Agent-Based Context Awareness Platform For IoT- A Survey

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***Abstract*- Within cyber-physical networks, the Internet of Things is a futuristic idea, rich in promise as well as multifaceted requirements and implementation issues. Agent-Based Computing represents suitable and effective modeling, programming, and simulation paradigm for properly addressing them and fully supporting IoT system creation. Agent metaphors, principles, strategies, processes, and tools have all been used extensively in the development of IoT systems. In this paper, we have presented surveys and reports on the most recent contributions in this field.**

***Index Terms*-- Agent, Context, IoT, Semantic Technologies, Availability, Reusability, Modularity, Scalability.**

I. INTRODUCTION

The Internet was founded in 1980 and it has gone through a lot of phases. So Kevin Ashton was made the term ‘’Internet in 1999 at the MIT Auto-ID center [1]. Today, infrastructure systems like smart homes, cities, health, water networks, transportation, etc are more complex and rich than we ever imagined. All these visions are connected with a single concept which is Internet of Things (IoT). It may be things or physical objects that consist of embedded technologies that allow them to collect data. The IoT allows objects to be sensed and managed remotely over a network infrastructure, allowing for more direct interaction between the real world and computer systems. To put it another way, the IoT has resulted in automation in all fields [2]. The main aim of the Internet of Things is to connect devices and obtain information to build situational awareness and empower devices and humans to understand the context or situation properly, allowing for better decision-making and responses. Weather tracking, water and energy management, healthcare, education, retail, and traffic control are only a few of the places where IoT is being used [3]

1.1. Agent: Agent is a software robot we also called it softbot. A program that performs many actions consistently and independently on the behalf of a person or an organization. Such as, regularly archiving different files and retrieving electronic messages. For example, user agents which are special kinds of software agents which act in a way that "retrieves, renders, and promotes end-user interactions with Web material" on a user's behalf.

1.2. Context-Aware: The context-aware term was derived in 1994 by Schilit and Theimer. It is any information which is used to describe an entity's condition is referred to as context. A person, location, or thing is considered important to the relationship between an application and user. Users and applications are also referred to as an entity [4].

1.3. Context-Aware system: When a system makes use of context to give relevant information about services to the user it is said to be a context-aware system. Relevancy depends on the task of users. To create context-aware applications a context-aware system is used that can collect data from different devices for analyzing the environment, assuming the current situation and processing it as shown in figure 1. The result shows that the user is provided with relevant resources to adapt to the situation. [4]

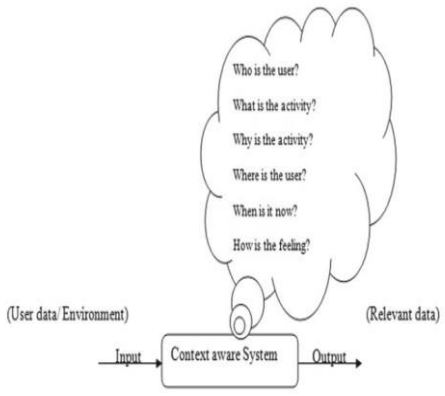

Figure 1: Context-Aware Agents for IoT Services. [4]

In this survey, the intention is to show how an agent-based context awareness platform is effectively employed. Therefore, the rest of the paper is divided into the following sections. The related work of several other scholars is

mentioned in Section 2. Critical analysis is presented in Section 3. Finally, the article is concluded in Section 3.

II. RELATED WORKS

We have addressed the associated work linked to our research work in this section. We have discussed the proposed methodology of other researchers. We studied data delivery and management approaches to IoT and presented a survey for an agent-based context awareness platform for IoT. This literature review will help readers to understand the Agent-Based Context awareness platform for IoT.

Moeiz Miraoui and Sherif Eletriby [1] proposed a multi-agent architecture for a smart living room. They focused on the aspects of context awareness. Their proposed architecture can be used in any smart space easily. They have presented an ontology-based context modeling method based on proper and brief context definitions. The presented architecture consists of software and hardware. It contains strong modularity along with high cohesion and low coupling inside the modules. They stated that they are currently implementing the three architecture modules in addition to the smart living room's hardware infrastructure, then they will proceed with the necessary testing and implementation evaluation.

Bemir et al [2] have done research associated with the title "Integration of semantics into sensor data for the IoT", which may be effective for other authors to contrast their research with already existing. The review queries are initially established, approaches for finding suitable publications are created, and the criteria for inclusion and exclusion are finally described. The key contribution of this analysis is the attempt to address established review-based queries on the final research paper data set and responses to each review query are firstly specified in general, after that supported separately from the literature.

Sanju Mishra and Sarika Jain [3] highlighted the value of ontology and identified it as a semantic paradigm in the Internet of Things. Researchers based on MRO assessment (Military Resource Ontology). Several methods, aspects, requirements, and tools for OE (Ontology Evaluation). To test the MRO, the authors adopted the methodology of verification and confirmation using quantitative and qualitative methods and evolution tools. Onto-Metric tool for metric-based evaluation and OOPs tool used for criteria-based evaluation. For application-based evaluation, a Query-Onto tool is made to perform skill queries, search concepts, and visualize ontology. Many metrics are analyzed in the conclusion. ONTOCOM is used to estimate the MRO range.

K.Deeba, and RA.K. Saravanaguru [4] suggested an agent-based architecture for IoT services. By using agent-based architecture, the essayist defined a data representation in the form of text and image that enables the sensors to present the information with resources that are needed to activate the resources to interact with agents. The essayist wrote the researcher's detailed associated work and also described it in a table. They used an agent to share the agent of the information type with applications to store all the information in the cloud. The essayist argues that IoT offers a lot of sensor information, nevertheless, information itself does not give value until we can transform it into implementable or intellectually, contextually relevant information.

Junping Wang and others [5] claimed in their paper that agent-based hybrid service delivery is defined as a novel platform that allows IoT and third-party service providers to coexist with multiple services. This article solves the dispatch and transformation of event messages among hybrid service visibility and container enablers of service. More importantly, in the assessment with the smart framework, whole collaboration outcomes among IoT infrastructure support services as well as third-party service providers were analyzed. The results of the analysis revealed that the system's architecture helps third-party service providers to efficiently set up, run, organize, and supervise various IoT services effectively.

Altti Ilari Maarala et.al [6] studied best practices to provide semantic and reasonable insights with familiar Web standards and context-aware IoT methods. The authors focused on awareness distribution and integration that is offering and obtaining awareness on the Internet of Things. Various mechanisms such as data reasoning, aggregation, and data provisioning have been analyzed and also carefully compared with chosen RDF metadata, illustrating scalability in terms of integrated IoT devices and volume size and this is the main contribution of the authors. Findings confirm that IOT-adaptable Semantic Web techniques and standards. Such techniques facilitate interoperability but also implement well to relatively close reasoning in data and IoT ecosystems. RDF offers tools to clarify and combine existing semantic data on the IoT ecosystem. RDF allows to describe of data meaning and combining the above distributed semantic data. It also allows RDF model inference and gives reasoning actionable insights. OWL Ontologies as well as directive reasoning offer promising directions to RDF data reasoning in various contexts, integrating knowledge from various ways of knowing. Existing logic engines could be used to rationalize RDF data and OWL-ontology on IoT applications.

Claudio Savaglio et al [7] aimed to demonstrate how ABC, i.e. agent-based computing, was effectively used to model, program, and simulate IoT systems. Indeed, to systematically conceptualize, realize and model distributed systems consisting of diverse interacting entities, the ABC offers concepts, metaphors, strategies, methods, and instruments. The authors, therefore, have, first of all, some observations directly based on ABC's key IoT creation problems and distinctive features. They reviewed many contributions for designing, computing, and simulation purposes that leverage ABC in the sense of IoT. In short, in this survey, the researchers wanted to note that it is important to carefully analyze the acceptance of the ABC model, however, as demonstrated by the many contributions provided in this report, it represents the most acceptable choices to date for the successful development of the majority of evolved (current and future) IoT systems.

Claudio Savaglio and others [8] in their article mainly discussed the well-ordered transformation which can be guided by the full realization of the goal of the IoT seem to be at its dawn. While emerging IoT technologies and sensors have already been established, intra-networks of things also

result in poorly interoperable ones. An Agent-based Cooperating Smart Object-based approach and programming model proposed in this article are effective determinations to provide meaningful interoperability at one of the various phases, such as devices, networks, middleware, services, and data, and to allow autonomous and cognitive management mechanisms to support the integration phase of the IoTs system under the guidance of a developed IoT platform ACOSO is currently being re-engineered to enable smart object virtualization by using edge- and cloud-based infrastructures. It is necessary to follow its further extension to the Internet of Vehicles.

Teemu Leppanen et.al [9] described that a remote crowdsensing service, supported by an agent-based smart object that includes agents at edges and devices, provides the creation process and system architecture. A mobile crowdsensing smart object was studied, developed, and implemented as an IoT edge framework by the researchers. By following the guidance given by the agent-oriented IoT creation approach (Agent-based Cooperating smart object ACOSO-Meth) as well as the resource-oriented architecture (ROA) concepts, researchers addressed the methodology and interoperability challenges. They used the RO agent framework to build the agent-based SO, where the functionality is spread through edge devices as a multi-agent system (MAS). They presented the crowdsensing SO operation as a MAS in the remainder of the paper, described how Crowdsensing SO is built appropriately by using ACOSO-Meth agent-oriented method and the ROA resource-oriented paradigm and also discussed the approach's implications.

Yehia Kotb et.al [10] presented a workflow network-based structure for coordination between agents to permit coordination between computing tools in the fog and make a cooperative IoT service delivery system. In this article, the Petri net-based cooperative architecture for fog-based IoT systems has been proposed. The framework presented an algorithm to produce workflows that are based on the comparabilities between the agent abilities of IoT devices belonging to various processing sites in the fog. The workflow network-based agent cooperation architecture in this article enables collaboration between computing devices in the fog and forms a cooperative IoT service delivery system. In order to boost mission fulfillment, the authors tackled the problem of multi-fog IoT agent cooperation. To notice the topology and framework of the resulting cooperative set of computational agents in fog, a cooperation operator is used. In order to offer a method for resolving the enhancement issue mathematically, the operator translates the issue defined as a series of workflow networks into mathematical representations. Many open fields of study remain to be explored. The cooperative capacity of numerous fog computing sites is a key problem arising from cooperation and resource sharing. Since fog computing sites can be owned by multiple network providers, unless certain types of rewards and profit sharing are guaranteed, fog computing devices and IoT tools may not cooperate. Security and privacy are another issue that can arise from collaboration.

Table 1. Parametric Based Comprison

Parameters	References									
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Modularity	✓	-	-	✓	-	-	✓	-	-	-
Scalability	✓	-	✓	-	✓	-	✓	✓	-	✓
Reusability	✓	-	-	-	-	-	-	-	-	-
Maintainability	✓	-	-	-	-	-	-	-	-	-
Availability	✓	-	-	-	✓	-	-	-	-	✓

III. CRITICAL ANALYSIS

This section indicates the critical analysis of the previous studies, that is described in a tabular form as shown in **Table 2.**

Table 2. Summarized Related Work

No	Study	Year	Proposed Work	Semantic Based	Type of Paper
[1]	Moeiz Miraoui and Sherif Eletriby	2016	Multi-agent architecture and ontology based modeling method have been proposed.	Yes	Journal
[2]	Bemir et al.	2020	A systematic literature review approach in which attaching semantic annotations to sensor data, standards, current models, and IoT trend domains that use semantics were all examined.	Yes	Literature review
[3]	JunPing Wang et al.	2013	A hybrid service architecture is proposed which allow third-party service provider to effectively develop, distribute, lunch, orchestrate, and control running instances of internet of thing services.	Yes	Journal
[4]	Sanju Mishra and Sarika Jain	2020	Many tools, Approaches and aspects for ontology evaluation was discussed. Main focus was on MRO for that purpose verifications and validations approaches have been followed.	Yes	Journal
[5]	Altti Ilari Maarala et.al	2016	Semantic reasoning system working in real IOT environment was developed by using modern semantic reasoning techniques.Scalability and capability is evaluated.	Yes	Journal

Table 2. Summarized Related Work

No	Study	Year	Proposed Work	Semantic Based	Type of Paper
[6]	K.Deeba, and RA.K. Saravanaguru	2019	Agent based architecture is proposed for IOT services which characterized data representation. .	Yes	-
[7]	Claudio Savaglio et al.	2017	many important contribution in this direction have surveyed and reported in this paper.	Yes	Survey
[8]	Claudio Savaglio et al.	2016	this paper discusses an agent-based approach that can facilitate the creation of interoperable, autonomic, and cognitive IoT systems, both "in the small" and "in the large" (MAS).	Yes	-
[9]	Teemu Leppanen et al.	2018	The implementation phase of a mobile crowdsensing service, given by the agent based smart object that comprised of agents in both edge and user devices are defined	Yes	-
[10]	Yehia Kotb et al.	2019	Petri net-based architecture is proposed for the fog-based internet of thing (IoT) services.	Yes	-

IV. CONCLUSION

IoT's main aim is to connect devices and collect data through them in order to construct situational awareness. It enable the humans and machines to understand the context or current situation properly and allow them for better decision making as well as responding. In this paper, we have studied the best practices for agent based context awareness platform for IoT and surveyed the ten recent research paper. In these papers researcher made a good effort. They have done a lot of agent-based work, some of them adopted other's techniques and rest have proposed their own methodology. We have highlighted the work of these researchers in our Literature Review. And also made a critical analysis on their proposed work. We have compared the parameter of these papers as shown in Table 1. Although, we choosed mostly semantic based papers so each of them have discussed or mentioned the one or more semantic technology.

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