A MULTI AGENT BASED ELECTRICITY METER MANAGEMENT SYSTEM

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Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Artificial Intelligence

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement 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 acknowledgement 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).

Signature: Date: 21st July 2024

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

Name of Supervisor:

Dr. A T P Silva

Signature of the Supervisor: Date: 22/7/2024

ABSTRACT

Electricity grid is evolving from a one-way power flowing traditional grid to a two-way power flowing Smart Grid with embedded generators, battery storages and electrical vehicles driven by the need for addressing climate change challenges. Following these changes of the electricity grid, electricity meters also have evolved from mechanical meters to Smart Meters that are capable of measuring two-way power flow, communicating in both ways and controlling power flow. Advanced Metering Infrastructure is becoming the key system in Smart Grid, making Smart Meter the key component in Smart Grid. Moving from traditional grid to Smart Grid has to face the challenge of managing millions of different types of meters in the same system. This research work using Multi Agent Technology will address this critical challenge.

For the purpose of providing a solution for the challenge of managing electricity metering system, planning and policy evaluation part in management were considered. The planning activities were divided into several planning subtasks. The considered subtasks of management in this study consist of preparation of annual maintenance plan, preparation of material plans and evaluation of metering policies. By its nature the considered problem is currently tackled by the power system professionals, it was identified their approach involve dividing planning tasks among different individuals with different authorities and responsibilities. The inspiration for using Multi Agent Planning technology derived from that. Further, it was seen that the domain knowledge and the problem solving knowledge can also be separated. This led to modeling the domain knowledge as an OWL ontology and the problem solving knowledge into the skills of the agents in the designed Multi Agent System. The system takes metering ontology, meter database, meter issues, working days of employees and stock levels as inputs to the system for providing outputs of maintenance plan, material plan and policy evaluation report. Designed Multi Agent System consists of four types of agents namely; MA agent, EA agent, SK agent and ES agent. MA agent acts as the interface agent and takes inputs from the user. Based on the user inputs, MA agent assigns EA agent planning or policy evaluation tasks. Upon receiving instructions from MA agent, EA agent prepares Activity Plans comparing meter data base and meter issues with the SPARQL queries on OWL ontology. Subsequently, depending on MA agent's instructions, EA agent allocates tasks of material planning and preparation of Activity Schedule to SK agent and ES agents respectively. Once the ES agents prepared their Activity Schedules, EA agent merges those into one schedule. OWL ontology was created using Protégé ontology editing tool and the Multi Agent System was developed in Microsoft VScode. The developed system was evaluated using a set of data relevant to actual smart meters. Evaluation was done in three steps; manually by human employees, using a spreadsheet and using the developed system. Results revealed that the developed system can produce required plans more quickly with much more details.

Key Words: MAS, MAP, Ontology, AMI, Electricity Metering

DEDICATION

It is with great pleasure that I am dedicating this thesis to all who have helped me in the journey of education including my supervisor Dr. A T P Silva, all of my teachers, my wife, parents, brothers and my good friends.

ACKNOWLEDGEMENT

My sincere gratitude to Dr. A T P Silva for supervising this project and giving invaluable guidance and timely feedback along the way.

Further, I would like to appreciate all the lecturers of Department of Computational Mathematics for the guidance given to me throughout this program.

Ceylon Electricity Board, my place of work, is acknowledged for inspiring me to carry out this project in a practical way and the extended support.

Finally, heartfelt gratitude to my family for standing by me and for believing in me and also my colleagues and friends for the support and companionship throughout.

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LIST OF ABBREVIATIONS

Abbreviation	Description
CEB	Ceylon Electricity Board
LECO	Lanka Electricity Company Private Limited
AI	Artificial Intelligence
PUCSL	Public Utilities Commission of Sri Lanka
MAS	Multi Agent Systems
MAP	Multi Agent Planning