TrafficView: Traffic Data Dissemination using Car-to-Car Communication

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Motivation

- Email, not new in any sense for most of us
- E-loan?
- E-Harmony?
- E-?
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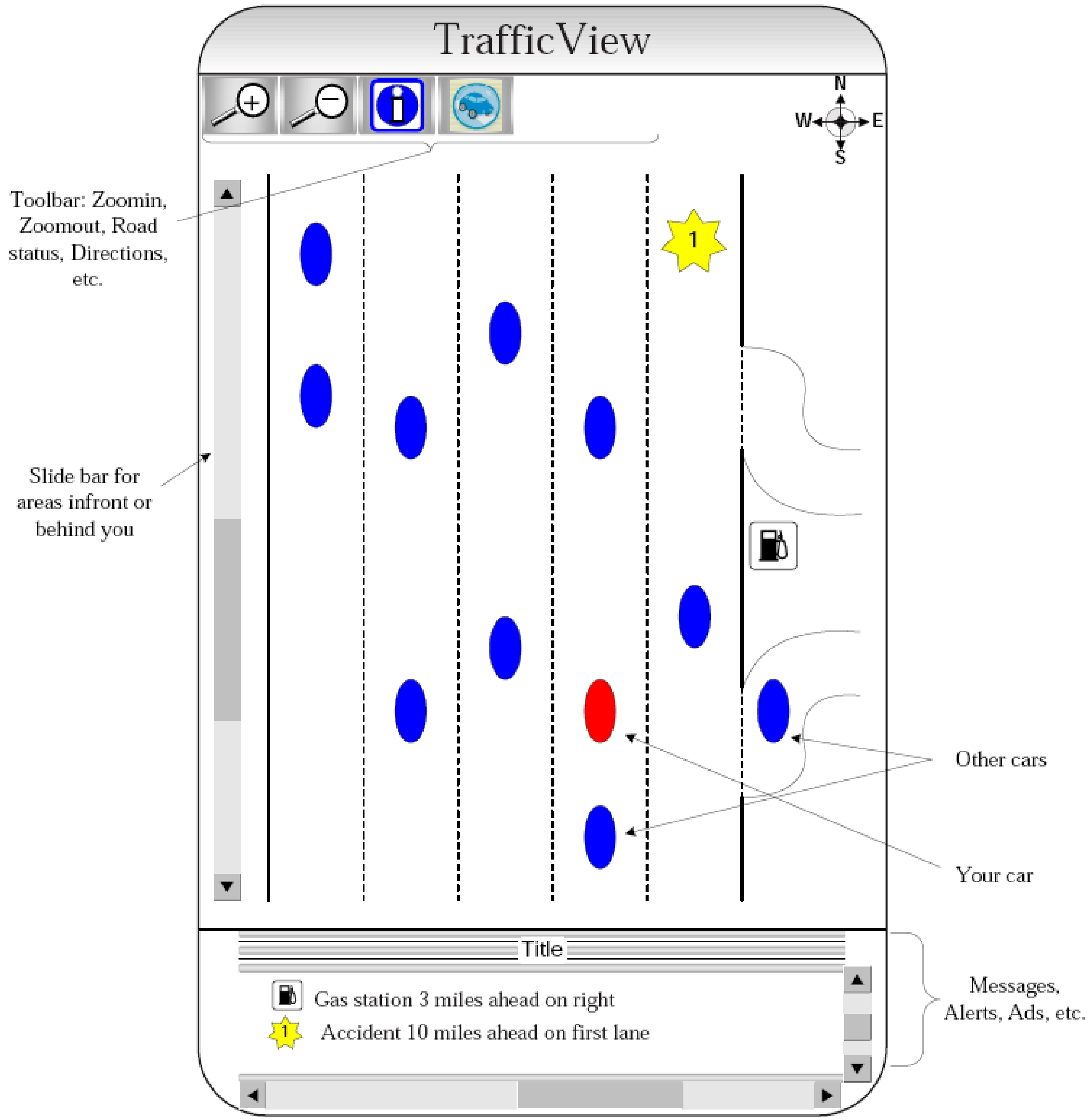
- E-Road?
  - If there will be, what will be like?
  - Imagine one!

Motivation: One example

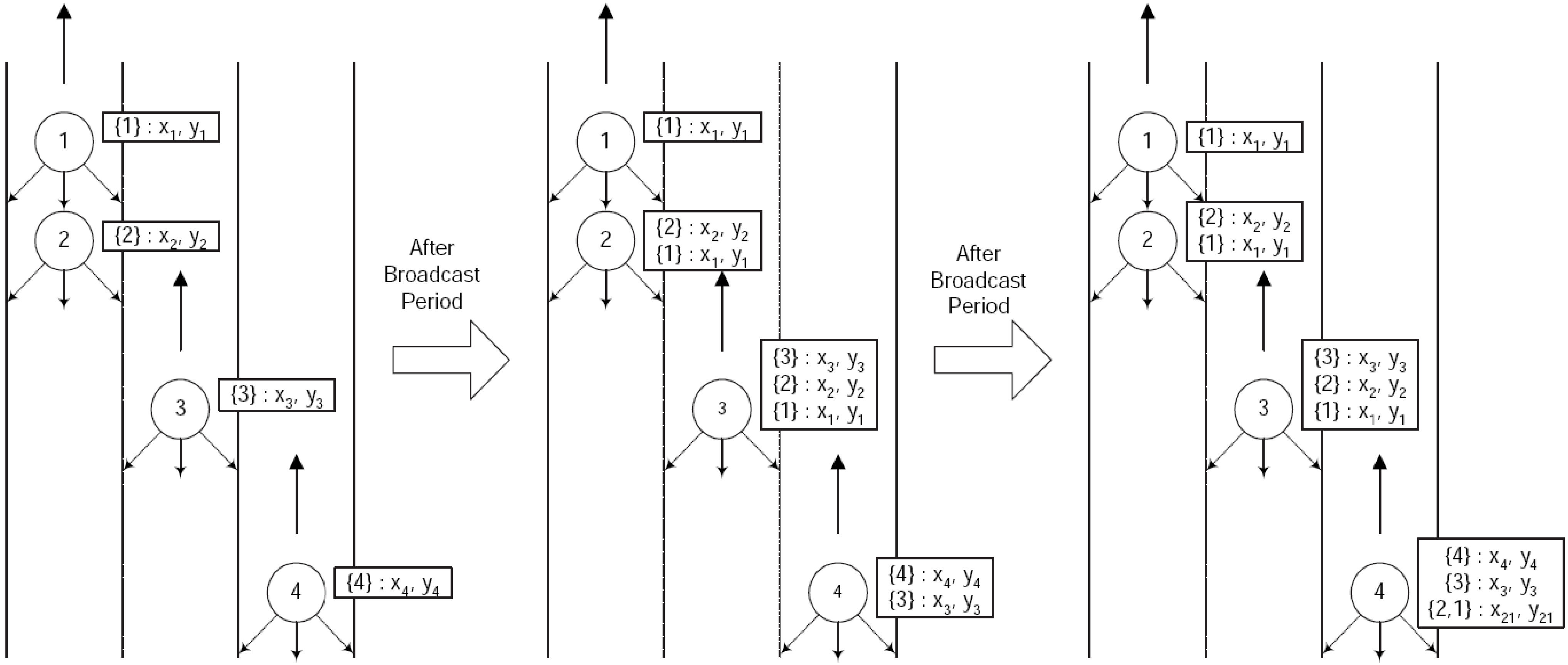


What devices would be needed?

What needs to be considered

- Rapid change in link topology
- Frequently disconnected network
- Data compression/aggregation
- Prediction of vehicle’s positions
- Energy is not an issue

One problem is ...



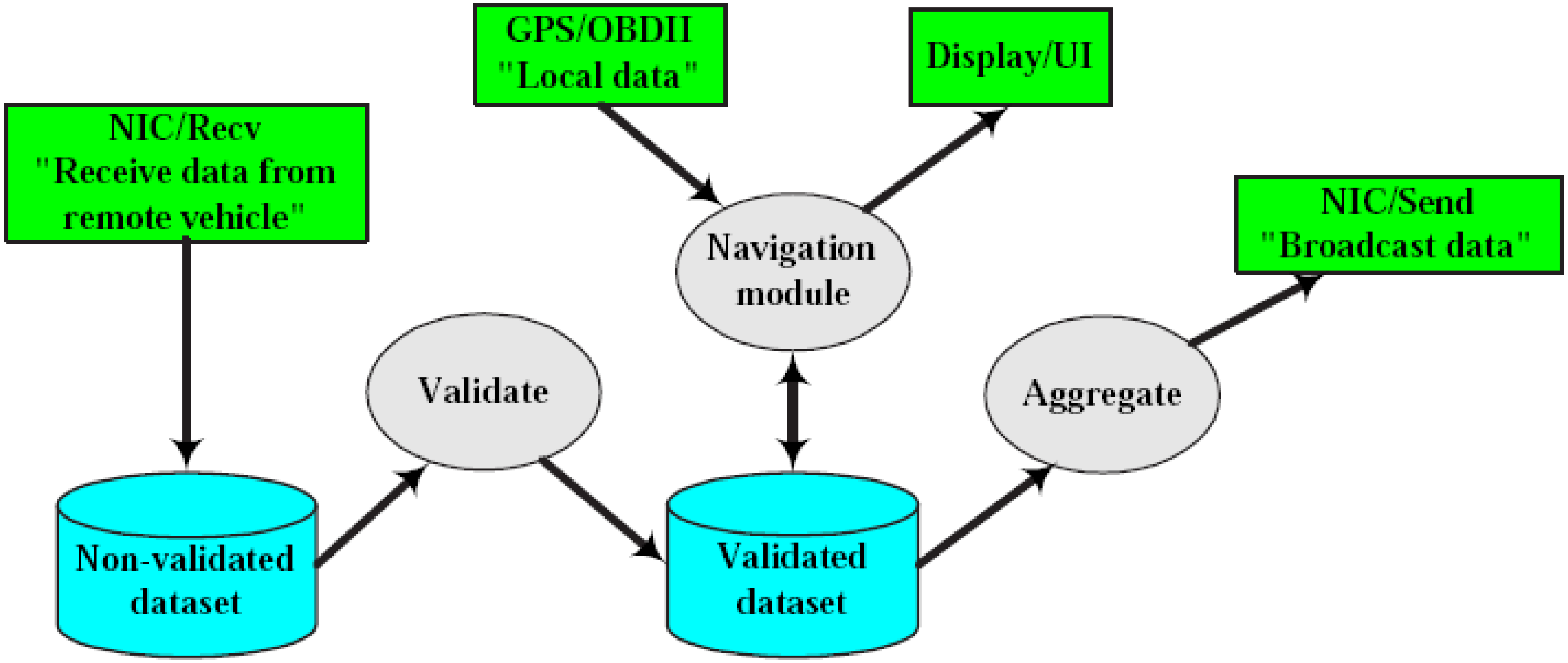
Look at the possible traffic

- Each advertisement: 50 bytes
  - ID, position, speed, and broadcast time (BT)
- Within 100m, 5 lanes, 5 meters apart: 5K bytes
- Within 20Km: 1M bytes
-
- Transmission range of 250m (802.11b)
  - 250MB!

Research goal

- Find a method to disseminate in a scalable manner
- Two fundamental ones:
  - Flooding
  - Diffusion
- Diffusion
  - Limit the size of broadcast packet: 2312 bytes
  - Delayed forwarding:

System design



Data aggregation for scalable diffusion

$$(ID_1, POS_1, SPD_1, BT_1) \ldots (ID_n, POS_n, SPD_n, BT_n)$$

$$(\{ID_1, \ldots, ID_n\}, POS_a, SPD_a, BT_a)$$

$$\begin{aligned}
POS_a &= \textstyle\sum_{i=1}^{n} \alpha_i \times POS_i \\
SPD_a &= \textstyle\sum_{i=1}^{n} \alpha_i \times SPD_i \\
BT_a &= \min\{BT_1, \ldots, BT_n\} \\
\alpha_i &= \frac{(\sum_{i=1}^{n} d_i) - d_i}{(n-1)\sum_{i=1}^{n} d_i}
\end{aligned}$$

One trick

- Aggregation criteria
  - Position
  - Speed
  - BT
  - Relative distance
- Distance?

Ratio-based aggregation

- Divide the road into a number of regions
- Assign an aggregation ratio to each region
- A ratio is the inverse of the number of individual records (vehicles) that would be aggregated into a single record
- Each region is assigned a portion of the broadcast packet
- *Which region takes what portion of the B-packet?*

Cost-based aggregation

$$cost = \frac{|d_1 - d_a| \times s_1 + |d_2 - d_a| \times s_2}{d_a}$$

Sample records

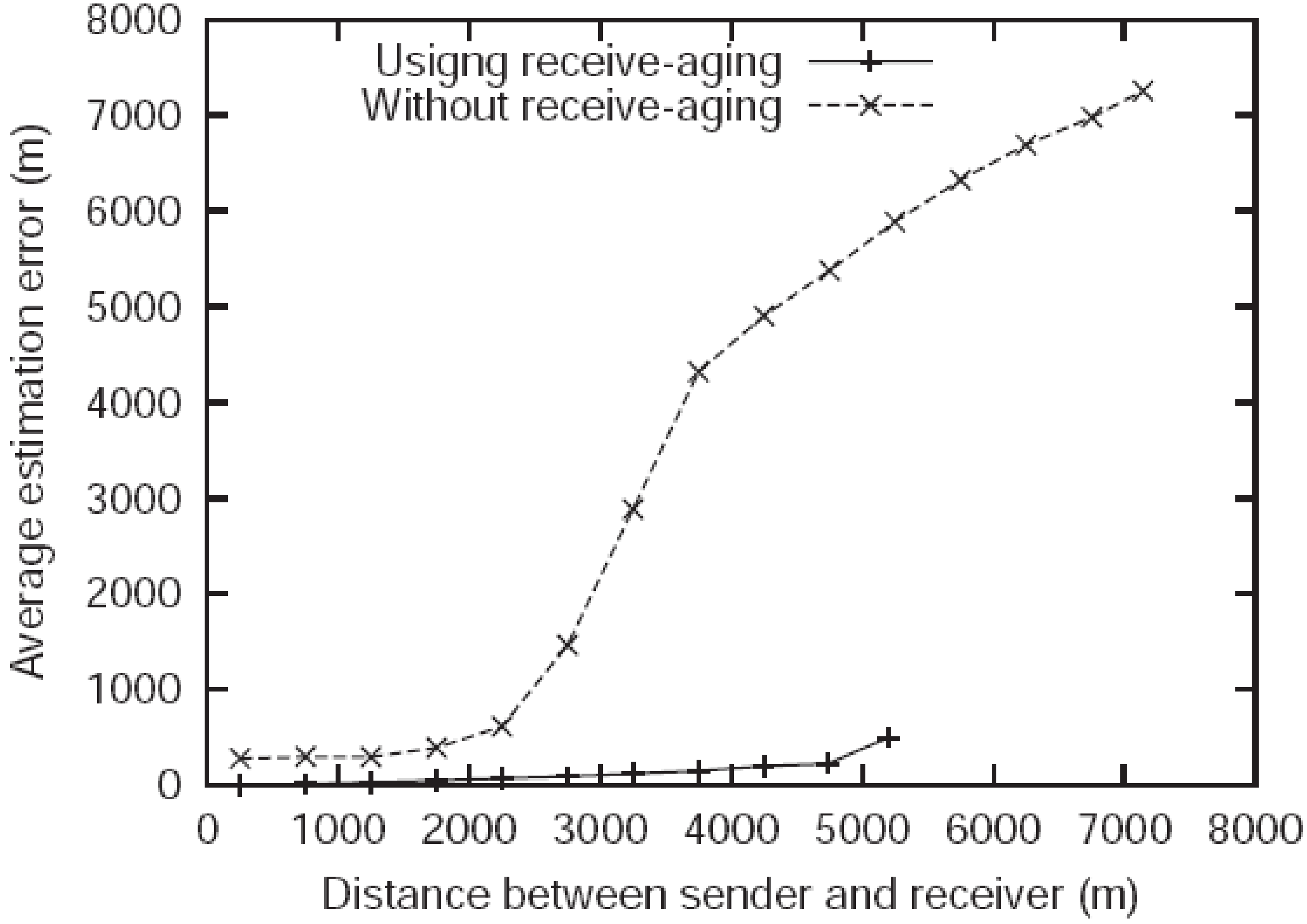
ID	relative distance	speed	broadcast time
1	40	30	9.80
2	65	25	9.75
3	120	35	9.00
4	140	20	8.80
5	250	30	6.90
6	280	15	6.75
7	600	30	4.25

Comparison of aggregations

ID(s)	relative distance	speed	broadcast time
1, 2, 3	67.56	29.39	9.00
4, 5, 6	215.22	21.68	6.75
7	600	30	4.25

ID(s)	relative distance	speed	broadcast time
1, 2	49.52	28.09	9.75
3, 4	129.23	28.07	8.80
5, 6	264.15	22.92	6.75

Information aging



Simulation: traffic scenario

- Entries and exits at every 1000m
- Speed changes
  - Max speed x (0.75 + rand(-2,2) x 0.125)
- Changing lanes
  - Probability to stay: 0.6
  - Probability to move right and left: 0.2
- 15,000 meters, 4 lanes, 802.11b, 2312 bytes

Evaluation metrics

- Accuracy: for each region of 500 meters long
- Visibility: the average distance to the vehicles a node knows about
- Knowledge percentage: regins of 200 meters long, how much percentage of nodes of the regions are known to a node

Parameter settings

Name	a_1	a_2	a_3	p_1	p_2	p_3
param1	0.5	0.25	0.17	0.5	0.5	0.5
param2	0.75	0.5	0.25	0.5	0.5	0.5
param3	0.5	0.25	0.17	0.4	0.6	0.8
param4	0.5	0.25	0.17	0.3	0.43	0.75

Different simulations

Name	Total nodes	Avg. speed	Avg. gap
Rush-hour	690	10	100
City	780	20	100
High-density highway	870	30	100
Low-density highway	548	40	175

Results

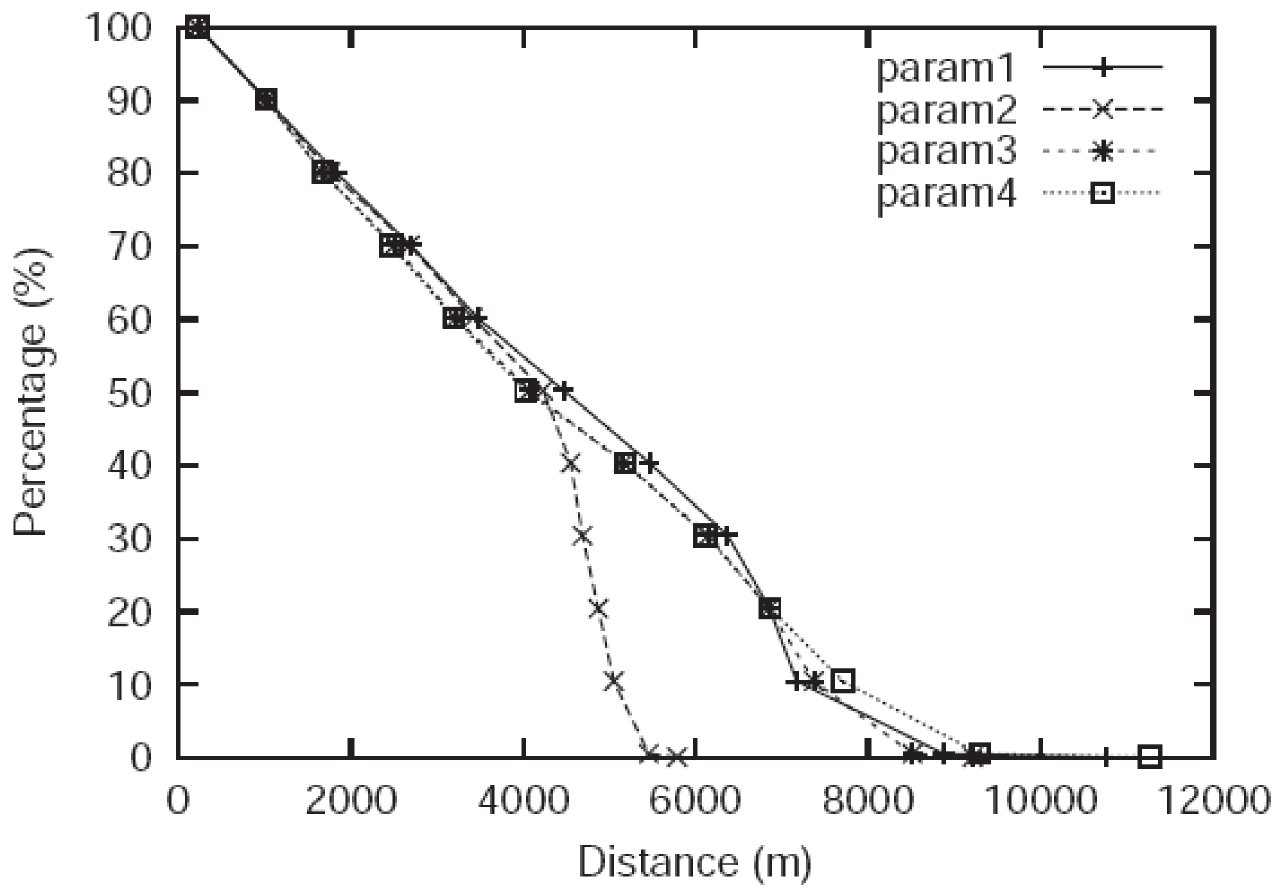


Figure 9: Visibility graphs for Ratio-based using different aggr. parameters

Results

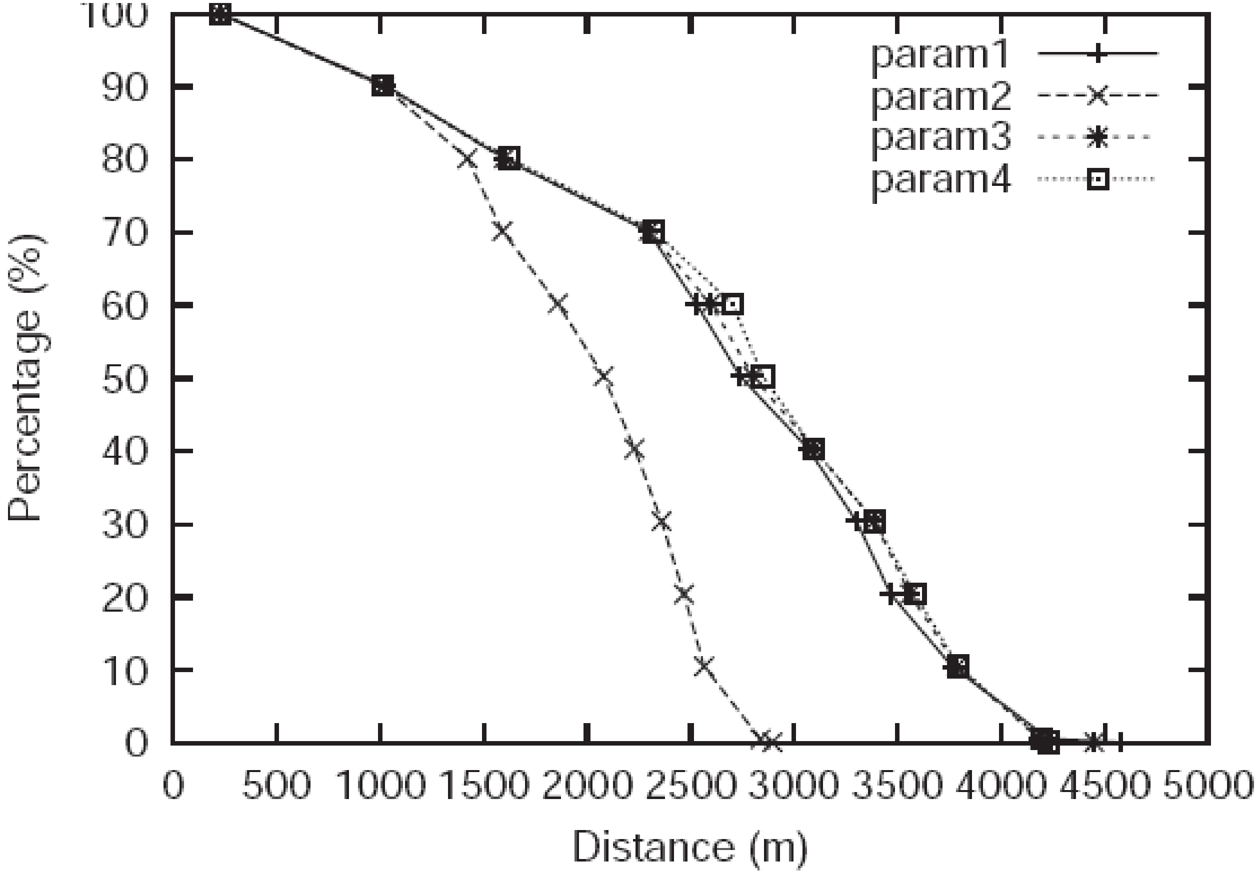


Figure 10: Visibility graphs for Cost-based using different aggr. parameters

Results

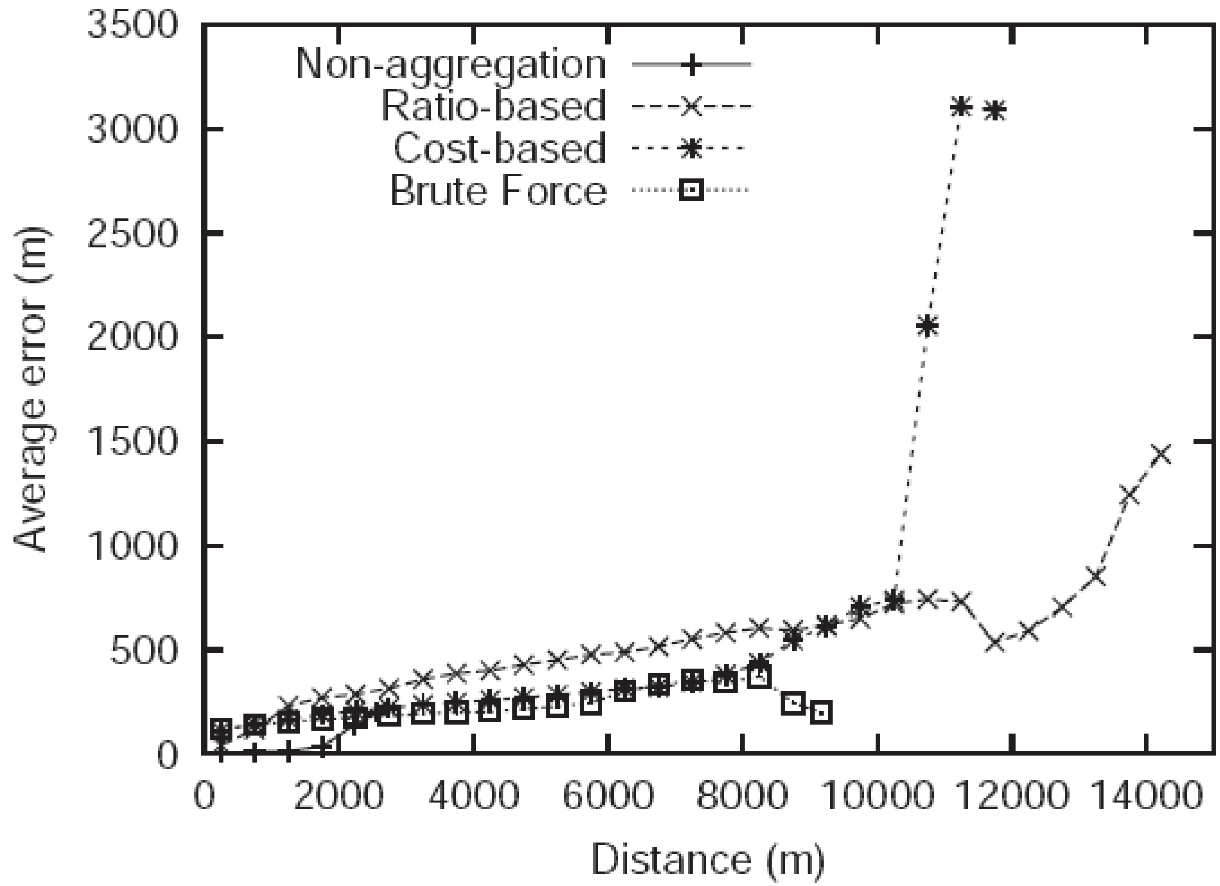


Figure 14: Average error for different aggregations using *High scenario*

Results

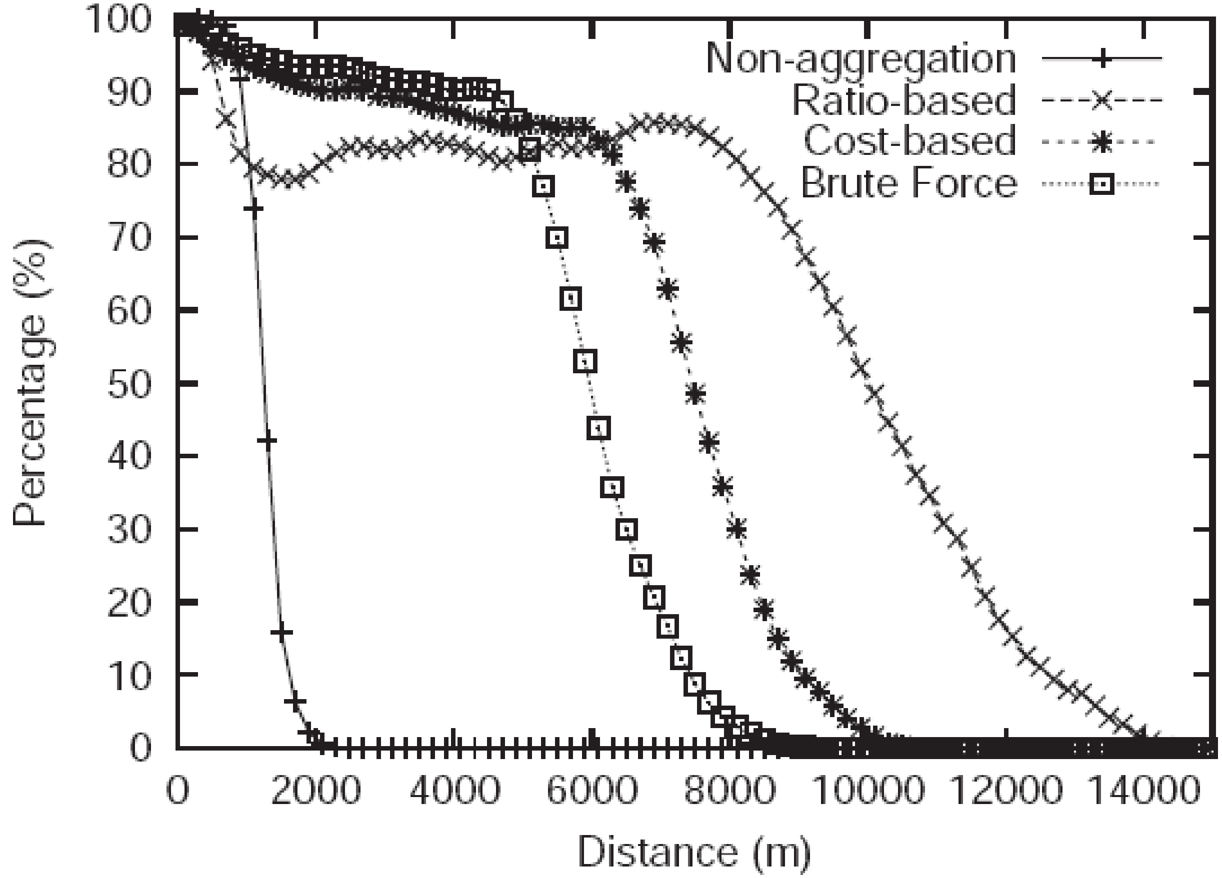


Figure 15: Average knowledge for different aggregations using *High scenario*