지능형 IoT 에 대한 조사 - Cognitive Computing Frameworks, 트렌드 이슈

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A Survey on Smart Internet of Things – Trend Issues, Cognitive Computing Frameworks

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요 약

From the last past decade, the Internet of Thing (IoT) area has attracted a lot of attention from researchers. It is said to be a promising technology with great impact in people life, since it redefines the relationship objects have with Human and between themselves. It allows objects to gather data from the real world and communicate with others through the internet. This enabled many opportunities for service providers, companies, factories, environmental monitoring, healthcare, smart cities, and soon. Therefore, today, IoT is densely used in various domains of life, and knows an exponential growth. However, although many advancements have been achieved, several challenges keep causing issues and still need to be overcome. This paper gives an overview on the current trend issues in IoT on which researchers are focusing. It's also explores different proposed frameworks to allow the application of cognitive computing as an integrated process of an Internet of things (IoT) systems, to bring a great advanced in the way machine may communicate with human and their surroundings. This is known as cognitive IoT (CIoT), which allows machines to produce a human-like behavior, then providing enhanced level of capabilities to IoT.

I. INTRODUCTION

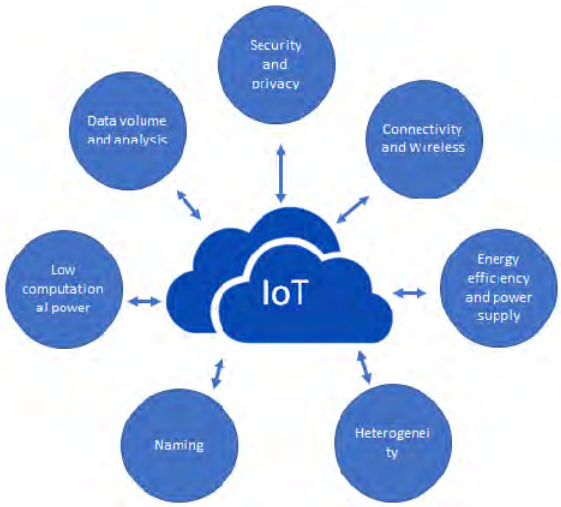
Nowadays a constant growing number of interconnected objects through internet is becoming omnipresent in our daily life, leading to the Internet of Things (IoT). Also, the quantity of data generated by those objects and the rate at which they produce them are becoming more and massive, to the point that classical big data analysis methods are becoming inefficient to digest such a huge amount of data. Another aspect is that they are still tightly human dependent for decision making.

The use of cognitive computing with IoT, known as Cognitive Internet of things (CIoT) is seen as a major enhancement for researches about IoT. It is a new paradigm which empowers IoT with a level of intelligence [1]. This has indeed brought considerable advancements in the way smart objects perceive their environment, as it allows to insufflate intelligence into objects which can afterwards interactively learn from the external world and make related decisions.

To date, in attempt to find solutions to issues observed either in traditional IoT and enable his values, considerable advancements have been achieved by researchers. Cognitive computing seems to be among the most prominent [1] [2]. This paper gives an overview study of the state of

art cognitive computing techniques used in IoT and provides insights on a possible architecture for "Intelligent" IoT. Therefore, the next parts of this paper present the current issues observed in IoT. And overlook on cognitive computing solutions currently proposed in that area.

II. IoT Trends Issues and challenges



(Fig 1) Overview of IoT trends issues and challenges

IoT is in an intensively growing expansion. Although it is actually attracting tons of researchers' interest, considerable advancements still need to be achieved for a full integration of IoT in our daily life. Indeed, the challenges that has to be overcome by researchers in IoT are numerous. [3][8] Depicted fairly well the current (i.e Fig 1) that we may summarize as follow:

- **Security and privacy:** It has received a significant attention from researches dealing with that aspect of IoT. IoT network should offer mechanisms to protect user privacy, detect and prevent threats. [8] Also showed that device limitations have an impact on security whom researchers need to be aware when design security solutions for IoT.
- **Connectivity and Wireless:** The heterogeneity of connected devices over internet implies that IoT needs to deal with of hardware architectures and new wireless connectivity standards.
- **Energy efficiency and power supply:** Many IoT devices run on battery and need to do so on an extended period, several years. Therefore, efficient power consumption and supply are required.
- **Heterogeneity:** The interest in IoT resulted of in the development of various IoT architecture, applications and standards whom we need to accommodate for intercommunication. [9]
- **Data volume and analysis:** Sensing the external world, IoT networks generate massive quantity of data. Classic Big data requires many operational mechanism in addition to new technologies for storing, processing and management of data. One challenge of IoT is to extract valuable information from such vast amount of data.
- **Naming:** up to 50 billion of objects are intended to be connected to internet by 2020. Therefore, each object will need to be uniquely identified over the overall internet. New translation and addressing schemes are required to catch with IoT growth.
- **Low Computational power:** IoT enabling devices, such as sensors and actuators are small devices with limited computing capability and storage.
- **DDos Attack:** [5] showed in his work that there is an increasing fear of vulnerability of IoT devices. The fact that billions of devices are connected to internet is providing the opportunity for massive distributed denial of service attacks, thus increasing their threats. On October 2016, online services like twitter, Netflix, Paypal were victims of such attacks [5].

III.Cognitive Computing Frameworks in IoT

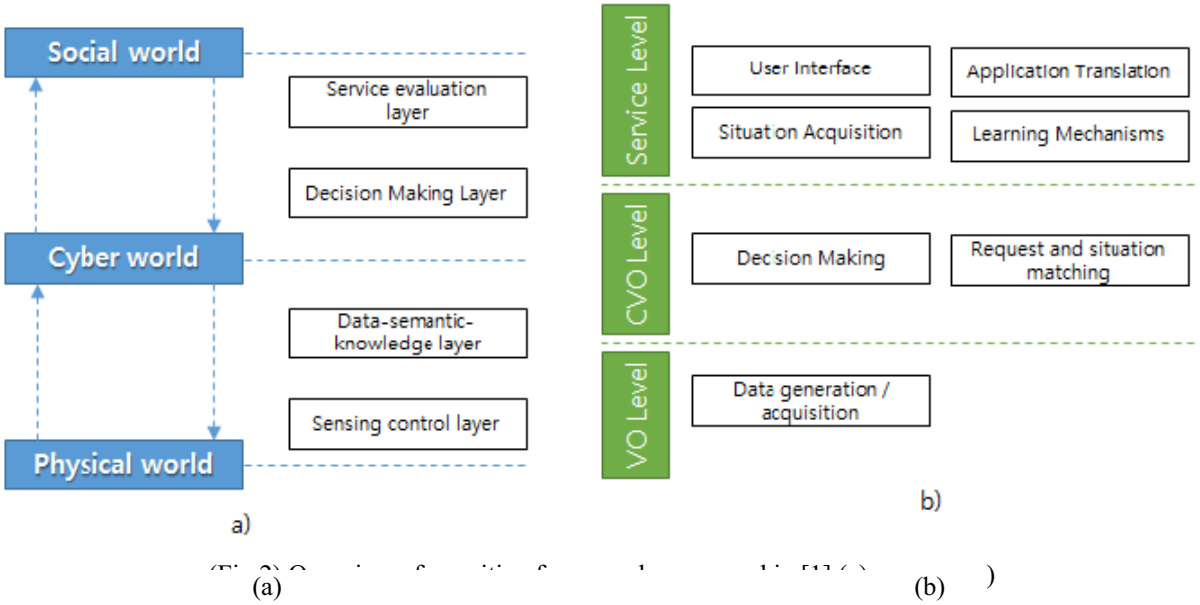
Cognitive IoT recently attracted a lot of attention from researchers. It has indeed unlocked possibilities in what can be done with sensors network [5]. Several approaches have been proposed to improve specifics part of IoT ecosystems.

In [1] authors designed an optional general-purpose framework for cognitive IoT to bridge physical and social world. They framework is intended to characterize perception-action cycle, massive data analytics, semantic derivation and knowledge discovery, intelligent decision making, and on-demand service provisioning cognitive

tasks (Fig 2a). It is divided into four layers, Service evaluation layer, decision making layer, data-semantic knowledge layer and sensing control layer. They explained the cognitive model with mathematical formula beyond the scope of this paper. The proposed solution focused on profit gained using the framework, in term of quality of data, quality of information and quality of experience, but also on the cost needed to integrate such model. However, this faces several challenges like being apply in real field, the largely scalable, to assure a good quality of service, and so on.

[4] Tried to address the problem of heterogeneous underlying network in IoT. They proposed a cognitive management framework for enabling autonomous applications in the IoT. It is able to dynamically select the appropriate behavior through self-management functionality in a context-aware fashion. It was intended to enhance reliability, context/situational-awareness and energy-efficiency of IoT applications. It leveraged object virtualization concept used for microservices implementation, on which it based its architecture built on three functionality levels: Service level, composite virtual objects (CVO), and virtual objects (VO) (Fig 2b). It is characterized by the fact that each level holds entities in charge of the self-configuration, self-optimization and self-healing, and learning. The framework proposes a set of three operation: Dynamic CVO creation, knowledge-based CVO instantiation, and CVO self-healing. It also provided reuse of object across various domains and showed that the decision time remains relatively constant while managed objects increased. Although this seems to work, authors specified that "composing the best solution for handling some situation and in a real-time fashion" is the principal challenge of that solution.

Authors of [6] proposed a context-aware cognitive management framework for fog computing applied in traffic control system. It leverages capabilities of cognitive computing, context-aware IoT and fog computing. The proposed solution consists of two layers: (1) Data Semantic Knowledge and Analysis layer on the cloud, which learns from the managed entities. (2) And Management Layer, on the Fog whose role consists in managing the fog instances. This is a centralized learning with decentralized decision-making approach, as the essential of training and learning tasks is made by the first layer, data semantic layer, while the second layer essentially collects data and decides how to act using the knowledge gained by the Data Semantic Knowledge and Analysis layer. This framework is meant to support real-time service and low-latency devices.



(a) (b)

Apart from the previous ones, other authors proposed different solution to leverage cognitive computing for IoT systems. For this purpose, [7][10] proposed a solution based on cognitive radio networks (CRNs) to address respectively spectrum-related issues and power consumption issues.

CONCLUSION

In this paper, we tried to investigate on the actual state of main issues currently observed in IoT. We showed that although researchers have put great efforts to address some problems, the way is still long. Many advancements in security, power supply, interconnecting is in progress and still required improvements. We also discussed of cognitive computing solutions proposed to address IoT challenge by offering architectural and management frameworks to integrate cognitive tasks in an IoT environment, and deal with concepts such as heterogeneity, real-time, low latency and data analysis. As we have seen, there is not a standard architecture adopted for cognitive computing yet and the proposed ones mainly focus on specific aspect of the IoT system.

This paper only focuses on three proposed frameworks for cognitive IoT and keeps an overview on the proposed solutions. Further investigations may be carried on the applications and efficiency of such architecture in a real field.

ACKNOWLEDGEMENT

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