

# Distributed User Modeling for Situated Interaction

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**Abstract:** A distributed service to model and control contextual information in mobile and ubiquitous computing environments is presented in this paper. We introduce the general user model ontology GUMO for the uniform interpretation of distributed situational information in intelligent semantic web enriched environments. We show the relation to the user model markup language USERML, that is used to exchange partial models between different adaptive applications. Our modeling and retrieval approach bases on semantic web technology and conflict resolution concepts.

## 1 Motivation

Systems that adapt to their users need to represent and use information about them. Increasing mobility and ubiquity of interactive systems make context-aware, situation-adaptive and especially user-adaptive computing more important. One challenge is to let different systems communicate about their user models. This challenge has been motivated by the expected result that *permanent evaluation of user behavior with different systems and devices will lead to better models and thus allow better functions of adaptation like adaptive web-sites, recommended products, adaptive route planning or better speech interaction*. However, this communication about user related data calls for an extended privacy treatment. We suggest, that apart from the privacy enhanced user modeling service, the user's privacy settings should be attached to each partial information. Thus, the fundamental data structure in our approach, the SITUATIONALSTATEMENT [Hec03], collects apart from the main information also meta data like temporal and spatial constraints, explanation components and privacy preferences. Distributed sets of SITUATIONREPORTS form a coherent, integrated, but still hybrid accretion concept of ubiquitous situation models.

## 2 Architecture for an Highly Distributed SITUATIONSERVICE

Our so called `u2m.org` SITUATIONSERVICE manages information about users, about their contexts and the situation in general. It contributes additional benefit compared to a pure situation server or context broker that only manage information. The presented service is an application independent server with a distributed approach for accessing and storing information, the possibility to exchange and understand data between different applications as well as adding privacy and transparency to statements. A key feature is that

the semantics for all user model and context dimensions are mapped to the general user model & context ontology GUMO, see [HBS<sup>+</sup>05] or <http://www.gumo.org>. Thus the inter-operability between distributed user-adaptive and context-aware systems is granted. Figure 1 shows the main actors and modules of the `u2m.org` SITUATIONSERVICE.

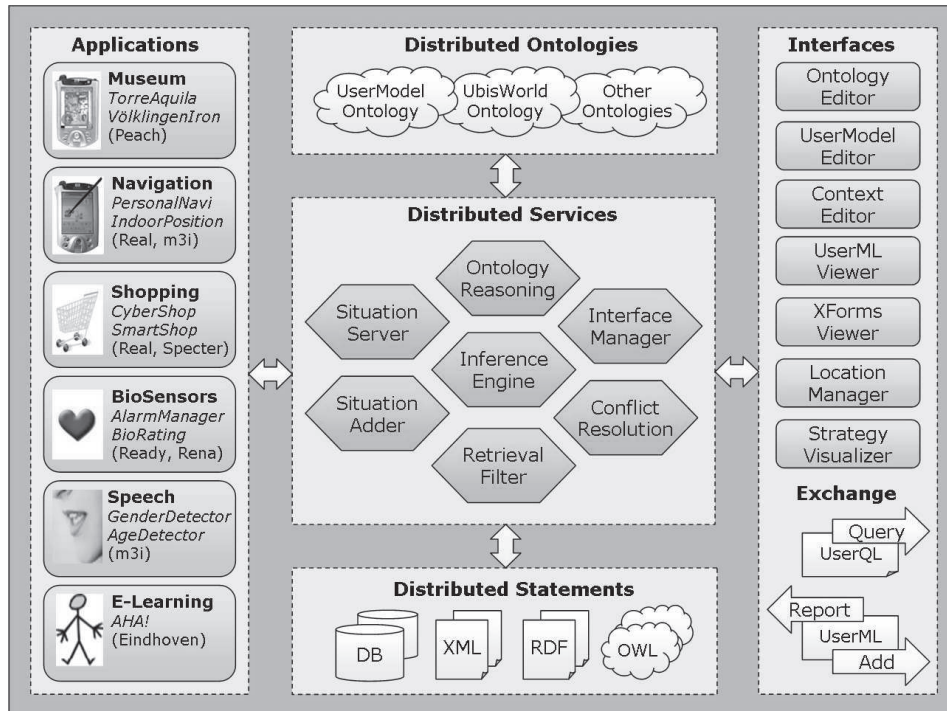


Abbildung 1: Modularized architecture of the `u2m.org` SITUATIONSERVICE

The **Distributed Services** box is surrounded by its connected environment. Even though the items are shown conceptually close to each other, they are spatially spread throughout the whole scenery. Such modules that represent tasks and roles are:

- *Situation Server*, a web-server that manages the storage of the statements
- *Situation Adder*, a parser that analyzes incoming statements and distributes the repositories.
- *Retrieval Filter*, a procedure that controls the retrieval of situation statements
- *Conflict Resolution*, a complex process that detects and resolves possible conflicts
- *Inference Engine*, a proactive engine that applies meta rules and triggers events
- *Interface Manager*, a control mechanism that integrates the user interfaces
- *Ontology Reasoning*, a reasoner that applies knowledge from the various ontologies

The **Applications** box sorts the applications that already cooperate with the SITUATIONSERVICE according to their application domain: *museum*, *navigation*, *shopping*, *biosensors*,

*speech* and *e-learning*. The **Distributed Statements** box points to the clear separation between data and software. The repositories are completely independent from the services which allows various services to operate independently on the same knowledge bases. This is only possible because the `privacy` and `administration` attributes are attached to each `SITUATIONALSTATEMENT` and not (as in most other systems) handled by the broker system. The **Distributed Ontologies** box points to the clear separation between the syntax and the semantic as discussed in the following section. These ontologies are used for the interpretation of statements, for the detection of conflicts and for the definition of expiry defaults and privacy defaults. The communication between the boxes and items is indicated by the bipolar arrows. `UserQL` is used to ask the queries, `UserML` is used to report the answers and to add new statements.

### 3 User Modeling with UserML and GUMO

Ontologies provide a shared and common understanding of a domain that can be communicated between people and heterogeneous, widely spread application systems, as pointed out in [Fen01]. GUMO is collecting the user's dimensions that are modeled within user-adaptive systems like the *user's heart beat*, the *user's age*, the *user's current position*, the *user's birthplace* or the *user's ability to swim*. Furthermore, the modeling of the user's interests and preferences like *reading poems* or *playing adventure games* is analyzed. Secondly, the contextual dimensions like *noise level* in the environment, *battery status* of the mobile device, or the outside *weather* conditions are modeled. The main conceptual idea is the division of user model & context dimensions into the three parts: auxiliary, predicate and range as shown below.

$$\begin{array}{c} \text{subject } \{ \text{UserModel\&ContextDimension} \} \text{ object} \\ \Downarrow \\ \text{subject } \{ \text{auxiliary, predicate, range} \} \text{ object} \end{array}$$

Apart from these five so called mainpart attributes, there are predefined attributes about the situation, the explanation, the privacy and the administration as shown in figure 2 which presents the concept of `SITUATIONREPORTS`. Thus, our basic

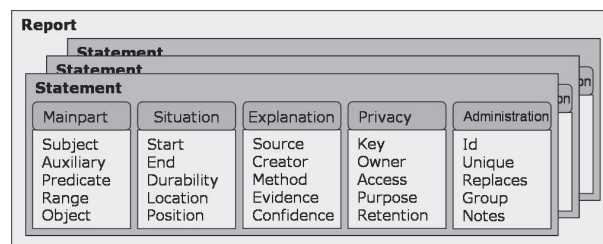


Abbildung 2: A `SITUATIONREPORT` is defined as a bag of `SITUATIONALSTATEMENTS`

context modeling is more expressive than simple attribute-value pairs or RDF triples. If

one wants to say *something about the user's interest in football*, one could divide this into the auxiliary=*hasInterest*, the predicate=*football* and the range=*low-medium-high*. GUMO is designed according to this USERML approach. Approximately one thousand groups of auxiliaries, predicates and ranges have so far been identified. However, it turned out that actually everything can be a predicate for the auxiliary *hasInterest* or *hasKnowledge*, what leads to a problem. The suggested solution is to identify basic user model dimensions on the one hand while leaving the more general world knowledge open for already existing other ontologies on the other hand. Candidates are the general suggested upper merged ontology SUMO, see [PNL02], and the UBISONTOLOGY, see [SH05], to model intelligent environments. Which groups of user dimensions can be identified? In [Jam01] and [Kob01] rough classifications for such categories can be found. Identified user model and context auxiliaries are for example *hasKnowledge*, *hasInterest*, *hasPlan*, *hasProperty*, *hasPlan*, *hasRegularity* and *hasLocation*. We restrict ourselves in this paper to present user model predicates that fit to the auxiliary: *hasProperty*, the so called *BasicUserDimensions*. The following listing presents the concept *Physio-*



Abbildung 3: Some *BasicUserDimensions*: Emotional States, Characteristics and Personality. The complete ontology can be inspected with a foldable tree browser at [www.gumo.org](http://www.gumo.org)

*logicalState* defined as `owl:Class`. It is defined as a subclass of *BasicUserDimensions*. A class defines a group of individuals that belong together because they share some properties. Classes can be organized in a specialization hierarchy using `rdfs:subClassOf`.

```
<owl:Class rdf:ID="PhysiologicalState.700016">
  <rdfs:label> Physiological State </rdfs:label>
  <rdfs:subClassOf rdf:resource="#BasicUserDimensions.700002" />
  <gumo:identifier> 700016 </gumo:identifier>
  <gumo:lexicon>state of body or bodily functions</gumo:lexicon>
  <gumo:privacy> high.640033 </gumo:privacy>
  <gumo:website rdf:resource="&GUMO;concept=700016" />
</owl:Class>
```

Every concept has a unique `rdf:ID`, that can be resolved into a complete URI. Apart from solving the problem of conceptual ambiguity, this number facilitates the work within relational databases, which is important for the implementation. The lexical entry `gumo:lexicon` is defined as *the state of the body or bodily functions*, while it could also be realized through a link to an external lexicon. Some `expiry` examples are:

- physiologicalState.heartbeat - can change within seconds
- mentalState.timePressure - can change within minutes
- characteristics.inventive - can change within months
- personality.introvert - can change within years
- demographics.birthplace - can't normally change at all

The idea behind `gumo:expiry` is that if no new value is available on the SITUATION-SERVICE one can still work with old values, combined with reduced confidence values. To support the distributed construction and refinement of GUMO, we developed a specialized online editor to introduce new concepts, to add their definitions and to transform the information automatically into the required semantic web language.

**Summary.** We have introduced a distributed, integrated user modeling architecture for situated interaction. The user model exchange language `UserML` has been presented as well as the general user model & context ontology GUMO. Our approach bases on semantic web technology and conflict resolution in order to be flexible enough to support adaptation in human-computer interaction in mobile and ubiquitous computing.

**Acknowledgements.** This work has been supported by the German Science Foundation (DFG)'s International Post-Graduate College *Language Technology and Cognitive Systems* at Saarland University and University of Edinburgh.

## Literatur

- [Fen01] Dieter Fensel. *Ontologies: A Silver Bullet for Knowledge Management and Electronic Commerce*. Springer-Verlag Berlin Heidelberg, 2001.
- [HBS<sup>+</sup>05] Dominik Heckmann, Boris Brandherm, Michael Schmitz, Tim Schwartz und Baroness Margeritta von Wilamowitz-Moellendorf. GUMO - the General User Model Ontology. In *Proceedings of the 10th International Conference on User Modeling*, Edinburgh, Scotland, Jun 2005.
- [Hec03] Dominik Heckmann. Introducing Situational Statements as an integrating Data Structure for User Modeling, Context-Awareness and Resource-Adaptive Computing. In Andreas Hoto und Gerd Stumme, Hrsg., *LLWA Lehren - Lernen - Wissen - Adaptivität (ABIS2003)*, Seiten 283–286, Karlsruhe, Germany, Oktober 2003.
- [Jam01] Anthony Jameson. *Systems That Adapt to Their Users: An Integrative Perspective*. Habilitation, Saarbrücken, Germany, Juni 2001.
- [Kob01] Alfred Kobsa. Generic User Modeling Systems. *User Modelling and User-Adapted Interaction Journal*, 11(1-2):49–63, 2001.
- [PNL02] Adam Pease, Ian Niles und J. Li. The Suggested Upper Merged Ontology: A Large Ontology for the SemanticWeb and its Applications. In *AAAI-2002Workshop on Ontologies and the Semantic Web*, Working Notes, 2002. <http://projects.teknowledge.com/AAAI-2002/Pease.ps>.
- [SH05] Christoph Stahl und Dominik Heckmann. Using Semantic Web Technology for Ubiquitous Location and Situation Modeling. *The Journal of Geographic Information Sciences CPGIS: Berkeley*, 10(2), 2005.