Ph.D. Thesis Format

The Ph.D. thesis must be written in the prescribed format as mentioned below:

Printing Format: **BOTH SIDE PRINTING**
Type of Paper: **Executive Bond**
Font: **Times New Roman**
Minimum No. of Pages of the Thesis shall be - 110 & Maximum shall be – 250.
Format of Spine (Year, Title and Author)

- Thesis front(cover) page
- Title Page (bifurcated with a transparent sheet)
- Copyright(Backside of Title Page)
- Declaration by the Scholar
- Certificate by Supervisor
- MSP Certificate
- Dedication page(if any)
- Acknowledgement
- List of Symbols & Abbreviations
- Table of Contents / Index
- List of Tables
- List of Figures
- Abstract

Chapters

1. Introduction (shall include problem statement, objectives, hypothesis, Research methodology, scope, rationale, contribution and thesis outline)
2. Indian Knowledge System
3. Literature survey
4.
5.
6.

..
..
..

Chapters related to the Thesis work

Last Chapter: Conclusion and Future Work
References (shall be in APS/APO Style)
Appendices if any
Plagiarism report
List of Publications and Conferences (copy of atleast two publications)
2 best Certificate of paper presentation in National / International Conferences/Seminar/ Symposium/Workshop related to the research work of Thesis.

Diagrams
14.Thesis Report
15.General Guidelines

<u>Colour of the Thesis Cover :</u>

S.No.	Name of the School	Background Colour	Colour of the font on Cover	Sample
1	Business Study	Navy Blue	Golden	**Ph.D Thesis**
2	Basic & Applied Sciences	Maroon	Golden	**Ph.D Thesis**
3	Engineering	Black	Silver	**Ph.D Thesis**
4	Education	Sky Blue	Black	**Ph. D Thesis**
5	Humanities & Social Sciences	Grey	Black	**Ph. D Thesis**
6	Languages	Red	White	**Ph.D Thesis**
7	Life Sciences	Pista Green	Black	**Ph.D Thesis**
8	NSS	Orange	White	**Ph.D Thesis**
9	Knowledge Management & Information Media	Brown	Silver	**Ph.D Thesis**

(TITLE PAGE)

TITLE OF THE THESIS

Thesis submitted in fulfilment of the requirement for the degree of

DOCTOR OF PHILOSOPHY

By

NAME OF THE CANDIDATE

Registration No.

Under the supervision of

Name of the PhD Supervisor

NAME OF THE DEPARTMENT/CENTRE

SCHOOL NAME

CENTRAL UNIVERSITY OF JAMMU, J&K- 181143

January, 2024

DEPARTMENT/CENTRE NAME

Central University of Jammu

राया-सूचानी**(बागला),** जिला **सांबा -181143,**जम्मू **(जम्मूएवंकश्मीर)**

Rahya-Suchani **(Bagla),** District **Samba-181143,** Jammu **(J &K)**

DECLARATION BY THE SCHOLAR

I, **Student Name**, registered as a Ph.D. scholar in the Department Name, do hereby solemnly declare that the work reported in the Ph.D. thesis entitled "**Title of the Thesis**" submitted by me to the **Department Name, Central University of Jammu, J&K, India,** in partial fulfillment of the requirement for the award of the degree of Doctor of Philosophy is my original work, except where otherwise stated, and has not previously formed the basis for the award of any Degree, Diploma, Associate-ship, Fellowship or other similar title or recognition.

Place: Jammu

Date:

Candidate Name

DEPARTMENT/CENTRE NAME

Central University of Jammu

राया-सूचानी(**बागला**), जिला**सांबा -181143,**जम्मू (**जम्मूएवंकश्मीर**)

Rahya-Suchani **(Bagla),** District **Samba-181143,** Jammu **(J &K)**

Date: ……………….

CERTIFICATE

This is to certify that **Student Name**, Research Scholar in the Department of Computer Science & Information Technology, Central University of Jammu, under Reg. No. has completed her Ph.D. thesis entitled "**Title of the Thesis**". I have gone through the draft of the thesis and found it worthy of consideration in partial fulfillment of the requirements for the award of Doctor of Philosophy. It is further certified that:

- The thesis is worthy of consideration for the award of the Degree of Doctor of Philosophy and fulfills the requirements of the relevant ordinance.
- The thesis has not been awarded or submitted for the award of any other degree or diploma.
- The thesis embodies the original work of the scholar herself, consists of no plagiarism, and fulfills the requirements of the University Grants Commission (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulations, 2017.
- The candidate has worked under my guidance and supervision for the period required under the relevant ordinance.
- The candidate has put in the required attendance and has participated in the seminars/group discussions in the department during the period, and the conduct of the scholar remained satisfactory during the period of her research.

Name of The Supervisor	**Name of the Head**
(Supervisor)	**(Head of the Department)**

DEPARTMENT/CENTRE NAME

Central University of Jammu

राया-सूचानी(**बागला**), जिला**सांबा -181143,**जम्मू (**जम्मूएवंकश्मीर**)

Rahya-Suchani **(Bagla),** District **Samba-181143,** Jammu **(J &K)**

Date: ……………….

MINIMUM STANDARD PROCEDURE (MSP) CERTIFICATE

This is to certify that **Student Name**, a bonafide research scholar of this department has submitted her Ph.D. thesis entitled, **"Title of the Thesis "**, on dated ………………………. This thesis is in accordance with UGC (Minimum Standards and Procedures for Awards of M.Phil./Ph.D. Degree) Regulations, 2016.

Supervisor **Head of the Department** **Dean**

Acknowledgement

Indeed my words at my command are not adequate to express the depth of my modesty and humbleness before the almighty without whose endless magnanimity and blessings this majestic task could not have been accomplished.

I express my sincere gratitude to Hon'ble Vice-Chancellor Prof. Sanjeev Jain, Central University of Jammu, and Prof. Devanand, Dean, School of Basic and Applied Sciences, Central University of Jammu for their kind support extended to me for the successful completion of this research work.

I place on record unbounded gratitude to my Supervisor, Dr. Yashwant Singh, HoD, and Professor, Department of Computer Science and Information Technology, Central University of Jammu, J&K, India for their belief in me. In them, I found that the best are not only efficient, effective, and result driven, but at "core they are persons with best qualities as human beings". Humanity, scientific potentials, kindness, simplicity, and novelty of ideas are the arms of their great personality. I am greatly indebted to my supervisor for allowing me to work under his supervision and for his invaluable painstaking efforts taken toward my study.

I owe my thanks to my knowledge-rich teachers of the department, Dr. Bhavna Arora, Dr. Arvind Selwal, Dr. Deepti Malhotra, and Dr. Neerendra Kumar for their constant suggestions, motivation, and timely feedback during my research work.

A special thanks to Dr. Pradeep Singh and Dr. Nagesh Kumar for guiding me throughout this process and helping me at every level for further refinement of my work.

I also like to thank Mr. Jatinder Singh and Ms. Jyoti for their ever-welcoming nature and their technical assistance when needed.

The silver lining to all these efforts was drawn by my friends cum colleagues without whom I may not be able to withstand a single day of this long humongous journey. A heartfelt gratitude to Ms. Niharika Sharma, Ms. Deepika Sharma, Ms. Mehak Mengi and Mr. Amit

Acknowledgement

Sharma. It would be unfair if I fail to mention the presence of Dr. Deep Kumar Bangotra who has constantly assisted me to cross the hard journey of success and always stands by my side through rough and tough. I also like to thank my seniors Dr. Rohini Mahajan, Dr. Sonam Gandotra, Dr. Bhagyalaxmi, and Ms. Pooja Anand who always showers me with love and care. The moral support of my junior research scholars Ms. Sheerein Zadoo, Ms. Sheikh Imroza Manzoor, Ms. Abreen Sabha, Ms. Neha Koul, Ms. Sakshini Hangloo, Ms. Geeta Sharma, Mr. Ajay Kumar, Mr. Himanshu Sharma, Mr. Zakir Ahmad Sheikh, Mr. Kuljeet Singh, and Mr. Narinder Verma can never go unacknowledged. I wish them all the best in their future endeavors.

It will never be possible to pay the price of sacrifices that my parents have made for my success and the hardships they have gone through during my study. The devoted prayers of my mother Smt. Kamlesh Kumari and dreams of my father Sh. Sukh Raj have made me accomplish this task in distress. Last but not least, my siblings especially Mr. Vishal Rana with their never-ending faith in me and my capabilities cannot be put in words. Their imperceptible blessings have made me sail through the toughest times.

- *The merits in the thesis are by virtue of all the acknowledged people and the shortcomings are my own copyright.*

Place: Jammu

Date: *(Student Name)*

Table of Contents

Contents | Page No.

List of Abbreviations

SAMPLE

Abbreviations	
IoT	Internet of Things
MAC	Media Access Control
GPS	Global Positioning System
IEEE	Institute of Electrical and Electronics Engineers
PSAGA	Priority Super frame Guaranteed Access
T-MAC	Timeout MAC
S-MAC	Sensor MAC
ZISENSE	Zigbee Sense
TSCH	Time Synchronised Channel Hopping
DCA	Duty Cycling Algorithm
Z-MAC	Zebra MAC
DC-ACO	Duty Cycled Ant Colony Optimisation
ESR	Energy Source Region
MAP-ACO	Multi Agent Path Finding Ant Colony Optimisation
IEM-ACO	Improved Energy and Mobility Ant Colony Optimisation
FC	Fog Computing
BD	Big Data
WSN	Wireless Sensor Networks
CO_2	Carbon Dioxide
MPTCP	Multipath Transmission Control Protocol
PLC	Power Line Communication
M2M	Machine to Machine
ML	Machine Learning
DL	Deep Learning
QoS	Quality of Service
RFID	Radio Frequency Identification
LPWA	Low Power Wide Area
LoRa	Long Range
SIDs	Source IoT Devices

List of Figures

List of Tables

SAMPLE

Abstract

The ever-growing ubiquitous IoT network encompasses tiny objects to giant machines that communicate with each other via the internet. IoT technology offers people-centric and industry-centric services on demand. Miniaturized sensors play an important role in an IoT network. The Internet protocol (IP) based smart sensors could be deployed in an unattended or harsh environment for so long due to their inherent features. The sensors in an IoT network are used for measuring temperature, humidity, motion, seismic activities, underwater events, and mining fields. The resource-constrained nature of IoT nodes such as computation, storage, and battery power limited the data transmission to longer distances. The smart nodes in IoT are lossy and support minimum data rates of tens to hundreds of kilobits per second (Kbps). The data sensed by sensor nodes is sent to the base station or sink node by traversing through multiple hops called routing. The routing of data through multiple hops is the most energy-consuming process because of the maximum resource utilization during data delivery to respective destinations. Likewise, inefficient data delivery encounters challenges like more delay due to congestion, insecurity, scalability, and heterogeneity of devices. All these factors hamper the energy efficiency of an IoT network.

The radio frequency-based sensors manage energy consumption by turning off and on their radios periodically. This process of preserving energy by activating and deactivating the sensor nodes is called duty cycling. The existing duty cycling techniques often waste more energy due to issues like overhearing, over-emitting, and idle listening. The Institute of Electronics and Electrical Engineering (IEEE) 802.15.4 superframe structure only supports fixed duty-cycling and cannot be dynamically adapted. Therefore, devising adaptive and efficient duty-cycling techniques is of greater significance in dynamic IoT networks. On the other hand, prevalent routing techniques suffer from single source problems, connection loss, unicast transmission, and mobility issues. Such types of routing techniques are not a good fit for IoT networks which are highly dynamic. The metaheuristic routing techniques are gaining higher acceptance for accomplishing energy efficiency because of the overall improvement in Quality of Service (QoS) metrics such as delay, packet loss ratio, network lifespan, throughput, energy consumption, and goodput.

The “Meta” means to reach the higher state and heuristic means to explore the search space by hit and trial beyond the local minimum. Taking into consideration the energy consumption issue during routing and excessive radio dissipation of smart nodes in heterogeneous IoT networks, we have proposed a high-level energy-efficient metaheuristic routing framework along with an adaptive duty cycling mechanism. The Duty Cycling mechanism activates or deactivates the nodes on sensing the data on demand. The wake-up radio scheme employs the low radio receiver to wake up the nodes only when required. The proposed duty-cycled improved ant colony mechanism (DC-ACO) in our thesis work is compared against three techniques i.e. IEM-ACO, ESR, and MAP-ACO. Ant colony routing is one of the metaheuristic approaches being motivated by the ant’s behavior to find the food source via the shortest tour depending on the pheromone intensity. The same ideology has been followed for route identification in an optimistic manner in our thesis work. The improved ACO takes into account the mobility/speed of nodes, residual energy, minimum, and average energy, and hop distance which are the critical parameters for a network like IoT.

The proposed DC-ACO approach could be successfully applied in distributed and dynamic applications like Vehicle Routing, Traffic Management, E-Healthcare, Travelling Salesman, Scheduling Problems, and Connection and connectionless network routing. In our thesis work, the application of DC-ACO is evaluated in Smart Healthcare System with special emphasis on the priority of data packets based on the criticality of data i.e. DC-ACOP. The Healthcare data packets are categorized based on the severity of data i.e. high, very high, low, and very low priority. The 3 bits are used for setting the priority. The highly prioritized data is delivered first to the destination node to minimize energy consumption and delay so that the medical services will be availed on time. The DC-ACOP approach is compared with PEERP, PriNergy, and PBR to determine the efficacy of the algorithm in terms of key performance indicators such as delay, throughput, energy consumption, and network lifetime.