

Towards the Semantic Web

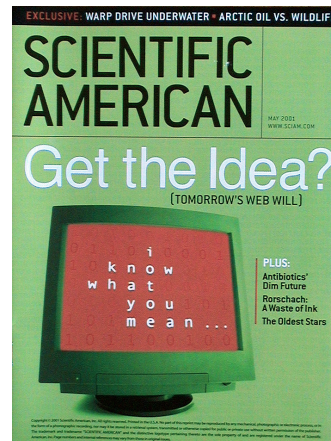
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XML Finland, October 2002

Towards the Semantic Web

- Motivation: “Departure from tools”
- Semantics
- Reasoning
- Agents
- Q & A



Towards the Semantic Web

WWW now

- Humans do everything
- Computers as tools
- Problems abound

WWW in the future

- Computers do a lot more
- Computers work *on our behalf*
- Fewer problems...

How do we get there...?

Departure from the “tool paradigm”

Tools & Beyond (examples)

Tools

- hammer & nails
- calendaring software
- almost any software today
- e.g., Google

Beyond tools

- building contractor
- automated “secretary”
- various personal assistants...
- answers from a “semantic search agent”

I will make a case for the need of *artificial intelligence* (AI)

Semantics

Motivation for the Semantic Web

- **Problem: Web was built for humans**
 - human interpretation needed to “understand” content (it does not scale)
 - consequently, automation is difficult
 - it is particularly difficult to automate “unforeseen” situations
- **Rough solution: make the Web friendlier for machines**
 - we need “machine-understandable” content (not “machine-readable”, we already have that)
 - (note: by “machine-understandable” we mean content with *accessible formal semantics*)
- **The Web is more than just a “library”**
 - think of it as infrastructure for services & functionality
- **Drivers**
 - automation (e.g., in search), interoperability (e.g., in e-commerce)
 - but: compelling business models are still missing

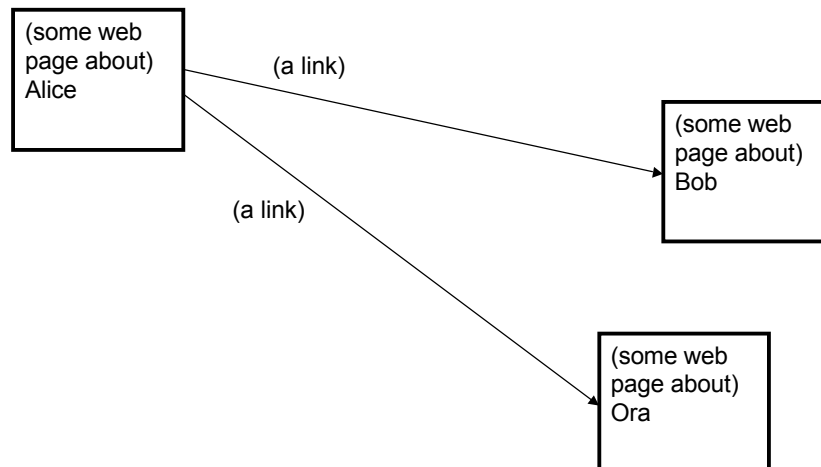
WWW: an Architecture for Linkages

- Current Web architecture essentially gives us a framework for “pointing”
- Problem is that this pointing has no meaning
 - (except sometimes through human interpretation)

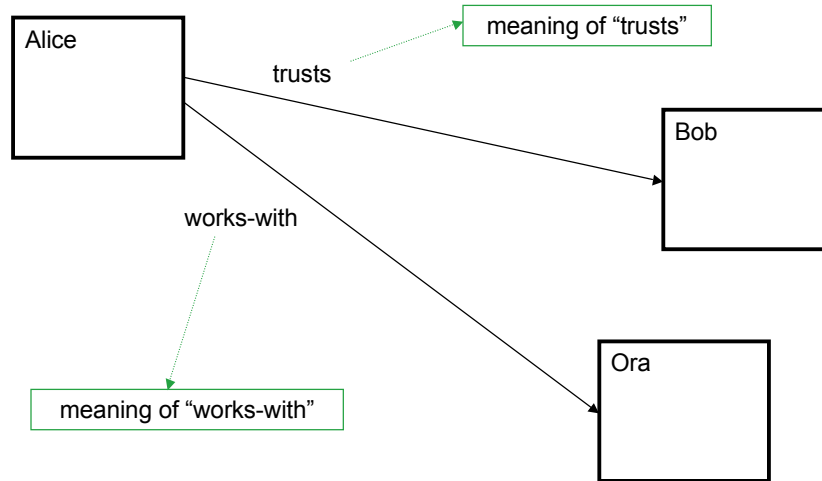
Can we improve on this?

Note: for us (humans), separating our own interpretation from (largely syntactic) representation is hard

Linkages on the “Old Web”



Linkages on the “Semantic Web”



Linkages on the “Semantic Web” (2)

- **Semantic Web resources (the “nodes”)** can
 - stand alone, or
 - denote other things (e.g., physical entities)
- **Hypertexts become “semantic” networks**
 - this is good for agents and automation
 - e.g., semantic navigation of hypertexts
 - how does one “name” the semantic links and nodes?

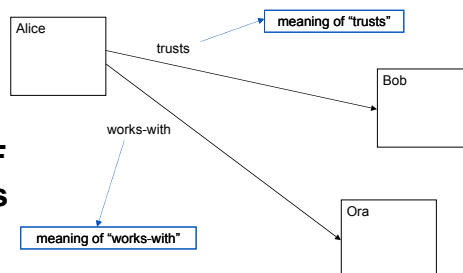
Semantics via Sharing

- **Controlled vocabularies**
 - interoperability improves if the same term is always used to denote the same thing (e.g., instead of arbitrary keywords, choose from a list)
- **What is an “ontology”**
 1. a controlled vocabulary
 2. a concept taxonomy
 3. other relations between concepts
 - Gruber: “A specification of conceptualization”
- **Library scientists are good with this stuff**
 - e.g., Dewey Decimal System is an ontology

Resource Description Framework



- **Originally conceived as W3C’s metadata model**
 - document metadata for digital libraries, content rating, site maps, etc.
 - normative reference: Lassila & Swick, “Resource Description Framework Model and Syntax Specification”, W3C Recommendation, 1999
- **RDF has**
 - a data model of directed labeled graphs (DLGs)
 - an XML-based syntax for serializing DLGs
- **Nodes & arcs in an RDF DLG are named by URIs**
 - important for robust vocabulary creation



“It’s a Model, Stupid!”

- **Simple data model**
 - think of it either as *directed labeled graphs* or in object-oriented terms
 - more powerful than the trees XML gives you
- **Graphs decompose into object/attribute/value -triples**
 - “subject/predicate/object” = a statement
 - (in RDF parlance, nodes are called “resources” and arcs “properties”)
- **Everything in an RDF graph is named by URIs**
 - when naming is not based on mere words, name conflicts can be avoided
 - graphs can span multiple hosts (servers, etc.)
- **RDF is followed by more powerful languages**
 - DAML+OIL (from the DARPA Agent Markup Language program)
 - OWL (from W3C’s WebOnt working group)

Is It Enough to Just Use XML?

- **Short answer: no**
 - the typical - albeit incorrect - answer is “yes”
- **Long answer: XML offers a way to introduce new syntax (new names, tags, ...), but no way of introducing or coordinating semantics**
- **XML has a tree-like data model**
 - if your (representational) problem does not lend itself to be a tree, you lose (sorry)
 - (and this is even before we get to the “semantics” part)
- **Hype (from a Sun white paper): “The industry is clearly focusing in on [XML] as the *lingua franca* to enable Web services...”**
 - not only is XML not a *lingua franca*, it is not even a *lingua*

XML: not Machine Accessible Meaning (1)

林克昌 根留台灣 可能增高

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- (thanks to Frank van Harmelen, VUA)

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name

education

work

personal

CV

XML: not Machine Accessible Meaning (3)

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<personal>

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Using Semantics for Reasoning

More about Ontologies

- **How to build ontologies?**
 - we could form committees...
 - (the Dublin Core initiative took several years to decide on 15 core metadata elements)
 - my preference is the “Darwinian” approach
 - good and/or popular ontologies will prevail
 - we must have a framework which allows ontology extension (RDF does)
 - probably some combination of official standards and de-facto standards is the way to go
- **Several “upper ontology” projects underway**
- **Ontologies enable reasoning**
 - this allows the move from “syntactic” to “semantic” processing
 - but: where does “semantic data” come from (enter AI)

Reasoning and Inference

- Reasoning allows one to draw inferences based on generalized “rules”
 - generation of “more” semantic information
 - simplest practical form: polymorphism in OO systems
- Enabled by ontologies
- Reasoning eases interoperability
 - relationships between different but compatible ontologies & data could be inferred

Reasoning example:

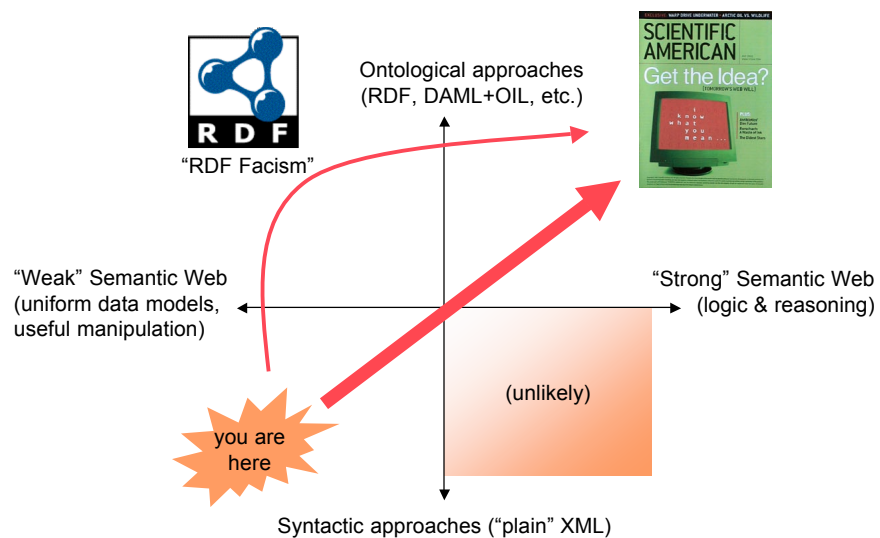
1. X is a Cat
2. a Cat is a Mammal
3. a Mammal gives birth to live young



- X gives birth to live young

Note: This is AI

Semantic Web: Characterizations



Interoperability of Services

- **Semantic Web, via ontologies and reasoning, will improve interoperability of information systems**
- **This can be applied to “services”**
 - semantic description of service interfaces enables automatic discovery, composition, etc.
 - DARPA's DAML-S activity (Stanford, CMU, Yale, SRI, BBN, Nokia)
 - analog to “Tower of Babel” (from Genesis 11:1-9)
 - will Web Services succeed without the Semantic Web? (I think not)
- **Substitution of “equivalent” services**
- **Web Services are a good abstraction of all kinds of functionality**

Agents

Fulfillment of the Vision

- **Autonomous agents**
 - delegation of decision-making power
 - computers/systems working on users' behalf
- **“Serendipitous” interoperability**
 - uncoreographed encounters of agents, other systems
 - ease pressures on *a priori* standardization
- **But: we need certain things**
 - “processing models” for the Semantic Web
 - how do agents conduct dialogues (e.g., when acquiring additional functionality)?
 - note: we have only worked on standardizing representation so far
 - AI (at the very least in the form of reasoning)

Fulfillment of the Vision: the AI We Need

- **Knowledge representation**
 - (obvious: the Semantic Web is all about KR)
 - formal semantics as “the Manifest Destiny of AI”
- **Automated planning**
 - enables autonomous operation
 - useful in many tasks (e.g., service composition)
- **Machine learning**
 - enables adaptivity
 - could be used in bootstrapping semantic annotations for existing content
- **The “AI Paradox”**
 - well-understood things stop being AI (e.g., OOP, rules, logic)
 - parallels between AI and the Semantic Web: the latter also has aspects which, once adopted, will stop being “Semantic Web”

Summary

- **Use of human interpretation does not scale**
- **We need to**
 - move from tools to autonomous systems that work on our behalf
 - introduce formal semantics (machine-understandable content)
- **Ontologies □ Reasoning □ Agents**
 - we have only done the first step and started on the second...
 - (business models for all this are needed)
- **We need artificial intelligence to ultimately fulfill the Semantic Web vision**
 - (some of you may have been misinformed about this earlier)

Questions?

- <mailto:ora.lassila@nokia.com>

