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Towards a Balanced and Reliable Localization of Services in Heterogeneous Vehicular Ad Hoc Networks

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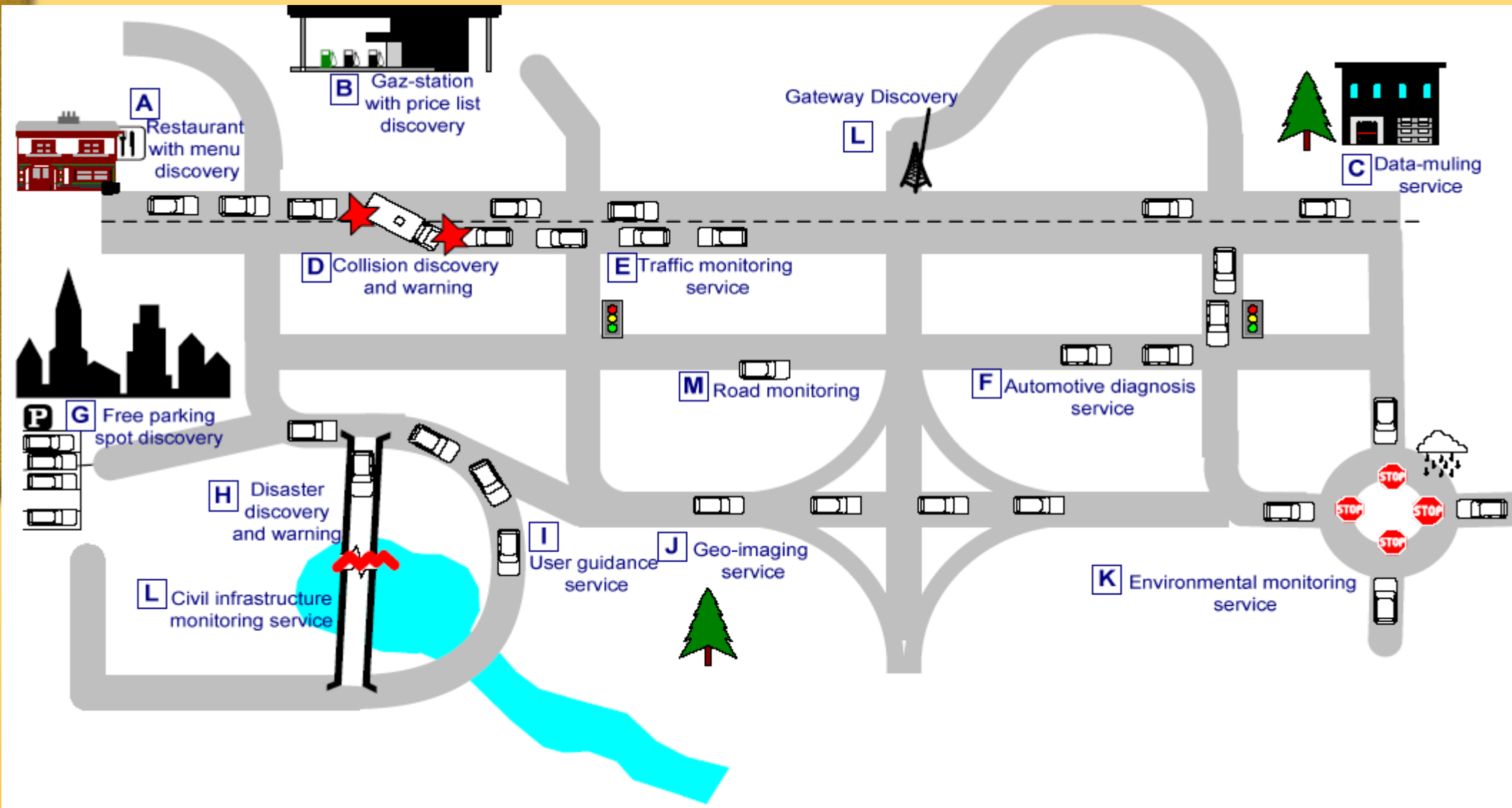
- Motivation and Objectives
- Design of the Fault Tolerant, Load Balancing and QoS based Service Discovery Protocol: FTQoSLocVSDP
- Performance Evaluation
- Conclusion

Introduction



Introduction

- Vehicular networks have gained special attention from the research community.
- Service discovery is a crucial challenge in Vehicular Networks.
- Very little work has been done on the design of fault tolerant, load balancing and QoS based service discovery protocol in vehicular networks.
- We enhance our previous work LocVSDP with fault tolerance, load balancing and QoS features.
- Fault tolerance is important for the good functioning, robustness and reliability of service discovery protocols.
- QoS and Load balancing permit to balance the discovery load and satisfy drivers' QoS requirements.

Design of the Fault Tolerant, Load Balancing and QoS based Discovery Protocol

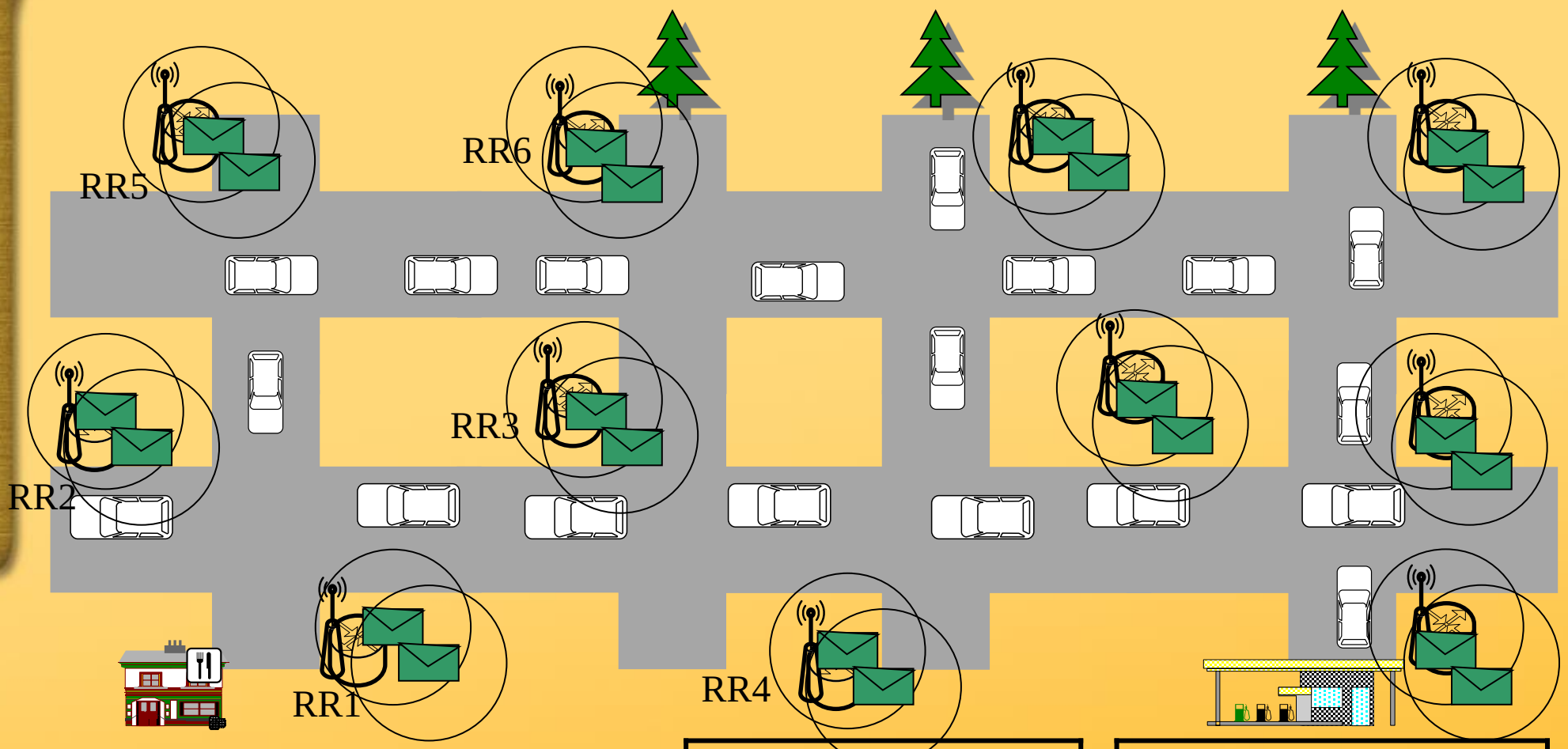
The proposed fault tolerant, load balancing and QoS location based service discovery protocol (FTQoSLocVSDP)

- Permits the discovery of location-aware and time-sensitive services in Vehicular Networks.
- Integrates service information into the network layer and uses diverse channels.
- Tolerates road components failures.
- Guarantees load balancing.
- Satisfies drivers' and passengers' QoS requirements.

Description of the Fault Detection Mechanism

- RRs exchange beacon messages periodically.
- The current RR determines the lists of its direct neighbors (list1) and second neighbors (list2).
- RR does not receive a beacon message from its direct neighbor *RRn:*
  - *RRn* is faulty or,
  - the link to *RRn* is faulty.
- If RRn ϵ to RRi_list2 ➔ link to RRn is faulty.
- If RRn $\notin$ to RRi_list2 ➔ RRn is faulty.

Description of the Fault Detection Mechanism



Beacon messages (TTL=2)

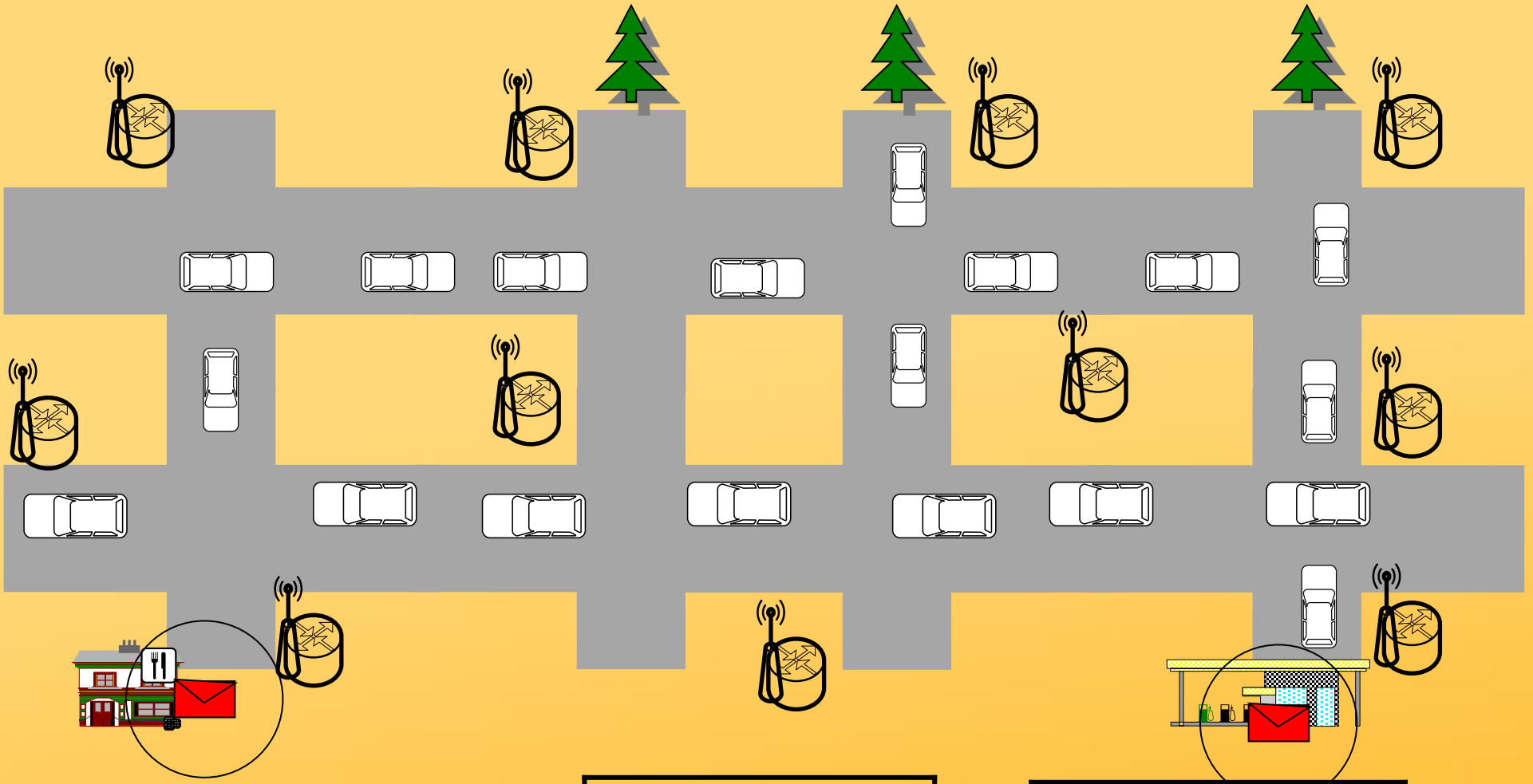
Direct Neighbors(RR1)
RR2
RR3
RR4

Second Neighbors(RR1)
RR2
RR3
RR4
RR5
RR6

Fault Tolerant and QoS based Service Advertisement Phase

- Service providers advertise themselves:
  - SPs send service advertisement messages to the neighboring road components.
- A service provider includes in the advertisement message some QoS properties.
- The neighboring road components that receive the advertisement message:
  - update their service information table with the received service information.
  - update their routing information table with the received routing information.

Fault Tolerant and QoS based Service Advertisement Phase



Service Advertisement

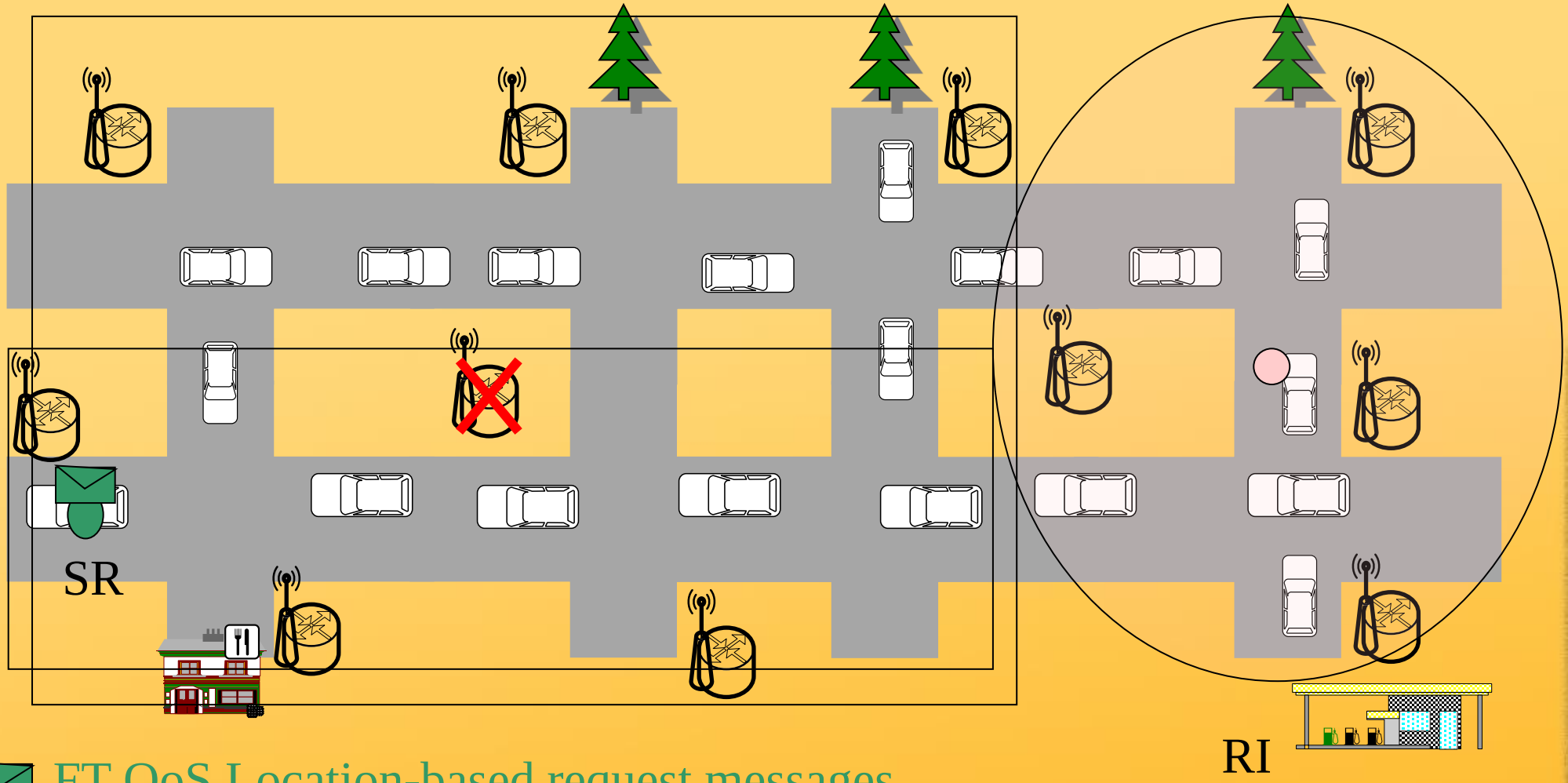
Service Information
SP1
SP2
…

Routing Information
Rte1
Rte2
…

Fault Tolerant and QoS based Service Request Propagation Phase

- A driver or passenger that needs to find a service, generates a fault tolerant and QoS based service request message.
- The service requester indicates its region of interest where he wishes to find the service.
- The service requester includes in the request message:
  - QoS requirements of the service provider or,
  - QoS requirements of the routing path towards the service provider.
- The service requester sends its request message towards the RI.
- At the reception of the request message:
  - If *RRc* that is not supposed to forward the request message detects that another roadside router *RRf* that is supposed to send the request message is faulty
    - ➔ the *RRc* performs the request message forwarding instead of the faulty *RRf*.
  - If a roadside router *RRl* forwards the *request message* and detects that the link leading to another roadside router *RRk* that is supposed to forward the request message is faulty
    - ➔ *RRl* forwards the request message with a force broadcast flag.

Fault Tolerant and QoS based Service Request Propagation Phase

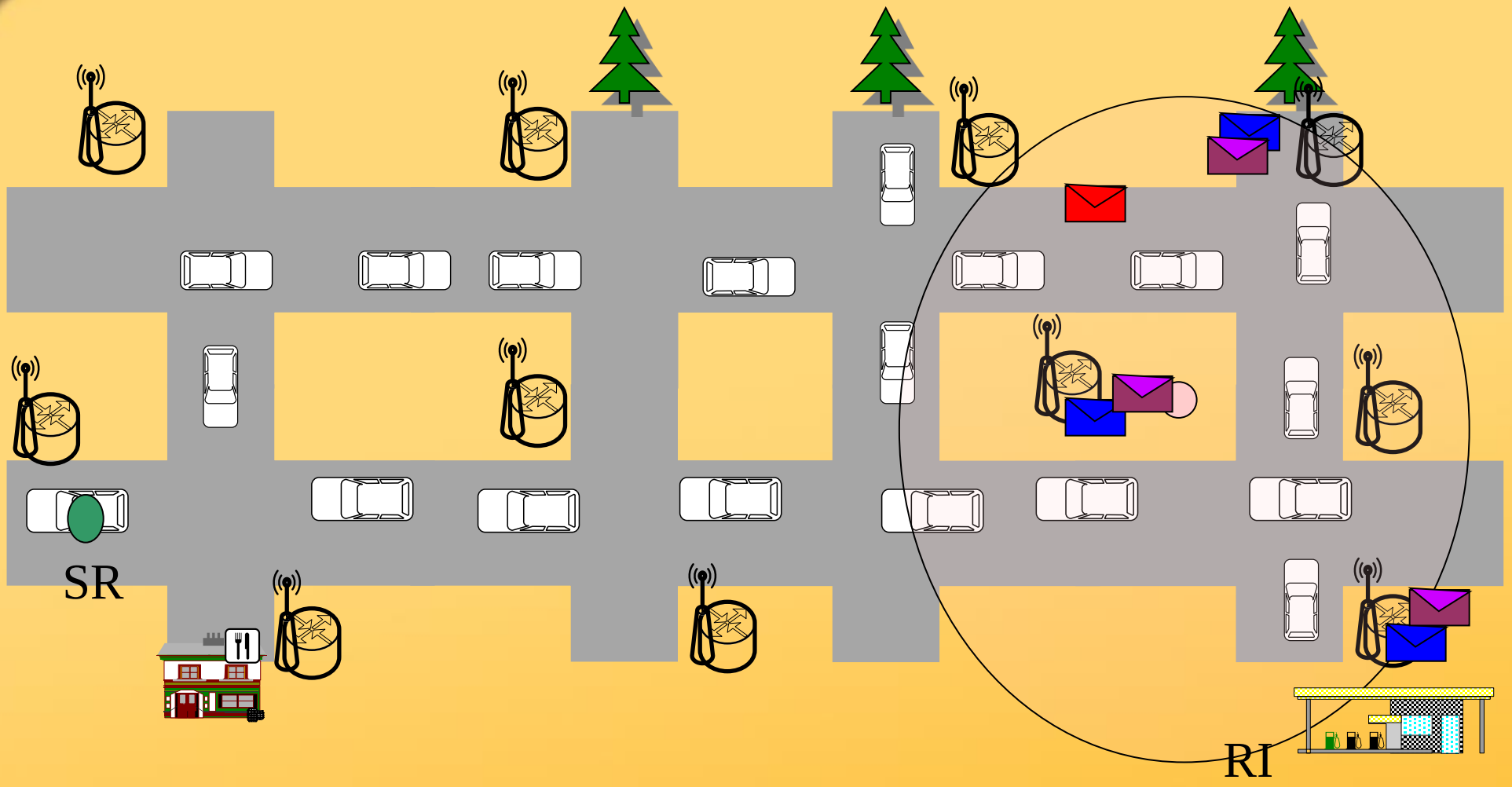


FT QoS Location-based request messages

Fault Tolerant and QoS based Leader Election and Service Reply Generation Phase

- At the reception of a request message by a RR inside RI ➔ the leader election process starts.
- The *RRi* generates a fault tolerant and QoS based election message that includes:
  - its load and,
  - its distance to the center of the RI.
- RRi broadcasts the election message.
- Neighboring RRs inside RI that receive the *election message*, store the load and the distance to the center of the RI.
- They generate their own *election messages*, with their loads and distances to the center of the RI.
- They broadcast their *election messages*.
- All neighboring RRs inside the RI exchange their loads and distances to the center of the RI.
- Neighboring RRs inside RI build a spanning tree.
- The elected leader RR, is the less loaded and closest RR to the center of the RI among all the RRs inside the RI.
- Every RR sends its knowledge about the requested service provider to its parent in the spanning tree in a fault tolerant and QoS based local service reply message.
- The leader RR receives all the *local reply messages* from the other RRs inside the RI in order to generate a unique service reply message.

Fault Tolerant and QoS based Leader Election and Service Reply Generation Phase



Election messages

Parent message

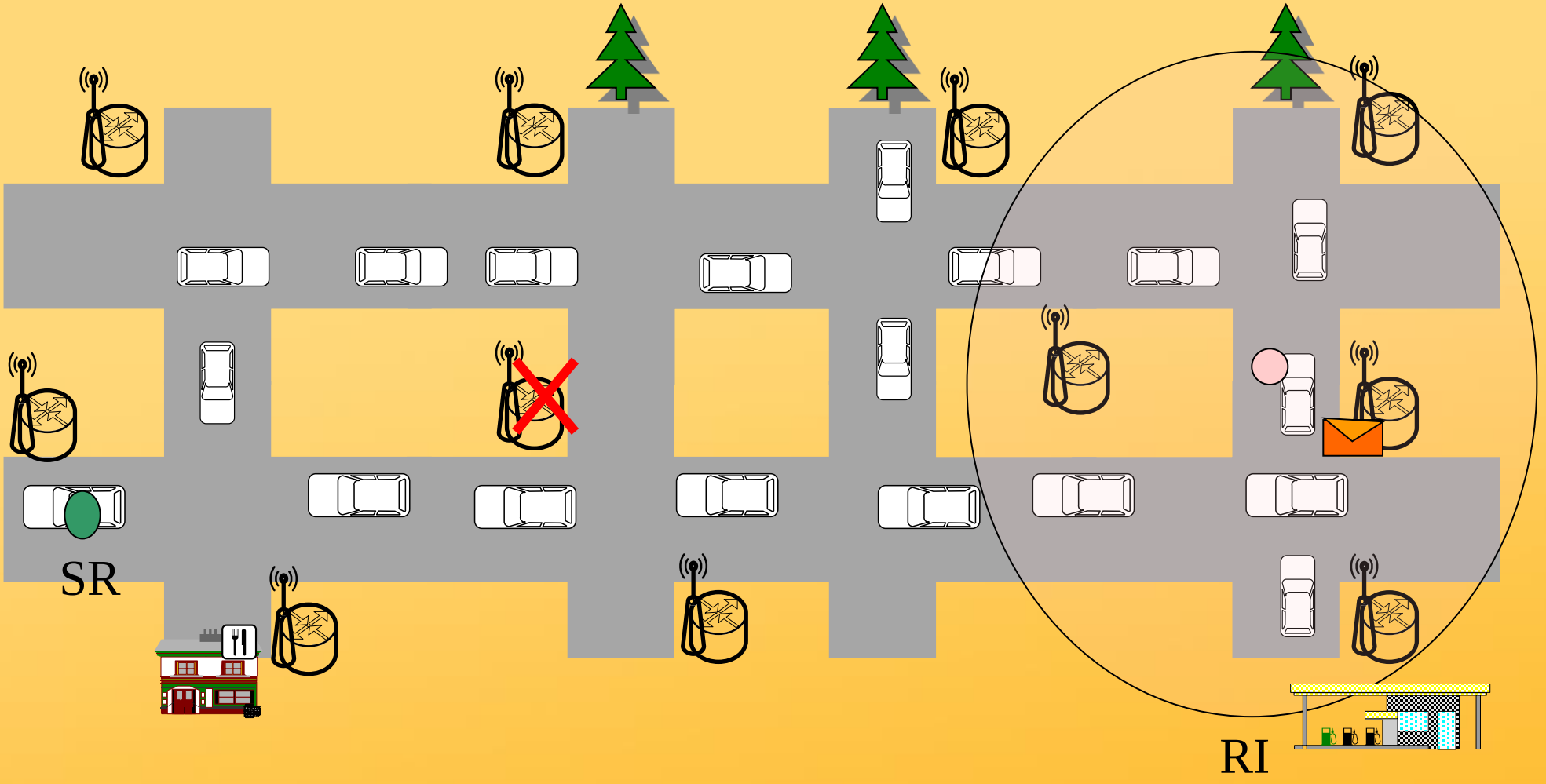
Local reply message

Fault Tolerance and QoS based Service reply propagation phase

- A unique fault tolerant and QoS based service reply message is generated by the elected leader RR.
- The leader RR includes in the *reply message* the collected service providers' information that satisfy the service request and the QoS requirements specified in the request message.
- The leader RR specifies the location of the service requester in the *reply message* and includes the QoS requirements in the returned routing path specified by the requester.
- Only road components that are closer to the service requester than the sending road component forward the *reply message*.
- At the detection of faulty RRs or links, the reply message is propagation through the fault tolerant and QoS based propagation mechanism.

LocVSDP

Location based service discovery



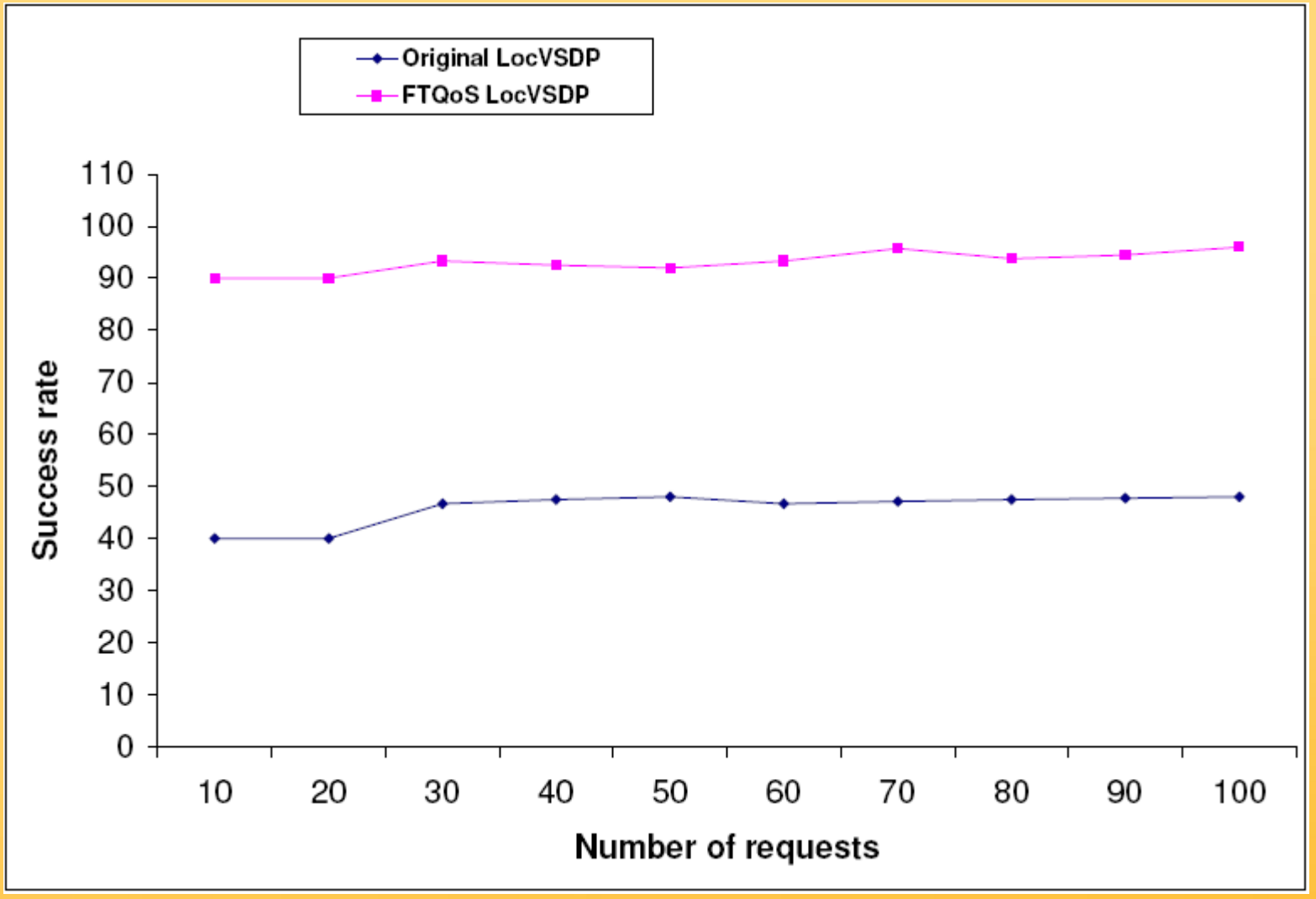
Location-based service reply messages

Simulation parameters

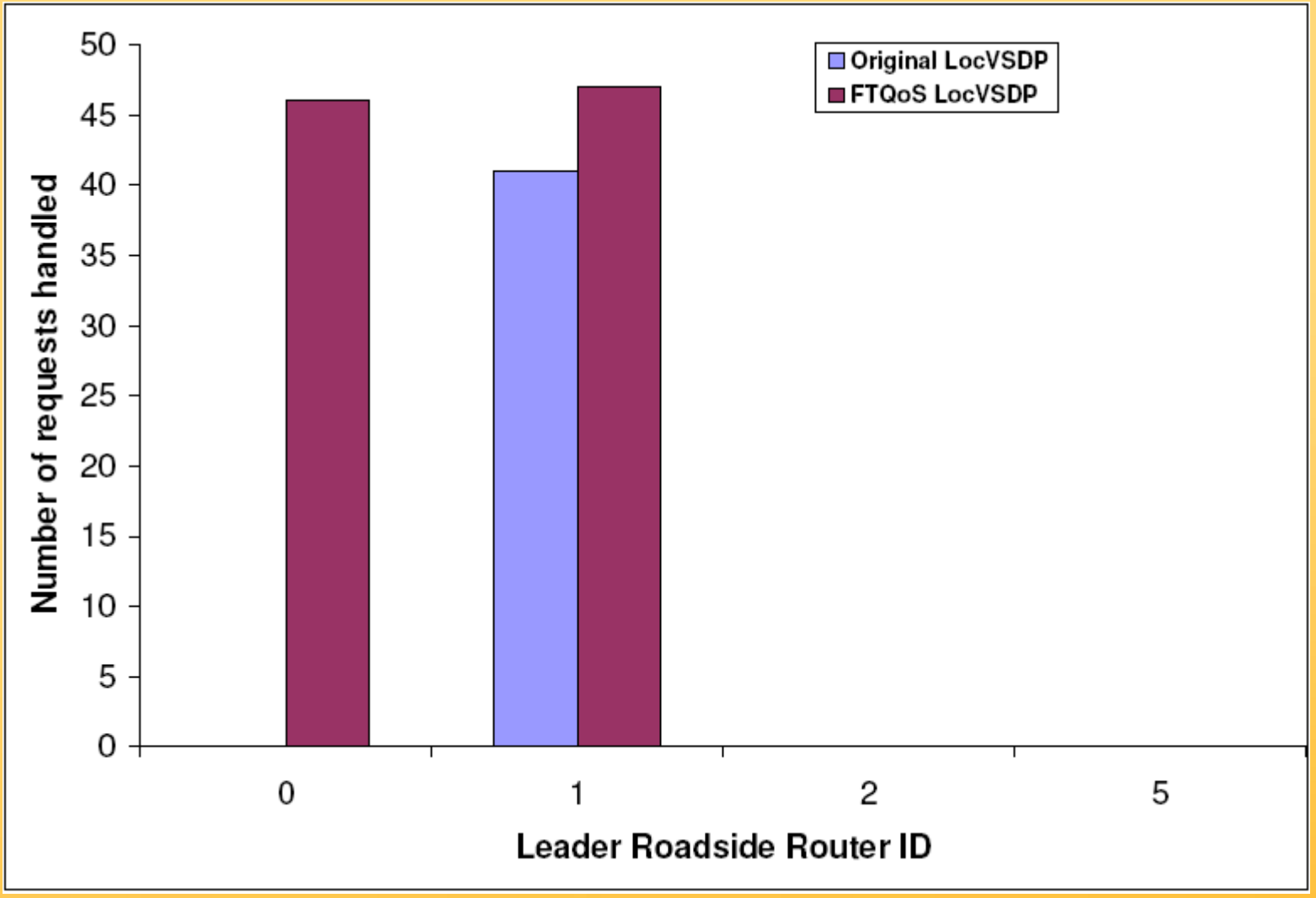
SIMULATION ENVIRONMENT FOR THE CITY SCENARIO

Parameter Name	*Parameter Value*
Wireless medium	802.11
Data transmission rate	11 Mbps
Transmission range (meters)	200
Average vehicle's speed (meter/second)	20
Simulation time (seconds)	1200
Simulation area (meter^2)	600*600=120000
Number of vehicles	130
Number of roadside routers	16
Number of clients	40
Number of service providers	9
Area of the region of interest	П * 100

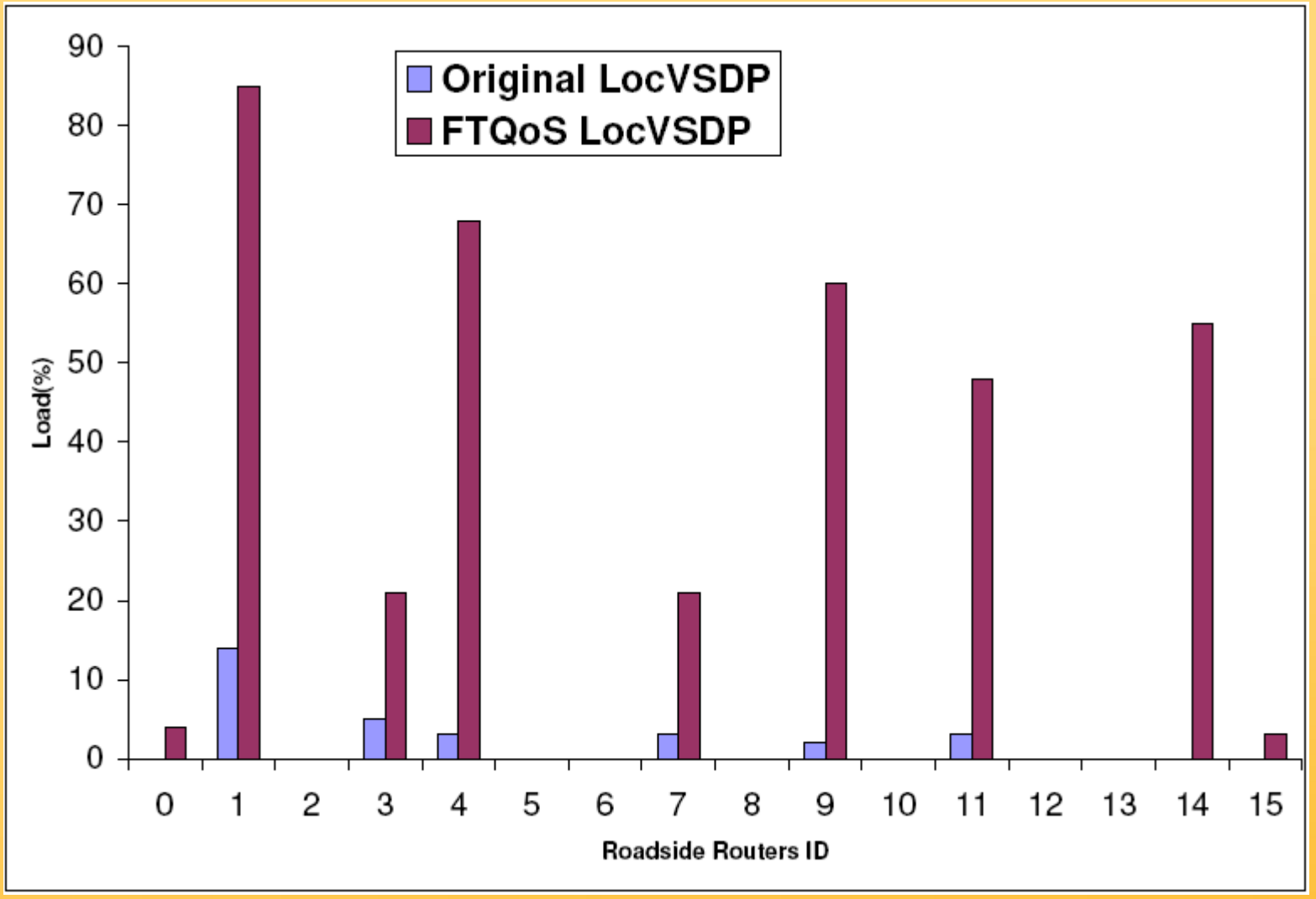
Success rate comparison



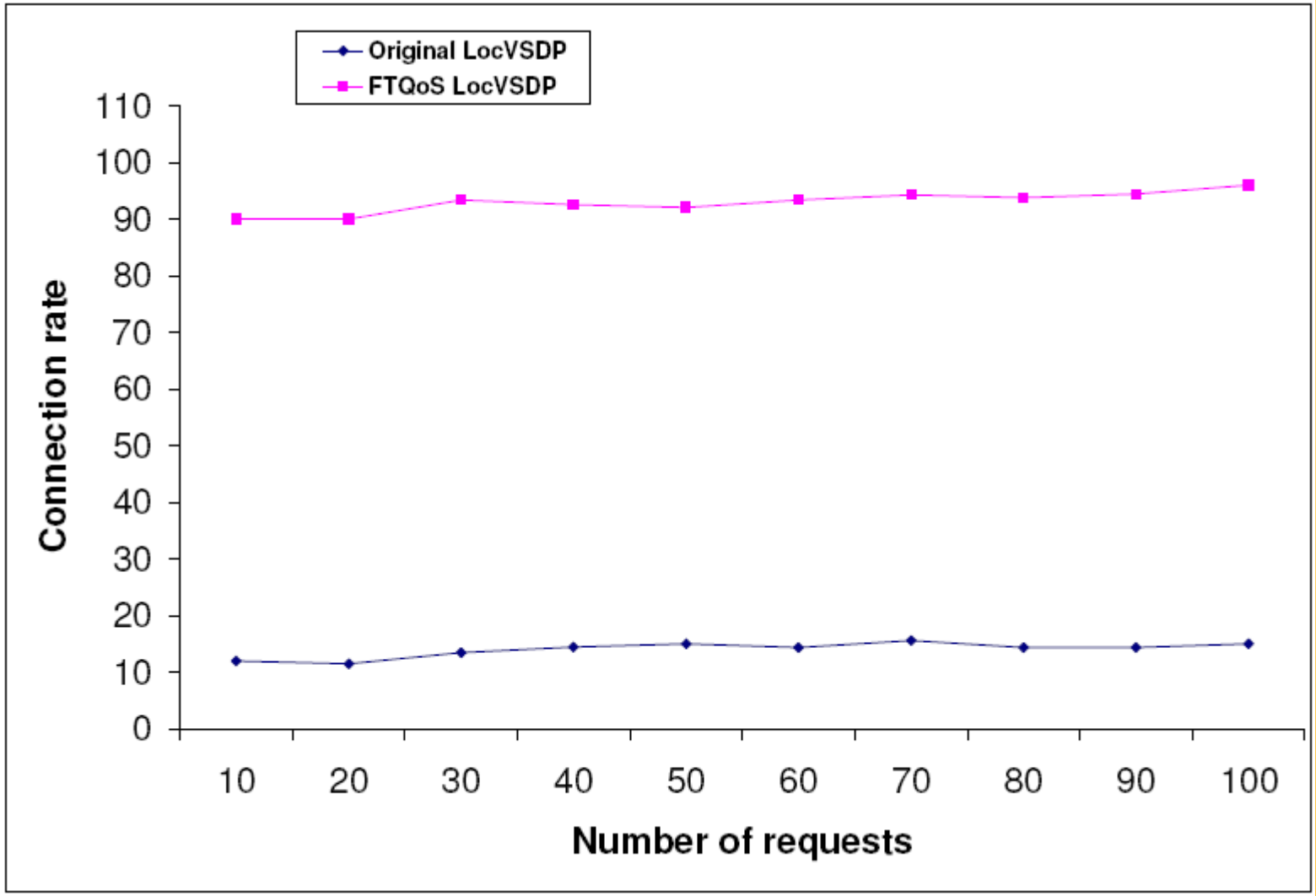
Comparison of load balancing on RRs inside the RI with the presence of RRs and Links failures



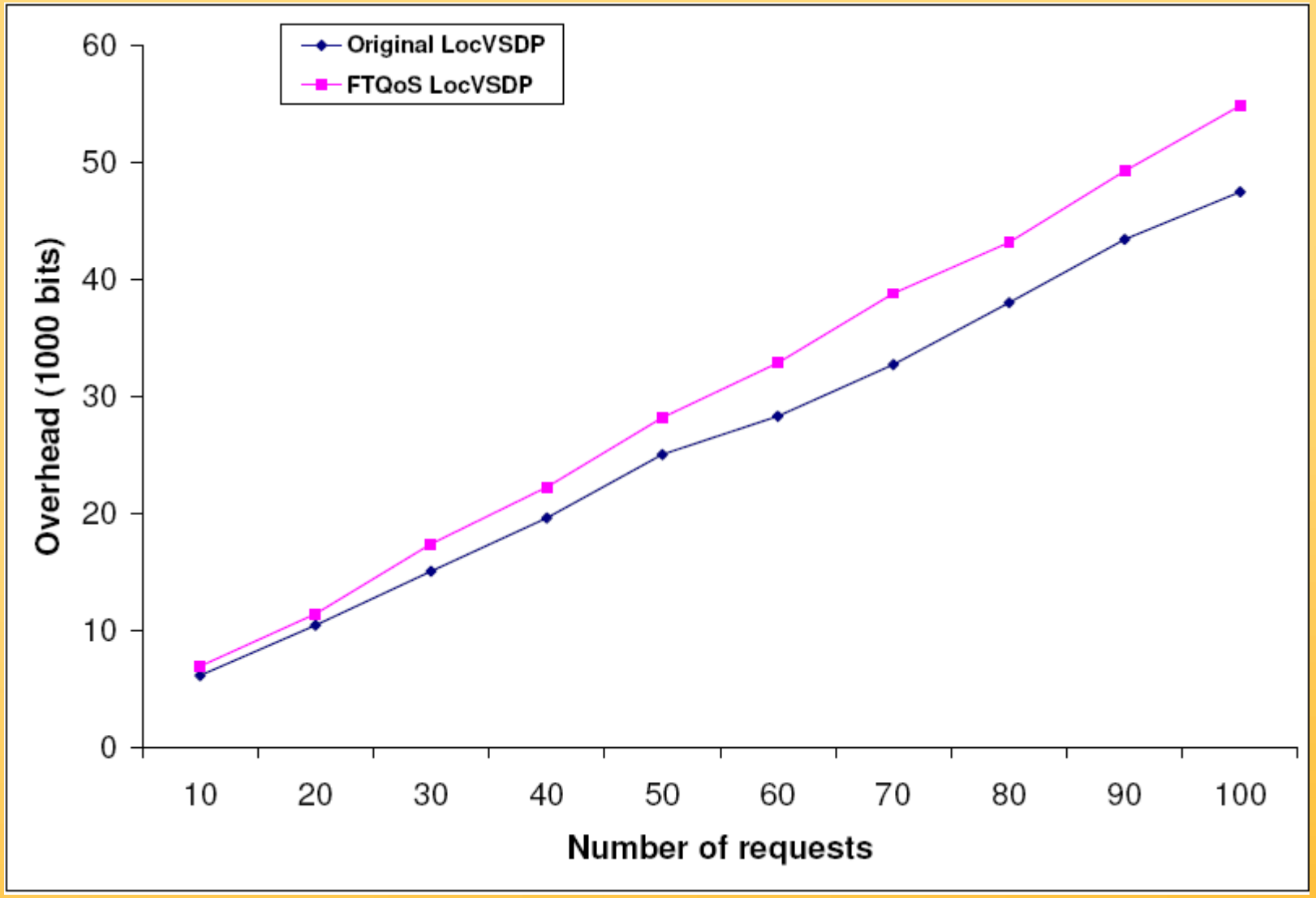
Comparison of load balancing on RRs in the forwarding zone with the presence of RRs and Links failures



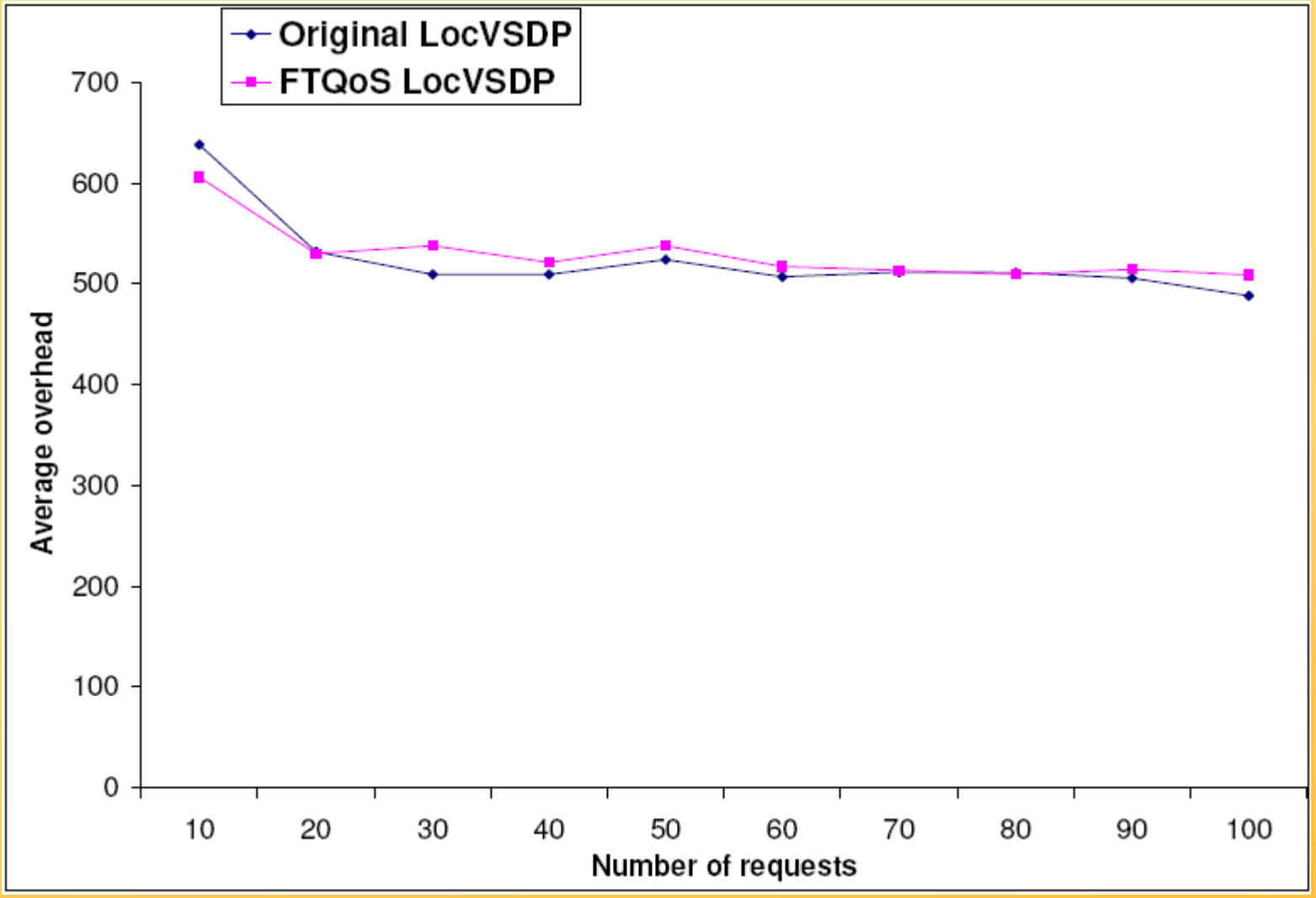
Connection rate comparison



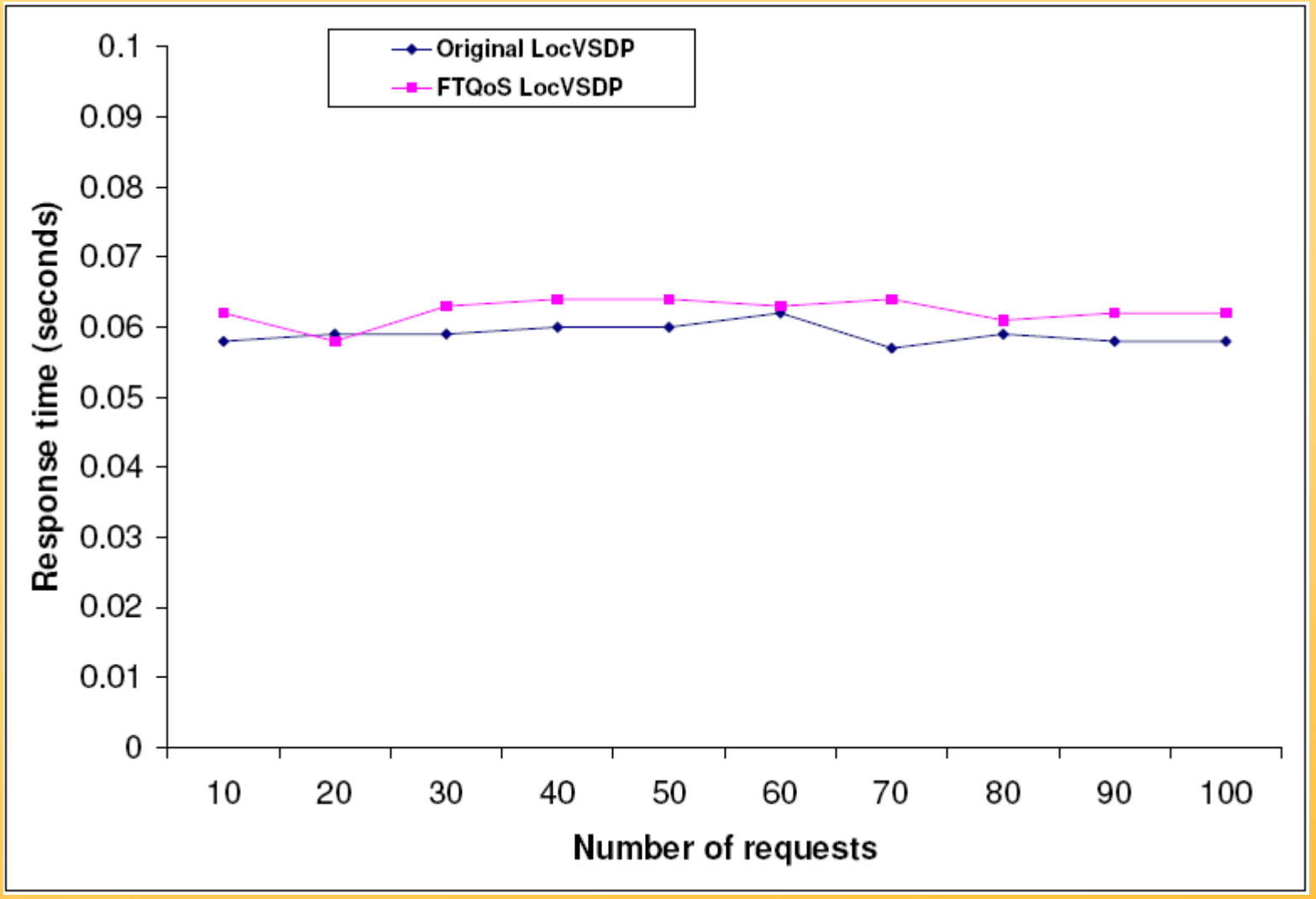
Bandwidth usage comparison



Average per request bandwidth usage comparison



Average response time comparison



Conclusion

Efficient location-based, fault Tolerance, load balancing and QoS based service discovery protocol for vehicular networks:

- Finds efficiently services in the specific region of interest included in a driver request message.
- built on top of the network layer allowing to find the service provider and its routing information at the same time.
- Tolerates RRs and links failures.
- Guarantees the load balancing in the VANet.
- Satisfies drivers' and passengers' QoS requirements.

Thank You

Performance Metrics

- ***Connection rate:*** indicates the average percentage of successful service connections; meaning that when the service requester receives the routing path to the service provider, it is able to connect to it through the returned routing path.

- ***Bandwidth usage:*** measures the total bandwidth usage of drivers' and passengers' service requests during the simulation time.

- ***Average per request bandwidth usage:*** computes the average bandwidth usage per request during the simulation time.

- ***Average response time:*** measures the average response time for successful requests. It measures the elapsed time for getting a valid service reply in response to a service request. This metric takes into account several factors such as transmission and message processing delay.