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Improving Performance of Object-Oriented Software for Distributed Systems using Restructuring Technique

A Thesis Submitted for the Degree of Doctor
of Philosophy in Electrical Engineering
(Computer and Control Engineering)

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Abstract

Recent years have seen increasing demands for faster computers that have led to the availability of distributed systems after the great advances in technology which decreased the prices of computers and processors units. The growing importance of distributed computing systems is reflected by the large applications that embrace them. At present, distributed computing permeates almost all aspects of computer science and engineering. Meanwhile, Object-Oriented programming is widely accepted for designing and implementing software systems application domains such as; air traffic control, high-speed communications, e-commerce and military systems. More and more software systems are built as distributed-object applications. Within this distributed heterogeneous environment, objects are the main building blocks that form the communication of distributed system. For such systems, performance is a key issue.

The main objective of this research work is to improve the performance of object-oriented based distributed systems. Two techniques were introduced to achieve such improvement. The first one is the restructuring technique which handles the software/hardware (SW/HW) mismatch problem. This problem often occurs in distributed computing environments. A novel restructuring technique was proposed to solve the mismatch problem taking into consideration both user and system requirements and/or constraints. The technique efficiently maps existing object-oriented software components into an available hardware satisfying the user and system performance requirements while achieving minimum total resource cost. A queuing model that considers the cost of both the execution and communication activities at each processing node is developed and used. This model provides a

way to evaluate the resources' cost required by the software modules. The restructuring technique uses a Genetic Algorithm - based search algorithm to find the optimal mapping of the software modules to the available processing nodes. The optimal mapping is defined to be the one that minimizes the overall resources' cost. The developed technique was applied to two of the most common architectures: the pipeline and the limited connectivity.

The second part of this dissertation proposes another technique which is the remapping technique. This technique aims to improve the performance of an existing object-oriented software system. The remapping technique considered the possibilities of remapping of the object-oriented software methods in each module to other processing nodes in the system with the goal of minimizing the total resource cost. Since the object is the sole of the object-oriented software, the concept of objects' data updating was introduced in this work. Data updating cost was included in the used queuing model and was evaluated as a part of the overall objective function. The queuing model was developed to extend the existing model system analysis to the level of class methods. The remapping technique used the simulated annealing – based algorithm to search for the solution that provides the best overall performance of the system.

Finally, simulators for each of the proposed techniques were implemented. The results of simulation programs proved the effectiveness of both techniques in improving the performance of the object-oriented distributed software.

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