A Comparative Analysis of OpenStack Autoscaling Engines: Evaluating Performance and Scalability, and Usability of Heat and Senlin under Real-World Workload Patterns

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DECLARATION

I declare that this is my own work, and this thesis/dissertation does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any other University or Institute of higher learning, and to the best of my knowledge and belief, it does not contain any material previously published or written by another person except where the acknowledgment is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

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The above candidate has carried out research for the master's thesis/dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Dr. M.P.A.P. Wijayasiri

Signature of the Supervisor: Date: 21.04.2025

DEDICATION

I dedicate this thesis to the individuals who have helped me along the way in my academic career. I appreciate seeing this journey through to the very finish.

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ABSTRACT

Cloud computing is a demanded field that opens the door for various possibilities due to its characteristics such as flexibility and on-demand availability. Basically, it presents an infrastructure for different kinds of services and tools via the public internet [1]. Auto-scaling, that is allocating and deleting resources without the involvement of the user, is one of the principal features in the domain of cloud computing. [2]. In domain of autoscaling on cloud systems, the demand for autoscaling systems, applications and services continues to surge, there is an increasing need for flexible and cost-efficient solutions to handle dynamic traffic patterns. Most of the time private cloud based autoscaling solutions are not used, because of the absence of proper information of the private cloud based autoscaling solutions and their performance. Specially in OpenStack who is the leading private cloud provider in the domain of cloud computing. As a result of this lack of knowledge and performance information of the private cloud based autoscaling solutions, the community are still using manual scaling methods when necessary or they are using public cloud based autoscaling solutions. However, there are several identified issues such as inefficiency and management challenges in manual scaling methods. When it comes to the public cloud based autoscaling solutions, there are set of challenges and cons for example, lack of cost-effectiveness, lack of transparency and administrative control, and vendor lock-in issues are few of them. As a solution for the above-mentioned issues, in this project we are giving the community an opportunity to get an idea about the OpenStack based autoscaling solutions (namely Heat and Senlin) and their behavior and performance against various kinds of practical workloads. As per our knowledge, there is not any previous literature that compares the different autoscaling solutions in OpenStack cloud. This work involves doing comprehensive research on the existing cloud-based auto-scaling solutions and the Zed version of fully functional OpenStack environment is implemented including the Heat and the Senlin projects. These autoscaling engines are tested with 10 different kinds of practical workloads which are generated using Apache JMeter and their performance metrics are recorded. These metrics are analyzed using MCDA method and the optimum autoscaling solution for each workload pattern is determined. We hope this work will contribute to the community who are interested in OpenStack based autoscaling to decide the proper autoscaling solution based on the nature of their workloads.

Keywords: Cloud computing, Auto-scaling, OpenStack, Heat, Senlin, MCDA

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LIST OF ABBREVIATIONS

Abbreviation	Description
VM	Virtual Machine
OS	Operating System
AWS	Amazon Web Services
GCE	Google Compute Engine
GCP	Google Compute Provider
VPS	Virtual Private Server
CMS	Content Management System
URL	Uniform Resource Locator
CPU	Central Processing Unit
RNN	Recurrent Neural Network
LSTM	Long Short-Term Memory network
AR	Auto Regressive
ARMA	Auto Regressive Moving Average
ES	Exponential Smoothing
API	Application Programming Interface
MQ	Message Queue
SLA	Service Level Agreement
MIMO	Multi-Input, Multi-Output
ML	Machine Learning
RT	Response Time
QPS	Queries Per Second
RDBMS	Relational Database Management System
MCDA	Multi-Criteria Decision Analysis

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