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Integration of Internet of Things and cloud computing with quality of service assurance approach

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Abstract:

Now a days the cloud computing and Internet of Things (IoT) become the most importance technologies that are both used in our life. As we know the Internet of Things (IoT) is generally characterized by real world small things,. It allows billions of devices to be connected and communicate with each other to share information that improves the quality of our daily lives. in the other ways, Cloud Computing has virtually unlimited capabilities in terms of storage and processing power, is a much more mature technology, and has most of the IoT issues at least partially solved. That is why their adoption and use are expected to be more extensive and more importance, thus, a novel IT paradigm in which Cloud and IOT are two complementary technologies merged together is expected to offer the best quality of services, and this new paradigm called Cloud Iot paradigm. Therefore, the integration of cloud and Internet of Things to providing the best service to users and have the highest level of customer satisfaction should always provide quality of service can be guaranteed. The purpose and the aim of this paper is to evaluate the integrity requirements of cloud services and Internet of Things, and to achieve this aim we used descriptive methodology to describe and to recognize about the cloud computing and the internet of things; so that quality of service in these services must be guaranteed.

Keywords: Cloud Computing, Internet of Things, Cloud based IoT, Integration and quality of services.

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دمج انترنت الاشياء والحوسبة السحابية مع ضمان جودة الخدمة

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الملخص:

في هذه الأيام، أصبحت الحوسبة السحابية وإنترنت الأشياء (IoT) من أهم التقنيات المستخدمة في حياتنا. كما نعلم، يتميز انترنت الأشياء بجعل العالم صغير من حولنا. فهو يسمح بربط مليارات الأجهزة والتواصل مع بعضها البعض لمشاركة المعلومات التي تعمل على تحسين جودة حياتنا اليومية. ومن جهة أخرى، تتمتع الحوسبة السحابية بقدرات غير محدودة من حيث قوة التخزين والمعالجة، ولهذا السبب من المتوقع أن يكون إدماجهما واستخدامهما ضروري ومهم لتقديم خدمات أفضل وأكثر جودة، ومن هذا المنطلق سينشأ لدينا نموذج جديد لتكنولوجيا المعلومات؛ نموذج سحابة انترنت الأشياء؛ الذي تكون فيه السحابة وإنترنت الأشياء (IOT) تقنيتان متكاملتان مدمجتان معا. وللاستفادة من التكامل بين السحابة وإنترنت الأشياء وتقديم أفضل الخدمات للمستخدمين والحصول على أعلى مستوى من رضا العملاء يجب أن يتوفر لدينا دائمًا جودة للخدمة التي يمكن ضمانها من إدماج التقنيتين معا. فالغرض من هذه الورقة والهدف منها هو تقييم متطلبات سلامة الخدمات السحابية وإنترنت الأشياء، ولتحقيق ذلك اتبعت الدراسة المنهج الوصفي للتعرف أكثر على كل من انترنت الأشياء والحوسبة السحابية؛ حتى نتمكن من ضمان جودة الخدمة في هذه الخدمات.

الكلمات المفتاحية: الحوسبة السحابية، إنترنت الأشياء، سحابة انترنت الأشياء، التكامل وجودة الخدمة.

Introduction

The Internet of Things (IoT) is a new technology paradigm envisioned as a global network of machines and devices capable of interacting with each other. The IoT is recognized as one of the most important areas of future technology and is gaining vast attention from a wide range of industries. The true value of the IoT for enterprises can be fully realized when connected devices are able to communicate with each other and integrate with vendor-managed inventory systems, customer support systems, business intelligence applications, and business analytics [1].

Therefore, this paper focused on the integration of Cloud and IoT, which is called the Cloud IoT paradigm. The Internet of Things (IoT) paradigm is based on intelligent and self-configuring nodes (things) interconnected in a dynamic and global network infrastructure [2]. So in the first the introduction of the new technologies (cloud computing and Internet of Things) have discussed. Then Cloud computing and Internet of Things (IoT) have been described and discussed to learn more about them and their services. Finally we discussed about the integration of Cloud computing and Internet of Things (IoT) that called the Cloud IoT, and also the quality of service in the cloud IoT , and the conclusions have been presented.

Literature Review

A wide range of research results have been found for QoS support in traditional networks, but, only a few research efforts are found with IoT and Cloud although it provides an exciting and promising vision for seamlessly connecting the virtual world of information to the real world. Dores et al. [1] have discussed the state of the art technologies such as Next Generation Networks (NGN), Internet of Things (IoT), Wireless Sensor Networks (WSN), Body Sensor Networks (BSN) and Cloud Computing and have evoked the need for the integration of the technologies in making the future internet a reality. The authors have adopted „Skynet‟ a free and open source platform for the development of IoT Cloud integration. Skynet is connected to cloud database and the IoT devices through communication protocols. This platform has the ability to register network devices, to store, update and exchange information. The information is not ciphered and the privacy of the information is not ensured and also the senders and receivers are not authenticated via

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secure connections. Subsequently, this open communication system is recommended only to the scenario, where the information can be seen and altered by everybody like an air conditioner thermostat. The authors have also performed a QoS test in terms of delay and jitter and have suggested that more research work is needed to enhance QoS with varied aspects which will assure guaranteed quality of services to users and the providers. Mohamed et al. [2] have coined the term “Cloud of Things” (CoT) for IoT and Cloud Computing Integration. The authors have described the necessity of integrating these two paradigms and the various issues involved in this context. They have presented the motive for the CoT as: the ever-increasing connected devices share a lot of data which cannot be locally or temporarily stored on the devices and the need foreseen is rental storage space and the efficient utilization of the data and the resources. It demands more processing and computation on rental basis, which is very hard to be realized at the IoT end, while cloud-computing makes this achievable.

This integration phenomenon creates more business opportunities and equally larger threats from the attackers. Some of the key issues of CoT are protocol support, energy efficiency, resource allocation, identity management, service discovery, quality of service provisioning, IPv6 deployment, data storage location, security and privacy and unnecessary communication of data. The authors have claimed that QoS is one of the major concerns since the amount of data increases at any moment and any type of data can be triggered. The authors have said that the dynamic prioritization of the request is required along with the QoS requirements such as bandwidth, delay, jitter and packet loss. Giuseppe et al. [3] have proposed a QoS monitoring as a Service architecture (QoSMoNaaS) for cloud services with a substantial study on Internet of Things applications. QoS MoNaaS provide a dependable monitoring facility which is realized as a pilot application in an SRT-15 project (Subscription Racing Application for 2015) a new cloud based platform to connect future internet (FI) applications and services. In this model SLA analyzer collects the information received by Key Performance Indicator (KPI) meter, analyses them, infers the values, and gives back to the KPI meter. The Breach Detector (BD) combines the output of the KPI monitor and the SLA analyzer to find the contract violations. The violation certifier enhances the results of the BR with timestamp and digital signature. This model enhances QoS monitoring facility to the realistic FI applications. The authors have insisted that the dynamic nature of cloud computing and internet of things require the QoS attributes which are capable of delivering real time services and applications with guaranteed quality. Ren et al. [4] have proposed a QoS architecture for IoT as the result of their thorough analysis of the existing QoS mechanism with regard to the characteristics of IoT in a layered basis, such as application layer, network layer and perception layer, which insisted the need for the reliable QoS architecture. Enumerating the QoS requirements for each layer, the authors have designed control mechanism for transferring and translation of QoS requirements from top to down. They have also designed cross-layer QoS management facility and brokers residing in the lower layers to support the control-mechanism. The authors have explained that the IoT‟s QoS problem can be solved by measuring the performance of the service and making clear QoS indicators as well as the interrelationship among them. The application and service layer directly answers the customer’s requirement, while the network layer fuses and transmits the information to modules in the upper layer and the perception layer is responsible for perceiving and collecting data. The authors, explaining the functions of each layer of their proposed work they did recommend that the research work is further needed to assure an end to end quality in availing and providing services in smart environment as IoT is integrated with heterogeneous networks. The existing research on IoT and Cloud demands the necessity for dynamic prioritization of the request along with the QoS requirements, which are capable of delivering real time services and applications with guaranteed quality. Hence, in this paper a novel Quality of Service architecture for the Internet of Things and Cloud Computing is proposed.

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Methodology of the study

The study followed the descriptive analytical methodology on the subject of the study to identify and to describe more about the cloud computing and the internet of things; and its significance to integrate them together to offer smart services and applications anywhere, anytime, any firm, any device and any network independent of any underlying technologies; for example with one IoT enabled Intelligent Smart Card (ISC). ISC eases the access of diversified applications and services distributed in a cloud environment with one Unique Identification (UID) number per citizen through the intelligent systems. The intelligent system processes the data at smart gateway and then uploads the necessary data to the cloud through IP/MPLS core network.

Cloud Computing

Cloud Computing enables a convenient, on demand and scalable networks access to a pool of configurable computing resources. Cloud Computing has virtually unlimited capabilities in terms of storage and processing power. Here are some definitions of cloud computing :

- Cloud computing is a model for enabling 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. (National Institute of Standards and Technology (NIST)) [3, 4].
- A style of computing where massively scalable IT-enabled capabilities are delivered ‘as a service’ to external customers using Internet technologies. (Gartner) [5].
- An emerging IT development, deployment and delivery model, enabling real-time delivery of products, services and solutions over the Internet. (IDC) [6].
- Cloud computing describes a service model that combines a general organizing principle for IT delivery, infrastructure components, an architectural approach and an economic

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model – basically, a confluence of grid computing, virtualization, utility computing, hosting and software as a service (SaaS). (The Group 451) However, each research group defines cloud computing by its own understanding and approaches so that it is very difficult to give the most general definition. Cloud computing is typically classified in the following four ways:

- Public cloud: In Public cloud the computing infrastructure is hosted by the cloud vendor. The customer has no visibility and control over where the computing infrastructure is hosted. The computing infrastructure is shared between any organizations .
- Private cloud: The computing infrastructure is dedicated to a particular organization and not shared with other organizations. Some experts consider that private clouds are not real examples of cloud computing. Private clouds are more expensive and more secure when compared to public clouds.
- Hybrid cloud Organizations may host critical applications on private clouds and applications with relatively less security concerns on the public cloud. The usage of both private and public clouds together is called hybrid cloud.
- Community Cloud: is type of cloud hosting in which the setup is mutually shared between many organizations that belong to particular community, i.e. banks and trading firms. It is multi-tenant setup that is shared among several organizations that belong to a specific group which has similar computing apprehensions. Cloud Computing is a disruptive technology with profound implications for the delivery of Internet services as well as for the IT sector as a whole. However, several technical and business-related issues are still unsolved. Specific issues have been identified for each service models, which are mainly related to security (e.g., data security and integrity, network security), privacy (e.g., data confidentiality), and service-level agreements, which could scare away part of potential users [7].

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Three types of cloud computing as shown in Figure.1 are summarized as follows:

- •IaaS (Infrastructure-as-a-Service)
- •PaaS (Platform-as-a-Service)
- •SaaS (Software-as-a-Service)

Cloud computing applies a utility model to produce and consume computing resources, in which the Cloud abstracts all types of computing resources, including storage, as services (i.e. Cloud services). The Cloud user (either application developer or application consumer) can access the Cloud services over the Internet, and the Cloud users pay only for time and services they need. The Cloud can also scale to support large numbers of service requests. Ultimately, Cloud computing takes care of the micro-lifecycle management of applications, and allows application managers to focus on application development and monitoring. The Cloud computing platform is designed to consist of a variety of services for developing, testing, running, deploying, and maintaining applications on the Cloud. Examples of Cloud computing platforms are The Amazon Web Services, Google App Engine, and Microsoft's Windows Azure platform [8].

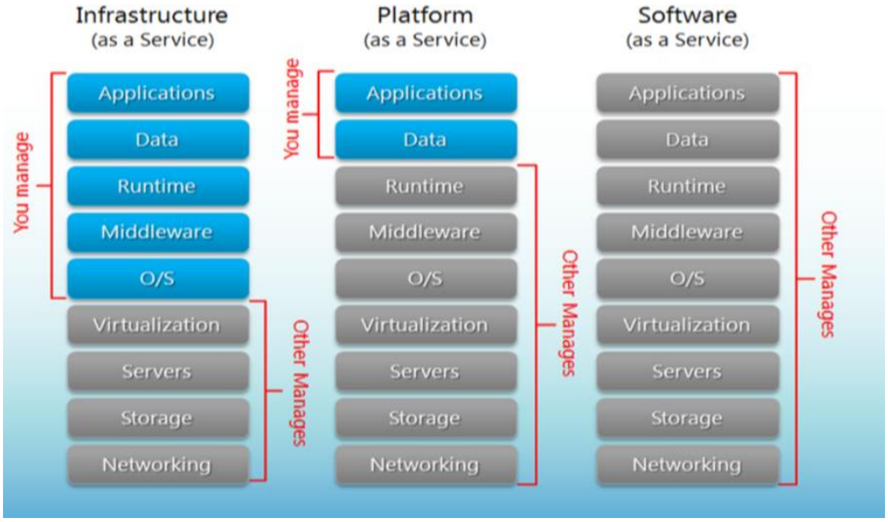

Figure 1. Types of cloud computing

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Internet of Things

IoT, the term first introduced by Kevin Ashton in 1999, is a future of Internet and ubiquitous computing. This technological revolution represents the future of connectivity and reachability. In IoT, ‘things’ refer to any object on face of the Earth, whether it is a communicating device or a non-communicating dumb object. Although the definition of ‘Things’ has changed as technology evolved, the main goal of making a computer sense information without the aid of human intervention remains the same. A radical evolution of the current Internet into a Network of interconnected objects that not only harvests information from the environment (sensing) and interacts with the physical world (actuation/command/control), but also uses existing Internet standards to provide services for information transfer, analytics, applications, and communications. IoT refers to ‘‘a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols’’ whose point of convergence is the Internet. The basic idea behind it is the pervasive presence around people of things, able to measure, infer, understand, and even modify the environment. IoT is fueled by the recent advances of a variety of devices and communication technologies, but things included in IoT are not only complex devices such as mobile phones, but they also comprise everyday objects such as food, clothing, furniture, paper, landmarks, monuments, works of art, etc. [9]. These objects, acting as sensors or actuators, are able to interact with each other in order to reach a common goal. The key feature in IoT is, without doubt, its impact on everyday life of potential users [10]. IoT has remarkable effects in both work and home scenarios, where it can play a leading role in the next future (assisted living, e-health, smart transportation, etc.). Important consequences are also expected for business (e.g. logistic, industrial automation, transportation of goods, security, etc.). According to these considerations, in 2008 IoT has been reported by US National Intelligence Council as one of the six technologies with potential impact on US interests towards 2025 [11]. Indeed, in 2011 the number of interconnected devices overtook the number of people.

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In 2012, the number of interconnected devices was estimated to be 9 billion, and it was expected to reach the value of 24 billion by 2020. Such numbers suggest that IoT will be one of the main sources of big data [12]. In the following, we describe a few important aspects related to IoT [13]:

- RFID. In IoT scenario, a key role is played by Radio-Frequency Identification (RFID) systems, composed of one or more readers and several tags. These technologies help in automatic identification of anything they are attached to, and allow objects to be assigned unique digital identities, to be integrated into a network, and to be associated with digital information and services [14]. In a typical usage scenario, readers trigger the tag transmission by generating an appropriate signal, querying for possible presence of objects uniquely identified by tags. RFID tags are usually passive (they do not need on-board power supply), but there are also tags powered from batteries [15, 16].
- (Wireless) sensor networks. Another key component in IoT environments is represented by sensor networks. For example, they can cooperate with RFID systems to better track the status of things, getting information about position, movement, temperature, etc. Sensor networks are typically composed of a potentially high number of sensing nodes, communicating in a wireless multi-hop fashion. Special nodes (sinks) are usually employed to gather results. Wireless sensor networks (WSNs) may provide various useful data and are being utilized in several areas like healthcare, government and environmental services (natural disaster relief), defense (military target tracking and surveillance), hazardous environment exploration, seismic sensing, etc. [17]. However, sensor networks have to face

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many issues regarding their communications (short communication range, security and privacy, reliability, mobility, etc.) and resources (power considerations, storage capacity, processing capabilities, bandwidth availability, etc.). Besides, WSN has its own resource and design constraints (that are application- and environment- specific) and that heavily depend on the size of the monitoring environment [18].

- Addressing. Thanks to wireless technologies such as RFID and Wi-Fi, IoT paradigm is transforming the Internet into a fully integrated Future Internet [19]. While Internet evolution led to an unprecedented interconnection of people, current trend is leading to the interconnection of objects, to create a smart environment [20]. In this context, the ability to uniquely identify things is critical for the success of IoT since this allows uniquely addressing a huge number of devices and controlling them through the Internet. Uniqueness, reliability, persistence, and scalability represent critical features related to the creation of a unique addressing schema [20]. Unique identification issues may be addressed by IPv4 to an extent (usually a group of cohabiting sensor devices can be identified geographically, but not individually). IPv6, with its Internet Mobility attributes, can mitigate some of the device identification problems and is expected to play an important role in this field.
- Middleware. Due to the heterogeneity of the participating objects, to their limited storage and processing capabilities and to the huge variety of applications involved, a key role is played by the middleware between the things and the application layer, whose main goal is the abstraction of the functionalities and communication capabilities of the devices. The middleware can be divided in a set of layers

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(see Figure 2): Object Abstraction, Service Management, Service Composition, and Application [20].

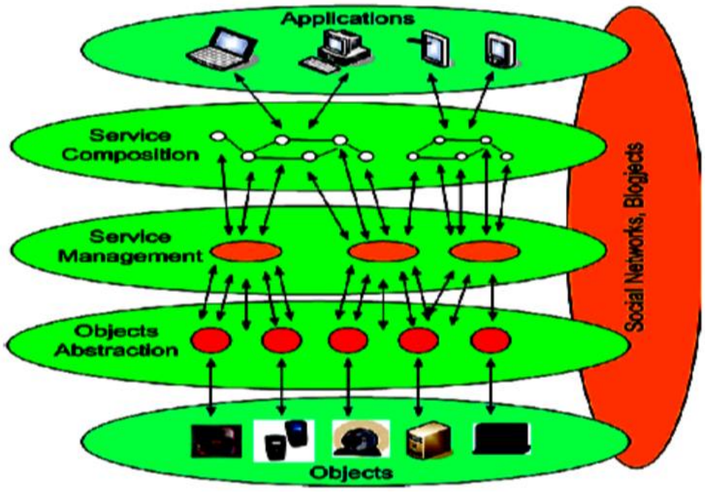

Figure 2. IoT paradigm: an overall view [2]

Integration of cloud and Internet of Things

IoT and cloud computing working in integration makes a new paradigm, which we have termed here as Cloud IoT. The two worlds of Cloud and IoT have seen an independent evolution. However, several mutual advantages deriving from their integration have been identified in literature and are foreseen in the future. On the one hand, IoT can benefit from the virtually unlimited capabilities and resources of Cloud to compensate its technological constraints (e.g., storage, processing, and energy). Specifically, the Cloud can offer an effective solution to implement IoT service management and composition as well as applications that exploit the things or the data produced by them. On the other hand, the Cloud can benefit from IoT by extending its scope to deal with real world things in a more distributed and dynamic manner, and for delivering new services in a large number of real life scenarios. These worlds are very different from each other and, even better, their characteristics are often complementary, as Table 1 shows. Such complementarity is the

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main reason why many researchers have proposed and are proposing their integration, generally to obtain benefits in specific application scenarios [14].

Table 1: Complementary aspects of Cloud and IoT [2]

	IOT	CLOUD
Displacement	**Pervasive**	**Centralized**
Reachability	**Limited**	**Ubiquitous**
Components	**Real world things**	**Virtual resources**
Computational capabilities	**Limited**	**Virtually unlimited**
Storage	**Limited or none**	**Virtually unlimited**
Role of the Internet	**Point of convergence**	**Means for delivering Services**
Big data	**Source**	**Means to manage**

Most of the papers in literature are actually seeing Cloud as the missing piece in the integrated scenario, i.e. they believe that Cloud fills some gaps of IoT (e.g. the limited storage). A few others, instead, see IoT filling gaps of Cloud (mainly the limited scope) [15]. Being IoT characterized by a very high heterogeneity of devices, technologies, and protocols, it lacks different important properties such as scalability, interoperability, flexibility, reliability, efficiency, availability, and security. Indeed, Cloud facilitates the flow between IoT data collection and data processing, and enables rapid setup and integration of new things, while maintaining low costs for deployment and for complex data processing [16]. Consequently, analyses of unprecedented complexity [17] are possible, and data driven decision making and prediction algorithms can be employed at low cost, providing means for increasing revenues and reduced risks [18]. Cloud IoT gave birth to a new set of smart services and applications that can strongly impact everyday life (Figure 3). Many of the applications described in the following (may) benefit from Machine-to-Machine communications (M2M) when the things need to exchange information among themselves and not only send them towards the cloud. These applications are the following [19].

- Healthcare

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- •Smart cities and communities
- •Smart home and smart metering
- •Video surveillance
- •Automotive and smart mobility
- •Smart energy and smart grid
- •Smart logistics
- Environmental monitoring

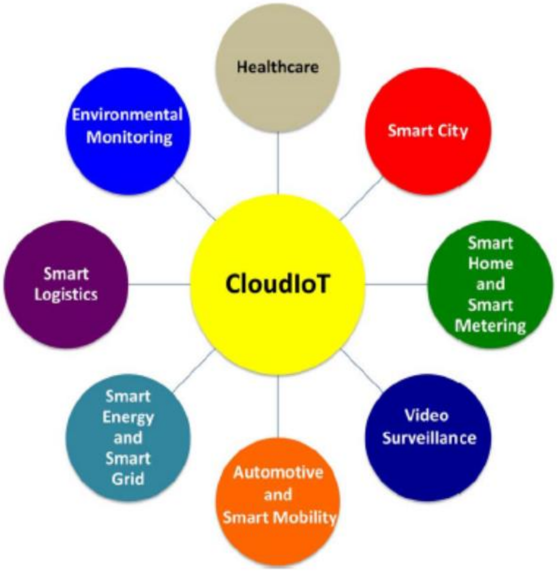

Figure 3. Application scenarios driven by the Cloud IoT paradigm [19].

Quality of service in integration of cloud and internet of things

One of the biggest challenges in this integral part of the future internet is the caliber to manage heterogeneous types of tasks in this system along with ensuring Quality of Services. In this way, IoT may rely on cloud computing for its functioning. When cloud environment supports such a system, it has to handle diversified data. Also, majority of applications in IoT are time bound or real time applications. Another critical area is dynamic resource provisioning that has to be addressed by cloud system. Moreover, when analyzed, resource types in a cloud infrastructure are also heterogeneous. Heterogeneous system consists of set of heterogeneous processors with different memory capacity, processing speed etc. IoT workloads include diverse applications with different priorities, performance and resource requirements. The various tasks will experience different execution cost in different machines, so task scheduling is a crucial issue to improve the efficiency of this architecture [19].

It is obvious that the Cloud IoT paradigm gives rise to the development of innovative and novel applications that are combination of IoT devices operated by multiple providers (for clouds, sensors, and data) and are hosted on public/private cloud environments. Consider a disaster management application that detects and alerts the citizens regarding floods.

This application may detect the level of flooding using data obtained from numerous IoT devices such as water flow sensors placed on the roads, weather, IP cameras owned by the municipalities and social media (e.g., Twitter and Facebook).

In a typical CloudIoT ecosystem, these sensors will be owned and operated by multiple providers such as councils, government bodies, private organizations and individuals. The disaster management application needs to deliver a certain level of quality of service (QoS) composed of both functional and nonfunctional components. The functional components may include the cost to obtain data from multiple providers, the rate at which data is produced, the types of sensors, the analytics required for detection and altering of events, application response time (based on network, processing delay), and the overall functional infrastructure to host the service(s). The nonfunctional components may include the accuracy of event detection, timing/deadlines such as the maximum time within which an event is detected and responders are dispatched, cost of event detection, data quality and sensor calibration issues [19].

In integration of IoT and Cloud, for creating a smart world, there are a few significant challenges, which need to be resolved while taking initiative in. The varied issues are interoperability, security, QoS, load balancing, mobility, IPv6 deployment, data management solution and acceptability of IoT applications by users and citizens

[20]. The review of the literature expresses that there is an impelling need to enhance the quality of service, which is very much vital and fundamental in IoT and Cloud. Moreover, the dynamic nature of the IoT and cloud computing require QoS attributes that are capable of delivering real time services with assured quality [20]. In this scenario, Qos is considered to be the most important parameters of the network capable of providing better services to the users and the providers where QoS should have a architecture consisting of standards which could be widely used in communication networks to improve overall performance by managing the traffic. Several research efforts have been taken to meet the QoS requirements, yet there is a need for unified, integrated QoS architecture for the IoT and cloud computing [20]. As the amount of data increases and the type and unpredictability also comes into play, QoS becomes an issue.

At any moment, any type and amount of data can be triggered. It may also be an emergency data as well. Dynamic prioritization of the requests would be required on the cloud side. QoS would mostly be measured in terms of bandwidth, delay, jitter, and packet loss ratio [20]. Depending upon the type of data and its urgency to be sent to the sync node, QoS must be supported. However, from the perspective of CloudIoT applications; network communication is an important but a smaller component. Parameters related to clouds (e.g., number of I/O operations and CPU throughput), devices (battery), network type, and application would have to be used in conjunction with network parameters (bandwidth, delay, and jitter) to determine the overall QoS of the CoT applications. To realize the larger vision of CloudIoT, in particular the sensing-as- aservice paradigm, it is important to understand and carefully develop QoS metrics and corresponding SLA's that take into consideration the complexity introduced by each layer. We define CloudIoT QoS metric as bellow:

QoS= f(Cloud QoS, network Qos, location, battery,…,N) (1).

Where, N represents the total number of parameters. As can be observed from the equation, from end-to-end QoS is a multidimensional and a complex problem that needs to be carefully addressed [17]. The current mechanisms for QoS provisioning and supporting service level agreements in IoT and clouds have major limitations. In the light of CloudIoT, these mechanisms will have to be radically reconsidered or even reinvented to meet the challenges posed by upcoming CloudIoT applications. Taple1 captures the complexities of CloudIoT applications from the physical device (data collection) to virtual layer (storage and processing) to the application layer (delivery). However, QoS guarantee for the CloudIoT is expectedly challenging, and an emerging discipline. This is due to the shortage of standardized, end-to-end approaches for QoS assurance (between the end user, IoT devices and the cloud), the complexity of the integration of different layers, and the presence of a plethora of QoS constraints and parameters at each layer. We expect that the traditional way of QoS assurance will not be sufficient [18].

Most research in QoS-based service selection focus on proposing a comprehensive pre-defined QoS schema to represent service requests and offers, or implementing a selection algorithm to achieve an optimized composition.

However, the process of obtaining QoS information is largely overlooked [19]. A genetic-algorithm-based service composition approach is proposed for cloud computing. In particular, a coherent way to calculate the QoS values of services in cloud computing is presented. Genetic Algorithms (GAs) are heuristic approaches to iteratively find near-optimal solutions in large search spaces [20]. Service providers report quality aspects of services as non-functional attributes. These attributes are mainly provided for service composers and developers. An alternative resource for such information is online reviews where users provide their feedback in form of reviews or comments. The experience with a service is called quality of experience (QoE). Quality of Experience (QoE) is a subjective measurement which reflects user's experience with a service. A user can provide her opinion on any aspect of a service, e.g., cost and performance. Each aspect of a service is called QoE attribute. Contrary to QoS, QoE reflects quality from the user’s point of view. The primary source of QoE is online reviews. Since reviews come from large number of users with diverse platforms and different geographical locations, QoE becomes a credible source of information [20]. In the literature about quality definitions, especially in network-related literature, some authors refer to QoE as a direct map of how the user perceives QoS. These related works usually consider QoE as a holistic evaluation, which is of no use for a system. To know if the user is not satisfied does not mean that the system is not working according to a service level agreement (SLA). After all, the only variables that matter, concerning how the user feels, are those about service stability and ones related to the standard deviation. Because of that, to be able to use the metrics in a self-correcting system, it is first necessary to define these metrics in a non-holistic way. More explicitly, definitions of QoE metrics mapped to palpable QoS metrics are of utmost importance for the chosen approach [20].

The result of the study

The results of this study confirm that QoS approaches in CloudIoT have become an important topic in the area in recent years and there remain open challenges and gaps which require future research exploration. In particular, tools, metrics and evaluation research are needed in order to provide useful and trustworthy CloudIoT services that deliver appropriate QoS [14]. The proposed quality of service architecture for Internet of Things and Cloud Computing uses differentiated services to meet the QoS requirements. The performance analysis proves that the proposed architecture is efficient and capable of delivering real time services with assured quality of service [15].

Conclusion and recommendation

In conclusion, the integration of cloud computing and the Internet of Things represents the next great leap forward in the future Internet. Application of this integration, which is called CloudIoT, valuable new paths will open for business and research. This integration can draw near future smart cities. The proposed quality of service architecture for Internet of Things and Cloud Computing

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uses differentiated services to meet the QoS requirements. The performance analysis proves that the proposed architecture is efficient and capable of delivering real time services with assured quality of service. The future work is to establish the security architecture for IoT and Cloud and to implement the same in real time scenario. However, the intersection between the Internet of Things, cloud and big data analysis systems remains almost intact. Moreover, Cloud platforms need to be enhanced to support the rapid creation of applications, by providing domain specific programming tools and environments and seamless execution of applications, harnessing capabilities of multiple dynamic and heterogeneous resources, to meet QoS requirements of diverse users. In addition, in the future work, a number of case studies will be carried out to test the effectiveness of the Cloud-based IoT approach in healthcare applications.

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