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IJSC SPECIAL ISSUE ON AMBIENT SEMANTIC COMPUTING GUEST EDITOR'S PREFACE

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This special issue on Ambient Semantic Computing (ASC) of the International Journal of Semantic Computing proposes a particular approach to the much debated new era of IT and computing, where computers leave the desktop and surround us everywhere. ASC is related to the terms Ubiquitous Computing, Pervasive Computing, and Ambient Intelligence – each of these terms is claimed by their protagonists to be a superset of the other ones, but they all turn out to be synonymous after a close inspection of the actual approaches used and results achieved under either of these headlines. ASC is not intended to become yet another synonymous term; rather, it is an invitation to combine Semantic Computing – the very topic of this journal – with the above mentioned synonymous fields in a particularly fruitful way. In our introduction to this special issue, we will first provide an overview of ASC and then position the enclosed three articles within the ASC landscape.

Keywords: ambient semantic computing, ambient intelligence, natural language processing.

1. Introduction to Ambient Semantic Computing

ASC is an emerging research area that is concerned with novel methods, algorithms, and concepts which fruitfully combine what we call *Ambient Intelligence* and *semantic technologies*.

By Ambient Intelligence, we refer to approaches that emphasize the dawning era of networked 'anytime anywhere' computers, worn by users and encountered in everyday life – without being perceived as computers. Ubiquitous Computing and Pervasive Computing can be considered to be synonymous to Ambient Intelligence despite the fact that different authors have provided slightly different definitions (e.g., emphasizing either the use of AI methods or the importance of HCI in Ambient Intelligence). Context-aware computing, multimodal and tangible interaction, and smart environments are examples for more focussed research fields comprised in Ambient Intelligence research.

By semantic technologies, we refer to Natural Language Processing (NLP), ontology related research, and computer perception approaches (vision, video analysis, situation detection, handwriting and speech recognition, etc.) that target human understanding of

the media 'perceived' by computers. We are convinced that the vision of Ambient Intelligence, i.e. a world of omnipresent 'hidden' computers that truly aid human beings – and neither hinder nor annoy nor frighten nor threaten – can only be achieved if these machines can deal with concepts that reflect human understanding and common sense. Therefore, the 'smartness' of ambient intelligence must be combined with the 'naturalism' of semantic technologies.

In a nutshell, Ambient Semantic Computing aims at a world where humans interact naturally with the smart world around them. The hardware basis for this surrounding smart world are cooperating (embedded and wearable) computers. While this definition sounds much like the unrealistic promises of the early AI, the approach is indeed different since the understanding of a user's situation and goals (or needs, respectively) is based on the novel and fast-paced fields of research mentioned above.

2. Related Fields of Research

Ambient Intelligence in itself is already considered a highly interdisciplinary field. Does it make sense to add another broad area (Semantic Computing), or does this lead to "all of computer science", making the notion useless? We advocate the term ASC despite this danger for two major reasons: i) the vision of natural interaction in a smart world can only be approached as a multi-disciplinary challenge – we live in a complex world and need complex solutions to improve it; only a "T-shaped" (broad-then-deep) approach can be successful, where a holistic architecture and understanding of the complex problem domain stands at the beginning, followed by deep treatment of the many individual problems; ii) the ASC vision is *not* discretionary since it focuses on applications where users are in the middle. To take two examples: neither scientific computing nor real-time process control (in their classical definition) are pure ASC topics.

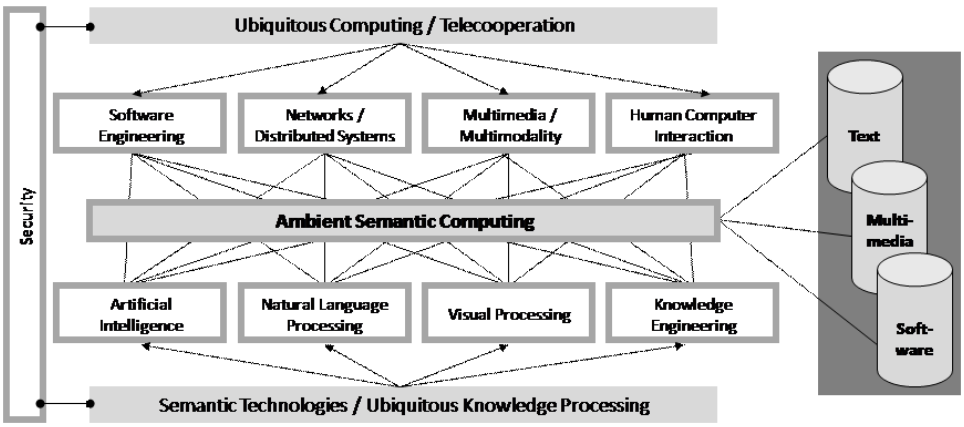

Fig. 1: Relations between Ambient Semantic Computing topics.

Fig. 1 above provides a coarse view of the multiple disciplines combined in ASC and illustrates some of their relationships. The reader can see that in essence, Ambient

Intelligence is combined with semantic technologies. Heterogeneous types of information, such as text or multimedia, and ambient artefacts such as software are involved in ambient semantic processing. Security is a cross-concern related to any application field involved; this concern plays a major role in the era of 'anytime anywhere' computers.

3. Papers Included in the Present Special Issue

Currently, ASC is a research roadmap rather than a well established research field. Moreover, this field is just shaping up. Therefore, none of the papers selected for the present special issue will, by itself, be fully representative of ASC. Rather, we based our selection (apart from quality aspects) on the attempt to cover the field as broadly and comprehensively as possible. This choice concerns several dimensions:

- In terms of application domains, we complemented the obvious domain of smart environments – where people interact with things rather than computers (Guo et al.) – with a domain of intangible objects, namely software as one of the most complex and (by nature) computer-penetrated intangible domains (Rilling et al.). The paper by Schermerhorn & Scheutz touches a third domain: robotics. We strongly advocate a closer look at this domain since many of the issues addressed in Ambient Intelligence and ASC have a lot of similarity with issues addressed (and often approached in an enlightening way) in the field of mobile robots. This similarity is due to the fact that both human-like behavior and humane user-robot interaction are often key requirements in this field. The authors of the third paper actually have a strong background and history in robotics. By applying their knowledge to the field of ASC, they provide some interesting insights into the similarities of robotics and ASC.
- In terms of their starting points on the roadmap towards ASC, the three papers also make up a representative mix. The paper by Guo et al. starts from an Ambient Intelligence standpoint and shows how Semantic Computing (in the form of their sixth-sense ontology) can provide a pivotal leap from hand-crafted, incompatible solutions to holistic yet modular and open, highly reusable and maintainable approaches in the field of smart environments and worlds. Rilling et al. start from a semantic model of the software development process and show how this approach can greatly help to master the increasing scale and global distribution of this process – a magnitude that one might call ubiquitous software development; in this respect, the paper is exemplary for many fields that are about to "go ubiquitous". As to the paper by Schermerhorn & Scheutz, a third very important point of departure is addressed: these authors focus on the issue of natural interaction, which is highlighted in the very definition of ASC. They provide insights into architectural issues related to this important challenge, emphasizing the integration of natural language processing (NLP), distributed agent technology, and speech understanding.
- As far as the breadth vs. depth trade-off is concerned, all three papers are rather on the breadth side. This may be disappointing for readers interested in precise, focussed, down-to-the-point articles. However, we would like to draw the reader's

attention to the fact that despite the breadth provided, none of the papers manages to cover the entire ASC field. We must accept the fact that major challenges of the information technology in our time are multidisciplinary integration challenges. As a consequence, a special issue that opens a new, broad field of research must concentrate on drawing the landscape before further contributions can concentrate on advancing narrow-but-deep issues.

4. Highlights of the Special Issue

The three papers presented in this special issue (Rilling et al., Schermerhorn & Scheutz, Guo et al.) were selected from a number of submissions that the editors received upon distributing the call for papers in the respective scientific communities of Ambient Intelligence and Semantic Computing. The aspects of these papers treated above showed that all of them regard ASC as an interdisciplinary field of research and fit into at least one of the topics mentioned, such as language-based and multimodal human-computer interfaces for Ambient Intelligence, combinations of distributed systems and natural language processing technologies to support knowledge work, knowledge management methodologies for semantically enabled distributed software, and context-enhanced information management and context-sensitive Ubiquitous Computing.

The paper by Rilling et al. regards the current software development and maintenance practice as a highly distributed process involving numerous support tools, resources and human developers, integrated in complex and often partially defined workflows and processes. They observe that identifying knowledge resources to be utilized in a given maintenance context is one of the major challenges for software developers. Based on this observation, they present an approach that tries to capture, combine and automatically apply the "ambient" knowledge through the use of ontology queries and reasoning services. The ontological model goes beyond the state of the art models by modelling the software maintenance processes and their constituents.

Guo et al.'s contribution is driven by the developments in the computing domain, leading from desktop PCs or computer-augmented appliances to smart objects - everyday objects such as cups equipped with computing capabilities. Smart objects utilize the information collected by sensors for reasoning and cooperation in order to support complex tasks. Building and maintaining the corresponding systems, which are composed of a large number of smart objects, is a complex and time consuming enterprise due to the lack of supporting infrastructure. The authors address this challenge by proposing a development environment called Sixth-Sense. Sixth-Sense explores Semantic Web technologies by defining a common ontology assisting the development of the smart object systems. The proposed ontology standard reflects several aspects that have not been previously addressed, such as the artifact properties, the physical relations between objects, e.g. the spatial relations, and the logical relations based on common sense knowledge. The usability of the Sixth-Sense environment is verified empirically in a user-based study.

Finally, the combination of sensing and networking hardware with natural language interaction capabilities is the subject of the work by Schermerhorn and Scheutz. The main contribution of their work is ADE, the Agent Development Environment. This distributed agent infrastructure includes a sophisticated engine for processing natural language and is connected to a goal manager that controls access to multiple sensing and actuating devices. The comprehensive ADE framework for embodied real-time systems implements what can be called a meta-architecture since it allows for a secure, fault-tolerant, large-scale target system architecture. ADE has been designed to incorporate sophisticated reasoning tools and integrates features for multi-agent- and single-agent-systems to significantly improve the long-term operation and maintenance of such systems.

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