A HYBRID APPROACH FOR DYNAMIC TASK SCHEDULING IN UNFORESEEN ENVIRONMENTS USING MULTI AGENT REINFORCEMENT LEARNING AND ENHANCED Q-LEARNING

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Degree of Master of Science in Artificial Intelligence

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Declaration

I declare that this dissertation does not incorporate, without acknowledgment, any material previously submitted for a Degree or a Diploma in any University and to the best of my knowledge and belief, it does not contain any material previously published or written by another person or myself except where due reference is made in the text. I also hereby give consent for my dissertation, if accepted, to be made available for photocopying and for interlibrary loans, and for the title and summary to be made available to outside organization.

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Supervised by

Name of Supervisor(s)	Signature of Supervisor(s)
Dr. Thushari Silva	Date: 30/10/2020

Dedication

I dedicate this thesis to my parents who are the pioneers and great pillars that reinforced my education and always supported and inspired me. This thesis is gratefully dedicated to all the lecturers of Department of Computational Mathematics, Faculty of Information Technology, University of Moratuwa.

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Abstract

The process of assigning most appropriate resources to workstations or agents at the right time is termed as Scheduling. The word is applied separately to tasks and resources in task scheduling and resource allocation accordingly. Scheduling is a universal theme being conferred in technological areas like computing and strategic areas like operational management. The core idea behind scheduling is the distribution of shared resources across time for competitive tasks. Optimization, efficiency, productivity and performance are the major metrics evaluated in scheduling. Effective scheduling under uncertainty is tricky and unpredictable and it's an interesting area to study. Environmental uncertainty is a challenging extent that effect scheduling based decision making in work environments where environment dynamics subject to numerous fluctuations frequently.

Reinforcement Learning is an emerging field extensively research on environmental modelling under uncertainty. Optimization in dynamic scheduling can be effectively handled using Reinforcement learning. This research is about a research study that focused on Reinforcement Learning techniques that have been used for dynamic task scheduling. This thesis addresses the results of the study by means of the state-of-the-art on Reinforcement learning techniques used in dynamic task scheduling and a comparative review of those techniques. This thesis reports on our research on a Hybrid Approach for Dynamic Task Scheduling in Unforeseen Environments using the techniques; Multi Agent Reinforcement Learning and Enhanced Q-Learning.

The proposed solution follows online and offline reinforcement learning approaches which works on real time inputs of heuristics like, Number of agents involved, current state of the environment and backlog of tasks and sub-tasks, Rewarding criteria etc. The outputs are the set of scheduled tasks for the work environment. The solution comes with an approach for priority based dynamic task scheduling using Multi Agent Reinforcement Learning & Enhanced Q-Learning. Enhanced Q-Learning includes developed algorithm approaches; Q-Learning, Dyna Q+ Learning and Deep Dyna-Q+ Learning which is proposed as an effective methodology for scheduling problem.

The novelty of the solutions resides on implementation of model-based reinforcement learning and integration with the model-free reinforcement learning algorithmic approach by means of Dyna-Q+ Learning and Deep Dyna-Q+ Learning for dynamic task scheduling in an unforeseen environment. The research project also concentrates on how the dynamic task scheduling is managed within a constantly updating environment which the Deep Dyna-Q+ has provided a ground solution to cater this requirement. The end solution has comparatively evaluated the product using evaluation metrics in each of the three Q-Learning variations developed. As per the evaluation results it was revealed Deep Dyna-Q+ implementation would cater well the problem of dynamic task scheduling in an unforeseen environment.

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Abbreviations

DL	-	Deep Learning
RL	-	Reinforcement Learning
DRL	-	Deep Reinforcement Learning
QL	-	Q Learning
DQL	-	Deep Q Learning
DQN	-	Deep Q-Network
MDP	-	Markov Decision Process
MARL	-	Multi Agent Reinforcement Learning
DDQ+	-	Deep Dyna Q+ Learning
GPU	-	Graphics Processing Unit