Knowledge Graphs 2021: The great (graph) convergence

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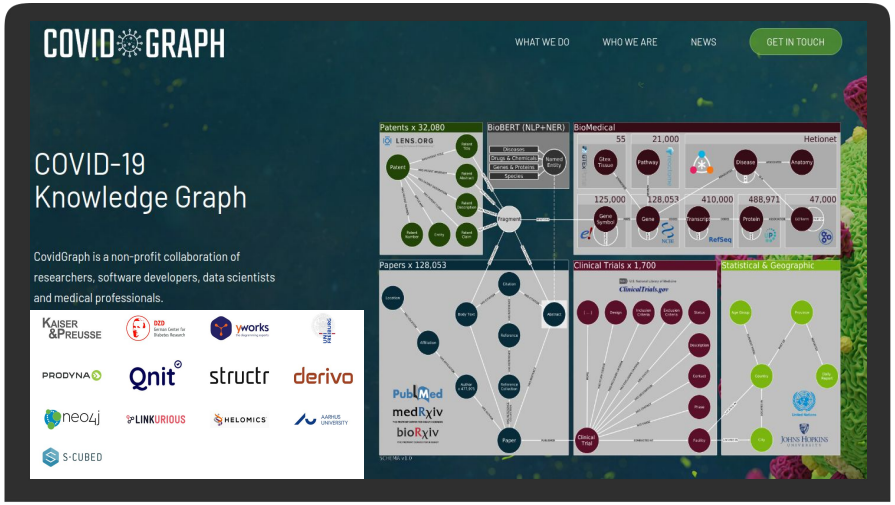
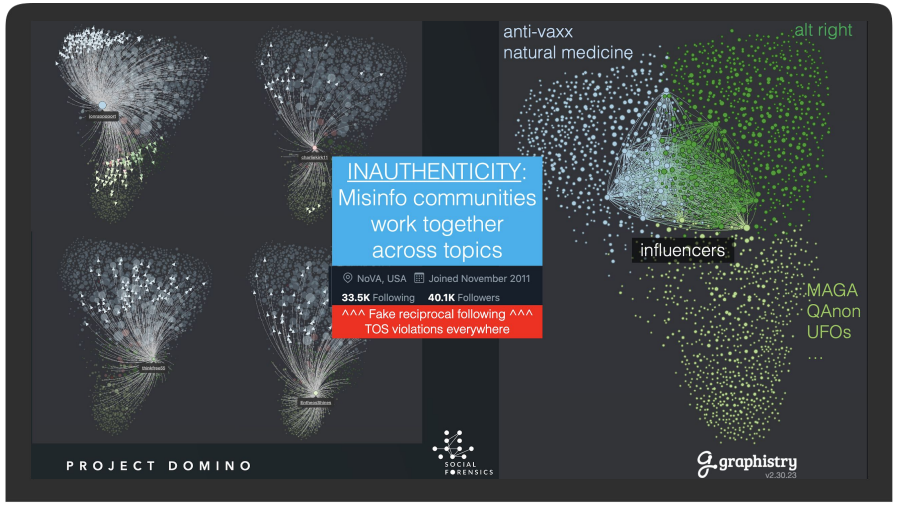
PhD in RDB to RDF mapping (2007)
6 Years at Ontology (UK)
2Y Stint at data virtualization: Denodo
Last 6 years: Neo4j
    The neosemantics project

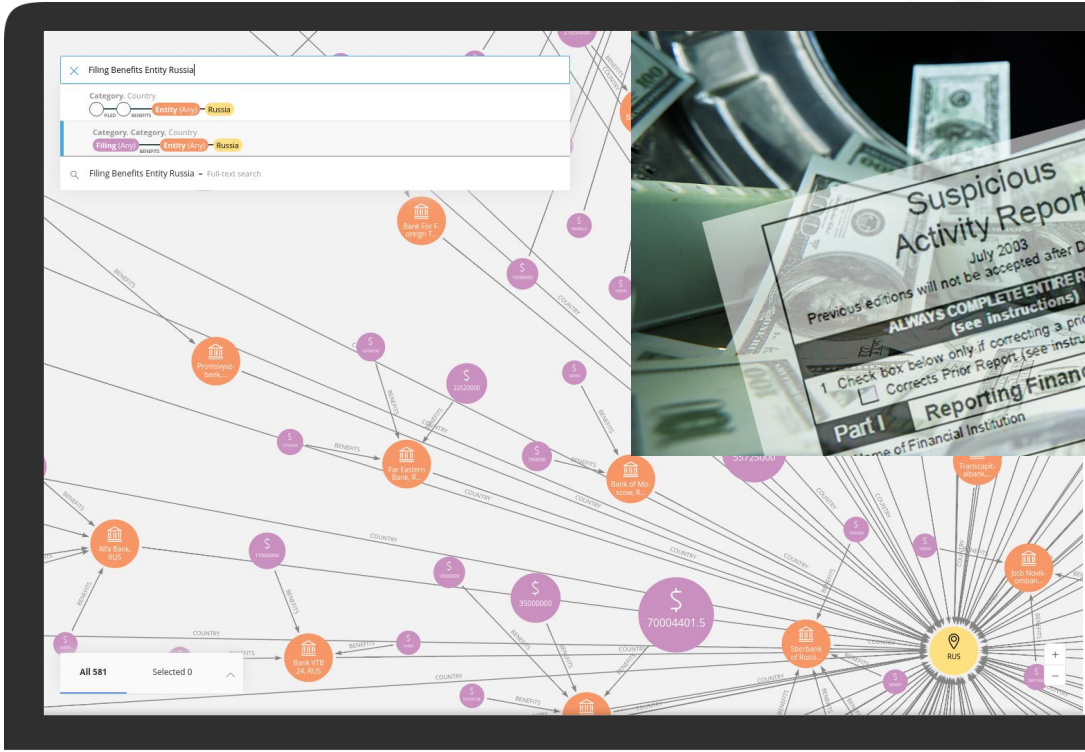
Graphs4Good in the times of COVID

Covid*Graph



Project Domino





https://www.icij.org/investigations/fincen-files/global-banks-defy-u-s-crackdowns-by-serving-oligarchs-criminals-and-terrorists

The Great graph Convergence

converge verb

Save Word

con·verge | \ kən-ˈvərj \

converged; **converging**

Definition of *converge*

intransitive verb

1 : to tend or move toward one point or one another : come together : MEET
// *converging* paths
// Police cars *converged* on the accident scene.

2 : to come together and unite in a common interest or focus
// Economic forces *converged* to bring the country out of the recession.

3 : to approach a limit as the number of terms increases without limit
// the series *converges*

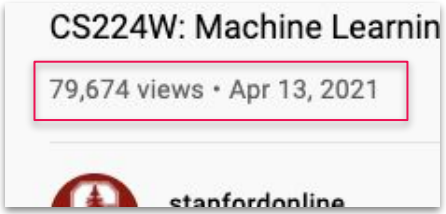
1 Huge interest in **graph ML**

2 Renewed interest in **RDF/ semantics**

3 Commercial Graphs **market growth**

1

Huge interest in **graph ML**



2

Renewed interest in
RDF/ Semantics

Gartner

How to Build Knowledge Graphs That Enable AI-Driven Enterprise Applications

- Take an agile approach to ontology and knowledge graph development to decrease time to value.
- Support a minimum viable graph (MVG) approach by incorporating machine learning techniques.

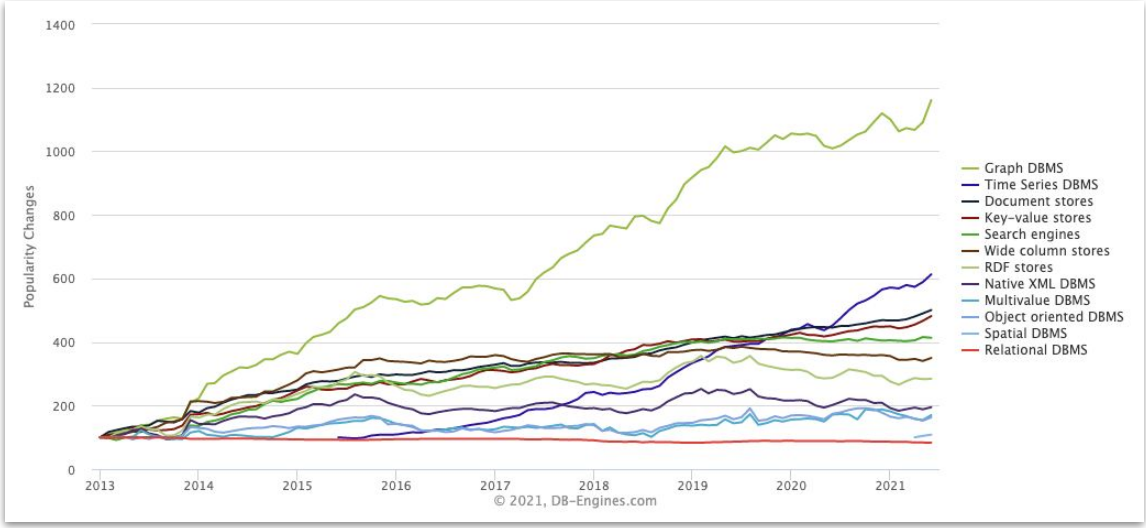
Gartner Identifies Top 10 Data and Analytics Technology Trends for 2021

Trend 8: Graph Relates Everything

Gartner predicts that by 2025, graph technologies will be used in 80% of data and analytics innovations, up from 10% in 2021, facilitating rapid decision making across the organization.

3

Commercial Graphs **market growth**



https://db-engines.com/en/ranking_categories

The trends come from different directions

Interoperability

And explicit semantics, of course, but targeted interoperability: ER

Better predictions

Graph features turn out to be significantly more predictive than attributes

Graph management

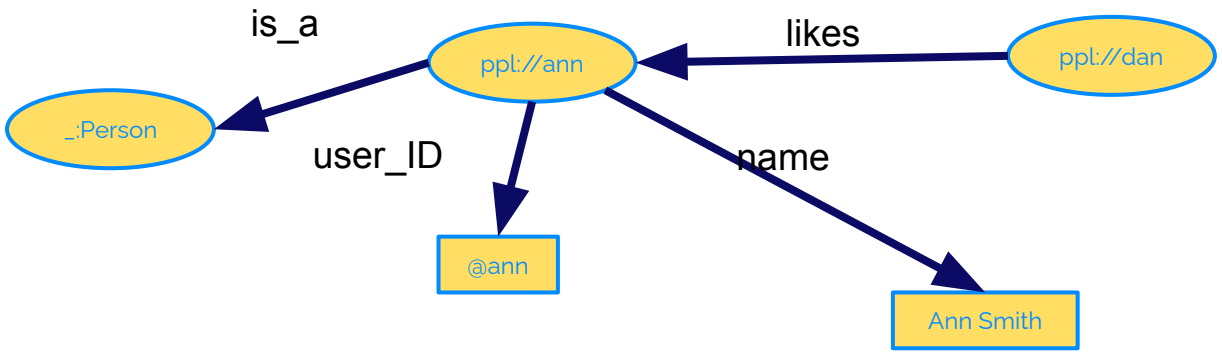
Shortest path to building a graph based solution both operational or analytical

Context: How do property graphs relate to RDF graphs?

GRAPH = VERTICES + EDGES

RDF statements (triples)

ppl://ann is a person
ppl//ann user ID is @ann
ppl://ann name is Ann Smith
ppl://dan likes ppl://ann



Vertices

Edges

PG connected objects (with properties)

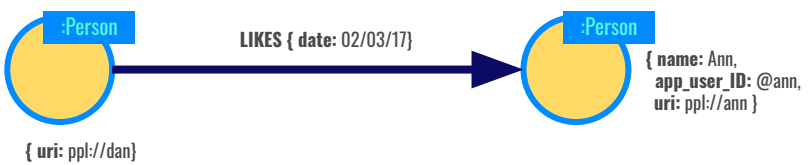
There is a person that is described by her name: Ann, her user ID: @ann and a globally unique identifier: <ppl://ann>

There is another person with a unique identifier: <ppl://dan>

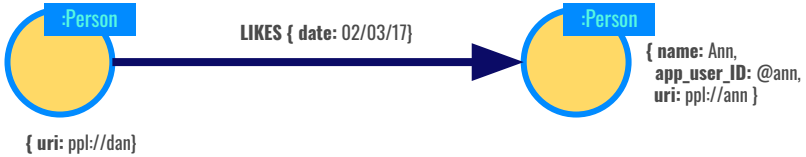
Dan likes Ann

Vertices

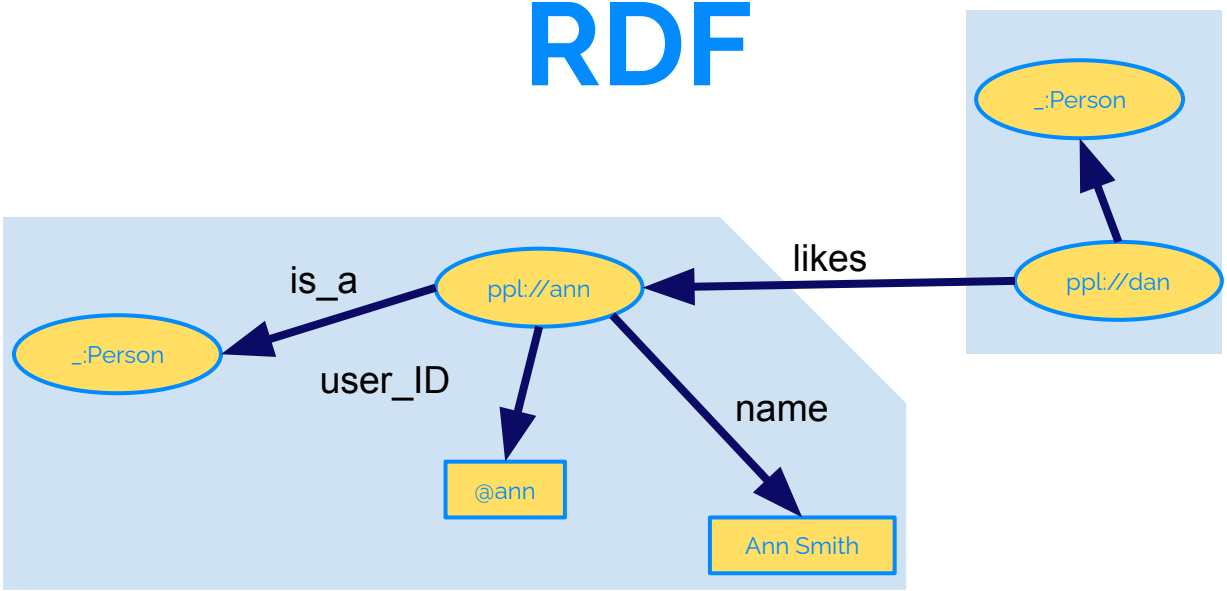
Edges



PG



RDF



Any RDF graph can be automatically imported into a PG DB in a lossless manner

Any Property Graph can be automatically serialised as RDF (or RDF*) in a lossless manner.

So there are really no diffs?

Just minor ones

- Property Graphs identify relationships (edges) uniquely
  - (some kind of native implementation of the singleton property http://dl.acm.org/citation.cfm?id=2567973)
- Multivalued properties are arrays/collections

Context: How do property graphs relate to RDF graphs?

SPARQL

```
prefix ms: <http://myschma.me/>
prefix rdf: <http://www[...]#>

SELECT ?who
{
  ?a a ms:Person .
  ?a ms:name ?asName .
  FILTER regex(?asName,'Ann')
  ?who ms:likes ?a .
}
```

Cypher

```
MATCH (who)-[:LIKES]->(a:Person)
WHERE a.name CONTAINS 'Ann'
RETURN who
```

A query: Who likes this person named Ann?

Context: How do property graphs relate to RDF graphs?

Integrity: ACID?
Storage: Native, RDB, NoSQL
Clustering: Consistency level
Workloads: Deep traversals, Algorithms.
Licensing & Support
Open/closed Source
Tech stack / integrations / architectures

Are we still Knowledge Graphs?

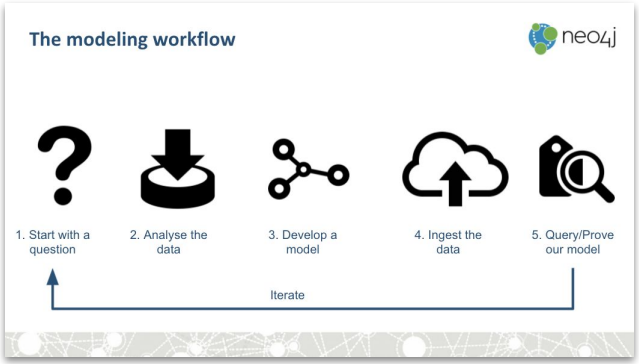
A KG is...

It's up to you really… here's an idea

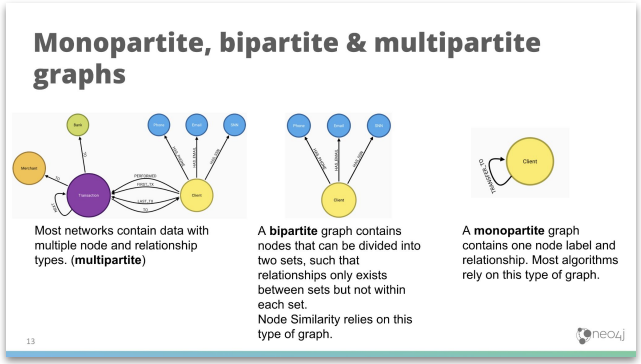
	Persisted in a DB	Described as RDF	Integrates disparate data	Models master data	Explicit & formal semantics	Queryable via SPARQL	A graph!	At scale!	Collaborative	…	KG
def#1	1	1	0	0	1	1	1	1	0		1
def#2	0	1	1	0	1	0	1	0	0		1
def#3	1	1	0	0	1	0	1	0	0		1
…											
def#183	1	0	0	0	0	0	1	1	0		0

How are Knowledge Graphs built with Neo4j?

KG construction



Purely pragmatic: Start from the end.
Keep usage in mind... Iterate



Query perf considerations. Model evolution, etc… change!

Then remodelling for analytics.
Monopartite, bipartite… views on KG

Observation#1

KG construction is largely an engineering task

- Important (huge) investment in modelling trainings
- (change!) Model Refactoring…
- Things are different on the consuming side (graphs help, at least via visual exploration)

Observation#2

Model reuse is (close to) non-existent

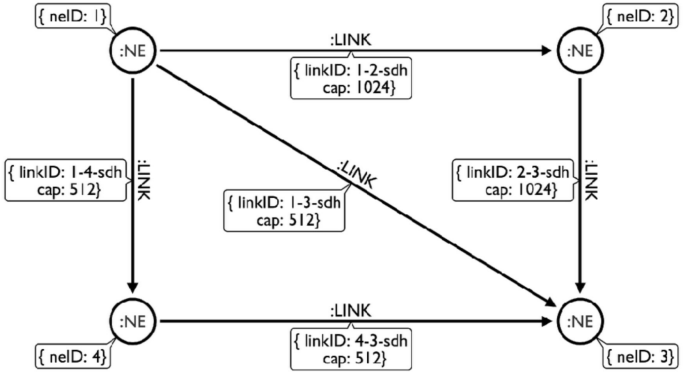
- There’s no such thing as a library of public Property Graph models
- What does a PG “ontology” look like? -> The multilayered network example.

The social network

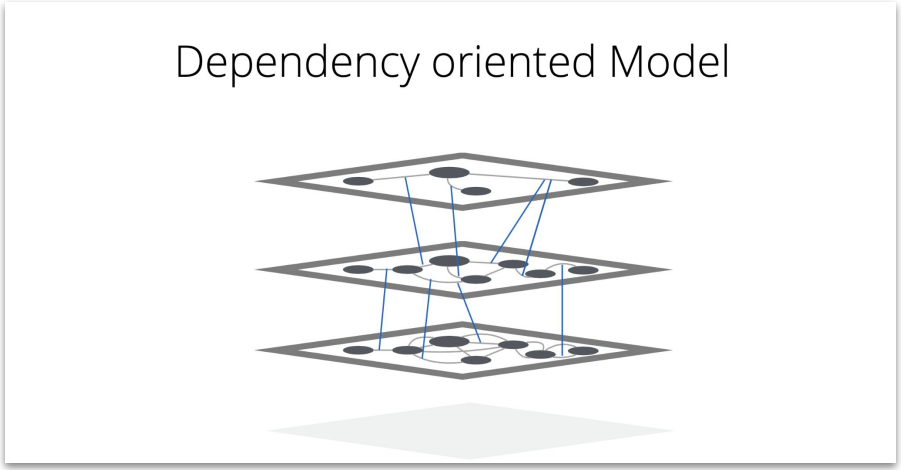
Route oriented Model

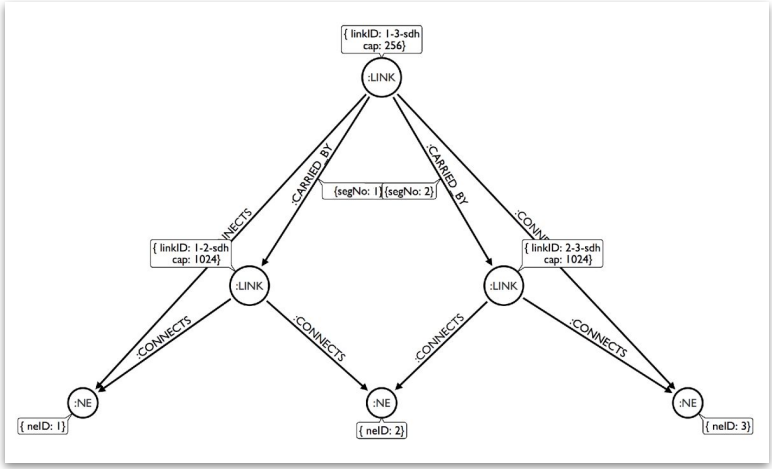
Shortest/most efficient path from A to B

Find diverse routes between A and B

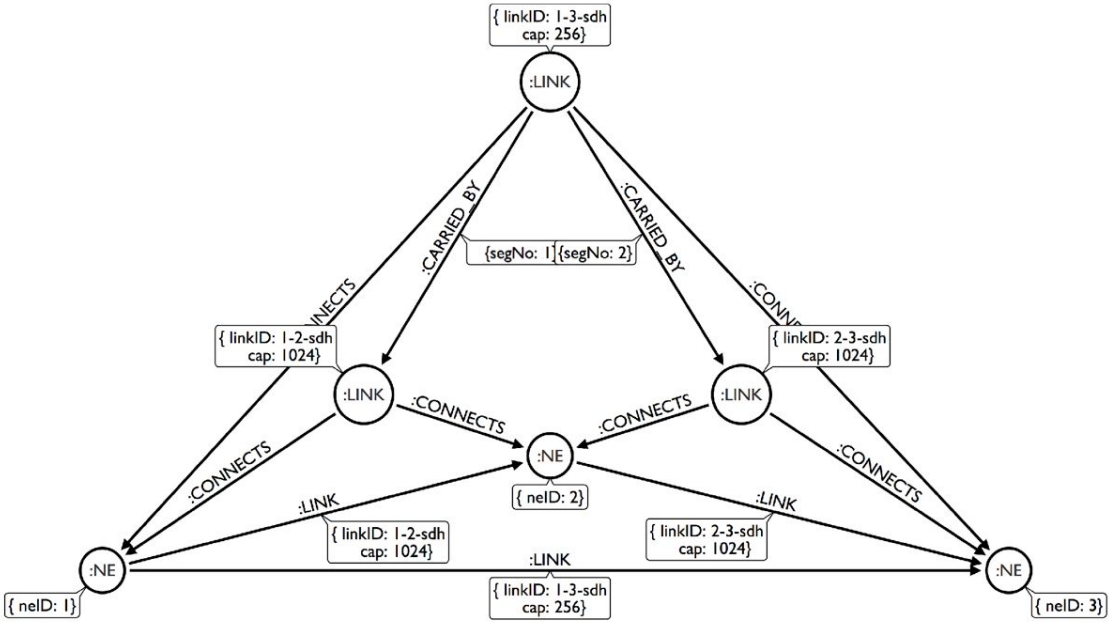


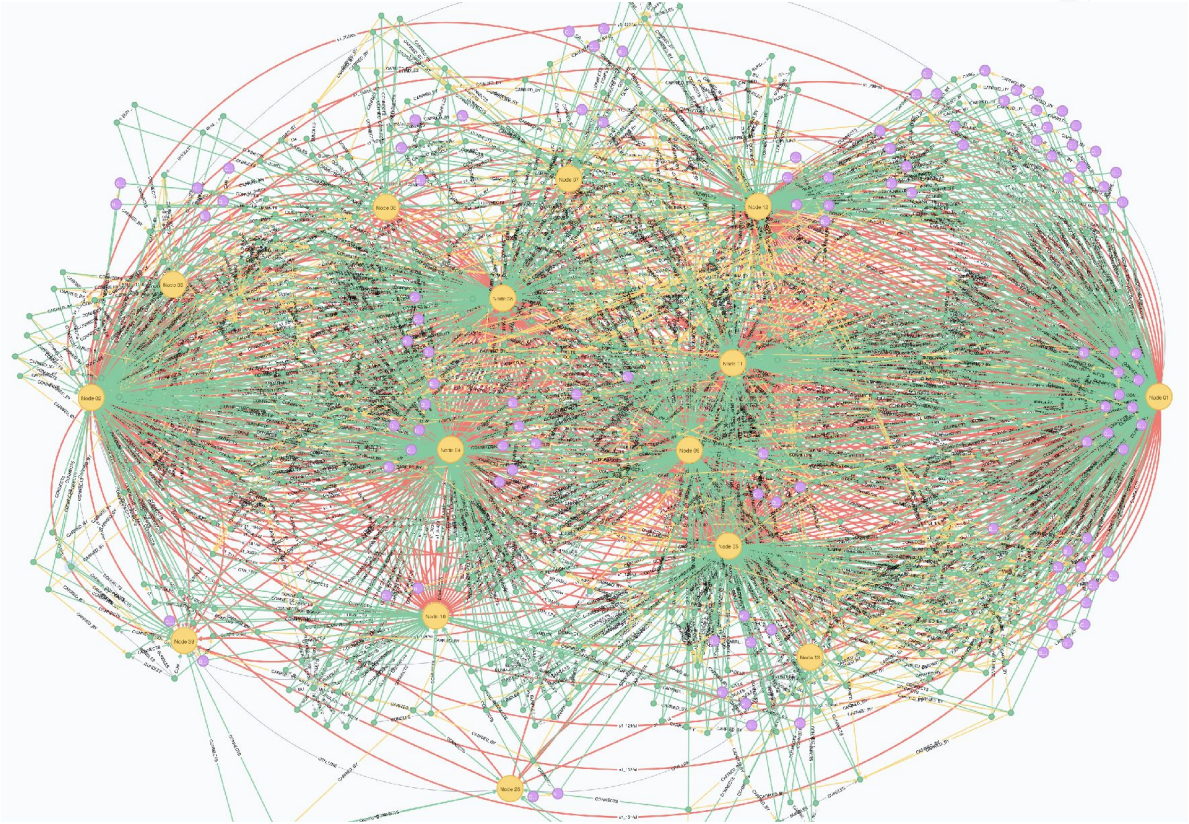
The organization

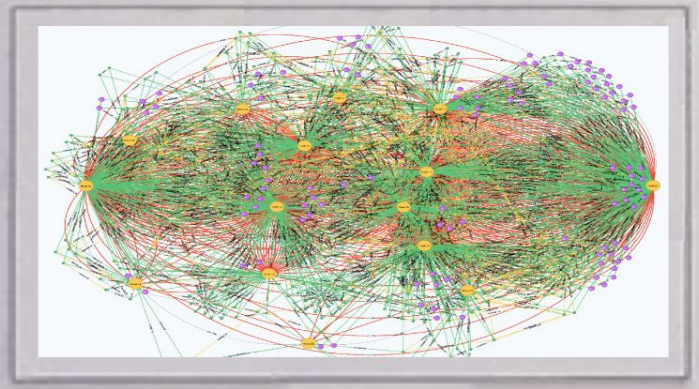




Dual Model







The loaders and the “inferencing” on the model

```
CALL apoc.load.(json|xml|csv|...) ...
    MERGE (aN:NE { neId: $aNeId}), (zN:NE { neId: $zNeId})
    MERGE (aN)<-[:CONNECT]-(l:Link)-[:CONNECT]->(zN) WITH l
```

```
CALL nm.spof(“123-sdh”,“317-sdh”)
CALL nm.disjoint(2,“n-1”,“n-7”, <max-cost>)
CALL nm.rca([“593-sdh”,“627-sdh”,“114-sdh”,...])
...
```

Observation#3

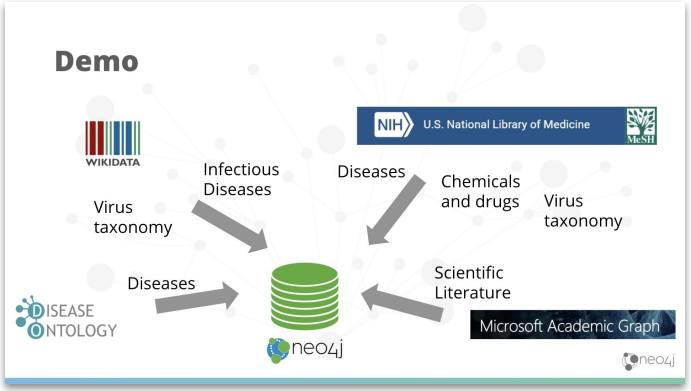
KG construction is augmented by automation (Graph Algos, ML…)

- Taxonomies “learnt” from the data.
  - Similarity algorithms
- Formalised as overlay ontologies
- Used to drive query expansion, similarity analysis, recommendation...

Observation#4

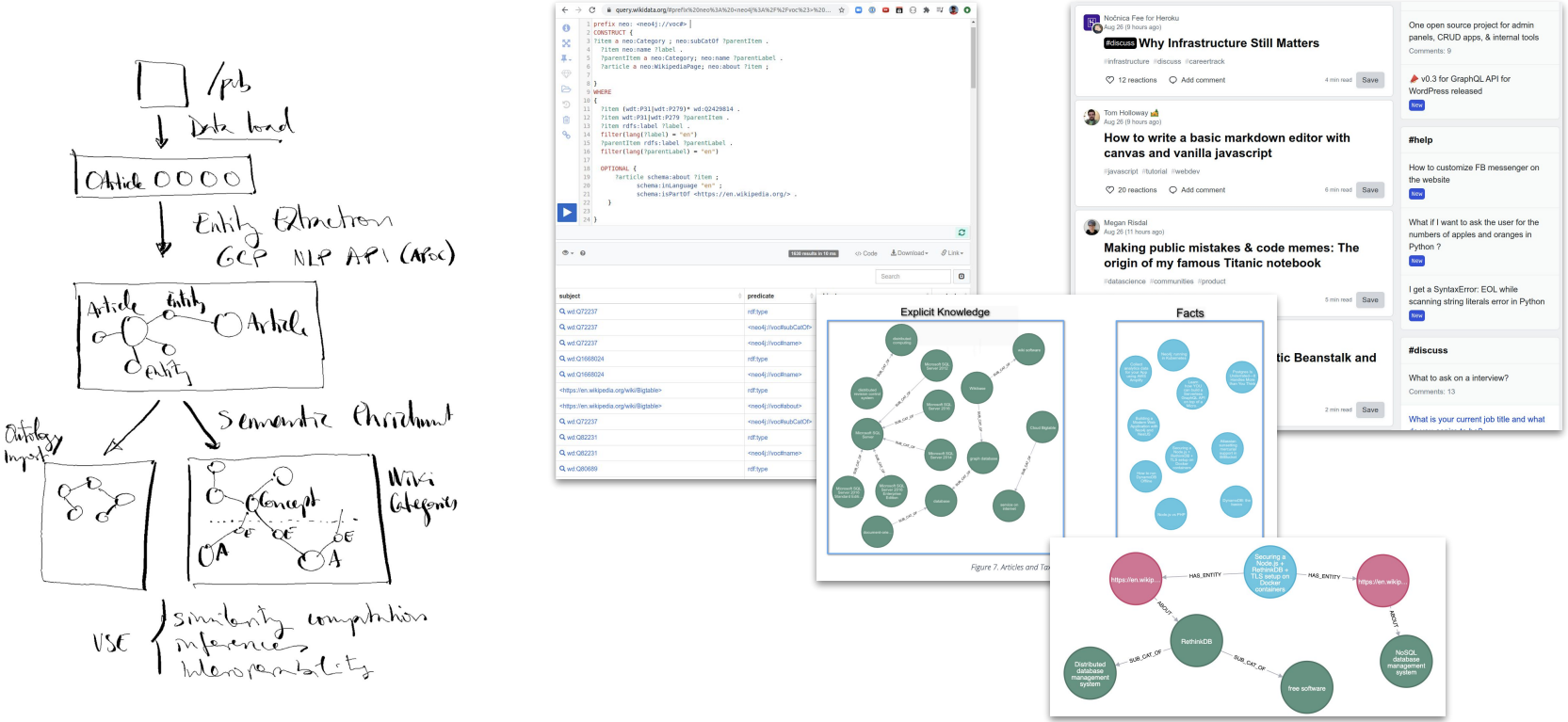
(private) KG construction use fragments of public KGs

- Wikidata
- Public ontologies



neo4j

Example: Tutorial- Building a KG using NLP and Ontologies



https://neo4j.com/developer/graph-data-science/build-knowledge-graph-nlp-ontologies/

n10s: RDF ~~vs~~ and PG

Observation#5

There’s no ‘standard’ property graph serialisation format. Wait a minute...

- Cloning a subgraph had to be done using scripting (cypher).
- RDF (kind of) did the job. RDF* makes it a lot easier

Observation#6

There’s a lot of valuable (RDF) graph data out there.

- Do I really need to flatten it before I make it a graph again in my DB?
- RDF endpoints + SPARQL CONSTRUCT is your friend.

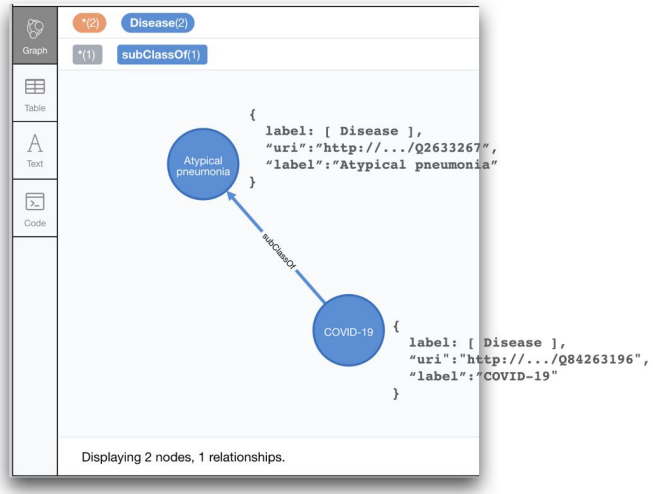
n10s: The bidirectional conversion

Take a triple...

- object is a Literal
  - ↳ a node with a property

    (deal with datatypes, lang tags, multivals, etc.)
- object is a resource
  - ↳ two nodes and a relationship
- predicate is *rdf:type*
  - ↳ a node with a label (optionally)

```
<http://www.wikidata.org/entity/Q84263196> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type>  <http://www.wikidata.org/category/Disease> .
<http://www.wikidata.org/entity/Q84263196> <http://www.w3.org/2000/01/rdf-schema#label>       "COVID-19" .
<http://www.wikidata.org/entity/Q84263196> <http://www.w3.org/2000/01/rdf-schema#subClassOf> <http://www.wikidata.org/entity/Q2633267> .
<http://www.wikidata.org/entity/Q2633267>  <http://www.w3.org/1999/02/22-rdf-syntax-ns#type>  <http://www.wikidata.org/category/Disease> .
<http://www.wikidata.org/entity/Q2633267>  <http://www.w3.org/2000/01/rdf-schema#label>       "Atypical pneumonia" .
```



https://jbarrasa.com/2016/06/07/importing-rdf-data-into-neo4j/

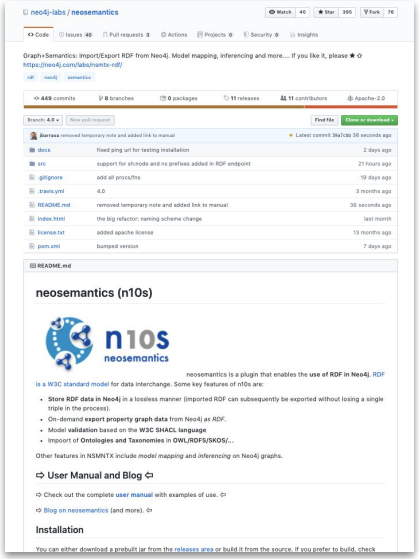
neo4j

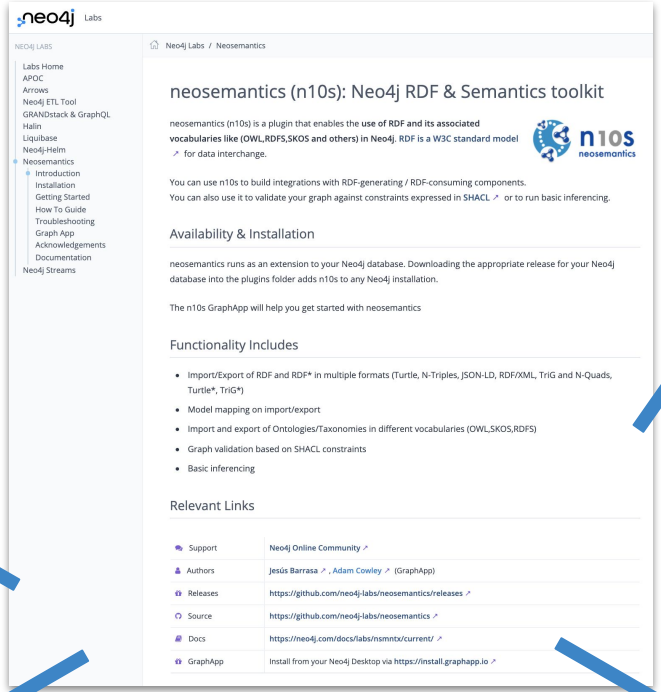
Enter neosemantics: n10s

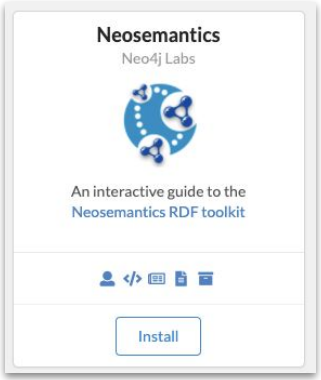
n10s is a plugin that enables the **use of RDF in Neo4j**

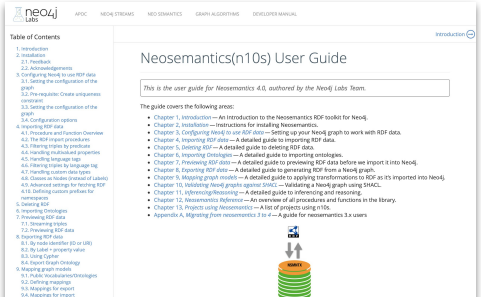
- **Import and store RDF data in Neo4j** in a **lossless** manner
- On-demand **export** property graph **data from Neo4j as RDF**
- model **mapping**
- Graph **data validation** based on SHACL shapes /constraints
- (limited) **Inferencing**

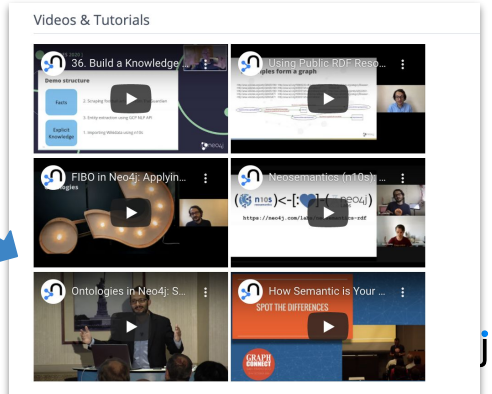
https://neo4j.com/labs/neosemantics











n10s in some key figures

5 Yrs

First commit in April 2016. **14 contributors** 50% are Neo4j staff.

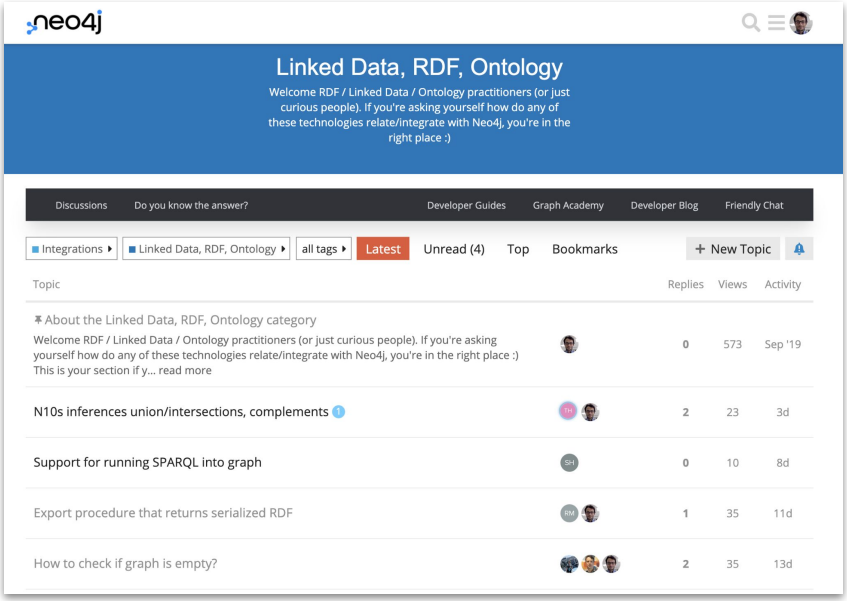
24.8K

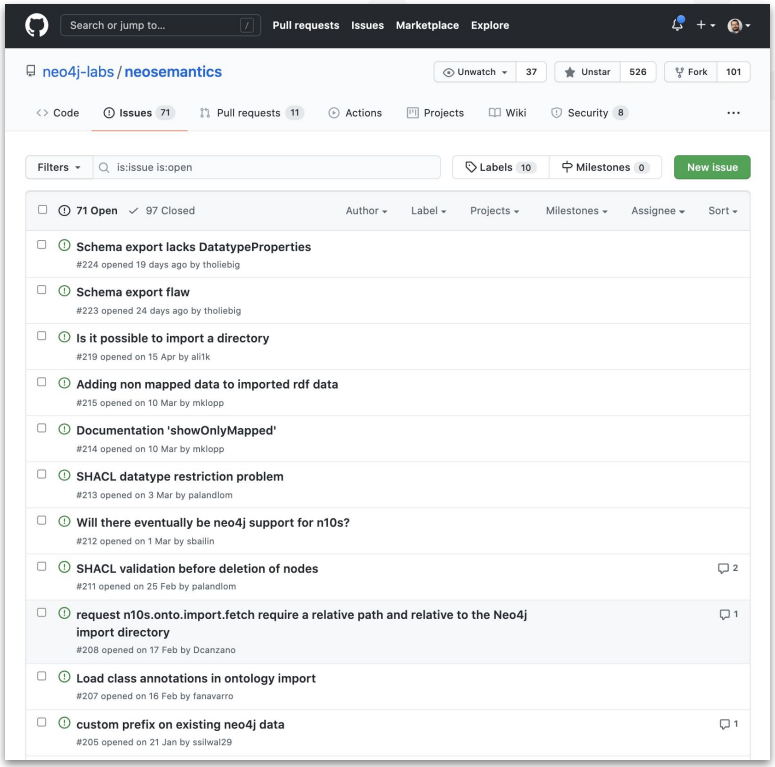
Downloads of neosemantics as of June 5th 2021.

526★

Top 20 actively maintained RDF projects on GitHub

n10s community



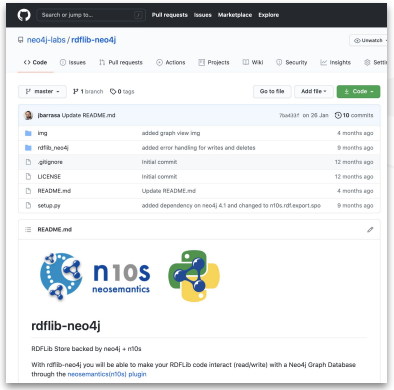


https://community.neo4j.com/c/integrations/linked-data-rdf-ontology/162

https://github.com/neo4j-labs/neosemantics/issues

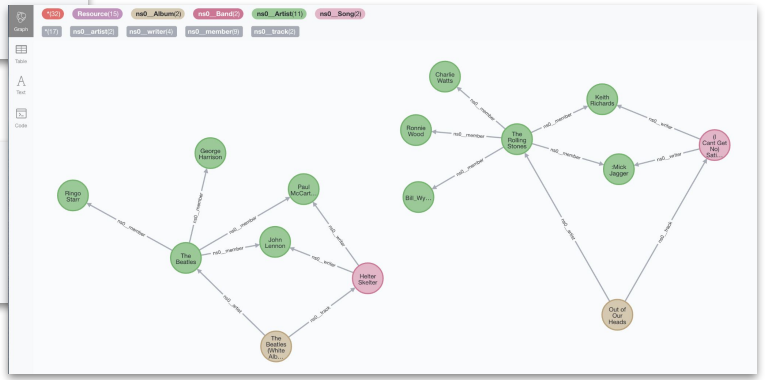
N10s satellite projects: rdflib-neo4j

```python
import rdflib

# create a neo4j backed Graph
g = rdflib.Graph(store='Neo4j')

# set the configuration to connect to your Neo4j DB
theconfig = {'uri': "neo4j://localhost:7687", 'database': 'rdfstore', 'auth': {'user': "neo4j", 'pwd
g.open(theconfig, create = False)

g.load("https://raw.githubusercontent.com/jbarrasa/datasets/master/rdf/music.nt", format="nt")

# For each foaf:Person in the store, print out their mbox property's value.
print("--- printing band's names ---")
for band in g.subjects(rdflib.RDF.type, rdflib.URIRef("http://neo4j.com/voc/music#Band")):
    for bandName in g.objects(band, rdflib.URIRef("http://neo4j.com/voc/music#name")):
        print(bandName)
```



An RDFLib Store backed by neo4j + n10s

```python
MUSIC = rdflib.Namespace("http://neo4j.com/voc/music#")
fm = rdflib.URIRef("http://neo4j.com/indiv#Fleetwood_Mac")

g.add((fm, rdflib.RDF.type, MUSIC.Band))
g.add((fm, MUSIC.name, rdflib.Literal("Fleetwood Mac")))
```



Observation#7

We are convinced of the value of making semantics explicit

- Automation is central to the creation of ontologies. Without it it’s close to pointless.
- Making the data smarter

Observation#8

But the sad reality is that the understanding of semantics outside the academic community is very poor

- People get SHACL validations… but not OWL inference
- Maybe that’s the right path?

The SHACL approach

- SHACL core
- DASH Constraints (http://datashapes.org/constraints.html)
  - `dash:coExistsWith`
  - `dash:subSetOf`
- Defined by TopQuadrant, supported by Ontotext

Takeaways

Updated from the version presented based on Christophe Debruyne's question ;-)

- Let's keep making data smarter together. Your contribution is welcome
  - Successful precedents: eccenca
- KG adoption in industry is in its infancy, we have a great future ahead of us.
- Call to action: be curious and spin up a Neo4j sandbox(*) and do RDF!

"It's all graphs!"

Juan Sequeda

(*)https://sandbox.neo4j.com/

Thank you!