Using the Semantic Web in Ubiquitous and Mobile Computing

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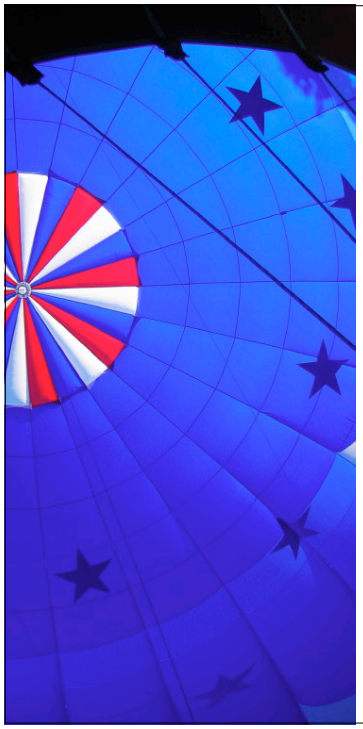
Game Plan

1. Semantic Web (the way I see it...)
2. Issues in Mobile Computing
3. Issues in Ubiquitous Computing
4. Semantic Web to the Rescue?
5. Conclusions (if any)

WARNING! Contains Personal Opinions



Semantic Web: Why I Like It

(a personal view)

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Some Background

- Web (content) was built for humans
  - **human interpretation** is needed to accomplish tasks on the Web
  - automation is difficult (esp. automating **unforeseen** situations)
  - we need "machine-friendly" content
    - information w/ **accessible formal semantics**
    - allow machines to **reason** about information
- Motivation & Drivers
  - origins are in **metadata**
  - initial goal: Enabling automation
  - short term goal: Interoperability
  - long term goal: Make computers work **on our behalf**
    - (instead of using them like tools)
    - remove humans from the loop

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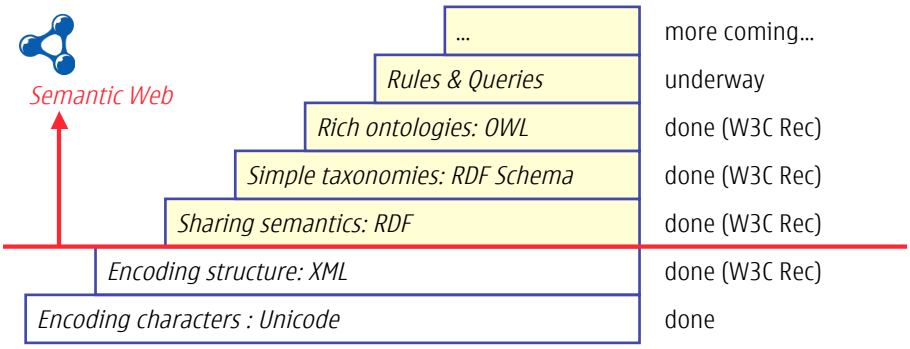
Semantics via Sharing

- Controlled vocabularies
  - better interoperability if same terms are 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
  - definition: "A specification of conceptualization" (Gruber)
- Library scientists are good with this
  - Dewey Decimal System **is** an ontology

Stepping Towards the Semantic Web



- Semantic Web is built in a layered manner
  - not everybody needs all the layers
- Some dangers looming (e.g., "two towers")

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What Should We Do Next?

- Now forget that we are talking about the Web...
- Modern PC applications are essentially just repositories for information (typically) in proprietary formats
  - combining or sharing information **across application boundaries** is impossible or difficult at best
  - any two applications can be engineered to enable information exchange, but we cannot anticipate all possible "pairings"
- In addition to the explicitly represented information, these systems hold a lot of **implicit** information
  - implicit information is largely **inaccessible** to current applications

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Implicit → Explicit

- e.g., your calendar may indicate that you have a flight reservation from Boston to Helsinki
  - **implying** that if you take the flight, you will then **be** in Helsinki
  - this information may be more useful (say, for meeting planning)
- Use of **reasoning** (= logical inference) will allow us to access the implicit information
- What do we need?
  - ubiquitous reasoning services
  - ontologies for all kinds of "common" concepts & information, e.g.
    - PIM data
    - geographical and organizational concepts (and instances)
    - classification of information (e.g., photo content)

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Issues in Mobile Computing & Ubiquitous Computing

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Mobile Web Access Today

- Web access on mobile devices is available today
- Some **technical limitations** exist
  - network (bandwidth, latency)
  - display (typically small)
  - input (often no full keyboard)
- Content is designed for "standard devices"
  - (= PCs: high bandwidth, large display)
  - most (commercial) content is **rendering-oriented**

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Some Issues with Mobile Web Access

- We can overcome the **technical** limitations, but the real limitations are of **different nature**...
- Mobile devices are used in "unusual" situations
  - when laptops, etc., are not viable (e.g., in the car)
  - typically, when paying attention to something else
    - mobile users are **attention-constrained**
  - consequently, **browsing** might not be the ideal paradigm for information access
- What do we need?
  - information/content that's not rendering-oriented
  - more automation (now, humans essentially do all the work)

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Some Things That Would Help

- Policies (prescriptive representations on how to act in a particular situation)
  - can control data access and usage (security & privacy)
  - support autonomous behavior
- Policy-awareness = ability to represent **and enforce** policies
- Context (information about "current situation")
  - can limit search
  - can limit choices in planning
  - can guide optimization
- Determining context benefits from policy-awareness

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Ubiquitous Computing (1)

- UbiComp is the ultimate interoperability nightmare!
  - instead of occasionally connecting a handful of devices, dynamically connect/disconnect/reconnect possibly hundreds of devices
- Traditional approach to interoperability: standardization
  - anticipate everything about the future
    - and *a priori* agree on how to act
  - (or: force all interactions to a restricted set of possibilities)
- What about unanticipated situations?
  - how do you agree dynamically on how to behave in a situation that wasn't covered by a standard?

  ⇒not "future-proof"

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Ubiquitous Computing (2)

- Connections with public and/or untrusted devices
  - cf. policy-awareness
- We may need to "borrow" functionality from other devices
  - this implies that we need to be able to represent and reason about contracts, payments, etc.
  - (alternatively: "digital communism")
- The UbiComp vision is largely contingent on
  - future-proofing
  - getting unanticipated "encounters" of devices to work

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Semantic Web to the Rescue?

- Semantic Web improves interoperability
  - e.g., via the use of reasoning
- Information, in more "raw" form, with semantics, can be used in many different ways
  - not tied to specific rendering, specific device, specific browser, etc.
  - context-awareness can help
- Semantic Web techniques (and other ontological) techniques can also be used for implementing
  - contexts & context-awareness [Lassila & Khushraj 2005]
  - policy-awareness [Kagal 2004]

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"Semantic Web Services" to the Rescue?

- Semantic Web technologies can be used for making content more "understandable" to automated systems
- When this idea is applied to Web Services
  - automatic discovery, composition and invocation are enabled
  - let's not forget the "Tower of Babble" (from Genesis 11:1-9)
- If we can infer what data and services are about, many things become possible, e.g.
  - dynamic, context-dependent generation of user interfaces
  - substitution of "equivalent" services
- Services may be a good abstraction of **all** functionality
  - (including **physical** functions)

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Conclusions

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What Did We Learn?

- Semantic Web (representation + reasoning)
  - helps with interoperability (of data)
  - can be used in making implicit information explicit
  - is a step towards making computers do more on our behalf
- Ubiquitous Computing
  - is an interoperability nightmare
  - will benefit from uniform representation for functionality
- Mobile Information Access
  - will benefit from information that does not presuppose presentation
  - can exploit contextual information
- We need a rich representation of policies
  - (and a framework for their enforcement)

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And Finally...

- Many problems in mobile and ubiquitous computing are (ultimately) problems of representation

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Questions? Comments? Time to wake up!

- some additional thoughts: http://www.lassila.org/blog/

- thanks to my colleagues Deepali Khushraj, Mark Adler and Heli Nyholm

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