AN ENERGY EFFICIENT GRAVITATIONAL MODEL FOR TREE BASED ROUTING IN WIRELESS SENSOR NETWORKS

Presented By

Md.Mahbubur Rahman

Md. Shohrab Hossain

Mohammad Mahfuzul Islam

Husnu S. Narman

Outline

- Wireless Sensor Networks
- Overview of Routing Protocols
- Related Works
- Proposed Tree Clustering Approach
- Results & Analysis
- Conclusion and Future works

Wireless Sensor Network (WSN)

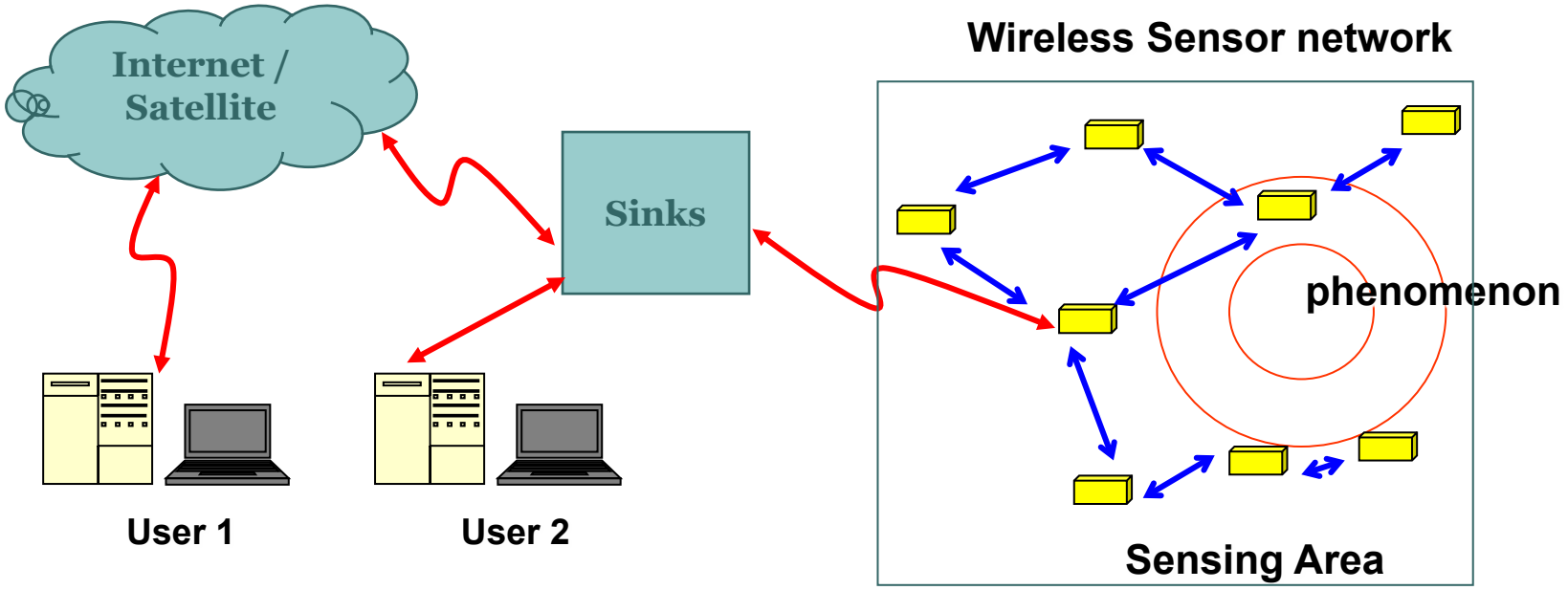
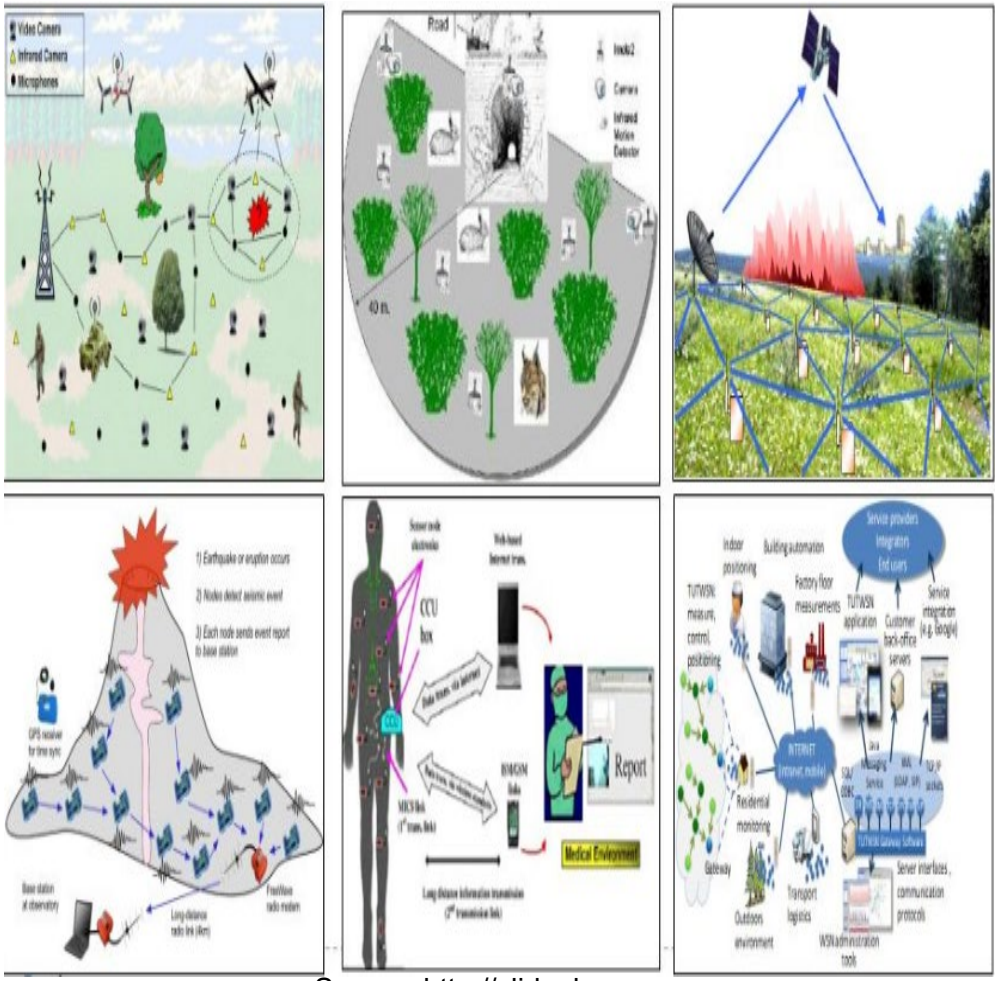


Figure 1: WSNs Architecture

Applications

- Area monitoring
- Environmental monitoring
  - Air pollution monitoring
  - Forest fires detection
  - Greenhouse monitoring
  - Landslide detection
- Industrial monitoring
  - Machine health monitoring
- Water/wastewater monitoring
- Smart Agriculture



Source: http://slideplayer.com

Wireless Sensor Network (WSN)

Challenges in WSN

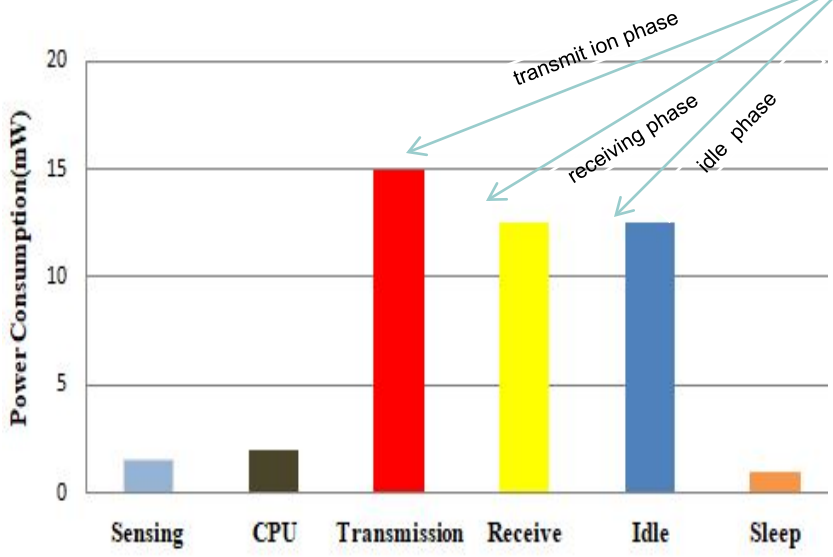
- Energy Efficiency
- Scalability
- Throughput
- Delay
- Data Aggregation
- Security
- Coverage

Key factors for energy wastage

- Collision
- Overhearing
- Retransmission
- Idle listening

Power Comparison of Nodes Subsystems of WSN

Communication and Idle Phases consume most energy.



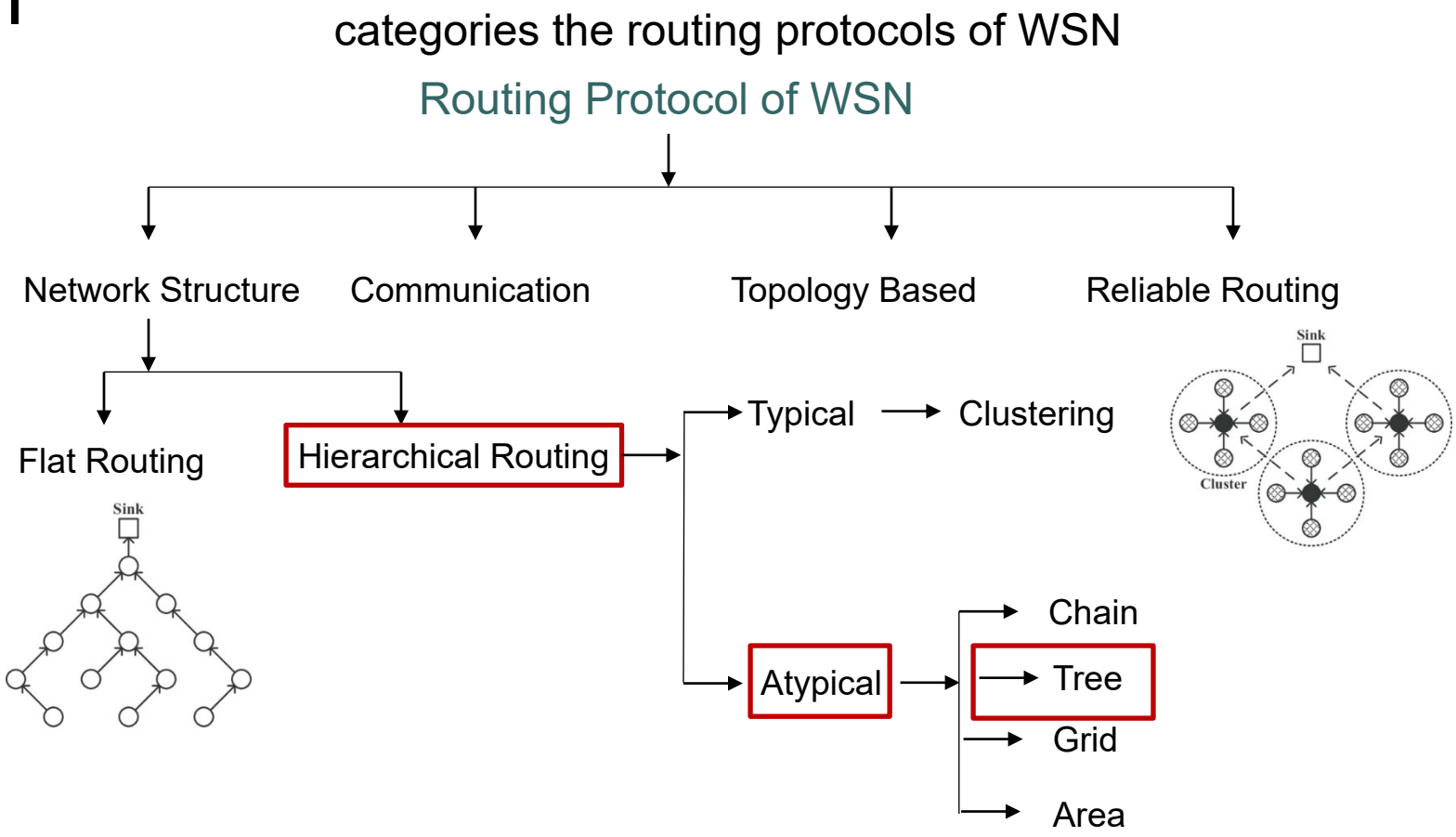
How to reduce energy consumption

Two Way

- **Communication Phase** (Efficient Routing Methodology)
- **Idle Phase** (Use of sleeping Mode)

Category the Routing Protocols of WSN

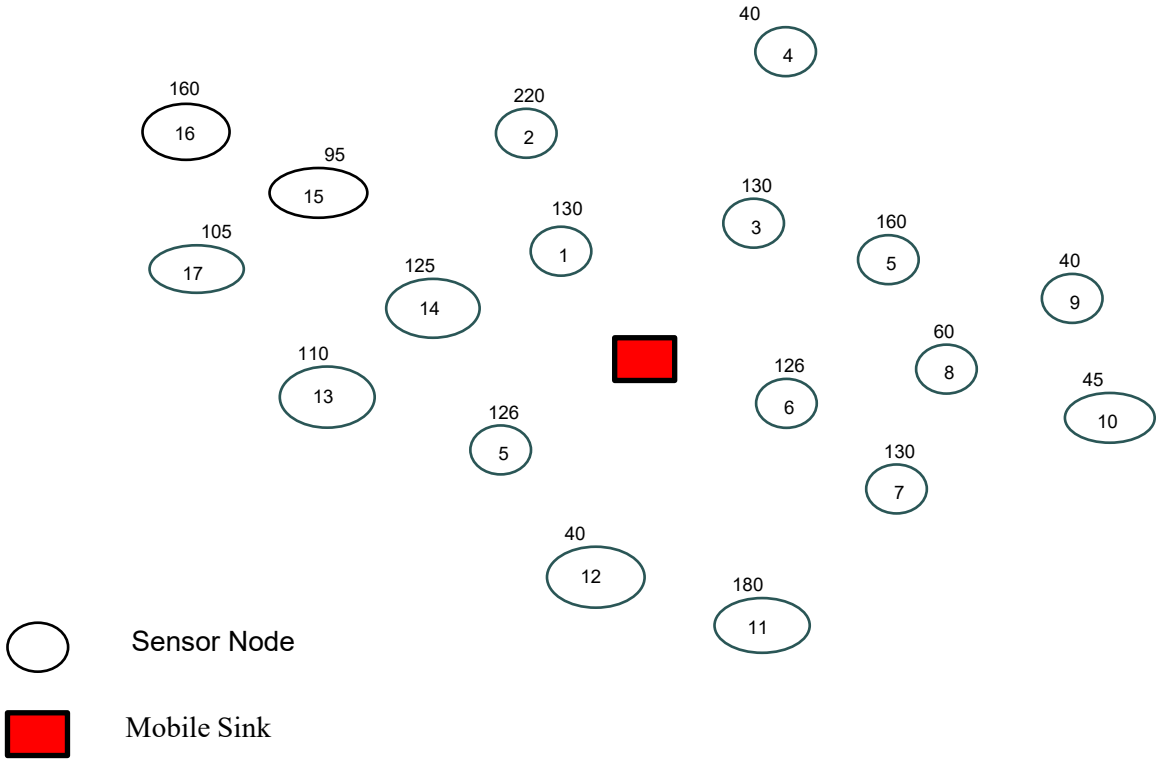
categories the routing protocols of WSN



Related Works:

- An Application-Specific Protocol Architecture for WSN (Heinzelman et.al,2002)
- Tree structure based data gathering for maximum lifetime in wireless sensor networks (Q. Zhang et. Al, 2005)
- . A delay-constrain and maximum lifetime data gathering algorithm for wireless sensor networks (J.Liang et.al, 2009)
- **An Efficient Tree-Based Power Saving Scheme for WSN With Mobile Sink(Chang et.al,2016)**

Efficient Tree-Based Power Saving Scheme for WSN With Mobile Sink(TRMS)

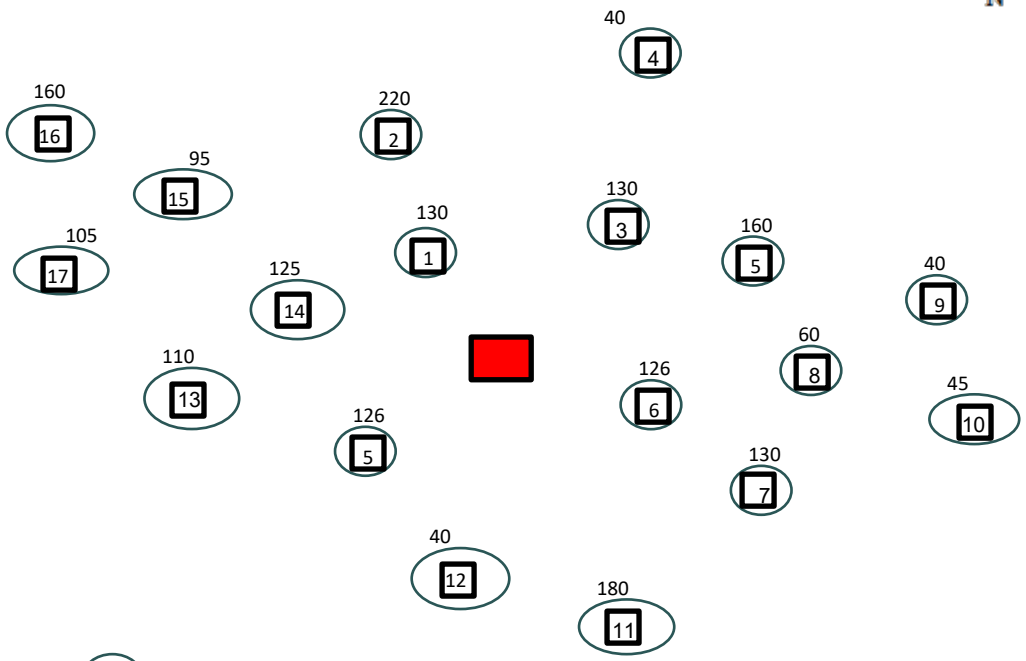


Efficient Tree-Based Power Saving Scheme for WSN With Mobile Sink(TRMS)

Every node broadcast GPS Location and Residual Energy

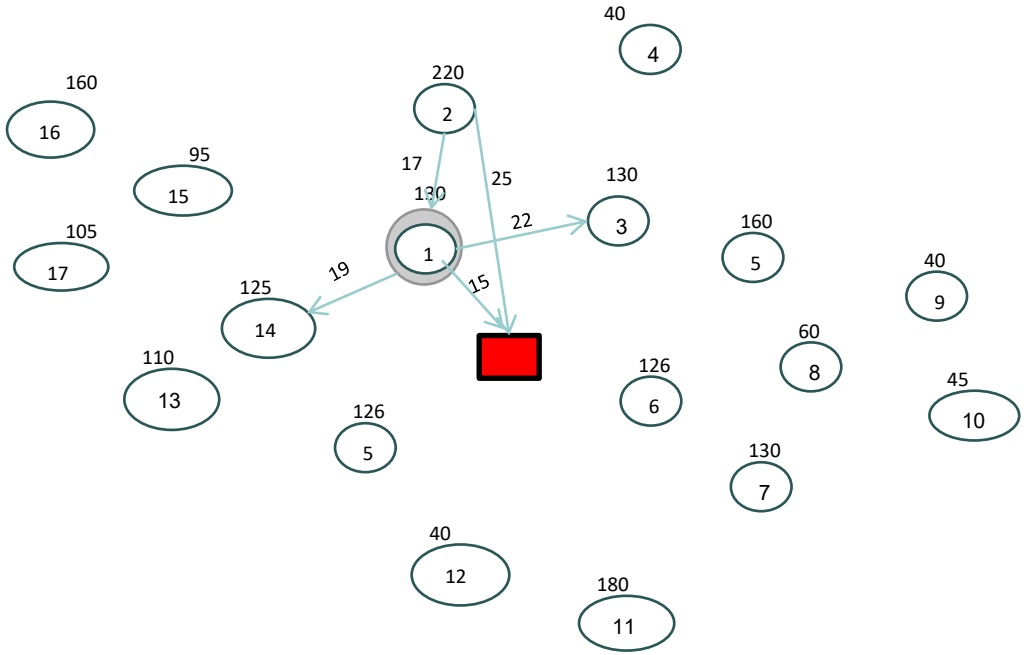
Calculate average energy

$$E_{avg} = \frac{\sum_{n=1}^{N} E_{energy,n}}{N} = 122$$

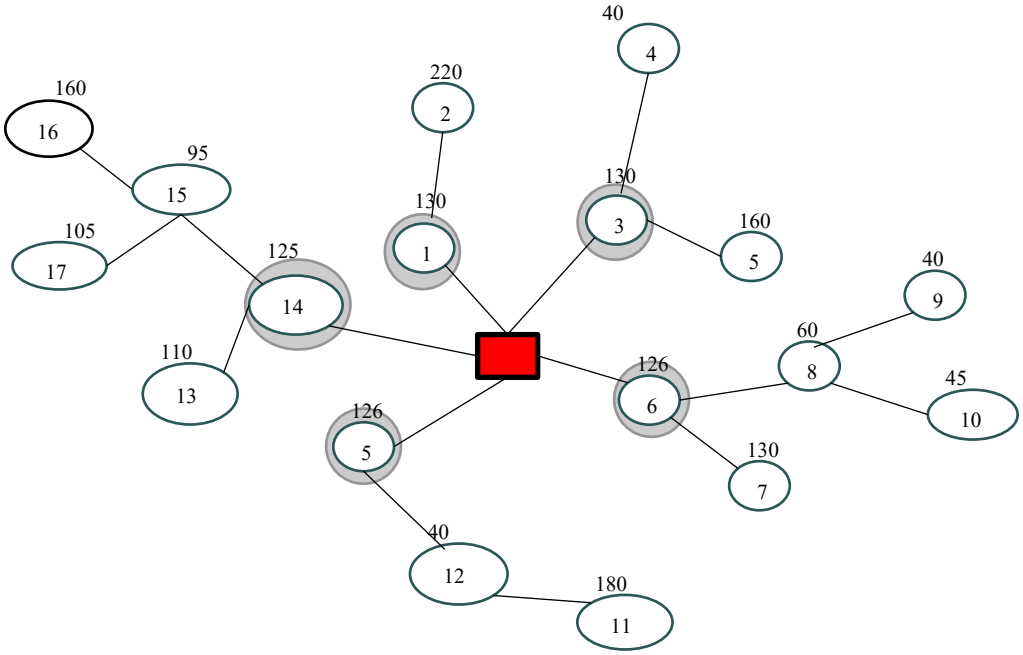


Node ID	Distance (d)
1	155
2	256
3	168
4	320
5	244
6	285
15	29
7	34
4	31
8	36
17	32
9	42
7	34
10	47
16	35
11	64
8	36
12	56
9	42
13	58
10	47
14	256
13	58
15	29
11	64
16	35
17	32

Efficient Tree-Based Power Saving Scheme for WSN With Mobile Sink(TRMS)



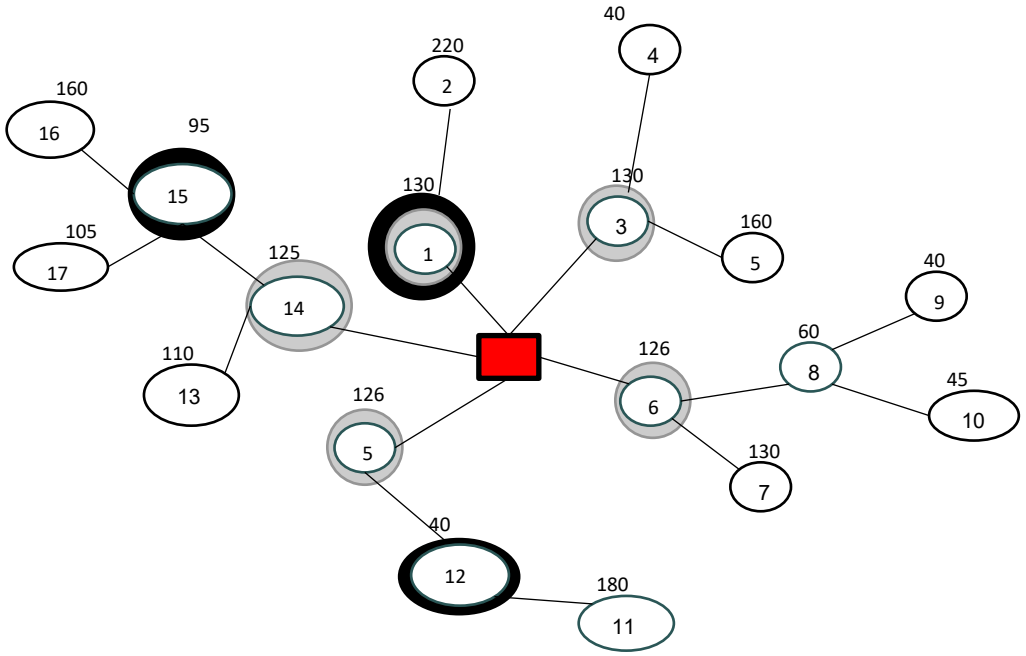
Efficient Tree-Based Power Saving Scheme for WSN With Mobile Sink(TRMS)



Critics

1. Criteria for selecting intermediate nodes is only distance from Sink so low energy node can have a great chance to become intermediate node.

2. Though CH is selected based on average energy but there have a chance to become a low energy node to CH.
4. GPS for all node is energy consuming.



Problems in selection

- ❑ Considering lower energy intermediate node can survive for the round or not
- ❑ Most of the time low energy intermediate nodes die out within the round

Critics

Die out of intermediate nodes causes:

- Packet Loss
- Possibility of disconnect
- Reduce Network Lifetime

Solution:

- Tree structure can be rebuild by avoiding low energy node as for intermediate node.

  Residual energy and distance both can be considered for build tree structure.
- Distance can be measure from RSSI

Motivation

- Lifetime of a node inversely propositional to its node-degree and distance.
- Lower-energy far node's can be avoid for being intermediate node.
- To construct a load balancing tree, higher energy nearby nodes should handle more traffic than the lower one by being intermediate node.

Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

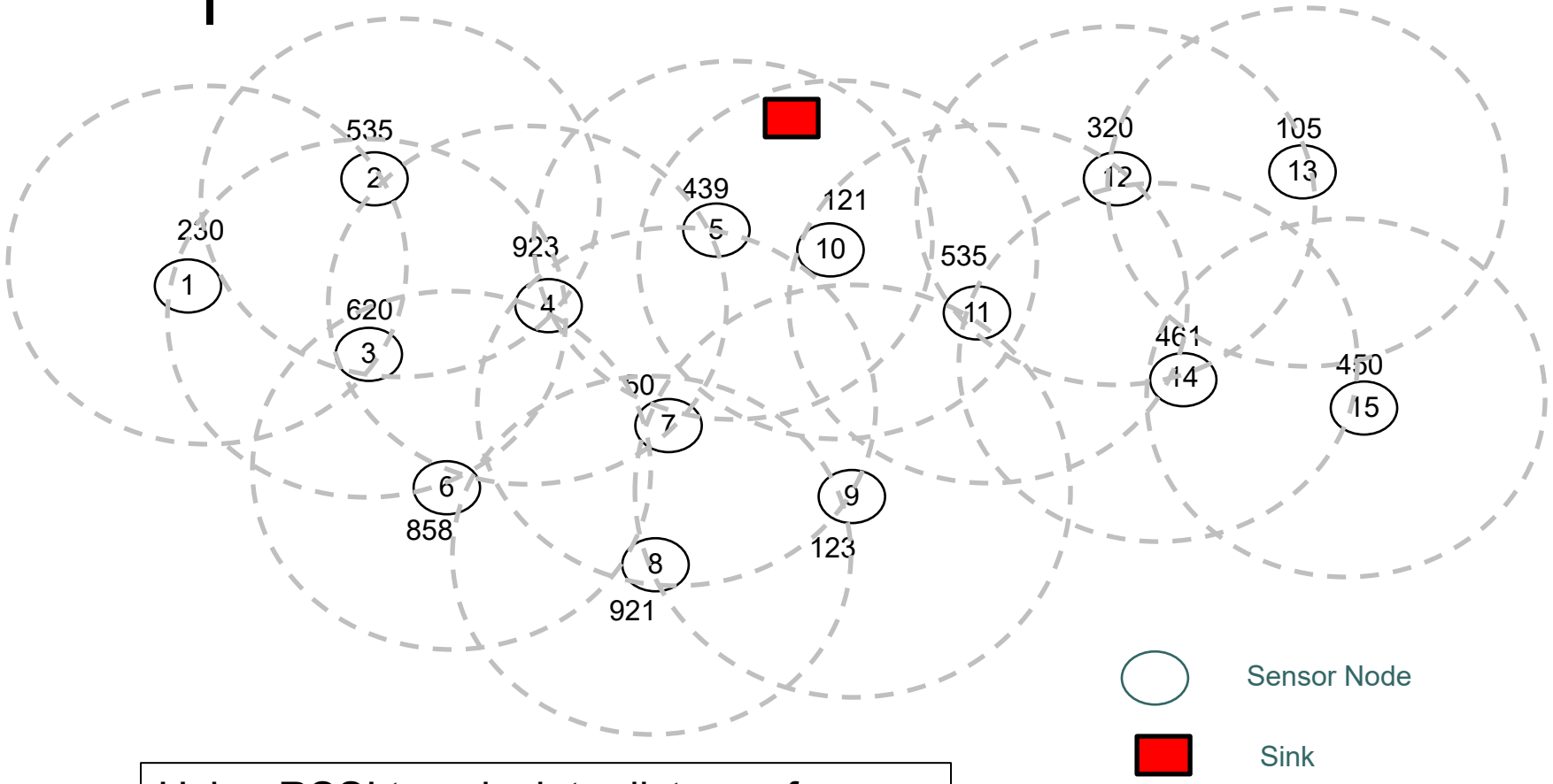
- Assumptions ⇨ Nodes use for different purpose
  - Network is heterogeneous
  - Nodes are randomly deployed
  - Node can control its transmission power

Phases:

1. Setup Phase ⟶ Network Formation
2. Steady State Phase ⟶ Network Operation

Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

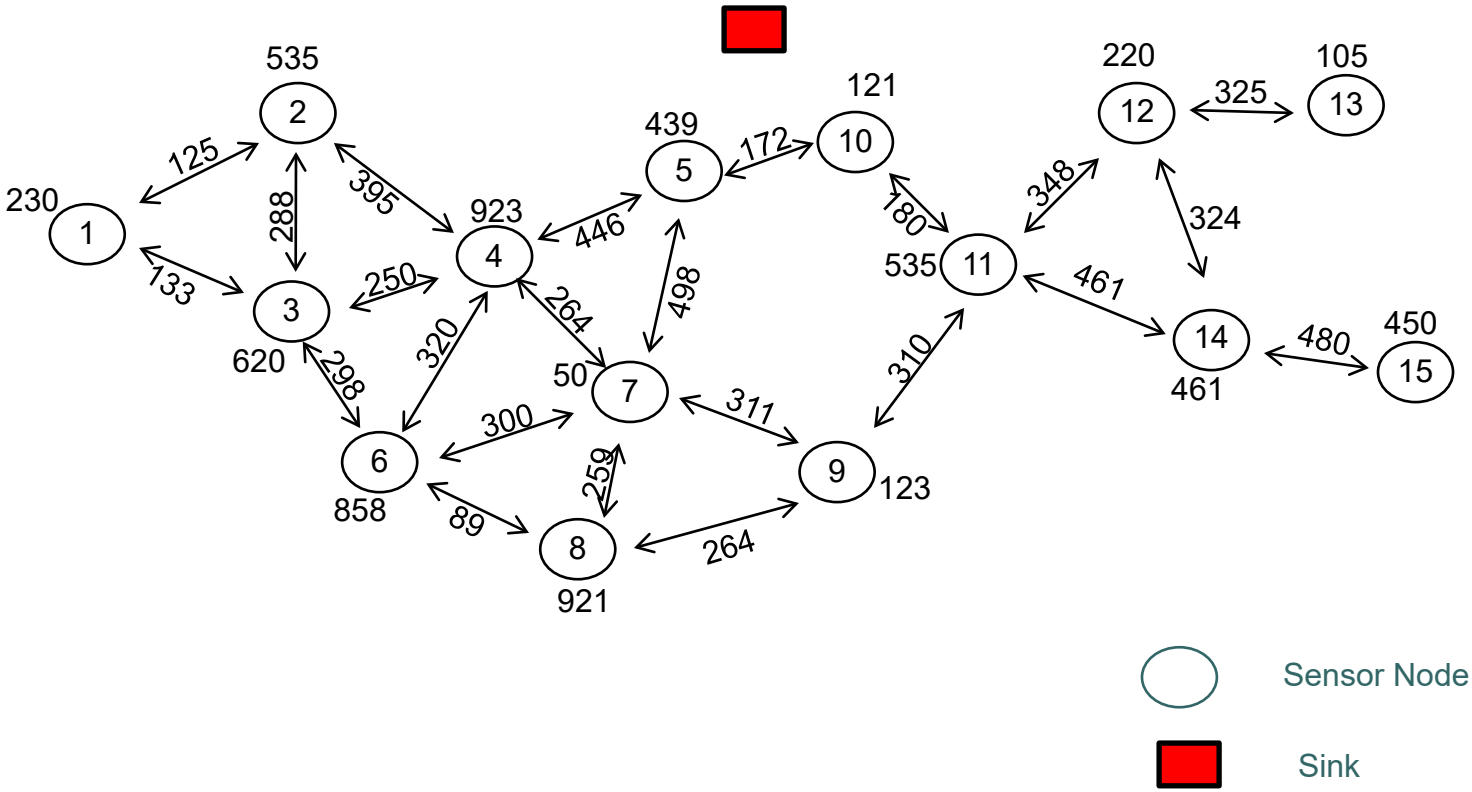
Setup Phase: Cluster formation and Cluster Head selection



Using RSSI to calculate distance from one node to neighboring nodes

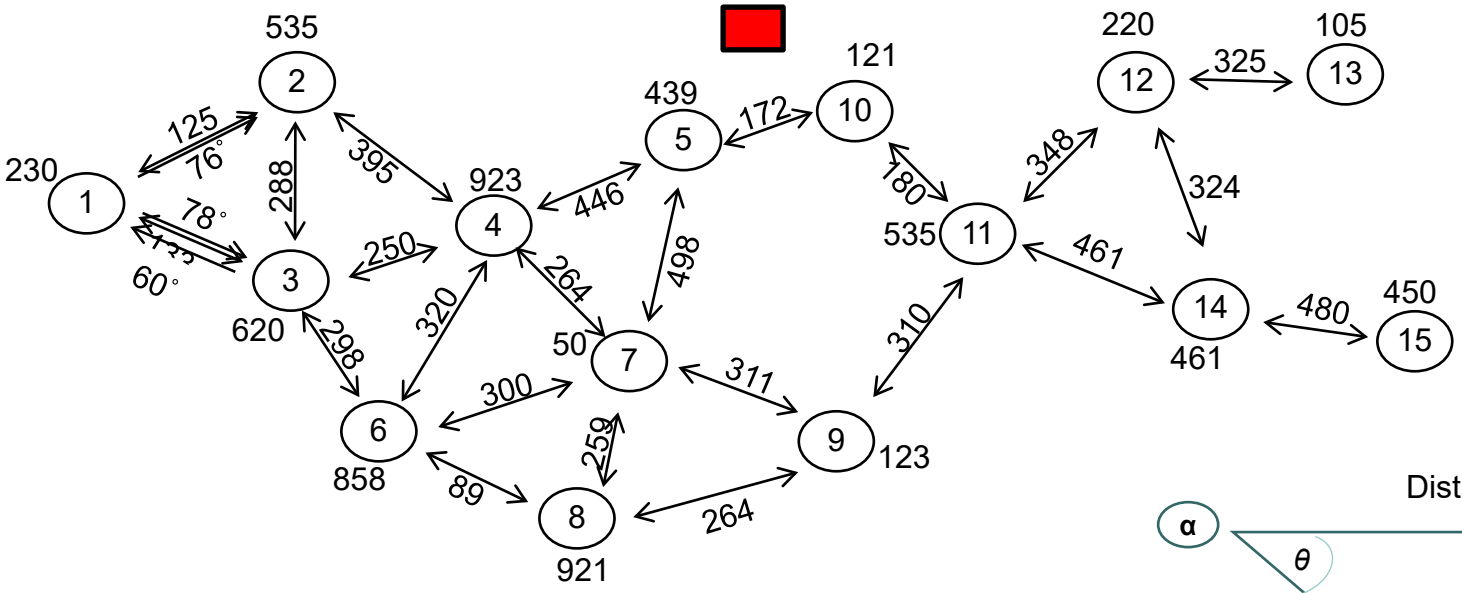
Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection



Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection



For Node 1 to 2

Max((1,2),(1,3))= (1,3)=78°

Find Reverse Angle (3,1)= 60°

$$\theta_{1,2} = \cos^{-1}\frac{d}{\sqrt{d^2+e^2}} = \cos^{-1}\frac{125}{\sqrt{125^2+535^2}} = 76^{\circ}$$

if ((1,3)>(3,1))

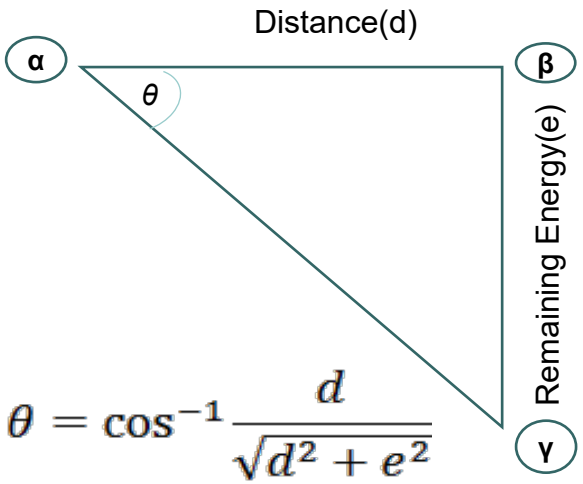
Connect(1,3)

else

Make 1 as a CH

For Node 1 to 3

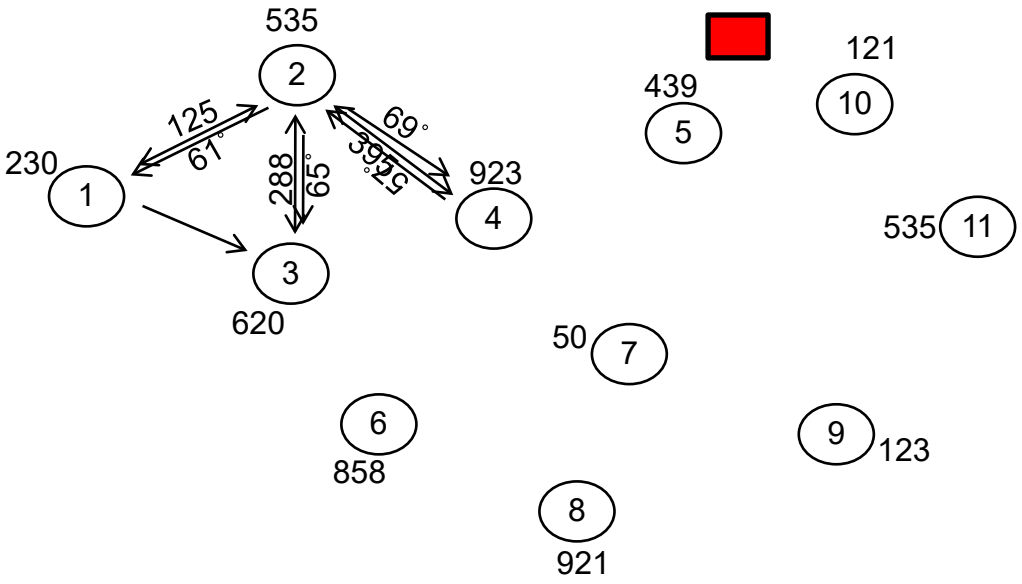
$$\theta_{1,3} = \cos^{-1}\frac{d}{\sqrt{d^2+e^2}} = \cos^{-1}\frac{133}{\sqrt{133^2+620^2}} = 78^{\circ}$$



$$\theta = \cos^{-1}\frac{d}{\sqrt{d^2+e^2}}$$

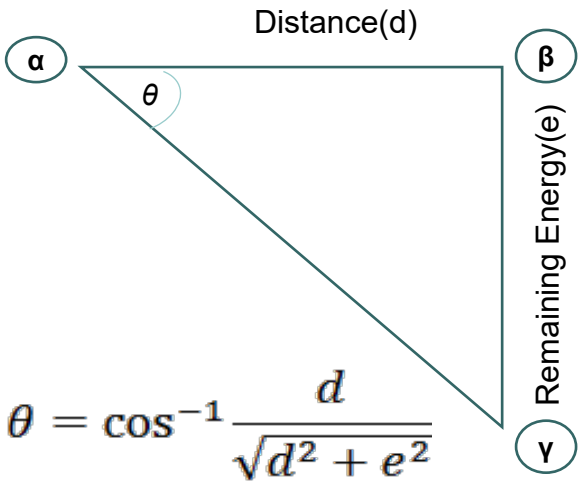
Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection



Max((2,1),(2,3),(2,4))= (2,4)=69º
Find Reverse Angle (4,2)= 57º

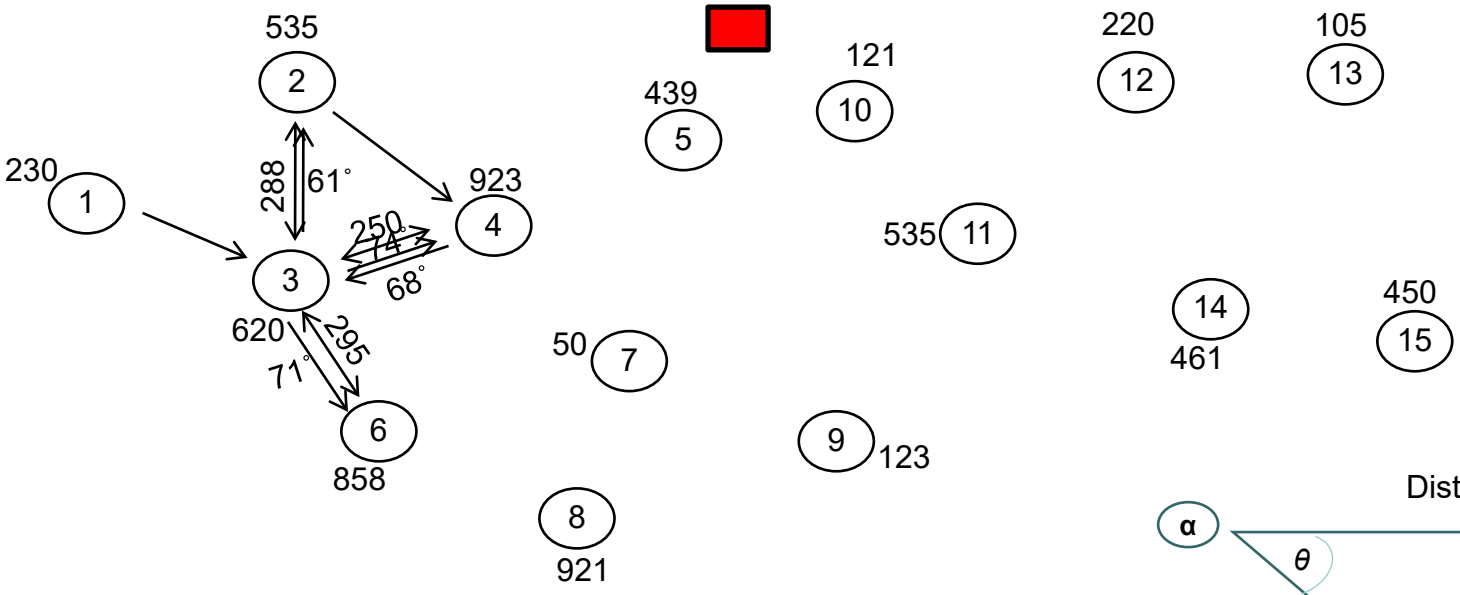
if ((2,4)>(4,2))
Connect(2,4)
else
Make 2 as a CH



$$\theta = \cos^{-1}\frac{d}{\sqrt{d^2 + e^2}}$$

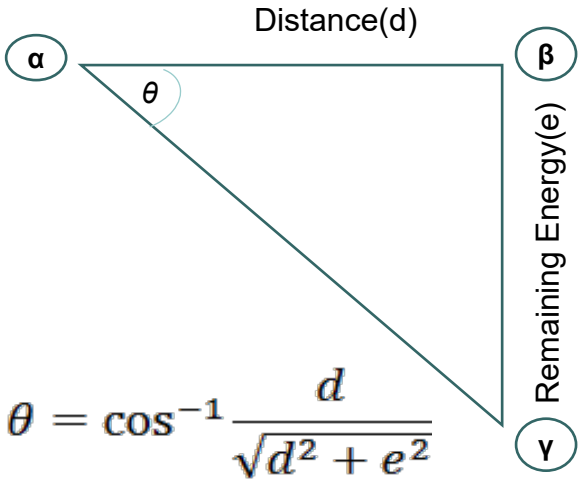
Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection



Max((3,2),(3,4),(3,6))= (3,4)=74º
Find Reverse Angle (4,3)= 68º

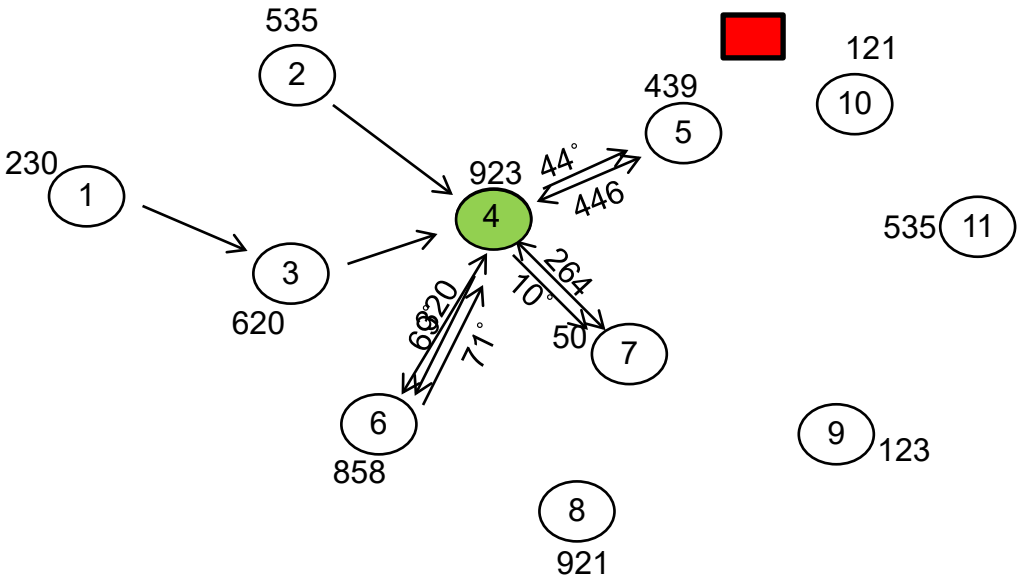
if ((3,4)>(4,3))
Connect(3,4)
else
Make 3 as a CH



$$\theta = \cos^{-1}\frac{d}{\sqrt{d^2 + e^2}}$$

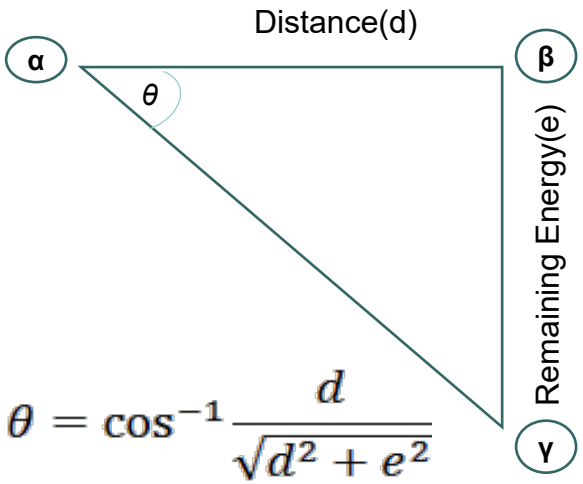
Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection



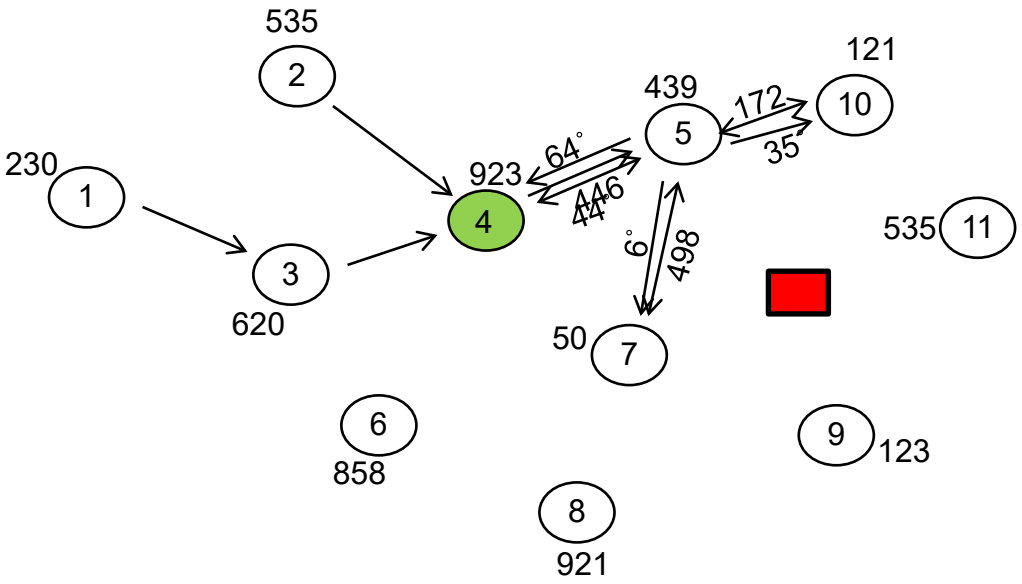
Max((4,5),(4,6),(4,7))= (4,6)=69º
Find Reverse Angle (6,4)= 71º

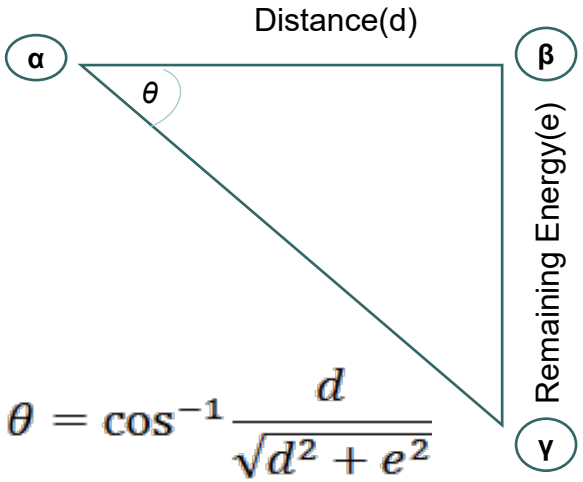
if ((4,6)>(6,4))
Connect(4,6)
else
Make 4 as a CH



Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection





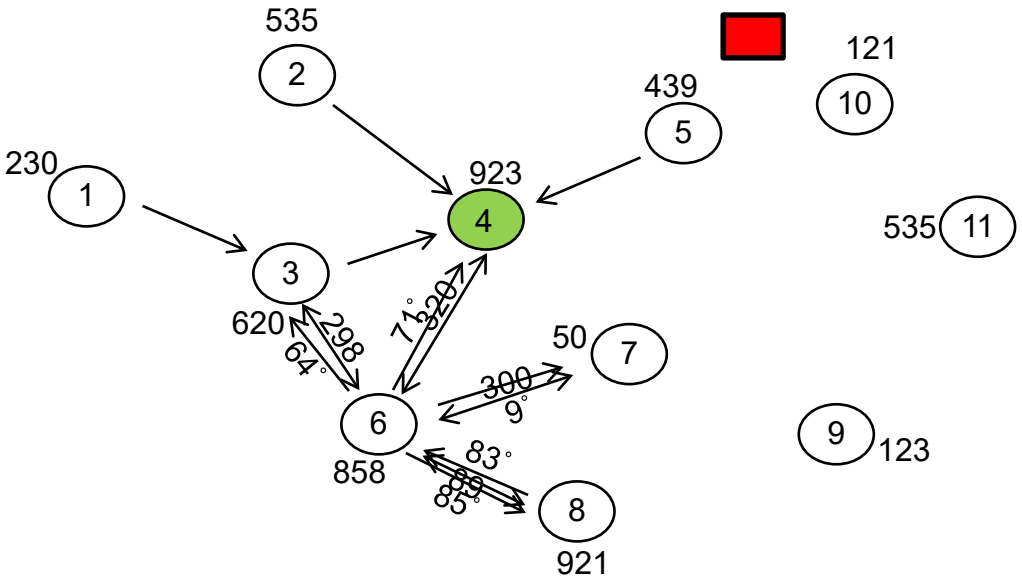
$$\theta = \cos^{-1}\frac{d}{\sqrt{d^2 + e^2}}$$

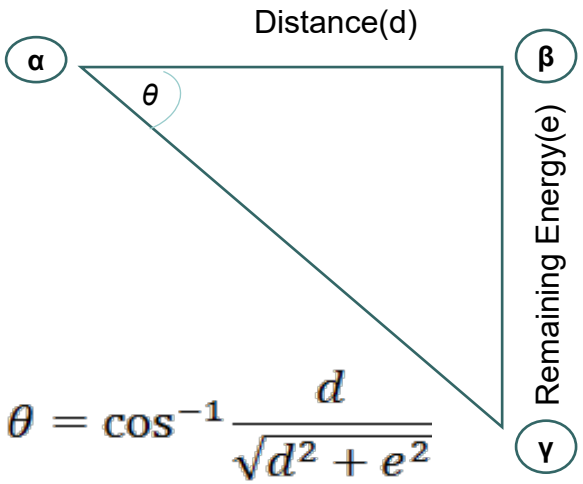
Max((5,4),(5,7),(5,10))= (5,4)=64º
Find Reverse Angle (4,5)= 44º

if ((5,4)>(4,5))
Connect(5,4)
else
Make 5 as a CH

Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection





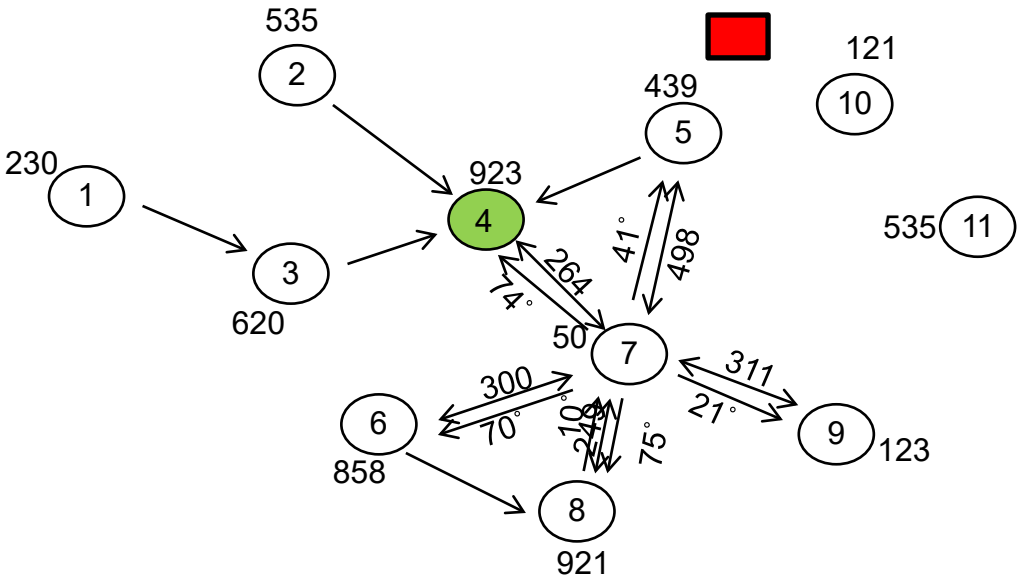
$$\theta = \cos^{-1}\frac{d}{\sqrt{d^2 + e^2}}$$

Max((6,3),(6,4),(6,8),(6,10))= (6,8)=85º
Find Reverse Angle (8,6)= 83º

if ((6,8)>(8,6))
Connect(6,8)
else
Make 6 as a CH

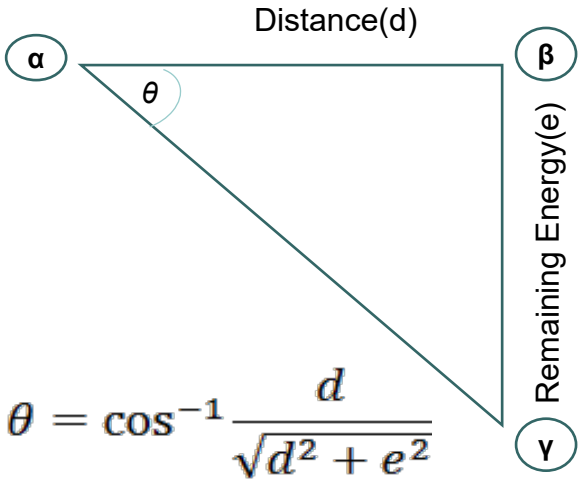
Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection



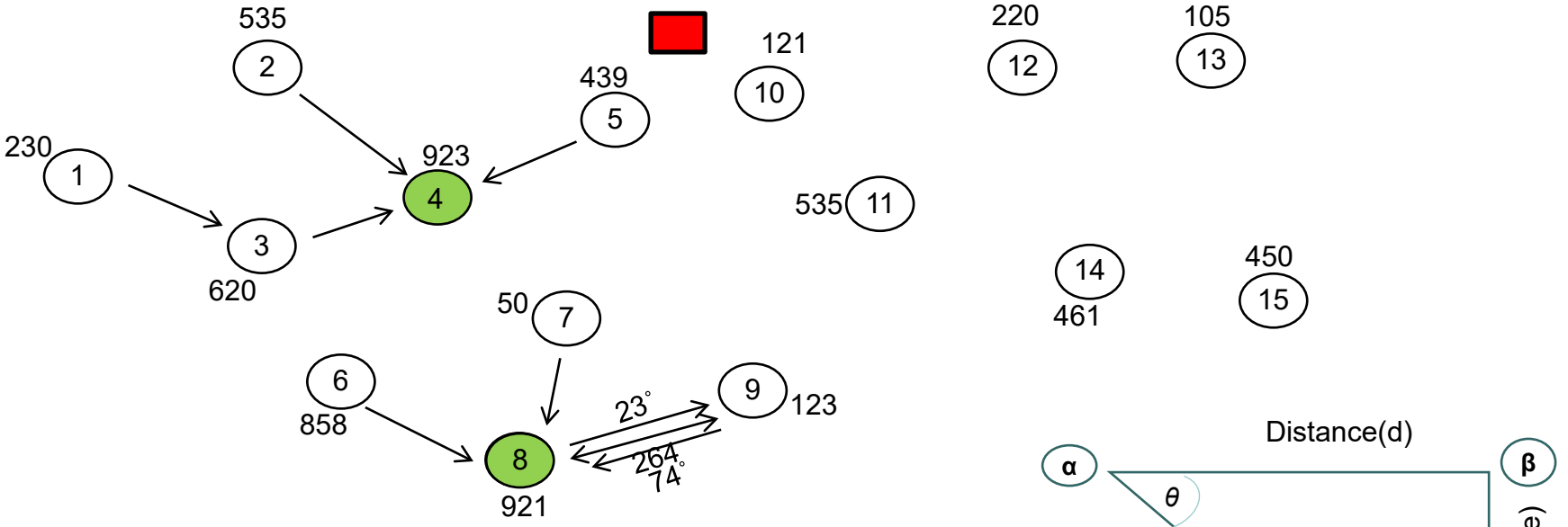
Max((7,4),(7,5),(7,6),(7,8),(7,9))= (7,8)=75º
Find Reverse Angle (8,7)= 10º

if ((7,8)>(8,7))
Connect(7,8)
else
Make 7 as a CH



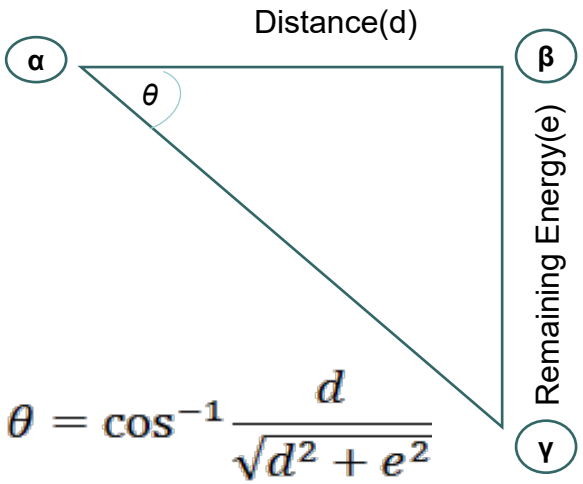
Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection



Max((8,9),)= (8,9)=23º
Find Reverse Angle (9,8)= 74º

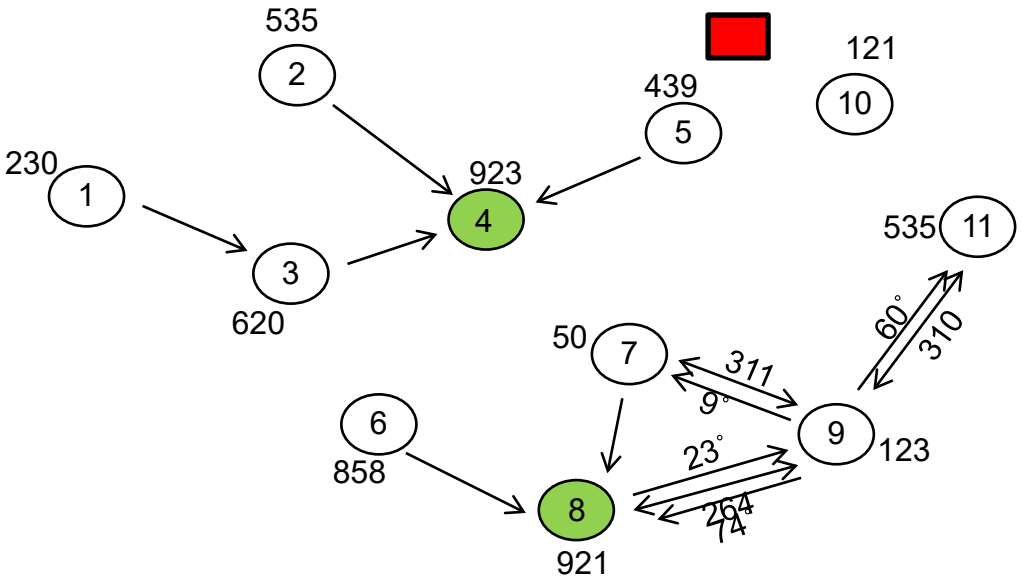
if ((8,9)>(9,8))
Connect(8,9)
else
Make 8 as a CH



$$\theta = \cos^{-1} \frac{d}{\sqrt{d^2 + e^2}}$$

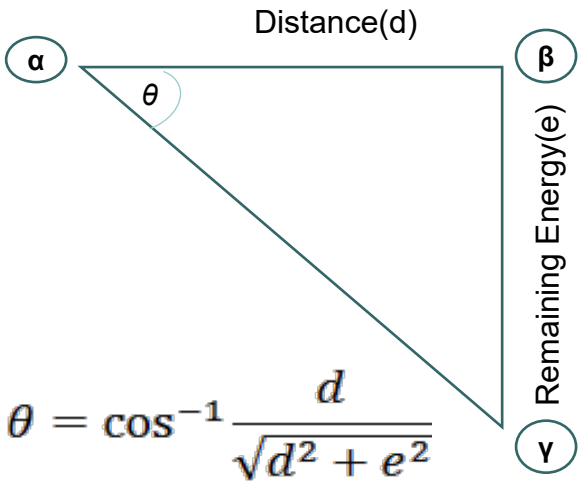
Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection



Max((9,7),(9,8),(9,11))= (9,8)=74º
Find Reverse Angle (8,9)= 23º

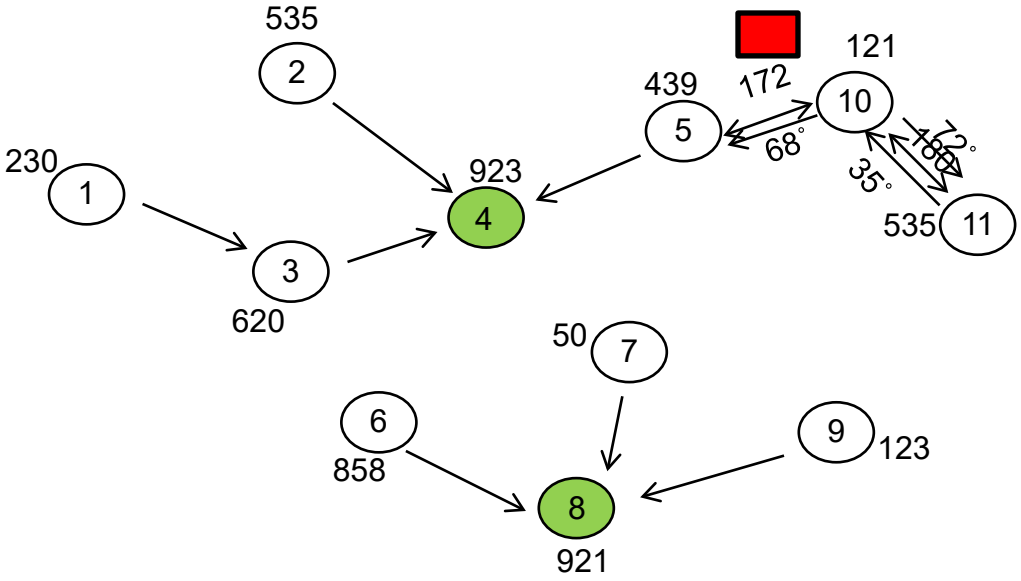
if ((9,8)>(8,9))
Connect(9,8)
else
Make 9 as a CH

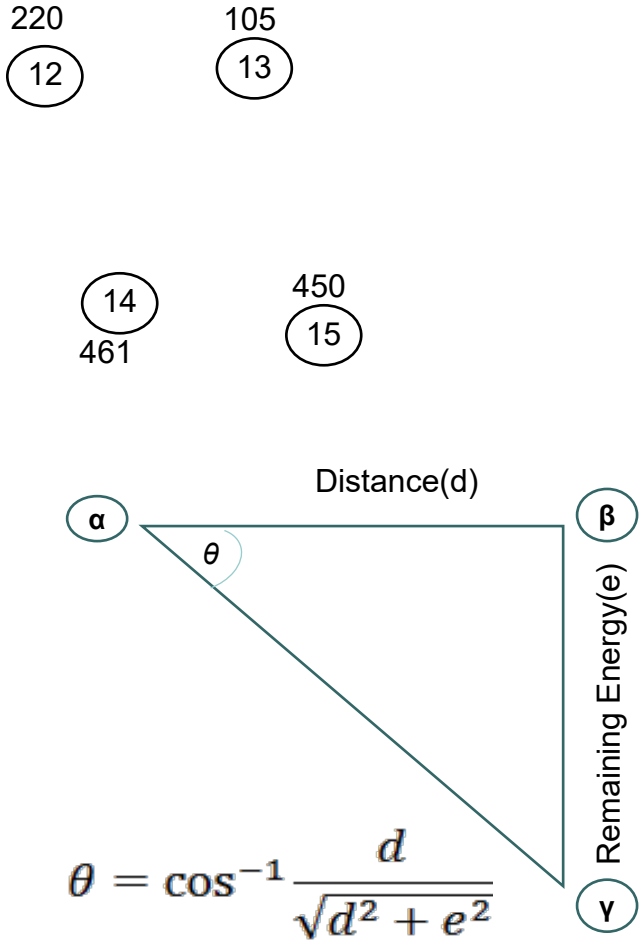


$$\theta = \cos^{-1} \frac{d}{\sqrt{d^2 + e^2}}$$

Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection





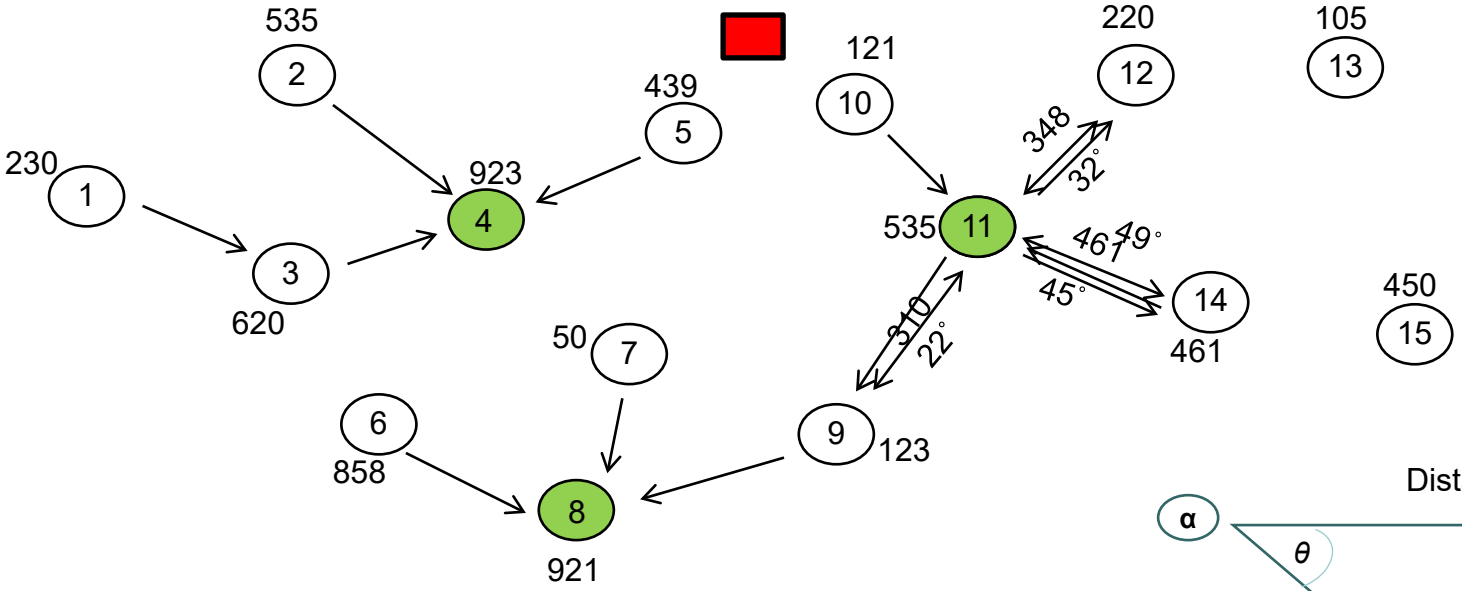
$$\theta = \cos^{-1}\frac{d}{\sqrt{d^2 + e^2}}$$

Max((10,5),(10,11))= (10,11)=72º
Find Reverse Angle (11,10)= 35º

if ((10,11)>(11,10))
Connect(10,11)
else
Make 10 as a CH

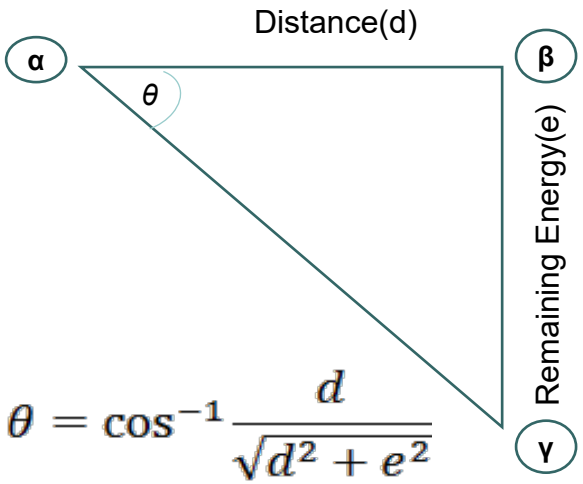
Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection



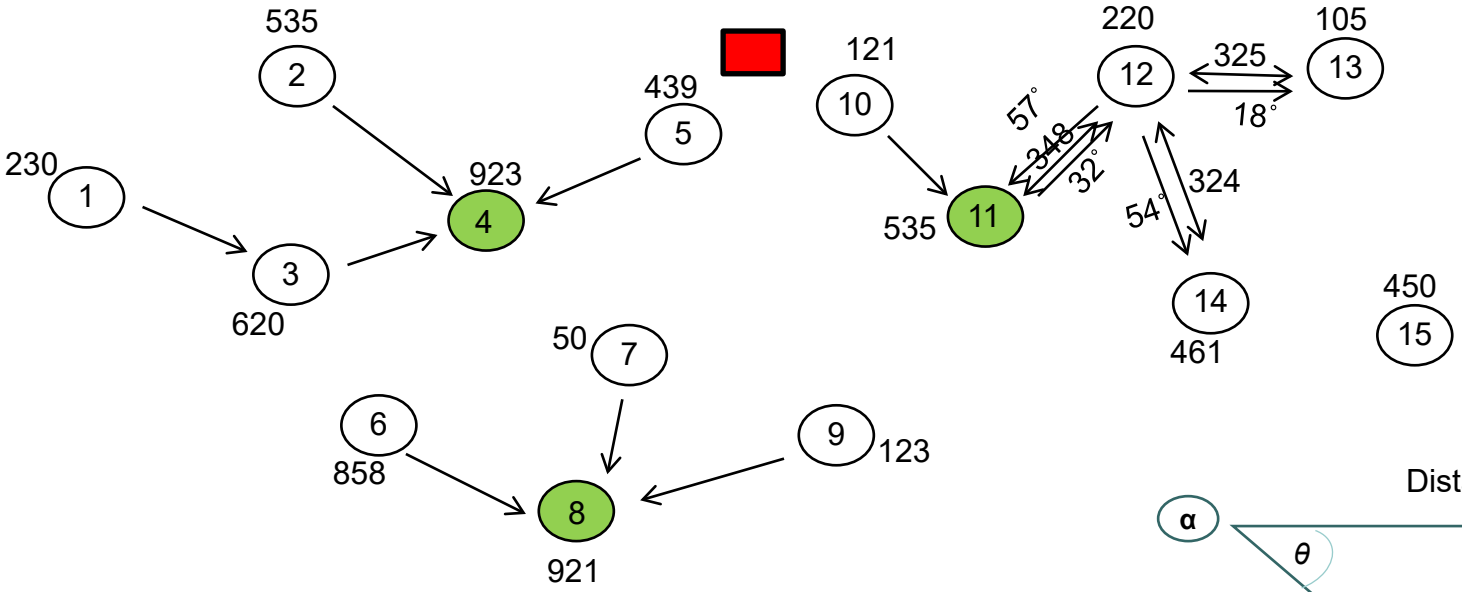
Max((11,9),(11,12),(11,14))= (11,14)=45º
Find Reverse Angle (14,11)= 49º

if ((11,14)>(14,11))
Connect(11,14)
else
Make 11 as a CH



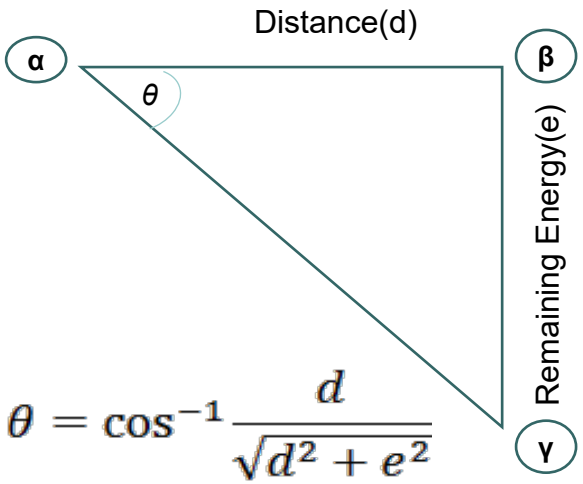
Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection



Max((12,1),(12,13),(12,14))= (12,11)=57º
Find Reverse Angle (11,12)= 32º

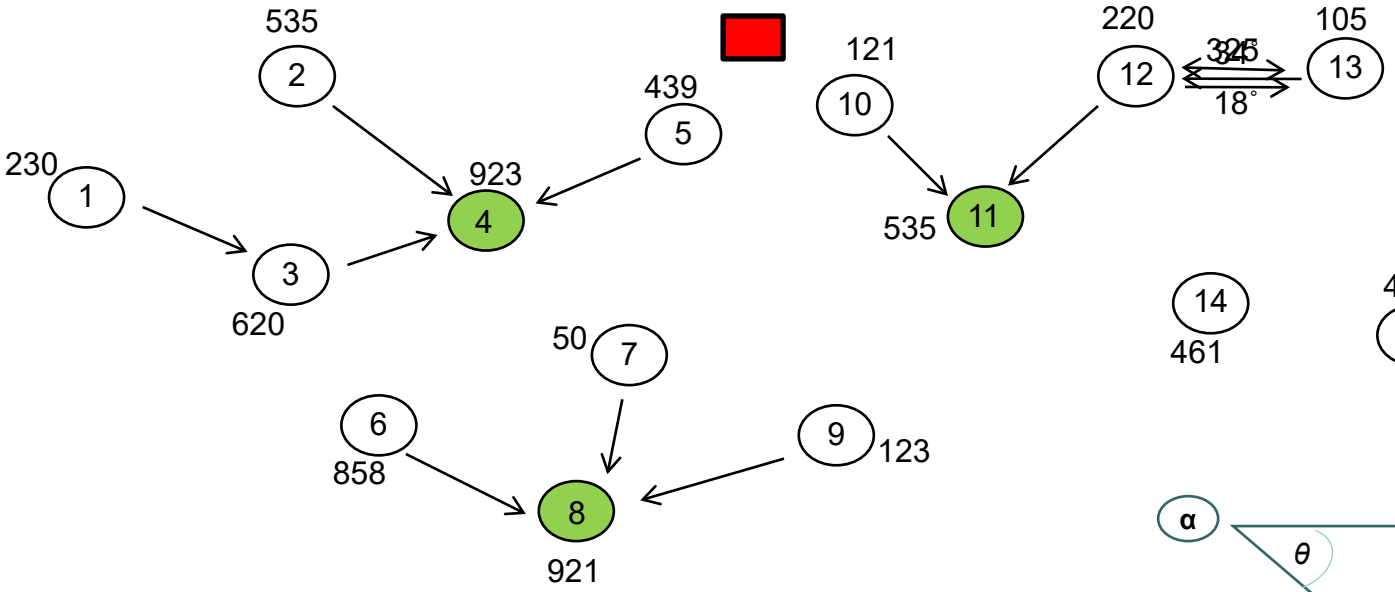
if ((12,11)>(11,12))
Connect(12,11)
else
Make 12 as a CH



$$\theta = \cos^{-1}\frac{d}{\sqrt{d^2 + e^2}}$$

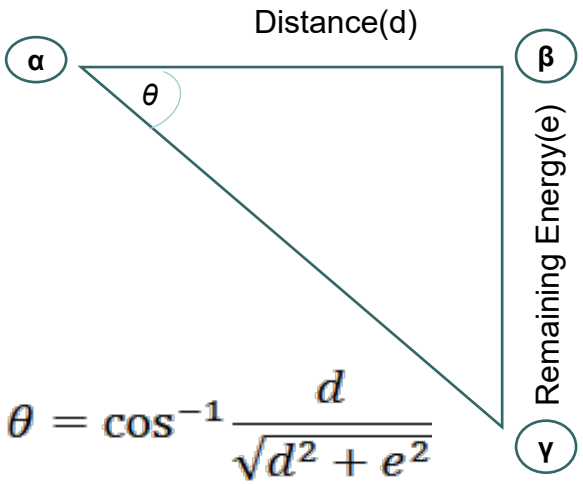
Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection



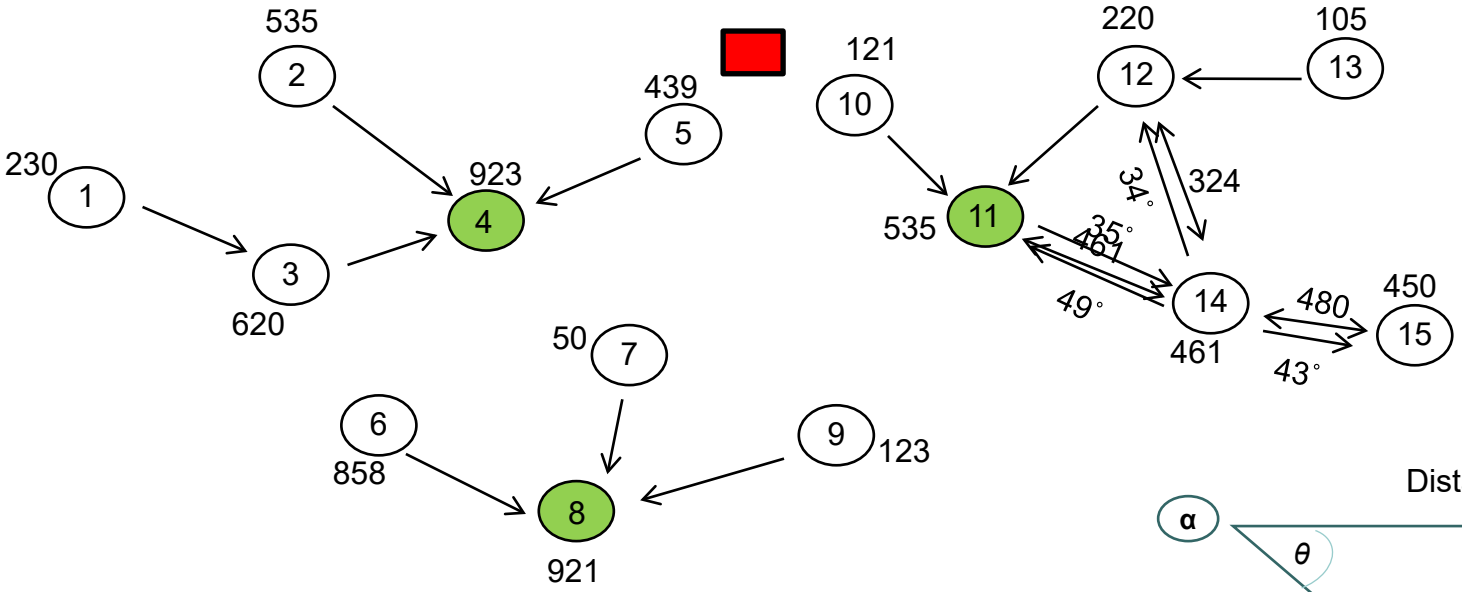
Max((13,12))= (13,12)=34º
Find Reverse Angle (12,13)= 18º

if ((13,12)>(12,13))
Connect(13,12)
else
Make 13 as a CH



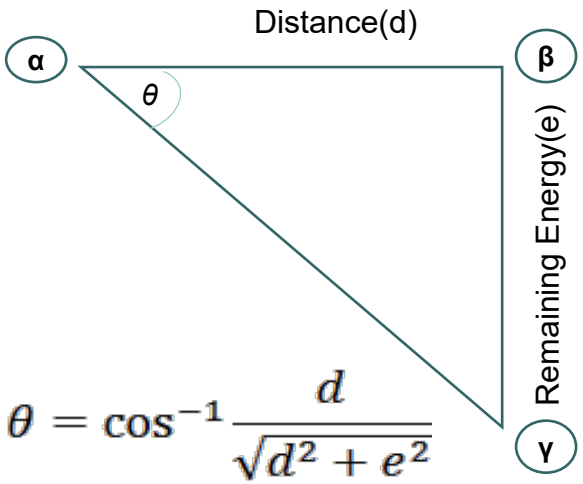
Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection



Max((14,11),(14,12),(14,15))= (14,11)=49º
Find Reverse Angle (11,14)= 45º

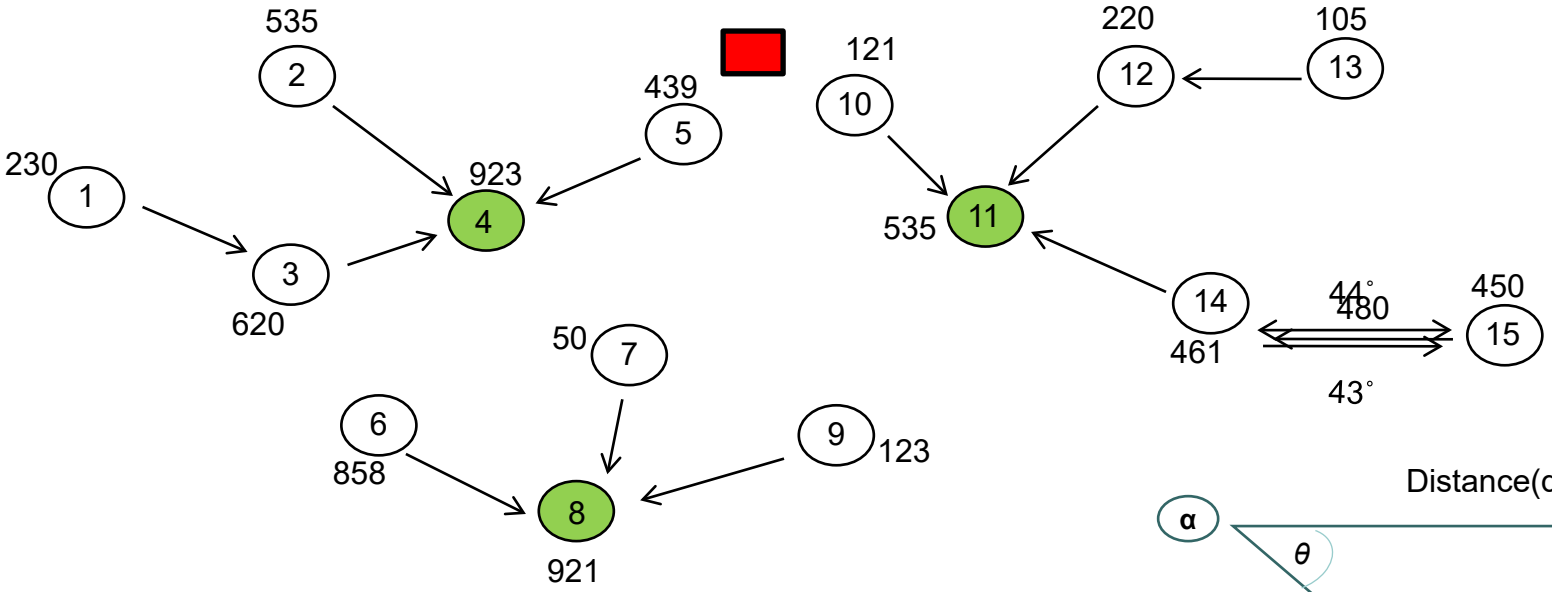
if ((14,11)>(11,14))
Connect(14,11)
else
Make 14 as a CH



$$\theta = \cos^{-1}\frac{d}{\sqrt{d^2 + e^2}}$$

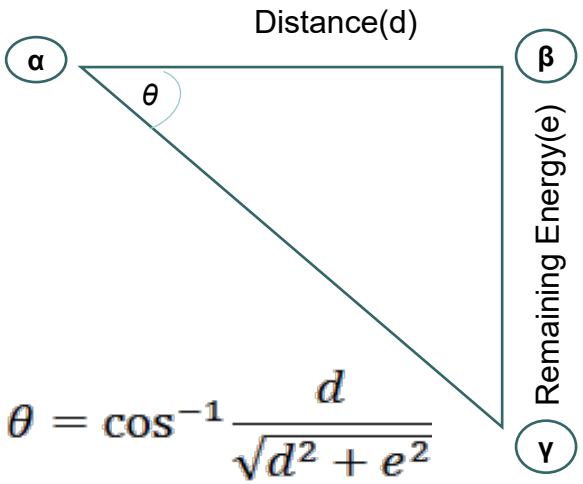
Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

Setup Phase: Cluster formation and Cluster Head selection



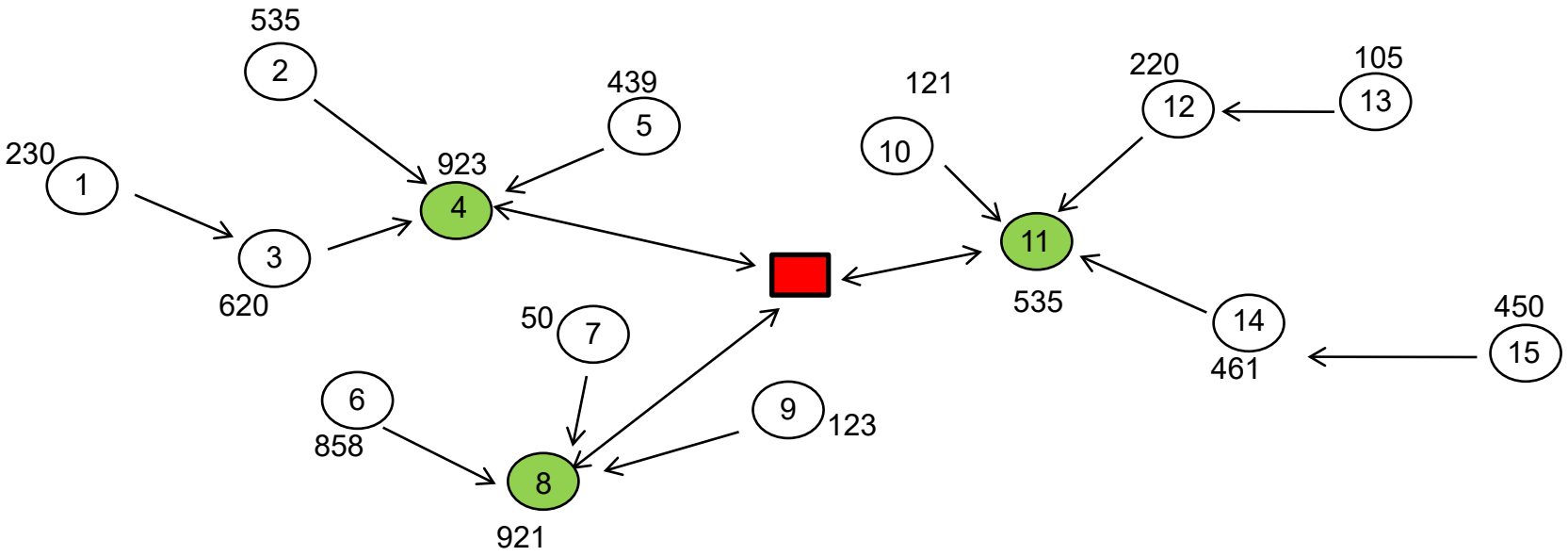
Max((15,14))= (15,14)=44º
Find Reverse Angle (14,15)= 43º

if ((15,14)>(14,15))
Connect(15,14)
else
Make 15 as a CH



Proposed Gravitational Model for Tree-Based Routing Protocol for WSN

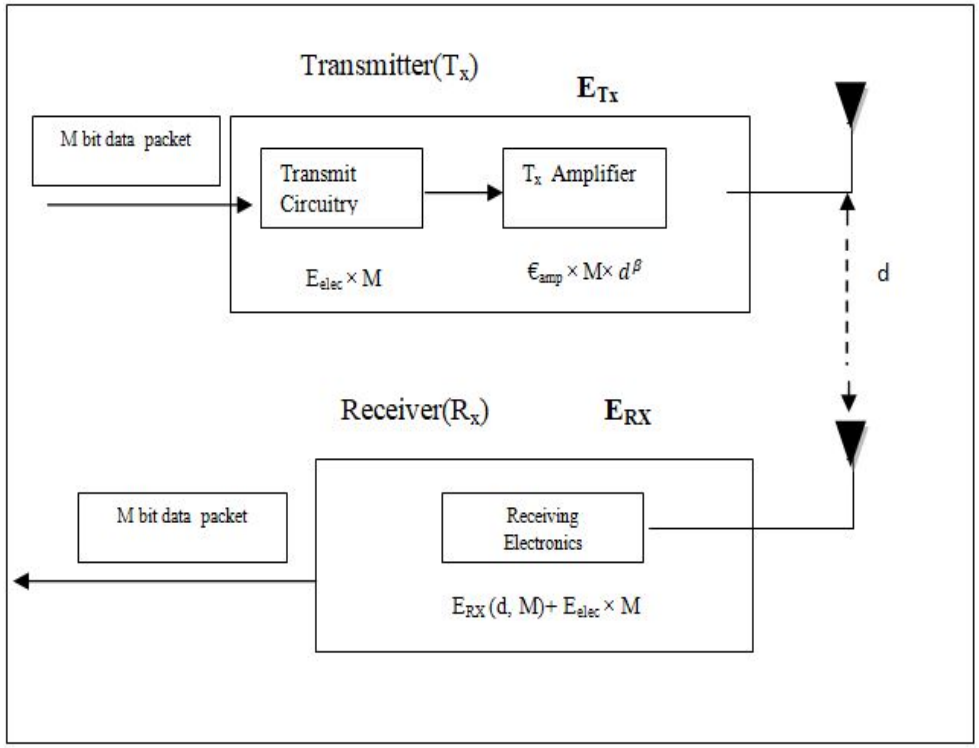
Final Network Structure



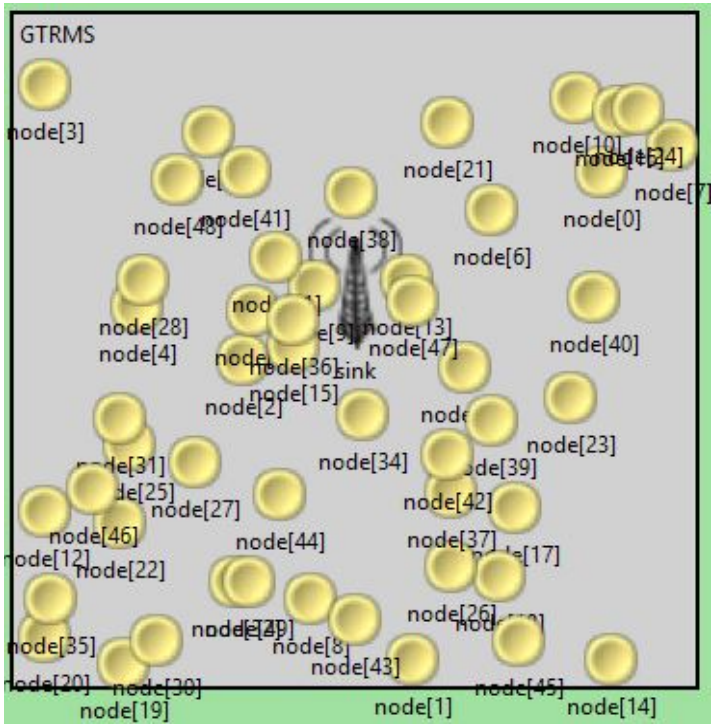
Steady State Phase : Transmission of Data

Result & Analysis

- **Radio Model**



- **Simulation Environment**



$$E_{TX}(M,d) = M * (E_{TX-elec} + E_{TX-amp}) \quad ; \text{Where}, E_{TX-amp} = \begin{cases} \varepsilon_{fs} d^2, d < d_0 \\ \varepsilon_{mp} d^4, d > d_0 \end{cases}$$

$$E_{RX}(M) = M * (E_{RX-elec} + E_{CA})$$

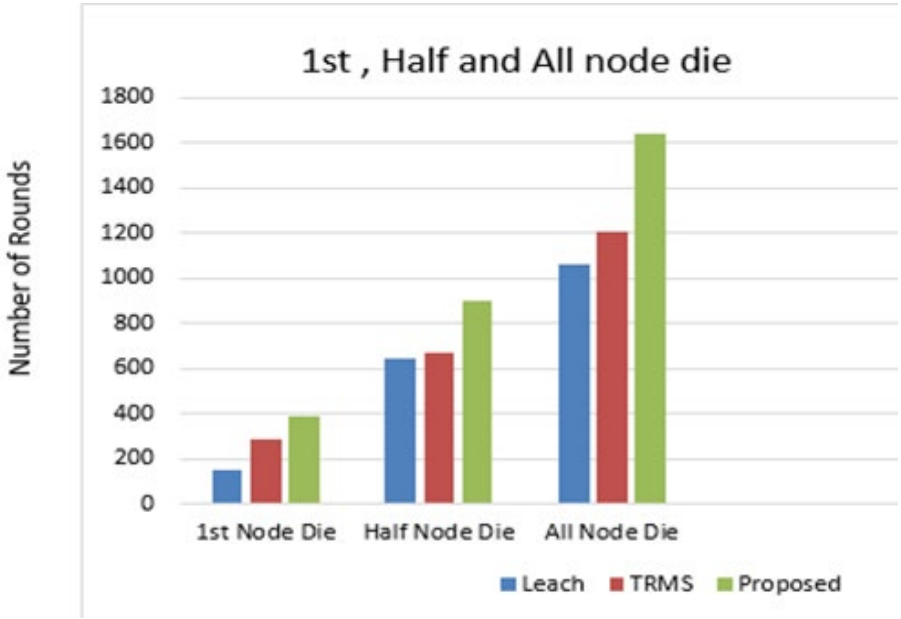
Result & Analysis

Simulation Parameters

Parameter	Value
Electronics Energy E_{elec}	50 nJ/bit
Energy for GPS receiver (E_{GPS})	20 nJ/bit/signal
Energy for data aggregation (E_{CA})	5 nJ/bit/signal
Initial energy of node (E_{init})	0.5 J(+/-)
Communication energy (ε_{fs})	10 pJ/bit/
Communication energy (ε_{mp})	0.0013 pJ/bit/
Threshold value of distance (d_0)	87 m
Packet Size	512 bytes
Sensing area $(m \times m)$	200×200
Number of Nodes (N)	50

Result & Analysis

- **First Node Die, Half Node Die and Last Node Die with respect to Round**



LEACH= 147
TRMS=285
Proposed =386

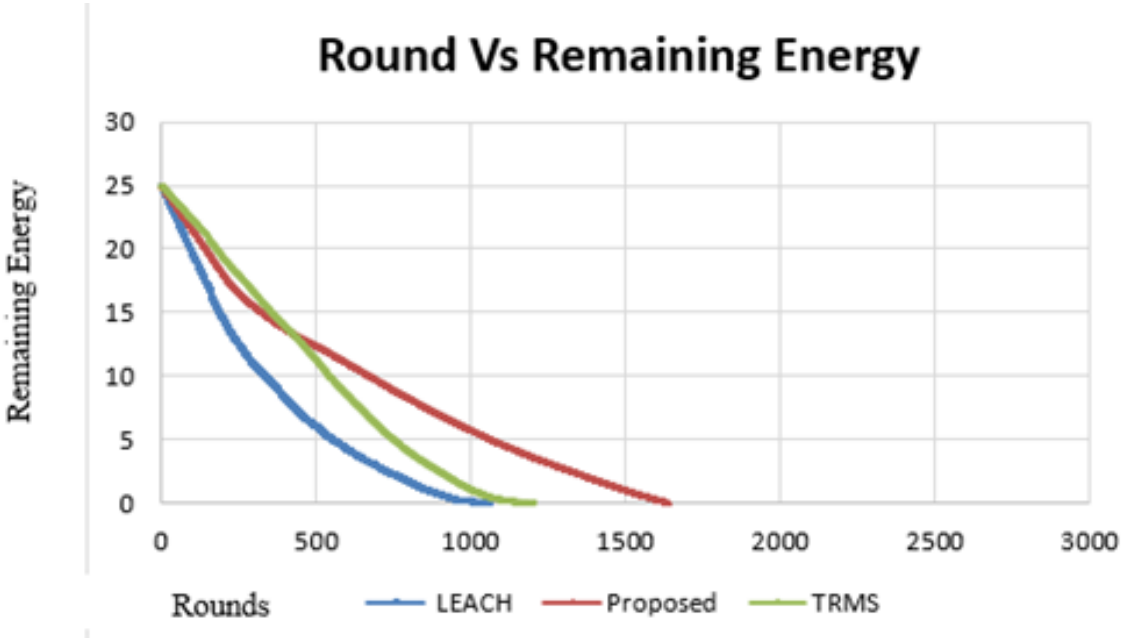
LEACH= 645
TRMS=666
Proposed =897

LEACH= 1060
TRMS=1205
Proposed =1638

For 50 Nodes

Result & Analysis

- **Remaining energy of the network with respect to Round**



Number of Rounds

For 50 Nodes

- 80%-90% energy consumed in around 1000 rounds in LEACH and TRMS whereas only 60% energy consumed for Proposed system

Conclusion & Future Work

- **Achievements:**
- Decrease the total energy lost per round
- Decrease path cost
- Removes bottlenecks of the network
- Increase the lifetime of the network

- Future Work
  - To test this scheme with real world implementation

Q & A

thank you!