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

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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…

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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**

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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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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"

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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
  - 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

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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

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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 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)

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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

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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

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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]

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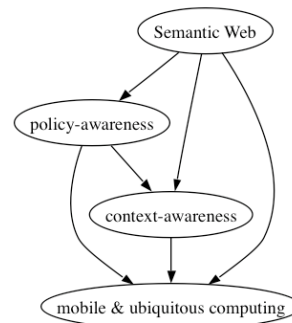
Conclusions (2)

- 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**

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Questions? Comments? Time to wake up!

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