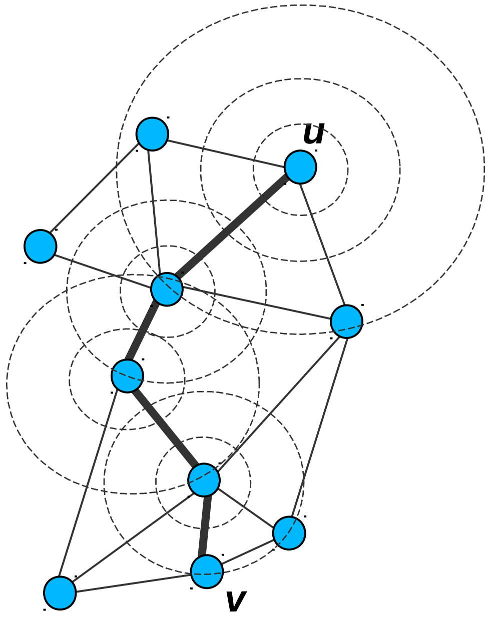
Position based routing

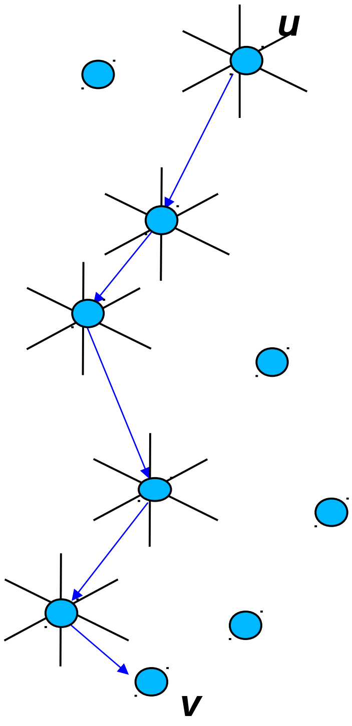
Topology Control

- Sparse topologies, low node degree
  - Storage complexity, storage efficiency
- Short paths, low energy paths
  - Energy: battery life time
    health issues
    (high frequency radiation)
- Low load
- Efficient distributed construction
  and maintenance
  scalability
  fault tolerance
  self-reconstruction



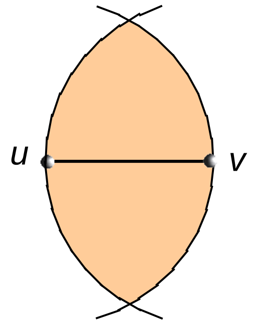
Position Based Routing

- The packages are forwarded „on the fly” to the next node based on the geographic position of
  - the current node,
  - the neighbors of the current node,
  - the destination node
- Routing table is not needed
  - Storage efficiency, low update costs
- Particularly suitable for networks, where
  - the nodes are moving with high velocity
  - topology changes are frequent
- Inherent, immediate support of geocasting
  - routing into a geographical region
  - routing to node(s) close to a given geographic position
- How the position of the destination can be detected?

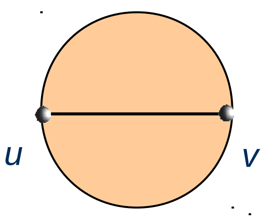


Planar topologies

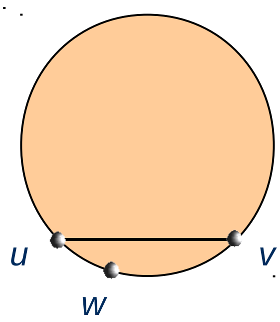
- Relative neighborhood graph *RNG(V)*
  $E_{RNG} = \{(u,v) : \forall\, w \in V,\ u \neq w \neq v,\ ||u,w|| \geq ||u,v||$ és $||v,w|| \geq ||u,v||\}$



- Gabriel graph *GG(V)*
  $E_{GG} = \{(u,v) : \forall\, w \in V,\ u \neq w \neq v,\ w \notin D(u,v)\}$,
  where D(u,v) is the (interior of the) disk with diameter uv

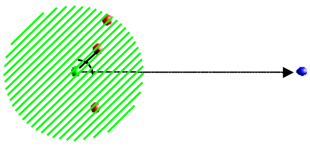


- Delaunay triangulation *Del(V)*
  $E_{Del} = \{(u,v) : \exists\, w \in V,\ u \neq w \neq v,\ \forall\, w' \in V,\ w' \notin D(u,v,w)\}$,
  where D(u,v,w) is the (interior of the) disk, which contains u,v,w on the boundary
- $RNG(V) \subseteq GG(V) \subseteq Del(V)$

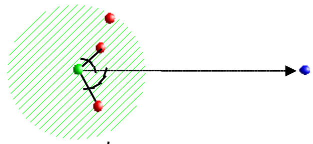


Position based routing

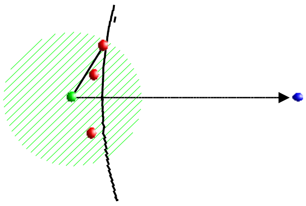
Compass:



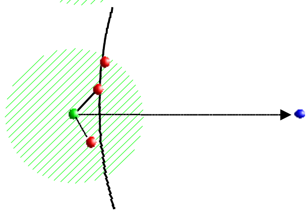
Random compass:



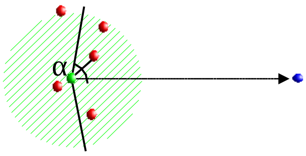
Greedy:



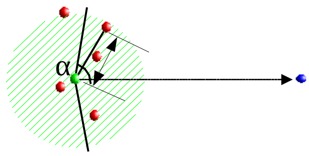
Greedy compass:



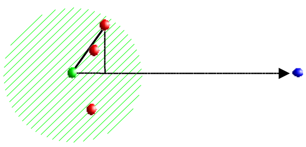
Next neighbor:



Farthest neighbor:

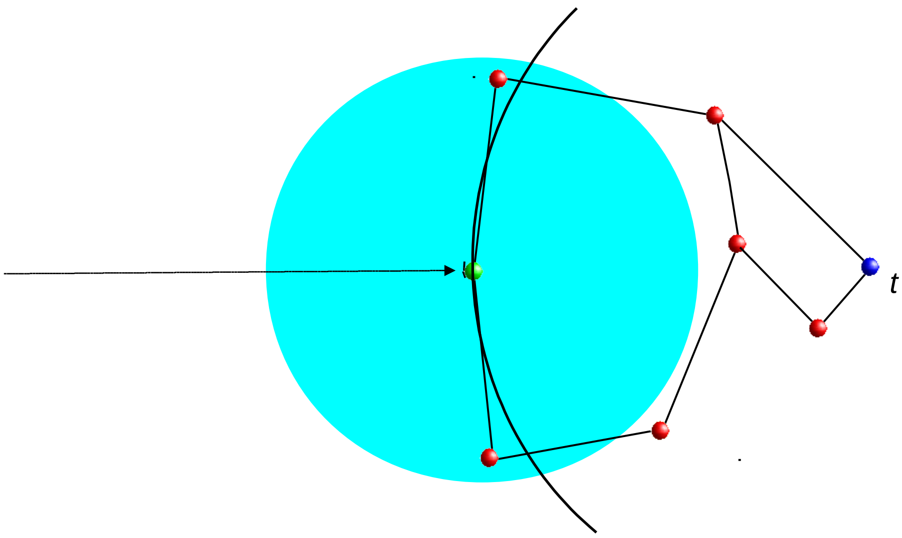


Most forward:



Greedy routing

- Greedy routing can get stuck at a local minima



Greedy routing

Theorem [Bose, Morin 99] Greedy routing guarantees the delivery of packets in the Delaunay triangulation.

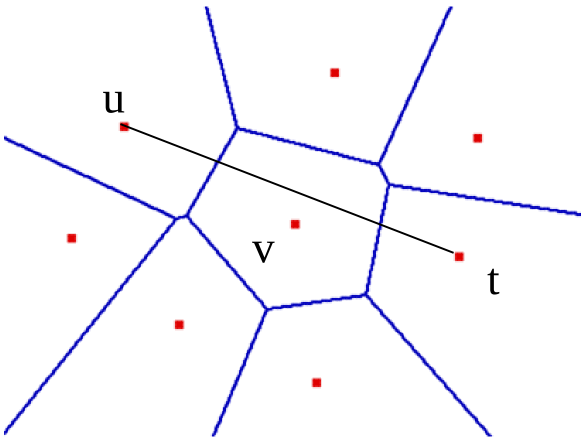
Proof:

We show that each node $u \neq t$ has a Delaunay neighbor v closer to t than u.

Consider the Voronoi diagram VD(V) of the point set V.

Let e be the first edge of VD(V) intersecting the line segment ut.

Edge e is on the boundary of the Voronoi cell of u and of the cell of an other node v.



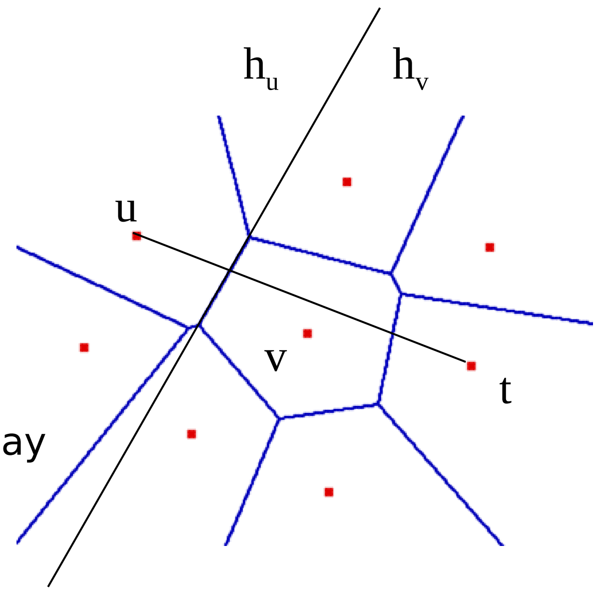
Greedy routing

Theorem [Bose, Morin 99] Greedy routing guarantees the delivery of packets in the Delaunay triangulation.

Proof (cont.)**:**

The supporting line of e partitions the plane into half planes h_u={x: ||u,x|| < ||v,x||} and h_v={x: ||v,x|| < ||u,x||}.
The target t is in h_v.

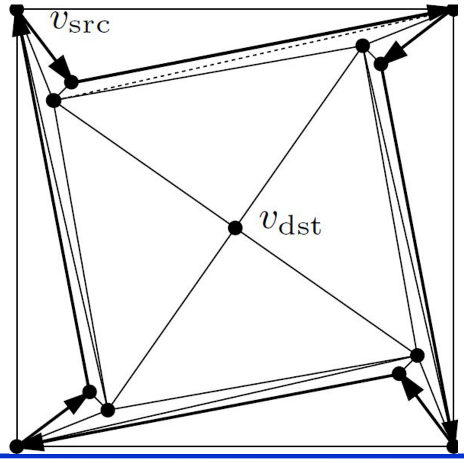
Since VD(V) is the dual of the Delaunay triangulation, u and v are neighbors in the Delaunay triangulation.



Compass routing

Theorem [Bose, Morin 99]: Compass routing guarantees the delivery of packets in the Delaunay triangulation (in each convex triangulation).

There exist triangulations, where greedy routing get stuck in a circle [Bose, Morin 99]:



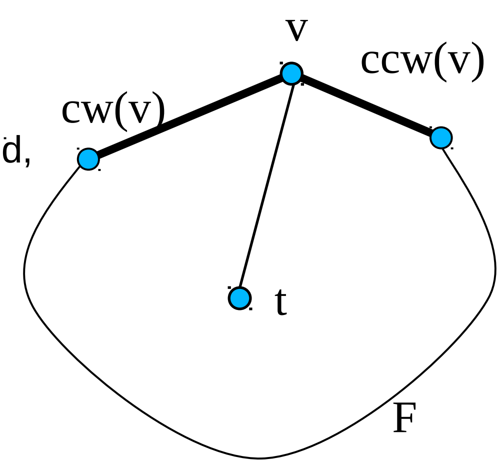
Random Compass routing

Theorem [Bose, Morin 99]: Random compass routing guarantees the delivery of packets in each triangulation.

Proof: Assume (for contradiction), there is a triangulation T, in which the packet is not delivered from some s to some t. Then there is a minimal set S, s.t.

(1) t not in S,
(2) the subgraph H of T induced by S is connected,
(3) for every v in S: cw(v), ccw(v) in S

The target t lies in the interior of a face F of H. Let v be a vertex on the boundary of F, s.t. the segment vt is contained in F (Existence of v is guaranteed)

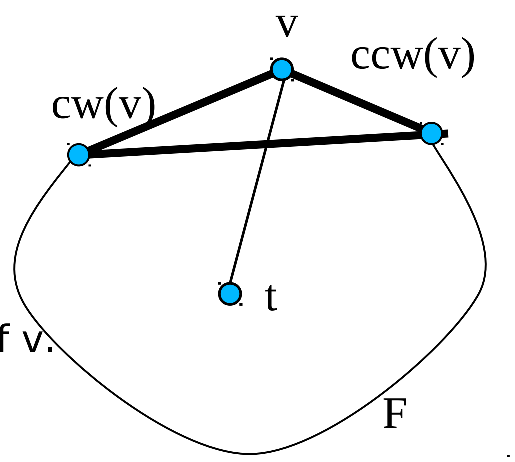


Random Compass routing

Theorem [Bose, Morin 99]: Random compass routing guarantees the delivery of packets in each triangulation.

Proof: (cont.)
Neighbors cw(v) and ccw(v) of v are also on the boundary of F and cw(v)≠ ccw(v) (since F contains vt in its interior).

Since T is a triangulation, v,cw(v),ccw(v) is a tringle in T.
This contradicts that v is on the boundary of v.



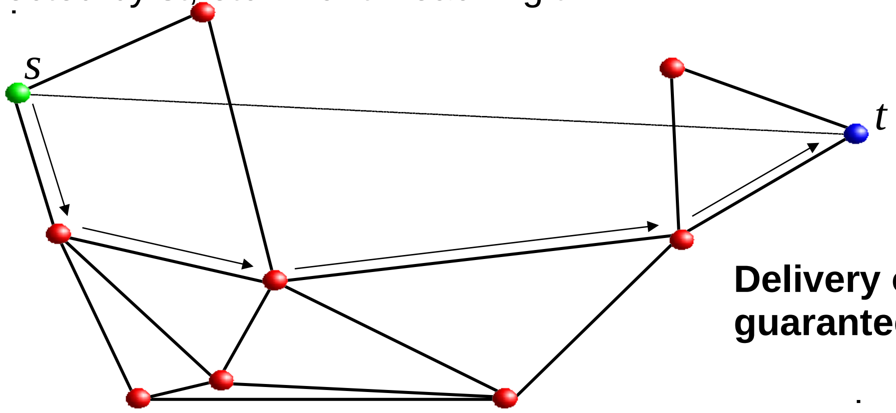
Random Compass Routing

There exist planar graphs, where random compass routing get stuck:

Face-Routing in planar topologies [Bose,Morin 99] [Karp,Kung 00]

Face 2 (perimeter routing):

- Traverse the bondary of the face, the interior of which is intersected by the segment st until reaching an edge crossing st
- Then traverese the bondary of the next face, whoose interior is intersected by st, etc… until reaching t

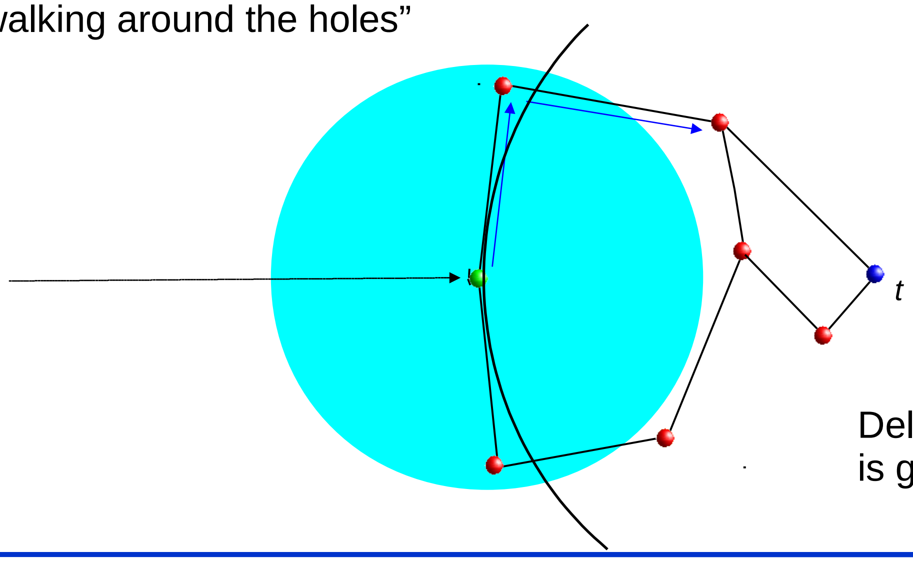


Delivery of packets is guaranteed !

Routing: GPSR [Bose,Morin 99] [Karp,Kung 00]

Greedy Perimeter Stateless Routing (GPSR):

- Greedy forwarding, if we get closer to the target t
- Otherwise: perimeter routing until we get closer to t
  "walking around the holes"



Delivery of packets is guaranteed!

Literature

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