

REVIEW

Convergence of Internet of things and mobile cloud computing

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As an integral element of future Internet, Internet of things (IoT) could be described as a real-world interaction with everything connected via intelligent network infrastructure and advanced communication technologies. Mobile cloud computing (MCC), on the other hand, offers an infrastructure wherein both data storage and data processing take place outside of the mobile device. As a more mature infrastructure, MCC offers several advantages, while the relatively new IoT has several limitations. In this paper, we present a survey of IoT limitations and MCC advantages. Specifically, we present the most advantageous aspects of MCC and how they alleviate the limitations of IoT. Furthermore, we discuss several IoT-enabled business services to highlight the benefits of converging IoT and MCC.

Keywords: information science; Internet of things; mobile cloud computing; systems engineering

1. Introduction

Internet of things (IoT) is the main technological revolution in computing, information and communication systems, describing a world of networked, digital elements where everything is interconnected. Specifically, IoT consists of diverse, interconnected information and communications technology (ICT) infrastructures, where the Internet, services and things play a key role in the control and automation processes (Atzori, Iera, & Morabito, 2010; Directorate-General for Communications Networks, 2013; Gubbi, Buyya, Marusic, & Palaniswami, 2013; ITU Internet Reports, 2005; Sundmaecker, Guillemin, Friess, & Woelfflé, 2010).

IoT could be defined as ‘a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual “things” have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network’. (European Research Cluster on the Internet of Things)

IoT constitutes an integral part of future Internet, which has several limitations as a relatively new technology. On the other hand, cloud computing (CC) and MCC, which involves mobile devices, is a more mature technology offering several advantages. It is clear that the convergence of IoT and MCC has great potential for success; therefore, this paper aims to present a survey of IoT limitations and MCC advantages. An emphasis is placed on presenting the most advantageous aspects of MCC and how they ameliorate the major limitations of IoT.

The remainder of the paper is organized as follows. In Section 2, we analyze the current limitations of the technologies provisioning the IoT, while Section 3 presents the contribution of several enhancements of MCC. Section 4 presents the specific contributions of MCC regarding the underlying IoT limitations, while Section 5 analyzes the benefits of the convergence of IoT and MCC and presents a survey of IoT-enabled business services. Finally, Section 6 includes discussions regarding our conclusions and future work.

2. Current limitations of the technologies provisioning the IoT

The idea of connecting things to the Internet has existed since its inception. This goal of global connection is not limited to specific digital devices or equipment. The Internet connects all objects and devices, which is the so-called IoT (Akyildiz, Brunetti, & Blázquez, 2008; Balasubramaniam & Kangasharju, 2013; Domingo, 2012a, 2012b; ITU-T Technology Watch Report, 2008).

In general, IoT requires sufficient support for ubiquitous communications and access to services and information. IoT enables humans and things to be connected anytime/anyplace, with anything/anyone, using any network and any service/application. Hence, IoT promises open access and control of the physical objects of the world through the Internet (Gorlatova et al., 2010; Jara et al., 2014; Jara, Zamora, & Gómez-Skarmeta, 2012; Lara, Lizcano, Martínez, & Pazos, 2013).

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By definition, IoT elements communicate directly without any human interaction, thus conserving energy that would have been consumed accomplishing a task. Therefore, the notion of Green IoT has emerged. Green IoT goals are twofold: to minimize the negative environmental impact of ICT and to use ICT to solve critical environmental issues. In correspondence with Green information technology (IT) to minimize the negative environmental impact of IT use, Green IoT aims to save information and communication energy, respectively (Atzori et al., 2010; Directorate-General for Communications Networks, 2013; Gubbi et al., 2013; Murugesan, 2008; Murugesan & Gangadharan, 2012; Sundmaeker et al., 2010).

In this context, Green IoT applications are linked with Green ICT (Murugesan, 2008; Murugesan & Gangadharan, 2012), which is defined as ‘*the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems, such as monitors, printers, storage devices, and networking and communications systems, efficiently and effectively with minimal or no impact on the environment*’. (Murugesan, 2008)

Please note that, based on current technology status, we indicate the major limitations of state-of-the-art technologies to support IoT deployment. The limitations of the technologies provisioning IoT are described below.

2.1. Architecture technology

IoT requires flexible architecture to maximize interactivity among heterogeneous distributed systems with various resources for providers of services and consumers of information, such as humans or connected objects or equipment. The distributed open architecture for feasible IoT should support interoperability of various systems, digital identification (ID) of multi-modal data decentralized flexible architecture, scalability, extensibility and interactivity among things, and things and humans (Nguyen, Tran, & Hluchý, 2013). Moreover, a special requirement of IoT flexible architecture includes providing effective routing/caching and synchronization for multiple multi-modal data in order to demonstrate several applications and services of things that currently lack reliable connectivity (Directorate-General for Communications Networks, 2013; ITU Internet Reports, 2005; ITU-T Technology Watch Report, 2008; Sundmaeker et al., 2010).

2.2. Ubiquitous communication and network technology

Multiple connected devices are pushing current communication technologies to their boundaries. Hence, IoT requires new technological investigations, such as ubiquitous communication, to support interactions between things and the Internet, between things with different connectivity, and between things and humans. Specifically, IoT requires advanced network management and ubiquitous

communication technologies to accommodate heterogeneous software-middleware and hardware devices that are simultaneously connected. It should be noted that network and ubiquitous communications technologies operations management include design, performance, privacy, security and reliability. In general, IoT network and communication technologies are required to be highly available bidirectional communication between real-world objects. It is expected that the potential number of objects to be connected to the Internet rises to 100,000 billion! (Castillo-Secilla, Aranda, Outeiriño, & Olivares, 2010; Directorate-General for Communications Networks, 2013; European Commission, 2013; Luo, Lu, & Cheng, 2013; Sundmaeker et al., 2010).

2.3. Data storage/caching and signal-processing technology

Regarding IoT devices, embedded computers and networks will monitor and control the physical processes of the web-enabled “things”. Therefore, the data that are generated from various IoT devices will grow enormously and will demand more effective data storage, caching, and generally management of the so-called big data (Slota, Nikolow, Skalkowski, & Kitowski, 2012; Zaslavsky, Perera, & Georgakopoulos, 2013). Hence, the convergence of computing, networked devices and the Internet requires new research that addresses data- and signal-processing technology. The most important challenge refers to data sharing, propagation and collaboration that have not been adequately investigated. IoT will support interactions among numerous heterogeneous sources of data and several heterogeneous devices through the use of standard interfaces and data models to ensure a high degree of interoperability among dissimilar systems (Directorate-General for Communications Networks, 2013; ITU Internet Reports, 2005; ITU-T Technology Watch Report, 2008; Sundmaeker et al., 2010).

2.4. Hardware technology

IoT requires the adaption of novel hardware technologies to allow communication between things and the Internet. Specifically in-depth investigation is required in the area of very large scale integrated circuits containing scalable hardware systems that vary the topology mapped on the chip using advanced algorithms. Moreover, research on nano-electronics devices is emphasized on miniaturization, low-cost and increased functionality in design of scalable hardware systems for IoT deployment. This implies that no conventional hardware platform will be sufficient to support the whole design space. Complex and scalable hardware systems will be a regular requirement for efficient IoT development (Directorate-General for Communications Networks, 2013; ITU Internet Reports, 2005; ITU-T Technology Watch Report, 2008; Jara et al., 2014; Lara et al., 2013; Luo et al., 2013; Sundmaeker et al., 2010).

2.5. ID technology

Everything that is part of the IoT has a digital name that is described by unique identifiers, and the interaction among those things is specified by a digital unique identity (DUID). By assigning each thing participating in the IoT a DUID, or DUIDs, it is possible to refer to each thing as an individual with its own characteristics, requirements and information trail, its own flow pattern through the real world and its own sequence of interactions with other things. The most important challenge refers to creating global ID schemes (Batalla & Krawiec, 2014). Furthermore, it is important that identifiers are not constrained by current choices of technology for storing and communicating DUIDs or their current limitations, since we should expect that the data carrier technology will evolve over time and current limitations, such as those on memory capacity available for identifiers, will become more convenient (Akyildiz & Jornet, 2010; Castillo-Secilla et al., 2010; Directorate-General for Communications Networks, 2013; ITU-T Technology Watch Report, 2008; Sundmaeker et al., 2010).

2.6. Power and energy storage technologies

Power and energy storage technologies are the primary contributors to the deployment of IoT. Specifically, power and energy storage technologies are key enablers of IoT's energy efficient applications and services. To meet IoT green application and service power requirements, the typical energy generation units consist of two categories: the harvester and the energy storage. Energy storage, from harvesting to conservation and usage, are fundamental to the development of the green IoT. It should be noted that the most essential energy harvesting technologies for IoT storage devices are solar energy and piezoelectric harvesting. Current limitations require in-depth investigation into nano-electronics and micro-systems integration to fulfill the main goal of ultra-low power devices for energy efficient storage technologies (Castillo-Secilla et al., 2010; Directorate-General for Communications Networks, 2013; ITU Internet Reports, 2005; ITU-T Technology Watch Report, 2008; Sundmaeker et al., 2010).

2.7. Security and privacy technologies

The key issues in IoT are privacy and confidentiality of industry processes. For confidentiality, various valid encryption technologies exist, and one of the goals is to make encryption techniques more energy efficient. Regarding privacy, the situation is more crucial due to public unawareness. Therefore, additional research in the field of service-oriented architecture is needed to support dynamically changing environments with a high degree of security and privacy (Akyildiz & Jornet, 2010; Alcaraz, Roman, Najera, & Lopez, 2013; Directorate-General for Communications Networks, 2013; ITU-T Technology Watch Report, 2008; Sundmaeker et al., 2010).

2.8. Software technology and algorithms

One of the main challenges in implementing IoT applications and services is the lack of a widely accepted software technology. Orchestrating the software in heterogeneous distributed systems to function in a complex system is not an easy task. IoT requires a high-performance database software-platform that enables the management and utilization of huge amounts of data for interaction between things, and between things and humans with different connectivity. Such a technology solution should take into account different parameters, such as massive-distributed networks, embedded software platforms that use advanced-dedicated algorithms and development of novel models of interactions (Directorate-General for Communications Networks, 2013; ITU-T Technology Watch Report, 2008; Luo et al., 2013; Sundmaeker et al., 2010).

3. Advantages of MCC

3.1. Cloud computing

CC constitutes a very active research area since it offers many advantages; however, it has limitations as well. Most of the advantages are referenced in the National Institutes of Standards and Technology definition of CC itself (Mell & Grance, 2011):

“CC is a model for enabling ubiquitous, convenient, on demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.”

Following are the five main characteristics (Mell & Grance, 2011; Sasikalam, 2011) that offer the greatest advantages:

- *On-demand self-service*: resources are automatically provisioned without the need for human interaction.
- *Broad-network access*: access to services is provided to heterogeneous thin or thick platforms.
- *Resource pooling*: the provider's physical and virtual resources, such as storage, processing, memory, network bandwidth and virtual machines, are pooled to satisfy the demands of multiple customers.
- *Rapid elasticity*: services can be provisioned to customers both rapidly and elastically.
- *Measured service*: the various cloud services, such as storage, processing, bandwidth and active user accounts, can be measured, controlled, optimized and charged/paid on a per-use basis.

3.2. Mobile cloud computing

The advantages of CC are extended and enhanced by the appearance of MCC (Abunaser & Alshattawi, 2013; Xinogalos, Psannis, & Sifaleras, 2012). MCC is simply CC wherein some of the devices are mobile; however, these mobile devices are not bound to have advanced features

Table 1. Architectural model of MCC.

Layer	Description
Software as a Service (SaaS)	Clients run applications on a cloud infrastructure
Platform as a Service (PaaS)	An integrated environment for building, testing and deploying custom applications is offered to clients
Infrastructure as a Service (IaaS)	Provision of hardware, servers, data storage and networking components to clients
Data centers	Servers linked with high-speed networks, located in places with high-power stability and low-disaster risk

because complex data processing and complex computing take place in the cloud. As follows, the most important advantages of MCC are analyzed and described.

3.2.1. Flexible and efficient architecture

MCC takes advantage of the flexible and efficient (i.e. fulfilling users' requirements for services) architectural model that is comprising four layers (Dinh, Lee, Niyato, & Wang, 2013), as presented in Table 1. All the services offered by this architecture are measured and paid/charged according to their usage (Mell & Grance, 2011).

3.2.2. Unlimited data storage capacity

MCC offers data storage capabilities on the cloud through wireless networks, providing a solution to a major restriction of mobile devices (Dinh et al., 2013). The storage capacity is unlimited, while dynamic provisioning allows for dynamic allocation and de-allocation of data storage capacity (Dinh et al., 2013).

3.2.3. Data processing (data and signal processing)

In MCC, both data storage and processing take place on the cloud. Moving computing power, data storage and data processing outside of the mobile device enable the user to utilize a variety of underlying services (Dinh et al., 2013). Nowadays, modern 4G long-term evolution wireless networks are capable of transferring large amounts of data from the mobile device to the cloud and vice versa with high-speed connectivity (Amin, Iraj, & Nurminen, 2013; Technical Specification Group Radio Access Network, 2012).

3.2.4. Hardware and processing power

CC offers the necessary hardware resources, usually comprising server, storage and network components, for supporting cloud services (Mell & Grance, 2011). Moreover, a major limitation of mobile devices that refers to running energy/time consuming and compute-intensive applications is alleviated (Chetan, Kumar, Dinesh, Mathew, & Abhimanyu, 2010; Dinh et al., 2013) by taking advantage of the enhanced processing power infrastructure offered by the cloud.

3.2.5. ID technology

In MCC, the requests of users and information, such as ID and location, are transmitted to central processors of the cloud. The operators of the cloud are able to provide mobile users with services for authentication, authorization and accounting based on the home agent and subscribers' data stored in the cloud's databases. The subscribers' requests that are delivered to the cloud are processed to provide mobile users with the requested services (Dinh et al., 2013).

3.2.6. Security and privacy technology

MCC, as stated by (Zou, Wang, Liu, & Bao, 2010), has the potential to provide a data security model for cloud providers and users. A characteristic example is the potential protection of copyrighted digital contents from unauthorized distribution (Zou et al., 2010). In addition, cloud vendors can offer subscribers various security services and can enhance the effectiveness of such services by taking advantage of the record created from a large number of users (Oberheide, Veeraraghavan, Cooke, Flinn, & Jahanian, 2008). Examples of services are remote virus scanning, detection of malicious code, as well as authentication (Oberheide et al., 2008).

3.2.7. Software installation, update and integration

The cloud vendor is responsible for software installation, update and integration. Software integration of applications and services is accomplished automatically, while customization is simplified. Even software solutions for compatible applications are offered, minimizing the need (and cost) for integration. An example is Google Apps for Business (Google). However, as Dinh et al. (2013) mention, even services from different providers can be easily integrated in order to fulfill the users' requirements.

3.2.8. Quick deployment and scalability

IT solutions for a business – including services, applications and hardware – are quickly deployed, providing the opportunity for a quicker and cheaper start-up. Also, expansion is easier since a business can take advantage of its provider's resources for expanding the services it offers in the case of increased demand (Zhang, Cheng, & Boutaba, 2010). Deployment and scalability also applies to mobile

applications that can be easily scaled to meet users' needs, which cannot be predicted (Dinh et al., 2013).

3.2.9. Simpler backup and recovery

Backup of data is automatically carried out by the cloud provider, while recovery is much easier. Hence, cloud providers have to be especially competent and reliable in this area. Infrastructure providers are much more effective and efficient in managing such business risks as hardware failures (Zhang et al., 2010).

3.2.10. Easy access to applications and data

Access to applications and data is easy without place, time and device restrictions because access to applications and

data is possible from any device connected to the Internet (e.g. smart phones, tablets, laptops and workstations) from anywhere and at any time (Zhang et al., 2010). Moreover, HTML5 provides the technology for off-line MCC applications that enhance the users' experience with applications on mobile devices even when the device is off-line (Xinogalos et al., 2012).

3.2.11. Extending battery lifetime

Battery lifetime is one of the main limitations of mobile devices (Xinogalos et al., 2012). In order to save execution time and power consumption on mobile devices, large computations requiring complex processing can be offloaded to powerful servers in the cloud (Chetan et al., 2010; Dinh et al., 2013).

Table 2. Contributions of MCC to IoT limitations.

IoT limitation	Contribution of MCC
Architecture technology [2.1]	<ul style="list-style-type: none"> MCC takes advantage of a <i>flexible and efficient</i> architectural model that comprises four layers (SaaS, PaaS, IaaS, and data and centers) [3.2.1]
Ubiquitous communication and network technology [2.2]	<ul style="list-style-type: none"> Broad-network access is accomplished Access to services is provided to <i>heterogeneous thin or thick platforms</i> [3.1] Access to applications and data is possible from <i>any device</i> connected to Internet, from <i>anywhere</i> and <i>at any time</i> [3.2.10] MCC offers on-demand self-service: <i>resources are automatically provisioned</i> without the need for human interaction [3.1]
Data storage/caching and signal-processing technology [2.3]	<ul style="list-style-type: none"> In MCC, both data storage and processing take place on the cloud [3.2.3] Moving computing power, data storage and data processing outside of the mobile device enable the opportunity to offer underlying services to a variety of mobile users, not just to smart phone users [3.2.3] HTML 5 provides the ability to use MCC applications even when the device is off-line [3.2.10]
Hardware technology [2.4]	<ul style="list-style-type: none"> Enhanced processing power infrastructure is offered by mobile cloud [3.2.4]
ID technology [2.5]	<ul style="list-style-type: none"> MCC transmits users' requests and information to central processors of the cloud that provide services for authentication, authorization and accounting [3.2.5]
Power and energy storage technologies [2.6]	<ul style="list-style-type: none"> Unlimited storage capacity is provided on request [3.2.12] Enhanced processing power infrastructure is offered by mobile cloud [3.2.4] Large computations requiring complex processing can be offloaded to powerful servers in the cloud, in order to save execution time and power consumption on mobile devices [3.2.11]
Security and privacy technologies [2.7]	<ul style="list-style-type: none"> MCC has the potential to provide a data security model for cloud providers and users, such as protection of copyrighted digital contents from unauthorized distribution [3.2.6] Cloud vendors can offer their subscribers various security services and can enhance the effectiveness of such services by taking advantage of the record created from a large number of users. Examples of services are remote virus scanning, detection of malicious code, as well as authentication [3.2.6]
Software technology and algorithms [2.8]	<ul style="list-style-type: none"> The cloud vendor is responsible for software installation, update and integration [3.2.7] Software integration of applications and services is accomplished automatically, while customization is simplified [3.2.7]

3.2.12. Cost efficient

MCC provides tremendous advantages regarding services costs

- *Software and multiple-user licenses*: cloud services are cheaper and scalable solutions are provided, such as one-time-payment and pay-as-you-go.
- *Installation and update of software and maintenance of servers*: the cloud vendor is responsible for having the applications/services updated and running.
- *Hardware*: servers for software and data storage and backup are provided by the cloud vendor. Unlimited storage capacity is provided upon request.
- *Operating cost*: resources can be allocated and de-allocated on-demand, lowering operating costs (Marston, Li, Bandyopadhyay, Zhang, & Ghalsasi, 2011; Zhang et al., 2010). Dynamic provisioning allows mobile users to run applications without having to reserve the required resources in advance (Dinh et al., 2013).

In conclusion, resources are rented based on the business's need and are paid for in accordance with usage; hence, there is no need for investment to infrastructure (Zhang et al., 2010). In addition, this applies to mobile applications (Dinh et al., 2013).

4. Contribution of MCC to IoT limitations

The advantages of CC and MCC, which comprise a combination of CC and mobile networks, are numerous. These advantages are nicely summarized in the definition provided by Marston et al. (2011) that encompasses both the advantages of CC from a business perspective and an IT perspective:

“It is an information technology service model where computing services (both hardware and software) are delivered on-demand to customers over a network in a self-service fashion, independent of device and location. The resources required to provide the requisite quality-of-service levels are shared, dynamically scalable, rapidly provisioned, virtualized and released with minimal service provider

interaction. Users pay for the service as an operating expense without incurring any significant initial capital expenditure, with the cloud services employing a metering system that divides the computing resource in appropriate blocks.”

We believe that these advantageous features of MCC contribute heavily to the evolution of IoT (Zhou, 2012). In essence, the limitations of IoT could be alleviated by taking advantage of MCC. Moreover, the solutions for issues that have not been adequately confronted in MCC, such as privacy issues and lack of accepted open standards, could be researched in a unified way. The synergy of IoT and MCC could benefit from the following (Table 2).

5. Business opportunities of IoT and MCC

Technological advances have greatly increased the expectations and capabilities of businesses (Ems, 2012). The convergence of IoT and MCC brings new applications as well as innovative business opportunities in the services sector. Several companies in diverse sectors, such as health care or supply chain (Mehrsai, Karimi, & Thoben, 2013), can utilize IoT to increase their revenues and operational efficiencies. Recent surveys on IoT applications have been presented by Atzori et al. (2010) and Miorandi, Sicari, De Pellegrini, & Chlamtac, (2012). As shown in Table 3, there is an indicative list of application domains, for which IoT and MCC can be proved to be valuable business trends.

In the logistics sector, if we consider the vehicles (or pallets) and the packages of products as different ‘things’, then the communication of these ‘things’ regarding their location, dimensions or weights, provide new means for business intelligence. Furthermore, this communication based on radio-frequency identification (RFID) technology enables companies to provide improved parcel-tracking services to customers. A recent work by Wang, Zhu, & Ma (2013) describes a novel approach based on an agent-based hybrid service delivery, that enables third party service providers to efficiently manage IoT services. Another breakthrough idea based on sensor equipment and Internet-connected cars is the Google driveless-car project (Saitoh, Kondoh, & Komatsu, 1989). Moreover, electronic payment

Table 3. Business application domains of convergence of IoT and MCC.

Applications	Business opportunities of convergence of IoT and MCC
Logistics	<ul style="list-style-type: none"> • Optimizing inventory accuracy by using intelligent shelves and RFID technology in products (Hardgrave, Aloysius, & Goyal, 2009)
Transportation	<ul style="list-style-type: none"> • Monitoring traffic congestion using mobile phones in real time, and proposing alternative routes • Reducing the operational cost by using smart commercial trucks that can exchange information about the products (e.g. weight, dimensions)
Manufacturing	<ul style="list-style-type: none"> • Improving production processes by using IoT and MCC technologies (Wang & Xu 2013)
Health care	<ul style="list-style-type: none"> • Providing efficient therapy management by using patient's personal devices and RFID cards (Jara, Zamora, & Skarmeta, 2011)
Emergency management	<ul style="list-style-type: none"> • Developing emergency response operations by utilizing efficient cooperation and accurate locations (Yang, Yang, & Plotnick, 2012)

systems for Android mobile phones that are based on IoT are now on the rise (e.g. train-ticketing application; Nasution, Husni, & Wuryandari, 2012).

An economic perspective of IoT was recently reported by Fleisch (2010), which presented seven value drivers related to cost reduction for businesses and users. Furthermore, the changes delivered by the machine-to-machine (M2M) communication in the market require certain standardization efforts. Therefore, standardization bodies actively participate in the standardization of M2M products and services (Katusic, Weber, Bojic, Jezic, & Kusek, 2012). Although the list is not exhaustive, the convergence of MCC and IoT technologies is shown to avail multiple benefits.

6. Conclusions

IoT constitutes an integral part of future Internet, consisting of both physical and virtual ‘things’, with identities, physical attributes and virtual personalities. These things can be characterized as autonomous entities, reacting to real-world events, running processes, creating services and so on, even without human intervention. This means that things can communicate with each other directly, saving the communication energy with the human user, a notion closely related to Green IT. As Green IT aims to minimize the negative environmental impact of IT use, Green IoT aims to save communication energy. Moreover, IoT is closely related to the notion of mobile devices and CC, or MCC, since the cloud acts as a front end for IoT that, nowadays, consists mainly of mobile devices.

In this paper, we presented a survey of IoT limitations and the potential contributions offered by MCC, which is more mature but is still evolving. It is clear that, although there are still issues with MCC, extended research has been carried out and several MCC applications have been deployed. Gathered research, technical know-how and real-world experience from utilizing MCC can contribute greatly to the realization of IoT. MCC can contribute to many limitations of IoT, while several open issues for both MCC and IoT, such as devising acceptable open standards and enhanced security and privacy, could be researched in a unified way due to high expectations. Moreover, new business opportunities of the convergence between IoT and MCC are discussed for different application domains. The synergy of IoT and MCC will motivate new business models. A critical assessment of various MCC advances regarding specific IoT green applications constitutes future research direction. Finally, a future goal is the cross-discipline technology integration to validate the convergence of green IoT and MCC framework.

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