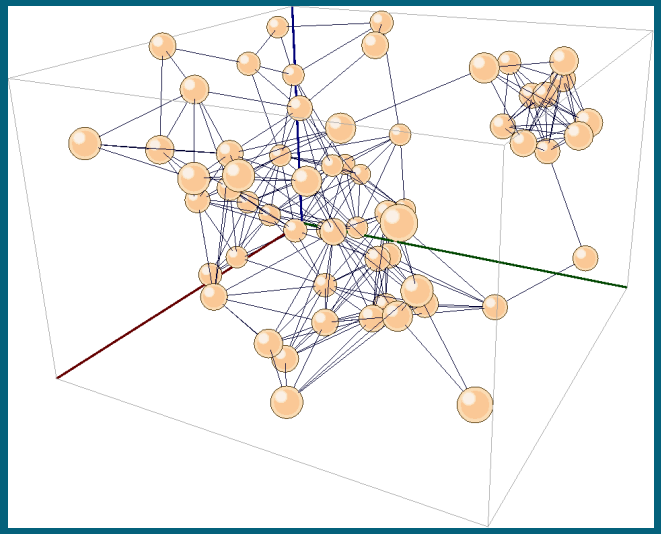

Position-based Routing Protocols for 3D MANETs

Wireless Networks

Daniele Ronzani
Ph.D in Brain Mind and Computer Science
dronzani@math.unipd.it

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Introduction

- Routing is a mechanism to send a packet from a source to a destination
  - Routing in a MANET is difficult due to the continue change of topology
  - There are several routing protocols that tackle the problem.
- Focus on position-based protocols in 3D MANETs
  - State-of-the-art of position-based routing protocols in 3D topologies
  - 2D → 3D
  - Different performance results

Routing in MANETs (1)

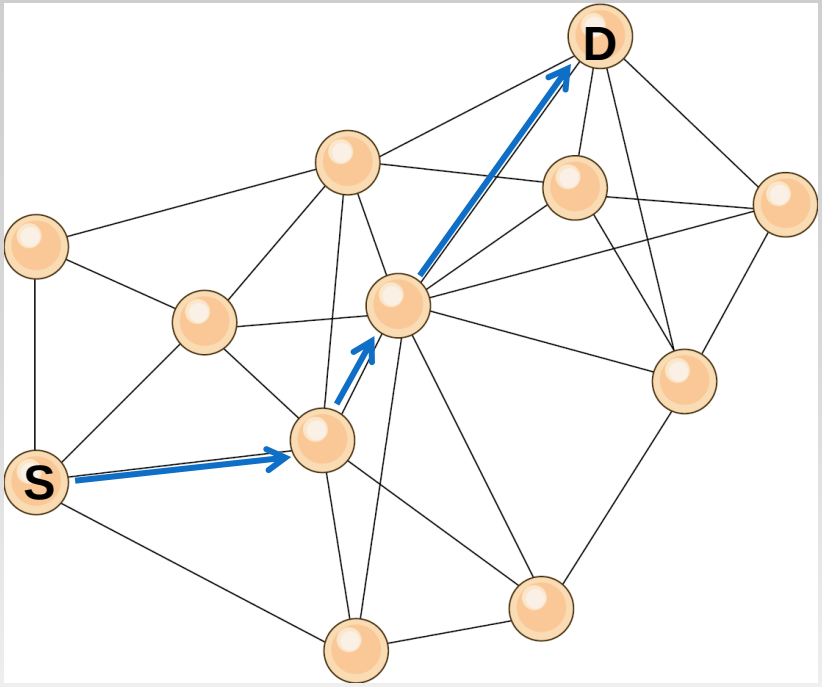
What is a MANET?

- Mobile Ad-hoc Network (MANET)
  - Self-organizing, self-administred network of mobile nodes
  - No fixed infrastructure
  - Interesting, timely and challenging topic
- Drone Ad-hoc Network (DANET)
  - Drones (UAVs) as nodes
  - Several applications
    - Civilian
    - Tactical
    - Emergency
    - Entertainment

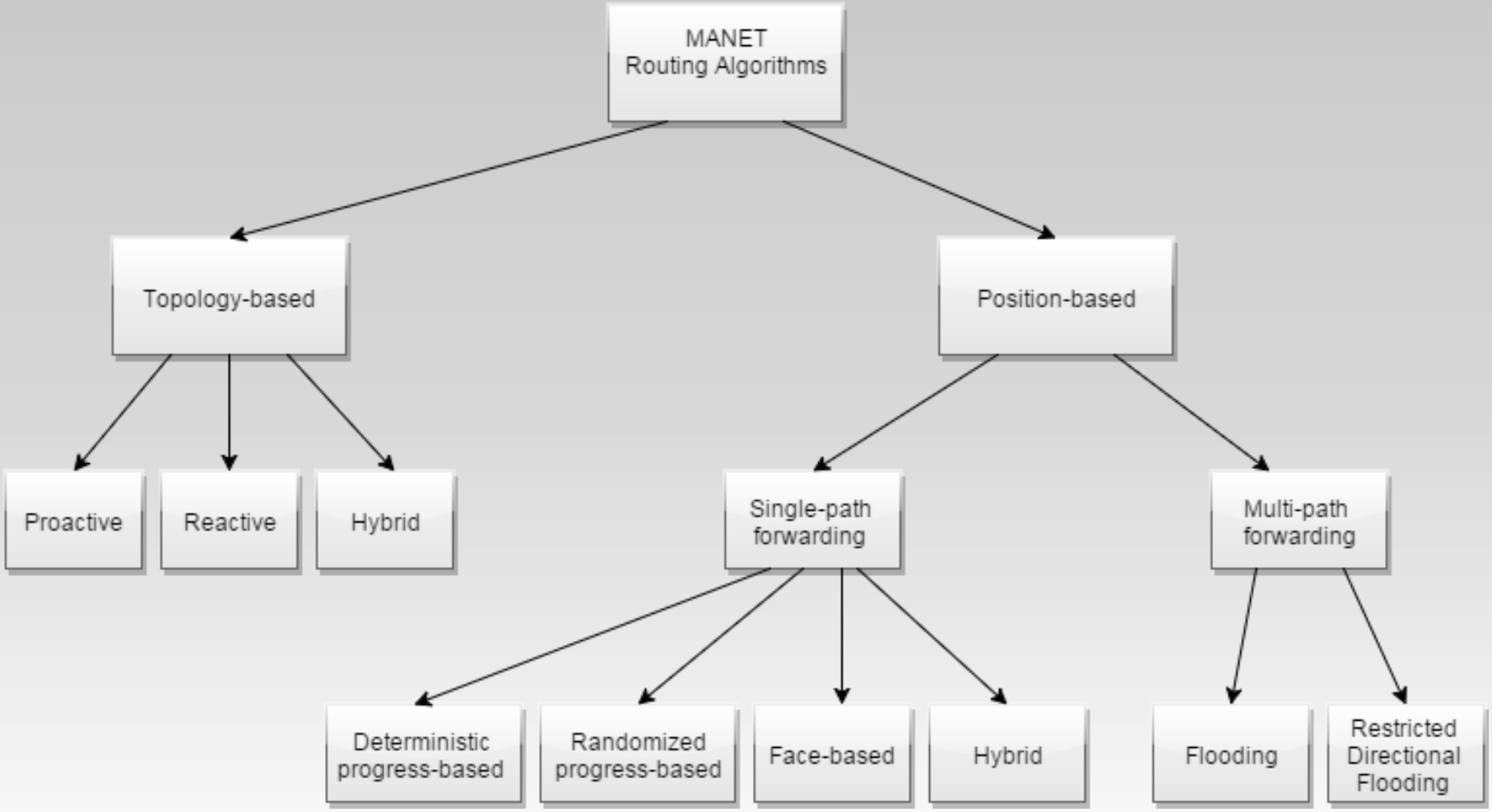
Routing in MANETs (2)

What is routing?

- Find a path from a source to a destination
  - Multi-hop routing
- Main routing challenges
  - Link failures
  - Limited bandwidth
  - Limited energy
- Two main approaches
  - Topology-based
  - Position-based



Taxonomy


MANET
Routing Algorithms
Topology-based
Position-based
Proactive
Reactive
Hybrid
Single-path
forwarding
Multi-path
forwarding
Deterministic
progress-based
Randomized
progress-based
Face-based
Hybrid
Flooding
Restricted
Directional
Flooding

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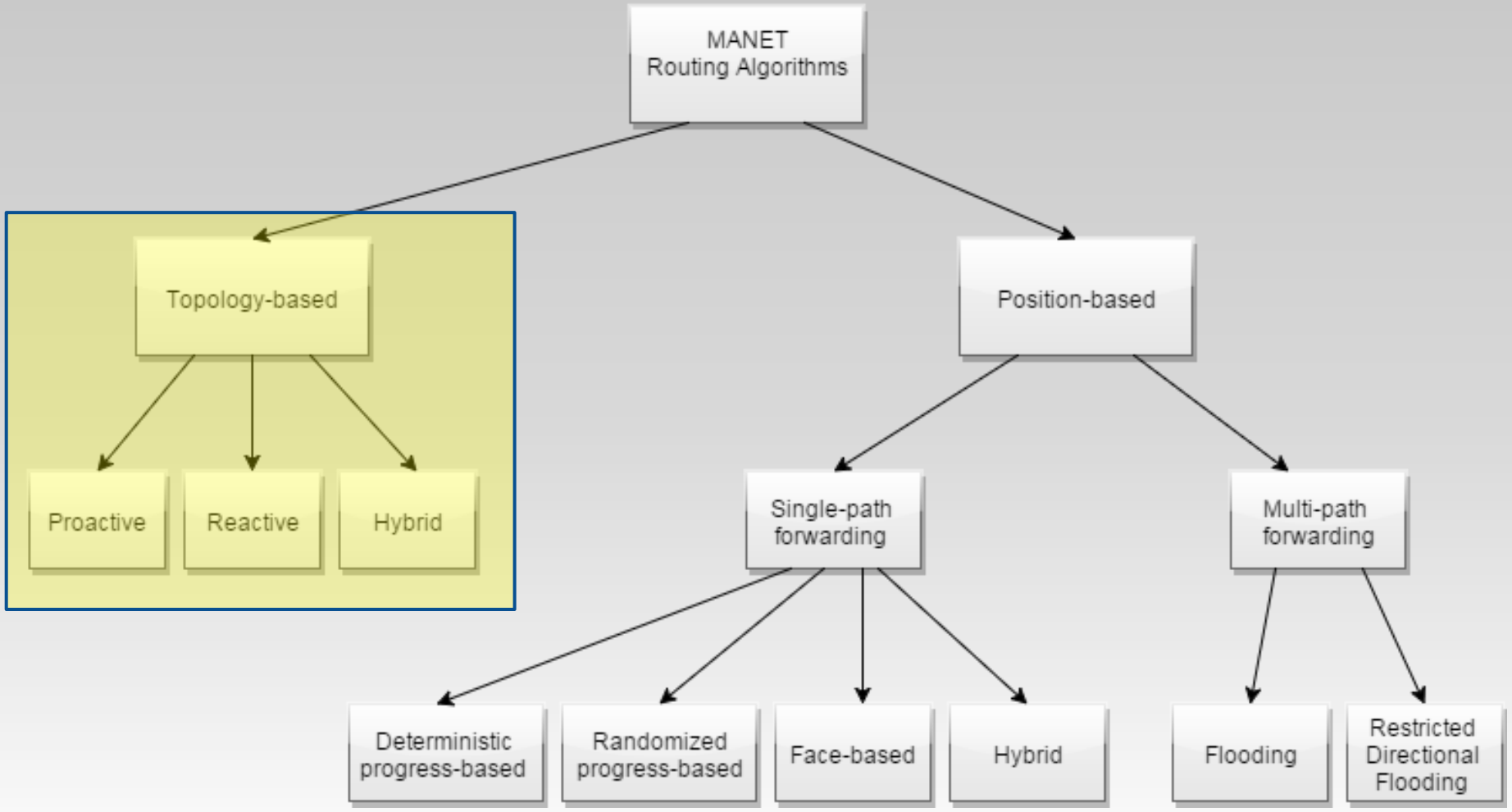
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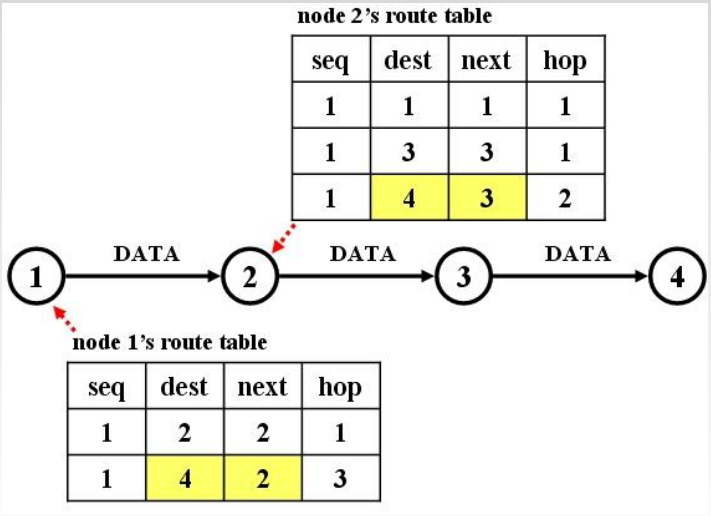
Topology-based

- Use information about links
- Routing table
- Proactive, reactive and hybrid approaches
- Reactive approach is more suitable for MANETs
  - Need route only when required
  - There are not continuos table updates
  - AODV, DSR, etc ..

…BUT…



Topology-based

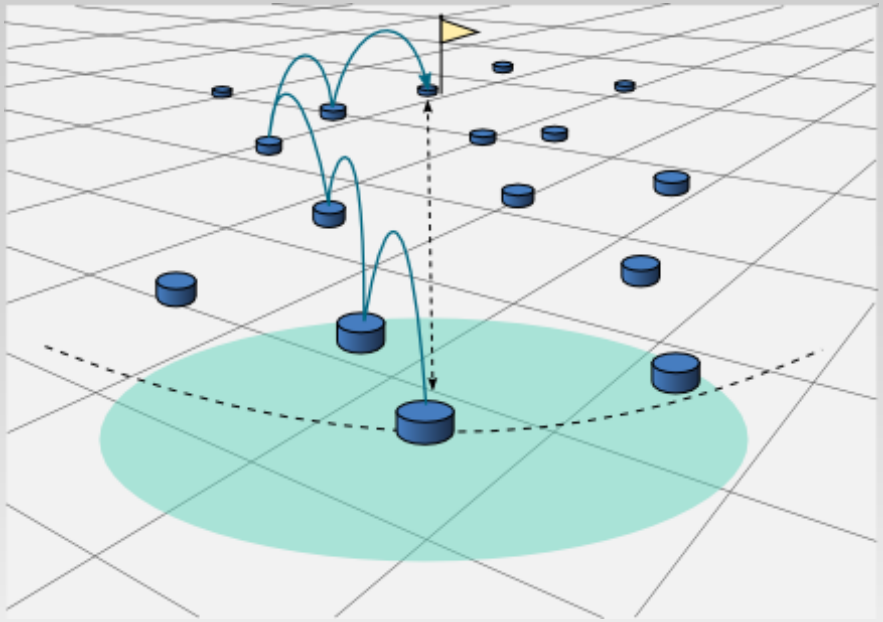
- There are some limitation also using these protocols, if we have a very mobile and large networks
  - Huge amount of control traffic
    - Reactive approaches need to flood the request packets
  - Need of a routing table
    - Node memory
  - Need information about entire network

- In limited bandwidth, limited energy and large networks, this is not really nice!!!

NOT SCALABLE!

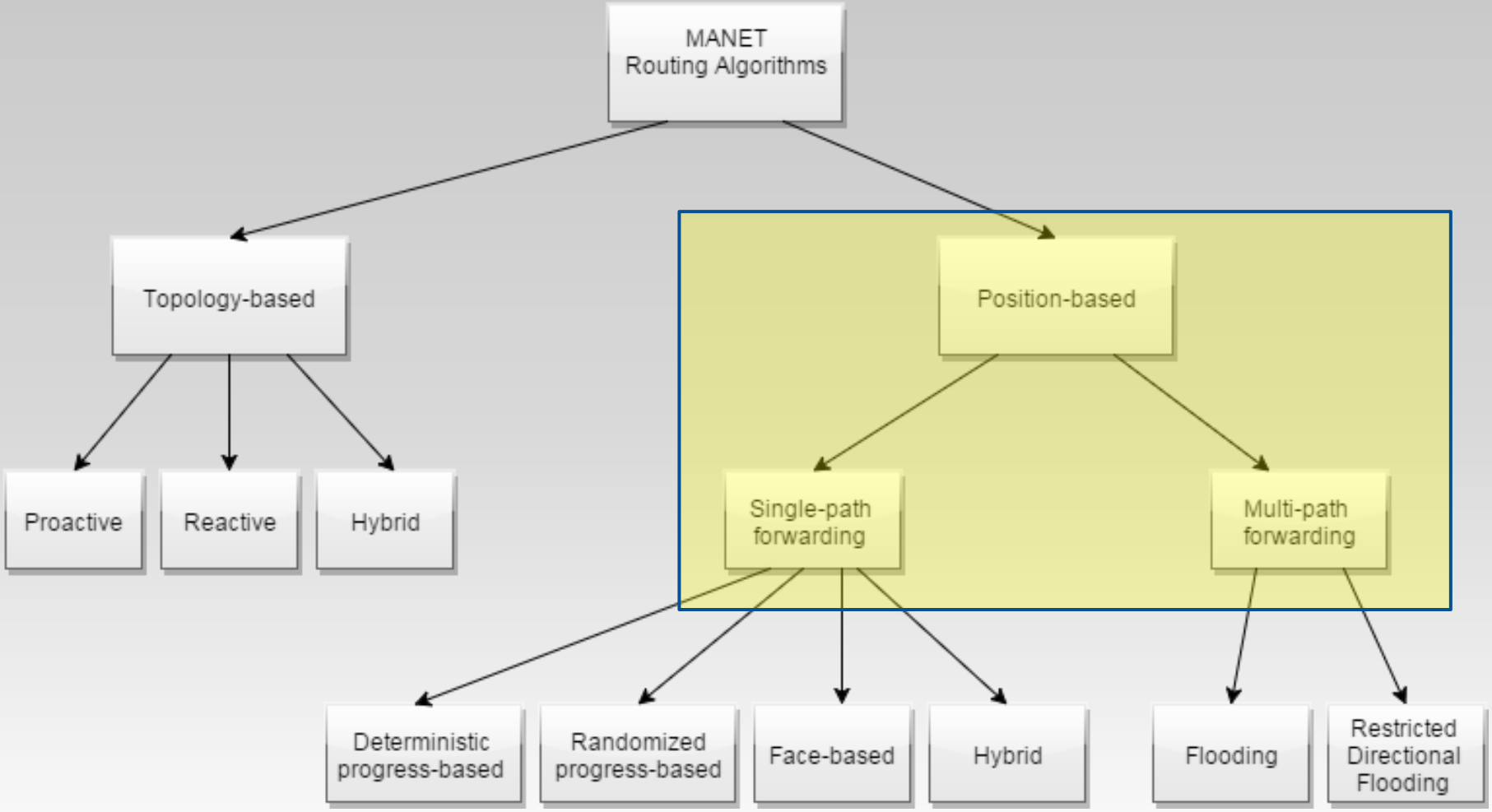
Position-based

- Use geographic position information for forwarding decision
  - Location service (GPS)
- No need for a routing table
  - Only neighbors' information
- Limited control overhead
- Assumption:
  - Data message contains the location of destination



More scalable

Taxonomy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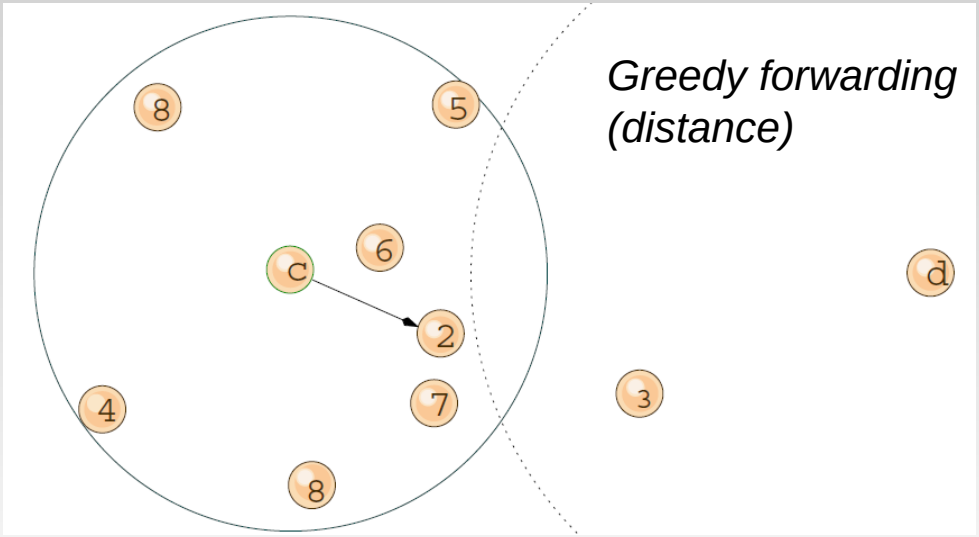
Single Path Forwarding (1)

- A node sends a single copy of packet to one neighbor
  - Deterministic progress-based
  - Randomized progress-based
  - Face-based

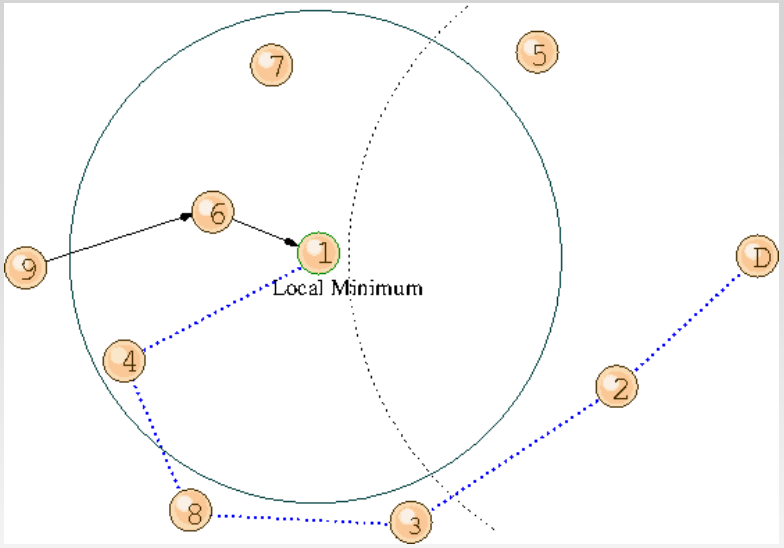
Single Path Forwarding (2)

Deterministic progress-based

- A node forwards the packet to one of its neighbors that make progress to the destination.
  - Greedy strategy
  - Local minima

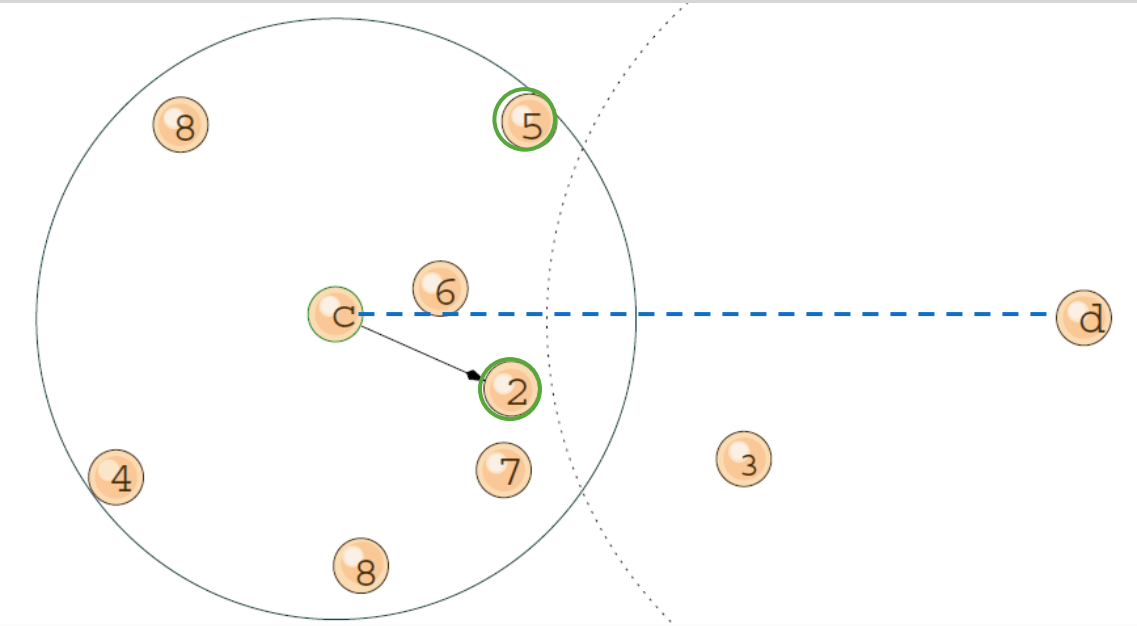


Failure of greedy forwarding



Single Path Forwarding (3)
Randomized progress-based

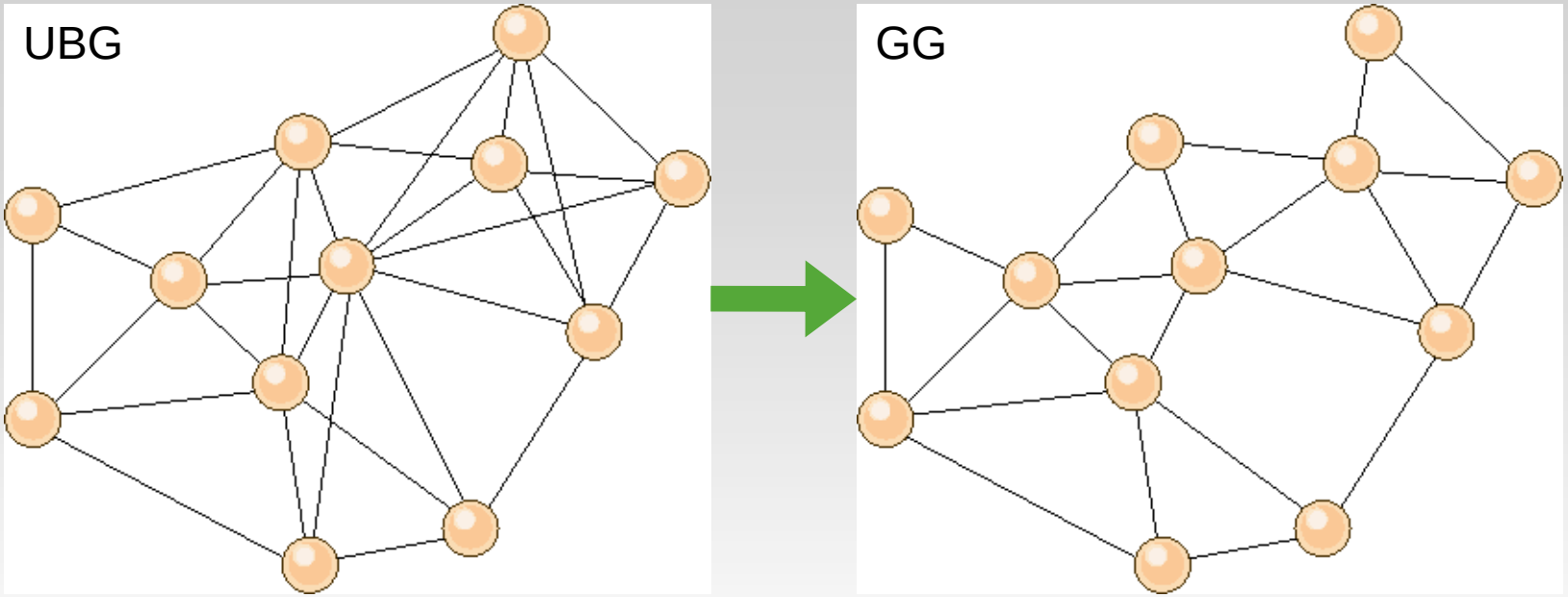
- Try to solve the local minimum problem
- AB algorithm
  1. Selects two candidate nodes using a greedy strategy
  2. Choose the next node randomly
- Threshold value on the hop number to stop the forwarding process



Single Path Forwarding (4)

Face-based

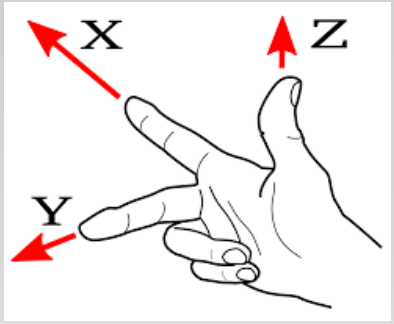
- The packet walks adjacent faces to reach the destination
- Graph planarization → planar sub-graph
- Remove cross links

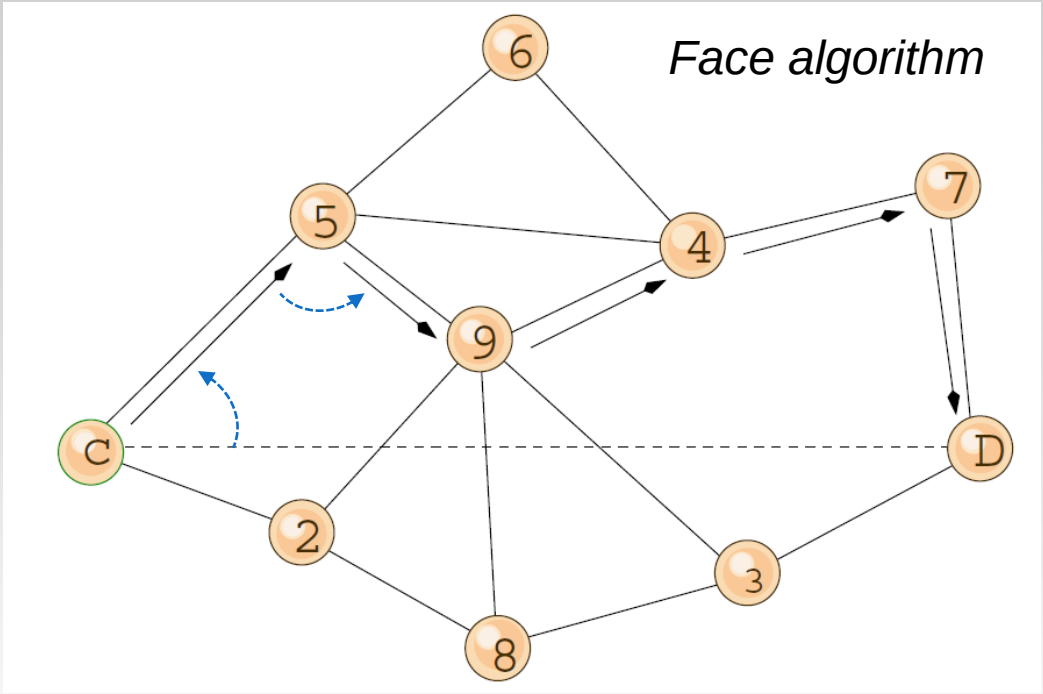


Single Path Forwarding (5)

Face-based

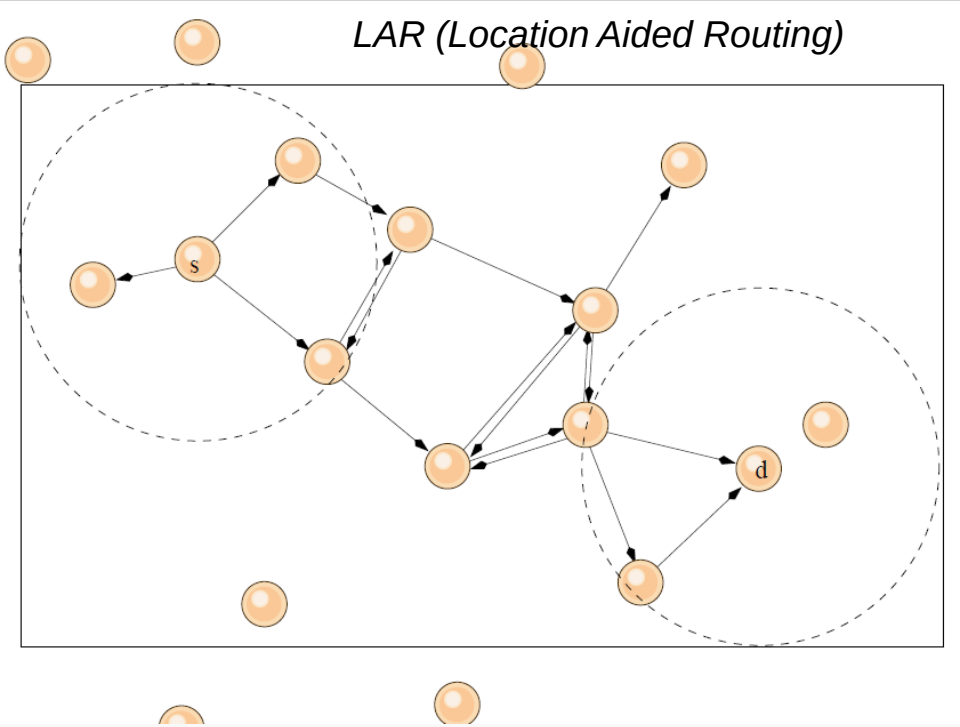
- Right Hand Rule
- Delivey guaranteed in 2D graphs





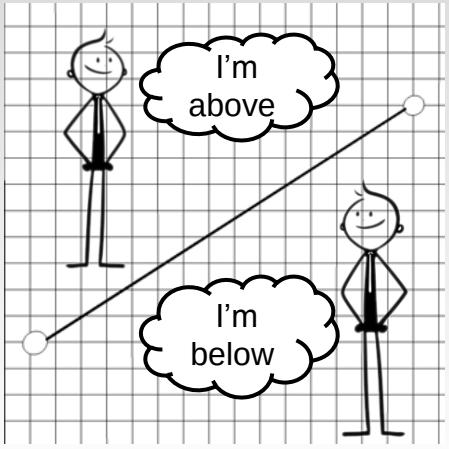
Multi Path Forwarding

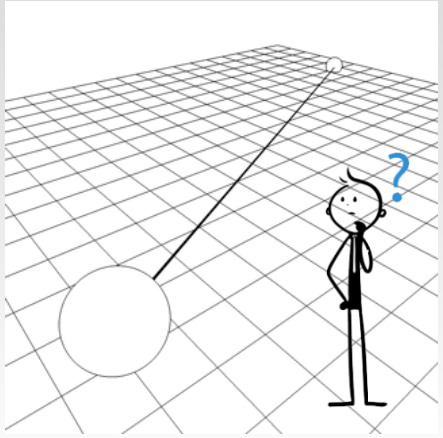
- A node send the same packet to multiple neighbors
- LAR: uses a rectangle that includes transmission ranges of source and destination
- Limited flooding

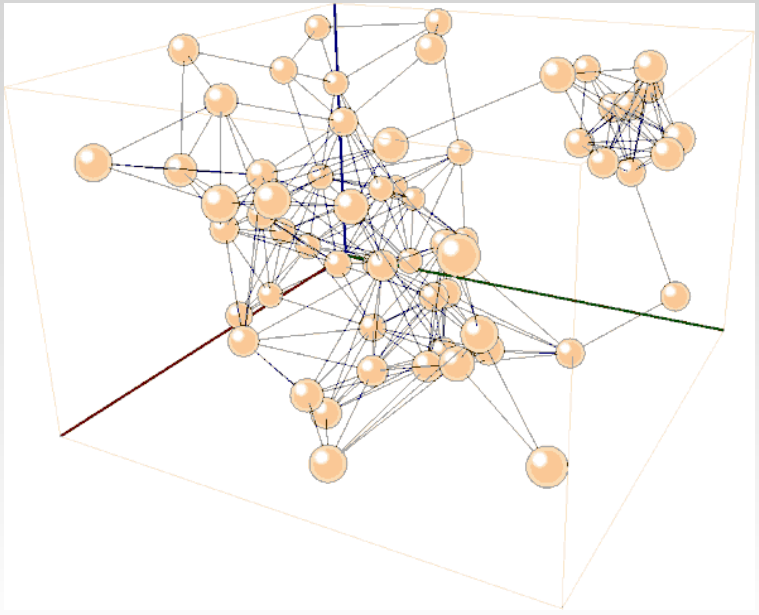


Extension to 3D

- Position-based routing focused on 2D networks
  - E.g., Vehicular Ad-hoc Networks (VANETs)
  - DANETs are intrinsically 3D
- Difficult to extend 2D concepts to 3D space
  - NO planarization
  - NO above and below a line







Solutions (1/4)

- 3D Deterministic progress-based
  - Extension is trivial
  - Euclidean distance
- 2D

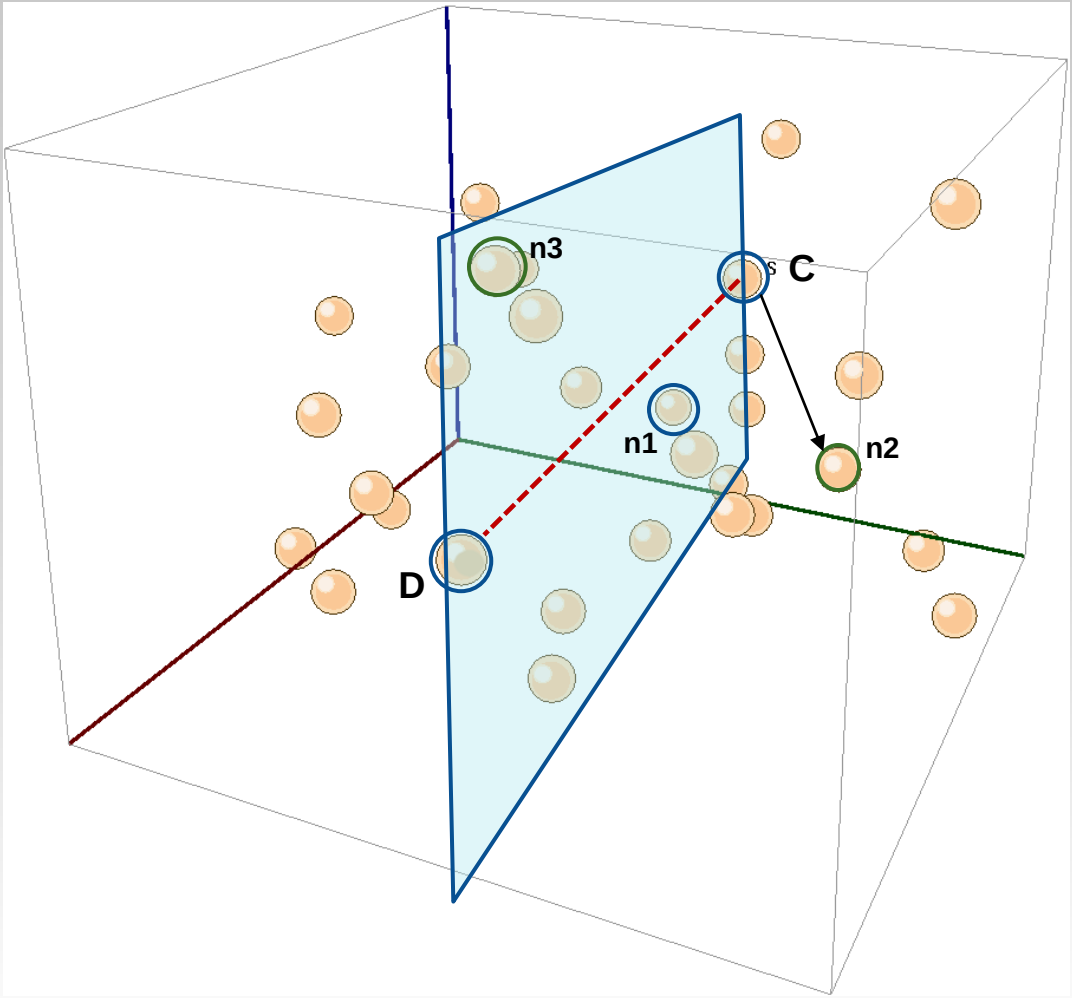
$$dist(u,v) = \sqrt{(u_x - v_x)^2 + (u_y - v_y)^2}$$

- 3D

$$dist(u,v) = \sqrt{(u_x - v_x)^2 + (u_y - v_y)^2 + (u_z - v_z)^2}$$

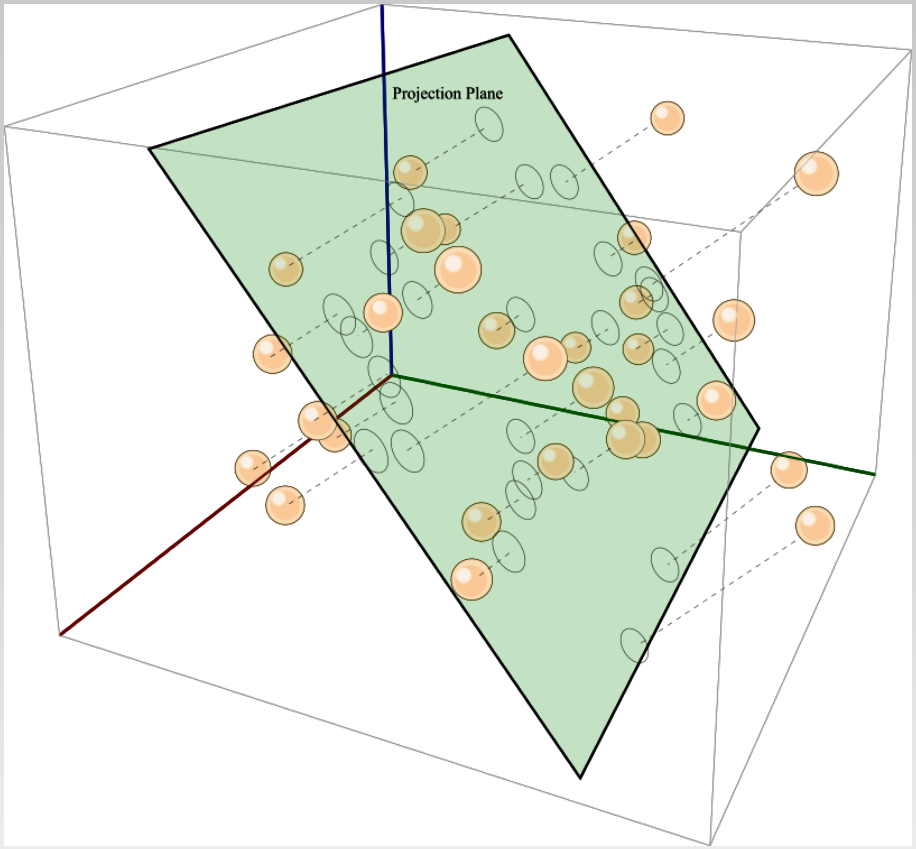
Solutions (2/4)

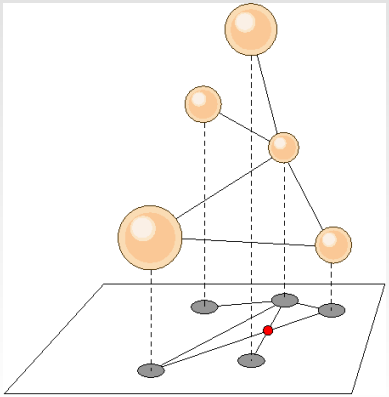
- 3D Randomized progress-based
- AB3D algorithm
  - Candidates are selected above and below a plane
  - The plane passes through C, D and the first candidate n1.



Solutions (3/4)

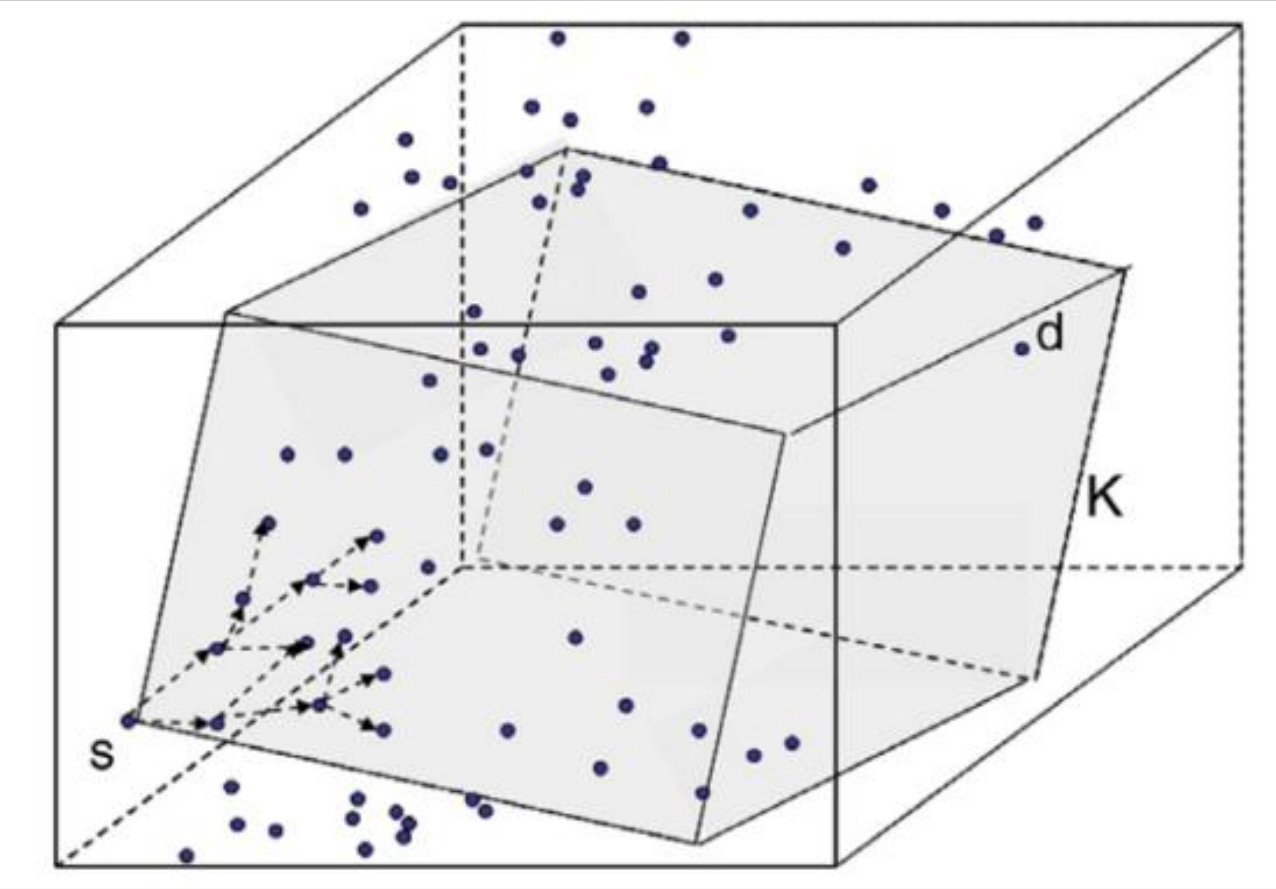
- 3D Face
  - Project nodes on a plane
  - Start face routing on this projected graph
  - Packet delivery is not guaranteed!!





Solutions (4/4)

- 3D Flooding (3D LAR)



Simulation Scenario

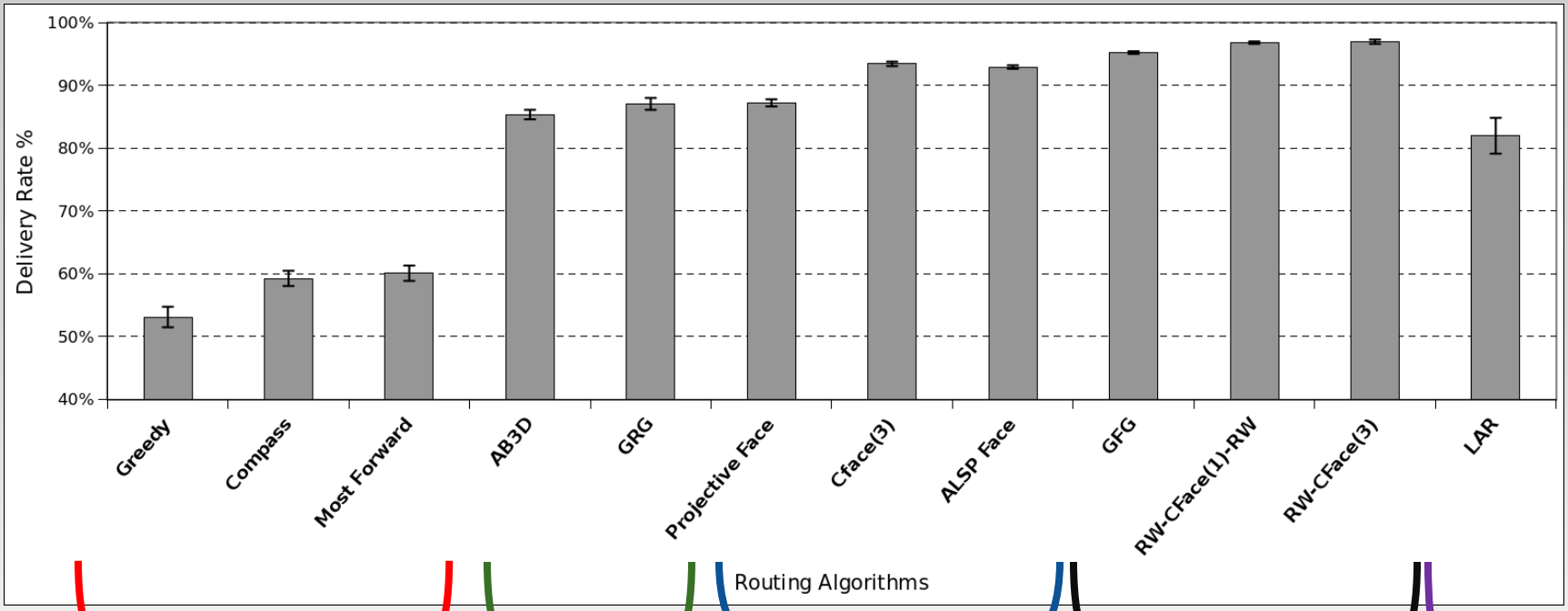
- NS-2 simulation environment
- Cube of 500 meters of side length
- Transmission range of 100 meters
- Single Packet
  - Network sizes: 50, 100, **150**, 200 nodes
  - Application examples: sensor data, pictures

Performance Metrics

- Delivery Rate
  - Percentage of delivered packets at the recipient
- Path Dilation
  - Average ratio of the number of hops traveled to the minimum path length

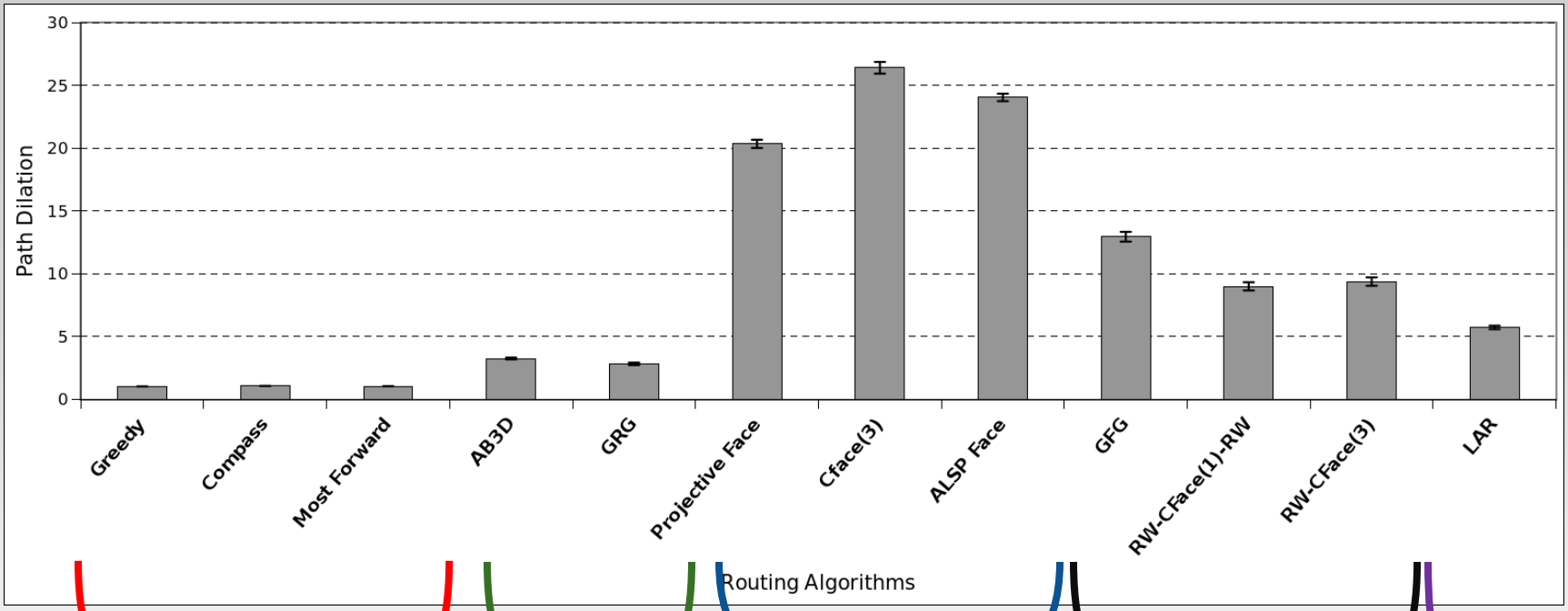
Performance Results (1/2)

- Single Packet – 150 nodes
- Delivery Rate



Performance Results (2/2)

- Single Packet – 150 nodes
- Path Dilation



Conclusion and Future Works

- Position-based protocols perform better than topology-based ones
  - Scalable
  - Require less resources (memory, energy, bandwidth)
- Several forwarding algorithms in 3D graphs
  - 2D geometric concepts not adaptable to 3D space
  - Delivery not guaranteed with local strategy
- Promising approaches could be improved to achieve good results
  - Hybrid solutions
  - Reduce search space
  - Information regarding past decisions
    - Memory (Depth First Search) → POSSIBLE THESIS!!

Some References

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