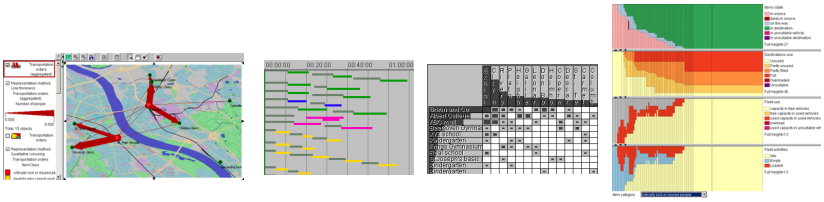


Visual Analytics Approach to User-Controlled Evacuation Scheduling

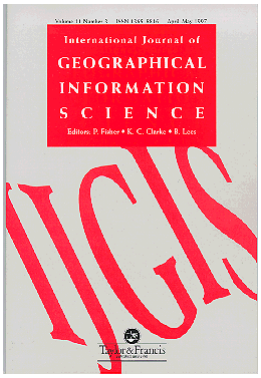
Natalia & Gennady Andrienko, Ulrich Bartling
Fraunhofer Institute IAIS
Sankt Augustin
Germany
http://www.ais.fraunhofer.de/and

Fraunhofer Institut Intelligente Analyse- und Informationssysteme

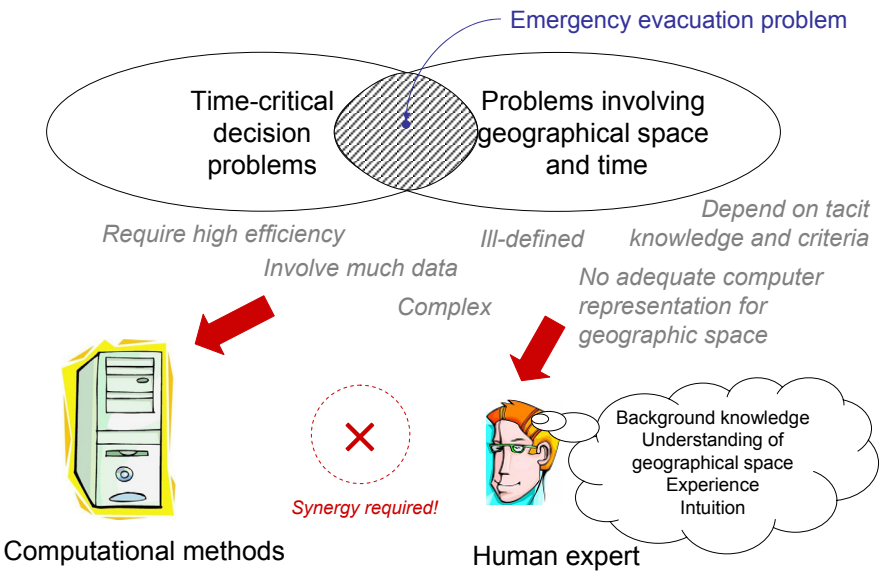
Outline

- Introduction
- Problem analysis and task-oriented design
- Example work scenario
- User-controlled schedule modification
- Conclusion

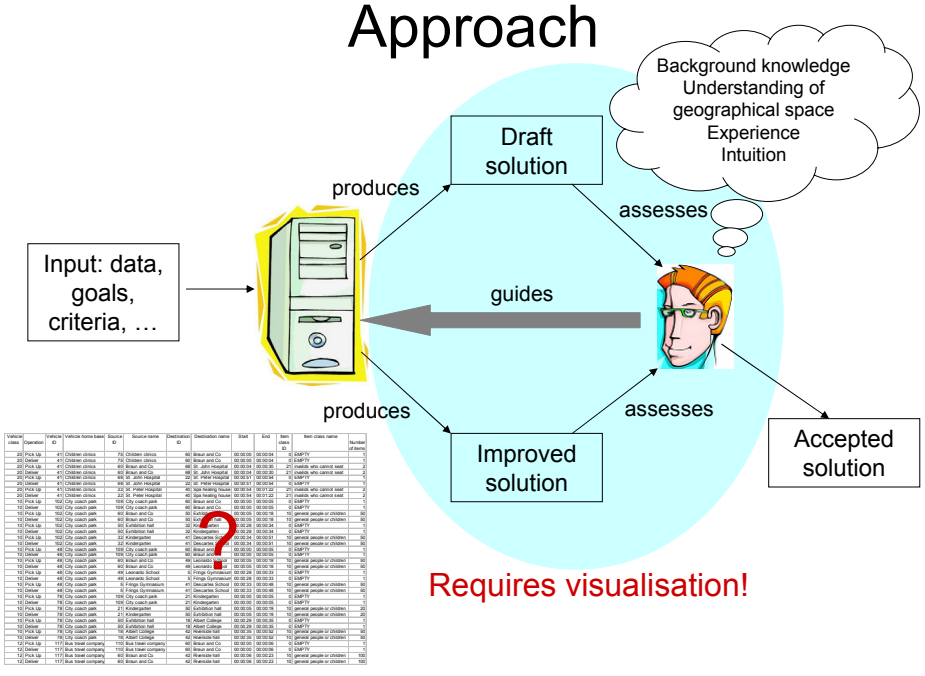
"GeoVisual Analytics for Spatial Decision Support: Setting the Research Agenda", IJGIS, 2007, v.21(8)



In particular: specifics and complexities of decision problems involving geographical space and time



Approach



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Emergency evacuation problem

- Several categories of people
  - General public; critically sick or injured people; disabled people who can/cannot sit, prisoners, …
- Multiple source locations
  - Number of people of different categories
  - Time constraints (e.g. latest allowed departure time)
- Multiple destinations
  - Suitability and capacity for different categories
- Different types of vehicles
  - E.g. buses, ambulance cars, police vans, …
  - Suitability and capacity for different people categories
- Task:
  - divide people into groups fitting in available types of vehicles
  - assign the groups to suitable destinations
  - find appropriate vehicles to deliver them
  - set the times for the trips of the vehicles

Scheduling Algorithm

- For transportation problems, heuristic methods work better than deterministic approaches
- We apply Breeder Genetic Algorithm *(devised by Bartling & Muehlenbein)*
- Extended functionality as compared to typical tools for business applications:
  - Divides the total number of people in a location into groups fitting in available vehicles
  - Chooses an appropriate destination for each group
- “Any-time” method:
  - valid solution exists at any moment
  - while the quality is progressively improved as the algorithm continues its work

Algorithm output

e.g.
- 14 source locations
- 4692 people
- 6 categories
- 105 vehicles
- 7 vehicle types
- 25 destinations

~ 400 transportation orders

OrderId	SourceName	DestName	ItemClass	Number	VhcId	VhcType	VhcHBName	StartTime	EndTime
12-4	St. John Hospital	St. Peter Hospital	LEER	0	12	20	University clinics	00:32:40	00:40:40
72-1	Braun and Co	Exhibition hall	general people or children	50	72	10	City coach park	00:11:00	00:20:40
61-4	Albert College	Descartes School	general people or children	40	61	10	City coach park	00:31:00	00:50:20
29-1	Braun and Co	Rehabilitation Centre	critically sick or injured people	1	29	21	Children Clinics	00:05:00	00:11:20
63-0	City coach park	ABC mall	LEER	0	63	10	City coach park	00:00:00	00:11:00
43-6	Beethoven Gymnasiu	Galileo College	general people or children	50	43	10	City coach park	00:48:20	01:11:00
53-0	City coach park	ABC mall	LEER	0	53	10	City coach park	00:00:00	00:11:00
12-1	St. Peter Hospital	University clinics	invalids who cannot seat	2	12	20	University clinics	00:08:00	00:16:10
56-3	Kindergarten	Plato Gympasium	general people or children	50	56	10	City coach park	00:33:20	00:50:00
58-4	Albert College	City hall	general people or children	20	58	10	City coach park	00:37:00	00:43:40
46-0	City coach park	Real school	LEER	0	46	10	City coach park	00:00:00	00:13:00
43-1	ABC mall	Leonardo School	general people or children	20	43	10	City coach park	00:12:00	00:21:40
58-5	City hall	Albert College	LEER	0	58	10	City coach park	00:44:40	00:50:40
91-2	Elder home	Children Clinics	sabled people using wheelchairs	8	91	13	Bus travel compan	00:27:40	00:36:00
86-0	Bus travel company A	Albert College	LEER	0	86	10	Bus travel compan	00:00:00	00:11:00
61-1	Braun and Co	City hall	general people or children	40	61	10	City coach park	00:11:00	00:23:40
23-0	Children Clinics	Braun and Co	LEER	0	23	20	Children Clinics	00:00:00	00:05:00
47-1	Braun and Co	Helmholtz Gymnasium	general people or children	50	47	10	City coach park	00:11:00	00:24:40
40-5	Beethoven Gymnasiu	St. Teresa's school	general people or children	20	40	10	City coach park	00:28:40	00:44:40
52-4	St.Joseph's basic sch	Helmholtz Gymnasium	general people or children	50	52	10	City coach park	00:34:20	00:44:00
20-3	Elder home	Children clinics	invalids who cannot seat	2	20	20	St. John Hospital	00:26:20	00:33:30
103-0	Jailhouse	Prison	LEER	0	103	30	Jailhouse	00:00:00	00:46:00
11-0	St. Peter Hospital	Braun and Co	LEER	0	11	21	St. Peter Hospital	00:00:00	00:08:00
17-1	Braun and Co	Children clinics	critically sick or injured people	1	17	21	University clinics	00:16:00	00:22:20
6-2	Braun and Co	Children clinics	invalids who cannot seat	2	6	20	St. Peter Hospital	00:17:20	00:23:30
58-3	Exhibition hall	Albert College	LEER	0	58	10	City coach park	00:22:00	00:37:00
54-2	City hall	Albert College	LEER	0	54	10	City coach park	00:25:20	00:31:20
52-2	Braun and Co	City hall	general people or children	40	52	10	City coach park	00:13:20	00:25:40
44-0	City coach park	Braun and Co	LEER	0	44	10	City coach park	00:00:00	00:11:00
52-5	Helmholtz Gymnasiur	St.Joseph's basic schc	LEER	0	52	10	City coach park	00:45:40	00:53:40
61-3	City hall	Albert College	LEER	0	61	10	City coach park	00:25:00	00:31:00
25-6	University clinics	St. Peter Hospital	LEER	0	25	20	Children Clinics	00:47:00	00:55:00
61-0	City coach park	Braun and Co	LEER	0	61	10	City coach park	00:00:00	00:11:00
81-5	Albert College	Heighbourhood House	general people or children	40	81	10	City coach park	00:56:00	01:08:20

- No time to inspect all the orders!
- Cannot be summarized in a few indicators!

Schedule evaluation

Questions to be answered:

- Does the plan achieve the goal?
  - Goal: all people are timely delivered to appropriate destination places by appropriate vehicles
- Is it feasible?
- Is it rational?

Possible problems

Undelivered people	Can emerge due to lack or deficiency of resources Require human to find appropriate corrective measures (additional vehicles, additional or intermediate destinations, …)
Late deliveries w.r.t. time constraints	
Use of improper vehicles	
Delivery to improper places	
Overuse of resources	Excluded by the algorithm, but correctness should be demonstrated
Multiple vehicles in same place	May be a problem or an advantage; requires human's local knowledge
Idle vehicles	Lower priority; may be examined when time permits
Choice of distant destinations	
Low use of vehicle capacities	

Effectiveness problems (i.e. goal not attained) | Feasibility problems | Rationality problems

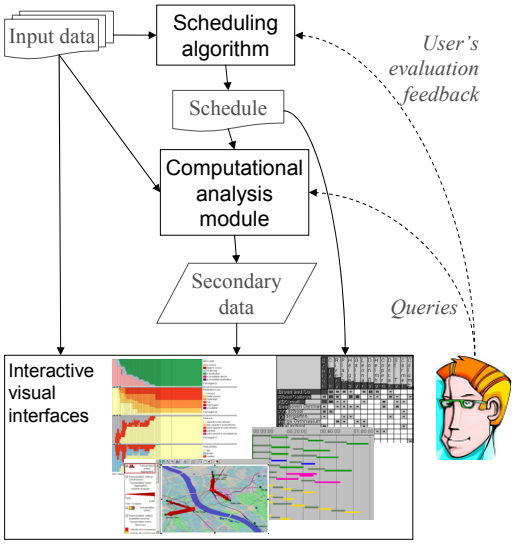
Requirements

- The *presence or absence* of effectiveness and feasibility problems must be immediately visible
- In case of problems, the *reasons* must be immediately seen or easy to find out
  - Undelivered people, use of improper destinations ⇐ lack of suitable destinations
  - Late deliveries, use of improper vehicles ⇐ deficiency of suitable vehicles
  - Multiple vehicles in same place: examine each place individually
- It must be possible to spot and explore rationality problems when time permits

Visual Analytics Approach

'Visual Analytics Mantra' by D.Keim:

Analyze First –
Show the Important –
Zoom, Filter and Analyze Further –
Details on Demand



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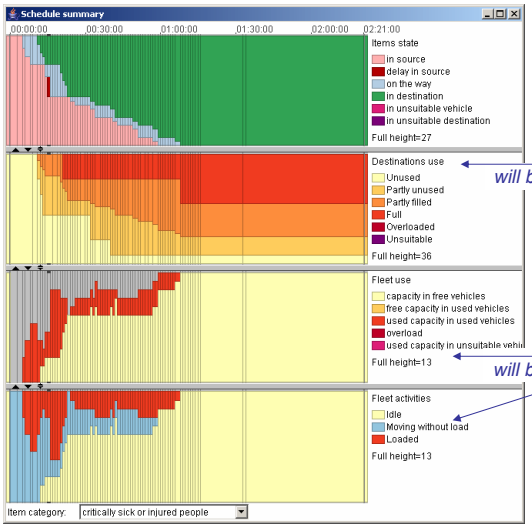
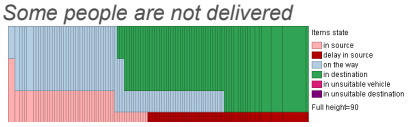
Analyze First – Show the Important

Summary display of the transportation progress:



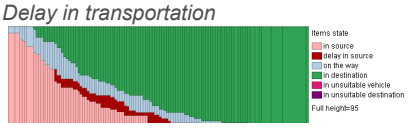
Signals of problems:

Some people are not delivered



will be seen here — *Reason: lack of destinations*

Delay in transportation

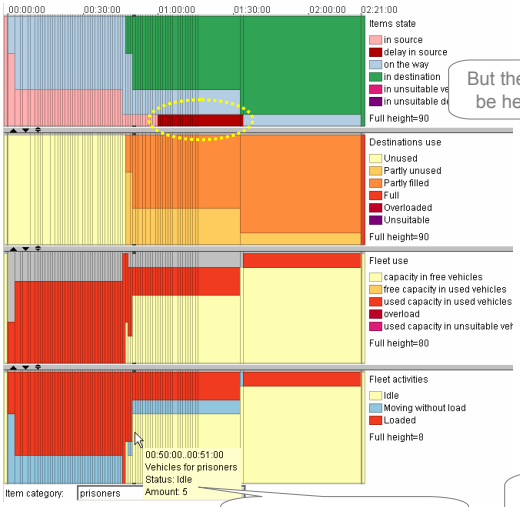


will be seen here — *Reason: not enough vehicles*

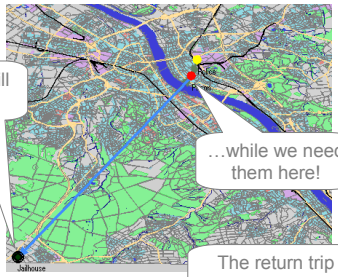
Not always the reason is evident…

Zoom, Filter and Analyze Further

Find a non-evident reason for a delay



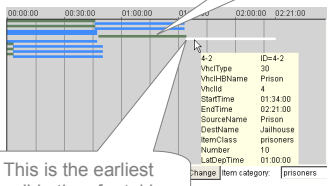
At this time we shall have 5 free vehicles!



But they will be here…

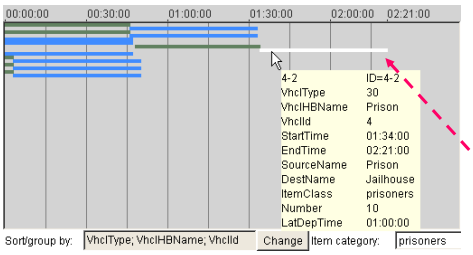
…while we need them here!

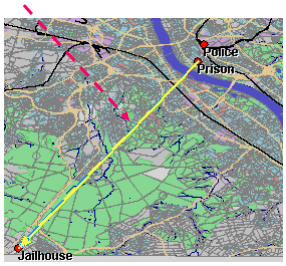
The return trip takes 47 minutes



This is the earliest possible time for taking the remaining prisoners

Details on demand

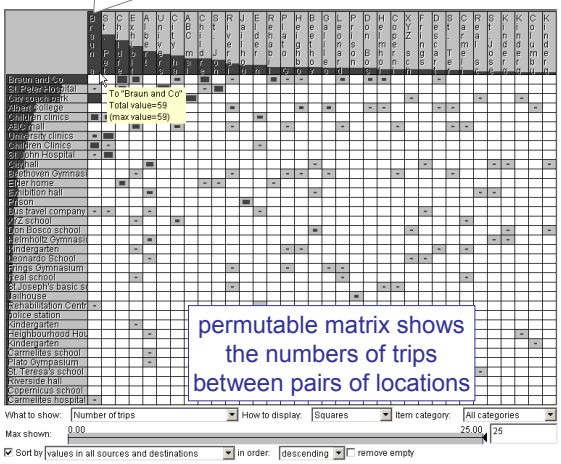




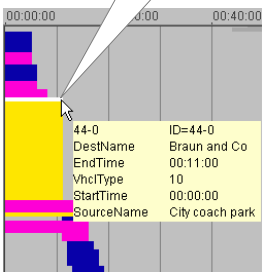
Zoom, Filter and Analyze Further

Check the feasibility

So many trips to 'Braun and Co'!
How are they distributed in time?

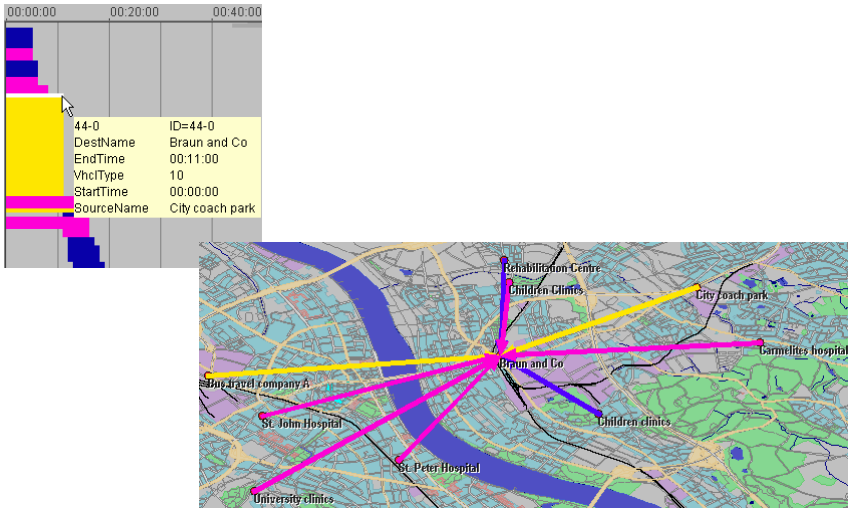


23 buses come simultaneously!



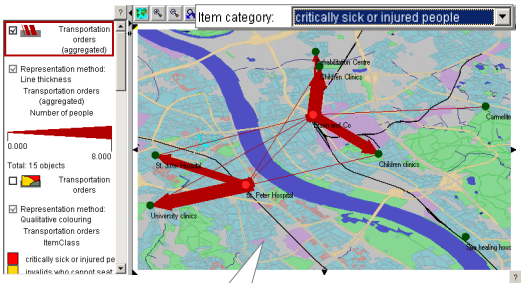
…but this is a big chemical plant with a large parking

Details on demand



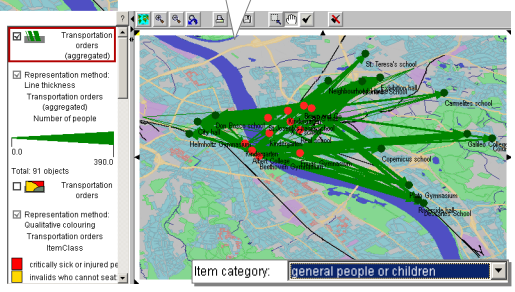
Zoom, Filter and Analyze Further

Assess the rationality



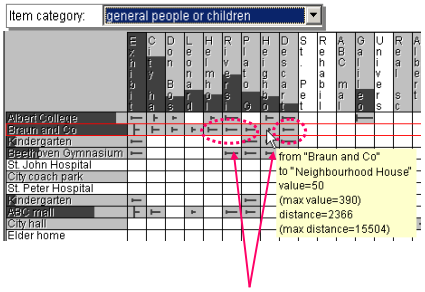
The choice of the destinations for the critically sick and injured persons seems quite reasonable

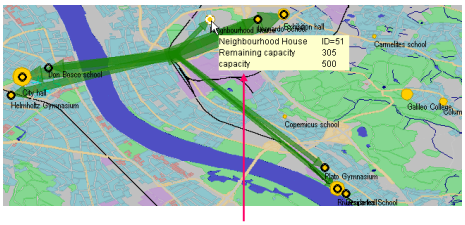
But it is hard to see anything when we focus on the general people…



Zoom, Filter and Analyze Further

Assess the rationality (continued)

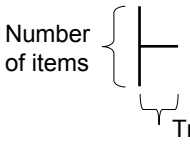




Some people will be moved quite far…

… while the capacities in the closer destinations are not fully used

T-shaped signs:



The planner may wish to change this…

if the time permits!

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Reasons for Schedule Modification

- Undelivered people
  - Requires finding additional destinations
- Unacceptable delays
  - Requires finding additional vehicles or closer destinations (possibly, intermediate)
- Multiple vehicles in same place
  - The planner may shift some orders forward in time
- Non-rational choice of destinations and use of capacities in destinations
  - The planner may exclude distant places
- Situation changes after the evacuation started
  - New people appear, some destinations become unavailable (e.g. roads blocked), some vehicles get out of use, trips take longer than expected, …

General Procedure

- Divide the orders into fixed and modifiable
  - by people category (e.g. 'critically sick' → fixed, 'prisoners' → modifiable)
  - by time: fix all trips starting before t
    - *in particular, for adapting to the changing situation*
  - by source location (e.g. from 'Braun and Co' → modifiable)
  - by a combination of these criteria
- Update the input data
  - Add data about new sources, people, resources
  - Remove unavailable resources
  - Correct the travel times
- Re-run the scheduling algorithm (it is appropriately designed)

Conclusion

- Solving complex problems related to space & time requires a synergy between computers and human experts
- Visual analytics methods can support this
- We did a task-oriented design of VA tools for schedule assessment
- We verified the adequacy of the tools
- Trials with users are planned