



CSCE 581: Introduction to Trusted AI

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

PROF. BIPLAV SRIVASTAVA, AI INSTITUTE

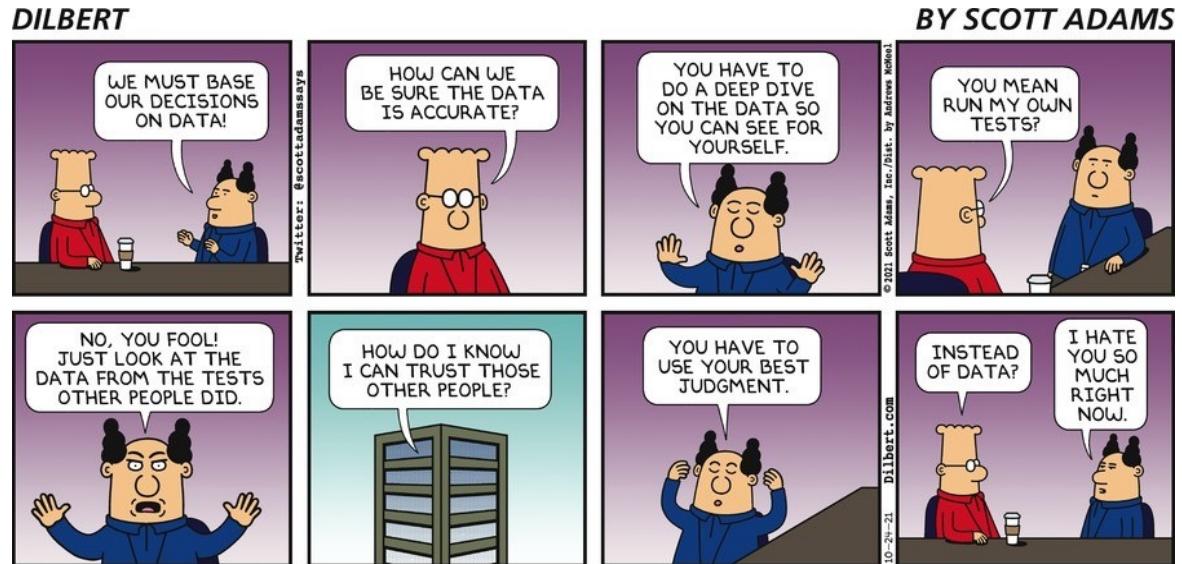
20TH AND 22ND JAN 2026

Carolinian Creed: "I will practice personal and academic integrity."

Credits: Copyrights of all material reused acknowledged

Organization of Lectures 3, 4

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



Credit: Dilbert

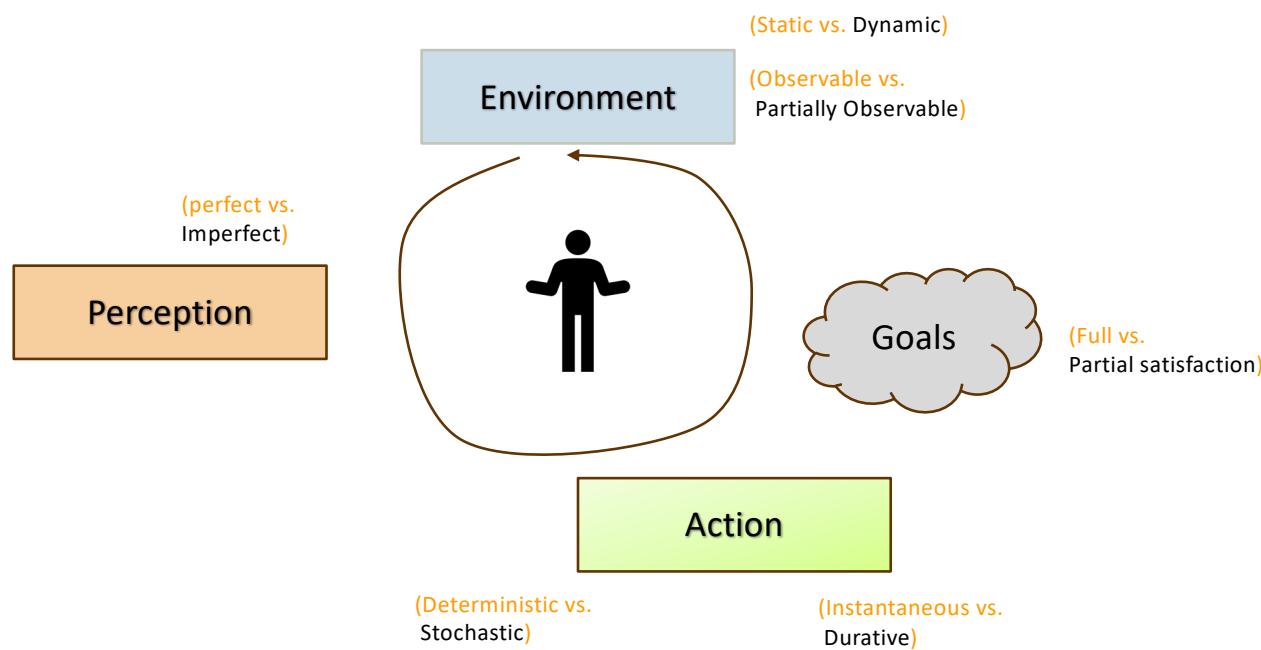
Introduction Section

Recap from Week 1

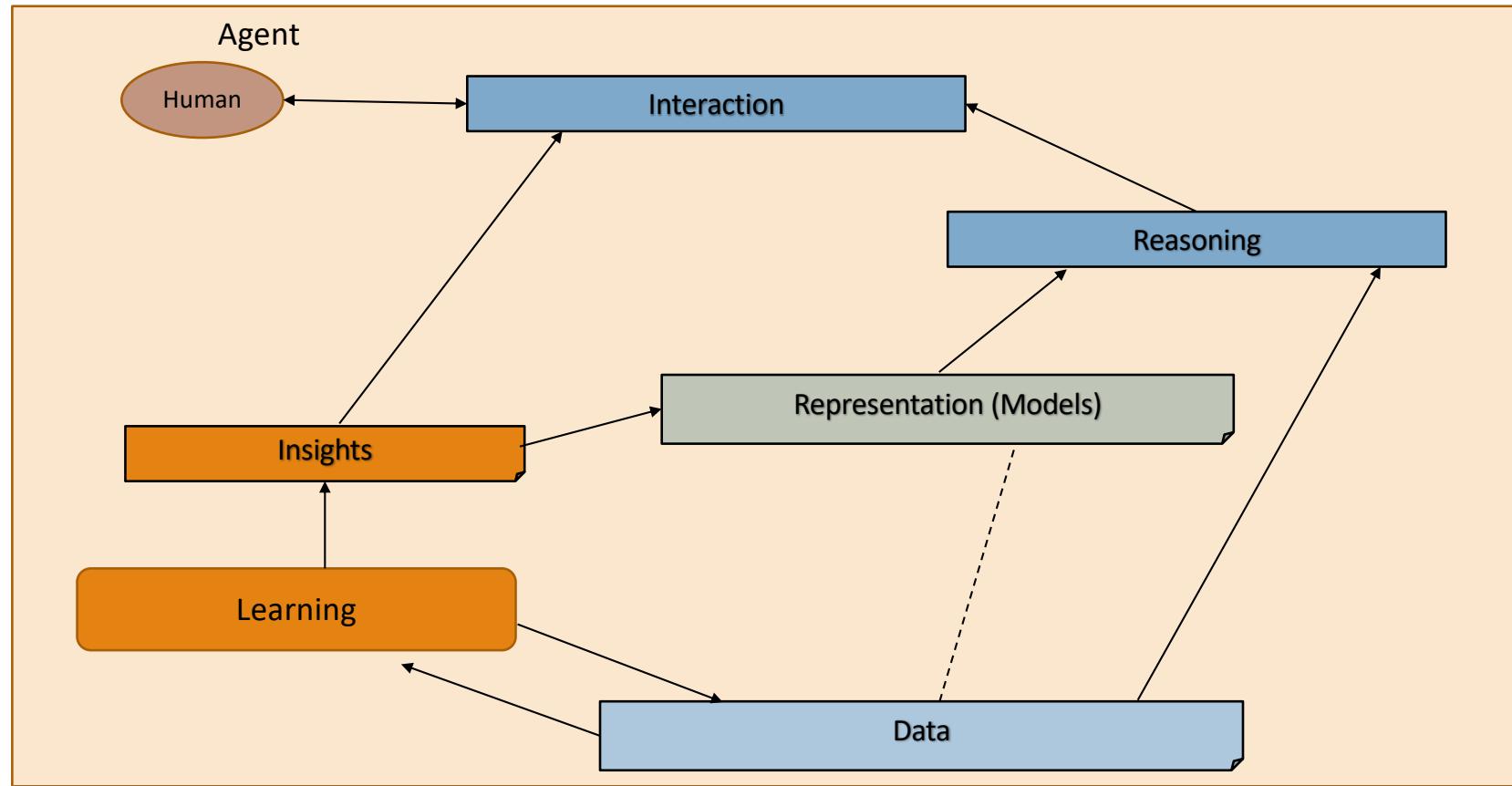
Week 1: Introduction to Trusted AI

- 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

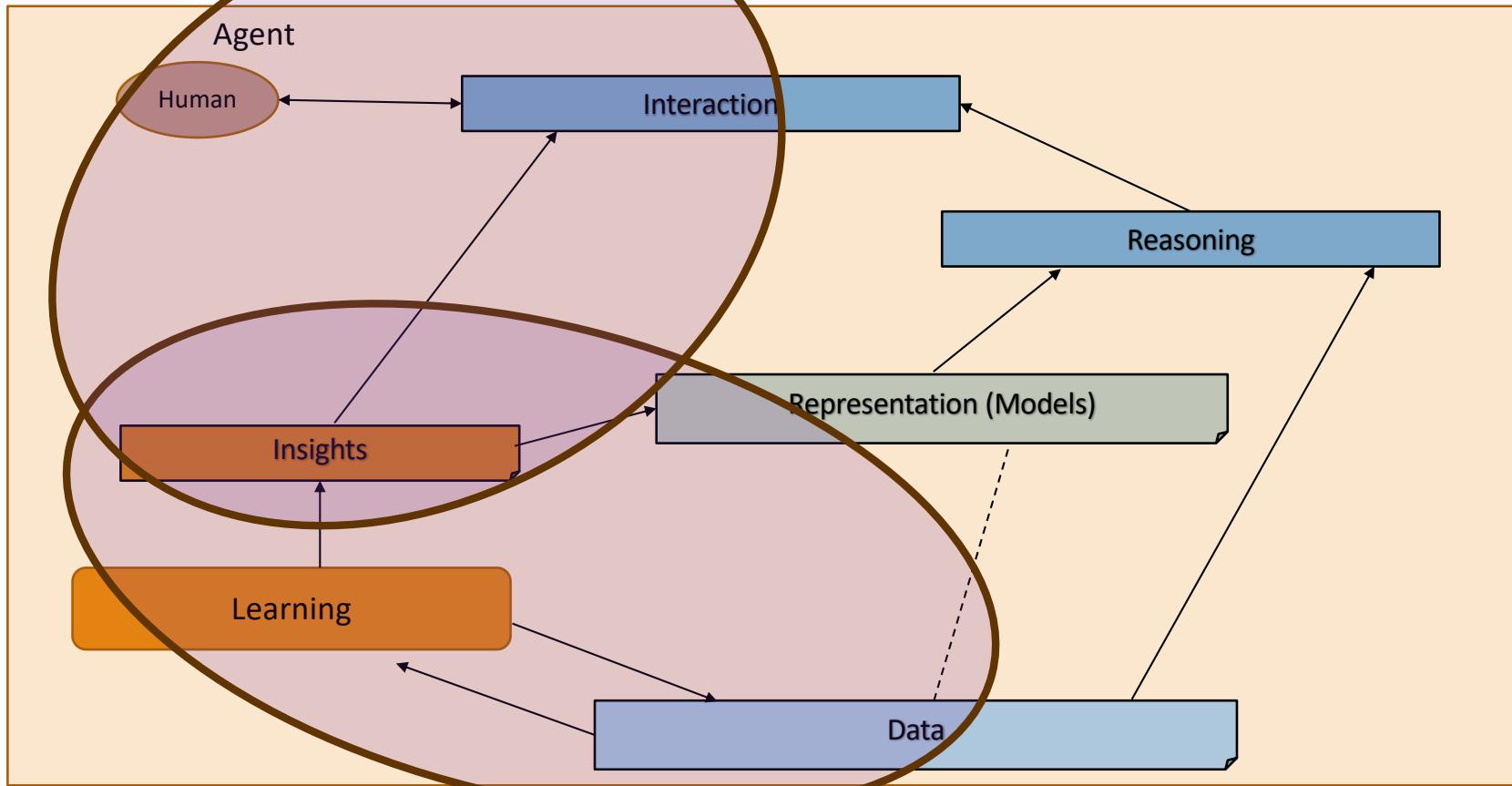
Intelligent Agent Model



Relationship Between Main AI Topics



Relationship Between Main AI Topics (Covered in Course)



High Level Semester Plan (Adapted, Approximate)

CSCE 581 –

- Week 1: Introduction: AI and Trust
- Week 2: Background: Data and Organization for AI
- 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

TAI News

#1 NEWS - Risks of AI in Schools **Outweigh** Benefits, Report Says

Link - <https://www.npr.org/2026/01/14/nx-s1-5674741/ai-schools-education>

Full report - <https://www.brookings.edu/articles/a-new-direction-for-students-in-an-ai-world-prosper-prepare-protect/>

- **Context**
 - Study includes focus groups and interviews with K-12 students, parents, educators and tech experts in 50 countries, as well as a literature review of hundreds of research articles.
- **Findings**
 - It found that using AI in education can "undermine children's foundational development" and that "the damages it has already caused are daunting," though "fixable."
 - **Pro:**
 - AI can help students learn to read and write
 - **Cons:**
 - AI poses a grave threat to students' cognitive development
 - AI poses serious threats to social and emotional development
- **Insight**
 - Learning is the process of self-discovery
 - Use AI to help student's learning (self-discovery), not replace learning

#2 NEWS - Guest Speaker

<TBD>, by Dr. Kush Varshney

March 17, 2025



Dr. Varshney is an IBM Fellow based at the Thomas J. Watson Research Center, Yorktown Heights, NY, where he directs [Human-Centered Trustworthy](#) AI research. He applies data science and predictive analytics to human capital management, healthcare, olfaction, computational creativity, public affairs, international development, and algorithmic fairness, which has led to the Extraordinary IBM Research Technical Accomplishment for contributions to workforce innovation and enterprise transformation, and IBM Corporate Technical Awards for Trustworthy AI and for AI-Powered Employee Journey. He and his team created several well-known open-source toolkits, including [AI Fairness 360](#), [AI Explainability 360](#), [Uncertainty Quantification 360](#), and [AI FactSheets 360](#). AI Fairness 360 has been recognized by the Harvard Kennedy School's Belfer Center as a tech spotlight runner-up and by the Falling Walls Science Symposium as a winning science and innovation management breakthrough.

He independently-published a book entitled 'Trustworthy Machine Learning' in 2022, available at <http://www.trustworthymachinelearning.com>. He is a fellow of the IEEE.

Personal website: <https://krvarshney.github.io>

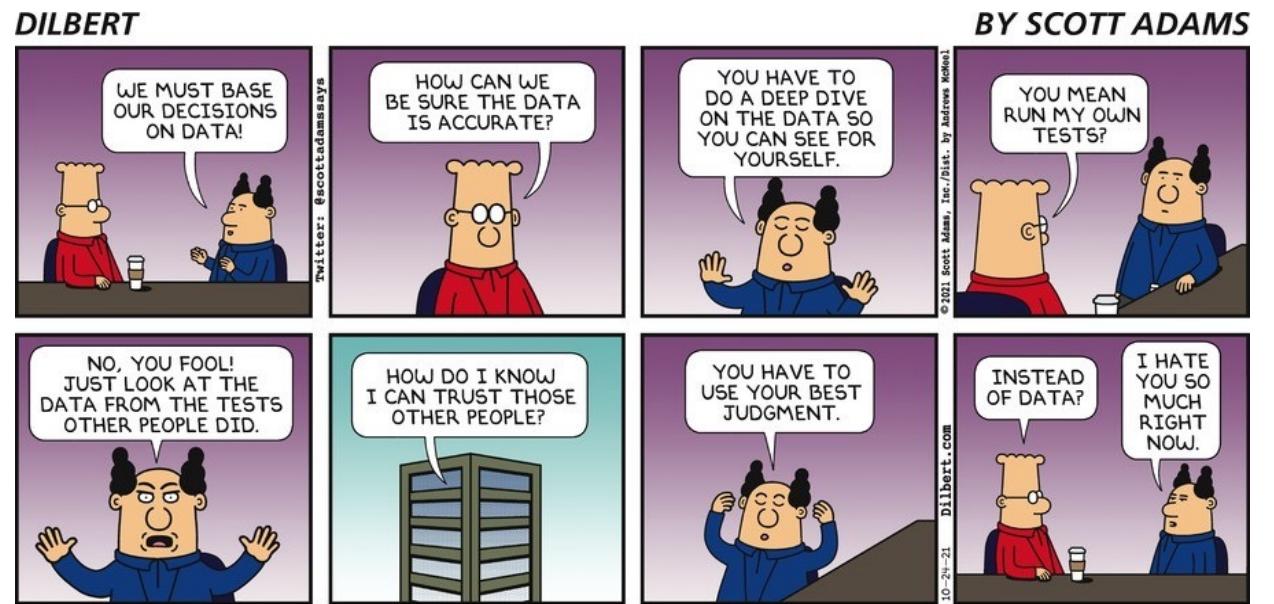
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Full report - <https://www.brookings.edu/articles/a-new-direction-for-students-in-an-ai-world-prosper-prepare-protect/>

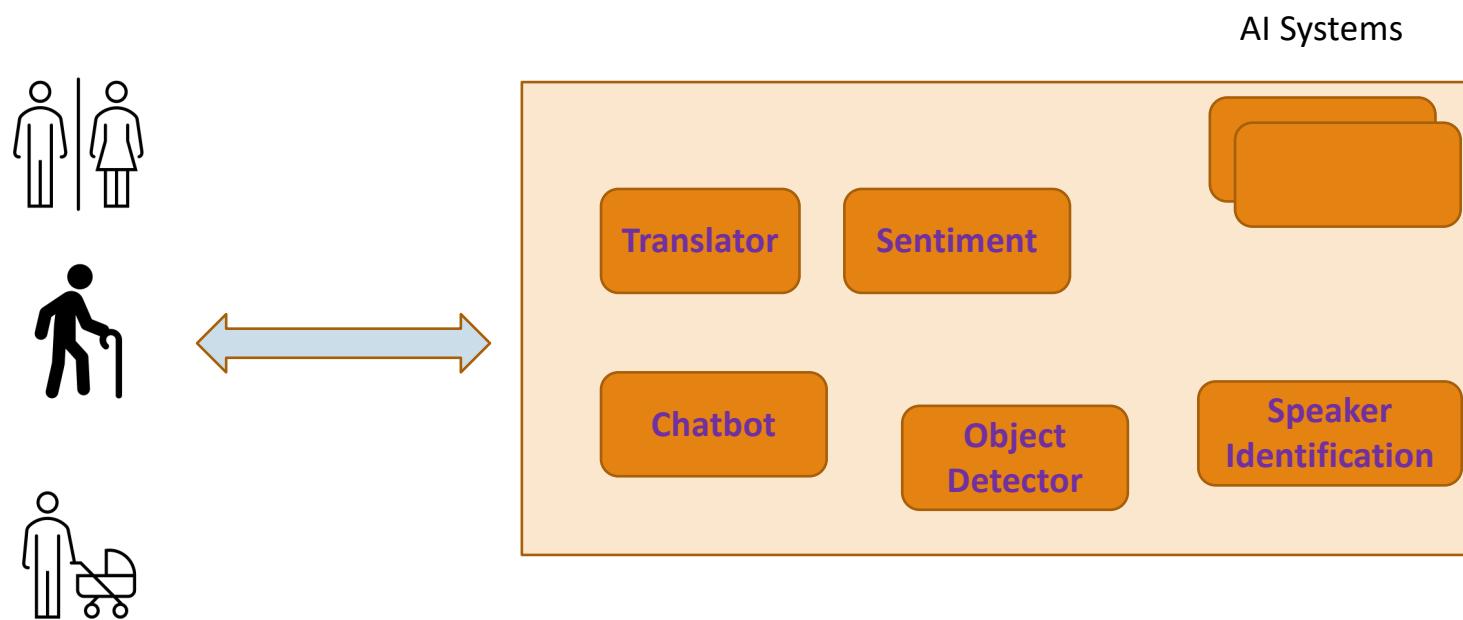
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Main Section



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

TDEBot

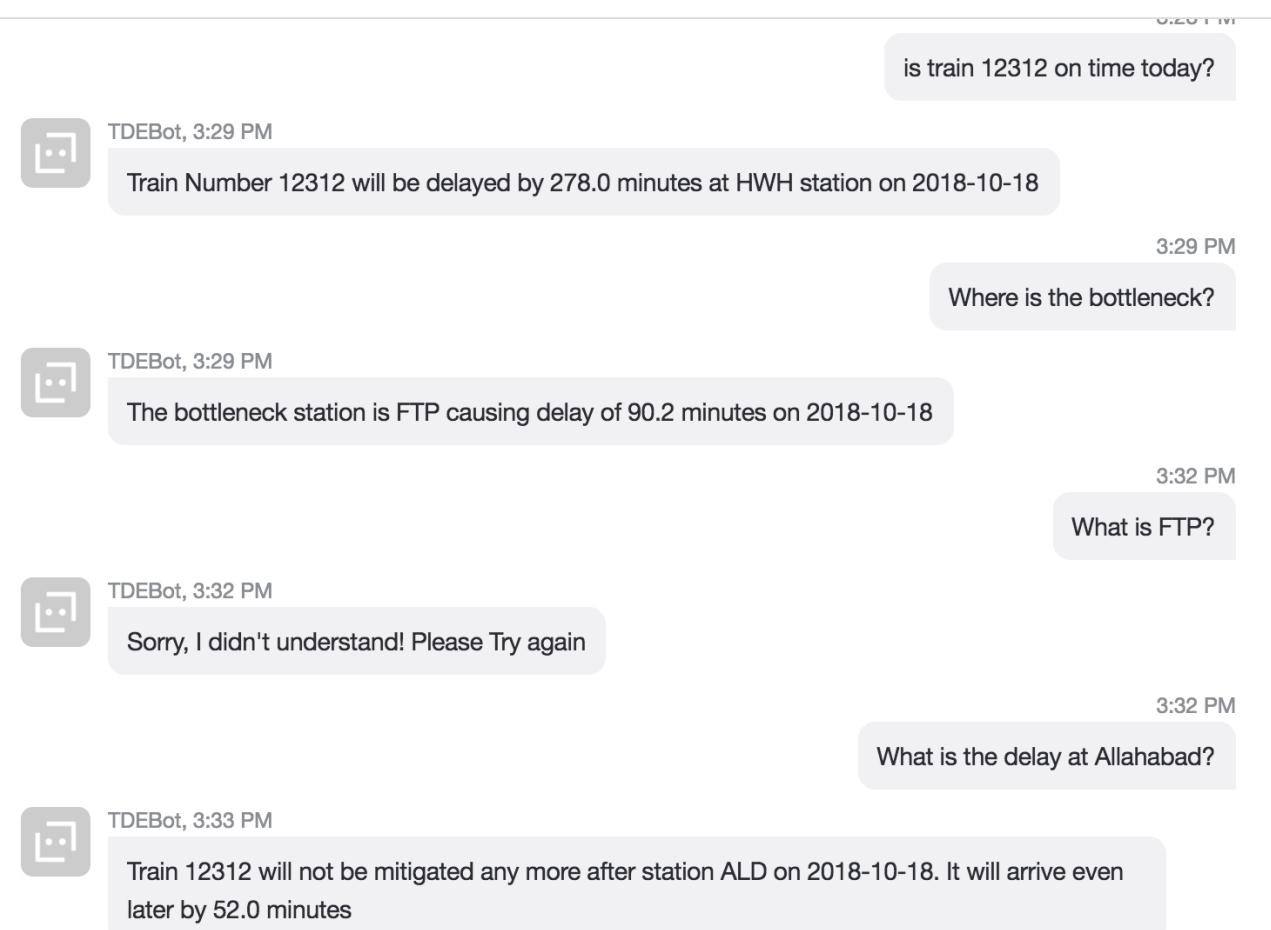
Illustration: A Seemingly Innocuous Chatbot

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]



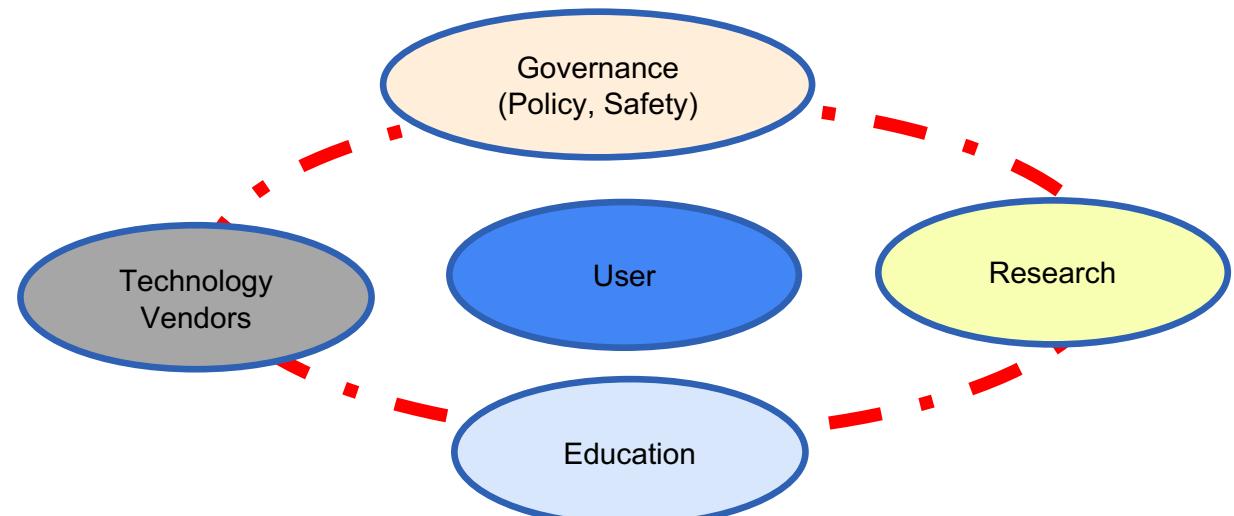
Takeaway – Trust in AI

- 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”)

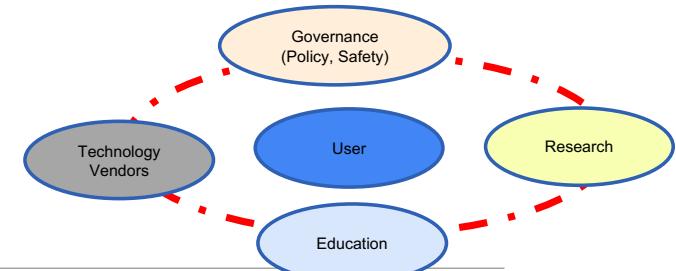
Technology Adoption Ecosystem

Building user's trust in technology with:

- (Research and) Develop technology
- Educate users about the technology's usage
- Research on pain points to improve
- Help create governance, including regulations, to mitigate any consequent risks



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]

GenAI Trust Controversies

- 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.
- See more in our readings list

Data – The Fuel for AI

Motivation for Data Understanding

- Financial fraud detection in transactional data:

<https://www.kaggle.com/datasets/sriharshaedala/financial-fraud-detection-dataset/>

- What kind of AI/ analysis needed?
- How do we explain a flagged transaction?
- How is a person or organization impacted by it?

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

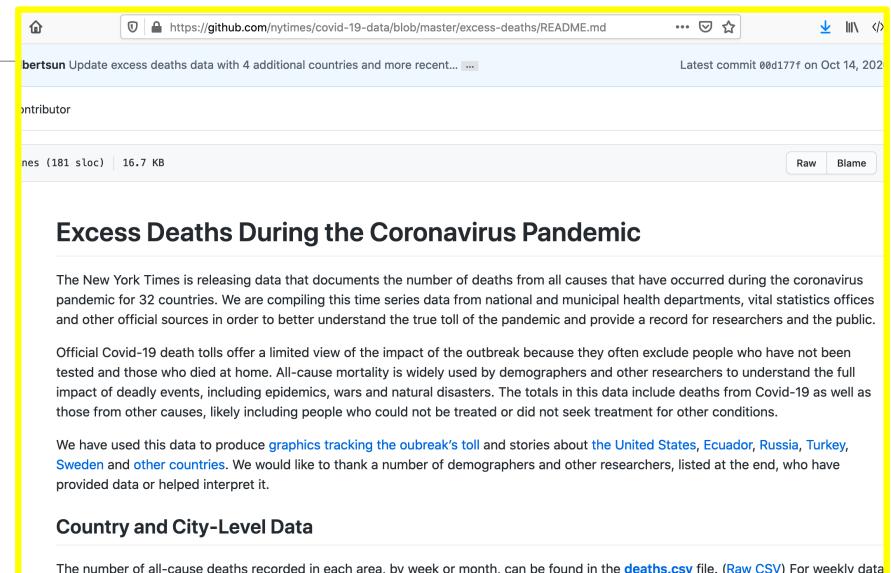
- The structure of meta-data is fixed, but the structure of data is allowed to change. Example: XML, JSON
- Benefits
 - Relatively easy to analyze, e.g., commands similar to SQL in languages like OQL or Xquery
 - Structure of data easy to extend
- Disadvantage
 - Size of data is larger than structured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

```
[{"date": "20210109", "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": 363554, "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": "5eb9c8ed71ea9818f7981f07d0b3e8bd8a73003b"}, {"date": "20210108", "states": 56, "positive": 21637132, "negative": 202809998, "pending": 11633, "hospitalizedCurrently": 131889, "hospitalizedCumulative": 720767, "inIcuCurrently": 23731, "inIcuCumulative": 38607, "onVentilatorCurrently": 7787, "onVentilatorCumulative": 3760, "dateChecked": "2021-01-08T24:00:00Z", "death": 363554, "hospitalized": 720767, "totalTestResults": 264165031, "lastModified": "2021-01-08T24:00:00Z", "recovered": null, "total": 0, "posNeg": 0, "deathIncrease": 3500, "hospitalizedIncrease": 6545, "negativeIncrease": 1335238, "positiveIncrease": 261993, "totalTestResultsIncrease": 2000196, "hash": "5eb9c8ed71ea9818f7981f07d0b3e8bd8a73003b"}]
```

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	<u>Filename extension</u>	.txt
• Components: characters, words, paragraph	<u>Internet media type</u>	text/plain
• Representation	<u>Type code</u>	TEXT
• Uncompressed / encoding – ASCII, UTF-8, UTF-16	<u>Uniform Type Identifier (UTI)</u>	public.plain-text
• Compressed - .zip	UTI conformation	public.text
• Lossy compression -	Type of format	<u>Document file format, Generic container format</u>
• Language: English, French, ...		
• Programming libraries: nltk, spacy		

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.wavefor m-audio
Developed by	IBM & Microsoft
Initial release	August 1991; 29 years ago [3]
	Multiple Channel Audio Data and WAVE Files
Latest release	(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>	video/avi
<u>Uniform Type Identifier (UTI)</u>	video/msvideo
Developed by	video/x-msvideo
Initial release	'Vfw '
<u>Container for</u>	Microsoft
Extended from	public.avi
	November 1992;
	27 years ago
	Audio, Video
	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,

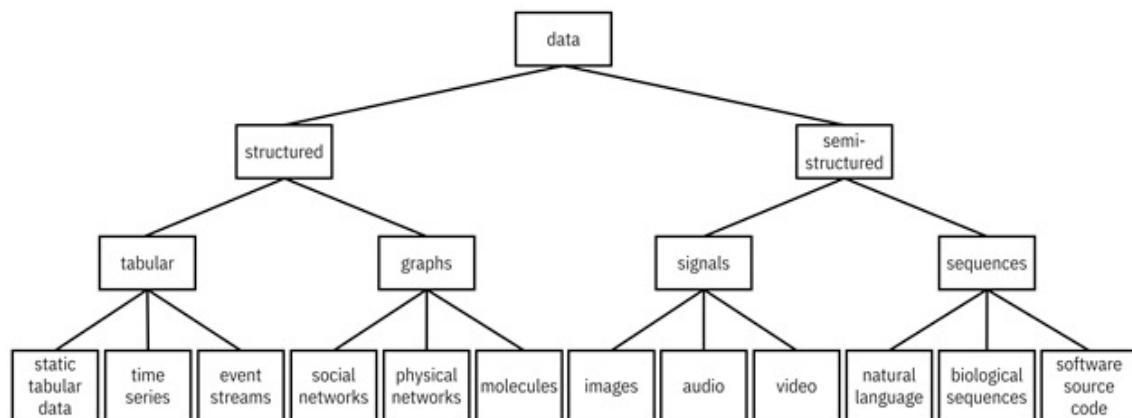


Image credit:

<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

A screenshot of the US Data.gov website. The top navigation bar includes links for DATA, TOPICS, RESOURCES, STRATEGY, DEVELOPERS, and CONTACT. Below the navigation are category icons for Agriculture, Climate, Ecosystems, Energy, Local Government, Maritime, Ocean, and Older Adults Health. Two dataset cards are visible: "U.S. Hourly Precipitation Data" (855 recent views) and "NCDC Storm Events Database" (331 recent views). Both cards include links for HTML, JSON, CSV, ESRI REST, KML, and more.

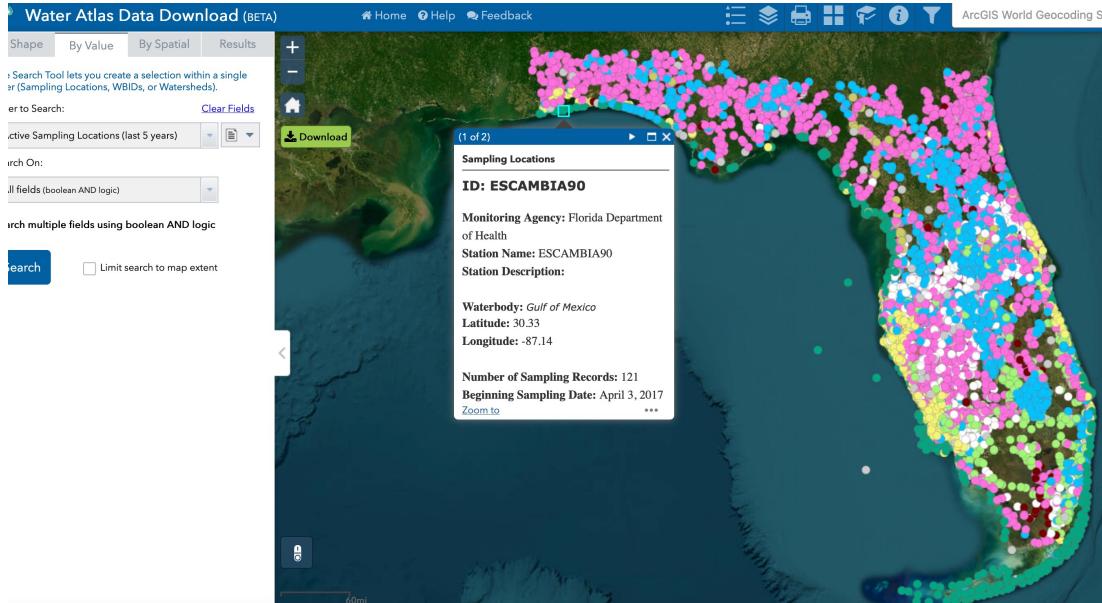
USA

A screenshot of the India data.gov.in website. The top navigation bar includes links for Skip to navigation, Skip to main content, and DataGov States/ULB. The main banner features the text "DATASETS FROM HEALTH SECTOR". Below the banner are sections for ANALYTICS (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, 2,043 visualizations), CATALOG (Udyog Aadhaar Memorandum (MSME Registration)), and INDICATOR DASHBOARD (Drinking Water And Sanitation, Health, Transport, Labour And Employment).

India

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

Volume
Variety
Velocity
Veracity
...



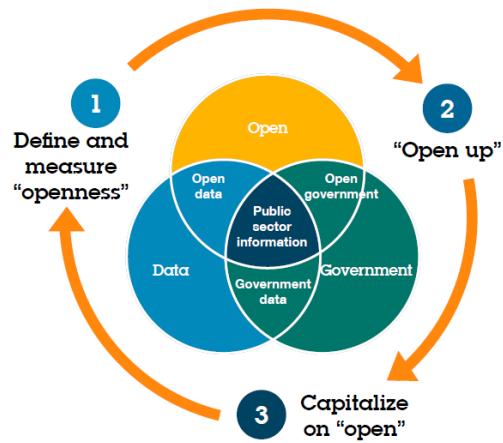
Data: <https://github.com/biplav-s/course-tai/tree/main/sample-code/common-data/water>



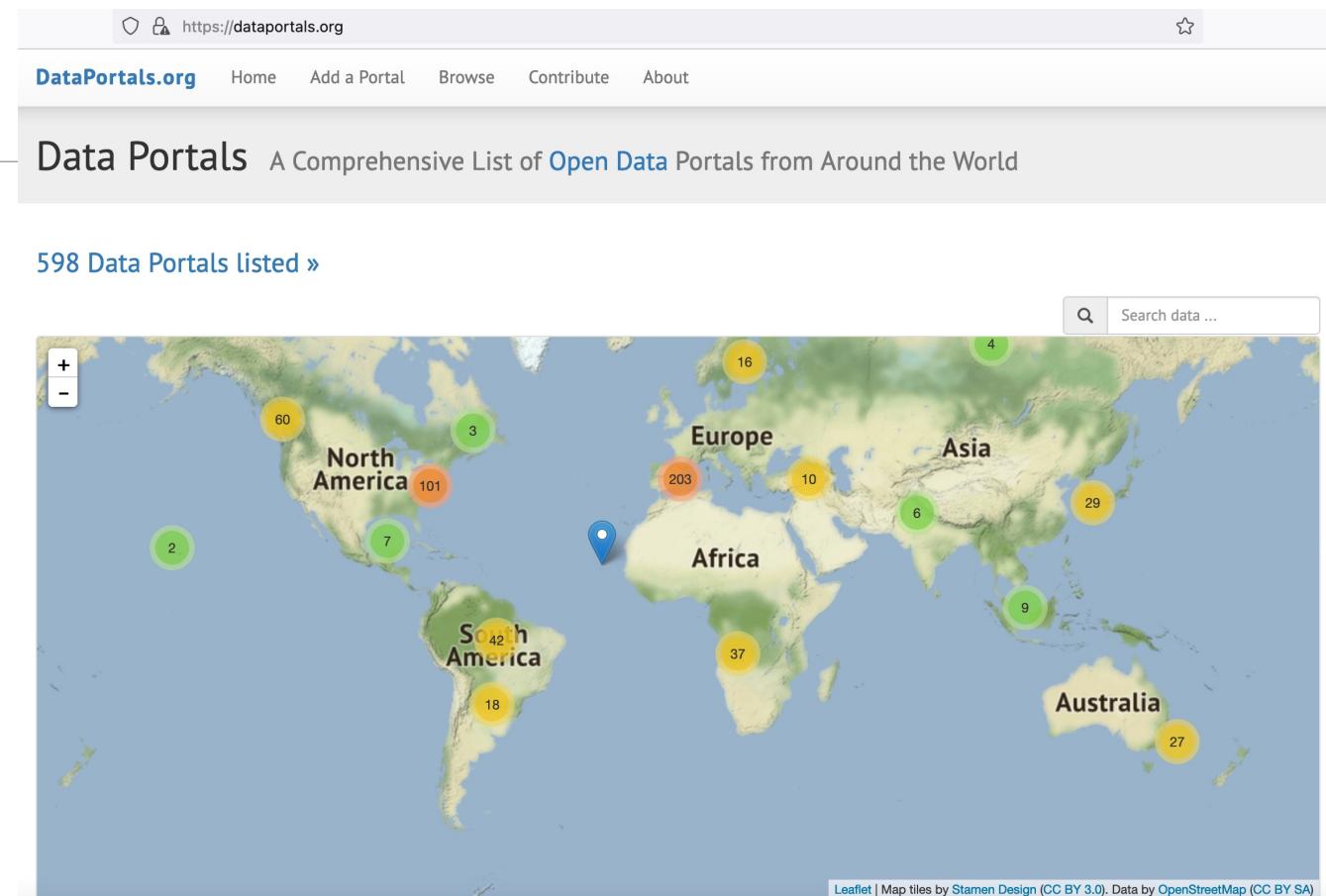
"Your recent Amazon purchases, Tweet score and location history makes you 23.5% welcome here."

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



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](#)

https://citydashboard.org/london/

London

51.51 N, 0.13 W

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

WEATHER STATION (CASA TEAM)

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

WEATHER (METAR)

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

TRAFFIC CAMERAS (TFL)

York Road/Leake Street	
Camera 00001.04226 unobtainable	

TUBE LINE STATUS (TFL)

Line	Status	More
Bakerloo	Good Service	[more]
Central	Good Service	[more]
Circle	Part Closure	[more]
District	Good Service	[more]
DLR	Good Service	[more]
Elizabeth	Good Service	[more]
H & C	Good Service	[more]
Jubilee	Good Service	[more]
Overground	Part Closure	[more]
Metropolitan	Good Service	[more]
Northern	Good Service	[more]
Piccadilly	Part Closure	[more]
Trams	Good Service	[more]
Victoria	Good Service	[more]

LONDON CYCLE HIRE (TFL)

NAN % NAN %	
Stations Full	Stations Empty
0	0
Bikes Available	Bikes or Docks Faulty

IN SERVICE (TFL)

6092 London buses	
322	Underground trains

AIR POLLUTION (DEFRA)

µg/m³ TIME AVGD	OZONE	NO ₂	SO ₂	PM _{2.5}	PM ₁₀
Bloomsbury	Marylebone Rd	N Kensington			

BICYCLES (LBH)

Goldsmiths' Row 4012 yesterday	
3571	

STOCKS (YAHOO)

FTSE 100 Index 7121.88 91.22 (1.28%)	
3	

TRAFFIC CAMERAS (TWO AT RANDOM) (TFL)

75 Knightsbridge/Williams St	London Rd/Arragon Rd
Sun 27 Aug 03:11	Sun 27 Aug 02:43
All Knightsbridge by Albert Gate	London Rd/Arragon Rd
Camera 00001.06730 unobtainable	

BBC LONDON NEWS (BBC)

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)

Edit to future cycle route Mapped planned C35 route at Peckham Rye Update addresses in SW19 postal district. kxplus kxplus

Powered by

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
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
0                 "text/xml"
1                 "application/json"
```

```
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)"}, ...]
 ...}]}
```

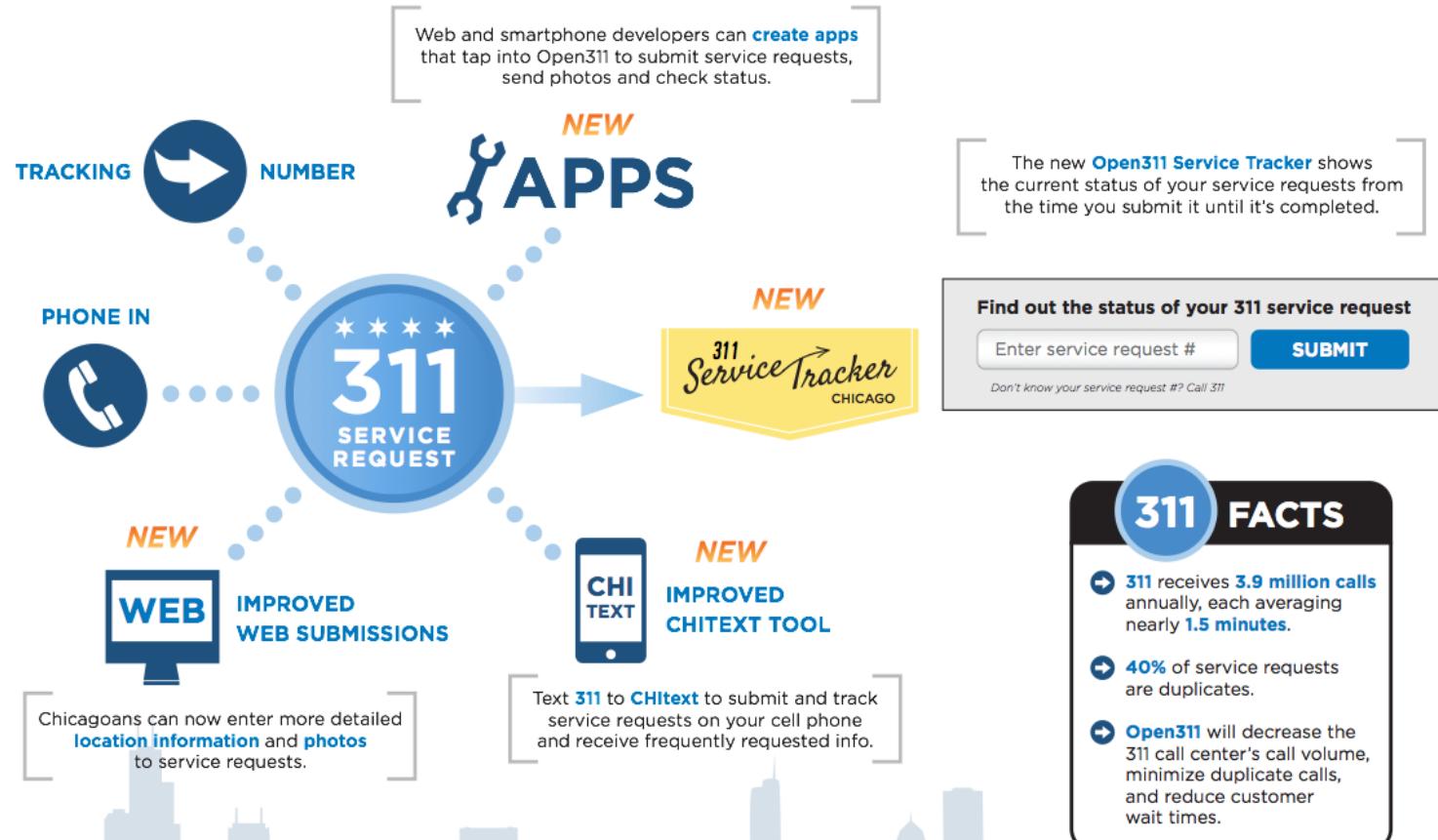
# Demonstration: Open 311

<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)

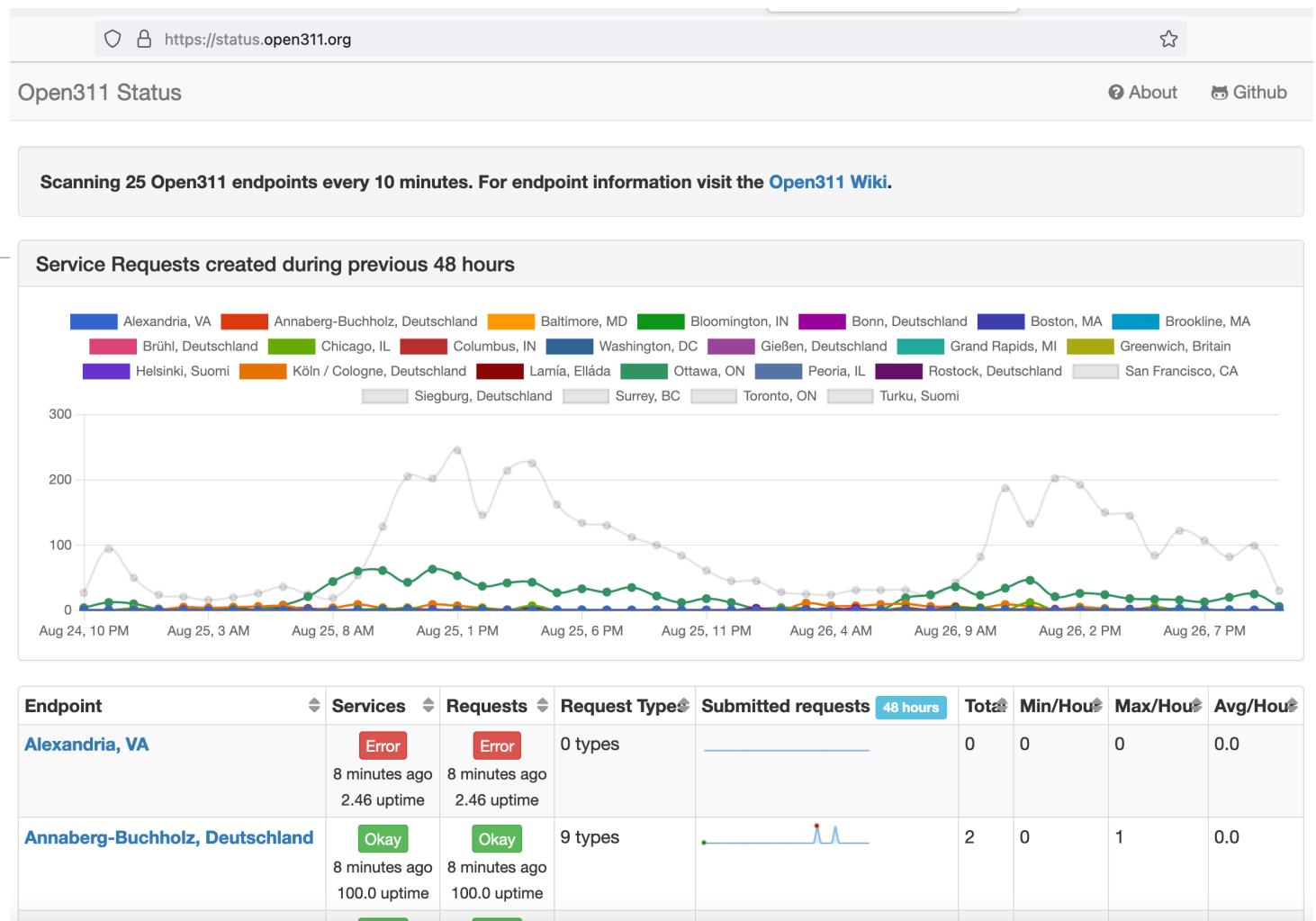
The screenshot shows a web browser displaying the Chicago 311 Service Tracker website at [servicetracker.cityofchicago.org/requests/13-00210540](http://servicetracker.cityofchicago.org/requests/13-00210540). The page title is "Rodent Baiting / Rat Complaint". Key details include:

- #13-00210540**
- Address:** 1502 N Wicker Park Ave
- Created:** February 23, 2013
- Received via:** Other
- Status:** Closed (indicated by a green ribbon icon)

The "Activity" section shows the following timeline:

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

# Scaling with Open 311



<https://status.open311.org/>

# Exercise 2 – Programmatically Access Data

---

1. See sample code on GitHub:

- <https://github.com/biplav-s/course-d2d-ai/blob/main/sample-code/l2-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

---

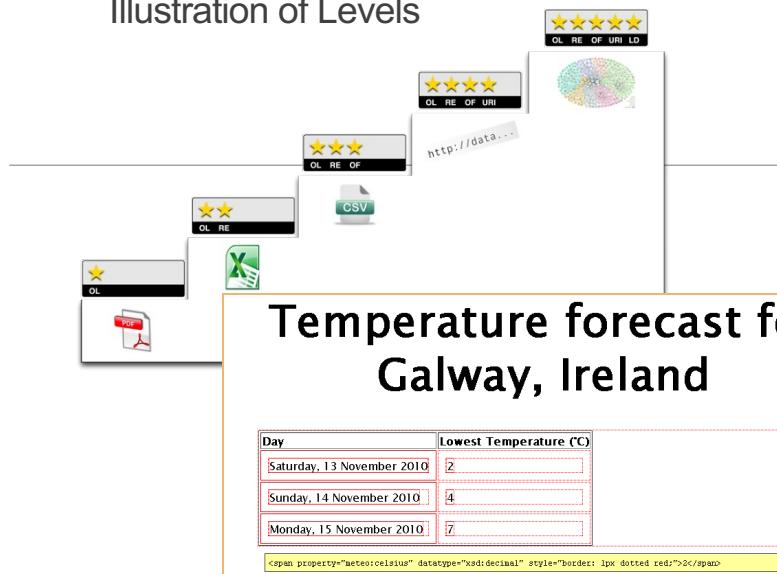
- Text of legislations - LegiScan, <https://legiscan.com/>
- Voter FAQs - <https://github.com/ai4society/election-dataset>
- Compendium of benchmarks and datasets:
  - <https://zilliz.com/learn/popular-datasets-for-natural-language-processing>,
  - UCI dataset – <https://archive.ics.uci.edu/datasets?search=&Types=Text>
  - 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



Source: <http://5stardata.info/>

1

| 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

| A                                               | B                       |
|-------------------------------------------------|-------------------------|
| <b>Temperature forecast for Galway, Ireland</b> |                         |
| Day                                             | Lowest Temperature (°C) |
| Saturday, 13 November 2010                      | 2                       |
| Sunday, 14 November 2010                        | 4                       |
| Monday, 15 November 2010                        | 7                       |

1

IM DATA TO DECISIONS WITH OPEN DATA: A PRACTICAL INTRODUCTION TO AI

53

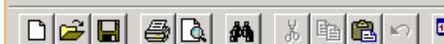
## Temperature forecast for Galway, Ireland

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

<span class="highlight" style="border: 1px dotted red;">>2c</span>

### 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

3

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

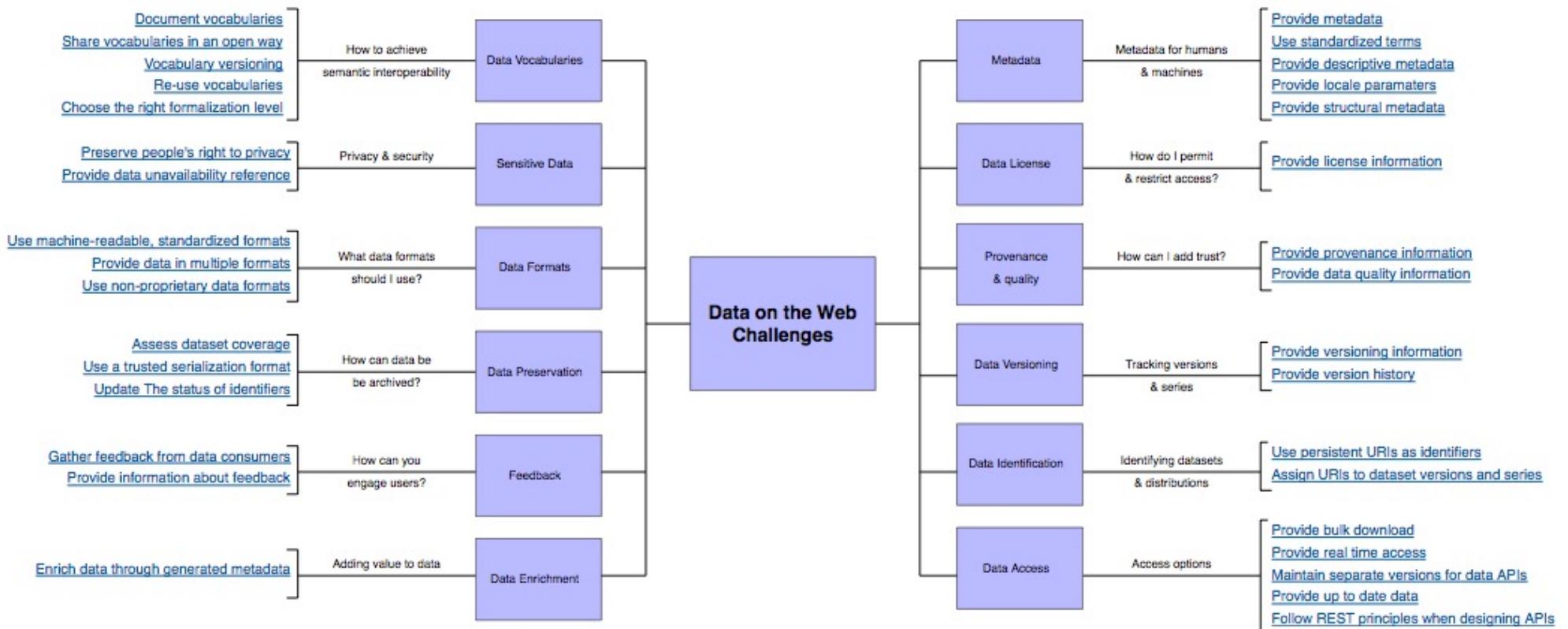
<a class="highlight" href="http://en.wikipedia.org/wik...>Temperature</a> <span class="highlight" style="border: 1px dotted red;">>2c</span>

5

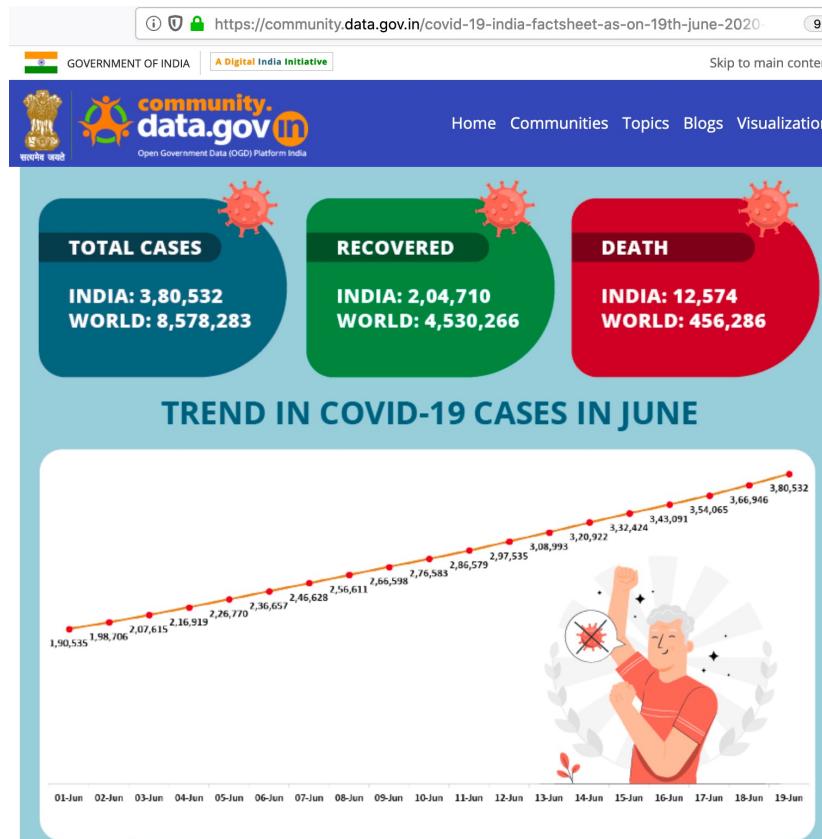
# Helping Publish Good Quality Open Data is Key

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

# Project Discussion

---

- Welcome class inputs on individual projects

# Project Discussion

---

- Class inputs requested on individual projects
- Group project (?)
  - Kaggle competition - Google / Kaggle competition around MedGemma launched today -  
<https://www.kaggle.com/competitions/med-gemma-impact-challenge>. Models:  
(<https://huggingface.co/collections/google/health-ai-developer-foundations-hai-def>)

# Trust Scenario

---



Alan – wants to give an entity

What decisions should be made by Alan?

Can AI help Alan make better decisions?

## Candidates

- Want money
  - May be more needy (or effective) than others
  - May be more efficient (less wasteful) than others in using it
- May change behavior after receiving donation
- May use money in different ways than promised

# Projects in Automated Trusted Entity Exchange

- **Actors**

- AA: gives that entity
- BB: deserves a prized entity (e.g., recognition, organ, car, food, ...)
- CC: wants that entity

- **Events:**

- T1 - CC declares their interest in the entity
- T2 - AA gives the entity to BB
- T3 - BB gives the entity away to CC // possibly under duress
- T4 - <You are called to judge actors related to entity exchange>

What if chain of events was done by automated agents or agents + humans?

What behaviors will we be ascribe to various (hybrid) actors?

Ethical Concepts Applied to Actors:

- Awarding or Donating or Gifting or Quid-pro-quo/ Swapping favors (entities) – AA, BB ?
- Deserving – [BB, by axiom], CC ?
- Stealing or Extorting – CC ?
- Entity (Money) Laundering – BB ?
- Bribery – AA, BB, CC ?
- Corruption – AA, BB, CC ?
- ...

# Potential Individual Project

---

- **Individual** - Consider a behavior in entity exchange use case (**Bribery, Donation, Awarding, Corruption, ...**)
  - Formalize the use-case for computational analysis (with actors, events and exchanges)
    - Research humanities on what they mean in law and philosophy
    - Consider typical examples
  - Determine the behavior is legal / illegal, and why
    - Consider multiple regions and settings
  - Given a new situation (data)
    - Process data
    - Determine type of behavior it is
- **Group** – Assemble individual projects into a combined system
  - **Ethical decision making**, for agents and dummies
- Reference:
  - Tackling Corruption With Agents & ICT: A Vision, <https://arxiv.org/abs/1701.06426>, 2016

# Other Ideas

---

- Financial fraud detection in transactional data:

<https://www.kaggle.com/datasets/sriharshaedala/financial-fraud-detection-dataset/>

- How do we explain a flagged transaction?

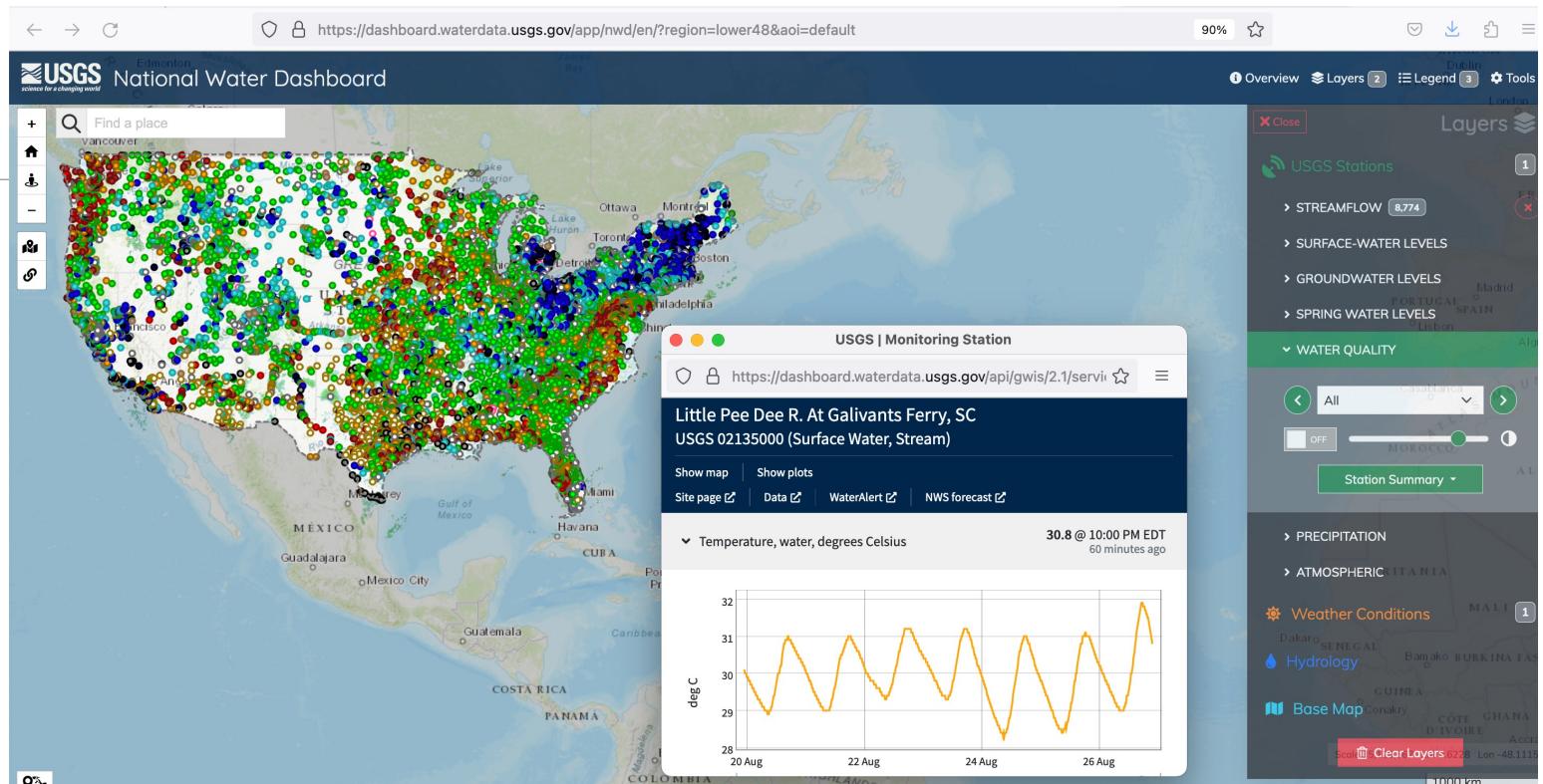
# Week 2, Lecture 4

---

---

# 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

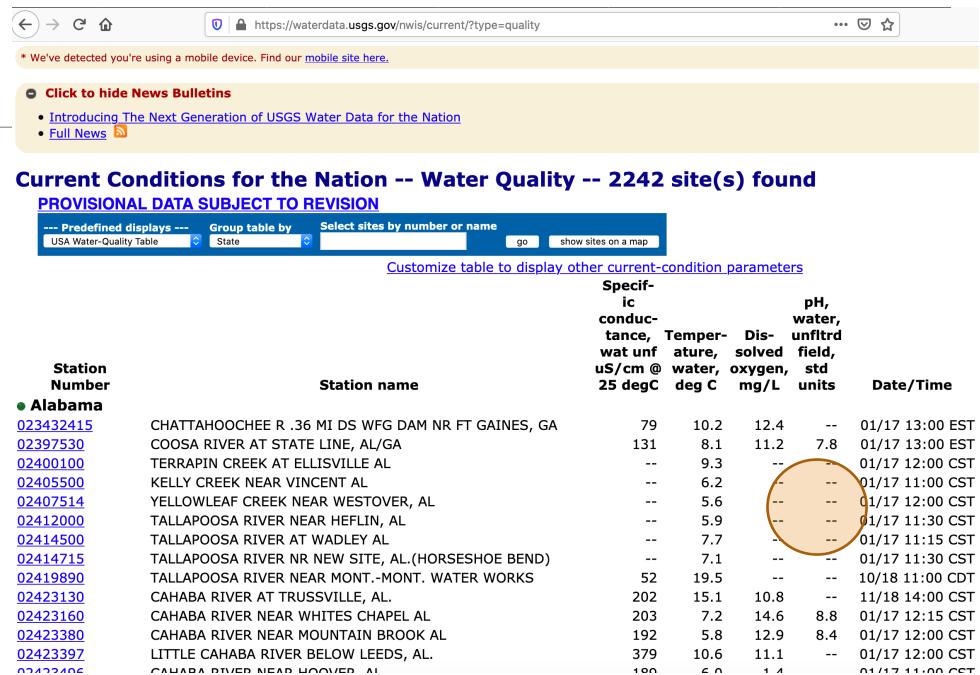
- Missing completely at random
- Missing at random (a group not wanting to participate)
- Missing not at random (a group not able to participate)

## • 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, and Date/Time. A red circle highlights the "Date/Time" column.

| Station Number            | Station name                                       | Specific conductance<br>25 degC | Temperature<br>wat unf<br>deg C | Dissolved oxygen<br>mg/L | pH,<br>water,<br>uniftrd<br>field,<br>std<br>units | Date/Time       |
|---------------------------|----------------------------------------------------|---------------------------------|---------------------------------|--------------------------|----------------------------------------------------|-----------------|
| <a href="#">023432415</a> | CHATTahoochee R .36 MI DS WFG DAM NR FT GAINES, GA | 79                              | 10.2                            | 12.4                     | --                                                 | 01/17 13:00 EST |
| <a href="#">02397530</a>  | COOSA RIVER AT STATE LINE, AL/GA                   | 131                             | 8.1                             | 11.2                     | 7.8                                                | 01/17 13:00 EST |
| <a href="#">02400100</a>  | TERRAPIN CREEK AT ELLISVILLE AL                    | --                              | 9.3                             | --                       | --                                                 | 01/17 12:00 CST |
| <a href="#">02405500</a>  | KELLY CREEK NEAR VINCENT AL                        | --                              | 6.2                             | --                       | --                                                 | 01/17 11:00 CST |
| <a href="#">02407514</a>  | YELLOWLEAF CREEK NEAR WESTOVER, AL                 | --                              | 5.6                             | --                       | --                                                 | 01/17 12:00 CST |
| <a href="#">02412000</a>  | TALLAPOOSA RIVER NEAR HEFLIN, AL                   | --                              | 5.9                             | --                       | --                                                 | 01/17 11:30 CST |
| <a href="#">02414500</a>  | TALLAPOOSA RIVER AT WADLEY AL                      | --                              | 7.7                             | --                       | --                                                 | 01/17 11:15 CST |
| <a href="#">02414715</a>  | TALLAPOOSA RIVER NR NEW SITE, AL.(HORSESHOE BEND)  | --                              | 7.1                             | --                       | --                                                 | 01/17 11:30 CST |
| <a href="#">02419890</a>  | TALLAPOOSA RIVER NEAR MONT.-MONT. WATER WORKS      | 52                              | 19.5                            | --                       | --                                                 | 10/18 11:00 CDT |
| <a href="#">02423130</a>  | CAHABA RIVER AT TRUSSVILLE, AL.                    | 202                             | 15.1                            | 10.8                     | --                                                 | 11/18 14:00 CST |
| <a href="#">02423160</a>  | CAHABA RIVER NEAR WHITES CHAPEL AL                 | 203                             | 7.2                             | 14.6                     | 8.8                                                | 01/17 12:15 CST |
| <a href="#">02423380</a>  | CAHABA RIVER NEAR MOUNTAIN BROOK AL                | 192                             | 5.8                             | 12.9                     | 8.4                                                | 01/17 12:00 CST |
| <a href="#">02423397</a>  | LITTLE CAHABA RIVER BELOW LEEDS, AL.               | 379                             | 10.6                            | 11.1                     | --                                                 | 01/17 12:00 CST |
|                           | CAHABA RIVER NEAR HOOVER, AL                       | 100                             | 6.0                             | 1.1                      | --                                                 | 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

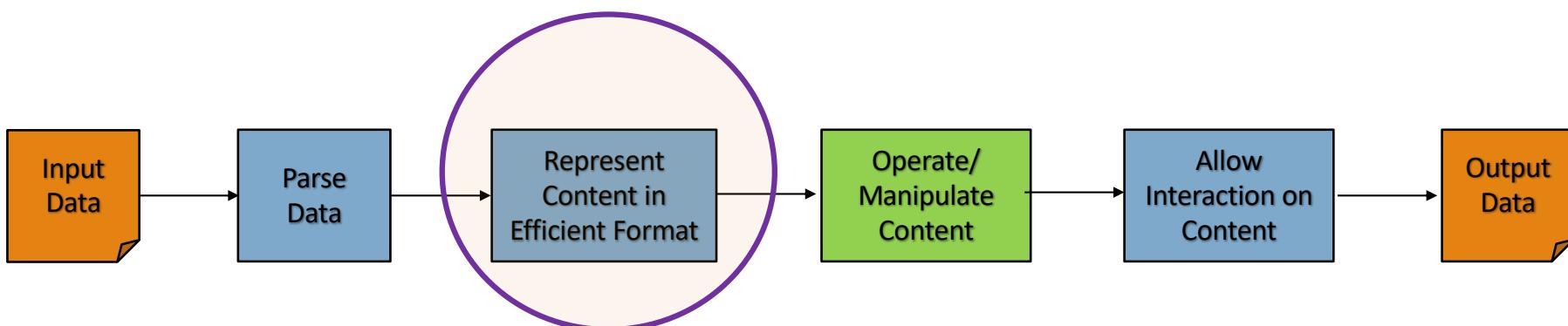
---

<https://github.com/biplav-s/course-d2d-ai/blob/main/sample-code/I5-dataprep/>

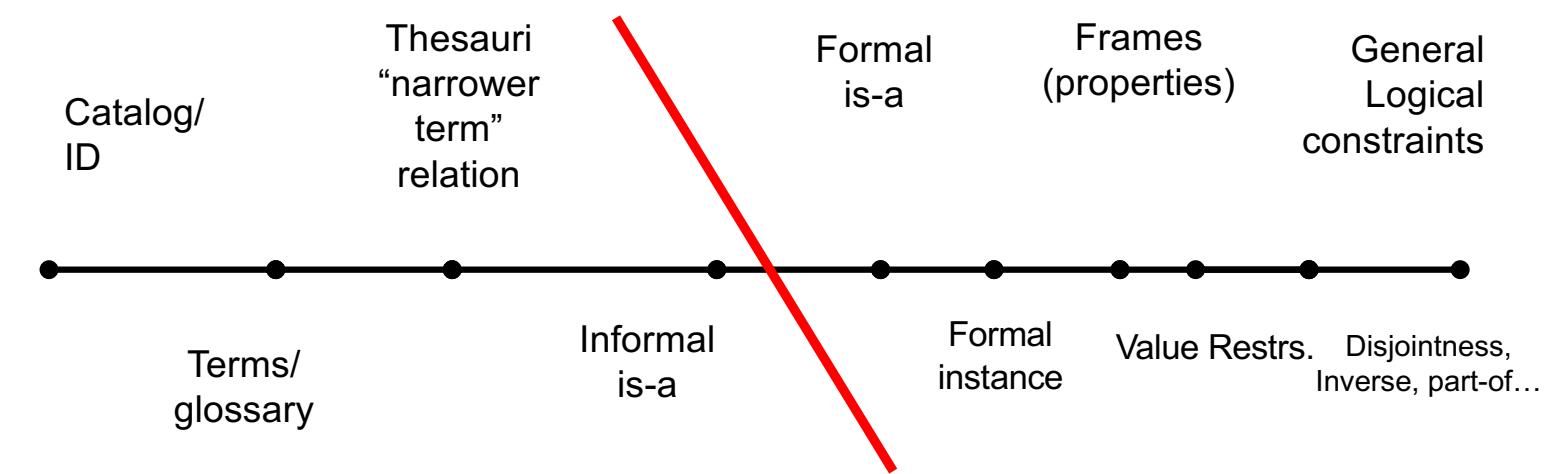
- Basic concepts: **DataPreparation-Numeric.ipynb**
- An illustration: **Clean-RealSample.ipynb**

# 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><sup>[7][8]</sup> | 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.

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

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## Sources:

Achille Fokoue, Anastasios Kementsietsidis Tutorial

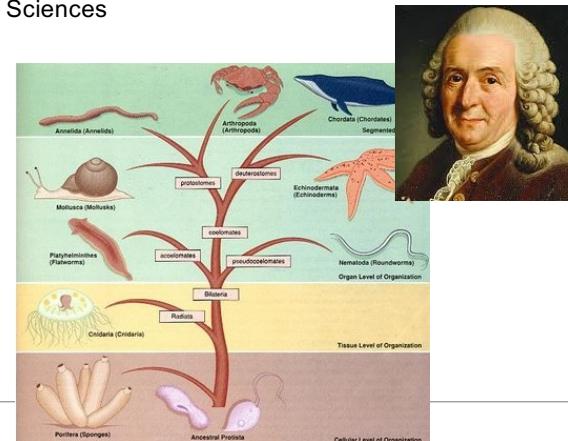
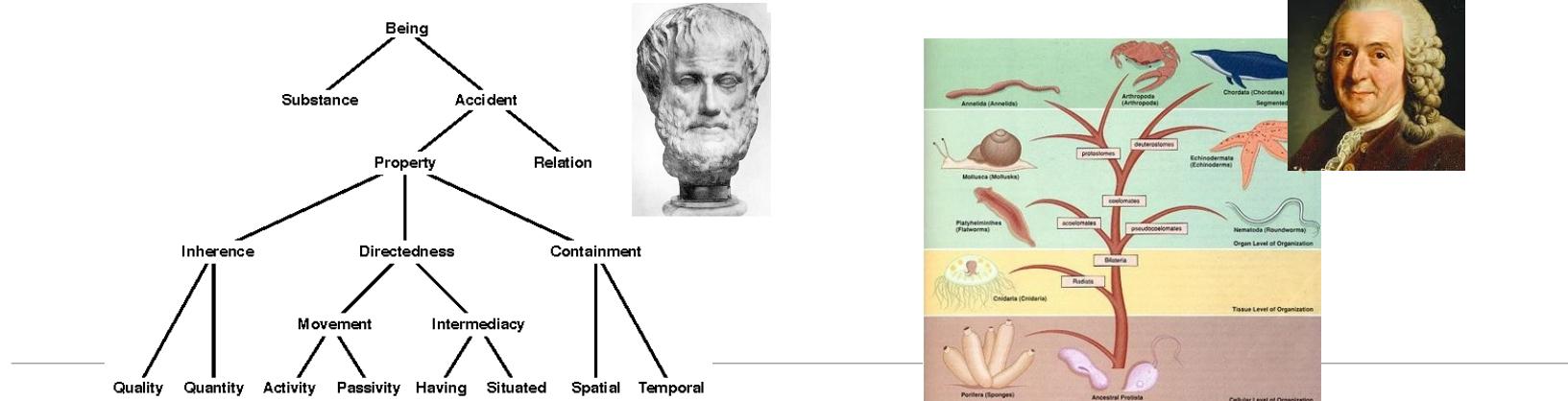
SCRIBE presentation by Rosario Usceda Sosa, Biplav Srivastava, Bob Schloss

- <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

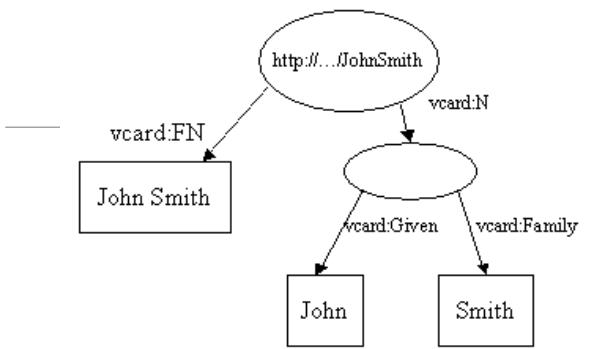


In a Smart City domain, we’re concerned with modeling the *city data* (city activity data, city departments, assets, KPIs), not the city itself (the full set of spatial and temporal relations between people and objects in the city). Ontologies help us to structure and reason about city events, entities 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">
 <vcards:FN>John Smith</vcards:FN>
 <vcards:N rdf:nodeID="A0"/>
</rdf:Description>
</rdf:RDF>
```

# OWL extends RDF...

---

## RDF-schema

- Class, subclass
- Property, subproperty

## + Restrictions

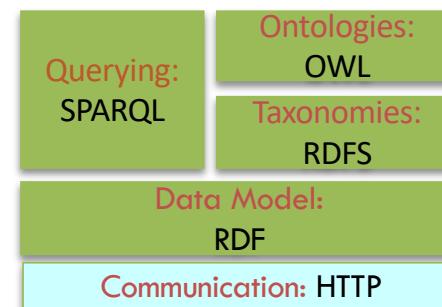
- Range, domain
- Local, global
- Existential
- Cardinality

## + Combinators

- Union, Intersection
- Complement
- Symmetric, transitive

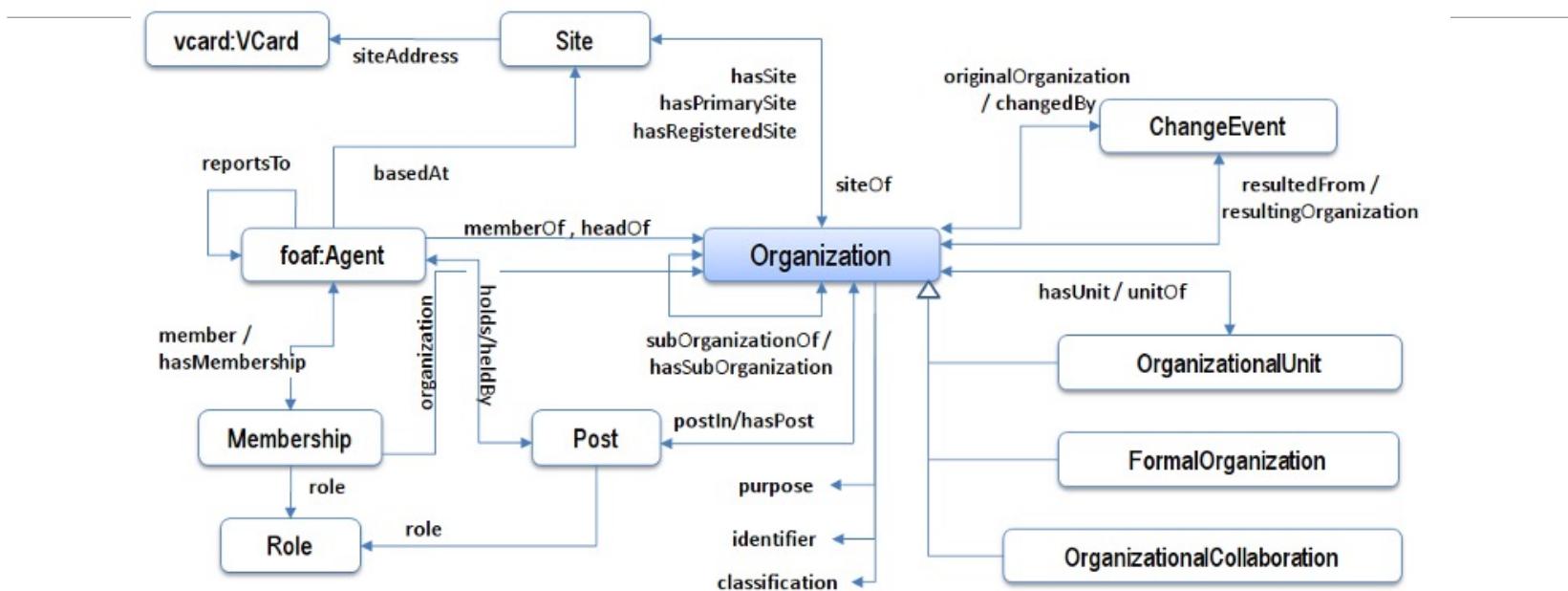
## + Mapping

- 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

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

```

@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;
 dc:created "2010-05-28"^^xsd:date;
 dc:modified "2010-06-09"^^xsd:date;
 dc: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> ;
.

```

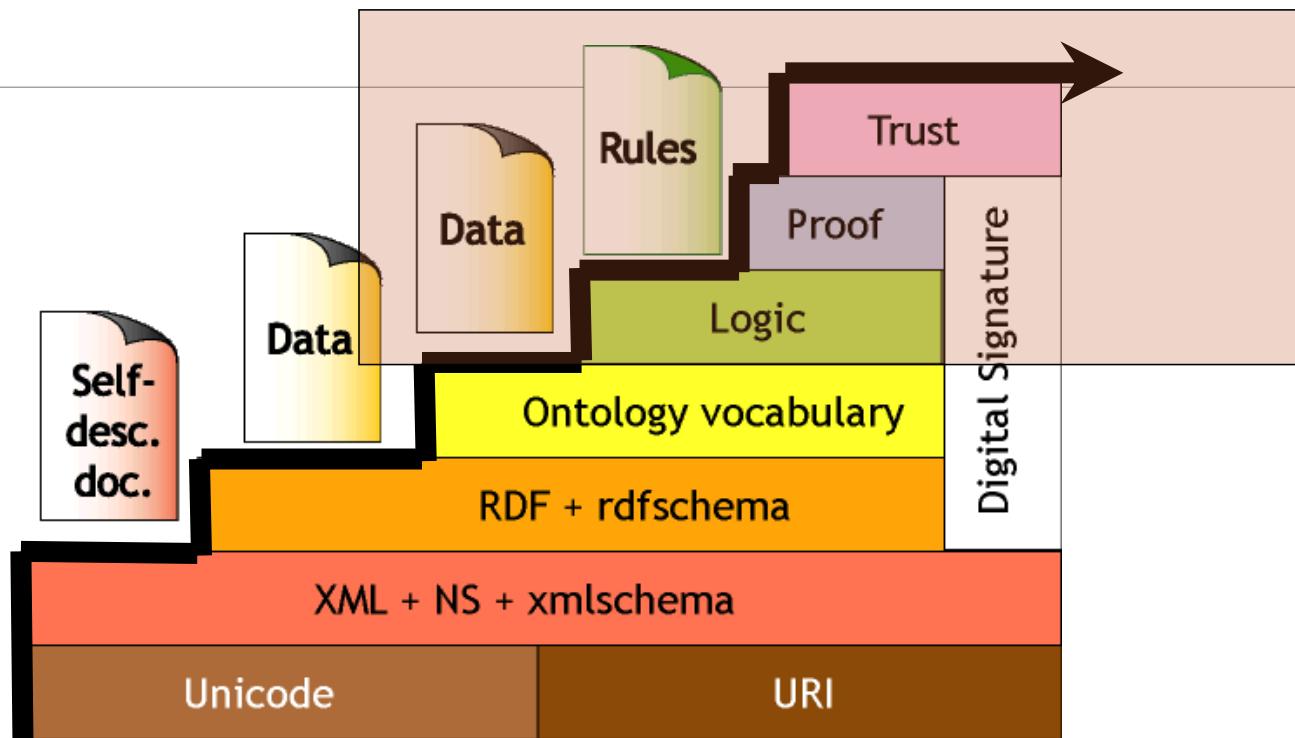
```

- <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#">
+ <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>
 <owl:Class rdf:about="http://www.w3.org/ns/org#Role" />
 <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" />
<rdf: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

```

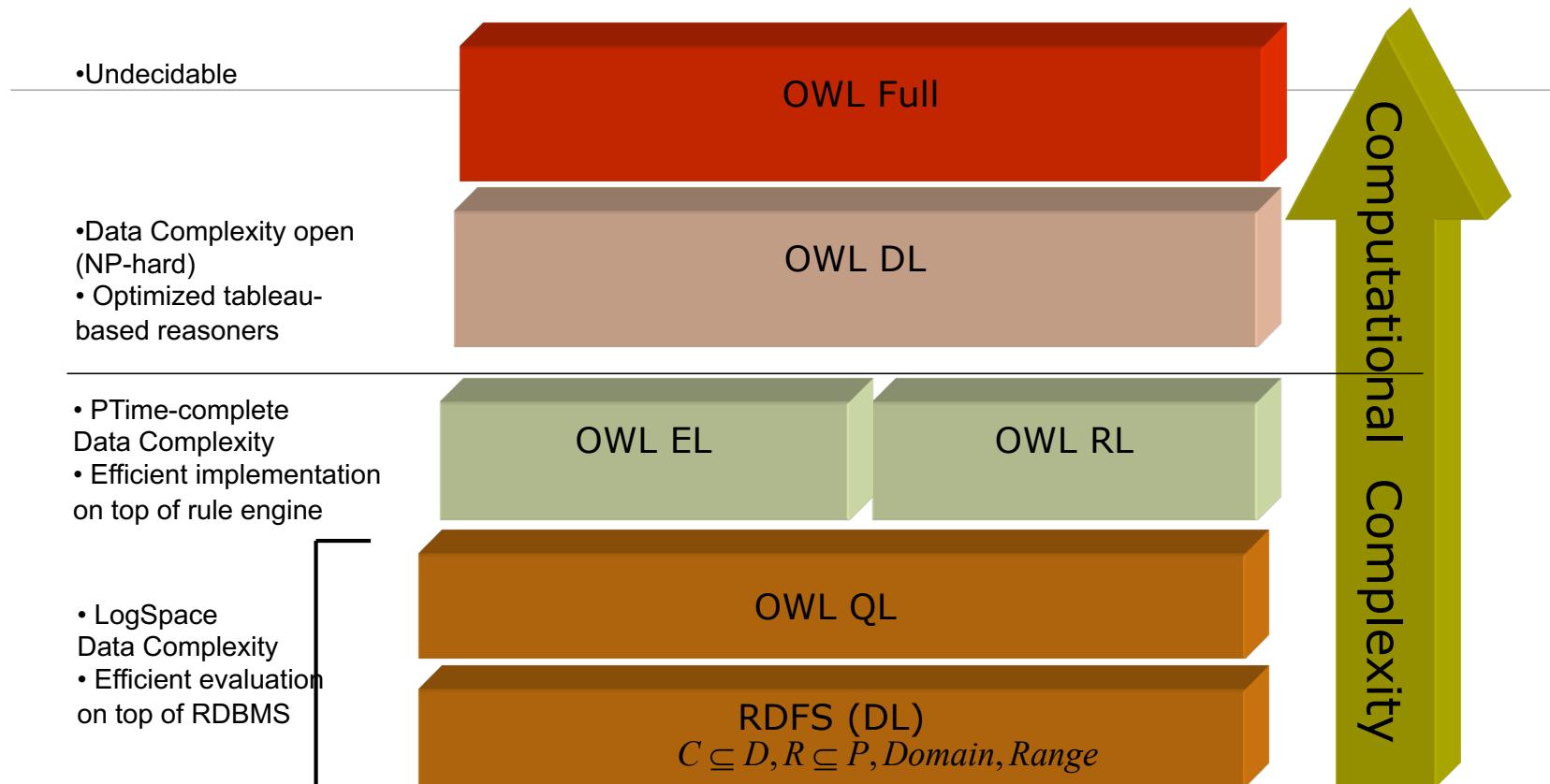
<http://www.w3.org/ns/org>

# 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>
  - 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: 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