packets are coded into a single packet and then transmitted to the sink node whereas in wang's general network each received packets are relayed to the sink node without performing any encoding operation hence overall efficiency of the network improves in

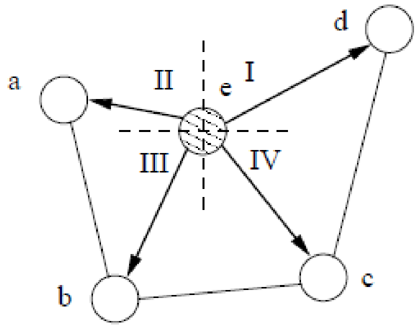

Figure 2: Sample network coding method

5. Methodology

1) Modules

a) Network Coding

Network coding is a technique which can be used to improve network's throughput, efficiency and scalability, as well as resilience to attacks and also allows encoding the incoming packets the encoding and decoding methods of linear network area. Encoding operation: A node, which wants to transmit encoded packets. The coded packets are transmitted with the n coefficients in the network. The encoding vector is used at the receiver to decode the encoded data packets the output encoded packet is given by

$$Y = \sum_{i=1}^{n} q_i G_i, \qquad q_i \in GF(2^s)$$

b) Decoding operation

A receiver node solves a set of linear equations to retrieve the original packet from the received coded packets. The encoding vector q is received by the receiver sensor nodes with the encoded data.

$$Y^j = \sum_{i=1}^{n} q_i^j G_i, \qquad j = 1, \ldots, m$$

2) Network coding with omnidirectional antennas

Using omnidirectional antennas, the transmission range of each node is divided into several sectors and transmission must occur within that sector thus reducing the number of transmissions and reducing the interference as well as energy consumption on reception of packets from neighboring nodes the network coder nodes encodes the data and transmitted
toward the sink node.

3) Estimation of upper bounds of Network lifetime using duty cycle

The estimation of upper bounds of lifetime and energy savings due to duty cycle.

a) Energy consumption method of duty cycle each sensor nodes will consume energy at different stages such as sensing, generating data, transmitting, receiving and sleeping state energy consumption in time t by a source node per second across a distance d with path loss exponent n is

$$E_{tx} = R_d(\alpha_{11} + \alpha_2 d^n)$$

where Rd transreceiver relay data rate the total energy consumption of a source node without acting as relay

$$E_S = t[p(r_s e_s + E_{tx}) + (1-p)E_{sleep}]$$

The energy consumption in time t by intermediate node acting as a relay is

$$E_{txr} = R_d(\alpha_{11} + \alpha_2 d^n + \alpha_{12}) = R_d(\alpha_1 + \alpha_2 d^n)$$

b) Energy consumption method of Network coding and duty cycle energy consumption in bottleneck zone are viewed as

i. To relay the data bits which are received from outside of the bottleneck zone
ii. Due to sensing operation
iii. Encoding the sensed data
iv. Transmitting the encoded data to the sink node.

The total energy consumption inside the bottlenevk zone to relay the data bits generated outside the bottleneck zone is

$$E_{1GD} \geq \sum_{i=1}^{\lfloor Np\frac{A-B}{A} r_s t \rfloor} \sum_{j=1}^{\lfloor \frac{m+1}{2} \rfloor} E_{ij}$$

the sensing energy consumption by active nodes in bottleneck zone is

$$E_{2GD} = Np\frac{B}{A} r_s e_s t$$

the energy consumption to relay the data bits generated inside the bottleneck zone is

$$E_{3GD} = p\frac{N}{A} r_s t \iint_B l(x) dS$$

$$E_{3GD} \geq p\frac{N}{A} r_s t \iint_B \left(\alpha_1 \frac{n}{n-1} \frac{x}{d_m} - \alpha_{12}\right) dS$$

the total energy consumption in bottleneck zone is given by

$$E_D = E_{1GD} + E_{2GD} + E_{3GD} + (1-p)tN\frac{B}{A}E_{sleep}$$

$$E_D = \left\lfloor \frac{m+1}{2} \right\rfloor Npr_s t\frac{A-B}{A}\left(\alpha_1 \frac{n}{n-1} \frac{D}{d_m}\right) + Np\frac{B}{A} r_s t e_s + p\frac{N}{A} r_s t \iint_B \left(\alpha_1 \frac{n}{n-1} \frac{x}{d_m} - \alpha_{12}\right) dS + (1-p)tN\frac{B}{A}E_{sleep}$$

4) Estimation of upper bounds of lifetime using network and duty cycle

The energy consumption has been estimated by combining network coding and duty cycle

a) Estimation of upper bound using network coding without duty cycle energy consumption in the bottleneck zone to relay the data generated from outside the bottleneck zone

$$E_{1NC} \geq \sum_{i=1}^{\lfloor N\frac{A-B}{h\cdot A}r_s t\rfloor} \sum_{j=1}^{\lfloor\frac{m+1}{2}\rfloor} E_C(ij) + \sum_{i=1}^{\lfloor N\frac{(A-B)(h-1)}{h\cdot A}r_s t\rfloor} \sum_{j=1}^{\lfloor\frac{m+1}{2}\rfloor} E_R(ij)$$

$$E_{1NC} \geq \left\lfloor \frac{m+1}{2} \right\rfloor N r_s t \alpha_1 \frac{n(A-B)}{A(n-1)} \frac{D}{d_m} \frac{1+k(h-1)}{kh}$$

b) a fraction of traffic generated in the bottleneck zone are relayed through coder nodes so the energy consumption in the bottleneck zone to relay the data generated inside the bottleneck zone is

$$E_{3NC} = \frac{N}{A} r_s t \int\int_B l(x) dS$$

$$\Rightarrow E_{3NC} \geq \frac{N}{A} r_s t \iint_B \left(\alpha_1 \frac{n}{n-1} \frac{x}{d_m} - \alpha_{12}\right) dS$$

The estimation of upper bound of the network lifetime with network coding is given by

$$E_{NC} = E_{1NC} + E_{2NC} + E_{3NC} \leq \frac{NB}{A} E_b$$

$$\Rightarrow \left\lfloor \frac{m+1}{2} \right\rfloor \alpha_1 \frac{D}{d_m} \frac{n(A-B)}{A(n-1)} N r_s t \frac{1+k(h-1)}{kh} + N\frac{B}{A} r_s e_s t + \frac{N}{A} r_s t \iint_B \left(\alpha_1 \frac{n}{n-1} \frac{x}{d_m} - \alpha_{12}\right) dS \leq \frac{NB}{A} E_b$$

$$\Rightarrow t \leq \frac{d_m B E_b}{Q_\varphi} = T_{uNC}$$

and the term Q_φ is given by

$$Q_\varphi = r_s \alpha_1 \frac{n}{n-1} \left[\left\lfloor \frac{m+1}{2} \right\rfloor D(A-B) \frac{1+k(h-1)}{kh} + \iint_B x dS \right] + r_s(e_s - \alpha_{12}) d_m B$$

5) Estimation of upper bound using network coding with duty cycle

The energy consumption inside the bottleneck zone to relay the data generated outside of the bottleneck zone is

$$E_{1NCD} \geq \sum_{i=1}^{\lfloor Np\frac{A-B}{h\cdot A}r_s t\rfloor} \sum_{j=1}^{\lfloor\frac{m+1}{2}\rfloor} E_C(ij) + \sum_{i=1}^{\lfloor Np\frac{(A-B)(h-1)}{h\cdot A}r_s t\rfloor} \sum_{j=1}^{\lfloor\frac{m+1}{2}\rfloor} E_R(ij)$$

$$E_{1NCD} \geq \left\lfloor \frac{m+1}{2} \right\rfloor p N r_s t \alpha_1 \frac{n(A-B)}{A(n-1)} \left[\frac{D}{d_m} \frac{1+k(h-1)}{kh} \right]$$

The upper bound of the lifetime using duty cycle and network coding based approach is given by

$$E_{NCD} = E_{1NCD} + E_{2NCD} + E_{3NCD} + (1-p) t N \frac{B}{A} E_{sleep} \leq \frac{NB}{A} E_b$$

$$\Rightarrow \left\lfloor \frac{m+1}{2} \right\rfloor p N r_s t \alpha_1 \frac{n(A-B)}{A(n-1)} \frac{D}{d_m} \frac{1+k(h-1)}{kh} + N\frac{B}{A} t p r_s e_s + p\frac{N}{A} r_s t \iint_B \left(\alpha_1 \frac{n}{n-1} \frac{x}{d_m} - \alpha_{12}\right) dS + (1-p) t N \frac{B}{A} E_{sleep} \leq \frac{NB}{A} E_b$$

$$\Rightarrow t \leq \frac{d_m B E_b}{Q_\delta} = T_{uNCD}$$

and Q_δ is given by

$$Q_\delta = p r_s \alpha_1 \frac{n}{n-1} \left[\left\lfloor \frac{m+1}{2} \right\rfloor D(A-B) \frac{1+k(h-1)}{kh} + \iint_B x dS \right] + B d_m \left[p r_s (e_s - \alpha_{12}) + (1-p) E_{sleep} \right]$$

6. Performance Analysis

a) Throughput

Throughput is the rate of successful message over a communication channel. the amount of data is transmitted from source to the destination in a specified amount of time and it is measured in kbps, Mbps or Gbps.

b) Energy Consumption

The energy consumption rate for sensors in wireless sensor networks varies by the protocols the sensors use for communications and it is measured in joules.

c) Packet Delivery Ratio

It is the ratio of number of delivered data packet to the destination. the node density increases with proposed network coding approach has higher packet delivery ratio than the duty cycle based approach.

7. Simulation Results

Energy consumption in joules with Network coding (red) and without network coding based approach (green)

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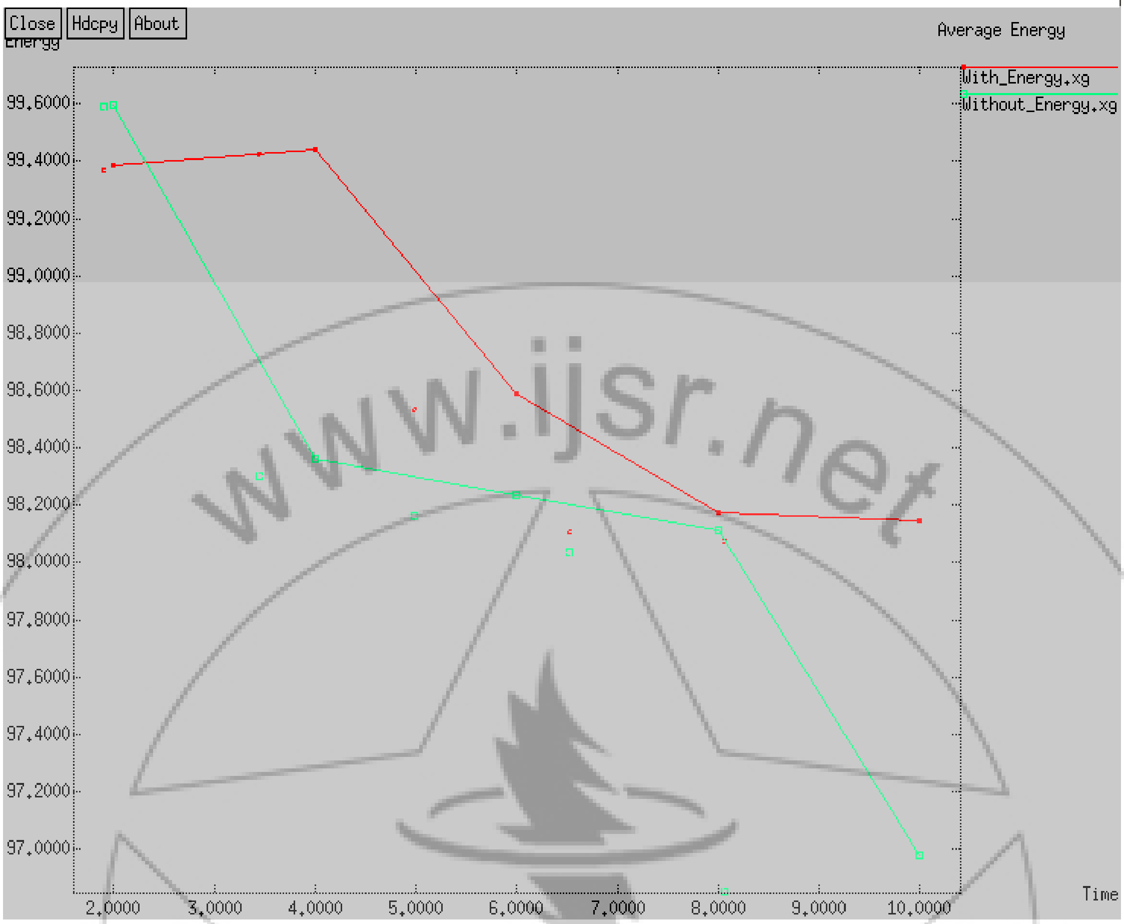
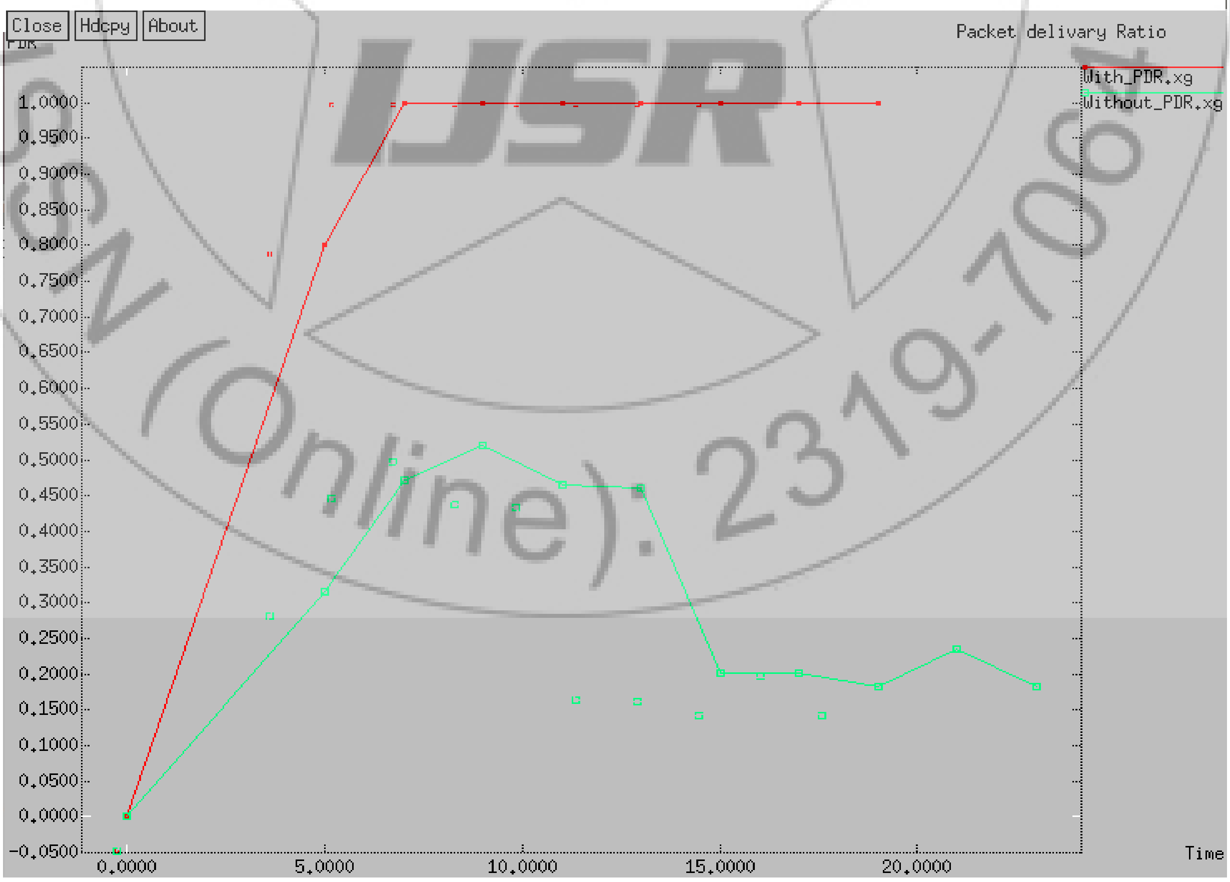
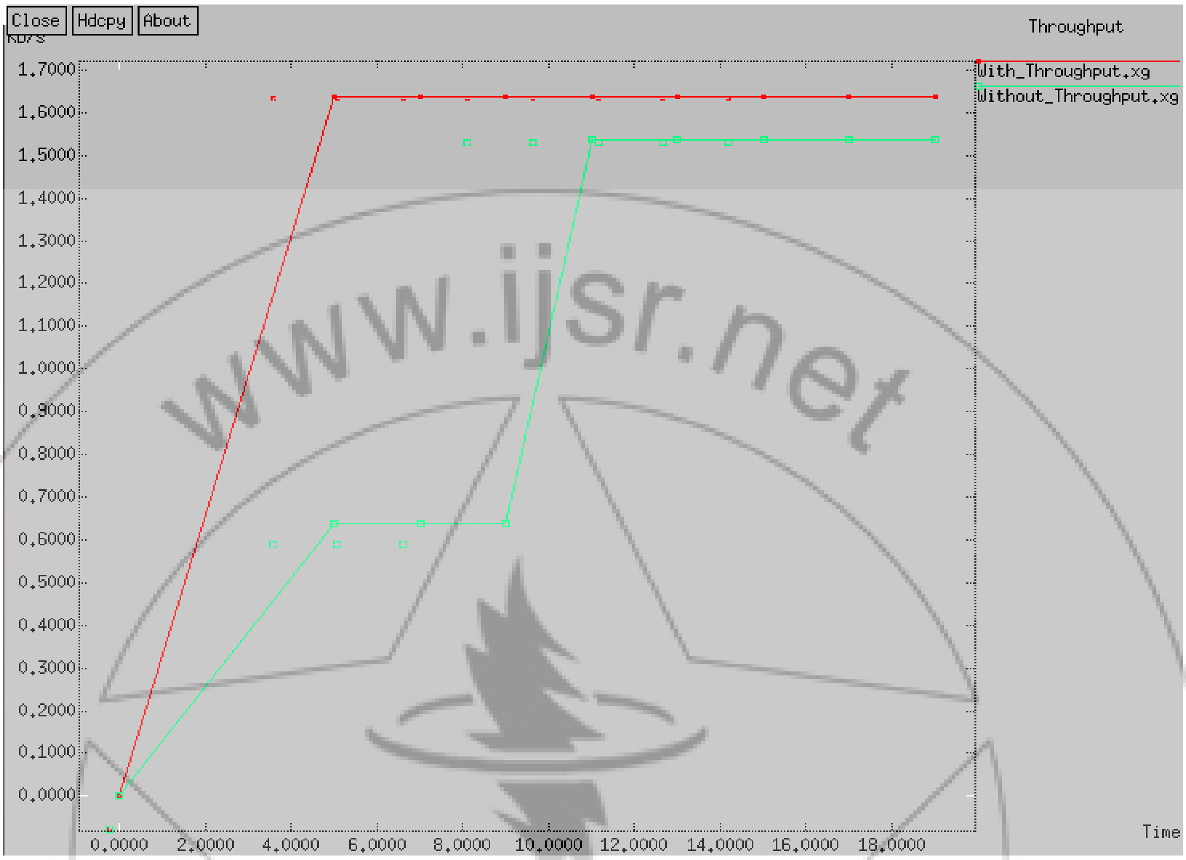


b. Packet delivery ratio with Network coding (red) and without network coding approach(green)



c. Throughput in Kbps with Network coding (red) and without Network coding (green)



8. Conclusion

In wireless sensor network, simulation results reveal that there is rapid decrease in the energy consumption in proposed network coding based approach than duty cycle approach hence the packet delivery ratio for the proposed approach have been observed that there is a significant improvement in packet delivery ratio is achieved with less number of packet loss than duty cycle approach and in throughput the sink receives more amount of bits with network coding approach than without network coding

9. Future Scope

The future scope of the present work is Energy enhancement analysis can be done by selecting nodes as network coder nodes which are at k hops where (k=1,2..) away from the sink. Further, the proposed analysis may be improved by proper designing of MAC and routing protocols for energy constrained or duty cycled Wsn.

References

[1] Q. Wang and T. Zhang, "Bottleneck zone analysis in energy-constrained wireless sensor networks," IEEE Commun. Lett., vol. 13, no. 6, pp. 423– 425, June 2009
[2] S.-Y. Li, R. W. Yeung, and N. Cai, "Linear network coding," IEEE Trans. Inf. Theory, vol. 49, no. 2, pp. 371–381
[3] M. Bhardwaj, T. Garnett, and A. Chandrakasan, Upper bounds on the lifetime of sensor networks," in Proc. 2001 IEEE ICC, pp. 785–790
[4] R. R. Rout, S. K. Ghosh, and S. Chakrabarti, "Network coding-aware data aggregation for a distributed wireless sensor network," in Proc. 2009 IEEE ICIIS, pp. 32–36.
[5] C. Fragouli, J.Widmer, and J.-Y L. Boudec. A network coding approach to energy efficient broadcasting: from theory to practice. In Proc. of IEEE INFOCOM, 2006

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