Data Aggregation and Roadside Unit Placement for a VANET Traffic Information System

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September, 15th 2008
San Francisco, CA, USA
Global Targets

Develop a navigation system based on current traffic information

Steps to proceed:
1. Identify a suitable metric
2. Develop an aggregation scheme based on frequently updated floating data
3. Identify possible locations for supporting units
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Cars gather information by making observations about the time to pass a road segment.
Assumptions

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The Need for an Aggregation Scheme

Quantity of information
Information increases quadratically with the distance

Bandwidth
Packets can transport a limited amount of data only
Network capacity has to be considered
Implementation

Multi level aggregation:

1. **Hierarchical aggregation**
   - Cars have detailed knowledge about closer vicinity
   - Cars have rough insight in regions far away

2. **Aggregation based on the landmark principle**

   Aggregation of street segments between two landmarks of the same hierarchy
Landmark Aggregation
## Landmark Aggregation

![Diagram of Landmark Aggregation](image)

The diagram illustrates the concept of Landmark Aggregation, showing how data is aggregated at various landmarks and points in time.
Landmark Aggregation
Hierarchical Aggregation
Hierarchical Aggregation
Characteristics of a VANET

- Only few vehicles are equipped with VANET technology (especially during roll-out)
- Equipment density of VANET technology is very low
- Network of equipped cars is partitioned into multiple parts

⇒ Supporting units
Functionality

- Behave like stationary cars
- Receive information by passing cars
- Supporting units are linked
- Share a common knowledge base
- Broadcast common knowledge
Supporting Units

**Placement**

- Where to place supporting units?
- How many units are needed?
- How to test the effects of positions?
Scenario
Motivation and Prerequisites

The Aggregation Approach

Supporting Units

Genetic Algorithm

Evaluation

Summary

Placement

Scenario

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Preparations for Evaluation

- Identify 100 possible locations for supporting units
- Vary the number of supporting units
- Test different subsets of these variations
Random Placement of Supporting Units

Placement

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Hard optimization problem

Range of possible placements is huge:

- With 10 active supporting units: $1.73 \cdot 10^{13}$
- With 30 active supporting units: $2.9 \cdot 10^{25}$
- Fast optimization is needed!
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⇒ Genetic Algorithms
Genetic Algorithm

Solving the optimization problem by using genetic algorithms

- Representation of possible SU locations with 4 active SUs

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<tr>
<th>SU-vector</th>
<th>SU_0</th>
<th>SU_1</th>
<th>SU_2</th>
<th>SU_3</th>
<th>SU_4</th>
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- Fitness calculation and selection for recombination

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<th>Rank</th>
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<td>C</td>
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Genetic Algorithm

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Expected Results

- Low equipment ratio (5%) reduces accuracy
- Important information is gathered primarily in the city center
- A small number of SUs provides a significant benefit

⇒ Comparison between:
  - Journey time without traffic information
  - Journey time with disseminated traffic information

⇒ Benefit is the objective function for the genetic algorithm
Location of ten active SUs
Location of thirty active SUs
Effects of Supporting Units

![Graph showing the effects of supporting units on relative travel time. The graph compares static and dynamic routes with varying numbers of supporting units.]

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Results

Effects of Supporting Units (CDF)

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Effects of Supporting Units (CDF)

Fraction of nodes

Relative travel time (CDF)

100 SU
30 SU
10 SU
5 SU
0 SU
Summary

Analysis of an navigation system

- Development of an aggregation scheme for 2D traffic information data based on
  - Hierarchical aggregation
  - Landmark routing

- Generation of a Genetic Algorithm to evaluate
  - The number of supporting units
  - The placement of supporting units
Thank you for your attention!

Questions?

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Example Car

Std journey time: 725.65 s
Aggr journey time: 586.00 s
Global journey time: 586.00 s

Journey time savings: −139.65 s (0.81)
Example Car

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Data Aggregation and Roadside Unit Placement for a VANET Traffic Information System
Evolution of SU vector with 30 active SUs
Evolution of SU vector with 10 active SUs
Toolchain

ns-2 \rightarrow VISSIM

movement + traffic log file

random initial SU vectors

individual SU vector

application simulator

geneic algorithm

optimal SU vector

time savings (fitness)