Preface

As we walk, our locomotion reveals our destinations.
As we talk, our speech reveals our intentions.
As we gesture, our motions reveal our thoughts.

As we read, our gaze reveals our focus of attention.
As we type, our keystrokes reveal our intentions.
As we surf the web, our clicks reveal our interests.

Jon Orwant - DOPPELGÄNGER PROJECT
[Orwant, 1995]

Ubiquitous User Modeling

Dominik Heckmann

Supervisors: Wolfgang Wahlster & Jon Oberlander

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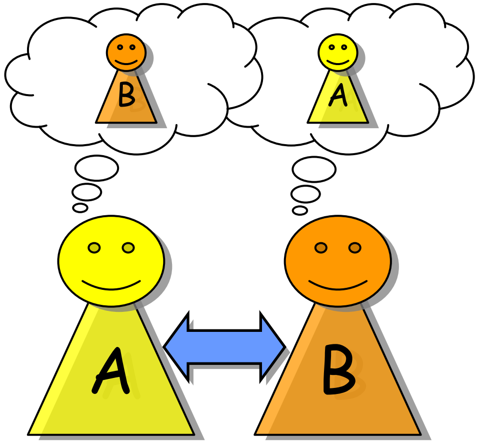
Trier, July 10th, 2005

Outline of the Talk

- Part 1: (Motivating Questions)
  - What is user modeling?
  - Why de we need *ubiquitous* user modeling?
  - How to define ubiquitous user modeling?
- Part 2: (Engeneering Questions)
  - How do we realize ubiquitous user modeling?
  - What are the problems and the contributions?
  - What is the overall service architechture like?

Comparison of Human-Human vs. HCI User Modeling and User-Adaptivity

Human-human interaction



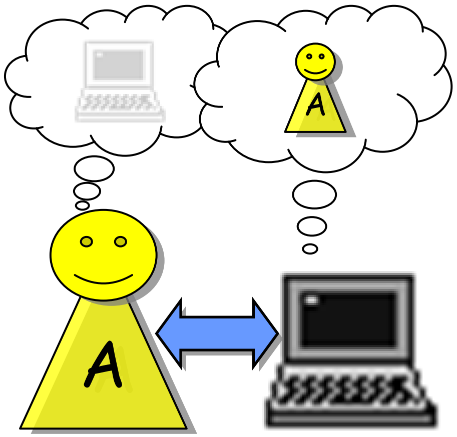
H1 User model their interaction partner →

age, gender, mother language
cognitive load, time pressure, emotion
mood, clothes, plans, knowledge

H2 User show adaptive behavior →

We adapt vocabulary (age)
We adapt speech volume (noise)
We adapt speech rate (time pressure)

Human-computer interaction



H3 Systems model their users: **User Modeling**

H4 Systems adapt to their users: **User-Adaptivity**

User Model

Context Model
Situation Model

Why *Ubiquitous* User Modeling?

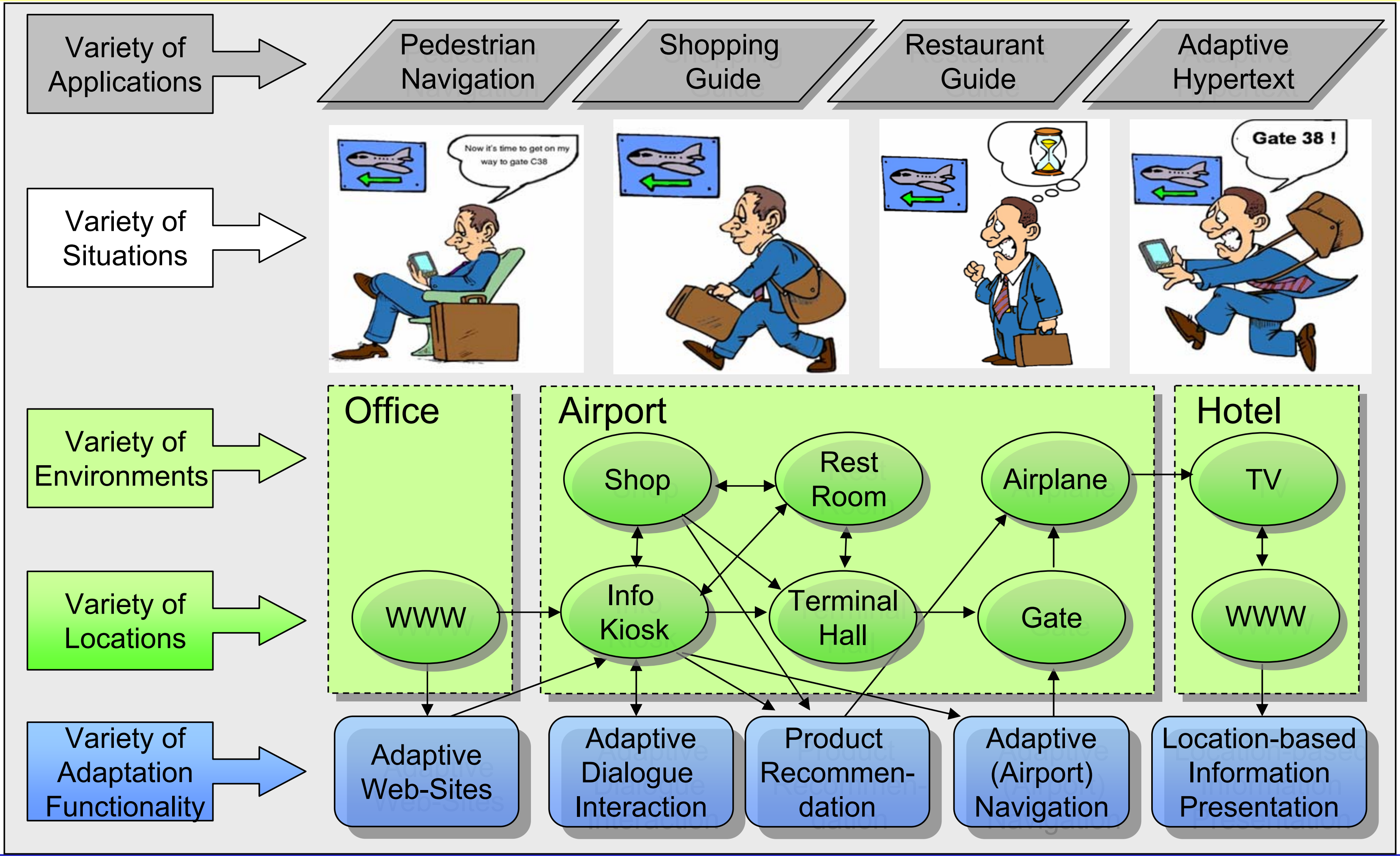
More and more interactions take place between humans and different stationary, mobile or web-connected IT-systems in daily life.

There is a shift from the „desktop metaphor“ to the metaphors of „mobile computing“, „ubiquitous computing“ and „intelligent environments“

If we manage to integrated all distributed, user-related assumptions (that are currently applied by these systems individually) into one consistent model, then we could expect several improvements

We expect that ongoing evaluation of user behavior with systems that share their user models will improve the coverage, the level of detail, and the reliability of the integrated user models (and thus allow better functions of adaptation)

Motivating Example for Ubiquitous User Modeling in the Airport Scenario



Variety of Applications

Pedestrian Navigation

Shopping Guide

Restaurant Guide

Adaptive Hypertext

Variety of Situations

Variety of Environments

Office

Airport

Hotel

Variety of Locations

WWW

Shop

Rest Room

Airplane

TV

Info Kiosk

Terminal Hall

Gate

WWW

Variety of Adaptation Functionality

Adaptive Web-Sites

Adaptive Dialogue Interaction

Product Recommen-dation

Adaptive (Airport) Navigation

Location-based Information Presentation

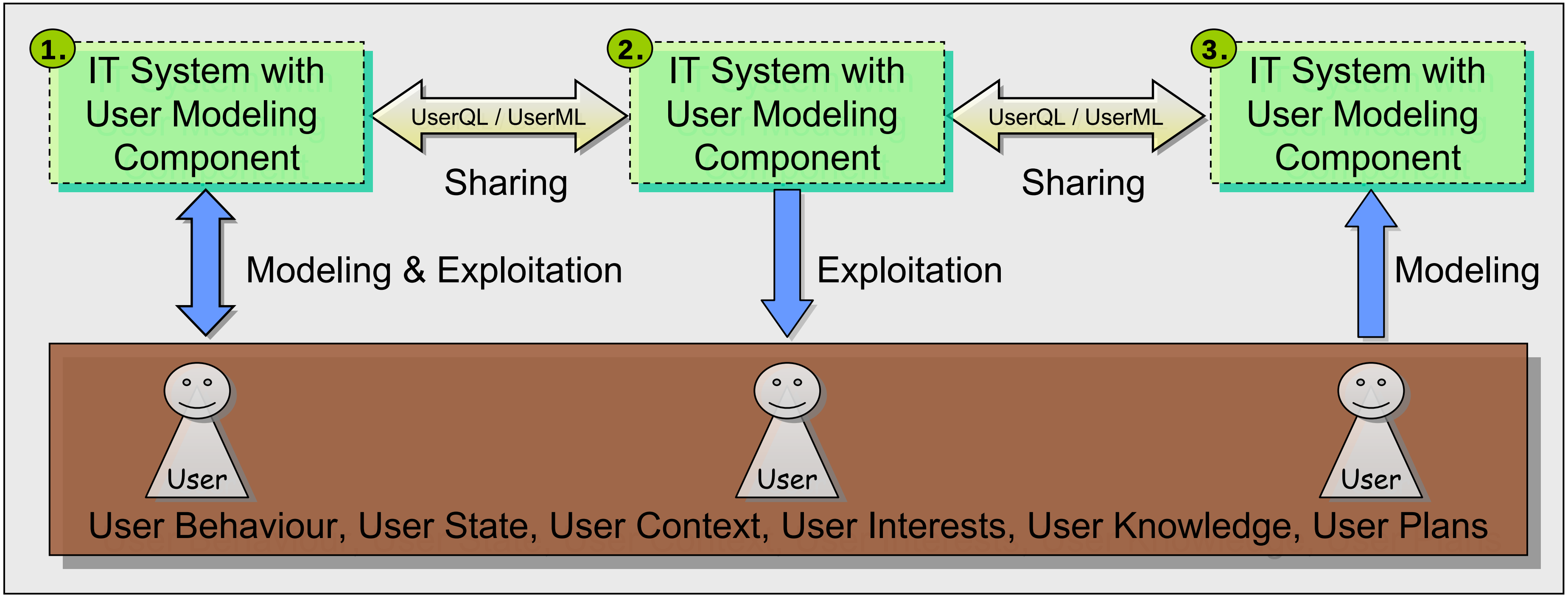
How do we define Ubiquitous User Modeling?

Definition (Ubiquitous User Modeling)

> Ubiquitous user modeling describes ongoing modeling and exploitation of user behavior with a variety of systems that share their user models for mutual or individual adaptation goals.

- Ubiquitous user modeling can be differentiated between general user modeling by the three additional concepts: ongoing modeling, ongoing sharing and ongoing exploitation.
- Ubiquitous user modeling implies that the user’s behavior and the user’s state are constantly tracked at any time, at any location and in any interaction context → important need for privacy control !

(Generalize the example into a) Conceptual View to Ubiquitous User Modeling



1. IT System with User Modeling Component

2. IT System with User Modeling Component

3. IT System with User Modeling Component

User Behaviour, User State, User Context, User Interests, User Knowledge, User Plans

PART 2:
Tasks, Design Decisions and Methods

- Main Tasks
  - Enable user model exchange and knowledge-sharing between user-adaptive systems on the web and within instrumented environments
  - Enable facilities for the user to inspect and control the represented and exchanged user-related data

- Main Design Decisions
  - Support decentralization, inconsistencies, conflict resolution
  - Support scrutability, modularity, clearity, external ontologies

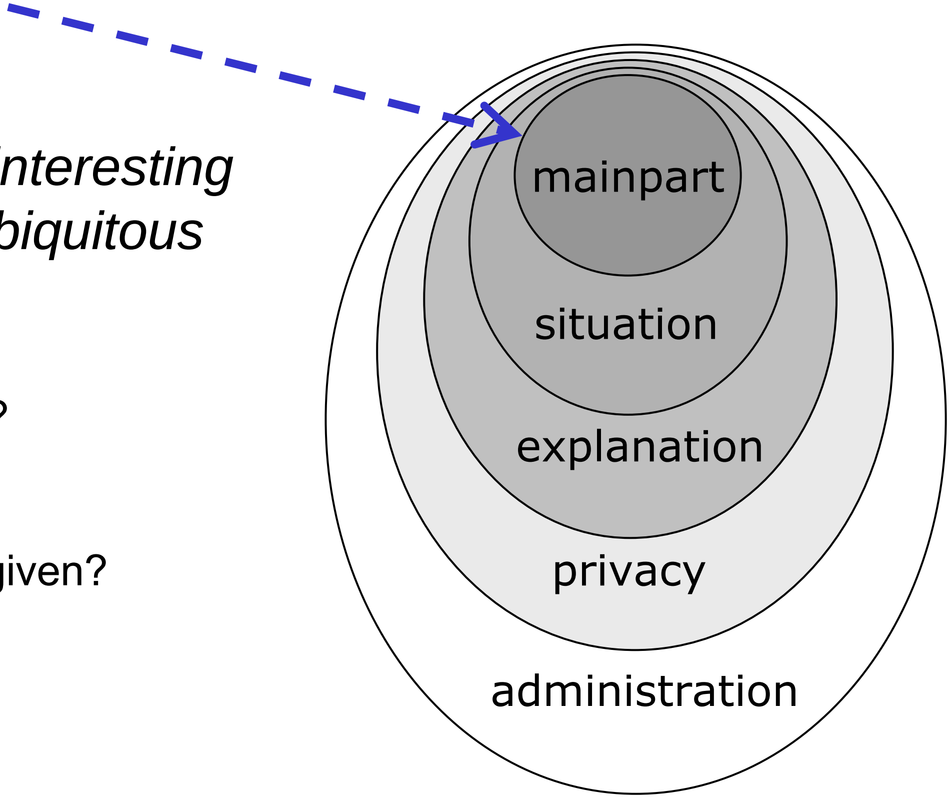
- Main developed Methods
  - Relation-based user model representation: SituationalStatements
  - RDF-based user model exchange language: UserML, UserQL
  - OWL-based user model ontology: GUMO, UbisWorldOntology
  - Web-based user model tools: UserModelEditor, UbisBrowser, OntologyEditor, OntologyTreeBrowser, LocationMonitor, …
  - Service-based user model broker: www.u2m.org

What will be exchanged?

Mainpart + Meta Data = SituationalStatement

„Peter ist under high time pressure“

Which meta data is interesting for distributed and ubiquitous user modeling?



When and how long is the statement valid?
Where is Peter under time pressure?

Who claims this and which explanation is given?
What is the evidence and the confidence?

Who is the owner of this information?
What are the privacy settings?

How can the statement be uniquely identified?
Can the statement be grouped with others?

Situational Statement / Box

Mainpart

Subject	= Peter
Auxiliary	= hasProperty
Predicate	= timePressure
Range	= low-medium-high
Object	= high

Situation

Start	= 2005-04-16T19:15
End	= 2005-04-16T19:25
Durability	= few minutes
Location	= airport.dutyfree
Position	= x34-y22-z15

Explanation

Source	= peter.repository
Creator	= airport.inference
Method	= deduction13
Evidence	= id2, id3
Confidence	= most-probably

Privacy

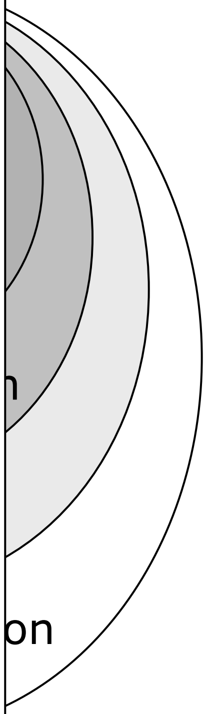
Key	= ********
Owner	= Peter
Access	= friends-only
Purpose	= research
Retention	= few days

Administration

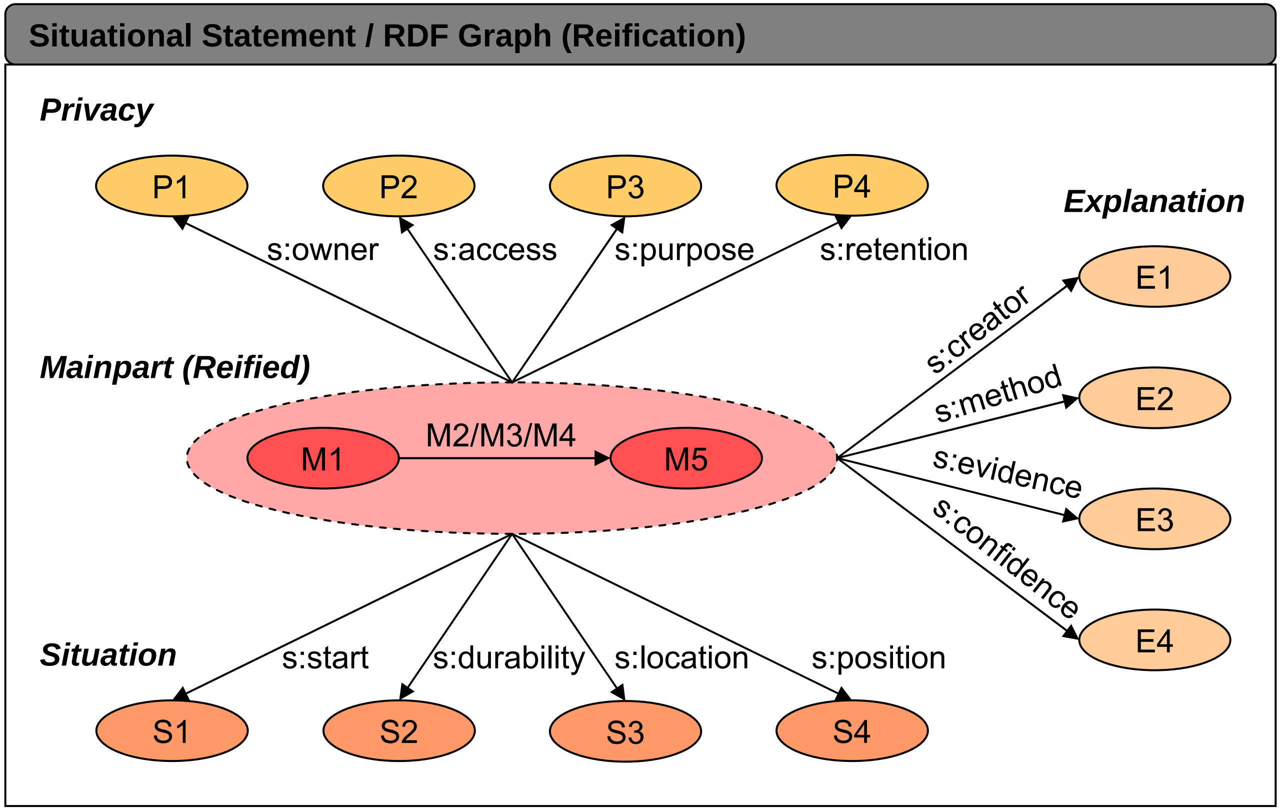
id	= 23
unique	= u2m.org#154123
replaces	= u2m.org#154006
group	= UserModel
notes	= ;-(

Situational Statement / RDF-XML

```
<rdf:RDF
    xmlns:rdf=“http://www.w3.org/1999/02/22-rdf-syntax#“
    xmlns:st=“http://www.u2m.org/2003/situation#“
    xml:base=“http://www.u2m.org/2003/statements“>
<rdf:Description rdf:ID=“statement_XY“>
        <st:subject> A1 </st:subject>
        <st:auxiliary> A2 </st:auxiliary>
        <st:predicate> A3 </st:predicate>
        <st:range> A4 </st:range>
        <st:object> A5 </st:object>
        <st:start> A6 </st:start>
        <st:end> A7 </st:end>
        <st:durability> A8 </st:durability>
        <st:location> A9 </st:location>
        <st:position> A10 </st:position>
        <st:source> A11 </st:source>
        <st:creator> A12 </st:creator>
        <st:method> A13 </st:method>
        <st:evidence> A14 </st:evidence>
        <st:confidence> A15 </st:confidence>
        <st:key> A16 </st:key>
        <st:owner> A17 </st:owner>
        <st:access> A18 </st:access>
        <st:purpose> A19 </st:purpose>
        <st:retention> A20 </st:retention>
        <st:id> A21 </st:id>
        <st:unique> A22 </st:unique>
        <st:replaces> A23 </st:replaces>
        <st:group> A24 </st:group>
        <st:notes> A25 </st:notes>
</rdf:Description>
</rdf:RDF>
```

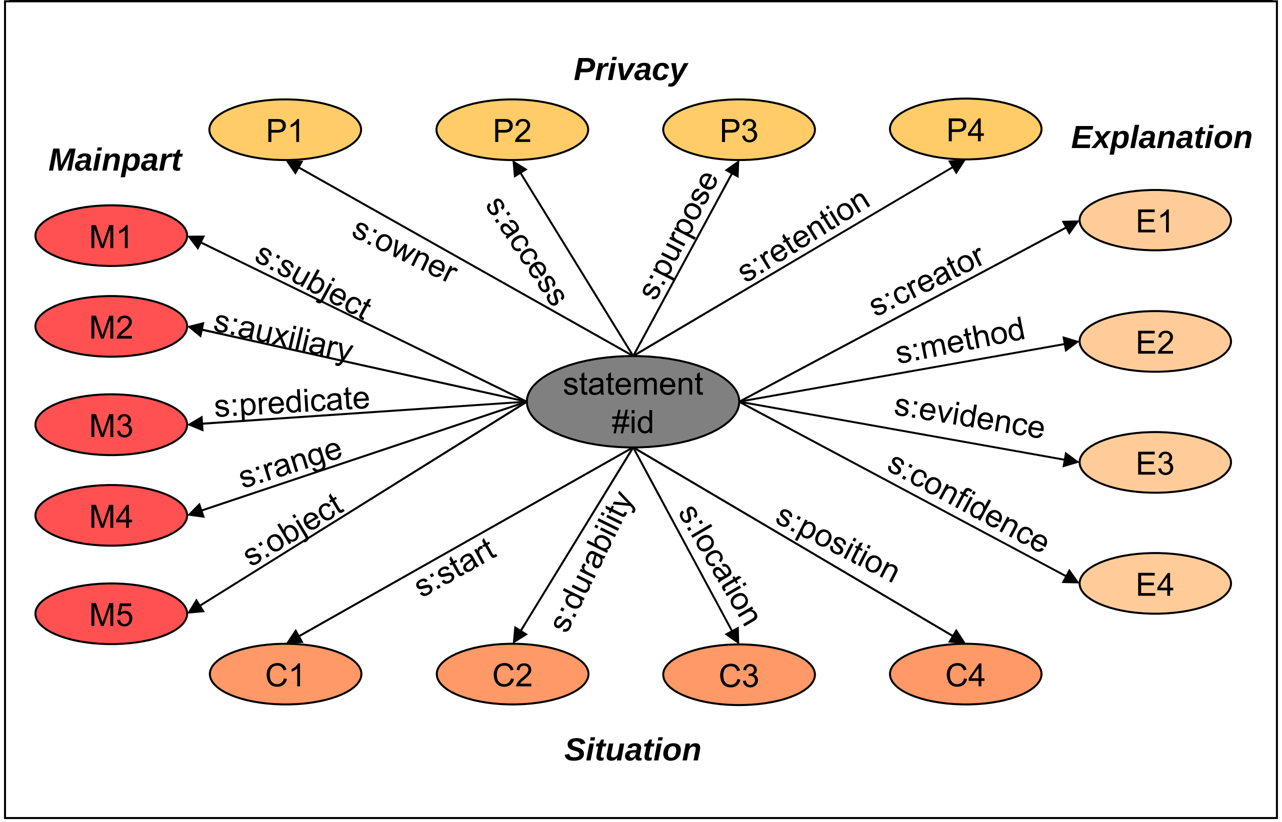


Reification-based RDF Representation

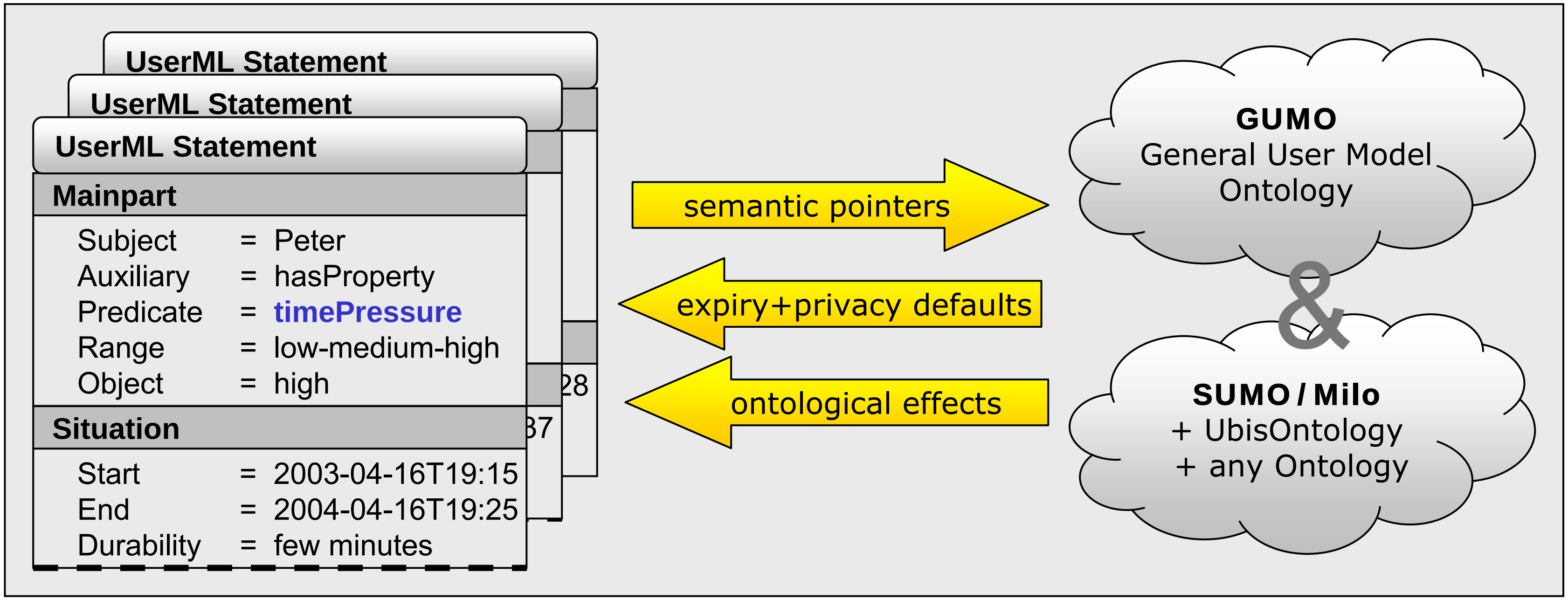


Relational RDF Representation

Situational Statement / RDF Graph



From SituationalStatements to GUMO



UserML Statement

UserML Statement

UserML Statement

Mainpart

Subject	=	Peter
Auxiliary	=	hasProperty
Predicate	=	timePressure
Range	=	low-medium-high
Object	=	high

Situation

Start	=	2003-04-16T19:15
End	=	2004-04-16T19:25
Durability	=	few minutes

GUMO
General User Model
Ontology

SUMO / Milo
+ UbisOntology
+ any Ontology

From SituationalStatements to GUMO

- default expiry of information → into the ontology?
  - physiologicalState.heartbeat: can change within seconds
  - mentalState.timePressure: can change within minutes
  - emotionalState.happiness: can change within minutes
  - characteristics.inventive: can change within months
  - personality.introvert: can change within years
  - demographics.birthplace: can't normally change at all

- default privacy settings → into the ontology?
  - disabilities.colorblindness: should be accesible for presentation systems
  - disabilities.wheelchair: intersting for pedestrian navigation systems
  - demographics.birthplace: accessible or hidden?
  - emotionalState.happiness: accessible or hidden?

From RDF Triples to Five-tuples

- Argument 1: different auxiliaries for each user model dimension
  - Peter is currently teaching
  - Peter likes teaching very much
  - Peter knows a lot about teaching
- Argument 2: different ranges for each user model dimension
  - Peter’s time pressure is low (within a scale of low-medium-high)
  - Peter’s time pressure is 0.6 (within a numeric scale between 0 and 2)
  - Peter’s time pressure is 30% (within 0% - 100%)

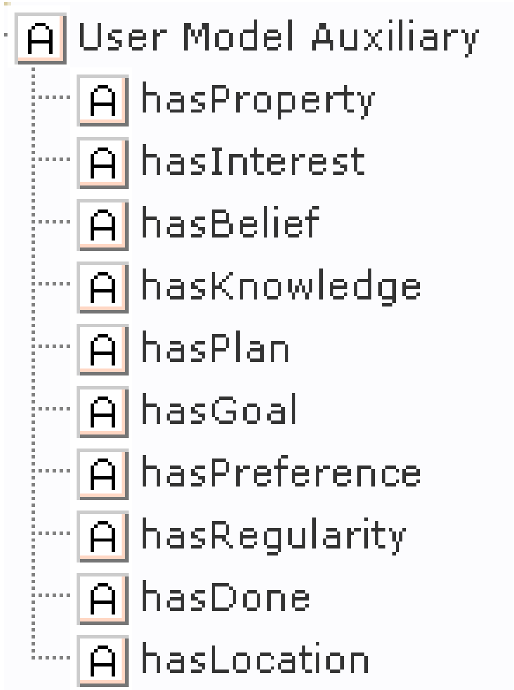
From RDF triples to five-tuples:

$$\texttt{subject}\left\{\ \textit{user model dimension}\ \right\}\texttt{object}$$

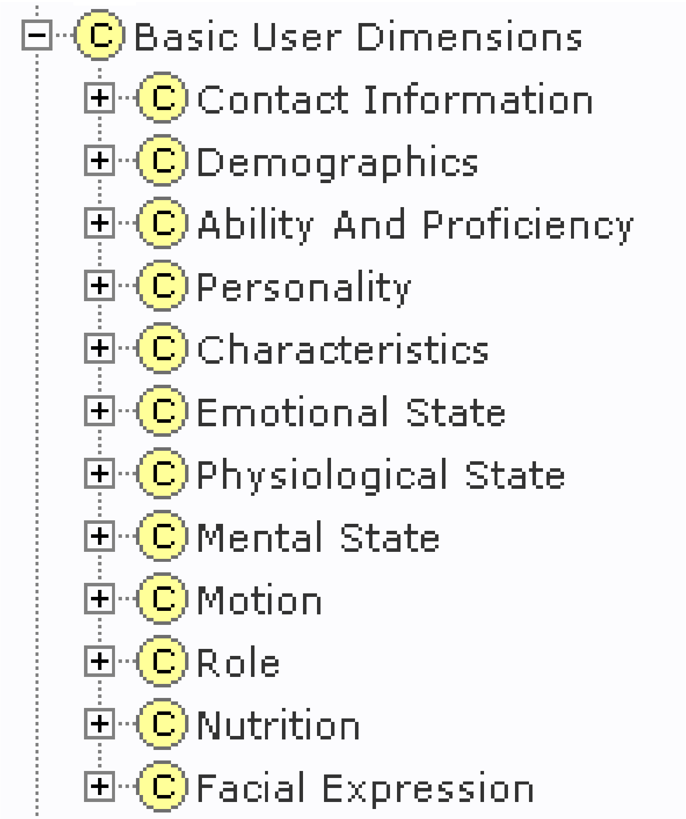
$$\Updownarrow$$

$$\texttt{subject}\left\{\begin{array}{c}\texttt{auxiliary}\\ \texttt{predicate}\\ \texttt{range}\end{array}\right\}\texttt{object}$$

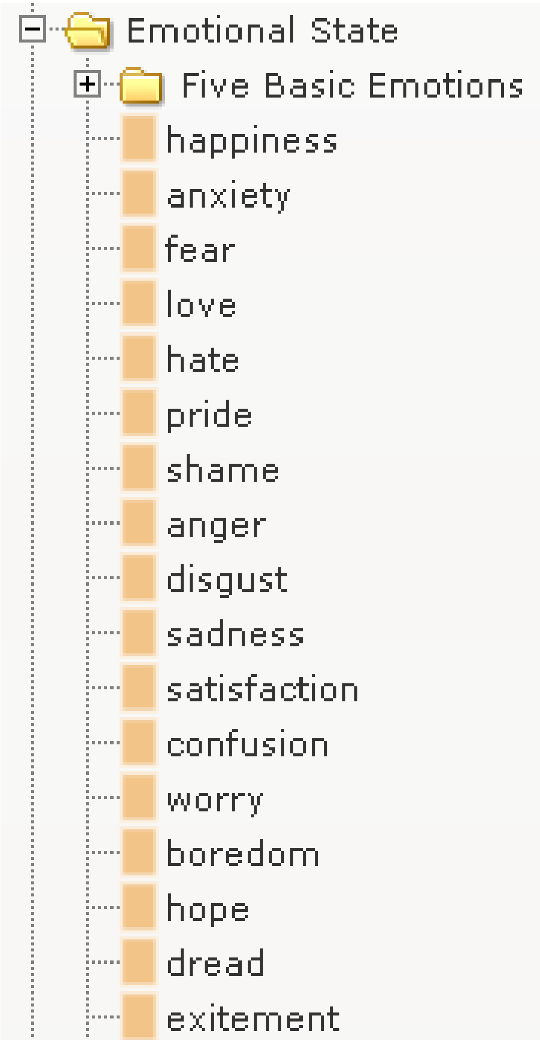
User Model Auxiliaries and Basic User Dimensions (Classes+Intances)



- A User Model Auxiliary
  - A hasProperty
  - A hasInterest
  - A hasBelief
  - A hasKnowledge
  - A hasPlan
  - A hasGoal
  - A hasPreference
  - A hasRegularity
  - A hasDone
  - A hasLocation



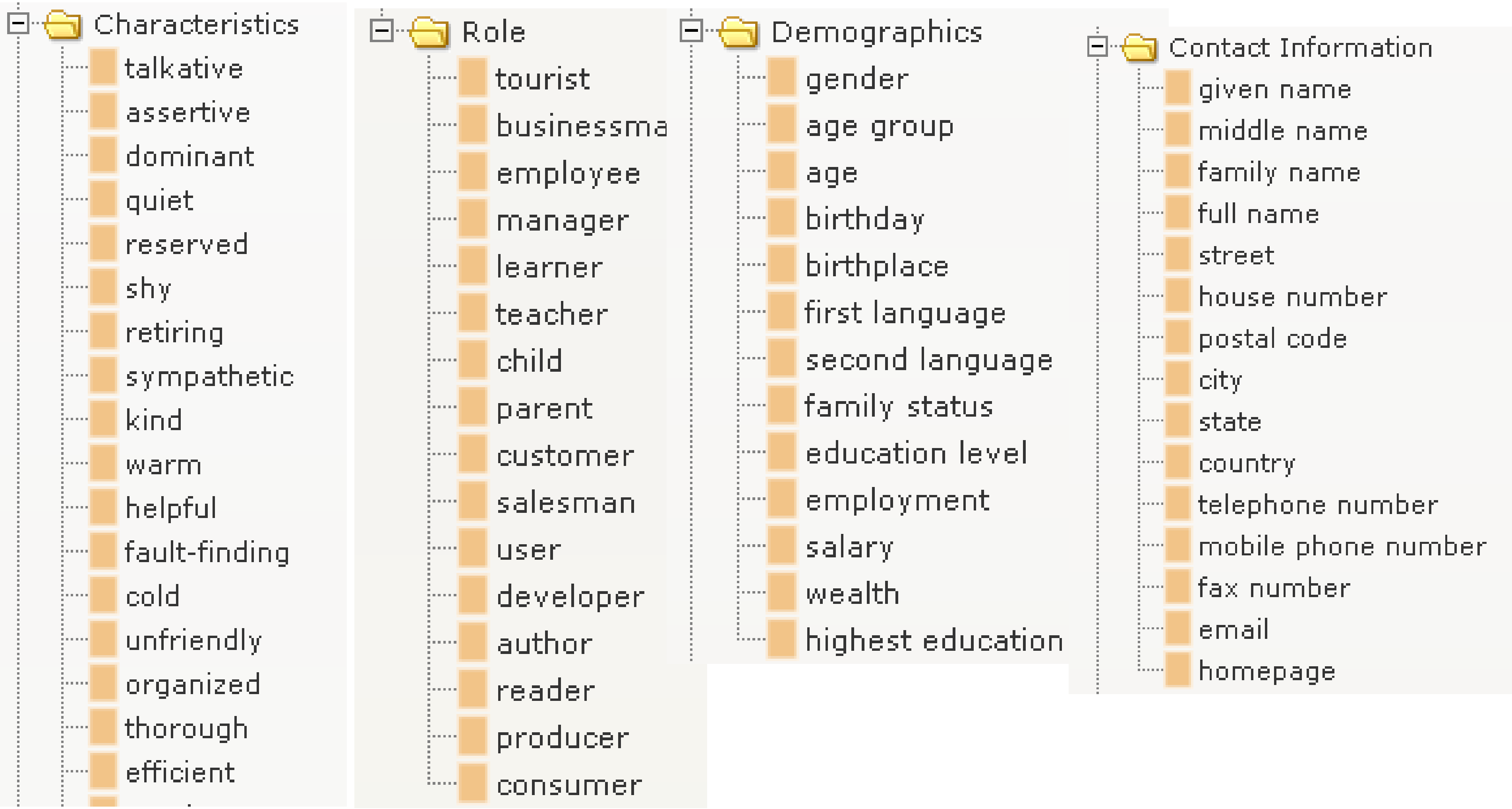
- ⊟ C Basic User Dimensions
  - ⊞ C Contact Information
  - ⊞ C Demographics
  - ⊞ C Ability And Proficiency
  - ⊞ C Personality
  - ⊞ C Characteristics
  - ⊞ C Emotional State
  - ⊞ C Physiological State
  - ⊞ C Mental State
  - ⊞ C Motion
  - ⊞ C Role
  - ⊞ C Nutrition
  - ⊞ C Facial Expression



- ⊟ Emotional State
  - ⊞ Five Basic Emotions
  - happiness
  - anxiety
  - fear
  - love
  - hate
  - pride
  - shame
  - anger
  - disgust
  - sadness
  - satisfaction
  - confusion
  - worry
  - boredom
  - hope
  - dread
  - exitement

literature study, Prof. Jameson`s tutorial, introspection

Further Example Elements in the General User Model Ontology (GUMO)



- Characteristics
  - talkative
  - assertive
  - dominant
  - quiet
  - reserved
  - shy
  - retiring
  - sympathetic
  - kind
  - warm
  - helpful
  - fault-finding
  - cold
  - unfriendly
  - organized
  - thorough
  - efficient

- Role
  - tourist
  - businessma
  - employee
  - manager
  - learner
  - teacher
  - child
  - parent
  - customer
  - salesman
  - user
  - developer
  - author
  - reader
  - producer
  - consumer

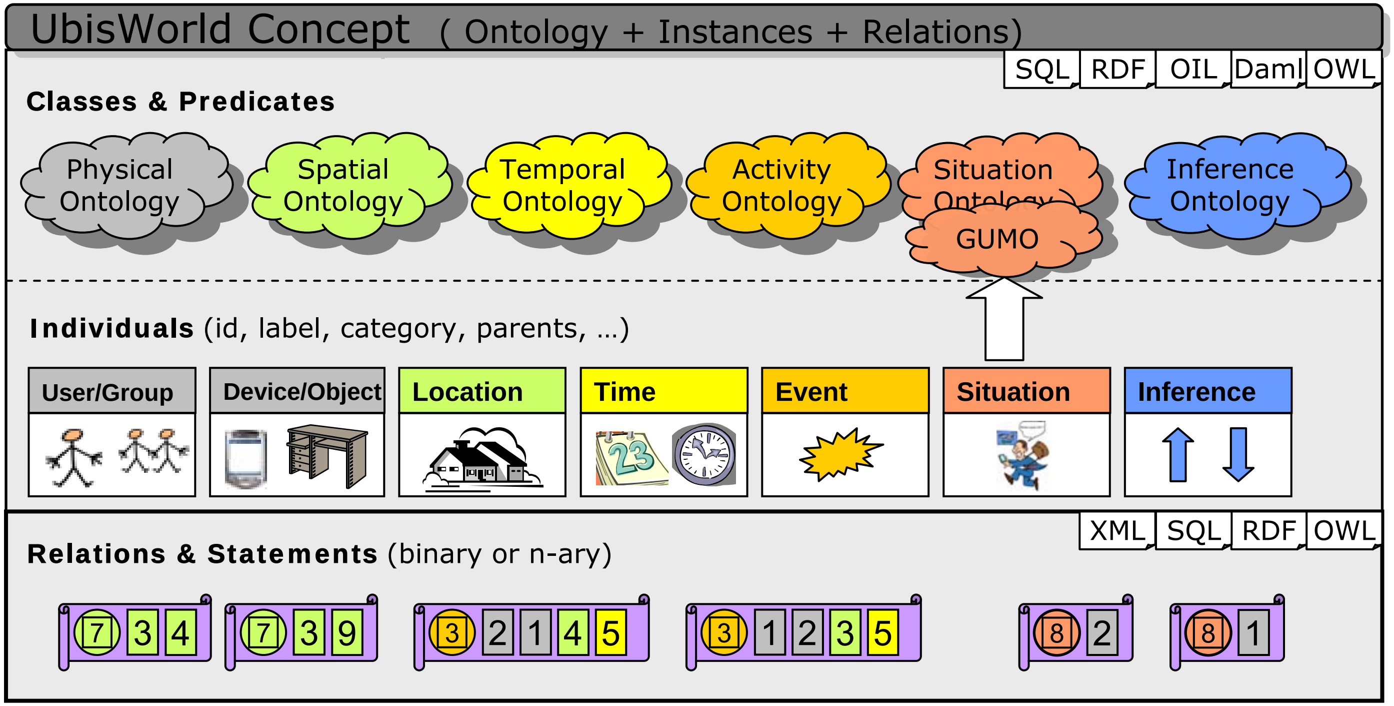
- Demographics
  - gender
  - age group
  - age
  - birthday
  - birthplace
  - first language
  - second language
  - family status
  - education level
  - employment
  - salary
  - wealth
  - highest education

- Contact Information
  - given name
  - middle name
  - family name
  - full name
  - street
  - house number
  - postal code
  - city
  - state
  - country
  - telephone number
  - mobile phone number
  - fax number
  - email
  - homepage

Semantic Web Representation
Predicate = rdf:Description

```
<rdf:Description rdf:ID="Happiness.800616">
        <rdfs:label> Happiness </rdfs:label>
        <u2m:identifier> 800616 </u2m:identifier>
        <u2m:expiry> minutes.520050 </u2m:expiry>
        <u2m:privacy> medium.640032 </u2m:privacy>
        <u2m:image rdf:resource="http://u2m.org/UbisWorld/img/happiness.gif" />
        <u2m:website rdf:resource="&UserOL;concept=800616" />
        <rdf:type rdf:resource="#EmotionalState.700014" />
        <rdf:type rdf:resource="#FiveBasicEmotions.700015" />
</rdf:Description>
```

Gumo is part of UbisWorld
BUT: Gumo will become part of SUMO



UbisWorld Concept (Ontology + Instances + Relations)

SQL RDF OIL Daml OWL

Classes & Predicates

Physical Ontology

Spatial Ontology

Temporal Ontology

Activity Ontology

Situation Ontology

GUMO

Inference Ontology

Individuals (id, label, category, parents, …)

User/Group

Device/Object

Location

Time

Event

Situation

Inference

XML SQL RDF OWL

Relations & Statements (binary or n-ary)

7 3 4

7 3 9

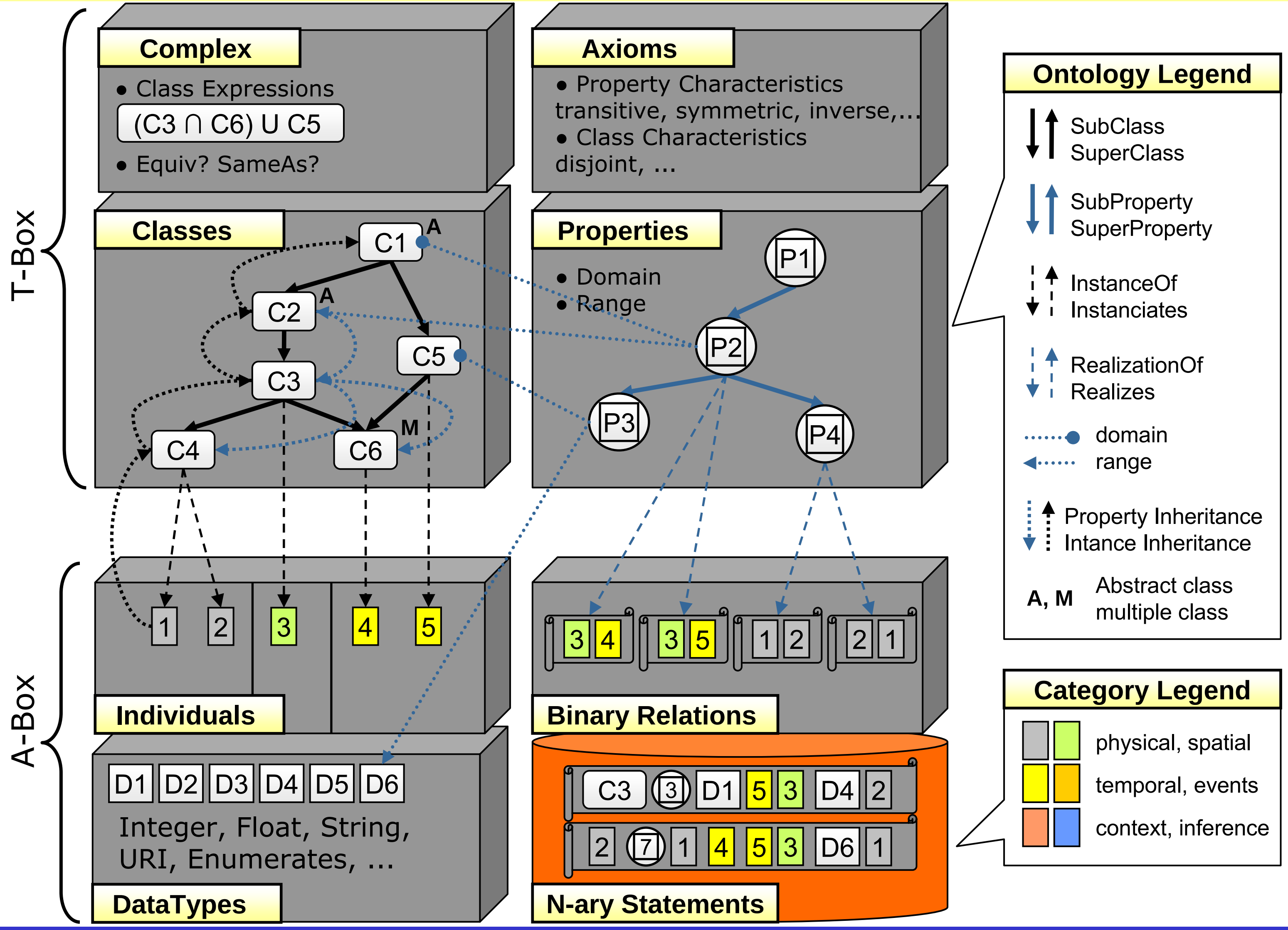
3 2 1 4 5

3 1 2 3 5

8 2

8 1

Integration of Situational Statements into the rest of the ontology



T-Box

Complex

- Class Expressions

(C3 ∩ C6) U C5

- Equiv? SameAs?

Axioms

- Property Characteristics transitive, symmetric, inverse,...
- Class Characteristics disjoint, ...

Classes

Properties

- Domain
- Range

A-Box

Individuals

Binary Relations

DataTypes

D1 D2 D3 D4 D5 D6

Integer, Float, String, URI, Enumerates, ...

N-ary Statements

Ontology Legend

SubClass
SuperClass

SubProperty
SuperProperty

InstanceOf
Instanciates

RealizationOf
Realizes

domain
range

Property Inheritance
Intance Inheritance

A, M Abstract class
multiple class

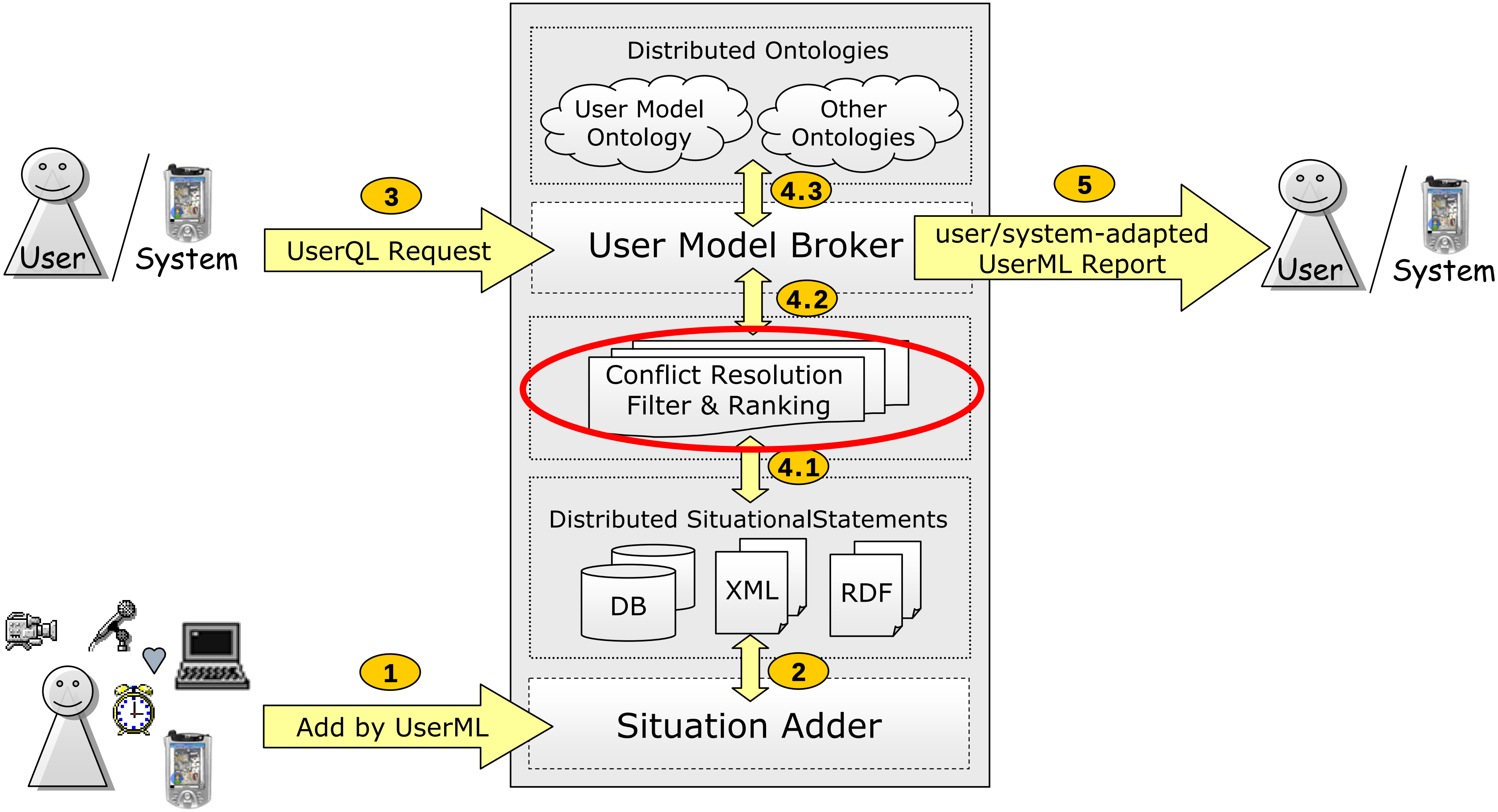
Category Legend

physical, spatial

temporal, events

context, inference

Information flow with UserML & UserQL (Add, Query, Report)



Conflict Resolution Strategies

- **mostRecent(n)** Especially where sensors send new statements on a frequent basis, values tend to change quicker as they expire. This leads to conflicting non-expired statements. The *mostRecent(n)* resolver returns the *n* newest non-expired statements, where *n* is a natural number between 1 and the number of remaining statements.

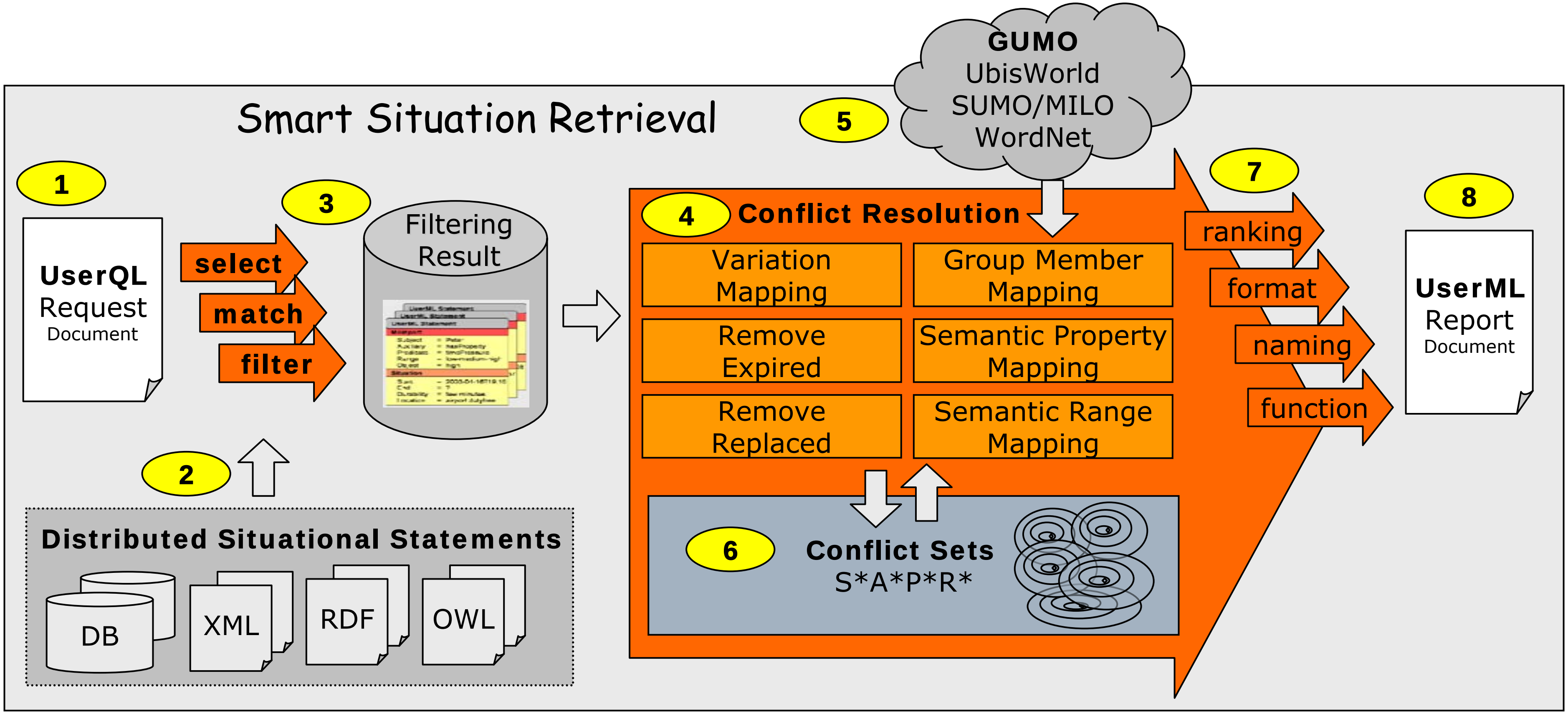
- **mostNamed(n)** If there are many statements that claim A and only a few claim B or something else, than *n* of the ”most named” statements are returned. Of course it is not sure that the majority necessarily tells the truth but it could be a reasonable rule of thumb for some cases.

- **mostConfident(n)** If the confidence values of several conflicting statements can be compared with each other, it seems to be an obvious decision to return the *n* statements with the highest confidence value.

- **mostSpecific(n)** If the range or the object of a statement is more specific than in others, the *n* ”most specific” statements are returned by this resolver.

- **mostPersonal(n)** If the creator of the statement is the same as the statement's subject (a self-reflecting statement), this statement is preferred by the *mostPersonal(n)* resolver. Furthermore, if an *is-friend-of relation* is defined, statements by friends could be preferred to statements by others.

Smart Situation Retrieval with Queries and Conflict Resolution



Smart Situation Retrieval

1 **UserQL** Request Document

3 **select** **match** **filter**

Filtering Result

2

Distributed Situational Statements

DB XML RDF OWL

5 **GUMO** UbisWorld SUMO/MILO WordNet

4 **Conflict Resolution**

Variation Mapping | Group Member Mapping

Remove Expired | Semantic Property Mapping

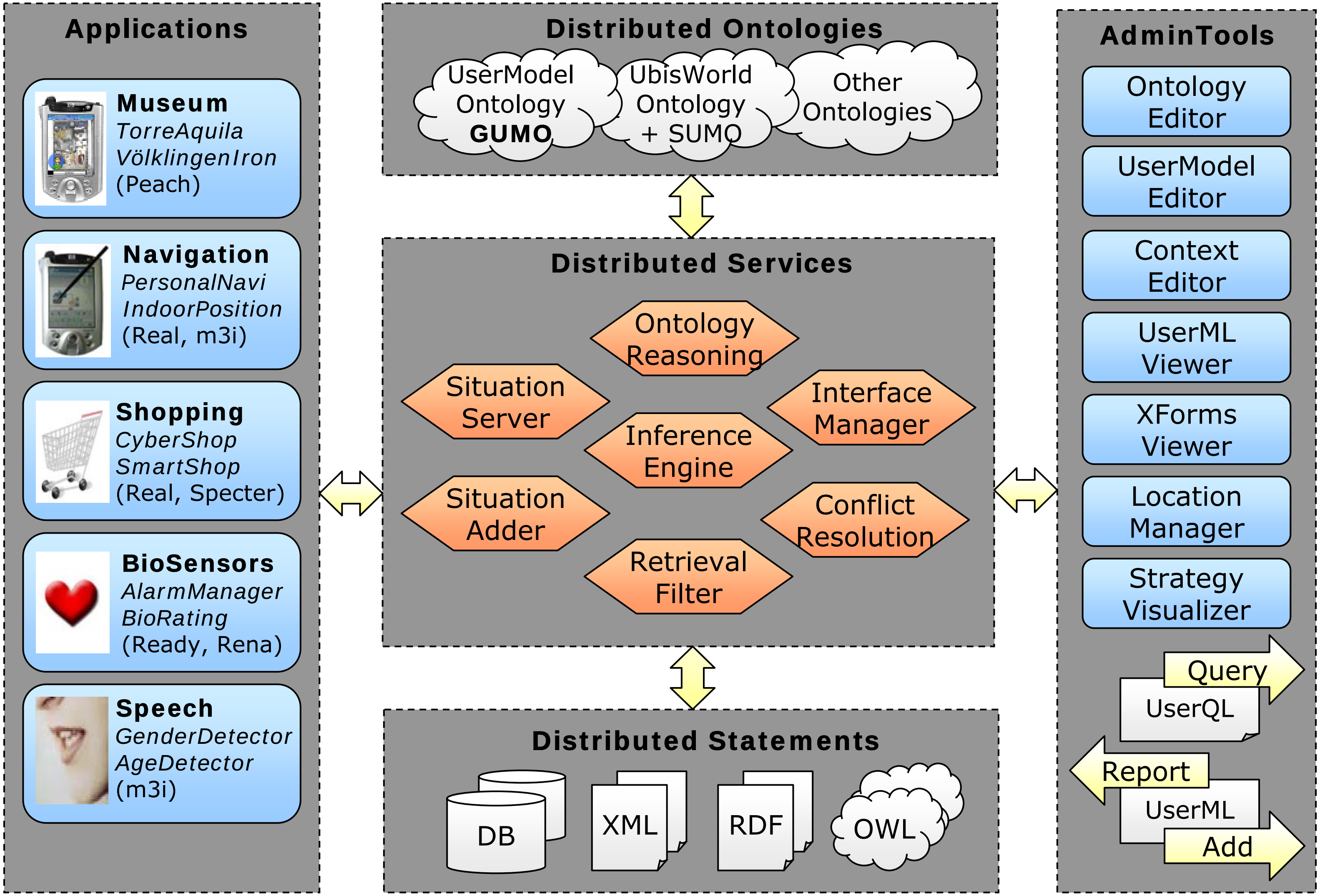
Remove Replaced | Semantic Range Mapping

6 **Conflict Sets** S*A*P*R*

7 ranking format naming function

8 **UserML** Report Document

Summary: Overall Architecture



Applications

- **Museum** *TorreAquila* *VölklingenIron* (Peach)
- **Navigation** *PersonalNavi* *IndoorPosition* (Real, m3i)
- **Shopping** *CyberShop* *SmartShop* (Real, Specter)
- **BioSensors** *AlarmManager* *BioRating* (Ready, Rena)
- **Speech** *GenderDetector* *AgeDetector* (m3i)

Distributed Ontologies

- UserModel Ontology **GUMO**
- UbisWorld Ontology + SUMO
- Other Ontologies

Distributed Services

- Ontology Reasoning
- Situation Server
- Interface Manager
- Inference Engine
- Situation Adder
- Conflict Resolution
- Retrieval Filter

Distributed Statements

- DB
- XML
- RDF
- OWL

AdminTools

- Ontology Editor
- UserModel Editor
- Context Editor
- UserML Viewer
- XForms Viewer
- Location Manager
- Strategy Visualizer

Query
UserQL
Report
UserML
Add

Conclusion & Future Work

- Contributions
  - Motivation and definition of ubiquitous user modeling
  - SituationalStatements (UserML)
    (introduces n-ary relations into Semantic Web Languages)
  - GUMO = mid-level ontology for user model dimensions
  - User model broker for distributed user-adaptive applications
  - “Smart Situation Retrieval”
  - Overall architechture for ubiquitous user modeling

- Further Work
  - Integrate GUMO into SUMO/MILO family
  - Evaluate the user interfaces

Thank you very much!