Technische Universität Braunschweig

Institute of Operating Systems and Computer Networks

Breadcrumb Routing: Query-Response Geocast for Mobile Originators in Vehicular Networks

IEEE Vehicular Networking Conference 2014

Julian Timpner, Mario Wozenilek, Lars Wolf, December 3, 2014

Parking Search

Parking Search

Communication Challenges

Objective

Retrieve information from destination via ad-hoc communications

Challenges

- Connections are intermittent
- Which nodes are present in the destination area?
- How to route the query to the destination?
- How to organize the response?
- **How to route the response back?**

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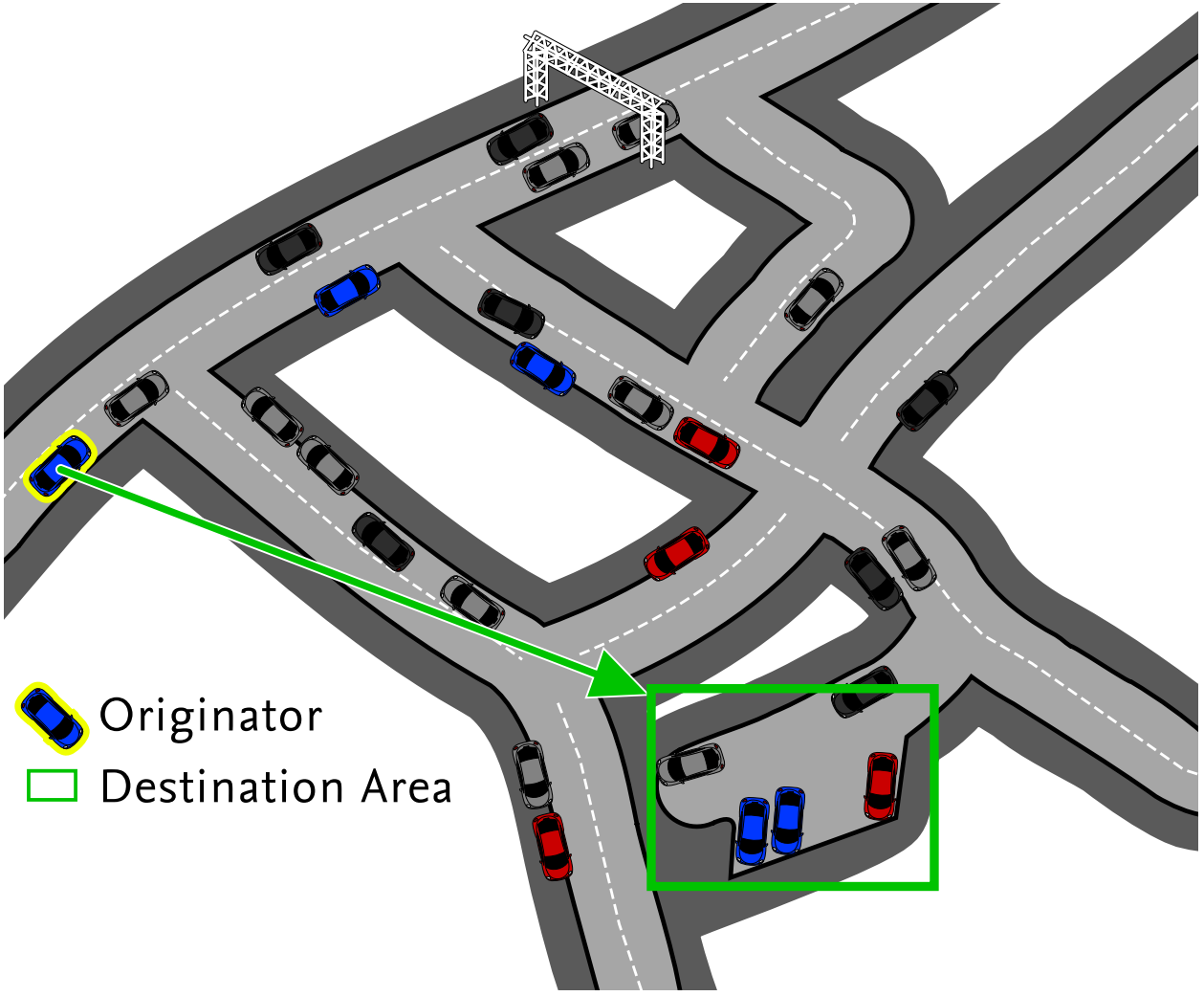
Routing to Mobile Originator



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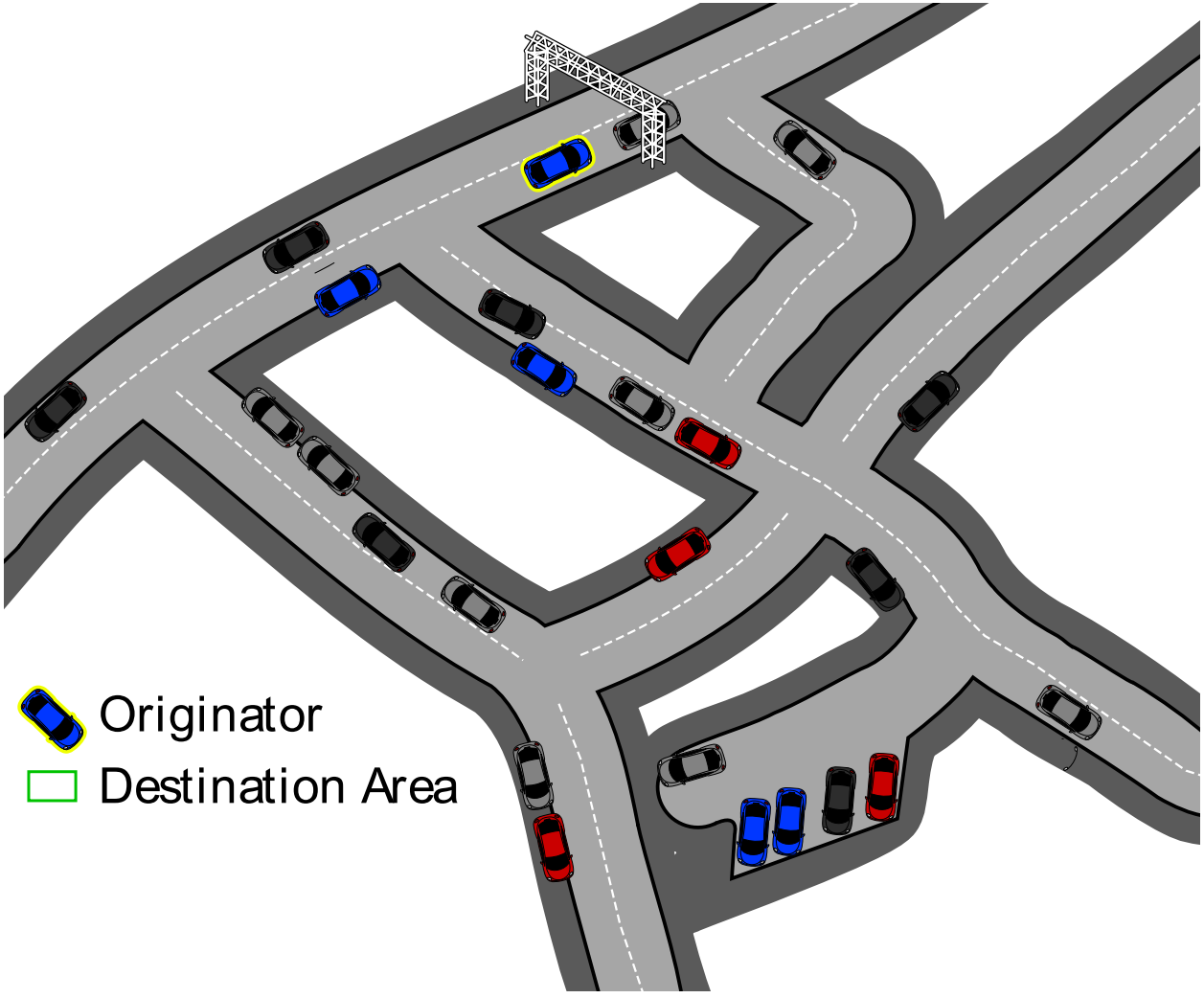

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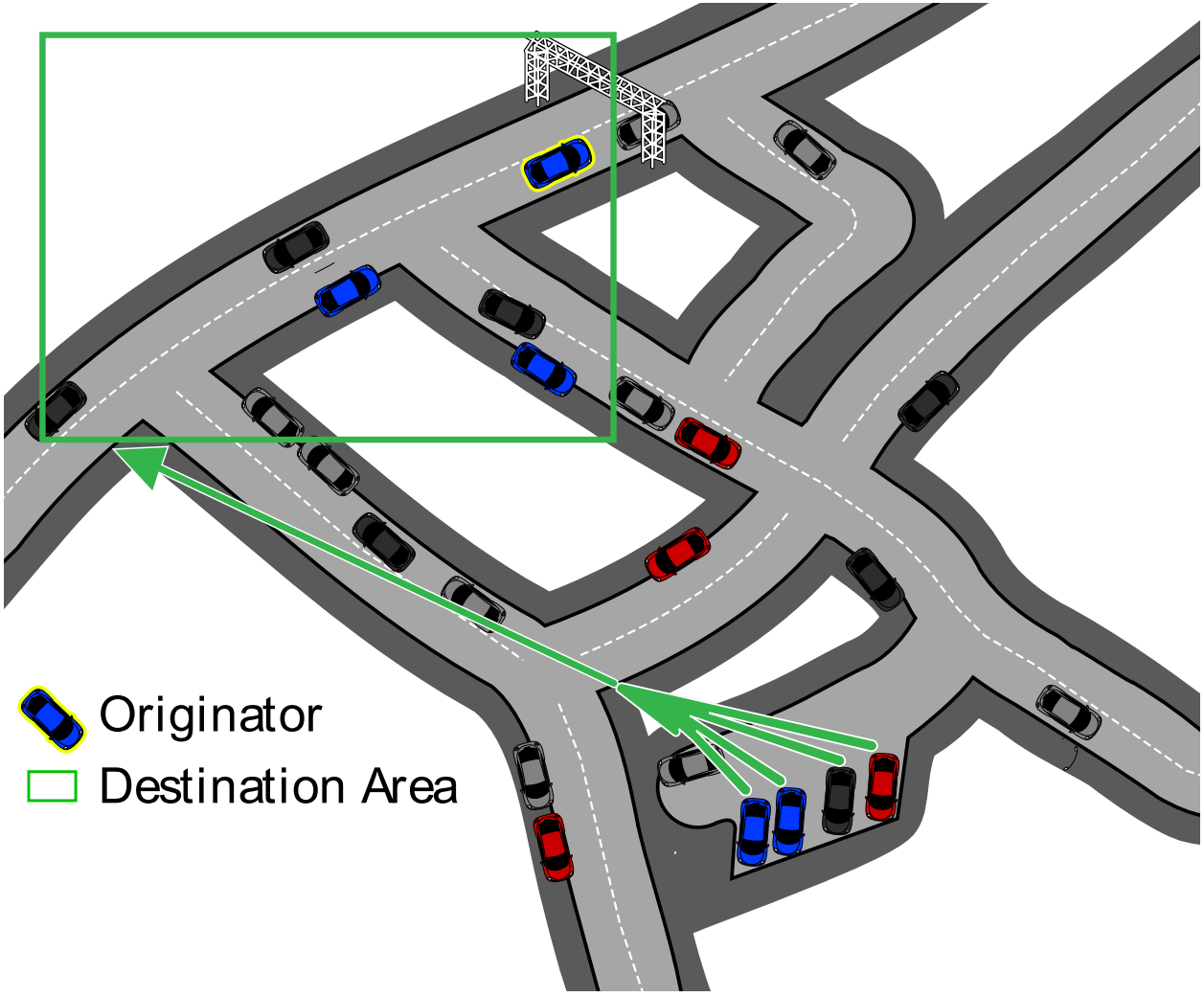


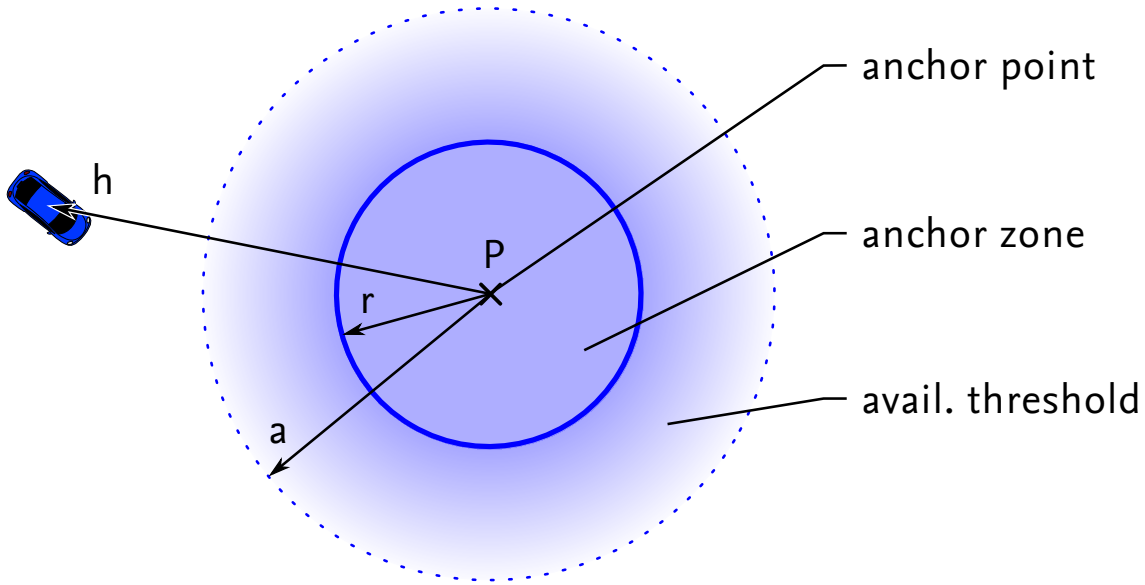
Breadcrumbs

["Wohlfahrtsmarke" 1961]

"Hansel and Gretel", published by The Brothers Grimm in 1812

Breadcrumb Geocast Routing (BGR)

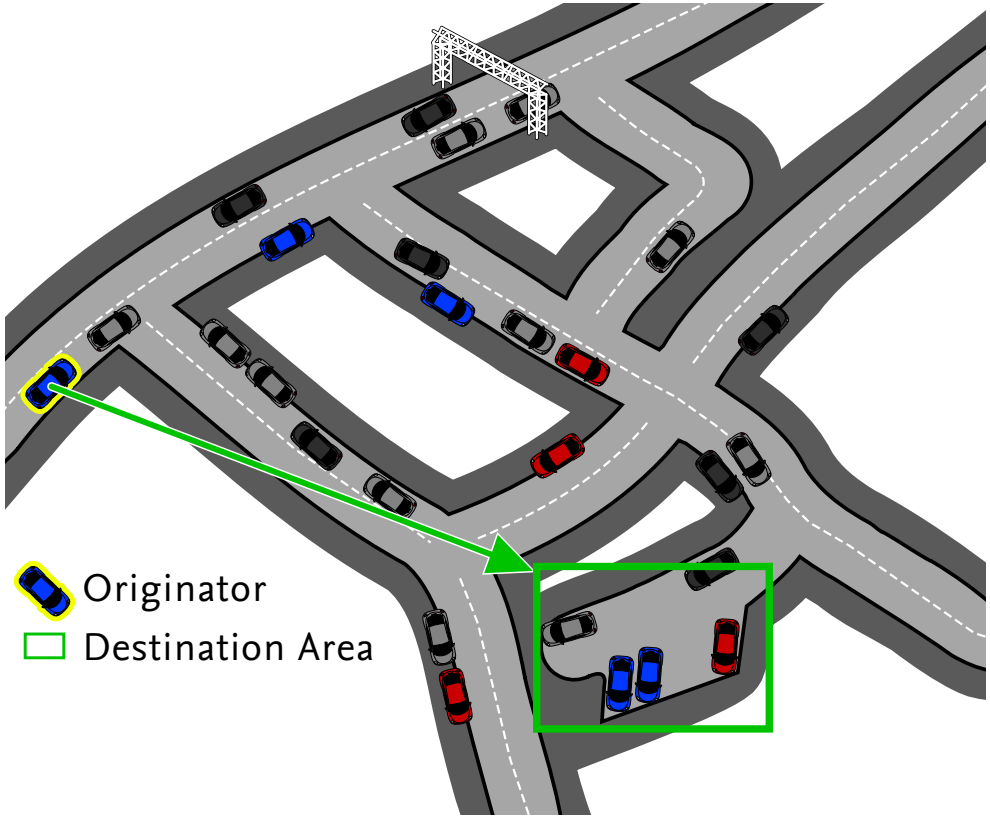
- Breadcrumbs are based on "Floating Content"[1] approach
- Responses are redirected at breadcrumbs



[1] Ott et al. "Floating Content: Information Sharing in Urban Areas" (2011)

1. Geocast Phase

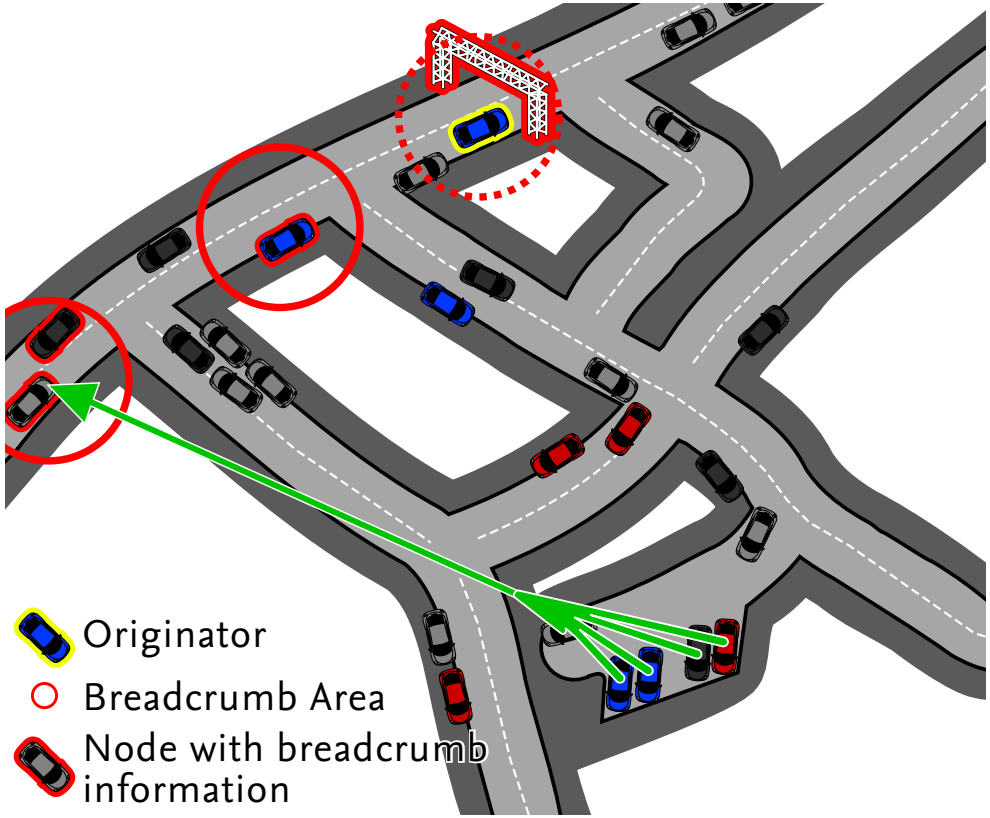
- Originator initiates breadcrumbs
- Nodes forward messages according to used geocast strategy[2]



[2] "GeoVanet: A Routing Protocol for Query Processing in Vehicular Networks" (2011)

2. Response Phase

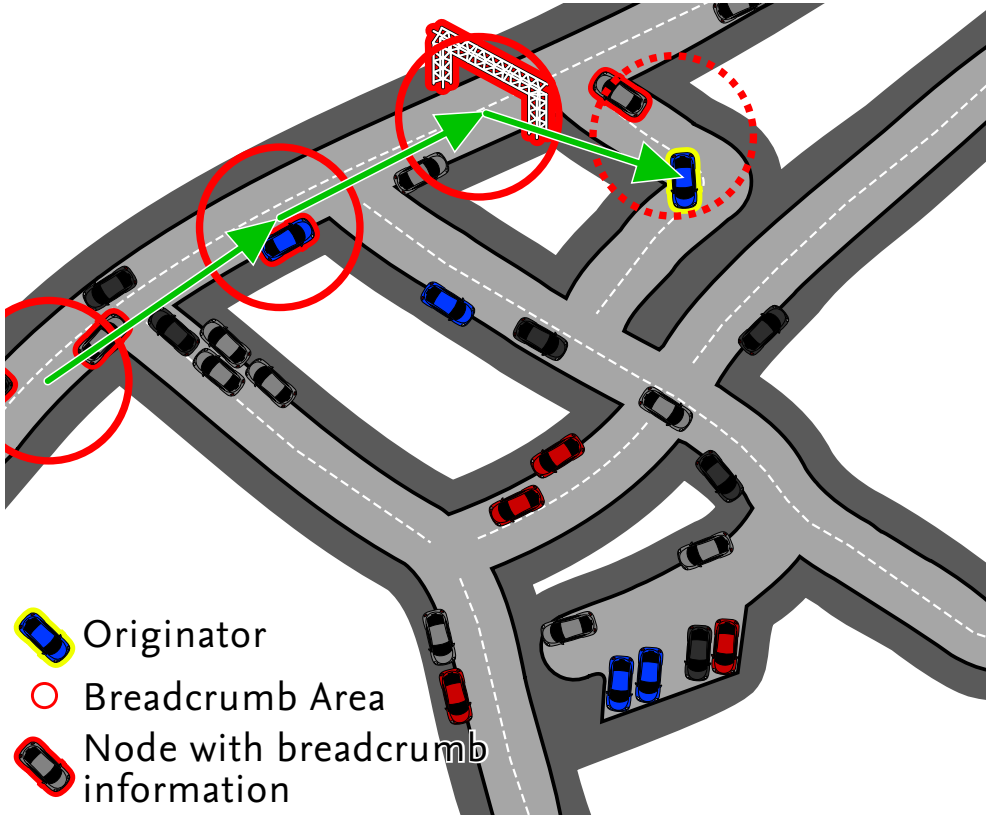
- Originator drops more breadrumbs, if necessary
- In the destination area, responding node is determined (VITP[3])
- Response is sent to first breadcrumb via geocast



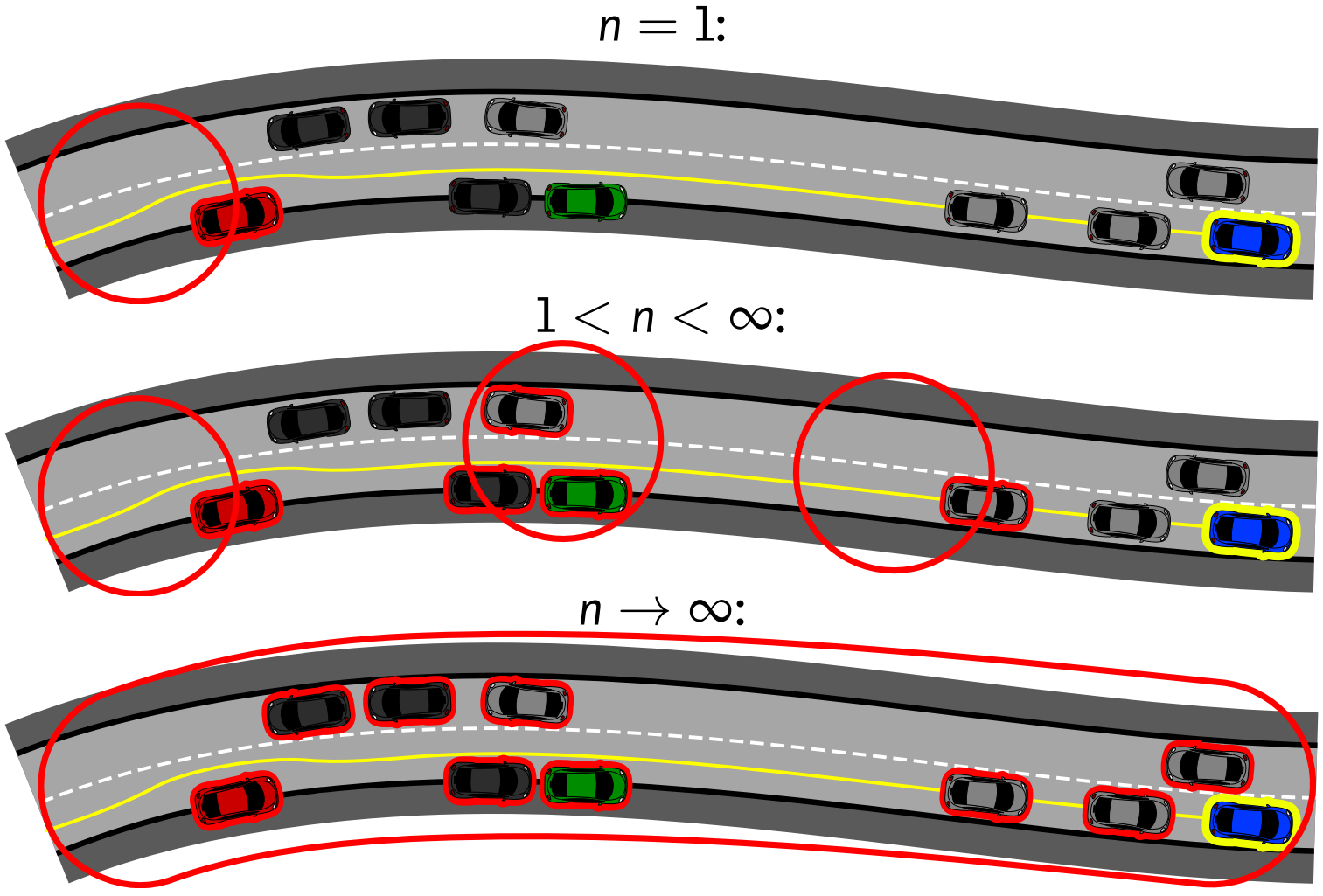
[3] Dikaiakos et al. “VITP : An Information Transfer Protocol for Vehicular Computing”

3. Tracking Phase

- Receiving breadcrumbs redirect message to subsequent breadcrumb
- Response is delivered to query originator
- Breadcrumbs dissolve upon reception of response or exceeded TTL



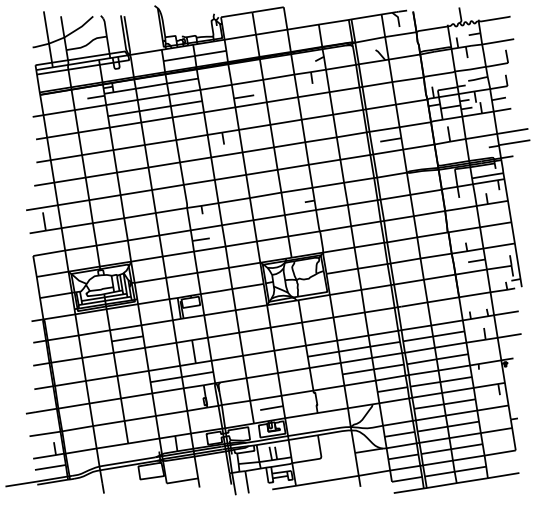
Breadcrumb Distribution



Scenarios

San Francisco

- Area: 5.39 km^2
- Roads: 108.78 km
- Nodes: 1850



Helsinki

- Area: 14.67 km^2
- Roads: 119.2 km
- Nodes: 2000

Parameters and Metrics

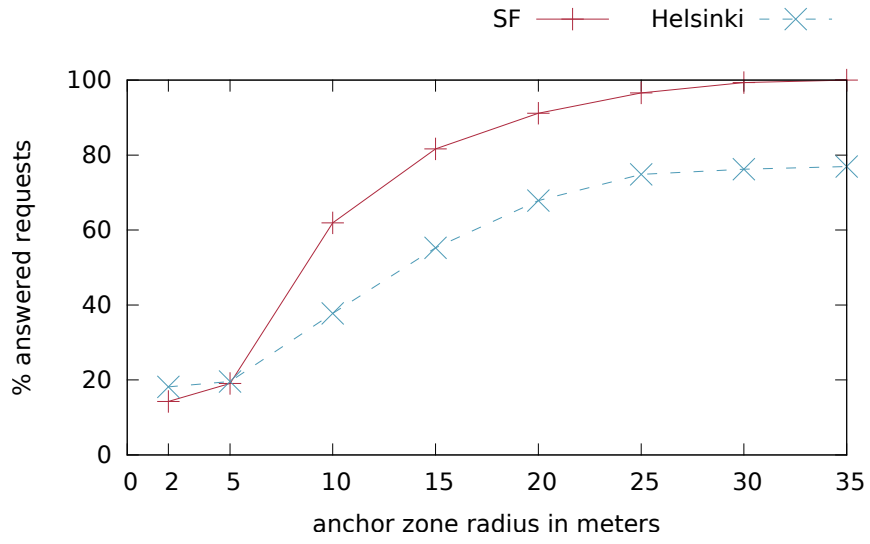
Parameters

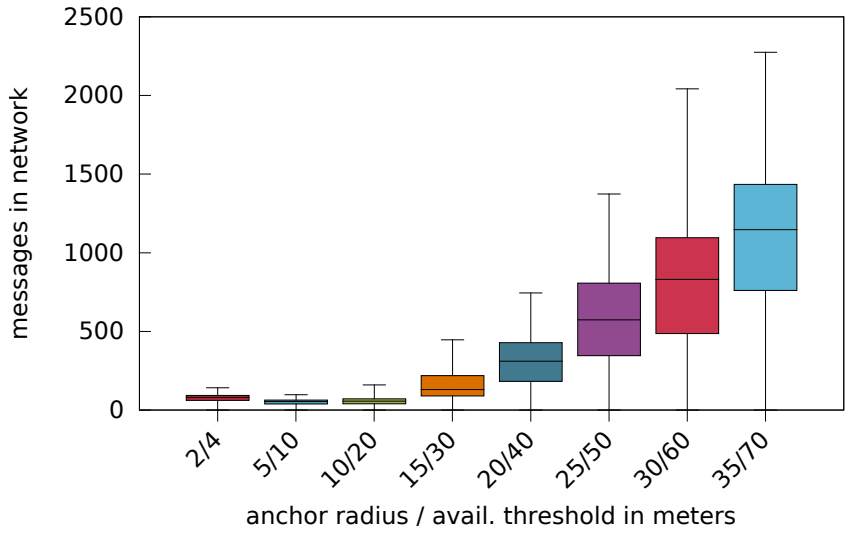
- Breadcrumb size
- Breadcrumb distance

Metrics

- Network traffic
- Delivery rate
- Hop count
- Delivery delay
- (Breadcrumb availability)

Breadcrumb Size



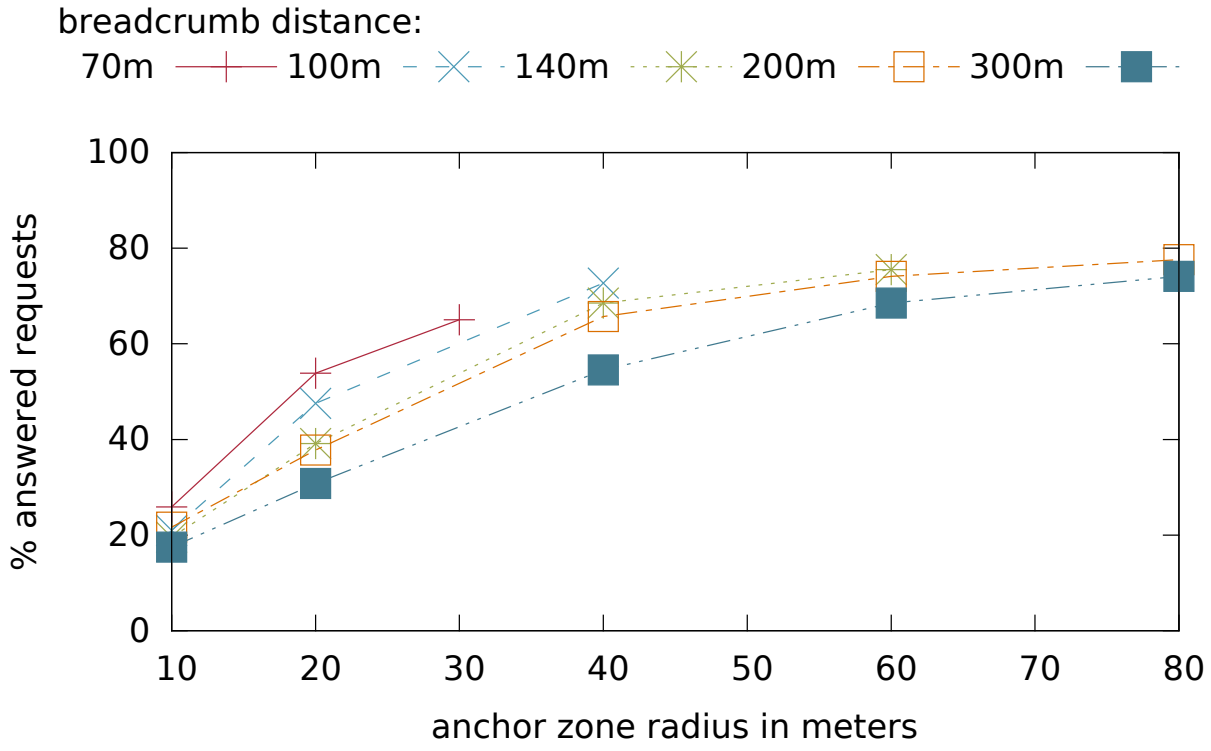


(Breadcrumb distance 100 m)

$\Rightarrow$ Minimum breadcrumb size $r = 15 - 20$ m (delivery rate)

$\Rightarrow$ Breadcrumb size should be as small as possible (traffic)

Breadcrumb Distance

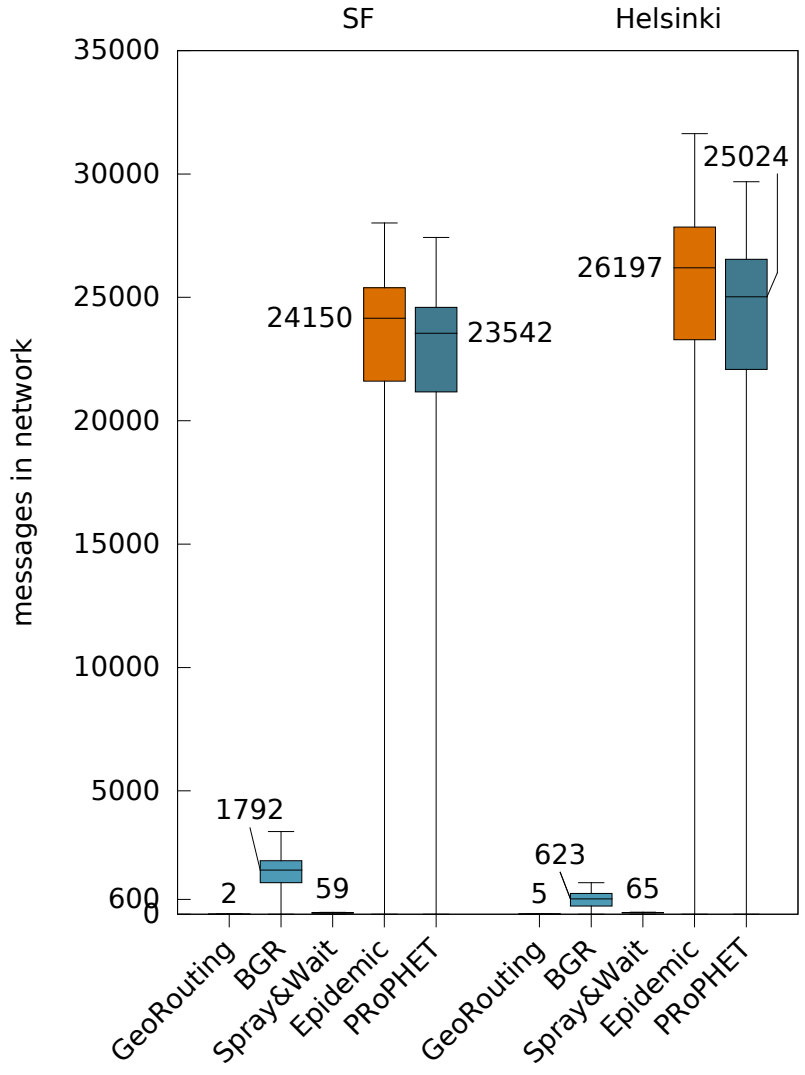


(Breadcrumb size 25 m)

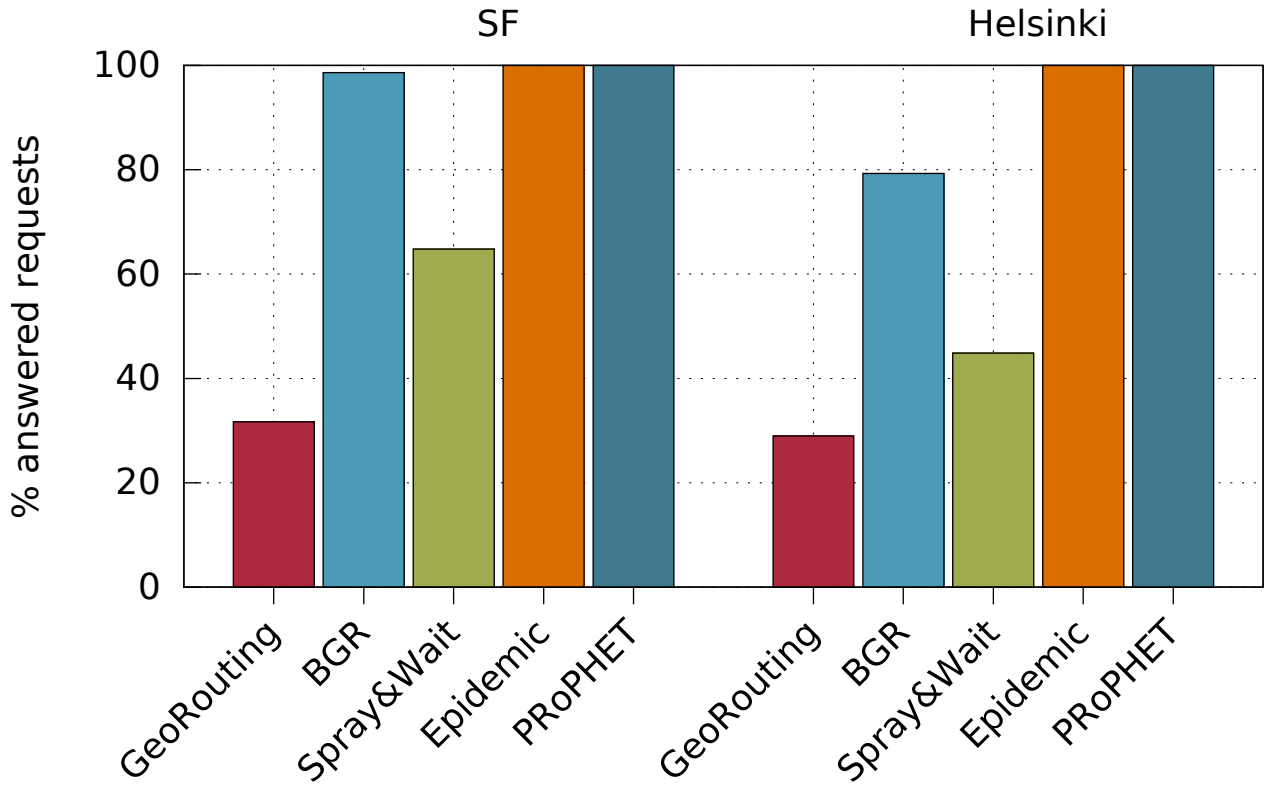
⇒ Breadcrumb distance has minor impact

⇒ Breadcrumbs should be as close as possible, without overlapping

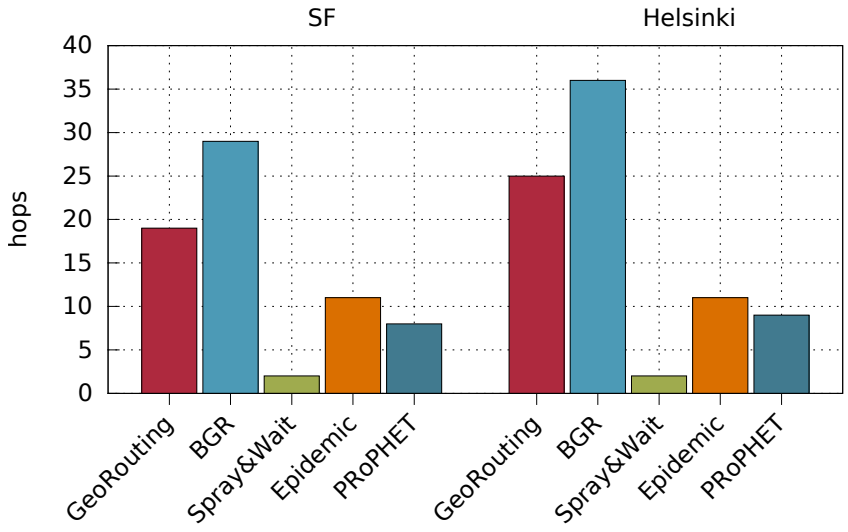
Network Traffic

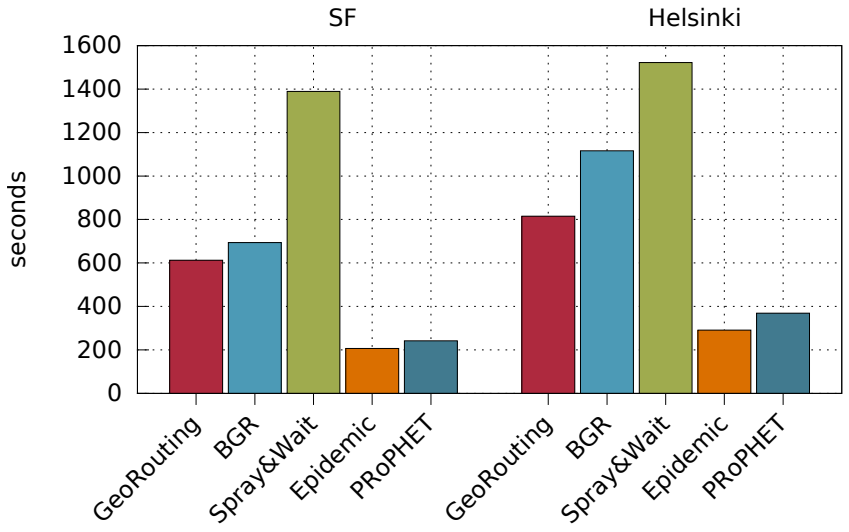


Delivery Rate



Hop Count & Delay





Conclusion

- Breadcrumb Geocast Routing (BGR)
- Routing responses to moving originators
- Can be used on top of ex. geocast protocols
- Breadcrumb size is key parameter
- Low network traffic
- High delivery rates

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- Low network traffic
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Thank you!

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Section 5

Appendix

Related Works I

J. Ott et al. “Floating Content: Information Sharing in Urban Areas”. In: *Proc. IEEE Int. Conf. on Pervasive Computing and Communications (PerCom)*. Seattle, WA: IEEE, Mar. 2011, pp. 136–146.

M. D. Dikaiakos et al. “VITP : An Information Transfer Protocol for Vehicular Computing”. In: *Proc. 2nd ACM Int. Workshop on Vehicular Ad Hoc Networks (VANET ’05)*. Cologne, Germany: ACM Press, Sept. 2005, pp. 30–39.

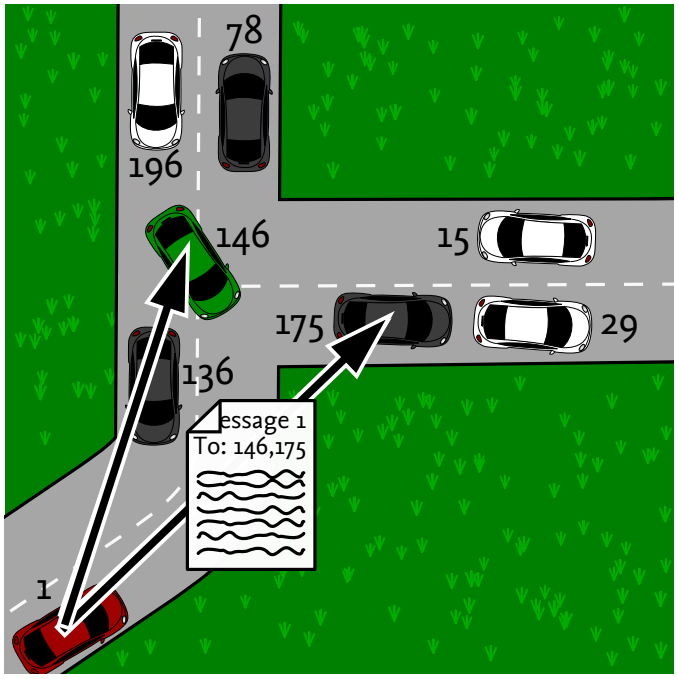
T. Delot et al. “Decentralized Pull-Based Information Gathering in Vehicular Networks Using GeoVanet”. In: *Proc. 12th IEEE Int. Conf. on Mobile Data Management (MDM ’11)*. Vol. 1. Lulea, Sweden: IEEE, June 2011, pp. 174–183.

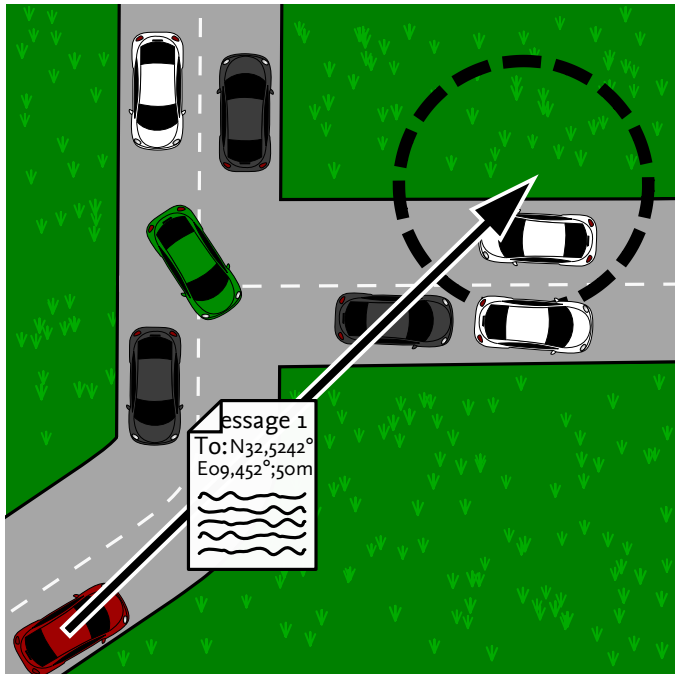
Related Works II

 T. Delot et al. “GeoVanet: A Routing Protocol for Query Processing in Vehicular Networks”. In: *Mobile Information Systems* 7.4 (2011), pp. 329–359.

Geocast

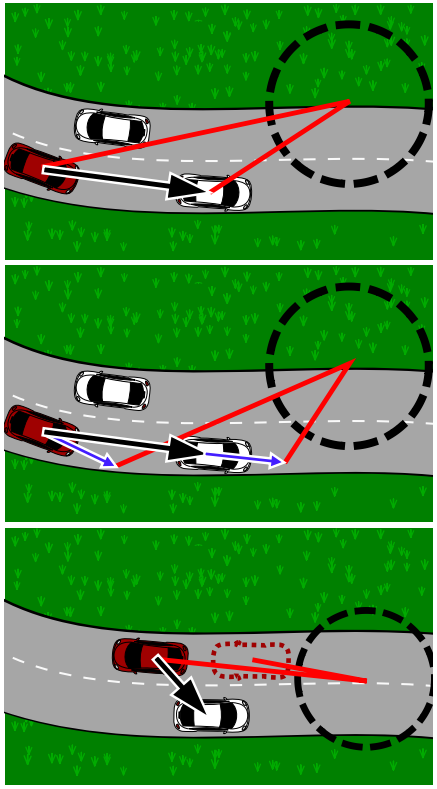
- No node specific addresses
- Instead, geographic location as address
- Nodes must be able to determine their geographic location
- Nodes compare their location to the destination location





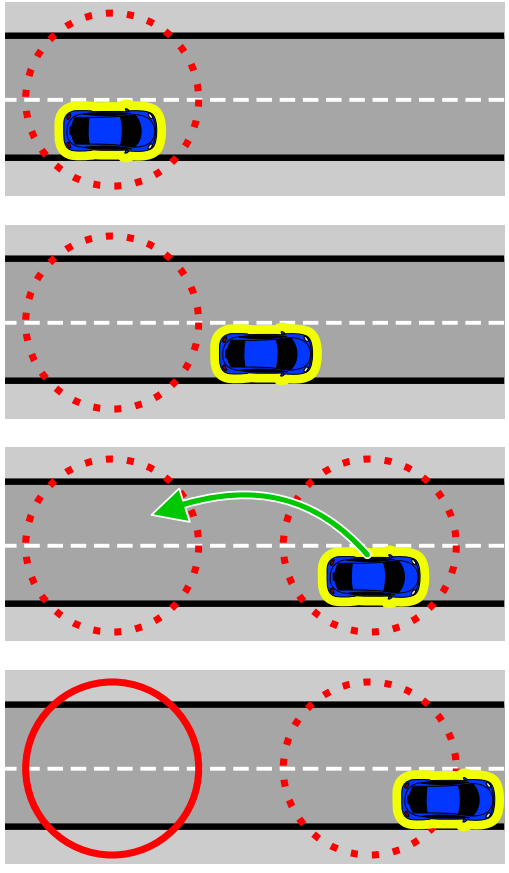
Geocast Routing Strategies

- Position based geocast
  - Message is forwarded to node closest to destination
- Speed vector based geocast
  - Geographic vector based on speed and past location
  - Message is forwarded to node whose vector ends the closest to the destination
- Gecoast based on GeoVANET
  - Forward only if current node is not moving closer to destination
  - Message is forwarded to the nearest neighbor moving towards the destination



Delayed Dropping

1. New breadcrumb is triggered and stored
2. Originator moves away from old anchor point
3. a) New breadcrumb is triggered and stored
   b) Old breadcrumb is updated and sent via geocast
4. Old breadcrumb is established at its anchor point



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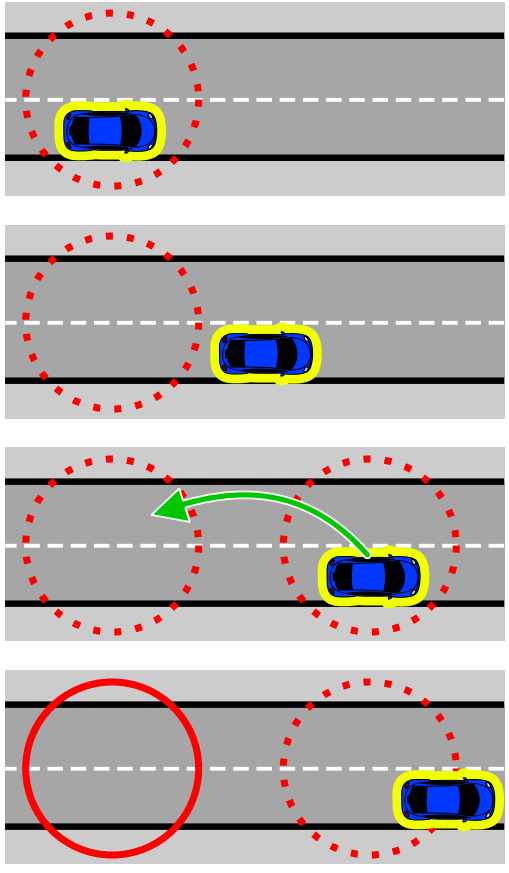

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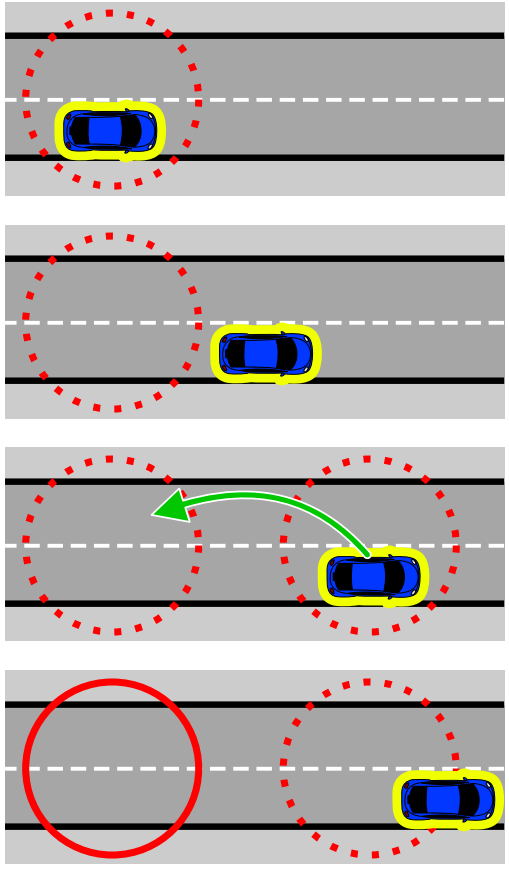

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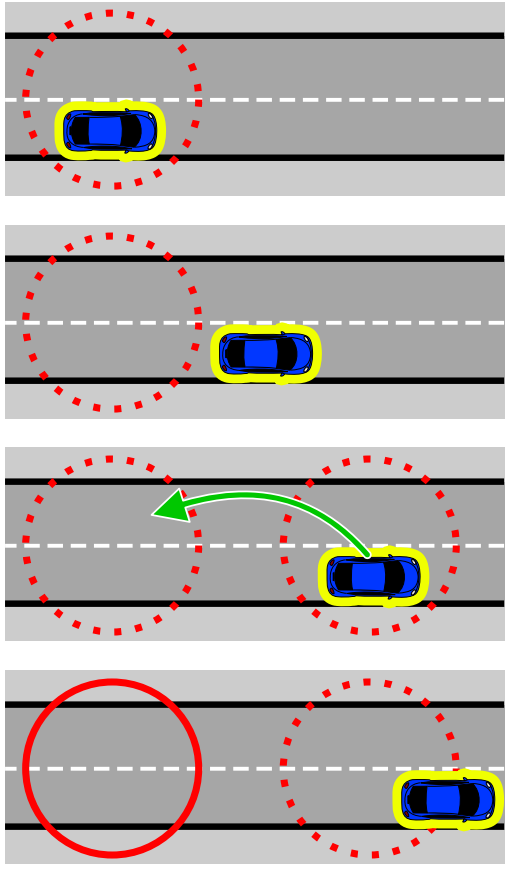

Default Settings

- Node count corresponds to 17 veh/km in all scenarios[4]
- Only driving cars initiate messages

Setting	Value	Setting	Value
Breadcrumb distance	100 m	Time between new messages	120 s to 360 s
Breadcrumb size	50 m	Response delay	480 s
Randomly moving cars	17 veh/km	Simulated period	12 h
Message buffer size	500 MB	Transmission rate	22 Mbit/s
Max. number of copies	1	Transmission range	25 m
Time to live (Request)	60 min	Driving speed	18 km/h to 54 km/h

[4] Based on real world traffic data from Braunschweig, Germany, at morning rush hour

RoadGraph

- Highly detailed digital map (single lanes)
- Lane side descriptions
- Improves routing decisions
  - Nodes calculate intermediate destinations to prevent local minima
  - Introduction of additional information (e.g. node density) to manipulate message paths