User Models meet Digital Object Memories in the Internet of Things

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Abstract

In this paper, we argue that Digital Object Memories in the Internet of Things are closely related to partial user models in Personalization and that research can gain insights by analogy from both sides. We describe UbisMemory, a Semantic Web middleware for partial user models and digital object memories. We describe the content representation, the service and its technical issues. We argue that Digital Object Memories can be extended and merged with "Digital User Memories" or life-long user models. We argue that Life-Logging for objects and for humans are closer related than expected.

Introduction

"Personalization and Recommendation on the Web and Beyond" is the new title of the ABIS workshop series. In this paper we are looking at the word "Beyond" and what could be meant by it. We move from the Web to the real world and return back: the so called "Internet of Things". We look at how memories of users and memories of objects differ, interact and become blurred. User modeling aspects have recently turned more and more into a broader view of "context-awareness". This important focus on the context reveals that human-computer interaction takes place in different environments – with the immense increase of mobile technology, this context becomes more and more the real world itself. The desktop metaphor has been replaced by life-long user modeling in the real world.

A second path to this paper comes from the other direction. The concept of Digital Object Memories (DOM) has recently been introduced, see [1] or [7]. In the upcoming and fast growing research area "Internet of Things" (IoT), the "Digital Object Memories" play a central role to enable its ideas, strategies and goals. Embedded systems, mostly based on Semantic Web Technologies, Context-Awareness and intelligent identification mechanisms enable the technical implementation. Intelligent, instrumented environments are the foundation, where the digital object memories develop and grow. The dimension of storage or location of object memories is orthogonal to its options and possibilities that are enabled by the highly context aware environments. That means, at the service layer, it is not important if the digital object memory is stored directly locally with the object, or even if the identification of the object is defined directly locally with the object. Important is only that each object can be identified uniquely by the service layer and that the object's memory can be accessed somehow. In the internet everything that can be uniquely identified is called a resource. Thus we talk about memories attached to resources.

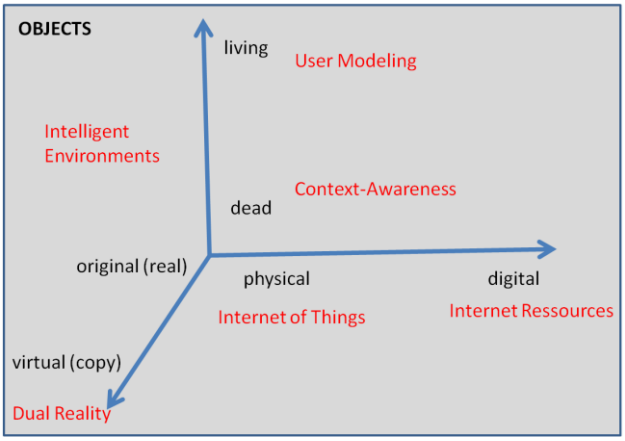

Figure 1: Object Dimensions for Digital Memories of Users and Objects, in relation to the reseach areas

If we abstract from technical issues like RFID, power supply, networking, sensors etc. at least two philosophical questions could arise between user models and digital object memories.

a) If we look at the persuasion in artificial intelligence of "Materialism" and "Strong AI", there is no difference concerning the potentiality of intelligence between a "dead" object and a "living" object like a human being. Thus, Digital (INANIMATE) Object Memories and Digital (LIVING) Object Memories can be considered as equivalent. The latter one has been researched since decades under the term of "user modeling".

b) A second philosophical issue might arise: do non-living objects get a personality as soon as they store their history in a DOM (of course with the help of the sensors and actuators in the intelligent environments)? To support the close relation between User Modeling and Digital Object Memories we could have also taken an approach from the opposite direction and make the "gedankenexperiment" and personify dead objects as soon as they manage a memory. The statement

by Tara Bloom "*Memory maketh the man* – we are who we are thanks to our experiences."

What matters for this paper and the UbisMemory service is the possibility of uniform handling of Digital Memories, for objects and humans. Thus the user models meet the digital object on the technical layer, however if one is able to adapt the materialism's point of view, also on the philosophical layer.

One advantage of this approach is that we can later introduce a uniform handling of privacy issues, like the so called onion model.

Important is the handling of "Digital Memories", independent, if they describe an object, a human, or an immaterial resource, like an entity on the web, or even a simulated resource in dual reality.

The developed middleware mainly looks at the management of "Digital Memories", independently if they are carried along, distributed in the environment or centrally stored

The viewpoint matters and DOMs have a kind of "object-oriented" viewpoint: nor the software-system is in the center, that handles all information and that communicates with all users, neither the intelligent environment. In the center is only the object, looking out to the world and managing its "personal" memory.

In Figure 1 we try to show that user modeling is closely related to the Internet of Things, if we manage to broaden the object dimensions.

Farm Scenario to look at DOM issues

Imagine you want to transform a farm into an intelligent environment and you want to apply the technology of digital object memories for a use case in the rural farming production of eggs. One question that arises is WHAT is the object? For which objects is it interesting to manage DOMs? Well it could be the hen, it could be the egg that will be eaten by the consumer. It could be the product, to say the box of eggs that will be bought by the consumer. It could be the chicken run. To say, it could actually be everything. It depends on the use case, the business case or the application. Looking through the glasses of "intelligent environments": everything in the context is an object of interest, to be on the save side. Looking through the glasses of "user modeling", especially the farmer is of interest. However, the farmer's user model could be based on all the other objects memories, if we take the context into account.

Interesting is the issue of knowledge representation and knowledge exchange in the Internet of Things, in comparison to the knowledge representation and knowledge exchange in Personalization. The following situation serves as basis to discuss the issue of object memories in this paper:
The hen "Lilli" has layed an egg yesterday in its barn in Elm, Germany. At that time is was 25 degrees Celsius. The Egg is packed with 5 others into a box, which is put on a pallet, which is moved by farmer Bob with a tractor from the farm „Erlenhof" to the merchants place.

Which parts of this information can be sensed by which sensors, which parts should be stored where? Should this information be distributed to the different objects or resources (hen, egg, box, pallet, farmer, farm …) that might collect data for their Digital Object Memories? Or should the description of the situation be stored in this intelligent farm environment. Or does it even make sense to introduce a centralized storage service and broker for partial digital object memories and partial user models?

The rest of this paper is arranged as follows: we discuss the issue of storage of object memories in the next section, and introduce parts of the UbisMemory system in section three, followed by a concluding discussion.

Storage of Object Memories

A first question that arises is where should the object's memory be stored? Well, an obvious solution is to attach it directly to the object itself. Interestingly, for the eggs in the farm scenario is that parts of the object memory are written on the eggs directly. One can read the date, the country, even the chicken run where the egg was laid (of course not in digital form).

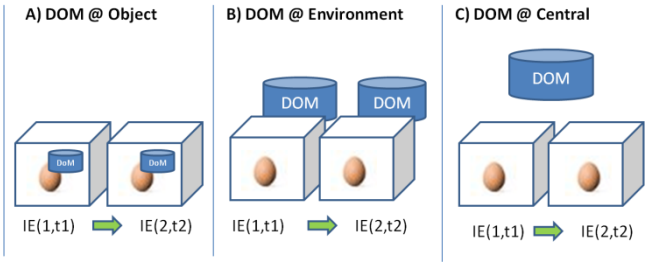

Figure 2: Local (A), Distributed (B), versus Central (C) Storage (IE = Intelligent Environment)

What could be the advantage of a central DOM repository? Well imagine the egg is further processed, like a scrambled egg. What to do if the consumer gets an egg-related disease after a couple of days? In that case It would be especially important to find out all the DOM-details like "the chicken run" that produced the egg.

In that scenario, the DOM gets interesting days after the object has been destroyed. If we only rely on A), where the DOM is stored directly at the object, we have a problem. An additional C) DOM @ Central would be of great help. Another argument of a centralized DOM-archive is the possibility of a uniform user interface to inspect the memories and to set privacy issues.

As conclusion, all three versions A), B) and C) have their rights of existence, their advantages and disadvantages. The UbisMemory service that is described hereafter focuses firstly on the centralized C) and secondly on distributed B).

UbisMemory

UbisMemory mainly addresses the issue of "Content Sharing" within ubiquitous computing, that can be compared to [1]. The UbisMemory middleware is integrated into the test bed architecture called UbisWorld 3.0, see [8], for research on ubiquitous user modeling in the era of

Semantic Web and Web 2.0 facing the Internet of Things in ubiquitous computing.
The basic storage idea is founded on **SituationalStatements** that form a relation-based user model & context representation, see[5]. The exchange protocol is defined as the earlier introduced **UserML,** which is an XML & RDF-based exchange language. Interesting is the question of what will be exchanged? Apart from the "Mainpart", also Meta Data are exchanged.
Which meta data is important for ubiquitous user modeling?

- When and where is the statement valid?
- Who claims this and which explanation is given?
- What is the evidence and the confidence?
- What will be done with the DOM/UM?
- When will this information be deleted?
- Who is the owner of this information?
- What are the privacy settings?
- How can the statement be uniquely identified?
- Can the DOM/UM entries be grouped with others?

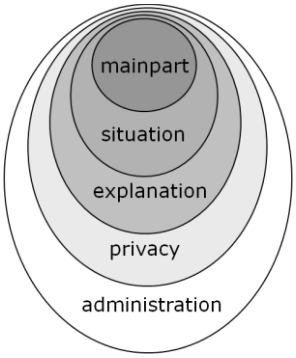

Figure 3: onion model of statements with several layers of meta-data

This meta-data can be used to define filters to tailor the parts of DOMs in the case of a DOM request.

Instead of describing the full UbisMemory architecture, see [8] for more details, we pick out the following three topics and describe them in more detail: privacy issues, exploitation and the user interface.

UbisMemory supports a fine grained semantic Location Modelling for DOMs. It is based on HUGO, the "Huge Ontology" with currently over 20 Million semantically described places. HUGO, see [7], is based on Linked Data, enriched with an Web 2.0 approach to add collaboratively new locations. It ranges from countries, cities, streets to individual houses, rooms and even shelves in furniture. Especially for detailed DOMs, a fine-grained location model is needed that goes beyond the GPS coordinates or the position with two dimensional coordinates, since interaction often takes place inside a house or a production place.

DOM Exploitation

To consider systems that integrate adaptation as exploitation of DOMs and the context is introduced in [9]. In [7] it is shown that complex applications can still be realized with cheap and weakly instrumented smart objects. This is done by establishing digital object memories.
How can the UbisMemory be integrated into the full process loop of enabling smarter and more intelligent applications on the basis of digital object memories? Well, in order to exploit the Digital Object Memories, a full process loop of the following four steps have to be implemented.

1) Instrumentation (i.e of the farm, or the farmer)
2) Interpretation (inference from sensor data to memory)
3) Communication (exchange of DOMs)
4) Adaptation (exploitation of DOMs & context)

Some techniques are discussed in [4] on how the interpretation from Sensor Data to Memories via LOGs and JOURNALS can be done.
UbisMemory only applies to the third step of "communication". In this sense it serves as a broker of DOMs. They can be stored there & retrieved from there. Together with a privacy handling mechanism, a broker service has been established.

Privacy Issues in UbisMemory

The exploitation of the resulting memories need to be regulated. In the farm scenario: *For example, who should be allowed to read the information on what fodder was given to the hen that layed the egg?*
We can support fine-grained privacy handling, since the SituatinalStatements apply the onion model which means that the mainpart information is only available if the privacy filter has been passed. A detailed description can be found in [6].

UbisMemory's User Interface

We have developed a general user interface to inspect the digital object memories as well as partial life-long user models, (as discussed in section one). Figure 4 shows a screenshot. The user interface can be accessed[1] via http://ubisworld.org/statementstore/.

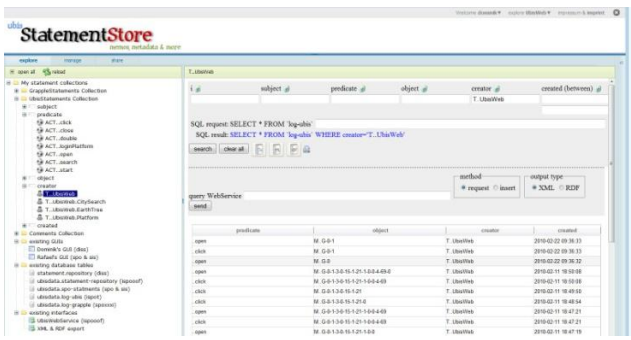

Figure 4: ubis.StatementStore, the user inteface of UbisMemory to inspect and control the Digital Memories of Objects and Users.

[1] however certain access rights need to be requested first.

The key idea is to decouple every situational statement into its semantic roles and allow for each of them a filtering by selection. By this approach you can select every object, and every attribute value pair that describes the memory item in mind, together with its meta-level information like timestamp, location, and privacy information like the owner of this bit of information.

CONCLUSION

In this paper we argue that user models will eventually meet digital object memories in the internet of things. In [2] we have stated that: *a comprehensive log of the user's behavior together with corresponding context descriptions allows adaptive systems to learn about users, to identify their habits, and to improve the quality of user support. In addition, users can apply such knowledge to learn from others and about themselves.* Now, how much more interesting and fruitful can it be if we log the objects behavior's, situations and contexts with the overall approach of Digital Object Memories become together with the Internet of Things? We expect a better quality of object support and a better quality of the objects (or products) themselves. For example, if we transfer the onion model of statements from user model research to digital object memories. Highly interesting are social implications and philosophical issues if we assume that objects gain a certain level of personality by their new memories. Instead of looking at Digital Object Memories only, we looked at "digital memories of objects", while we extend the view of "object" to the three dimensions physical-digital, real-virtual, and inanimate-living. With this generalization, we are able to combine User Modeling and Context-Awareness even in Dual Reality scenarios under the integrating concept of "Digital Memories of Objects". Thus, classical Digital Object Memories and Life-Long User Models can be treated in our approach with the same middleware.

In this paper we tried to contribute to the four following topics: **Memory Representation**: which we realize with SituationalStatements as introduced in [5]. **Memory Architectures**: We pointed to UbisMemory, a middleware approach which also allows for the realization of object memory functionality. This includes infrastructures for the centralized or distributed organizing, storing, and brokering of object-related information, however based on a remote infrastructure, not on the object itself. **Privacy Aspects**: Who "owns" the data stored in an object's memory, who can access/delete/correct it? How long must/should memory content be stored, and can trust be established for the object memory? **Human Memory Access:** This topic comprises technologies and concepts to make an object memory's content accessible to human users. With the UbisMemory browser, called StatementStore, we try to structure and relate the wide variety of diverse data that might be contained in the memory due to its open nature. The presented middleware architecture is integrated into an interesting test bed for research on ubiquitous user modeling in the era of Semantic Web and Web 2.0 facing the Internet of Things in ubiquitous computing. This UbisWorld 3.0 tool set can be tested online at www.ubisworld.org. What is "beyond" the Web? Well, the real world! However, the real world is currently in the process to become part of the Web by the movement of the Internet of Things. Interesting is to see the upcoming research of Personalization together with the Internet of "all" Things, real or virtual, alive and inanimate.

ACKNOWLEDGMENTS

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REFERENCES

[1] Kröner, A.; Schneider, M.; Mori. J. 2009. A Framework for Ubiquitous Content Sharing. IEEE Pervasive Computing, Vol. 8, No. 4, pp. 58-65. IEEE Press.

[2] Wahlster, W., Kröner A., Schneider, M., and Baus, J. 2008. Sharing Memories of Smart Products and Their Consumers in Instrumented Environments. In it – Information Technology, Vol. 50(1), Special Issue on Ambient Intelligence, pp. 45-50, Oldenburg

[3] Heckmann,D. , Schwartz,T., B. Brandherm, M. Schmitz, and M. von Wilamowitz- Moellendorff. GUMO - The General User Model Ontology. In Proc. of Int. Conf. on User Modeling, Edinburgh, UK, 428–432, 2005.

[4] Kröner, A, Heckmann, D, & Wahlster, W., 2006. SPECTER: Building, Exploiting, and Sharing Augmented Memories. In K. Kogure (Ed.), *Workshop on Knowledge Sharing for Everyday Life 2006 (KSEL06)* (pp. 9-16). Kyoto, Japan.

[5] Heckmann, D. (2003b). Introducing situational statements as an integrating data structure for user modeling, context-awareness and resource- adaptive computing. In *ABIS2003*, pages 283-286, Karlsruhe, Germany.

[6] Heckmann, D. (2003a). Integrating Privacy Aspects into Ubiquitous Computing: A Basic User Interface for Personalization. In Krüger, A. and Malaka, R., editors, Artificial Intelligence in Mobile Systems (AIMS 2003), pages 106-110, Seattle, USA. in conjunction with the Fifth International Conference on Ubiquitous Computing.

[7] Schneider, M., Kröner, A. "The Smart Pizza Packing: An Application of Object Memories," *Proc. 4th Int'l Conf. Intelligent Environments* (IE 08), Inst. Eng. and Technology, 2008.

[8] Heckmann, D. Matthias Loskyll, Rafael Math, Pascal Recktenwald, Christoph Stahl. UbisWorld 3.0: a Semantic Tool Set for Ubiquitous User Modeling, Demonstration description in online proceedings of First International Conference on User Modeling, Adaptation, and Personalization (UMAP 2009)

[9] Plate C. et al., "Recomindation: New Functions for Augmented Memories," *Proc. Adaptive Hypermedia and Adaptive Web-Based Systems* (AH 06), Springer, 2006, pp. 141–150.