UAV based SD-WSN

Application Design

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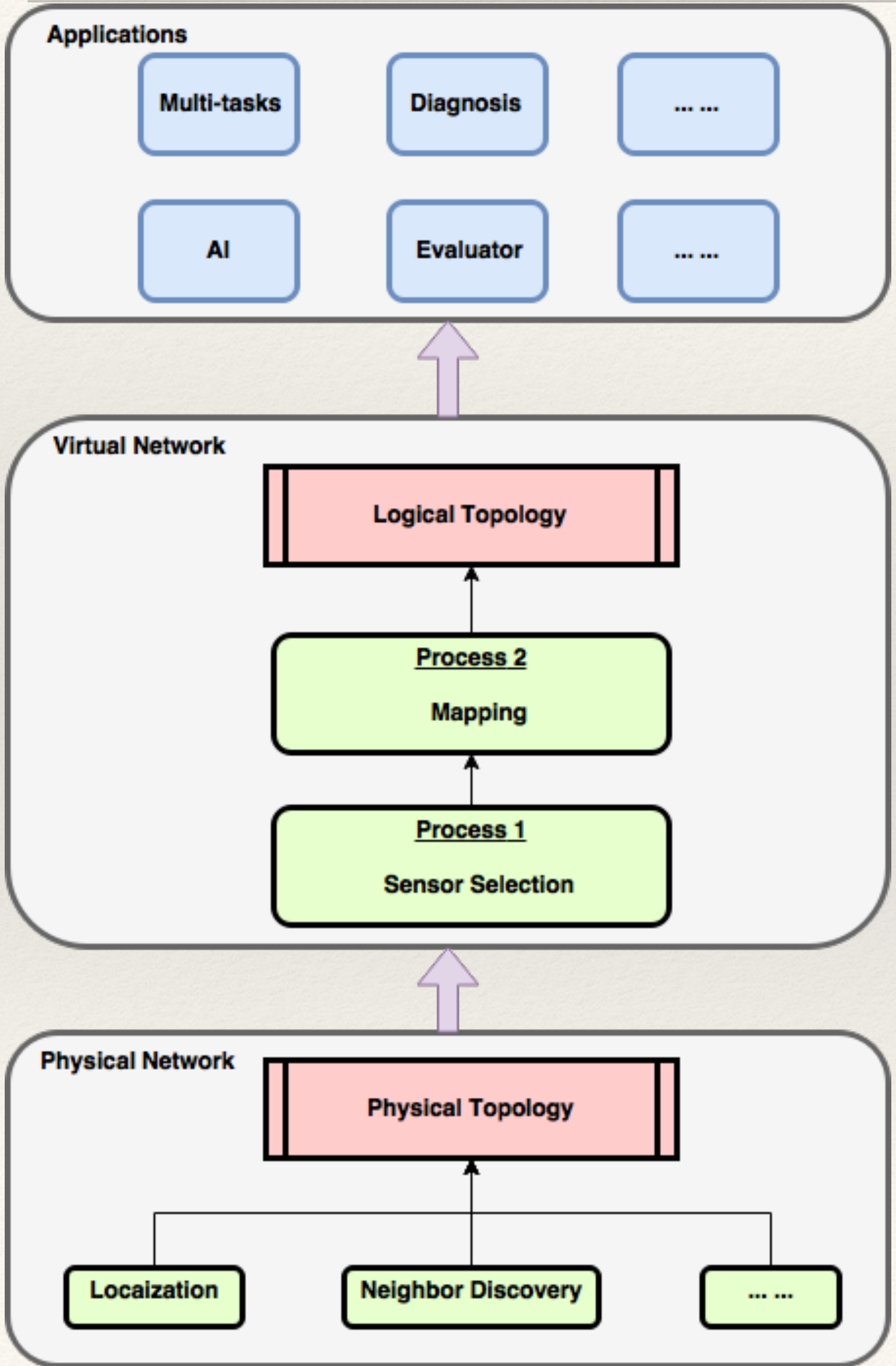
- Architecture
- Design
- Evaluation metrics

Implement modules



Algorithms:

- Sensor selection algorithm
- Mapping algorithm
- Logical routing algorithm

Applications:

- Multi-task
- Evaluator
- Diagnosis && AI && … …

Design

Physical topology : uniform distribution (Density ρ).

Sensor selection algorithm

1. A simple Algorithm: threshold δ —— The distance between sensors && the overlapping of sensing area && the similar neighbor list.

2. SRSSS Algorithm (AAAI-16) —— trained by an AI model based on the collected data.

Output : Redundant nodes

Algorithm 1 The SRSSS Algorithm

Input: Data arrive sequentially. Set α, β, and γ;
Initialize:
$(\mathbf{W}^0, \widehat{\mathbf{W}}^0, \mathbf{z}^0, \mathbf{v}^0, \Lambda_1^0, \Lambda_2^0, \Lambda_3^0, \rho_1, \rho_2, \rho_3, \tau, \max_\rho)$
are initialized by adopting ADMM on a mini-batch data;
for $t = 0, 1, 2, \ldots,$ **do**
  if $t = kL$, $k = 0, 1, 2, \cdots$, enter model update :
    1. update $\mathbf{W}^{k+1}$ by (6);
    2. update $\widehat{\mathbf{W}}^{k+1}$, $\mathbf{z}^{k+1}$ by (7) and (9);
    3. update $\mathbf{v}^{k+1}$ and ξ^{k+1} by (11) and (12);
    4. let ϕ_k, the set of active sensors in the next phase, be the indices of value 1 in $\mathbf{v}^{k+1}$;
    5. update the multipliers
$$\Lambda_1^{k+1} = \Lambda_1^k + \rho_1(\mathbf{W}^{k+1} - \widehat{\mathbf{W}}^{k+1});$$
$$\Lambda_2^{k+1} = \Lambda_2^k + \rho_2(\mathbf{z}^{k+1} - \mathbf{v}^{k+1});$$
$$\Lambda_3^{k+1} = \Lambda_3^k + \rho_3(\mathbf{c}^T\mathbf{z}^{k+1} + \xi - P);$$
    6. update the parameter ρ_1, ρ_2 and ρ_3 by $\rho_i = \min(\tau\rho_i, \max_\rho), i = 1, 2, 3;$
  end if
  if $t > kL$ and $t < (k+1)L$, remain in prediction phase:
    7. predict output from sensors $[n] - \phi_k$ from the output by sensors in ϕ_k and $\mathbf{W}^{k+1}$;
  end if
end for
Output: Vector $\mathbf{v}^{k+1}$.

Design

Mapping

Redundant nodes are mapped to a virtual node. They can awaken each other according to their residual energy. When:

$$\text{ResidualEnergy}(i) \leq \xi * \text{ResidualEnergy}(k)$$

turn node i to node k.

These virtual nodes are called **critical nodes** in the logical topology while other nodes are called **ordinary nodes.**

Logical routing algorithm

Critical nodes first (CNF) algorithm

```
function CNF(Graph, source, ):

      create vertex set Q
      Set the weights of the critical nodes as a minimal number pi;

      for each vertex v in Graph:             // Initialization
          dist[v] ← INFINITY                  // Unknown distance from source to v
          prev[v] ← UNDEFINED                 // Previous node in optimal path from source
          add v to Q                          // All nodes initially in Q (unvisited nodes)

      dist[source] ← 0                        // Distance from source to source

      while Q is not empty:
          u ← vertex in Q with min dist[u]    // Node with the least distance
                                                      // will be selected first
          remove u from Q

          for each neighbor v of u:           // where v is still in Q.
              alt ← dist[u] + length(u, v)
              if alt < dist[v]:               // A shorter path to v has been found
                  dist[v] ← alt
                  prev[v] ← u

      return dist[], prev[]
```

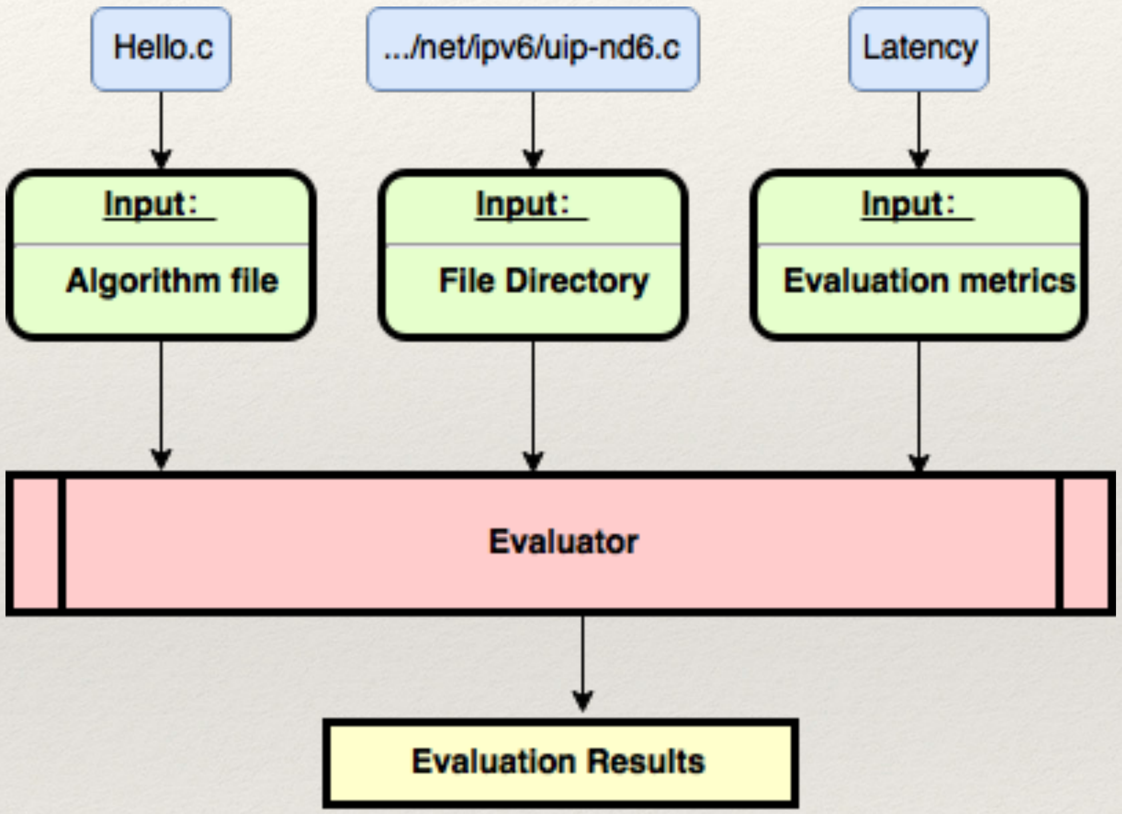
Design

Evaluator

- Provide APIs for users to update network algorithms through OTA.
    - Input: the algorithm function and its location/standard name(tell where to replace it)

- Evaluate the performance of the new algorithm.
    - Input: the evaluation metrics

In our implementation, we will take neighbor discovery algorithms for experiments.



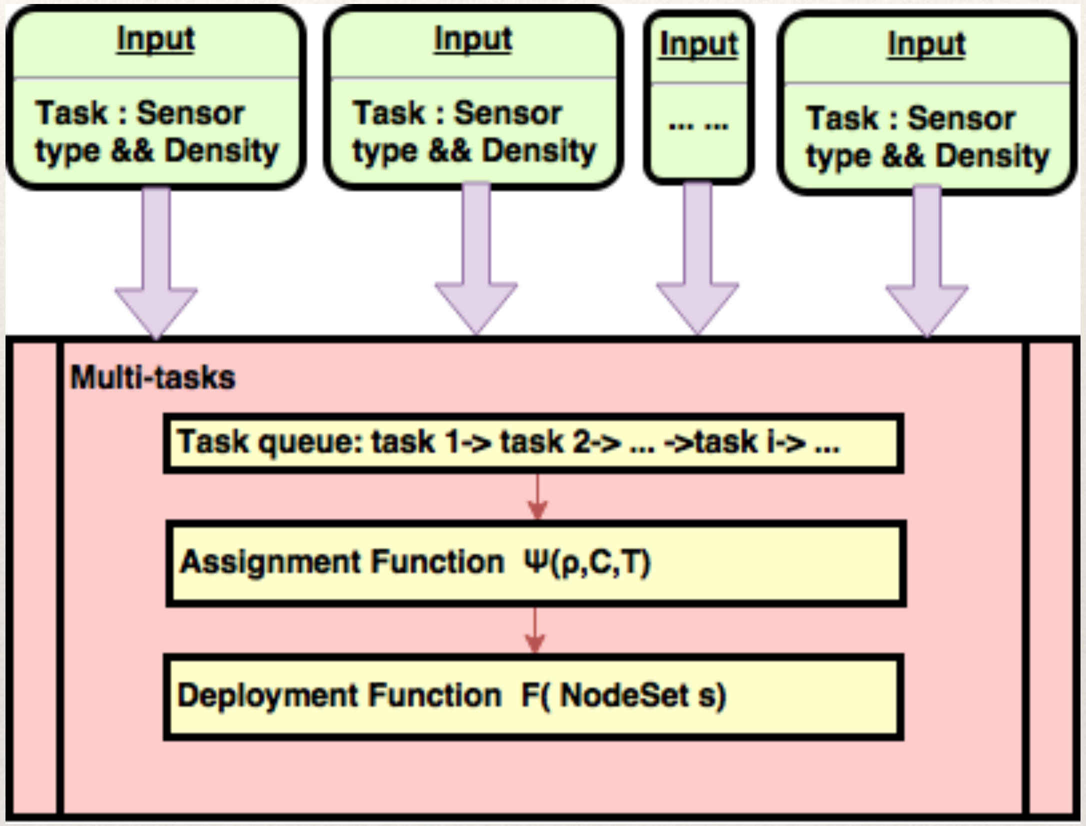
Design

Multi-tasks:

Each task has a deployment density ρ;

Assign tasks to the sensors with less tasks first.

Assign tasks to critical nodes fitst



Diagnosis(To be designed later):

AI(To be designed later):

Evaluation metrics

- **High performance**
  - END-END Packet Delivery Ratio vs. node number
  - Throughput vs. node number
- **Robustness**
  - Throughput vs ratio of energy-exhausted nodes
  - Routing-repair time vs number of failed links
- **Energy-Efficiency**
  - Lifetime vs node number (network size)
- **Scalability**
  - Latency vs Task number
  - Reconfiguration time vs number of new adding nodes/flow table modification/…

Evaluation baseline

Baseline

- **SDN**---SDN-WISE: Design, prototyping and experimentation of a stateful SDN solution for WIreless SEnsor networks." *Computer Communications (INFOCOM), 2015 — Packet Delivery Ratio —latency*
- **Routing:** RPL(routing protocol for low power and lossy networks) is a IPv6 standards working under low-power and low-cost constraints rpl build routing need builiding overhead energy, throughput, routing repair time(routing fast repair)
- **Multi-task**: Energy minimization in multi-task software-defined sensor networks."IEEE transactions on computers 2015 ---multi-task energy—sensing rate, coverage ratio requirement
- **Evaluator:** compared existing neighbor discovery algorithms (Hello, Searchlight, blinedate, etc.)
- **Diagnosis:** Gong, Wei, Kebin Liu, and Yunhao Liu. "Directional diagnosis for wireless sensor networks." *IEEE Transactions on Parallel and Distributed Systems* 26.5 (2015): 1290-1300.
- **AI** (not decided yet)

Thank you all