



CSCE 581: Introduction to Trusted AI

Lectures 3 and 4: Introduction to AI, Trust and Real-World Applications

PROF. BIPLAV SRIVASTAVA, AI INSTITUTE

21ST AND 23RD JAN 2025

Carolinian Creed: “I will practice personal and academic integrity.”

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Organization of Lectures 3, 4

- Introduction Section
 - Recap from Week 1 (Lectures 1 and 2)
 - Results of expectation survey
 - Announcements, course scope
- Main Section
 - L3: Trusted Decisions, Data
 - L4: Data Prep, Knowledge Graph
- Concluding Section
 - About next week – Lectures 5, 6
 - Ask me anything

Credit: Dilbert

Introduction Section

A Lesson in Trust

Weather alerts and Closing campus, Canceling classes

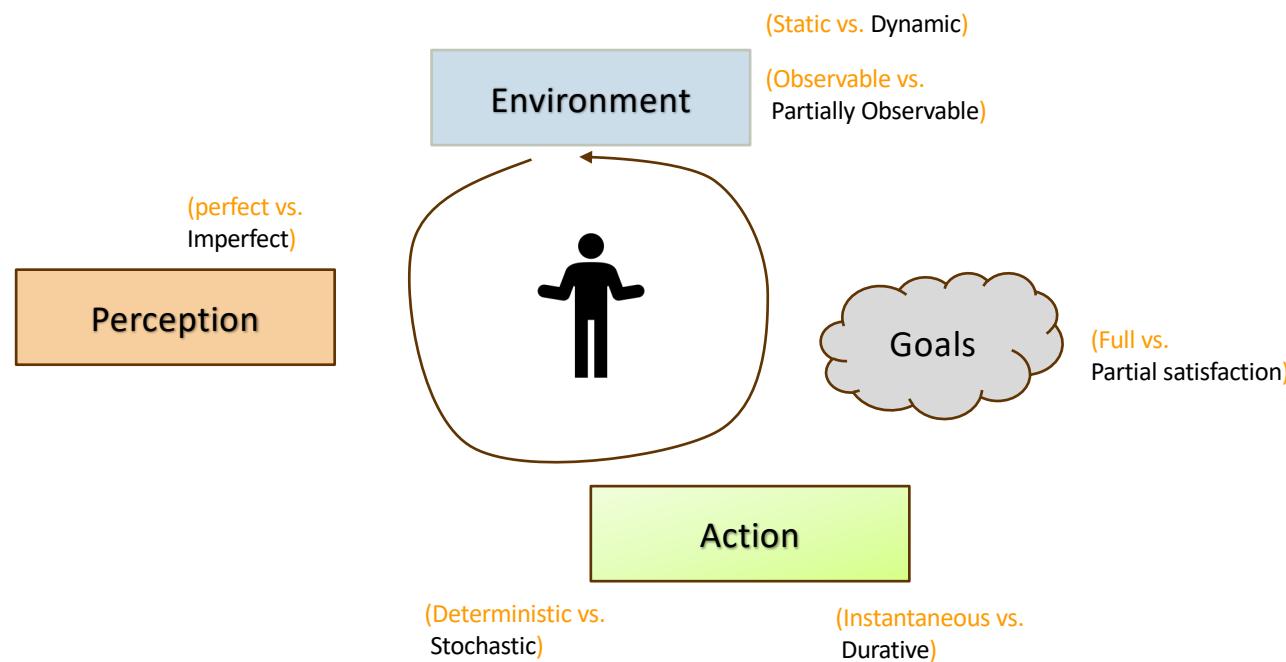
- Event order and response by actors // Choice 1 (Actual): Trustable ??
 - Alert1 -> Close campus -> Cancel class
 - Alert2 -> Unclose (Open) campus -> Uncancel (Normal) class
 - Alert3 -> Close campus -> Cancel class
 - ...
- Event order and response by actors // Choice 2: A more trustable way ??
 - Alert1 -> Close campus -> Online class (or recorded) OR CANCEL class
 - Alert2 -> Unclose (Open) campus -> No Change
 - Alert3 -> Close campus -> No Change
 - ...
- *Which one would you have preferred, and WHY?*

Recap from Week 1

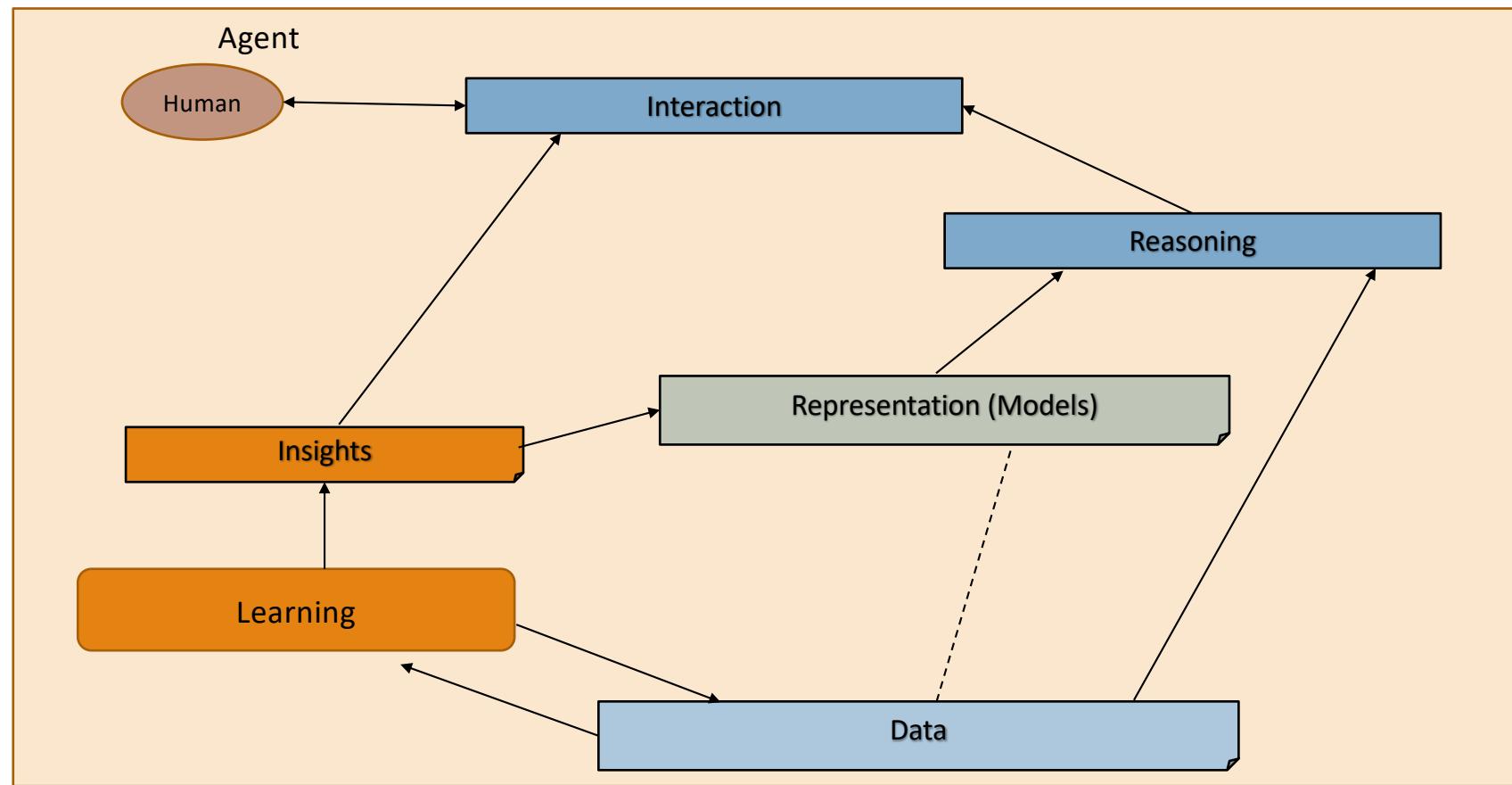
Week 1: Introduction to Trusted AI

- Lecture 1: AI and Trust
 - AI as intelligent agent
 - Trust problem
 - Flexibility to adjust between AI methods and handling trust based on students' expectations
 - CSCE 581: AI/ ML topics and with a focus on fairness, explanation, Data privacy, reliability
 - CSCE 580: Classical AI topics and a focus on implementation

Intelligent Agent Model



Relationship Between Main AI Topics

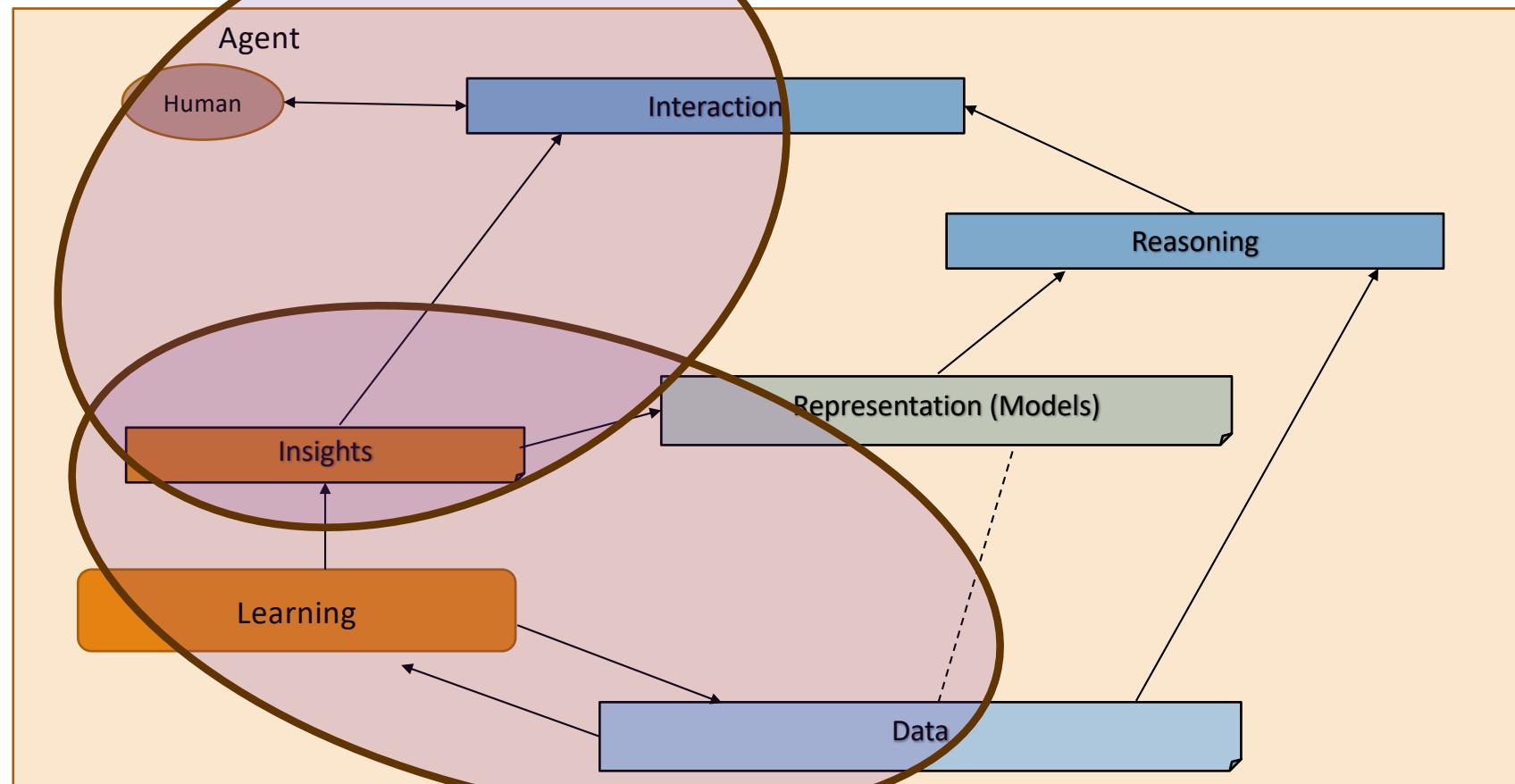


Recap from Week 1

Week 1: Introduction to Trusted AI

- Lecture 1: AI and Trust
 - AI as intelligent agent
 - Trust problem
 - Flexibility to adjust between AI methods and handling trust based on students' expectations
 - CSCE 581: AI/ ML topics and with a focus on fairness, explanation, Data privacy, reliability
 - CSCE 580: Classical AI topics and a focus on implementation
- Lecture 2: Case studies
 - Data analysis for traffic improvement (South Carolina), Trust –
<https://ai4society.github.io/projects/traffic-page/index.html>
 - Recommendations and Trust [Fairness and Teaming Recommendation] –
https://ai4society.github.io/projects/group_rec/index.html

Relationship Between Main AI Topics (Covered in Course)



Expectations Survey

- 60% response rate
- AI background (1-5 scale): 2 (50%), 3 (33%)

One thing want to learn

- I'd like to learn how researchers are working towards mitigating hallucinations in LLMs
- How can the recipients (readers) of AI-generated information think that the information they see is trustworthy
- How reliable is AI and how far will it go?
- LLMs
- I aim to explore Trustworthy AI from an interdisciplinary conceptual perspective, focusing on its applications across domains such as healthcare. My interests include human-in-the-loop use cases emphasizing explainability for both the developers(us) and users, alongside examining our work's social contexts and implications.
- I want to learn the ways in which we can test the accuracy of our models in the scope of computer vision

Trust topics to cover

- News platforms and posts in social media platforms
- job replacements? and privacy concerns ?

AI problems to cover

- Unsure (All sound fun to learn)
- I think using AI to simulate the development of a small society is an interesting topic. I've read that some game developers are trying to apply AI to non-player characters in order to achieve more realistic experiences and self-evolving stories. I also heard that a team (from Stanford if I remembered correctly) built a computer-simulated community, using GPT-3 to simulate the behavior and conversations of individual residents to simulate a self-evolving mini-society.
- ethical concerns?
- My interest primary is Machine Learning
- I am primarily interested in social computing and healthcare applications.
- computer vision! I work for Boeing doing Augmented Reality research and would love to learn more details about the development of Computer Vision.

Expectations Survey and Action

- 60% response rate
- AI background (1-5 scale): 2 (50%), 3 (33%) => AI topics will be explained before trust issues covered

Trust topics to cover

- News platforms and posts in social media platforms
- job replacements? and privacy concerns ?

One thing want to learn

- I'd like to learn how researchers are working towards mitigating hallucinations in LLMs
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- I want to learn the ways in which we can test the accuracy of our models in the scope of computer vision

Legends: a) LLMs covered in the context of trust, b) Computer vision only touched in passing, c) All in green will be covered

AI problems to cover

- Unsure (All sound fun to learn)
- I think using AI to simulate the development of a small society is an interesting topic. I've read that some game developers are trying to apply AI to non-player characters in order to achieve more realistic experiences and self-evolving stories. I also heard that a team (from Stanford if I remembered correctly) built a computer-simulated community, using GPT-3 to simulate the behavior and conversations of individual residents to simulate a self-evolving mini-society.
- ethical concerns?
- My interest primary is Machine Learning
- I am primarily interested in social computing and healthcare applications.
- computer vision! I work for Boeing doing Augmented Reality research and would love to learn more details about the development of Computer Vision.

Legends: All in green will be covered, games and computer vision will be touched upon

High Level Semester Plan (Adapted, Approximate)

CSCE 581 –

- Week 1: Introduction
- Week 2: Background: AI - Common Methods
- Week 3: The Trust Problem
- Week 4: Machine Learning (Structured data) - Classification
- Week 5: Machine Learning (Structured data) - Classification – Trust Issues
- Week 6: Machine Learning (Structured data) – Classification – Mitigation Methods
- Week 7: Machine Learning (Structured data) – Classification – Explanation Methods
- Week 8: Machine Learning (Text data, **vision**) – Classification,

Large Language Models

- Week 9: Machine Learning (Text data) - Classification – Trust Issues, LLMs
- Week 10: Machine Learning (Text data) – Classification – Mitigation Methods
- Week 11: Machine Learning (Text data) – Classification – Explanation Methods
- Week 12: Emerging Standards and Laws, **Real world applications**
- Week 13: Project presentations
- Week 14: Project presentations, Conclusion

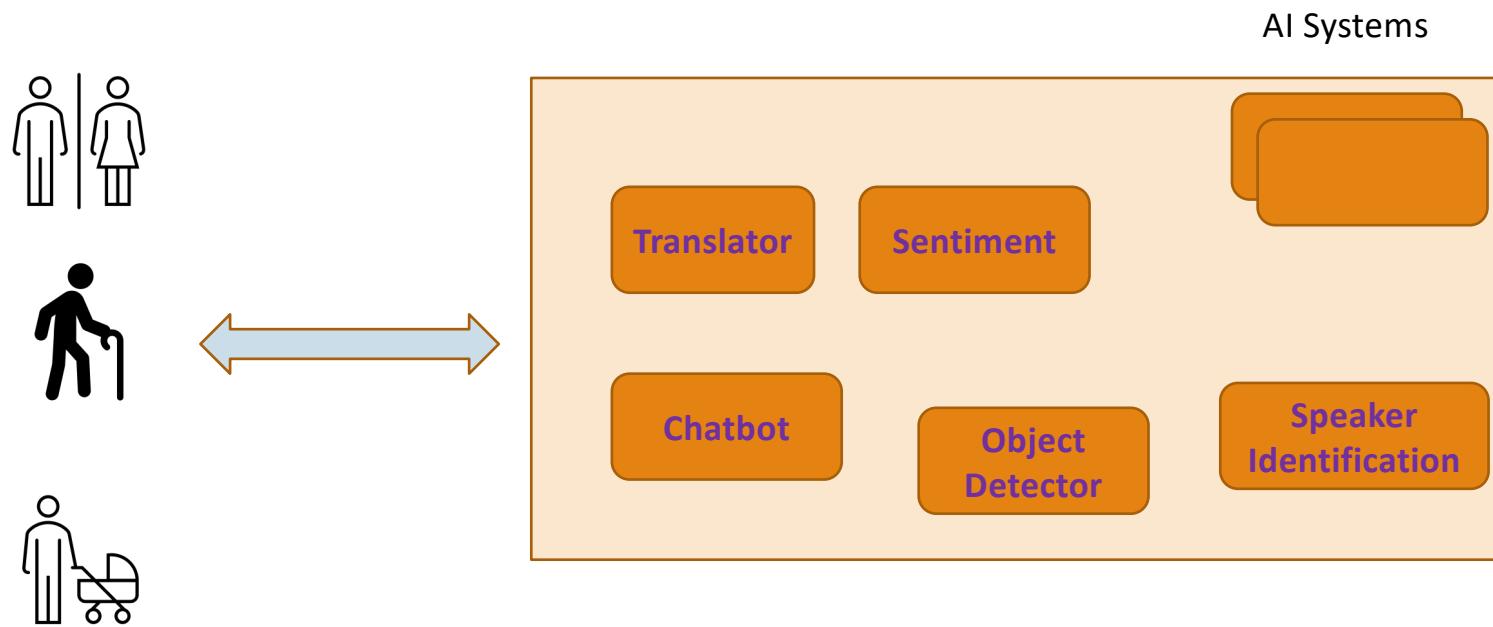
AI/ ML topics and with a focus on fairness, explanation, Data privacy, reliability

Main Section



AI and The Problem of Trust

Technology and People



Trust: *Can people trust AI systems to perform capably, consistently, and with human values?*

What are the Components of Trust (Technology)

1. Competent – does what it is supposed to do
2. Reliable – including, well tested
3. Upholds human values, social good
 1. Fairly and ethically used
 2. Adequate data management & preserves privacy
4. Allows human-technology interaction
 1. Explainable, transparent
 2. How does the system give its result?

Reference: Trustworthy Machine Learning, Kush R. Varshney, 2022
<http://www.trustworthymachinelearning.com/>

Components of Trust for AI

1. Competent – does what it is supposed to do
2. Reliable – including, well tested
3. Upholds human values
 1. Fairly and ethically used
 2. Adequate data management & preserves privacy
4. Allows human-technology interaction
 1. Explainable, transparent
 2. How does the system give its result?

	AI – Word Tag Cloud	AI – Image Search	AI – Self-driving Car	AI-powered Chatbot: Medical Guide
Competent	x	x	?	x
Reliable	x	?	?	?
Upholds human values	?	?	?	?
Allows human interaction	x	x	?	?

x: yes; -: not applicable; ?: questionable

Illustration: A Seemingly Innocuous Chatbot

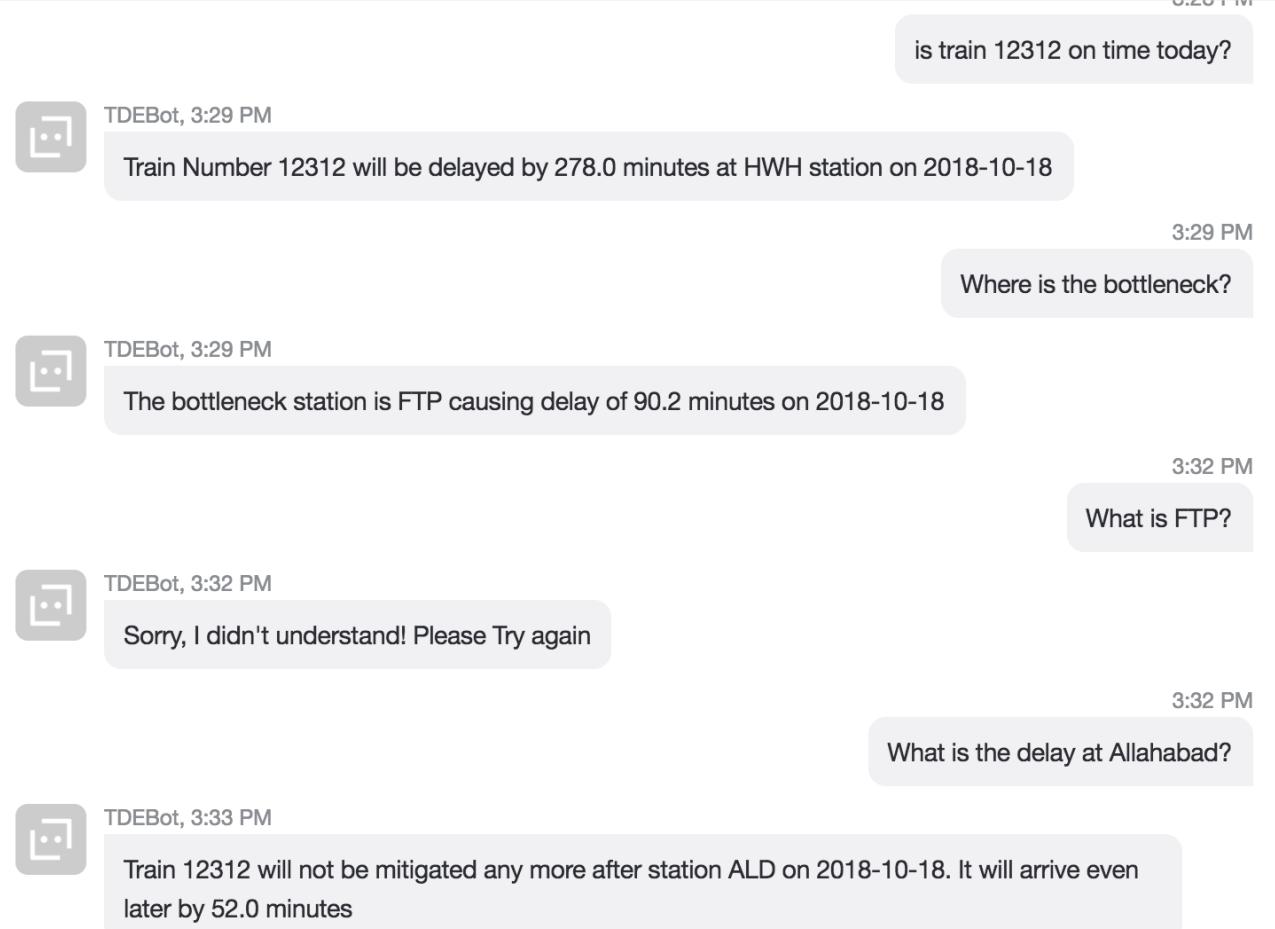
TDEBot

Potential Issues

- Leak information
- Abusive language
- Complex response

References:

- 1.Ramashish Gaurav, Biplav Srivastava, Estimating Train Delays in a Large Rail Network Using a Zero Shot Markov Model, IEEE International Conference on Intelligent Transportation Systems (ITSC). On Arxiv at:
<https://arxiv.org/abs/1806.02825>, June 2018 [Train delay, prediction]
- 2.Himadri Mishra, Ramashish Gaurav, Biplav Srivastava, Train Status Assistant for Indian Railways, On Arxiv at: <https://arxiv.org/abs/1809.08509>, Sep 2018, Video: <https://www.youtube.com/watch?v=a-ABv29H6XU> [Chatbot, Train delay assistant]



Takeaway – Trust in AI

- Recall ingredients of a trusted technology – competence, robustness, human values, human-technology interaction.
- Operationally, in AI, trust improves with clarity on
 - **Data**
 - **Methods**
 - **Evaluation**
- Positive, proven, impact in socio-technical ecosystem of usage (**Ecosystem** and “killer application”)

How to Lose Trust and Invite Next AI Winter

- Not revealing conflict-of-interest about access to data before testing a trained model [OpenAI/O3 and benchmarking controversy, ..] [Vitiates Data, Evaluation]
- Not submitting papers revealing approach for peer review [Many AI companies – e.g., OpenAI/ GPT, Google/ Gemini, Anthropic/ Claude] [Vitiates Data, Methods, Evaluation]
- Not releasing models/ weights partially or fully [Most AI companies with proprietary models] [Vitiates Data, Methods, Evaluation]
- Not engaging with usability and interoperability issues, including regulation and data privacy [Most AI companies, many researchers] [Vitiates Data, Evaluation, Ecosystem]
- Not investing in standardization of hard benchmarks [AI companies and researchers cherry-picking benchmarks, not looking beyond] [Vitiates Data, Methods, Evaluation, Ecosystem]
- Avoiding social problems – which are great long-term business bets – for quick media hype .. [AI companies and researchers avoiding elephants in the room – elections, health, ..] [Vitiates Ecosystem]
- Not sufficiently investing in AI education and public resources [situation slowly changing] [Vitiates Ecosystem]

AI Trust News

- Dr Kush Varshney, IBM Research, will give invited lecture on March 18, 2025 (Tuesday) !
 - We are using his book !
- OpenAI and lack of trust
 - OpenAI's o3 and comparison with Theranos scandal (Jan 2025); showing exceptional results on EpochAI's FrontierMath benchmark while having access to much of the test data, and funding the same.
 - Claim of results, <https://www.nature.com/articles/d41586-025-00110-6>
 - Controversy: <https://analyticsindiamag.com/ai-news-updates/openai-just-pulled-a-theranos-with-o3/>,
<https://content.techgig.com/technology/is-openai-misleading-the-ai-world-the-o3-benchmark-controversy/articleshow/117392266.cms>
 - Earlier, OpenAI and other LLM companies gave up on providing information for elections!,
 - Source: <https://openai.com/index/how-openai-is-approaching-2024-worldwide-elections/>
 - Rozado, D. 2024. The Political Preferences of LLMs. arXiv:2402.01789.

AI Trust News

- Federal govt and AI regulations
 - Regulations
 - Why and why don't
 - Impact: contextual
 - For US
 - (2025) Rescinding on AI regulation exec order, <https://www.foley.com/insights/publications/2025/01/2023-ai-executive-order-revoked/>
 - (2023) Exec order, <https://web.archive.org/web/20250103015352/https://www.whitehouse.gov/briefing-room/presidential-actions/2023/10/30/executive-order-on-the-safe-secure-and-trustworthy-development-and-use-of-artificial-intelligence/>
 - What it means

Acknowledgement: Alex Aydin (John)

Data – The Fuel for AI

Overview: Types of Data

- By content structure: Structured, unstructured and semi-structured
- By media: text, audio, visual, multi-media

- By source
 - Open data
 - Social data
 - Sensor data
 - Proprietary data

- Value is by fusing data across all types
 - sources, content structure and media

Types of Data - Structured

- The structure of data is fixed. Example: columns in a database
- Benefits
 - Can be stored and queried efficiently, e.g., by commercial databases
 - Easy to analyze, e.g., by SQL or programs – pandas in Python
- Disadvantage
 - Hard to handle data's structural changes. E.g., adding a new column. Complex data migration procedures

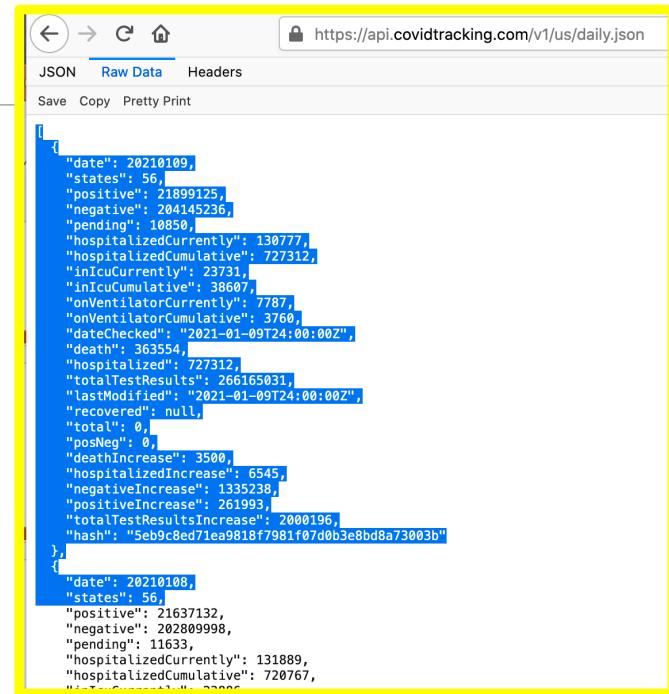
```
country,placename,frequency,start_date,end_date,year,month,week,deaths,expected_deaths,excess_deaths,baseline  
...  
France,,weekly,2020-04-27,2020-05-03,2020,4,18,10498,10357,141,2010-2018 weekly average  
...
```

Source: <https://github.com/nytimes/covid-19-data/tree/master/excess-deaths>

NYT COVID datasets: <https://github.com/nytimes/covid-19-data/>

Types of Data – Semi-Structured

- The structure of meta-data is fixed, but the structure of data is allowed to change. Example: XML, JSON
- Benefits
 - Relatively easy to analyze, e.g., commands similar to SQL in languages like OQL or Xquery
 - Structure of data easy to extend
- Disadvantage
 - Size of data is larger than structured representation as metadata is added with each record



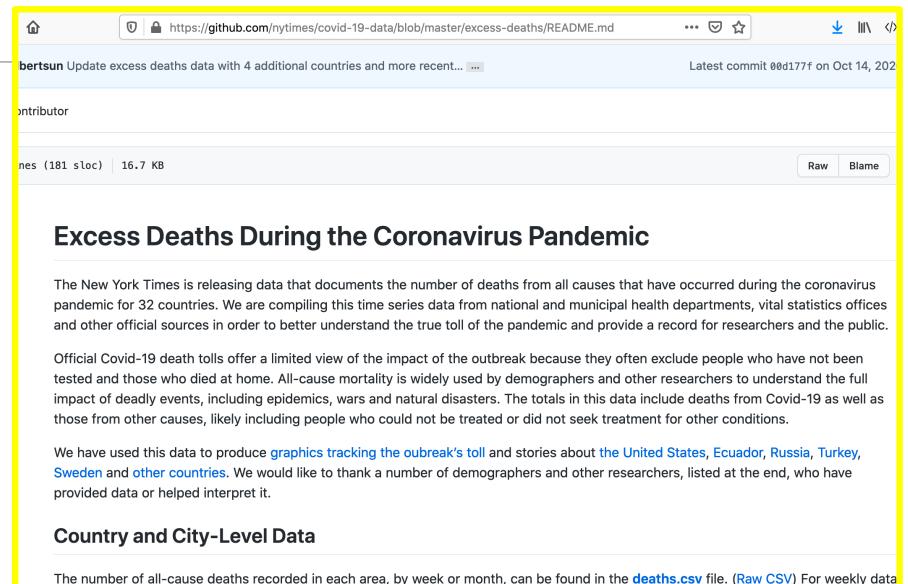
A screenshot of a web browser displaying JSON data from the URL <https://api.covidtracking.com/v1/us/daily.json>. The browser interface includes a back button, forward button, refresh button, and a home icon. Below the address bar, there are tabs for 'JSON' (which is selected), 'Raw Data', and 'Headers'. Underneath the tabs are buttons for 'Save', 'Copy', and 'Pretty Print'. The main content area shows two JSON objects. The first object has a date of 2021-01-09, 56 states, and various counts for positive, negative, and pending cases. The second object has a date of 2021-01-10, 56 states, and similar counts. A yellow box highlights the JSON data.

```
[{"date": "2021-01-09", "states": 56, "positive": 21899125, "negative": 204145236, "pending": 10850, "hospitalizedCurrently": 130777, "hospitalizedCumulative": 727312, "inICUCurrently": 23731, "inICUCumulative": 38607, "onVentilatorCurrently": 7787, "onVentilatorCumulative": 3760, "dateChecked": "2021-01-09T24:00:00Z", "death": 36354, "hospitalized": 727312, "totalTestResults": 266165031, "lastModified": "2021-01-09T24:00:00Z", "recovered": null, "total": 0, "posNeg": 0, "deathIncrease": 3500, "hospitalizedIncrease": 6545, "negativeIncrease": 1335238, "positiveIncrease": 261993, "totalTestResultsIncrease": 2000196, "hash": "5eb9c8ed71ea9818f7981fb0d0b3e8bd8a73003b"}, {"date": "2021-01-10", "states": 56, "positive": 21637132, "negative": 202809998, "pending": 11633, "hospitalizedCurrently": 131889, "hospitalizedCumulative": 720767, "inICUCurrently": 23731, "inICUCumulative": 38607, "onVentilatorCurrently": 7787, "onVentilatorCumulative": 3760, "dateChecked": "2021-01-10T24:00:00Z", "death": 36354, "hospitalized": 720767, "totalTestResults": 268475031, "lastModified": "2021-01-10T24:00:00Z", "recovered": null, "total": 0, "posNeg": 0, "deathIncrease": 3500, "hospitalizedIncrease": 6545, "negativeIncrease": 1335238, "positiveIncrease": 261993, "totalTestResultsIncrease": 2000196, "hash": "5eb9c8ed71ea9818f7981fb0d0b3e8bd8a73003b"}]
```

Source: <https://api.covidtracking.com/v1/us/daily.json>

Types of Data – Unstructured

- The data has no structure.
Example: text
- Benefits
 - Easy to change structure
 - Content can be compactly stored
- Disadvantage
 - Hard to analyze content. Example: word analysis, sentiments, topic, ...



Source: <https://github.com/nytimes/covid-19-data/blob/master/excess-deaths/README.md>

NYT COVID datasets: <https://github.com/nytimes/covid-19-data/>

Textual Data

- Media: text
- Components: characters, words, paragraph
- Representation
 - Uncompressed / encoding – ASCII, UTF-8, UTF-16
 - Compressed - .zip
 - Lossy compression -
- Language: English, French, ...
- Programming libraries: nltk, spacy

Filename extension	.txt
Internet media type	text/plain
Type code	TEXT
Uniform Type Identifier (UTI)	public.plain-text
UTI conformation	public.text
Type of format	Document file format , Generic container format

Details: https://en.wikipedia.org/wiki/List_of_file_formats

Sound

- Media: sound
- Components: phoneme
- Representation
 - Uncompressed - .wav, .aiff
 - Compressed lossless -
 - Lossy compression - .mp3, .aac (iTunes)
- Programming libraries: [playsound](#), [simpleaudio](#), [winsound](#), [python-sounddevice](#), [pydub](#), [pyaudio](#)

Details: https://en.wikipedia.org/wiki/Audio_file_format

Filename extension	.wav .wave
Internet media type	audio/vnd.wave, ^[1] audio/wav, audio/wave, audio/x-wav ^[2]
Type code	WAVE
Uniform Type Identifier (UTI)	com.microsoft.waveform-audio
Developed by	IBM & Microsoft
Initial release	August 1991; 29 years ago ^[3]
Latest release	Multiple Channel Audio Data and WAVE Files (7 March 2007; 13 years ago (update) ^{[4][5]})
Type of format	audio file format , container format
Extended from	RIFF
Extended to	BWF , RF64

Visual

- Media: image, video
- Components: pixel, frame
- Representation
 - Uncompressed – bitmap
 - Compressed lossless - .gif
 - Lossy compression - .jpeg
 - Containers: AVI (.avi) and QuickTime (.mov)
- Programming libraries: PIL, OpenCV

<u>Filename extension</u>	.avi
<u>Internet media type</u>	video/vnd.avi ^[1]
<u>Type code</u>	'Vfw '
<u>Uniform Type Identifier (UTI)</u>	public.avi
Developed by	Microsoft
Initial release	November 1992; 27 years ago
<u>Container for</u>	Audio, Video
Extended from	Resource Interchange File Format

Types of Data

- By media: Text, Sound (speech), Visual (image, video), Multi (modal, media)
- By structure: unstructured, semi-structured, structured
- By features: time-series, labeled/ unlabeled, spatio-temporal,

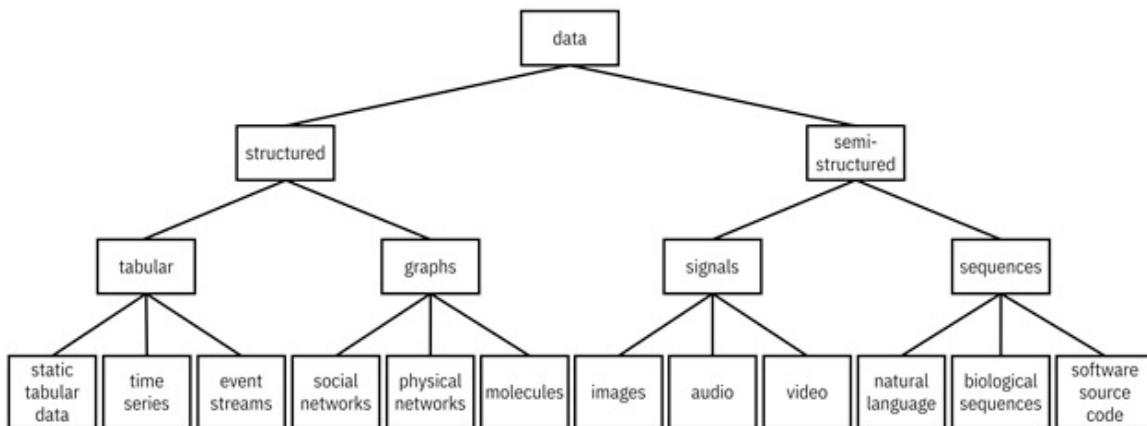


Image credit:

<http://www.trustworthymachinelearning.com/trustworthymachinelearning-04.htm>

Open Data

“Open data and content can be **freely used, modified, and shared by anyone for any purpose**”

<http://opendefinition.org/od/2.1/en/>

Open Data is an Old Concept in a New Setting

- Open data is the notion that data should not be hidden, but made available to everyone to **reuse**. **The idea is not new.**
- Scientific publications follow this: “standing on the shoulders of giants”
- Data quality and open publishing process is critical

The screenshot shows the homepage of Data.gov. At the top, there's a navigation bar with links for DATA, TOPICS, RESOURCES, STRATEGY, DEVELOPERS, and CONTACT. Below the navigation is a grid of icons representing various sectors: Agriculture, Climate, Ecosystems, Energy, Local Government, Maritime, Ocean, and Older Adults Health. A large map of the United States is visible on the left. Two specific datasets are highlighted: "U.S. Hourly Precipitation Data" (with 855 recent views) and "NCDC Storm Events Database" (with 331 recent views). Each dataset entry includes a brief description, a preview image, and download links for various formats (HTML, JSON, CSV, etc.).

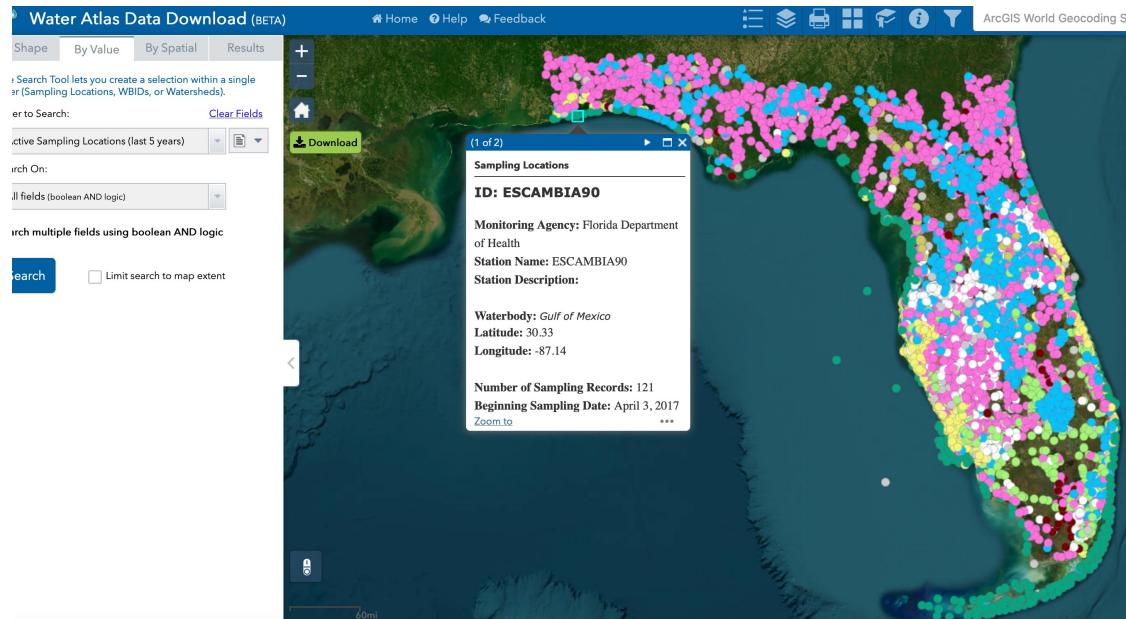
USA

The screenshot shows the homepage of data.gov.in. The header includes links for Skip to navigation, Skip to main content, DataGov States/ULB, and a search bar. The main banner features a yellow background with the text "DATASETS FROM HEALTH SECTOR" and several circular icons representing different health-related topics. Below the banner, there are three main sections: ANALYTICS, CATALOG, and INDICATOR DASHBOARD. The ANALYTICS section displays various statistics: 395,534 resources, 8,380 catalogs, 173 departments, 28.58 M times viewed, 8.19 M times downloaded, 354 chief data officers, 32,392 APIs, and 2,043 visualizations. The CATALOG section shows a lightbulb icon with people around it, and the INDICATOR DASHBOARD section shows icons for Drinking Water And Sanitation, Health, Transport, and Labour And Employment.

India

Open Data Should Not to Be Confused With Orthogonal Trend – Big Data

Volume
Variety
Velocity
Veracity
...



Data: <https://github.com/biplav-s/course-tai/tree/main/sample-code/common-data/water>

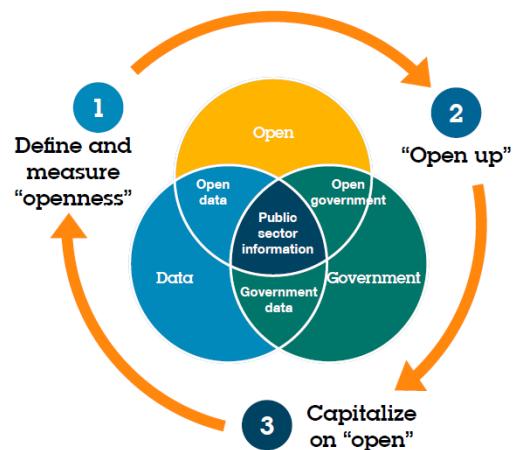


"Your recent Amazon purchases, Tweet score and location history makes you 23.5% welcome here."

Cartoon critical of big data application,
by T. Gregorius

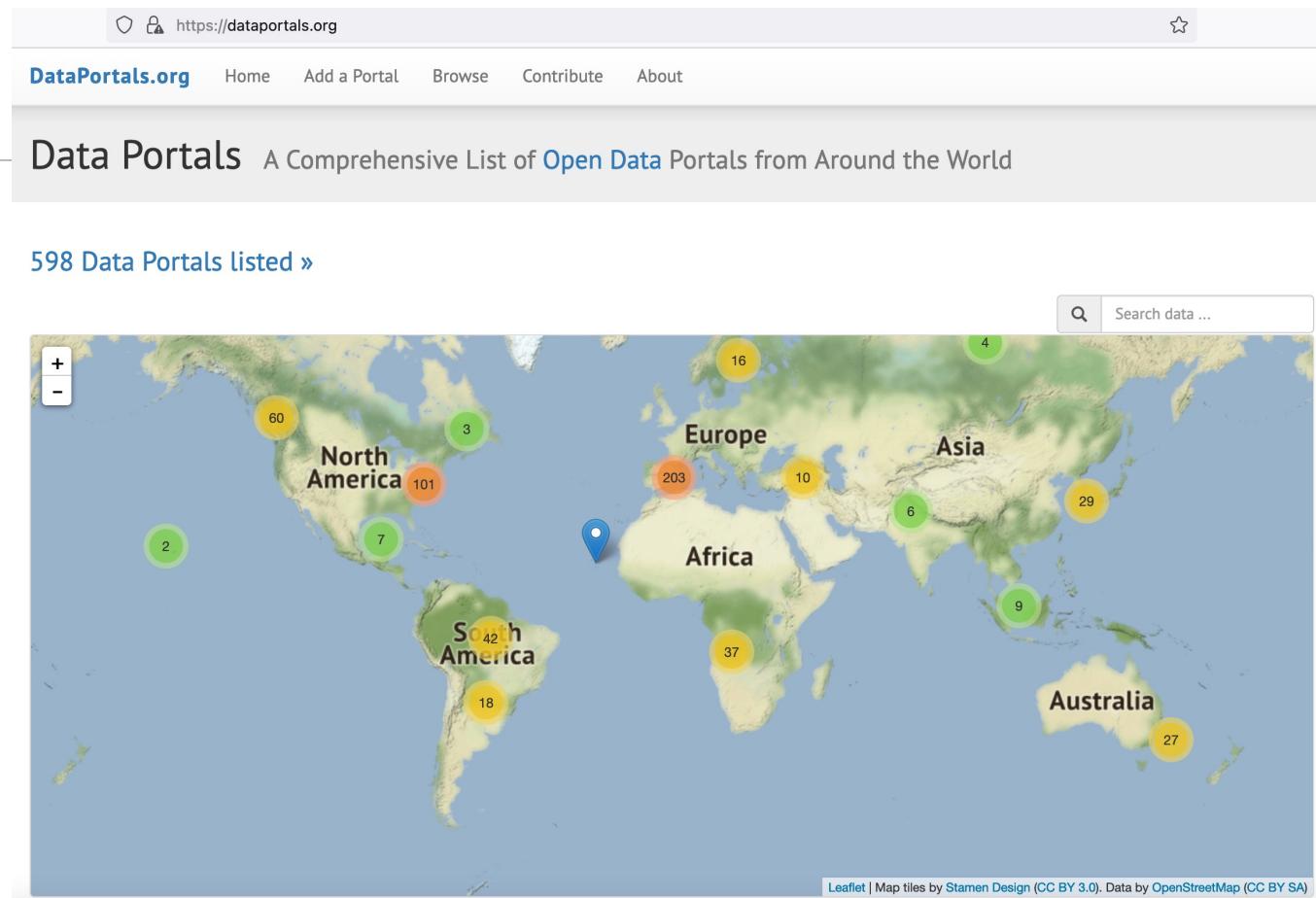
http://upload.wikimedia.org/wikipedia/commons/thumb/b/b3/Big_data_cartoon_t_gregorius.jpg/220px-Big_data_cartoon_t_gregorius.jpg

~600 Data Catalogs of Open Data



Source: IBM Institute for Business Value.

As on 26 Aug 2024



Demo: US Open Data

- Site: <https://data.gov>
- Tools: <https://resources.data.gov/categories/data-tools/>

Open Datasets

- data.gov OF ANY COUNTRY
 - Portal: <https://dataportals.org/>
 - US: <https://www.data.gov/> or any US state
 - India: <https://data.gov.in>
- Text of legislations - LegiScan, <https://legiscan.com/>
- Kaggle datasets: <https://www.kaggle.com/datasets>
- Google datasets search:
<https://datasetsearch.research.google.com/>

City Dashboard - London

CityDashboard aggregates simple spatial data for cities around the UK and displays the data on a dashboard and a map.

<http://citydashboard.org/london/>
<http://citydashboard.org/about.php>

[Birmingham](#)
[Brighton](#)
[Cardiff](#)
[Edinburgh](#)
[Glasgow](#)
[Leeds](#)
[London](#)
[Manchester](#)

Sat 26 Aug @ 22:23:19
Go to Map - Go to Grid - Change City

WEATHER STATION (CASA TEAM) 12
STATION WIND SPEED WIND GUSTS DIRECTION TEMPERATURE HUMIDITY RAIN TODAY PRESSURE FORECAST
CASA Office: Bloomsbury W1 Data not updated for 11442 hours

WEATHER (METAR) 871
London City Winds W-280 at 8kt, Vis 10km, Scattered clouds at 4500ft SW at 6 mph 14 C

TRAFFIC CAMERAS (TfL) 3
York Road/Leake Street Camera 00001.04226 unobtainable

TUBE LINE STATUS (TfL) 1
Bakerloo Good Service
Central Good Service
Circle Good Service
District Good Service
DLR Good Service
Elizabeth Good Service
H & C Good Service
Jubilee Good Service
Overground Part Closure
Metropolitan Good Service
Northern Good Service
Piccadilly Part Closure
Trams Good Service
Victoria Good Service

LONDON CYCLE HIRE (TfL) 61
NAN % NAN %
Stations Full Stations Empty
0 0
Bikes Available Bikes or Docks Faulty

IN SERVICE (TfL) 1
6092 London buses
322 Underground trains

AIR POLLUTION (DEFRA) 1771
µg/m³ TIME AVG OZONE NO₂ SO₂ PM₂.₅ PM₁₀
Bloomsbury
Marylebone Rd
N Kensington

BICYCLES (LBH) 3571
Goldsmiths' Row 4012 yesterday

STOCKS (YAHOO) 8
FTSE 100 Index 7121.88 91.22 (1.28%)

TRAFFIC CAMERAS (TWO AT RANDOM) (TfL) 12
75 Knightsbridge/Williams St Sun 27 Aug 03:11 Camera 00001.06730 unobtainable
London Rd/Arragon Rd Sun 27 Aug 02:43
A4 Knightsbridge by Albert Gate London Rd/Arragon Rd

BBC LONDON NEWS (BBC) 71
Bow fire: Homes 'severely damaged' in east London
blaze Fresh dates for London hot air balloon event after summer cancellations Superloop: West London express Heathrow to Harrow bus service launched

OPENSTREETMAP UPDATES (OSM) 271
Edit to future cycle route Edit to future cycle route
Edit to future cycle route Edit to future cycle route
Mapped planned C35 route at Peckham Rye Update addresses in SW19 postal dist. kxplus kxplus

[Tweet](#) [About](#)

Attempt for Dashboards - Amsterdam



[2016] <http://citydashboard.waag.org/>

Exercise 1 - Explore

1. Google data search tool: <https://datasetsearch.research.google.com/>
2. US open data: <https://www.data.gov/>
3. Select a problem domain and search for data
4. Discuss your experience

Accessing Data

Example: Open 311 (<http://open311.org/>)

Refers to non-emergency events like graffiti, garbage, down trees, abandoned car, ...

- Not human life threatening
- 60+ cities support it world-wide

Discovering Open 311 of a City

<http://311api.cityofchicago.org/open311/discovery.json>

```
changeset          "2012-09-14T08:00:00-05:00"
contact            "Contact developers@cityofchicago.org for assistance"
key_service        "Visit http://test311api.cityofchicago.org/open311 to request an API Key"
endpoints          0
specification     "http://wiki.open311.org/GeoReport\_v2"
url               "http://311api.cityofchicago.org/open311/v2"
changeset          "2012-09-14T08:00:00-05:00"
type              "production"
formats            0
                   "text/xml"
                   "application/json"
                   1
                   "text/xml"
                   "application/json"
                   1
specification     "http://wiki.open311.org/GeoReport\_v2"
url               "http://test311api.cityofchicago.org/open311/v2"
changeset          "2012-09-14T08:00:00-05:00"
type              "test"
formats            0
                   "text/xml"
                   "application/json"
                   1
```

```
311api.cityofchicago.org/open311/discovery.json
JSON Raw Data Headers
Save Copy Collapse All Expand All Filter JSON
changeset: "2012-09-14T08:00:00-05:00"
contact: "Contact developers@cityofchicago.org for assistance"
key_service: "Visit http://test311api.cityofchicago.org/open311 to request an API Key"
endpoints:
  0:
    specification: "http://wiki.open311.org/GeoReport\_v2"
    url: "http://311api.cityofchicago.org/open311/v2"
    changeset: "2012-09-14T08:00:00-05:00"
    type: "production"
    formats:
      0: "text/xml"
      1: "application/json"
  1:
    specification: "http://wiki.open311.org/GeoReport\_v2"
    url: "http://test311api.cityofchicago.org/open311/v2"
    changeset: "2012-09-14T08:00:00-05:00"
    type: "test"
    formats:
      0: "text/xml"
      1: "application/json"
```

Demonstration: Open 311

List of services

- <http://311api.cityofchicago.org/open311/v2/services.json>
 - Result
-

```
[{"service_code": "4ffa4c69601827691b000018", "service_name": "Abandoned Vehicle", "description": "Abandoned vehicles are taken to auto pound 3S or 3N where they are -- if not redeemed by the owners -- sold for scrap.", "metadata": true, "type": "batch", "keywords": "code:SKA", "group": "Streets & Sanitation"},
```

```
{"service_code": "4ffa9cad6018277d4000007b", "service_name": "Alley Light Out", "description": "One or more alley lights out, on a wooden pole in the alley itself, are reported under this service request type. Important information needed when reporting alley lights out includes: the exact address that the light/lights are behind, how many lights are out, and if the light(s) are completely out or if they blink on and off intermittently. Alley light repairs are done during the day when the lights are not on, so this information is essential to expedite the repair work.", "metadata": true, "type": "batch", "keywords": "code:SFA", "group": "Transportation"},
```

```
...]
```

Details of a service

- <http://311api.cityofchicago.org/open311/v2/services/4ffa4c69601827691b000018.json>
 - Result
- ```
{"service_code": "4ffa4c69601827691b000018",
"attributes": [
{"variable": true, "code": "FQSKA1",
"datatype": "singlevaluelist", "required": false, "order": 1,
"description": "Vehicle Make/Model",
"values": [
{"key": "ASVEAV", "name": "(Assembled From Parts,Homemade)" },
 {"key": "HOMDCYL", "name": "(Homemade Motorcycle, Moped.Etc.)" },
 {"key": "HMDETL", "name": "(Homemade Trailer)" }, ...
]
...
]}}
```

# Demonstration: Open 311

---

<http://311api.cityofchicago.org/open311/v2/services/4ffa9cad6018277d4000007b.json>

Result

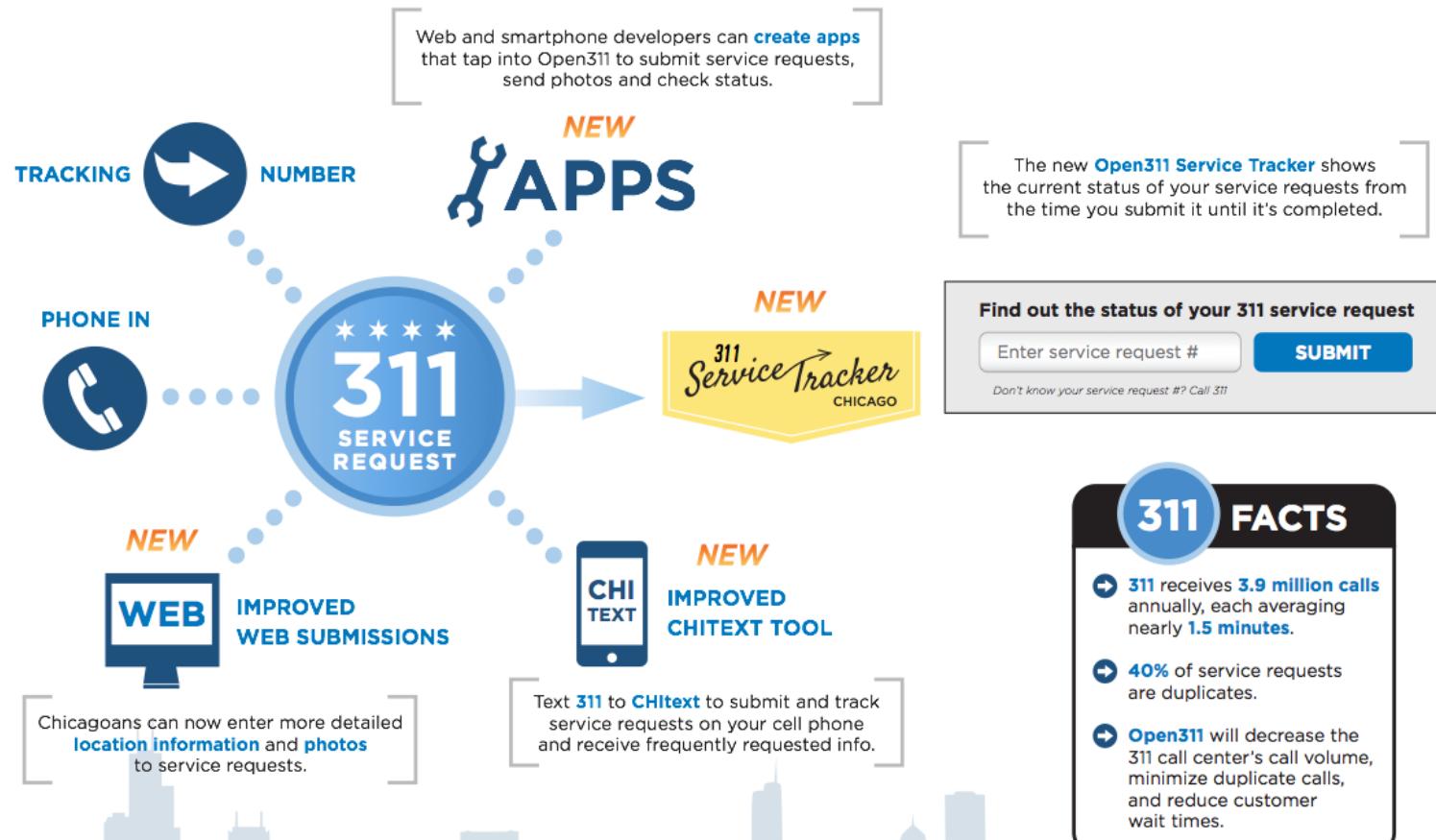
```
{"service_code":"4ffa9cad6018277d4000007b",
 "attributes":
 [{"variable":true,"code":"ISTHELI2",
 "datatype":"singlevaluelist","required":true,"order":1,
 "description":"Is the light located in your alley or the street?",
 "values":[{"key":"ALLEY","name":"Alley"},
 {"key":"STREET","name":"Street"}]},

 {"variable":true,"code":"POLEWORM",
 "datatype":"singlevaluelist","required":true,"order":2,
 "description":"Is the pole wooden or metal?",
 "values":[{"key":"METAL","name":"Metal"},
 {"key":"WOODEN","name":"Wooden"}]},

 {"variable":true,"code":"ISTHELI3",
 "datatype":"singlevaluelist","required":true,"order":3,
 "description":"Is the light directly behind this address?",
 "values":[{"key":"NO","name":"No - Light Not Directly Behind Address"},
 {"key":"YES","name":"Yes - Light Directly Behind Address"}]},

 {"variable":true,"code":"A511OPTN",
 "datatype":"string","required":false,
 "datatype_description":"Enter number as 999-999-9999","order":4,
 "description":"Input mobile # to opt-in for text updates. If already opted-in, add mobile # to contact info."}]}
```

# Chicago: Service Tracking



# Example: Application over Open Data (Chicago)

The screenshot shows a web browser displaying the Chicago 311 Service Tracker website at [servicetracker.cityofchicago.org/requests/13-00210540](http://servicetracker.cityofchicago.org/requests/13-00210540). The page title is "Rodent Baiting / Rat Complaint". Key details include:

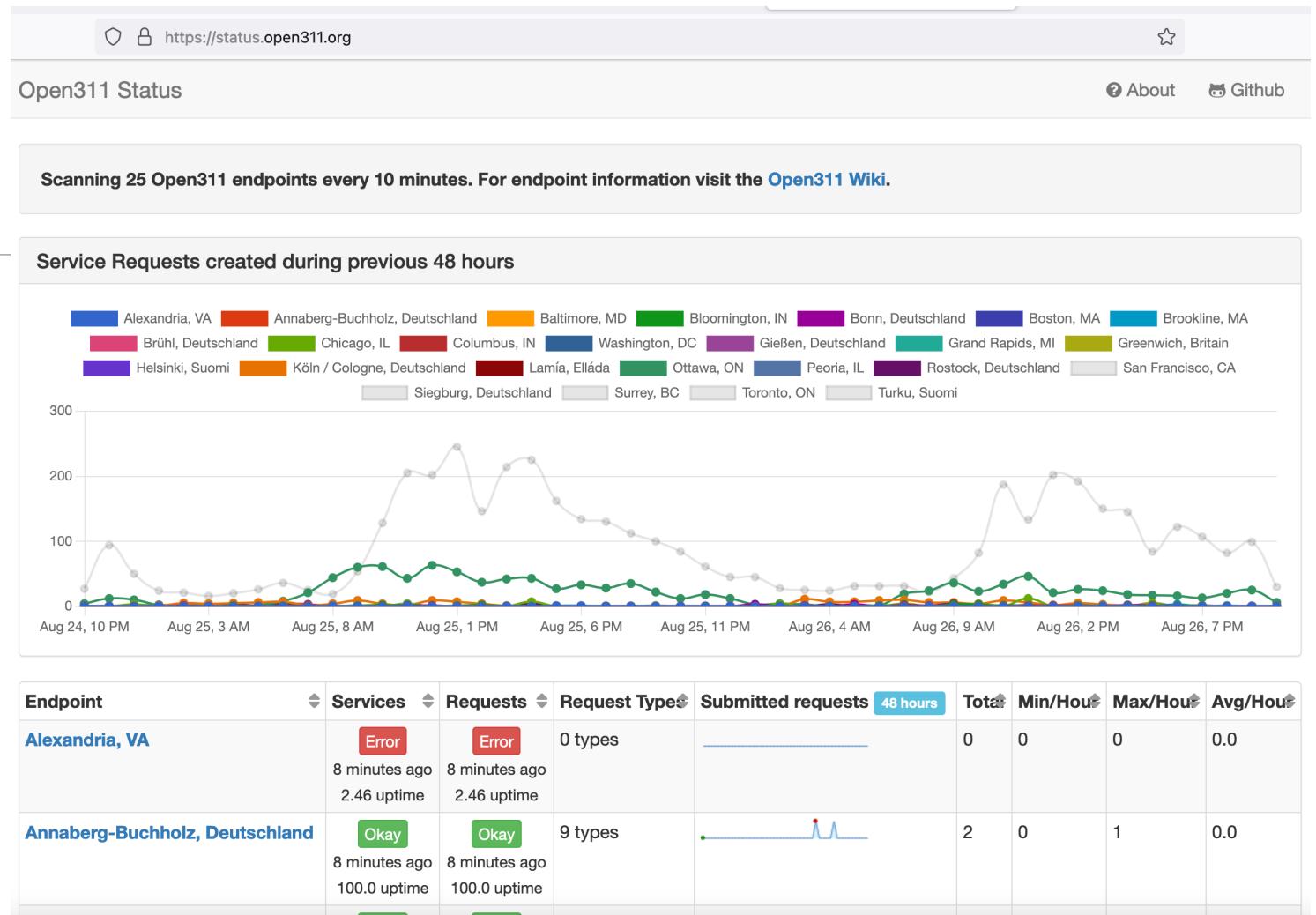
- #13-00210540**
- Address:** 1502 N Wicker Park Ave
- Created:** February 23, 2013
- Received via:** Other

A green ribbon on the right indicates the status is **Closed**.

**Activity**

| Date                    | Action                                                                                    |
|-------------------------|-------------------------------------------------------------------------------------------|
| 05-Mar-2013<br>10:04 AM | Request closed                                                                            |
| 05-Mar-2013<br>10:04 AM | Dispatch Crew Completed                                                                   |
| 23-Feb-2013<br>10:16 PM | Rodent Baiting / Rat Complaint<br>Department: Bureau of Rodent Control - S/S<br>via Other |

# Scaling with Open 311



# Exercise 2 – Programmatically Access Data

---

1. See sample code on GitHub:

- <https://github.com/biplav-s/course-d2d-ai/blob/main/sample-code/I2-opendata/Explore%20OpenData.ipynb>

2. Explore APIs of another city of your choice

# Exercise 3 – Programmatically Access Data

---

1. Water data
2. Text data

Code samples: <https://github.com/biplav-s/course-ai-tai-f23/blob/main/sample-code/Class2-data.md>

# Text Data

---

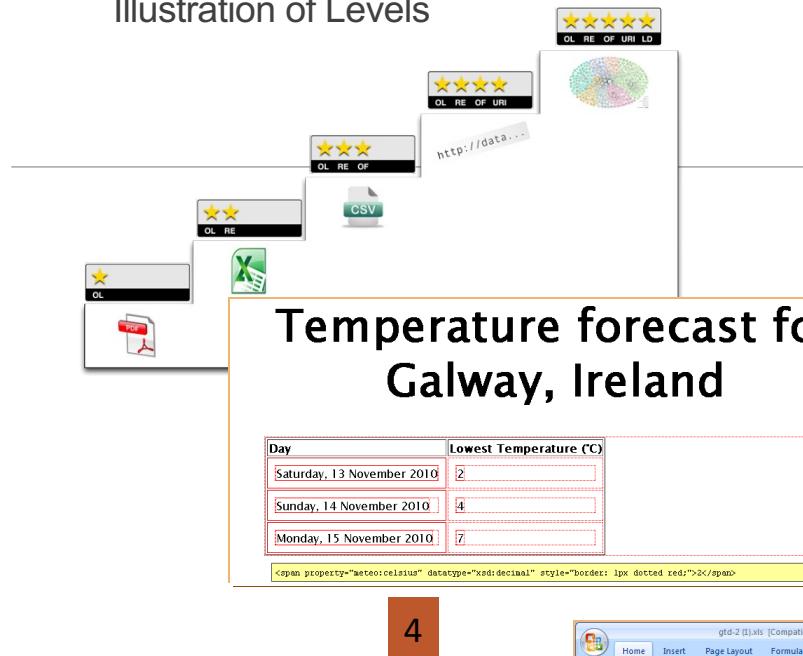
- Text of legislations - LegiScan, <https://legiscan.com/>
- Voter FAQs - <https://github.com/ai4society/election-dataset>
- Compendium of benchmarks and datasets:
  - <https://zilliz.com/learn/popular-datasets-for-natural-language-processing>,
  - UCI dataset – <https://archive.ics.uci.edu/datasets?search=&Types=Text>
  - Kaggle - <https://www.kaggle.com/datasets?search=text>
- NLP task specific -
  - <https://paperswithcode.com/task/named-entity-recognition-ner/>
  - ...

# Quality of Data

---

## Does Opening Data Make It Reusable? No

Illustration of Levels



### Temperature forecast for Galway, Ireland

| Day                        | Lowest Temperature (°C) |
|----------------------------|-------------------------|
| Saturday, 13 November 2010 | 2                       |
| Sunday, 14 November 2010   | 4                       |
| Monday, 15 November 2010   | 7                       |

4

### Temperature forecast for Galway, Ireland

| Day                        | Lowest Temperature (°C) |
|----------------------------|-------------------------|
| Saturday, 13 November 2010 | 2                       |
| Sunday, 14 November 2010   | 4                       |
| Monday, 15 November 2010   | 7                       |

en.wikipedia.org/wiki/Temperature

### gtd-3.csv - WordPad

File Edit View Insert Format Help



"Temperature forecast for Galway, Ireland",

"Day", "Lowest Temperature (C)"  
 "Saturday, 13 November 2010", 2  
 "Sunday, 14 November 2010", 4  
 "Monday, 15 November 2010", 7

2

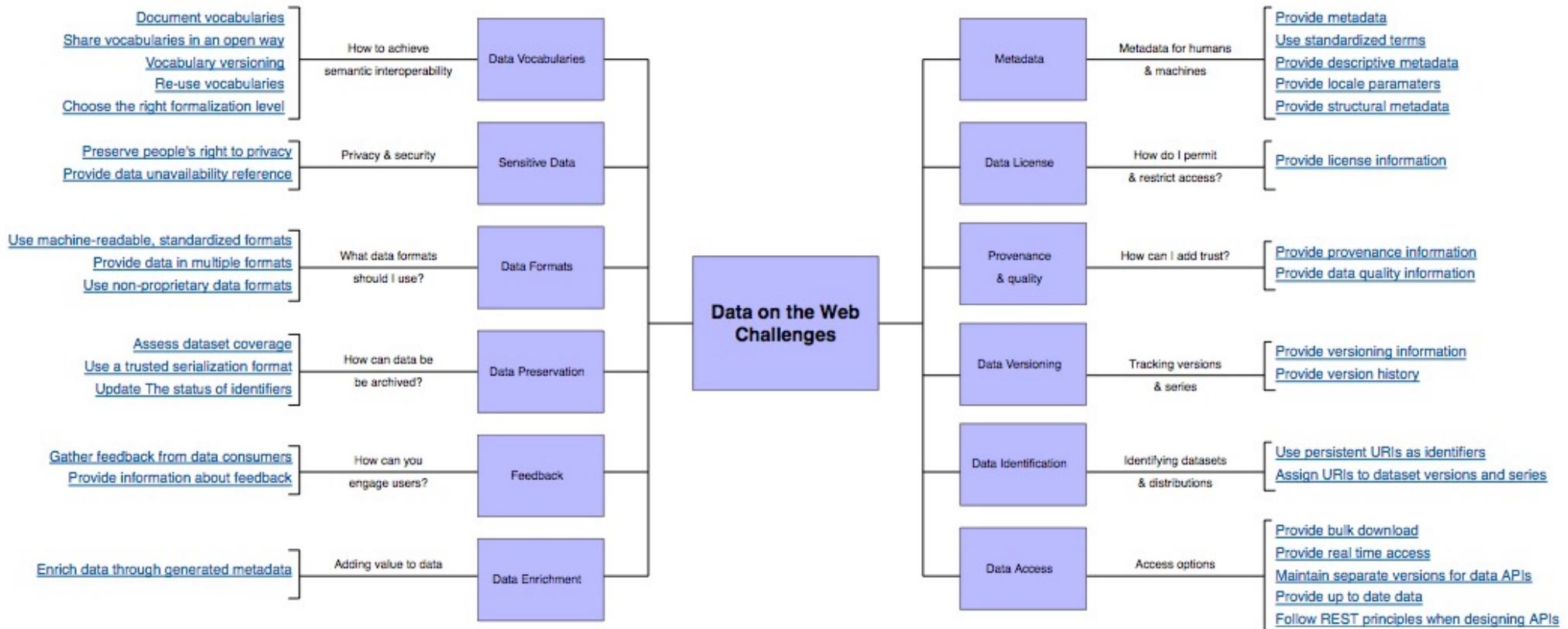
### Temperature forecast for Galway, Ireland

| Day                        | Lowest Temperature (°C) |
|----------------------------|-------------------------|
| Saturday, 13 November 2010 | 2                       |
| Sunday, 14 November 2010   | 4                       |
| Monday, 15 November 2010   | 7                       |

1

# Helping Publish Good Quality Open Data is Key

Have data policy in place  
 Publish with best practices, have semantics, promote reuse  
 Figure courtesy: <http://www.w3.org/TR/2015/WD-dwbp-20150625/>



# Data Quality of Public Data in India



## Right to Information

- Not even 1\*
- Information available to requester, but no one else

## Data.gov.in

- 2-3\*
- Available in CSV, etc but not uniquely referenceable

Open data movements are moving to linked data form for semantics

# Annotated – Indian Open Data

---

Vocabulary services: <http://vocab.nic.in/index.php>

- Authoritative
- Standardized codes

## Examples

- States in the Union: <http://vocab.nic.in/rest.php/states/json>
- Districts in a state (“UP”): <http://vocab.nic.in/rest.php/district/up/json>
- State legislatures: <http://vocab.nic.in/rest.php/orgn/sg/legislature/json>
- Union government offices in a state (“TN”): <http://vocab.nic.in/rest.php/orgn/ug/state/tn/json>

# Quality of Data in SC

---

- Data
  - <https://sc.gov/data-and-transparency>
  - <https://rfa.sc.gov/data-research/population-demographics/census-state-data-center/housing-units-in-structure-2015-2019>
  - Comment: Lots of pds and reports: combines/ confounds data with presentation
- Quality of data
  - 1-3 star
  - Not easily amenable for analysis

# Guideline: Human Impact of Data and AI

---

- We study technology (AI) but it works with data
- Data, when from people or about people, can have issues like bias
  - **Example:** data reveals a view which is influenced by data collection practices
  - **Difference:** **World as it is**, world according to data and **world as it should be**
- The course and instructor believes in
  - Not promoting bias of any kind
  - Respecting everyone regardless of background

# Discussion Exercise: Your Resumes

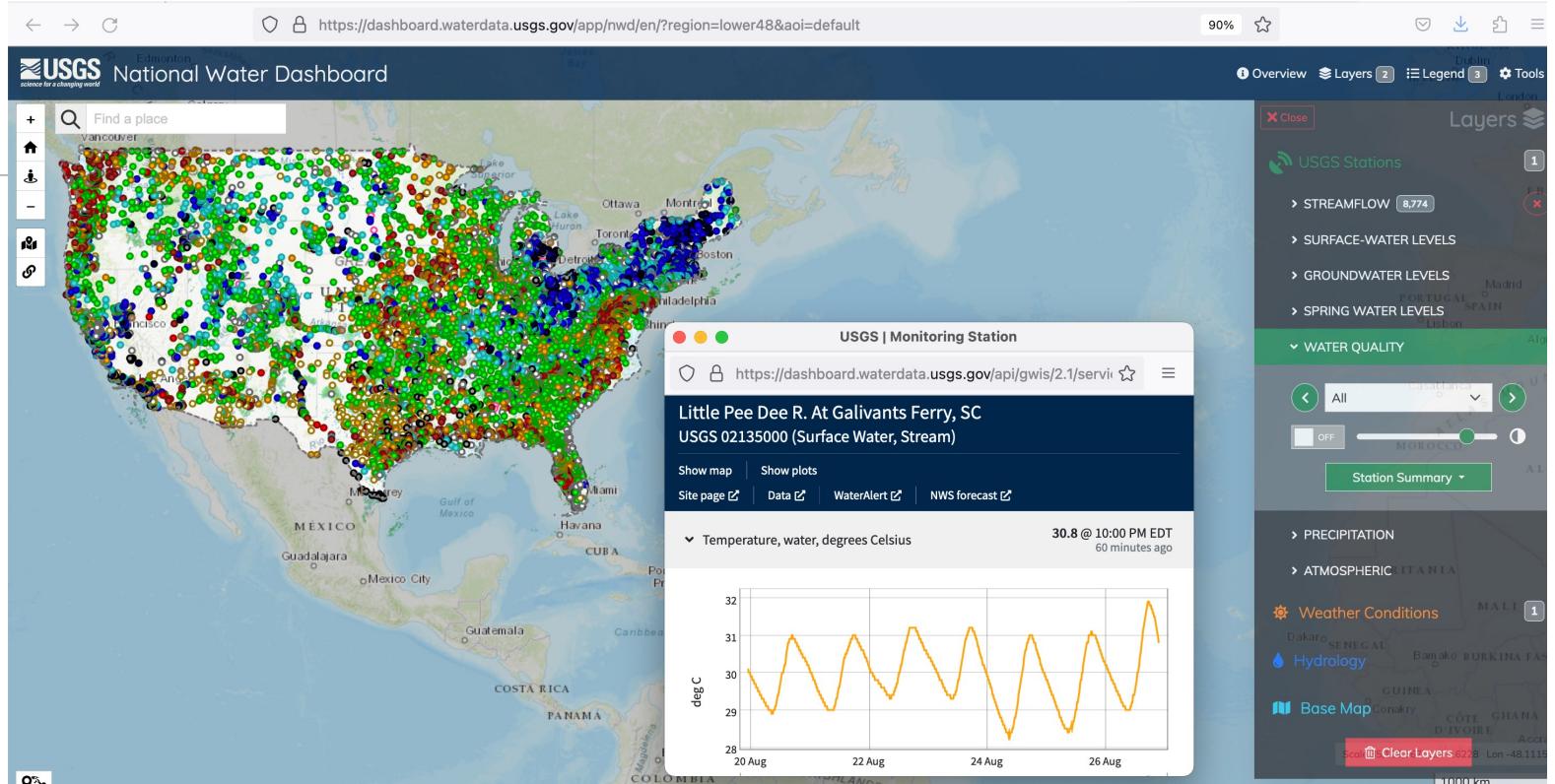
---

- What does a search (Google search) tell about you?
- What does a LLM/ ChatGPT tell about you?
- Task:
  - Put your resume at: <TBD>
- Course task: We will analyze them as part of AI/ data science activity in a later class

---

# Working With Data – Preparing and Organizing Information

# Water Data



<https://dashboard.waterdata.usgs.gov/app/nwd/en/?region=lower48&aoi=default>

Claims data from 13,000 locations online on 26 Aug 2023

# How Do We Start Working With This?

---

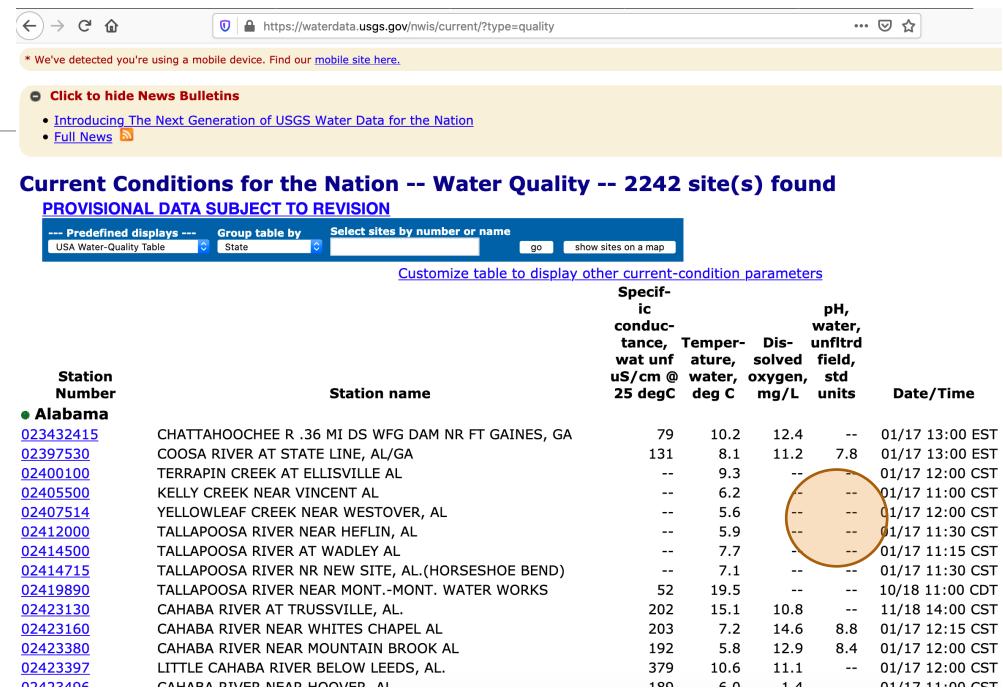
- Access and licensing (Class 3)
- Cleaning, organizing and finding related information (Class 4 – this class)
- Representing formally (in logic) to draw insights (using inferencing) – (Class 4 – this class)

Is this important ? YES !

- Understanding impact of hurricanes
- Planning during regular times – homes, schools, roads; hospital services; electricity, ...
- Economic development

# Common Problem: Missing Value

- Occurrence
  - Missing completely at random
  - Missing at random (a group not wanting to participate)
  - Missing not at random (a group not able to participate)
- What does it mean?
  - The value was not provided
  - The value does not exist or has no practical interpretation
  - The value is being hidden (redaction)
  - Others: The value is not reliable, ...
- How to detect it?
  - By checking for specific values: NA, Not applicable, out-of-range value, 0, -1, "".



The screenshot shows a web browser displaying the USGS Water Data for the Nation website. The URL is https://waterdata.usgs.gov/nwis/current/?type=quality. The page title is "Current Conditions for the Nation -- Water Quality -- 2242 site(s) found". The main content is a table of water quality data for Alabama. The columns include Station Number, Station name, Specific conductance, Temperature, Dissolved oxygen, pH, Date/Time, and various parameters like wat unf, ature, solved field, and std units. A red circle highlights the "Date/Time" column for the last row of data.

| Station Number | Station name                                       | Specific conductance<br>25 degC | Temperature<br>deg C | Dissolved oxygen<br>mg/L | pH, water,<br>unftrd field,<br>std units | Date/Time       |
|----------------|----------------------------------------------------|---------------------------------|----------------------|--------------------------|------------------------------------------|-----------------|
| 023432415      | CHATTahoochee R .36 MI DS WFG DAM NR FT GAINES, GA | 79                              | 10.2                 | 12.4                     | --                                       | 01/17 13:00 EST |
| 02397530       | COOSA RIVER AT STATE LINE, AL/GA                   | 131                             | 8.1                  | 11.2                     | 7.8                                      | 01/17 13:00 EST |
| 02400100       | TERRAPIN CREEK AT ELLISVILLE AL                    | --                              | 9.3                  | --                       | --                                       | 01/17 12:00 CST |
| 02405500       | KELLY CREEK NEAR VINCENT AL                        | --                              | 6.2                  | --                       | --                                       | 01/17 11:00 CST |
| 02407514       | YELLOWLEAF CREEK NEAR WESTOVER, AL                 | --                              | 5.6                  | --                       | --                                       | 01/17 12:00 CST |
| 02412000       | TALLAPOOSA RIVER NEAR HEFLIN, AL                   | --                              | 5.9                  | --                       | --                                       | 01/17 11:30 CST |
| 02414500       | TALLAPOOSA RIVER AT WADLEY AL                      | --                              | 7.7                  | --                       | --                                       | 01/17 11:15 CST |
| 02414715       | TALLAPOOSA RIVER NR NEW SITE, AL.(HORSESHOE BEND)  | --                              | 7.1                  | --                       | --                                       | 01/17 11:30 CST |
| 02419890       | TALLAPOOSA RIVER NEAR MONT.-MONT. WATER WORKS      | 52                              | 19.5                 | --                       | --                                       | 10/18 11:00 CDT |
| 02423130       | CAHABA RIVER AT TRUSSVILLE, AL                     | 202                             | 15.1                 | 10.8                     | --                                       | 11/18 14:00 CST |
| 02423160       | CAHABA RIVER NEAR WHITES CHAPEL AL                 | 203                             | 7.2                  | 14.6                     | 8.8                                      | 01/17 12:15 CST |
| 02423380       | CAHABA RIVER NEAR MOUNTAIN BROOK AL                | 192                             | 5.8                  | 12.9                     | 8.4                                      | 01/17 12:00 CST |
| 02423397       | LITTLE CAHABA RIVER BELOW LEEDS, AL.               | 379                             | 10.6                 | 11.1                     | --                                       | 01/17 12:00 CST |
| 02423406       | CAHABA RIVER NEAR HOOVER, AL                       | 190                             | 5.0                  | 1.4                      | --                                       | 01/17 11:00 CST |

# Missing Value – Handling

---

- Ignoring missing value (Omission)
  - Reduces available data
- Impute new value (Imputation)
  - Mean or median
  - Default value
- Analysis techniques which are robust against missing value
  - Expectation maximization

# Code Examples

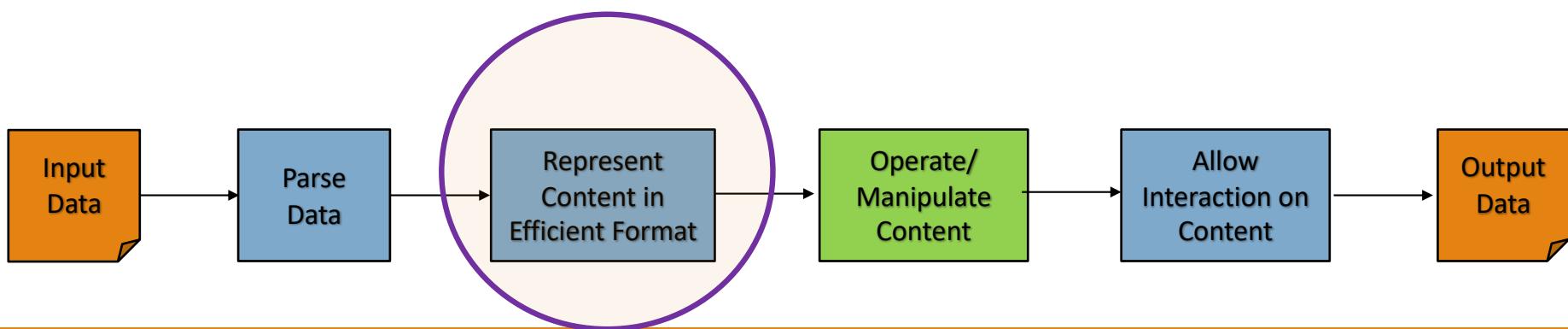
---

<https://github.com/biplav-s/course-d2d-ai/blob/main/sample-code/l5-dataprep/>

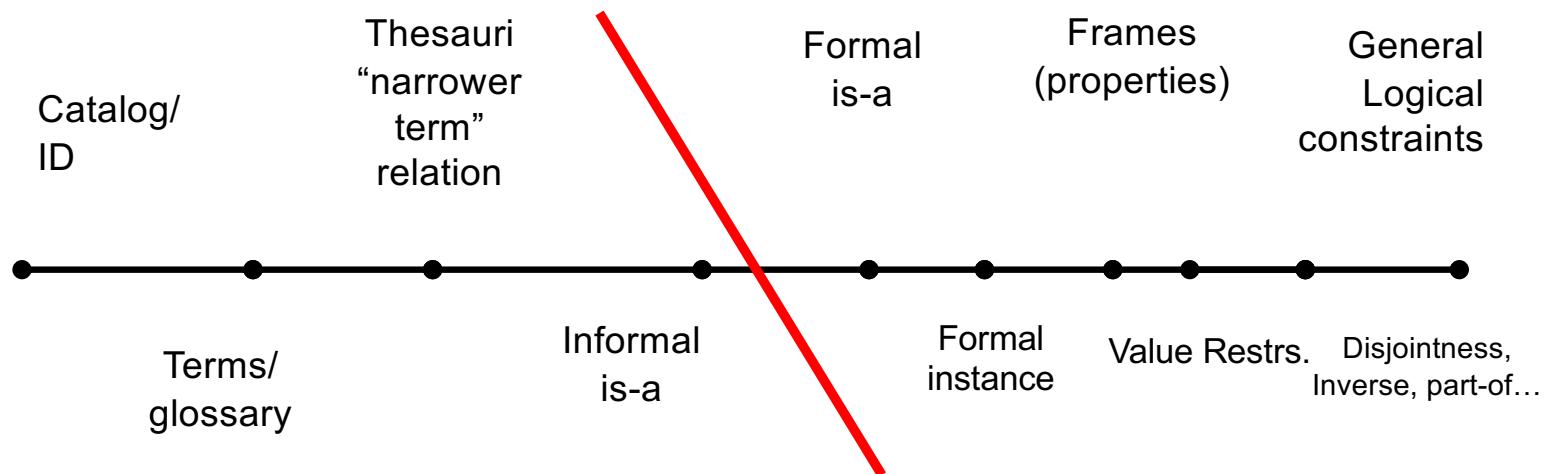
- Basic concepts: **DataPreparation-Numeric.ipynb**
- An illustration: **Clean-RealSample.ipynb**

# Annotation: Knowledge Graphs and Ontology

---



# The Spectrum of Annotation Methods



Ontologies Come of Age McGuinness, 2001, and From AAAI Panel 99 – McGuinness, Welty, Uschold, Gruninger, Lehmann  
Plus basis of Ontologies Come of Age – McGuinness, 2003

# Thesaurus – Authoritative Entities and Relationships

---

Countries: [https://en.wikipedia.org/wiki/List\\_of\\_ISO\\_3166\\_country\\_codes](https://en.wikipedia.org/wiki/List_of_ISO_3166_country_codes)

| ISO 3166 <sup>[1]</sup>                                |                                                           |                                      |                             | ISO 3166-1 <sup>[2]</sup>   |                             |                                       | ISO 3166-2 <sup>[3]</sup>     |  |
|--------------------------------------------------------|-----------------------------------------------------------|--------------------------------------|-----------------------------|-----------------------------|-----------------------------|---------------------------------------|-------------------------------|--|
| Country name <sup>[5]</sup>                            | Official state name <sup>[6]</sup>                        | Sovereignty <sup>[6]</sup><br>[7][8] | Alpha-2 code <sup>[5]</sup> | Alpha-3 code <sup>[5]</sup> | Numeric code <sup>[5]</sup> | Subdivision code links <sup>[3]</sup> | Internet ccTLD <sup>[9]</sup> |  |
| Afghanistan                                            | The Islamic Republic of Afghanistan                       | UN member state                      | AF                          | AFG                         | 004                         | ISO 3166-2:AF                         | .af                           |  |
| <b>Akrotiri and Dhekelia – See United Kingdom, The</b> |                                                           |                                      |                             |                             |                             |                                       |                               |  |
| Åland Islands                                          | Åland                                                     | Finland                              | AX                          | ALA                         | 248                         | ISO 3166-2:AX                         | .ax                           |  |
| Albania                                                | The Republic of Albania                                   | UN member state                      | AL                          | ALB                         | 008                         | ISO 3166-2:AL                         | .al                           |  |
| Algeria                                                | The People's Democratic Republic of Algeria               | UN member state                      | DZ                          | DZA                         | 012                         | ISO 3166-2:DZ                         | .dz                           |  |
| American Samoa                                         | The Territory of American Samoa                           | United States                        | AS                          | ASM                         | 016                         | ISO 3166-2:AS                         | .as                           |  |
| Andorra                                                | The Principality of Andorra                               | UN member state                      | AD                          | AND                         | 020                         | ISO 3166-2:AD                         | .ad                           |  |
| Angola                                                 | The Republic of Angola                                    | UN member state                      | AO                          | AGO                         | 024                         | ISO 3166-2:AO                         | .ao                           |  |
| Anguilla                                               | Anguilla                                                  | United Kingdom                       | AI                          | AIA                         | 660                         | ISO 3166-2:AI                         | .ai                           |  |
| Antarctica <sup>[a]</sup>                              | All land and ice shelves south of the 60th parallel south | Antarctic Treaty                     | AQ                          | ATA                         | 010                         | ISO 3166-2:AQ                         | .aq                           |  |
| Antigua and Barbuda                                    | Antigua and Barbuda                                       | UN member state                      | AG                          | ATG                         | 028                         | ISO 3166-2:AG                         | .ag                           |  |
| Argentina                                              | The Argentine Republic                                    | UN member state                      | AR                          | ARG                         | 032                         | ISO 3166-2:AR                         | .ar                           |  |

# (Unique) US Counties Information

In COVID sample code: <https://github.com/biplav-s/course-d2d-ai/blob/main/sample-code/I3-health/CovidExploration.ipynb>,

reference made to **FIPS** code

## References:

- [https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=nrcs143\\_013697](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=nrcs143_013697)
- [https://github.com/kjhealy/fips-codes/blob/master/county\\_fips\\_master.csv](https://github.com/kjhealy/fips-codes/blob/master/county_fips_master.csv)

**Question:** how many Richland counties are there in US ?

**Answer:** 14

## County FIPS Codes

| FIPS  | Name     | Stat |
|-------|----------|------|
| 01001 | Autauga  | AL   |
| 01003 | Baldwin  | AL   |
| 01005 | Barbour  | AL   |
| 01007 | Bibb     | AL   |
| 01009 | Blount   | AL   |
| 01011 | Bullock  | AL   |
| 01013 | Butler   | AL   |
| 01015 | Calhoun  | AL   |
| 01017 | Chambers | AL   |
| 01019 | Cherokee | AL   |
| 01021 | Chilton  | AL   |
| 01023 | Choctaw  | AL   |
| 01025 | Clarke   | AL   |
| 01027 | Clay     | AL   |
| 01029 | Cleburne | AL   |
| 01031 | Coffee   | AL   |
| 01033 | Colbert  | AL   |
| 01035 | Conecuh  | AL   |

# Is-a Relationship

---

# List of Countries, States, ... (County), City

---

- United Nations: <https://unece.org/trade/cefact/unlocode-code-list-country-and-territory>
- US Source: <https://github.com/grammakov/USA-cities-and-states>

# Schema.org

---

- Website: <https://schema.org/docs/about.html>
- GitHub: <https://github.com/schemaorg/schemaorg>
- An organization of metadata information for entities found on the web. Mostly backed by web search companies.
- Explore
  - Thing: <https://schema.org/Thing>
  - Product:

# Schema.org

## Example 2

No Markup   Microdata   RDFa   JSON-LD   Structure

*Example notes or example HTML without markup.*

```

Dell UltraSharp 30" LCD Monitor
```

87 out of 100 based on 24 user ratings

\$1250 to \$1495 from 8 sellers

Sellers:

```

 Save A Lot Monitors - $1250

 Jon Doe's Gadgets - $1350
...
```

No structure

# Schema.org

Example 2

No Markup Microdata RDFa JSON-LD Structure

Example notes or example HTML without markup.

```

Dell UltraSharp 30" LCD Monitor
87 out of 100 based on 24 user ratings
$1250 to $1495 from 8 sellers
Sellers:

Save A Lot Monitors - $1250

Jon Doe's Gadgets - $1350
...

```

No structure

Structure in JSON-LD format

## Example 2

No Markup Microdata RDFa JSON-LD Structure

Example encoded as JSON-LD in a HTML script tag.

```
<script type="application/ld+json">
{
 "@context": "https://schema.org",
 "@type": "Product",
 "aggregateRating": {
 "@type": "AggregateRating",
 "bestRating": "100",
 "ratingCount": "24",
 "ratingValue": "87"
 },
 "image": "dell-30in-lcd.jpg",
 "name": "Dell UltraSharp 30\" LCD Monitor",
 "offers": {
 "@type": "AggregateOffer",
 "highPrice": "$1495",
 "lowPrice": "$1250",
 "offerCount": "8",
 "offers": [
 {
 "@type": "Offer",
 "url": "save-a-lot-monitors.com/dell-30.html"
 },
 {
 "@type": "Offer",
 "url": "jondoe-gadgets.com/dell-30.html"
 }
]
 }
}</script>
```

# Schema.org

Example 2

No Markup Microdata RDFa JSON-LD Structure

*Example notes or example HTML without markup.*

```

Dell UltraSharp 30" LCD Monitor

87 out of 100 based on 24 user ratings
$1250 to $1495 from 8 sellers

Sellers:

 Save A Lot Monitors - $1250

 Jon Doe's Gadgets - $1350
...

```

## No structure

Example 2

No Markup Microdata RDFa JSON-LD Structure

*Example encoded as JSON-LD in a HTML script tag.*

```
<script type="application/ld+json">
{
 "@context": "https://schema.org",
 "@type": "Product",
 "aggregateRating": {
 "@type": "AggregateRating",
 "bestRating": "100",
 "ratingCount": "24",
 "ratingValue": "87"
 },
 "image": "dell-30in-lcd.jpg",
 "name": "Dell UltraSharp 30\" LCD Monitor",
 "offers": [
 {
 "@type": "AggregateOffer",
 "highPrice": "$1495",
 "lowPrice": "$1250",
 "offerCount": "8",
 "offers": [
 {
 "@type": "Offer",
 "url": "save-a-lot-monitors.com/dell-30.html"
 },
 {
 "@type": "Offer",
 "url": "jondoe-gadgets.com/dell-30.html"
 }
]
 }
]
}</script>
```

## Structure in JSON-LD format

### Example 2

No Markup Microdata RDFa JSON-LD Structure

*Structured representation of the JSON-LD example.*

<b>@type</b>	Product
<b>name</b>	Dell UltraSharp 30" LCD Monitor
<b>offers</b>	
<b>@type</b>	AggregateOffer
<b>offerCount</b>	8
<b>lowPrice</b>	\$1250
<b>highPrice</b>	\$1495
<b>offers</b>	
<b>@type</b>	Offer
<b>url</b>	http://example.org/jondoe-gadgets.com/dell-30.html
<b>offers</b>	
<b>@type</b>	Offer
<b>url</b>	http://example.org/save-a-lot-monitors.com/dell-30.html
<b>image</b>	http://example.org/dell-30in-lcd.jpg
<b>aggregateRating</b>	
<b>@type</b>	AggregateRating
<b>ratingValue</b>	87
<b>ratingCount</b>	24
<b>bestRating</b>	100

## Induced Structure

# Schema.org - continued

---

- **Exploration Exercise**

- Services: <https://schema.org/Service>
- Event: <https://schema.org/Event>

- Benefit:

- Easy to incorporate annotations
- Uses popular development tools and technologies (JSON, Microformat)

- Disadvantage

- Cannot perform deep inferencing
- Popular in certain communities

# Formalizing Knowledge in an Ontology

---

## Sources:

Achille Fokoue, Anastasios Kementsietsidis Tutorial

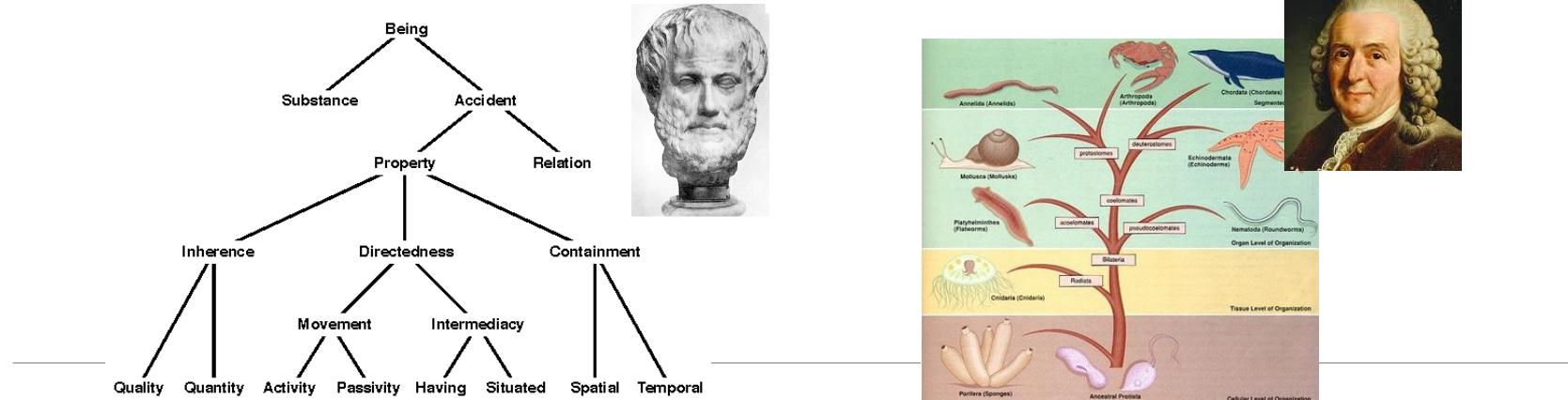
SCRIBE presentation by Rosario Usceda Sosa, Biplav Srivastava, Bob Schloss

- <https://github.com/rschloss/ismp>,
- [https://researcher.watson.ibm.com/researcher/view\\_group.php?id=2505](https://researcher.watson.ibm.com/researcher/view_group.php?id=2505)

## What is an ontology, anyway?

In Computer Science, “An ontology is a formal explicit description of concepts in a domain of discourse (**classes** (sometimes called concepts)), **properties** of each concept describing various features and **attributes** of the concept (slots (sometimes called roles or properties)), and **restrictions** on slots (facets (sometimes called role restrictions)). An ontology together with a set of individual instances of classes constitutes a knowledge base. In reality, there is a fine line where the ontology ends and the knowledge base begins.” [Noy, 2000]

Not to be confused with ontologies (and/or taxonomies) in Philosophy or Life Sciences

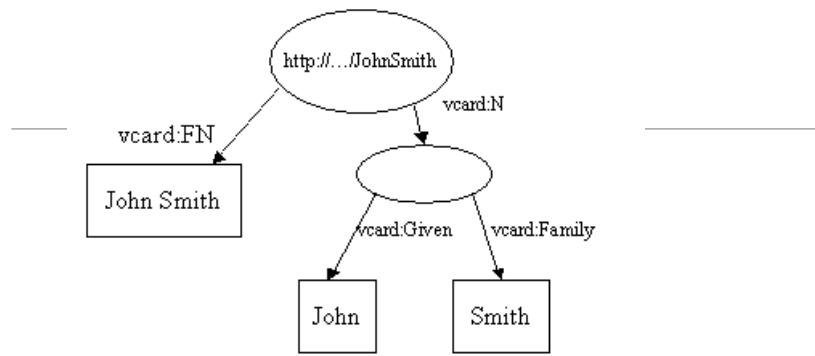


In a Smart City domain, we’re concerned with modeling the *city data* (city activity data, city departments, assets, KPIs), not the city itself (the full set of spatial and temporal relations between people and objects in the city). Ontologies help us to structure and reason about city events, entities and services.

**Ontology = Class + Relations + Constraints**

**Knowledge Base = Ontology + instances + (Standard) Inference and rules**

# RDF / Turtle Example



---- Turtle ----

```
<http://somewhere/JohnSmith>
 <http://www.w3.org/2001/vcard-rdf/3.0#FN>
 "John Smith" ;
 <http://www.w3.org/2001/vcard-rdf/3.0#N>
 [<http://www.w3.org/2001/vcard-
 rdf/3.0#Family>
 "Smith" ;
 <http://www.w3.org/2001/vcard-
 rdf/3.0#Given>
 "John"
] .
```

```
<rdf:RDF
 xmlns:rdf="http://www.w3.org/1999/02/22-rdf-
syntax-ns#"
 xmlns:vcard="http://www.w3.org/2001/vcard-
rdf/3.0#" >
 <rdf:Description rdf:nodeID="A0">
 <vcard:Given>John</vcard:Given>
 <vcard:Family>Smith</vcard:Family>
 </rdf:Description>
 <rdf:Description
 rdf:about="http://somewhere/JohnSmith">
 <vcard:FN>John Smith</vcard:FN>
 <vcard:N rdf:nodeID="A0"/>
 </rdf:Description>
</rdf:RDF>
```

# OWL extends RDF...

---

## RDF-schema

- Class, subclass
- Property, subproperty

## + Restrictions

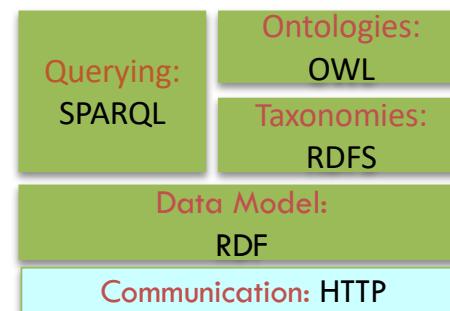
- Range, domain
- Local, global
- Existential
- Cardinality

## + Combinators

- Union, Intersection
- Complement
- Symmetric, transitive

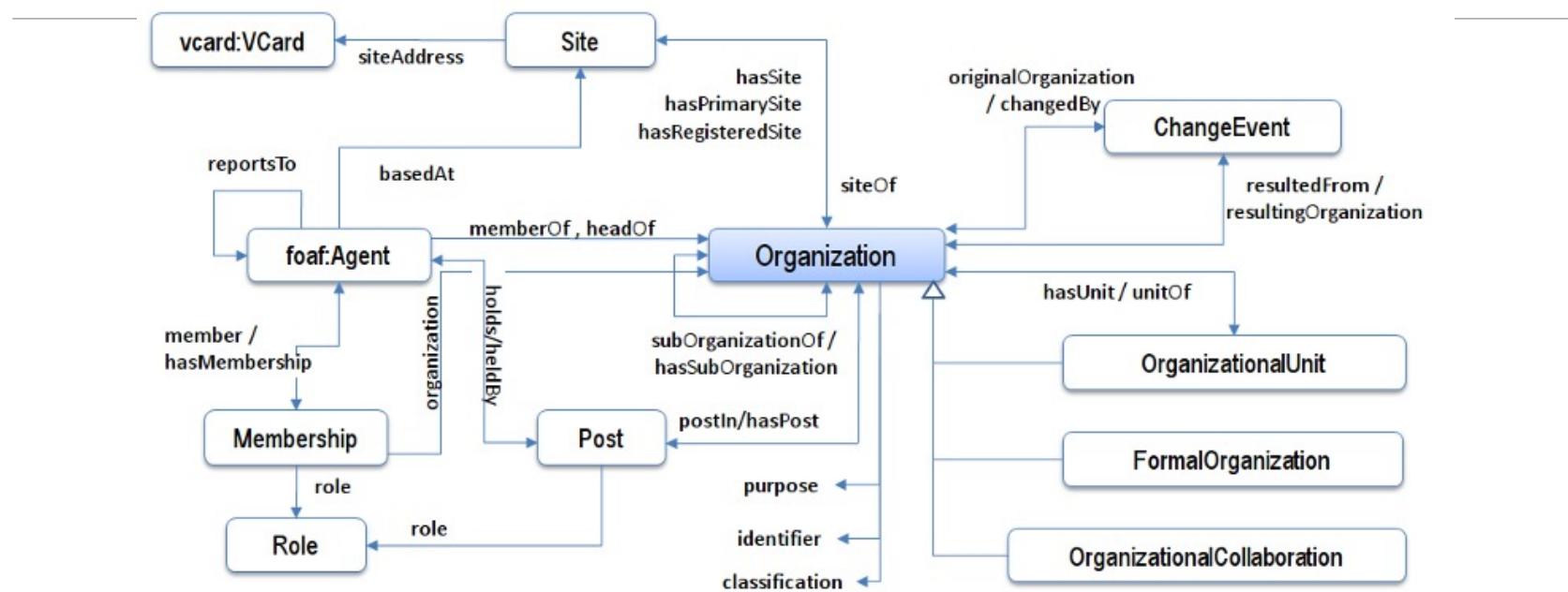
## + Mapping

- Equivalence
- Inverse



**Source:** Achille Fokoue, Anastasios Kementsietsidis Tutorial

# Larger Example: Organization Ontology



Ontology description: <http://www.w3.org/TR/vocab-org/>

Ontology: <http://www.w3.org/ns/org.ttl>

# Larger Ontology

```

@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix skos: <http://www.w3.org/2004/02/skos/core#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .

...
@prefix : <http://www.w3.org/ns/org#> .

-- Meta data ----

<http://www.w3.org/ns/org#>
 a owl:Ontology;
 owl:versionInfo "0.7";
 rdfs:label "Core organization ontology"@en;
 rdfs:comment "Vocabulary for describing organizational structures, specializable to a broad variety of types of organization."@en;
 dct:created "2010-05-28"^^xsd:date;
 dct:modified "2010-06-09"^^xsd:date;
 dct:modified "2010-10-08"^^xsd:date;
 ...
 rdfs:seeAlso <http://www.w3.org/TR/vocab-org/> ;
 .

-- Organizational structure ----

org:Organization a owl:Class, rdfs:Class;
 rdfs:subClassOf foaf:Agent;
 owl:equivalentClass foaf:Organization;
 rdfs:label "Organization"@en;
 rdfs:label "Organisation"@fr;
 owl:hasKey (org:identifier);
 rdfs:comment """Represents a collection of people organized together into a community or other social, commercial or political structure. ... Alternative names: _Collective_ _Body_ _Org_ _Group """@en;
 rdfs:comment """Représente un groupe de personnes organisées en communauté où tout autre forme de structure sociale, commerciale ou politique. ... code provenant d'une liste de code."""@fr;
 rdfs:isDefinedBy <http://www.w3.org/ns/org> ;
 .

```

<http://www.w3.org/ns/org.ttl>

```

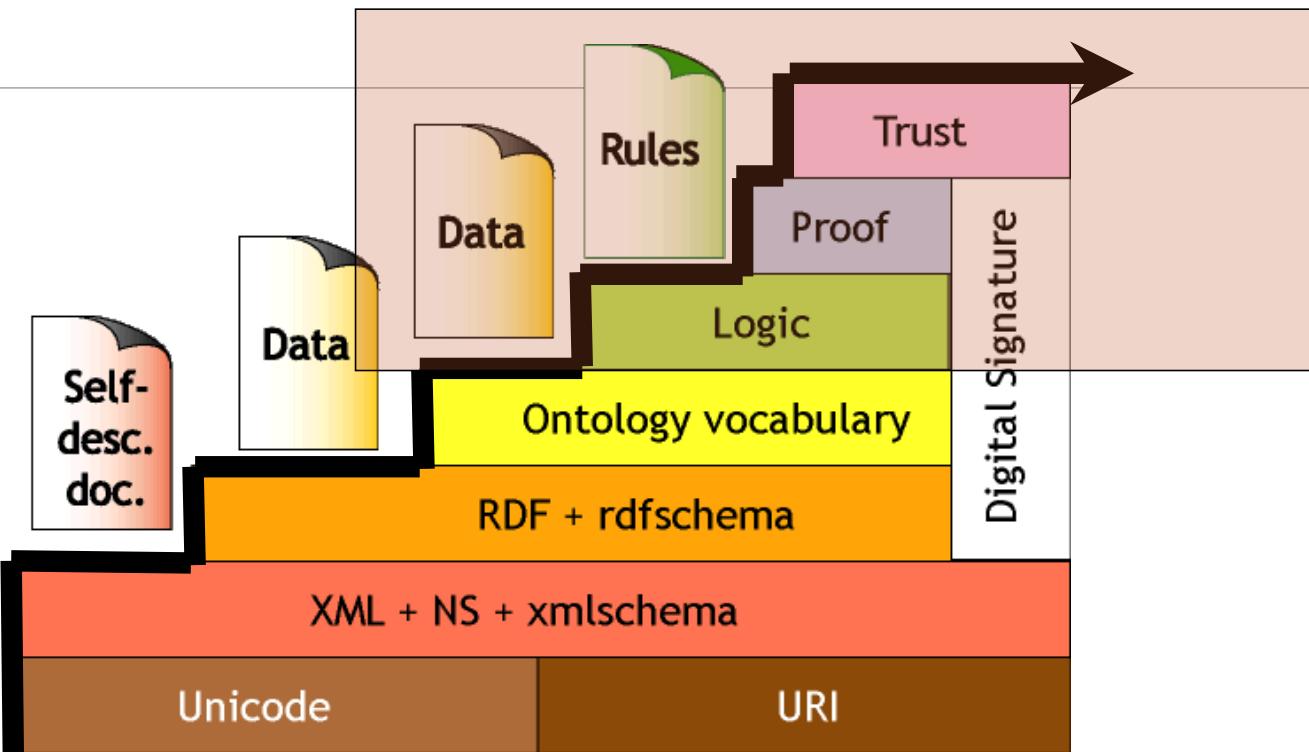
- <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:skos="http://www.w3.org/2004/02/skos/core#" xmlns:foaf="http://xmlns.com/foaf/0.1/"
 xmlns:org="http://www.w3.org/ns/org#" xmlns:gr="http://purl.org/goodrelations/v1#"
 xmlns:owl="http://www.w3.org/2002/07/owl#" xmlns:dct="http://purl.org/dc/terms/"
 xmlns:prov="http://www.w3.org/ns/prov#" xmlns:owlTime="http://www.w3.org/2006/time#"
 xmlns:xsd="http://www.w3.org/2001/XMLSchema#" xmlns:vcard="http://www.w3.org/2006/vcard/ns#"
 xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#">
-- Meta data ----

+ <owl:Ontology rdf:about="http://www.w3.org/ns/org#">
+ <rdfs:Class rdf:about="http://www.w3.org/ns/org#Organization">
- <rdfs:Class rdf:about="http://www.w3.org/ns/org#Role">
 <rdfs:label xml:lang="fr">Rôle</rdfs:label>
- <owl:disjointWith>
 <owl:Class rdf:about="http://www.w3.org/ns/org#ChangeEvent" />
 <owl:disjointWith>
 <rdfs:subClassOf rdf:resource="http://www.w3.org/2004/02/skos/core#Concept" />
- <owl:disjointWith>
 <owl:Class rdf:about="http://www.w3.org/ns/org#Site" />
 <owl:disjointWith>
 <rdfs:comment xml:lang="fr">Indique le rôle qu'une Personne ou un autre Agent peut avoir dans une Organisation. Les instances de cette classe décrivent le rôle dans l'absolu; pour indiquer une personne ayant ce rôle spécifique dans une Organisation, utilisez une instance de `org:Membership'. Il est courant que les rôles soient organisés dans une sorte de taxonomie, ce qui peut être représenté avec SKOS. Les propriétés de libellés standards de SKOS devraient être utilisées pour libeller le Rôle. D'autres propriétés additionnelles pour ce rôle, comme une fourchette de Salaire peuvent être ajoutées par une extension de ce vocabulaire.</rdfs:comment>
- <owl:disjointWith>
 <owl:Class rdf:about="http://www.w3.org/ns/org#Membership" />
 <owl:disjointWith>
 <rdfs:label xml:lang="en">Role</rdfs:label>
 <rdfs:isDefinedBy rdf:resource="http://www.w3.org/ns/org" />
 <rdfs:type rdf:resource="http://www.w3.org/2002/07/owl#Class" />
 <rdfs:comment xml:lang="en">Denotes a role that a Person or other Agent can take in an organization. Instances of this class describe the abstract role; to denote a specific instance of a person playing that role in a specific organization use an instance of `org:Membership'. It is common for roles to be

```

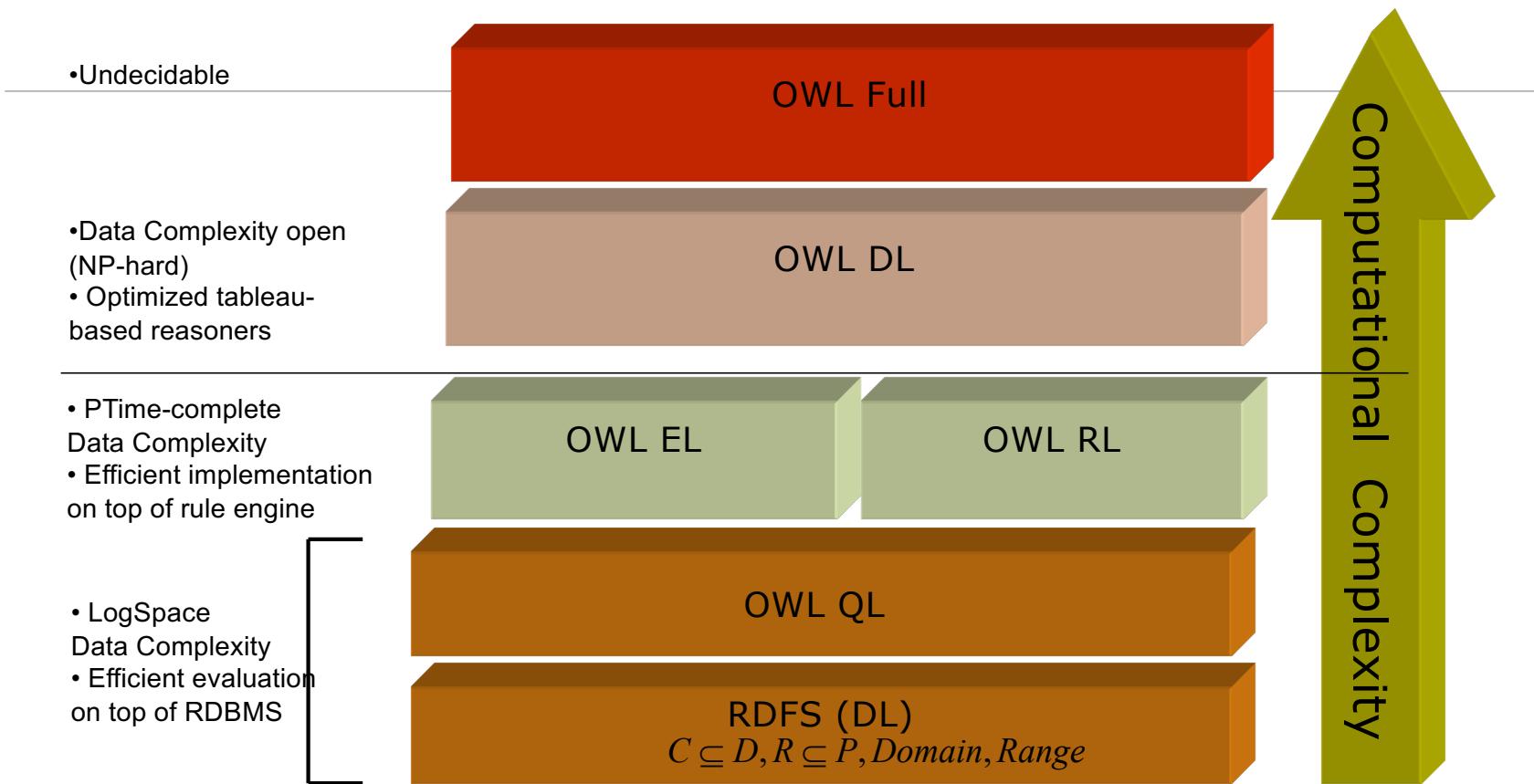
<http://www.w3.org/ns/org>

# Moving to the future of the web



Semantic Web LayerCake (Berners-Lee, 99; Swartz-Hendler, 2001)

# Challenge of Reasoning on Ontologies



## What makes a good ontology for data integration?

A *good* ontology is a *useful* ontology, an ontology that *both* humans and systems can process.

### Human Usability

**Communicable.** Naming, natural language support, etc.

**Concise.** A simple way to describe the key entities of the model and yet able to infer many facts

**Consistent.** Naming conventions and modeling patterns

**Authoritative** to domain experts

**Documented**, not just descriptions, but also provenance

**Managed and maintained** by people throughout the model lifecycle.

**Reusable** in similar domains, for similar instances.

- ❑ *Formal representation of knowledge in a particular domain*
- ❑ *Formally defines key concepts and relations in the domain*
- ❑ *Specifies relationships between those key concepts and relations*
- ❑ *Supports automated reasoning about entities in the domain*

### System Usability

**Scalable** so large amounts of data can be parsed, stored and retrieved.

**Efficient** query and inferencing

**Programmable** solutions, both in open and closed data paradigms.

**Open** infrastructure and tools

# Using Ontology

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- Visually via tools like Protégé - <https://protege.stanford.edu/>
- Programmatically with APIs like
  - Jena (Java) - <https://jena.apache.org/documentation/ontology/>
  - OwlReady2 (Python) - <https://bitbucket.org/jibalamy/owlready2/src/master/>
  - Rdflib (Python) - <https://github.com/RDFLib/OWL-RL>
- A compendium of resources - <https://github.com/totogo/awesome-knowledge-graph>

# Code Illustration

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On Github:

<https://github.com/biplav-s/course-nl/blob/master/l11-ontology/Exploring%20ontologies.ipynb>

# Knowledge Graph

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- No clear definition
  - ["Towards a Definition of Knowledge Graphs," by Lisa Eherlinger and Wolfram Wöß, CEURWorkshop Proceedings. 2016, <http://ceur-ws.org/Vol-1695/paper4.pdf>](http://ceur-ws.org/Vol-1695/paper4.pdf)
  - For practical purposes, concepts and their relationships; not constraints
  - Driven by applications in search and information integration
  - See discussion at: <http://accidental-taxonomist.blogspot.com/2019/05/knowledge-graphs-and-ontologies.html>
- But ontology as knowledge graph widely used in industries
  - Industry-Scale Knowledge Graphs: Lessons and Challenges, CACM 2019, <https://cacm.acm.org/magazines/2019/8/238342-industry-scale-knowledge-graphs/fulltext>

# KG Usage

	<b>Data model</b>	<b>Size of the graph</b>	<b>Development stage</b>
<b>Microsoft</b>	The types of entities, relations, and attributes in the graph are defined in an ontology.	~2 billion primary entities, ~55 billion facts	Actively used in products
<b>Google</b>	Strongly typed entities, relations with domain and range inference	1 billion entities, 70 billion assertions	Actively used in products
<b>Facebook</b>	All of the attributes and relations are structured and strongly typed, and optionally indexed to enable efficient retrieval, search, and traversal.	~50 million primary entities, ~500 million assertions	Actively used in products
<b>eBay</b>	Entities and relation, well-structured and strongly typed	Expect around 100 million products, >1 billion triples	Early stages of development and deployment
<b>IBM</b>	Entities and relations with evidence information associated with them.	Various sizes. Proven on scales documents >100 million, relationships >5 billion, entities >100 million	Actively used in products and by clients

Figure courtesy: Industry-Scale Knowledge Graphs: Lessons and Challenges, CACM 2019

# Concluding Section

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# Week 2-3: Concluding Comments

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- We looked at
  - Trusted decisions
  - Data and characteristics
  - Common ways to prepare data
  - How to organize content for inferencing / reasoning
- Prepares us for understanding trust issues

# About Next Week – Lectures 5, 6

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# Lecture 5, 6: AI / ML Methods

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- Common AI methods
- ML landscape
- Supervised ML

1	Jan 14 (Tu)	Introduction, Trusted AI
2	Jan 16 (Th)	Case Studies: Data Analysis for AI, Analysis for Trust [Traffic], Recommendations and Trust [Fairness and ULTRA]
3	Jan 21 (Tu)	Review: Trusted Decisions, Expectations, Course Scope; Data
4	Jan 23 (Th)	AI: Data Prep, Knowledge Graph
5	Jan 28 (Tu)	Common AI methods: ML Landscape
6	Jan 30 (Th)	AI - Structured: Analysis – Supervised ML
7	Feb 4 (Tu)	AI - Structured: Analysis – Supervised ML
8	Feb 6 (Th)	AI - Structured: Analysis – Supervised ML – Trust Issues
9	Feb 11 (Tu)	AI - Structured: Analysis – Supervised ML – Trust Issues
10	Feb 18 (Th)	AI - Structured: Analysis – Supervised ML – Mitigation Methods
11	Feb 18 (Tu)	AI - Supervised ML: Explanation Tools