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MATCHING ONTOLOGIES FOR EMERGENCY EVACUATION PLANS

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Matching ontologies for emergency evacuation plans

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Abstract. In case of emergency, the coordination of different services deals with different working methods, different languages, different instruments, different sensors and different data representations. Thus, the coordination of services includes heterogeneity problems that can be managed with the help of ontology matching techniques. In this paper we present a scenario where the requirements for ontology matching arise from emergency evacuation plans, in the specific domain of civil protection applications. We envisage what kind of smart sensor technologies could be used to support critical decisions when heterogeneous sources of information have to be matched.

1 Introduction

In the context of semantic web and web services, heterogeneity represents a key feature. One of the critical issues of semantic web services is the way the resources of the semantic web have to be integrated as a whole. In fact, the ontologies that are used to express information by means of sets of discrete entities (e.g., classes, properties, rules) are affected by heterogeneity, which requires proper integration techniques [1, 2]. *Ontology matching*, namely the ability of finding suitable relationships between entities from different ontologies, is essential to achieve semantic interoperability and it may have huge social impact.

For example, when a large–scale disaster occurs many people from different organizations may reach the critical area in a short time, and the need for integration of heterogeneous and rapidly evolving sources of data emerges. In this context disaster management is strongly related, at different levels of abstraction, to environmental monitoring and ambient computing [3]. From a practical point of view, the monitoring of an area involved in a disaster can be regarded as a special example of environmental monitoring. In general, environmental monitoring applications require sensing different quantities (e.g., temperature, moisture or brightness), possibly evolving in time and space, as well as some information related to the physical context in which some services are available [4]. The purpose of these services can be merely informative, or aimed at making decisions. In situations where an impending danger may affect the life of several people at the same time, the criticalness of decisions and the dynamics of all

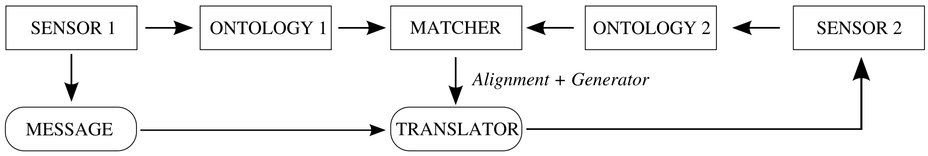

Fig. 1. Agent communication, adapted from [6].

events must be analyzed effectively in real-time, and thus the evolution in time and space of interesting quantities should be monitored as well.

In order to design flexible services in such extreme conditions, defining the ontologies of the various smart devices employed (along with their capabilities) and implementing suitable matching strategies is a viable and effective approach [6]. Heterogeneous ontologies have to get in correspondence in order to understand messages sent by related sensors. Sensors can perform ontology matching by themselves or by taking advantage of alignment or matching services, and when they find a mutual agreement they can transform the alignment in a program that translates the messages in axioms enabling the interpretation of the messages, as represented in Fig. 1.

This paper presents a potential real-world scenario where the ontology matching requirements are related to the management of emergency evacuation plans from large buildings. In particular, we envisage how management of emergency evacuation plans from large buildings can take advantage from ontology matching. The case study considered in the following, although still at a quite preliminary stage, results from a close collaboration between the Civil Protection Department, various research centers and local companies, and with the help of both staff members and volunteers of various rescue corps.

The rest of the paper is organized as follows: Section 2 introduces the basic issues related to emergency situations and specifically describes the requirements of the emergency evacuation plan scenario posed to ontology matching. Then, Section 3 summarizes the conclusions and outlines future work.

2 Matching ontologies in emergency situations

In case of emergency, an effective coordination of people from different organizations (e.g., civil protection, police, ambulance, fire brigades, red cross) is essential. The services offered by such organizations are characterized by different working methods, different languages, different instruments, sensors, and data representations. Thus, the coordination of services certainly includes problems requiring ontology matching. Several monitoring systems can indeed collect data for different organisations and for different purposes, using different sensor technologies.

Although the different solutions deal with huge amount of data, the interpretation and analysis is not consistent. Proper standardisation of data collection processes is necessary, including applied technology and data storing formats, to facilitate communication between services on a more consistent basis. Also, un-

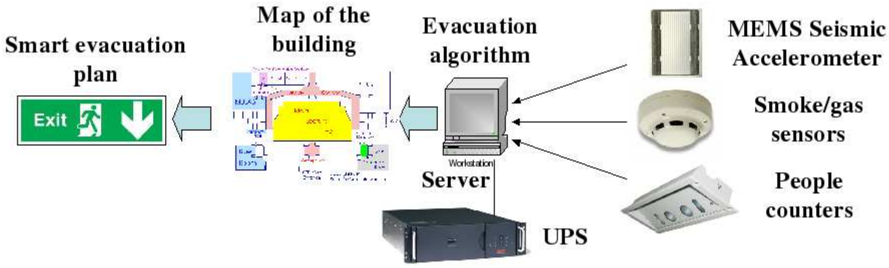

Fig. 2. Example of sensor communication and ontology matching based on sensor ontologies in order to facilitate decision making.

certainty over the network consistence arises during emergencies (e.g., in terms of sensors full functionality, or possible interaction that may occur with robots or automated agents with own sensors), as exemplified in Fig. 2.

2.1 Emergency evacuation plans

As presented in Sec. 1, applications evolve in changing environments where devices are replaced and added, and then it is not possible to establish unique and definitive ontologies. Thus, applications have to be expressed in terms of generic features that are matched against the actual environment. An interesting civil protection applicative scenario, in which smart sensor networks could be particularly useful, concerns with the optimal management of emergency evacuation plans from large buildings. As known, all public buildings (e.g., offices, shopping malls, schools) are usually equipped with a certain number of safety exits as well as by evacuation plans that should be carefully respected, in particular in case of dangerous events (e.g., fires or earthquakes). Usually, the basic safety requirements are defined by national regulations. However, the actual effectiveness of any pre-set evacuation plan can be limited by several issues, such as the impossibility for occasional visitors (e.g., customers) to know the evacuation strategy, the unpredictability of crush behavior in panic conditions, the lack of information about number and about the distribution of people inside the building. To solve such problems a smart sensor network could be deployed in a building in order to automate the whole evacuation process. This network might consist, for instance of:

– Redundant smoke or gas sensors to detect the presence of fire or the risk of an explosion (redundancy is essential in this case to reduce the risk of false alarms);
– Low-cost micro-electro-mechanical accelerometers for seismic events monitoring [8] placed along the most important architectural elements of the building;
– Smart video people counters located in proximity to doors, stairs or corridors in order to estimate in real–time not only the total amount of people in the building, but also their distribution [9–11].

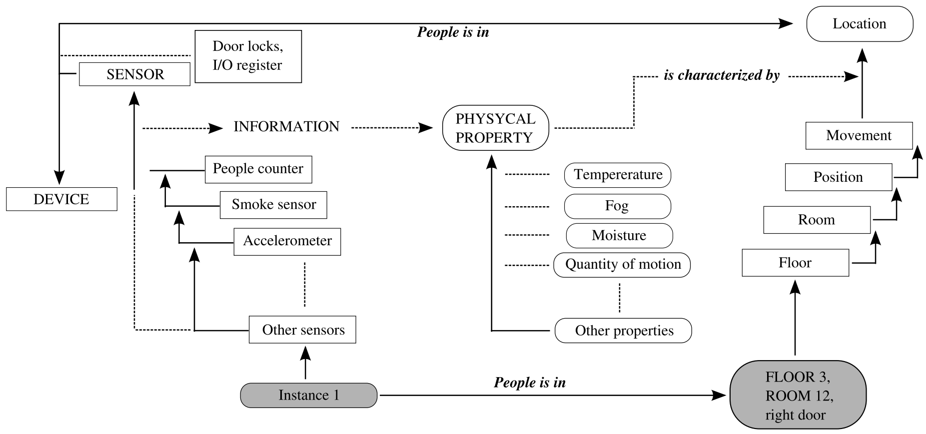

Fig. 3. Ontologies related to the objects found in the building during evacuation, inspired by [12], with instances linked to their classes.

The data collected by the various sensors could be transferred through wired or wireless connections (e.g., Ethernet or Wifi) to a central server (suitably connected to an emergency Uninterruptible Power Supply, UPS) which in turn could activate visual or sound alarms in order to manage the evacuation process in the safest possible way. For instance, when a fire is detected, a software application running on the server could estimate the level of risk in each area of the building and then switching on the emergency signals and the way-out light indicators, keeping into account the position and the distance of different users from the impending danger. In this way, people could be safely and orderly guided towards the safest exits, and in addiction the intrinsic risks related to a mass evacuation (especially for children, for elderly people and for people with disabilities) could be significantly reduced.

2.2 Emerging requirements

Usability of devices depicted in Fig. 2 is unpredictable since they are subjected to being added/replaced or malfunctioning at any time. For instance, when a robot enters a building during evacuation, it will introduce sensors that will provide more precision or information which has not been considered at application design time and again ontology description languages can help solving this problem [12]. Fig. 3 shows possible specific ontologies related to the objects found in the building during evacuation.

From this scenario we can derive requirements for matching solutions in the context of emergency evacuation plans. In particular, requirements concern specific behaviours, such as requirements of being automatic (not relying on user feedback), being correct (not delivering incorrect matches), being complete (delivering all matches) and being performed at run time. These requirements confirm the application requirements reported in [6], with reference to multi-agent communication. Another important requirement concerns the execution time, which has been indicated to be under 2 seconds by the Civil Protection staff, in order to operate under stable and safe conditions.

3 Conclusions

In this paper, an applicative example is proposed in which the joint application of both ontology matching strategies and smart sensor networks can be successfully used to optimize building evacuation. Multiple sensors could be used to estimate in real–time the total amount of people and their distribution in the building, while proper matching of the sensor ontologies should facilitate and greatly improve the decision making process. Future works include studies to elaborate and to formalize the scenario, to choose and to develop a suitable matching algorithm (e.g., as in [13]), and and extensive end-to-end testing.

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