VITP: An Information Transfer Protocol for Vehicular Computing

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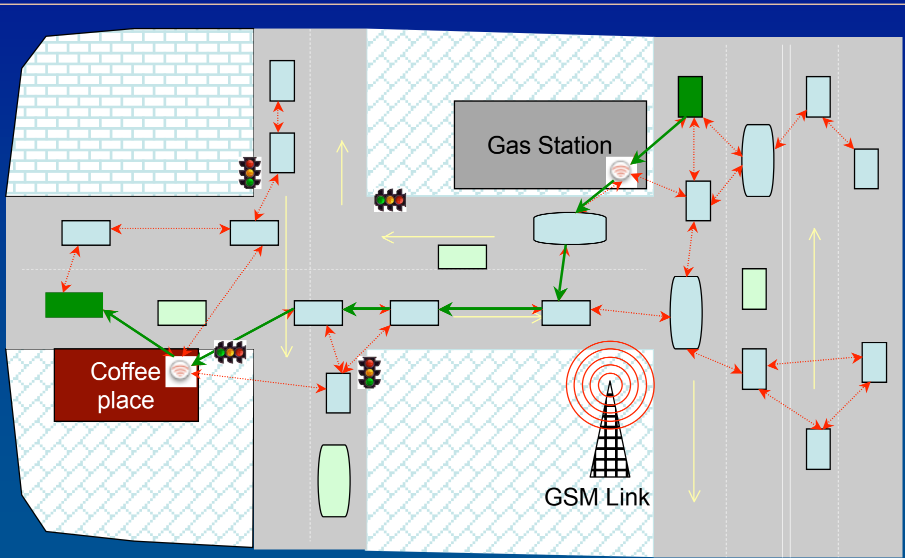
Technological context

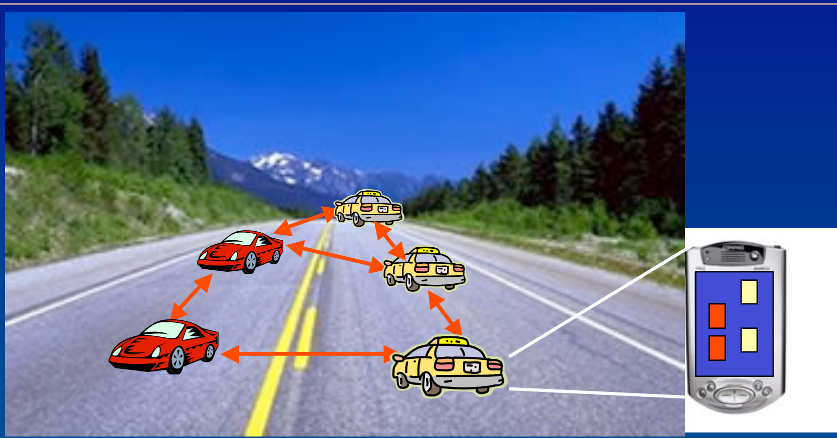
A vehicle as a platform…

- Comprising on-board sensors collecting information about its geographic location, operational conditions and environment.
- Fusing sensor data with geographic information.
- Operating as a node of a wireless ad-hoc network.
- Alternatively accessible through a cellular GSM/GPRS network.

VANET infrastructure



Previous work: TrafficView



- Enable drivers to view traffic in front of their cars, farther than they can see
- Based exclusively on vehicle-to-vehicle communication

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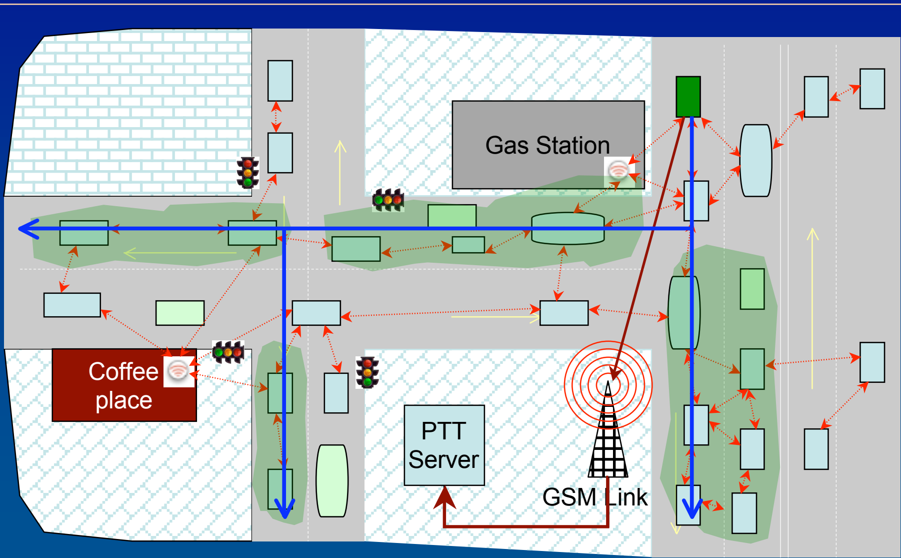
A motivating scenario for VITP



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Motivation and Contribution

- Location-oriented service provision to vehicles, taking advantage of the VANET infrastructure.
- On-demand distribution of information about:
  - Traffic conditions
  - Alerts
  - Roadside services
- Proposed solution:
  - ➩ Vehicular service provision based on extended client-server computing model established over the VANET.
  - ➩ Service interactions carried through the Vehicular Information Transfer Protocol (VITP).

Building blocks

- The Vehicular Information Transfer Protocol (VITP).
- VITP Peers.
- A location encoding scheme.
- VITP features: performance optimizations (caching), quality assurance (termination conditions), privacy protection.

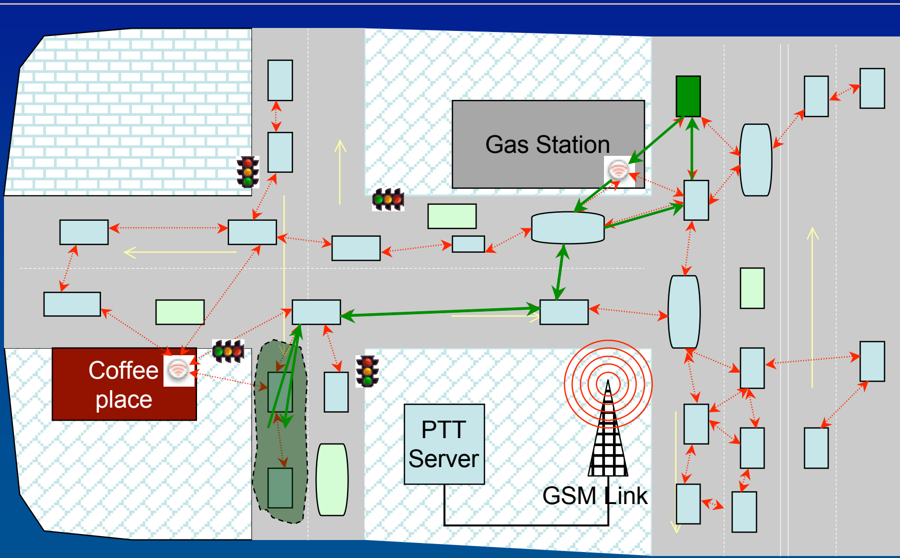
Outline

- Introduction and motivation
- VITP: key design concepts
- VITP-message specification
- Early evaluation through simulation
- Conclusions and Future Work

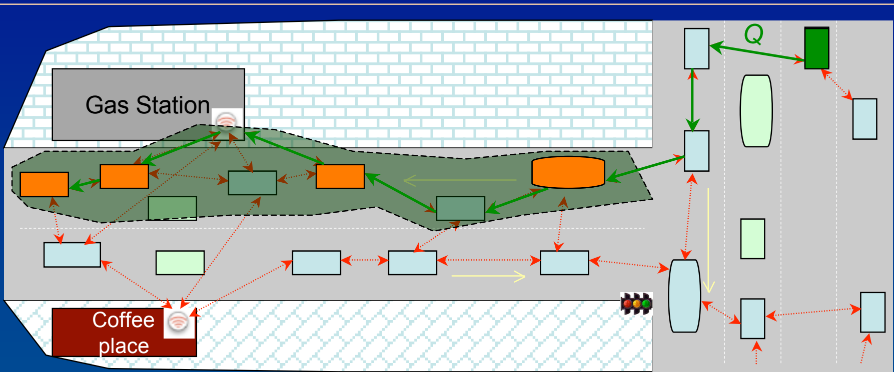
Vehicular Information Transfer Protocol

- Application-layer, stateless protocol.
- Supports the deployment of vehicular services on-top of VANET infrastructures.
- Specifies the syntax and semantics of VITP messages.
- VITP messages carry location-oriented requests and replies between VITP peers of a VANET.
- Is agnostic to underlying protocols (for routing and/or MAC-layer).

Location-oriented requests



Virtual Ad-Hoc Servers (VAHS)

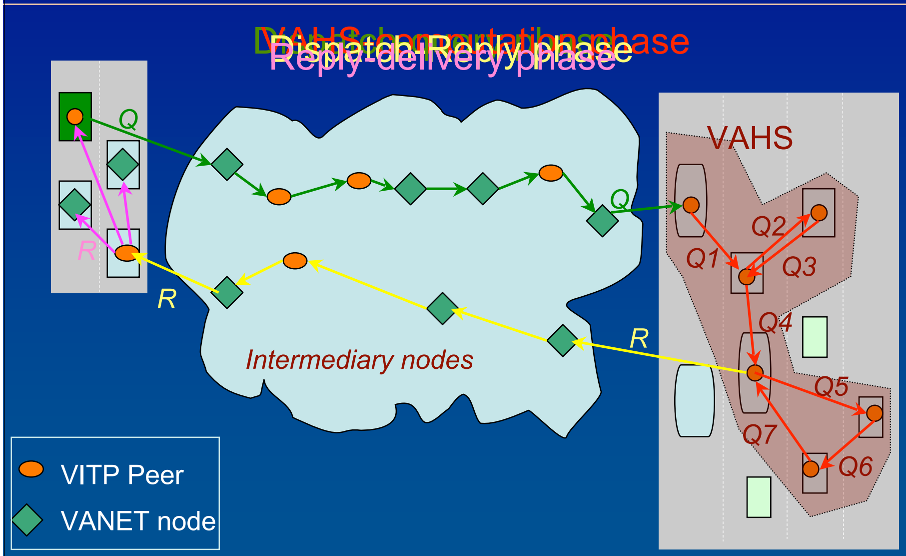


- The server that computes the reply is a dynamic collection of VITP peers that:
  - Run on vehicles moving inside the target-location area of Q.
  - Are willing and able to participate in Q's resolution.

VAHS (ctd)

- Established on the fly in an ad-hoc manner.
- Identified with a query and its target-location area.
- Maintain no explicit knowledge (state) about its constituent VITP peers.
- Follow a best-effort approach in serving queries.
- VAHS members maintain no information about other members of the VAHS.

VITP transactions



Return Conditions

- Determine at which point in time the resolution of a VITP request can be considered done (VAHS computation completes).
- RC decision depends upon:
  - Query semantics: RC must be defined explicitly in the query specification.
  - Timeout condition: either pre-set by higher-level application semantics or default.

Other protocol features

- Support for caching.
- Message identifiers.
- Privacy protection.
- Dissemination vs. pull-based retrieval.

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VITP-message format

METHOD <uri> VITP/<*version_num*>
Target: [*rd_id_dest,seg_id_dest*]
From: [*rd_id_src,seg_id_src*] with <*speed*>
Time: <current_time>
Expires: <expiration_time>
Cache-Control: <directive>
TTL: <time_to_live>
msgID: <unique_key>
Content-Length: <number_of_bytes>
CRLF
<message body>

VITP uri format

/<type>/<tag>?[<rc_expr>&…]&<param_expr>&…

- *type:* classes of physical-world entities involved in the request (vehicle,service).
- *tag*: actual information sought (traffic, alert, gas, index).
- Example VITP requests:

GET /vehicle/traffic?[cnt=10&tout=2000ms]&tframe=3min

GET /service/gas?[cnt=4&tout=1800ms]&price<2USD

POST /vehicle/alert?[cnt=*&tout=*]&type=slippery-road

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Simulation setup

- Our own traffic-generator tool, modeling:
  - Highway traffic.
  - Highway with entries and exits every 1km.
  - Vehicles evenly distributed on the road, changing their speed and lane independently.
- Parameters: road length, number of lanes, average speed, average gap, number of service nodes, number of VITP peers.
  - A 3-lane, 25km-long highway.
  - Average vehicle speed of 20m/s.

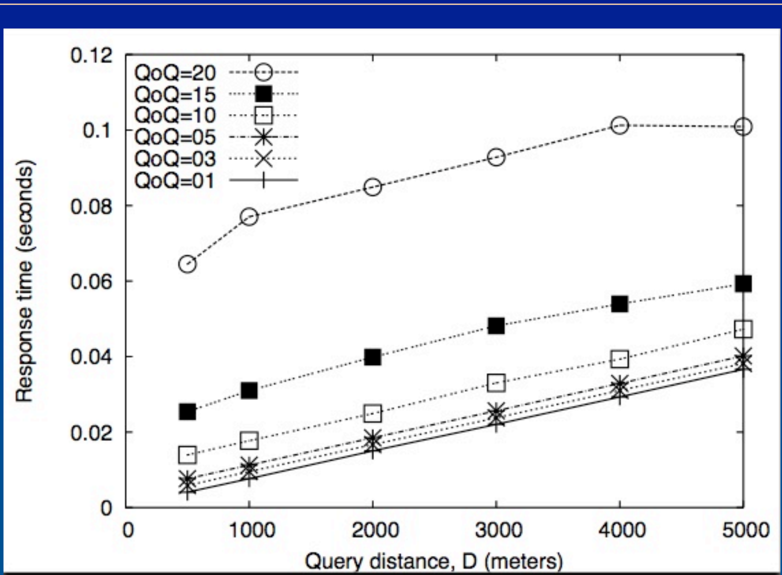
Simulation setup

- Ns-2 simulator, modeling:
  - An 802.11-compliant network.
  - 11 Mbps.
  - 250m transmission range.
  - Messages forwarded with geographic routing toward their destination (allow for three trials per neighbor).

Metrics

- Response time: average (elapsed) time of successful VITP transactions.
- Dropping rate: percentage of unsuccessful queries for which vehicles time-out before receiving reply.
- Accuracy of VITP reply.
- Efficiency: percentage of messages actually employed in calculating a result.

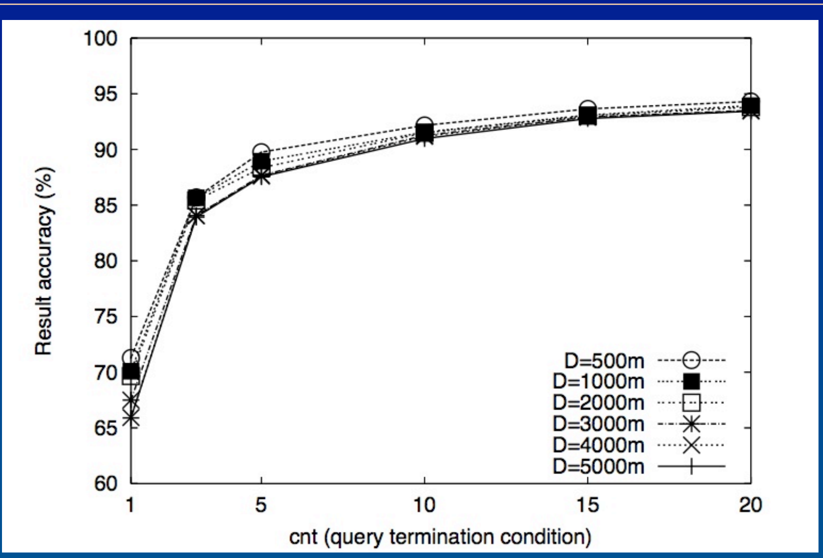
Response time vs. Query distance



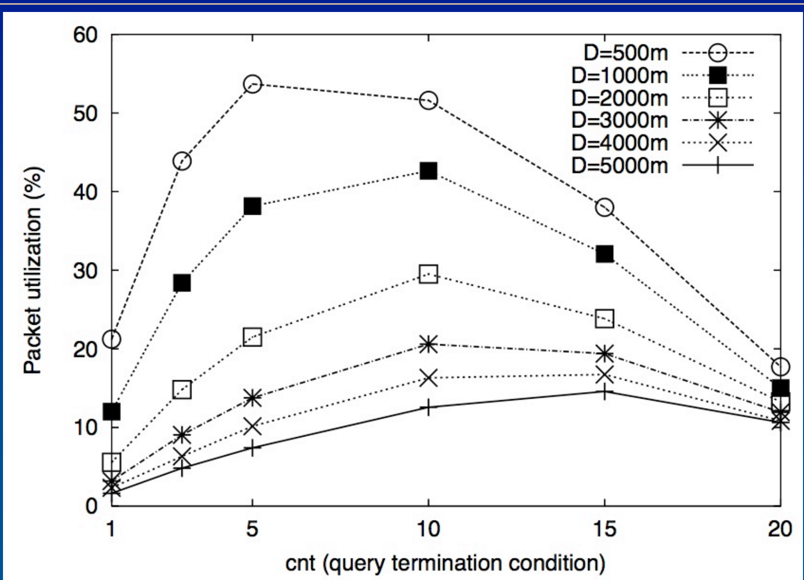
Dropping rates vs. Query distance

Query distance (D)	Forward drop rate (%)	Backward drop rate(%)
500	11.84	0.47
1000	18.41	0.64
2000	36.06	1.52
3000	50.70	2.72
4000	60.69	3.65
5000	65.95	4.24

Accuracy vs. Sampling size (cnt)



Efficiency vs. Sampling size



Summary of simulation study

- Our simulation studies show that:
  - VITP is a viable approach.
  - The choice and tuning of Return Conditions affect the accuracy of VITP results, the dropping rate of VITP transactions, and response time.
  - There is a sampling-size value (*cnt*) that results to optimal efficiency with adequate accuracy: the choice of *cnt* should be done with care in realistic scenarios.
  - The dropping rates in the query-dispatch phase can be prohibitively high.
  - Need to investigate mechanisms to cope with this (caching, alternative networks).

Conclusions

- VITP has the expressive power to support the vehicular-service provision through location-oriented requests.
- VITP has simple, yet powerful semantics.
- VITP is lightweight, stateless and can be easily implemented on embedded processors and resource-limited devices.
- VITP can be used to establish more generic location-based services.

Ongoing and Future work

- We plan to investigate:
  - Finalization of the VITP specification, initiating a standardization process.
  - The effects of caching to overall VITP performance.
  - A more elaborate evaluation environment to assess VITP performance.
  - Alternative approaches for computing VITP replies.
  - The interplay between the VITP layer and the underlying routing protocol.
- We are currently in the process of developing a reference implementation for a VITP peer.

Acknowledgments

Any questions?

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