Intelligent Data Gathering Mechanisms for IoT-enabled Wireless Sensor Networks

Thesis submitted in partial fulfillment
for the award of the degree of

Doctor of Philosophy

by

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Dedicated to both my families—the one that raised me, and the one that embraced me with open arms

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Abbreviations

Abbreviation	Description
ABC	Artificial Bee Colony
ACO	Ant Colony Optimization
APN	Articulation Point Node
BS	Base Station
CH	Cluster Head
CM	Cluster Member
DASO	Donkey And Smuggler Optimization
DBP	Delay Bound Path
DBRKM	Delay Bound Reduced K-Means
DCD	Data Collection Delay
DERP	Dynamic Escape Route Planning
DESSN	Dynamic emergency Evacuation system for Shortest-Safe path Navigation
DFN	Data Forwarder Node
DFS	Depth First Search
DP	Dynamic Programming
DPDP	Deep Policy Dynamic Programming
DRL	Deep Reinforcement Learning
EAPC	Energy-Aware Path Construction
EC	Energy Consumption

Abbreviation	**Description**
ECSSN	Emergency evacuation system for Clogging free and Shortest-Safe path Navigatio
EDEDA	Energy and Delay Efficient Data Acquisition
EERPS	Energy Efficient Rendezvous Points Selection
FEBIM	Fire Evacuation Building Information Modeling
FN	Far-away Nodes
GA	Genetic Algorithm
GA-SMT	Genetic Algorithm based Sink Mobility Technique
GBA	GTSP-Based Algorithm
GN	Gateway Node
GNN	Graph Neural Network
GTA	Group Teaching Algorithm
GTSP	Generalised Travelling Salesperson Problem
GWO	Gray Wolf Optimization
IIoT	Industrial Internet of Things
IoT	Internet of Things
IRDA	Improved Reed-Deer Algorithm
KNN	K-Nearest Neighbour
MARL	Multi-Agent Reinforcement Learning
MDC	Mobile Data Collector
MILP	Mixed Integer Linear Programming
MOGWO	Multi-Objective Gray Wolf Optimization
MRFO	Manta-Ray Foraging Optimization
MS	Mobile Sink
OCRS-MD	Obstacle Aware Connectivity Restoration using Mobile Data carrier
OVTP	Objective Variable Tour Planning
PSO	Particle Swarm Optimization

Abbreviation	**Description**
QoS	Quality of Service
RDP	Reduce Delay Path
REP	Reduced Energy Path
RESM	Region Energy Conscious Sink Movement
RKM	Reduced K-means
RLBSO	Reinforcement learning Brain Storm Optimization
RP	Rendezvous Point
RSARSA	Radar-assisted State–Action–Reward–State–Action
SNs	Sensor Nodes
TDMA	Time Division Multiple Access
TEO-MCRP	Thermal Exchange Optimization Clustering Routing Protocol
TSP	Travelling Salesman Problem
UAV	Unmanned Aerial Vehicle
VGDRA	Virtual Grid Based Route Adjustment
VS	Virtual Structure
WRP	Weighted Rendezvous Planning
WSN	Wireless Sensor Network

List of Symbols

Symbol	Description
$\mathcal{N}$	Number of deployed sensor nodes.
$\mathcal{S}$	Set of sensor nodes. $\mathcal{S}$ = sn_1, sn_2, sn_3, sn_4.....sn_n.
r	Communication range of sensor nodes.
m	Number of rendezvous points.
$\mathcal{R}$	Set of rendezvous points. $\mathcal{R}$ = $\mathcal{RP}_1$, $\mathcal{RP}_1$, $\mathcal{RP}_1$....$\mathcal{RP}_m$.
rpid	Id assigned to each RP. rpid = 1,2,3,4....m. For eg. rpid of $\mathcal{RP}_7$ is 7.
$\mathcal{TD}ist(sn_i)$	Euclidean distance between the sensor node and the next-hop node.
$\mathcal{D}ist(sn_i, sn_j)$	Euclidean distance between node sn_i and sn_j.
$\mathcal{HC}ounts(sn_i)$	Number of hops required by sn_i to send data to RP.
$\mathcal{S}um\mathcal{D}(\mathcal{RP}_j)$	Sum of distances among nodes allocated to $\mathcal{RP}_j$
$\mathit{allot}(sn_i)$	A variable that holds the rpid of the RP to which the sensor node is allocat
$\mathcal{AR}$	Archive which contains non-dominated solutions.
$\mathcal{E}_{ij}$	Edge between node i and j.
$\mathcal{EC}$	Energy Consumption.
$\mathcal{DCD}$	Data Collection Delay.
$\mathcal{DLBO}$	Data Lost Due to Buffer Overflow.
$InDeg_i$	In-degree of a node i.
$\mathbb{L}$	Length of the MS data collection path.
C_s	Current grid cell in forward search direction.

Symbol	**Description**
C_d	Current grid cell in backward search direction.
S_g	Source grid cell.
D_g	Destination grid cell.
$NG_i(C_s)$	Neighbour grid cells of cell C_s.
ξ_i	Remaining energy of node i.
$\mathcal{W}_\rangle$	Weight function.
$\mathbb{AJ}$	Adjacency list of nodes in the network.
$\mathbb{AP}$	List of APNs.
$\mathbb{F}$	List of faulty nodes.
$\mathbb{D}$	List of dead nodes.
$\mathbb{RL}$	List of recovery nodes.
$\mathbb{P}$	MDC path.
d	Distance between source and destination node
G	Graph of network
V	Set of vertices
E	Set of edges
a	Vertex in set V
$ngb(a)$	Set of neighboring vertices of vertex a
e_{ab}	Edge connecting vertices a and b
S	Source or Evacuee
D	Door or Exit
F	Fire region
W	Wall
K	Set of fire spread rate/speed
T	Time when a fire will reach all the exit nodes