Web 3.0

Decentralization & the semantic web

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What we’ll discuss

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- Decentralisation
- Decentralized: infrastructure vs authority
- Why bother with decentralized networks?
- Advantages of decentralization
- Disadvantages of decentralization
- How nodes relate to each other
- Structure of decentralized networks
- The things you need to create decentralized systems

Decentralized

Infrastructure vs authority

Google Cloud

- Huge distributed system
- Paired datacenters
- Sharding to serve users
- Controlled by a single party: Google

Gnutella (P2P filesharing protocol)

- Many peers storing local files
- Peers connect to other peers to ask for files
- Peers download from others
- Super-peers can optimize some routing

Why bother with decentralized systems?

- Centralized systems often require a **trusted third party** aka a **centralized authority**.
    - We trust banks to handle transactions responsibly.
    - We trust governments to count our votes correctly.
    - We trust certificate authorities to give out the right certificates.
    - We trust tech companies to handle our information responsibly.
- Anywhere where there is a ‘trusted party’ involved, there is a chance of misuse.
- With decentralized systems, you trust the **technology** rather than an **entity**.

However…

Decentralization of authority is complicated

The (naïve) promises of decentralized authority

- **Privacy** — No single entity, no mass surveillance
    - How about **PRISM**?
- **Integrity** — No single entity, no mass control
    - How about governments?

Potential advantages of decentralized systems

- We don’t have to trust a third party
- It’s less likely to be a single point of failure
- There is less censorship
- It’s likely to be an open development environment
- The potential for ownership alignment (the more value you provide to a network, the more ownership you get)

Disadvantages of decentralization

- Very complex to implement
- Requires a lot of different disciplines (mathematics, computer science, sociology, etc.)
- As no single entity has full control and different parties have to agree on changes, change can become slow
- It may create problems we don’t see in centralized systems (e.g. consensus)

Differences in decentralized networks

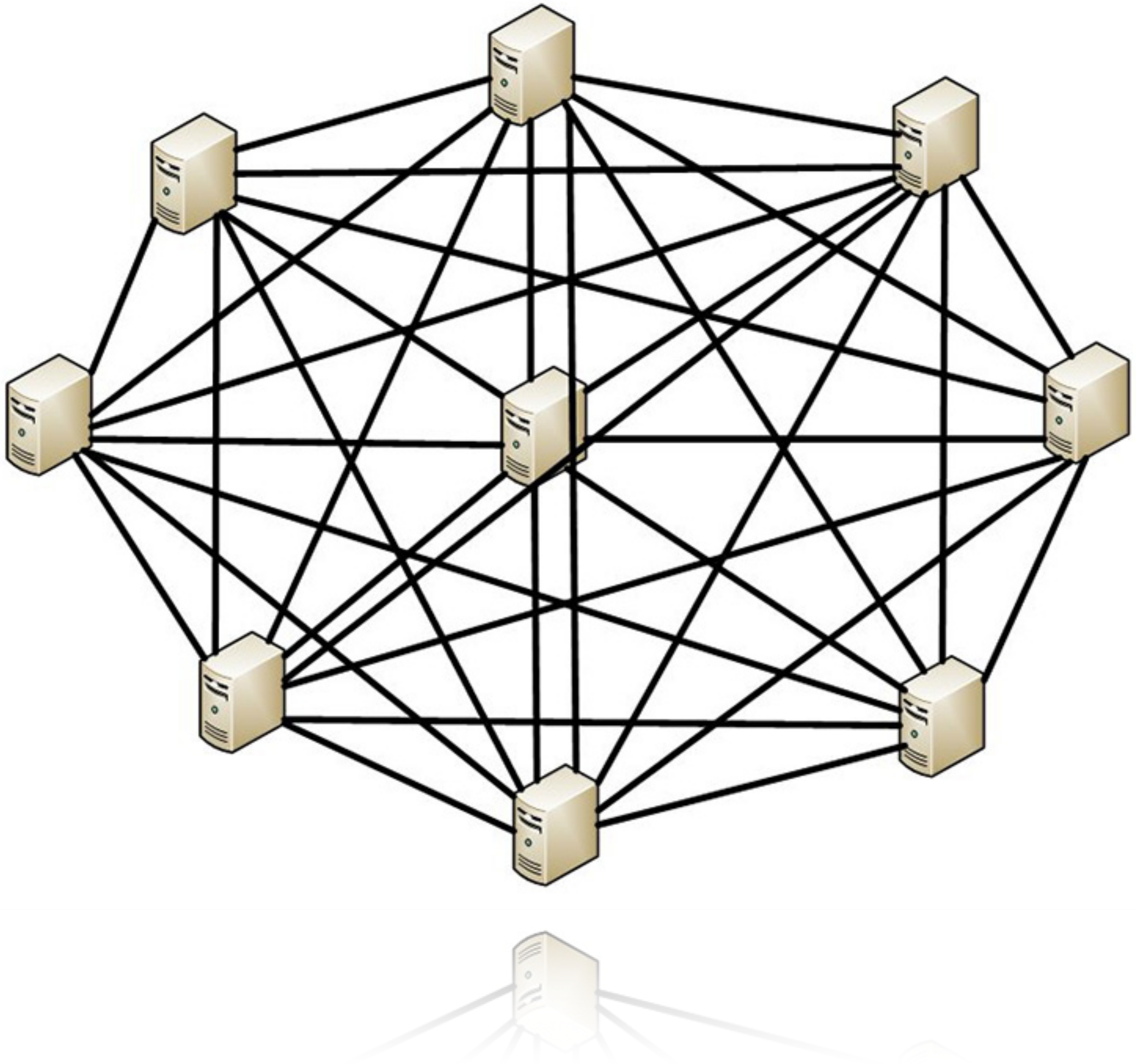
Different ways nodes can relate to each other

- Distributed networks
  - Well defined entities relating to each other (e.g. the Google Cloud example mentioned earlier
  - Closed world, single authority (admission)
- Federated networks
  - Nodes belonging to different authorities come together to form ‘one big network’
  - Think: Facebook integrates with MySpace
  - Imbalance of power
- Peer-to-peer networks
  - Open world, no central “admission control”
  - Sybil attack

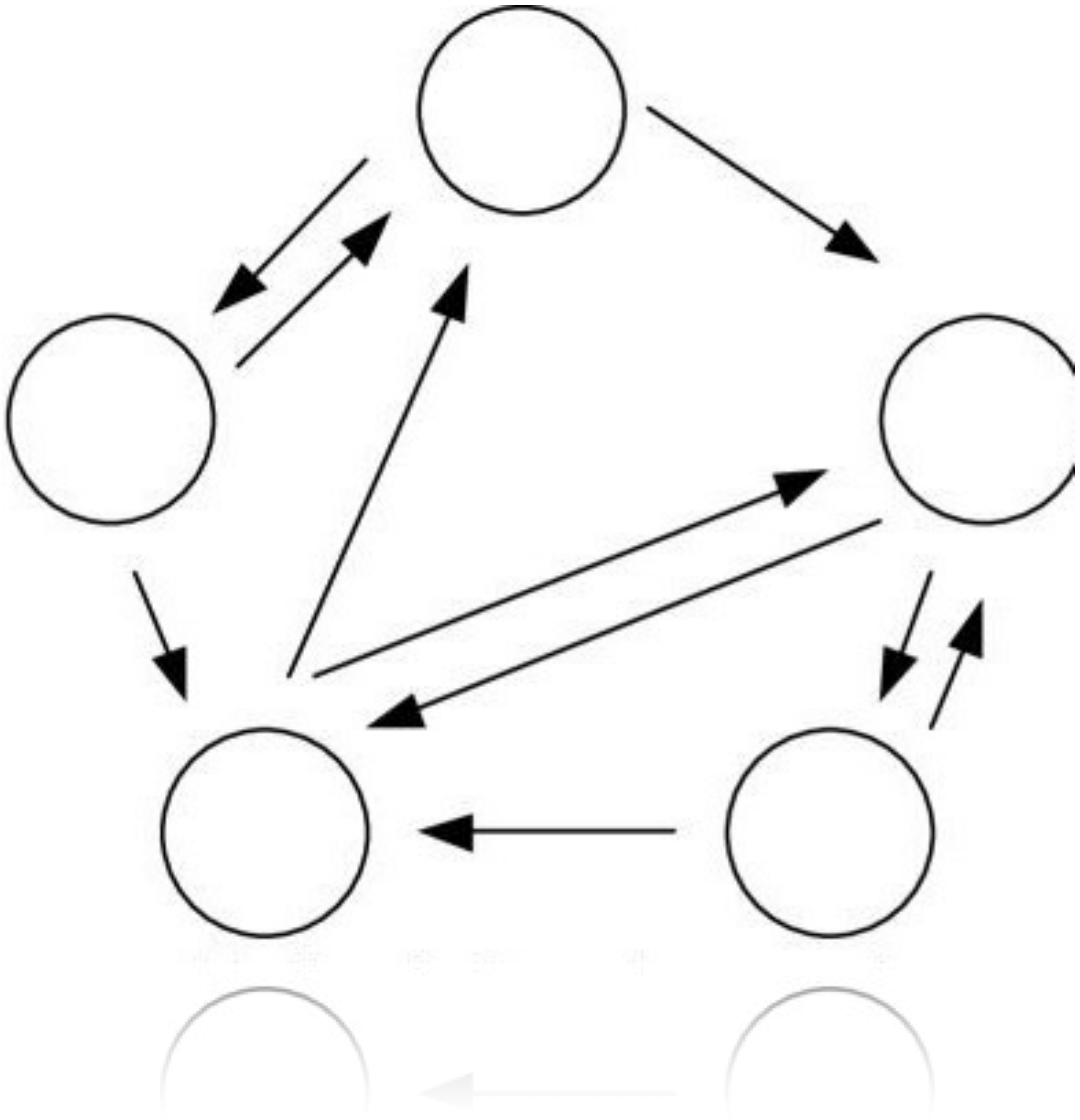
Different ways nodes can communicate with each other

- **Mesh**
  - Every node talks to every other node
  - Not efficient
- **Gossip**
  - Nodes pass messages to other nodes until everyone got the message
  - Broadcast only
- Social
  - Nodes only talk to nodes they ‘know and trust’
  - Messages might not reach the entire network
- Content centric
  - Nodes talk to other nodes that have a certain piece of content

Mesh



Gossip



Consensus

Getting everyone inside a network to agree on a **single source of truth**

Why is consensus hard?

The Byzantine Generals Problem

When do you need consensus?

- Generally: in peer-to-peer systems (but not all)
  - Chat applications
  - Cryptocurrencies
  - Storage systems
- When you need a single source of truth

Examples of decentralized applications

- Chat
- Social networking
- Cryptocurrencies
- Storage
- Computation
    - Single party
    - Multi party
    - Smart contracts
- etc.

The Semantic Web

What are semantics?

The meanings of words and phrases in a particular context

Classic example

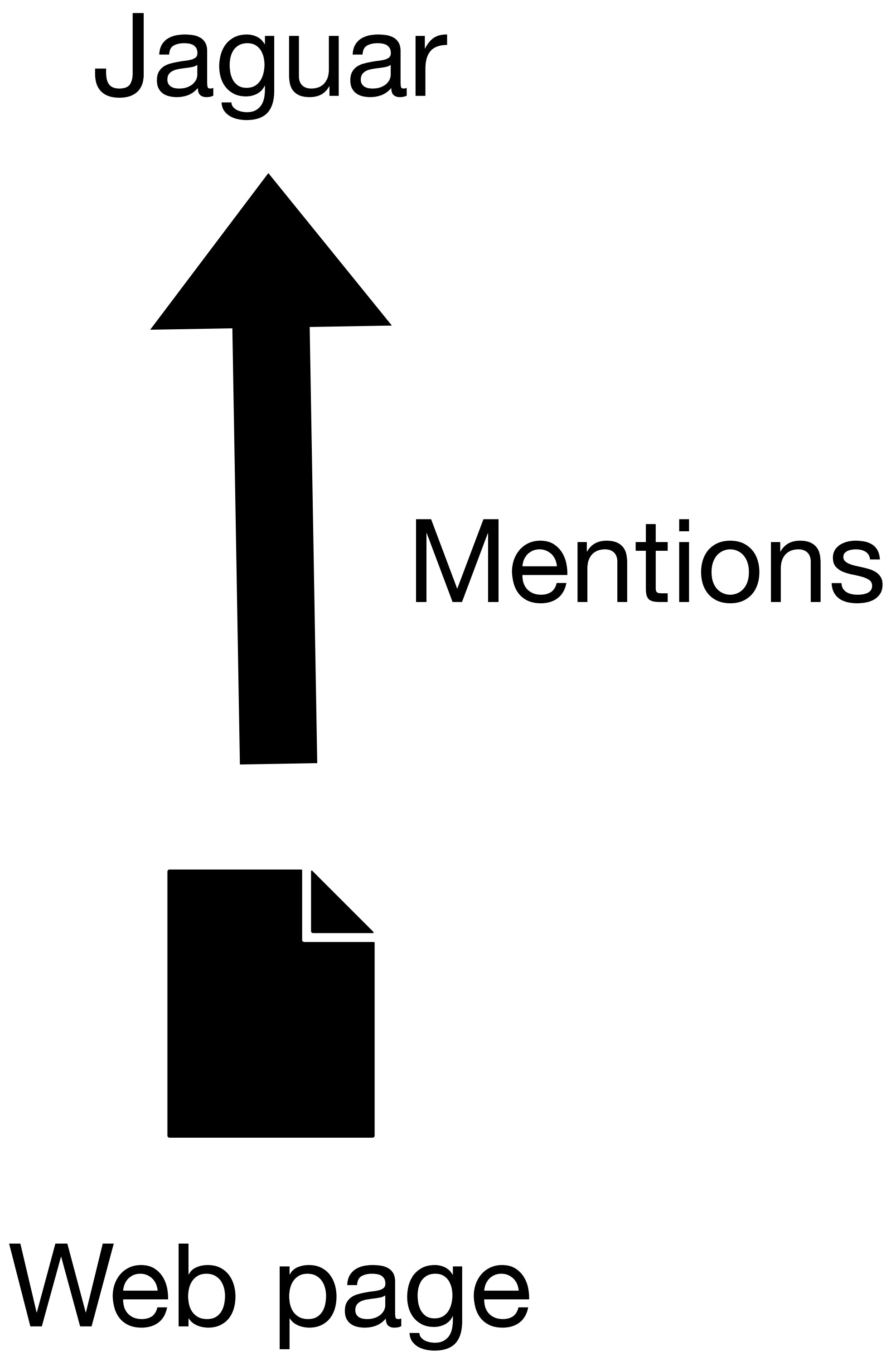
If you google the word ‘jaguar’, how does Google know you mean the animal or the car?

The semantic web

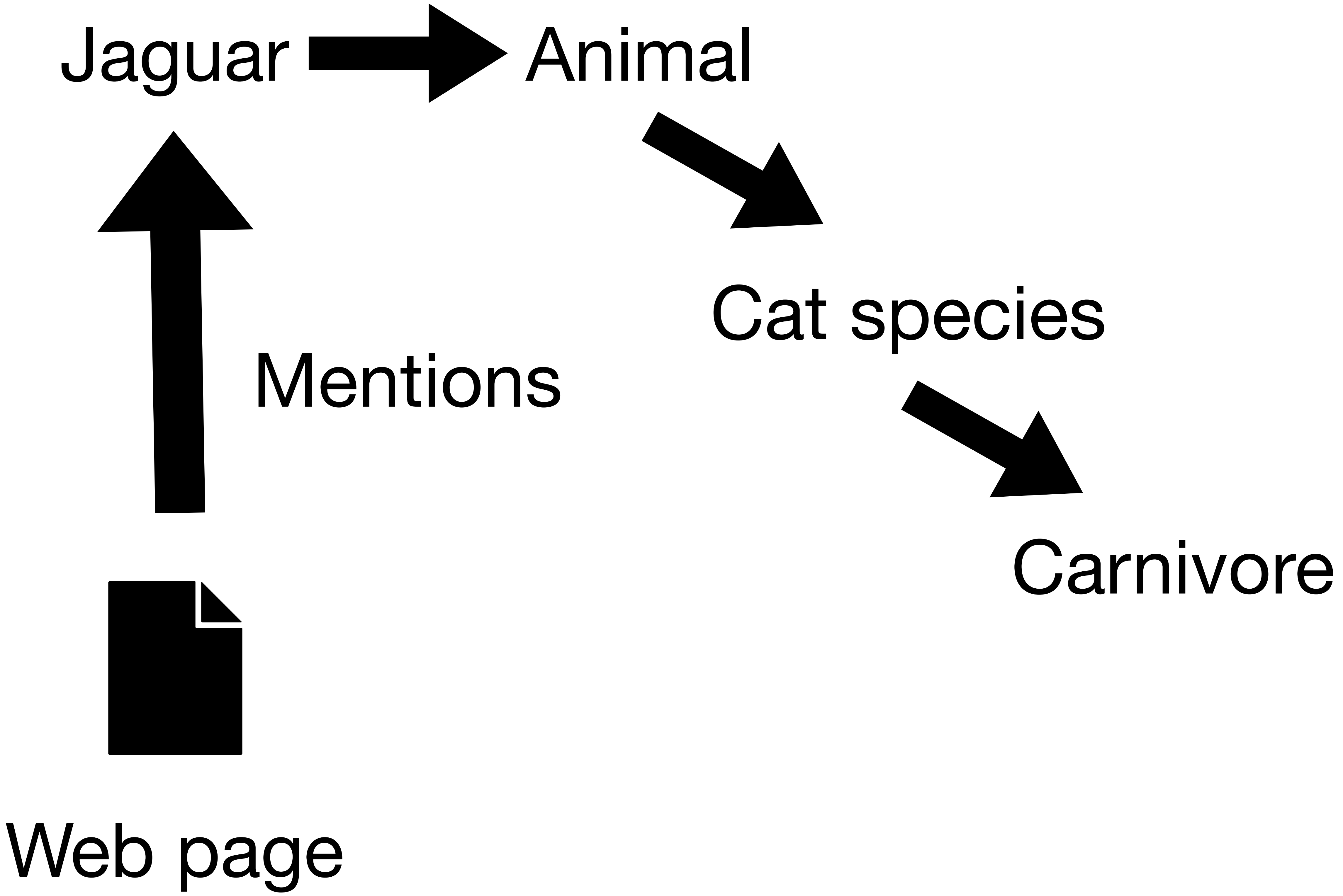
In a nutshell

- **Describes** data in a particular context
- Enables machines and humans to **interpert** data more accurately
- Enables machines and humans to **merge/combine** data from different sources
- Gives machines and humans a better **understanding** of **what the data is about**

Instead of this…



Semantics describe the thing that is mentiont

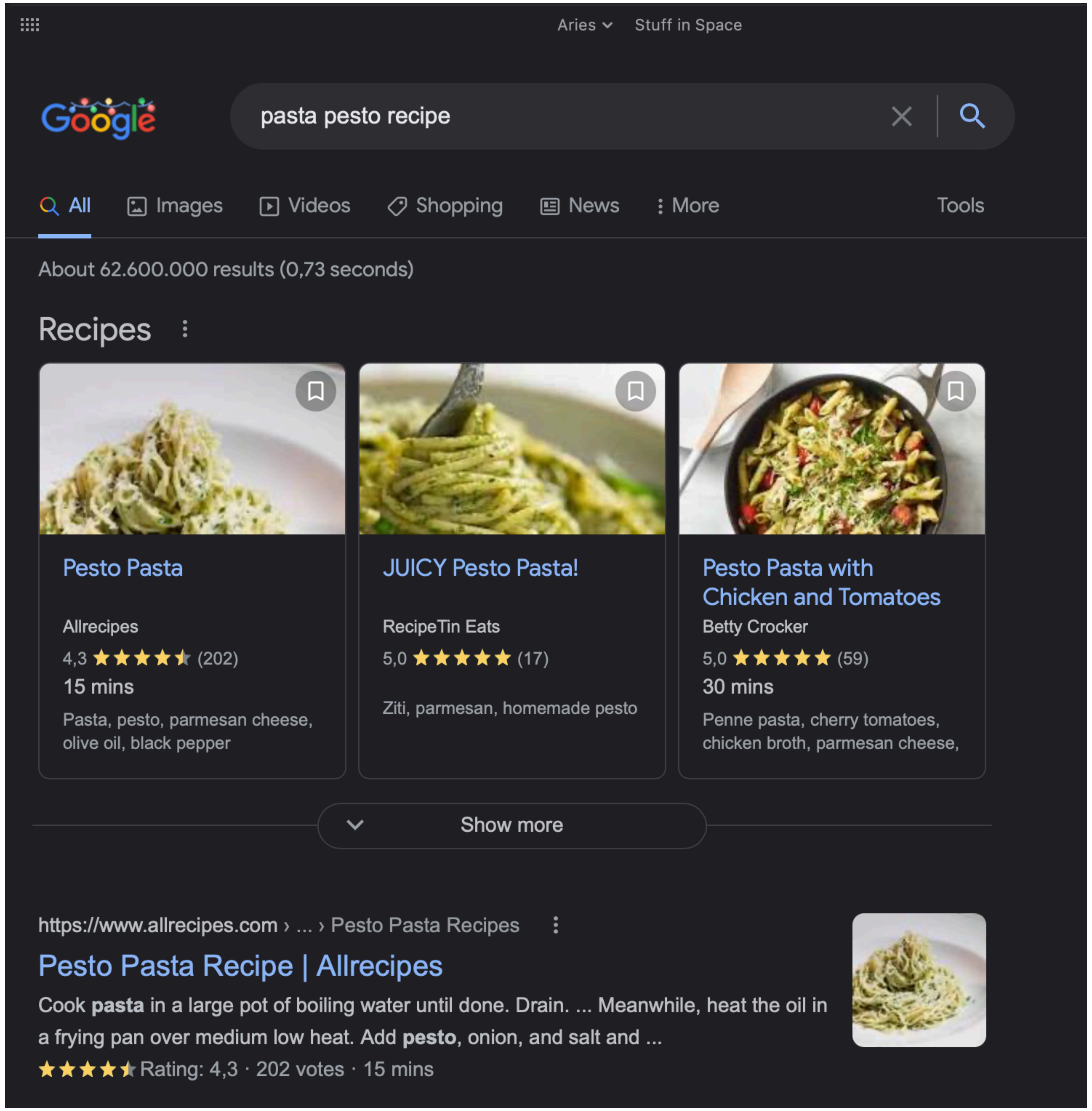


Semantic standards

- Resource Description Framework (RDF)
  - A model of how to structure data descriptions
- RDF Vocabulary Description Language 1.0: RDF Schema (RDFS)
  - A model of how to structure collections of related data descriptions
- SPARQL (query language for RDF)
  - Gives us a way to search the web for data descriptions

Semantics in action

Google’s recipe indexing



pasta pesto recipe

About 62.600.000 results (0,73 seconds)

Recipes

Pesto Pasta
Allrecipes
4,3 ★★★★½ (202)
15 mins
Pasta, pesto, parmesan cheese, olive oil, black pepper

JUICY Pesto Pasta!
RecipeTin Eats
5,0 ★★★★★ (17)
Ziti, parmesan, homemade pesto

Pesto Pasta with Chicken and Tomatoes
Betty Crocker
5,0 ★★★★★ (59)
30 mins
Penne pasta, cherry tomatoes, chicken broth, parmesan cheese,

https://www.allrecipes.com › ... › Pesto Pasta Recipes

Pesto Pasta Recipe | Allrecipes

Cook **pasta** in a large pot of boiling water until done. Drain. ... Meanwhile, heat the oil in a frying pan over medium low heat. Add **pesto**, onion, and salt and ...

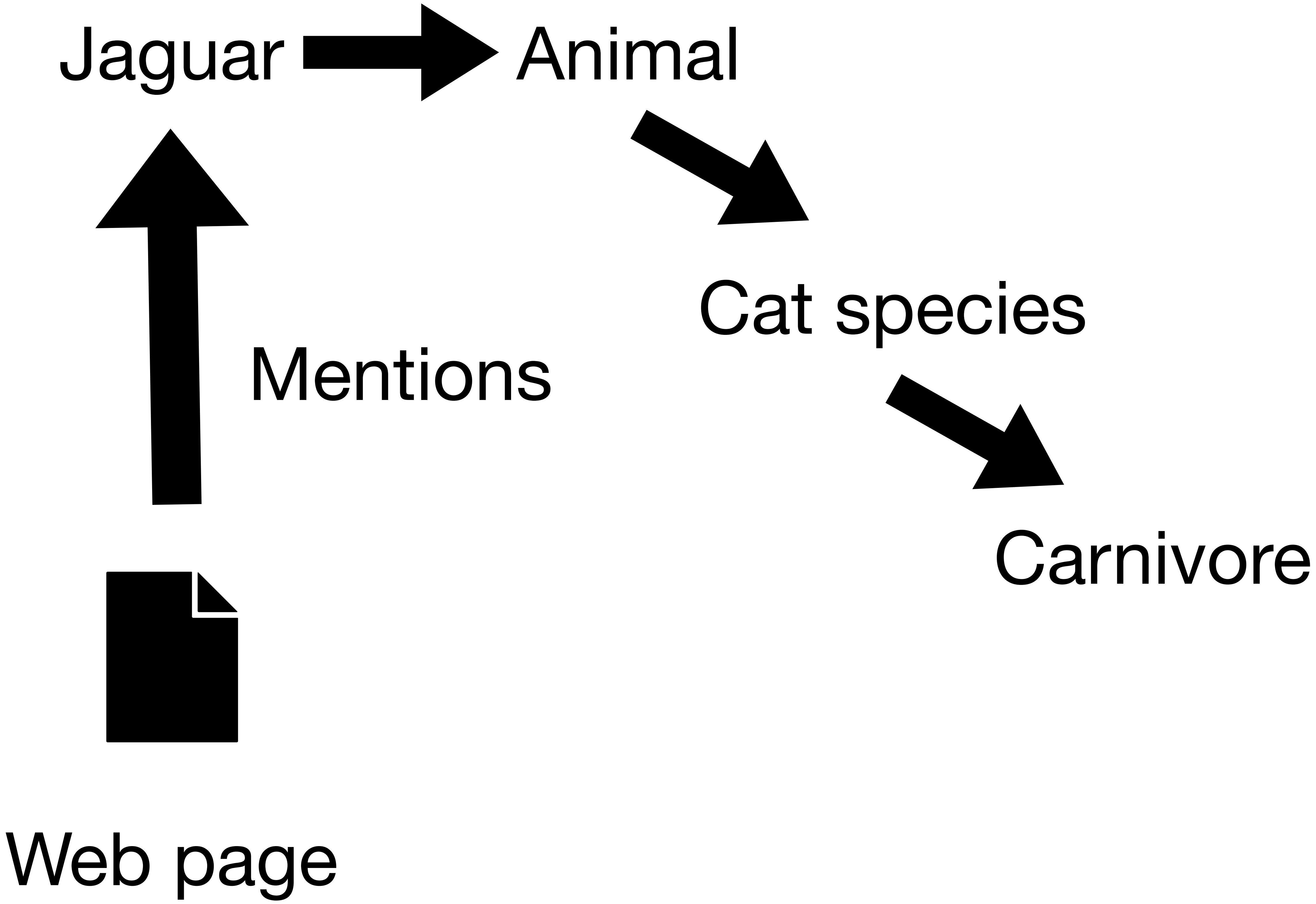
★★★★½ Rating: 4,3 · 202 votes · 15 mins

Linked data

Linked data

Semantic relationships

Instead of this…



Jaguar

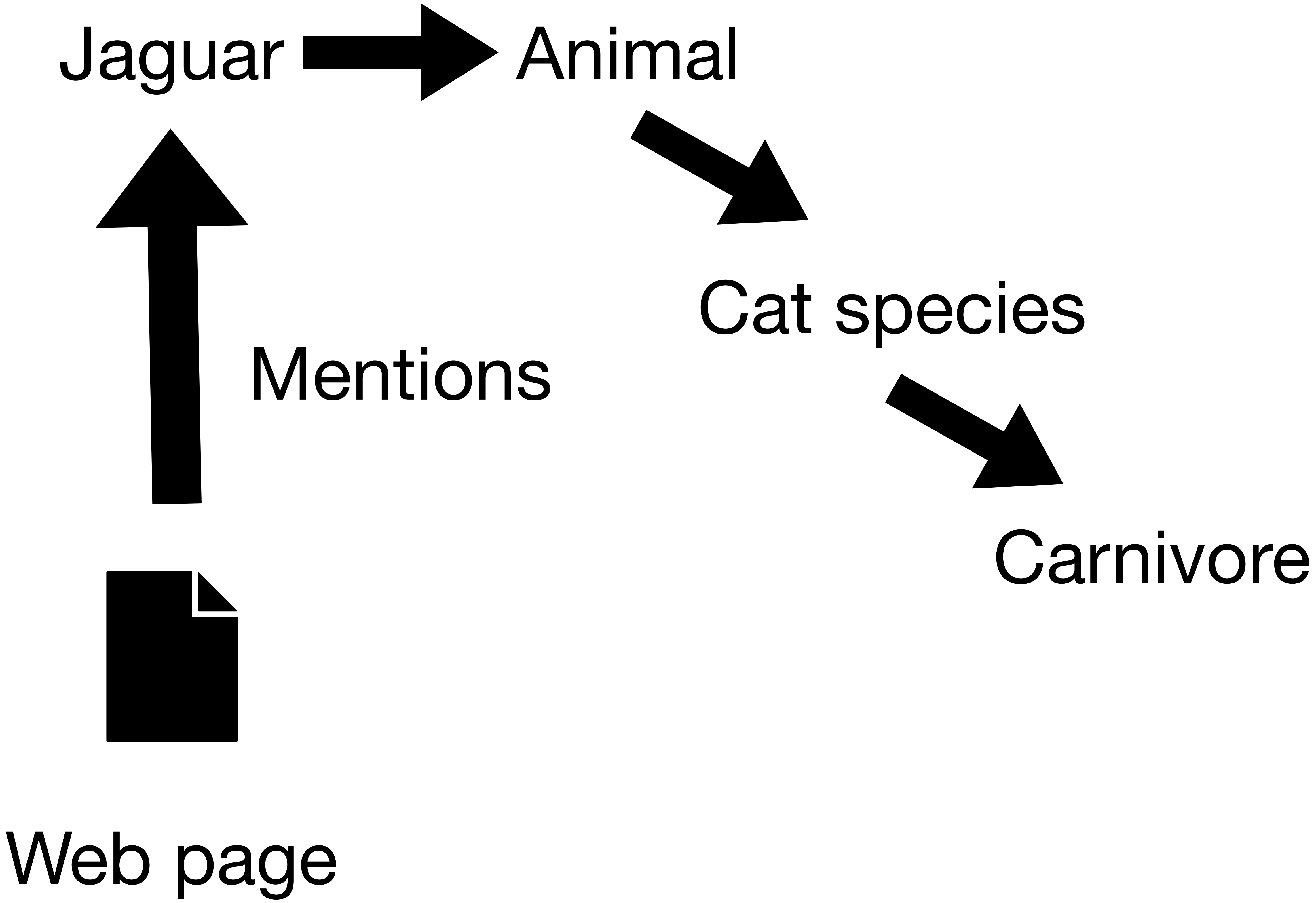
Animal

Cat species

Carnivore

Mentions

Web page



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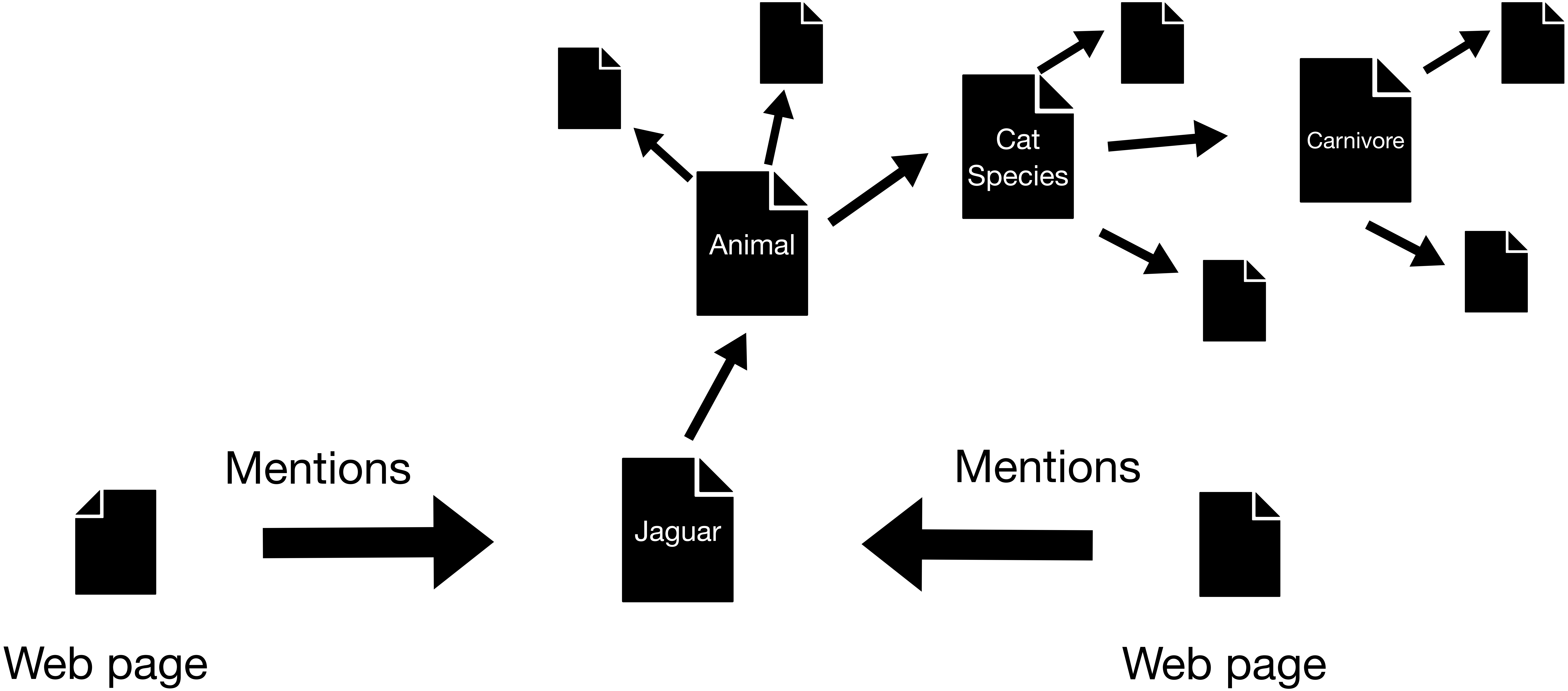
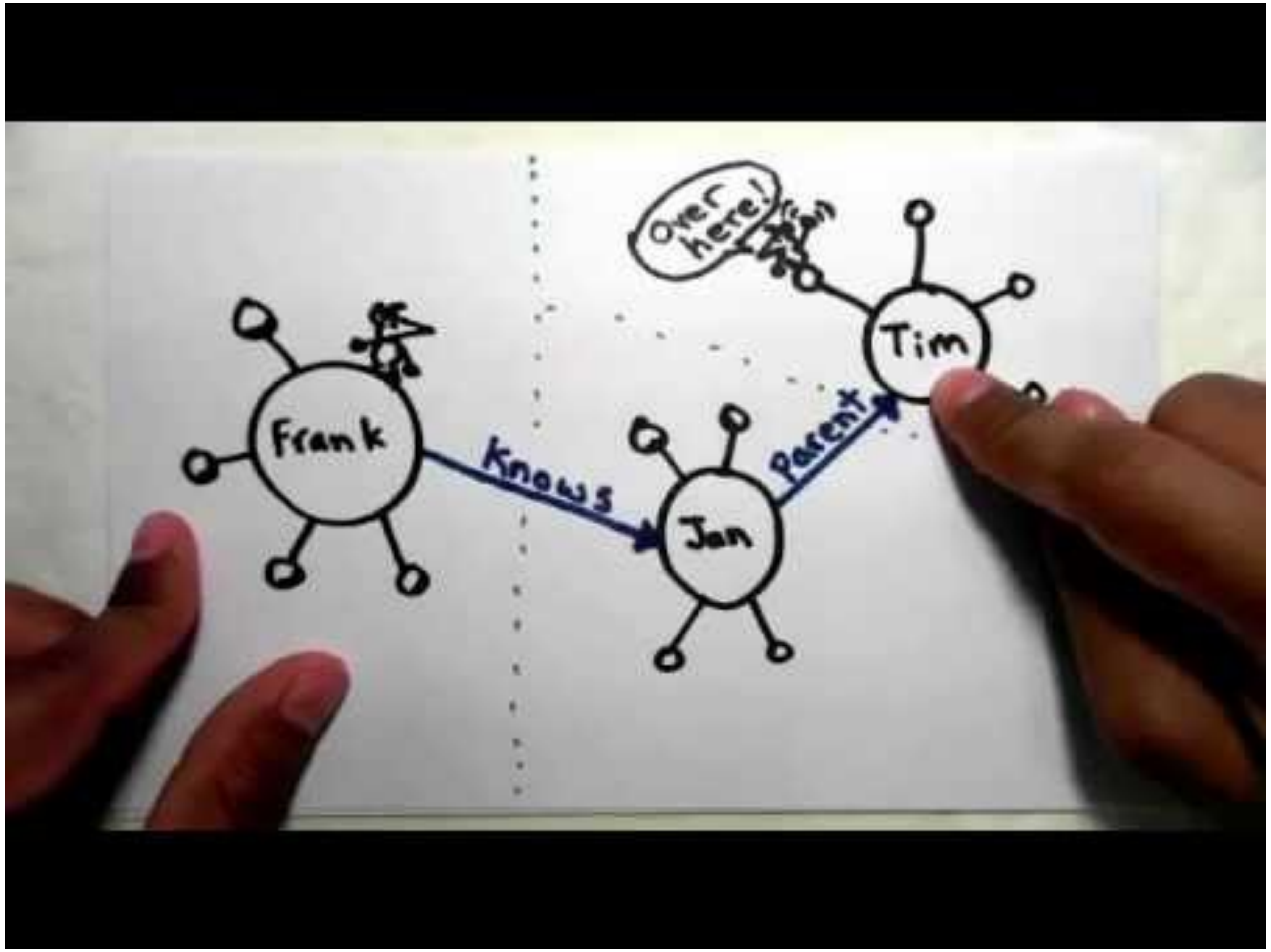


An explanation



Tim Berners-Lee

A description by the inventor of the web himself.

Relevant questions

For the final presentation

- Does the technology rely on semantics and/or linked data?
  - If so
    - What is its use? What for?
    - What technologies, standards or models are used to do so?
  - If not
    - Are there any benefits if it would?