Border Landmark Selection and Applications in Self-Configurable Wireless Networks

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Problem Formation

Landmark Selection Algorithms

Applications of Landmarks

Conclusion
**Definition**

The border landmarks are a set of $K$ nodes in the network, which form a polygon with the maximum area.
Lemma

Given a set of $N$ points in a planar space, the polygon formed by $K$ out of these $N$ points must overlay with the convex hull of the point set, if the polygon has the maximum area among all polygons formed by any $K$ out of $N$ points and the maximum is unique.

Figure: Illustration of Lemma.
Convex Hull-based (CHB) Algorithm

Figure: Illustration of Algorithm CHB.
Examples of CHB

(a) No distance estimation errors. \( N = 20 \).

(b) No distance estimation errors. \( N = 400 \).

(c) With distance estimation errors. \( N = 100 \).

Figure: Results of the convex hull-based algorithm.
Center Node Elimination (CNE) Algorithm

Ψ = ∅.

for $i = 1: N$ do
  if node $i$ has required stability and computing power then
    $Ψ = Ψ + i$.
  end if
end for

for $m = 1: N - K$ do
  for all $i ∈ Ψ$ do
    $C_i = \sum_{j=1, j\neq i}^{N} \frac{1}{S_{i,j}}$.
  end for
  Search for node $i$, with $C_i ≤ C_j$ ($j ∈ Ψ$ and $j \neq i$).
  $Ψ = Ψ - i$.
  $S_{i,j} = ∞$, for $1 ≤ j ≤ N$.
end for
Examples of CNE

(a) N=20, K=4.

(b) N=100, K=4.

(c) N=400, K=4.

(d) N=100, K=5.

(e) N=100, K=6.

(f) N=100, K=8.
Hierarchy-Structured (HS) Algorithm

- Basic Ideas
- HS Algorithm
Examples of HS Algorithm

(a) Top layer.  (b) Middle layer.  (c) Lowest layer.

Figure: Examples of hierarchy-based approach. $N = 400$, $K = 4$. 
Coverage Ratio

Figure: Coverage Ratio under different algorithms.
Impact of hierarchical layers

Figure: Impact of hierarchical layers
Coordinates Calculation

**Figure:** Coordinates errors.
Border Detection

Figure: K = 64

Figure: K = 128
Landmark-based Routing

- Greedy Forwarding Routing Algorithm
- Virtual Coordinates

\[ V_i = [S_{i l_1}, S_{i l_2}, \ldots, S_{i l_k}, \ldots], \]  

(1)

where \( l_k \in \Phi_0 \). Based on the virtual coordinates, the virtual distance from Node \( i \) to Node \( j \) is defined in a way similar to Mahalanobis distance:

\[ D_{ij} = \|V_i - V_j\| = \sqrt{\sum_{l_k \in \Phi_0} \left( \frac{S_{i l_k} - S_{j l_k}}{S_{j l_k}} \right)^2}. \]  

(2)
Routing Success Rate

**Figure:** Routing success rate in regular network.

**Figure:** Routing success rate in irregular networks.

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Conclusion

- We proposed three algorithms for border landmark selection.
- There are pros and cons for different algorithms.
- Applications in border detection, routing and positioning algorithms.