PTV GROUP

the mind of movement

MapMatching – Why? How?

Bernd Welter

Manager Technical Consulting
Works for PTV since 2000
Located in Karlsruhe

xServer Key user
Administrator xServer Forum
xSamples developer

Agenda

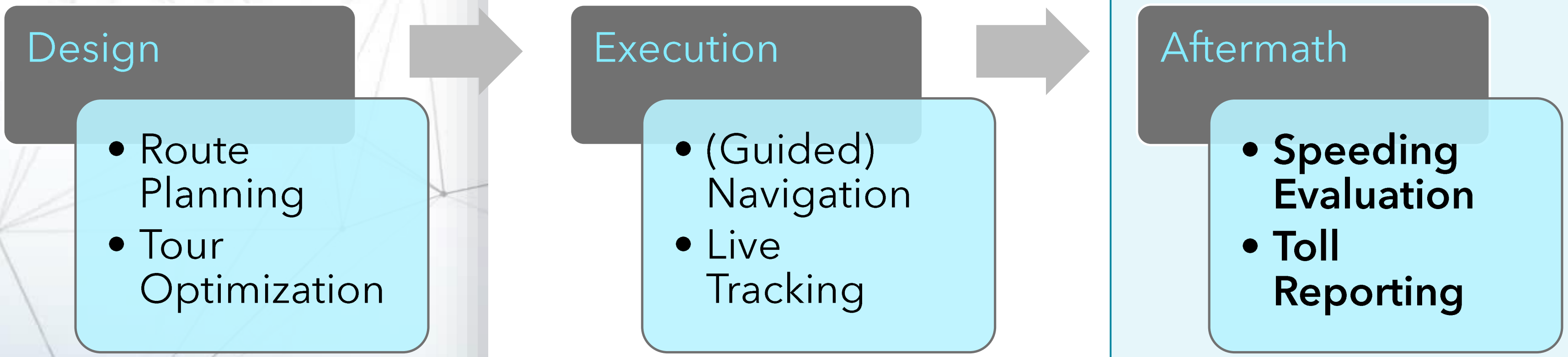
1.	Usecase Overview	(TC)
2.	Introduction	(TC)
3.	Technical Overview	(DEV)
4.	Server Configuration	(DEV)
5.	Discussion	(*)

PTV GROUP
the mind of movement

Introduction

Workflow

1. What is the idea behind map matching?
2. What is it used for?



Design
- Route Planning
- Tour Optimization

Execution
- (Guided) Navigation
- Live Tracking

Aftermath
- **Speeding Evaluation**
- **Toll Reporting**

Sensors record data

- GPS position
- Date / Time
- Speed
- Heading
- …

Sensor data available for

- Post processing

PTV GROUP
the mind of movement

Usecases

Usecases

1. Did the drivers **follow a given route**?
   e.g. security transport
   → quality of service
   (Attention: separate LIVE/alert from aftermath/report)

2. Did the drivers **care for the speed** limits?
   e.g. insurance companies
   → reduced tarifs

3. What is the **toll amount** on a specific route?
   e.g. cross check with subcontractors
   → reduce costs
   → don’t pay too much
   → pay what they deserve

Goals

Today we want to give answers to the following questions

1. What details can be used as **input parameters**?
   (e.g. coordinates, timestamp, …)
2. What **methods** are available and which **result elements** do they return?
3. Which **parameters** should be understood by each MapMatcher client developer (API and profile)?
4. Which parameters are **"highend" style** and should be used in emergency case only?

If an answers are missing → check the MapMatch forum
https://xserver.ptvgroup.com/forum/viewforum.php?f=8

PTV GROUP
the mind of movement

Goals

In other words

1. We want you to understand the potential of the interface for your usecases
→ extend your application

2. Understanding the necessary params and config settings for correct and optimal usage
→ quality of output
→ performance

PTV GROUP
the mind of movement

PTV GROUP

the mind of movement

Map matching with xMapmatch

Johannes Stober
Pascal Muller-Molinet

Agenda

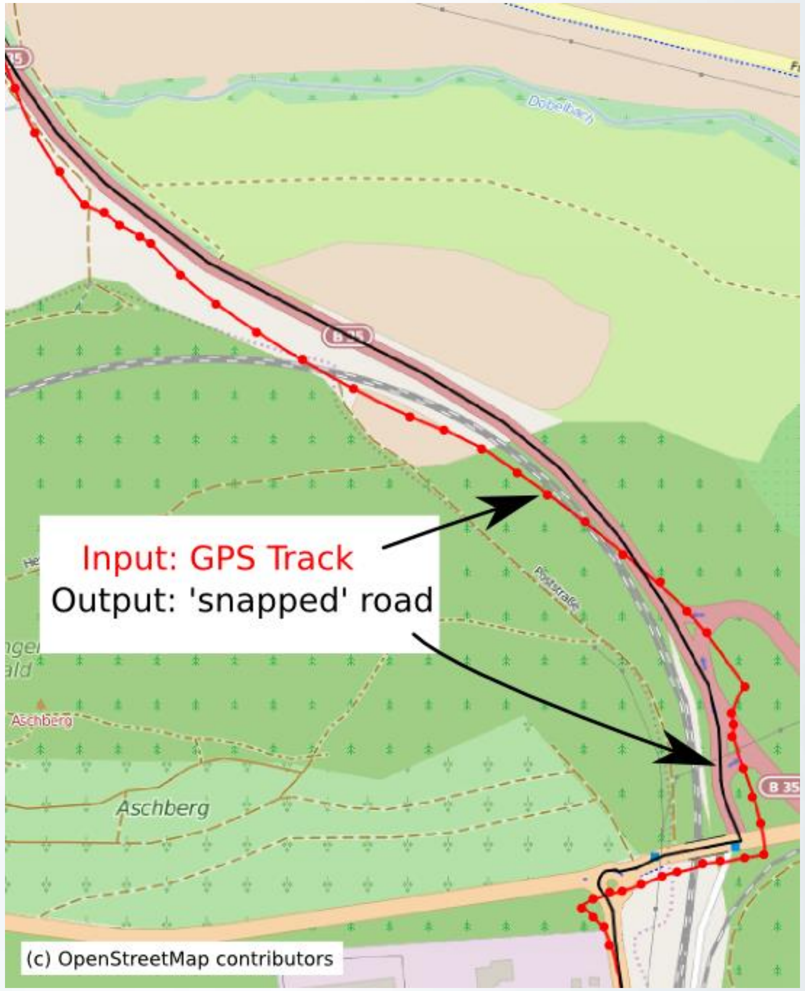
1. Introduction to map matching
2. Importance, challenges, constraints
3. Interface xMapmatch
4. Matching procedure
5. Parameterization of xMapmatch
6. Questions & discussion

PTV GROUP
the mind of movement

Introduction to map matching

„Map matching is the procedure to match geographic coordinates to a logical model of the real world."

- Most common: relate sequence of recorded location points (e.g. GPS) to edges of an existing road network graph (digital map)
- Result is a sorted list (coordinates, edges etc.) representing the travel of a person or a vehicle (so-called *trajectory*)



Input: GPS Track
Output: 'snapped' road

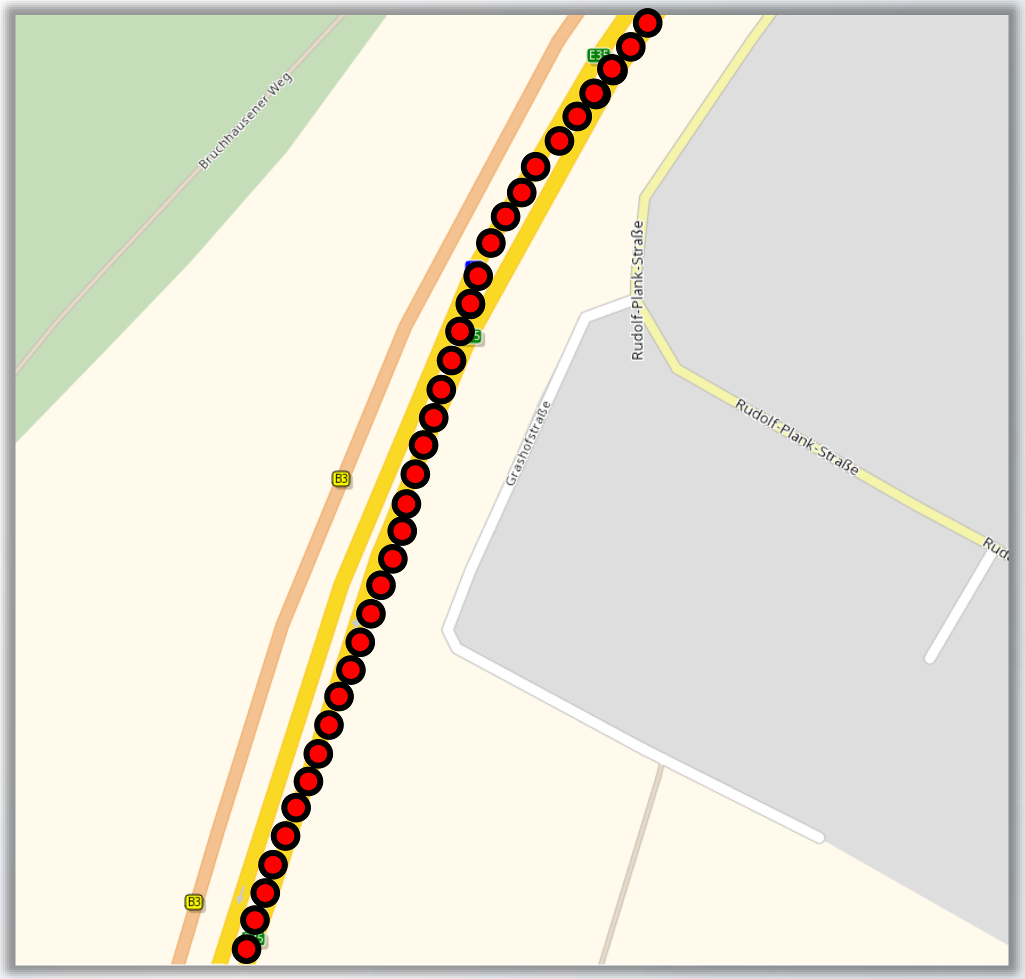
(c) OpenStreetMap contributors

Importance and challenges

„Having parallel roads/lanes: how to decide the correct one?"

Examples:

- Highway lanes in both directions
- Parallel roads in urban areas



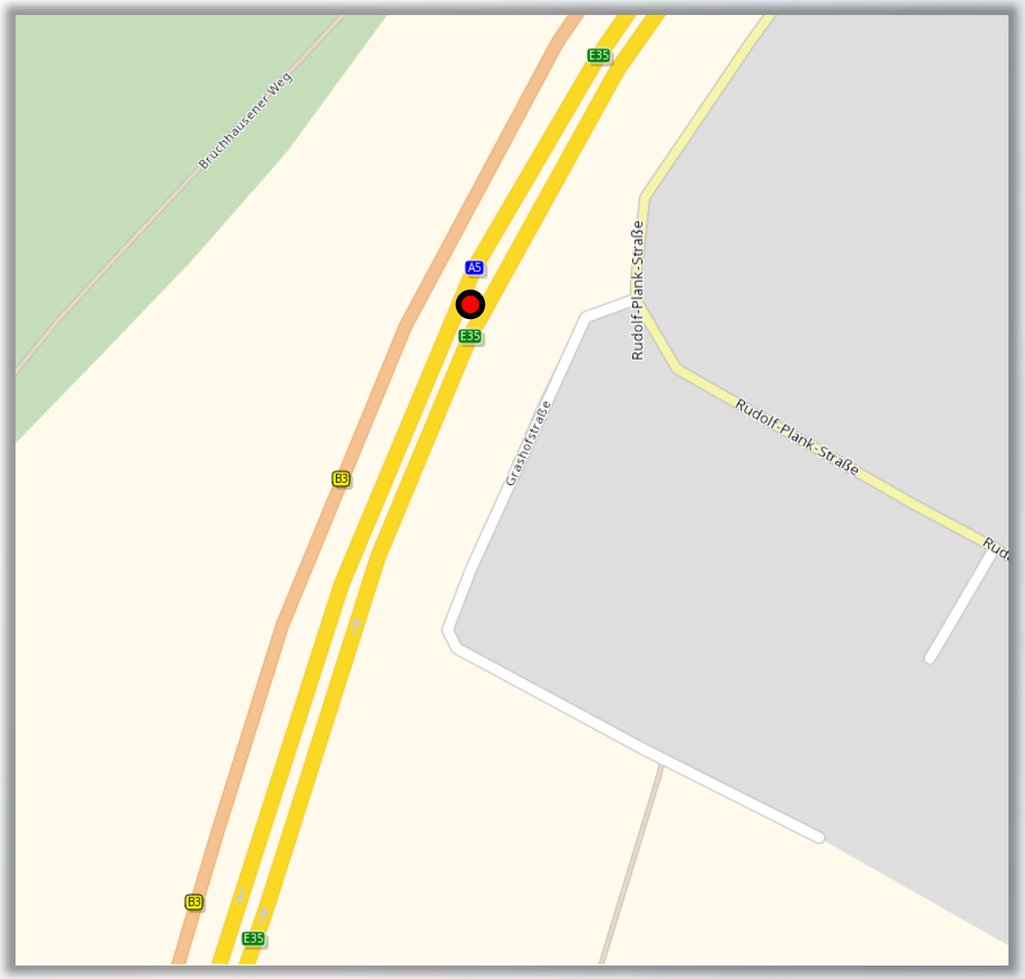
PTV GROUP
the mind of movement

Importance and challenges

„Having parallel roads/lanes: how to decide the correct one?"

Examples:

- Highway lanes in both directions
- Parallel roads in urban areas



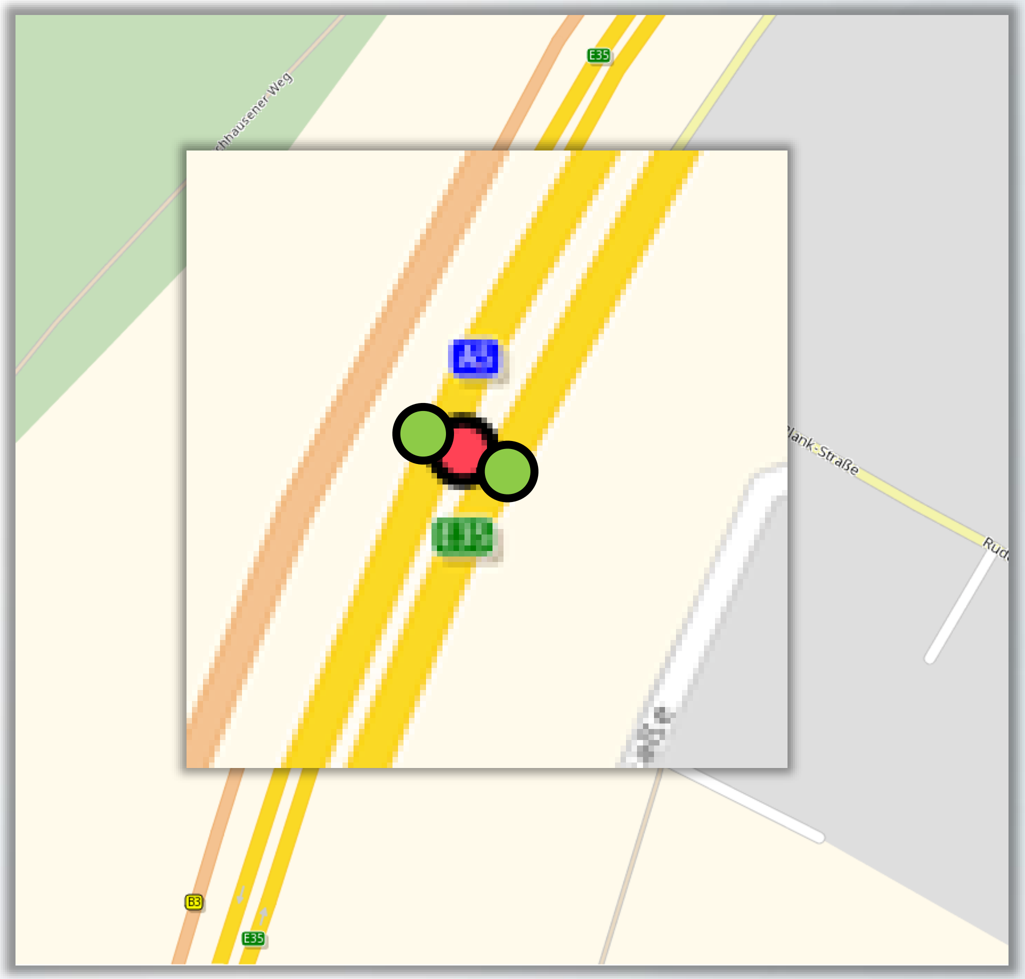
PTV GROUP
the mind of movement

Importance and challenges

„Having parallel roads/lanes: how to decide the correct one?“

Examples:

- Highway lanes in both directions
- Parallel roads in urban areas

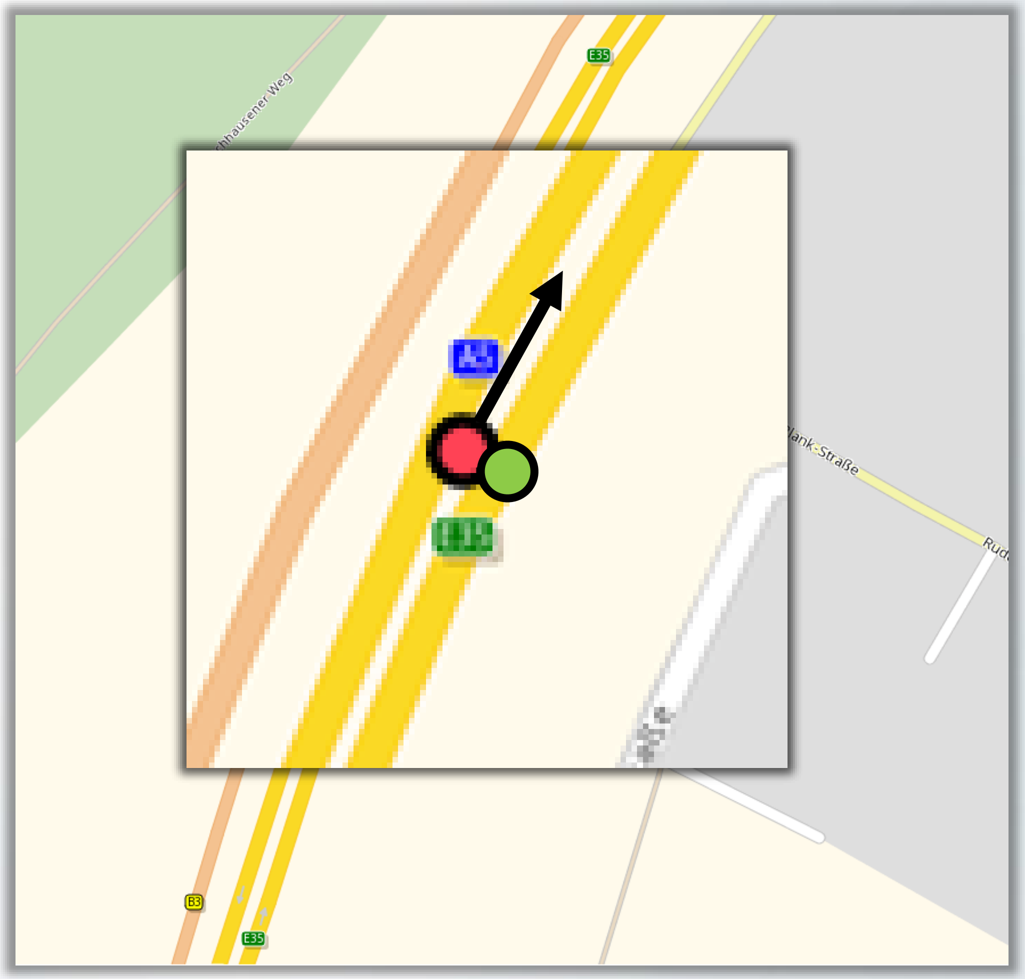


Importance and challenges

„Having parallel roads/lanes: how to decide the correct one?“

Examples:

- Highway lanes in both directions
- Parallel roads in urban areas

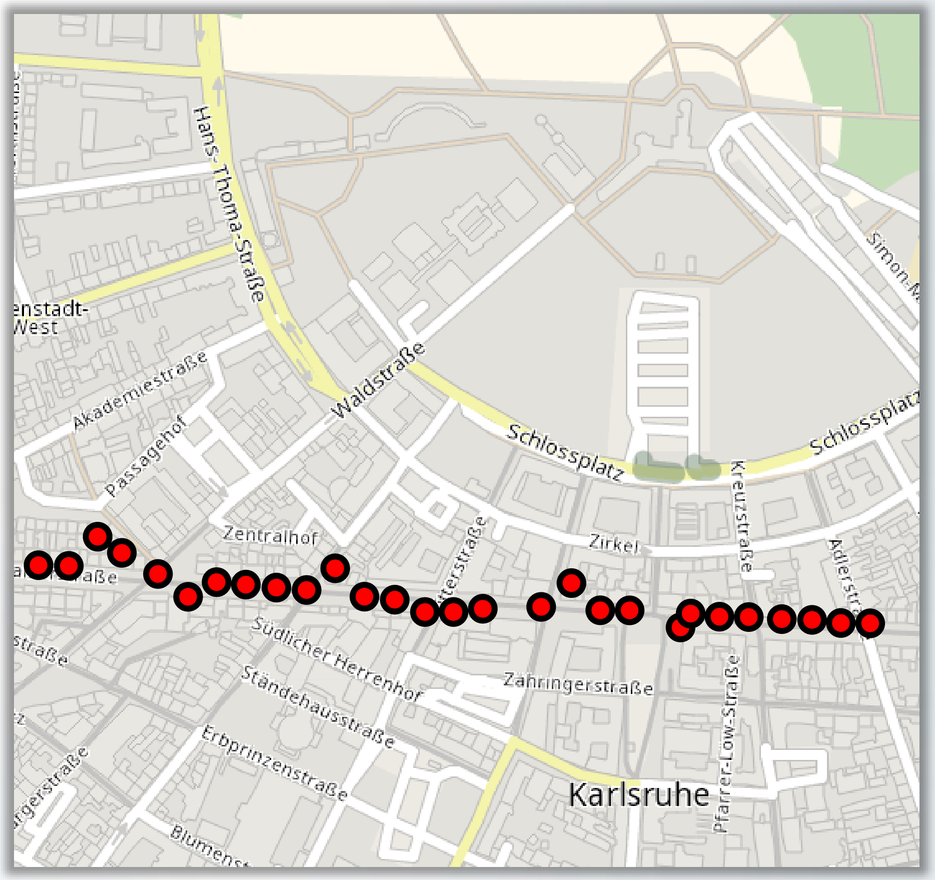


Importance and challenges

Bad GPS quality

Examples:

- Inaccurate positioning
- Inaccurate headings
- Especially difficult in inner city/dense urban areas

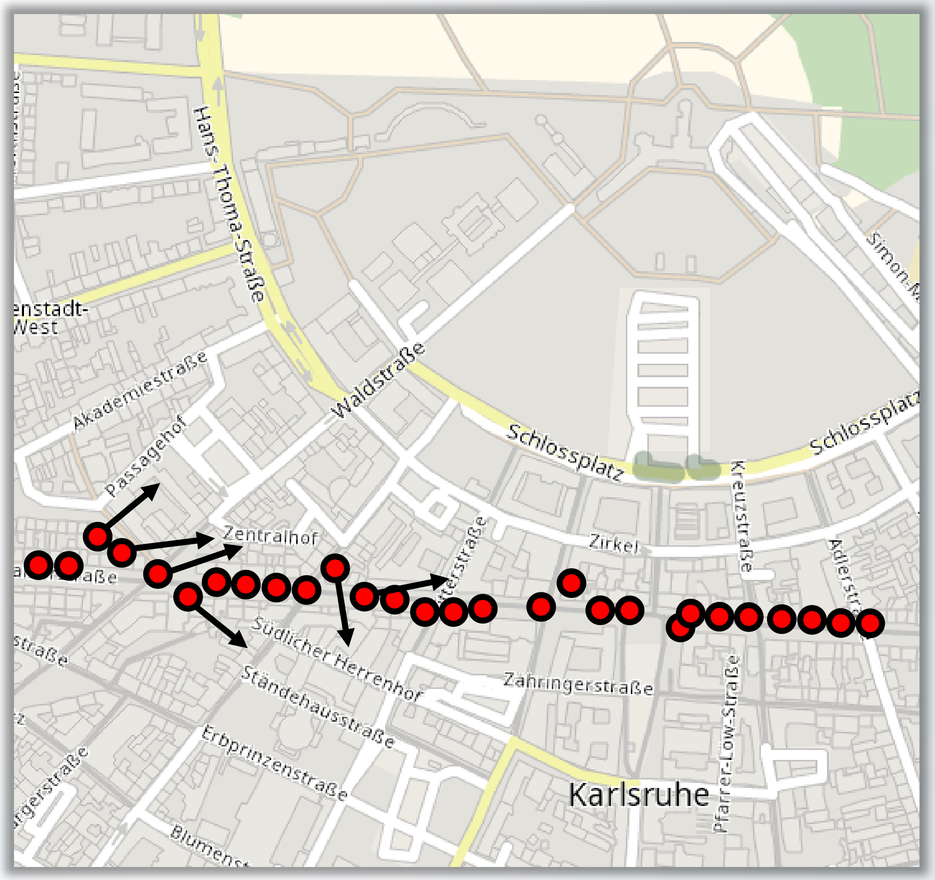


Importance and challenges

Bad GPS quality

Examples:

- Inaccurate positioning
- Inaccurate headings
- Especially difficult in inner city/dense urban areas



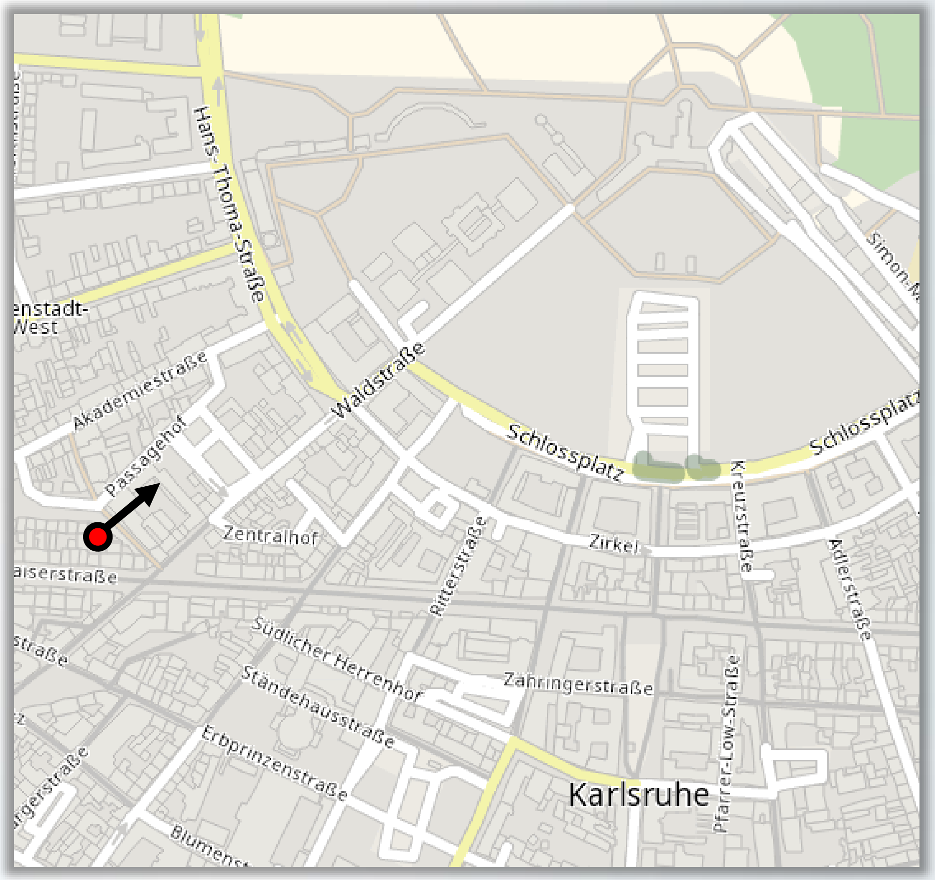
PTV GROUP
the mind of movement

Importance and challenges

Bad GPS quality

Examples:

- Inaccurate positioning
- Inaccurate headings
- Especially difficult in inner city/dense urban areas



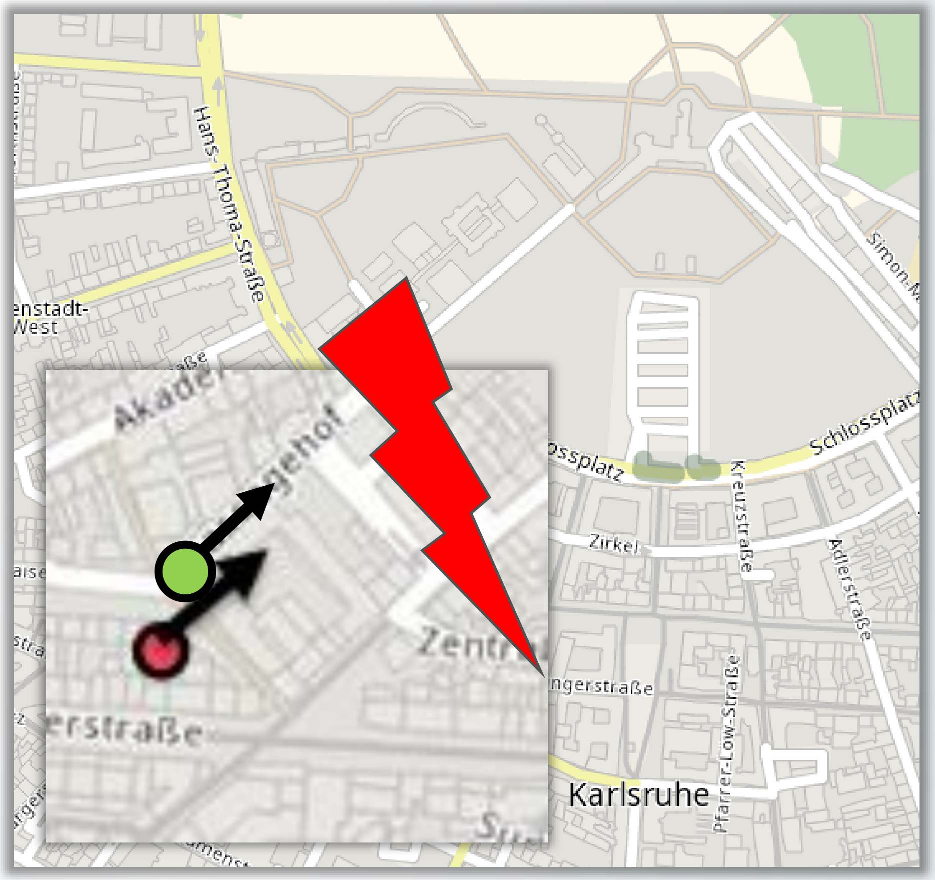
PTV GROUP
the mind of movement

Importance and challenges

Bad GPS quality

Examples:

- Inaccurate positioning
- Inaccurate headings
- Especially difficult in inner city/dense urban areas



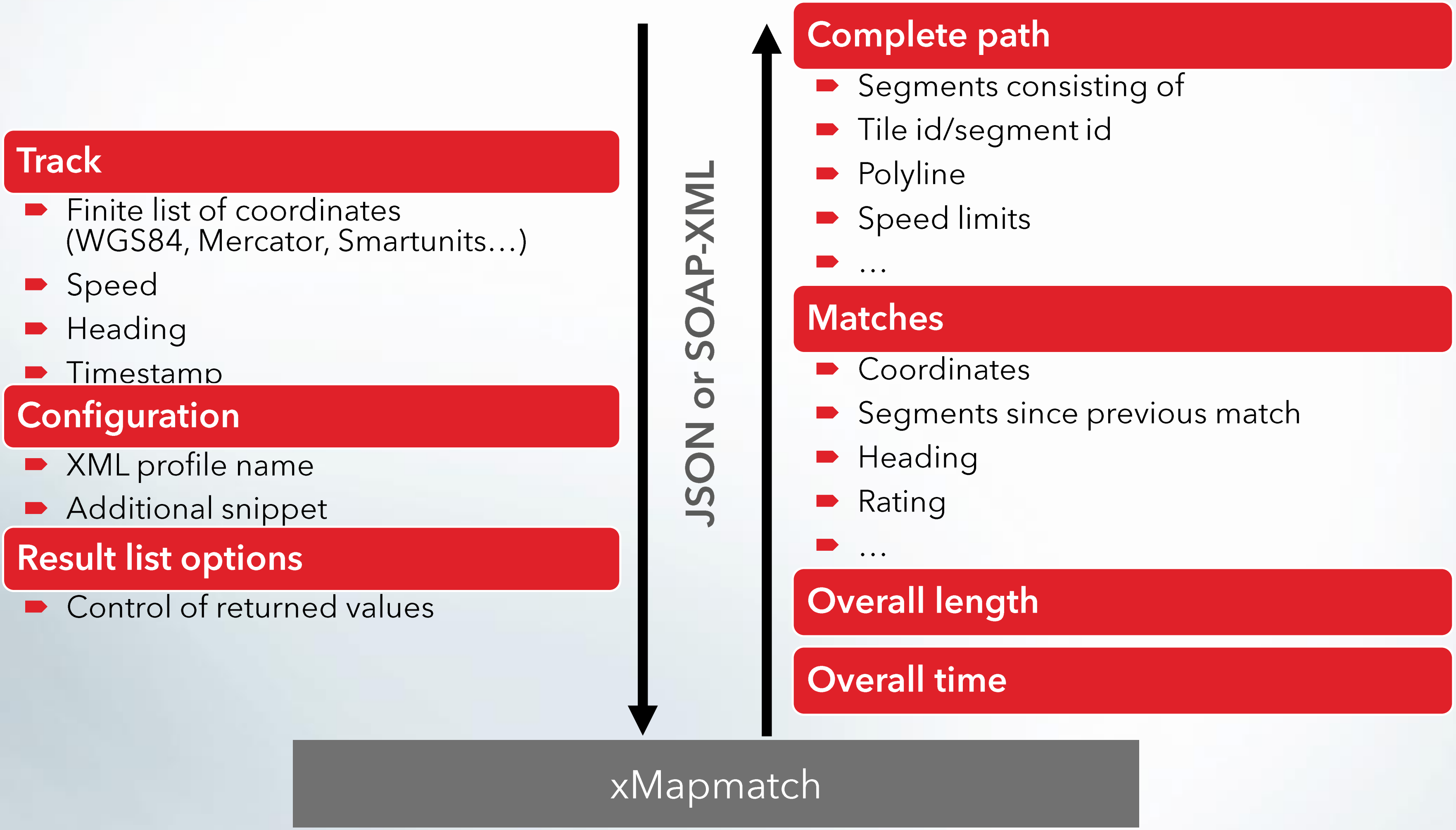
PTV GROUP
the mind of movement

Constraints for map matching

- Which input data can be used (e.g. coordinates, heading, speed etc.)?
- How is the density of the input positions?
- How accurate is the data about the input positions?
- What are the requirements to the matching quality?
- What are the requirements to the matching performance?

➔ These constraints can have massive influence on matching quality and performance!

Interface of xMapmatch



Track

- Finite list of coordinates (WGS84, Mercator, Smartunits…)
- Speed
- Heading
- Timestamp

Configuration

- XML profile name
- Additional snippet

Result list options

- Control of returned values

JSON or SOAP-XML

Complete path

- Segments consisting of
- Tile id/segment id
- Polyline
- Speed limits
- …

Matches

- Coordinates
- Segments since previous match
- Heading
- Rating
- …

Overall length

Overall time

xMapmatch

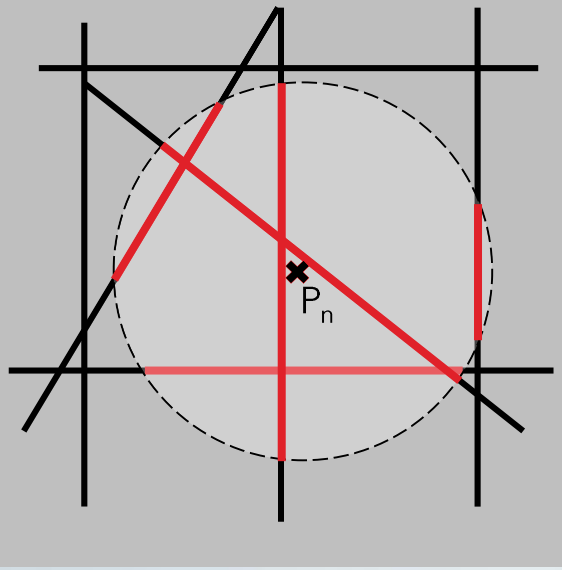
Matching procedure

- xMapmatch uses **two different matching modes**:
  - **Local matching** only considers the information about the current input position to determine the currently best matched location
  - **Global matching** in addition considers also information about the matching candidates of previous input positions

Matching procedure

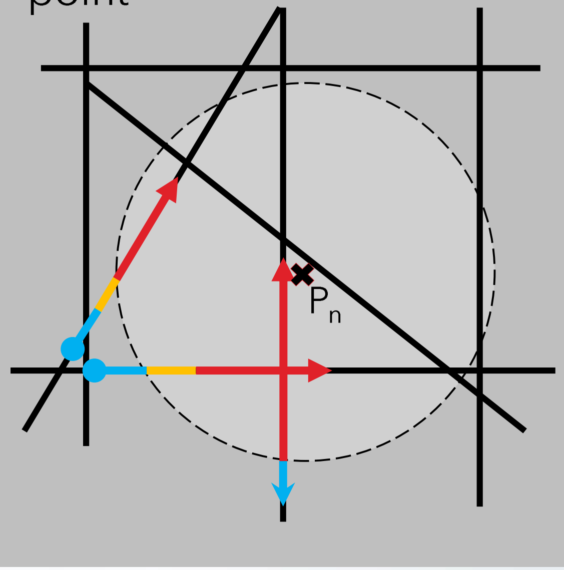
Local Matching

- Look for candidates in maximum distance around input point



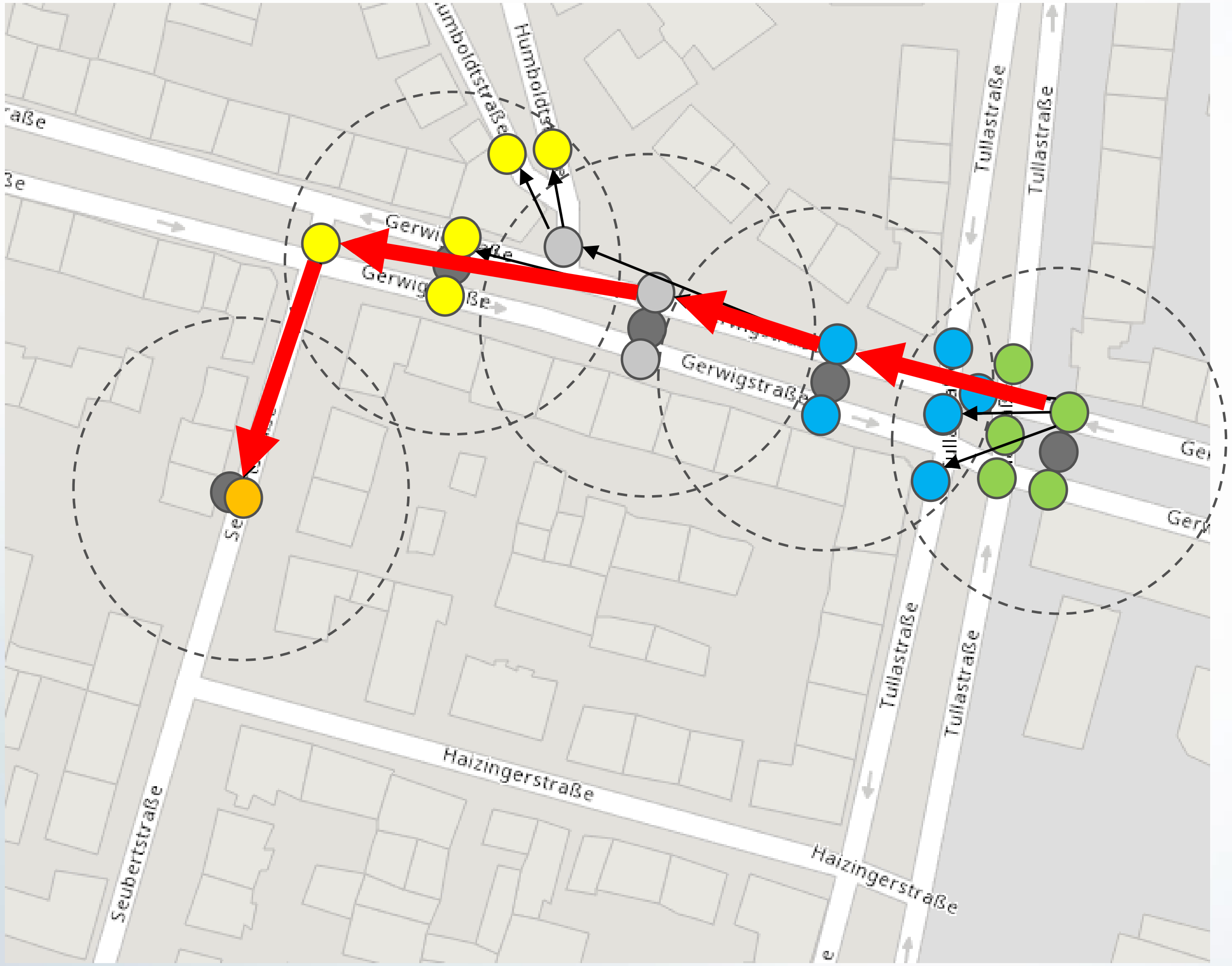
Global Matching

- Look for candidates
  - in reasonable network distance from previous candidates
  - In maximal distance around input point



PTV GROUP
the mind of movement

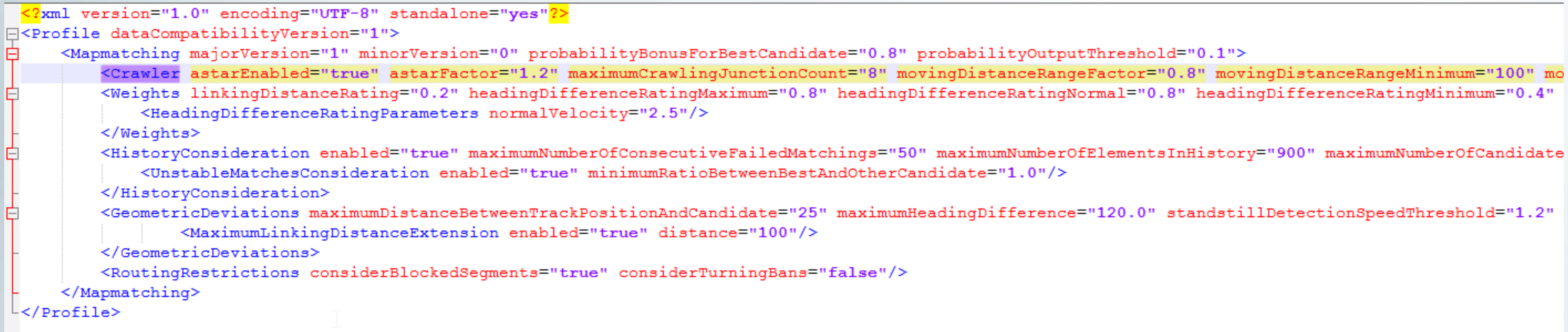
Matching procedure



Parametrization

A lot of configuration parameters affect quality and performance, for example:

- Maximum linking distance
- Crawling range (relative and absolute)
- Maximum number of consecutive failed matchings
- Maximum crawling junction count
- Weights for linking distance, heading, …
- Maximum standstill speed

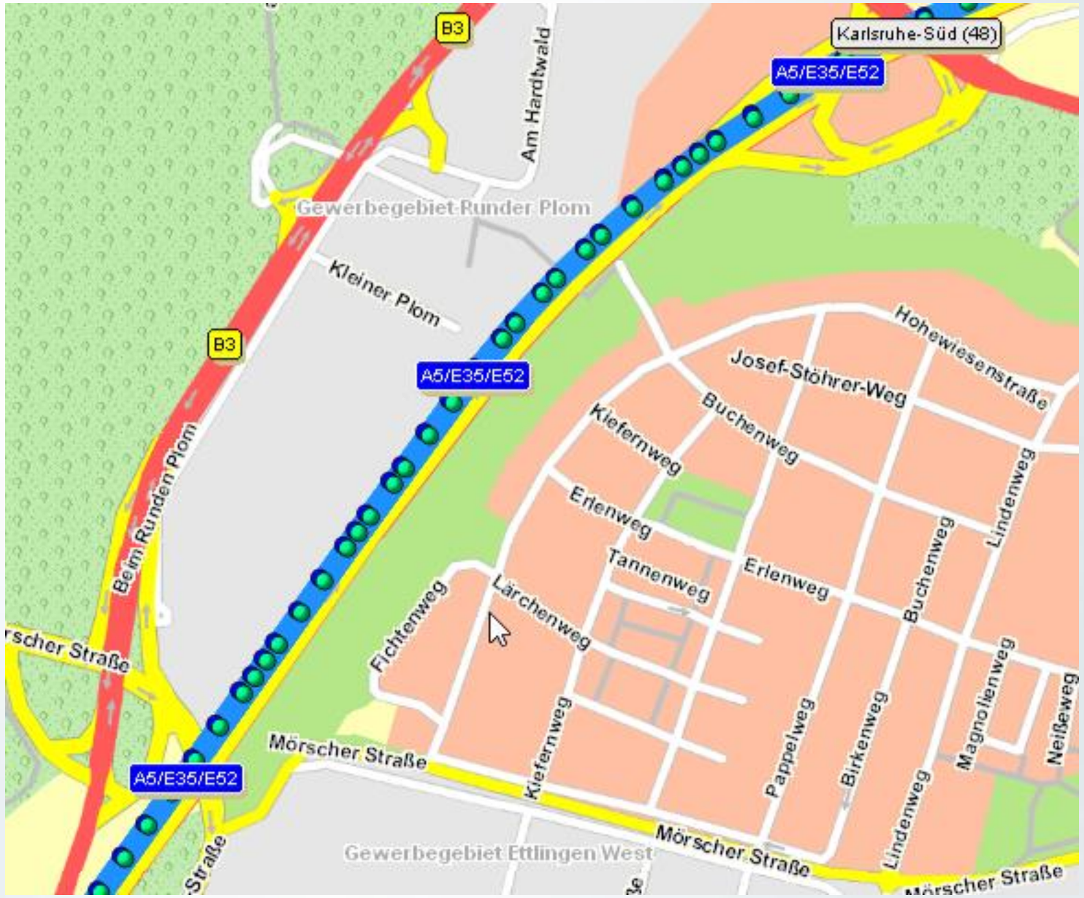


```xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<Profile dataCompatibilityVersion="1">
    <Mapmatching majorVersion="1" minorVersion="0" probabilityBonusForBestCandidate="0.8" probabilityOutputThreshold="0.1">
        <Crawler astarEnabled="true" astarFactor="1.2" maximumCrawlingJunctionCount="8" movingDistanceRangeFactor="0.8" movingDistanceRangeMinimum="100" mo
        <Weights linkingDistanceRating="0.2" headingDifferenceRatingMaximum="0.8" headingDifferenceRatingNormal="0.8" headingDifferenceRatingMinimum="0.4"
            <HeadingDifferenceRatingParameters normalVelocity="2.5"/>
        </Weights>
        <HistoryConsideration enabled="true" maximumNumberOfConsecutiveFailedMatchings="50" maximumNumberOfElementsInHistory="900" maximumNumberOfCandidate
            <UnstableMatchesConsideration enabled="true" minimumRatioBetweenBestAndOtherCandidate="1.0"/>
        </HistoryConsideration>
        <GeometricDeviations maximumDistanceBetweenTrackPositionAndCandidate="25" maximumHeadingDifference="120.0" standstillDetectionSpeedThreshold="1.2"
                <MaximumLinkingDistanceExtension enabled="true" distance="100"/>
        </GeometricDeviations>
        <RoutingRestrictions considerBlockedSegments="true" considerTurningBans="false"/>
    </Mapmatching>
</Profile>
```

RoadRunner development at PTV

- For usage on **thin devices**
- **Crawling** from track position to track position (global matching)
- Segments are taken into account only if they are reachable inside the given crawling range

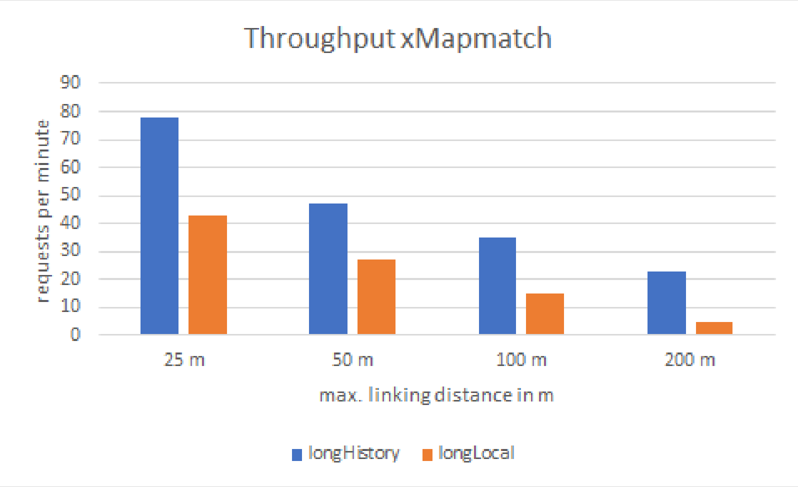
➔ Good performance for dense tracks!

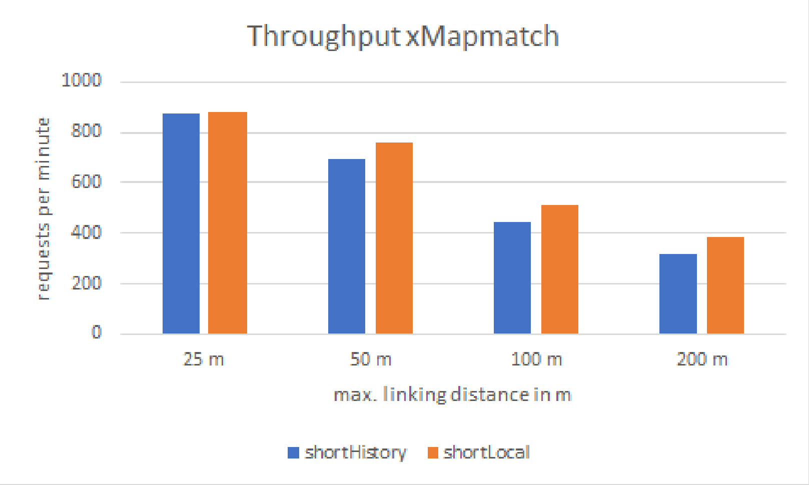


PTV GROUP
the mind of movement

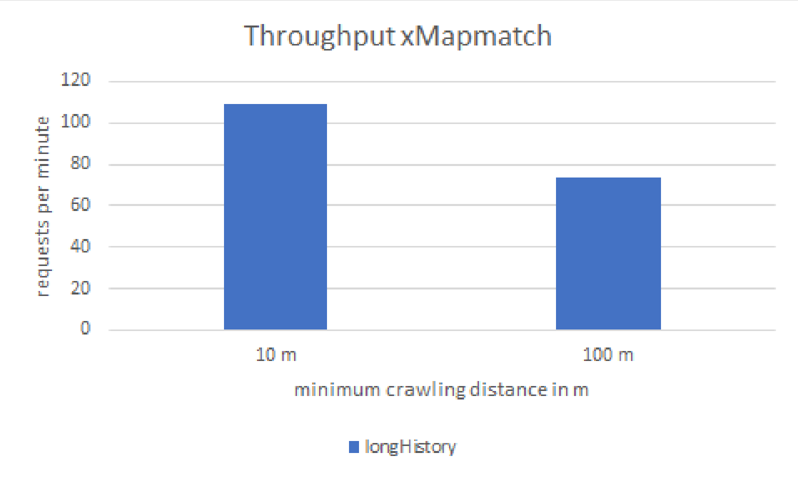
Performance

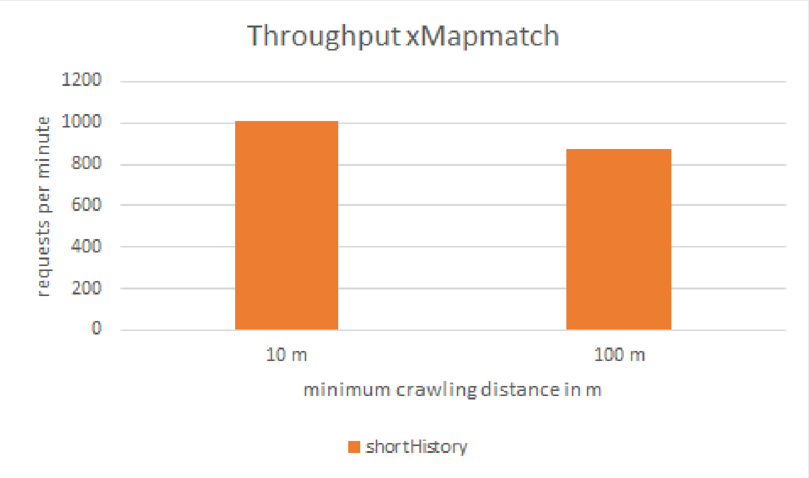
Maximum linking distance:





Minimum crawling distance:





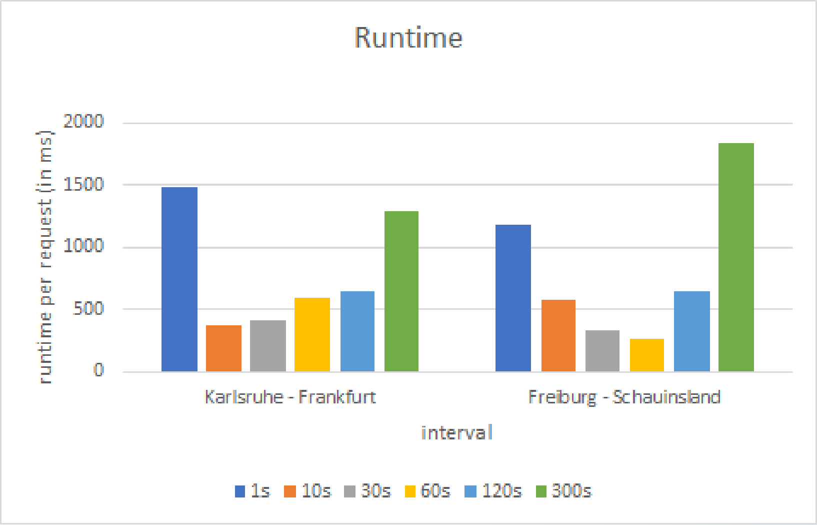
Mapmatching of sparse tracks

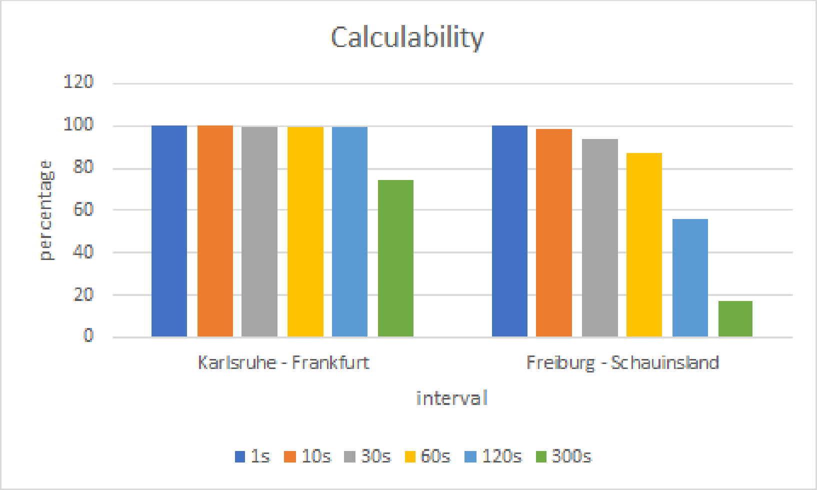
- All possible paths from the origin position are calculated
- Exponential growth of possible paths ☹

➔ Runtime increases disproportionally

- Introducing a new config parameter called *maximumCrawlingJunctionCount* to avoid endless calculations

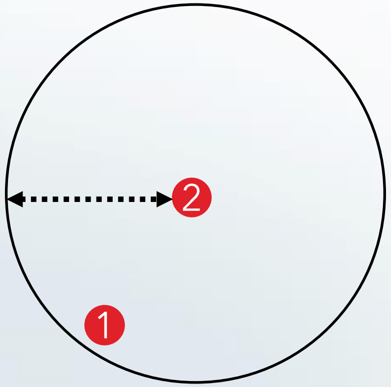
➔ No matching for tracks which are more sparse

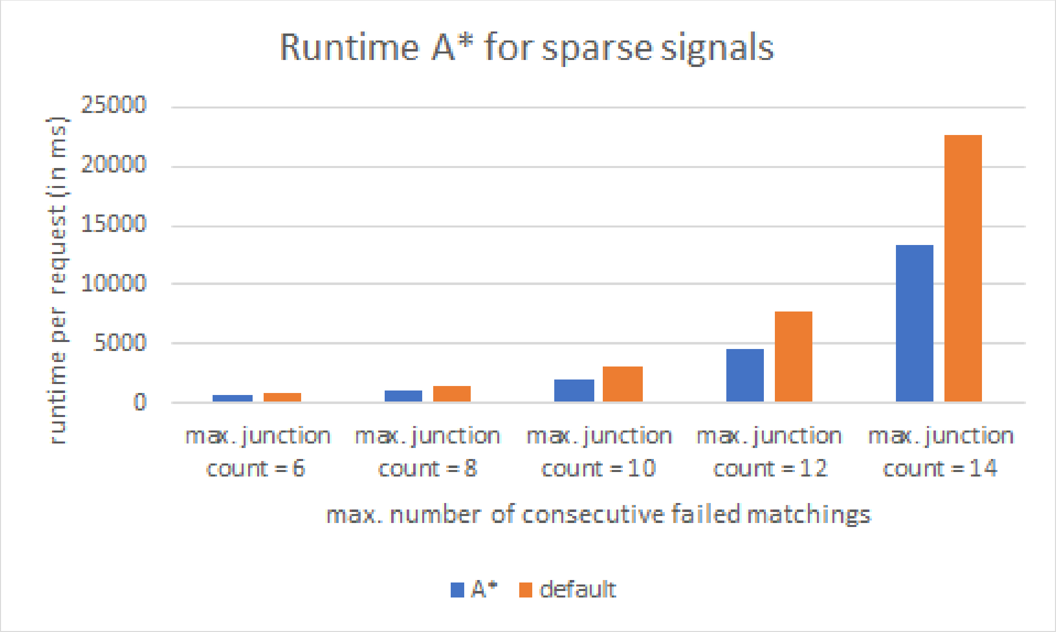




Improvement since version 1.26.0.0

- Using geometrical informations for reducing the search space
- Base idea of A* algorithm for routing was adapted
- Segments too far from the destination *(crawlDist + linkDist)* are skipped
- New configuration parameter *astarEnabled* added to switch this improvement on/off



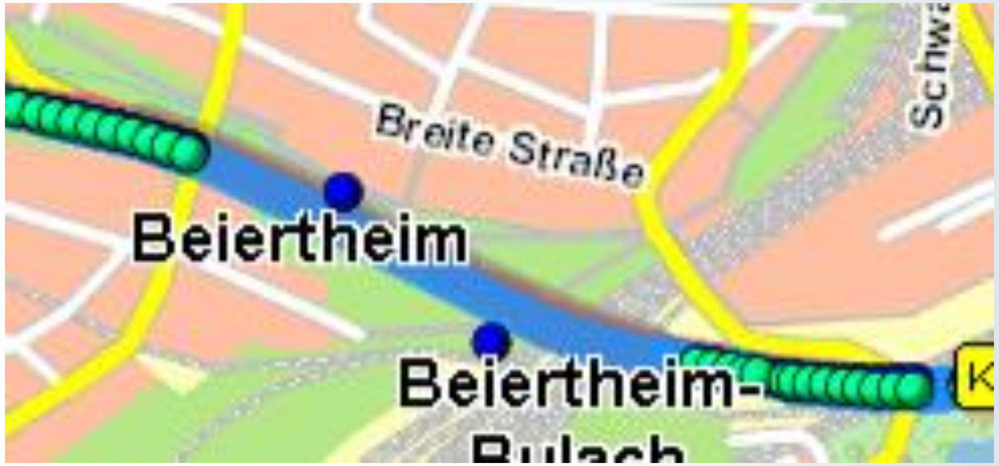


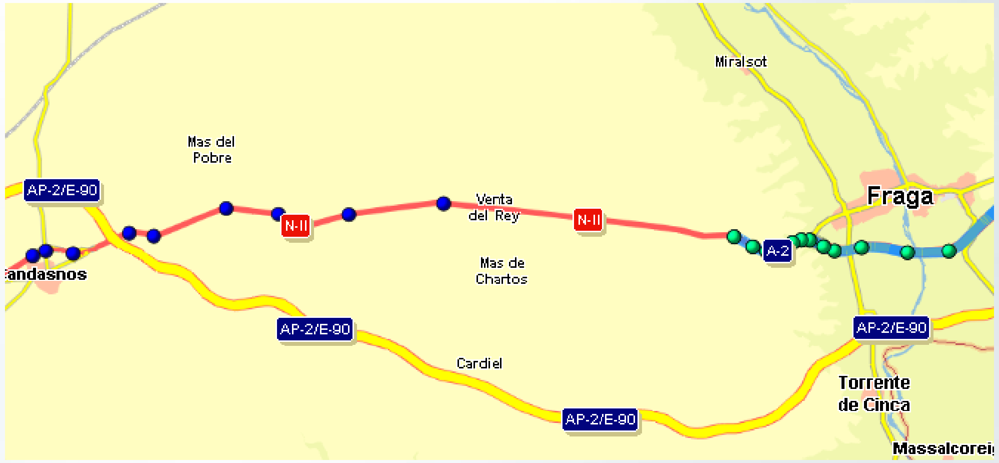
PTV GROUP
the mind of movement

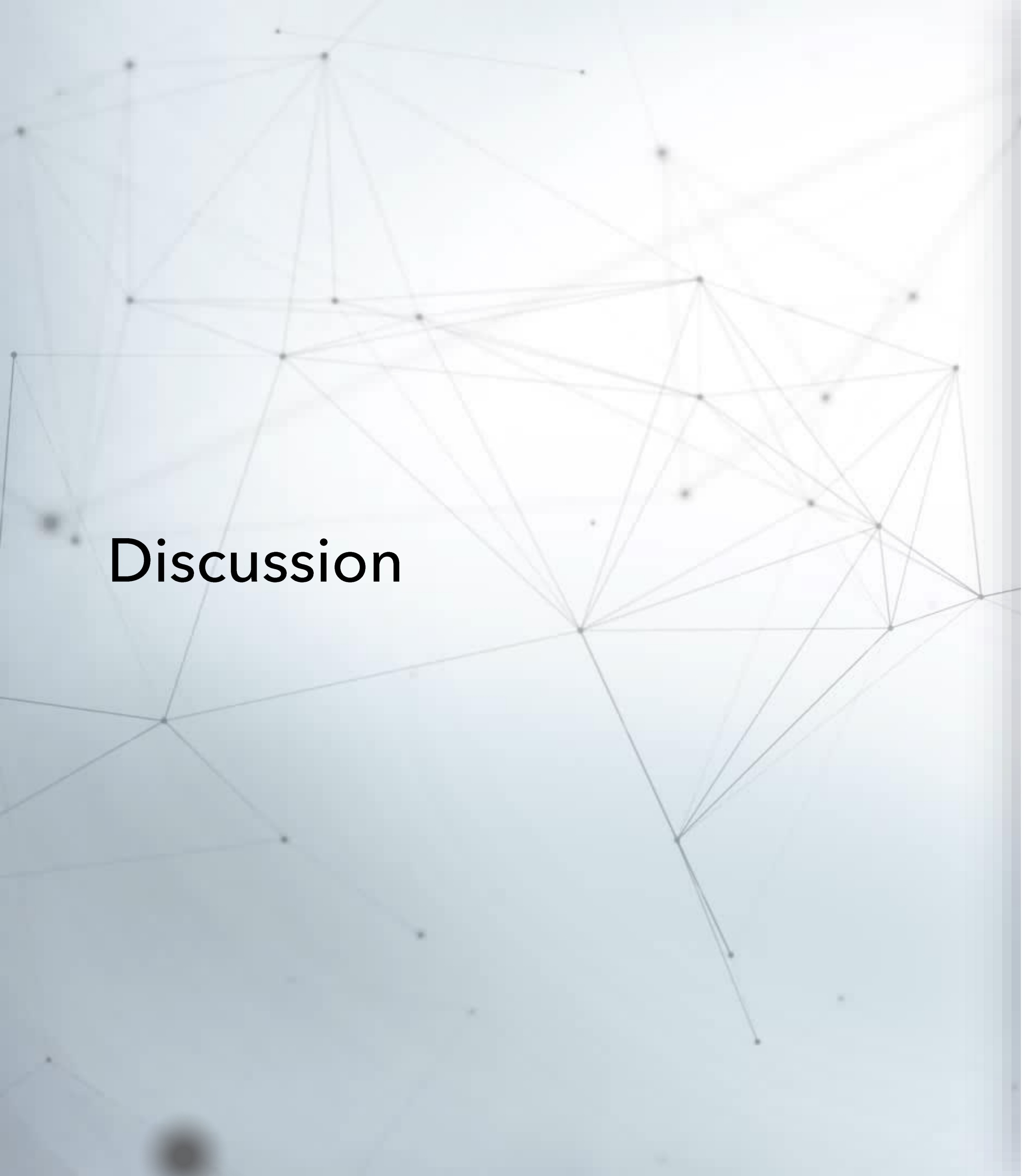
Handling of failed matchings

- If a match fails the xMapmatch tries to find a path from the last successful match to the current track point
- After a defined number of unsuccessful attempts a new trajectory will be set up (config parameter)
- So some outliers can be conquered ☺
- For abortions because of passing the allowed number of junctions for the next points this limit will be exceeded more and more
- Less track points will be matched and the runtime is going worse ☹

→ For the standard profile „sparse-signal“ this config parameter was set 0 (instead of 50)







Discussion

Discussion

- Does it make sense to split a long sequence of locations into smaller packages?
  Is this valid for parallel processing to speed up performance?
  E.g. [1….1000] into [1..500]+[501..1000]

Ressources

Further info is available at

- **Joost Claessen's Testclient**
  https://github.com/ptv-jcl/XMapmatchTestClient

- **PTV xMapMatch Server Forum**
  https://xserver.ptvgroup.com/forum/viewforum.php?f=8

- **German product page**
  http://xserver.ptvgroup.com/de/products/ptv-xserver/ptv-xmapmatch/

- **Usecase documentation**
  http://xserver.ptvgroup.com/fileadmin/files/PTV-COMPONENTS/DeveloperZone/Documents/xServer_public/manual/Default.htm#Use%20cases/xMapmatch/OVER_Use_Cases_PTV_xMapmatch.htm%3FTocPath%3DUse%2520Cases%7CPTV%2520xMapmatch%7C_____0

- **Factsheet**
  http://xserver.ptvgroup.com/fileadmin/files/PTV-COMPONENTS/Downloads/4_Products/6_PTV_xMapmatch/EN_PTV_xMapmatch_Server_Factsheet.pdf

Generic RESSOURCEs and …

1. DevComp Consulting
   → bernd.welter@ptvgroup.com
   larsnorman.moritz@ptvgroup.com

2. DevComp Support
   → support.de@xServer.ptvgroup.com

3. Our Forum (free of cost – englisch)
   → http://xserver.ptvgroup.com/forum

4. Developer Blog
   → http://devblog.ptvgroup.com/

5. PTV xServer INTERNET
   http://xserver.ptvgroup.com/en-uk/cookbook/content-and-services/general-information/

6. Further questions?
   →SALES!

PTV GROUP

the mind of movement

www.ptvgroup.com