# Energy-efficient routing in wireless sensor networks for delay sensitive applications

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# Outline

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# Introduction

- Certain  applications such as volcanic monitoring ; where sensor nodes are deployed to monitor the seismic activities and emission levels of volcanic craters, are highly delay-sensitive.

- In these applications, data should be transmitted to the control center within a prescribed delay (time) in observance of any unusual activity.

- In this work, a new heuristic, routing strategy for solving delay-constrained, energy-efficient routing problem (DCEERP) is described.

- The strategy employs power control and also models the channel access delay caused by 802.11-like MAC layer to solve the DCEERP

# Problem Formulation

- Let s be a sensor node generating time-sensitive data to be sent to the sink t; d' be the maximum, tolerable , end-to-end delay in the transmission; let P denote the set of possible paths between s and t; $d_i$ and $E_i$ denote end-to-end delay and energy consumed along the path $P_i$ Є P. Given the above , the DCEERP can be formulated as:

- Find a path $P_i$*, such that $P_i^*$ Є $P^{c}$, and $E_i^* \leqslant E_j$ for every $P_j$ Є $P^c$ where , $P^c = \{ P_i / P_i$ Є $P$ and $d_i \leqslant d \}$

# Assumptions

- The sensor nodes are stationary and are aware of their geographical locations.
- Each node is equipped with 2 radios:
  - Low-power radio for short range communication
  - High-power radio for long range communication
- Both radios (in each node) operate at different frequencies.
- Long range radio is only used when delay constraint cannot be satisfied using the short range radio.
- The sensor nodes use 802.11 –like channel access scheme for each of the 2 wireless channels

# Network Architecture

- Geographical area under monitor is divided into sectors of angular width ɵ and angular bands of thickness b
- Sensed region viewed as a grid in polar co-ordinates
- Network grid is generated when the sink advertises the values of ɵ and b over the entire network
- Each grid cell has a gateway – a node close to the cell's center that aggregates the information sensed in that particular cell
- All the gateways in the network form a communication backbone
- After hearing the sink's advertised values of ɵ and b, sensor nodes located within a small distance ε from a cell 's geographical center start a random timer.

# Network Architecture(Contd)

- The node whose timer expires first advertises itself as the cell’s gateway. Other nodes on hearing the advertisement cancel their timers.
- There are 2 phases ;– intra-cell and inter-cell phases in relaying data from a sensor node to the sink.
  - Intra-cell:- node-to-gateway transmission within same cell (within time d’’ < d’)
  - Inter-cell :- gateway-to-sink transmission (within time d’- d’’)
- A gateway can only act as an intermediate hop for sensory data that originates in the same sector as the gateway

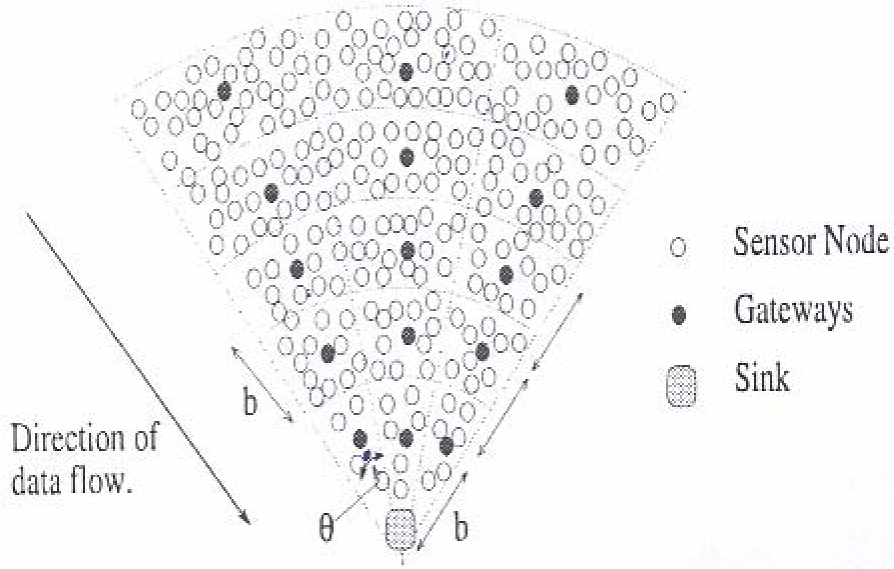


Fig. 1. Network Architecture.

# Solution Algorithm

1) **If** the delay along $g_N$'s basis path is less than $d$,
   a) The basis path from any given gateway is its DCEERP solution.
   b) Return.
2) **Else**
   a) For each $n = 1$ to $N$,
      i) Since the delay across short-range links can be calculated, remove all paths from $\mathcal{P}_n$ that may not satisfy the delay constraint.
      ii) Arrange members of $\mathcal{P}_n$ in the increasing order of energy consumption.
   b) $U \rightarrow \oslash$
   c) Iterate the following until the delay for the solution path from each of the gateway does not change anymore.
      i) For $n = N$ to 2,
         A) Use the current value for $U$ to determine the lowest index path $P_n^* \in \mathcal{P}_n$ that satisfies the delay constraint.
         B) Modify $U$ to add any new gateway in $P_n^*$ that may use its long range radio. Add the appropriate range as well.
   d) Return.

Fig. 2. Procedure to determine DCEERP solution paths.

# Conclusion

- A new heuristic approach for finding energy-efficient paths that satisfy the delay constraint in sensor network is presented.