

KAIST Research Series

Series editors

I.S. Choi, Daejeon, Republic of Korea

J.S. Jeong, Daejeon, Republic of Korea

S.O. Kim, Daejeon, Republic of Korea

C. Kyung, Daejeon, Republic of Korea

B. Min, Daejeon, Republic of Korea

More information about this series at <http://www.springer.com/series/11753>

Chan-Hyun Youn · Min Chen
Patrizio Dazzi

Cloud Broker and Cloudlet for Workflow Scheduling

 Springer

Chan-Hyun Youn
School of Electrical Engineering
KAIST
Daejeon
Korea (Republic of)

Patrizio Dazzi
Area della Ricerca di Pisa
ISTI-CNR
Pisa
Italy

Min Chen
Embedded and Pervasive Computing (EPIC)
Lab
Huazhong University of Science and
Technology
Wuhan, Hubei
China

ISSN 2214-2541

KAIST Research Series

ISBN 978-981-10-5070-1

DOI 10.1007/978-981-10-5071-8

ISSN 2214-255X (electronic)

ISBN 978-981-10-5071-8 (eBook)

Library of Congress Control Number: 2017943825

© Springer Nature Singapore Pte Ltd. 2017

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by Springer Nature

The registered company is Springer Nature Singapore Pte Ltd.

The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Contents

1	Integrated Cloud Broker System and Its Experimental Evaluation	1
1.1	Cloud Broker System Overview	1
1.1.1	Service Provider and User Perspectives	2
1.1.2	Cloud Resource Broker Perspectives	3
1.1.3	Bipartite SLAs Between Stakeholders	4
1.2	VM Resource Management Schemes in Cloud Brokers	6
1.2.1	Resource Management System in Heterogeneous Cloud Environment	6
1.2.2	Technical Requirement of Brokers for Heterogeneous Cloud Resource Management	8
1.2.3	Application Characteristics and Requirements for Application Aware Resource Management Scheme in Heterogeneous Cloud Environment	10
1.2.4	Architecture of Brokers for Heterogeneous Cloud Resource Management	12
1.3	Adaptive Resource Collaboration Framework [13]	14
1.3.1	The Architecture of ARCF [13]	16
1.3.2	Resource Monitoring	18
1.4	Science Gateway Overview	20
1.5	Scientific Workflow Applications	21
1.5.1	Programming Models for Scientific Applications [26]	22
1.5.2	Next Generation Sequencing for Genome Analysis	23
1.6	Conventional Service Broker for Scientific Application in Cloud	24
1.6.1	Service Broker for Computational Chemistry Tool	25
1.6.2	A Distributed Bio-workflow Broker on Clouds	27

1.7	Cost Adaptive Resource Management in Science Gateway	29
1.7.1	Pricing Model for Scientific Computing	29
1.7.2	Cost Adaptive Resource Allocation in Science Gateway	31
1.8	Workflow Scheduling Scheme with Division Policy.	32
1.9	Test Environments for Performance Evaluation on Resource Management Schemes of the Science Gateway	36
1.10	Performance Evaluation on Resource Management Schemes of Science Gateway	39
	References.	43
2	VM Placement via Resource Brokers in a Cloud Datacenter.	47
2.1	Introduction	47
2.2	Computing-Aware Initial VM Placement	49
2.2.1	Overview	49
2.2.2	Computing-Aware Initial VM Placement Algorithm	49
2.3	VM Reallocation Based on Resource Utilization-Aware VM Consolidation and Dispersion	52
2.3.1	Overview	52
2.3.2	System Architecture	52
2.3.3	Cost Optimization Model of TP-ARM in Clouds	54
2.3.4	Heuristic Algorithms for the Proposed TP-ARM Scheme	58
2.3.5	Evaluation	61
2.3.6	Conclusion	72
	References.	72
3	Cost Adaptive Workflow Resource Broker in Cloud	75
3.1	Introduction	75
3.2	Background and Related Works	76
3.2.1	Workflow Control Schemes	76
3.3	Objectives.	78
3.3.1	Guaranteeing SLA.	78
3.4	Proposed System Model for Cost-Adaptive Resource Management Scheme	79
3.4.1	Assumption	79
3.4.2	Requirement Descriptions	79
3.4.3	A Layered Cloud Workflow System (LCW)	80
3.5	Proposed Cost Adaptive Workflow Scheduling Scheme	83
3.5.1	Workflow Resource Allocation Optimization Problem.	84
3.5.2	Obtaining Expected Throughput Based on Estimated Completion Time	84

- 3.6 Proposed Marginal Cost Based Resource Provisioning Scheme 86
 - 3.6.1 VM Resource Allocation Procedure 87
 - 3.6.2 Marginal Cost Based Adaptive Resource Reservation Scheme 90
 - 3.6.3 Adaptive Resource Allocation Heuristics 91
- 3.7 Experiment and Results 95
 - 3.7.1 Evaluation Environments. 95
 - 3.7.2 Evaluation of the Proposed ARRS 98
 - 3.7.3 Evaluation of the Proposed A3R Policies 100
- 3.8 Conclusions 101
- References. 102
- 4 A Cloud Broker System for Connected Car Services with an Integrated Simulation Framework 105**
 - 4.1 Introduction 105
 - 4.2 A Cloud Broker System for V2C Connected Car Service Offloading. 106
 - 4.2.1 V2C Connected Car Service 106
 - 4.2.2 An Architecture of the Cloud Broker System with Service Offloading Strategies. 109
 - 4.3 An Integrated Road Traffic-Network-Cloud Simulation Framework for V2C Connected Car Services Using a Cloud Broker System 112
 - 4.3.1 An Overview. 112
 - 4.3.2 An Architecture of the Integrated Simulation Framework 113
 - 4.3.3 The Extension of the Integrated Simulation Based on the Inverse Simulation Technique 123
 - 4.3.4 A Proof-of-Concept Study of the Service Execution with the Cloud Broker System 128
 - 4.4 Conclusion 131
 - References. 131
- 5 Mobile Device as Cloud Broker for Computation Offloading at Cloudlets 135**
 - 5.1 Introduction 135
 - 5.1.1 Overview of the Cloud Category 135
 - 5.1.2 Computation Offloading from Remote Cloud to Mobile Cloudlet 135
 - 5.1.3 Cloud Broker from Cloud to Mobile Device. 138
 - 5.2 New Architecture of Computation Offloading at Cloudlet 139

5.3	A Study on the OCS Mode	141
5.3.1	Computation Allocation	141
5.3.2	Computation Classification	142
5.4	Allocation Problem in Mobile Device Broker.	143
	References.	146
6	Opportunistic Task Scheduling Over Co-located Clouds	147
6.1	Introduction	147
6.2	Background and Related Works	148
6.2.1	Task Offloading Based on Remote Cloud	149
6.2.2	Task Offloading Based on Mobile Cloudlets.	150
6.3	Opportunistic Task Scheduling Over Co-located Clouds Mode	150
6.3.1	Motivation.	150
6.3.2	OSCC Mode	151
6.4	OSCC Mode.	153
6.4.1	Task Duration	155
6.4.2	Energy Cost	157
6.5	Analysis and Optimization for OSCC Mode.	158
6.5.1	Analysis for Task Duration in OSCC Mode	158
6.5.2	Analysis for Energy Cost in Remote Cloud Mode, Mobile Cloudlets Mode and OSCC Mode	160
6.5.3	Optimization Framework.	163
6.6	Performance Evaluation	163
6.6.1	Task Duration	163
6.6.2	Energy Cost in Remote Cloud Mode, Mobile Cloudlets Mode and OSCC Mode	167
6.6.3	Optimization Framework.	168
	References.	170
7	Mobility-Aware Resource Scheduling Cloudlets in Mobile Environment	173
7.1	Introduction	173
7.1.1	Mobile Environment of Heterogeneous Network.	173
7.1.2	Resource Scheduling in Cloudlet	174
7.2	Resource Scheduling Based on Mobility-Aware Caching.	175
7.2.1	Caching Model in SBS and User Device	175
7.2.2	Mobility-Aware and SBS Density Caching (MS-Caching)	176
7.2.3	Simulation Results and Discussions	178
7.3	Resource Scheduling Based on Mobility-Aware Computation Offloading.	181
7.3.1	Edge Cloud Computing.	181
7.3.2	Caching Vs. Computation Offloading	182

- 7.3.3 Hybrid Computation Offloading 182
- 7.3.4 Simulation Results and Discussions 184
- 7.4 Incentive Design for Caching and Computation Offloading 186
- References. 187
- 8 Machine-Learning Based Approaches for Cloud Brokering 191**
 - 8.1 Introduction 191
 - 8.2 Different Ways to Achieve Machine Learning 192
 - 8.3 Different Methodologies for Machine Learning 193
 - 8.4 Machine Learning and Cloud Brokering. 196
 - 8.5 The Current Landscape of Machine-Learning Enabled Cloud
Brokering Approaches 196
 - 8.5.1 Machine-Learning Based Application Placement
in Cloud Federation 197
 - 8.5.2 Machine-Learning Solutions to Deal with Uncertainty 202
 - 8.5.3 Genetic-Based Solutions for Application Placement 206
 - 8.6 Conclusion 210
 - References. 211