Optimizing home care services

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Problems related to this field

| PROBLEM	WHAT TO OPTIMIZE	PROBLEM ABBREVIATION
Delivery problem	Optimize route	mTSP
Delivery problem with time windows	Optimize route with time windows	VRPTW
Home care scheduling	Optimize route with time windows and other constraints	Modified VRPTW

Motivation and aim

Home care optimization is important, because

-It reduces costs

-It maximizes patient satisfaction

-It maximizes worker satisfaction

-It helps cut down greenhouse gas emissions

The aim is to minimize traveling time of home care workers considering

-Compatibility of a worker to a patient

-Availability of workers

-Time windows of patients

-Transportation means of workers

Patients of a day assigned to workers
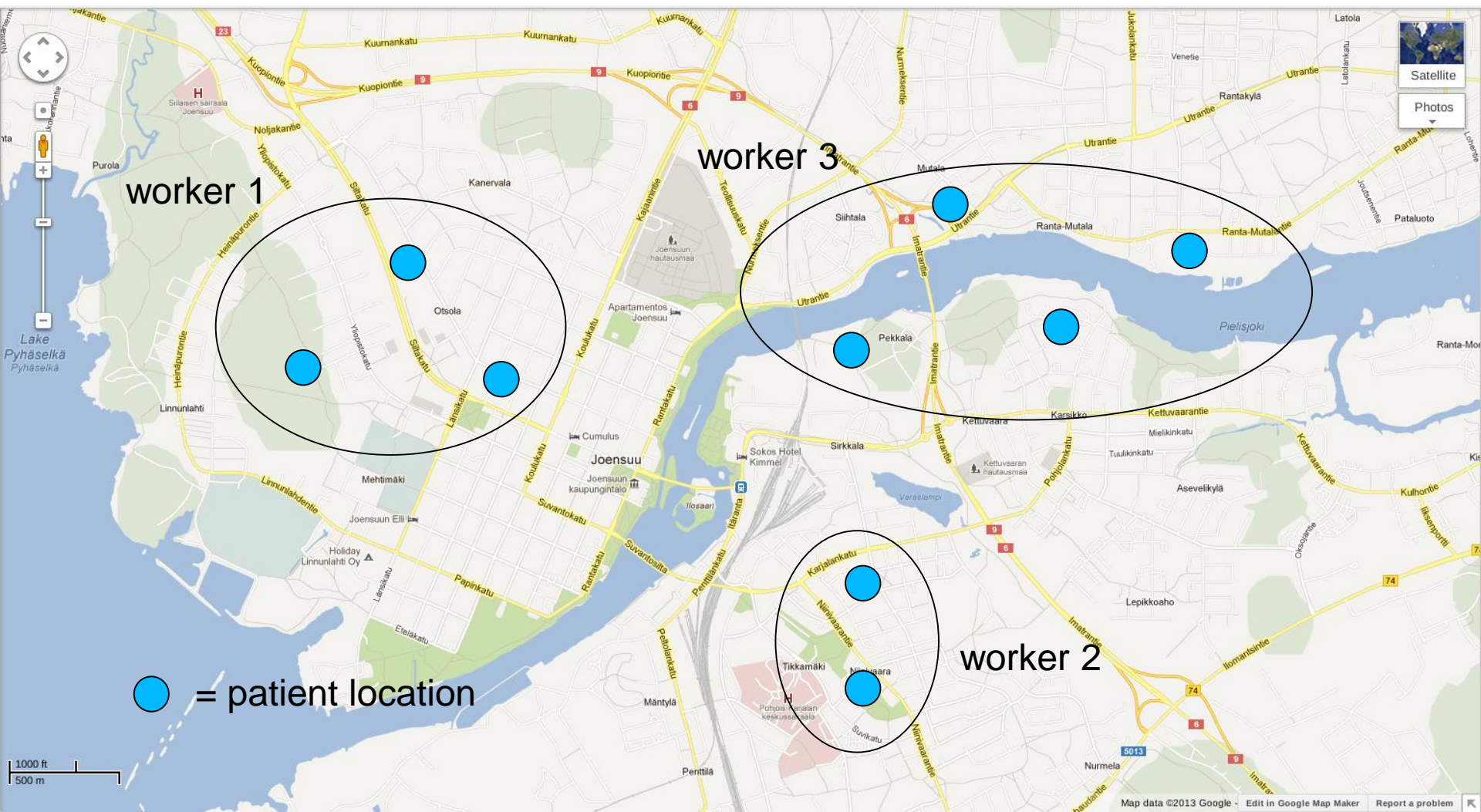
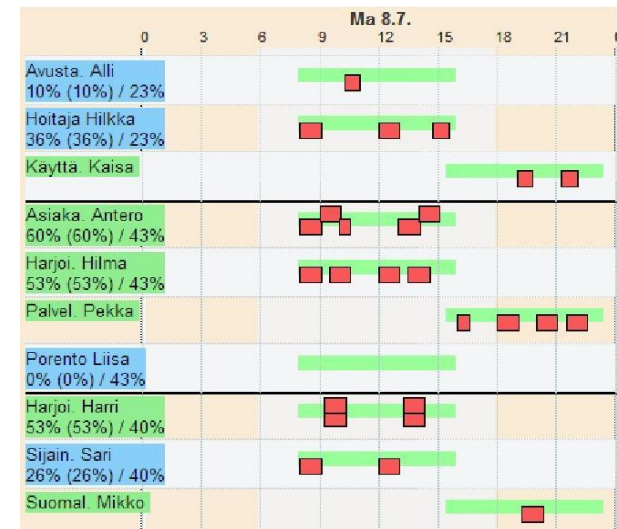# An example of an existing commercial solution: Hilkka-system by Fastroi

-Workshift planning
-Daily task assignments
        Requirements of patients are weighted by their criticality
-Mobile application for workers

Time

Workers

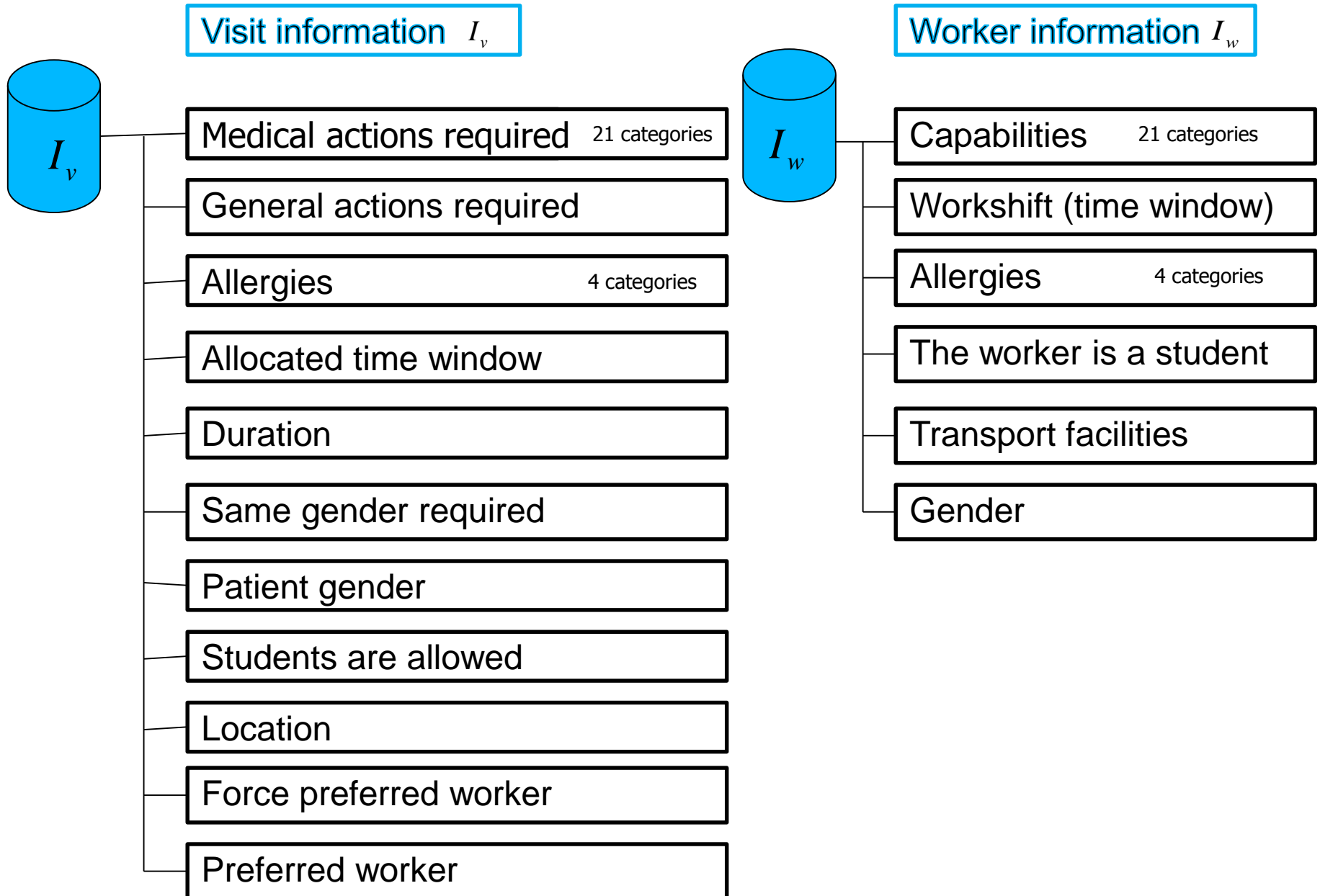# An example of research group: KAHO Sint Liven, Ghent, Belgium

* M.Misir, K.Verbeek, P.Causmaecker, G.V.Berghe, Hyper-heuristics with a dynamic heuristic set for the home care scheduling problem, *2010 IEEE Congress on Evolutionary Computation*

T. Vermeulen, K. Vangheluwe, J. Maervoet, K. Verbeeck, P. Verhoeve, and B. Stubbe. Nucia - nurse call simulation in agent environments. In *Proceedings of the European Simulation and Modeling Conference 2010*. ESM'2010, 2010

B. Bilgin, P. Demeester, M. Misir, W. Vancroonenburg, G. Vanden Berghe, (2012). One hyperheuristic approach to two timetabling problems in health care. *Journal of Heuristics, 18* (3), 401-434

P. Smet, B. Bilgin, P. De Causmaecker, G. Vanden Berghe, (2013). Modelling and evaluation issues in nurse rostering. *Annals of Operations Research*.

M. Mihavlov, P. Smet and G. Vanden Berghe, Automatic constraint weight extraction for nurse rostering: A case study, in *Proc. of the 27th Annual Conference of the Belgian Operations Research Society (ORBEL)*, Kortrijk, Belgium, 2013
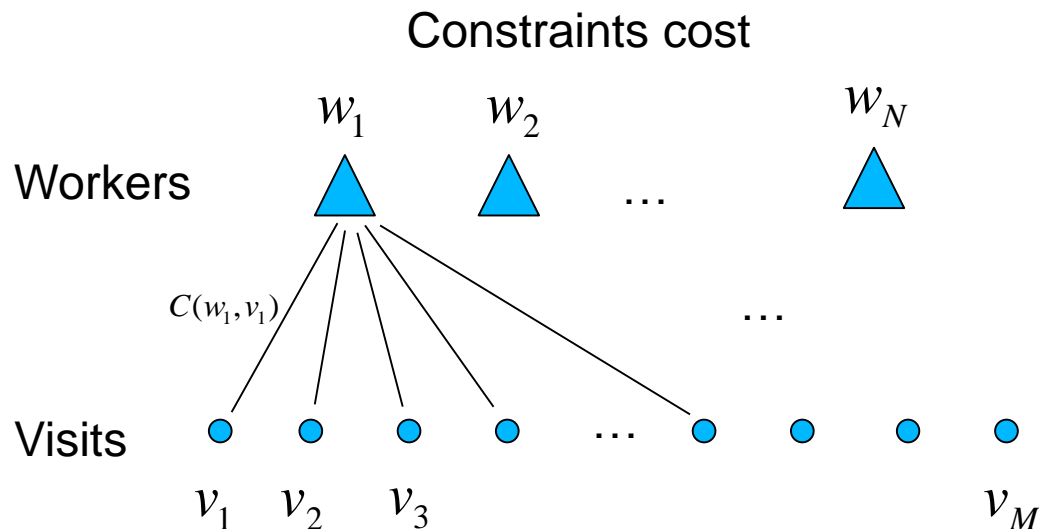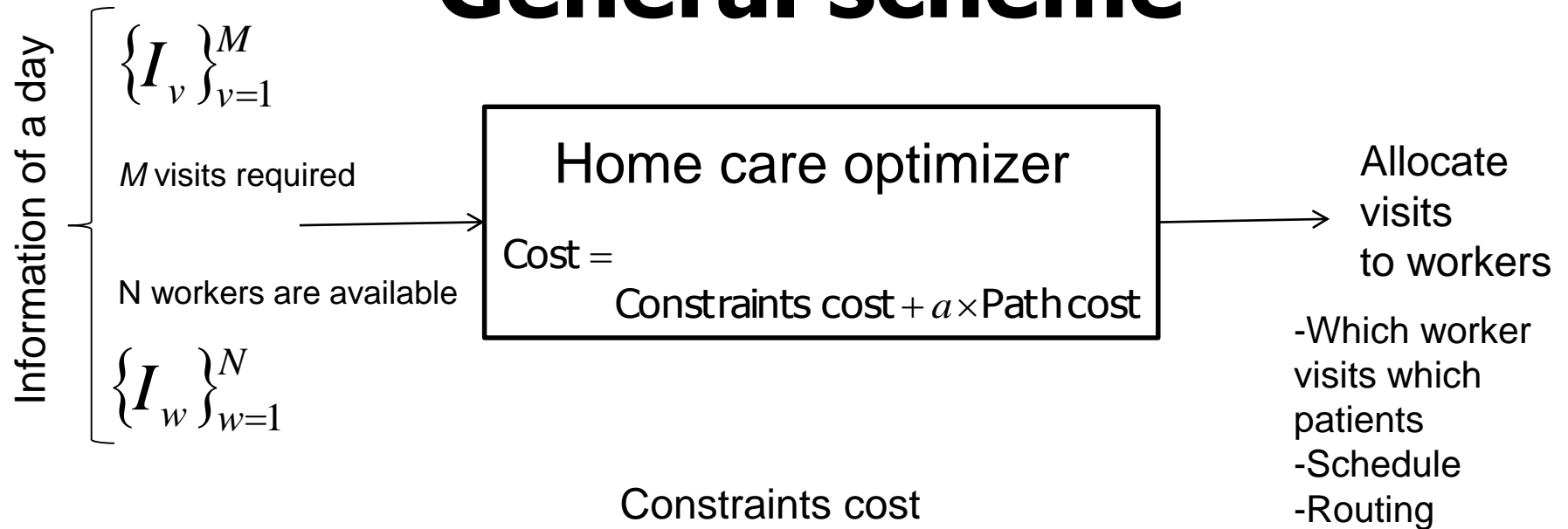
http://allserv.kahosl.be

Research works around the globe

* A.Rendl, M. Prandtstetter, G. Hiermann, J. Puchinger, G. Raidl, Hybrid Heuristics for Multimodal Homecare Scheduling, Integration of AI and OR Techniques in Constraint Programming for Combinatorial Optimization Problems,Lecture Notes in Computer Science, Volume 7298, 2012, pp 339-355

* C. Akjiratikarl, P. Yenradee, and P.R. Drake. PSO-based algorithm for home care worker scheduling in the UK. Computers and Industrial Engineering, 53(4):559–583,2007.

K. Martin and M. Wright. Using particle swarm optimization to determine the visit times in community nurse timetabling. In Proceedings of the 7th International Conference on the Practice and Theory of Automated Timetabling (PATAT'08), Montreal, Canada, August 19–22 2008

Typical input information

Visit information I_v

I_v

Medical actions required	21 categories
General actions required	
Allergies	4 categories
Allocated time window	
Duration	
Same gender required	
Patient gender	
Students are allowed	
Location	
Force preferred worker	
Preferred worker	

Worker information I_w

I_w

Capabilities	21 categories
Workshift (time window)	
Allergies	4 categories
The worker is a student	
Transport facilities	
Gender	

General scheme

Information of a day

$$\{I_v\}_{v=1}^{M}$$

M visits required

N workers are available

$$\{I_w\}_{w=1}^{N}$$

Home care optimizer

$$\text{Cost} = \text{Constraints cost} + a \times \text{Path cost}$$

Allocate visits to workers

-Which worker visits which patients
-Schedule
-Routing

Constraints cost

w_1 w_2 w_N

Workers

…

$C(w_1, v_1)$

…

Visits

v_1 v_2 v_3 … v_M

The visits need to be equally distributed for workers.

Constraints cost

w_1 w_2 w_N

Workers

...

$C(w_1, v_1)$ ...

Visits

v_1 v_2 v_3 v_M

$$\text{Constraints Cost}(w, v) = \sum_{i \in \text{categories}} L_i(w, v) P_i, \qquad L_i(w, v) = \{0,1\}$$

Categories	Penalties
$1,...,21 = \text{Requirements - Capabilities}$	$P_1,..., P_{21}$ (should be very high)
$22 = \text{Work shift}$	P_{22} (important)
$23,...,26 = \text{Allergies}$	$P_{23},..., P_{26}$ (important)
$27 = \text{Student allowed}$	P_{27} (important)
$28 = \text{Gender}$	P_{28} (important)
$29 = \text{Force preferred worker}$	P_{29} (important)

When there is a mismatch in category i for a visit and a worker, then the penalty P_i is accumulated in the constraints cost.

Constraints $\text{Cost}(w,v) = \sum_{i \in \text{categories}} L_i(w,v)P_i, \qquad L_i(w,v) = \{0,1\}$

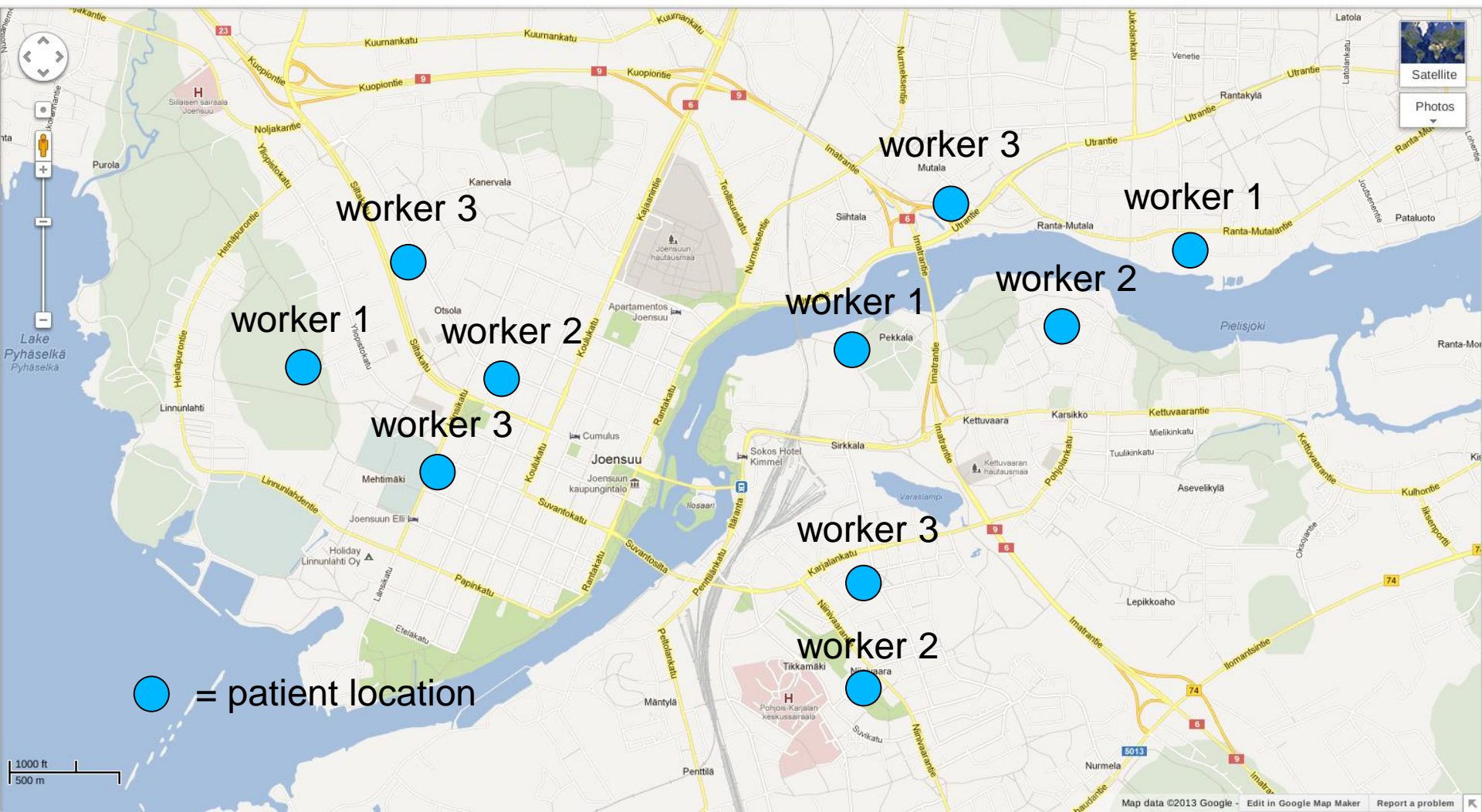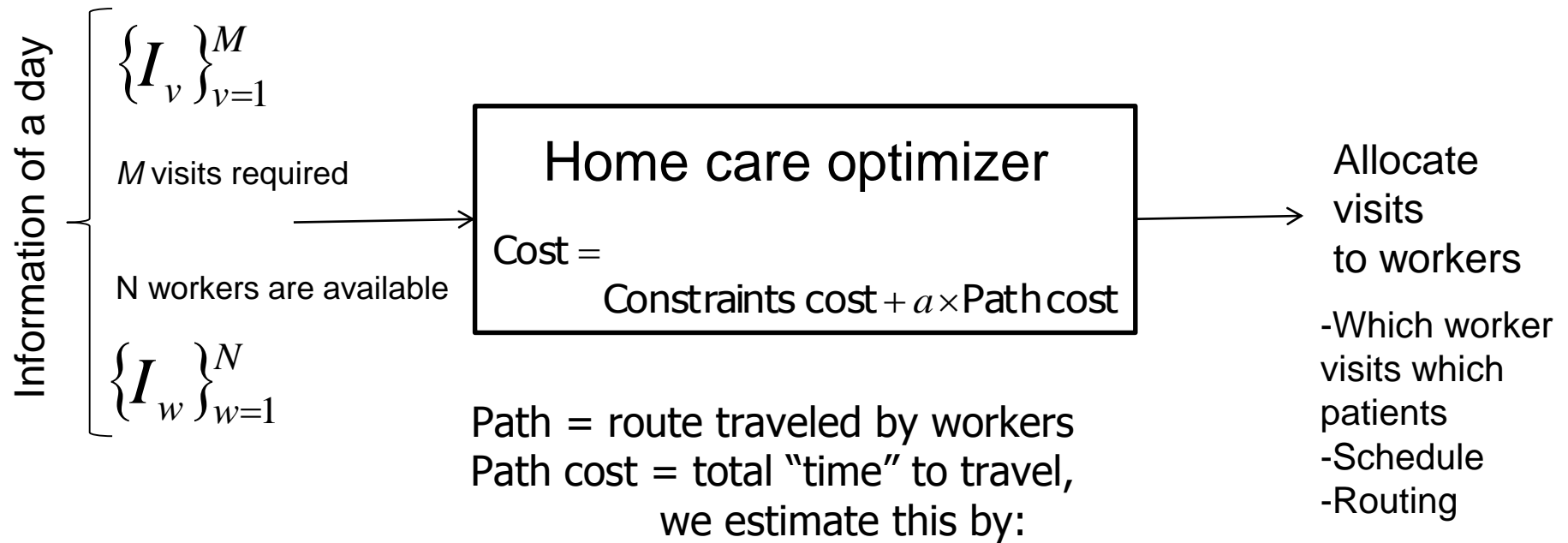| Categories	Penalties
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Example:

Categories   1,...,21   22 23,...,26 27   28   29

Information for worker w | 0101... | 1 | 1010 | 1 | 1 | 1 |

Information for visit v | 1010... | 1 | 1000 | 0 | 1 | 1 |

$$C(w,v) = (P_1 + P_3 + ...) + (0) + (P_{23}) + ...$$
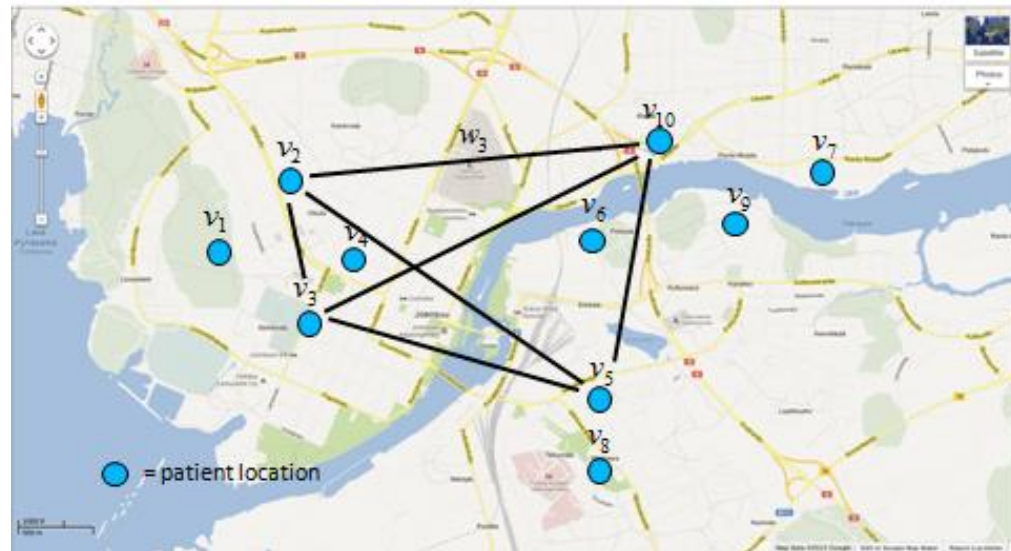
The assignment problem is solved by Hungarian algorithm.

The output of costraints cost optimization

Information of a day

$$\{I_v\}_{v=1}^{M}$$

M visits required

N workers are available

$$\{I_w\}_{w=1}^{N}$$

Home care optimizer

Cost =
Constraints cost $+ a \times$ Path cost

Allocate
visits
to workers

-Which worker
visits which
patients
-Schedule
-Routing

Path = route traveled by workers
Path cost = total "time" to travel,
we estimate this by:

$$\text{Path cost} = \sum_{\substack{v_i \text{ and} \\ v_j \text{ are in the} \\ \text{same cluster}}} time(v_i, v_j)^2$$

= patient location

Local search to minimize the cost function
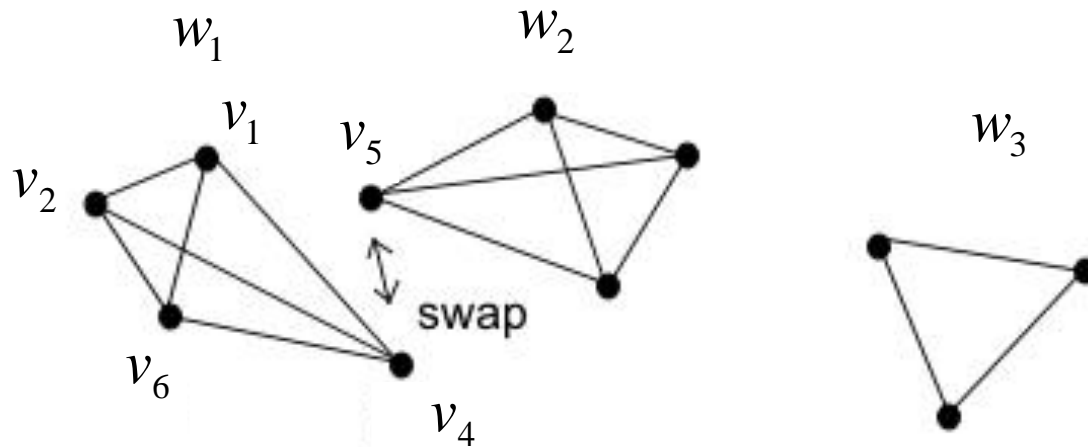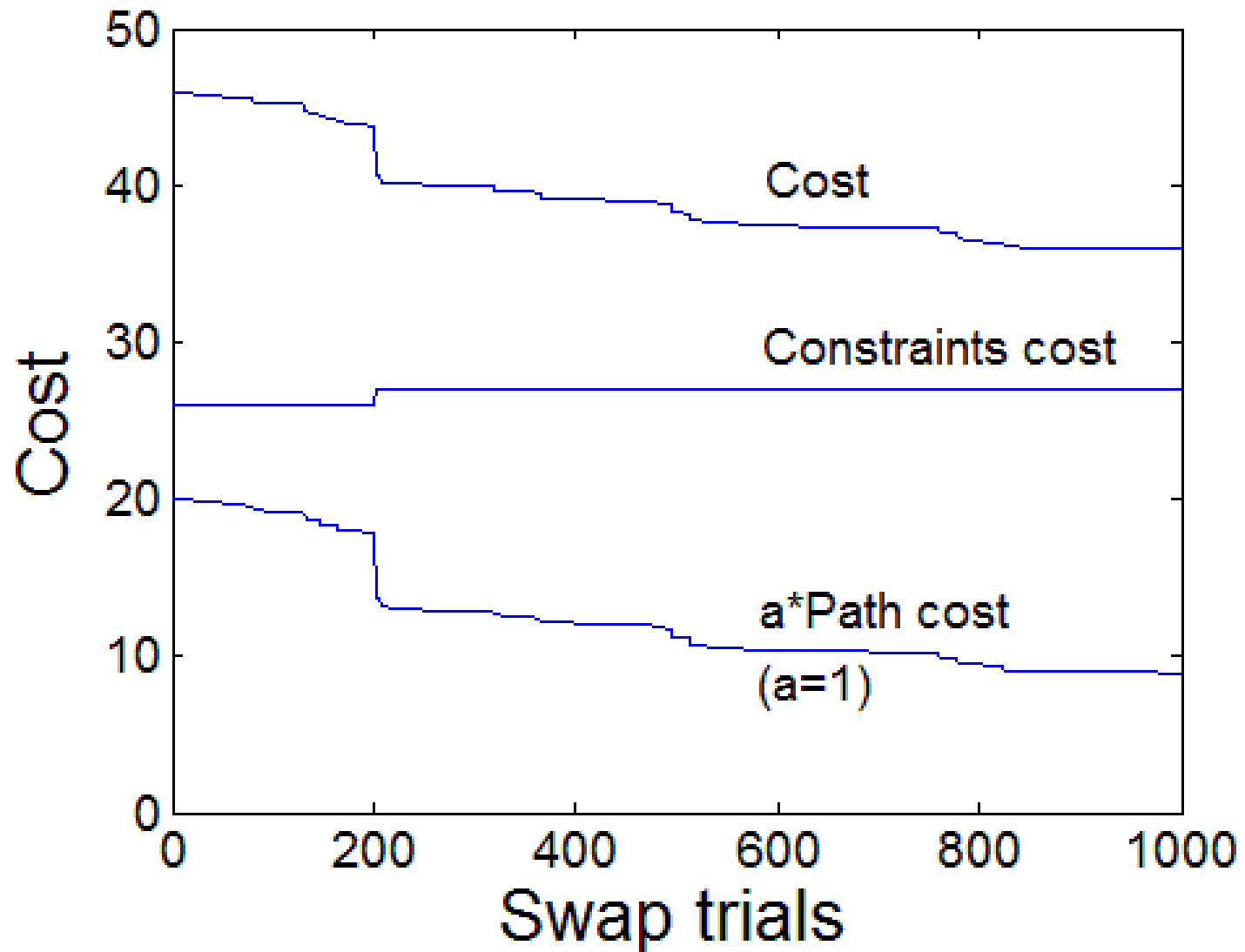

Cost function = Constraints cost + a×Path cost

User sets parameter a.
Local search = making swaps between points
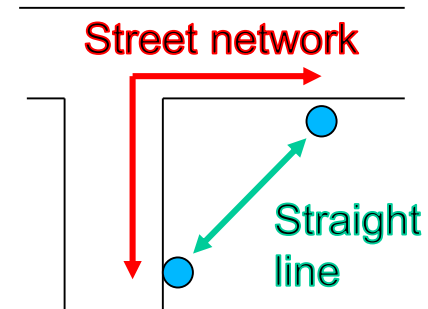(patients) in different clusters (workers)

Experiment with straight line distance vs. street network distance

We compared partitions created by using

- straight line distance

- street network distance

In comparison we used the Adjusted Rand validity index (ARI) between the partitions. It's range is from 0 (totally different partitions) to 1 (same partitions). Result:

ARI = 0.23

This means, that the partitions are different.

The optimization may be run on web

http://cs.uef.fi/homer/