Navigo: Interest Forwarding by Geolocations in Vehicular Named Data Networking

G. Grassi[1] D. Pesavento[1] G. Pau[1] L. Zhang[2] S. Fdida[1]

[1]University Pierre and Marie Curie (UPMC)

[2]University of California (UCLA)

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Navigo

Navigo is a location based packet forwarding mechanism for vehicular Named Data Networking (NDN)

- Navigo discovers the geographic area where the data resides
- It proposes an algorithm to guide the data requests along the shortest path on the V2V channel over the road topology

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Outline

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NDN - the best fit for VANET

NDN puts **contents** at the center of its communication model

- IP is host centric: it has difficulties coping with mobility and multihoming
- Naming data decouples communication from specific interfaces and endpoints.
- NDN naturally supports multihoming and mobility.
- Each application names the data it wants to fetch or provide
- The network directly uses these names to process the packets

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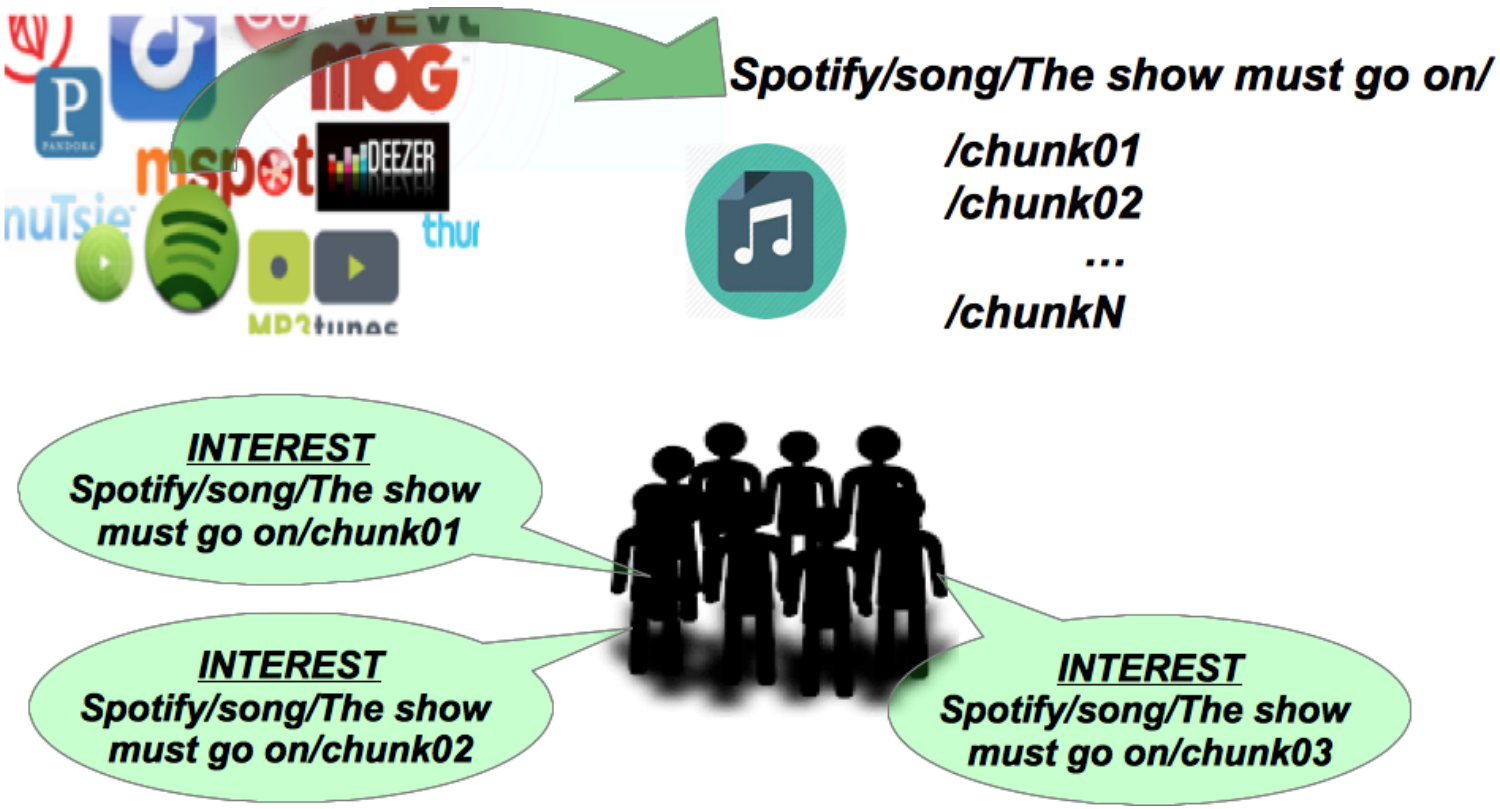
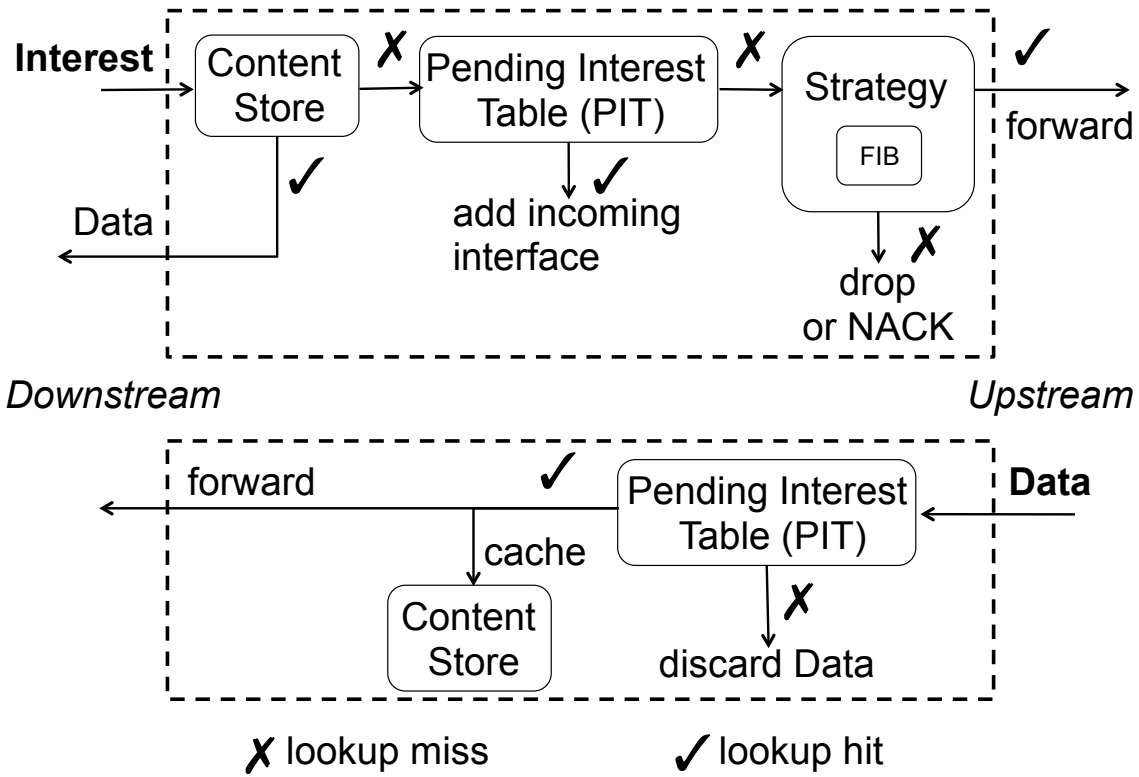
NDN - Naming Data



NDN - Architecture

- The network directly uses these names to process the packets
  - Interest goes through CS, PIT and FIB
  - Content follows the Interest breadcrumbs left in the PIT



NDN in VANET

V-NDN: the first implementation of NDN for VANET

- It introduces a 2.5 Link Adaptation Layer (LAL) which:
  - Enables NDN over 802.11-broadcast
  - Provides reliability capabilities and duplicate suppression
- Limitations: lack of smart packet forwarding mechanism

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Naming geographic areas

- The world is divided into regions according to the Military Grid Reference System (MGRS)
- Each area is named with a label
  - i.e. 4QFJ 123 678 identifies a 100x100 meters area

Mapping data names to geo-areas

- Navigo discovers the location (area) of the Data provider (i.e. producer, RSU, caches) and binds it with the Data names
  - The Interest is sent in all the directions if no information about the name is present
  - Data provider attaches its location (MGRS area label) to the Data
  - Nodes learn the new binding

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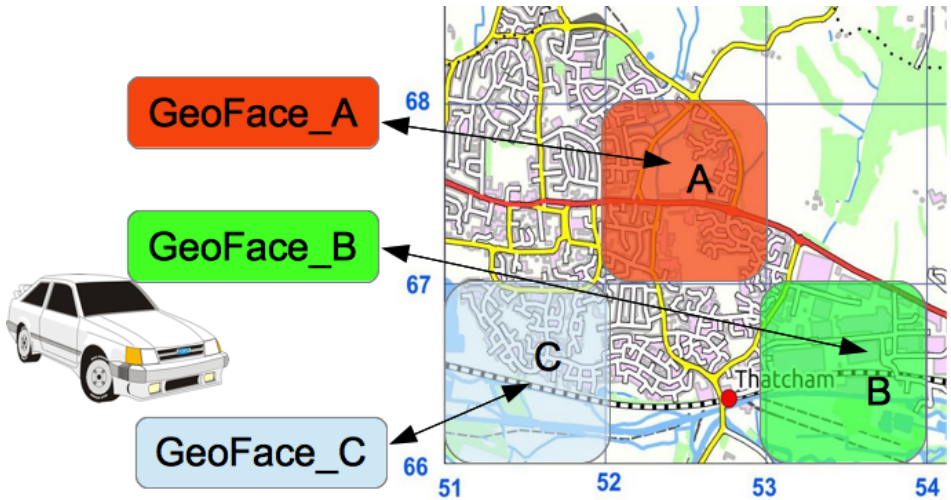
GeoFaces

In the NDN architecture there is no such thing as geo-areas

- The forwarding process is based on the FIB, which stores names-faces pairs only
- Navigo introduces the concept of geographical faces (GeoFace): an abstraction to the network physical interface
  - It binds each geo-area to a GeoFace
  - GeoFace_A sends packets only towards the geo-area A and receives Data generated from geo-area A only
  - The FIB stores the binding among data names and GeoFaces
  - An application may bind a name with a GeoFace



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Interest forwarding

Forwarding Interest *I* for a Content named *N*

- No match in the FIB $\rightarrow$ Interest flooding
  - If the Content *N* comes back from geo-area *X* $\rightarrow$ registers *N*-F_X into the FIB
- Only 1 GeoFaces F_X for *N*
  - With probability *p* (0.95) $\rightarrow$ use F_X to forward *I*
  - With probability *1-p* $\rightarrow$ Exploration phase: flood *I*
- Multiple GeoFaces for *N* $\rightarrow$ round robin among the faces
- If *I* is not satisfied within a certain amount of time $\rightarrow$ remove the binding GeoFace-*N*

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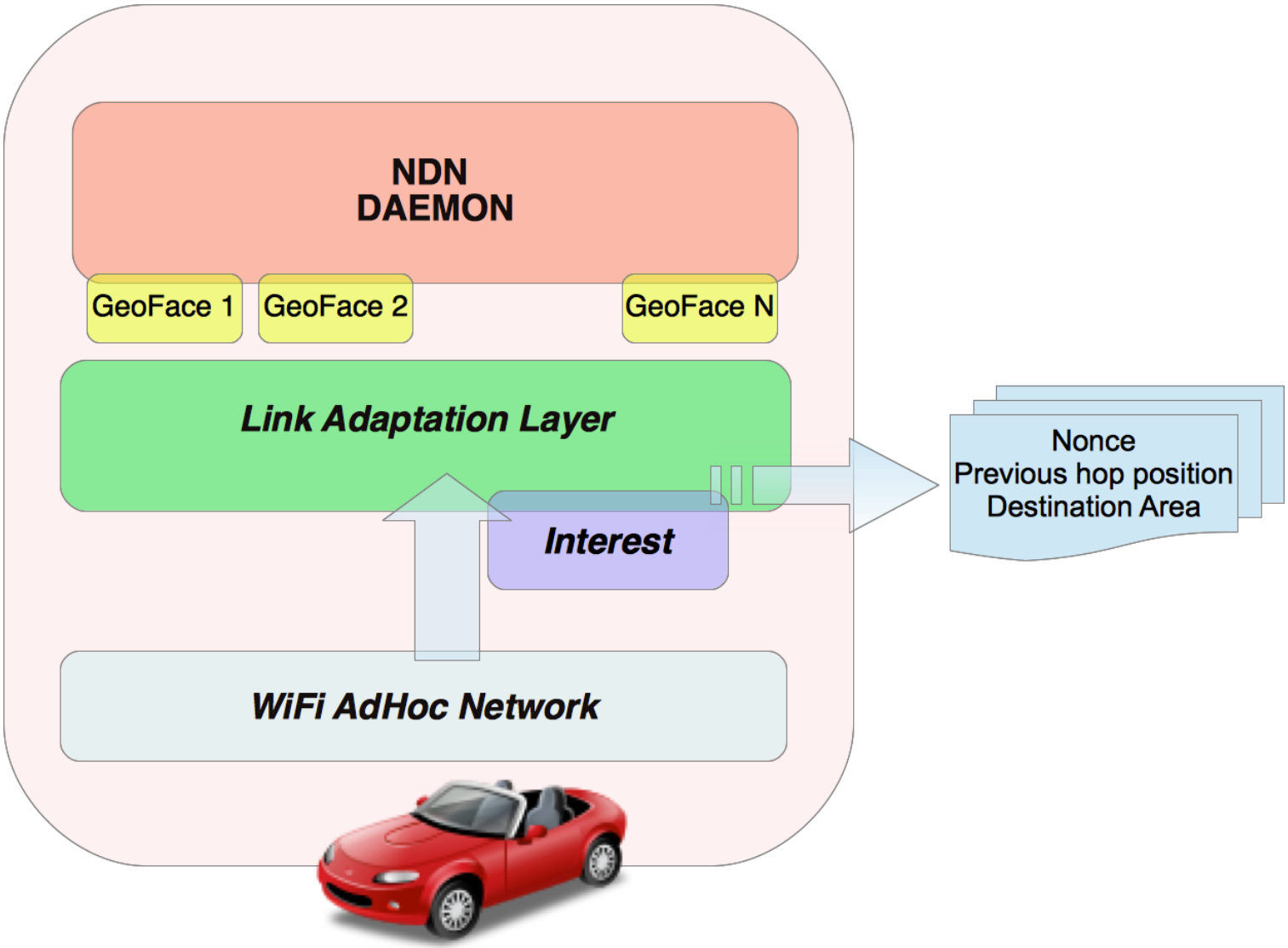
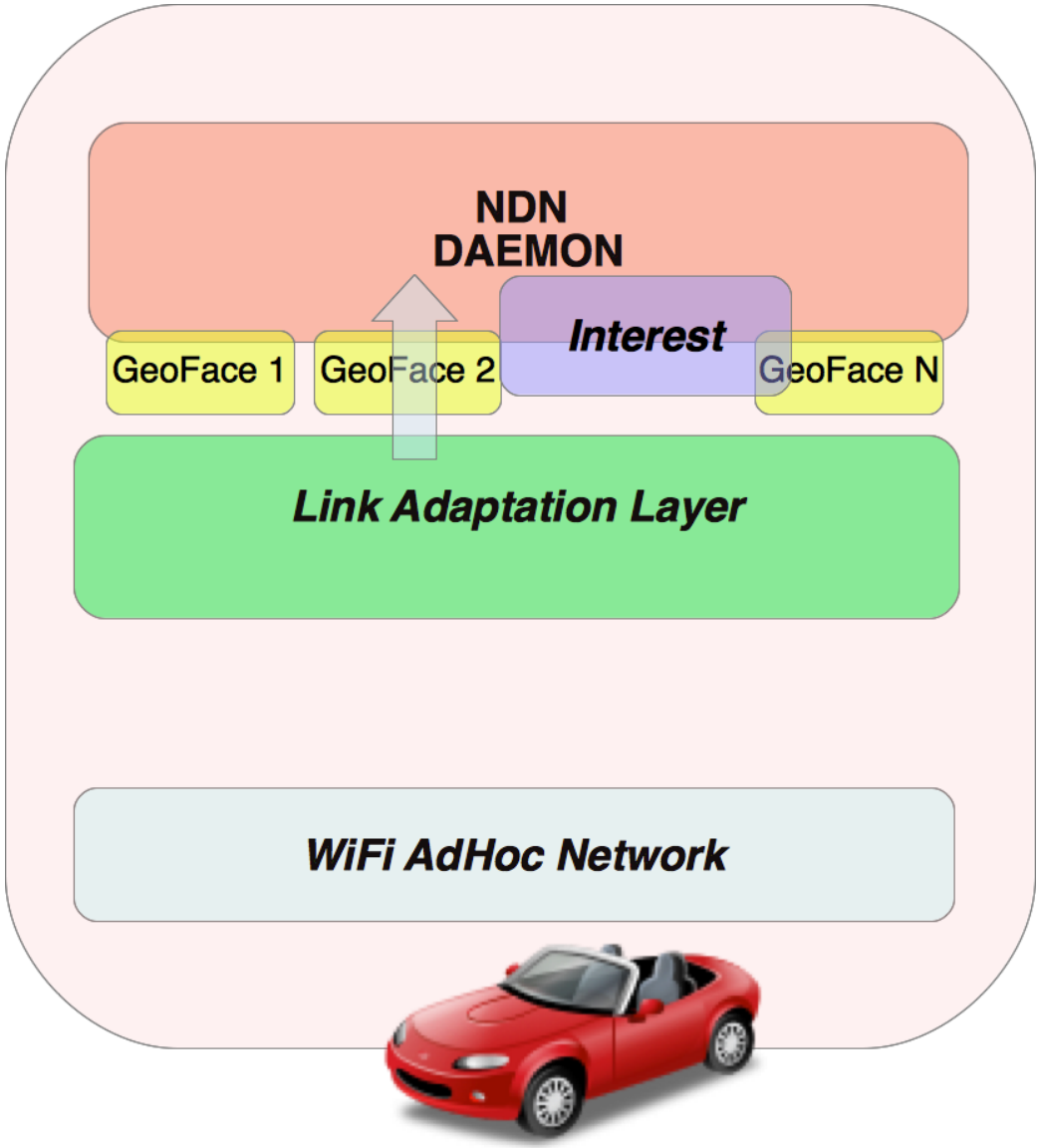
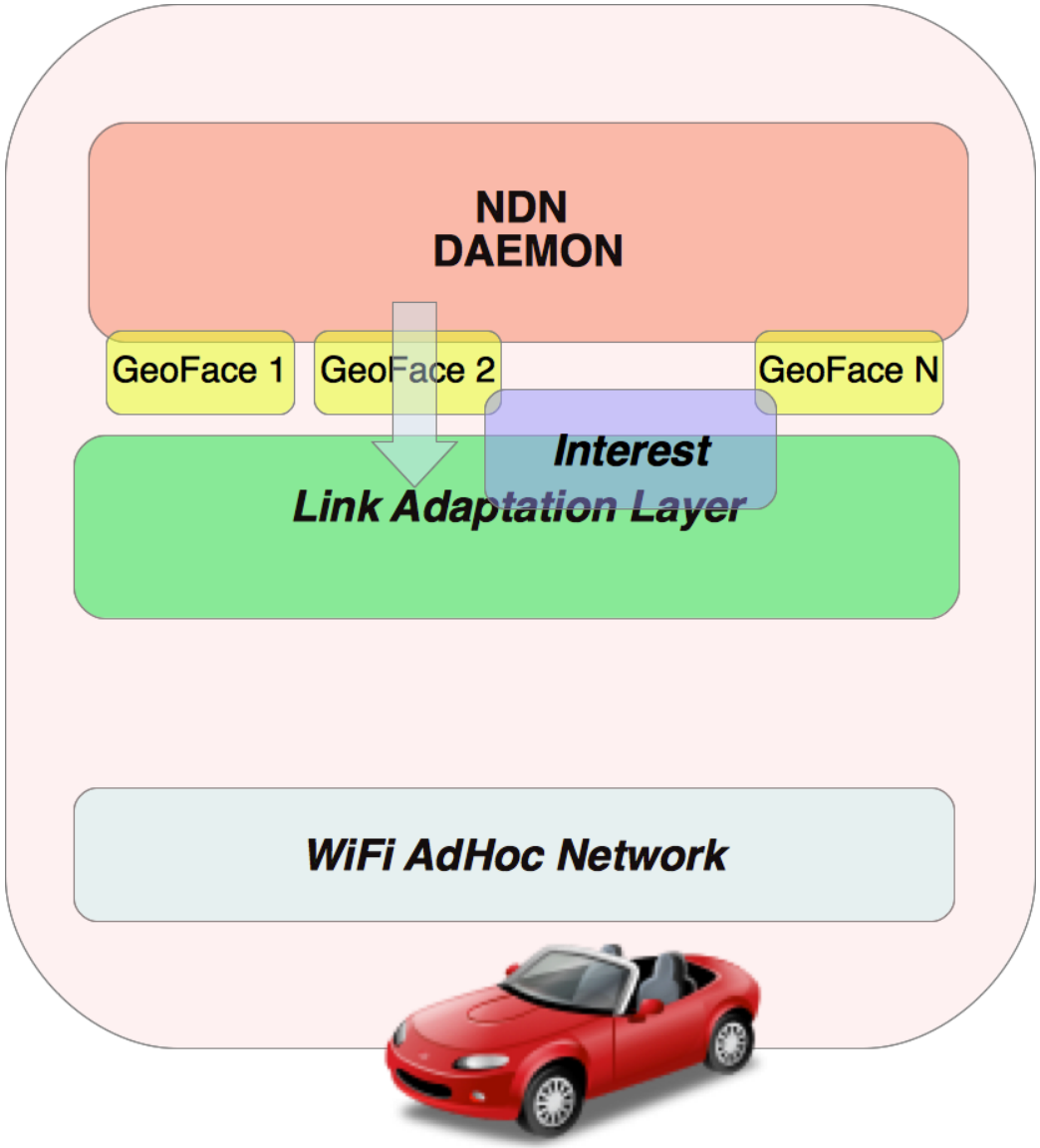
Forwarding process



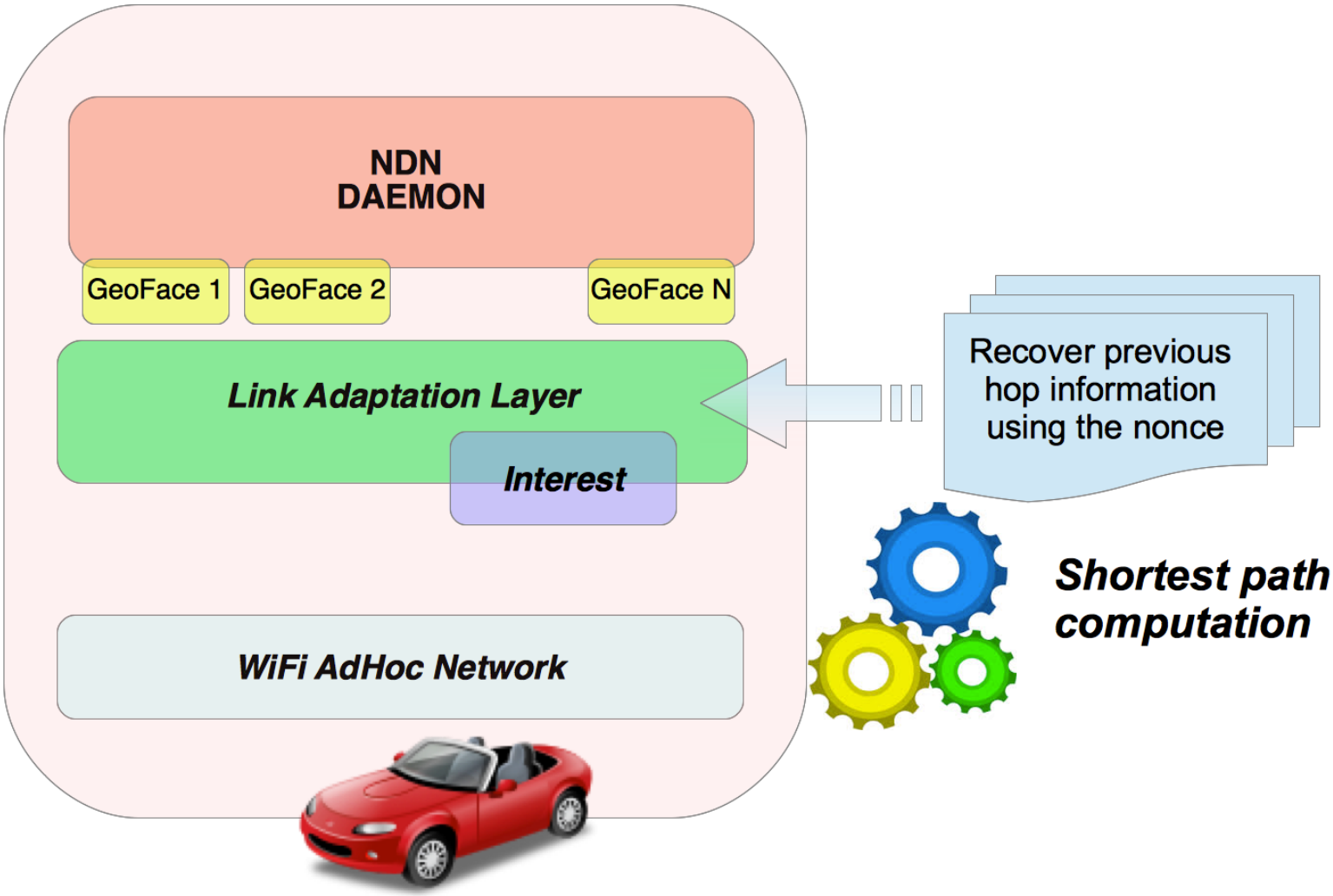
Forwarding process



Forwarding process



Forwarding process

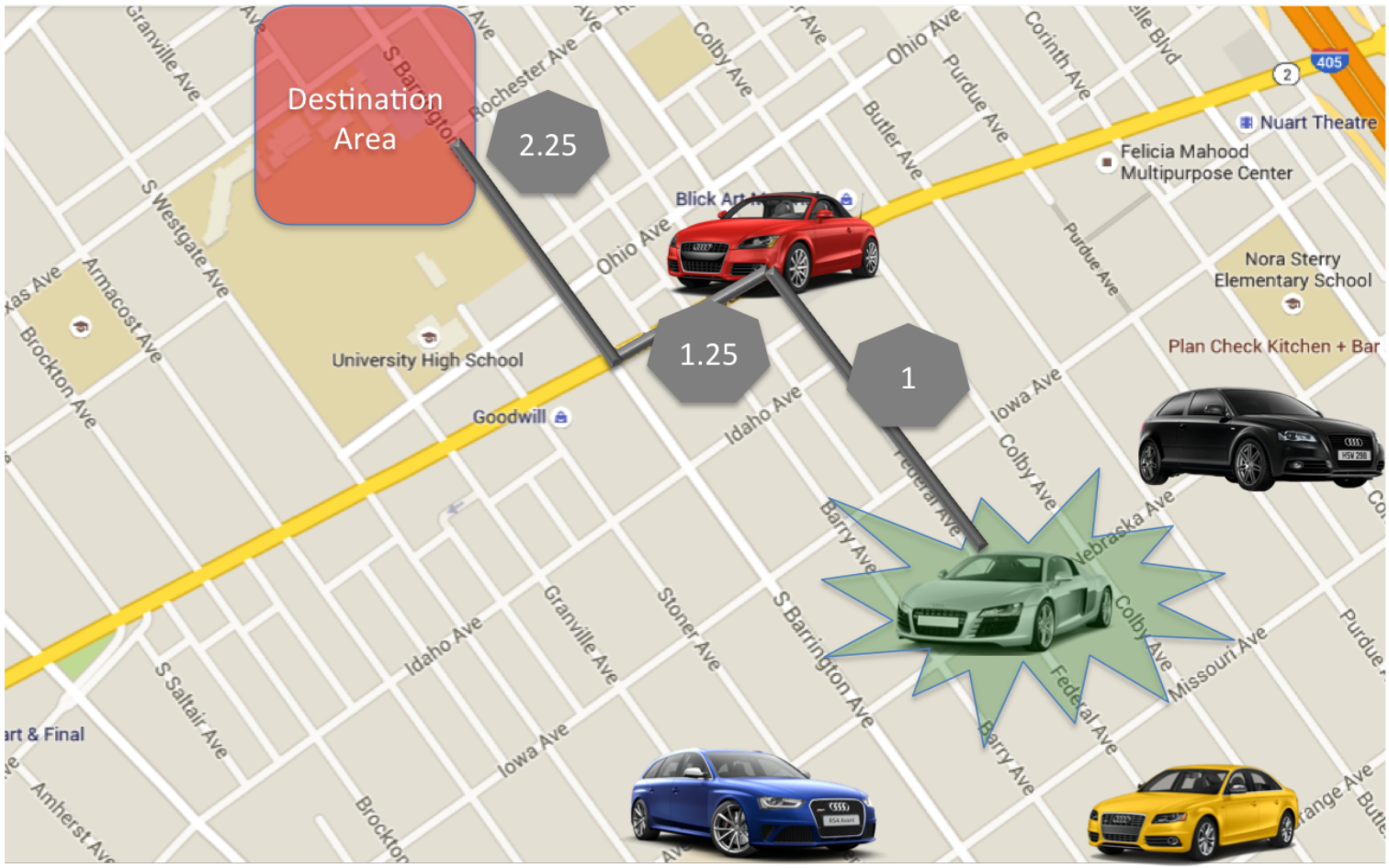


Shortest path

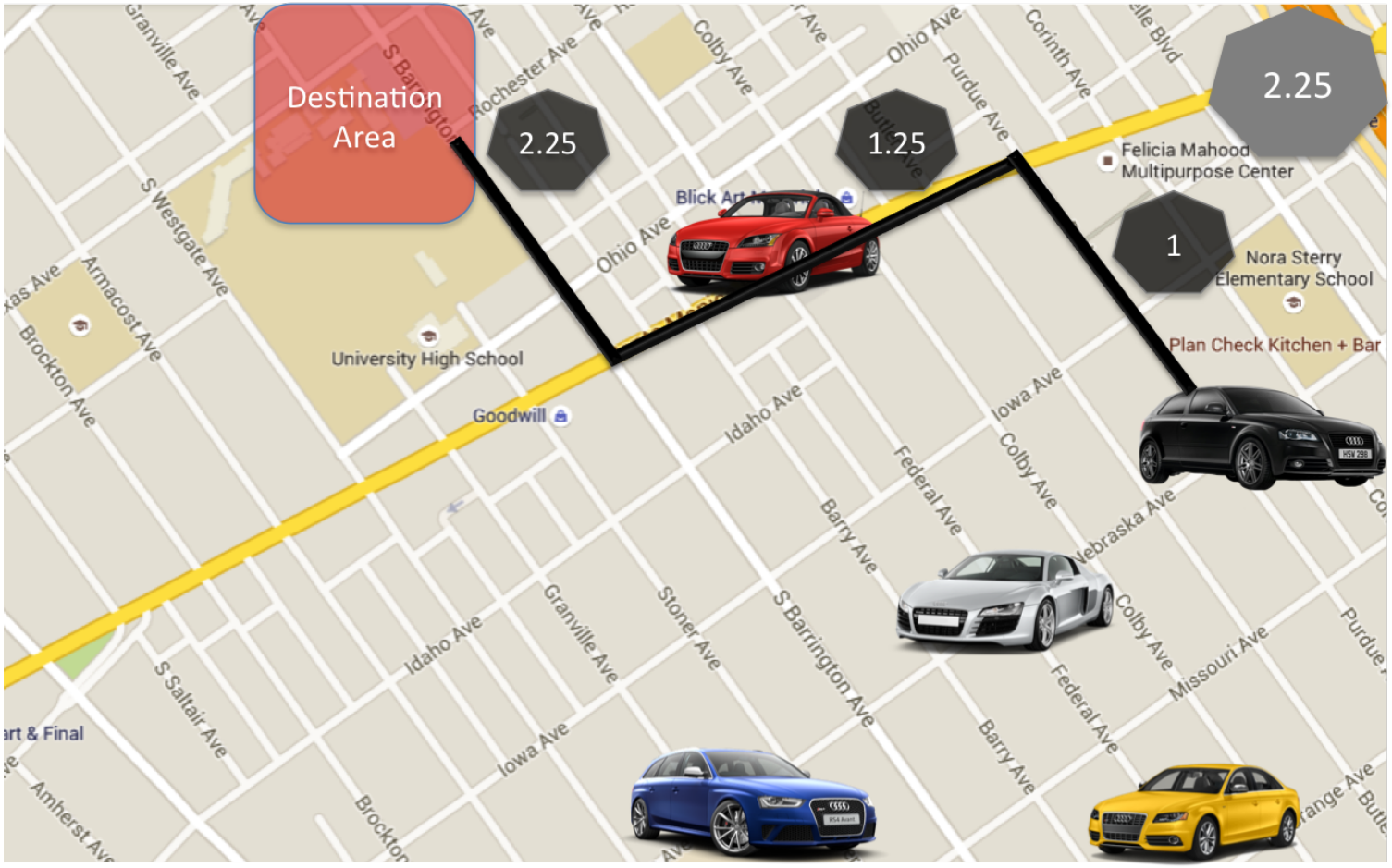
Road topology as forwarding graph

- Using cars as building block of a path exposes the communication to vehicles movement
- Using roads as path for the packet is more reliable
- Navigo uses Dijkstra on the road graph to compute the shortest path to reach a destination area
- Main roads have priority over small streets

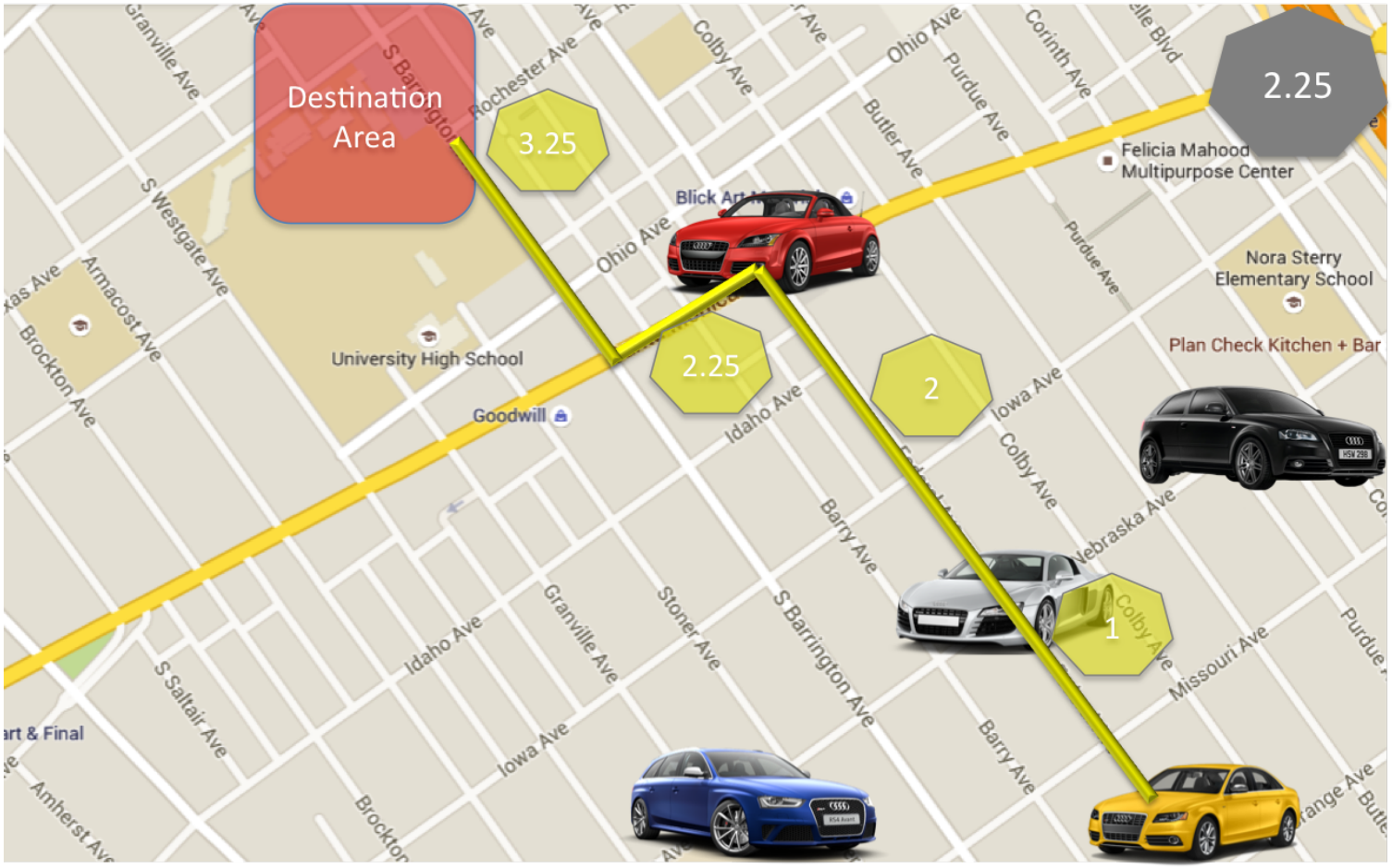
Shortest Path



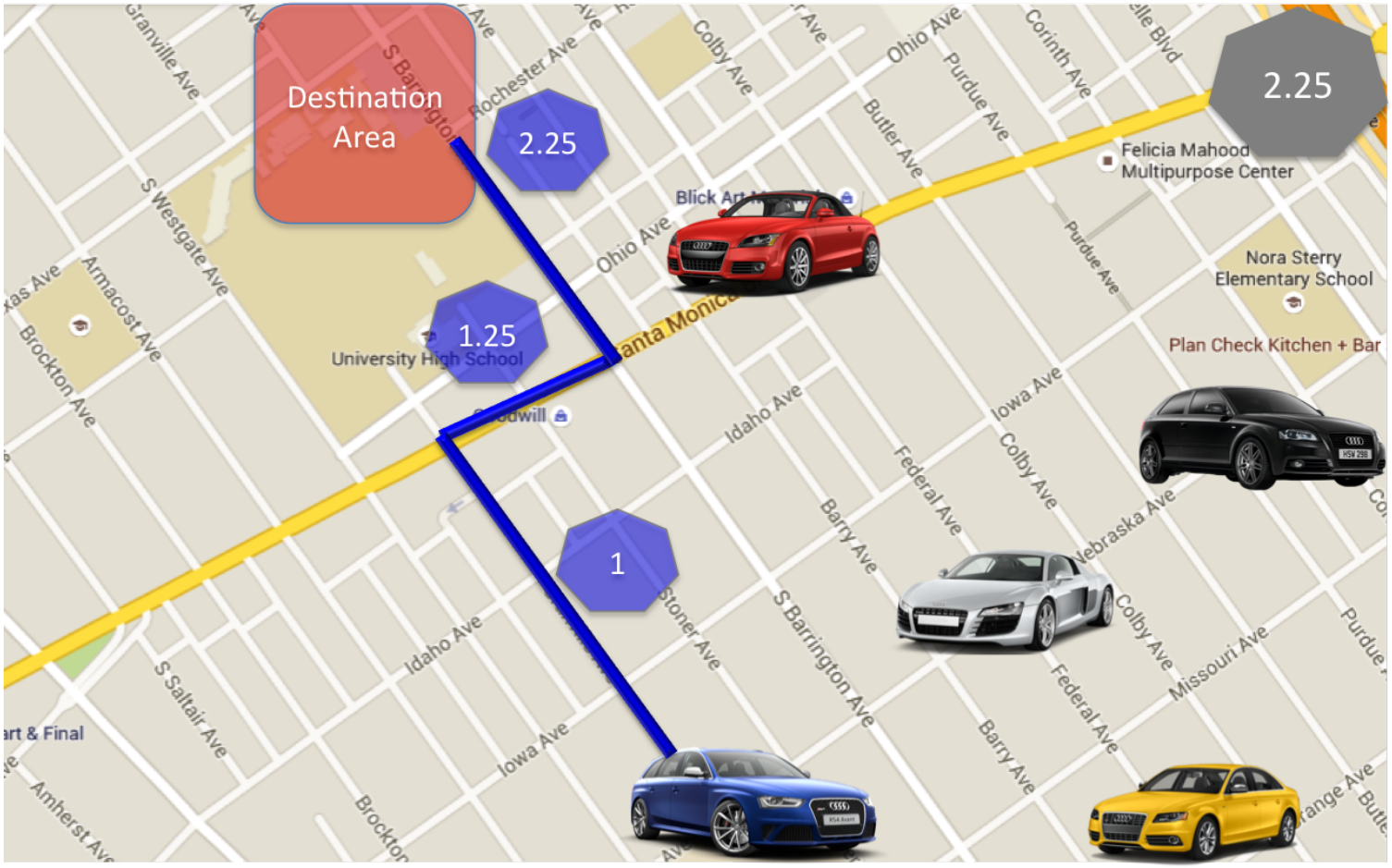
Shortest Path



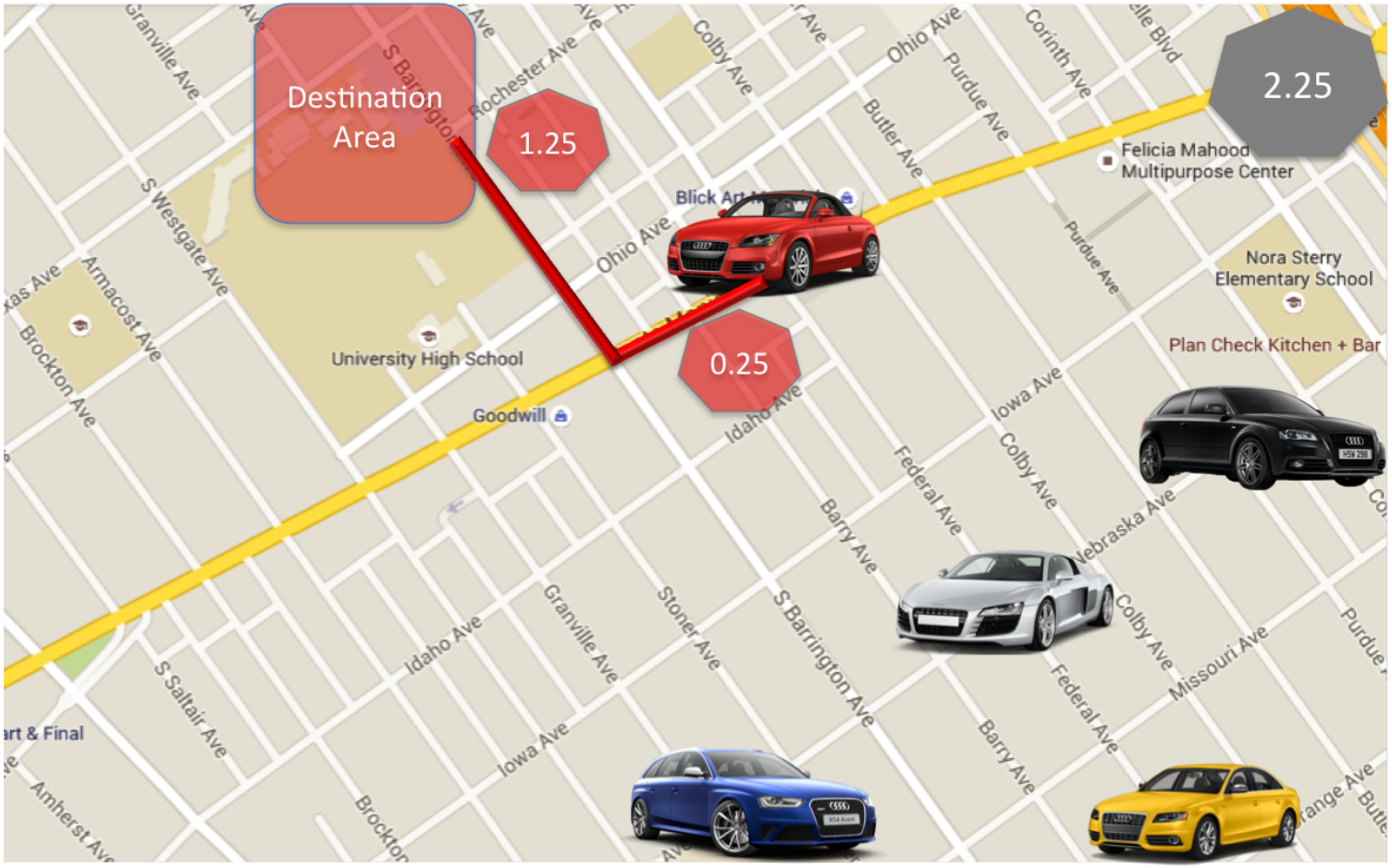
Shortest Path



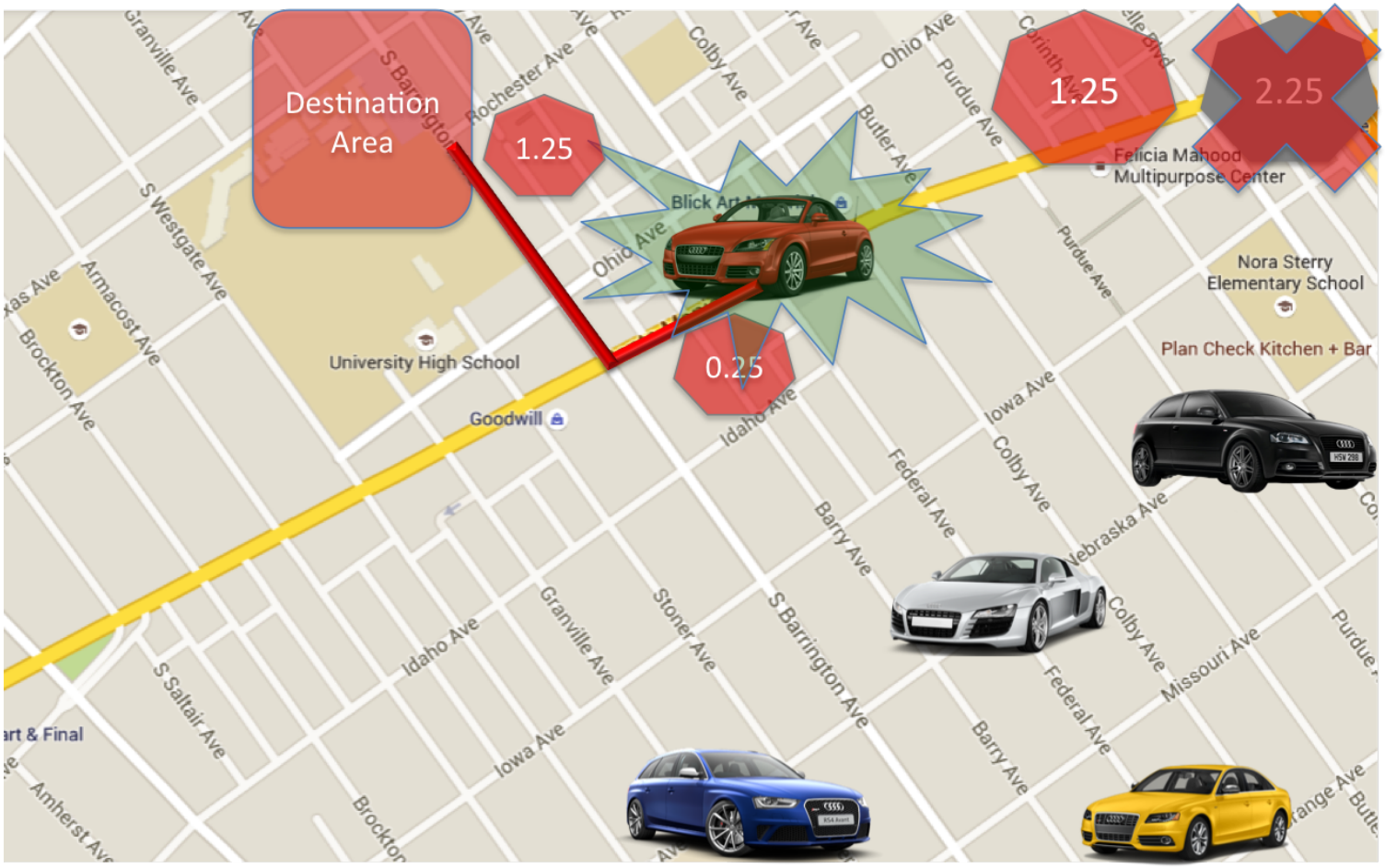
Shortest Path



Shortest Path



Shortest Path



Forwarding process

•Attaches the destination area
•Calculate waiting timer

If no one has forwarded the packet

Sends the packet

Waiting for an implicit ack

If no ack

Waiting timer

A node postpones a packet transmission based on its position and the type of packet

- Data has priority over Interest
- Cars at the intersection have priority
- Farther is a car from the previous hop, less it waits

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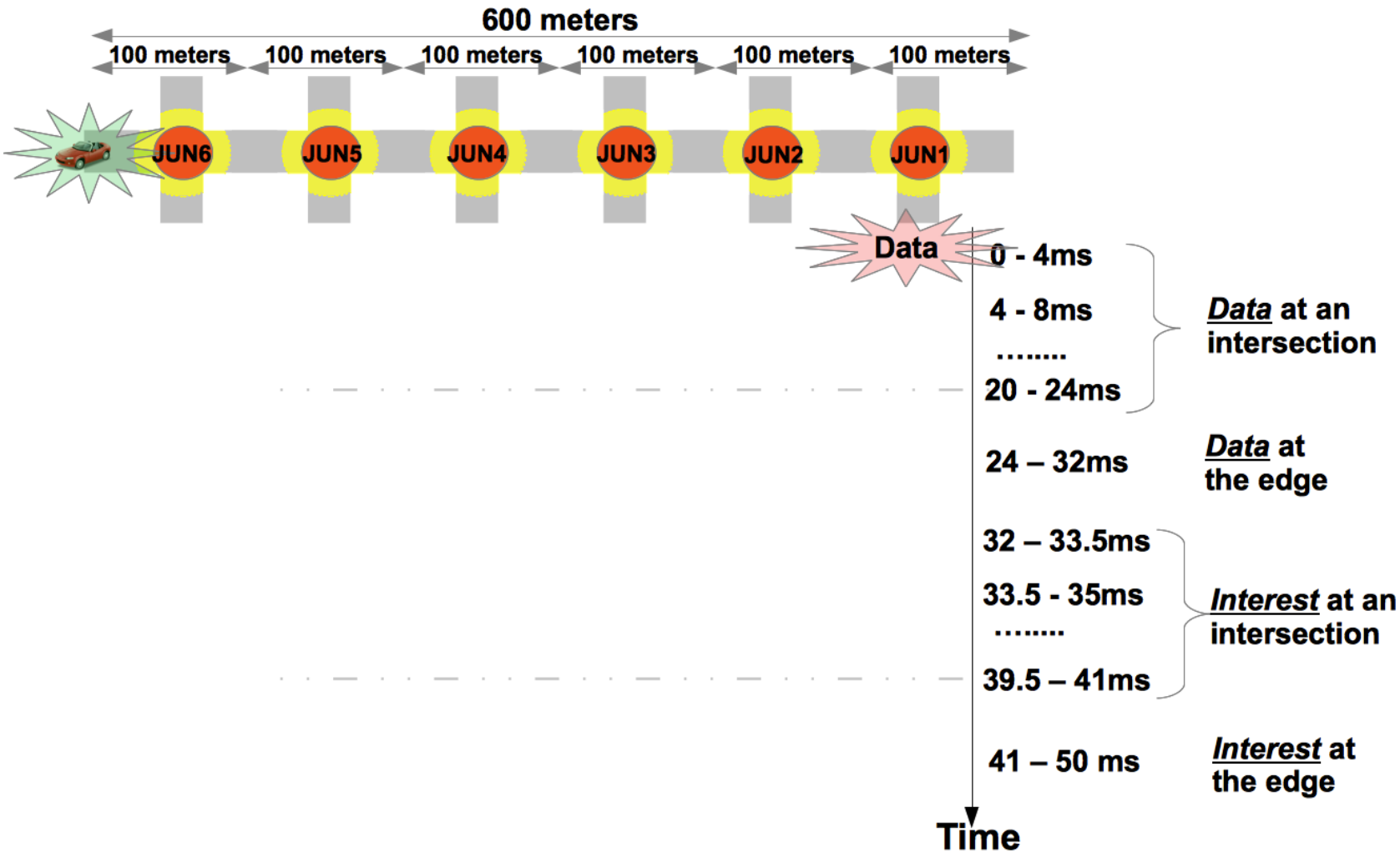
Forwarding process



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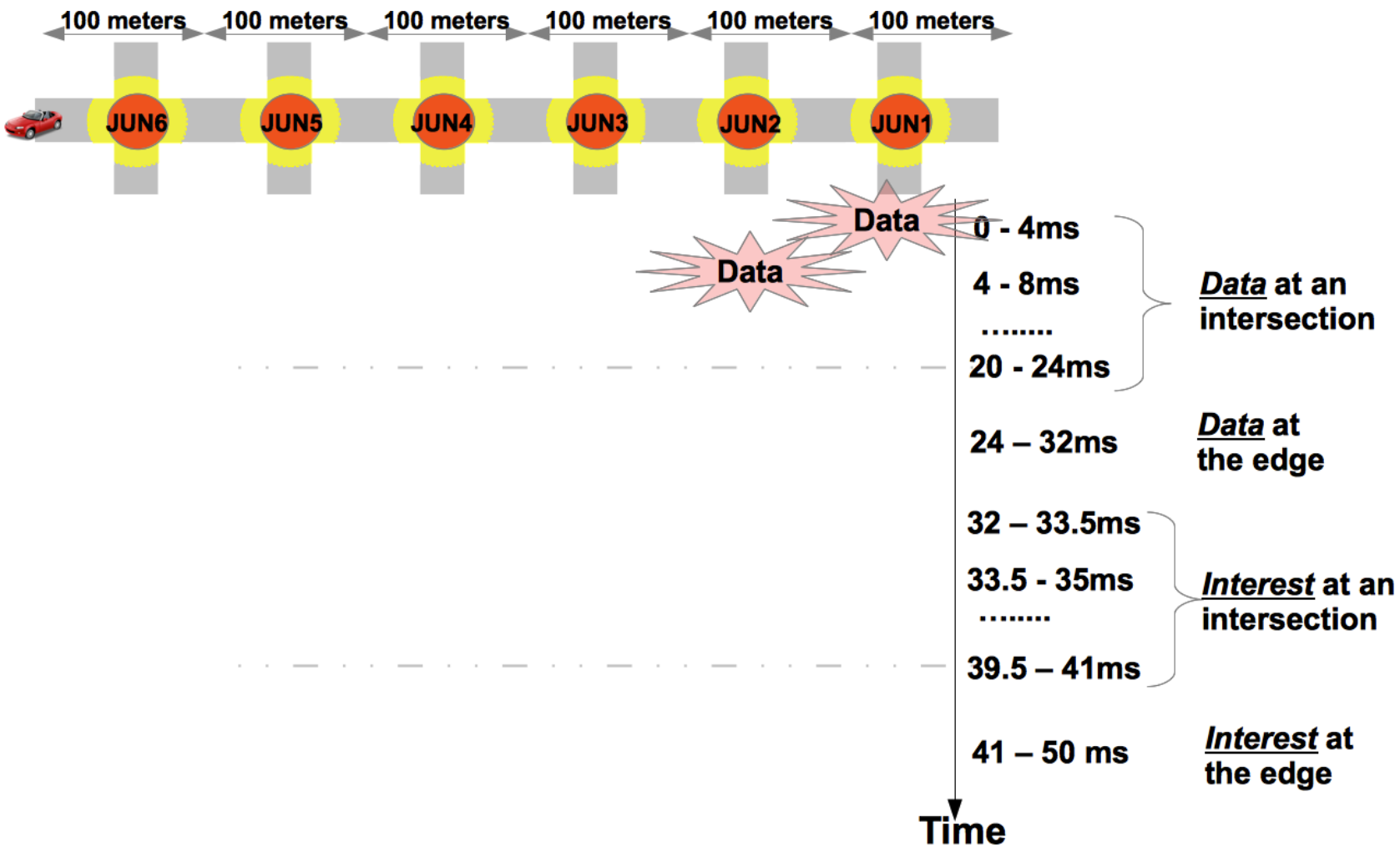

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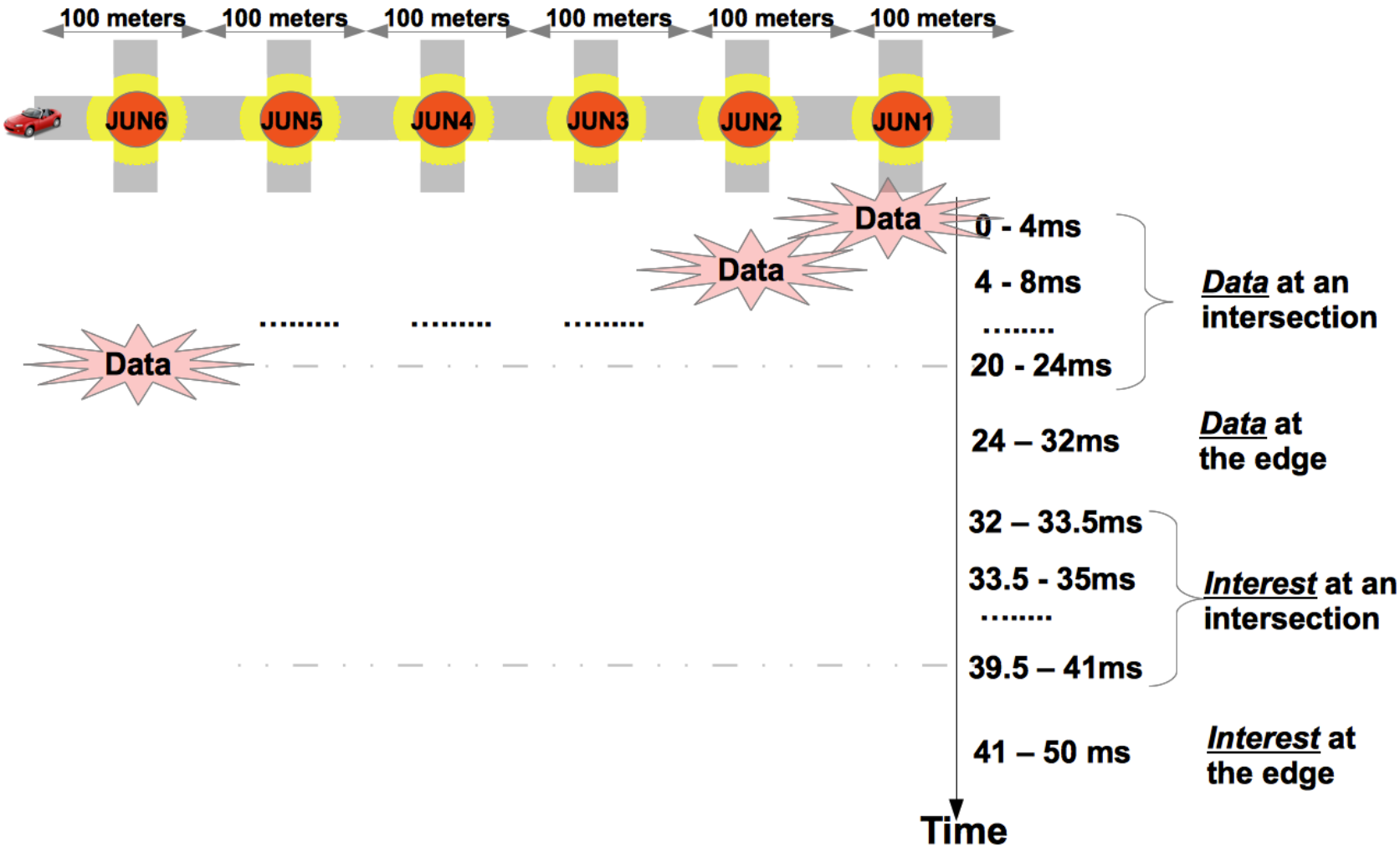

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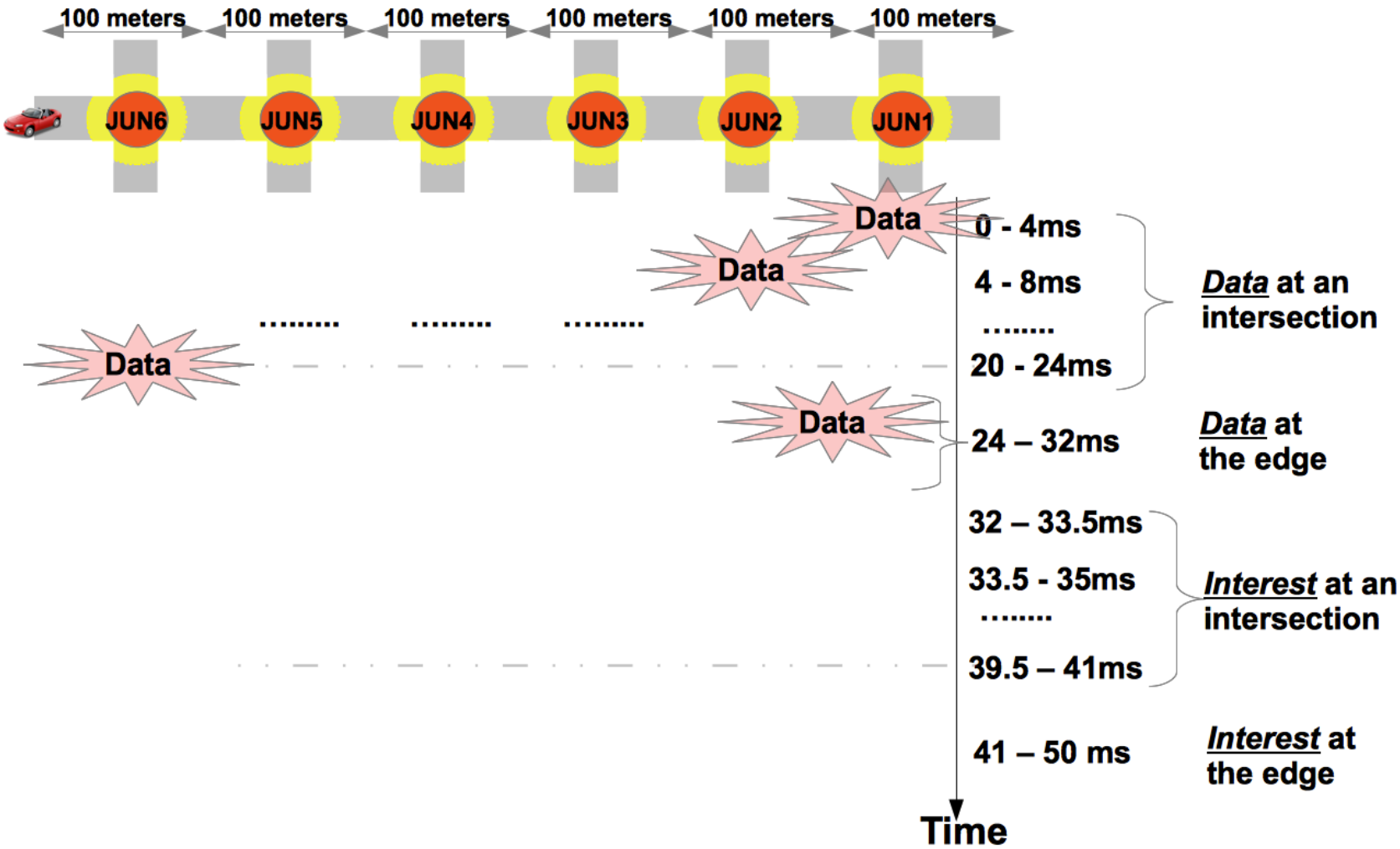
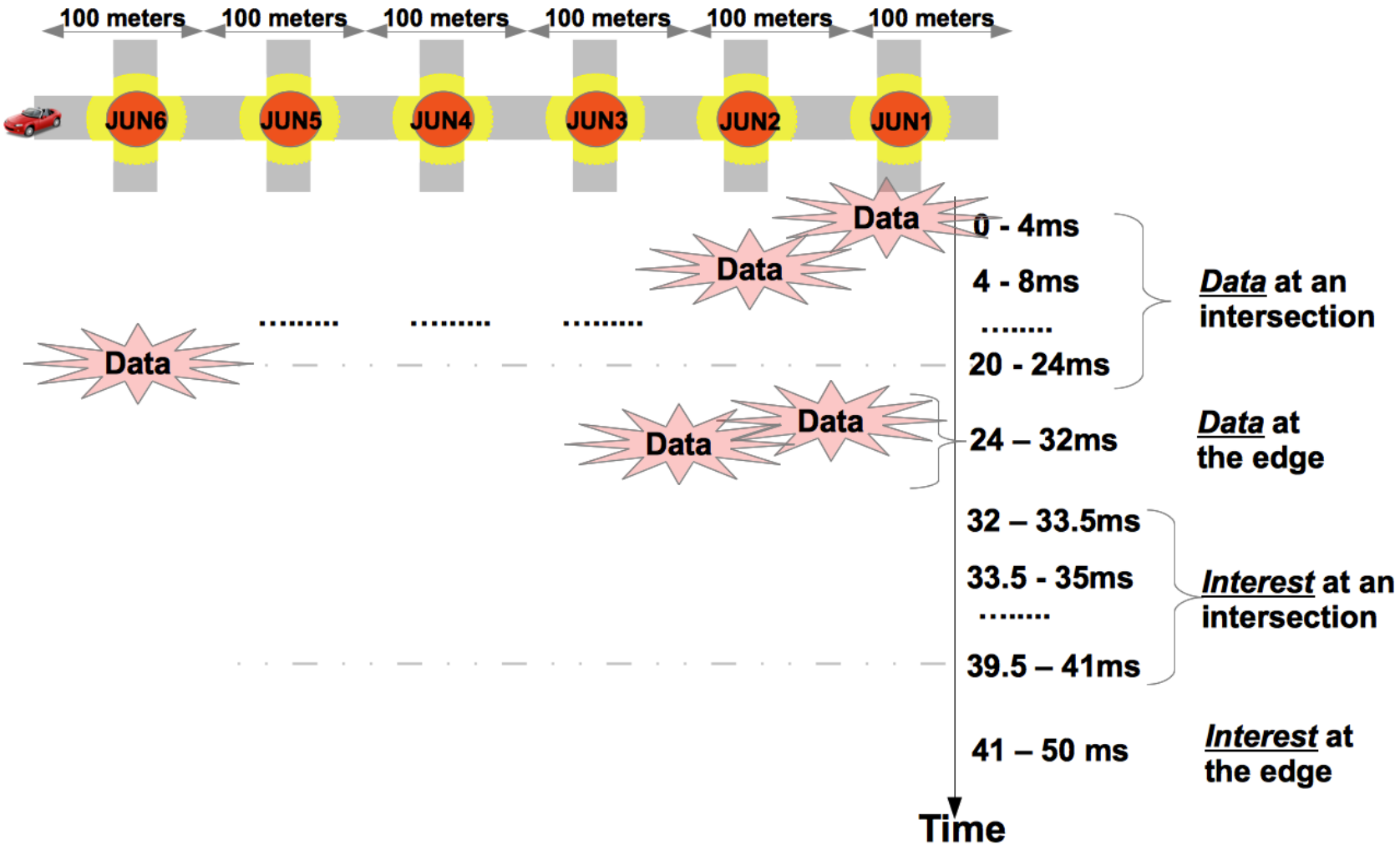


Forwarding process



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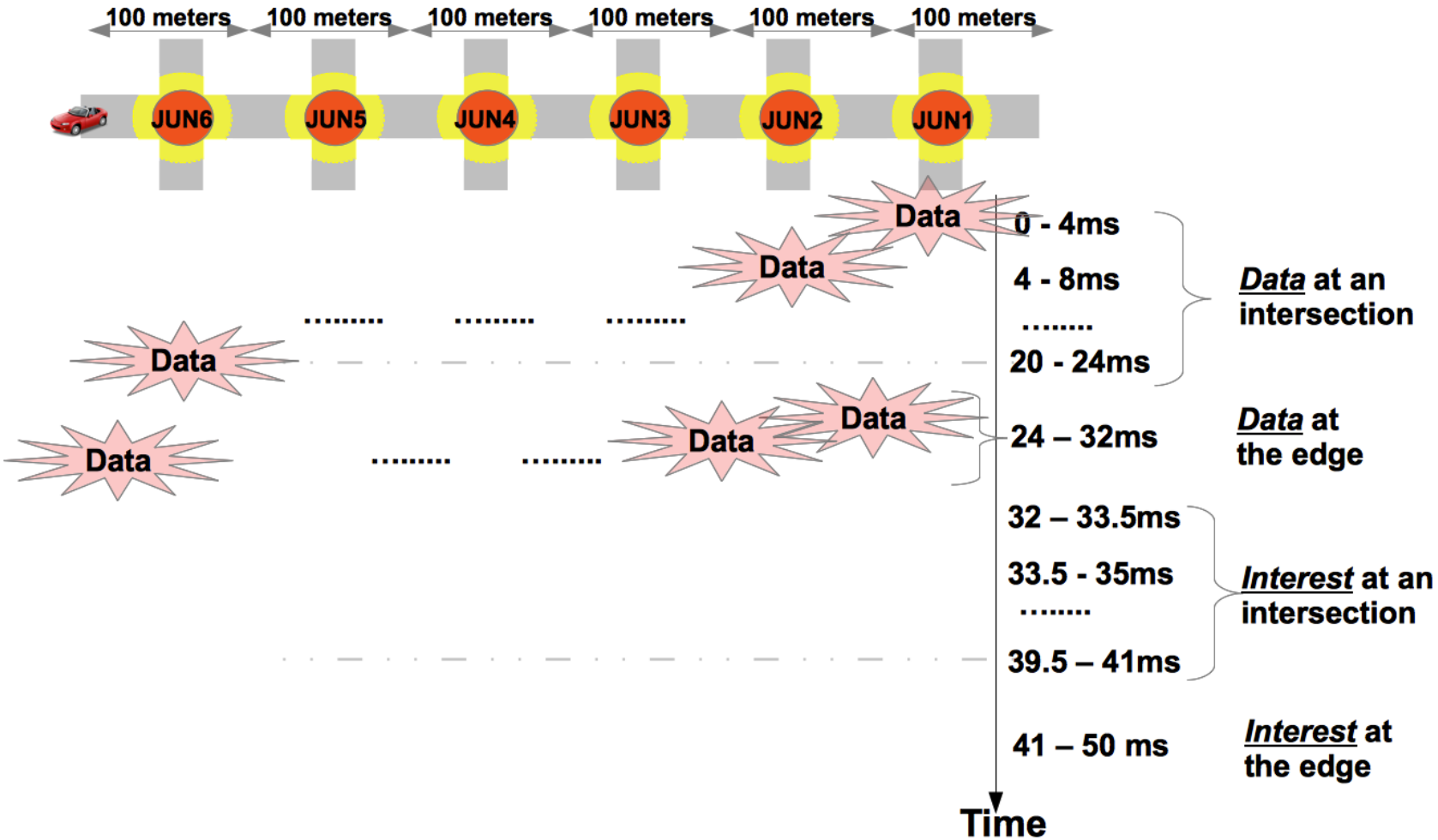

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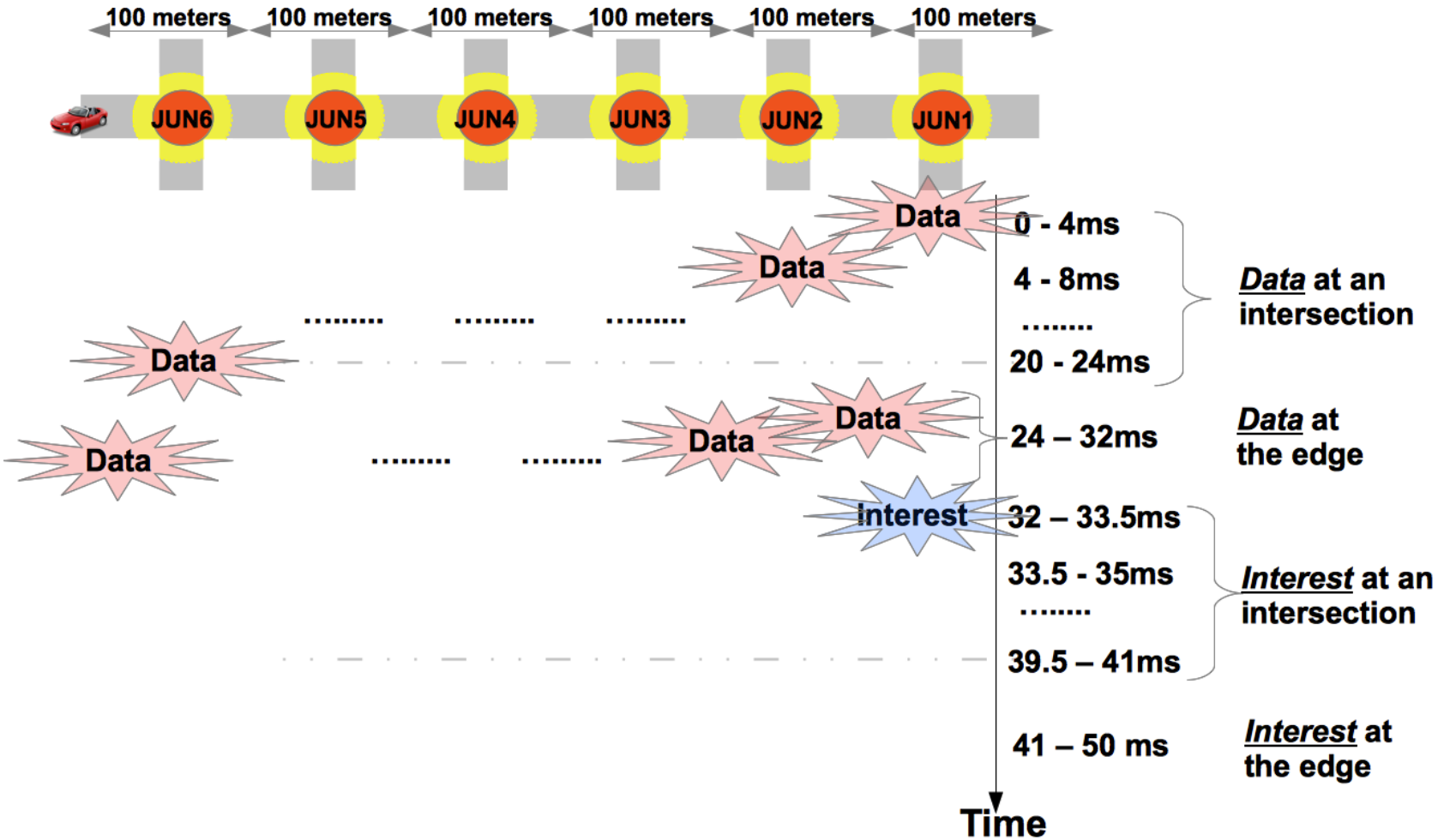

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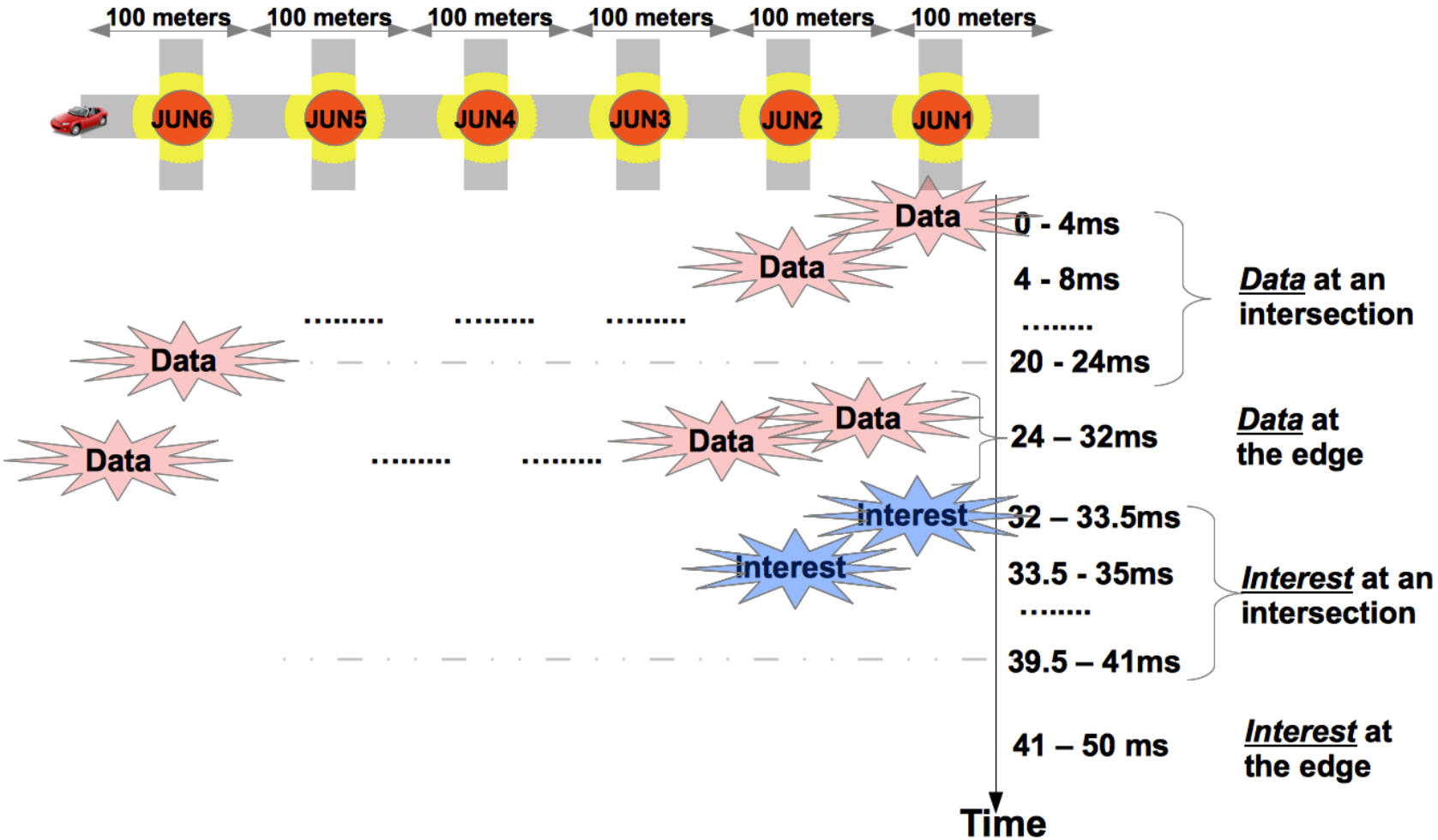

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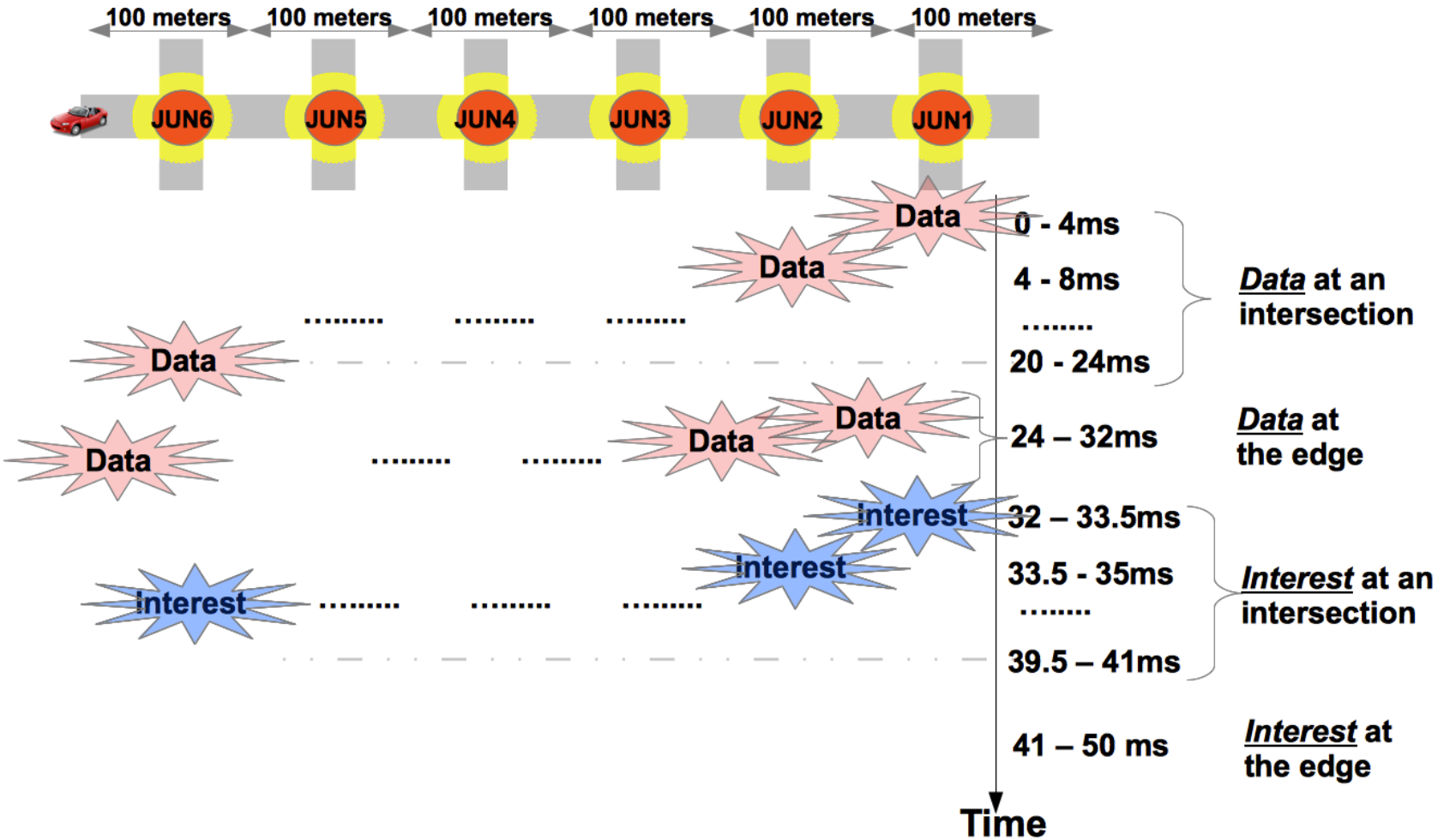

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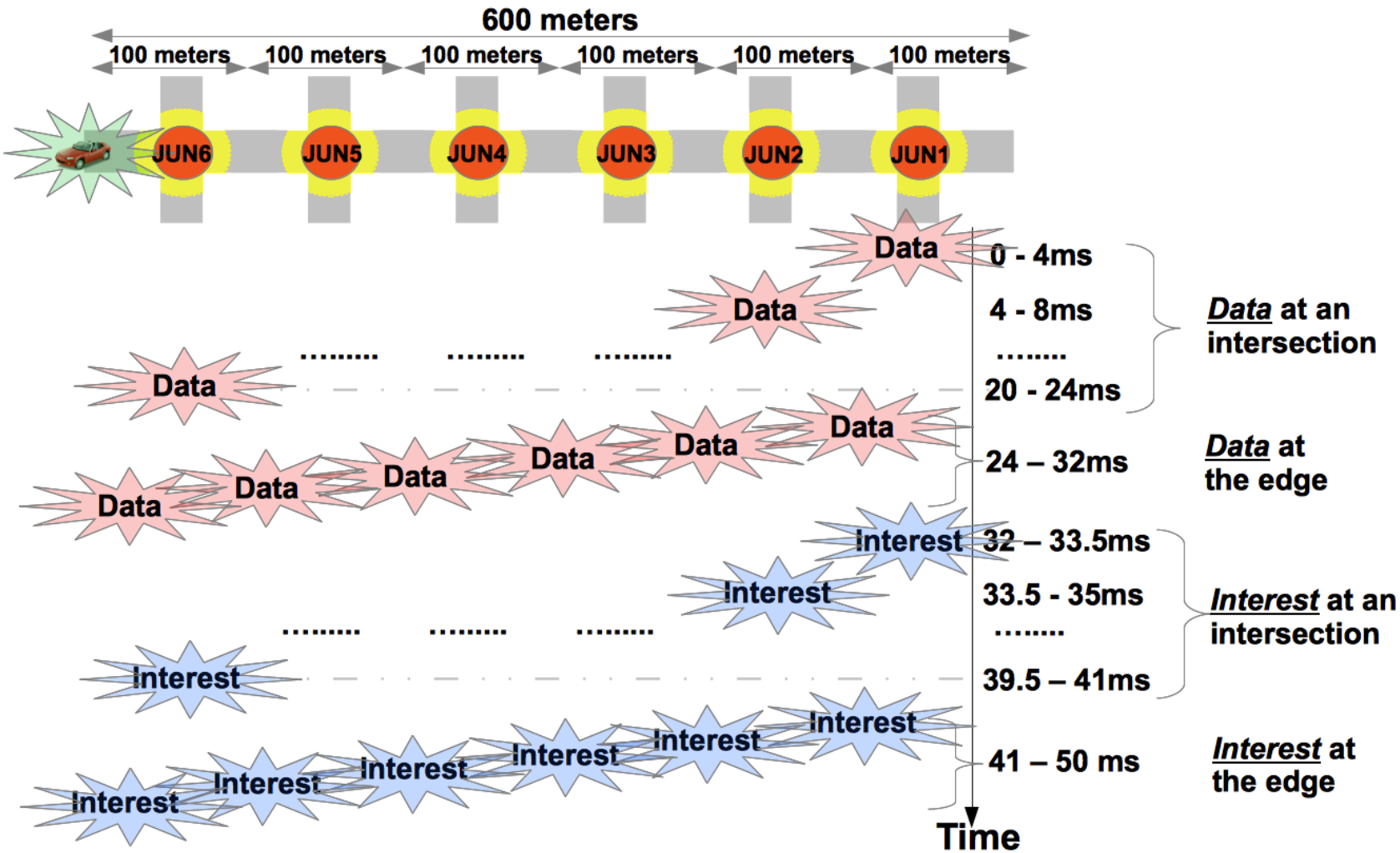

Outline

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Scenario

- Urban scenario (a 2Km x 2Km residential area of Los Angeles) with dense traffic (812 - 1048 cars)
- Traffic shaped based on the importance of roads
- 4 RSUs connected to the Internet
- Application: music streaming (i.e. Spotify)

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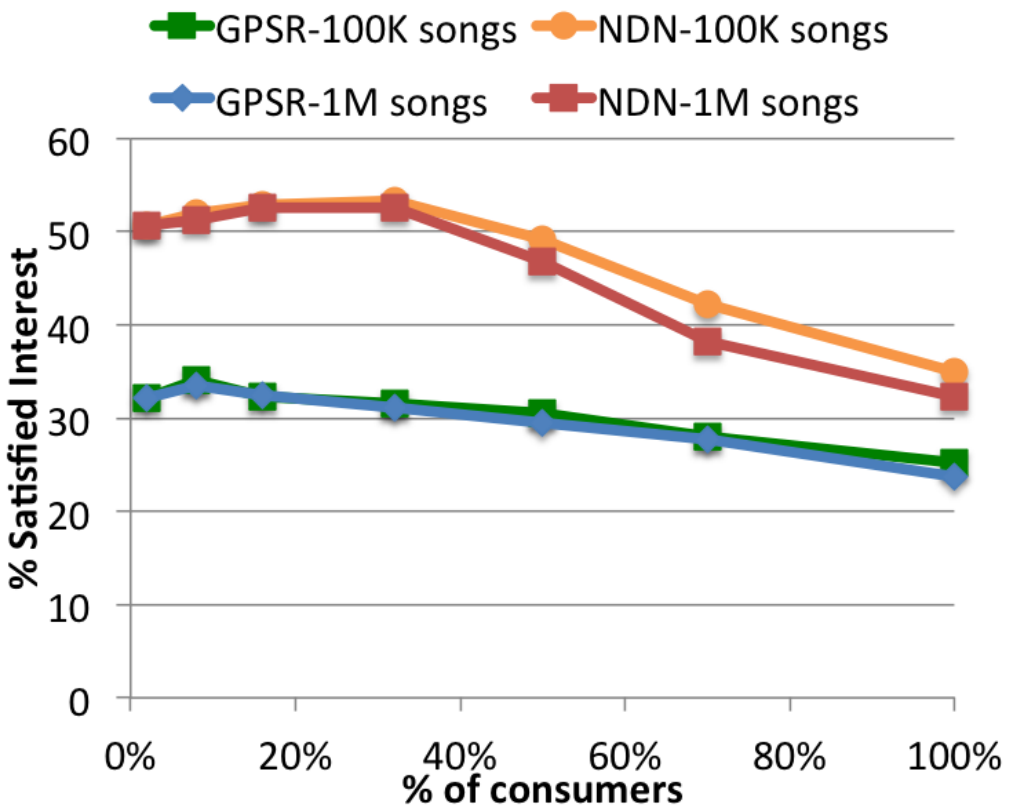
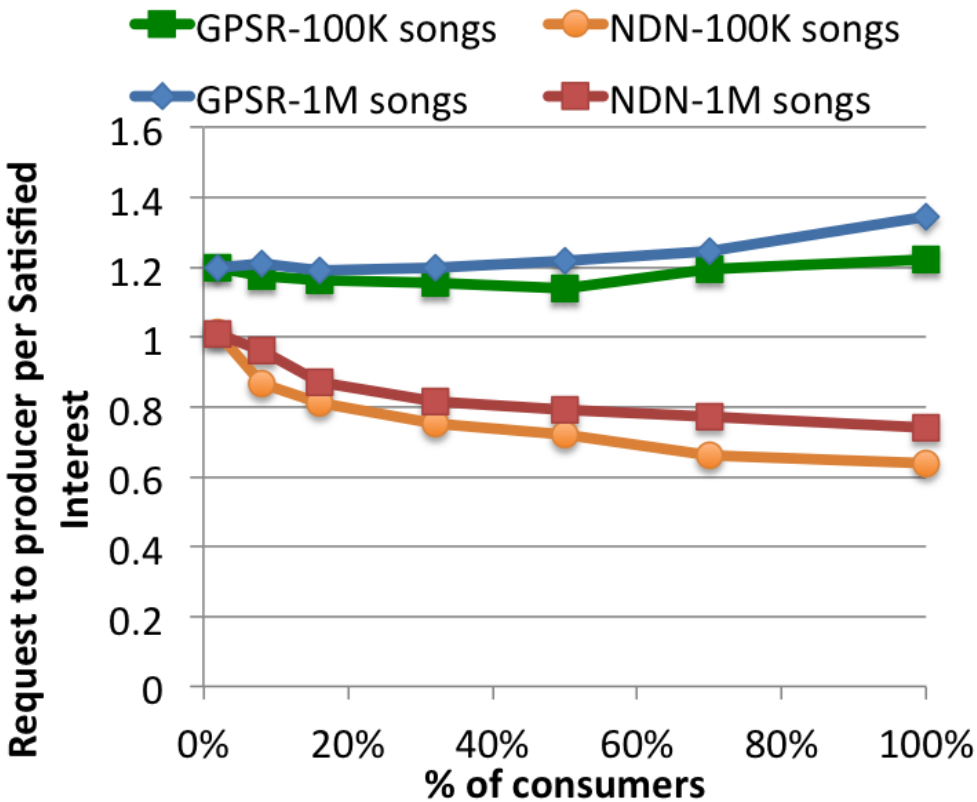
Results: Success rate



Results: Load on the infrastructure



Conclusion

Navigo: a self-learning scheme for data delivery in highly dynamic vehicular scenarios

- Navigo enables applications to contribute to the forwarding process
- It learns data geographical location without requiring any additional location service
- Future works: study the system under congestion

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That's all

Thank you for your attention

Questions?

giulio.grassig@lip6.fr

Previous publications:

- (V-NDN) VANET via Named Data Networking (IEEE INFOCOM Workshop on Name Oriented Mobility (NOM), 2014)

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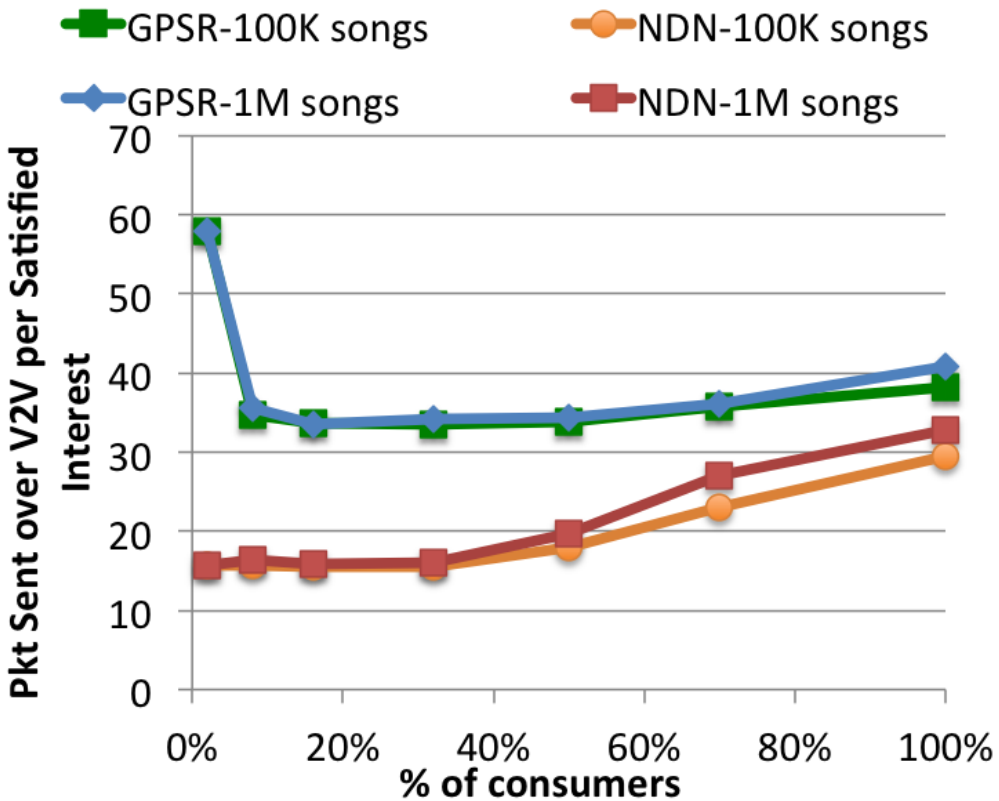
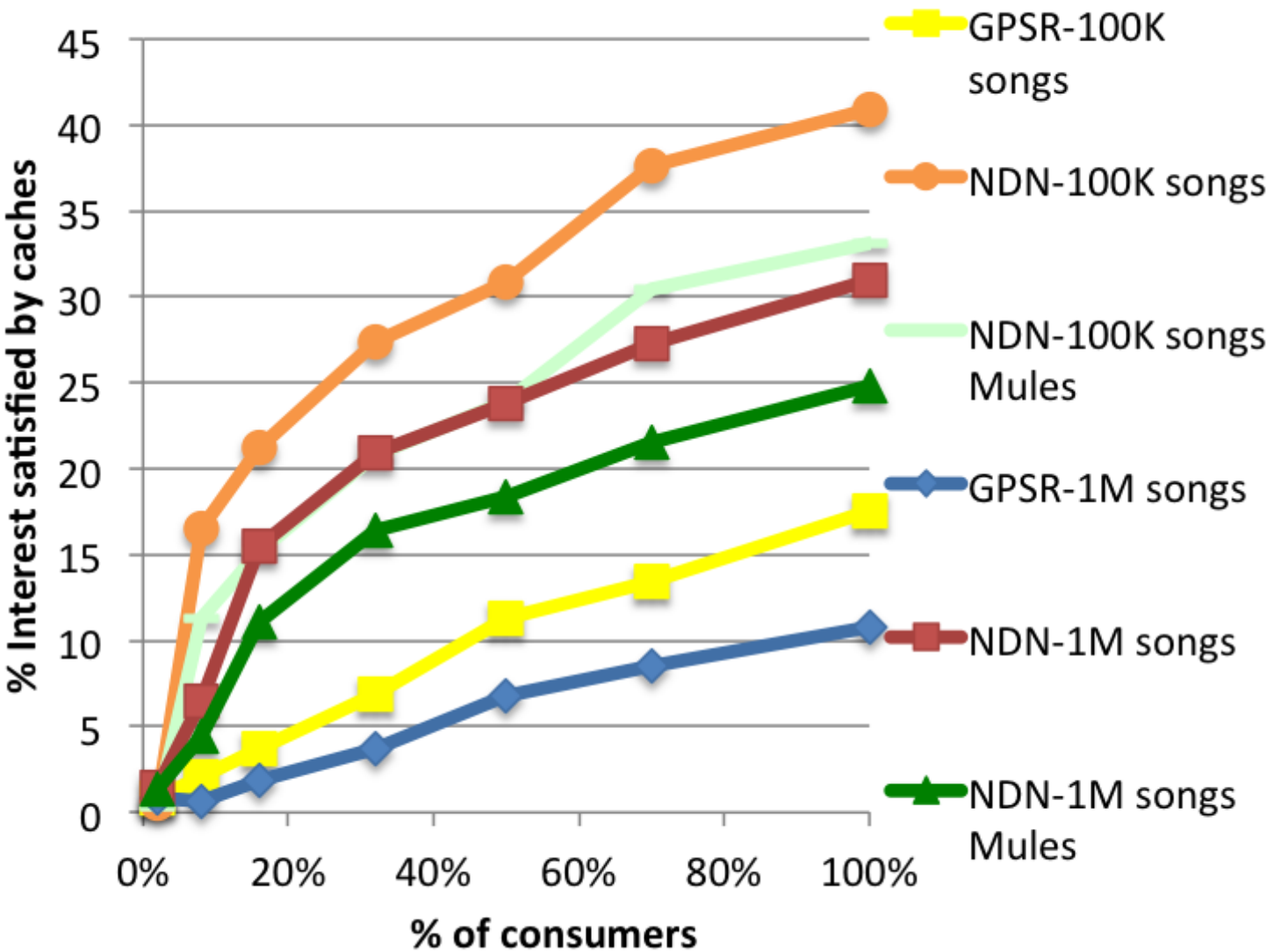
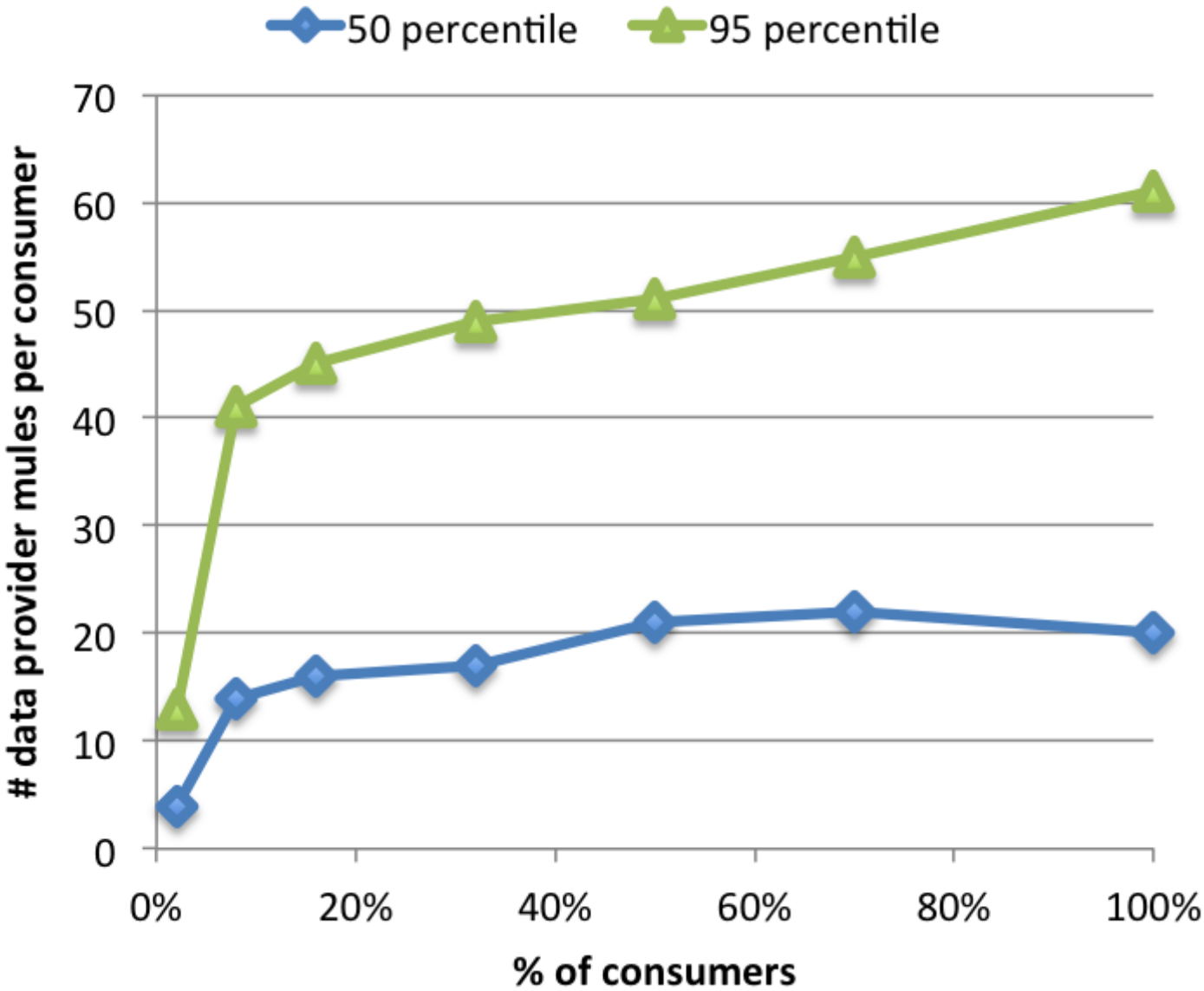
Results: Protocol overhead



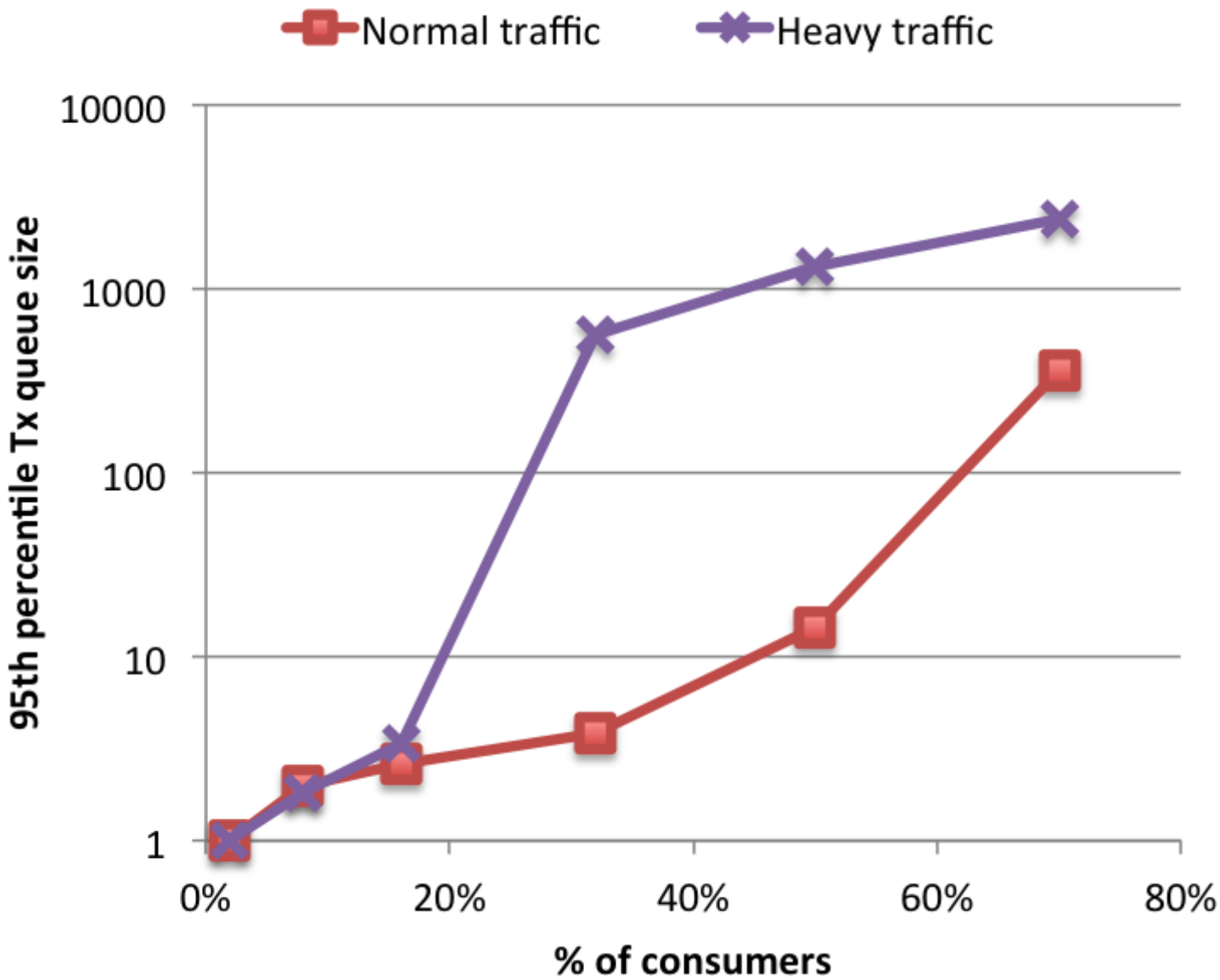
Caches


% Interest satisfied by caches
45
40
35
30
25
20
15
10
5
0
0%
20%
40%
60%
80%
100%
% of consumers
GPSR-100K songs
NDN-100K songs
NDN-100K songs Mules
GPSR-1M songs
NDN-1M songs
NDN-1M songs Mules

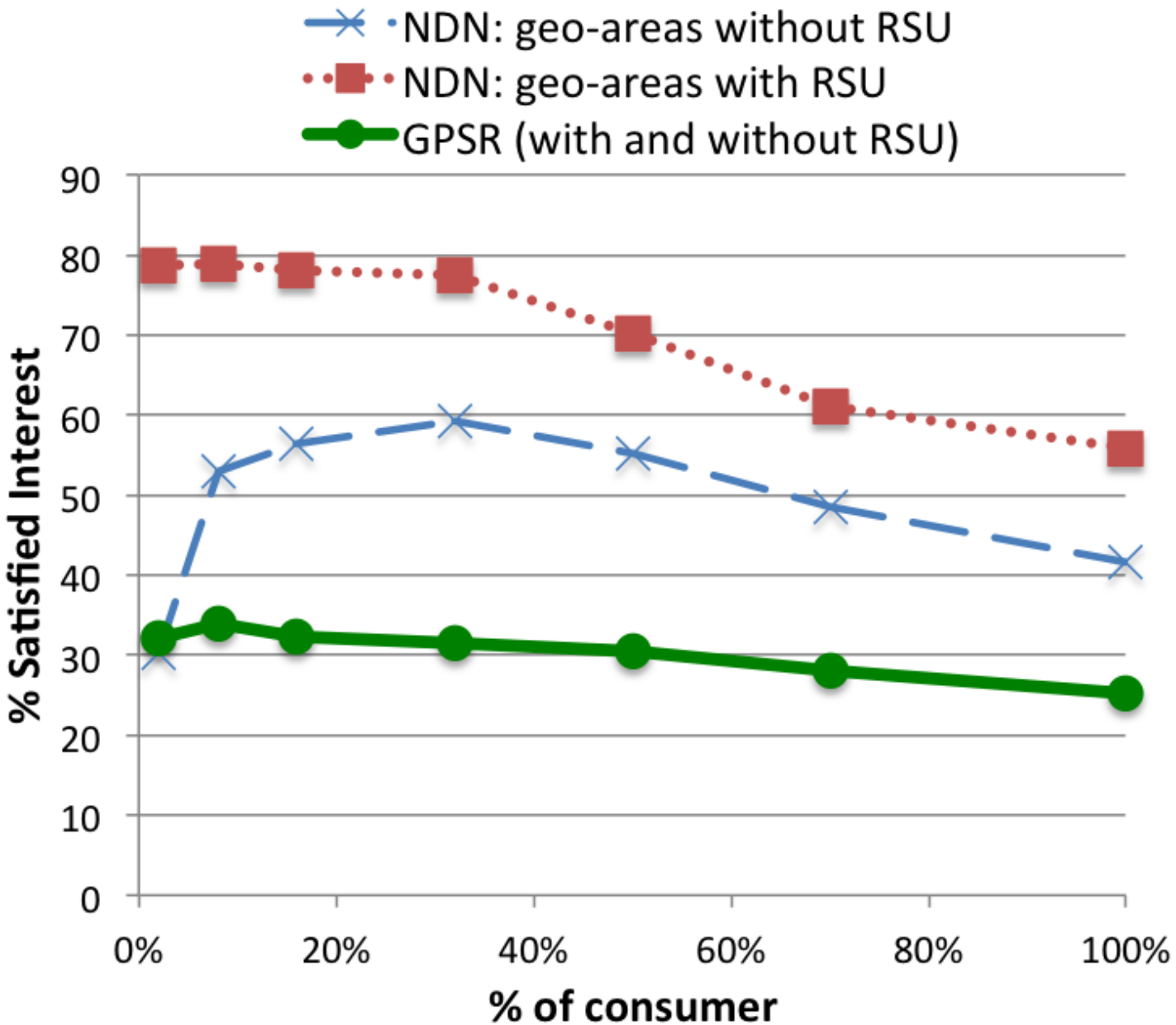
Mules


50 percentile
95 percentile
data provider mules per consumer
70
60
50
40
30
20
10
0
0%
20%
40%
60%
80%
100%
% of consumers

Tx queues


Normal traffic
Heavy traffic
10000
1000
100
10
1
95th percentile Tx queue size
0%
20%
40%
60%
80%
% of consumers

Success Rate by Areas



Results: User satisfaction