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)

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
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

- Encoding characters: Unicode
- Encoding structure: XML
- Sharing semantics: RDF
- Simple taxonomies: RDF Schema
- Rich ontologies: OWL
- Rules & Queries
- ... more coming...

Semantic Web

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

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)
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**
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)

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
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”

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
**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]

**“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)
Conclusions

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)
And Finally...

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

Questions? Comments? Time to wake up!

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

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