

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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General Terms: Algorithm, Theory

Additional Key Words and Phrases: distributed computation, shortest path, negative cycle, depth first search, diffusing computation

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.

* Former editor of Programming Techniques and Data Structures, of which Ellis Horowitz is the current editor.

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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.

Distributed Computation On Graphs Shortest Path Algorithms

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Distributed Computation On Graphs Shortest Path Algorithms:

This book delves into Distributed Computation On Graphs Shortest Path Algorithms. Distributed Computation On Graphs Shortest Path Algorithms is a crucial topic that must be grasped by everyone, from students and scholars to the general public. The book will furnish comprehensive and in-depth insights into Distributed Computation On Graphs Shortest Path Algorithms, encompassing both the fundamentals and more intricate discussions.

1. The book is structured into several chapters, namely:
 - Chapter 1: Introduction to Distributed Computation On Graphs Shortest Path Algorithms
 - Chapter 2: Essential Elements of Distributed Computation On Graphs Shortest Path Algorithms
 - Chapter 3: Distributed Computation On Graphs Shortest Path Algorithms in Everyday Life
 - Chapter 4: Distributed Computation On Graphs Shortest Path Algorithms in Specific Contexts
 - Chapter 5: Conclusion
 2. In chapter 1, this book will provide an overview of Distributed Computation On Graphs Shortest Path Algorithms. The first chapter will explore what Distributed Computation On Graphs Shortest Path Algorithms is, why Distributed Computation On Graphs Shortest Path Algorithms is vital, and how to effectively learn about Distributed Computation On Graphs Shortest Path Algorithms.
 3. In chapter 2, this book will delve into the foundational concepts of Distributed Computation On Graphs Shortest Path Algorithms. The second chapter will elucidate the essential principles that must be understood to grasp Distributed Computation On Graphs Shortest Path Algorithms in its entirety.
 4. In chapter 3, the author will examine the practical applications of Distributed Computation On Graphs Shortest Path Algorithms in daily life. The third chapter will showcase real-world examples of how Distributed Computation On Graphs Shortest Path Algorithms can be effectively utilized in everyday scenarios.
 5. In chapter 4, the author will scrutinize the relevance of Distributed Computation On Graphs Shortest Path Algorithms in specific contexts. This chapter will explore how Distributed Computation On Graphs Shortest Path Algorithms is applied in specialized fields, such as education, business, and technology.
 6. In chapter 5, the author will draw a conclusion about Distributed Computation On Graphs Shortest Path Algorithms. This chapter will summarize the key points that have been discussed throughout the book.
- This book is crafted in an easy-to-understand language and is complemented by engaging illustrations. It is highly recommended for anyone seeking to gain a comprehensive understanding of Distributed Computation On Graphs Shortest Path Algorithms.

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tindakan atau sikap yang dilakukan oleh individu atau