Context-Aware Module for Social Computing Environments

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Abstract. The continuous evolution of the information and telecommunication technologies has led to new forms of social interaction, including social networks. Social interaction is a new paradigm that studies the use of information technologies with social purposes. Social computing envisions a new kind of computation where humans and machines collaborate to compute and resolve a problem. In this paper we present a context-aware module for the PANGEA architecture that incorporates contextual information to enrich the social knowledge representation.

Keywords: Multi-agent systems, Human-agent societies, Context-Aware Computing.

1 Introduction

During recent years social computational solutions have emerged to provide new ways for interaction and communication. Some examples are Amazon, where the humans contribute to the computation including their opinions and recommendations about the products, Captcha [25], where both humans and computers collaborate to provide an efficient authentication system, etc. Social computing is a new computational model where human and computers collaborate to improve social relationships using computer science [26], [4], [7], [15], [7], [9]. For Wang et al. [26] Social Computing is the computational facilitation of social studies and human social dynamics as well as the design and use of ICT technologies that consider social context. In this sense, it is important to define new mechanisms to include contextual information in the social computing model. For Robertson et al. [17] social computing requires and effective combination of computational and human resources: On the one hand, humans bring their competences, knowledge and skills, together with their networks of social relationships and their understanding of social structures. On the other hand, ICT can search for and deliver relevant information. Humans can then use this information within their contexts to achieve their goals and, eventually, to improve the overall environment in which they live.

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One of the open challenges for Social Computing is to provide more realistic ways to improve social behaviors and relationships using computer science. The existing solutions have focused on theoretical underprintings, technological infrastructure and applications. However, it is necessary to capture contextual information to enrich the social model, thus providing more realistic computational tools for the cooperation between humans and computers. In this paper, we present an extension of the PANGEA [29] architecture a multiagent architecture based on virtual organizations [2], [3], that incorporates a context-aware computing model [27], [23], [21] to obtain contextual information. In this paper, we extend the PANGEA architecture and we define all the infrastructure components, both sensor networks and computing, especially at a hardware level. We define a broker that interacts with the sensing technologies and a set of adapters that normalize the data. The broker communicates with the rest of the platform by means of adapters. We design a new model to integrate the JDL information fusion model within the virtual organization-based multiagent architecture [4], [18], [23], [19]. Particularly, we focus on designing new algorithms for mixtures of experts specialized in fusing information obtained from wireless sensor networks.

The rest of the paper is organized as follows: section 2 revises the related work. Section 3 presents the proposed model. Finally, in section 4 the preliminary conclusions obtained are presented.

2 Related Work

Recent tendencies have led to the social computing paradigm of designing social systems. One of the challenges to be addressed to obtain an extended model with context-aware computing abilities is the procurement of effective management architectures for WSNs. Until now, WSNs and their applications have been developed without considering a management solution that can dynamically adapt to both the changes that occur in the environment, and to user needs. Some approaches as the MANNA management architecture for WSNs propose the functional, information, and physical management architectures, that take into account the specific characteristics of this type of network [12]. However, this architecture does not take into account either adaptive and organizational aspects, or intelligent information fusion (IF). Lim *et al.* [12][13] propose a sensor grid architecture, called the scalable proxy-based architecture for sensor grid (SPRING), to address these design issues [12]. However, the architecture is focused on a sensor grid design and not on exploitation. H-WSNMS uses the concept of a virtual command set, H-WSNMS, to facilitate management functions for specific WSN applications from the individual WSN platforms [26], but does not take IF algorithms into account and is not designed on the basis of organizational aspects. MARWIS is a management architecture for heterogeneous wireless sensor networks (WSNs). It supports common management tasks such as monitoring, (re-)configuration, and updating program code in a WSN [21]. MARWIS, however, does not take organizational aspects into account and does not fuse information. Yu *et al.* [26] propose a lightweight middleware system that supports WSNs to handle real-time network management using a hierarchical framework [27]. Although they take organizational aspects into account, they do not consider IF algorithms and user services. G-Sense [15] is an architecture that integrates mobile and static wireless sensor networks in support of location-based services, participatory sensing, and human-centric sensing applications. It does not, however, take organizational aspects into account, nor does it include IF technologies. Nowadays it is possible to find different proposals for architectures that manage wireless sensor networks [7][14][4][12]; however, most of them are designed for specific environments or specific purposes and none of them combines organizational aspects, IF techniques, advanced storage mechanisms and open integration design.

Although significant progress has been made in the development of architectures to manage wireless sensor networks, at present there is no single open platform that efficiently integrates heterogeneous WSNs, and provides both intelligent IF techniques and intelligent services. Therefore, there is no platform in the market that facilitates the communication and integration of the wide variety of existing sensors, providing intelligent IF facilities, intelligent management of user services. The proposed Virtual Organization (VO) of multiagent architecture is based on the social computing paradigm and will provide intelligence to the platform with adaptation to the needs of the application problem, while the cloud environment will ensure the availability of the required resources at all times.

3 PANGEA Architecture

PANGEA (Platform for Automatic coNstruction of orGanizations of intElligents Agents) [29] is an agent platform to develop open multi-agent systems; it can manages roles, norms, organizations and suborganizations that facilitate the inclusion of organizational aspects. The services offered by the agents are included independently from the agent, facilitating their flexibility and adaption. PANGEA incorporates a CBR-BDI reasoning mechanism available for the agents. The basic agent types defined in PANGEA can be seen in Figure 1, they are:

- OrganizationManager: the agent responsible for the actual management of organizations and suborganizations. It is responsible for verifying the entry and exit of agents, and for assigning roles. To carry out these tasks, it works with the OrganizationAgent, which is a specialized version of this agent.
- InformationAgent: the agent responsible for accessing the database containing all pertinent system information.
- ServiceAgent: the agent responsible for recording and controlling the operation of services offered by the agents. It works as the Directory Facilitator defined in the FIPA standard.
- NormAgent: the agent that ensures compliance with all the refined norms in the organization.

- CommunicationAgent: the agent responsible for controlling communication among agents, and for recording the interaction between agents and organizations.
- Sniffer: manages the message history and filters information by controlling communication initiated by queries.
- DiscoveryAgent: implements an intelligent mechanism to discover services.
- MonitorAgent: interacts with the platform to show the information to the end user.

PANGEA is a service-oriented platform that can take maximum advantage of the distribution of resources. To this end, all services are implemented as Web Services. This makes it possible for the platform to include both a service provider agent and a consumer agent, thus emulating a client-server architecture. The provider agent (a general agent that provide a service) knows how to contact the web service, the rest of the agents know how to contact with the provider agent due to their communication with the ServiceAgent, which contains this informacion about services.

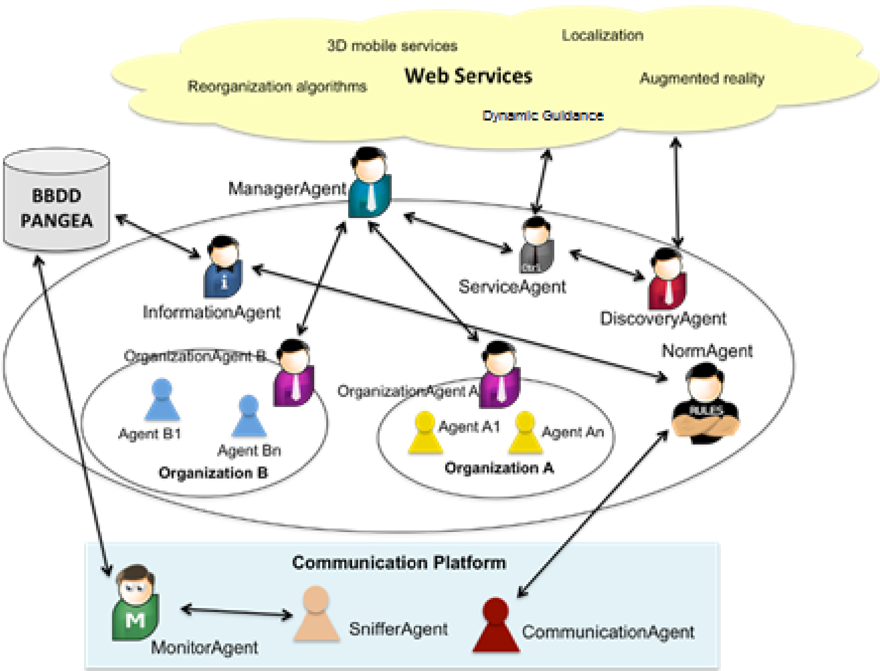

Fig. 1. First-person training view

3.1 Extensions for Context-Aware Computing

The extended model for the PANGEA architecture allows obtaining and managing contextual information that can provide an added value to design social computing models and obtain immersion at the MAS level. Contextual information can enrich the humans' information providing more realistic data about the humans' situation, including human actions and behaviors in a given society. Context-aware systems manage information that characterizes an individual and her environment. These systems require sensor networks to capture the context information and intelligent systems that can manage the information efficiently.

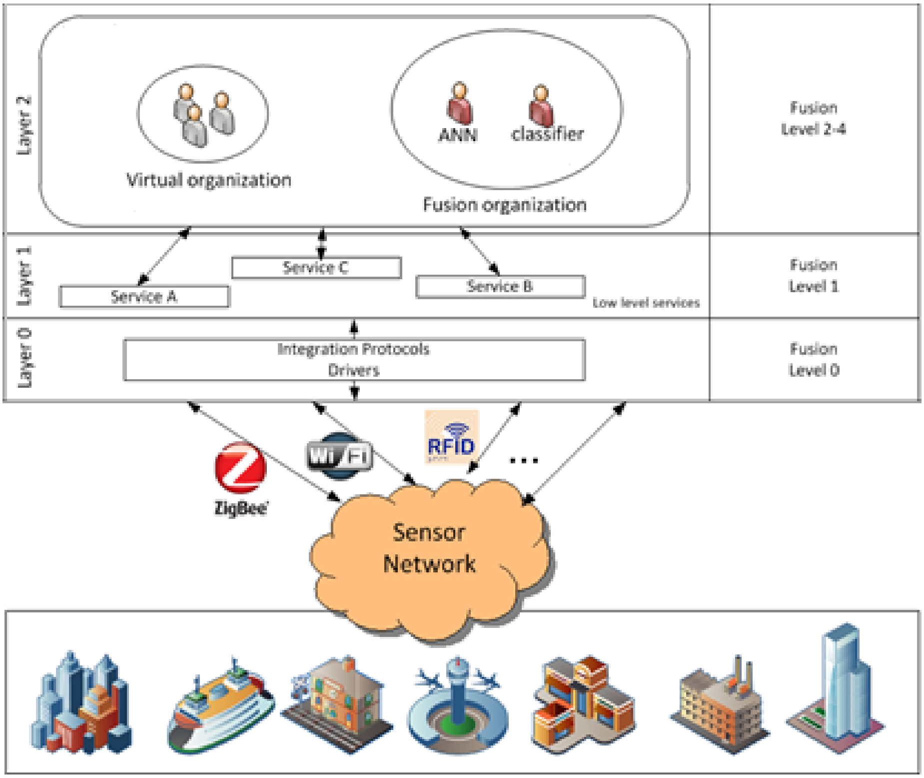

Fig. 2. Extended model for the sensor and physical layers

The proposed extended model is deployed into a layered architecture as shown in Figure 2. As we can see, the extended model is composed of different layers associated with the different functional blocks. The fusion levels of information are distributed along the different layers that can be found in the description of the JDL fusion model [1][17]. As defined in JDL, existing levels of data fusion from 0 to 6 are Data Assessment, Object Assessment, Situation Assessment, Impact Assessment, and Process Refinement. These levels are distributed in the different layers of the architecture shown in Figure 2.

The following section describes the components and main features of the architecture:

- **Layer 0. Sensing/performance technologies.** Layer 0 of the platform is a broker that defines communication with sensor networks of different natures (Wi-Fi, ZigBee, Bluetooth, etc.), and obtains the raw data from sensor networks. This process of acquiring raw data from sensor networks is associated with *Level 0 - Data Assessment*. The main novelty of this layer is the ability to provide the platform and the upper layers with openness regarding the connection to sensor networks of different natures. It thus ensures that upper layers of the architecture have access to information and are able to perform data fusion at different levels.
- **Layer 1. Low-level services.** Given the information exchanged with the environment through layer 0 as described above, the existing functional requirements and a set of low-level services will now be defined; specifically those that depend on the types of networks and technologies integrated into every deployment. After obtaining the raw data, a gateway is provided, defined through adapters that allow the information received to be standardized. The data processing corresponds to *Level 1 - Object Assessment* as indicated by the JDL classification shown above. In this first stage, the platform provides services such as filtering of signals, normalization services or other treatment services at the basic level signals. These services are provided by the adapters and is associated with algorithms that perform initial treatment of the data, so that these data can be presented to higher layers in a more homogenized way. Each of these services expose an API to higher layers that allows interaction with each low-level service, and thus, with the underlying sensing/performance technologies.
- **Layer 2. Information fusion algorithms.** This layer includes le*vels 2 to 4 of IF displayed on the JDL model.* The platform is structured as a VO of MAS. Each organization includes the roles required to facilitate an intelligent management of the information obtained from the lower levels of the architecture. The MAS incorporates agents specifically designed to interact with low-level services. In addition, we introduce the design of intelligent agents specialized in IF. For this purpose, roles that allow merging information automatically through supervised learning and previous training have been included.

4 Conclusions

This paper has presented an extended model for social computing for the PANGEA architecture, aimed at extending the concept of social computing to obtain immersion at the MAS level. Social computing has gained relevance during recent years, trying to combine sociology and computer sciences to design social systems. The extended model proposed in this paper is currently being detailed and evaluated using location-aware systems. A location-aware system can notably help to obtain real-time information that can be used for social computing purposes in different applications that can make use of location data to create social machines. Some examples can be the prediction of social dynamics, design of activities, urban architectural design, management of emergency situations or other several social behaviors that can be analyzed and supported by computational technologies. Particularly, in future work, we want to focus on a case study to design an agent-based social simulation model for work environment and to introduce new variables in the simulation model, such as individual and group behavior obtained from the location of the participants. The agent-based social simulation model will be an extension of a previous model aimed at emulate human behaviours in a work environment to predict the labour integration of handicapped people.

The inclusion of a context-aware module in the PANGEA architecture can help us to introduce and analyse contextual information and patterns related to interaction and collaboration behaviours that usually are hidden in real societies. More specifically, the use of location-aware techniques can help us to detect friendship or other collaboration events that cannot be regulated in current agent-based social simulation models. The use of fusion will allow the implementation of specific experts, signal agents to process and filter signal data. One of the main advantages of this implementation is the high adaptability of the platform to dynamically incorporate new agents (experts, mixtures, filtering algorithms, etc.). Thus, a fusion agent will make use of the information provided by two or more expert agents to generate high level information services. The IF process requires communication among the different layers of the architecture that will be implemented through message passing protocols.

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