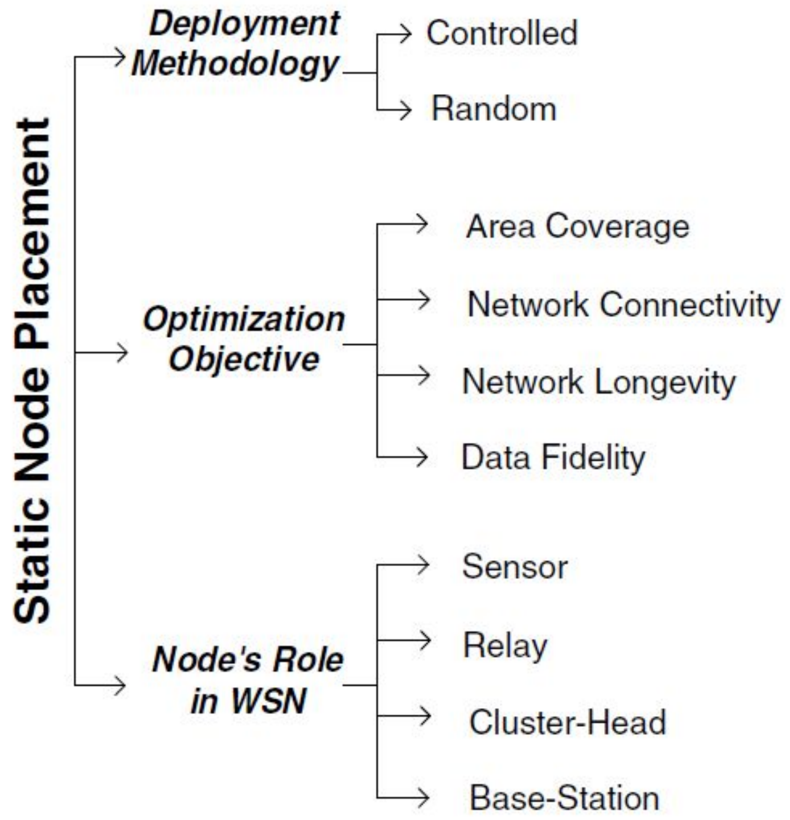
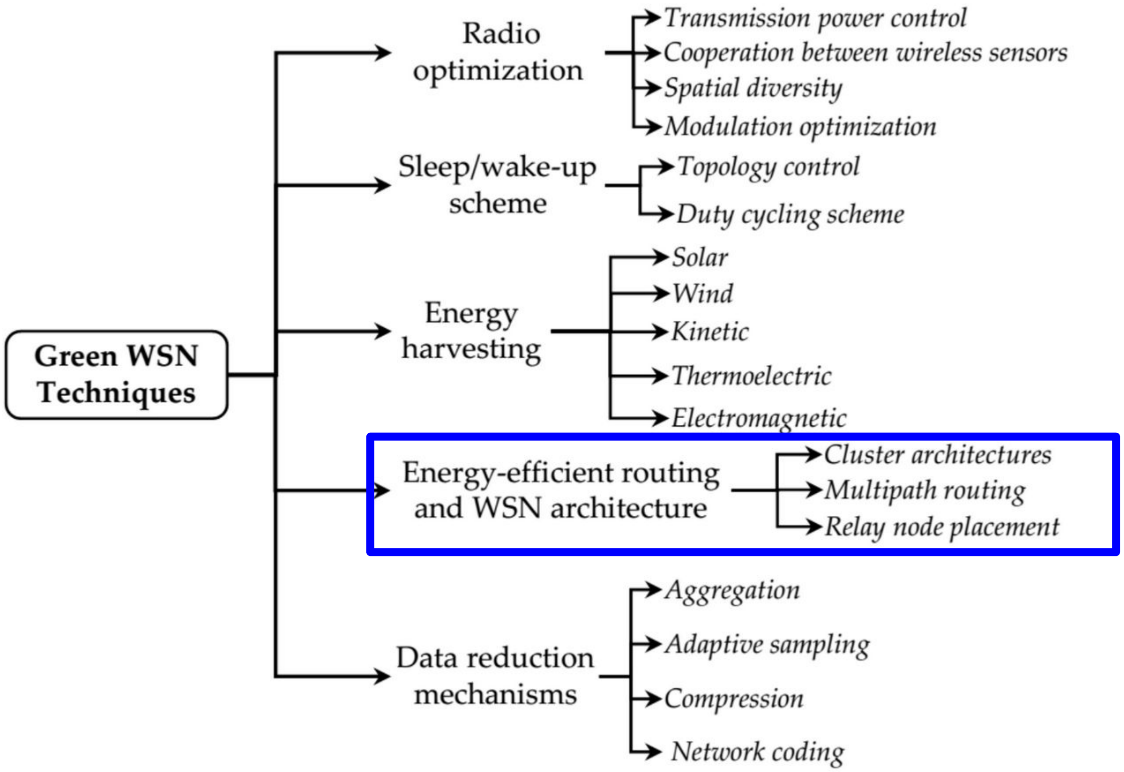
Gateway Placement

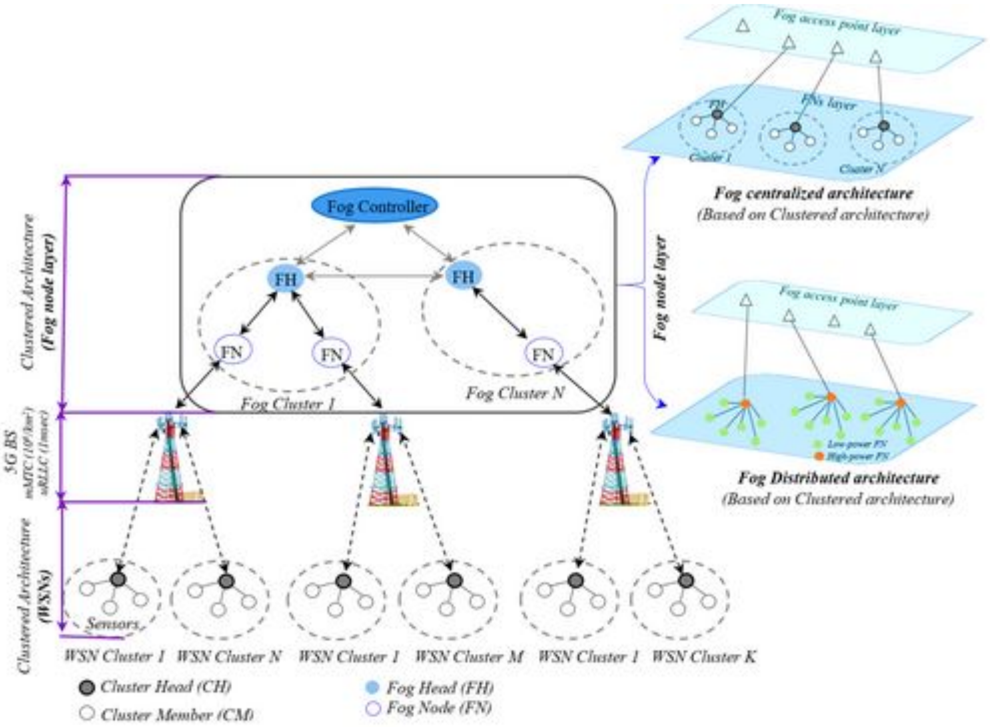
Different classifications of static strategies for node placement in WSN[3]



Classification of energy-efficient techniques for WSNs



Cluster architecture



Cluster architecture can improve energy saving in WSN in several ways:[73]

• It decreases the communication distance within the cluster, which reduces the need for high transmission power.

• It reduces the number of transmissions by leveraging data fusion at the cluster head.

• It cuts down energy-consuming activities such as coordination and data aggregation by distributing them to the cluster head.

• It allows for some nodes to be powered off within the cluster, as the cluster head assumes forwarding responsibilities.

• It distributes energy consumption evenly among nodes by rotating the cluster head position.

Classification of Clustering

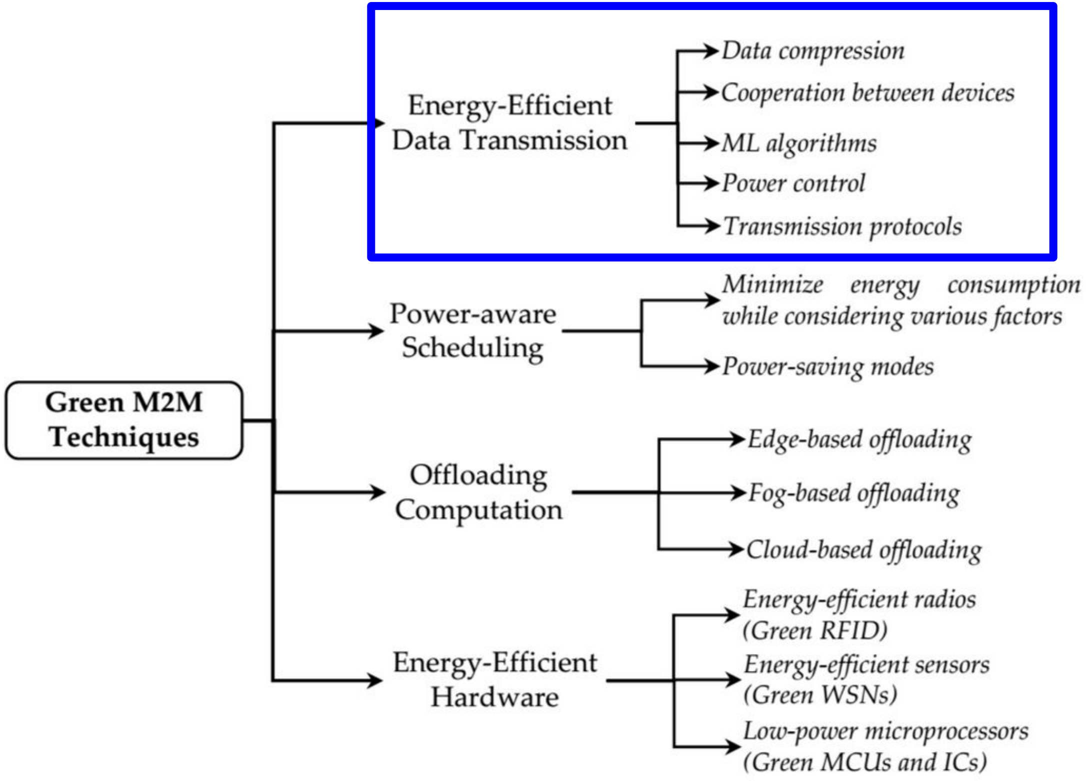
- **Centroid-based clustering:** Centroid-based clustering algorithms, such as k-means clustering, group data points together based on their distance to a central point.

- **Density-based clustering:** Density-based clustering algorithms, such as DBSCAN, group data points together based on their density.

- **Distribution-based clustering:** Distribution-based clustering algorithms, such as Gaussian mixture modeling, group data points together based on their underlying statistical distribution.

- **Hierarchical clustering:** Hierarchical clustering algorithms, such as Ward's method, group data points together by building a hierarchy of clusters.

Classification of energy-efficient techniques for M2M communications



LoRaWAN Classes

The LoRaWAN standard classifies devices into three classes: Class A, Class B, and Class C.

- Class A devices are designed for low-power applications, and have the ability to receive downlink messages on RX1 and RX2 windows. Class A devices are typically used in applications in which power consumption is a critical concern, and have a sleep time between transmissions.
- Class B devices have a more complex receiving schedule, and require end-device-gateway synchronization. Class B devices are typically used in applications that require a higher level of responsiveness, and have more frequent transmissions.
- Class C devices have one continuous waiting slot, which allows them to receive downlink messages at any time. Class C devices have the highest power consumption, and are best-suited to applications that require a high level of connectivity, and low latency

LoRaWAN Modes

LoRaWAN also supports two different modes of operation: confirmed and unconfirmed.

- In the confirmed mode, the NS sends an ACK packet to the ED, for each packet that is successfully delivered: this ensures that the ED knows that the packet has been received, and can take appropriate action if necessary.
- In unconfirmed mode, the NS does not send an ACK packet, which reduces the overhead of the network, but also increases the risk of lost packets

LoRaWANSIM

- inputs of the simulator are the arrangement of the nodes, the propagation model, and a set of parameters that determines the behavior of the protocol stack layers.
- outputs is the several performance metrics, such as the ULDR (Uplink Data Rate) and the performance of the total and mean energy consumption of each ED

Limitation:

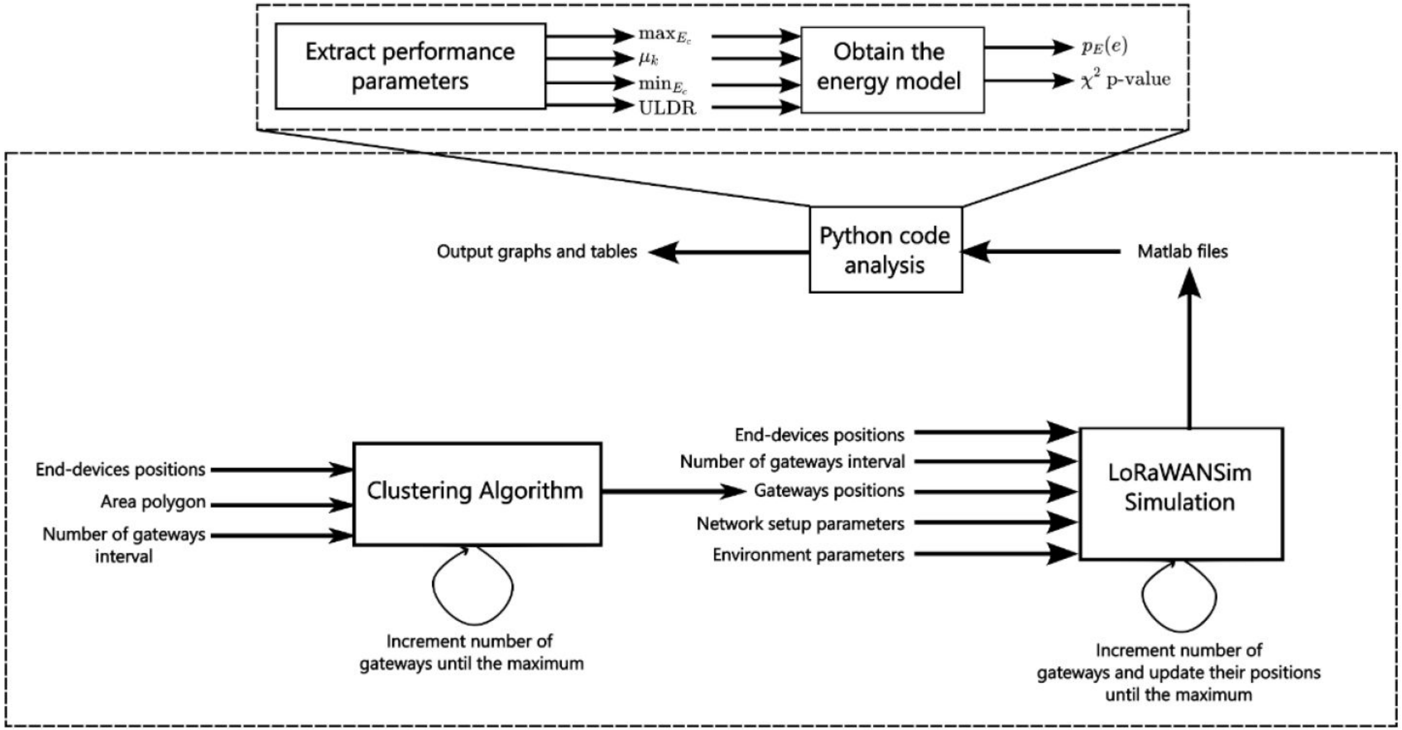
it does not consider energy consumption in the processing and input/output (I/O) modes

The parameters used as input to the simulator

Parameter	Description	Values
N	Number of nodes	{500}
G	Number of GWs	{1 . . . 20}
R [km]	Area radius	{9}
P_T^{ED} [dBm]	ED transmission power	{14, 12, 10, 8, 6, 4, 2}
G_A^{ED} [dBi]	ED antenna gain	{5}
P_T^{GW} [dBm]	GW transmission power	{16}
G_A^{GW} [dBi]	ED antenna gain	{5}
σ [dB]	Shadowing parameter	{3}
n	Propagation model parameter	{3.66}
CR [bits/s]	Coding rate	{1}
BW [kHz]	Bandwidth	{125}
DC [%]	Duty cycle restriction	{100} (no DC restriction)
T [s]	Period between transmissions	{60, 600}
H [Boolean]	Header Presence?	{1} (true)
L_p [bytes]	Message preamble length	{8}
B_{UL} [bytes]	Uplink packet size	{20}
B_{DL} [bytes]	Downlink packet size	{20}
RX1DROffset	Offset between the SF of transmission and RX1 reception window	{0} (no offset)

Network Layout Parameters			
N	Number of EDs	G	Number of GWs
R	Circular area radius [km]		
Radio propagation parameters			
P_{T}^{ED}	Transmit power of the ED [dBm]	P_{T}^{GW}	Transmit power of the GW [dBm]
G_{A}^{ED}	ED Antenna Gain [dB]	G_{A}^{GW}	GW Antenna Gain [dB]
h_m	Height of the ED [m]	h_b	Height of the GW [m]
σ	Shadowing standard deviation [dB]		
Radio resource management parameters			
SF	Spreading Factor	RX1DROffset	Shift between Uplink and RX1 SF
DC	Duty Cycle Limitation		
Data traffic parameters			
B_{UL}	Uplink Payload Size [bytes]	B_{DL}	Downlink Payload Size [bytes]
H	Packet Header presence	$L_{preamble}$	Length of the preamble
T	Uplink packet periodicity [s]		
SIR threshold parameters			
γ	SIR Threshold [dB]		
Physical layer parameters			
CR	Coding Rate	BW	Sweep interval [kHz]

Proposed Method



Result

- The study also found that increasing the time between transmissions decreased power consumption, and that the energy efficiency of the system was improved, reducing the mean and maximum energy consumption

- The FCM and K-Means techniques were superior in the different scenarios, with different numbers of GWs for the specific studied parameters.

Metric	Explanation
Number of gateways	A LoRaWAN with only one sink will operate differently than one with multiple sinks.
Number of nodes	Increasing the number of nodes demands higher performance of the LoRaWAN.
RSSI	The RSSI measured by a node provides an indication of the coverage range of the gateway and how reliable communication will be.
SNR	The SNR experienced by a node also provides an indication of how reliable communication will be.
Distance from gateway	Distance measurements can be combined with connectivity measurements (RSSI, SNR, PER) to determine a gateway's effective range.
Payload size	Ideally network performance was evaluated for multiple payload sizes as these impacts transmission times.
Transmit power	Transmitting at higher power levels (dBm) can achieve greater range but regulatory restrictions apply.
Network reliability	Network reliability can be defined in several ways: number of packets received successfully, the number of valid received packets or examining the PER.
Power consumption	Power consumption values for the motes can be used to estimate the network's lifetime.

Factors for Optimal Gateway Placement

Goals: Energy Consumption, Maximize Coverage

Constraints: Power, Space, Latency and Security

Characteristics: WMN and LoRaWAN