Optimizing the computation and communication energy costs of Wireless Sensor Networks

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Outline

- Notations
- Network and Assumptions
- Optimization Problems
  - Minimize total energy with Quality of Information (QoI) as constraint
  - Maximize QoI with total node energy as constraint
- Future Plans and directions

Notations

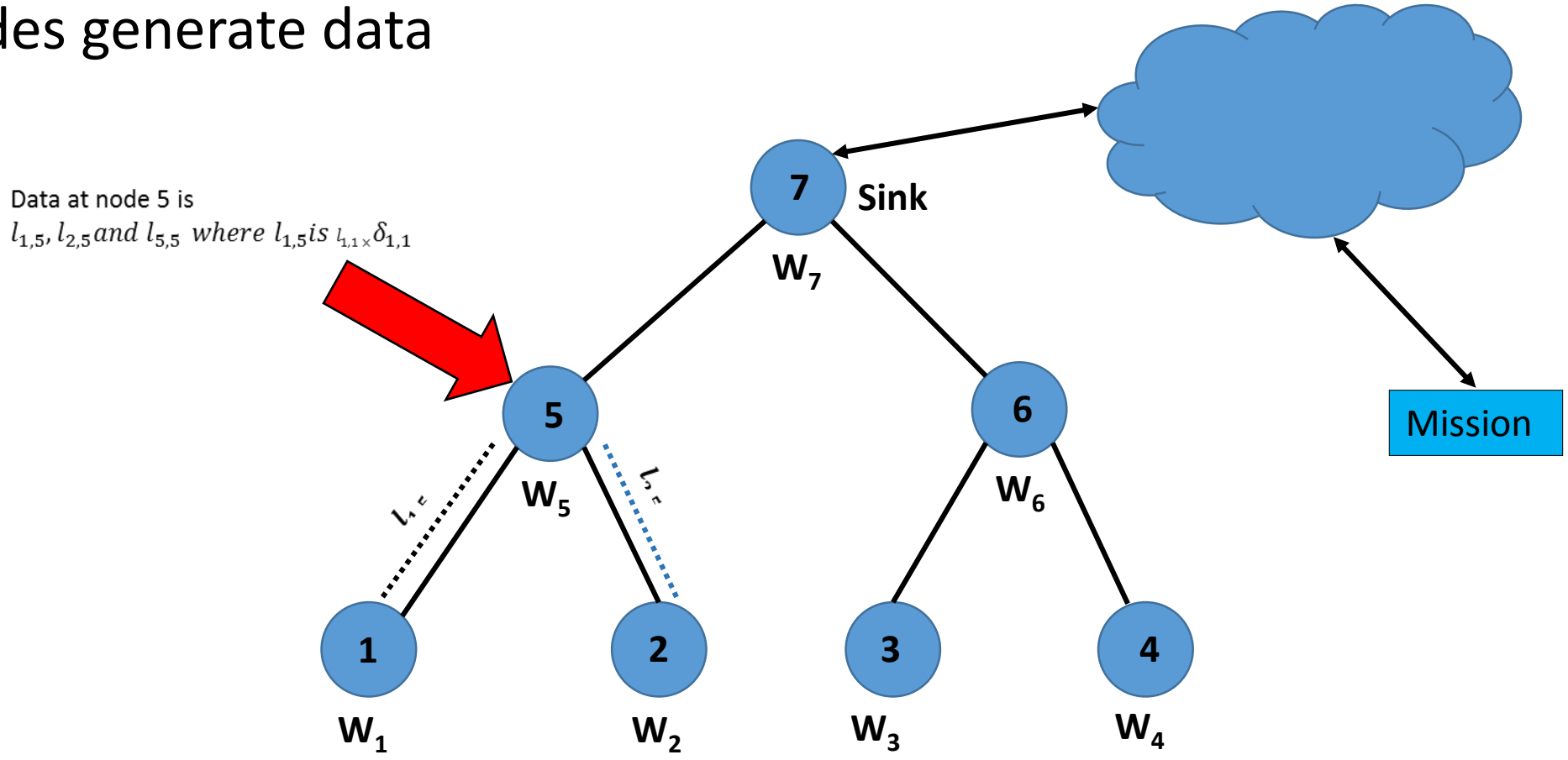
- Let $l_{i,j}$ be the number of bits at node j (where j$\in$ $path(i)$) that were generated by source i
- Let $\delta_{i,j}$ be the reduction rate at node j for data generated at node i, where reduction rate is (Volume of output data)/(Volume of input data)
- Let α_j be the per bit reception (Rx) energy cost
- Let β_j be the per bit transmission (Tx) energy cost
- Let ζj be the per bit computation (compression) cost

Notations (cont.)

- Let w_i be the weight assigned to the data generated at node i
  - The weight helps in ascertaining that highly important data is transmitted without any compression
- Let the total energy $E_{i,j}^{Total}$ consumed at different nodes (j) due to the source nodes(i) be
  - $E_{i,j}^{Total} = l_{i,j\neq i}\alpha_j + l_{i,j}\,\delta_{i,j}\,\beta_j + l_{i,j}\zeta_j f\left(\delta_{i,j}\right)$
    - $f\left(\delta_{i,j}\right) = \left(\frac{1}{\delta_{i,j}} - 1\right) for \delta_{i,j} > 0 \; and \; \delta_{i,j} \leq 1$
- Let γ_i be the Quality of Information (QoI) lower bound for source i's data while N be the total number of source nodes in the network

Network and Assumptions

- Let the network be arranged in a tree like structure, where all the nodes generate data



Network and Assumptions (cont.)

- All the nodes are capable of producing data
  - Data is of different type and different value
- There is a known path from any source node to the sink given by the set path(i)
  - E.g. path(1) consists of {1,5,7}, path(5)={5,7}
- All the nodes can compress the data including the source resulting in multilevel compressions
- QoI relies on the weighted data delivered.

Optimization Problem (1)

- $\min_{\delta_{i,j}} \quad \sum_{i=1}^{N} \sum_{j \in path(i)} E_{i,j}^{Total}$

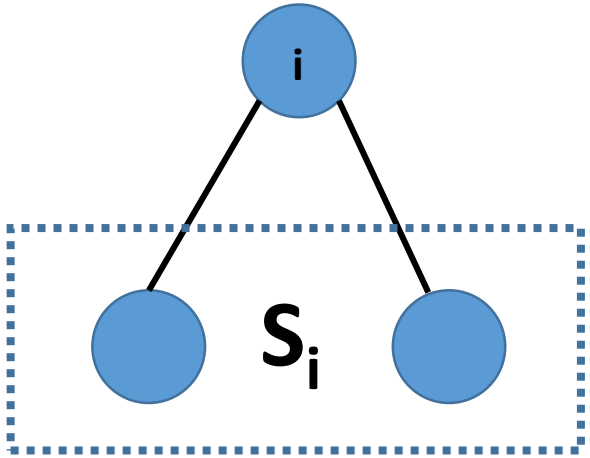
$$E_{i,j}^{Total} = l_{i,j \neq i} \alpha_j + l_{i,j}\, \delta_{i,j}\, \beta_j + l_{i,j} \zeta_j f(\delta_{i,j})$$

S.T $\quad \frac{1}{w_i} l_{i,i} \prod_{j \in path(i)} \delta_{i,j} \geq \gamma_i \; \forall \; i = 1 \ldots . N$

- Geometric Programming problem (posynomial)
  - Can be turned into a convex problem

Optimization Problem (2)

- Let Si be the set of source nodes that transmit their data to the node i.
- $\forall\ j\ \in S_i$:
  - Let W_j be the weights of j source nodes
  - *Let* l_j be the data generated at source nodes j
  - $\delta_{i,j}$ be the reduction rate at node i.
- Let Q_i be the QoI function for node i
  - $Q_i(S_i, \{W_j, j\ \in S_i\}, \{l_j, j \in S_i\}, \{\delta_{i,j}\ , \text{j} \in S_i\})$



To be decided

- $max \quad \sum_{i=1}^{N} Q_i$

S.T $l_j \alpha_j + l_j\, \delta_{i,j}\, \beta_j + l_j \zeta_j f(\delta_{i,j}) \leq E_i^{available}$

Future Plans

- Incorporate fusion and decompression operations into the model
- Further refine the existing work on placement of fusion operators, by relaxing some of the assumptions
- Extend the model to other network topologies
- Include the storage cost along with computation and communication energy costs
- Utilize multi-objective optimization to optimize both QoI and energy efficiency