Applying **Semantic Web** in Mobile and Ubiquitous Computing: Will Policy-Awareness Help?

Ora Lassila  
Research Fellow  
Nokia Research Center  
Cambridge, MA, USA  
November 2005

---

**What Do I Want to Say, and Why?**

- I have started to think that ubiquitous computing may not happen without Semantic Web technologies
  - what are the key technologies we need?
  - what are the important topics for further research?
- I’d like to see the Semantic Web community focus on other things than just “the Web”
- We (Nokia Research Center) have started a new lab and I would like to advertise it...
My Game Plan

1. Issues in Mobile & Ubiquitous Computing
2. Using the Semantic Web
3. Context-Awareness & Policy-Awareness
4. Conclusions (if any)
5. Discussion...

WARNING! Contains Personal Opinions

Mobile Web Access Today

- Web access on mobile devices is available today
- Some **technical limitations** exist
  - network (narrow bandwidth, high 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)

Ubiquitous Computing (1)

• Ubiquitous Computing is an 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
  - uniform representation of functionality is useful (e.g., Semantic Web Services)
  - this implies that we need to be able to represent and reason about contracts, payments, etc.
  - (alternatively: “digital communism”)
- The Ubiquitous Computing vision is largely contingent on
  - future-proofing
  - getting unanticipated “encounters” of devices to work

Now Forget All About the Web...

- Information, in more “raw” form, with semantics, can be used in many different ways
  - not tied to specific rendering, specific device, specific browser, etc.
- 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 $\rightarrow$ 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 functionality/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)

Context-Awareness

- “context” = information about “current situation”

- Can guide decisions about
  - what information gets presented (and how)
  - optimization of user interfaces

- Can assist service discovery

- Automation & autonomy
  - contextual information can be used to limit choices in planning

- Context-determination is easier if you have access to maximal amount of information
  - enter policy-awareness
**Policy-Awareness**

- Ability to represent, reason about, and **enforce** policies
- Policies are prescriptive representations on how to act in some future situation
  - Can control data access and usage (security & privacy)
  - Support autonomous behavior
  - What about contracts?
- Trying to determine current context benefits from policy-awareness
  - E.g., access to some information permitted given that it is **only** used for context-determination

**Conclusions (1)**

- Semantic Web (representation + reasoning)
  - Helps with interoperability
  - Can be used in making implicit information explicit
  - Is a step towards making computers do more on our behalf
- Semantic Web techniques useful when implementing
  - Contexts & context-awareness [Lassila & Khushraj 2005]
  - Policy-awareness [Kagal 2004]
Conclusions (2)

- Mobile Information Access
  - will benefit from information that does not presuppose presentation
  - can exploit contextual information

- Ubiquitous Computing
  - is an interoperability nightmare
  - needs technologies for “future-proofing”

- We need a rich representation of policies (and a framework for their enforcement)

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

Questions? Comments? Time to wake up!

- mailto:ora.lassila@nokia.com

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