Introducing ”Situational Statements” as an integrating Data Structure for User Modeling, Context-Awareness and Resource-Adaptive Computing

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Abstract

Ubiquitous computing will have a unifying influence on user modeling, context-awareness and resource-adaptivity. The idea of this paper is to suggest a basic, semantically founded, uniform data structure that is simple but still expressive enough to cover all representational needs. An extended triple, which is based on RDF resources is introduced as well as an XML application for so called ”Situational Statements”.

1 Introduction

In user modeling, context-awareness and resource-adaptive computing, information about the object of interest is gathered and further processed into higher level knowledge in order to receive hypothesis about possibilities for adaption of the system’s behavior. Often, data from low-level sensors are integrated into the inference process. In terms of knowledge representation, the question arises, if the basic bits of information can be represented in a uniform manner. Ubiquitous computing serves here as a motivation for unifying the representations, since in a ubiquitous computing scenario, all three kinds of adaptation will interact in a distributed way. Users will live together with intelligent spaces and devices that communicate with each other. Due to the distribution and interaction of different systems, one approach could be to define a uniform basic data structure, that defines a logic representation, a semantic interpretation and an exchange format in the form of an XML application.

Figure 1 points to the three different focuses of the three topics: the user, for user-adaptation, the location, for context-adaptation and the resource, for resource-adaptation. Representing information about the user like

Figure 1: User, Location, Resource(Device)

her age, or her current time pressure, information about the context like the noise level, or the temperature, or information about the resource for example the resolution and size of the display or the level of remaining energy in a battery, are analyzed in this short paper. This work is under progress.

2 Situational Statements

The basic idea behind situational statements is that they should form the main data structure for representation and communication about user-, context-, and resource-adaptation, while all other data structures are surrounding them. The meta level information of a statement like ”who is responsible for this piece of information”, or ”what is the confidence value for it”, is combined with the actual content of the statement like ”the cognitive load of this person is high”. Furthermore the basic information content is enriched with temporal and spatial constraints like ”this property holds between now and tomorrow”. Thus, situational statements can contain content data, restriction data and meta data. The underlying concepts are defined in the following sections.

2.1 The Model with Resources and Triples

The underlying model is based on the ideas of RDF/RDFS, (see e.g. [Champin, 2001]), which means that it works with descriptions about ”resources” that are qualified with URIs and namespaces. Resources in this sense here should not be mistaken with the ”device” resources, instead they can be considered as being the basic entities of a graph. Situational statements identify resources with qualified Uniform Resource Identifiers (URI) as described in [Lassila *et al.*, 1999], with the slight difference that URIs can have an optional fragment identifier: a text added to the URI with a ”#” between them. Situational Statements consider every qualified URI (with or without fragment identifier) as a full resource by itself. Since every qualified URI is unique, one could consider resources as linking unique IDs to the referred objects and concepts. Resources are not in the main focus but they allow to simplify the representation of complex structures. In order to keep the representation simple, the qualified URIs can be abbreviated by XML namespaces. For the sake of clarity, we will rather use the XML non-expanded notation ; that is, prefixes `UserOL:` and `UbisWorld:` will be used instead of `http://www.u2m.org/UserOL#` and `http://www.u2m.org/UbisWorld#` respectively. Thus, resources are conceptual mappings to entities, and with situational statements, a predefined structure of such mappings is suggested.

Figure 2: The Model of the Basic Triple

Basic Triples
The base element of the model about situational statements is the (RDF) triple: a resource (the subject) is linked to another resource (the object denoting the value) through an arc labelled with a third resource (the predicate). We will say that the `subject` has a property `predicate` valued by `object`. See figure 2 for a graphical representation.
For example, the triple in figure 3 could be read as "the subject *Peter of UbisWorld* has the property *CognitiveLoad of the UserOL Ontology* with the value *high from Range #1233"*.

Figure 3: "Peter has a high cognitive load"

Extended Triples
An "Extended Triple" is a 7-tuple, that extents the basic triple (subject, predicate, object) with temporal- and spatial restrictions as well as meta-data about ownership & privacy and evidence & confidence. The idea is to allow more powerful, but still structured, statements about situations. See figure 4 for a conceptual graph of a general extended triple. The dashed lines in the extended triples has the meaning of "adding information" to the basic triples.

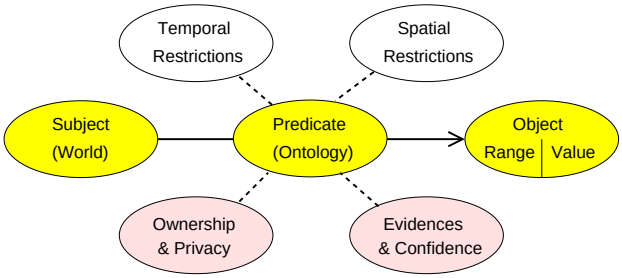

Figure 4: The Concept for Extended Triples

In the extended triple example of figure 5, the basic statement that *Peter has a high cognitive load* is enriched with additional information to a statement like *Peter is now and in the next 60 seconds most probably under a high cognitive load if he does not leave the examination hall. This can be explained by the list of evidences #2211. Peter is the owner of this information and due to his privacy settings, it is freely available only for friends.*

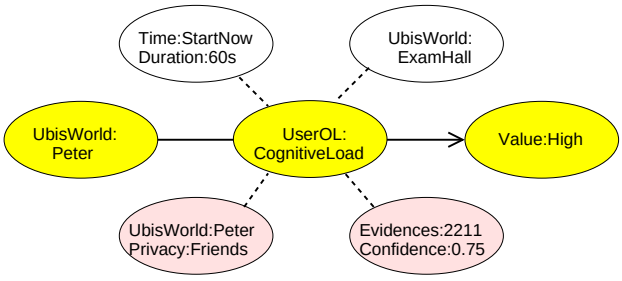

Figure 5: A complex example of a Situational Statement

UbisWorld
The examples of this paper are embedded in a world model called UbisWorld, see [Heckmann, 2003b] UbisWorld can be used to represent some parts of the real world like an office, a shop, a museum or an airport. It represents persons, objects, locations as well as times, events and their properties and features. The main focus is put on research issues of ubiquitous computing and user modeling. Apart from the representational function, UbisWorld can be used for simulation, inspection and control. See [Heckmann, 2003a] and [Heckmann, 2003c] for more details.

2.2 The Semantics of this Model

In order to allow a clear interpretation of this model, there is a need to define the meaning of the concept. The relationship of the vocabulary of the situational statements, that has been described so far, is expressed in extended BNF in figure 6.

```
SituationalStatement =
                    ExtendedTriple;
ExtendedTriple = Content,
                    Restriction,
                    Meta;
Content          = Subject,
                    Predicate,
                    Object;
Restriction      = TemporalRestriction,
                    SpatialRestriction;
Meta             = OwnerAndPrivacy,
                    EvidenceAndConfidence;
```

Figure 6: The relationships in extended BNF

In a logical approach, these sets can be defined properly. The axioms, constrains and relations could also be expressed formally but here only some of them are listed.

Definition: [Resources, Statements, Questions]

Let $\mathbb{R}$ be the finite set of all *Resources*.
Let $\mathbb{S}$ be the set of all *Situational Statements*.
Let $\mathbb{Q}$ be the set of all *Situational Questions*.
Let $\mathbb{S}^{User}$ be the set of all *UserModel Statements*.
Let $\mathbb{S}^{Device}$ be the set of all *DeviceModel Statements*.
Let $\mathbb{S}^{Context}$ be the set of all *ContextModel Statements*.

$$\mathbb{S} = \mathbb{S}^{User} \cup \mathbb{S}^{Device} \cup \mathbb{S}^{Context}$$
$$\mathbb{Q} = \mathbb{Q}^{User} \cup \mathbb{Q}^{Device} \cup \mathbb{Q}^{Context}$$

Together with the BNF and the definition above, the vocabulary for a semantic mapping is provided. Still, in this paper, a concrete semantic is omitted. Some semantical aspects are mentioned below

- The content is only valid according the time constraint, which means between the start time and the added duration. After expiry the content is either unknown or the confidence value is adjusted.
- The content is only valid as long no new information from the same source is available. This means that the content can be overwritten.
- The confidence value is set between 0 and 1 and is based on a list of evidences.
- The situational statements may only be used if the owner allows this according to his privacy settings.
- The frame axiom and the closed world could be embedded.

- The location of measurement is, if applicable, of interest and can be expressed.

The meaning of situational statements can differ from application to application, but a clear semantic definition can be supported. In this description most details are underspecified. For example the time constraints and the confidence value could be realized by start-time, end-time, confidence-value but they could also be realized by a more complex function between these three variables. In the next section, an XML representation for a special instance of situational statements is presented.

3 XML for Situational Statements

Using XML as knowledge representation language has the advantage that it can be used directly in the Internet environment. But still the question remains, how to represent the situational statement syntactically. In the subsections below, two possible versions are shown.

3.1 A short Version with Attributes

The short XML representation only uses one tag with attributes. The main idea was to stay as simple as possible and reduce the syntactical sugar. Especially for data exchange and resource limited situations, this representation seems to be the candidate.

```
<SituationalStatement
    subject = "UbisWorld:Peter"
    predicate = "UserOL:CognitiveLoad"
    object = "High"
    start = "20030517.140334"
    duration = "600s"
    confidence = "0.75"
    owner = "UbisWorld:Peter"
    privacy = "UserOL:friends-only"
    viewer = "UbisWorld:Joerg"
/>
```

3.2 A full Version

The second version is more verbose, but in fact does not contain more information. Still, it offers more structure and can better be extended than the short version.

```
<SituationalStatement version="Full_0.1">
   <content>
     <subject><UbisWorld:Peter /></subject>
     <predicate><UserOL:CognitiveLoad /></predicate>
     <predicate-range><UserOL:L-M-H /></predicate-range>
     <object>High<object>
   </content>
   <restriction>
     <start>20030517.140334</start>
     <duration>600s</duration>
     <location>not-specified<location>
   </restriction>
   <meta>
     <owner><UbisWorld:Peter /></owner>
     <privacy><UbisWorld:friends-only /></privacy>
     <viewer><UbisWorld:Joerg /></owner>
     <evidence>not-specified</evidence>
     <confidence>0.75 </confidence>
   </meta>
</SituationalStatement>
```

These two representations are based on the RDF resource idea, which means that the resources are only stated or linked as IDs. the semantics for example for `<UserOL:CognitiveLoad />` is defined in a document with the name ”UserOL”. See figure 7 for a small part of it’s taxonomy. One advantage of this modularized approach is that the ontology and the representational formalism are separated, which means that everybody could use his own ontology while using the same representation and tools. According to the definition of ”Situational Statements” a representation for ”Situational Questions” will be defined in the next step.

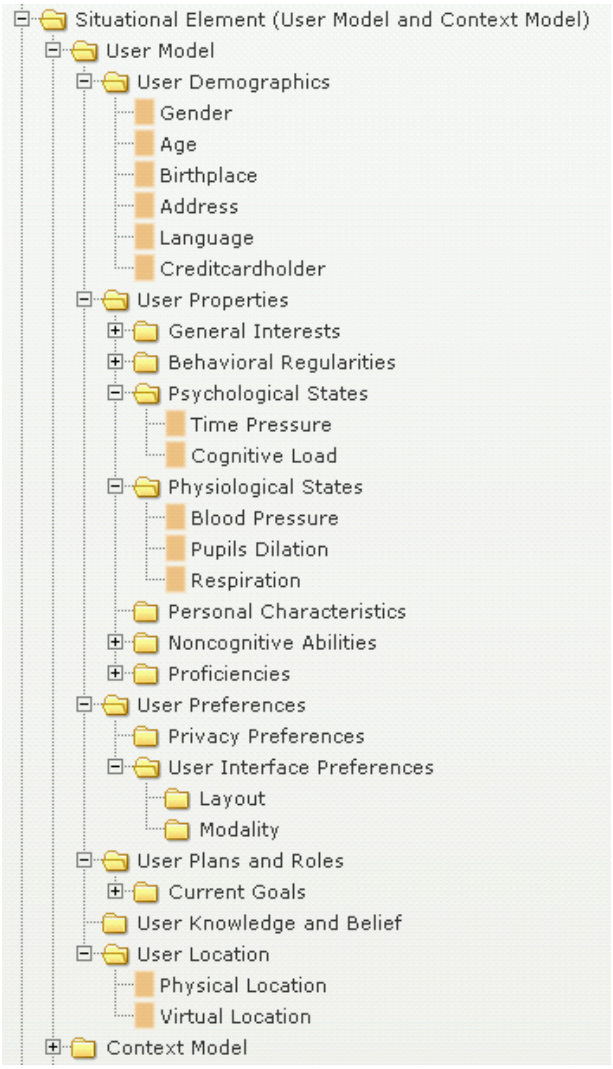

Figure 7: A part of the UserOL Taxonomy

4 First Applications

As a proof of concept user modeling, context-awareness and resource-adaptivity is implemented in UbisWorld as well as privacy handling while all of them are based on the same situational statement syntax. In UbisWorld, the ontology behind situational statements is embedded in a wider ontological context. See figure 8 for an overview of the taxonomy.

Situational statements are also used in an application of a pedestrian navigation scenario, which will be presented at the same ABIS workshop. See [Wasinger *et al.*, 2003] for more information.

5 Conclusion

We think that ubiquitous computing will have a unifying influence on user modeling, context-awareness and resource-adaptivity. The development of a basic, expressive, well-defined data structure to express property attributes could be a help for this research community. The main technical idea of ”Situational Statements” is to use the concept of resources in order to point to global available ontologies like UserOL. The deeper motivation behind this idea is to simplify communication about partial user-, context-, and resource models via the Internet. In this paper, we have put the focus on the aspect of representation.

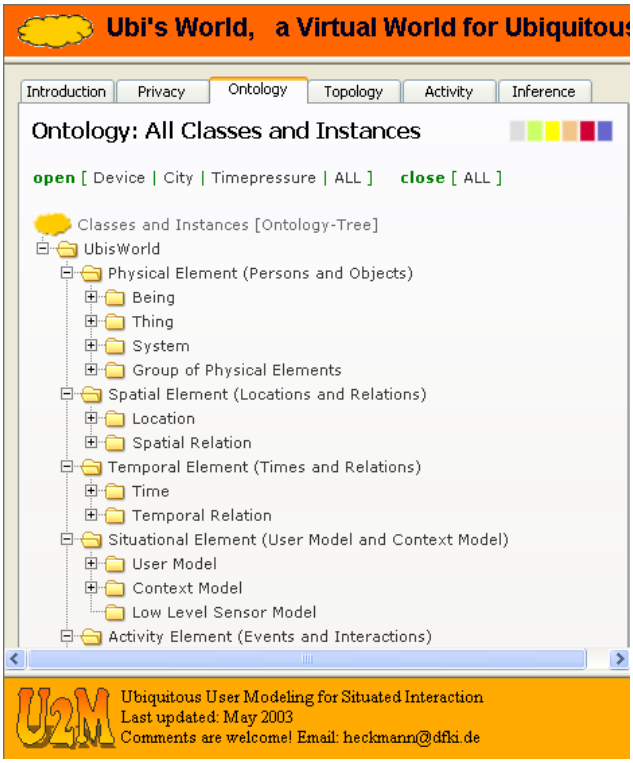

Figure 8: Overview of UbisWorld Taxonomy

Acknowledgments

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