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Privacy and Security in Internet-based Computing: Cloud Computing, Internet of Things, Cloud of Things: a review

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Abstract

This paper gives insights into the most important existing problems of security and privacy of the Cloud Computing (CC), Internet of Things (IoT) and Cloud of Things (CoT) concepts especially confidentiality issue. With the evolution of ubiquitous computing, everything is connected everywhere, therefore these concepts have been widely studied in the literature. However, intrusions and vulnerabilities will be more recurrent due to the systems complexity and the difficulty to control each access attempt. To tackle this issue, researchers have been focused on various approaches enforcing security and privacy. In the present paper, risk factors and solutions regarding these technologies are reviewed then current and future trends are discussed.

Keywords: Cloud Computing, Internet Of Things, Cloud of things, security, privacy,confidentiality.

1. Introduction

It can be noticed that the way we use technologies is changing, a dramatic transformation is shaping the world from isolated systems to ubiquitous Internet-based-enabled 'things'. These things are capable of communicating with each other by sending data which contain valuable information. However, this new world built on the basis of Internet, contains numerous challenges as regard to the security and the privacy perspective.

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1.1. Motivation

In recent years, due to the fast development of new and more efficient computing methods, the interest of academics and practitioners has been shifting toward Internet-based Computing. Commonly known applications are Internet of Things (IoT), Cloud Computing (CC) and Cloud of Things (CoT).

After a number of technology variants have appeared over the years, we found a need to classify those that can help secure computing. As a matter of fact, there is no review on which solutions are described as regard to these three points of views (i.e. IoT, CC and CoT). Besides, thousands of users of IoT, CC and CoT are communicating with each other, sharing ressources and exchanging high amount of sensitive data and information impose a great need of additional level of security especially to guaranty confidence in service providers as much as controlling the dissemination of personal data and to detect and eliminate vulnerabilities[?] . Thus, in this article, the main challenges for privacy and security purposes are described along with an analyze of various constraints and the main techniques used to face one of them such as how to enable the users control over the dissemination of their attributes and data .

1.2. Context

1.2.1. Internet-based Computing
Internet of Things. It is defined as a networked interconnection of devices in everyday use that are often equipped with ubiquitous mechanism. The Internet of Things (IoT) is based on processing of large amount of data in order to provide useful service. Along with physical objects, the IoT is composed of embedded software, electronics and sensors. This allows objects to be controlled remotely via the connected network infrastructure and facilitates direct integration between the physical world and computer communication networks. Therefore, it significantly contributes to improve robustness, accuracy, efficiency, and economic profits. This is why IoT has been widely applied in different applications such as environment monitoring, energy management, building automation, transportation, etc.[?] .

Cloud Computing. CC is a new computational paradigm which provides a novel business model for companies/organizations to adopt IT without large investment. CC also provides a new vision of internet-based, highly performance distributed computing systems in which computational resources are given as a service. It is common to define the cloud computing model just as the United States National Institute of Standards and Technologies (NSIT)[?] did it - "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." Two important aspects of the cloud model are Multi-tenancy and elasticity. The former allows the sharing of the same service instance with others tenants. Whereas the latter allows to scale up and down resources allocated to a service based on the current service demands. However, the improvement resource utilization, cost and service availability remains the target for both of them[?] .

Cloud of Things. Over the last years, IoT and CC have evolved gradually and continuously.They represent two of the most regarded Information and Communications Technology (ICT) concepts. As mentioned in many recent works, those different concepts can be integrated in order to create a new one called Cloud of Things (CoT)[?,?] . Hence, CoT is a novel concept which has emerged from the consolidation of the IoT and CC concepts.

Scientific estimations say that the IoT will grow to 35 billion items by 2020[?,?] . Such growth will make IoT one of the principal sources of Big Data of which the specificities could be the volume, heterogeneity, velocity, complexity, and value. Cloud computing is a more mature technology compared to IoT. It can offer virtually unlimited capabilities (e.g., storage and computation) to support IoT services and application that can exploit the data produced from IoT devices. It is not surprising that in recent years, a number of new CoT concepts arose from IoT such as Sensing-as-a-Service, Video-Surveillance-as-a-Service, Big Data Analytics-as-a-Service, Data-as-a-Service, Sensor-as-a-Service, etc.

1.2.2. Challenges
The IoT is defined in[?] as " *a global industry movement that brings together people, process, data, and things to make networked connections more relevant and valuable than ever before. Today, more than 99 percent of things in*