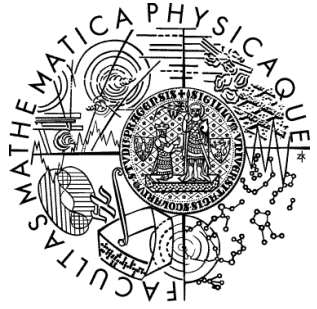

Multicriteria Navigation Systems

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Motivation

- *How to get from one place to another?*

- various types of **users/routes/transportation**
- multiple **levels** of transportation network
- various **sources** of information

Multi-modal path search

Different transportation characteristics	→	different methods of path search/navigation
Different transportation speeds	→	„highway hierarchy“ principles
Different information sources	→	integrating data from different sources

- Resulting connection should cover the combination of all relevant networks

Multi-criteria path search

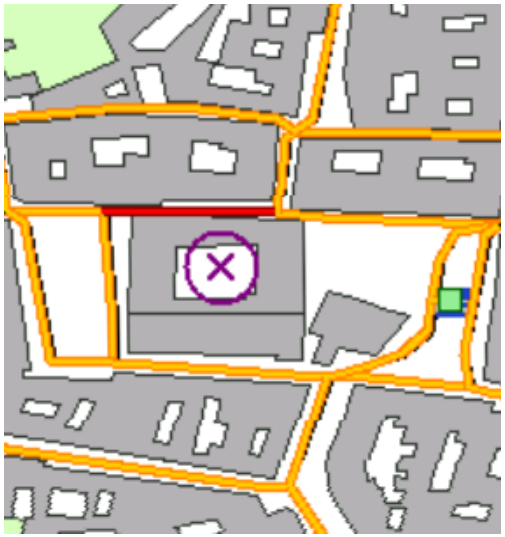
Multiple modes of transportation	→	different types of parameters
Various travellers/passengers	→	translating user requirements into path search parameters
Dynamic character of transportation networks	→	deriving ways to satisfy user requirements

JRGPS project

- Multi-modal navigation in town/city
  - Combines **public transport services** and **walk**
- Off-line application
  - No dependency on actual connection availability
  - Lower cost for everyday use
  - Actualization on demand
- Mobile devices
  - Limited computation capacity

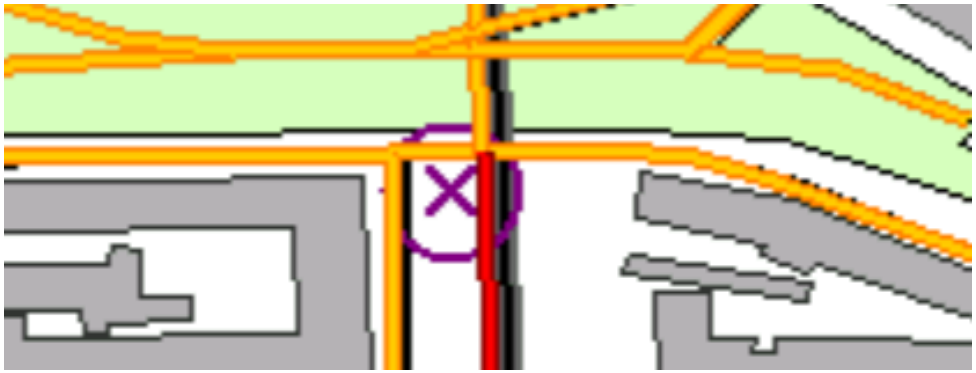
Issues of Pedestrian Navigation

- Pedestrian network
  - The path can typically start anytime
  - Time limited passages
  - **Starting position (GPS) must be within pedestrian network**
  - Public transportation refuges
  - …



Issues of Pedestrian Navigation

- Pedestrian network
  - The path can typically start anytime
  - Time limited passages
  - Starting position must be within pedestrian network
  - Public transportation refuges
  - **Grade-separated crossings**

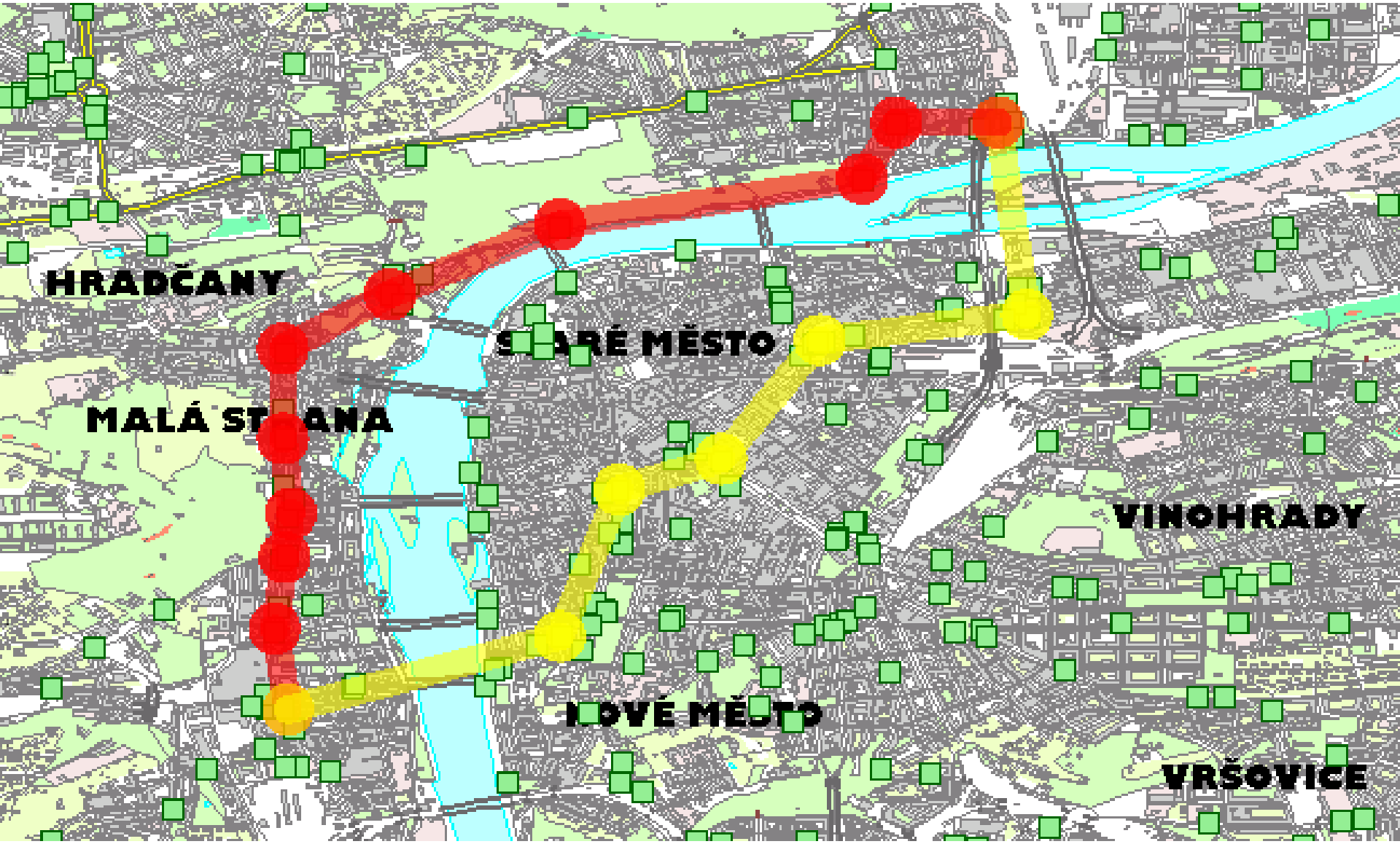


Issues of Pedestrian Navigation

- Pedestrian network
  - The transport can typically start anytime
  - Time limited passages
  - Starting position must be within pedestrian network
  - Public transportation refuges
  - Grade-separated crossings
  - Crosswalks, sidewalks
  - Superelevation, barriers, accessibility of the path

Issues of Navigation for Public Transportation

- Public transportation network
  - The path typically starts at certain moments or periodical intervals given by a timetables
  - **Path plan may be significantly different for two relatively close moments**
  - …


HRADČANY
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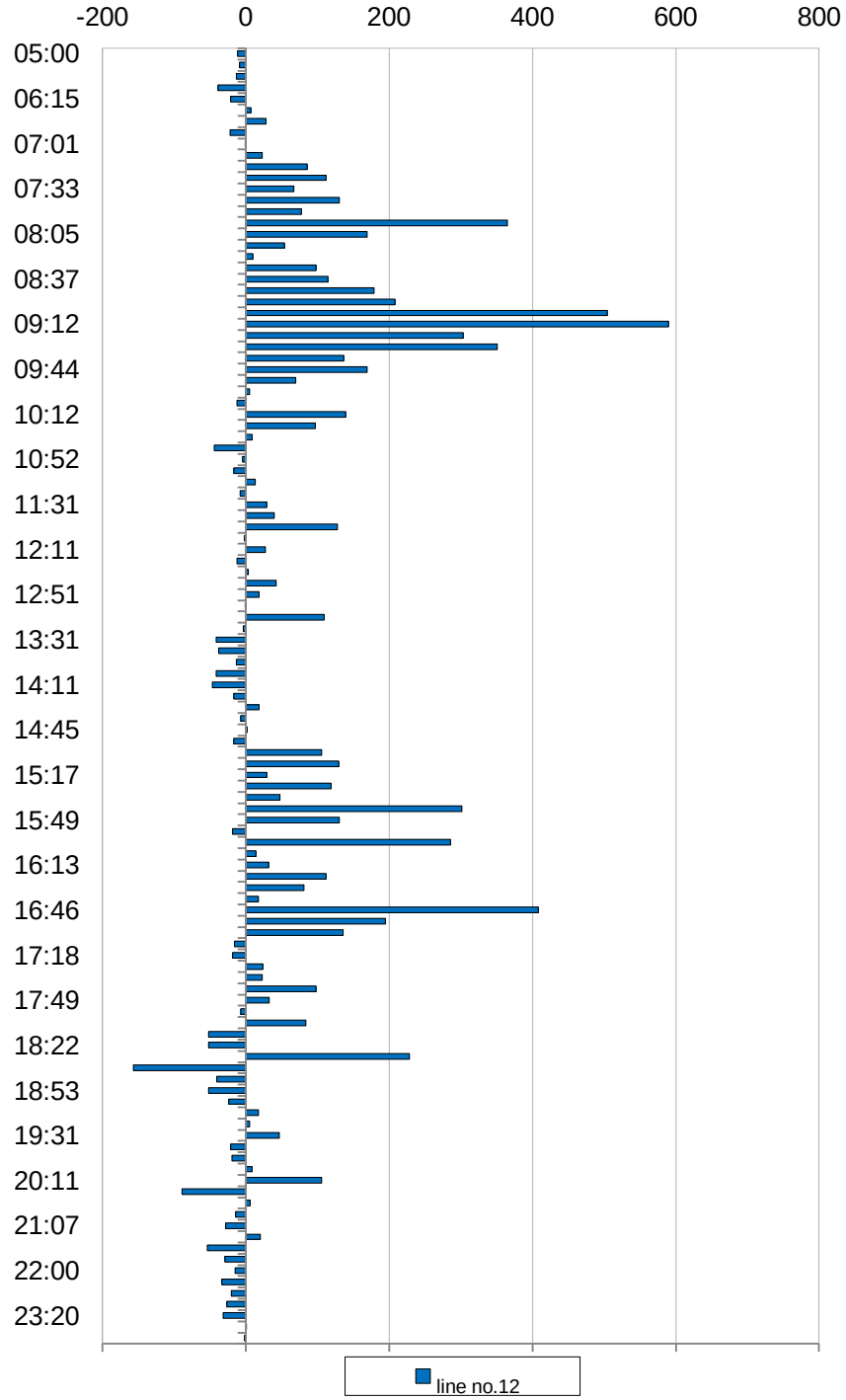
Issues of Navigation for Public Transportation

- Public transportation network
  - The path typically starts at certain moments or periodical intervals given by a timetables
  - Path plan may be significantly different for two relatively close moments
  - **Path reliability, frequency of services**
  - …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10:52
11:31
12:11
12:51
13:31
14:11
14:45
15:17
15:49
16:13
16:46
17:18
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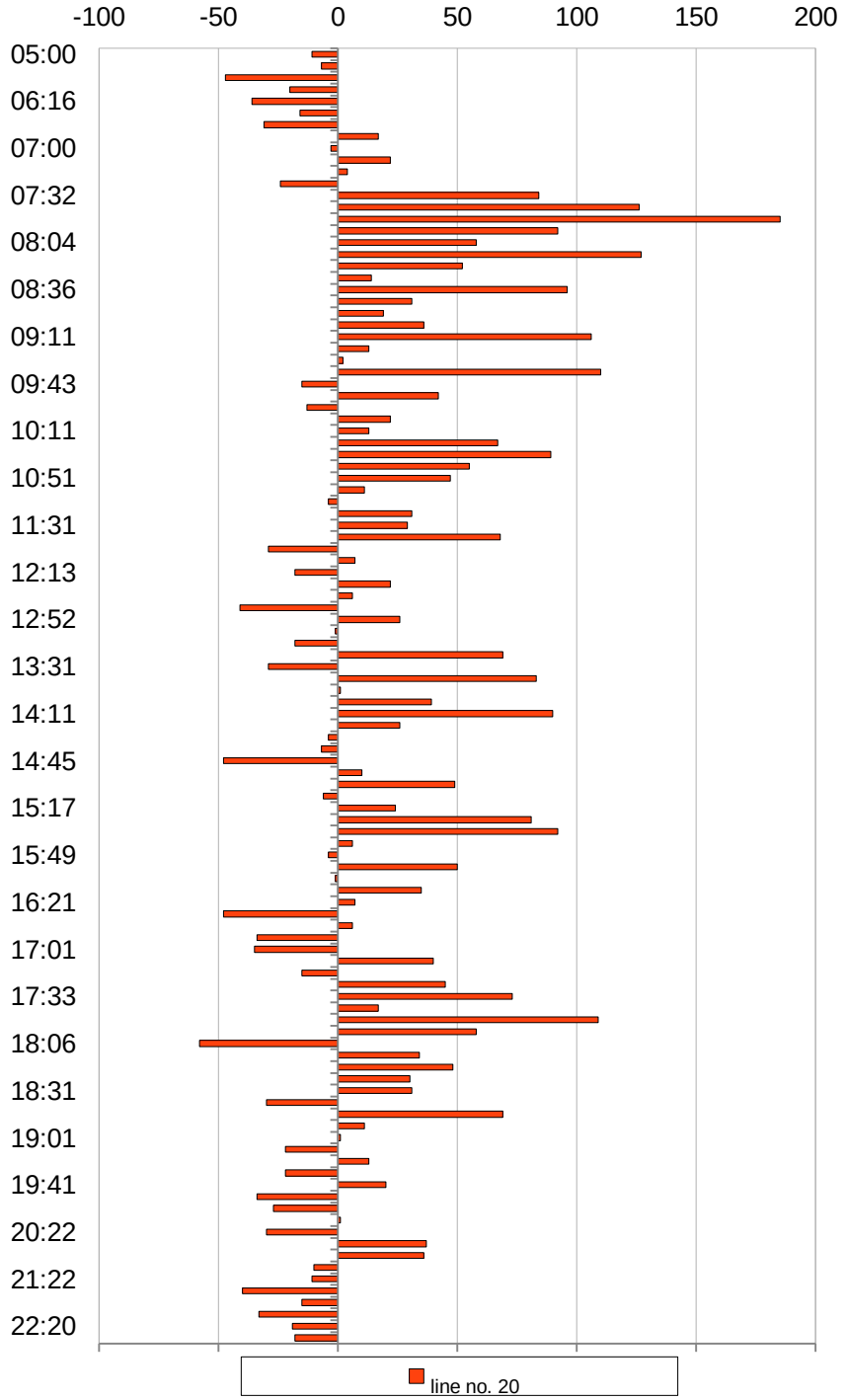
18:22
18:53
19:31
20:11
21:07
22:00
23:20
line no.12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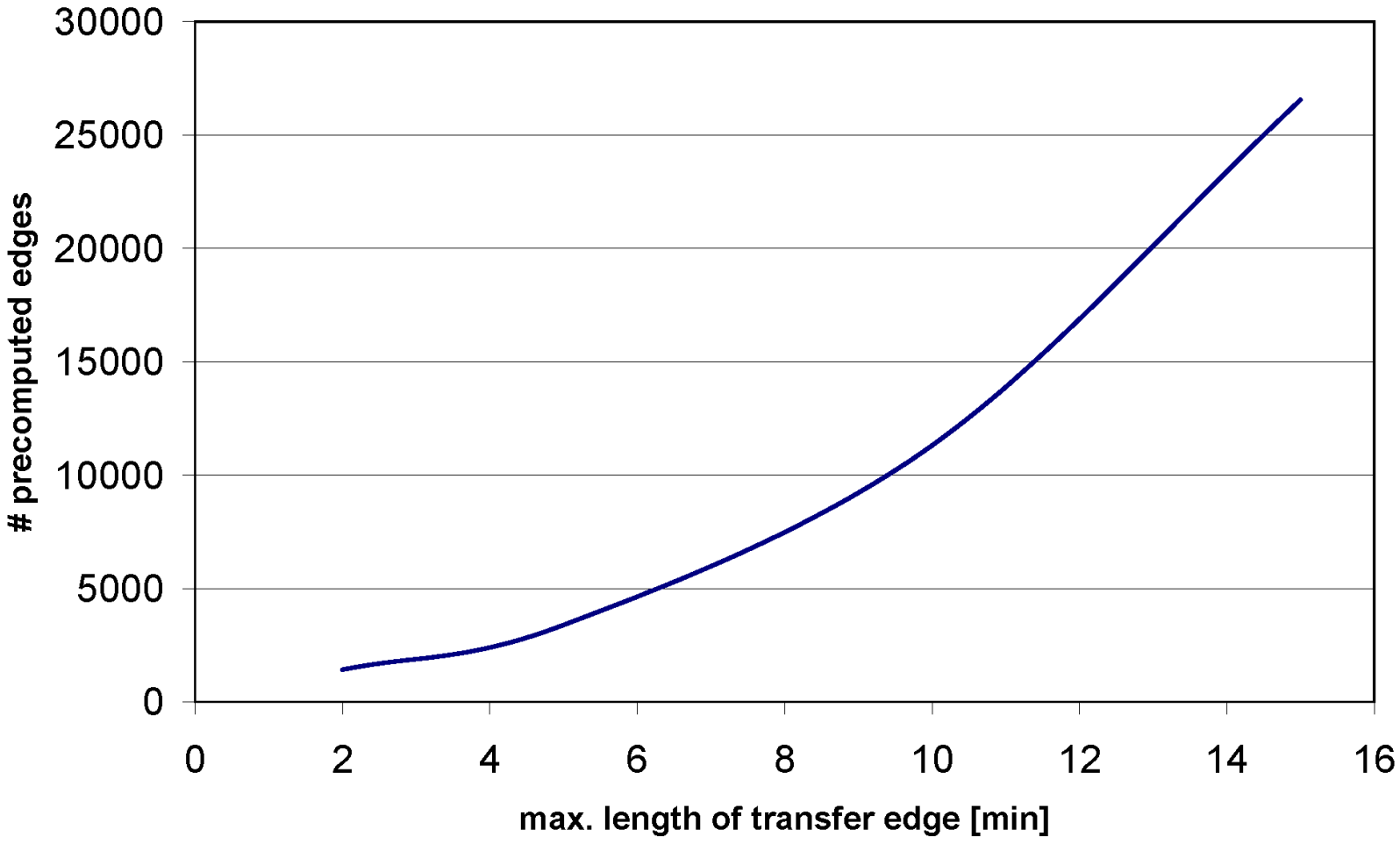
10:51
11:31
12:13
12:52
13:31
14:11
14:45
15:17
15:49
16:21
17:01
17:33
18:06
18:31
19:01
19:41
20:22
21:22
22:20
line no. 20

Issues of Navigation for Public Transportation

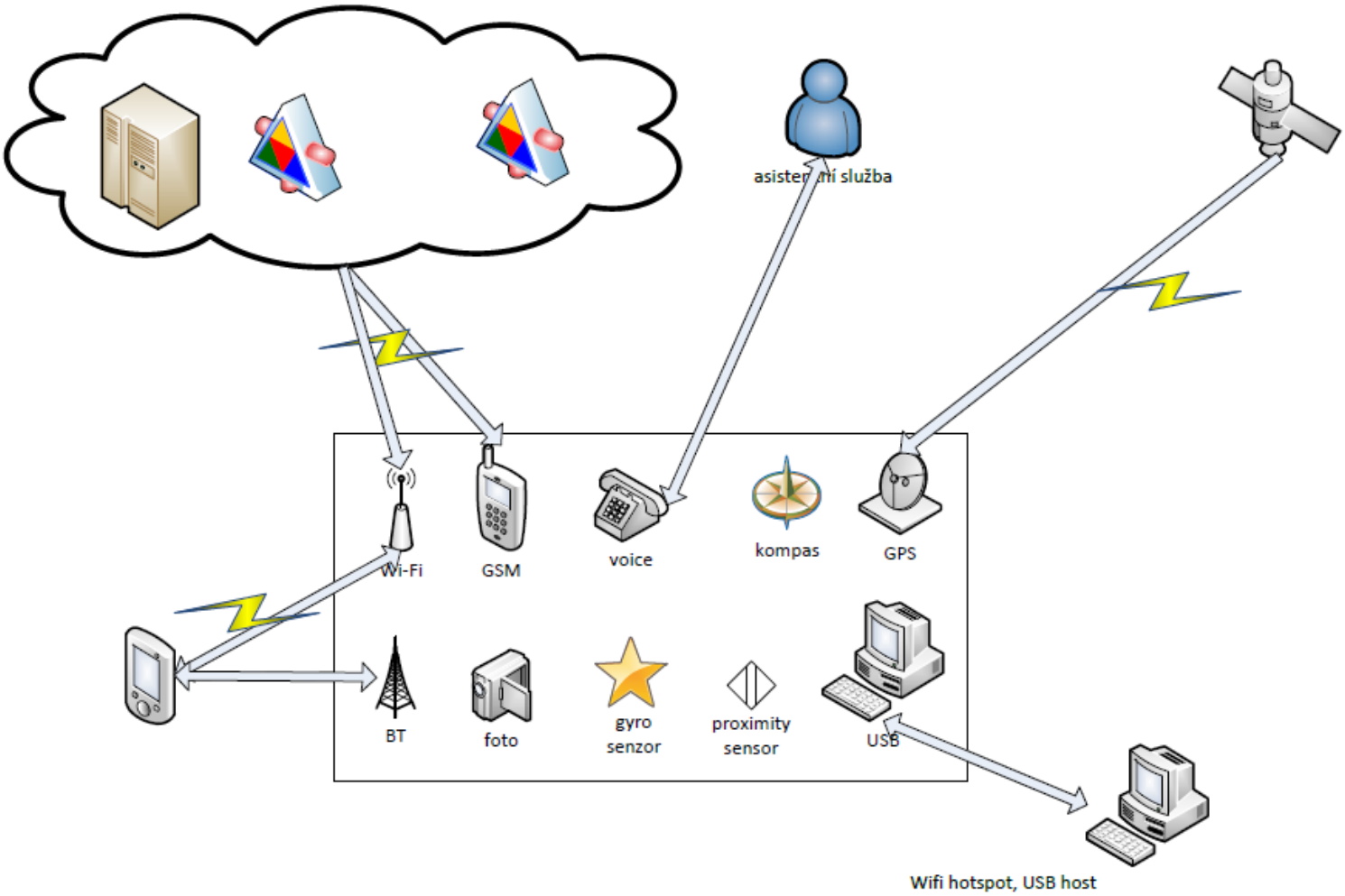
- Public transportation network
  - The path typically starts at certain moments or periodical intervals given by a timetables
  - Path plan may be significantly different for two relatively close moments
  - Path reliability, frequency of services
  - Time validity, exceptions
  - Length of platform, advantageous position within the vehicle

Connecting PTN and Pedestrian network – precomputation

- Searching walk transfer between stops of public transportation
  - Precomputed values saves computation time
  - The number of precomputed transfer edges grows strongly with the length of transfer
- The limit of length of precomputed transfer edges
  - High enough to make the connection search relevant
  - Low enough not to slow down the computation


30000
25000
20000
15000
10000
5000
0
precomputed edges
0
2
4
6
8
10
12
14
16
max. length of transfer edge [min]

Navigation for mobile devices

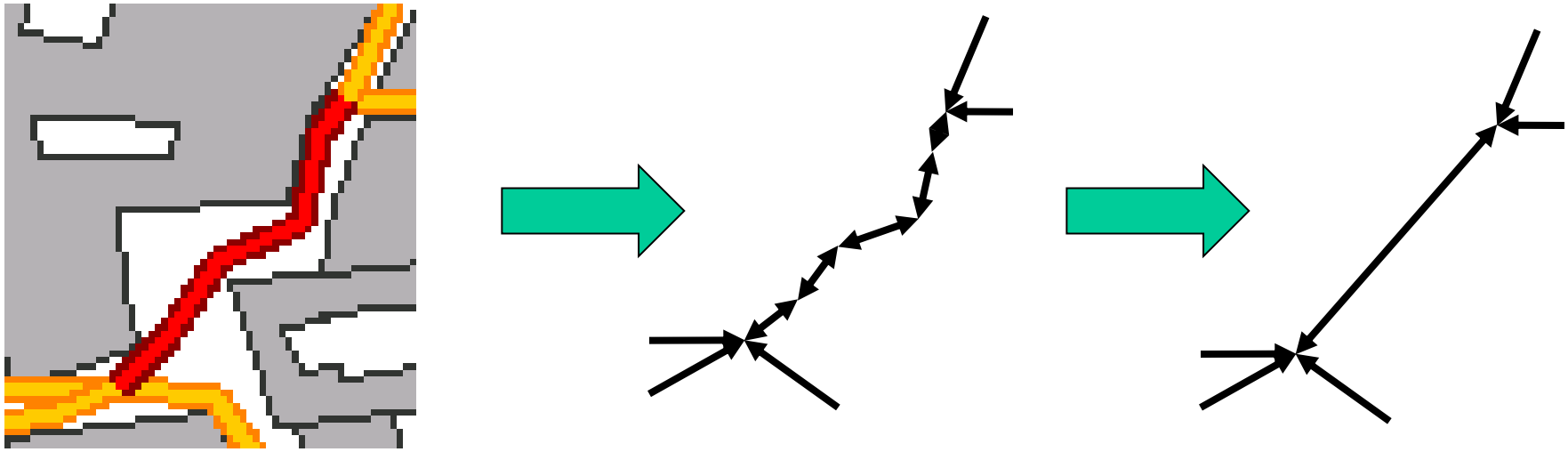


Navigation for mobile devices - advantages/disadvantages

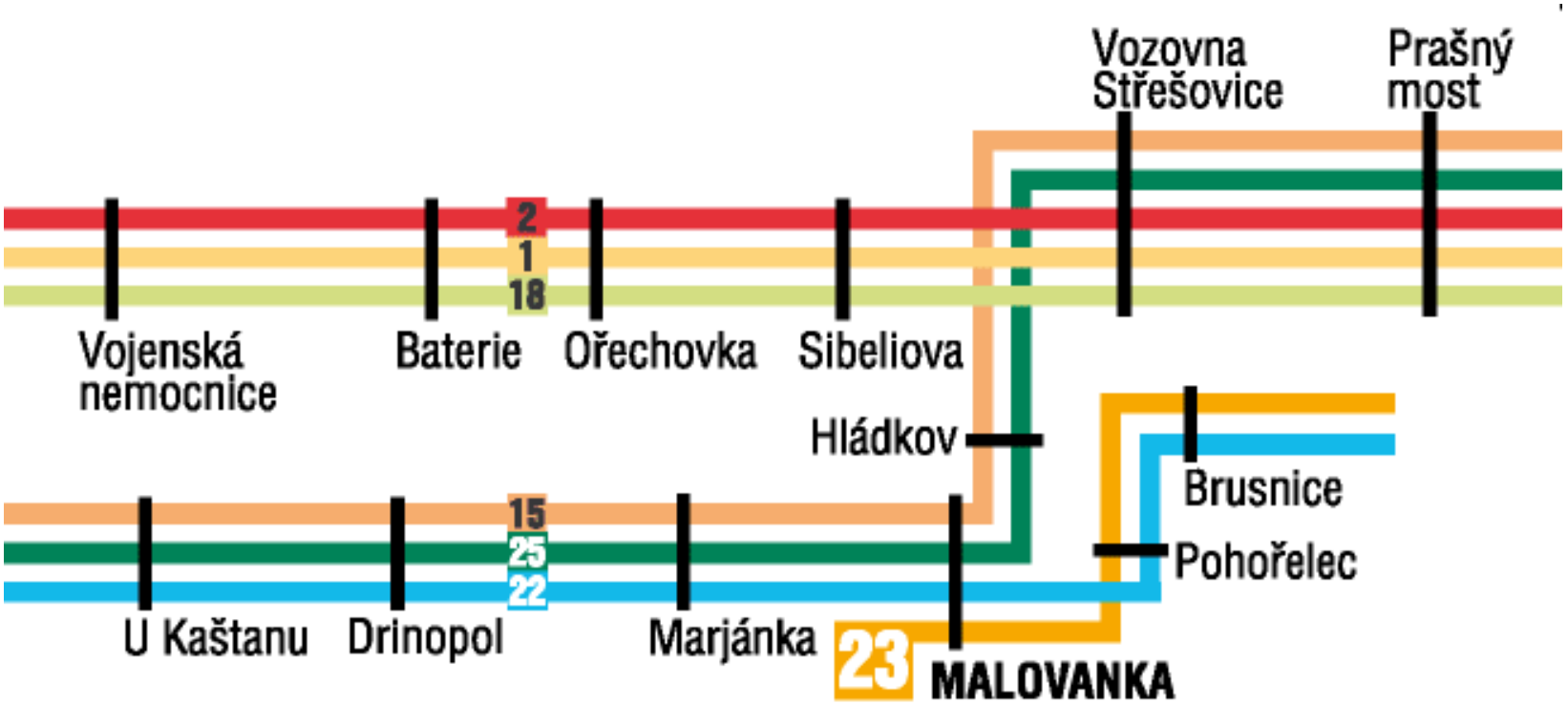
Connectivity	Limited resources
• Decomposition to services • Dynamic data updates	• Precomputation of transfers • Network reduction • Algorithm optimization

Pedestrian Network Reduction

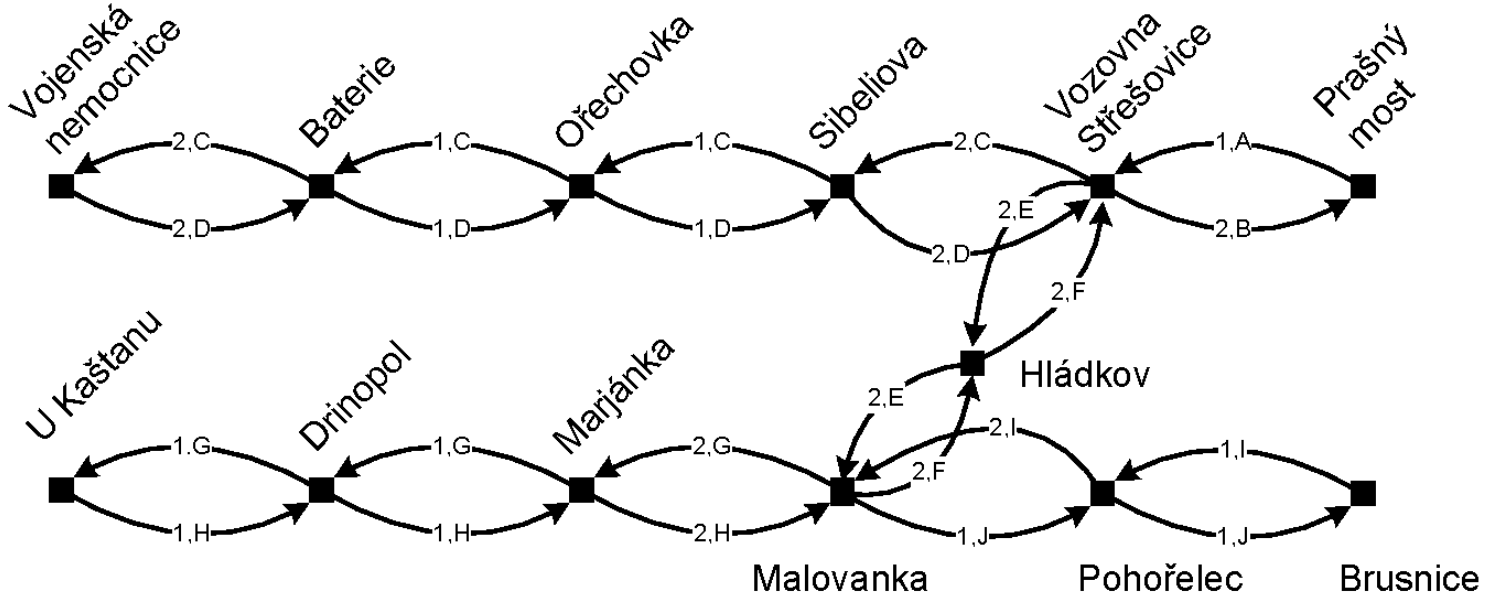
- The character of the path **is** important
  - Superelevation, barriers, accessibility of the path
- The shape of the street **is not** important



PTN Reduction, original network



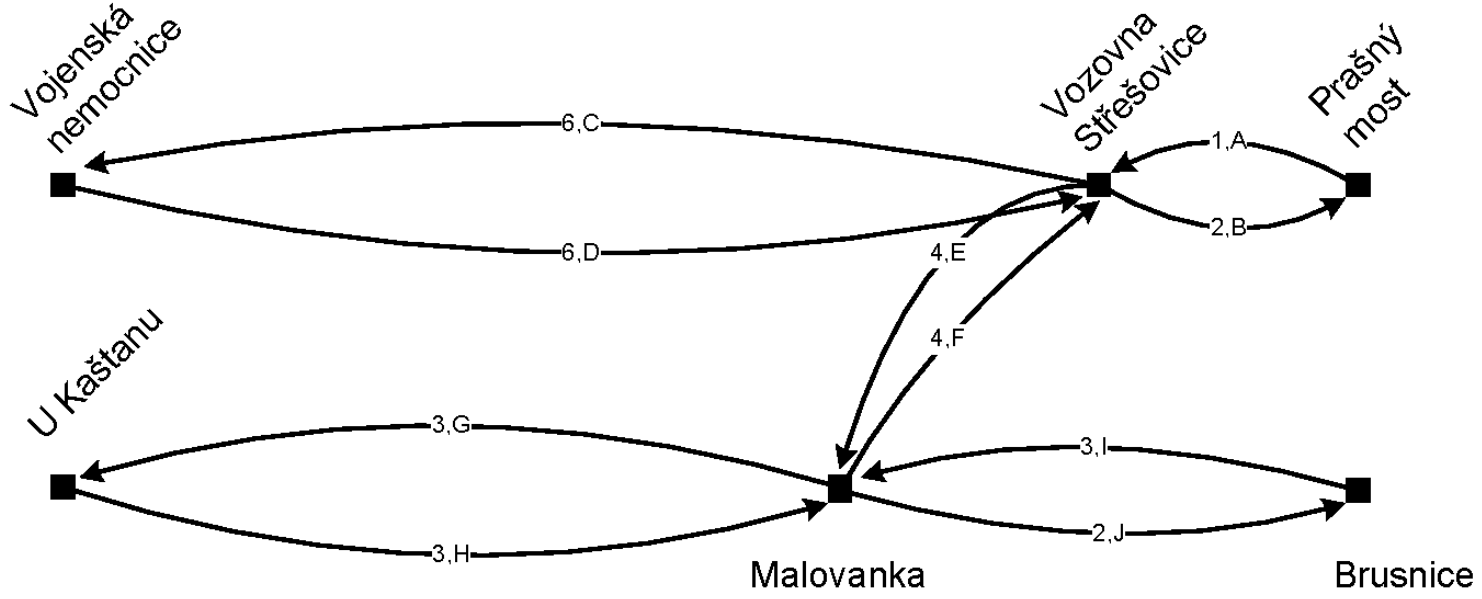
PTN Reduction, level 1



Malovanka ... stop

2,A ... connection realized by „pseudoline A“ with travel time 2 minutes

PTN Reduction, level 2

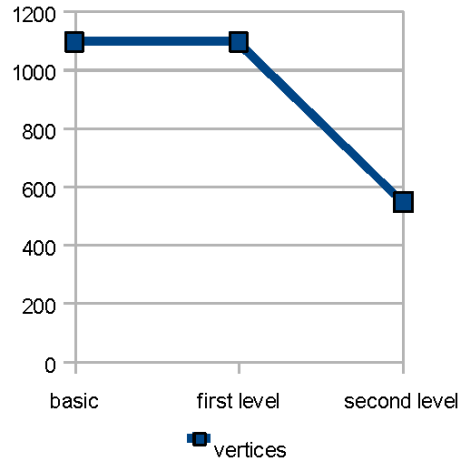


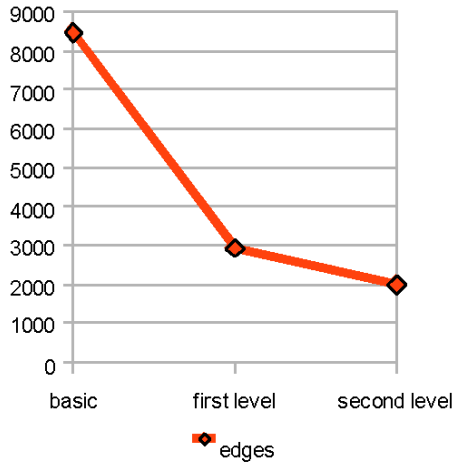
Malovanka ... stop

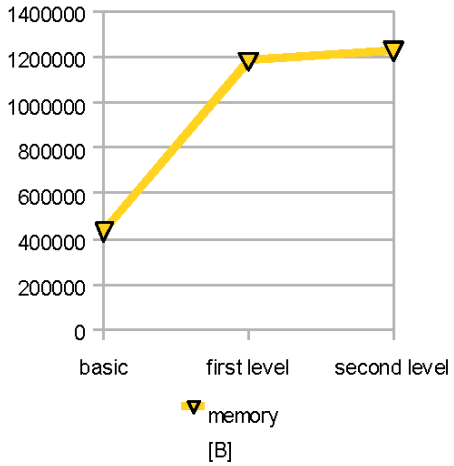
2,A ... connection realized by „pseudoline A“ with travel time 2 minutes

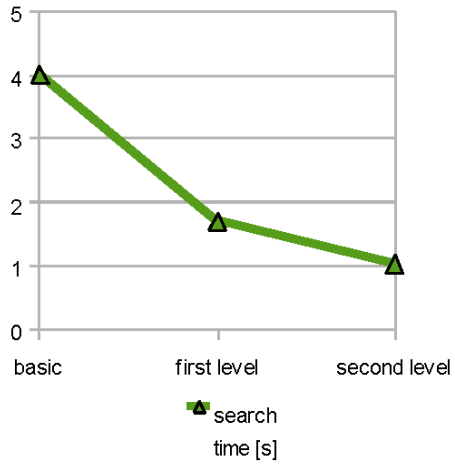
PTN Reduction

- Orthogonal solution

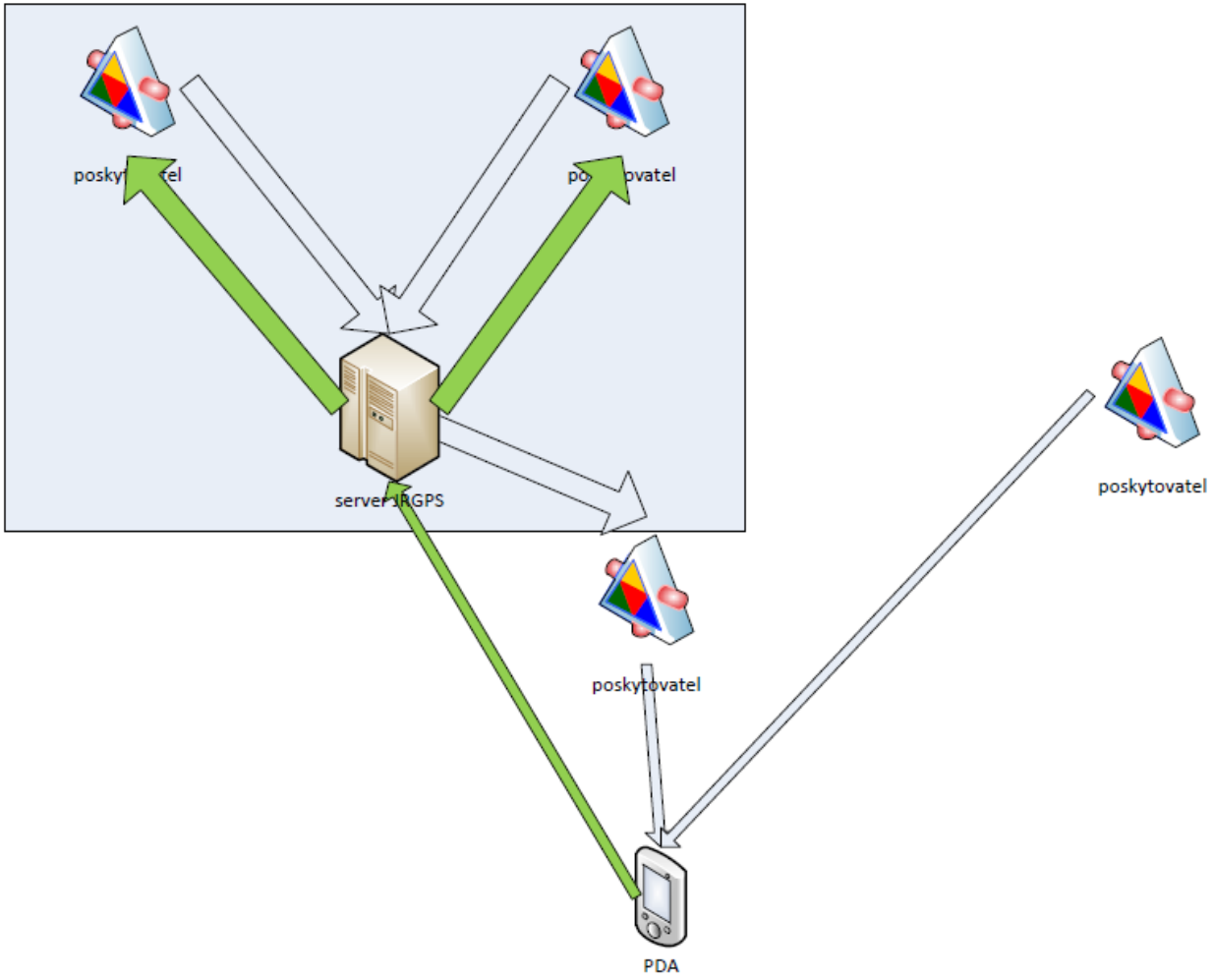




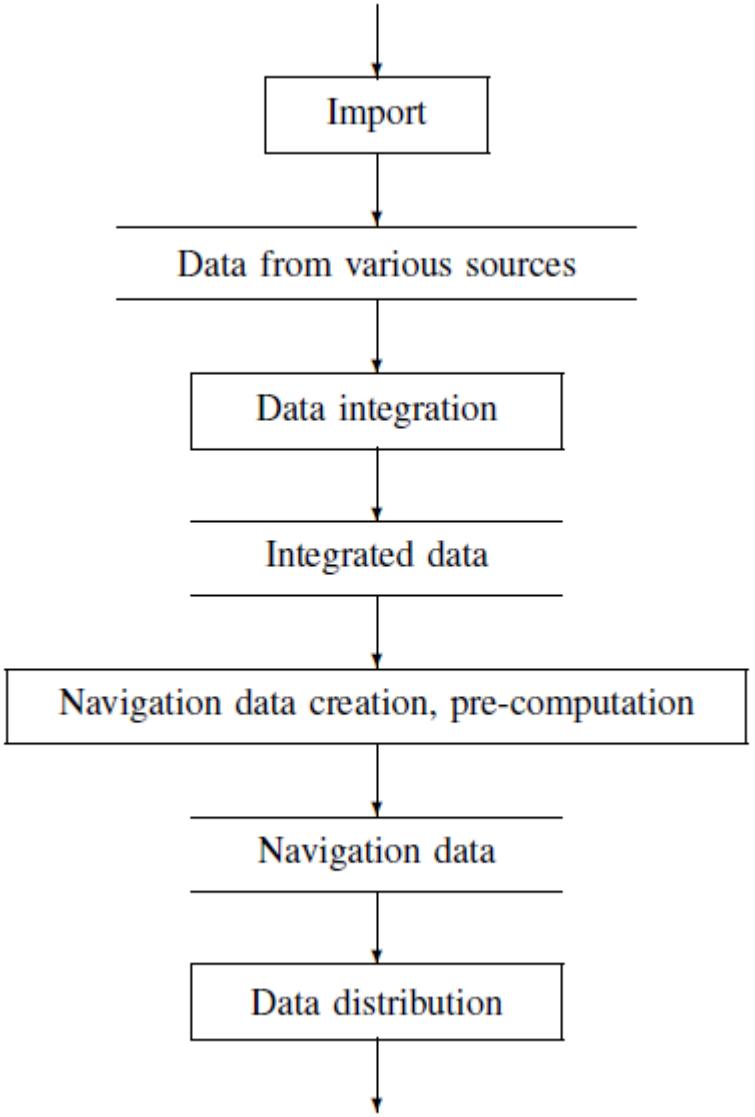


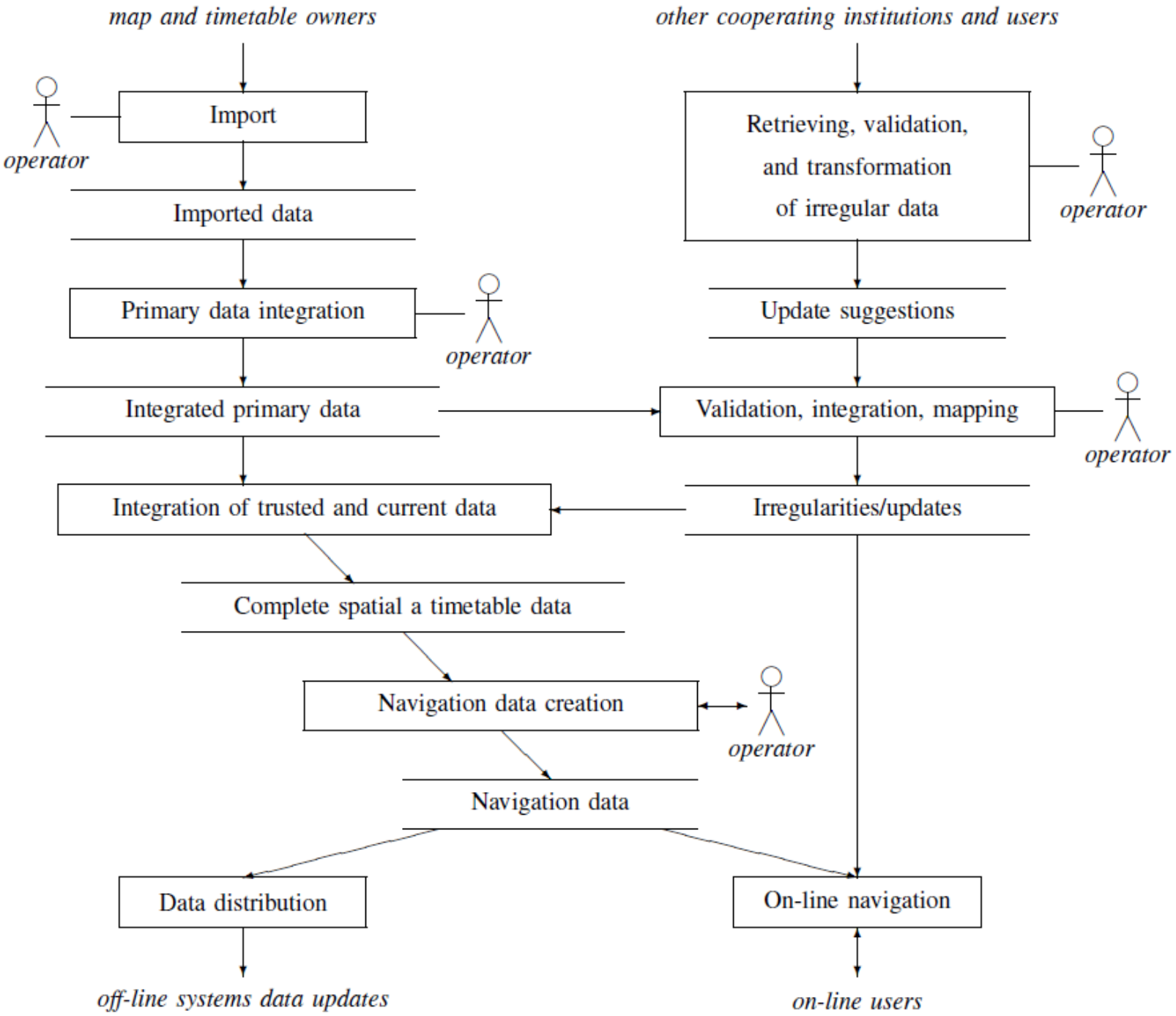


Decomposition to services



System structure



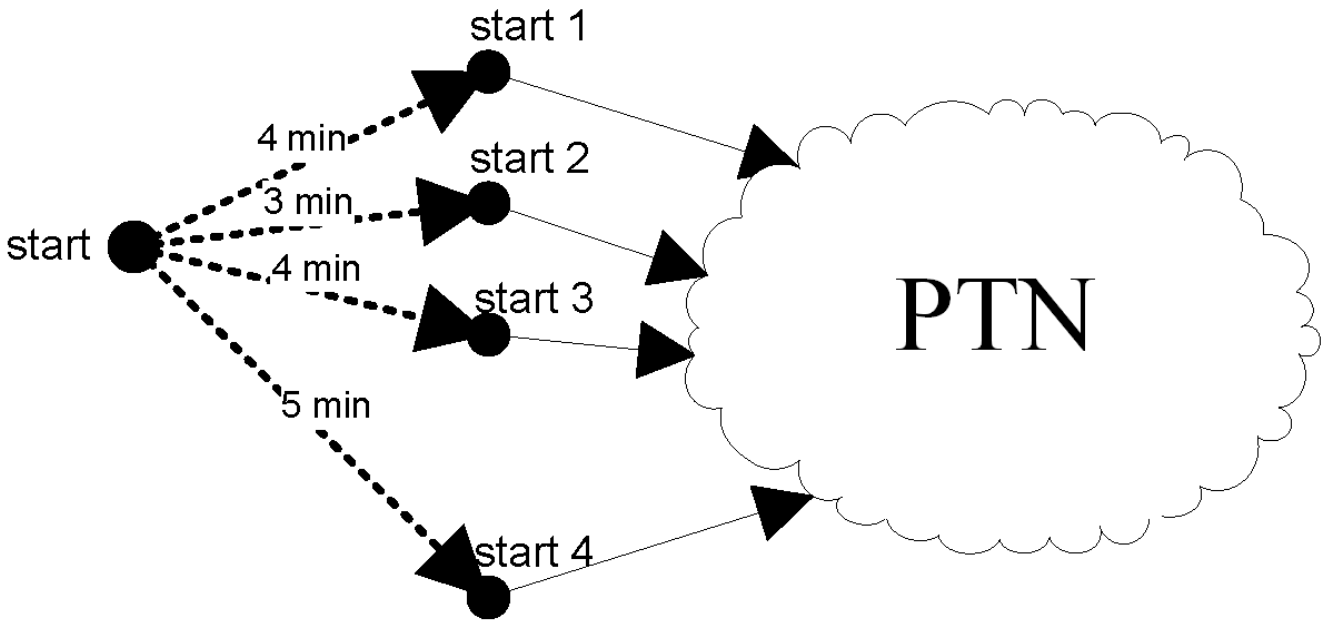

map and timetable owners
other cooperating institutions and users
operator
Import
Retrieving, validation,
and transformation
of irregular data
operator
Imported data
Primary data integration
operator
Update suggestions
Integrated primary data
Validation, integration, mapping
operator
Integration of trusted and current data
Irregularities/updates
Complete spatial a timetable data
Navigation data creation
operator
Navigation data
Data distribution
On-line navigation
off-line systems data updates
on-line users

Multiple criteria

- Traveller
  - walk speed, movement capabilities, dimensions, luggage, walk range, safety preference, reliability preference, umbrella, is late, group size
- Network
  - transfers, cost, speed, frequency, comfort, latency, reliability, exclusions, failures, capacity of service
- Path
  - time, cost, miss resistance, reliability, weather, traffic situation, failures, actual load of service

User friendly

- User places
  - Predefined „home“, „office“, etc.



Combining networks – Complex Navigation

- Time dependent path sections
  - Does not tolerate late coming passengers
- Time independent path sections
  - Can be moved in time to satisfy various conditions

Conclusion

- Complex navigation systems have a strong potential
  - Hierarchy of transportation networks
  - Multi-criteria path search
- Both on-line and off-line services have advantages
  - Our off-line solution proves, that the computation capacity of today‘s mobile devices is sufficient
- Proper navigation of pedestrians requires very detailed map base