CERTIFICATE

I certify that the thesis entitled "**Energy Efficient Clustering and Routing Techniques in Hierarchical Wireless Sensor Networks**" submitted for the degree of Doctor of Philosophy (PhD) in Electronics and Communication Engineering, is the record of research work carried out by **Mrs. Y. P. Makimaa (19PHELF002)** during the period of her study from July 2019 to March 2024 in the department of Electronics and Communication Engineering at Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore under my guidance and supervision and the thesis has not formed the basis for the award of any Degree / Diploma / Associate ship / Fellowship or any other similar titles of any candidate of this Institute or any other University / Institution of Higher Learning.

Signature of the HoD

Signature of the Supervisor

Signature of the Dean

DECLARATION

I, **Ms.Y.P.Makimaa**, hereby declare that the thesis entitled "**Energy Efficient Clustering and Routing Techniques in Hierarchical Wireless Sensor Networks**" submitted to the Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, in the partial fulfilment of the requirements for the award of the Degree of **Doctor of Philosophy (PhD) in Electronics and Communication Engineering** is a record original and independent research work carried out by me during the period from July 2019 to March2024 under the guidance of **Dr.R.Sudarmani M.E., Ph.D.**, Associate Professor and HoD, Department of Electronics and Communication Engineering, School of Engineering, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore and has not formed the basis for the award of any Degree/Diploma/Associate ship/Fellowship or any other similar titles in this Institute or any other University / other similar Institution of Higher Learning.

Y.P. Makimaa

Signature of the Supervisor **Signature of the Research Scholar**

ACKNOWLEDGEMENT

First and foremost, praises and thanks to the God, the Almighty, for His showers of blessings throughout my research work to complete the research successfully.

I would like to place on record my reverential gratitude to Late. Ayya **Dr.T.S.AVINASHILINGAM** Avl., Founder President and First Chancellor of Avinashilingam University for Women, Coimbatore for providing the temple of learning and I owe my sincere and humble gratitude to Late Amma **Dr. RAJAMMAL P. DEVADAS** Avl., Former Chancellor, Avinashilingam University for Women, Coimbatore for their heavenly blessings.

I place my gratitude to **Dr.T.S.K.MEENAKSHISUNDARAM**, Chancellor and Managing Trustee, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for providing good infrastructure, working atmosphere in this prestigious institution and help rendered towards the successful completion of the study.

I express my immense gratitude to **Dr.V.BHARATHI HARISHANKAR**, Vice Chancellor, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for the academic support and the facilities provided to carry out the research work.

I express my special thanks to **Dr.S.KOWSALYA**, Registrar, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for extending precious help to carry out the research.

I place my gratitude and heartfelt thanks to **Dr.P.LALITHA**, Dean, Research and Development and **Dr.K.MANIMOZHI**, Controller of Examinations, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for the valuable and constructive suggestions for the smooth conduct of the study.

I also record my thanks to **Dr.B.SARGUNAM,** Professor and Dean, School of Engineering, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for her support, timely help, encouragement and cooperation rendered towards the completion of this research.

I wish to express my deep and sincere gratitude to my supervisor **Dr.R.SUDARMANI M.E., Ph.D.**, Associate Professor and HoD, Department of Electronics and Communication Engineering, School of Engineering, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for giving me the opportunity to do research and providing in valuable guidance throughout this research. She taught me the methodology to carry out the research and to present the research work as clearly as possible. It was a great privilege to study under her guidance.

I am very much grateful to my Doctoral Committee Member **Dr.N.SATHISH KUMAR**, Professor, Department of Electronics and Communication Engineering, Sri Ramakrishna Engineering College, Coimbatore, for his constant support and encouragement throughout my work.

I also convey my thanks to the **FACULTY MEMBERS, NON-TEACHING** staff and **RESEARCH SCHOLARS** of the Department of Electronics and Communication Engineering for their co-operation and support throughout my work.

Finally, I express my warm gratitude to all my **FRIENDS** and other **FAMILY MEMBERS** for their valuable help and suggestions rendered for the completion of the research work.

Y.P. MAKIMAA

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

WSN	Wireless Sensor Networks
WC	Wireless Communication
SU	Sensing Unit
ADC	Analog to Digital Converter
RAM	Random Access Memory
ROM	Read Only Memory
EEPROM	Electrically Erasable Programmable Read Only Memory
CH	Cluster Head
GA	Genetic Algorithm
DE	Differential Evolution
PSO	Particle Swarm Optimization
ACO	Ant Colony Optimization
BFO	Bacterial Foraging Optimization
QoS	Quality of Service
CSO	Chicken Swarm Optimization
SSA	Squirrel Search Algorithm
FSA	Fish Swarm Algorithm
ABC	Artificial Bee Colony optimization
FFO	Fire Fly Optimization
GWO	Grey Wolf Optimization
BPSO	Binary Particle Swarm Optimization

TCO	Termite Colony Optimization
HSA	Harmony Search Algorithm
RTA	Reliable Trustworthy Approach
BA	Bat Algorithm
NLSTD	Node Location Speed Time based Detection
LEACH	Low Energy Adaptive Clustering Hierarchy
TDMA	Time Division Multiple Access
CDMA	Code Division Multiple Access
ACE	Algorithm for Cluster Establishment
MSRP	Multi Criteria Based Secured Routing Protocol
ODNB	On Demand and Node Behaviour
MWSN	Mobile Wireless Sensor Network
ODR	On Demand Routing
TMS	Trust Management System
ESMR	Energy Efficient and Secure Mobile node Re-authentication scheme
AODV	Ad-hoc On Demand Distance Vector Routing
TSRF	Trust aware Secure Routing Framework
DoS	Denial of Service
TEC	Total Energy Cost