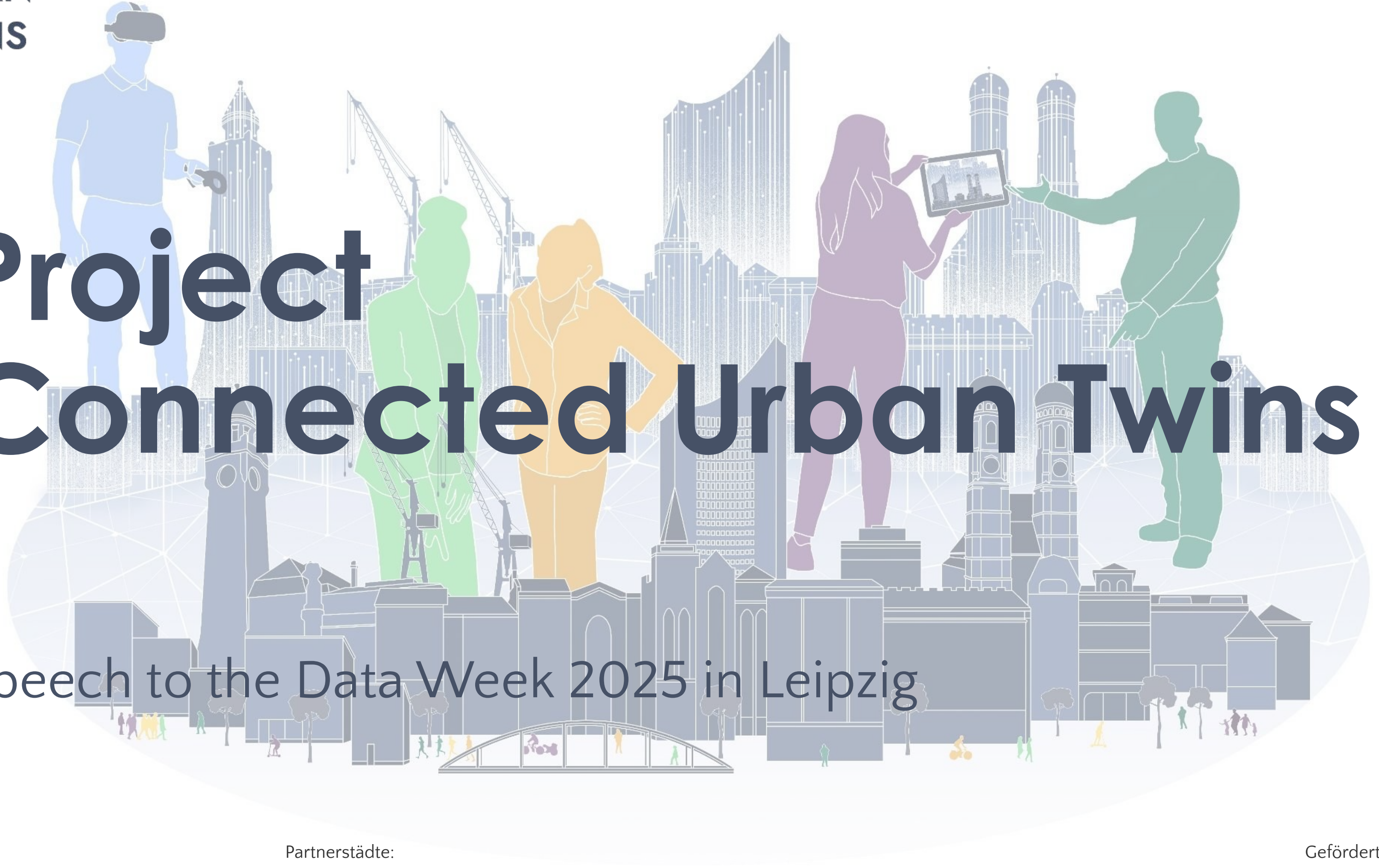

Project Connected Urban Twins

Speech to the Data Week 2025 in Leipzig

Partnerstädte:

Hamburg

Stadt Leipzig

Landeshauptstadt München

Gefördert durch:

Bundesministerium für Wohnen, Stadtentwicklung und Bauwesen

KFW

12. Juni 2025

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Background in Computer Science
and GIO-Engineering

City of Leipzig
Office for GEO-Information and spatial Order
CUT-Project, Leipzig
Responsible for Development of DT

GEO Base Twin of Leipzig

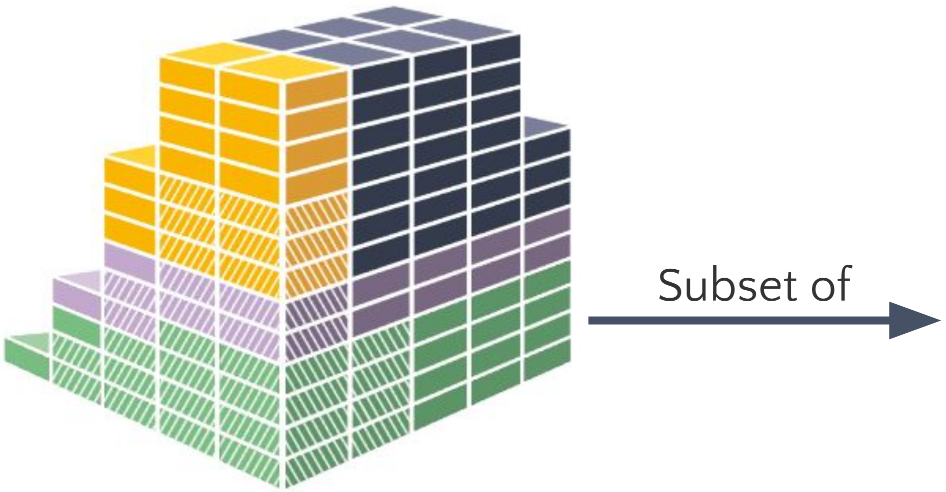
Taxonomy, Semantic and Graph Applications

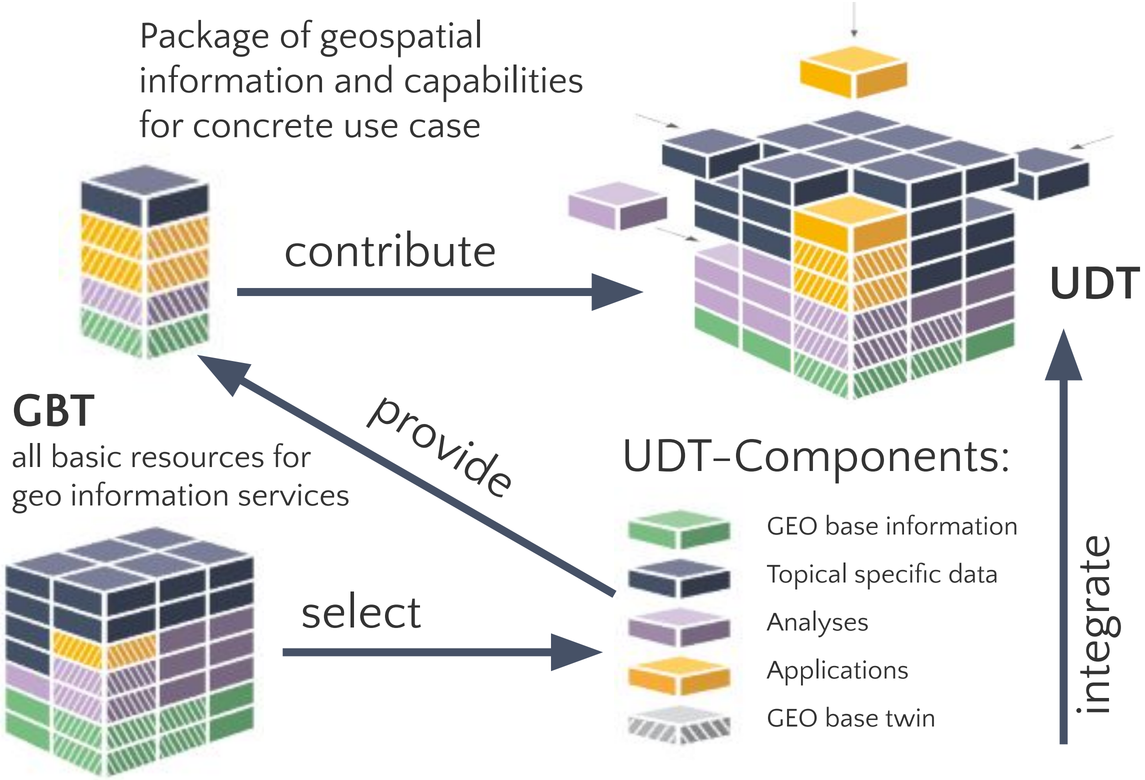
What is the Geo Base Twin (GBT)?

DIN SPEC 91607: 3.2 geo base twin

composition of all basic digital resources of municipal geo-data, applications and analyses

zfv_2023_1_Schubbe_et-al.pdf



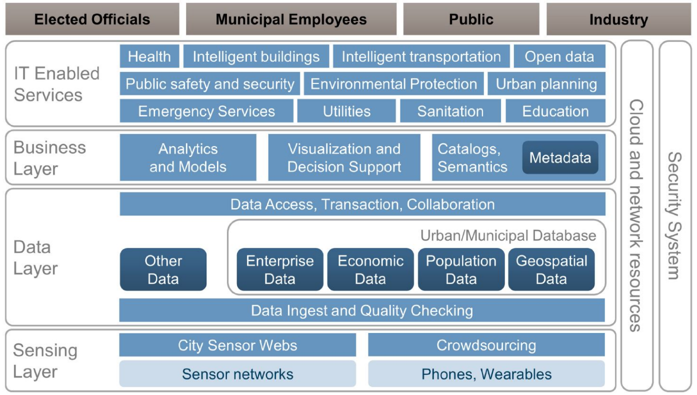


Digital Resources of the City Government

UDT and GBT as Composition of Digital Resources

How City Government can use the GBT?

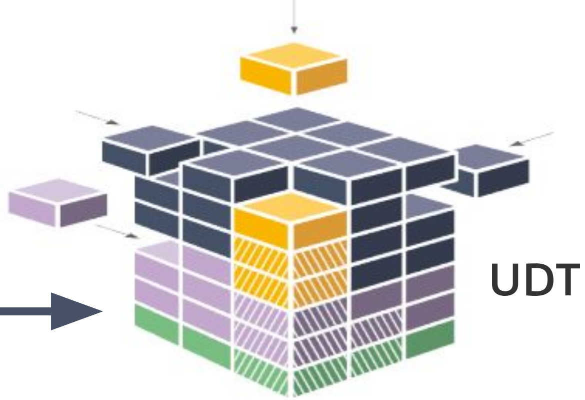
According to Data and Business Layer in DIN SPEC 91387



geospatial tween

Package of geospatial information and capabilities for concrete use case

contribute



UDT

Package of information and capabilities for concrete use case

ease find

Relevant components in specific categories

GBT

provide

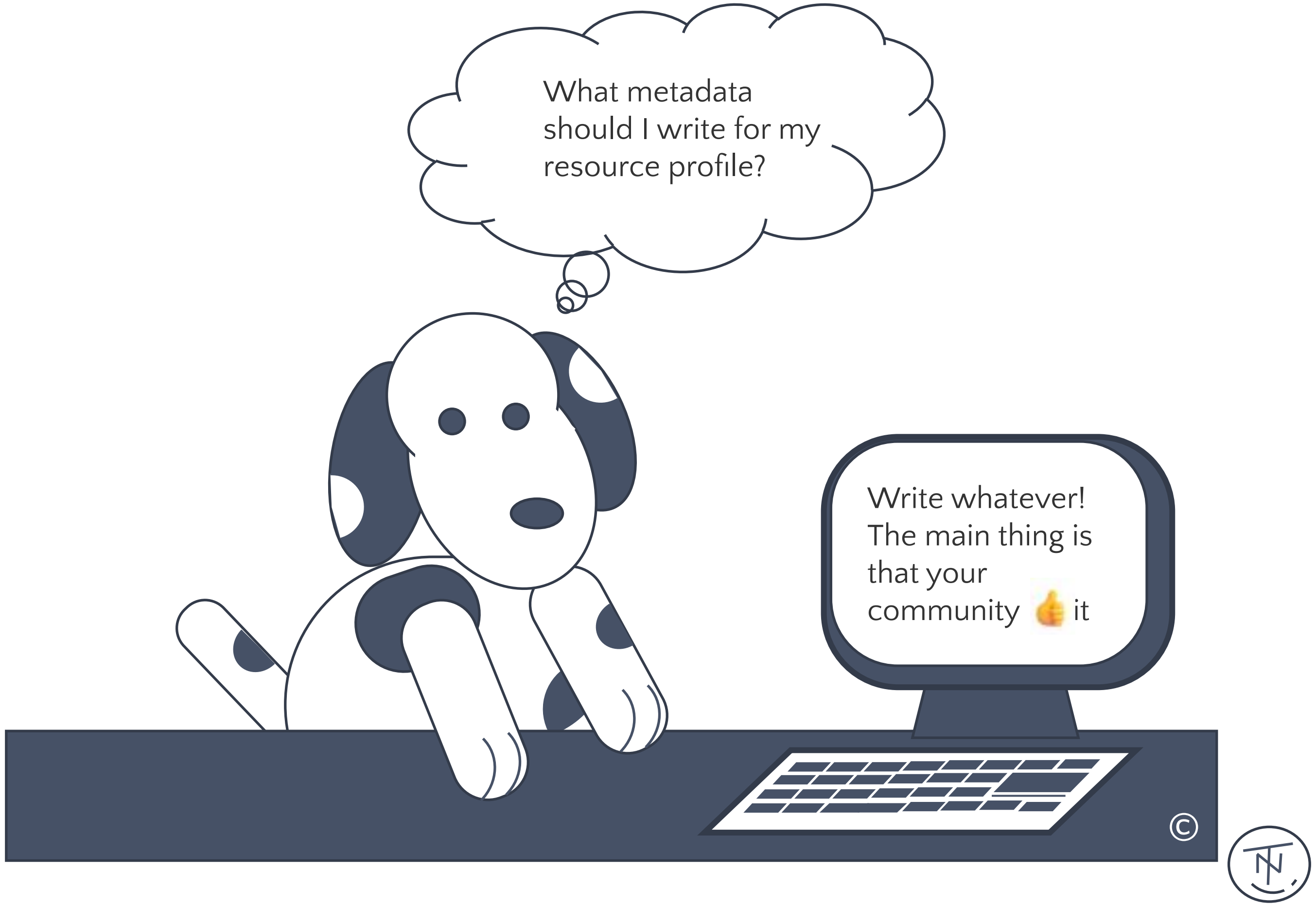
GEO base information
Topical specific data
Analyses
Applications
GEO base twin

specify

GEO Catalogue

- Metadata
- Links to Resources

Metadata describe resource profiles

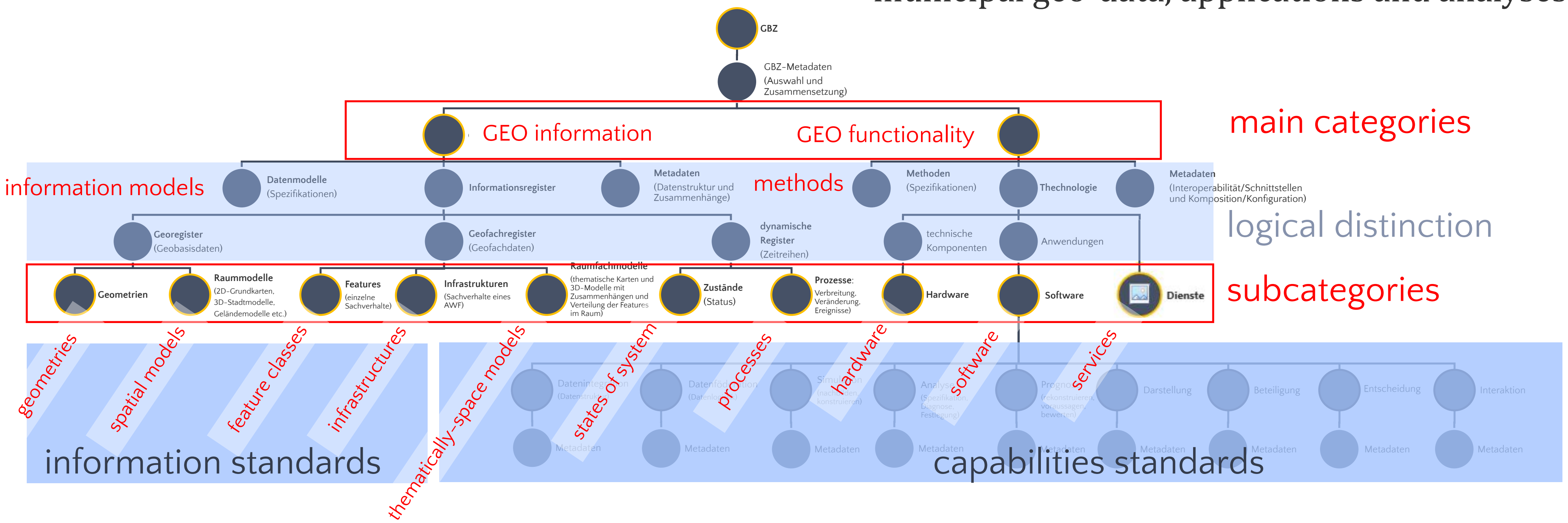


GIO Base Twin – Taxonomy and Metadata

- make a taxonomy to find categories
- look for rules about metadata

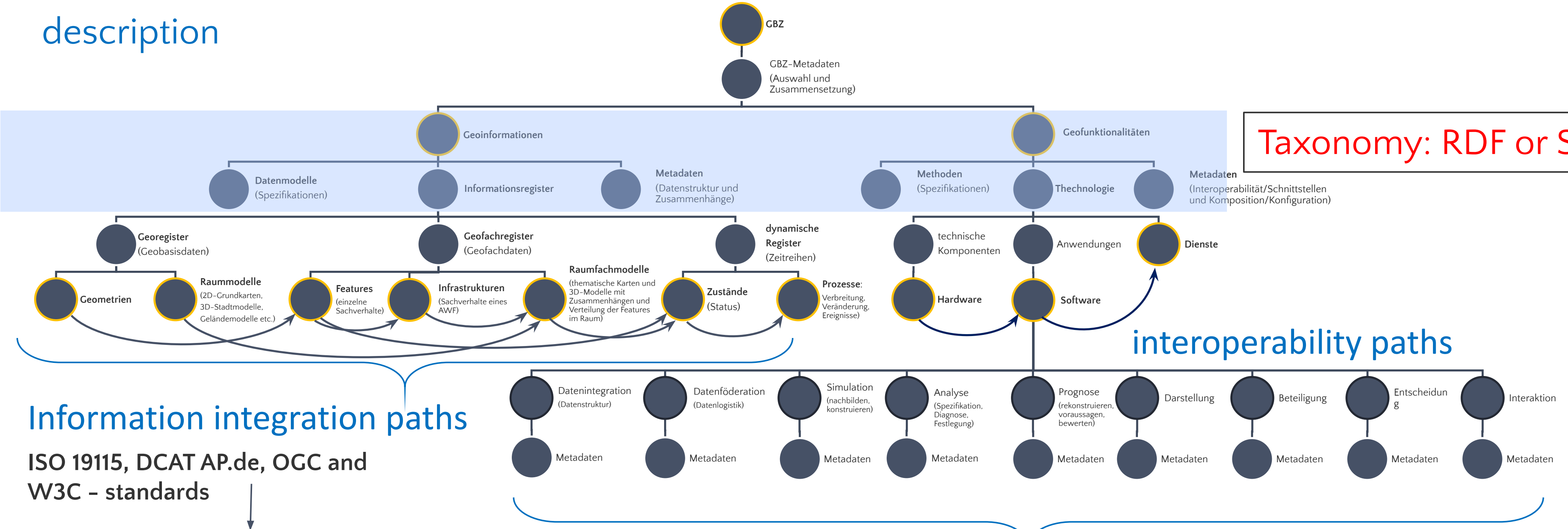
DIN SPEC 91607: 3.2 geo base twin

composition of all basic digital resources of municipal geo-data, applications and analyses



Semantic and interoperability capabilities of CKAN

- explain your categories with metadata
- find relationships between the categories and select metadata for resource description



Taxonomy: RDF or SKOS

Information integration paths

ISO 19115, DCAT AP.de, OGC and W3C – standards

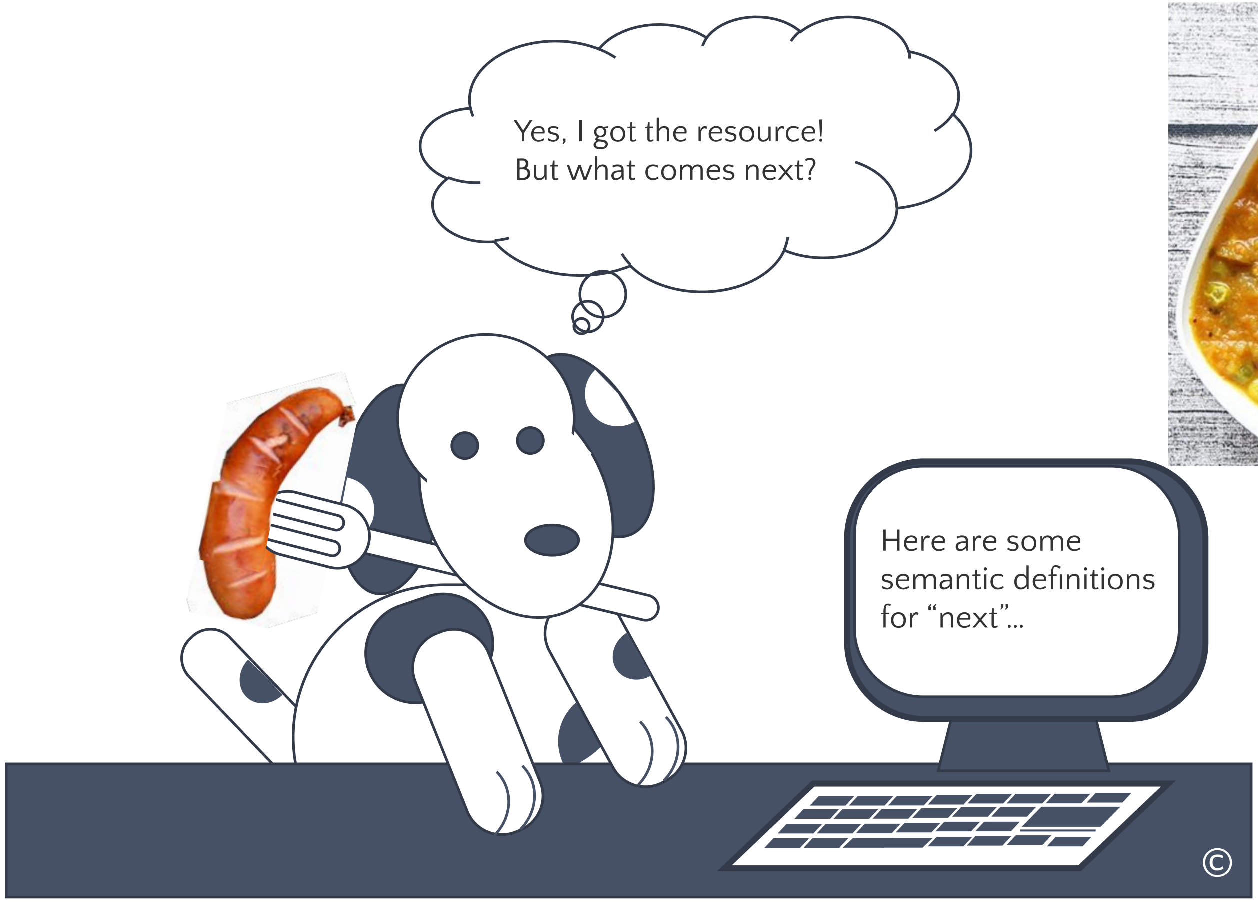
CKAN: RDF or SKOS-Turtle

CKAN: RPC and REST API

Operation and interoperability paths

DIN SPEC 91607: capabilities & API-description

How to deal with semantic?



Potato mash with curry and chickpea

- ✔ Spicy
- ✔ Vegan
- ✔ Bio
- ✔ EUR 17
- ✔ to eat one’s fill

Dealing with spatial and temporal context

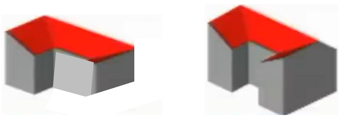
Need:

- The GBT is strong related to spatial and temporal context

Samples with CityGML3:

- How semantic deals with spatial or temporal changes of city objects?

1 Versioning



spatial structural changes

Beispiel: FME and CityGML – Generating 3D City Models in a Variety of Applications

```
<cityObjectMember>
  <Building gml:id=„104167“>
   <gml:name>A_house</gml:name>
    <boundedBy>
     <GroundSurface gml:id=8b7970xx“>
      <lod2MultiSurface>
       <gml: Polygon>
        <gml: exterior>
         <gml: LinearRing>
          <gml: posList> ….. </gml:posList>
         </gml: LinearRing>
        </gml: exterior>
       </gml: Polygon>
      </lod2MultiSurface>
     </GroundSurface>
    </boundedBy>
</cityObjectMember>
```

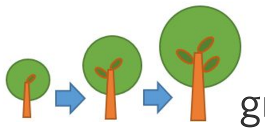
Cases based reasoning

2 Dynamizer

Beispiel: Schema documentation dynamizer

movement

https://www.flaticon.com/de/kostenlose-icons/auto Auto Icons erstellt von JessHG – Flaticon



growth

```
<dyn: Dynamizer>
  <dyn: attributeRef> string </dyn: attributeRef>
  <dyn: startTime> gml: TimePositionType </dyn: startTime>
  <dyn: endTime> gml: TimePositionType </dyn: endTime>
  <dyn: dynamicData>
    <!-- Attribute group reference
         gml: AssotiationAttributeGroup , Start Sequence -->
     <dyn: AbstractTimeseries> … </dyn: AbstractTimeseries>
   <!-- End Sequence -->
   </dyn: dynamicData>
   <dyn: sensorConnection> … </dyn: sensorConnection>
   <dyn: adeOfDynamizor> …. <dyn: adeOfDynamizer>
</dyn: Dinamizer>
```

Sequential changing property

Dealing with instrumental concepts

CUT

Need:

- With the GBT we provide instrument with wide spectrum of capabilities

Sample: "John is working on sheet metal with the hammer"
How semantic deals with instrumental and heterogeneous concepts?

3 Instrumental concept

instrument is only a placeholder

```
ex: John a skos: Concept ;
   skos: prefLabel "John" ;
   ex: workOn ex: MetalSheet ;
   ex: with ex:Hammer .

ex: MetalSheet a skos:Concept ;
   skos:prefLabel „MetalSheet" ;
   ex: changeFormWith ex: Hammer .

ex: Hammer a skos:Concept ;
   skos:prefLabel "Hammer„.
```

context grammar
Action – Schema.org Type

```
<rdf:Description rdf:about="http://example.org/Activity">
  <rdf:type rdf:resource="http://schema.org/Action"/>
  <schema:agent rdf:resource="http://example.org/John"/>
  <schema:instrument rdf:resource="http://example.org/Hammer"/>
  <schema:object rdf:resource="http://example.org/SheetMetal"/>
</rdf:Description>
```

4 heterogeneous concept

```
<rdf:Description rdf:about="http://example.org/SheetMetal">
  <ex:hasPart rdf:resource="http://example.org/Sheet"/>
  <ex:hasPart rdf:resource="http://example.org/Metal"/>
</rdf:Description>
<rdf:Description rdf:about="http://example.org/Sheet">
  <rdfs:label>Sheet</rdfs:label>
</rdf:Description>
<rdf:Description rdf:about="http://example.org/Metal">
  <rdfs:label>Metal</rdfs:label>
</rdf:Description>
```

Sheet = geometry
Metal = material

Identity by more properties

Dealing with emergence

Need:

- Many situations of the reality and their variations are emergent

5

emergence

possible to quantify

```
ex:Good a skos:Concept ;
    skos:prefLabel "Good" ;
    skos:definition "Air quality is good with low levels of pollutants." ;
    skos:broader ex:AirQuality ;
    ex:PM25 "12.1-35.4" ;
    ex:NO2 "41-100" ;
    ex:O3 "51-100" .
```

Fine dust
Nitrogen dioxide
Ozone

Sample: Air Quality

- How semantic deals with emergent status of system parameters?

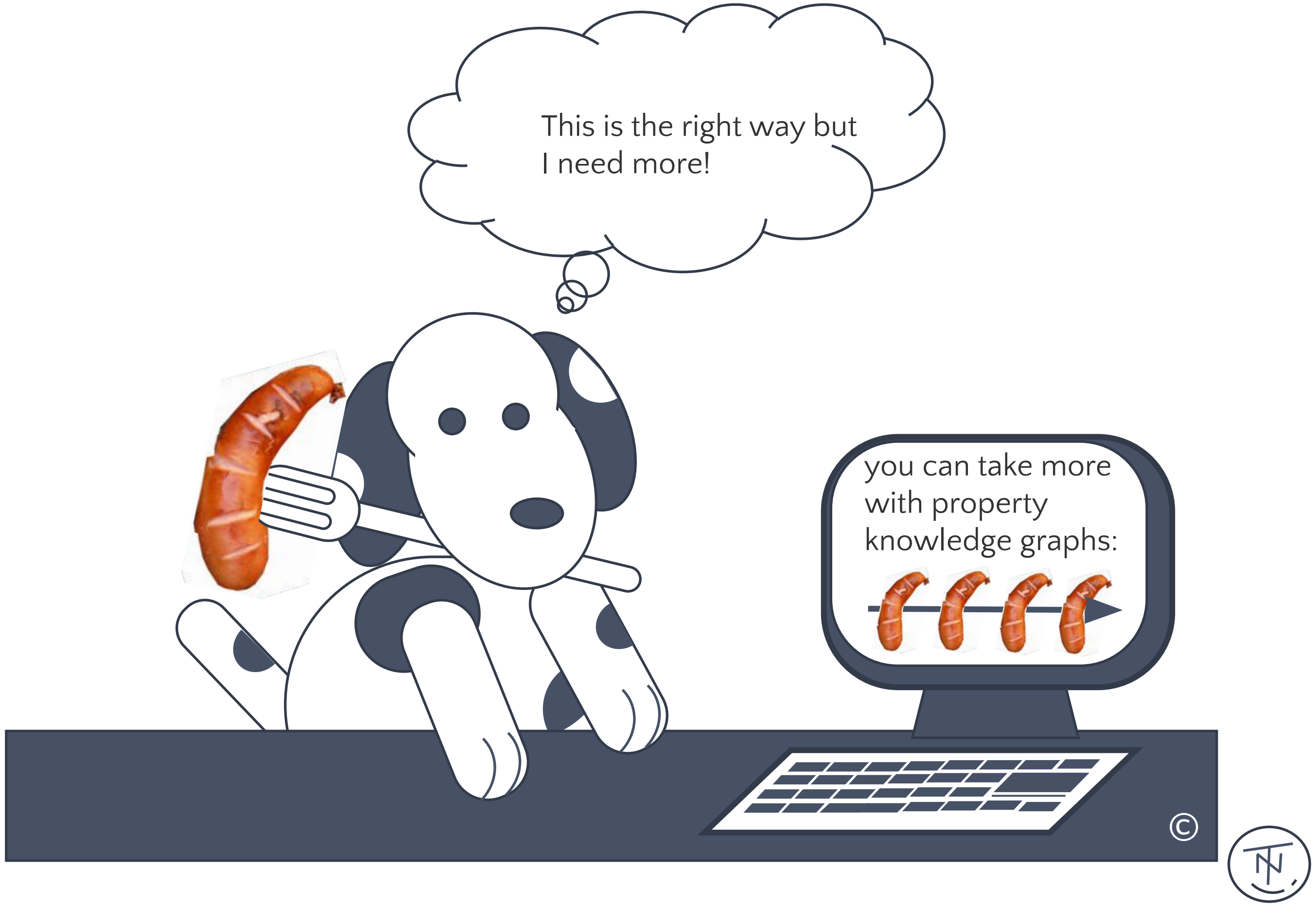
```
@prefix ex: <http://example.org/> .
@prefix skos: <http://www.w3.org/2004/02/skos/core#> .

ex:AirQuality a skos:Concept ;
    skos:prefLabel "Air Quality" ;
    skos:definition "Air quality depends on the amount of pollutants and is classified
into levels: very good, good, moderate, poor, and very poor." .

ex:VeryGood a skos:Concept ;
    skos:prefLabel "Very Good" ;
    skos:definition "Air quality is very good with minimal pollutants." ;
    skos:broader ex:AirQuality .

ex:Good a skos:Concept ;
    skos:prefLabel "Good" ;
    skos:definition "Air quality is good with low levels of pollutants." ;
    skos:broader ex:AirQuality .

ex:Moderate a skos:Concept ;
    skos:prefLabel "Moderate" ;
    skos:definition "Air quality is moderate with acceptable levels of pollutants." ;
    skos:broader ex:AirQuality .

ex:Poor a skos:Concept ;
    skos:prefLabel "Poor" ;
    skos:definition "Air quality is poor with high levels of pollutants." ;
    skos:broader ex:AirQuality .

ex:VeryPoor a skos:Concept ;
    skos:prefLabel "Very Poor" ;
    skos:definition "Air quality is very poor with very high levels of pollutants." ;
    skos:broader ex:AirQuality .
```

Challenges of the semantic approach

Challenges:
- **Ambiguity**: Concepts may have different meanings in different contexts
- **Granularity**: more details of the semantic model lead to complexity and make it difficult for understanding
- **Interoperability**: different systems and standards lead to different semantic models. This can complicate integration and interoperability

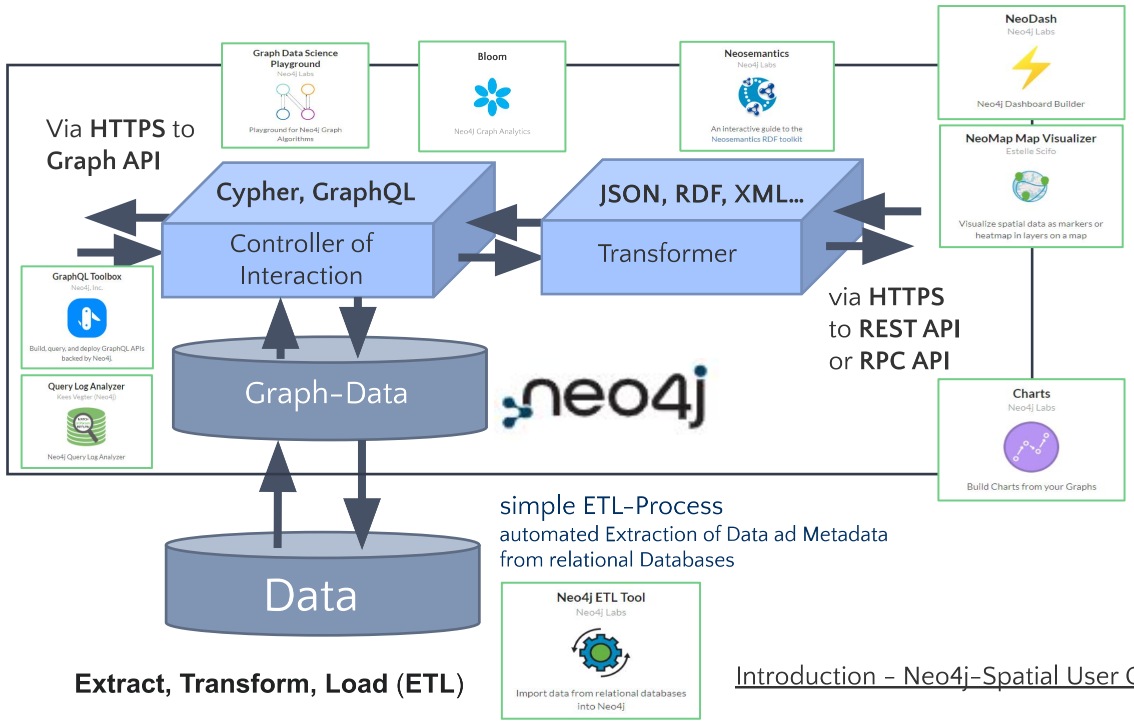
Suggestion:
- Make from every context meaning a case of mining and specify it carefully
- Select the right level of complexity to enable integration and interoperability but not to swap the users
- Consider the level of the users and their technologies and use cases. Ensure that the provided solution will work reliable

How to leverage GBT?



Graph- APIs for advanced Interoperability

Graph API Architecture



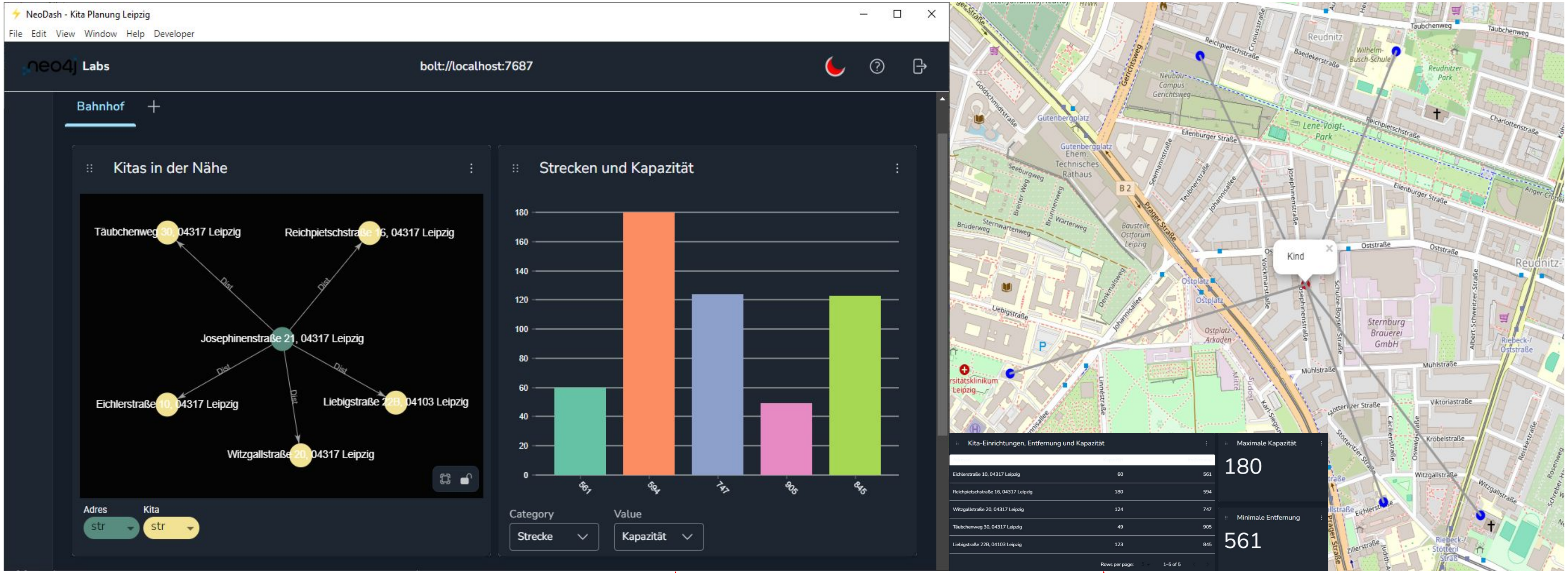
Introduction – Neo4j-Spatial User Guide

Graph APIs enable an intelligent and flexible interoperability not only for data operations, but also for analytics and visualisation:

- understandable for humans,
- interoperable with relational databases,
- data includes metadata,
- fast querying and calculations,
- powerful graph analytics
- spatial and temporal indexes and functioning (neo4j spatial)
- working with REST- and RPC-Interfaces,
- working with semantic (reuse concepts)
- simply customisable with low coding

Reachability of daycare with LPG and Neo4J

Example: Digital Twin of daycare planning in Leipzig



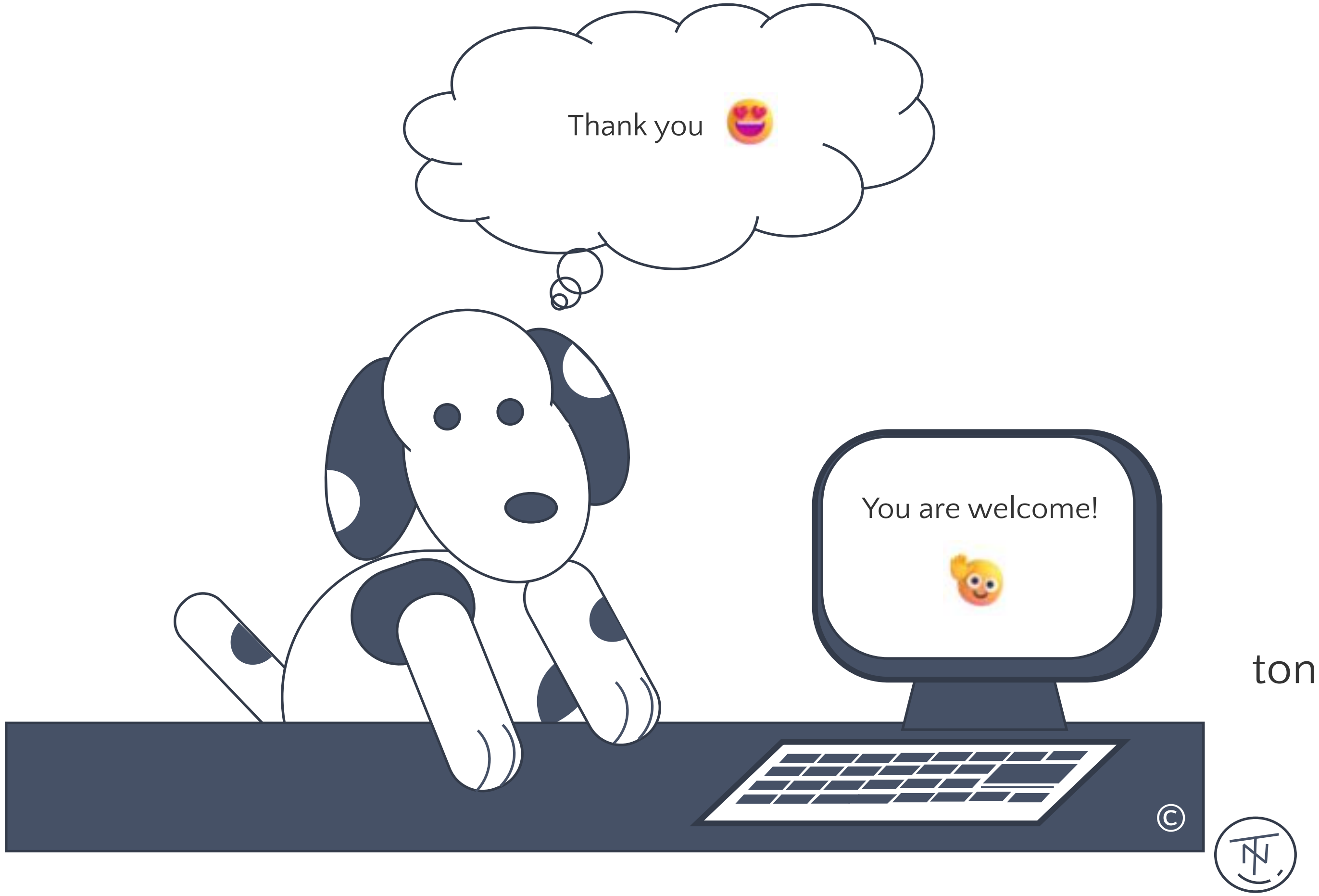
KiTa Erreichbarkeit

neo4j

NeoDash

Neomap

Thank you!



toni.tontchev@leipzig.de