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Guest editorial

Special issue: Intelligent agents and services for smart environments

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A smart environment is a (physical or virtual) location endowed with autonomous behaviour. It can sense what occurs within itself and its surroundings, and adapts its actions accordingly.

Intelligent multiagent systems and Semantic Web Services constitute relevant technologies to design and implement smart environments. They provide for decentralised and robust platforms upon which autonomous software modules can interact with themselves and with sensors and actuators, which in turn can relate directly to activities that occur within an environment. In turn, smart environments are also relevant applications and test beds for multiagent systems and for Semantic Web Services.

Among the challenges related to the design and implementation of smart environments, we highlight:

- Technical requirements related to real-time response using heterogeneous devices with possibly limited storage and processing capabilities.
- Socio-technical requirements due to smart environments being inhabited by humans, who typically produce partially reliable information.
- Ethical requirements related to smart environments interfering directly with social activities. Data collected by smart environments can raise, just to mention some concrete issues, privacy and ownership issues.

The applications of smart environments are many and of great diversity. Some possible applications are:

- Digital entertainment: many successful computer games provide for more immersive and therefore engaging experiences by interacting with users based on location- and context-sensitive information. We can have, for example, computer games in which the players are "tagged" by the individual (wireless) game controls they use, additional information about their behaviour is captured by multimodal sensors such as cameras and microphones, and a game responds to this information with multimodal output data (such as sounds, images and shaking) to build an immersive environment within which many players can interact. Such possibilities of interaction among players and between players and the game itself can be provided to players who are physically located within the same environment – e.g. the precincts of a theme park – or physically far apart – e.g. interacting through a virtual environment based on the WWW.
- Arts and culture: in interactive performance arts and in digitally enhanced museum exhibits, smart environments can contribute to enhance the experience of the audience in many ways:

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  - Through *augmented reality*, additional information about exhibits, as well as virtual exhibits can be displayed, thus enlarging the possibilities for a previously existing exhibition space. Augmented reality also provides for greater interactivity between the audience and museum exhibits, and between the audience and live performance artists.
  - Through the enhanced interactivity provided by real time sensors and actuators, and modern display technologies, *3D virtual environments and characters* can come to life and interact with individuals in the audience in personalised fashion.
  - Through smart environment technology in general, the audience – in museums as well as in live performance presentations – can actively and creatively participate in the construction of their experiences, thus moving from spectators to co-creators in cultural activities.

- Public services: location- and context-aware applications can greatly improve the delivery of public information to citizens, providing for the creation of *information logistics* systems in which the right information is delivered to the right person at the right place and moment. To give a concrete example, we can mention *public healthcare and telemedicine*:
  - A common situation in public healthcare is that of healthcare agents visiting the homes of families in remote locations, to gather information about their health, nutrition and hygiene conditions, and to provide them with orientation, basic procedures and medicine. Occasionally, these agents can face emergency situations, when they must follow procedures according to real time guidance from medical doctors and experts who are located elsewhere. Many recent projects have proposed to furnish the healthcare agents with mobile computational devices, such as PDAs and smartphones, to collect information while visiting the homes of families as well as to get information from healthcare centres, universities and hospitals through the mobile telephone network and wireless Internet connection. Despite the amazing recent technological developments of mobile devices, they are still limited in storage capacity, computational power and input/output interfaces. Location-aware feed of data and interactivity resources for mobile devices can be of paramount importance to increase the efficacy of the assistance that healthcare agents can provide in remote locations.
- Education: many research results have suggested that social interaction is among the most important factors to improve the efficacy of formal learning as promoted in educational institutions. Based on this observation, some researchers have proposed the augmentation of physical environments such as a university campus with digital technology, specifically addressing the support for group formation and interaction. Mobile devices and location-based information systems appear at the forefront of these proposals. For example, we can have a library augmented with location-aware information that can be accessed through mobile devices such as PDAs. Depending on who is using the PDA and where that person is within the library, different pieces of information can be presented to the user through the mobile device: a "digital compass" can point to the bookshelves where books of interest are located, similar books to the ones named by the user can be suggested, users with similar interests or who are experts in some topic and are physically close to the bearer of the PDA can be identified, etc.

Many technologies can be employed to design and implement such systems. We have observed that multi-agent systems and Semantic Web Services have been employed successfully in many projects as foundational technologies to build smart environments.

The reasons for this success relate to these systems providing for robust and decentralised implementations, which are particularly interesting for this type of applications. Moreover, these technologies allow a layered approach to design and implement smart environments, in which different levels of abstraction can be considered separately. This is particularly useful to design complex distributed systems – such as smart environments – in which clean, elegant and verifiable design and implementation can be absolutely necessary requirements.

The goal of this featured paper selection is to explore to what extent these specific technologies are appropriate to build smart environments. In order to develop this evaluation, we have considered important to bring to discussion foundational work – in which methodological issues are taken into account – as well as "battlefront work" – in which concrete experiences design-

ing and implementing smart environments are brought to discussion and public scrutiny.

The featured paper selection contains three articles that have been selected based on their quality, and which focus directly on facing the challenges mentioned above. We thank the authors for sharing their results with the community through this publication.

The first paper, *"WBLS: a Signal Presence-based Wi-Fi Localization System for Mobile Devices in Smart Environments"*, by Moura, Ribeiro and Costa, introduces a novel system for indoor localization of digital devices based on wireless signal strength, whose distinguished feature is robustness against noise and communication failures. The second paper, *"Semantic Enrichment of Places: Ontology Learning from Web"*, by Alves, Antunes, Pereira and Bento, introduces a system based on ontological engineering whose target are location aware information systems for public and outdoor environments. The third paper, *"The Engineering of Micro Agents in Smart Environments"*, by Bolzani and Netto, focuses more specifically on the design and construction of agents for agent-based, location aware information systems.

We also thank the paper reviewers, who have devoted their time to appreciate the excellent work of many authors – including those whose articles have not been selected for publication at this moment – and helped us select the three papers that are presented here. The guest review board for this paper selection was:

- Stefania Bandini, University of Milano-Bicocca, ITALY
- Flavio Soares Correa da Silva, University of Sao Paulo, BRAZIL
- Suresh Manandhar, University of York, ENGLAND
- Alessandro Mosca, University of Milano-Bicocca, ITALY
- Matteo Palmonari, University of Milano-Bicocca, ITALY
- Dave Robertson, University of Edinburgh, SCOTLAND
- Michael Schumacher, University of Applied Sciences, SWITZERLAND
- Wamberto Vasconcelos, University of Aberdeen, SCOTLAND
- Giuseppe Vizzari, University of Milano-Bicocca, ITALY

Last but definitely not least, we thank the Editors-in-chief of the KES Journal – Dr. R. J. Howlett and Dr. B. Gabrys – for supporting the preparation and publication of this selection of papers.

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