in the real world Coverage includes Understanding the parallel computing landscape and the challenges faced by parallel developers Finding the concurrency in a software design problem and decomposing it into concurrent tasks Managing the use of data across tasks Creating an algorithm structure that effectively exploits the concurrency you ve identified Connecting your algorithmic structures to the APIs needed to implement them Specific software constructs for implementing parallel programs Working with today s leading parallel programming environments OpenMP MPI and Java Patterns have helped thousands of programmers master object oriented development and other complex programming technologies With this book you will learn that they re the best way to master parallel programming too **Using OpenMP** Barbara Chapman,Gabriele Jost,Ruud Van Der Pas,2007-10-12 A comprehensive overview of

OpenMP the standard application programming interface for shared memory parallel computing a reference for students and professionals I hope that readers will learn to use the full expressibility and power of OpenMP This book should provide an excellent introduction to beginners and the performance section should help those with some experience who want to push OpenMP to its limits from the foreword by David J Kuck Intel Fellow Software and Solutions Group and Director Parallel and Distributed Solutions Intel Corporation OpenMP a portable programming interface for shared memory parallel computers was adopted as an informal standard in 1997 by computer scientists who wanted a unified model on which to base programs for shared memory systems OpenMP is now used by many software developers it offers significant advantages over both hand threading and MPI Using OpenMP offers a comprehensive introduction to parallel programming concepts and a detailed overview of OpenMP Using OpenMP discusses hardware developments describes where OpenMP is applicable and compares OpenMP to other programming interfaces for shared and distributed memory parallel architectures It introduces the individual features of OpenMP provides many source code examples that demonstrate the use and functionality of the language constructs and offers tips on writing an efficient OpenMP program It describes how to use OpenMP in full scale applications to achieve high performance on large scale architectures discussing several case studies in detail and offers in depth troubleshooting advice It explains how OpenMP is translated into explicitly multithreaded code providing a valuable behind the scenes account of OpenMP program performance Finally Using OpenMP considers trends likely to influence OpenMP development offering a glimpse of the possibilities of a future OpenMP 3 0 from the vantage point of the current OpenMP 2 5 With multicore computer use increasing the need for a comprehensive introduction and overview of the standard interface is clear Using OpenMP provides an essential reference not only for students at both undergraduate and graduate levels but also for professionals who intend to parallelize existing codes or develop new parallel programs for shared memory computer architectures   *Principles of Parallel Programming* Yun Calvin Lin,Lawrence Snyder,2008 With the rise of multi core architecture parallel programming is an increasingly important topic for software engineers and computer system designers Written by well known researchers Larry Snyder and Calvin Lin this highly anticipated first edition emphasises the principles underlying parallel computation explains the various phenomena and clarifies why these phenomena represent opportunities or barriers to successful parallel programming Ideal for an advanced upper level undergraduate course Principles of Parallel Programming supplies enduring knowledge that will outlive the current hardware and software aiming to inspire future researchers to build tomorrow s solutions   **Designing and Building Parallel Programs** Ian Foster,1995-01 At last a practitioner s guide to parallel programming Students and professionals who use parallel or distributed computer systems will be able to solve real problems with Designing and Building Parallel Programs This book provides a comprehensive introduction to parallel algorithm design performance analysis and program construction It describes the tools needed to write parallel programs and provides numerous examples A unique feature is

the companion on line version accessible via the World Wide Web using browsers such as Mosaic This provides a convenient hypertext version of the text with pointers to programming tools example programs and other resources on parallel and distributed computing **Introduction to Parallel Programming** Steven Brawer,1989 *Parallel Programming Patterns* Timothy G. Mattson,Berna Massingill,Beverly Sanders,2018-03-06 From cloud computing to smartphones today s highest growth software environments depend on parallel programming That s why parallel programming is increasingly viewed as a foundational job skill expected of every professional developer However parallel computing requires traditional application developers to think and work differently that s why it s so often viewed as difficult In Parallel Programming Patterns three leading experts cut through the complexity showing how to think parallel and offering practical solutions to many of the challenges you ll encounter Drawing on immense experience programming parallel systems and teaching others to do so the authors cover all this and more What you need to know about concurrency in parallel programs parallel architecture and the jargon of parallel computing How to find concurrency and decompose tasks and data How to select and work with algorithm and supporting structures How to work with implementation mechanisms for UE management synchronization and communication Getting started with OpenMP MPI and concurrent programming in Java

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