JSON-LD
for Linked Open Data
and Knowledge Graphs

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(allegrograph.com)

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Contents

- The world of Semantics and RDF and Graphs
- The world of JSON and Documents
- A powerful intersection: JSON-LD: JSON + RDF
- Store it in a document store or in a semantic graph database?

The world of Semantics and RDF

- Tim Berners-Lee in 1994: only humans can read the context on the web, computers can't. We need a meta data language that gives meaning to objects on the web.

- Invented RDF to add Semantics to objects.

RDF at the core is simple

[1] Use IRIs as a universal identifier mechanism

[2] Describe any type of (meta) data as triples

<subject> <predicate> <object>

subjects* and predicates are always IRIs

objects can be IRIs or any XSD datatype

[3] Add meaning to data by a self-describing logic called OWL

* ok, ok, subjects can also be blank nodes

NTRIPLES format for computers

- There is a person born in 1958 with first name “Jans” and last name “Aasman” who lives in a place with the name “Moraga” (pop 16000) that is part of state “California (pop 34 M)

```
<http://abc.com/person1> <http://abc.com/firstName> "Jans"  .
<http://abc.com/person1> <http://abc.com/lastName> "Aasman"  .
<http://abc.com/person1> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://abc.com/Person> .
<http://abc.com/person1> <http://abc.com/birthYear> "1958"  .
<http://abc.com/person1> <http://abc.com/livesIn> <http://abc.com/place1>  .
<http://abc.com/place1> <http://abc.com/name> "Moraga"  .
<http://abc.com/place1> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://abc.com/Place> .
<http://abc.com/place1> <http://abc.com/population> "16000"^^<http://www.w3.org/2001/XMLSchema#integer>  .
<http://abc.com/place1> <http://abc.com/partOf> <http://abc.com/state1>  .
<http://abc.com/state1> <http://abc.com/name> "California"  .
<http://abc.com/place1> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://abc.com/Place> .
<http://abc.com/state1> <http://abc.com/population> "34000000"^^<http://www.w3.org/2001/XMLSchema#integer>  .
```

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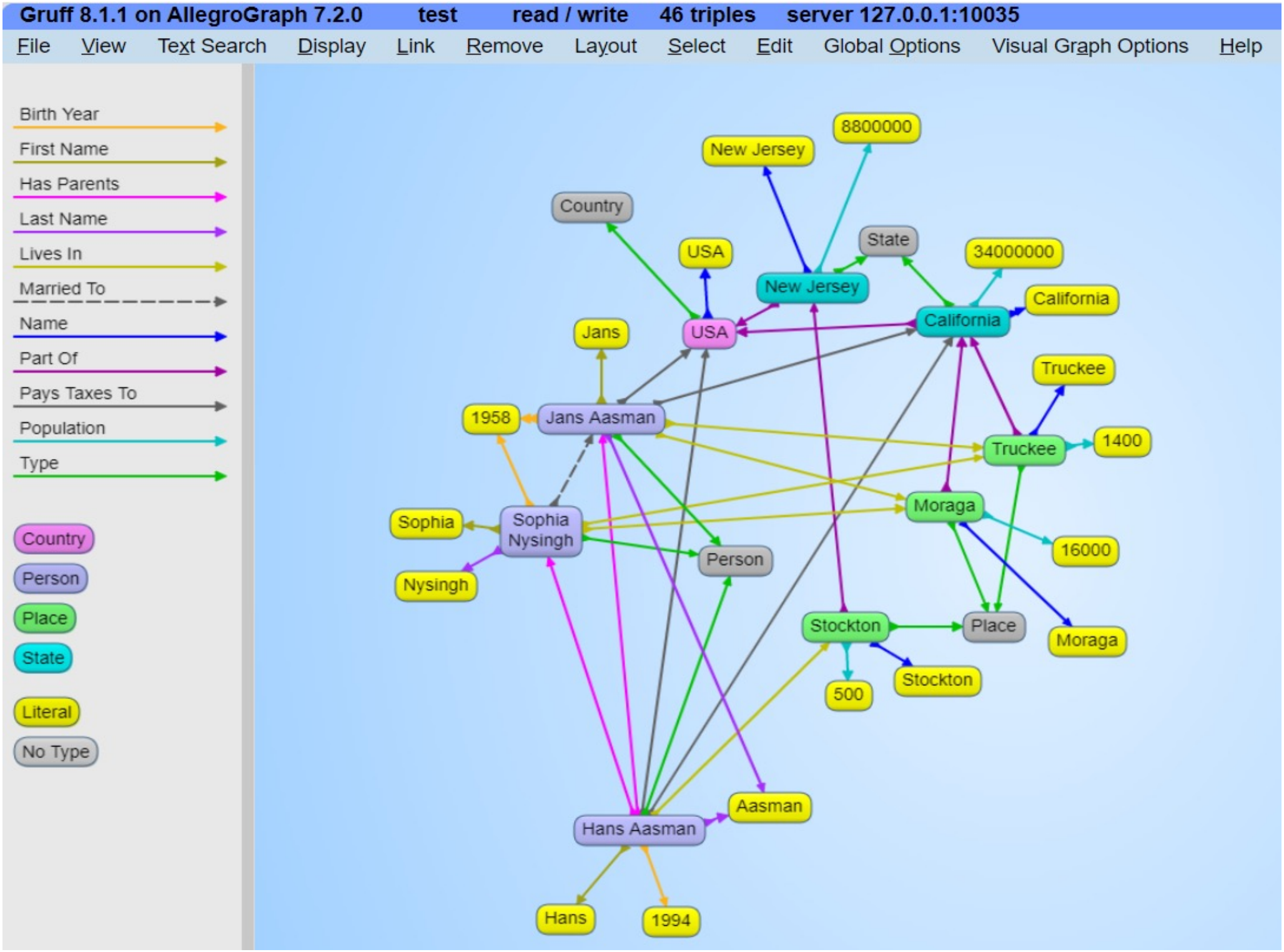
TURTLE for humans

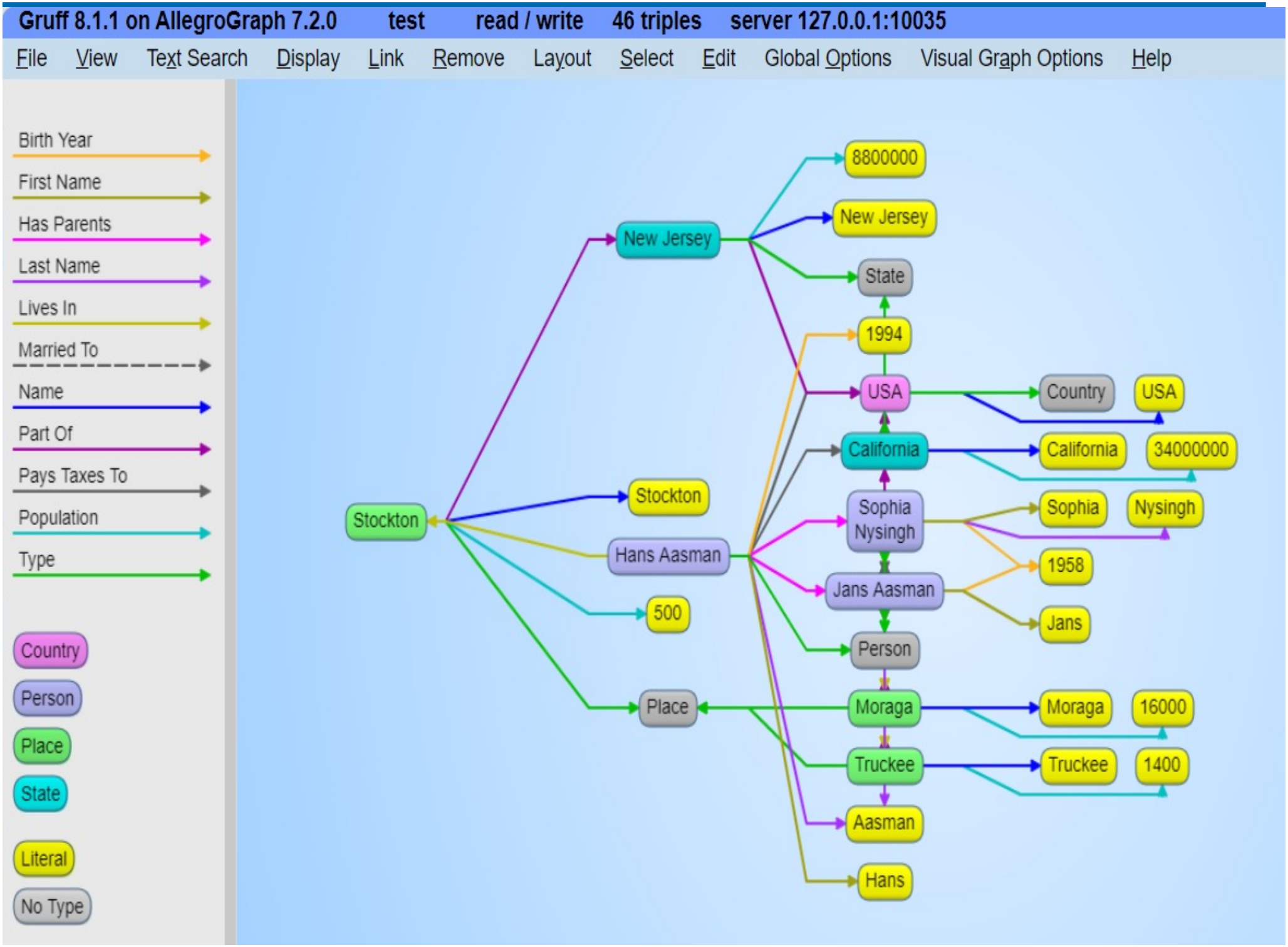
```
# Turtle, same information...

@prefix : <http://abc.com/> .
:person1 a :Person ;
         :firstName 'Jans';
         :lastName 'Aasman' ;
         :birthYear 1958 ;
         :livesIn :place1 .
:place1  a :Place
         :name 'Moraga' ;
         :population 16000 ;
         :partOf :state1.
:state1  a :State;
         :name 'California' ;
         :population 34000000 .
```

Make it slightly more interesting

```
@prefix : <http://abc.com/> .
:person1 a :Person ;
         :firstName 'Jans';
         :lastName 'Aasman' ;
         :birthYear '1958' ;
         :livesIn :place1 , :place2 .
:person2 a :Person ;
         :firstName 'Sophia';
         :lastName 'Nysingh' ;
         :birthYear '1958' ;
         :livesIn :place1 , :place2 ;
         :marriedTo :person1 .
:person3 a :Person ;
         :firstName 'Hans';
         :lastName 'Aasman' ;
         :birthYear '1994' ;
         :livesIn :place3 ;
         :hasParents :person1 , :person2 .
:place1  a :Place ; :name 'Moraga' ; :population 16000 ; :partOf :state1 .
:place2  a :Place; :name 'Truckee' ;  :population 1400 ;  :partOf :state1 .
:place3  a :Place; :name 'Stockton' ;  :population 500 ;  :partOf :state2 .
:state1  a :State ; :name 'California' ; :population 34000000 ; :partOf :country1 .
:state2  a :State ; :name 'New Jersey' ; :population 8800000 ; :partOf :country1 .
:country1 a :Country ; :name 'USA' .
:person1 :paysTaxesTo :country1, :state1 .
:person3 :paysTaxesTo :country1, :state1 .
```

Jans has two places, is married to Sophia. Jans pays taxes to California and USA and they have a son in Stockton, New Jersey


Gruff 8.1.1 on AllegroGraph 7.2.0 test read / write 46 triples server 127.0.0.1:10035
File View Text Search Display Link Remove Layout Select Edit Global Options Visual Graph Options Help
Birth Year
First Name
Has Parents
Last Name
Lives In
Married To
Name
Part Of
Pays Taxes To
Population
Type
Country
Person
Place
State
Literal
No Type
8800000
New Jersey
Country
State
USA
34000000
New Jersey
California
California
Jans
USA
Truckee
1958
Jans Aasman
Truckee
1400
Moraga
Sophia
Sophia Nysingh
16000
Person
Nysingh
Stockton
Place
Moraga
Stockton
500
Aasman
Hans Aasman
Hans
1994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Birth Year
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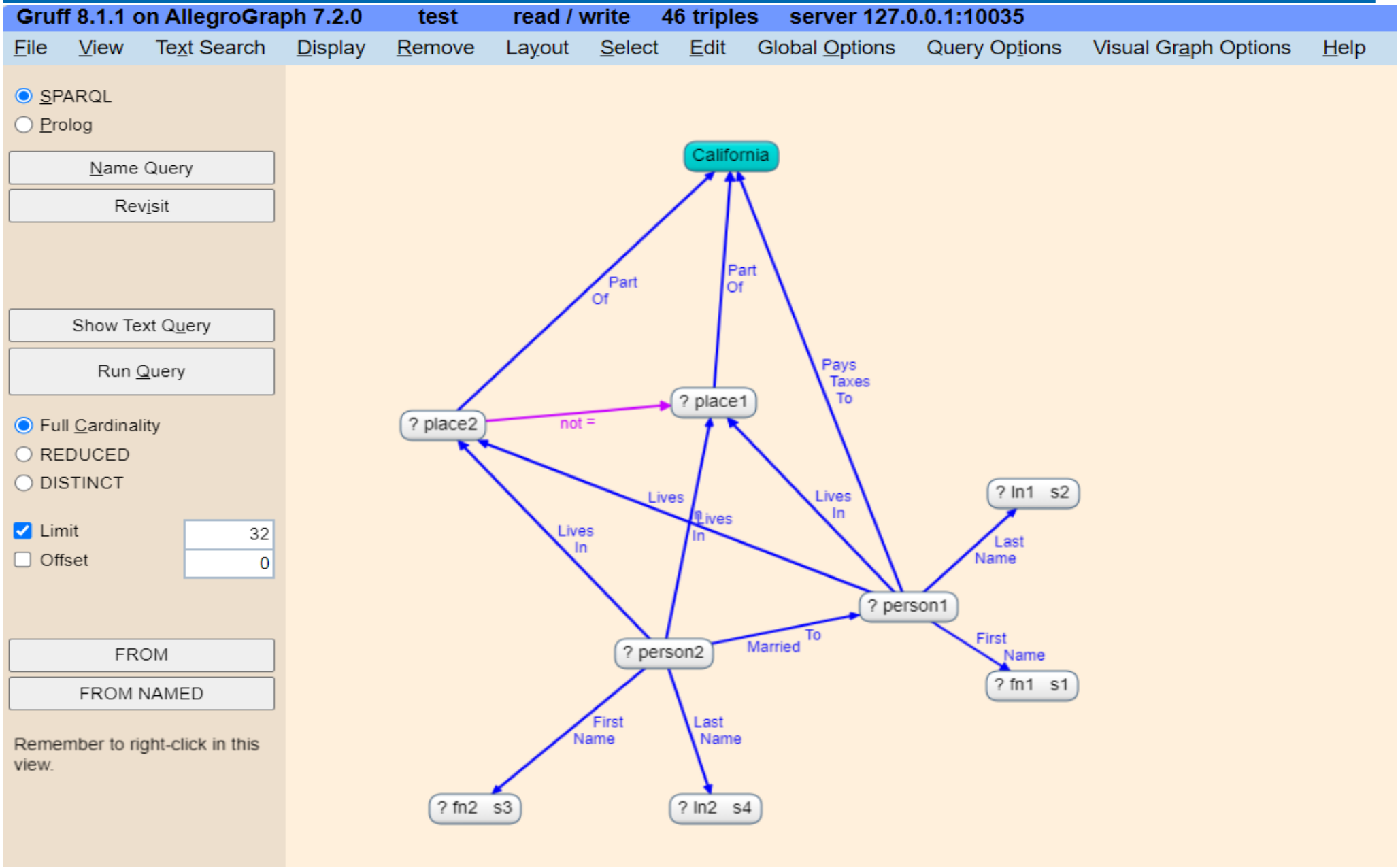
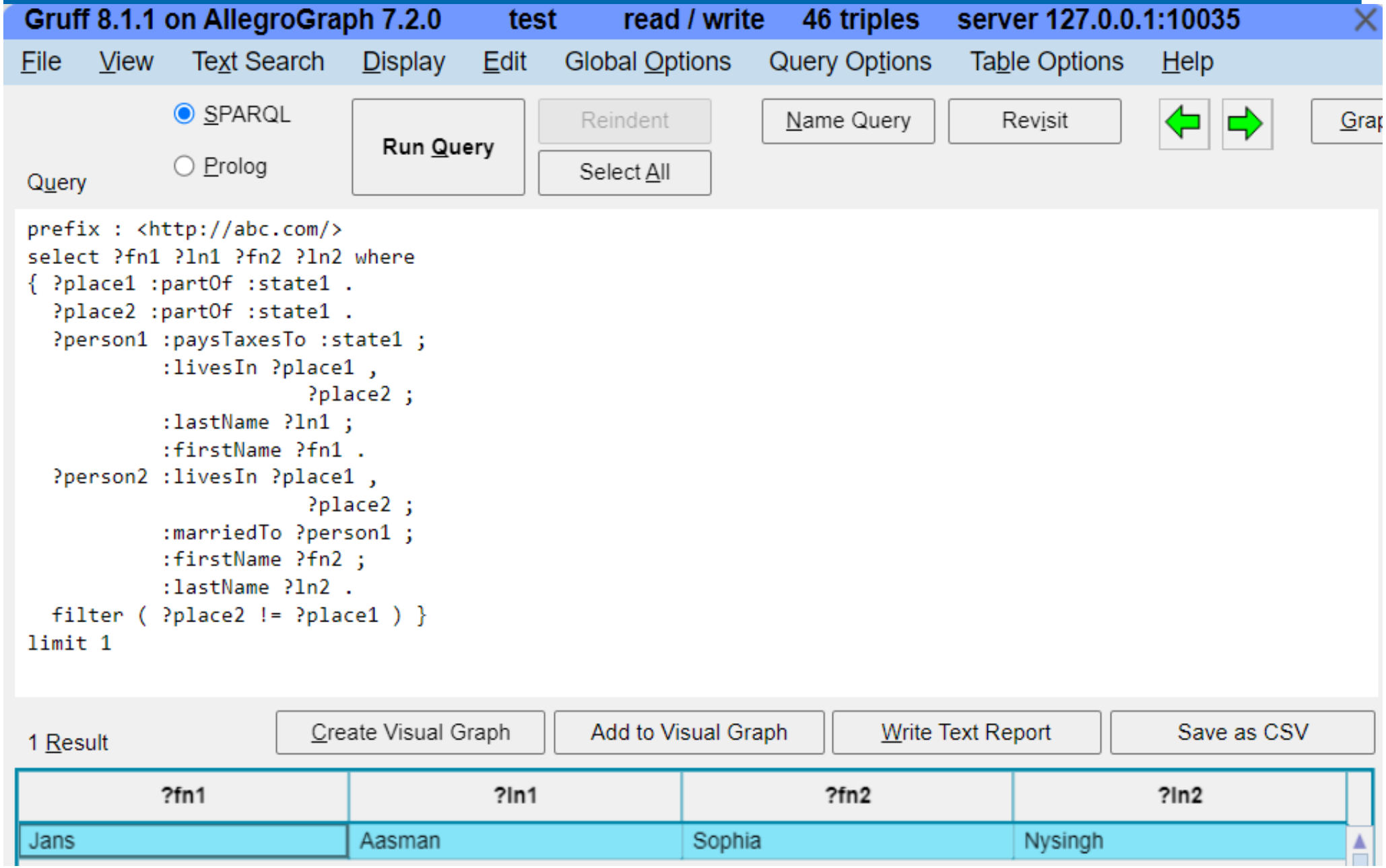
Married To
Name
Part Of
Pays Taxes To
Population
Type
Country
Person
Place
State
Literal
No Type
8800000
New Jersey
New Jersey
State
1994
USA
Country
USA
California
California
34000000
Stockton
Sophia Nysingh
Sophia
Nysingh
Stockton
Hans Aasman
1958
Jans Aasman
500
Jans
Person
Place
Moraga
Moraga
16000
Truckee
Truckee
1400
Aasman
Hans

Visual SPARQL: find two people that lives in two places in California where one person also pays taxes in California



Generated SPARQL

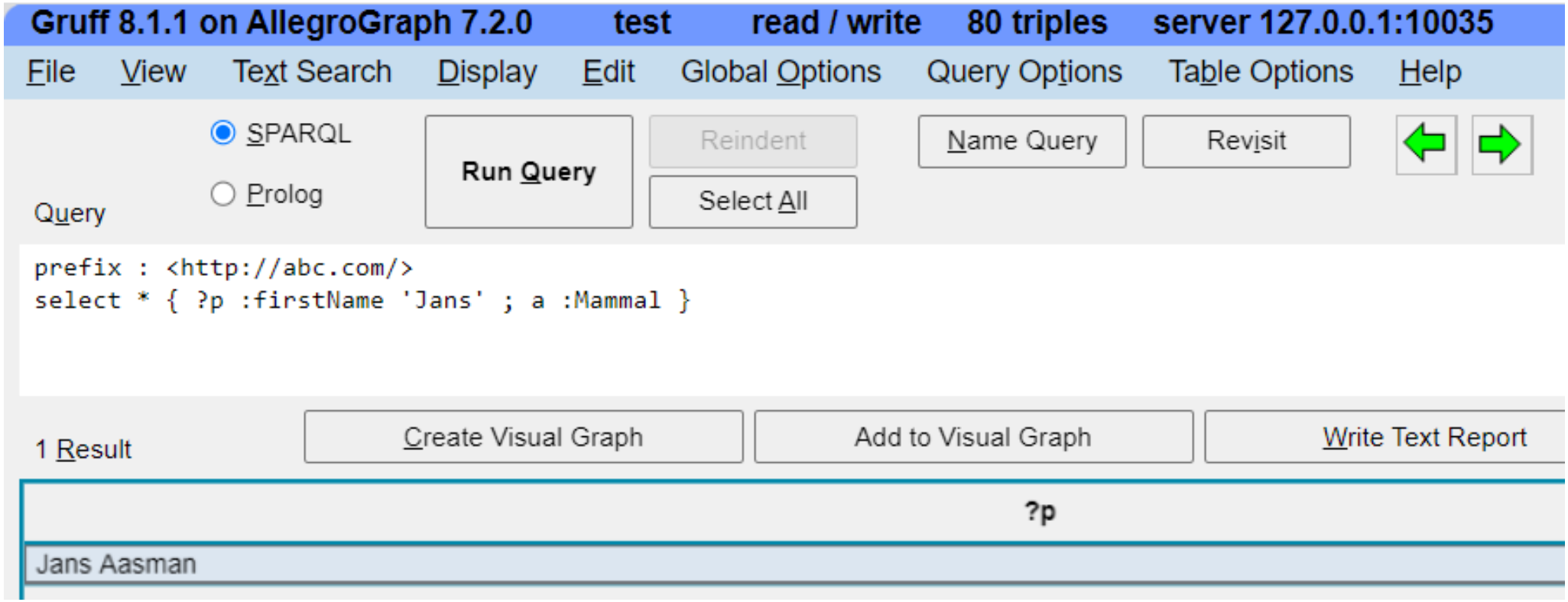


And a tiny ontology in OWL

```
:Person a owl:Class ; rdfs:subClassOf :Mammal.
:Mammal a owl:Class .
:hasParents a owl:ObjectProperty .
:hasChild owl:inverseOf :hasParents .
:marriedTo rdfs:domain :Person ;
           rdfs:range  :Person .
```

Is Jans a Mammal

- And now we can reason too



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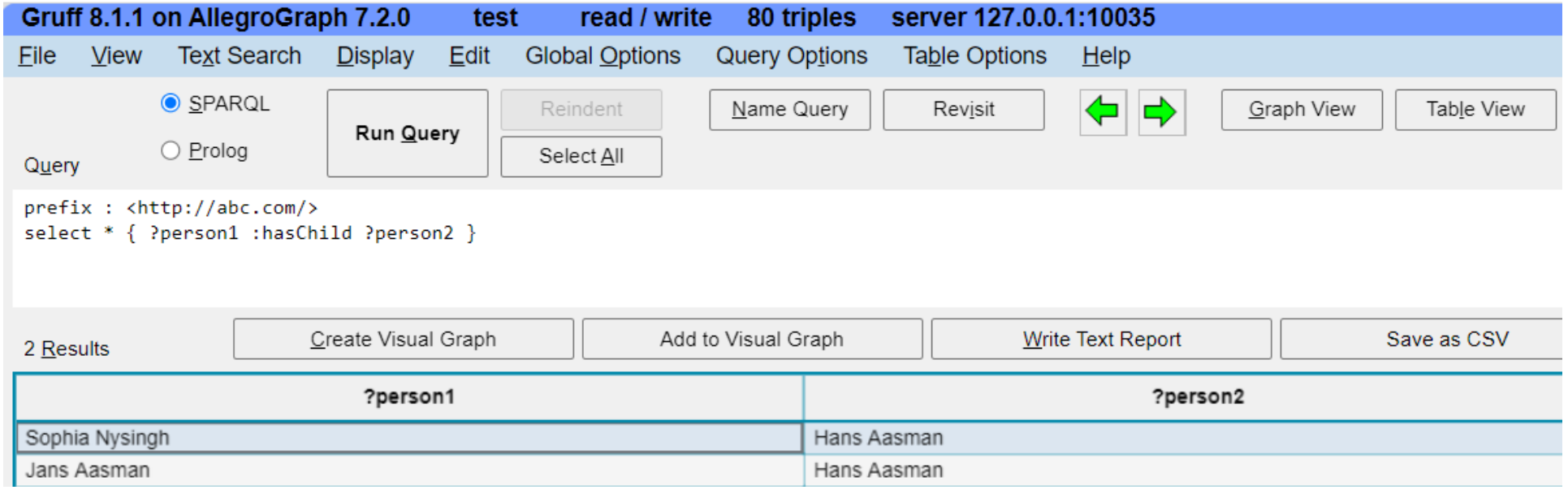
Does Jans have Children?



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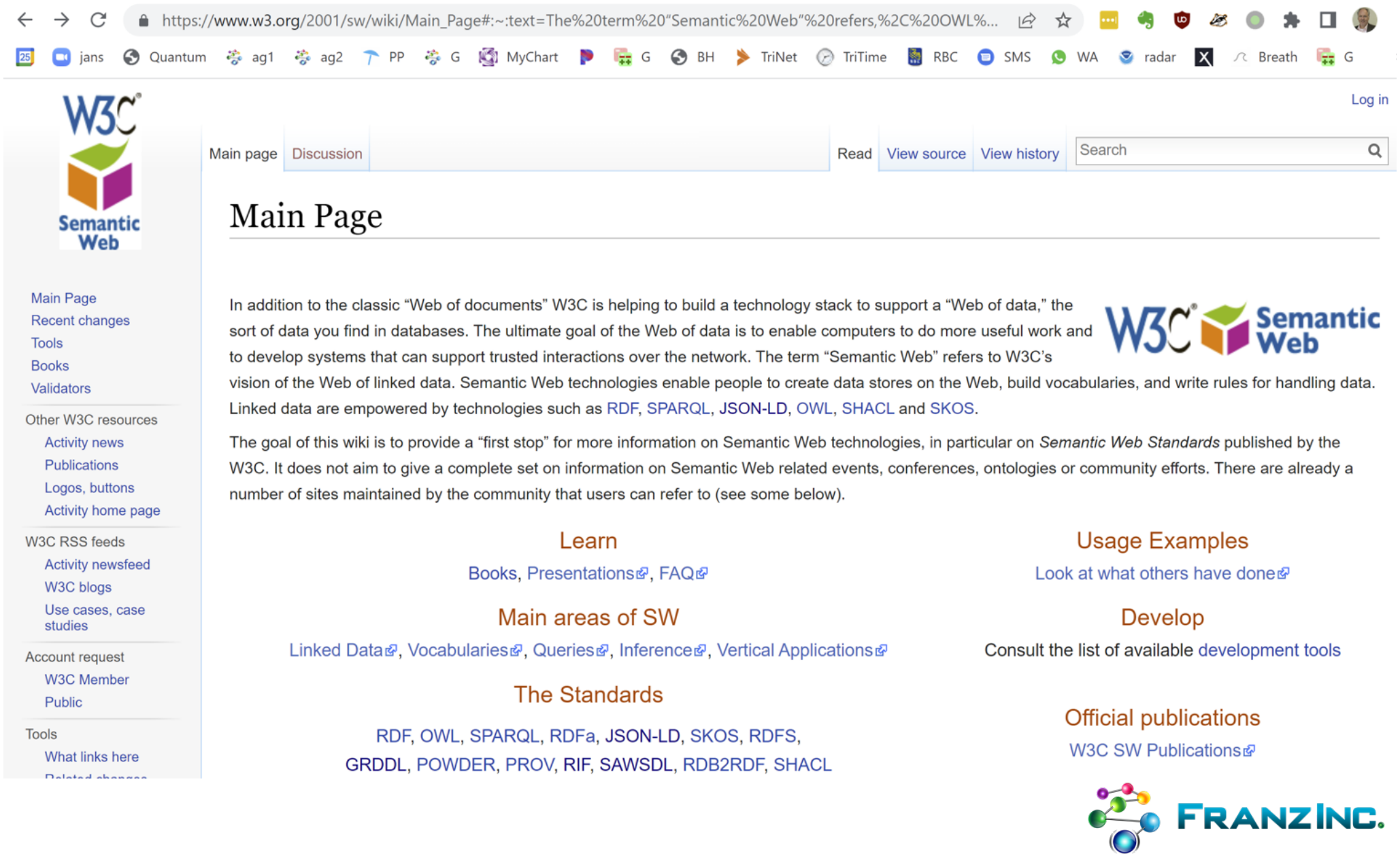
Semantic Technology Standards



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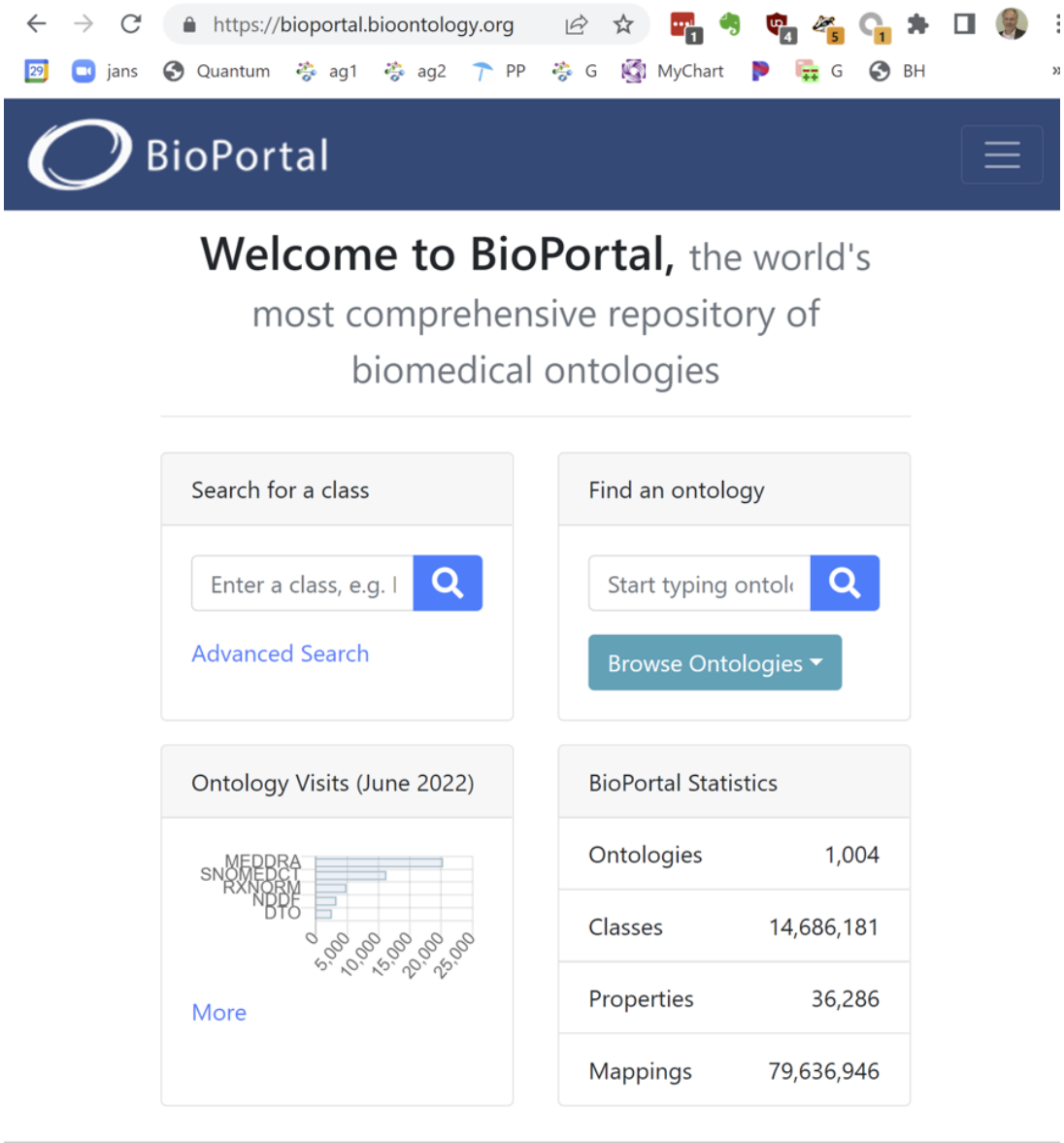
Where is RDF Used

- Nearly every Fortune 500 company is building SKOS taxonomies
- In Linked Open Data for public data and enterprise data
- Nearly every Fortune 500 company is building Knowledge Graphs

RDF for taxonomies and ontologies

- All Fortune 500 companies are now building taxonomies, almost all of them RDF based
  - To improve search over documents
  - To improve NLP processes
  - To harmonize documents, databases, and processes
  - To build knowledge graphs
- Most taxonomies and ontologies are meant to be cross-enterprise and therefore mostly open source
- Two examples:

RDF based open source taxonomies and ontologies: Healthcare and Life Sciences are furthest ahead



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20 banks worked together to get a Financial Industry Business Ontology

About FIBO

The Financial Industry Business Ontology

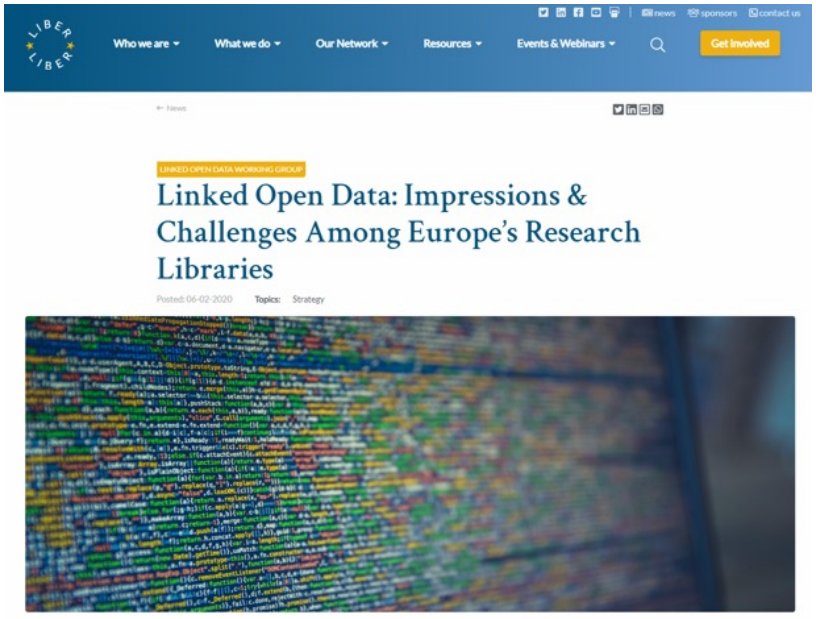
The Financial Industry Business Ontology (FIBO) defines the sets of things that are of interest in financial business applications and the ways that those things can relate to one another. In this way, FIBO can give meaning to any data (e.g., spreadsheets, relational databases, XML documents) that describe the business of finance.

FIBO is hosted and sponsored by the Enterprise Data Management Council (EDMC) and is published in a number of formats for operating use and business definitions. FIBO is a trademark of EDM Council, Inc. It is also standardized by the Object Management Group (OMG).

FIBO is developed as an ontology in the Web Ontology Language (OWL). The language is codified by the World Wide Web Consortium (W3C), and it is based on Description Logic. The use of logic ensures that each FIBO concept is framed in a way that is unambiguous and that is readable both by humans and machines.

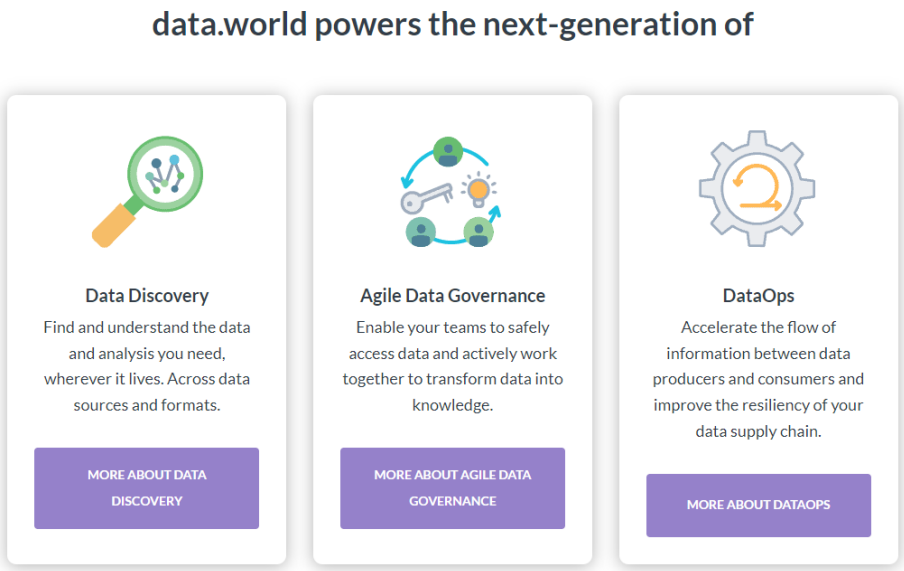
Linked Open Data (public)

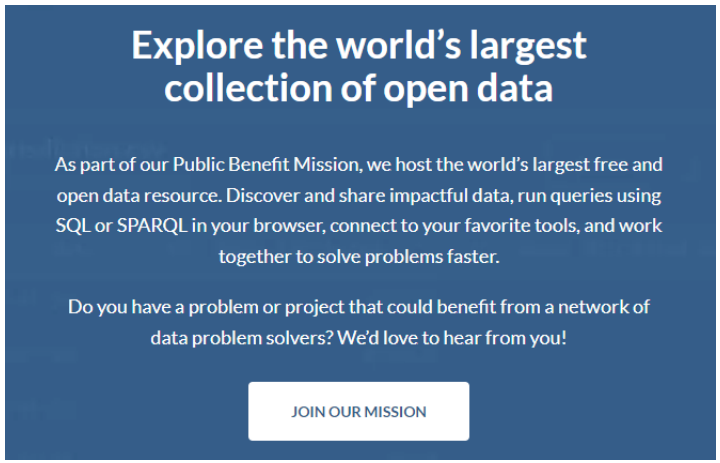
- (semi) public (meta) data available in various RDF formats or even fully formed Knowledge Graphs



Linked Open Data (enterprise)

- Create enterprise digital asset catalogs to get a handle on your data lakes





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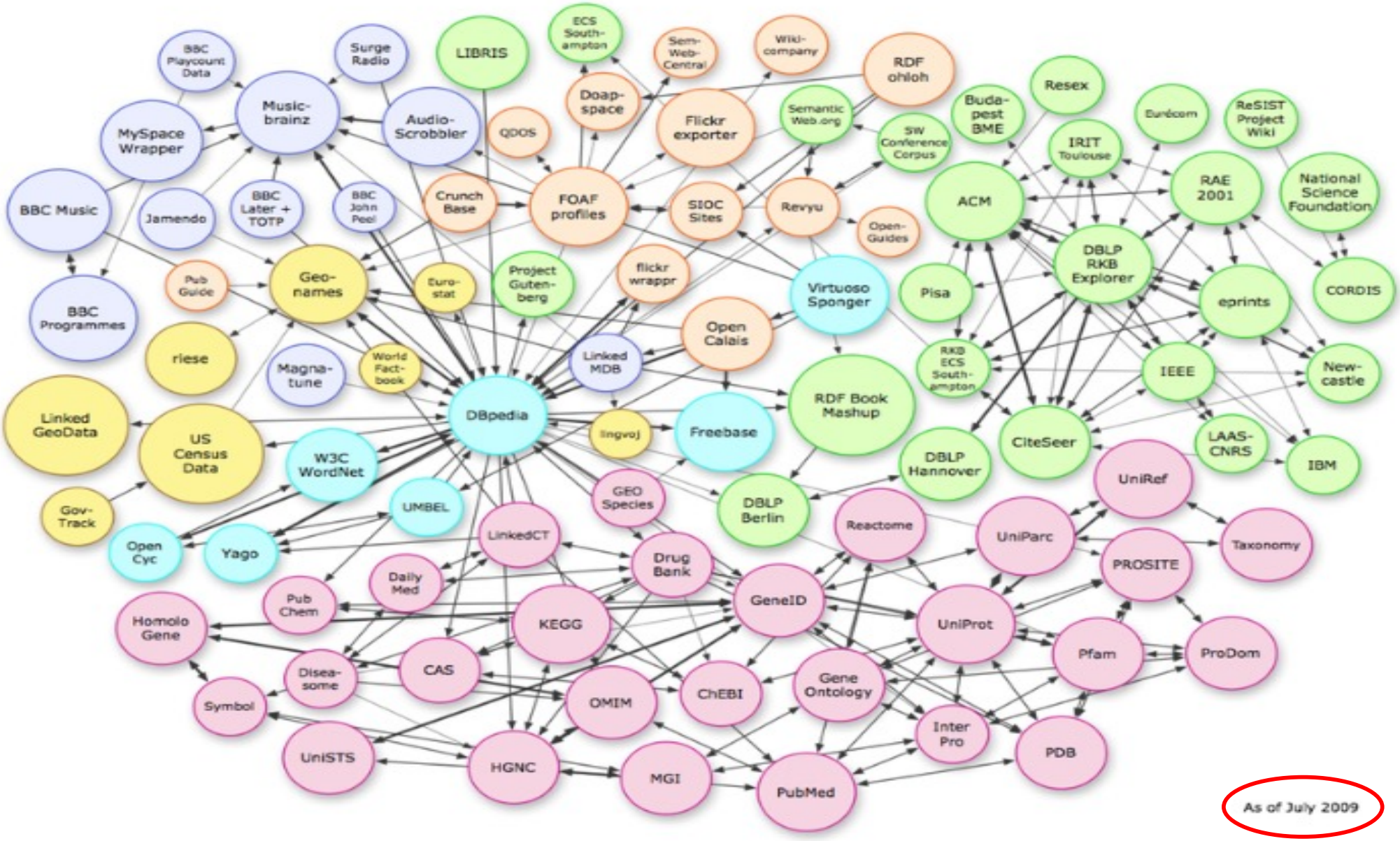
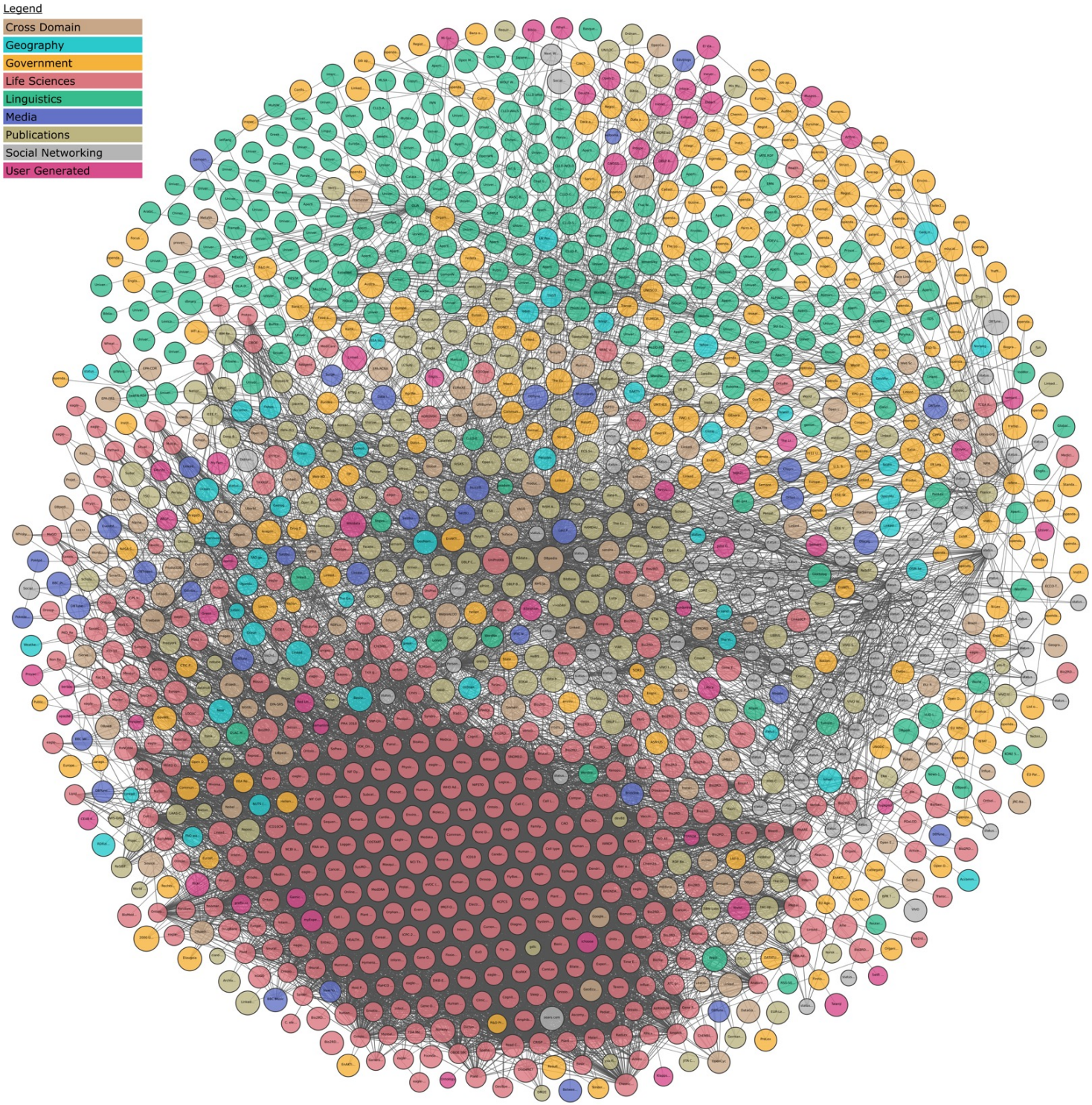
It started in the Semantic Web Community





Linked Open Knowledge 2022

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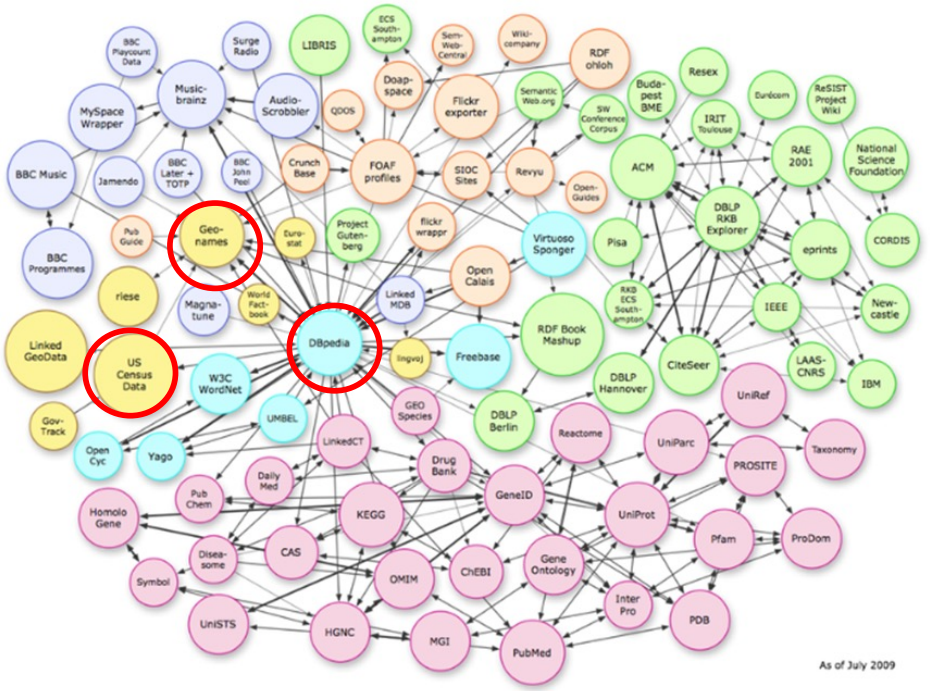
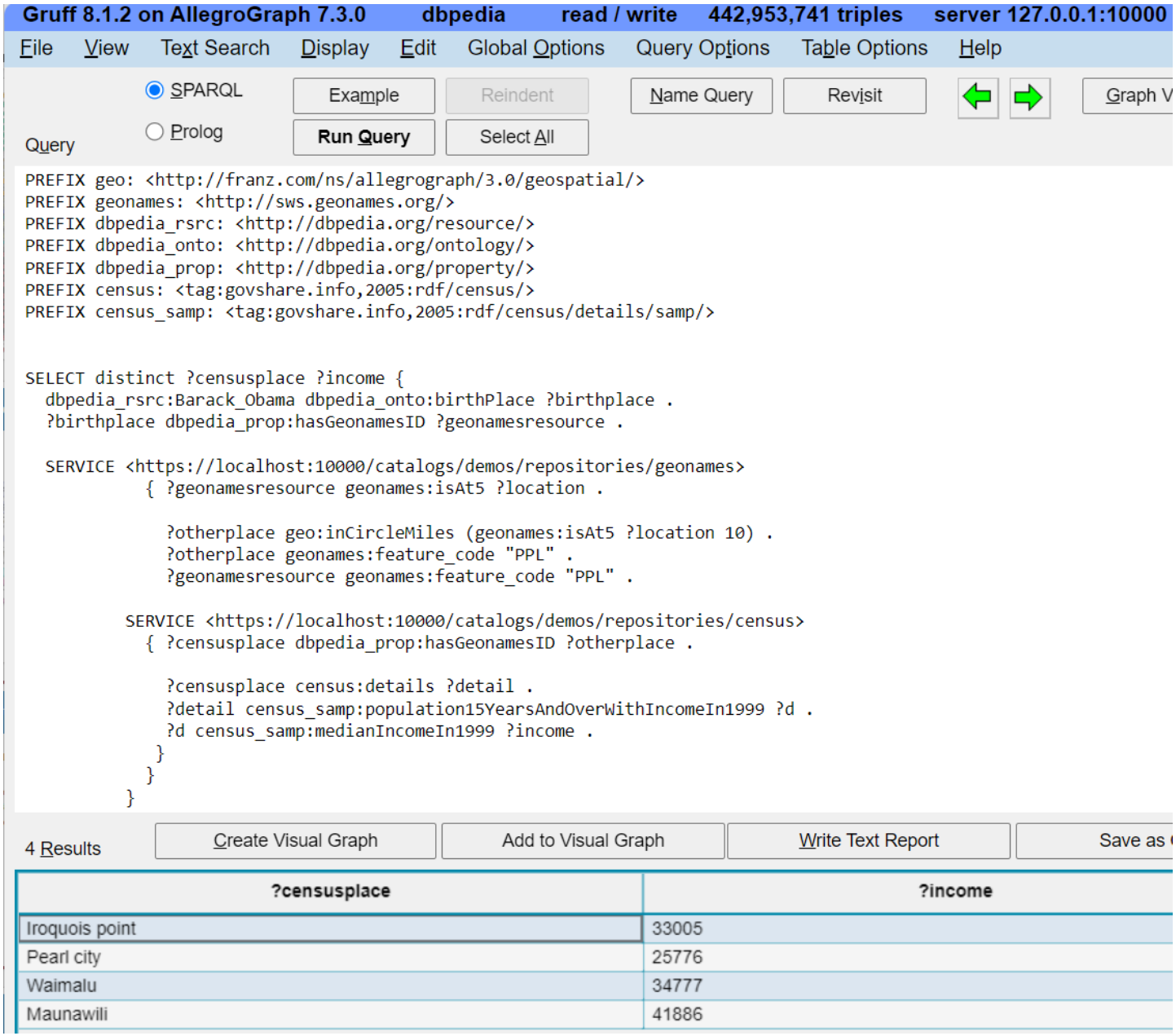
Federated queries over Linked Data

- What is the median income of the area where Barack Obama was born?
  - DPBedia to find Birthplace -> GeonamesID
  - GeoNames database to find other GeonamesIDs within 10 miles
  - Census to find median income for GeonamesIDs



Using service calls in SPARQL



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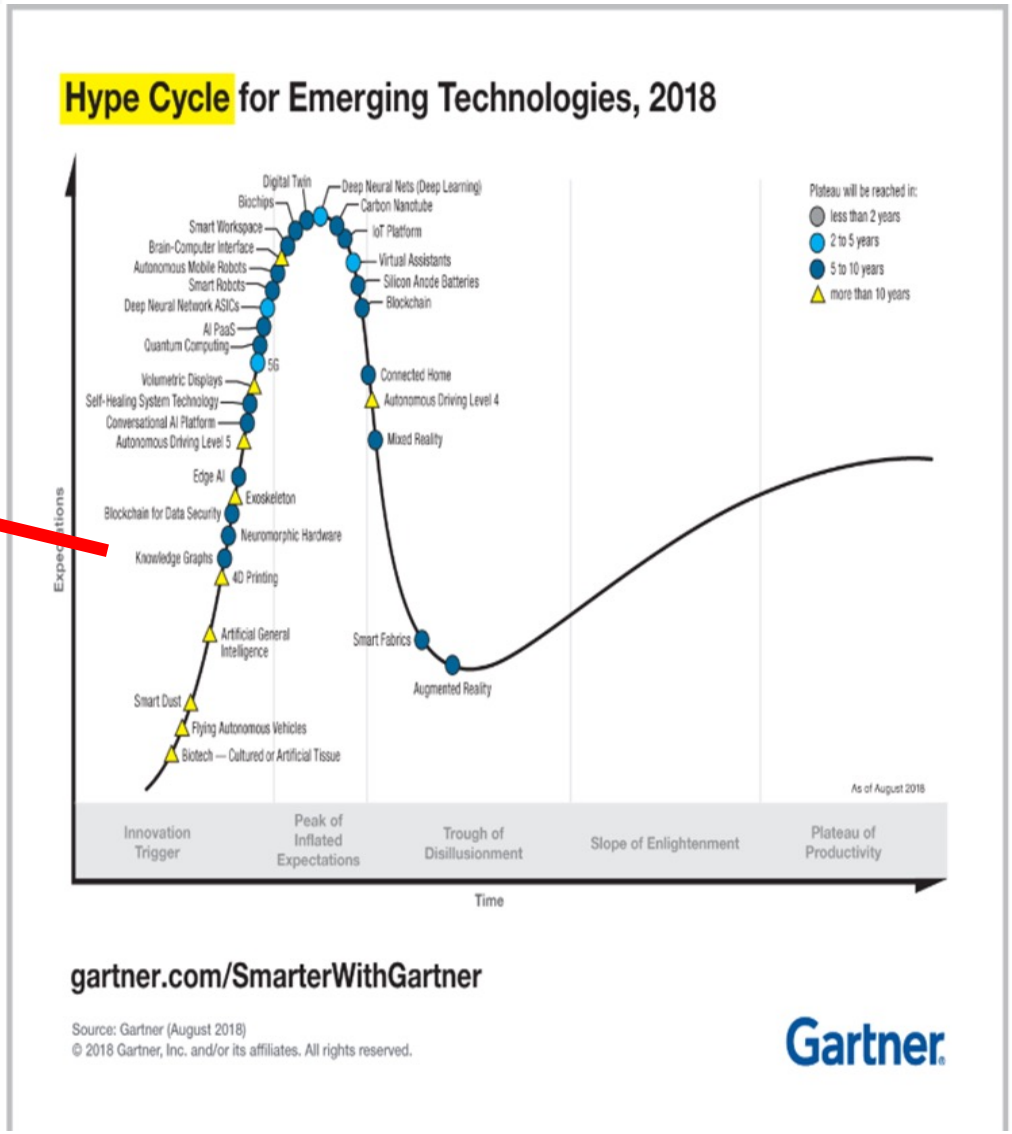
Knowledge Graphs on the rise



All the big ones in the US heavily investing in it

Day 1			
9:00	Christos Boutsidis	Goldman Sachs	Pythia: the Goldman Sachs Social Graph
9:20	Patricia Branum	Capital One	Knowledge Graph Pilot Improves Data Quality While Providing a Customer 360 View
9:40	David Newman	Wells Fargo	Knowledge Graphs and AI: The Future of Financial Data
10:00	Tim Baker	Refinitiv	Financial Crime
break 10:20 - 11:00	*Coffee and snacks will be provided*		
11:00	Denny Vrandecic	Google AI	Wikidata, Knowledge Graphs, and Beyond
11:20	Pierre Haren	Causality Link	Graphs
11:40	Dieter Fensel	OnLim	Talking Knowledge Graphs
12:00	Chris Brockmann	Eccenca	Knowledge Graph for Digital Transformation in the Supply-Chain
12:20	Tom Plasterer	Astrazeneca	FAIR Data Knowledge Graphs – From Theory to Practice
lunch 12:40 - 1:40	*A light lunch will be provided*		
1:40	Subhabrata Mukherjee	Amazon	Deep Learning for Knowledge Extraction and Integration to build the Amazon Product Graph
2:00	Teresa Tung	Accenture	Using a Domain Knowledge Graph to Manage AI at Scale
2:20	Alfio Gliozzo	IBM Research	Extending Knowledge Graphs using Distantly Supervised Deep Nets
2:40	Michael Tung	Diffbot	Knowledge Graphs for AI
break 3:00 - 3:30	*Coffee and snacks will be provided*		
3:30	Xiaoya Wei	Airbnb	Knowledge Graph at Airbnb
3:50	Amy Hodler	Neo4j	A Real-World Guide to Building Your Knowledge Graphs
4:10	Juan F. Sequeda	Capsenta	Designing and Building Enterprise Knowledge Graphs from Relational Databases in the Real W
4:30	Ron Snyder	ITHAKA / JSTOR	Why Wikibase? Why not?
4:50	Sören Auer	TIB	Creating a knowledge graph based Enterprise Data Innovation Architecture

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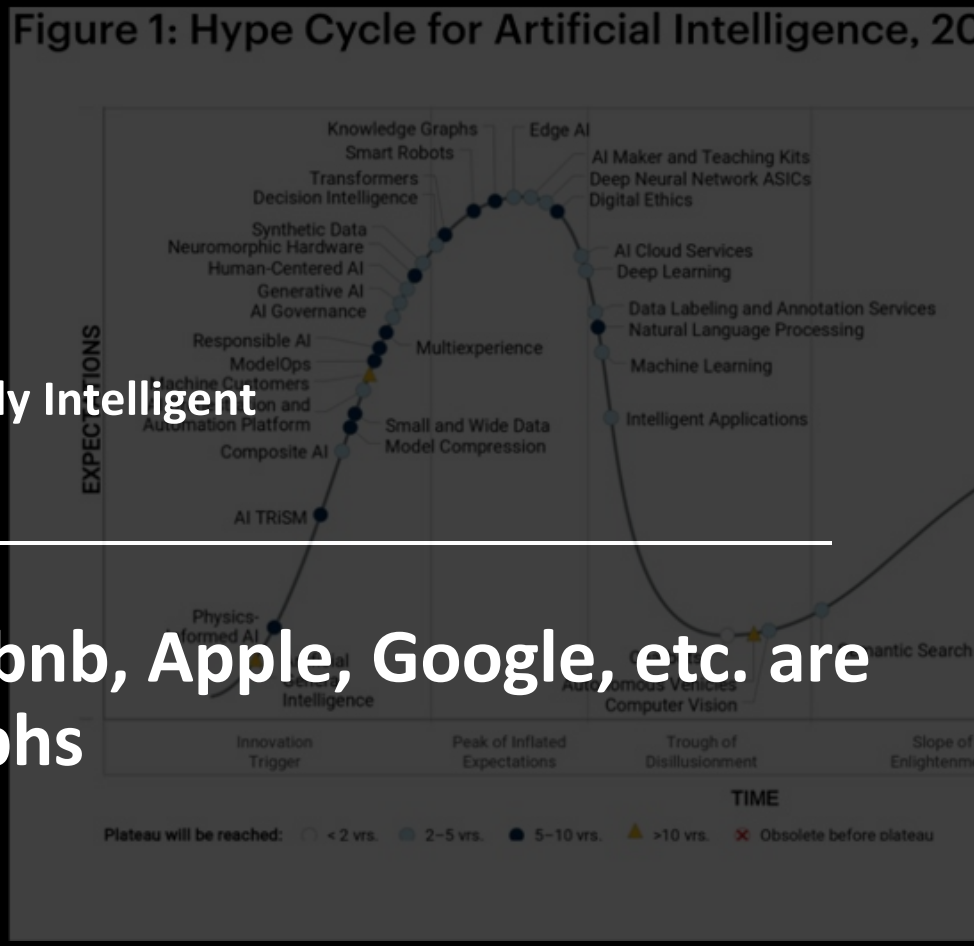
Data Silos ➡ Trapped Knowledge

- Enterprises lack a **single source of truth** on their customers and their data
- Data scientists are expensive and waste 90% of their time on prep
- Current solutions (ETL, Data Lakes, MDM, Neo4J) **exacerbate the Silo problem**

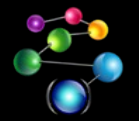
- **Knowledge Graphs:**
  - **Silo removal**
  - **KGs make Artificial Intelligence truly Intelligent**
  - **Basis for Enterprise Data Fabrics**

- **LinkedIn, ebay, Uber, Airbnb, Apple, Google, etc. are building Knowledge Graphs**



Graph Market will grow from $1.9 billion in 2021 to $5.1 billion by 2026, CAGR of 22.5%

Gartner Client inquiry interest in data fabric in 2021 is approx. 900% of that in 2019



- https://www.marketsandmarkets.com/PressReleases/graph-database.asp
- Gartner-Top Strategic Technology Trends for 2022:Data Fabric

Graph > Knowledge Graph > Data Fabric

#3 Watch out for graph databases

Carl Olofson, Research Vice President, IDC

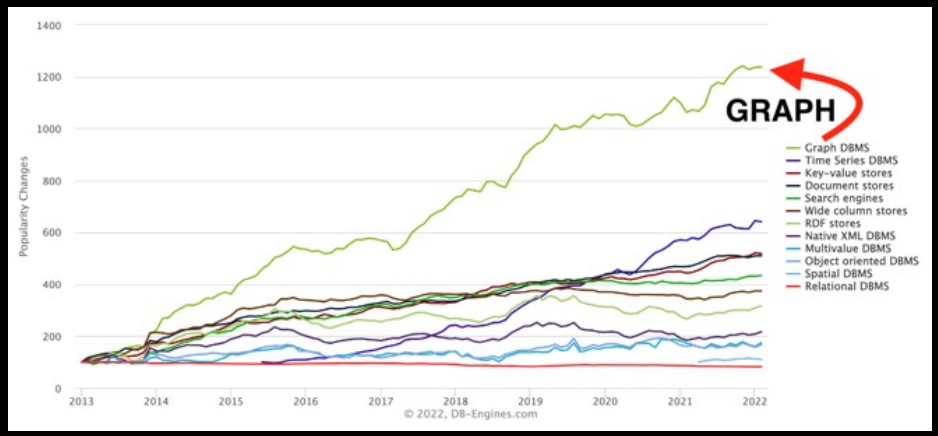
- Next revolution in database technology
- Potential for 600% growth over the decade
- Will slowly gain traction over the next five years
- Lots of use cases but not well understood
  - Semantic use cases (lots of AI examples)
  - Property graphs with dozens of use cases
- Graph databases dramatically different from traditional RDBMS

Gartner

Top Strategic Technology Trends for 2022: Data Fabric

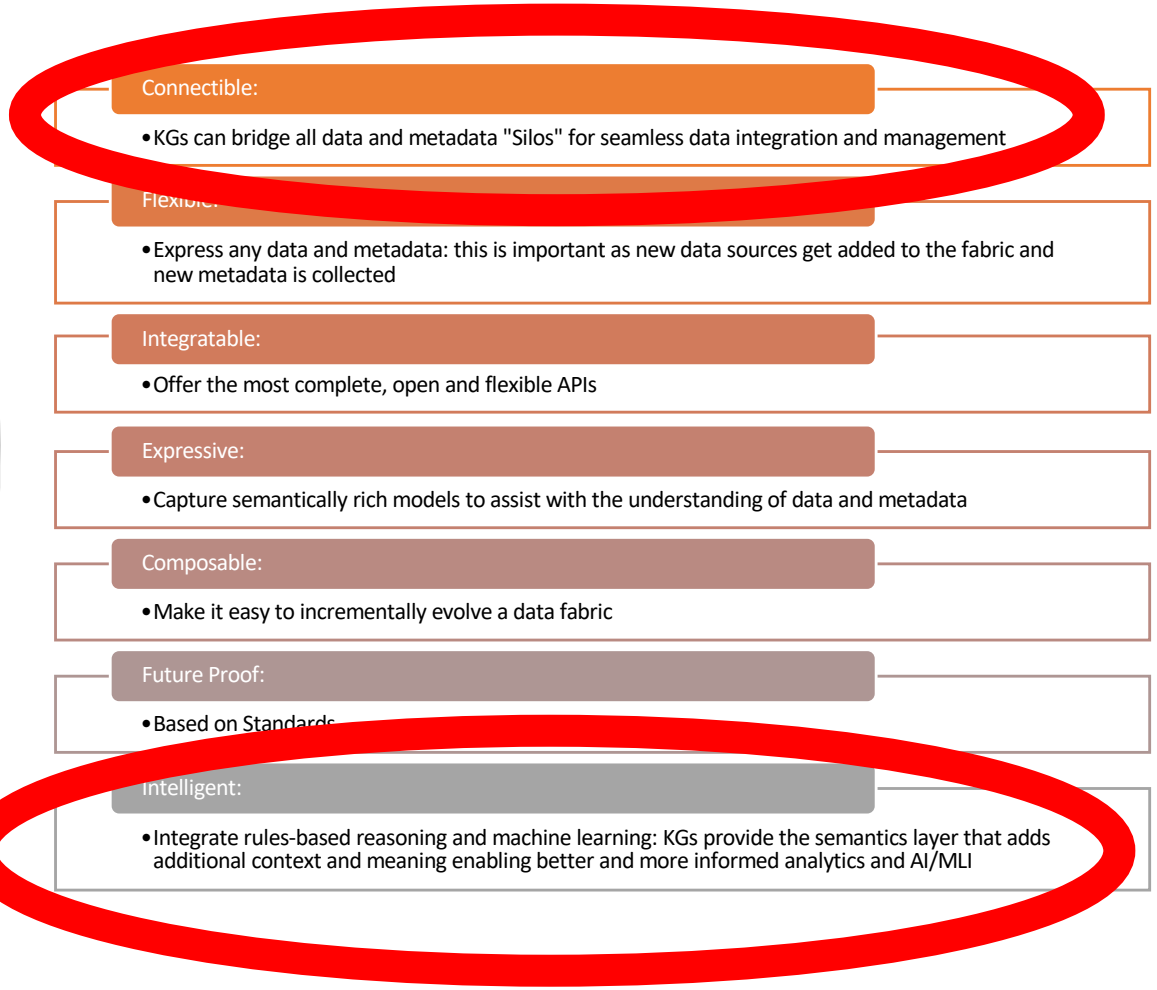
Published 18 October 2021 - ID G00749680 - 15 min read

By Mark Beyer, Ehtisham Zaidi, **and 2 more**

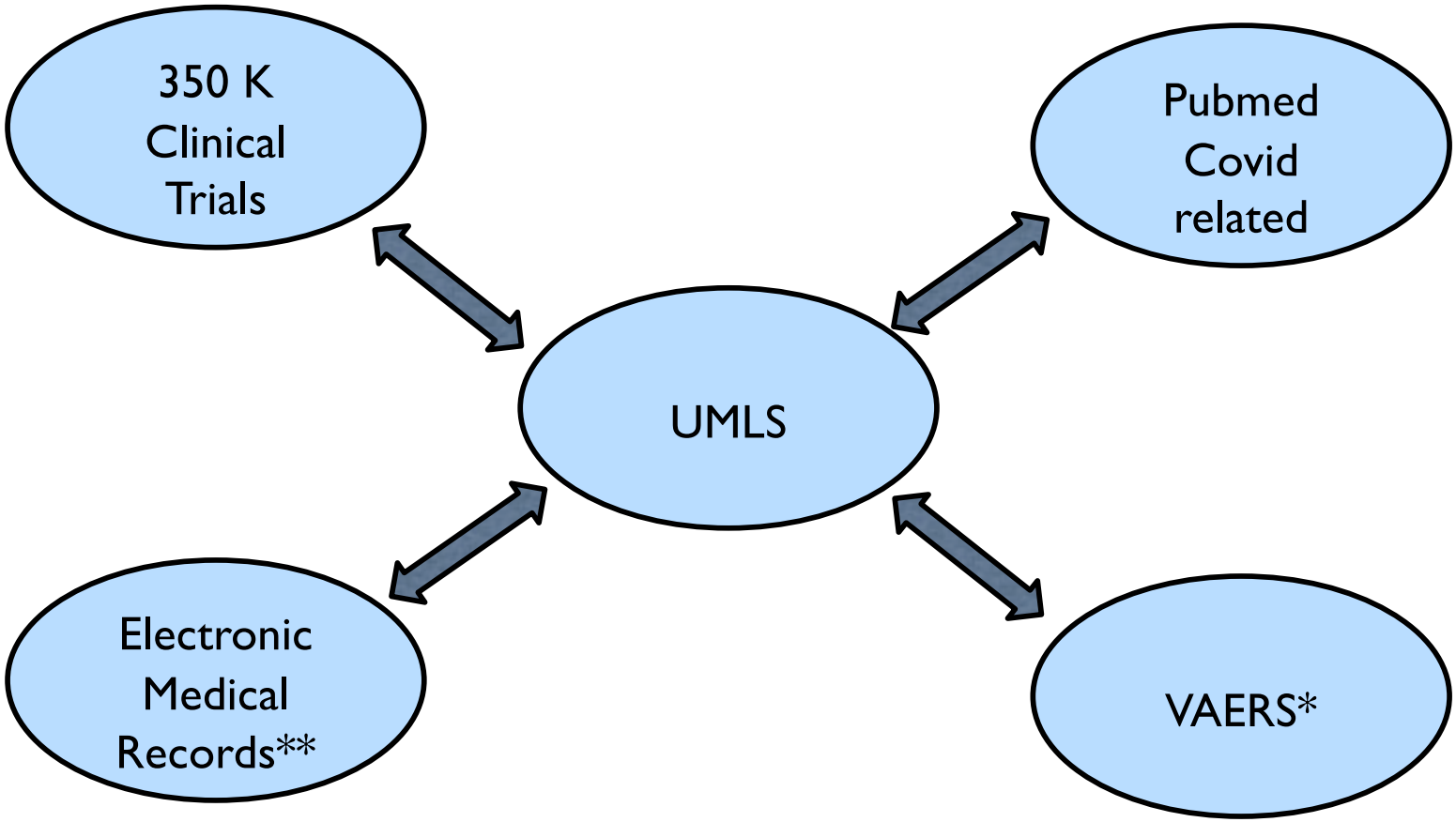


https://siliconangle.com/2022/01/09/analyst-predictions-2022-future-data-management/

Knowledge Graphs are the Key to Data Fabrics



An example open source knowledge graph for Long Covid Research



* Adverse vaccine reactions
** Synthea

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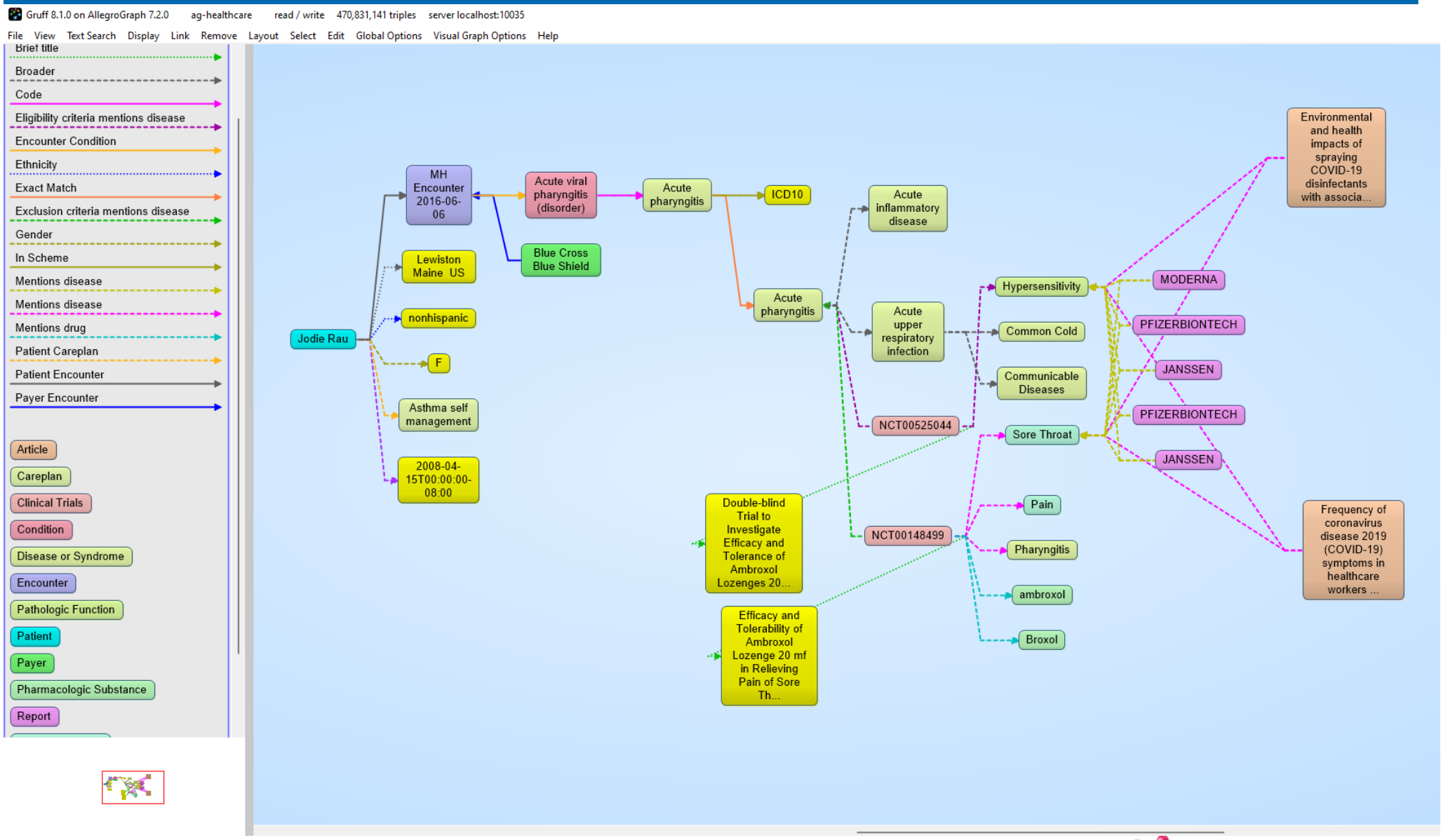
Used by Long Covid Researchers



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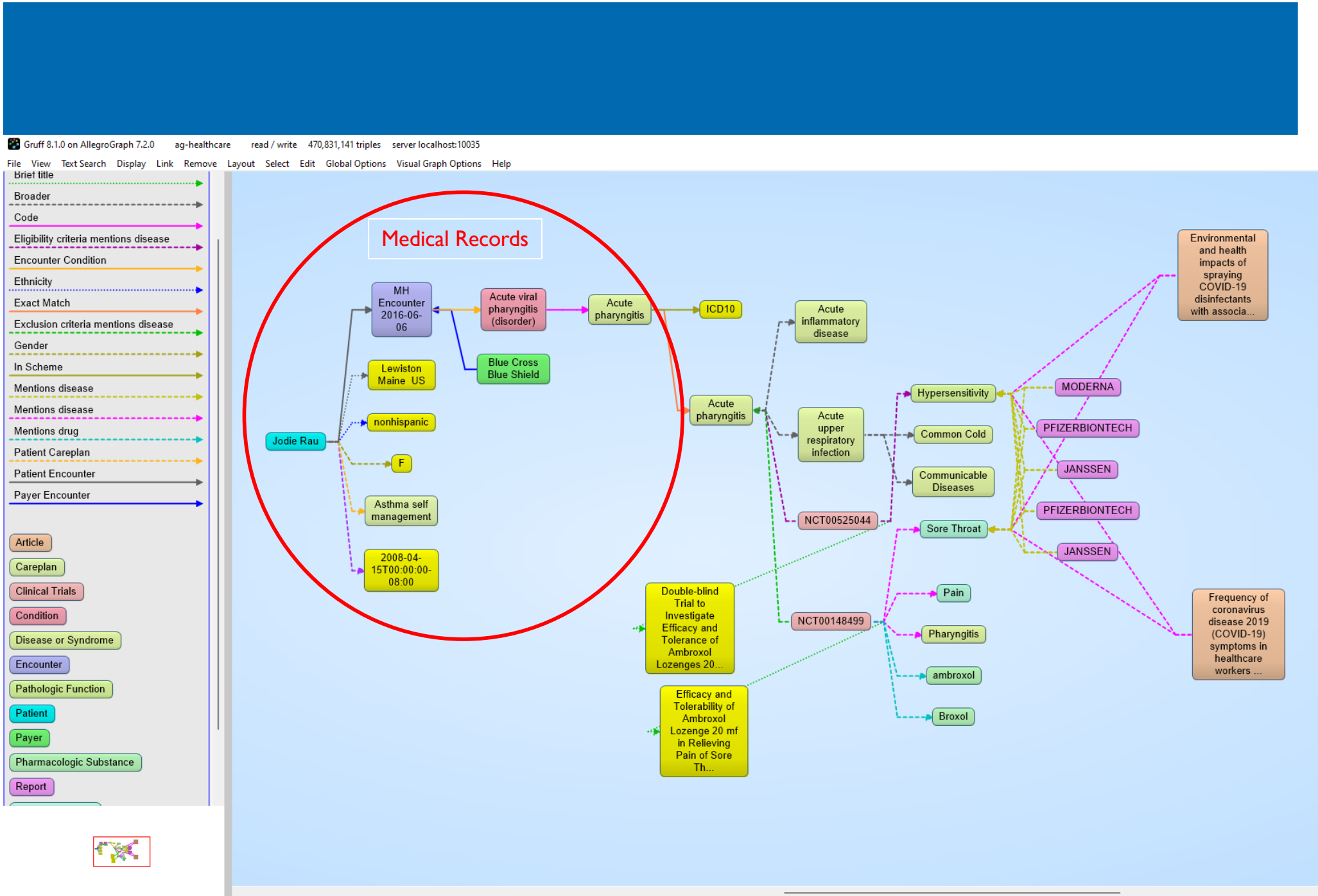
Gruff 8.1.0 on AllegroGraph 7.2.0
ag-healthcare
read / write
470,831,141 triples
server localhost:10035
File View Text Search Display Link Remove Layout Select Edit Global Options Visual Graph Options Help
Brief title
Broader
Code
Eligibility criteria mentions disease
Encounter Condition
Ethnicity
Exact Match
Exclusion criteria mentions disease
Gender
In Scheme
Mentions disease
Mentions disease
Mentions drug
Patient Careplan
Patient Encounter
Payer Encounter
Article
Careplan
Clinical Trials
Condition
Disease or Syndrome
Encounter
Pathologic Function
Patient
Payer
Pharmacologic Substance
Report
Medical Records
MH Encounter 2016-06-06
Acute viral pharyngitis (disorder)
Acute pharyngitis
ICD10
Lewiston Maine US
Blue Cross Blue Shield
nonhispanic
Jodie Rau
F
Asthma self management
2008-04-15T00:00:00-08:00
Acute pharyngitis
Acute inflammatory disease
Acute upper respiratory infection
Hypersensitivity
Common Cold
Communicable Diseases
NCT00525044
Sore Throat
Double-blind Trial to Investigate Efficacy and Tolerance of Ambroxol Lozenges 20...
NCT00148499
Pain
Pharyngitis
ambroxol
Broxol
Efficacy and Tolerability of Ambroxol Lozenge 20 mf in Relieving Pain of Sore Th...
MODERNA
PFIZERBIONTECH
JANSSEN
PFIZERBIONTECH
JANSSEN
Environmental and health impacts of spraying COVID-19 disinfectants with associa...
Frequency of coronavirus disease 2019 (COVID-19) symptoms in healthcare workers ...

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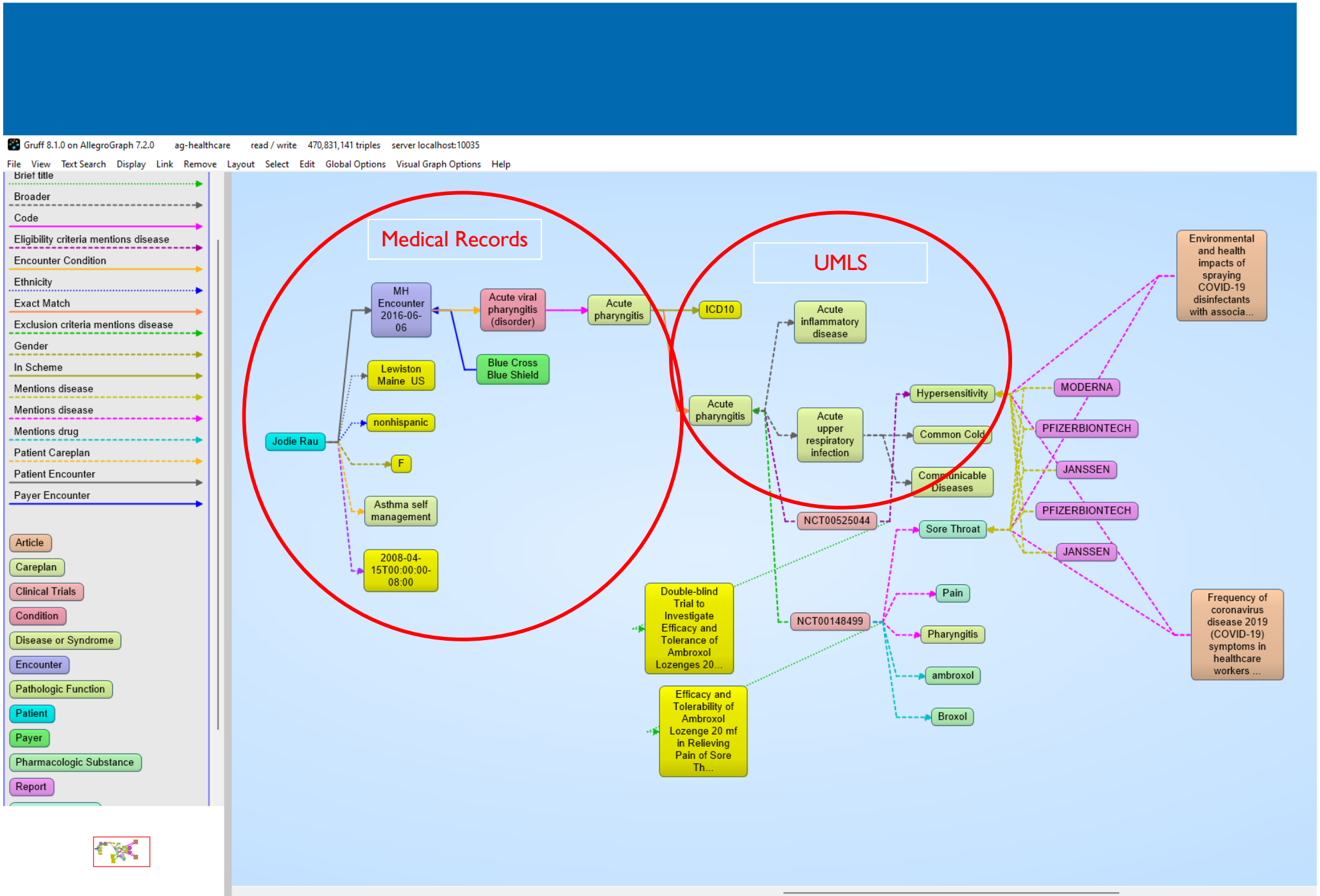
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Pathologic Function
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Pharmacologic Substance
Report
Medical Records
UMLS
Jodie Rau
MH Encounter 2016-06-06
Lewiston Maine US
nonhispanic
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Asthma self management
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Efficacy and Tolerability of Ambroxol Lozenge 20 mf in Relieving Pain of Sore Th...
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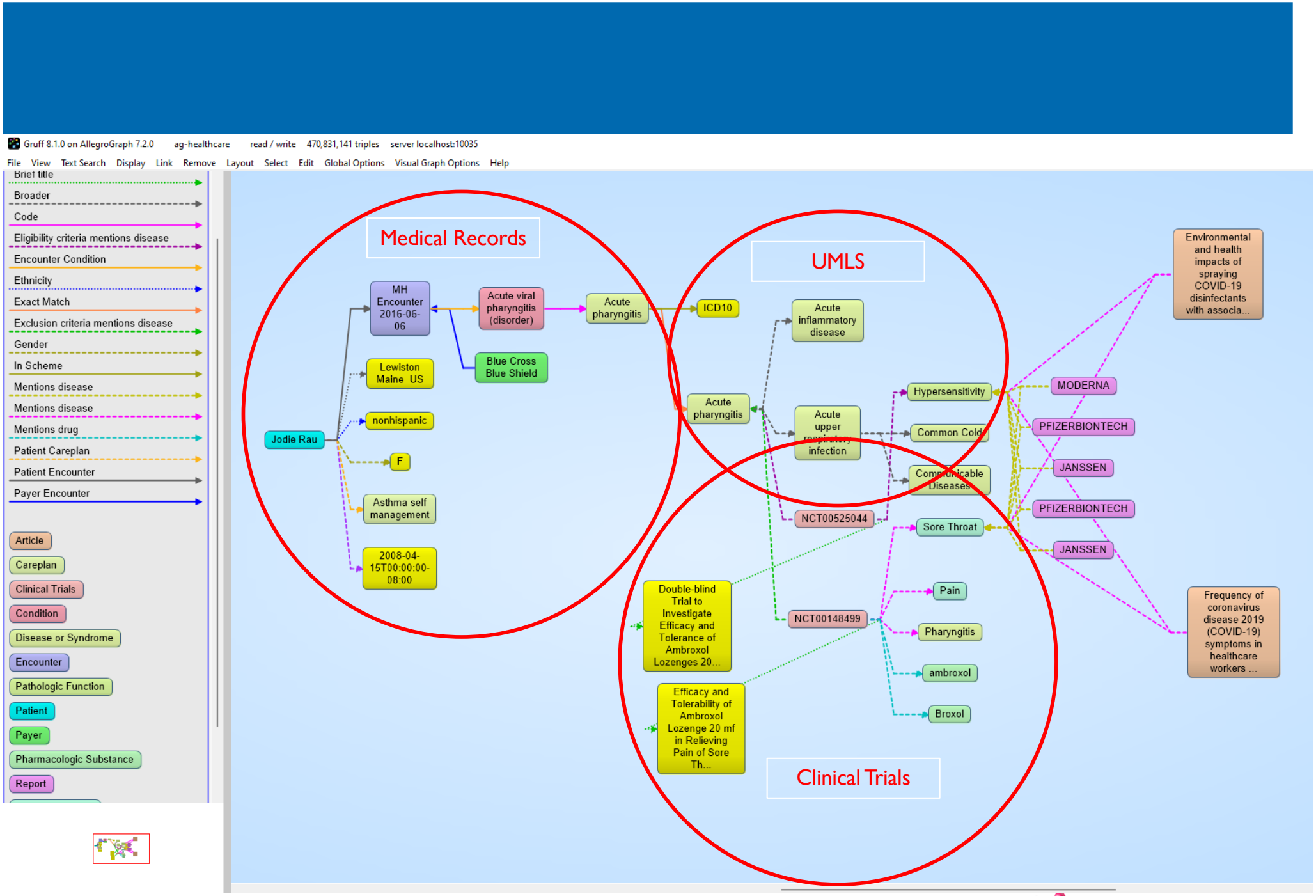
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Payer Encounter
Article
Careplan
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Disease or Syndrome
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Pathologic Function
Patient
Payer
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F
Asthma self management
2008-04-15T00:00:00-08:00
Acute pharyngitis
Acute inflammatory disease
Acute upper respiratory infection
Hypersensitivity
Common Cold
Communicable Diseases
NCT00525044
Sore Throat
NCT00148499
Pain
Pharyngitis
ambroxol
Broxol
Double-blind Trial to Investigate Efficacy and Tolerance of Ambroxol Lozenges 20...
Efficacy and Tolerability of Ambroxol Lozenge 20 mf in Relieving Pain of Sore Th...
MODERNA
PFIZERBIONTECH
JANSSEN
PFIZERBIONTECH
JANSSEN
Environmental and health impacts of spraying COVID-19 disinfectants with associa...
Frequency of coronavirus disease 2019 (COVID-19) symptoms in healthcare workers ...

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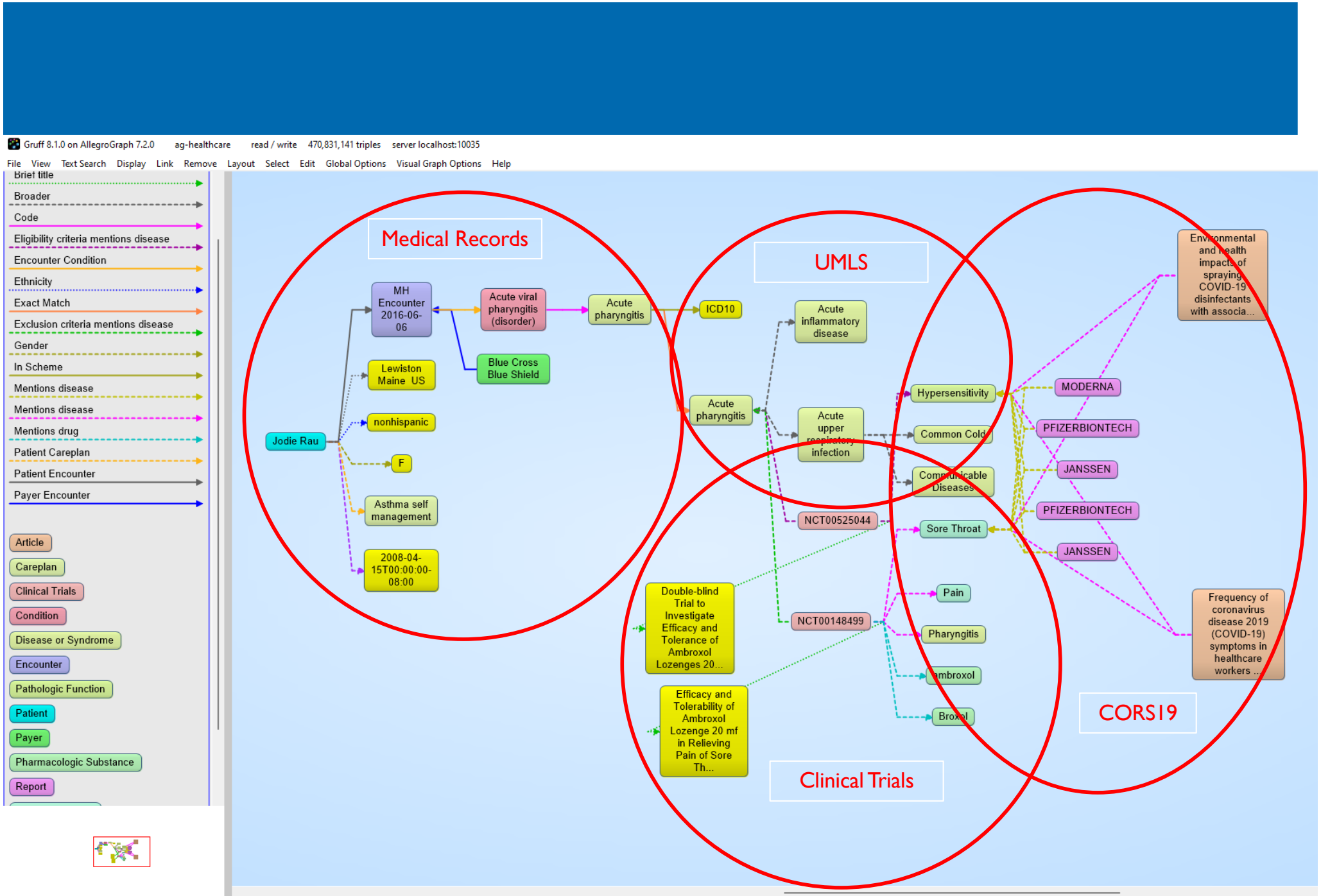
Gruff 8.1.0 on AllegroGraph 7.2.0
ag-healthcare
read / write
470,831,141 triples
server localhost:10035
File View Text Search Display Link Remove Layout Select Edit Global Options Visual Graph Options Help
Brief title
Broader
Code
Eligibility criteria mentions disease
Encounter Condition
Ethnicity
Exact Match
Exclusion criteria mentions disease
Gender
In Scheme
Mentions disease
Mentions disease
Mentions drug
Patient Careplan
Patient Encounter
Payer Encounter
Article
Careplan
Clinical Trials
Condition
Disease or Syndrome
Encounter
Pathologic Function
Patient
Payer
Pharmacologic Substance
Report
Medical Records
UMLS
CORS19
Clinical Trials
Jodie Rau
MH Encounter 2016-06-06
Acute viral pharyngitis (disorder)
Blue Cross Blue Shield
Lewiston Maine US
nonhispanic
F
Asthma self management
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ICD10
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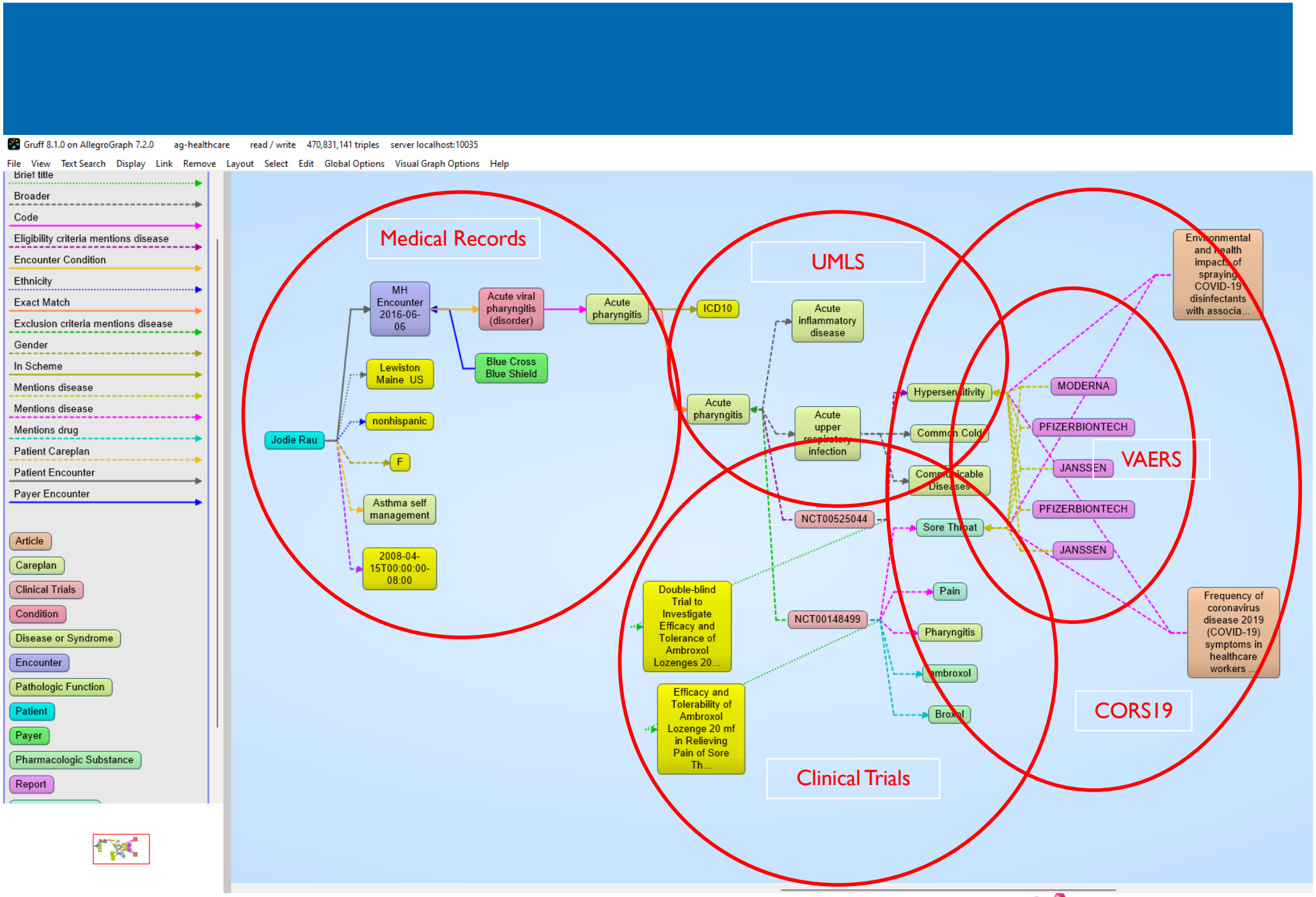
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Now onto JSON-LD

- Knowledge Graphs are getting popular very fast but developers a little bit scared to learn the W3C Semantic Stack.

How do you make it easy as MongoDB to

- Add data to a knowledge graph
- Retrieve data from a knowledge graph
- Validate your data

Solution: JSON-LD

- JSON-LD will help you add, retrieve, validate, and delete objects to a Knowledge Graph as easy as MongoDB

First about JSON: it somehow won

- Messaging:
  - the lingua franca for messaging and data exchange
- Configuration:
  - JSON is replacing XML for configuration of nearly anything
- Document and key/value store:
  - JSON is the main data format stored in Document Stores (Couchbase, Mongo, etc…)

JSON – the good

- Simple standard:
  - Json.org spec is 5 pages, XML spec on W3C = 60 pages ☺
  - only a few datatypes and with arrays!
  - you can make your own complex data types if you want
- Easy to read and parse by humans and machines
- Easy to store in document stores
- Easy to program: support in every programming language

When JSON runs into trouble

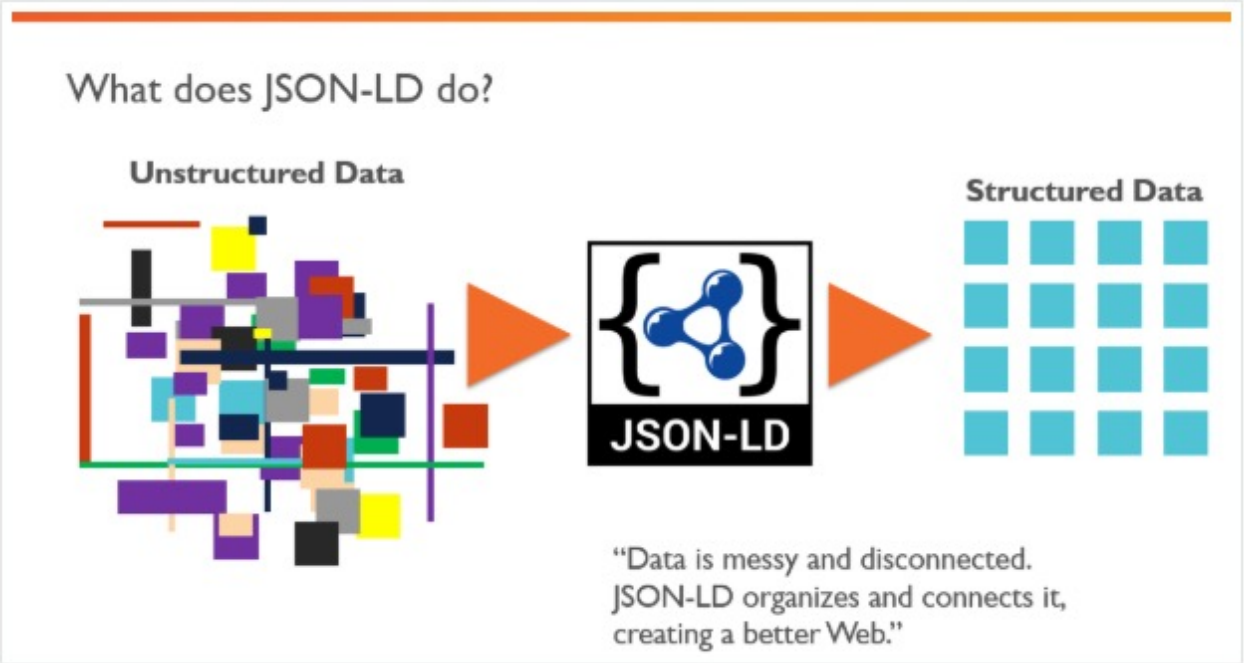
- In a hospital setting you might have > 1000 JSON types that stream between various sources and knowledge graphs
- All objects need to be persisted in a data lake but I don't want to create silos of document stores
- If I look at any random JSON object I have to find from the code to see what it means
- There are graphs in the data but how do I point from one object to the other in a standardized way?

We need our JSON to have Semantics

- Every JSON object needs an Identity that other objects can point to
- Every JSON object needs a Type
- Every Type has an ontology (schema) that describes
  - The attributes and datatypes
  - Links to other types of objects
  - Version information, links to processes and apps that use it
- And a standard Validation Language

JSON-LD = 100 % JSON +

- Add basic schema support to JSON: (but SHACL more complete)
- Add semantics to JSON objects: what does this attribute mean
- Designed to link JSON objects together
- Enables joins and graph search in document stores



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Learn from JSON-LD.ORG

JSON-LD Playground

Play around with JSON-LD markup by typing out some JSON below and seeing what gets generated from it at the bottom of the page. Pick any of the examples below to get started.

NOTE: The playground uses jsonld.js which conforms to JSON-LD 1.0 syntax, API, framing, and errata, the W3C Community Group JSON-LD 1.1 syntax, API, and framing drafts, and partial support of the W3C Working Group JSON-LD 1.1 syntax, API, and framing drafts. Also see the classic JSON-LD 1.0 playground and the RDF Distiller.

Examples: | Person | Event | Place | Product | Recipe | Library | Activity | Permalink | Gist | Shortcuts

JSON-LD Input | Options | Document URL

```
{
  "@context": "http://schema.org/",
  "@type": "Person",
  "@id": "foaf:person-1",
  "name": "Jane Doe",
  "jobTitle": "Professor",
  "telephone": "(425) 123-4567",
  "url": "http://www.janedoe.com"
}
```

Expanded | Compacted | Flattened | Framed | N-Quads | Normalized | Table | Visualized | Signed with RSA | Signed with Bitcoin

```
<http://xmlns.com/foaf/0.1/person-1> <http://schema.org/jobTitle> "Professor" .
<http://xmlns.com/foaf/0.1/person-1> <http://schema.org/name> "Jane Doe" .
<http://xmlns.com/foaf/0.1/person-1> <http://schema.org/telephone> "(425) 123-4567" .
<http://xmlns.com/foaf/0.1/person-1> <http://schema.org/url> <http://www.janedoe.com> .
<http://xmlns.com/foaf/0.1/person-1> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://schema.org/Person> .
```

It is everywhere: let's look at this product

A Guide to JSON-LD for Begi | JSON: The Fat-Free Alternati | Mad Hippie Antioxidant Facia | facial oil - Google Search

https://www.ulta.com/antioxidant-facial-oil?productId=xlsImpprod18731241&sku=2530018&cmpid=PS_

Apps | Home | dhammatalks

ULTA BEAUTY

Search | FIND A STORE | EMAIL SIGNUP | GIFT CARDS | SIGN IN | REWARDS

FREE STANDARD SHIPPING on any $50 purchase.

- SHOP BY BRAND
- NEW ARRIVALS
- MAKEUP
- NAILS
- SKIN CARE
- HAIR
- TOOLS & BRUSHES
- FRAGRANCE
- BATH & BODY
- MEN
- ULTA COLLECTIONS
- GIFTS
- SALES & COUPONS
- CURRENT AD
- BEAUTY TIPS
- ALLURE WINNERS
- BEAUTY SERVICES
- BOOK APPOINTMENT

Home / Skin Care / Moisturizers / Face Oil / Antioxidant Facial Oil

MAD HIPPIE

Antioxidant Facial Oil

REVIEWS > | Q&A >

1.02 oz Item 2530018

$24.99

1 | Add To Bag

Details

Make peace with your inner hippie while hydrating & protecting against photo-aging....Mad Hippie preservative-

Search for @context in the source

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JSON alone would lead to confusion, JSON-LD and SCHEMA.ORG to the rescue

```
{"aggregateRating":
    {"ratingValue":4.6,
     "reviewCount":66},
     "description":"Makepeace with your inner hippie while hydrating & protecting against
                    photoaging....Mad Hippie's preservative-free Antioxidant Facial Oil is
                    truly the most natural way to moisturize.",
     "brand":"Mad Hippie",
     "name":"Antioxidant Facial Oil",
     "image":"https://images.ulta.com/is/image/Ulta/2530018",
     "productID":"2530018",
     "offers":
        {"availability":"http://schema.org/InStock",
         "price":"24.99",
         "priceCurrency":"USD"}}
```

NO Meaning

WITH Meaning

```
{"@context":"http://schema.org",
 "@type":"Product",
 "aggregateRating":
     {"@type":"AggregateRating",
      "ratingValue":4.6,
      "reviewCount":66},
      "description":"Makepeace with your inner hippie while hydrating & protecting against
                     photoaging....Mad Hippie's preservative-free Antioxidant Facial Oil is
                     truly the most natural way to moisturize.",
      "brand":"Mad Hippie",
      "name":"Antioxidant Facial Oil",
      "image":"https://images.ulta.com/is/image/Ulta/2530018",
      "productID":"2530018",
      "offers":
         {"@type":"Offer",
          "availability":"http://schema.org/InStock",
          "price":"24.99",
          "priceCurrency":"USD"}}
```

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Massive e-commerce ontology – schema.org

AggregateRating

Thing > Intangible > Rating > AggregateRating

The average rating based on multiple ratings or reviews.

[more...]

- Canonical URL: http://schema.org/AggregateRating
- Leave public feedback on this term
- Check for open issues.

Property	Expected Type	Description
Properties from AggregateRating		
itemReviewed	Thing	The item that is being reviewed/rated.
ratingCount	Integer	The count of total number of ratings.
reviewCount	Integer	The count of total number of reviews.
Properties from Rating		
author	Organization or Person	The author of this content or rating. Please note that author is special in that HTML 5 provides a special mechanism for indicating authorship via the rel tag. That is equivalent to this and may be used interchangeably.
bestRating	Number or Text	The highest value allowed in this rating system. If bestRating is omitted, 5 is assumed.
ratingExplanation	Text	A short explanation (e.g. one to two sentences) providing background context and other information that led to the conclusion expressed in the rating. This is particularly applicable to ratings associated with "fact check" markup using ClaimReview.
	Number or	The rating for the content

Demo JSON-LD in Python

- Based on crunch base data from early 2000 till 2014
  - Core objects: Investments, acquisitions, investors, companies

- For developers: how can you implement basic CRUD with AllegroGraph JSONLD
  - You can add and retrieve Python dictionaries directly
  - Like many other document databases
  - Objects are indexed with triples but can also be stored as blobs
  - You can retrieve parts of objects in a SPARQL queries
  - And you can retrieve as dictionaries.

Conclusion: JSON-LD and SHACL for Knowledge Graphs

- Make life easier for User Experience and Application Developers that need to work with Knowledge Graphs.
- JSON-LD hides complexity of semantics and graphs
- SHACL easy way to validate new data.

Thank you

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