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Editorial

Analyzing and visual programming internet of things and autonomous decentralized systems

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ABSTRACT

The development of Internet of Things, fueled by cloud computing and big data processing from upper level, and by ubiquitous sensory and actuator devices from the lower level, has taken a sharp turn towards integrating the entire information, computing, communication, and control systems. This special issue selected seven papers from the 2015 IEEE twelfth International Symposium on Autonomous Decentralized Systems (ISADS). These papers cover the latest research on IoT and ADS based system science and system engineering methods; the wearable sensor network development and applications; and data analysis for security and reliability in IoT and ADS applications. As an addition to these selected topics, this guest editorial paper also adds IoT education and dissemination aspects to this special issue. As the IoT research and applications expand explosively into all the domains, schools and universities must prepare students to understand and to be able to program the IoT devices. This paper presents a visual programming environment that allows students without programming background to learn the key concepts of computing and IoT devices, and to program IoT devices into different application systems.

1. Introduction

The development of Internet and cloud computing has pushed the desktop-based computing platform into an internet and Web-based computing infrastructure. It has changed the concept of physical products or things into services. The endorsement and commitment to building and utilizing cloud computing environments as the integrated computing and communication infrastructure by many governments and major computing corporations around the world have led the rapid development of many commercial and mission-critical applications in the new infrastructure, including the integration of physical devices, which gives Internet of Things the unlimited computing capacity.

Internet of Things (IoT) was initially proposed and applied in the Radio-Frequency Identification RFID-tags to mark the Electronic Product Code (Auto-ID Lab) [1]. IoT concept is extended to refer to the world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business processes [2]. Internet of Intelligent Things (IoIT) deals with intelligent devices that have adequate computing capacity. Distributed intelligence is a part of the IoIT [3]. According Intel's report, there are 15 billion devices are connected to the Internet, in which 4 billon devices include 32-bit processing power, and 1 billon devices are intelligent systems [4].

A wireless sensor network (WSN) is spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location [5]. The combination of WSN with IoT enables WSN to the resources on Internet, particularly the cloud computing and big data analysis capacity, which enormously enlarges the capacity of WSN in today's applications.

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In addition to IoT and wireless sensor networks, a number of related concepts and systems have been proposed to take the advantage of Internet and cloud computing.

An autonomous decentralized system (ADS) is a distributed system composed of modules or components that are designed to operate independently but are capable of interacting with each other to meet the overall goal of the system. ADS components are designed to operate in a loosely coupled manner and data are shared through a content-oriented protocol. This design paradigm enables the system to continue to function in the event of component failures. It also enables maintenance and repair to be carried out while the system remains operational. ADS and the related technologies have a large number of applications in industrial production lines, railway signaling and robotics [6,7]. ADS concepts are the foundation of the later technologies such as cloud computing and Internet of Things.

A cyber-physical system (CPS) is a combination of a large computational and communication core and physical elements that can interact with the physical world [8,9,10]. CPS can be considered the extended and decentralized version of embedded systems. In CPS, the computational and communication core and the physical elements are tightly coupled and coordinated to fulfill a coherent mission. The U.S. NSF (National Science Foundation) issued a program solicitation in 2008 on CPS, envisioning that the cyber-physical systems of tomorrow would far exceed those of today in terms of adaptability, autonomy, efficiency, functionality, reliability, safety, and usability. Research advances in cyber-physical systems promise to transform our world with systems that respond more quickly (e.g., autonomous collision avoidance), are more precise (e.g., robotic surgery and nano-tolerance manufacturing), work in dangerous or inaccessible environments (e.g., autonomous systems for search and rescue, firefighting, and exploration), provide large-scale, distributed coordination (e.g., automated traffic control), are highly efficient (e.g., zero-net energy buildings), augment human capabilities, and enhance societal wellbeing (e.g., assistive technologies and ubiquitous healthcare monitoring and delivery) [11].

Kakuda presented the concepts, technologies, and case studies of the next generation of assurance networks [12]. The study made use of the available redundant computing and communication resources for dependability purposes. The paper laid out the roadmap to the design and implementation of the new generation assurance networks. These networks inherit different features from a number of systems, including cyber-physical system, scalability and service orientation from cloud computing, the adaptability and autonomy from autonomous decentralized systems [6], fault tolerance and real-time computing from the responsive systems [13], and distributed real-time and embedded (DRE) systems. DRE systems are based on a model driven architecture and model integrated computing [14] and are applied in the situation where application requirements and environmental conditions may not be known *a priori* or may vary at run-time, mandate an adaptive approach to management of quality-of-service (QoS) to meet key constraints such as end-to-end timeliness. Different DRE middleware systems have been developed by the members of the Distributed Object Computing (DOC) Group, which is a consortium consisting of universities and industry partners [15]. The new generation assurance networks also include many other common features such as trustworthiness and mobility [16,17]. Scheduling tasks and allocating resources in such environments require new strategies and techniques. The gang scheduling and real-time scheduling techniques in ad hoc distributed systems and on the elastic cloud environment ensure that related tasks are scheduled in groups and are running simultaneously [18,19,20], which can be used to coordinate the intelligent devices.

Robot as a Service (RaaS) is a cloud computing unit that facilitates the seamless integration of robot and embedded devices into Web and cloud computing environment [3,21]. In terms of service-oriented architecture (SOA), a RaaS unit includes services for performing functionality, a service directory for discovery, and service clients for user's direct access [22]. The current RaaS implementation facilitates SOAP and RESTful communications between RaaS units and the other cloud computing units. Hardware support and standards are available to support RaaS implementation. For example, Devices Profile for Web Services (DPWS) defines implementation constraints to enable secure Web Service messaging, discovery, description, and eventing on resource-constrained devices between Web services and devices. The recent Intel IoT-enabled architecture, such as Galileo and Edison, made it easy to program these devices as Web services. From different perspectives, An RaaS unit can be considered a unit of Internet of Things (IoT), Internet of Intelligent Things (IoIT) that have adequate computing capacity to perform complex computations [3], a Cyber-physical system (CPS) that is a combination of a large computational and communication core and physical elements that can interact with the physical world [4], and an Autonomous decentralized system (ADS).

This special issue selected seven papers from the IEEE twelfth International Symposium on Autonomous Decentralized Systems (http://isads2015.asia.edu.tw/). These papers cover the latest studies on IoT and ADS based system science and system engineering methods in natural disaster resilience; the wearable sensor networks development and applications; and data analysis for security and reliability in IoT and ADS applications, including forensics analysis and aviation data processing.

As the IoT research and applications expand explosively into all the domains in computing, information, and control systems, schools and universities must prepare students to understand and to be able to program the IoT devices [23]. As an extension to the domains covered by the selected papers, this paper presents a visual programming environment that allows novice developers to learn the key features IoT devices and to program IoT devices without dealing with the low level technique details. It uses the concepts of IoT as a Service and workflow integration to address the programming issues of all the aforementioned systems that are connected to the Internet and can be accessed through Internet. This programming environment is particularly useful for in IoT and programming education.

There are a number of great visual programming environments for computer science education. MIT App Inventor [24] uses drag-and-drop style puzzles to construct phone applications in Android platform. Carnegie Mellon's Alice is a