Chapter 67
Ontology-Driven Situation Assessment System Design and Development in IoT Domains

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ABSTRACT

An ontology-driven approach to software design and development of situation assessment systems (SAS) for IoT applications is considered. As SAS is used to build the situational model for the external environment, it highly depends on the operational domain. To simplify the transition from the domain description to SAS dataflow process the ontology-driven approach is proposed. The main idea of the approach is to explicitly formalize SAS dataflow process in an ontological form. For this purpose, a domain-independent SAS ontology is proposed that allows automation of the dataflow process design. The dataflow process ontology is used to automate development and runtime stages of SAS lifecycle. The proposed ontology is included into the proposed instrument set. The set can be used to build SAS systems for different domains described with OWL ontology. The set is evaluated on a traffic control scenario.

INTRODUCTION

An important trend in the Internet of Things (IoT) development is to increase the level of intelligence of individual nodes. For this reason, the concepts of the IoT and Multi-Agent Systems (MAS) are actively converging in recent year, see (Yu, Shen & Leung, 2013), (Alexakos & Kalogeras, 2015) and (Leong & Lu, 2014).

In general case, IoT can be considered as an open dynamic multi-agent environment. One of the key functions of intelligent agents operating in such environments is a situation assessment, based on the large volume of low-level data coming from the sensors and other nodes (agents).

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At the same time, development of appropriate software is an actual, complex and labor-intensive task in creating IoT systems. To effectively solve this problem, several approaches have been proposed in recent years. One promising approach is based on ontology-driven software engineering, see (Phalnikar & Joshi, 2010), (Corredor, Bernardos, Iglesias & Casar, 2012) and (Katasonov & Palviainen, 2010).

An ontology-driven approach to software design and development of situation assessment (sub)systems (SAS) for IoT applications is considered in the article. The approach is illustrated by the examples of traffic control scenario.

BACKGROUND

Effective traffic management requires the consideration of a number of dynamically changing factors: quality of roads and congestion, ramifications of transport infrastructure, weather conditions, timetables of enterprises operation, schedules of mass events (for example, sports competitions) etc. As advanced vehicles (cars, buses etc.) and road infrastructure are becoming more instrumented with sensors, actuators, and processing units, use of the concept of the IoT is becoming more attractive for solving this problem.

A lot of research has been devoted in recent years to different aspects of the use of IoT for traffic management, see (Anass, Yassine & Mohammed, 2016) and (Pyykönen, Laitinen, Viitanen, Eloranta & Korhonen, 2013).

To avoid emergency situations on the roads, the intelligence level of vehicles can be increased by providing them with reasoning capabilities. Such an approach enables to avoid the use of a central decision point since each vehicle is a decision point. The advantage of this approach is immediate solutions because every vehicle responds to neighboring vehicles and collaborates with them to reach a consensus in real time. Such an approach is considered in (Bermejo, Villadangos, Astrain & Cordoba 2013), where automatic reasoning is realized using ontologies.

Another approach to traffic management using knowledge integration and reasoning based on sensor ontology are considered in (Hotea & Groza, 2013).

In (Li, Gu & Zhang, 2012) the significance of increasing situational awareness and, consequently, the solution of situation assessment task is substantiated.

In (Al-Sakran, 2015) an architecture that integrates IoT with agent technology into a single platform is proposed. Agents handle effective communication and interfaces among a large number of heterogeneous highly distributed and decentralized devices within the IoT. The architecture introduces the use of an active radio-frequency identification (RFID), wireless sensor technologies, object ad-hoc networking, and Internet-based information systems in which tagged traffic objects can be automatically represented, tracked, and queried over a network.

However, the issues of software design automation for situation assessment sub-systems (SAS) were not considered.

Given the constant growth in number and type of information sources, the higher level of situational awareness is required to make high-quality decisions. Since the data supplied by the sensors are low-level, they must be processed to build a high-level model of the situation. In addition, to make informed decisions, it is also necessary to forecast the transport situation (for example, by the end of the mass sporting event). Within the cognitive agent architecture, this task is solved by SAS.

Problems related to situation assessment in complex dynamic environments are explored within the framework of situational awareness and data fusion concepts. According to the most famous concept