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Semantic Web

A brief introduction

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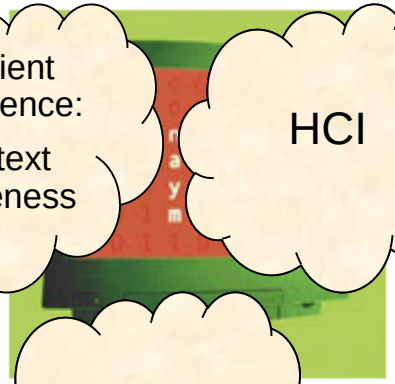
The Semantic Web vision: a bit of Sci-Fi…

The entertainment system was belting out the Beatles' "We Can Work It Out" when the phone rang. When Pete answered, his phone turned the sound down by sending a message to all the other *local* devices that [illegible]. His sister, Lucy, was on the line from the doctor's office: "Mom needs to see a specialist and then has [illegible]cal therapy sessions. Biweekly or something. I'm going to have my agent set up the appointments. [illegible]eed to share the chauffeuring.



Ambient Intelligence: Context Awareness

HCI

Autonomous Agent Interaction

Security

Planning & Scheduling

Supporting Decisions

[illegible]he doctor's office, Lucy instructed her Semanti[illegible]r handheld Web [illegible]er[illegible]e agent promptly retrieved information ab[illegible]*escribed treatment* from the [illegible]s agent, looked up several lists of *providers*, and checked for the ones *in-plan* for [illegible]insurance within a *20-mile* [illegible]dius of h[illegible] *home* and with a *rating* of *excellent* or *very* [illegible]n trusted rating services. It then began trying to find a ma[illegible]n between available [illegible]*itment times* (supplied by the a[illegible]ts of individual pr[illegible]ders thro[illegible]gh their Web sites) [illegible] Pete's and Lucy's busy schedules. (The [illegible] keywords indicate terms whose semantic[illegible]or meaning, were defined [illegible]the Semantic Web.)

In a few minutes the agent presen[illegible]didn't like it—University Hospital was all the way across town from h[illegible]driving back in the middle of rush hour. He set his own agent to redo[illegible]preferences about *location* and [illegible]*ce*. Lucy's agent, having *complete*[illegible]n the context of the present task, [illegible]y supplying access certificates and shortcuts to the dat[illegible]d already sorted through.

Almost i[illegible] the ne[illegible]an was presented: a much closer clinic and earlier times—but there wer[illegible]irst, Pete would have to resched[illegible]e a couple of his *less important* appointments. He checked what the[illegible]The other was something about the insurance company's list failing to include this provider u[illegible]r *ph*[illegible]ype and insurance plan status securely verified by other means," the agent reassured him. "(Details?[illegible]

Lucy registered her assent at about the same moment Pete was muttering, "Spare me the details," a[illegible](Of course, Pete couldn't resist the details and later that night had his agent explain how it had found that provide[illegible]even though it wasn't on the proper list.)

T. Berners-Lee, J. Hendler & O. Lassila. The Semantic Web: A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities. *Scientific American,* May 2001

The Semantic Web Vision: ingredients

- Expressing Meaning
  - Software agents will roam the web and carry out sophisticated tasks for users.
  - Machines become able to "understand" the data they merely display at present
- Knowledge Representation & Ontologies
  - Machines access structured collections of information.
  - Machines use rules to make inferences, choose courses of action and answer questions.
- Agents
  - Web services happen when agents "understand" both the function offered and how to take advantage of it.
  - Subassemblies of information are passed from one agent to another, each adding value to construct the final product requested by a user.
- Evolution of Knowledge
  - If properly designed, the Semantic Web can assist in the evolution of human knowledge.
  - A universal Web will open up the knowledge and workings of humankind to meaningful analysis by software agents, providing a new class of tools by which we can live, work and learn together.

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Premise: a promise

The concept of machine-understandable documents does not imply some magical artificial intelligence which allows machines to comprehend human mumblings. It only indicates a machine's ability to solve a ***well-defined*** *problem by performing* ***well-defined*** *operations on existing* ***well-defined*** *data. Instead of asking machines to understand people's language, it involves asking people to make the extra effort.*

Tim Berners-Lee, "What the Semantic Web can represent", 1998.

http://www.w3.org/DesignIssues/RDFnot.html

…so…where does this "well-definedness" come from?

Semantic Web: the vision…

The vision of the Semantic Web:

"… a plan for achieving a set of connected applications for data on the Web in such a way as to form a consistent logical web of data …" [1]

"… an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation …" [2]

1) T. Berners-Lee. Semantic Web RoadMap. http://www.w3.org/DesignIssues/Semantic.html
2) T. Berners-Lee, J. Hendler & O. Lassila. The Semantic Web: A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities. *Scientific American,* May 2001

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Representing Information on the Web

Ontologies will provide the vocabulary for making data (and their associated schemata) understandable by machines, by offering:

- Universal data models
- Standard semantics
- Stratified Inference layers

SW Agents will exploit distributed ontological (and ground) knowledge to:

- Understand users' request with respect to their own semantic vocabulary
- Collaborate with other agents upon common basis

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Accomplished objectives

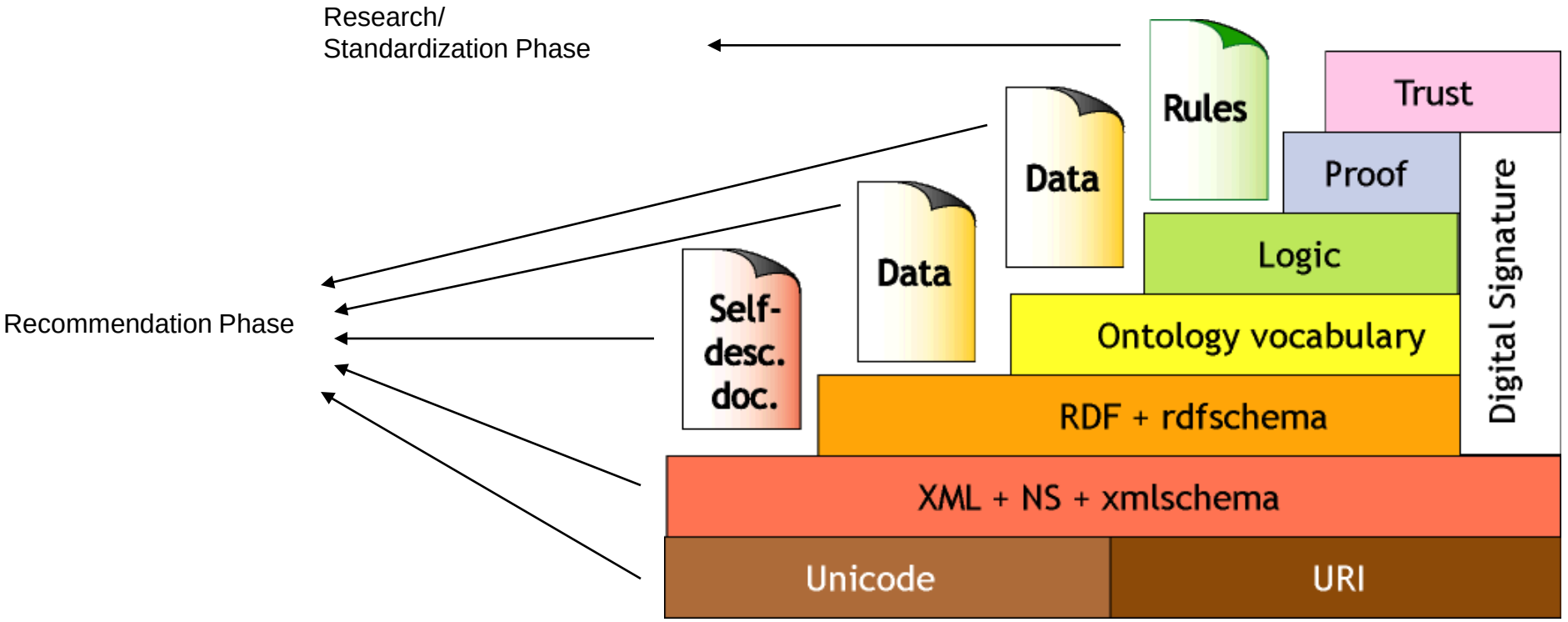
Two birds with one stone!

Replacing 80s relation model (DBs)

- Closer to human understandability (reminds of ER diagrams!)
- With well-founded logical ground

Putting data on the Web!

Semantic Web Stack



Ontology Languages

- Commitment to languages for knowledge representation on the Web, like *RDF* and *OWL*, should guarantee real knowledge interoperability between distribute information sources

- Moving from explicit syntax to semantics will not require *intelligent* machines, but just *standards* which they can understand

- …but…

Models and Meta-models: Semantics

- OWL, RDF etc.. are not world/domain models
- They are models for knowledge representation and thus meta-models for depicting real world objects
- E.g. If you say that `A ⊑ ∃p.B ⊑ C`, you can tell:
  - that all instances of `C` are as well instances of `A`
  - that all instances of `C` are subject to the range restriction on property `p` (which must point to objects in `B`)
  - …
- You cannot tell:
  - How the instances of `A` (or `C`…) actually relate to real world objects

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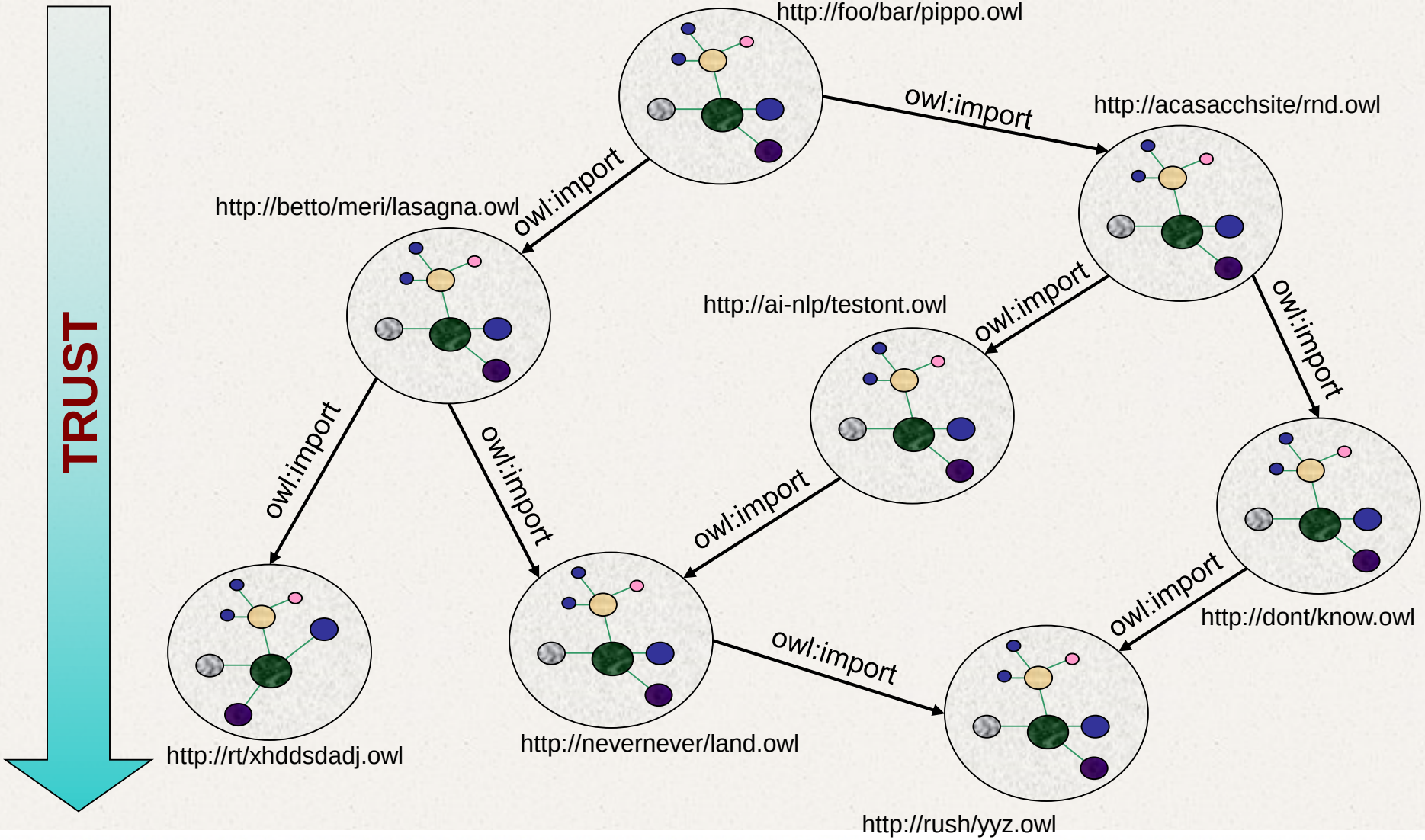
Ontology Semantics

- The semantics of each ontology are defined by:
  - The interpretation given by people using the ontology inside a given *framework*
  - The use that applications make of ontology concepts inside their committed framework

- Namespaces behave, under all the aspects, as object referents inside the same framework.
  - *humans* are expected to interpret *same* names in *same* namespace in the *same* way, as well as
  - *machines* are expected to use these data consistently.

Ontology Commitment: owl-import

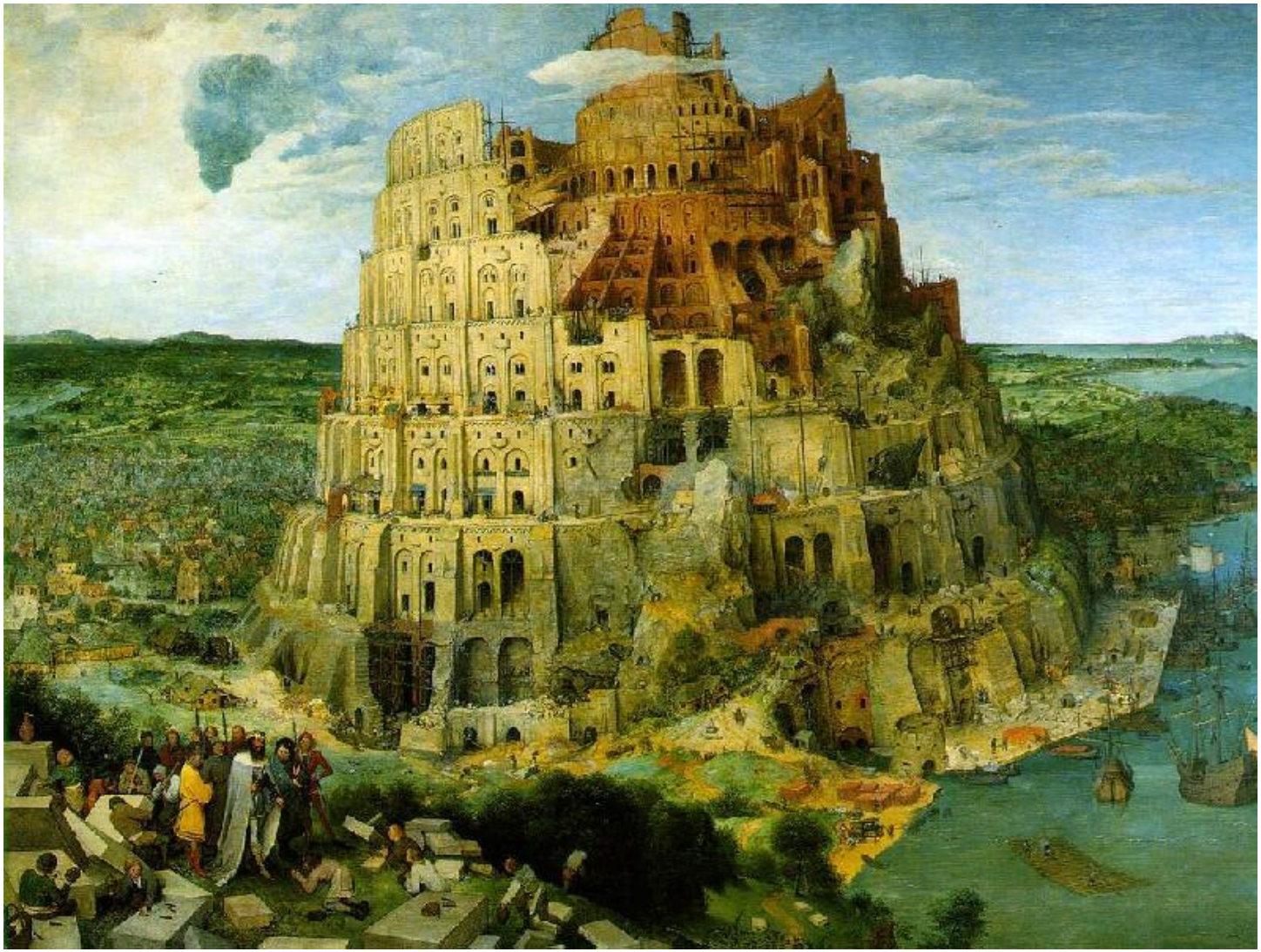


Ontology Commitment

- So (back to Berners-Lee's words), *no need of*
  - "magical artificial intelligence"
  - natural language understanding

  only if you commit at ontological level
  - not necessarily one monolithic "universal Web ontology"…
  - …but a trusted set of ontologies to be shared inside a given context.

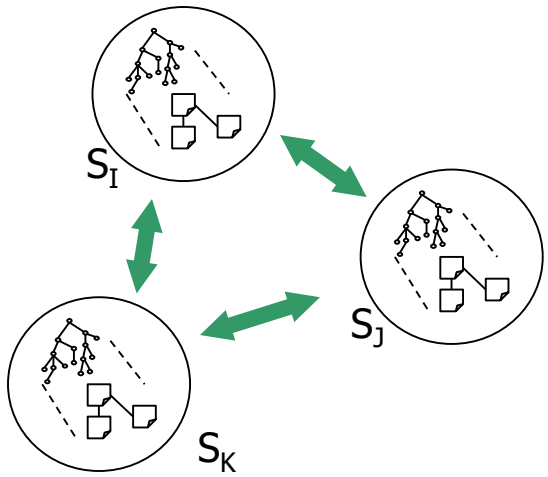
What happens if no semantic agreement occurs?



What happens if no semantic agreement occurs?

- Many, different, indipendent, ontologies exist and many more will be developed in the future about same or overlapping domains

- Integrating their information is important, both at:
  - Schema level
    - Knowledge migration and remote querying
  - Data level
    - Expanding knowledge about same objects



- This integration needs to be performed through
  - Ontology Merging (producing one global resource from existing ones)
  - Ontology Mapping (realizing mappings between existing resources)

Semantic Web: possible applications

- Complex queries involving background knowledge
  - Find information about "animals that use sonar but are neither bats nor dolphins"
- Locating information in data repositories
  - Travel enquiries
  - Prices of goods and services
  - Results of human genome experiments
- Finding and using "web services"
  - Visualise surface interactions between two proteins
- Delegating complex tasks to web "agents"
  - Book me a holiday next weekend somewhere warm, not too far away, and where they speak French or English

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