MAIoT - An IoT Architecture with Reasoning and Dialogue Capability

Juan Carlos Nieves[1(✉)], Daniel Andrade[2], and Esteban Guerrero[1]

[1] Department of Computing Science, Umeå University, 901 87 Umeå, Sweden
{jcnieves,esteban}@cs.umu.se
[2] Instituto Tecnológico Superior de Xalapa, 910-96 Xalapa, Veracruz, Mexico
daniel.andrade.sd@gmail.com

Abstract. This paper describes MAIoT, a Multiagent-based Architecture which aims to coordinate Internet of Things (IoT) devices. MAIoT is distinguished by its capabilities for allowing dialogues between IoT devices. To support theses dialogue capabilities, the IoT devices are wrapped into rational agents with reasoning and dialogue capabilities.

Keywords: Internet of Things · Multiagent systems · Rational agents · Dialogues

1 Introduction

The information technology (IT) industry and IT research communities have been working in the development of Internet of Thing (IoT) platforms in order to improve our daily life. For instance, IoT platforms have been developed in order to build up the so called *smart homes* which aim to improve the experiences of their inhabitants [7].

To achieve "smart" IoT capabilities, different open challenges have been identified [1,3,5]. Among them, we can point out: a.- *intelligence distribution*: interpretation of dispersed sensor-data and reasoning about it; b.-*standardization*: adoption of industrial standards; and c.- *flexibility*: "Plug & Play" smart objects deployed in environments. In this regard, *establishing dialogues* among smart devices and anticipate needs of a user are major challenges [7]. Against this background, we present here a Multiagent Architecture for Internet of Things (MAIoT) which aims to coordinate and provide IoT services. In this architecture, we follow a *dialogue-based* approach based on rational agents in order to coordinate IoT services. In these settings, *inquiry dialogues* aim to agree or disagree services supported by IoT devices. To conduct dialogues between IoT devices which are wrapped into rational agents, we follow an argumentation-based approach, introduced by [6], which supports collaborative decision making processes in the settings of the so called *agreement rules*.

E. Sucar et al. (Eds.): AFI 2016, LNICST 179, pp. 109–113, 2017.
DOI: 10.1007/978-3-319-49622-1_13

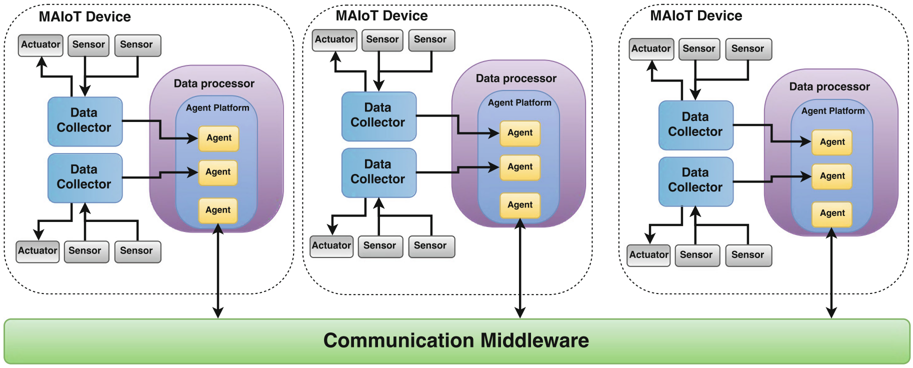

Fig. 1. Physical diagram of MAIoT architecture.

2 MAIoT Architecture

In this section, we describe our multiagent architecture for IoT devices. The MAIoT architecture hosts IoT devices in terms of the so called MAIoT devices. A MAIoT device is composed by three modules: *a data processor*, *a data collector* and *an agent platform*. The data processor hosts an agent platform and is connected to other data processors, each one with its own agent platform, through *a communication middleware*.

The data collector is controlled by one agent, see Fig. 1, and is integrated with sensors and actuators. The data collector has as aim both to perceive data from the environment through sensors and to send this data to the agent.

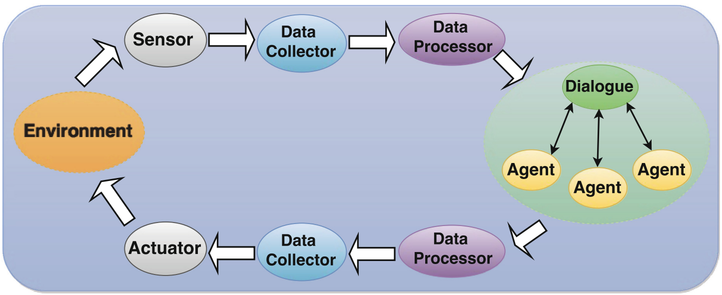

Fig. 2. Data workflow diagram of the MAIoT architecture.

The agents hosted by MAIoT devices exchange information with other agents hosted by different MAIoT devices through dialogues and provide services through their actuators. The agents take part of inquiry dialogues in order to agree IoT services which are defined according to user preferences and needs. Inquiry dialogues, among other types of dialogues, were defined by [8] in order to collaboratively build new knowledge. In our architecture, agents take part in the negotiation (an inquiry dialogue) of a topic in which the agents do not know if a given topic is true or false; hence, they require the collaboration of other agents, see Fig. 2.

To formalize our dialogue system, we follow the dialogue style introduced by [2,6], in which three types of moves are allowed: *open*, *assert* and *close*. In an open move, an agent starts a new dialogue with a given topic. In an assert move, an agent assert arguments related to a given topic; and in a close move an agent wants to finish the current dialogue; however, if another agent does not agree, this dialogue will not be closed and will still open.

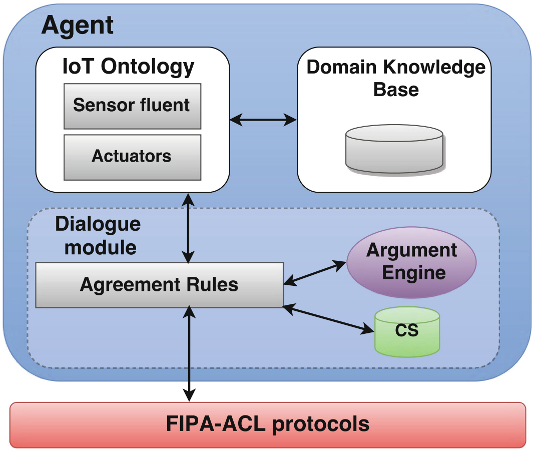

Fig. 3. Internal architecture of a MAIoT agent.

As Fig. 3 shows, agents are composed by three modules: an IoT ontology, a dialogue module and a domain knowledge base. In the **IoT ontology module**, information from sensors is interpreted in terms of the **Semantic Sensor Network Ontology**[1], and stored in the **Domain Knowledge base module**. In the **Dialogue module**, agents read messages from other agents through *FIPA ACL protocols*, and perform a decision-making process inquiring their own agreement rules and their **Domain knowledge bases**. Then, a decision about to execute of services, by means of actuators, is taken.

3 Ongoing Project

MAIoT devices are being used in an agent-based assistive architecture for computer-supported assessment: UmU-Act project [4].

[1] https://www.w3.org/2005/Incubator/ssn/ssnx/ssn.

The architecture integrates a generic core ontology based on medical and health terminologies with the IoT ontology in order to reason and share information among IoT agents. A MAIoT architecture has been implemented by considering three agents: *context*, *activity* and *coach* agents. This architecture is intended to track and evaluate human activity in a home-care environment. UmU-Act architecture considers MAIoT devices deployed in a Raspberry Pi[2] platform using Java Agent DEvelopment Framework (JADE)[3] framework, and Arduino[4] platform for capturing and managing of sensor data.

We will describe details of use cases and an evaluation of the MAIoT architecture in an oncoming extended version of this paper.

4 Conclusion and Future Work

In this paper, we introduce MAIoT, a Multi-agent Architecture for the Internet of Things with reasoning and dialogue capabilities. The major characteristics of the MAIoT architecture are summarized as follows: 1.- *Reasoning and dialogue capabilities*: MAIoT agents are endowed with reasoning capabilities by considering an argumentation-based approach. Internal reasoning processes of MAIoT agents combines a domain knowledge base and an IoT ontology; 2.- *IoT orientation*: interoperation of MAIoT agents is warranted by considering an IoT ontology. Interoperability and decentralization of smart devices can be achieved by considering a dialogue approach using IoT standard-based communications. 3.- *Flexibility and generalization*: MAIoT agents can be deployed as Plug & Play standard-complaint smart devices.

As future work, we will investigate the interaction between MAIoT agents and human agents (individuals), particularly aiming to support the improvement of individual's situations and quality of life [4].

References

1. Atzori, L., Iera, A., Morabito, G.: The internet of things: a survey. Comput. Netw. **54**(15), 2787–2805 (2010)
2. Black, E., Hunter, A.: An inquiry dialogue system. Auton. Agents Multi-agent Syst. **19**(2), 173–209 (2009)
3. Gubbi, J., Buyya, R., Marusic, S., Palaniswami, M.: Internet of things (iot): a vision, architectural elements, and future directions. Future Gener. Comput. Syst. **29**(7), 1645–1660 (2013)
4. Lindgren, H., Baskar, J., Guerrero, E., Nieves, J.C., Nilsson, I., Yan, C.: Computer-supported assessment for tailoring assistive technology. In: Proceedings of the 6th International Conference on Digital Health Conference, DH, Montréal, QC, Canada, 11–13 April, pp. 1–10 (2016)
5. Miorandi, D., Sicari, S., Pellegrini, F., Chlamtac, I.: Internet of things: vision, applications and research challenges. Ad Hoc Netw. **10**(7), 1497–1516 (2012)

[2] https://www.raspberrypi.org/.
[3] http://jade.tilab.com/.
[4] https://www.arduino.cc/.

6. Nieves, J.C., Lindgren, H.: Deliberative argumentation for service provision in smart environments. In: Bulling, N. (ed.) EUMAS 2014. LNCS, vol. 8953, pp. 388–397. Springer, Heidelberg (2015). doi:10.1007/978-3-319-17130-2_27
7. Pretz, K.: Laying the foundation for smarter homes - building smarter homes. Inst. **39**(4), 4–5 (2015)
8. Walton, D.N.: The New Dialectic: Conversational Contexts of Argument. University of Toronto Press, London (1998)