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- How can we use that information to answer **questions?**

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- How do we **prevent miscommunication** amongst different Web-based information sources?

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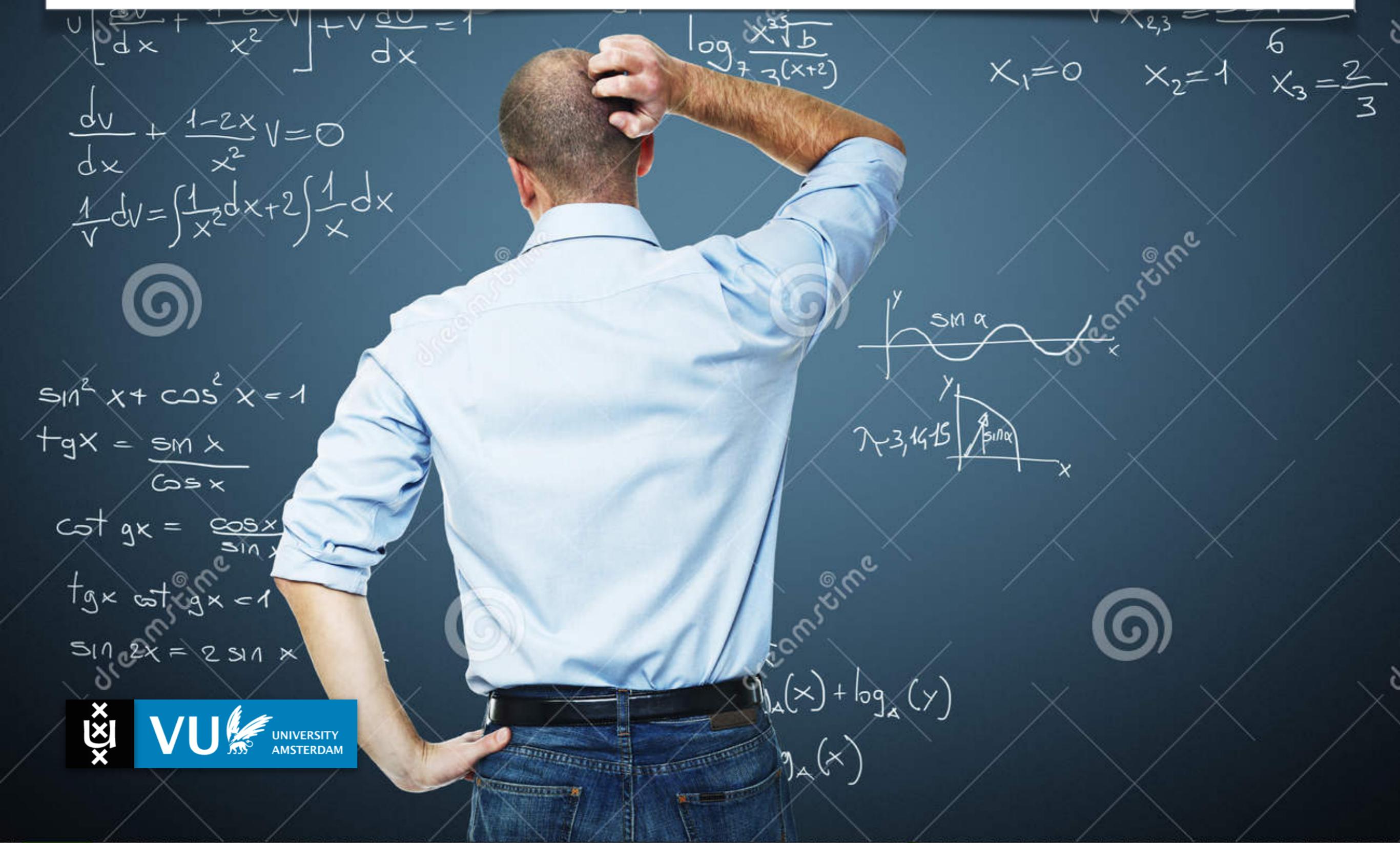
- What should **information** look like if we want to use the Web to share information between machines?
- How can we use that information to answer **questions**?
- How do we **prevent miscommunication** amongst different Web-based information sources?
- How do you **connect and integrate** different information sources?

Answers to these questions...

- What should **information** look like if we want to use the Web to share information between machines?
- How can we use that information to answer **questions**?
- How do we **prevent miscommunication** amongst different Web-based information sources?
- How do you **connect and integrate** different information sources?
- How can we build **applications** that use this information?

Problem

most web-accessible information is meant for people



where was gone with the w

https://www.google.nl/search?q=where+was+gone+with+the+wind+filmed&espv=210&es_sm=93

Google where was gone with the wind filmed

Web Images Maps Shopping Videos More Search tools

About 2,550,000 results (0.45 seconds)

Gone with the Wind (1939) - Filming Locations - IMDb
www.imdb.com/title/tt0031381/locations ▾
25+ items - Gone with the Wind (1939) Movies, TV, Celebs, and more...
Bidwell Park - Manzanita Avenue, Chico, California, USA
Northern California, California, USA.

Gone with the Wind (film) - Wikipedia, the free encyclopedia
[en.wikipedia.org/wiki/Gone_with_the_Wind_\(film\)](http://en.wikipedia.org/wiki/Gone_with_the_Wind_(film)) ▾
Jump to Filming - Filming[edit]. Principal photography began January 26, 1939, and ended on July 1, with post-production work continuing until November ...
Vivien Leigh - Olivia de Havilland - Leslie Howard - Scarlett O'Hara

Film locations for Gone With The Wind (1939) - Movie-Locations.com
[www.movie-locations.com](http://www.movie-locations.com/films/g/) › Films › G ▾
3 days ago - Filming locations for classic film Gone With the Wind, around Los Angeles and California.

Gone with the Wind: Tara and Twelve Oaks - Hooked on Houses
hookedonhouses.net/.../gone-with-the-wind-tara-twelve-oaks-aunt-pittyp... ▾
Mar 22, 2009 - When I first saw Gone with the Wind as a teenager, I was captivated. ... The movie was filmed in California, not anywhere near the South.

Gone with the Wind & Vivien Leigh home video footage discovered ...
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The actual home "Tara" used in the film 'Gone With the Wind' is ...
www.funtrivia.com/askft/Question90959.html ▾
Jan 9, 2008 - 4 posts - 4 authors
The actual home Tara used in the film Gone With the Wind is located ... Interestingly ...



What just happened?

What did Google do?

- It found pages with the terms specified
- Ranked them according to relevance and quality

How did Google do it?

- Statistical analysis
- Heuristics

What did Google **not** do?

Answer the query

- It shows some web pages where the answer may lie
- Relies on users to interpret the content of the pages
- Users need to combine information from several pages

Understand

- The query
- The content of web pages in the results

Often, search engines are good enough

Screenshot of a Google search results page for "where was gone with the wind filmed".

Google search bar: where was gone with the wind filmed

Search tools: +Rinke, Share, User profile

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... but not always

A screenshot of a Google search results page. The search query is "hotels in cities where EasyJet flies". The results are as follows:

- Ad related to hotels in cities where EasyJet flies**
[Vlietickets easyJet® - easyJet.com](#)
www.easyjet.com/nl/Vlietickets ▾
★★★★★ 31 reviews for easyjet.com
Ontdek al onze bestemmingen en boek snel en goedkoop bij easyJet®!
easyJet has 3,902 followers on Google+
Londen vanaf € 27,92 - Rome vanaf € 35,10 - Lissabon vanaf € 32,02
- [Cheap flights – Book cheap flights to Europe - easyJet.com](#)
www.easyjet.com/ ▾
Book cheap flights at the official easyJet.com site for our guaranteed best prices to over 130 destinations. Allocated ... Why book with Booking.com hotels?
- [Cheap flights to Amsterdam | easyJet](#)
www.easyjet.com/en/cheap-flights/netherlands/amsterdam ▾
Book cheap flights to Amsterdam and find tourism information on sightseeing, shopping, restaurants and nightlife in ... Accommodation deals ... Tolerant, welcoming and a lot of fun, Amsterdam is a city that likes to take things at a leisurely pace ...
- [4 Star Hotels in Amsterdam City | easyJet Holidays](#)
holidays.easyjet.com/netherlands/amsterdam/...city/4-star-hotels.htm ▾
Find the best 4 star hotels in Amsterdam City with easyJet Holidays. Book your luxury 4 star holiday in Amsterdam City today. ... Outbound: Outbound flight.
- [Cheap Flights | easyJet](#)
www.easyjet.com/en/cheap-flights ▾
Travel guides. Accommodation deals ... Accommodation deals ... City breaks ... No matter what sort of travel you're planning we've got the flights to get you there.

Let's go to the cinema!



Let's go to the cinema!

- VU Campus, 20:00 ...
- "Let's go see Inside Out now!"
- Need to find out which cinema plays the movie tonight, e.g. on <http://www.google.com/movies>
- Need to find out where those cinemas are...
- Need to find out which of those cinemas we can reach on time using public transport, e.g. on <http://maps.google.com>
- Web users still need to combine information from different sites
- Essentially a database join.

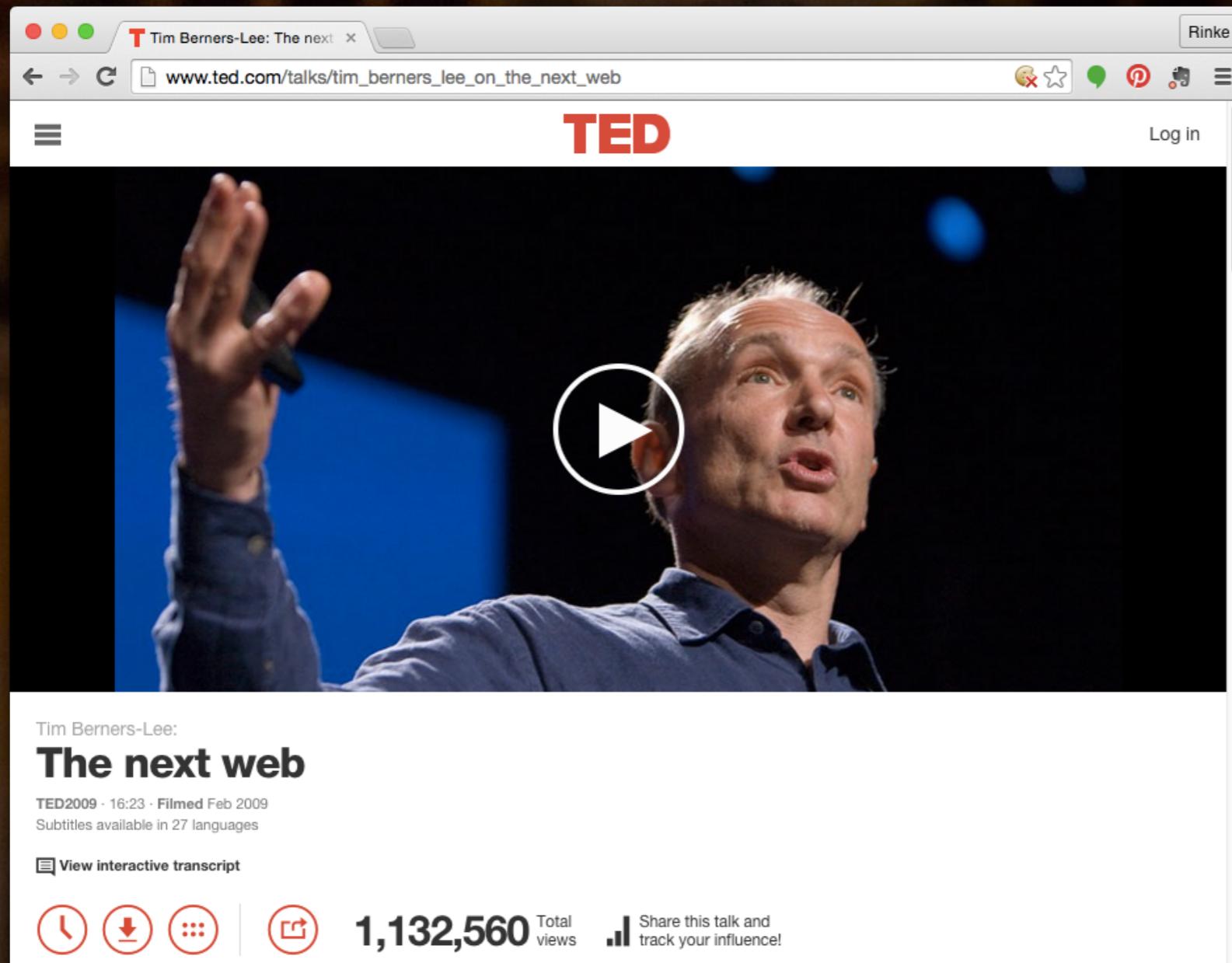
The solution?

- Wait for Google to produce a **Maps and Movies** mashup?
- But what about:
 - Real estate + public transport?
 - Plane schedules and pricing + weather information?
 - Car rental + tourism?
 - Public information + private information
(preferences, calendar, location, etc.)
- ... can hardly wait for a **separate mashup for each useful combination!**

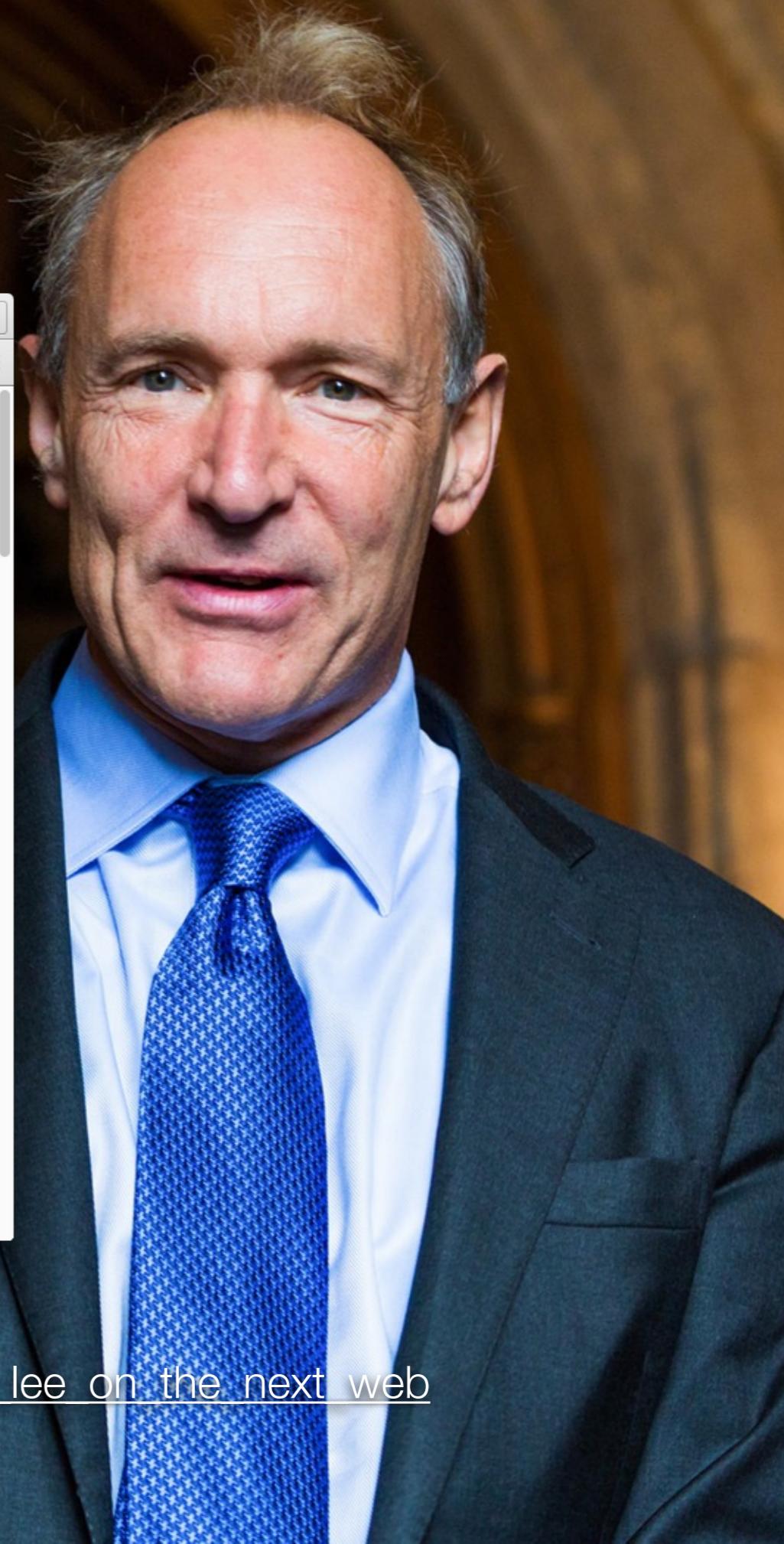
The Vision for a **Web of Data**

"There is lots of data we all use every day, and it's not part of the web. I can see my bank statements on the web, and my photographs, and I can see my appointments in a calendar. But can I see my photos in a calendar to see what I was doing when I took them? Can I see bank statement lines in a calendar? No. Why not? Because we don't have a **web of data**. Because data is controlled by applications and **each application keeps it to itself**."

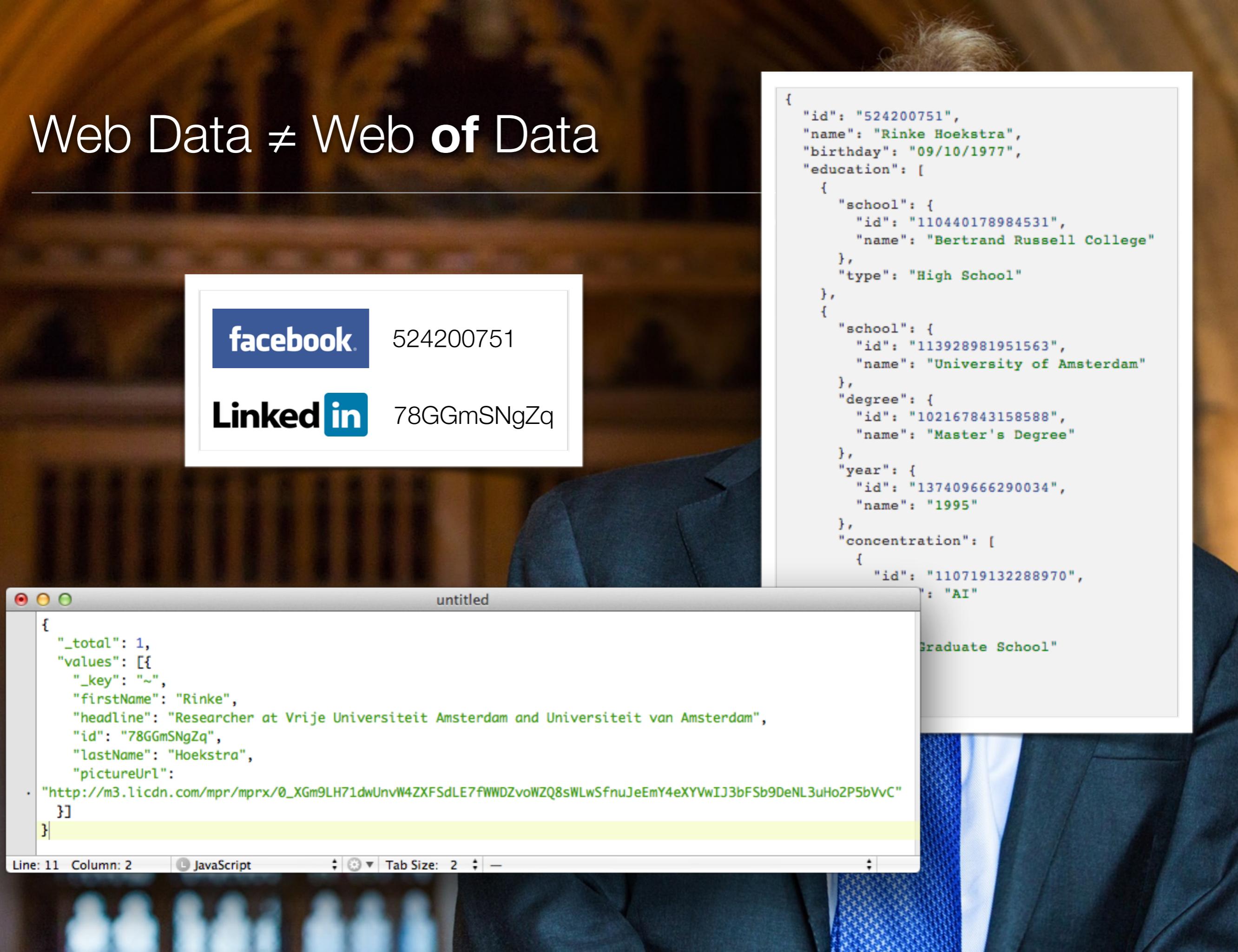
The Vision for a **Web of Data**



A screenshot of a TED talk page. The video player shows Tim Berners-Lee from the chest up, looking upwards and gesturing with his right hand. A large white play button is overlaid on the video frame. The TED logo is in the top right corner of the video player. Below the video, the title "Tim Berners-Lee: The next web" is displayed in bold black text. Underneath the title, it says "TED2009 · 16:23 · Filmed Feb 2009" and "Subtitles available in 27 languages". There are four small red circular icons with white symbols (a clock, a download arrow, a three-dot menu, and a share icon) followed by the text "1,132,560 Total views". To the right of the views count is a "Share this talk and track your influence!" button.



Web Data ≠ Web of Data

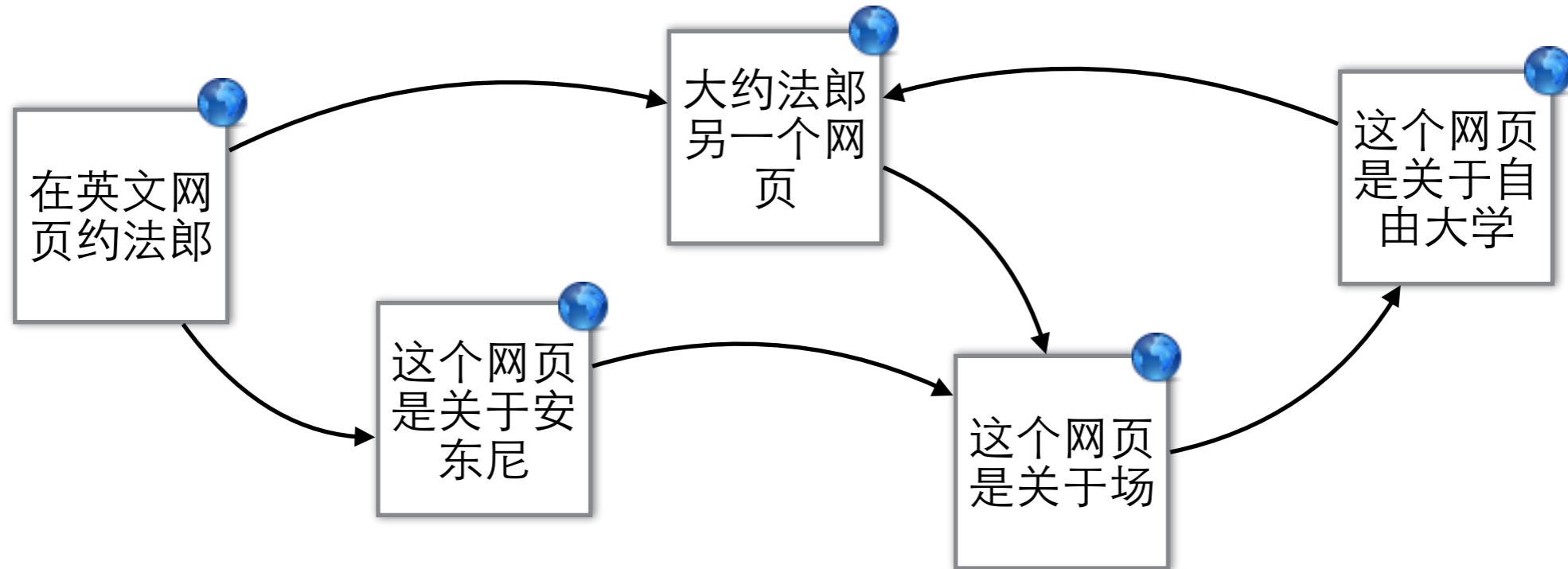


A screenshot of a computer screen showing a presentation slide. The slide has a dark background with a faint image of a person in a suit. In the center, there is a white rectangular box containing two social media profiles: Facebook (id: 524200751) and LinkedIn (id: 78GGmSNgZq). Below the box, a code editor window titled "untitled" displays JSON data. The JSON structure includes fields for total values, key, first name, last name, headline, and a picture URL. To the right of the code editor, a portion of the LinkedIn profile is visible, showing education details such as high school, university, degree, year, and concentration.

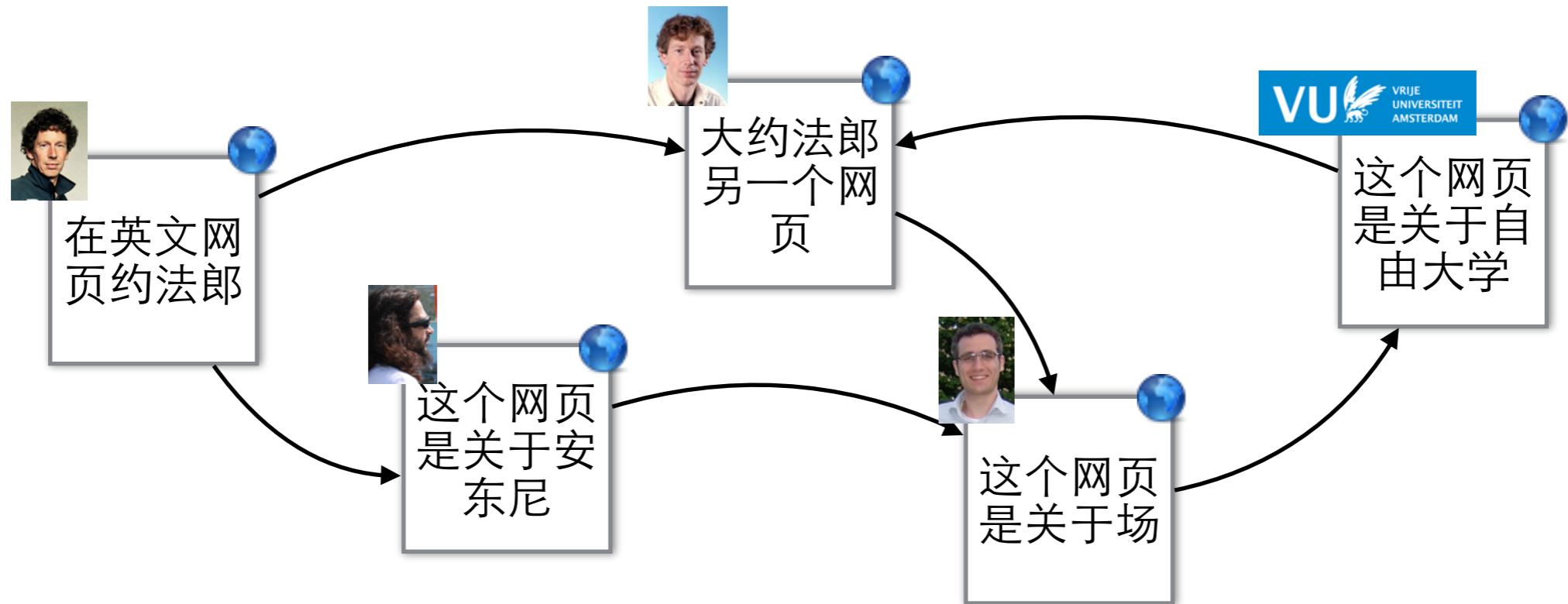
```
{  
  "_total": 1,  
  "values": [  
    {"  
      "_key": "~",  
      "firstName": "Rinke",  
      "headline": "Researcher at Vrije Universiteit Amsterdam and Universiteit van Amsterdam",  
      "id": "78GGmSNgZq",  
      "lastName": "Hoekstra",  
      "pictureUrl":  
        "http://m3.licdn.com/mpr/mprx/0_XGm9LH71dwUnvW4ZXFSdLE7fWWDZvoWZQ8sWLwSfnJeEmY4eXYVwIJ3bFSb9DeNL3uHo2P5bVvC"  
    }]  
}
```

```
{  
  "id": "524200751",  
  "name": "Rinke Hoekstra",  
  "birthday": "09/10/1977",  
  "education": [  
    {  
      "school": {  
        "id": "110440178984531",  
        "name": "Bertrand Russell College"  
      },  
      "type": "High School"  
    },  
    {  
      "school": {  
        "id": "113928981951563",  
        "name": "University of Amsterdam"  
      },  
      "degree": {  
        "id": "102167843158588",  
        "name": "Master's Degree"  
      },  
      "year": {  
        "id": "137409666290034",  
        "name": "1995"  
      },  
      "concentration": [  
        {  
          "id": "110719132288970",  
          "name": "AI"  
        }  
      ]  
    }  
  ]  
}
```

The Current Web of Text and Pictures

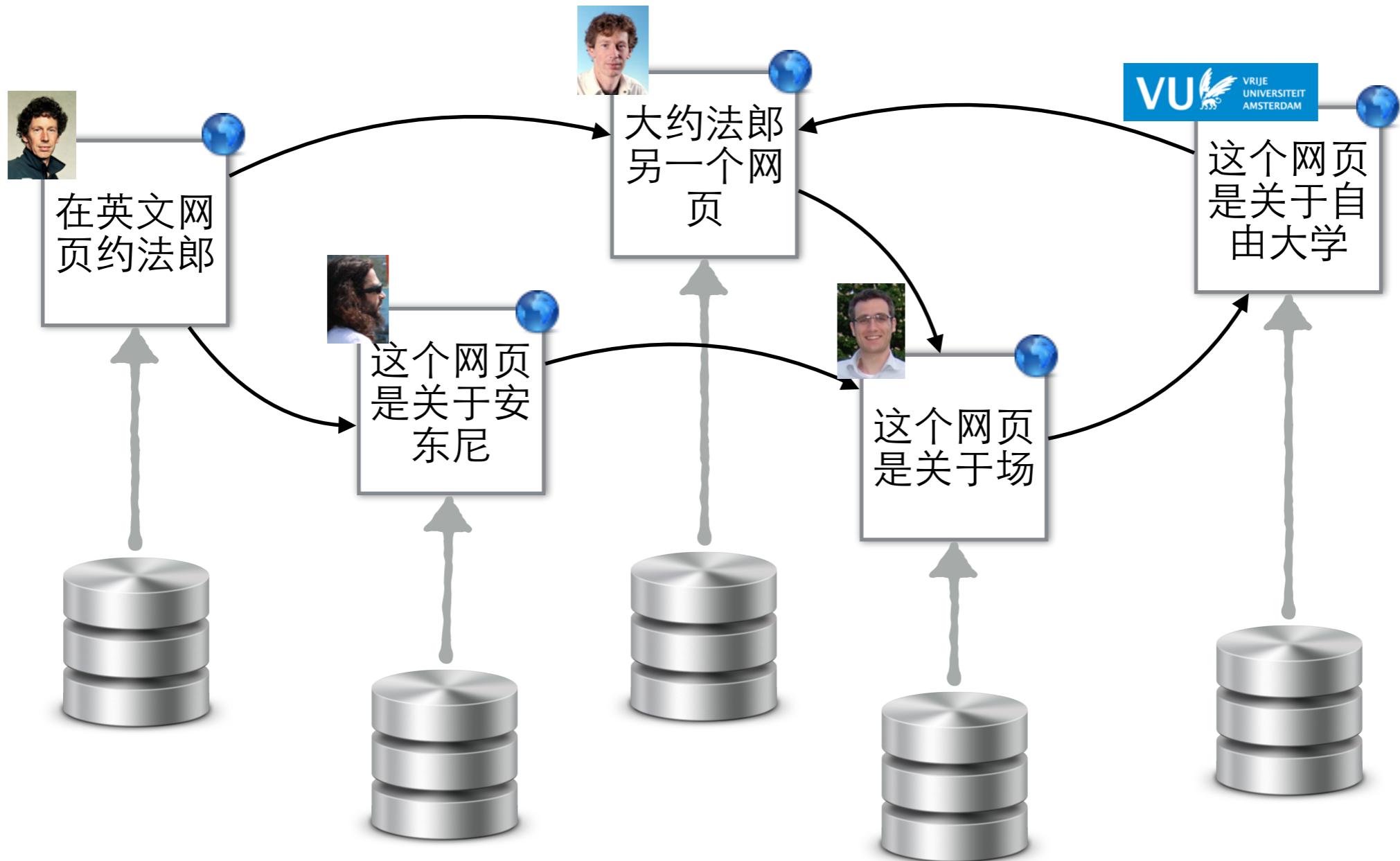


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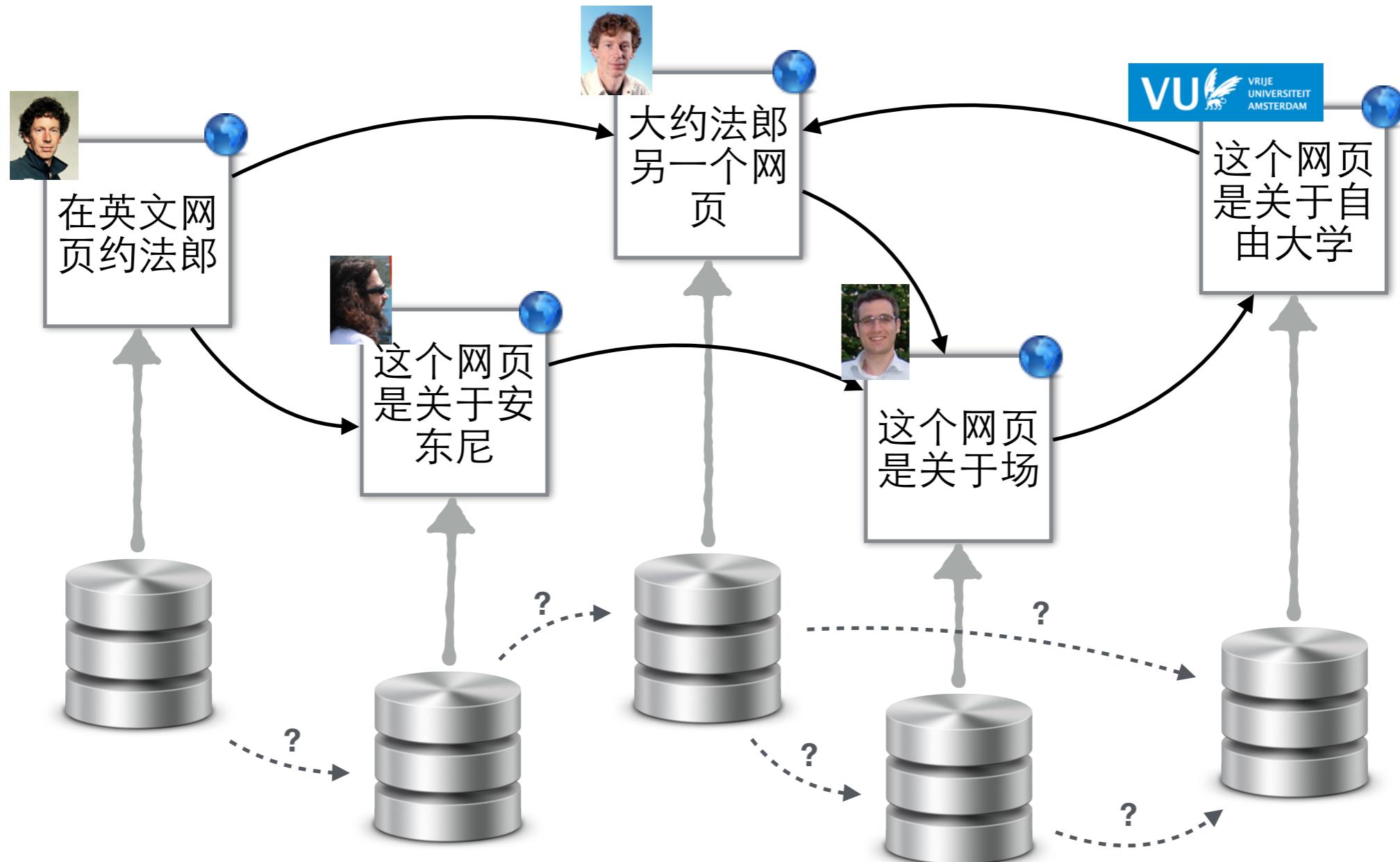
Linked **web pages**, written for **people**, used only by **people**

The Current Web of Text and Pictures



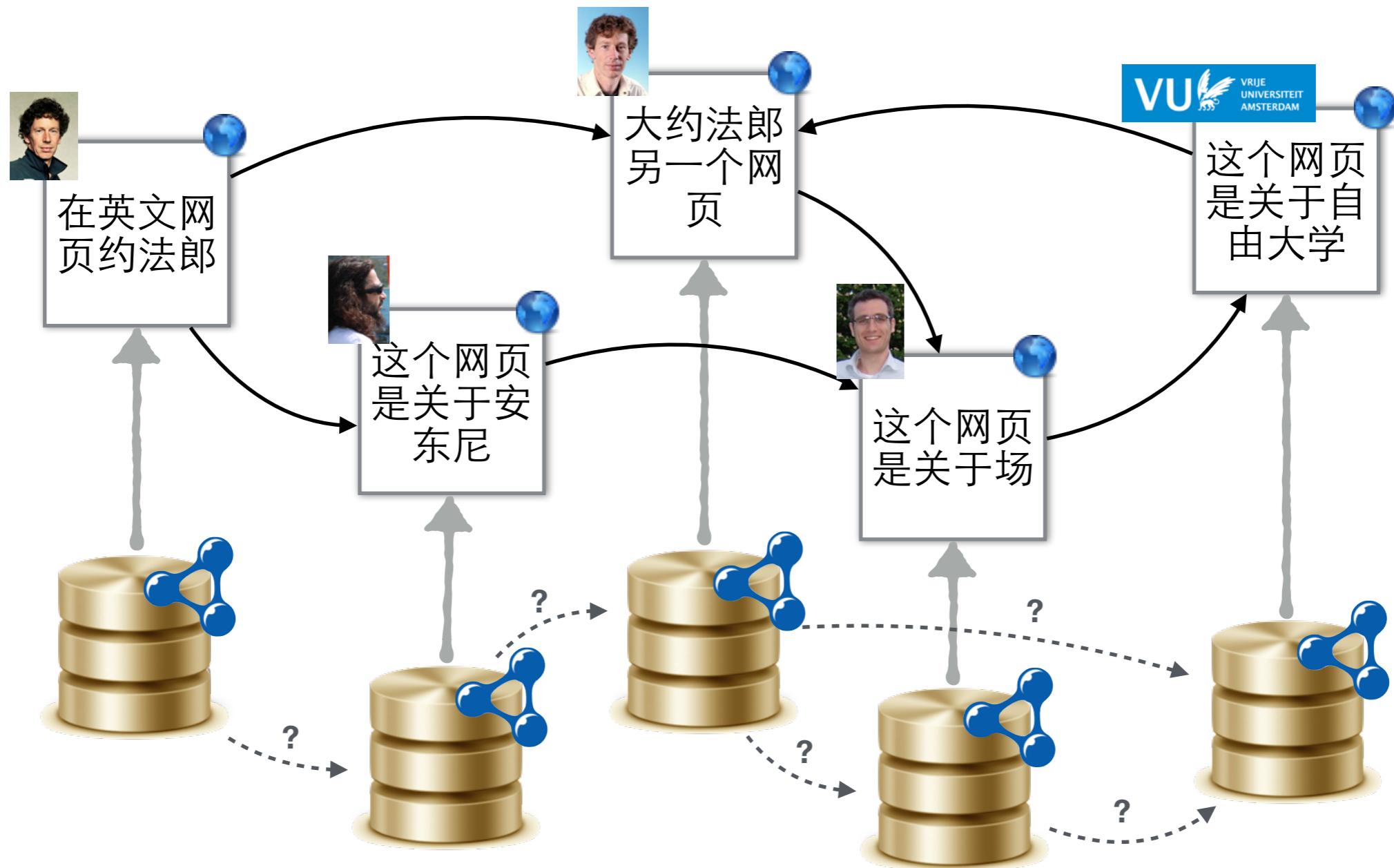
Many of these **pages** already use **data** that's usable by **computers**

The Current Web of Text and Pictures



But we can't **link** the **data**...

The Web of Data



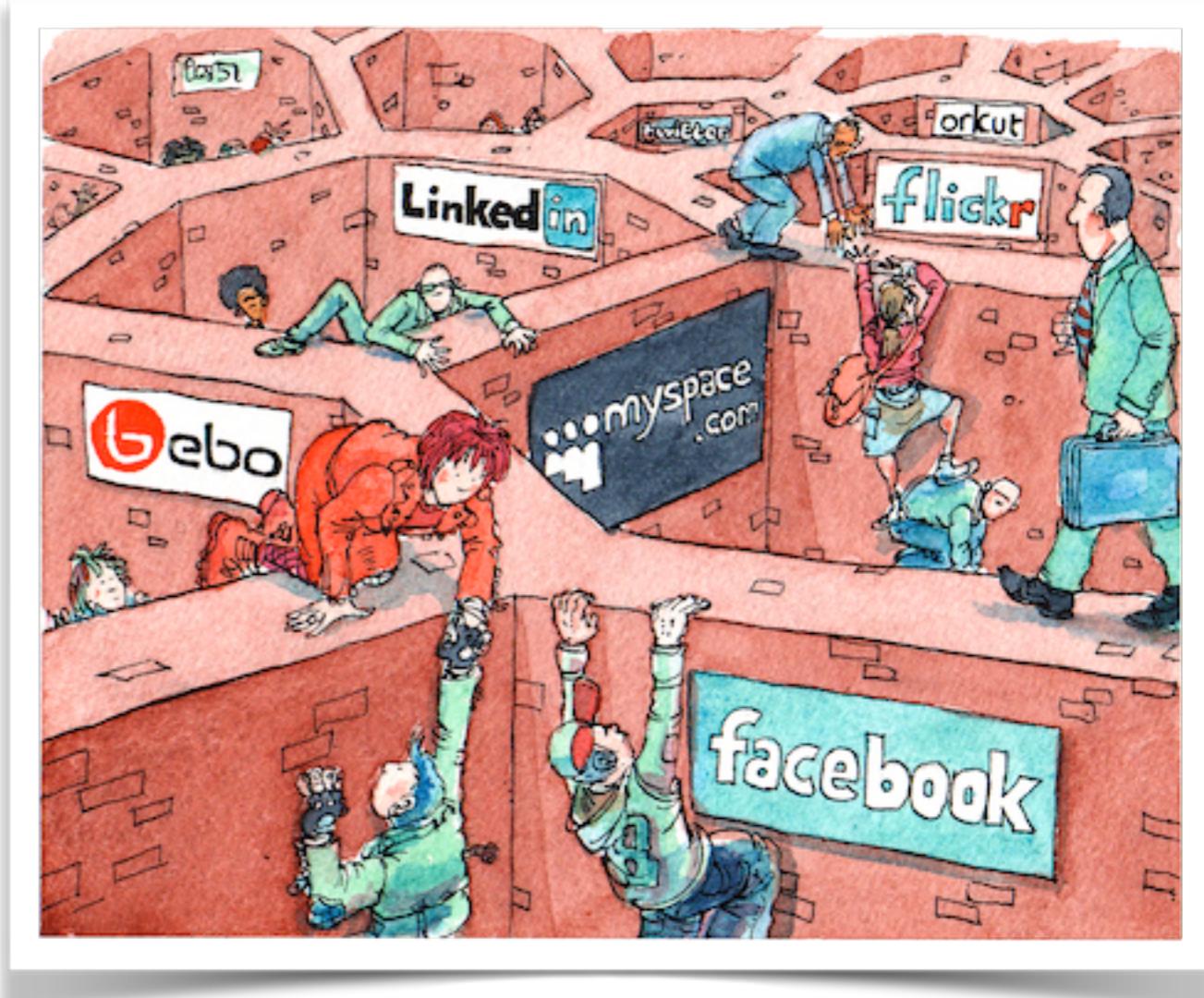
Linked Data, understandable for **machines**, useful for **people!**

The Vision for a **Semantic Web**

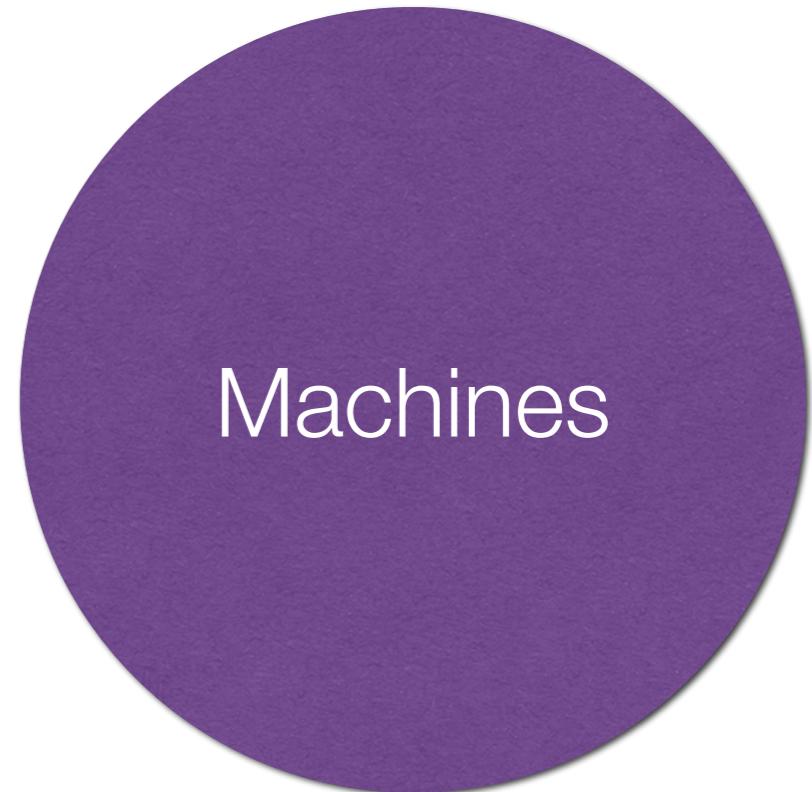
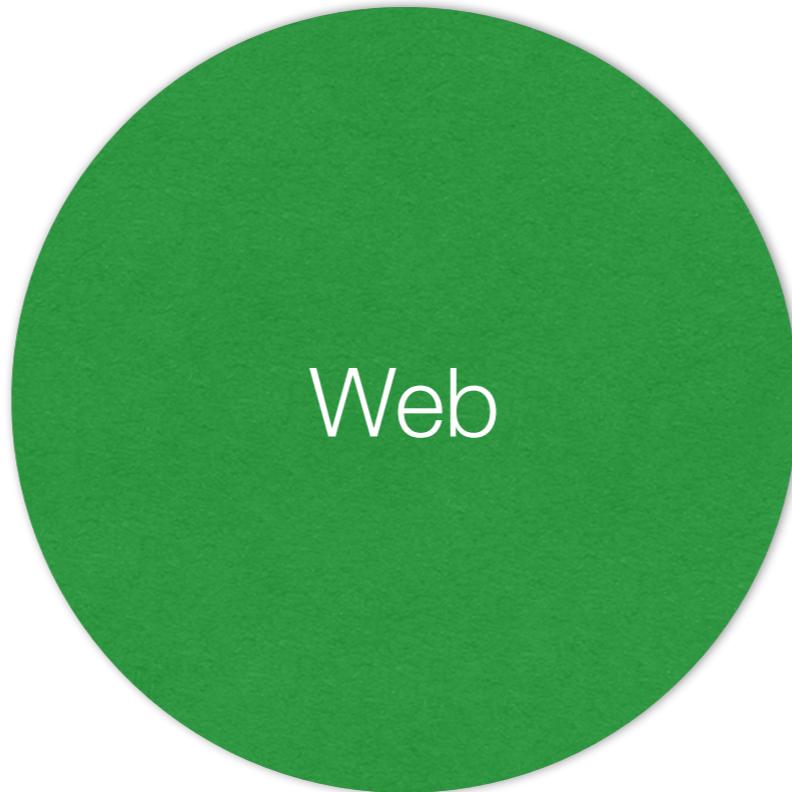
"I have a dream for the Web [in which computers] become capable of **analyzing** all the data on the Web—the content, links, and transactions between people and computers. A ‘Semantic Web’, which should make this possible, has yet to emerge, but when it does, the day-to-day mechanisms of trade, bureaucracy and our daily lives will be handled by machines talking to machines. The ‘intelligent agents’ people have touted for ages will finally materialize."

Imagine a **Semantic Web of Data**

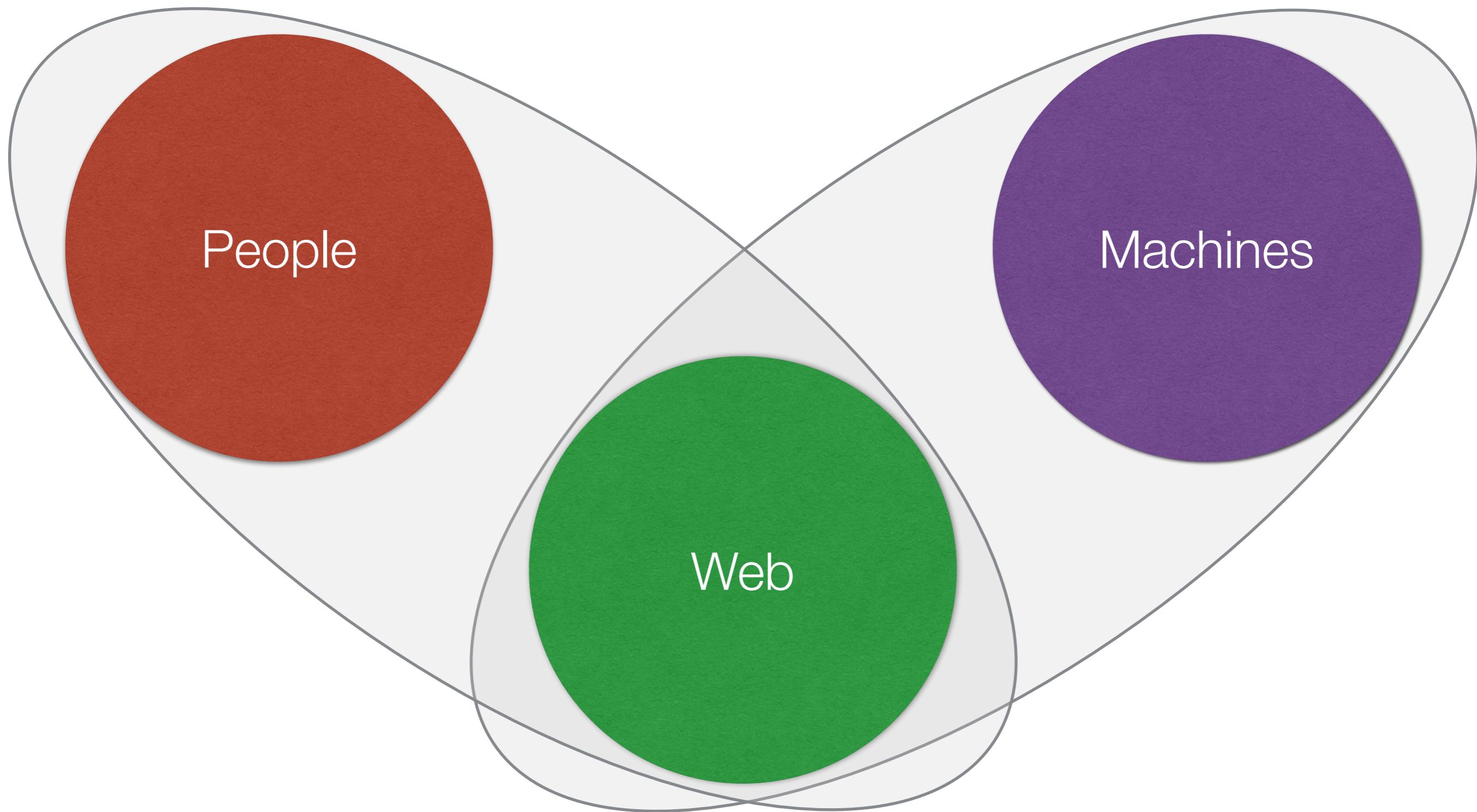
- Websites publish their information in a **machine-readable** format;
- The data published by different sources is **linked**;
- Enough **domain knowledge** is available to machines to make use of the information;
- Machines can **find and combine** published information in appropriate ways to answer the user's information needs.



But **how?**



But **how**?



4 proposals

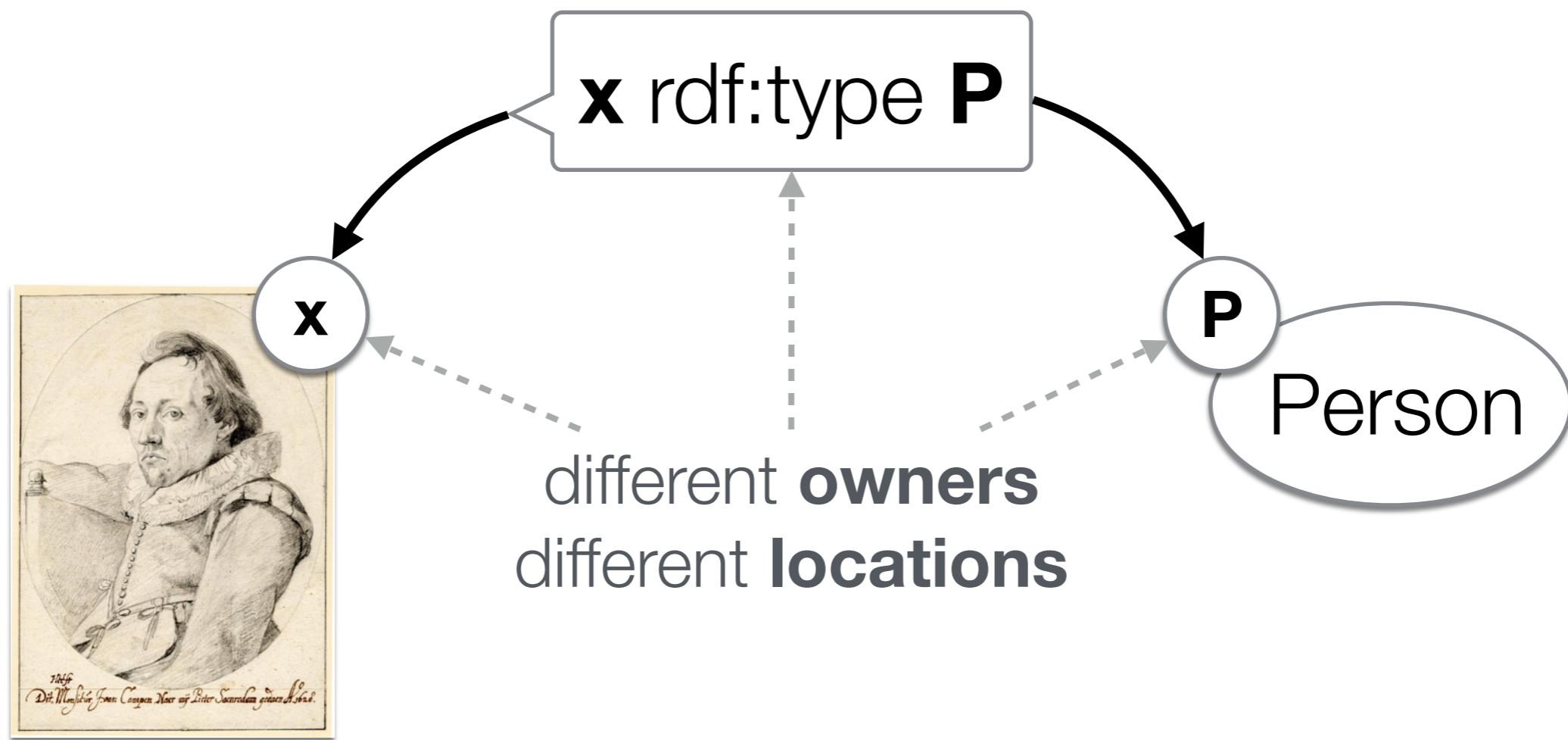




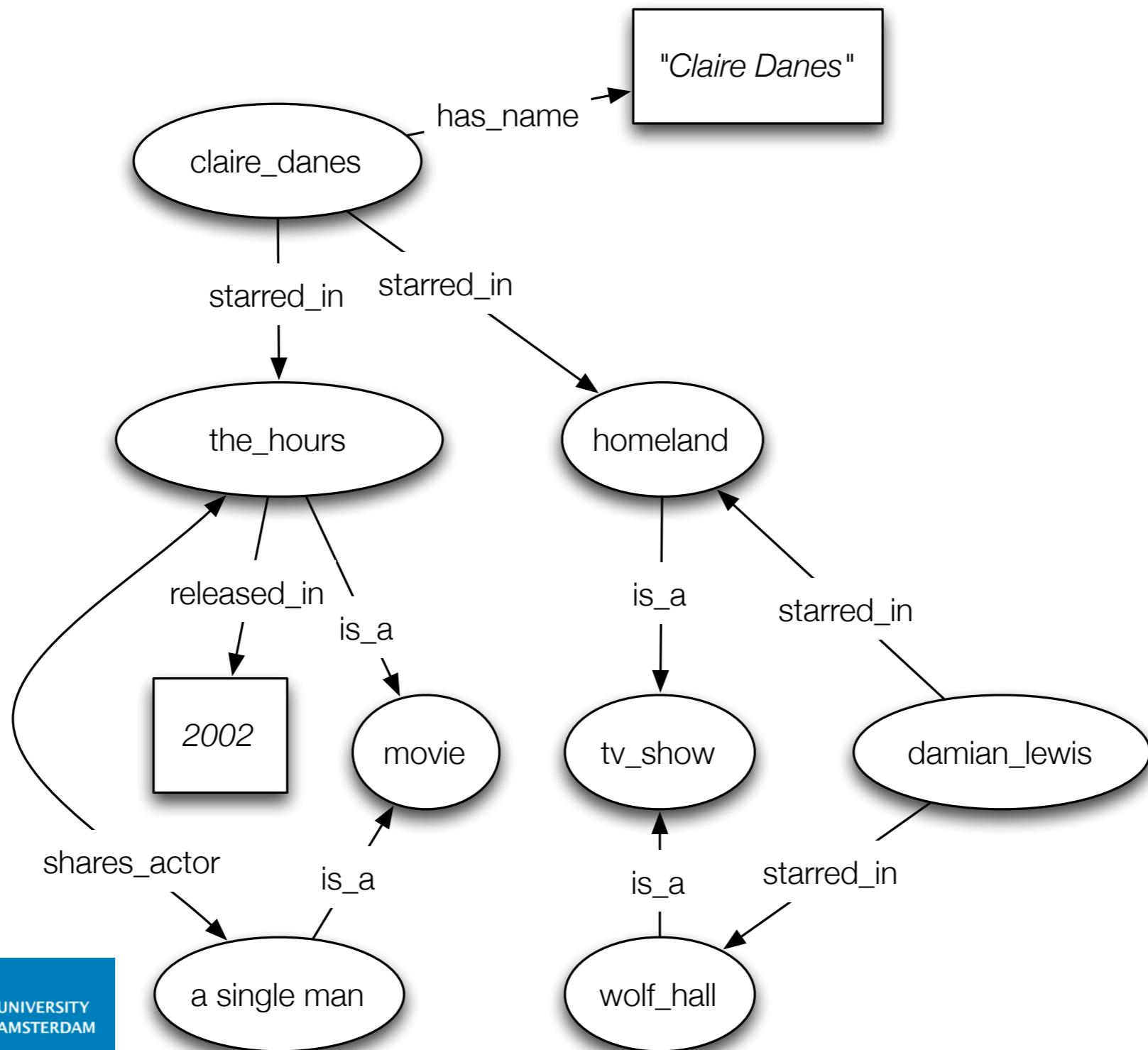
P1 Give all things a name



P2 The **names** are **addresses** on the Web



P3 Relations form a **graph** between **things**





P1 + P2 + P3 = A global graph of Linked Data

P4 Make explicit the **meaning** of things

- Not just the **data**, but its underlying **model** as well
 - Assign **types** to things
 - Assign **types** to relations
 - Organize types in a **hierarchy**
- Rules for **calculating** with that knowledge...
...impose **constraints** on possible interpretations

Modeling

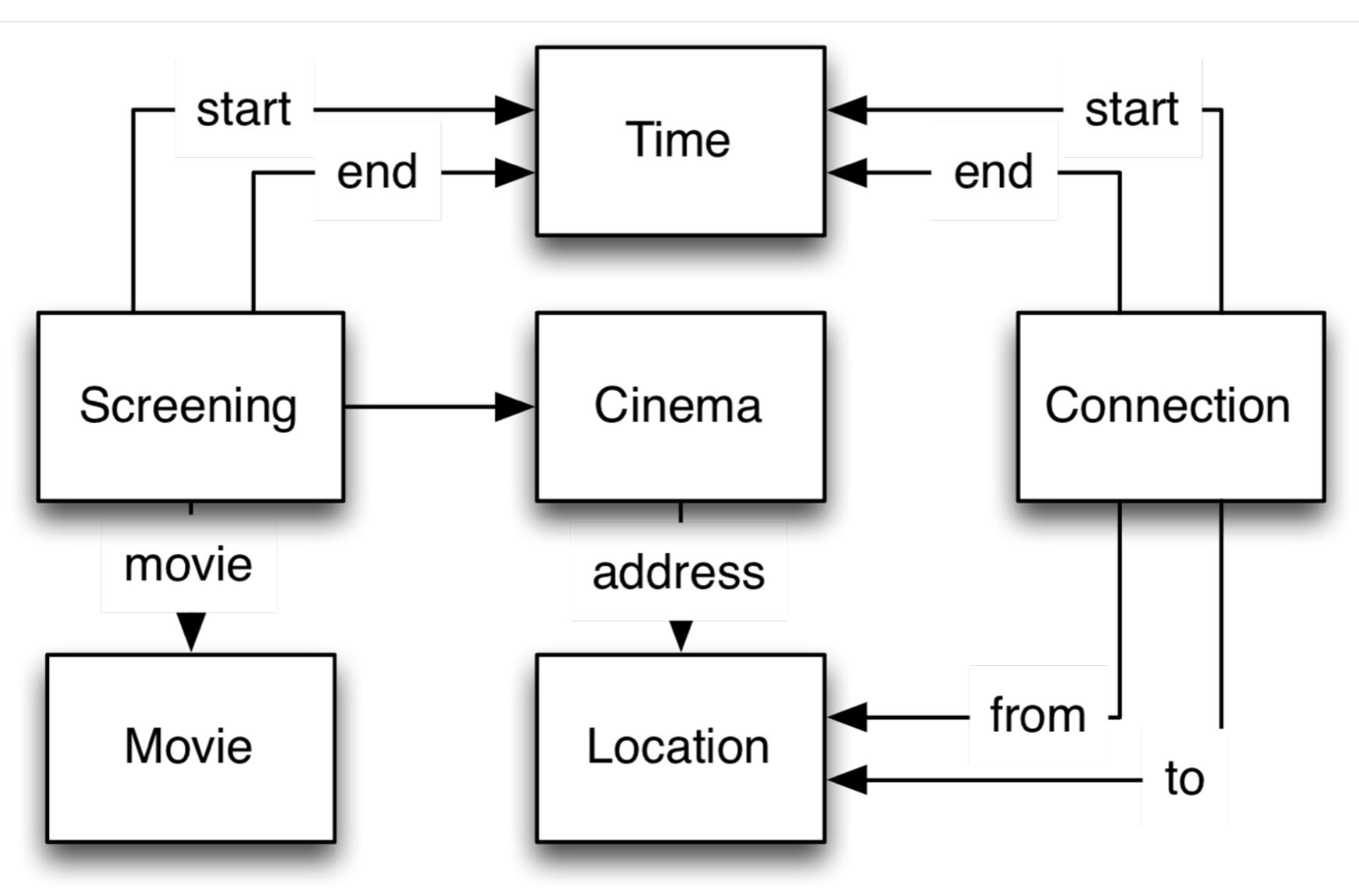
A model is a **simplified** representation of the real world, made for **understanding, structuring, predicting, communicating**

Examples

- Taxonomies, e.g. species, genus, family, etc. in biology
- Domain models, e.g. in UML
- Numerical models, e.g. Newtonian mechanics, stock market models

On the Web of Data these models are called **vocabularies** or **ontologies**

A Cinema Transport Model



What is the **vocabulary** and what are the **relations**?

A Query – what is it we want?

```
screening(s), movie(s, "Inside Out"),  
cinema(s, b), address(b, 1)  
connection(c), from(c, "VU Campus"), to(c, l),  
start(c, cStart), before("20:00", cStart),  
end(c, cEnd), start(s, sStart), before(cEnd, sStart).
```

Find a combination of s , b , l , c , $cStart$, $cEnd$ and $sStart$ that satisfies this and we have the answer!

- Maybe not the easiest way to ask, but it's a start.
- All data has an **underlying model**
- For the Web of Data to work, this model should be **explicit**.
- To answer complex, distributed queries, models from different domains need to be **connected**.

How will we make it work?

- A combination of **technological** and **social engineering** (since ~1999)
- Depends on
standards, increasing hardware **performance** and **bandwidth, tools**
- Application areas outside an open “Web” context
enterprise data integration, Big Data

Technological Engineering

standardisation,
knowledge engineering
knowledge representation

Social Engineering

standardisation,
principles of Web 2.0
stakeholder needs

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Technology: standards, standards, standards

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Uniform Resource Identifier (URI) to avoid naming conflicts

[http://dbpedia.org/resource/Inside_Out_\(2015_film\)](http://dbpedia.org/resource/Inside_Out_(2015_film))

Technology: standards, standards, standards

Uniform Resource Identifier (URI) to avoid naming conflicts

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The **Hypertext Transport Protocol** (HTTP) to access and move data

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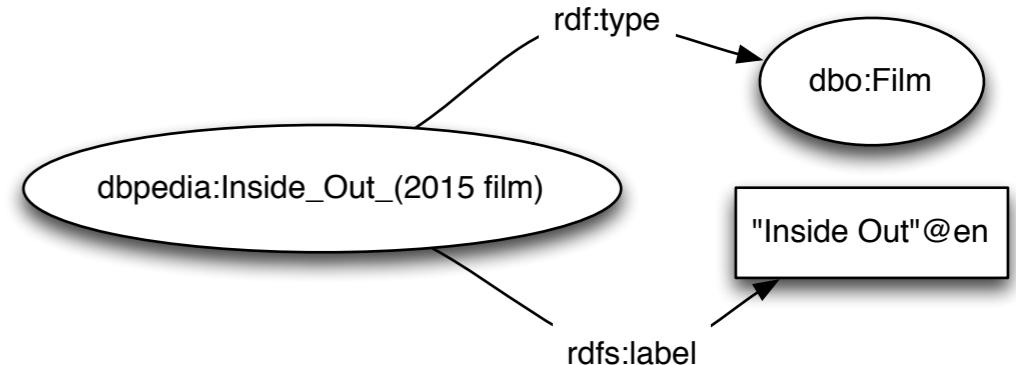
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The **Resource Description Framework (RDF)** as common data model



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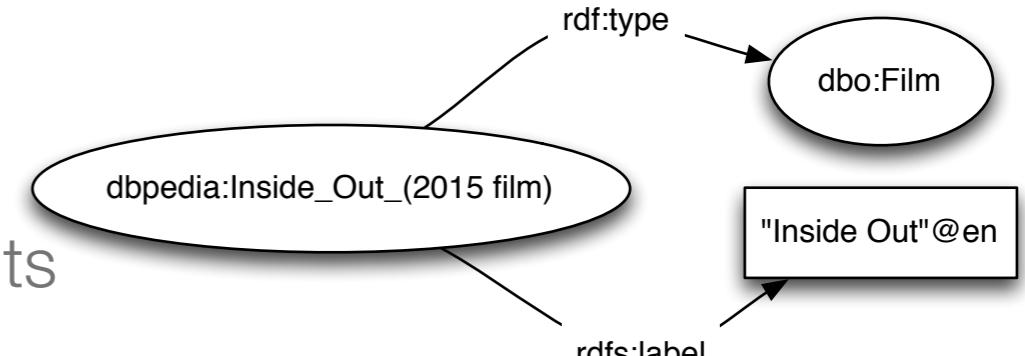
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[dbpedia:Inside_Out_\(2015_film\)](#)

The **Resource Description Framework (RDF)** as common data model



Syntaxes for expressing RDF data as documents

```
dbpedia:Inside\_Out\_\(2015\_film\) rdf:type dbo:Film .  
dbpedia:Inside\_Out\_\(2015\_film\) rdfs:label "Inside Out"@en.
```

Technology: standards, standards, standards

Technology: standards, standards, standards

Various **programming libraries** for accessing and manipulating RDF



Technology: standards, standards, standards

Various **programming libraries** for accessing and manipulating RDF



The **SPARQL** language for querying data over HTTP

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SELECT ?1 WHERE { dbpedia:Inside_Out_(2015_film) rdfs:label ?1 }
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Technology: standards, standards, standards

Various **programming libraries** for accessing and manipulating RDF



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Triple stores for **storing** large volumes of RDF data



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A family of increasingly expressive **languages** for **modelling**



Technology: standards, standards, standards

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Ontology editors for defining semantics



Technology: standards, standards, standards

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Reasoners for inferring new knowledge



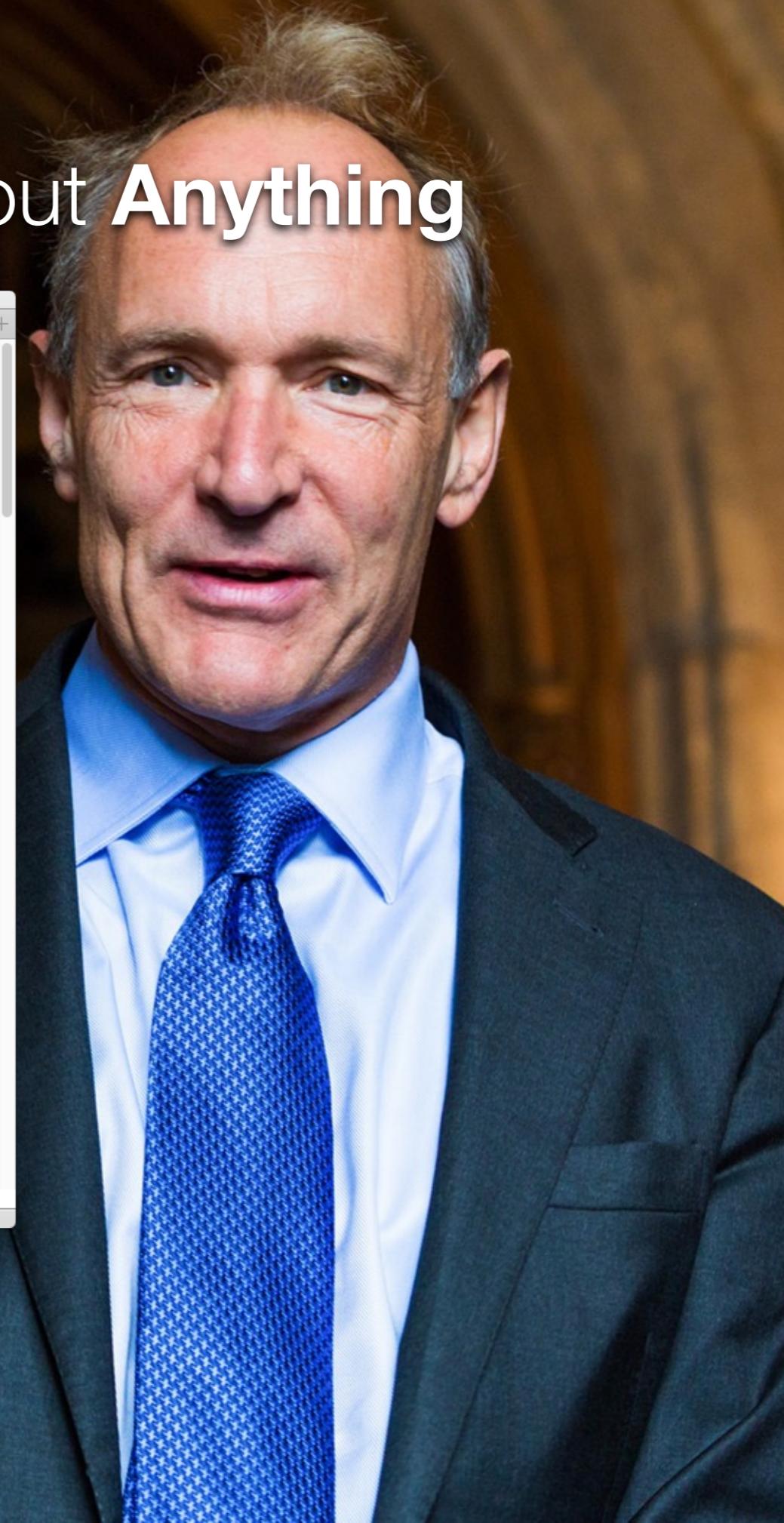
Anybody can say Anything about Anything



The screenshot shows a YouTube video player. The main video frame displays Tim Berners-Lee on stage, gesturing with his hands while speaking. The background behind him features large blue text that reads "Gov 2.0 EXPO". Below the video frame, the title of the video is "Gov 2.0 Expo 2010: Tim Berners-Lee, "Open, Linked Data for a Global Community"". To the right of the video frame, there is a sidebar titled "Up next" which lists several other video thumbnails and titles related to the expo.

Up next

- Gov 2.0 Expo 2010: Kathy "Creating Passionate Citizens" by O'Reilly 4,394 views
- Gov 2.0 Expo 2010: Gary Vaynerchuk, "The
- Jack Dangermond Interviewed by O'Reilly 2,961 views
- Gov 2.0 Expo 2010: Tim O'Brien "Government as a Platform" by O'Reilly 10,570 views
- Tim Berners-Lee: The next of open, linked data by TED 156,713 views
- What is Linked Data? by Manu Sporny 37,952 views
- The Semantic Web of Data by Berners-Lee by dilshod2006 30,190 views



Social: anyone can say anything about anything



Social: anyone can say anything about anything

DBpedia

```
dbpedia:Inside_Out_(2015_film) rdf:type dbo:Film .  
dbpedia:Inside_Out_(2015_film) refs:label "Inside Out"@en.
```



Social: anyone can say anything about anything

DBpedia

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dbpedia:Inside_Out_(2015_film) rdf:type dbo:Film .  
dbpedia:Inside_Out_(2015_film) refs:label "Inside Out"@en.
```

IMDB

```
dbpedia:Inside_Out_(2015_film) imdb:director imdb:Pete_Doctor .
```



Social: anyone can say anything about anything

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dbpedia:Inside_Out_(2015_film) refs:label "Inside Out"@en.
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Rotten Tomatoes

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dbpedia:Inside_Out_(2015_film) tomatoes:score "90%" .
```

Three statements from three sources about the same **subject**



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Rinke Hoekstra

```
dbpedia:Inside_Out_(2015_film) imdb:director foaf:me .
```

