Improving Emergency Services Planning for Bavaria with an Oracle Spatial and Graph Routing Solution

Marc Lazarovici  INM, Munich
THE INSTITUTE FOR EMERGENCY MEDICINE AND MANAGEMENT IN MEDICINE

- founded 2002
- first emergency medicine institute at a german-speaking university
- currently 37 people
MISSION: OPTIMIZING DELIVERY OF EMERGENCY CARE BY

- Research and expert reports
- Training & teaching
- Quality and risk management
Routing and geographical calculations – status quo ante

- Geo information system
  - ESRI ArcGIS Desktop
  - Network Analyst

- Routing analyses and spatial calculations
  - Routing between defined points (fastest, shortest)
  - Distance matrices
  - Coverage areas
  - Alarm priority lists
  - Accessibility

- Street maps
  - Digital Data Streets, Route (based on HERE-Navteq)
  - ESRI Shape-Format
ROUTING AND GEOGRAPHICAL CALCULATIONS – STATUS QUO ANTE

- Possible questions
  - Where should ambulance bases be located?
  - Which area is reached in the shortest time from which point?
  - Are there areas that can not be reached in a predefined interval?
  - Are there areas that can be reached from multiple ambulance bases in a predefined interval?
  - What are the service areas of hospitals?
  - ...
ROUTING AND GEOGRAPHICAL CALCULATIONS – STATUS QUO ANTE
ROUTING AND GEOGRAPHICAL CALCULATIONS – STATUS QUO ANTE
ROUTING AND GEOGRAPHICAL CALCULATIONS – STATUS QUO ANTE
ROUTING AND GEOGRAPHICAL CALCULATIONS – STATUS QUO ANTE

„The old way“

ESRI ArcGIS
- ambulance stations: ca. 500
- communal subdivisions: ca. 42,000
  - Network Analyst: 15,000 locations
  - distance matrix: 7,500,000 rows

Oracle Database
- DM-table
- other data
  - stored procedures
  - service areas
  - priority lists

SQL-Loader
- txt-file: x GB
INM ROUTING-MODUL – WHAT WE NEEDED

- Web-application with a service interface, using:
  - Java runtime container like Oracle WLS 10.3.6, WLS 12c or a simple tomcat with Oracle JDK
  - Oracle Routing Library
- Shell / Batch – Standalone application – can be called from browser, mapviewer, APEX, PL/SQL, Shell
- Oracle Spatial and Graph Java API
- Analyses taking into account
  - turn restrictions (starting with 12.1.0.2)
  - own speed profiles based on street categories
  - shortest or fastest route
  - service areas – statical and dynamical calculation
  - distance matrix (75,000 communal subdivision)
ROUTING AND GEOGRAPHICAL CALCULATIONS – THE NEW WAY

**webbrowser**
- HTML page
- APEX
- MapViewer

**Oracle Database**
- Spatial and Graph
- Geo-Data
  - communal struct, hospitals, ambulance stations
- HERE-street data
  - turn restrictions
  - speed profiles

**WebLogic-Server**
- INM Routing-Module
  - shortest Route
  - fastest Route
  - service areas (startpoint/endpoint)

**Oracle MapViewer**
- PL/SQL
  - shortest Route
  - fastest Route
  - service areas (startpoint/endpoint)
  - distance matrix

**APEX**
- MapViewer
SPPED PROFILES

- Integration of own speed profiles
  - Table SPEEDPROFILE
    - SPEEDPROFILE_ID NUMBER
    - RTW_KMH NUMBER
    - KTW_KMH NUMBER
    - NEF_KMH NUMBER
  - 24 street categories
    - e.g. Highway (fast, average, slow)
    - Speedway (fast, average, slow)
    - Motorway (fast, average, slow)
    - ... 
  - Definition according to street category name (using Stored Procedure)
  - SPEEDPROFIL_ID <-> FUNC_CLASS in EDGE
SPPED PROFILES

- Integration of own speed profiles
  - Table EDGE
    - EDGE_ID NUMBER
    - START_NODE_ID NUMBER
    - END_NODE_ID NUMBER
    - PARTITION_ID NUMBER
    - FUNC_CLASS NUMBER
    ...
  - Table PARTITION
    - PARTITION_ID NUMBER
    - NUM_NODES NUMBER
    - SUBNETWORK BLOB
    ...
  - FUNC_CLASS-Infos are being written to the compiled BLOB's -> not necessary to update routing network on change
SPPED PROFILES

- Correction of own speed profiles
  - Comparison of routing results (500,000 requests) with real travel times from stored mission data -> correction of calculated times by usage of a regression analysis
  - Pilot project to collect real GPS data
PRACTICAL EXAMPLE – POINT TO POINT ROUTING

- Request -> Routing from NODE 59518892 to NODE 674419175
  
  OUTPUT=SQL
  OUTPUT_SQL=default
  NETWORK=NET_INM
  START NODE=59518892
  START LABEL=starting point
  END NODE=674419175
  END LABEL=endpoint
  OUTPUT_GEOM_LENGTH=true
  TXT=RoutingTest
  JOBID=1
  PRJ=100
  SPEED=rtw
PRACTICAL EXAMPLE – POINT TO POINT ROUTING
PRACTICAL EXAMPLE – POINT TO POINT ROUTING, RESULTS

<table>
<thead>
<tr>
<th>JOB_ID</th>
<th>ROUTE_IDX</th>
<th>SUBROUTE_IDX</th>
<th>SUBROUTE_CNT</th>
<th>NODEID_START</th>
<th>NODEID_END</th>
<th>LINK_CNT</th>
<th>COSTS</th>
<th>GEOM</th>
<th>LENGTH</th>
<th>NODENAME_START</th>
<th>NODENAME_END</th>
<th>DETAILS</th>
<th>DATE_CREATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>59518892</td>
<td>674419175</td>
<td>157</td>
<td>12,07</td>
<td>MDSYS.SDO...</td>
<td>11396,2711...</td>
<td>Startpunkt</td>
<td>Endpunkt</td>
<td>100</td>
<td>09/05/2016 11:56:33</td>
</tr>
</tbody>
</table>

```plaintext
<table>
<thead>
<tr>
<th>JOB_ID</th>
<th>ROUTE_IDX</th>
<th>SUBROUTE_IDX</th>
<th>LINK_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-52820763</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>-733073539</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>3</td>
<td>-733073538</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>4</td>
<td>-586896330</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>5</td>
<td>733149107</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>6</td>
<td>733149108</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>7</td>
<td>-733154907</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>8</td>
<td>-733154906</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>9</td>
<td>-52822367</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>10</td>
<td>52823324</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>11</td>
<td>52823323</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>12</td>
<td>754719623</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>13</td>
<td>845972373</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>14</td>
<td>845972374</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>15</td>
<td>-576276883</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>16</td>
<td>-801200997</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>17</td>
<td>-801200996</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>18</td>
<td>-52821225</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>19</td>
<td>-67627644</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>20</td>
<td>67627643</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>21</td>
<td>-924065785</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>22</td>
<td>-924065784</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>23</td>
<td>-932312133</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>24</td>
<td>-932312132</td>
</tr>
</tbody>
</table>
```
PRACTICAL EXAMPLE – SERVICE AREAS

- Request -> Service-Area from Node 877666372, travel time 5 minutes
  
  NETWORK=NET_INM
  SPEED=rtw
  START_NODE=877666372
  LIMIT=5
  OUTPUT=SQL
  OUTPUT_SQL=default
  JOBID=2
PRACTICAL EXAMPLE – SERVICE AREAS
ROUTING MODULE – PARAMETERS AND OPTIONS

- Node definitions (start / end)
- Speed (RTW, HTW and NEF) or no speed profile
- Label, text and project name
- LIMIT in minutes for WithIn / WithOut
- Results saved into DB
- Encoding for HTML – e.g. preparing UTF-8 character set
- XML- or JSON-output
  - geometry as GML, GML3_2_1, GML3_1_1, TEXT (MDSYS.GEOMETRY), JSON
TURN RESTRICTIONS - BUG

- U-Turns on certain street types
ROUTING MODULE - PERFORMANCE

- JDBC Pool
- Deployment of the webservice in WebLogic-Server 12.1
  - Cluster with several Managed Servers
- Java-Heap-Size
  - 2-4 GB for -Xmx
  - 256 MB for -XX:MaxPermSize (up until Java 8)
- no problem with many parallel requests – round robin cluster
- Optimising caching policy in the LOD definition
  - Level 1 Node – number is dynamically calculated
  - Level 2 Node – number is limited to Integer.MAX_VALUE (2147483647)
- achieved aims
  - less reads from the DB, less network traffic
  - Wiederverwendung von bereits geladenen Routing - Daten
APEX APPLICATION - ADVANTAGES

- Possibility to work outside GIS – not only for specialists
- Preparing projects for customers
- Export to ESRI Shape-Format, further calculations in GIS if necessary
OVERVIEW
• First university institute in Germany with a focus on emergency medicine and management in medicine
• Offering consulting and analysis services for emergency medical services and emergency departments, as well as recommendations for preclinical and clinical emergency infrastructure

CHALLENGES / OPPORTUNITIES
• Need for optimization of routing for emergency rescue systems in Bavaria
• Need to move away from precalculated data sets
• High precision and complexity of routing (turning restrictions, speed profiles)

SOLUTIONS
Oracle Database 12c Enterprise Edition
• Spatial Option with GeoRaster, Network Data Model
• Partitioning
• MapViewer
• Java module
• APEX

RESULTS
• Appr. 1000 users via internet
• Central database including 900GB HERE ODF Release 3.2014 vector spatial data, structural and mission data, overall size appr. 2TB
• System is being used statewide to plan and adjust medical emergency services
SPECIAL THANKS TO:

Mathias Weber (GIS, Oracle Spatial, APEX)
mathias.weber@med.lmu.de

Markus Geis (Oracle administration)
markus.geis@med.lmu.de

Carsten Czarski (Oracle Germany)
Karin Patenge (Oracle Germany)
Hans Viehmann (Oracle Germany)
Erik Jost (grit GmbH)
THANK YOU!

Marc Lazarovici
Institute for Emergency Medicine, Munich