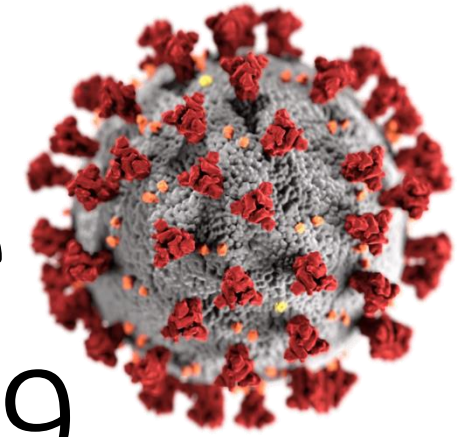

Knowledge Graph and the current pandemic COVID-19

Dr. Biswanath Dutta

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Documentation Research and Training Centre

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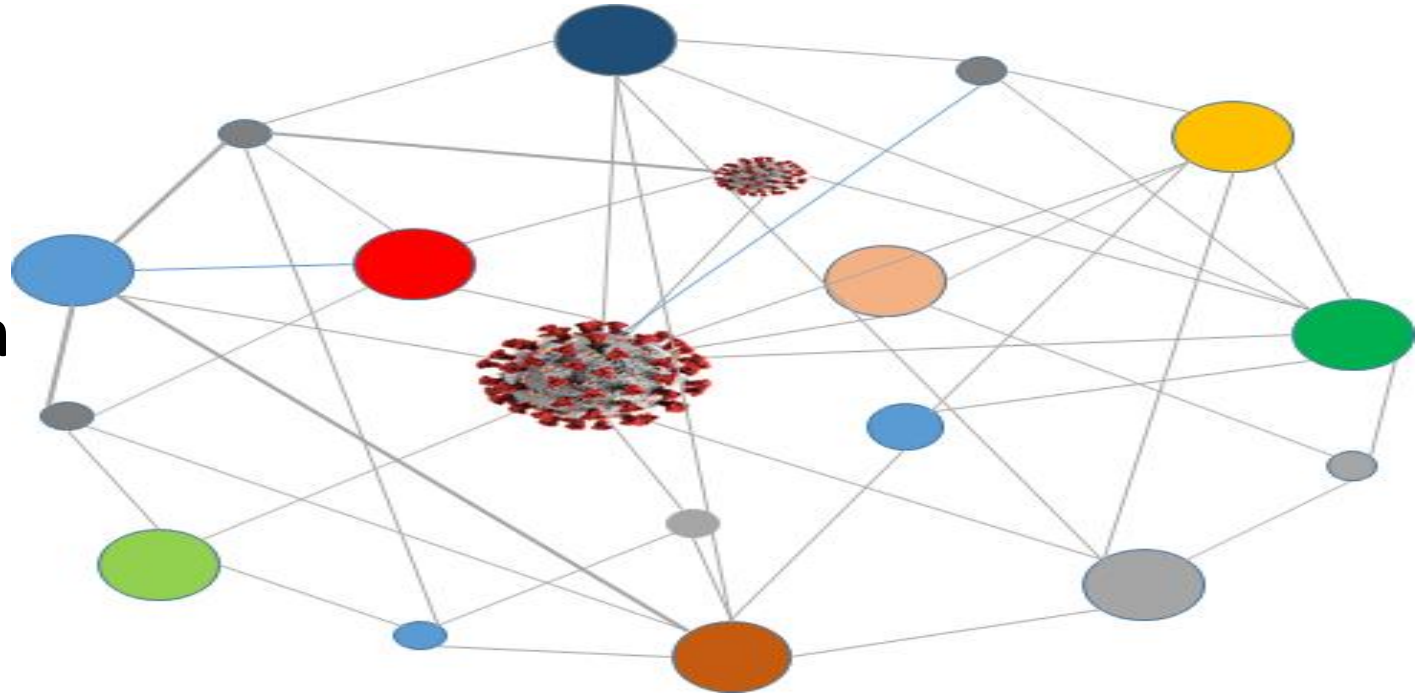
Email: dutta2005@gmail.com, bisu@drtc.isibang.ac.in

Outline

- Knowledge Graph
- KG Core Technologies
- CODO Ontology
- CODO Knowledge Graph



Background

Case	Date	Age	Sex	City	State	Cluster	Reason
1	2020-03-09T00:00:00	41	Male	Bangalore	Karnataka	From USA	Texas US
2	2020-03-10T00:00:00	0	Female	Bangalore	Karnataka	From USA	Spouse
3	2020-03-10T00:00:00	13	Female	Bangalore	Karnataka	From USA	Daughter
4		0		Bangalore	Karnataka	From Unit	London
5	2020-03-13T00:00:00	26	Male	Bangalore	Karnataka	From the	Greece
6	2020-03-12T00:00:00	76	Male	Kalburgi	Karnataka	From Mid	Saudi Ara
7		0			Karnataka	Unknown	No detail
8	2020-03-17T00:00:00	32	Male	Bangalore	Karnataka	From Unit	Co passer
9	2020-03-17T00:00:00	63	Male	Kalburgi	Karnataka	From Unit	Co passer
10	2020-03-17T00:00:00	20	Female	Bangalore	Karnataka	From Unit	UK

Situation by Country, Territory & Area

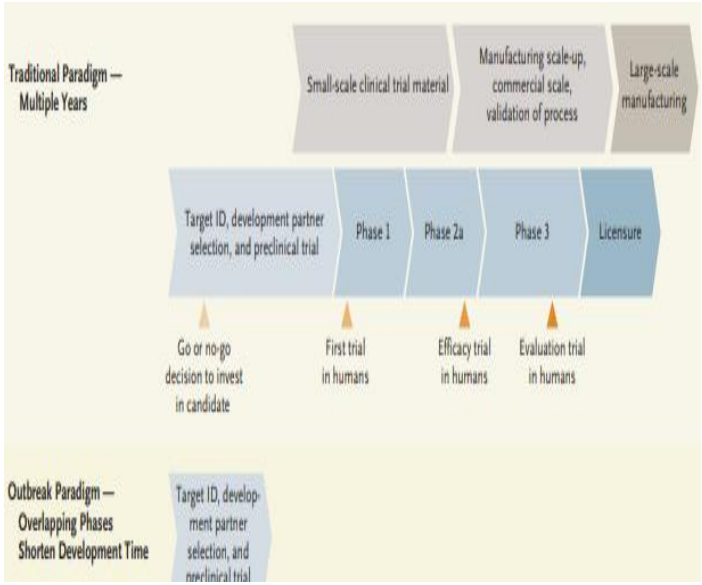
Name	Cases - cumulative total	Cases - newly reported in last 24 hours	Deaths - cumulative total
Global	**23,518,343**	**206,382**	**810,492**
United States o...	5,649,928	37,765	175,813
Brazil	3,605,783	23,421	114,744
India	3,167,323	60,975	58,390
Russian Feder...	966,189	4,696	16,568

In-depth: Excess mortality

Excess mortality refers to the number of deaths *from all causes* above and beyond what we would have expected to see under 'normal' conditions.[1] In this case, we're interested in how deaths during the COVID-19 pandemic compare to the average number of deaths over the same period in previous years.

Looking at excess mortality is helpful for understanding the total impact of the pandemic on deaths – both direct and indirect. It helps us understand the direct impact by capturing deaths caused by COVID-19 that were not correctly diagnosed and reported, for example because no test for the virus was conducted. It helps us understand the indirect

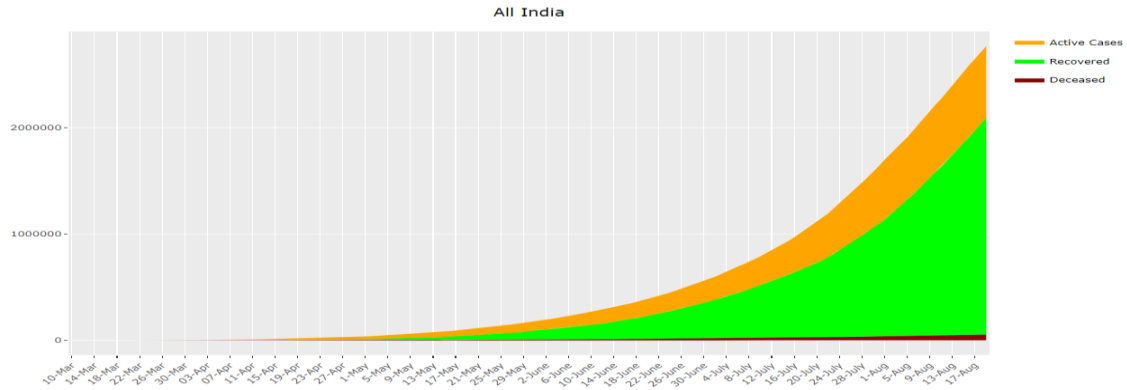
Data

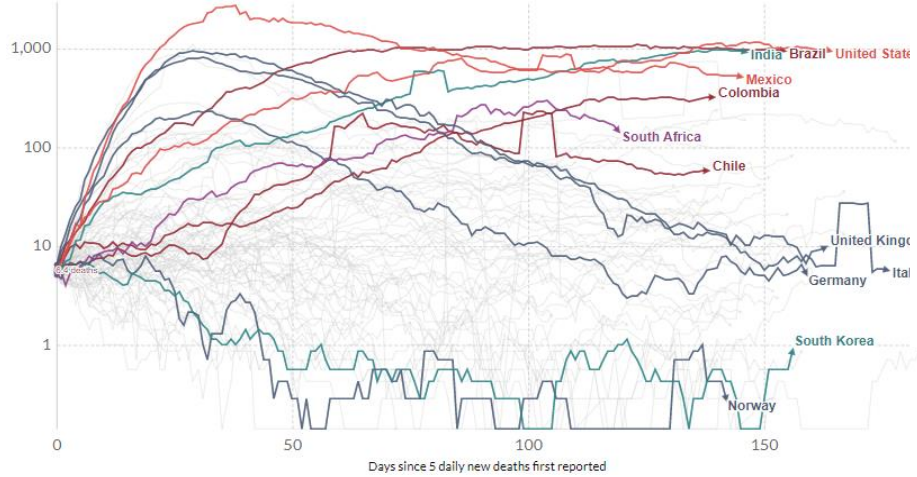


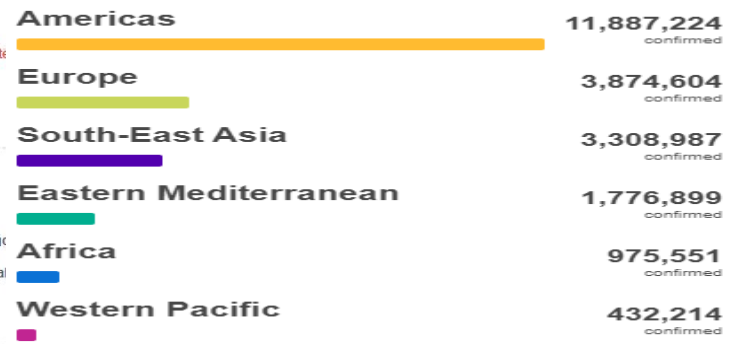
P59595 · NCAP_SARS

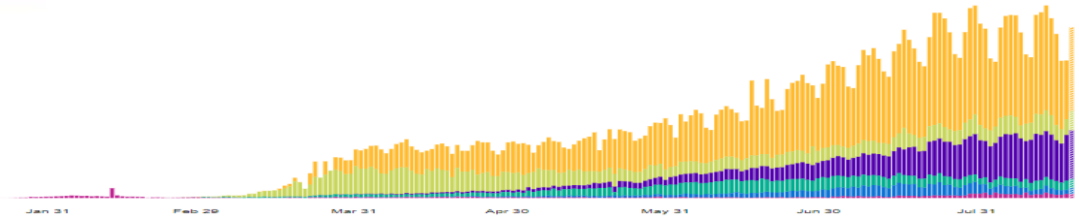
Name	Nucleoprotein
Organism	Severe acute respiratory syndrome cor
Gene	**Name** N 1 Automatic Annotation **ORF names** 9a
Evidence	1: Evidence at protein level
Annotation score	5/5

Background


All India
Active Cases
Recovered
Deceased
2000000
1000000
0


1,000
100
10
1
0
50
100
150
India
Brazil
United State
Mexico
Colombia
South Africa
Chile
United Kingd
Germany
Ital
South Korea
Norway
Days since 5 daily new deaths first reported


Americas
11,887,224
confirmed
Europe
3,874,604
confirmed
South-East Asia
3,308,987
confirmed
Eastern Mediterranean
1,776,899
confirmed
Africa
975,551
confirmed
Western Pacific
432,214
confirmed



Where are the problems?

What we advocate for

User empowerment

Machine empowerment

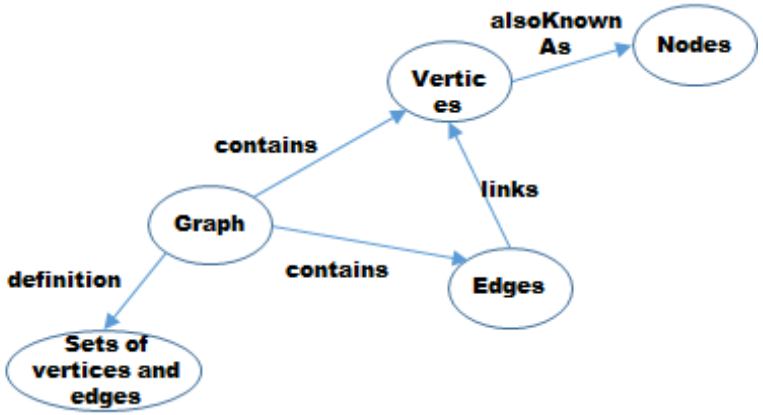
Knowledge Graph Approach

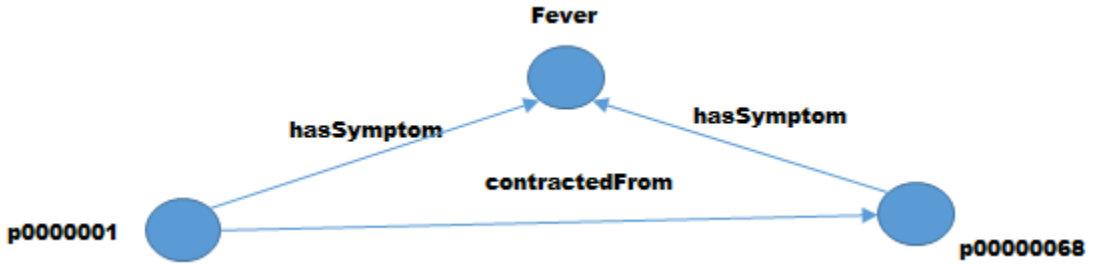
What is Knowledge Graph?

What is a Graph?

$$\text{Graph } G = (V, E)$$

where V is a set whose elements are called vertices (or, nodes), and E is a set of two-sets of vertices, whose elements are called edges (or, links)





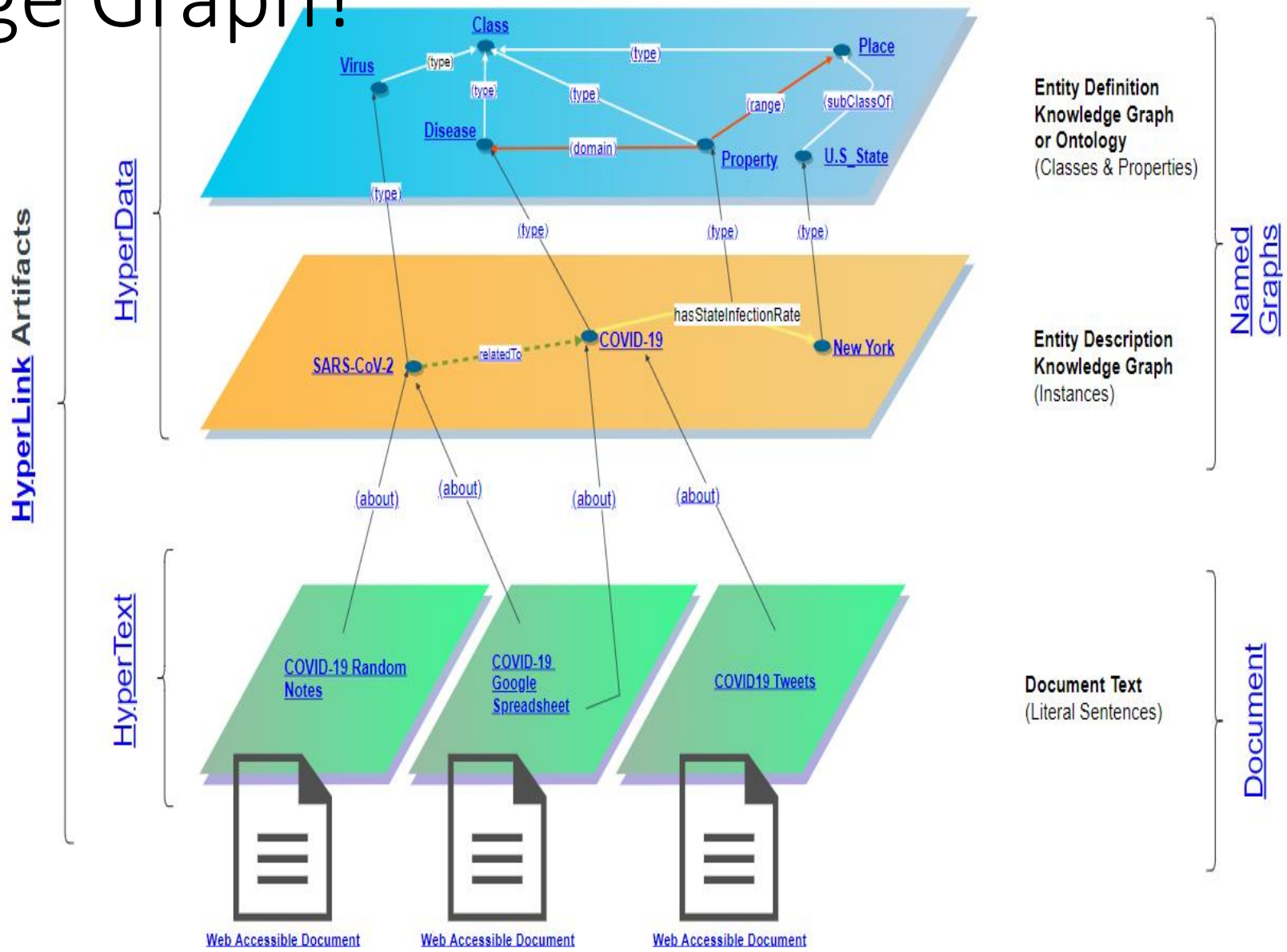
[Bender et al., 2010; Graph, 2002]

A typical example of composition and decomposition technique.

What is Knowledge Graph?

It is a manifestation of an intelligent **Web of Data** informed by an **ontology**.

[Idehen, Kingsley U., 2020]



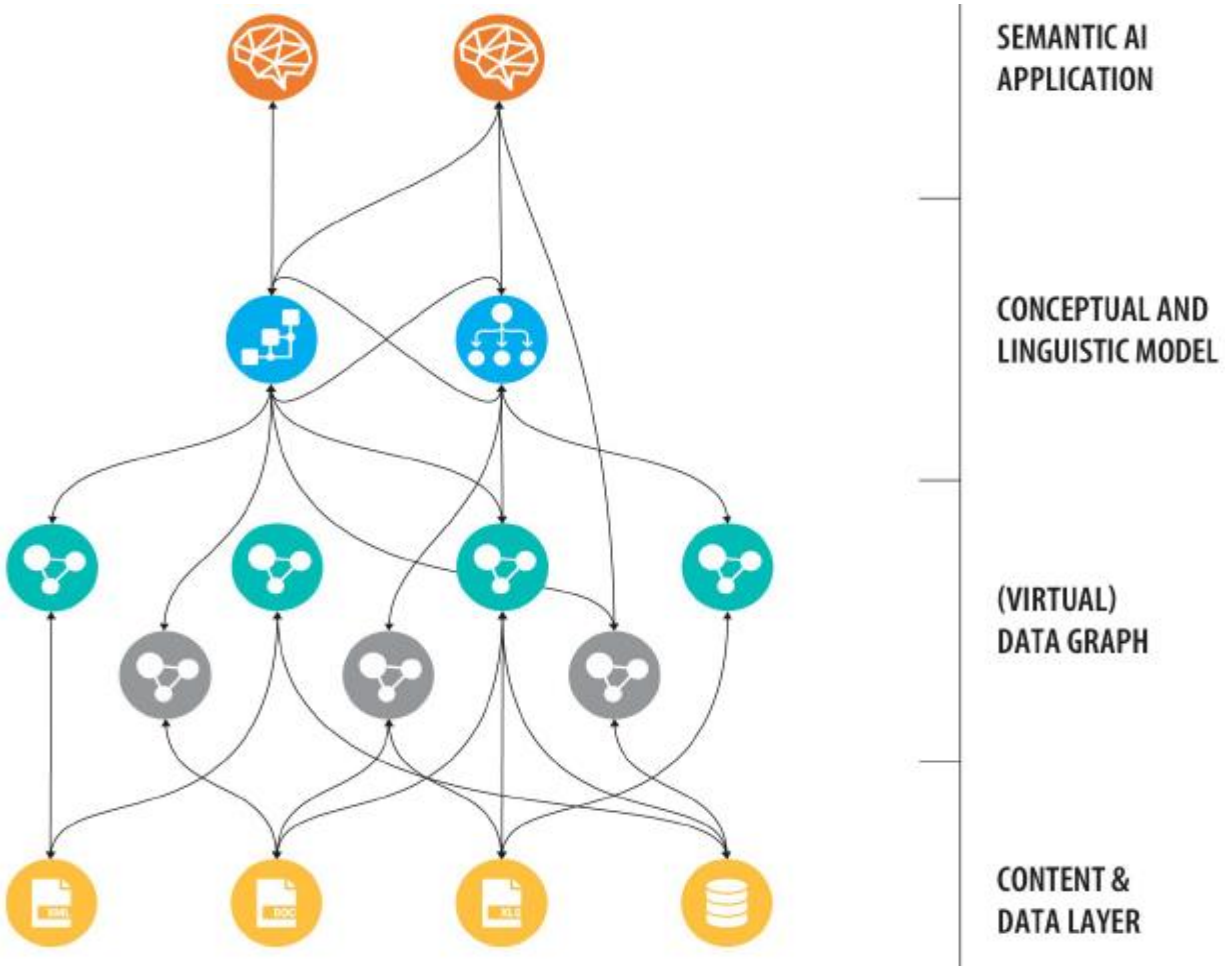
What is Knowledge Graph?

KG can be seen as a

Database: that can be queried

Graph: that can be analyzed as a network of data

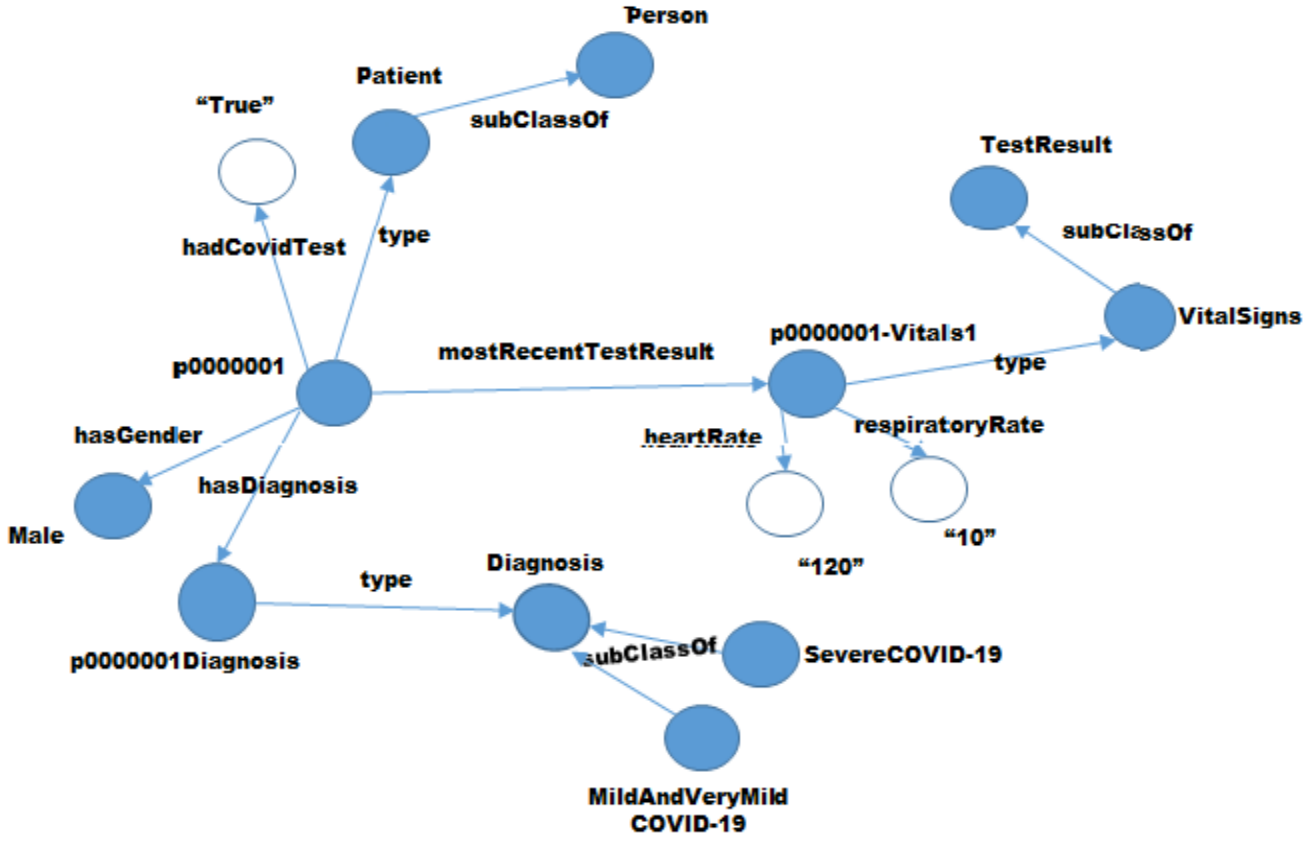
Knowledge base: new facts can be inferred



[Blumauer and Kiryakov, 2020]

What is Knowledge Graph?

KG is a graph-structured representation of the world of human knowledge consisting of definitions and inter-relationships of the concepts and entities.



Why Knowledge Graph?

Why Knowledge Graph?

KG Enables the search of Things (e.g., people, organization, place, event, artifacts).

Enables the retrieval of related information relevant to a query

Introducing the Knowledge Graph: things, not strings

Amit Singhal

SVP, Engineering

Published May 16, 2012

Search is a lot about discovery—the basic human need to learn and broaden your horizons. But searching still requires a lot of hard work by you, the user. So today I'm really excited to launch the Knowledge Graph, which will help you discover new information quickly and easily.

Take a query like [taj mahal]. For more than four decades, search has essentially been about matching keywords to queries. To a search engine the words [taj mahal] have been just that—two words.

But we all know that [taj mahal] has a much richer meaning. You might think of one of the world's most beautiful monuments, or a Grammy Award-winning musician, or possibly even a casino in Atlantic City, NJ. Or, depending on when you last ate, the nearest Indian restaurant. It's why we've been working on an intelligent model—in geek-speak, a "graph"—that understands real-world entities and their relationships to one another: things, not strings.

visvesvaraya

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About 56,10,000 results (0.53 seconds)

en.wikipedia.org › wiki › M._Visvesvaraya

M. Visvesvaraya - Wikipedia

Sir Mokshagundam **Visvesvaraya** KCIE FASc, more commonly known as Sir MV (15 September 1860 – 14 April 1962), was an Indian civil engineer and statesman and the 19th Diwan of Mysore, serving from 1912 to 1919. He received India's highest honour, the Bharat Ratna, in 1955.

Nationality: Indian
Awards: Bharat Ratna (1955)
Born: 15 September 1860; Muddenahalli, ...
Died: 14 April 1962 (aged 101); Bangalore, ...

Biography · Career timeline · Diwan of Mysore · Awards and honours

People also ask

- Who is the father of Engineering in India?
- Why we celebrate Engineer's Day in India?
- What did visvesvaraya invent?
- Why Engineering Day is celebrated on 15th September?

Feedback

Videos

M. Visvesvaraya

Indian civil engineer

Sir Mokshagundam Visvesvaraya KCIE FASc, more commonly known as Sir MV, was an Indian civil engineer and statesman and the 19th Diwan of Mysore, serving from 1912 to 1919. He received India's highest honour, the Bharat Ratna, in 1955. Wikipedia

Born: 15 September 1860, Muddenahalli

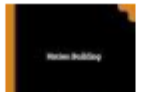
Died: 12 April 1962, Bengaluru

Education: College Of Engineering Pune (1883), Central College Bangalore (1881), United Mission High School

Awards: Bharat Ratna

Parents: Mokshagundam Srinivasa Shastry, Venkatalakshmamma

Books

Google Bangalore

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en.wikipedia.org › wiki › Bangalore

Bangalore - Wikipedia

Bangalore /bæŋgəˈlɔːr/, officially known as Bengaluru is the capital of the Indian state of Karnataka. It has a population of more than 8 million and a ...

Area code(s): +91-(0)80 **Official language:** Kannada
State: Karnataka **Country:** India

History of Bangalore · Bangalore Palace · Economy of Bangalore · Bangalore Fort

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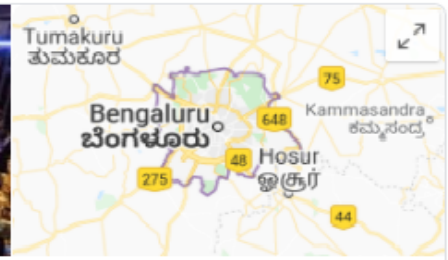


Bengaluru

City in Karnataka

Bengaluru (also called Bangalore) is the capital of India's southern Karnataka state. The center of India's high-tech industry, the city is also known for its parks and nightlife. By Cubbon Park, Vidhana Soudha is a Neo-Dravidian legislative building. Former royal residences include 19th-century Bangalore Palace, modeled after England's Windsor Castle, and Tipu Sultan's Summer Palace, an 18th-century teak structure.

Area: 709 km²

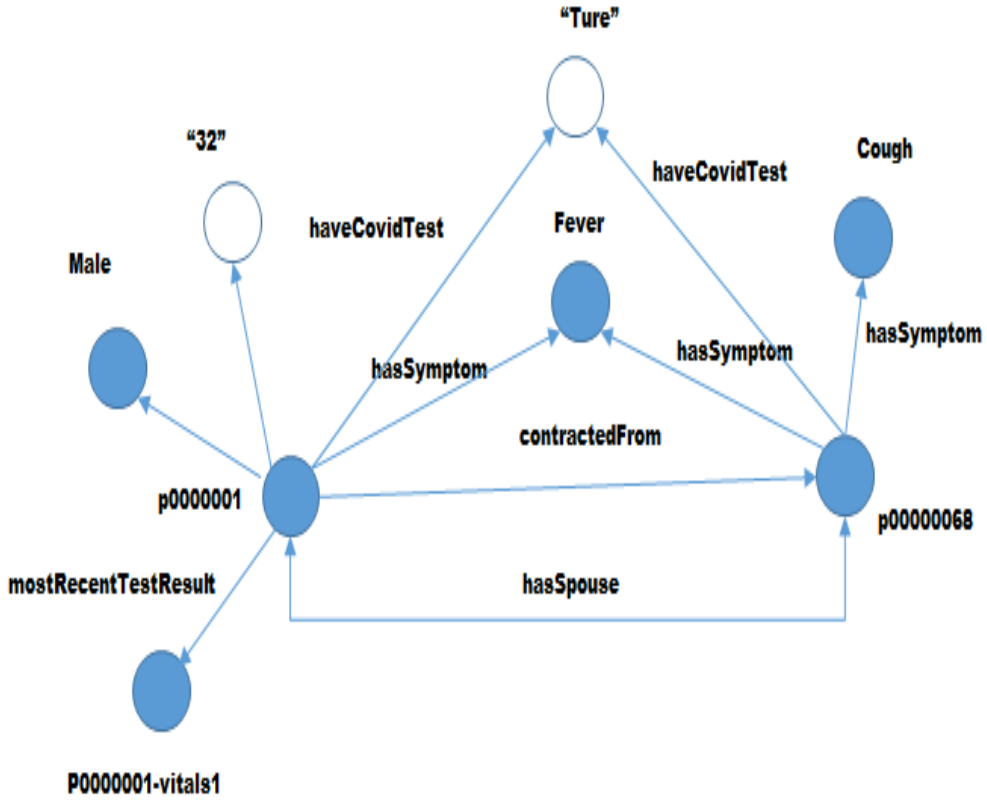
Metropolitan area: 8,005 km²

Why Knowledge Graph?

Enables the capture and explicit **expression of human knowledge by connecting(linking)** the objects and their relationships.

A tool for connecting **various pieces of data** scattered across the silos of databases, text documents, etc.

Enables easy fusion and development of **context**



Why Knowledge Graph?

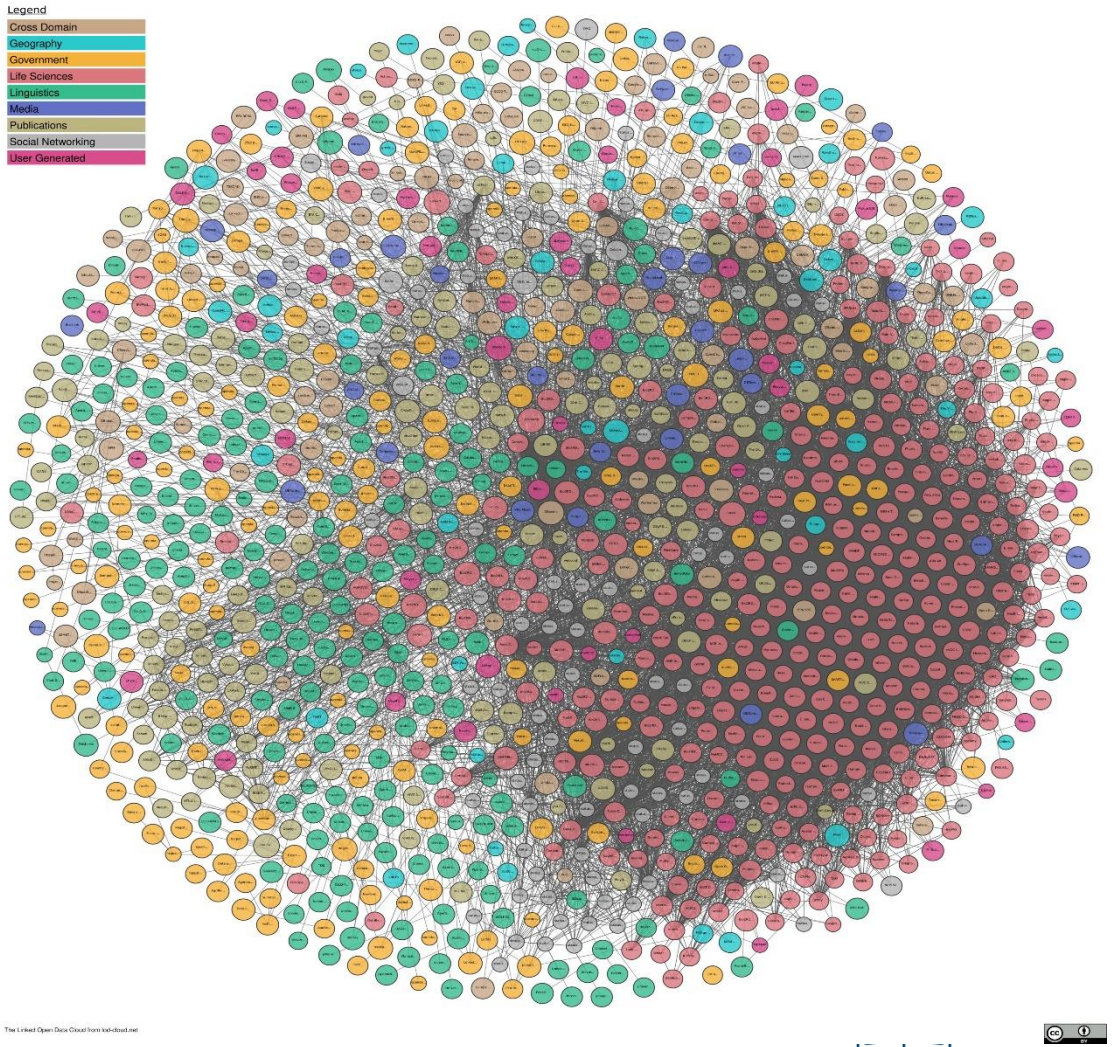
Facilitate easy linking with the other external resources

Implications:

Enriched knowledge

Creates a collaborative space towards building a **comprehensive** knowledge base (*graphs are by nature composable*)

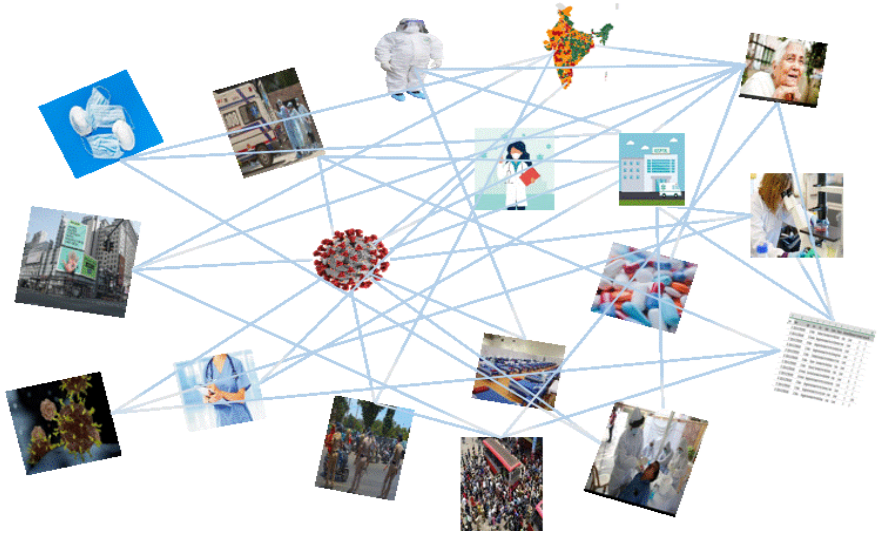
Linking of all relevant information about the objects (e.g., enterprise knowledge space, education, health)



[https://lod-cloud.net/]

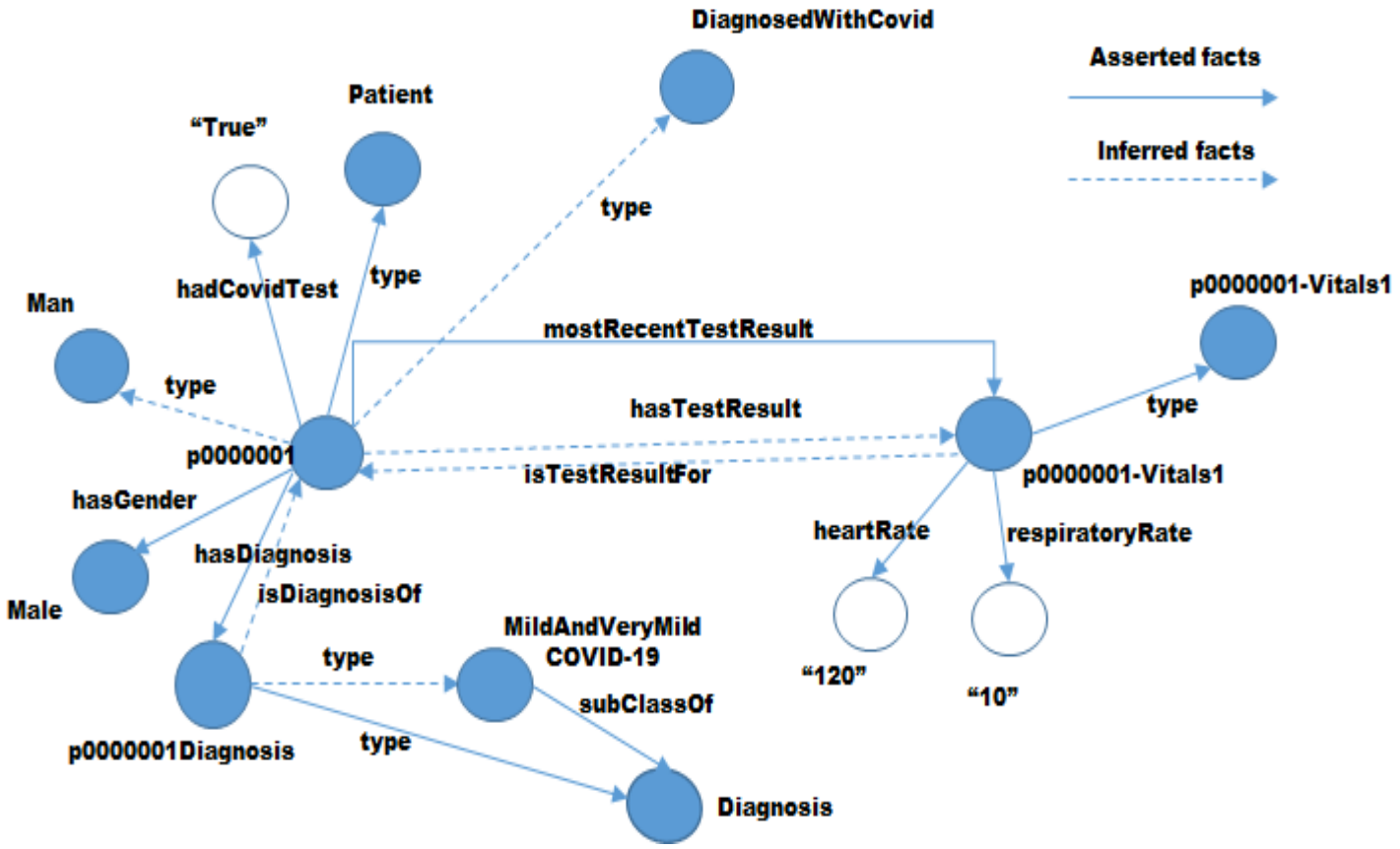
Why Knowledge Graph?

A data model for learning heterogeneous knowledge

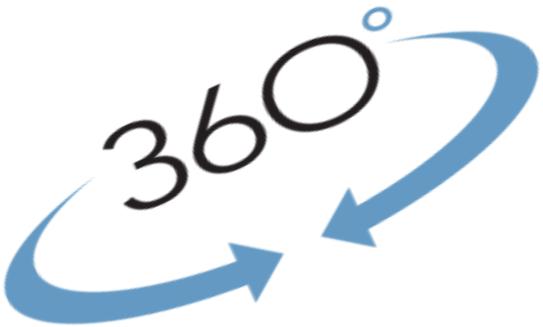


Why Knowledge Graph?

A tool to **extract insight** from data by interlinking and analyzing



Why Knowledge Graph?



Multi-faceted and all side views of objects

A tool to visualize the organizational strengths and weaknesses

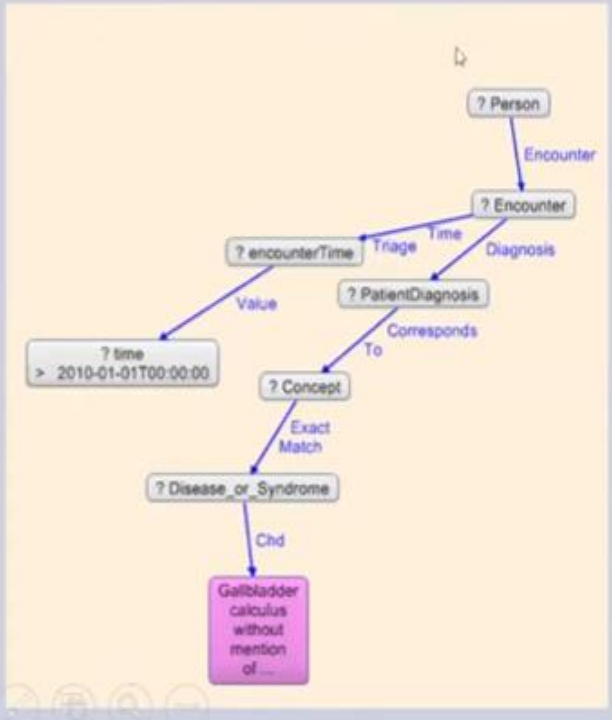
Why Knowledge Graph?

Simplified queries

How many patients had 'gallbladder calculus' in 2010 and later

SPARQL

```
Select (count(distinct  ?pt) as ?count) where {
  ?pt cdm:encounter ?enc .
  ?enc timew3c:begins/upper:value ?date ;
   cdm:diagnosis/upper:correspondsTo/skos:exactMatch ?cui.
filter (?date > '2010-01-01T00:00:00'^^xsd:dateTime)
?cui mth:chd*  mth:C0497327.}
```



SQL

(Part 1 of 3)

```
Select dx.dxCode, dx.dxCount, cl.dxClassName, cl.ClassCount
From (select distinct c.person_source_value as person,
c.condition_source_concept_id as dxCode, f.concept_name as
dxName,
a.concept_id_2 as dxClass, e.concept_name as dxClassName from
omopv5.concept_relationship a
join cdrn.condition_occurrence c on
a.concept_id_1=c.condition_source_concept_id join
omopv5.concept_ancestor d
on d.descendant_concept_id=a.concept_id_2 join omopv5.concept e
on e.concept_id=d.ancestor_concept_id
join omopv5.concept f on f.concept_id=d.descendant_concept_id
where a.relationship_id='Maps to' and
d.min_levels_of_separation=2 and e.standard_concept='S') dx JOIN
(select distinct c.person_source_value as person,
c.condition_source_concept_id as dxCode, f.concept_name as
dxName, a.concept_id_2 as dxClass, e.concept_name as
dxClassName from omopv5.concept_relationship a join
cdrn.condition_occurrence c on
a.concept_id_1=c.condition_source_concept_id join
omopv5.concept_ancestor d on
d.descendant_concept_id=a.concept_id_2
join omopv5.concept e on e.concept_id=d.ancestor_concept_id join
omopv5.concept f on f.concept_id=d.descendant_concept_id
where a.relationship_id='Maps to' and d.min_levels_of_separation=2
and e.standard_concept='S') cl on dx.dxClass=cl.dxClass
order by cl.dxClass desc
```

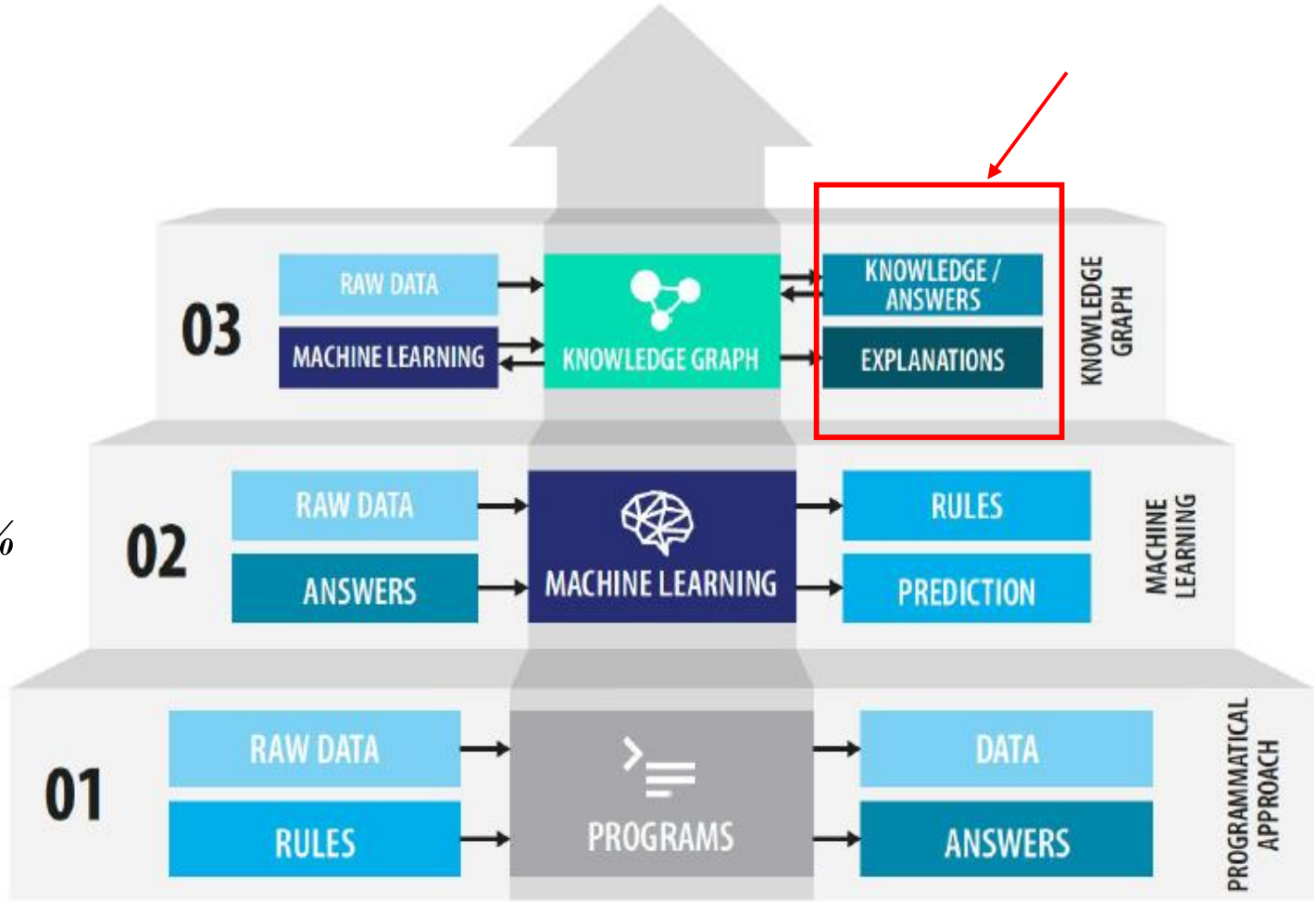
[Aasman (2020)]

Why Knowledge Graph?

Forms a backbone for AI and analytics platforms

A ML algorithm can say "*person X has a Y% chance of their tumor being cancer*" but most ML algorithms can't explain why.

Integrating ML and KG is a way forward in addressing this issue.



[Blumauer and Kiryakov (2020)]

KG usage: a quick review

- Web search
- Question answering
- Data integration
- Data collection and analysis
- Data visualization
- Machine learning and advanced analytics

KG Technology

Semantic Web

"*A web of data that can be processed directly and indirectly by machines*" – Tim Berners-Lee

An **extension**, not a replacement of the current web

A metadata based infrastructure for reasoning on the Web

Goal: provide a common framework to share data on the Web across application boundaries


Scientific American: Feature Article: The Semantic Web: May 2001

SCIENTIFIC AMERICAN

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Current Issue | Explore! | Ask the Experts | Marketplace | Search the Site

FEATURE ARTICLES

The Semantic Web

A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities

by TIM BERNERS-LEE, JAMES HENDLER and ORA LASSILA

SUBTOPICS:
Expressing Meaning
Knowledge Representation
Ontologies
Agents
Evolution of Knowledge

SIDEBARS:
Overview / Semantic Web

The entertainment system was belting out the Beatles' "We Can Work It Out" when the phone rang. Wh his phone turned the sound down by sending a message to all the other *local* devices that had a *volume* Lucy, was on the line from the doctor's office: "Mom needs to see a specialist and then has to have a ser sessions. Biweekly or something. I'm going to have my agent set up the appointments." Pete immediately agreed to share th doctor's office, Lucy instructed her Semantic Web agent through her handheld Web browser. T retrieved information about Mom's *prescribed treatment* from the doctor's agent, looked up sev and checked for the ones *in-plan* for Mom's insurance within a *20-mile radius* of her *home* and *excellent* or *very good* on trusted rating services. It then began trying to find a match between a *times* (supplied by the agents of individual providers through their Web sites) and Pete's and La (The emphasized keywords indicate terms whose semantics, or meaning, were defined for the a Semantic Web.)

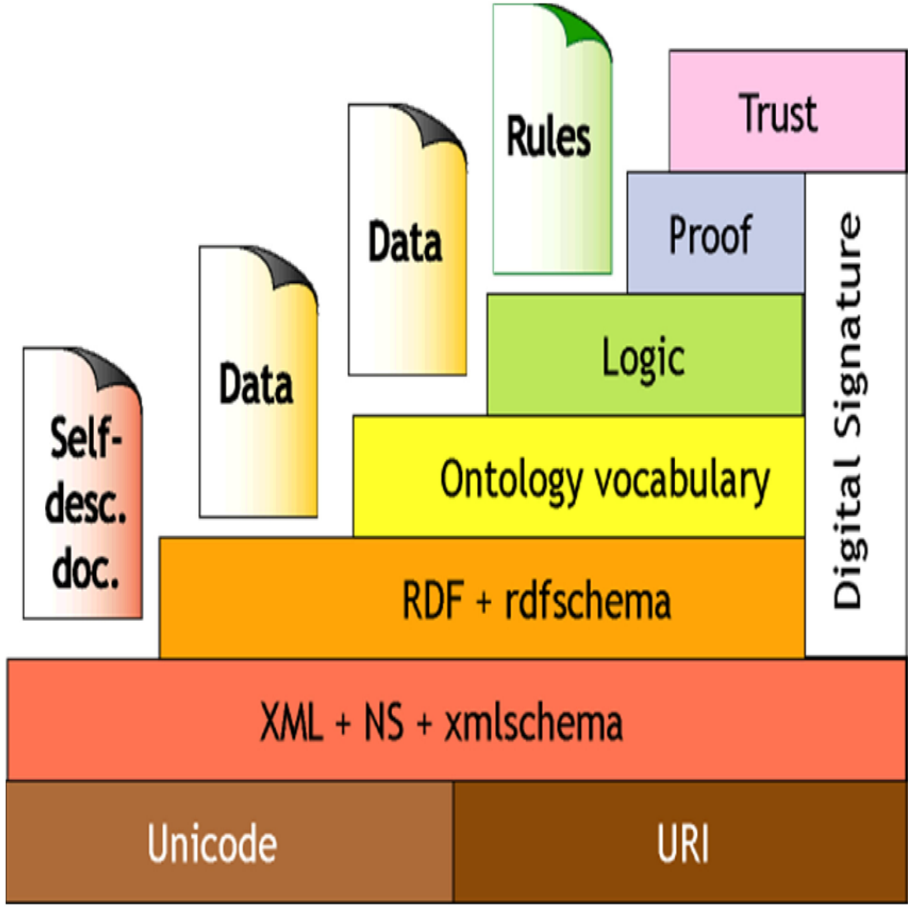
In a few minutes the agent presented them with a plan. Pete didn't like it—University Hospital town from Mom's place, and he'd be driving back in the middle of rush hour. He set his own ag with stricter preferences about *location* and *time*. Lucy's agent, having *complete trust* in Pete's agent in the context of the pr automatically assisted by supplying access certificates and shortcuts to the data it had already sorted through.

Technologies

[W3C Standards]

- International Resource Identifier (IRI)
- Resource Description Framework (RDF/RDF Schema)
- Web Ontology Language (OWL)
- SPARQL Protocol and RDF Query Language (SPARQL)
- Semantic Web Rule Language (SWRL)

- Reasoner



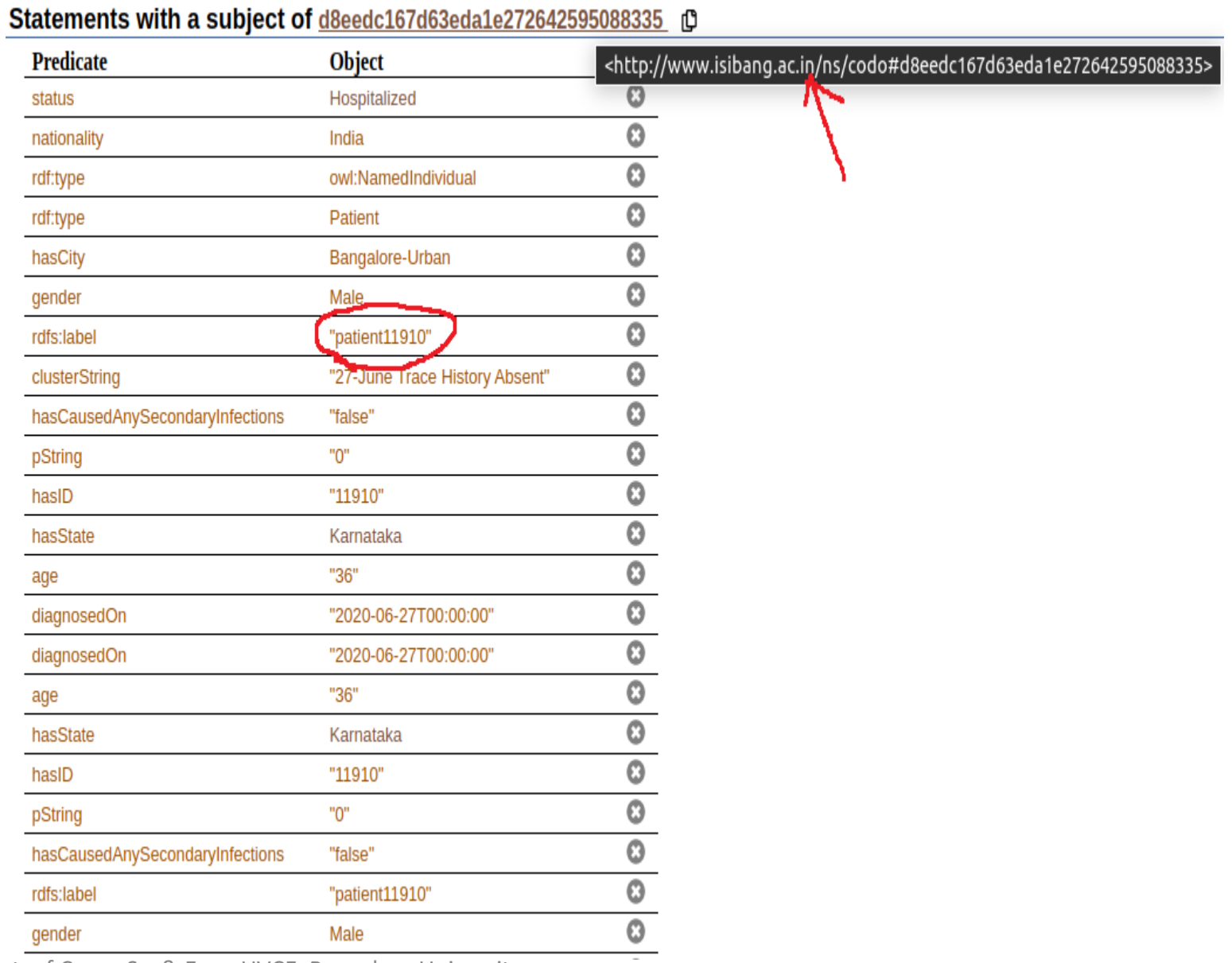
IRI

An IRI looks very much like a URL.

IRI's are more general than URLs and can describe resources to a finer level of granularity than an HTML page.

An IRI can be any resource such as a class, a property, an individual, etc.

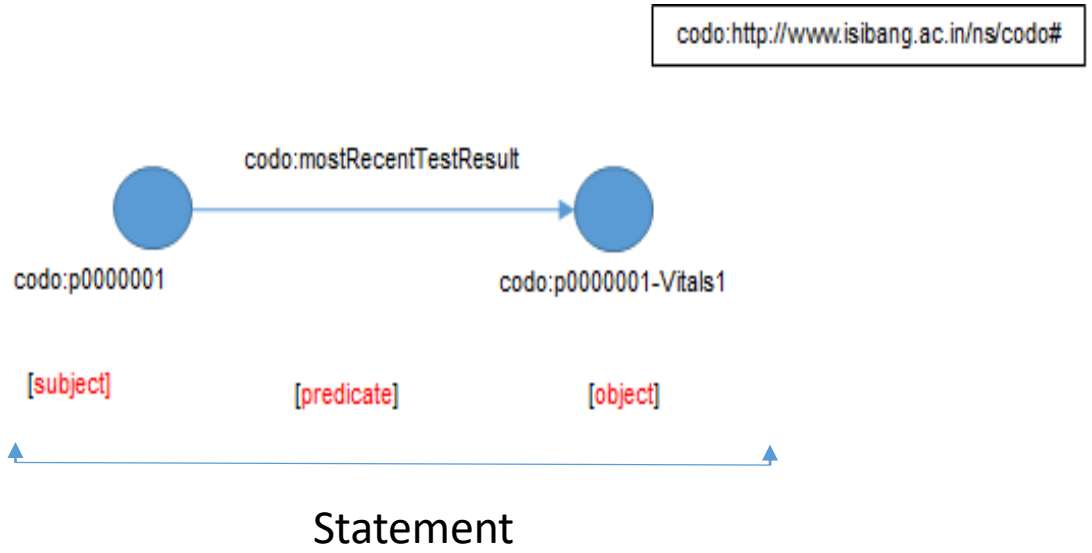
[DuCharme, 2011]



RDF

An abstract metadata data model.

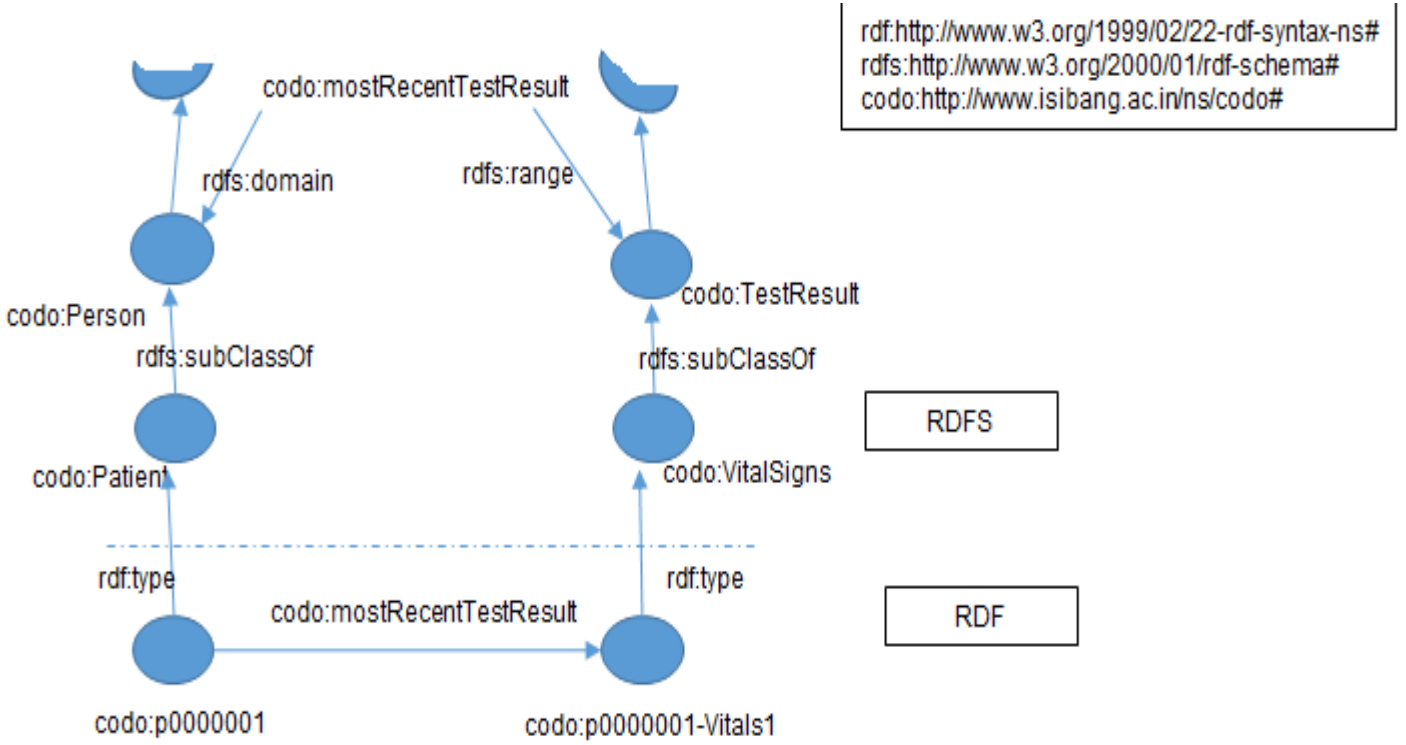
It is the foundation language for describing IRI data as a graph.



[W3C, 2014]

RDF Schema

RDFS is layered on top of RDF and provides basic concepts such as classes, properties, collections, etc.



[W3Ca, 2014]

OWL

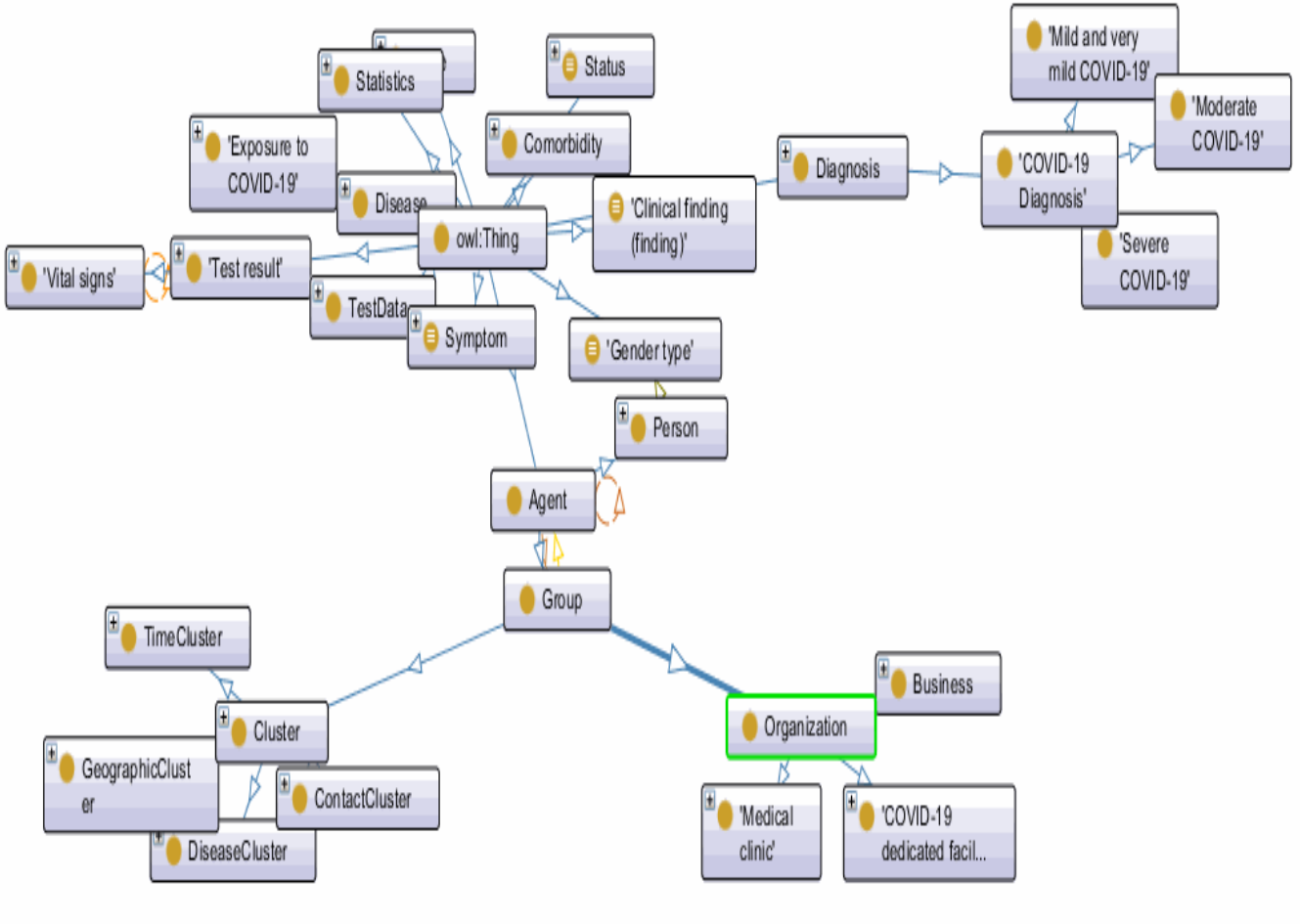
- OWL is layered on top of RDFS and provides the **semantics** for knowledge graphs.
- An implementation of Description Logics, a decidable subset of First Order Logic (W3C 2012).
- OWL enables the definition of reasoners which are automated theorem provers.

[W3Ca, 2014]

Ontology

A formal model that represents knowledge as a set of concepts within a domain and the relationship between these concepts

"A formal explicit specification of a shared conceptualization"
[Gruber, 1993]



SPARQL

A SPARQL query defines a graph pattern that is matched against the available data sources and returns the data that matches the pattern.

Allows federated queries across heterogeneous sources of data.

DL Query | Snap SPARQL Query

Snap SPARQL Query:

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX codo: <http://www.isibang.ac.in/ns/codo#>
PREFIX schema: <https://schema.org/>

SELECT ?p ?r
WHERE {
        ?p rdf:type  schema:Patient.
        ?p codo:hasDiagnosis ?d.
        ?d rdf:type codo:COVID-19Diagnosis.
        ?p codo:hasCloseRelationship ?r.
        ?r codo:hadCovidTest false.

}
```

Execute

?p	?r
codo:p000001	codo:p000004
codo:p000001	codo:p000005
codo:p000001	codo:p000006
codo:p000001	codo:p000007
codo:p000002	codo:p000008
codo:p000003	codo:p000010
codo:p000003	codo:p000012

[DuCharme, 2011]

SWRL

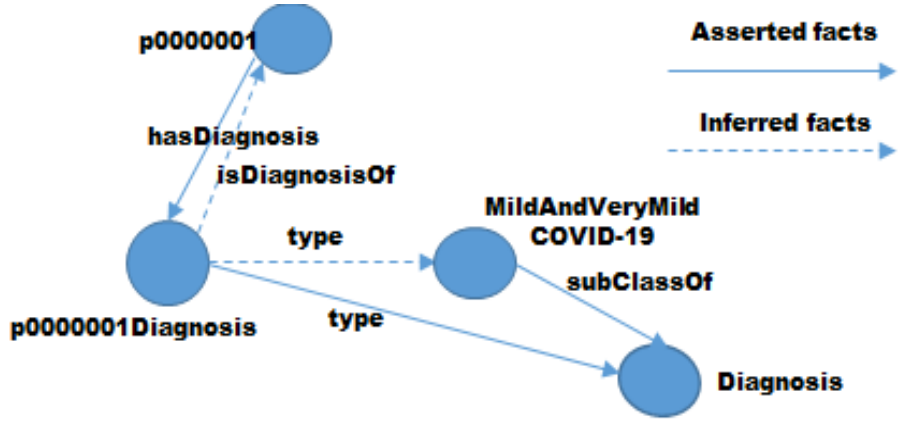
A rule-based language that extends OWL reasoners with additional constructs beyond what can be described with OWL's Description Logic language.

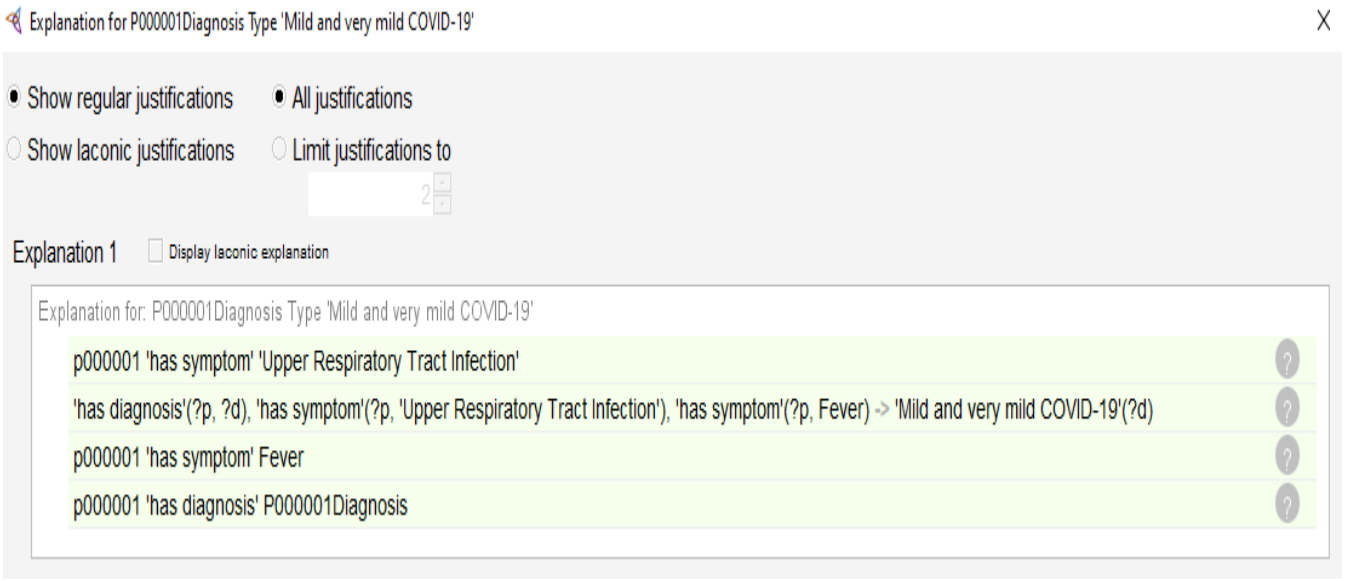
```
codo:hasDiagnosis(?p, ?d) ^ codo:hasSymptom(?p, codo:URTI) ^ codo:hasSymptom(?p, codo:Fever) ->
codo:MildAndVeryMildCOVID-19(?d)
```

[W3C, 2014]

Reasoner

- Reasoners are automated theorem provers.
- Reasoners first ensure that an **ontology** model is consistent.
  - If the model is not consistent the reasoner will highlight the probable **source of the inconsistency**.
  - If the model is consistent reasoners can then **deduce additional information** based on concepts described, such as transitivity, inverses, value restrictions, etc.





[W3Ca, 2014]

CODO

(1) CODO Ontology

(2) CODO Knowledge Graph

CODO: An Ontology for Collection and Analysis of Covid-19 Data

CODO v1.3 consists of

# of classes: 84

# of object property: 73

# of data property: 52

CODO: COviD-19 Ontology for Cases and Patient information

Release April 27, 2020

This version:
http://www.isibang.ac.in/ns/codo/1.0

Latest version:
http://www.isibang.ac.in/ns/codo/1.0

Authors:
Biswanath Dutta, (Indian Statistical Institute)
Michael DeBellis, (Semantic Consultant)

Publisher:
Indian Statistical Institute, (null)

Download serialization:
Format JSON LD | Format RDF/XML | Format N Triples | Format TTL

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Cite as:
Dutta, B. and DeBellis, M.(2020). CODO: an ontology for collection and analysis of COVID-19 data. In Proc. of 12th I
Development (KEOD), 2-4 November 2020 (accepted).

Abstract

Available from https://isibang.ac.in/ns/codo/index.html
https://github.com/biswanathdutta/CODO

Dutta, B. and DeBellis, M.(2020). CODO: an ontology for collection and analysis of COVID-19 data. In Proc. of 12th Int. Conf. on Knowledge Engineering and Ontology Development (KEOD), 2-4 November 2020 (accepted)

CODO Ontology Goals

- To serve as an explicit ontology for use by data and service providers to publish COVID-19 data using FAIR principles
- To develop and offer distributed, heterogeneous, semantic services and applications
  - E.g., decision support system, advanced analytics, such as behavior analysis of the disease, factors of disease transmission, etc.
- To provide a standards-based reusable vocabulary for the use of various organizations (e.g., government agencies, hospitals) to annotate and describe COVID-19 information

CODO Ontology Use cases

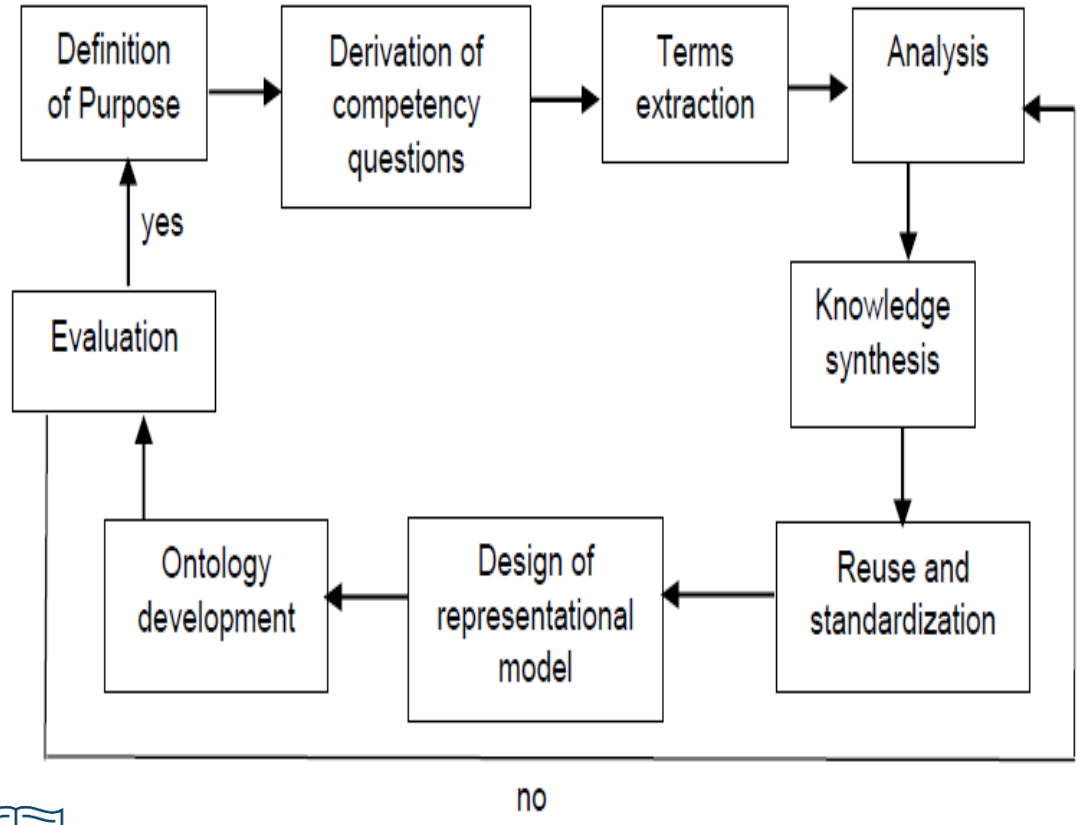
- Knowledge Graph creation
- Annotation of COVID-19 literature
- Application design (e.g., COVID-19 risk detection system)

CODO Ontology success stories, so far

- COVID-19 risk detection system for older people in residential aged care using ontology and machine learning technology (http://bioportal.bioontology.org/projects/Ping)

- Research community/ academicians expressed their interest to use CODO for building KGs

CODO Ontology Design Approach

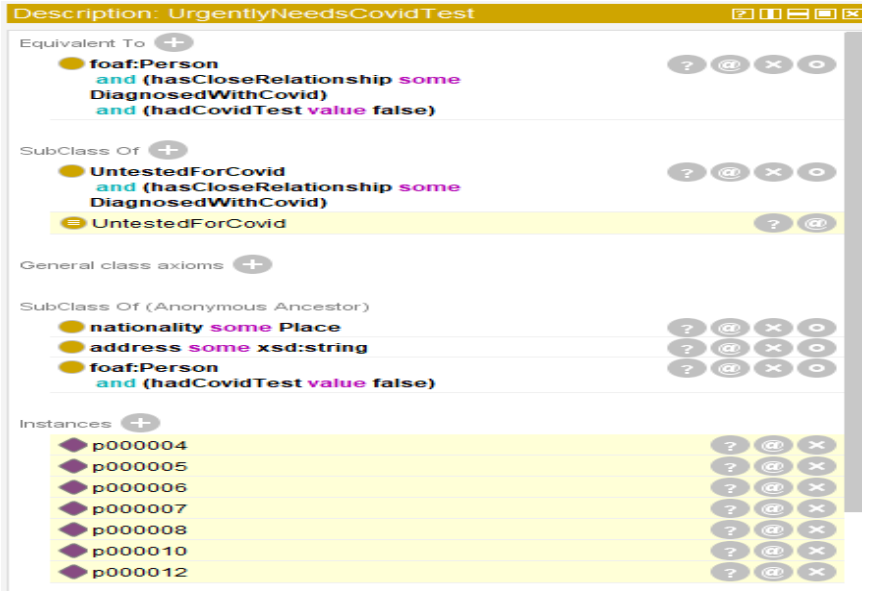


S2: **Competency questions**

i. Find all People p who are related to someone r who has been diagnosed with COVID-19 and who has not yet been tested.

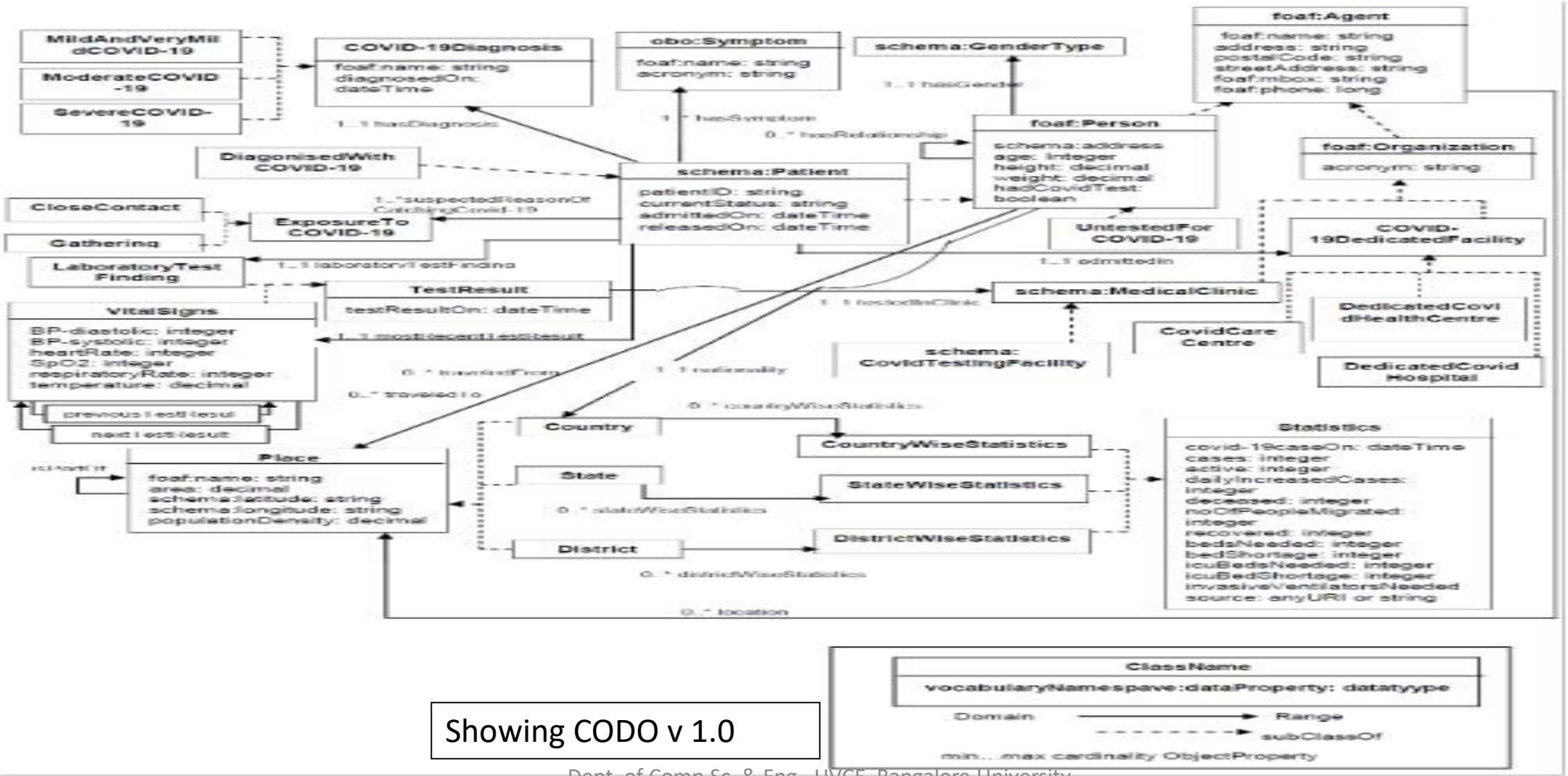
ii. Give me the primary reasons i for the maximum number of COVID-19 patients p.

iii. Give me the most prevalent symptoms s of Severe COVID-19 d.



Dutta, B. and DeBellis, M.(2020). CODO: an ontology for collection and analysis of COVID-19 data. In Proc. of 12th Int. Conf. on Knowledge Engineering and Ontology Development (KEOD), 2-4 November 2020 (accepted)

CODO Ontology block diagram



Showing CODO v 1.0

CODO Knowledge Graph

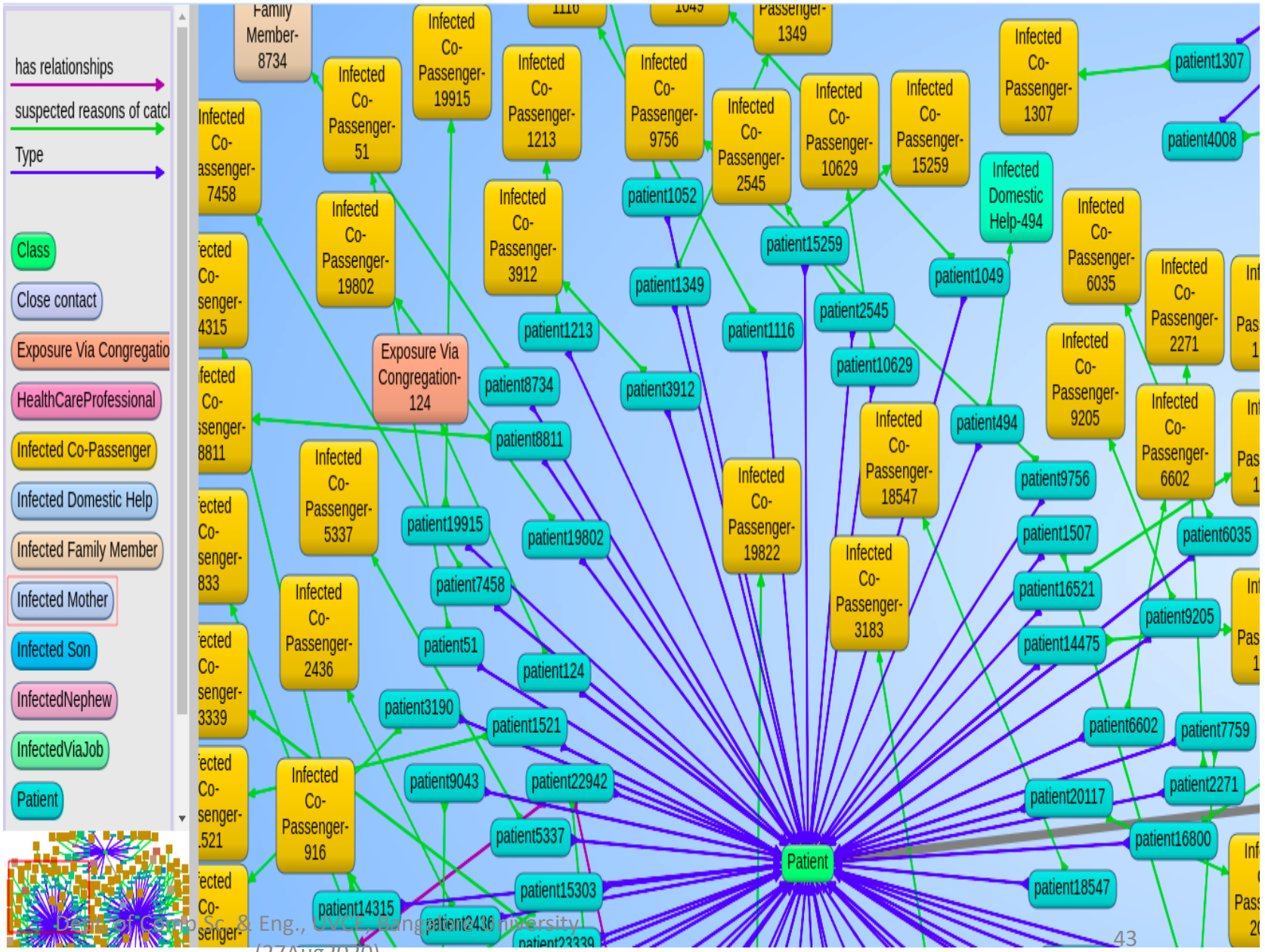
Primarily with the following two goals:

1. Transforming COVID-19 data as **FAIR Semantic** data
2. CODO ontology evaluation

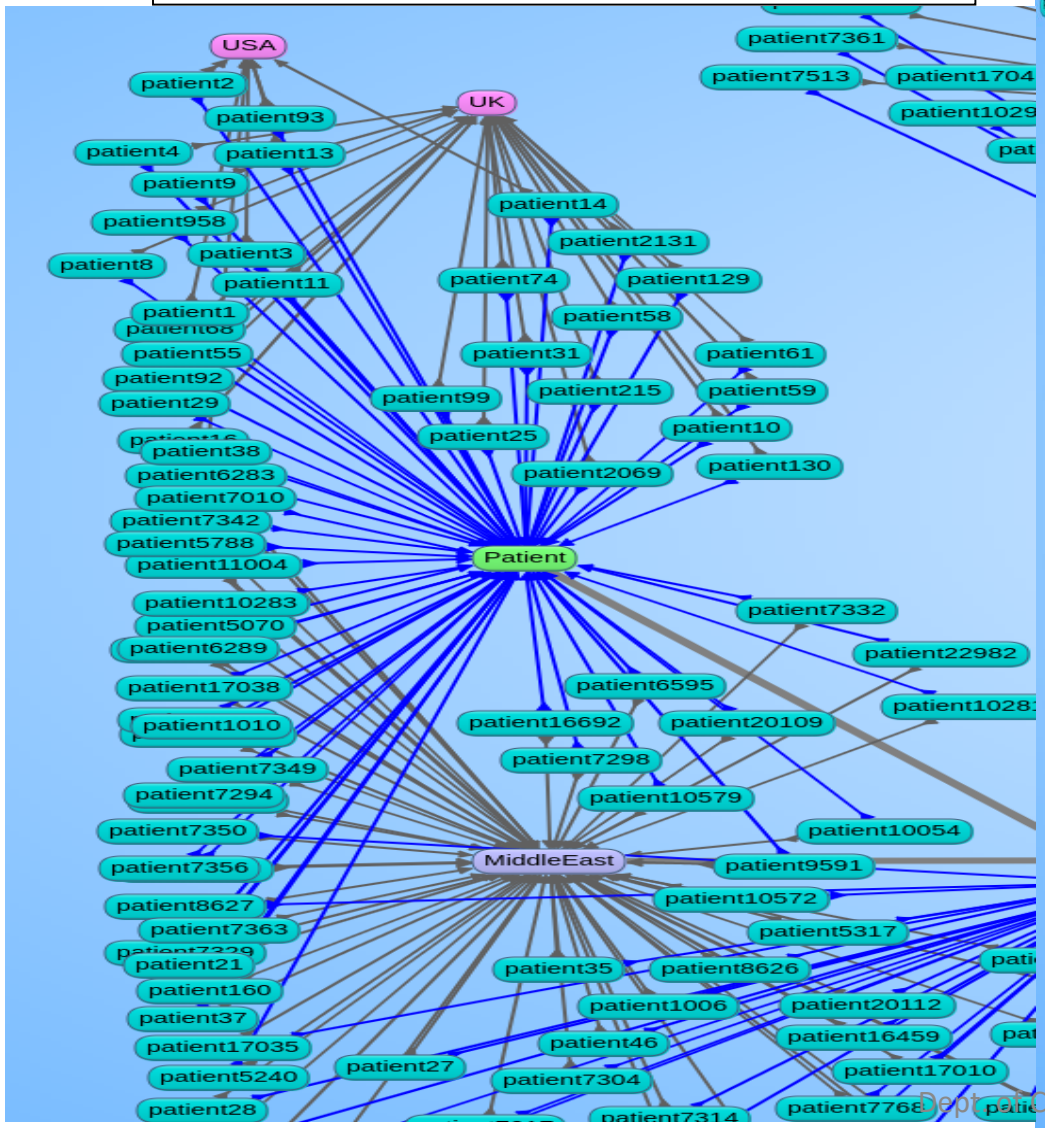
CODO Knowledge Graph

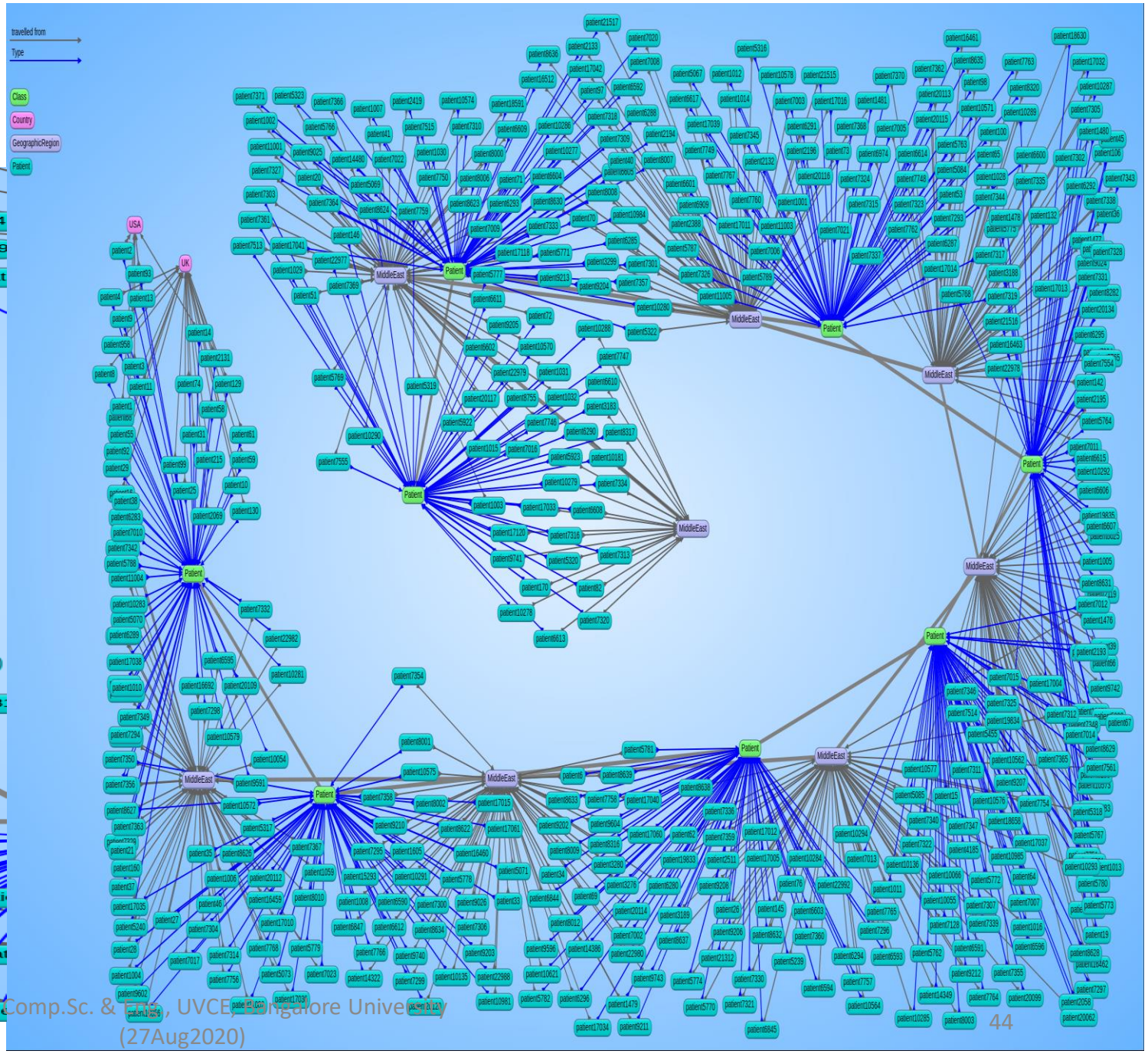
#Show the patients with the possible reasons of catching COVID-19. Also, display the relationships between the patients, if any.

```
SELECT ?p ?r ?l

WHERE {

?p rdf:type schema:Patient.

?p
codo:suspectedReasonOfCatchingCovid
-19 ?r.

OPTIONAL{?p codo:hasRelationship
?l.}

} LIMIT 150
```



```
SELECT ?p ?tf ?tt
WHERE {
        ?p rdf:type schema:Patient.
        ?p codo:travelledFrom ?tf.
  OPTIONAL{?p codo:travelledTo ?tt.}
} LIMIT 2000
```





CODO Knowledge Graph consists of …

- # of axioms: 338977
- # of individuals: 25996
- # of classes: 84
- # of object properties: 73
- # of data properties: 52

CODO KG Data source
https://www.isibang.ac.in/~athreya/incovid19/data.html
https://covid19.karnataka.gov.in/govt_bulletin/en

Experience/ challenges

- Data availability (e.g., clinical data)
- Standard format for data capture and communication
- Most of the datasets are not directly consumable, not suitable to the graph
  - This made the data transformation complicated, time consuming
- Inconsistent data (e.g., sometimes P1342, sometimes 1342. Sometimes P132-P134 and sometimes "P132 and P133 and P134")
- Typo errors
  - Data misplacement
  - Spelling errors (mostly the place names and this complicates the linkage with the external resources)

Access to CODO

- Both CODO Ontology and CODO Knowledge Graph can be accessed/downloaded from:
  - GitHub (https://github.com/biswanathdutta/CODO)
  - Browse CODO Ontology (https://isibang.ac.in/ns/codo/index.html)

- Persistent URI for CODO

Take home message

- Graph data is inevitable
- KG is a powerful way of representing data
- KG can solve many present day data integration and other related tasks
- KG and ML are not technologies that compete with each other but rather solve different problems

Acknowledgement

- Michael DeBellis (https://www.michaeldebellis.com/)
  - My friend and colleague for his continuous and active support in making CODO flourish

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Thank you!!!

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