

Position-Based Routing in Ad Hoc Network

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Introduction(1/3)

- Routing protocols have two mode:
 - **greedy mode**:when the forwarding node is able to advance the message toward the destination
 - **recovery mode**:applied until return to greedy mode is possible
- Both of them differ in metrics used(hop count,power,cost,congestion,etc)

Introduction(2/3)

- Two simple strategy:
 - If a message is "short", it can be broadcast(flooded)using an optimal broadcasting scheme.
 - If a message is "long", it is a task of broadcasting a short search message. The destination reports back to the source by routing a short message containing its position

Introduction(3/3)

- **Position-Based Routing Protocol :**

The destination node is known and addressed by means of its **location**. Routing is performed by a scheme based on this information, generally classified as a position-based scheme.

Table 1. A taxonomy of position-based routing protocols

Method	Loop-free	Localized	Path strategy	Metrics	Memory	Guar. del.	Scalability
<i>Shortest path</i>	Yes	No	Single-path	Hop count	No	Yes	No
<i>Greedy</i> [8], MFR [10]	Yes [11]	Yes	Single-path	Hop count	No	No	Yes
<i>Compass</i> (Kranakis+)	No [11]	Yes	Single-path	Hop count	No	No	Yes
<i>LAR</i> (Ko+), <i>DREAM</i> (Basagni+)	No [11]	Yes	Flooding	Hop count	Yes	No	No
<i>Greedy/flooding</i> [11]	Yes	Yes	Single/flooding	Hop count	Yes	Yes	Yes, dense
<i>First response</i> [14]	Yes	Yes	Single-path	Hop quality	No	No	Yes
<i>Variable radius</i> [13]	Yes	Yes	Single-path	Combined	No	No	Yes
<i>GRA</i> [5], <i>DFS</i> (Stojmenovic+)	Yes	Yes	Single-path	Hop count	Yes	Yes	Yes
<i>Shortest power path</i> (Ettus+)	Yes	No	Single-path	Power	No	Yes	No
<i>Shortest cost path</i> (Singh+)	Yes	No	Single-path	Cost	No	Yes	No
<i>Shortest power-cost path</i>	Yes	No	Single-path	Power-cost	No	Yes	No
<i>Power aware</i> [12]	Yes	Yes	Single-path	Power	No	No	Yes
<i>power-face-power</i>	Yes	Yes	Single-path	Power	No	Yes	Yes
<i>Cost aware</i> [12]	Yes	Yes	Single-path	Cost	No	No	Yes
<i>cost-face-cost</i> (Stojmenovic+)	Yes	Yes	Single-path	Cost	No	Yes	Yes
<i>Power-cost aware</i> [12]	Yes	Yes	Single-path	Power-cost	No	No	Yes
<i>Face, GFG</i> [15]	Yes	Yes	Single-path	Hop count	No	Yes	Yes
<i>Robust GFG</i> [1]	Yes	Yes	Single-path	Hop count	No	Yes	Yes

■ Table 1. A taxonomy of position-based routing protocols.

Advantages Of Using Position In Routing Decisions: Localized Ad Hoc Routes For Scalability(1/2)

- In a **localized routing algorithm**, each node makes a decision to which neighbor to forward the message based solely on location of itself, its neighboring node, and the destination.
- In a **nonlocalized routing algorithms**, each node maintains accurate topology of the whole network.

Advantages Of Using Position In Routing Decisions: Localized Ad Hoc Routes For Scalability(2/2)

- **Nonposition-based** solutions keep the best neighbor information on a route toward the destination, the communication overhead for maintenance of routing tables due to node mobility and topology changes is quadratic in network size.
- **Position-based** localized algorithms avoid that overhead, by requiring only accurate neighborhood information and a idea of the position of the destination

Path Strategies, Metrics, Memorization, Guaranteed Delivery, Location Updates, And Robustness (1/3)

- **Path Strategies:**

Power and bandwidth are two main limitations in wireless networks, single-path strategies are preferred.

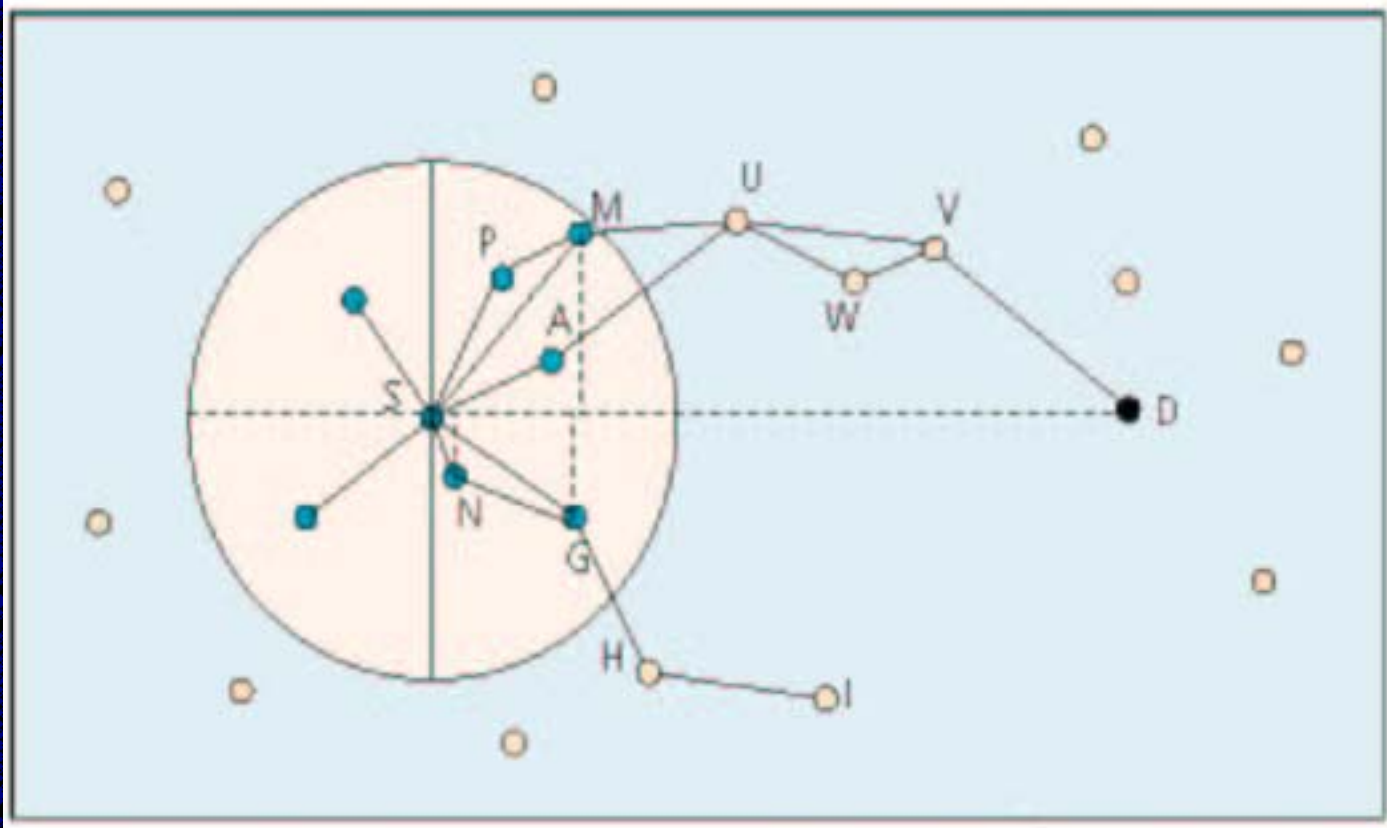
- **Metrics:**

The metrics used in simulations normally reflect the goal of designed algorithm, and are naturally decisive in route selection (hop count, power, cost...etc.)

Path Strategies, Metrics, Memorization, Guaranteed Delivery, Location Updates, And Robustness

(2/3)

- **Memorization:**
It is better to avoid memorizing past traffic at any node if possible.
- **Guaranteed Delivery:**
Wireless networks normally use a single-frequency communication model where a message intended for a neighbor is heard by all other neighbors within the transmission radius of the sender.
- **Robustness:**
Robust strategies handle the position deviation due to the dynamicity of the network.



1. Most Forward within Radius(MFR): $M \rightarrow UVD$
2. Greedy routing scheme: $G \rightarrow HI$
3. Direction-based-path(DIR): $A \rightarrow UWVD$
4. Nearest Forward Progress(NFP): $N \rightarrow GHI$
5. Nearest Closer(NC): $N \rightarrow GHI$

Path Strategies, Metrics, Memorization, Guaranteed Delivery, Location Updates, And Robustness

(3/3)

- If nodes can adjust their transmission power, the constant metric can be replaced by a power metric $u(d) = d^\alpha + c$ (for some constants α and c) that depends on distance d between nodes. The value of c , which includes energy lost due to start up, collisions, retransmissions, and acknowledgments.

Guaranteed Delivery With Memorization(1/2)

- **Geographic routing algorithm(GRA):**
GRA requires nodes to partially store routes toward certain destinations in routing tables.
- GRA applies the greedy strategy in forwarding messages.

Guaranteed Delivery With Memorization(2/2)

- TWO route discovery strategies: Breadth First Search(equivalent to flooding) and Depth First Search(DFS)
- DFS yields a single acyclic path from S to D. Each node puts its name and address on the route discovery packet p. Then it forwards p to a neighbor who has not seen p before.
- This neighbor is one of all the neighbors that minimize $d(S,y)+d(y,D)$, where $d(x,y)$ is the distance between nodes x and y.

Stateless Routing With Guaranteed Delivery(1/3)

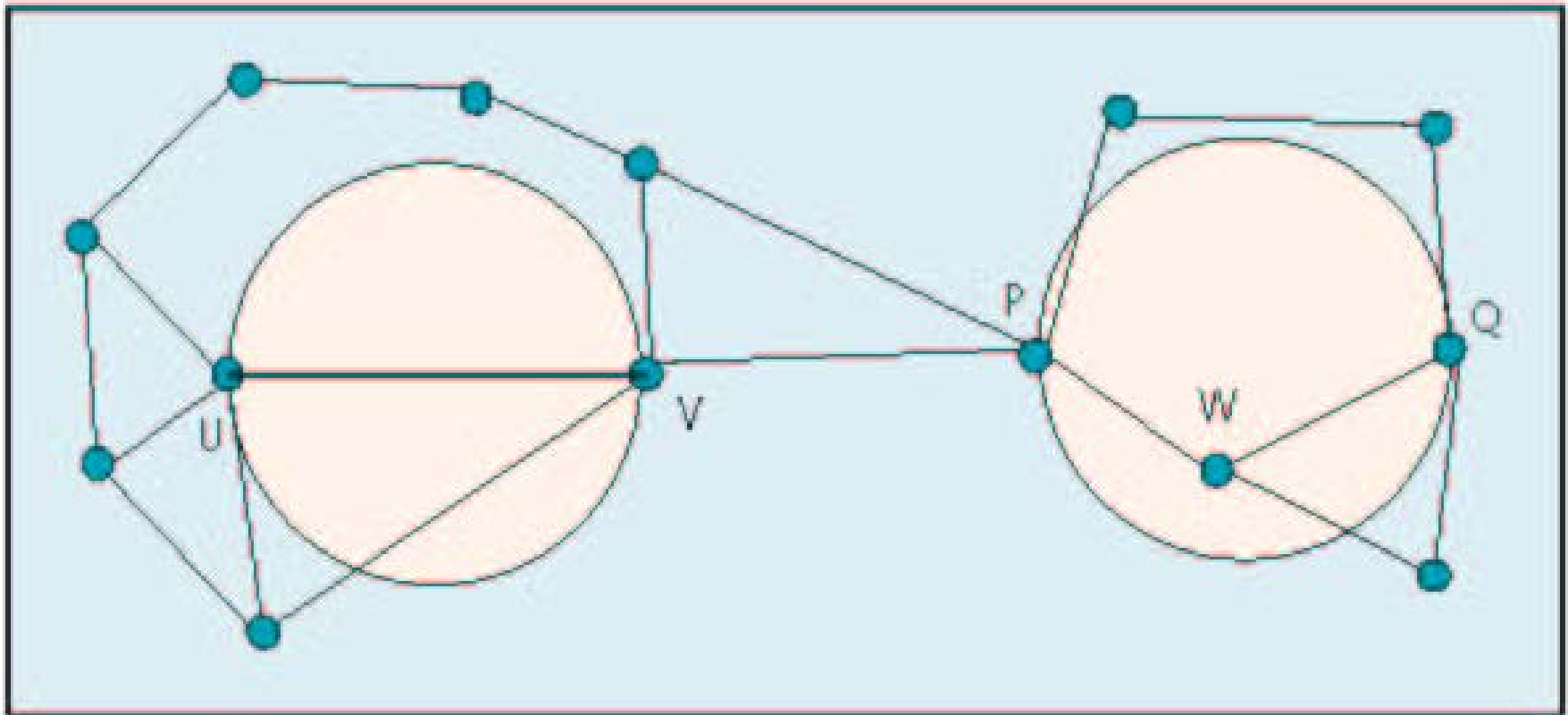
- **Stateless routing** schemes are localized schemes where nodes do not need to memorize past traffic.
- All decisions are based on the location of neighboring nodes, location of the destination, the position of the neighboring node that forwarded the message, and the information that arrives with the message.

Stateless Routing With Guaranteed Delivery(2/3)

- The **Face** :
such as the use of two-hop neighborhood information and the dominating set concept.
- In order to ensure message delivery, the face algorithm constructs a planar and connected so-called **Gabriel subgraph(GG)** of the unit graph, and then applies routing along the faces of the subgraph that intersect the imaginary line between the source and the destination.

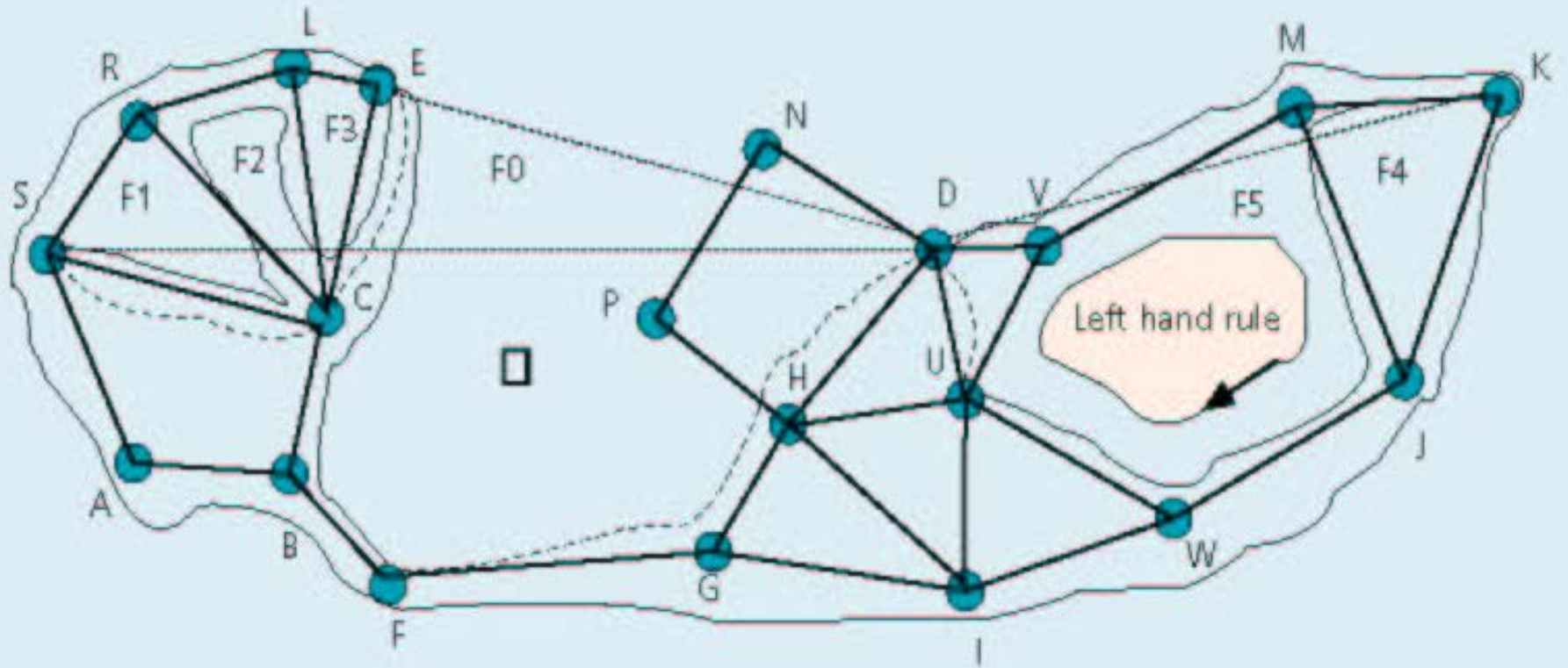
Stateless Routing With Guaranteed Delivery(3/3)

- **GG** is a spanning subgraph of the original network. It is defined as follows:
 - Give any two adjacent nodes U and V in the network, the edge UV belongs to GG if and only if no other node W of the network is located in the disk with UV as its diameter.
 - This test is fully localized, and requires no additional information other than the position of all neighboring nodes.



■ **Figure 2.** *Gabriel graph contains edge UV but not edge PQ since node W is inside the disk.*

- Figure 2 illustrates the test, and gives examples of edge UV that belongs to GG and edge PQ that does not since node W is inside the disk.



- Face route ($S \rightarrow D$): $S \rightarrow C \rightarrow R \rightarrow L \rightarrow C \rightarrow E \rightarrow L \rightarrow R \rightarrow S \rightarrow A \rightarrow B \rightarrow F \rightarrow G \rightarrow I \rightarrow W \rightarrow J \rightarrow K \rightarrow M \rightarrow V \rightarrow D$
- Greedy route ($S \rightarrow D$): $S \rightarrow C \rightarrow E \rightarrow C \rightarrow B \rightarrow F \rightarrow G \rightarrow H \rightarrow D$

Conclusions

- Greedy schemes have performance close to performance of optimal shortest path(weighted) algorithm for dense graphs, but low delivery rates for sparse graphs.
- Schemes that guarantee delivery may have high communication overhead for sparse graphs.
- The successful design of localized single-path loop-free algorithms with guaranteed delivery is an encouraging start for future research.