AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
CAIRO – EGYPT
Computers and Systems Department

Load Balancing in Distributed Multi – Agent Computing Systems

A Thesis
Submitted in partial fulfillment for the requirements of the degree of
Master of Science in Electrical Engineering

Submitted by
Maha Abdel Aziz Mohamed Metawei
Research Assistant - Computers and Systems Dept.
Electronics Research Institute

Supervised by
Prof. Salma Abdel-Kader Ghoneim
Professor in the Computers and Systems Engineering Dept.
Faculty of Engineering – Ain Shams University

Prof. Salwa Mohamed Nassar
Acting President of the Electronics Research Institute
Head of the High Performance and Grid Computing Group

Dr. Sahar Mohamed Mahmoud Haggag
Assistant Professor in the Computers and Systems Engineering Dept.
Faculty of Engineering – Ain Shams University

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AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
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Examiners Committee

Name: **Maha Abdel Aziz Mohamed Metawei**
Thesis: **Load Balancing in Distributed Multi – Agent Computing Systems**
Degree: **Master of Science in Electrical Engineering**

Name, Title and Affiliation Signature

1. Prof. Hani Mohamed Kamal Mahdi
Computers and Systems Engineering Department
Faculty of Engineering - Ain Shams University

2. Prof. Reem Mohamed Reda Bahgat
Dean of Faculty of Computers and Information - Cairo University

3. Prof. Salma Abdel-Kader Ghoneim
Computers and Systems Engineering Department
Faculty of Engineering - Ain Shams University

4. Prof. Salwa Mohamed Nassar
Acting President of the Electronics Research Institute

Date: 24/6/2012

جـامعــة عـين شـمـس
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المهندسة / مها عبد العزيز محمد مطاوع
مساعد باحث - قسـم الحاسبات و النظم
معهــد بحــوث الإلكترونيــات

تحت إشراف

ا.د. / سلمى عبد القادر غنيم
أستاذ بقسـم هندسة الحاسبات و النظم
كليـــة الهندســـة – جامعـــة عيـــن شمـــس

ا.د. / سلوى محمد نصار
قائم بأعمال رئيس معهــد بحــوث الإلكترونيــات

د. / سحر محمد محمود حجاج
مدرس بقسـم هندسة الحاسبات و النظم
كليـــة الهندســـة – جامعـــة عيـــن شمـــس

يونيو ٢٠١٢

C.V.

Name of the Researcher	: Maha Abdel Aziz Mohamed Metawei
Date of Birth	: 12 March 1984
Place of Birth	: Cairo, Egypt
First University Degree	: B.Sc in Electrical Engineering
Department	: Computers and Systems Engineering
University	: Ain Shams university
Date of Degree	: June 2006
Current Job	: Research Assistant in the Computer & Systems Dept., Electronics Research Institute (ERI)

STATEMENT

This Thesis is submitted to Ain Shams University in partial fulfillment of the degree of Master of Science in Electrical Engineering.

The work included in this thesis was carried out by the author in the department of computer and systems, Ain Shams University.

No part of this Thesis has been submitted for a degree or a qualification at any other university or institute.

Name : Maha Abdel Aziz Mohamed Metawei
Signature:
Date :

ABSTRACT

Maha Abdel-Aziz Mohamed Metawei, "Load Balancing in Distributed Multi – Agent Computing Systems," Bachelor of Science, Ain Shams University, 2006

Key Words: Load balancing, distributed systems, cluster computing, multi-agent computing, task migration, credit-based algorithms, communication.

Problem definition and survey:

The multi – agent computing paradigm has been widely employed in building and developing several distributed computing applications. This popularity is mainly due to the inherent autonomy and scalability of multi – agent systems.

The load balancing issue in multi – agent systems is of prime importance as it is in traditional computing systems. However, it is more difficult to tackle due to the complexity of multi – agent systems regarding their reactivity, pro-activity and mobility. To efficiently response to user's queries in a multi-agent application, the agents are required to complete their designated tasks using the shortest amounts of time. However, if the mappings of agents to machines are not handled properly, it is likely that some machines will be overloaded with too many agents while some other machines may be idle. This results in unnecessarily long query response times. Thus, we need a judicious agent's management scheme to monitor the execution of agents and properly balance the workload of machines.

In this research, a dynamic load-balancing scheme is developed for implementation in an agent-based distributed system. Load balancing is achieved via agent migration from heavily loaded nodes to lightly loaded ones. The credit based concept is used for the dual objective of: 1) the

selection of agents which are candidate for migration, and 2) the selection of destination nodes. This represents an elaboration of previous research work aimed at the selection of agents only. Multiple linear regression is used as a tool to achieve our dual objective.

The proposed scheme is assumed to be plugged onto a nodal system, and is composed of three phases. The first phase is an offline operation; a multiple linear regression model is built to calculate the parameters of the regression equations for both the agent selection and location policies. The second phase is an information gathering during system operation. The third phase is an online evaluation of those equations based on the information gathered from the system elements and pre-calculated regression parameters. Decisions are taken based on the output of each equation. A complexity analysis for the proposed system operation is performed, the complete operation is $O(n^2)$ where n is the number of agents on the local host.

The proposed system is implemented and tested using JADE (**J**ava **A**gent **DE**velopment Framework), the multiple linear regression operation is performed using R Statistical Tool. The experimental results show a modified system operation in terms of reduced user's query response time, by implementing agent load balancing. The effect of the proposed system on the system load distribution is also shown.

Summary

The thesis tackles the design, the implementation and the testing of a multi-agent based load balancing system. The thesis is composed of eight chapters together with the table of contents, the list of Figures and tables, the list of symbols and the references. The thesis contents are presented hereafter:

The thesis starts with:

- a list of Figures
- a list of tables
- and a list of abbreviations and symbols.

Following is a brief overview of the contents of the chapters:

Chapter 1: Introduction

It starts with a qualitative description of the mobile agent characteristics, description of mobile agent systems and its advantages over regular client-server designs.

Chapter 2: Load balancing for Mobile Agent Systems

This chapter gives the thesis general description as an attempt for load balancing in a dynamic environment based on Mobile Agent as a nodal system. It also gives a survey on the attempts reported in the literature on the use of multi-agent systems to implement load balancing systems for multi-agents applications.

Chapter 3: Proposed System Description

It is a detailed description of the proposed load balancing system, the mobile agents types, the preparation of the candidate agent lists for migration and candidate destination node lists, how to sometimes reject incoming load and

its reasons. It also gives a detailed description of the used algorithm and its complexity analysis thus the system operation time complexity.

Chapter 4: System Policies

It focuses on the system policies. It gives a detailed description of the multiple linear regression analysis to calculate the system coefficients used in those policies and how to gather the needed information. It also gives example of regression models for selection and location policies.

Chapter 5: Load Balancing System Implementation

It gives a detailed description of the system implementation, the agent development framework, the agent classes and the statistical tool used to perform the regression analysis.

Chapter 6: Experimental Environment

It explains the experimental environment, the machines specifications, the points of examinations and the assumptions made to determine the nodal load.

Chapter 7: Results and Discussions

It presents the experimental results with its discussions, it gives the system state after and before steady state. It also shows the effect of the proposed model for load balancing in terms of reducing the user response time.

Chapter 8: Conclusion and Future Work

It gives the conclusion and recommendations for future work including studying the system dependencies and calculating the actual time taken in agent mobility, also the feasibility of using a dynamic inter-agent communication pattern .

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Signature:

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