Ain Shams University

Faculty of Engineering

Performance Evaluation of Artificial Intelligence Computer Systems

A thesis submitted for the degree of Ph.D.
in Electrical Engineering
(Computers & Systems Dept.)

by

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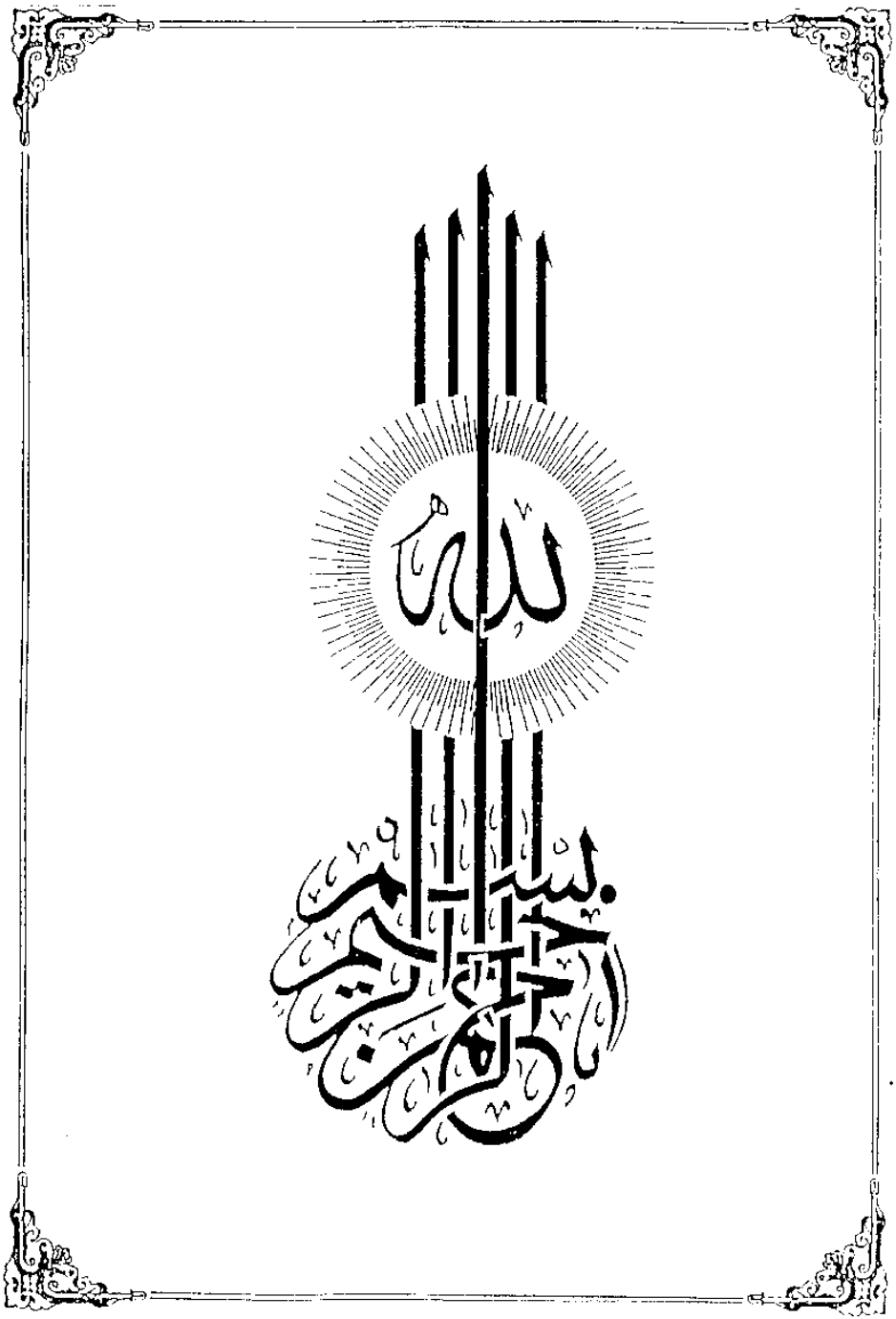

STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Ph. D. in Computer Engineering .

The work included in this thesis was carried out by the author in the Informatics Research Department, Electronics Research Institute, from June 1988 to April 1993 .

No part of this thesis has been submitted for a degree or a qualification at any other University or Institute .

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Summary

This thesis deals with performance evaluation of Artificial Intelligence (AI) computer systems. Concentration was on parallel processing for AI applications using logic programming. The thesis starts with a study of AI application demands from computer systems. A study of the multiprocessor system architectures, and sources of parallelism in logic programming (PROLOG) such as OR, AND, UNIFICATION, and STREAM parallelism is included. The thesis then surveys some algorithms to execute logic programs using the multiprocessor system architecture specifically the SPLITTING, AURORA model, and MUSE model techniques. The three selected techniques were studied, simulated on the computer, and compared. The comparative study takes into account some criteria such as the speed-up, execution time, processor utilization, and overhead. It was noticed that the performance of the MUSE technique was better than the other two techniques.

As the communication between the Processing Elements (PEs) of the multiprocessor system is important, three topologies of the interconnection networks were considered namely, the common shared bus, the crossbar, and the multiple bus networks. It was noticed that the multiple bus networks show its advantages over the other two because of its reconfigurability and multiple data paths between the processors and the memories. The cost of the multiple bus interconnection networks hit a reasonable and optimal balance among the three selected techniques , i.e. the bandwidth, throughput, and cost show an optimal performance.

Also Parallel Unification Machines (PUMs) were considered to exploit the unification parallelism (fine grain parallelism). It was noticed that the speed-up is not appreciable w.r.t. the number of matching processors used. This is so because of the overhead time consumed in management and overcoming the problem of inconsistency. It was more beneficial to direct the interest to large grain parallelism, (AND/OR) parallelism, instead of the fine grain one. The MUSE technique was selected for modification. An execution model was proposed to exploit AND/OR parallelism in logic programs. Also two scheduling algorithms were applied on two different AI programs as workloads (natural language processing parser, and an animal recognition expert system). It was noticed that the performance of the proposed model to exploit the AND/OR parallelism was better than its corresponding in the MUSE model to exploit OR parallelism only.

The scheduling algorithm matching with the semantics of the PROLOG search technique gives better performance than the other scheduling techniques. Also if the number of PEs increases, the global overhead time consumed will also increase; the overhead time will degrade the system performance. It is not recommended to increase the number of PEs as much as possible in a multiprocessor system but it is better to use a reasonable number of PEs specially when speed-up saturates.

Finally, Parallel Inference Machines (PIMs) were also considered to exploit the AND/OR parallelism in logic programs. A selected computer diagnostic expert system was used as a workload. The workload contained a large knowledge base. From the analysis and practical results, it was noticed that the multiprocessor system performance using the same workload to exploit AND/OR parallelism was slightly better than the performance of the PIMs up to a certain limit of PEs (in the selected case 20 PEs). After that number, the performance of the PIM was better than the multiprocessor system if the number of PEs increases. In fact the reason for the above results comes from the complexity of the workload and from the management technique used.

In general, it is recommended to use PIMs or logic machines in AI applications containing a large knowledge base. i.e. it is better to use AI machines to execute the large AI applications. While it is better to use conventional multiprocessor systems for the conventional applications (or for applications containing a small knowledge base).

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ABSTRACT

This thesis deals with performance evaluation of A.I. computer systems. A MUSE model was modified to exploit both AND and OR parallelism in logic programs (PROLOG). The study showed improvement over using MUSE based only on OR parallelism. Parallel Inference Machines were also investigated and compared with conventional machines.

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CHAPTER ONE

INTRODUCTION
&
SYSTEM DESCRIPTION

CHAPTER (1)

INTRODUCTION & SYSTEM DESCRIPTION

1.1 OBJECTIVE

The aim of this research is the study of the performance evaluation of Artificial Intelligence (AI) computer systems. AI is the area of computer science concerned with the design of intelligent computer systems , namely systems exhibiting characteristics normally associated with human intelligence. AI applications have certain special demands from computer systems. These applications are usually characterized by the following : symbolic processing , nondeterministic computations , dynamic execution , large potential for parallel and distributed processing and knowledge management. One major factor supporting the adoption of AI systems generation are ;

1- The handling of non-numerical data such as sentences , symbols , speech , graphics , and images is becoming increasingly important.

2- The processing tasks performed by computers are becoming more intelligent , moving from scientific calculations and data processing to AI applications. Some of those AI applications are expert systems , natural languages processing , machine learning , robotics , problem solving systems , and others.