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Distributed Computation on Graphs: Shortest Path Algorithms

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We use the paradigm of diffusing computation, introduced by Dijkstra and Scholten, to solve a class of graph problems. We present a detailed solution to the problem of computing shortest paths from a single vertex to all other vertices, in the presence of negative cycles.

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1. Introduction

This paper presents distributed algorithms based on the work of Dijkstra and Scholten [1], for solving graph problems using networks of communicating processes. The solution to one particular graph problem, that of finding shortest paths from a single vertex to all other vertices in a weighted, directed graph, in the presence of negative cycles, is discussed in detail. We then show how this solution may be applied to other graph problems including depth-first search in an undirected graph.

Our model of computation is a network of processes in which processes communicate only by sending and receiving messages; the model is presented in detail in Sec. 2. We describe the classical shortest path problem [2] and the necessary terminology from graph theory in Sec. 3. The distributed algorithm is given in Sec. 4 and its proof in Sec. 5. Applications to other graph problems are discussed in Sec. 6.

2. Model of a Network of Communicating Processes

A process is a sequential program which can communicate with other processes by sending/receiving messages. Two processes P and Q are said to be *neighbors* if they can communicate directly with one another without having messages go through intermediate processes. We assume that communication channels are bidirectional: if P can send messages to Q then Q can send messages to P. A process knows the identities of its neighbors; otherwise it is ignorant of the identities of all other processes and of the general structure of the network.

We assume a very simple protocol for message communication; this protocol is equivalent to the one used by Dijkstra and Scholten [1]. Every process has an input buffer of *unbounded* length. If process P sends a message to a neighbor process Q, then the message gets appended at the end of the input buffer of Q after a finite, arbitrary delay. We assume that (1) messages are not lost or altered during transmission, (2) messages sent from P to Q arrive at Q's input buffer in the order sent, and (3) two messages arriving simultaneously at an input buffer are ordered arbitrarily and appended to the buffer. A process receives a message by removing one from its input buffer.

The assumption of unbounded length buffers is for ease of exposition. We show, in Sec. 6, that for our problem the input buffer length of process Q can be bounded by the number of neighbors of Q.

3. The Shortest Path Problem

$G = (V, E)$ is a directed graph in which V is the set of vertices and E is the set of edges. Edge (v_i, v_j) has an associated length w_{ij}. If edge (v_i, v_j) exists then v_j is said to be a *successor* of v_i and v_i is said to be a *predecessor* of v_j. It is required to determine lengths of the shortest paths from a special vertex v_1 in V to all other vertices in V.[1] Since some w_{ij} may be negative, a cycle of negative total length (called a *negative cycle*) may exist in the graph. If a negative cycle is reachable from v_1 then all vertices reachable from that negative cycle will have a shortest path length of $-\infty$. The *distance* of a vertex v_i is the length of the shortest path from v_1 to v_i and is denoted by L_i.

[1] We assume familiarity with graph theoretic terms such as path, shortest path, etc.

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Distributed Computation On Graphs Shortest Path Algorithms

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Distributed Computation On Graphs Shortest Path Algorithms:

Distributed Computation on Graphs: Shortest Path Algorithms K. M. Chandy,J. Misra,TEXAS UNIV AT AUSTIN DEPT OF COMPUTER SCIENCES.,1982 The authors use the paradigm of diffusing computation introduced by Dijkstra and Scholten to solve a class of graph problems They present a detailed solution to the problem of computing shortest paths from a single vertex to all other vertices in the presence of negative cycles Author Integer Programming and Related Areas R.v. Randow,2012-12-06 **Parallel Computing and Transputer Applications** Mateo Valero,1992 Mathematics of Computing Parallelism *High-Speed Railway Operation Under Emergent Conditions* Limin Jia,Li Wang,Yong Qin,2021-07-17 This book addresses the current development status of high speed railways globally and analyzes their operational schemes and practices under emergent conditions It covers methods and problem solving philosophy with regard to complexity analysis capacity evaluation passenger flow forecasts operating strategies passenger flow allocation resource allocation and supporting technologies in the context of serious accidents and adverse environmental influences on train operation and service organization of high speed railways The abnormal scenarios emergent conditions adverse events and corresponding theoretical and applicational solutions dealing with the train operation both in line and network scale are all from real world cases related to and designed for Chinese high speed railway network which is the largest in scale the highest in complexity and the most difficult in tackling with the complex and diverse climate and geographical environment and thus makes the book both theoretically rigorous and practically applicable It not only helps readers consider the train and network interactions from the perspective of complexity science but also provides them with a philosophical framework and approaches available to construct their own roadmap and problem solving paradigms in their daily research or management This book is suitable for researchers postgraduates and managerial and engineering practitioners in railway related fields especially in high speed railway operation and emergency management **Algorithms - ESA '98** Gianfranco Bilardi,Giuseppe F. Italiano,Andrea Pietracaprina,Geppino Pucci,1998-01-01 9 Supercomputing Vladimir Voevodin,Sergey Sobolev,Mikhail Yakobovskiy,Rashit Shagaliev,2022-12-15 This book constitutes the refereed proceedings of the 8th Russian Supercomputing Days on Supercomputing RuSCDays 2022 which took place in Moscow Russia in September 2022 The 49 full papers and 1 short paper presented in this volume were carefully reviewed and selected from 94 submissions The papers are organized in the following topical sections Supercomputer Simulation HPC BigData AI Architectures Technologies Tools Distributed and Cloud Computing *Exploring New Frontiers of Theoretical Informatics* Jean-Jacques Lévy,Ernst W. Mayr,John C. Mitchell,2006-04-11 In recent years IT application scenarios have evolved in very innovative ways Highly distributed networks have now become a common platform for large scale distributed programming high bandwidth communications are inexpensive and widespread and most of our work tools are equipped with processors enabling us to perform a multitude of tasks In addition mobile computing referring specifically to wireless devices and more broadly to

dynamically configured systems has made it possible to exploit interaction in novel ways To harness the flexibility and power of these rapidly evolving interactive systems there is need of radically new foundational ideas and principles there is need to develop the theoretical foundations required to design these systems and to cope with the many complex issues involved in their construction and there is need to develop effective principles for building and analyzing such systems Reflecting the diverse and wide spectrum of topics and interests within the theoretical computer science community Exploring New Frontiers of Theoretical Informatics is presented in two distinct but interrelated tracks Algorithms Complexity and Models of Computation Logic Semantics Specification and Verification Exploring New Frontiers of Theoretical Informatics contains 46 original and significant contributions addressing these foundational questions as well as 4 papers by outstanding invited speakers These papers were presented at the 3rd IFIP International Conference on Theoretical Computer Science TCS 2004 which was held in conjunction with the 18th World Computer Congress in Toulouse France in August 2004 and sponsored by the International Federation for Information Processing IFIP **Surveys in Combinatorial Optimization** S. Martello,M. Minoux,C. Ribeiro,Gilbert Laporte,2011-09-22 A collection of papers surveying recent progress in the field of Combinatorial Optimization Topics examined include theoretical and computational aspects Boolean Programming Probabilistic Analysis of Algorithms Parallel Computer Models and Combinatorial Algorithms well known combinatorial problems such as the Linear Assignment Problem the Quadratic Assignment Problem the Knapsack Problem and Steiner Problems in Graphs and more applied problems such as Network Synthesis and Dynamic Network Optimization Single Facility Location Problems on Networks the Vehicle Routing Problem and Scheduling Problems *Proceedings of the Ninth Workshop on Algorithm Engineering and Experiments and the Fourth Workshop on Analytic Algorithms and Combinatorics* David Applegate,2007 Proceedings of the Seventh SIAM International Conference on Data Mining Proceedings of the Sundance Conference Held August 1,2,3, 1985 at Sundance, Utah, Under the Auspices of the Mathematics Department, Brigham Young University L. Kirk Tolman,1985 Extremal Paths in Graphs Ulrich Huckenbeck,1997 Web Information Systems and Applications Chunxiao Xing,Xiaoming Fu,Yong Zhang,Guigang Zhang,Chaolemen Borjigin,2021-09-16 This book constitutes the proceedings of the 18th International Conference on Web Information Systems and Applications WISA 2021 held in Kaifeng China in September 2021 The 49 full papers and 18 short papers presented were carefully reviewed and selected from 206 submissions The papers are grouped in topical sections on world wide web query processing and algorithm natural language processing machine learning data mining data privacy and security Fourth International Conference on Supercomputing and Third World Supercomputer Exhibition ,1989 **Introduction to Parallel Computing** Vipin Kumar,1994 Mathematics of Computing Parallelism **Congressus Numerantium** ,1970 **International Journal of Computer Systems Science & Engineering** ,2002 Acta Mathematica Vietnamica ,1995 **Supercomputing '89** ,1989 **Proceedings of International Computer Symposium, 1986** ,1986 **Proceedings, Fourth International Conference on**

Supercomputing and Third World Supercomputer Exhibition, Santa Clara Convention Center, Santa Clara, CA, USA, April 30-May 5, 1989: Supercomputing structures & computations ,1989

Distributed Computation On Graphs Shortest Path Algorithms Book Review: Unveiling the Power of Words

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