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Cloud Computing and IoT Convergence

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Abstract - *As the demand for higher computing resource systems and more distributed services is increasing, changes are required. Cloud computing has thus enabled distributed networks that enable computing resources in an online manner. This has further developed into concepts such as mobile cloud computing systems which provide mobile devices with resources to help minimize computing limitations. Other technologies, such as virtualization have made it possible to create an entirely new network infrastructure such as network function virtualization and software defined networks. However, the development of these new systems has also brought new challenges. Research topics such as securing the cloud, the impact of network function virtualization and software-defined networks on the cloud, and mobile cloud computing has arisen. These are only some of the future research topics required. Many more variations of cloud usage will be seen as these technologies develop. This paper provides the results of a survey done on the current research available on the above-mentioned topics.*

1. INTRODUCTION

The Cloud Computing concept has greatly matured over a previous couple of years. The concept implies that anything which will be hosted on the web, i.e., resources/services/data is on the market to be used, when needed, for the composition and provision of more sophisticated services. Key cloud characteristics are OnDemand service provision, ubiquitous access, resource pooling, further as elasticity. The IoT involves several billions of diverse devices inter-connected by 2020 vast amounts of quickly-emerging/ versatile data (i.e., "big data"), and diverse services. Connected devices are often sensors, actuators, smartphones, computers, buildings and home/work appliances, cars and road infrastructure elements, and the other device or object which will be connected, monitored or actuated. Devices are connected to the web, further like one another, via heterogeneous access networks. Services aim at resulting in a sensible, sustainable and inclusive society and economy. within the light of the problems discussed, the success of the IoT services can only be achieved if they're attributed with ubiquitous accessibility (i.e., more business opportunities), high-performance (e.g., thanks to the associated “big data”), efficiency (for improving the position of all stakeholders, e.g., providers and users), and scalability (e.g., as various volumes of users, resources and data could also be involved in commission provision). The Cloud features mentioned above are essential today for the IoT world, as an example, resource pooling enhances the reliability and efficiency of service provision, the on-demand, and elasticity features are fundamental for efficient and scalable service provision (resource provision where needed, for the quantity of your time needed), etc. of these facts make a quite compelling case for the merging of the Cloud and IoT paradigms.

2. IOT AND CLOUD COMPUTING

As to appreciate the vision of targeting future market potential several requirements must be taken into consideration, for instance.

1. Ubiquitous accessibility and connectivity, facilitation of maximum accessibility still as connectivity of the varied heterogeneous objects/services and various volumes of users including mobility through commonly agreed APIs and standards.
2. Dynamic management/orchestration of users, billions of devices still as massive amount of information produced by those connected devices.
3. Maximum resources utilization, enabling of sharing of IoT resources (objects, applications, platforms).
4. Personalization of users and services, providing services supported user’s preference and requirements including real-world context.

All the above functionalities must be:

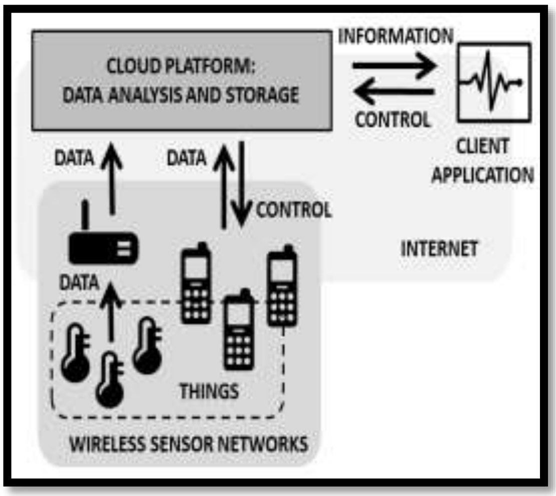
Reliability (e.g., for handing context/policy changes and accomplishing trust from the parts of the users) and scalability (e.g., as various volumes of users, resources and data is also involved in commission provision).

2.1 What cloud can offer?

Cloud computing relies on sharing of resources, which is very important requirements for IoT platform. Cloud Computing isn't only sharing the resources but also maximizing the resources. It’s also location independent; the users access the cloud services from any location and with any devices through the web connection. After we discuss the IoT platform then it should even be accessed from anywhere, any time. The virtualization of physical devices is another important characteristic; virtualization allows users to simply share the devices. Thanks to virtual world nature, it's also more homogeneous. The multitenancy features of cloud computing enables the sharing of resources to multiple users over spatial and time distribution. Additionally, Cloud offers elasticity and scalable of resources and application, the service and resources are easily accessible and available. IoT and Cloud Computing can make the work easier.

3. IOT – CENTRIC CLOUD

IoT-Centric Cloud could also be a paradigm that extends Cloud computing and services to the sting of the network, near objects. the thought is to distribute data to man oeuvre it closer to the end-users to eliminate latency, reduces high traffic, numerous hops, and support mobile computing and data streaming. during this paradigm, the data is processed and stored near users/near to sources. This creates dense geographical distribution and supporting end-user's security. it's useful when service is provisioned from the data coming from the same location. during this approach, the rata process and repair execute locally (distributed cloud processing, sub-workflow, data aggregation locally). Unlike traditional data center, IoT devices are geographically distributed over huge platforms, covering multiple management domains. because of its wide geographical distribution, the IoT-Centric Cloud paradigm is well-positioned for real-time big data and real-time analytics. IoT-Centric Cloud supports densely distributed data collection points, hence adding a fourth axis to the often-mentioned Big Data dimensions (volume, variety, and velocity).



The IoT-Centric Cloud ecosystem consists of Local Clouds and a worldwide Cloud. More specifically: a neighborhood Cloud is formed on-demand, it comprises the sufficient/appropriate computing/storage/ networking capabilities, and provides requested services to users in an exceedingly certain geographic region and fundamental measure yet as offers additional processing and storage capability to services. The world Cloud is seen within the "traditional" sense, as a construct with on-demand/elastic (illusion of infinite) processing power and storage capability. it's a "backbone infrastructure", which increases the business opportunities for service providers. Ubiquity/reliability/performance/efficiency/ scalability of service provision (more opportunities for offering services, more options on which to base service features just in case of context changes, more resources for contributing to the choices, elastic provision of resources on-demand, etc.). Local Clouds can involve an arbitrary sizable number of nodes (sensors, actuators, smartphones, etc.). The aggregation of resources comprises sufficient processing power and cupboard space. Networking can depend upon heterogeneous technologies (wireless plays a prominent role). The goal is to serve users of a specific area. during this respect, a neighborhood Cloud is that the virtualized processing, storage, and networking environment, which comprises IoT devices within the vicinity of the users; users will exploit the varied services composed of the Local Cloud's devices' capabilities.

4. CHALLENGES DUE TO IOT AND CLOUD COMBINATION

Although IoT and Cloud combination can overcome several individual IoT and Cloud challenges, however because of convergence of those two technologies additional challenges are foreseen. Most of the IoT data are unstructured and semi-structure those are coming from distributed sources, additionally the massive amounts of information coming from IoT sources. IoT-Cloud should provide real-time processing and repair provisioning techniques considering such Big Data. Other issues are to produce more dynamic resources management and orchestration techniques, dynamically offloading from clients/hosts to the cloud.

5. ADVANTAGES AND BENEFITS

One of the main advantages of cloud platforms is that resources can be attained using a pay-as-you-use. This pays-you-use is very attractive to companies that may need to run tasks periodically. Resulting in computing facilities or software packages to be underutilized. Using pay-as-you use enable the renting of high-level abstracted resources, instead of acquiring physical hardware. Another reason for the wide adoption of cloud platforms is that the cloud is a system that is scalable beyond the same type of physical systems. Cloud platforms provide the unique characteristic of a distributed system. Applications developed on the cloud are therefore accessible from anywhere where there is an Internet connection. Cloud brokers are becoming common as they can hide the intricacies that relate to the management of powerful but complex heterogeneous infrastructures such as clouds. Cloud platforms allow the reduction of the development time for many cloud-based applications. When the Internet of Things (IoT) becomes part of the system, the development time for these devices needs to be reduced as well. This is however difficult as one need hardware for testing these IoT devices. Other cloud services can be useful such as online development environments, compilers and simulators. Products such as Microsoft.NET Gadgeteer enable short development times, online testing and deployment to connected devices. More devices are being designed to be able to use web-based protocols such as HTTP. As cloud services use geographically distributed resources, it could be an appropriate infrastructure to allow for

Scientific Workflows (SWFs). Distributed resources and availability of resources between different cloud sites allow the execution of SWFs on multiple sites. Correctly designed scheduling algorithms can produce reasonable results compared with the generic and brute-force algorithms. Cloud services, big data analytics, and visualization frameworks allow for complex data predictions. Health-shock prediction is a case in point. By leveraging these systems, predictions can be made as to the causal factors affecting health shock, enabling the prediction, management, and mitigation of health-shocks.

6. DISADVANTAGES AND DRAWBACKS

One of the disadvantages of distributed systems is that the interaction with these systems is based on the connection to the internet. A slow internet connection would, therefore, result in a slow application/utilization of internet service. When providing the resources for an application it is therefore required to test the available resources. Due to the distribution of resources and the parallelism of processing previous testing methods provide inaccurate results. The systems need to be tested under different loads and different types of loads, such as possible services and applications that could be implemented. Critical tests to perform are to check under which conditions the system does not perform as expected. Another capability to be reviewed is the elasticity to test scalability and resource provisioning. Testing is made difficult for the following reasons:

1. Scalability - Cloud platforms provision resources in an on-demand method, needing testing methods to test this scalability.
2. Modern technologies - As new technologies are being developed, tests need to be able to make provisions for this.
3. Flexibility - Different architectures and infrastructures will perform differently under different loads. Testing should take this into account, enabling, and different products to be tested. IEEE African 2017 Proceedings 1570.
4. Client realism - Testing needs to be able to take specific real-world variables into account. One of the advantages of cloud computing is that a DevOps strategy can be followed. This means that development and operations can happen almost simultaneously due to short development cycles and easy factorizing and deployments of software.

7. MOBILE CLOUD COMPUTING

As cloud computing grows, people expect the same functionality from their mobile phone as their desktop. Even though resources have drastically increased in mobile phones, these resources are still not comparable to desktop computers. The major limits are processing, storage and power source. As a result, Mobile Cloud Computing (MCC) has been suggested. This concept allows mobile devices to upload data and computation to the cloud for processing by non-mobile computing systems. The processing results can then be sent back to the mobile device. There are two main methods to accomplish this namely, cloud and surrogates. Surrogates are computing systems on standby, waiting for computation commands to be uploaded. These systems are less secure compared to the cloud and are not committed if a higher priority job enters the queue. Cloud platforms are generally more resource-intensive as data needs to be sent to remote cloud platforms and require more authentications. The aim of MCC is to reduce the computation needed to be done on the mobile device. This, in turn, reduces the resource requirements and can result in an extension of resources such as battery life on the mobile device. Mobile cloud computing services have the following requirements:

1. Latency - This is the amount of time elapsed from when the event is triggered when the system receives the request.
2. Energy Consumption - This is the energy constraint on the system when performing the task or executing the application either locally or remotely.
3. Throughput - This is the amount of bandwidth required by the application to execute successfully and reliably.
4. Computing - This corresponds to the computing resources required by an application.
5. Data transfer - This is the amount of data that may need to be transferred from the application to the cloud. This may include inputs, outputs, algorithms or code.
6. Storage - The MCC needs to store the data generated by mobile devices.
7. Users - The cloud system allows for multiple users to access and use the resources.

There may however be a limitation to the number of users. Within the MCC, mobile devices can act as one or multiple of the following types of devices:

1. Sensors - Mobile phones have a multitude of sensors built into the device. This data can then be transmitted wirelessly to the cloud to be stored or processed.
2. Nodes - The mobile device may act as a node within a distributed system. The mobile device can subsequently aid in resource sharing.
3. Outputs - The mobile device can become a device making available certain data such as location specific data to the user. These mobile devices can go beyond and become actuators, by interfacing with the surrounding networks. To realize MCC, different cloud topologies need to be combined such as centralized cloud, cloudlets, and distributed clouds. A centralized cloud is the cloud environment to which systems connect remotely and which provides the resources for most applications. Cloudlets are small cloud infrastructures that are geographically limited. These cloudlets have limited resources and

provide connectivity to the central cloud. Finally, distributed clouds present the interconnection between mobile devices that share resources. The distributed cloud could be a cloud environment where connectivity is non-persistent. Another advancement that has been made within the mobile industry is dynamic voltage scaling (DVS). DVS allows the processor to cut back energy consumption by adjusting the operating frequency. It provides the flexibility to balance performance and power consumption. a chance for research has been created into how algorithms will be designed to use this advancement to see the foremost power efficient method when transferring data to the cloud. Many of the cloud interactions are energy expensive and happen too frequently. Using DVS, an optimal frequency will be determined by supported algorithms that take energy consumption and data transfer requirements like timing under consideration. Connecting Mobiles have also created the chance for applications like mobile crowdsensing.

8. SECURITY CONCERNS

With a distributed system such as used by the cloud, there are many potential points of failure. One of the largest concerns is Distributed Denial of Service (DDoS) attacks. An attacker can attack a small group of machines. If access can be obtained, these machines become zombie machines. Zombie machines will then systematically search for and test security flaws in other machines. When enough machines have been accessed, these will concurrently attack the system. This attack is considered a DDoS because multiple devices are attacking and their function is to deny authorized users' access to the service through flooding the system with false requests. This is a very concerning problem because in distributed systems there could be many devices susceptible to this attack. With customers having access to virtual machines, malicious/vulnerable programs could be loaded on to these machines. Early detection and system defenses are therefore critical. For a robust and authenticated cloud system, the following characteristics are necessary:

1. Access control to ensure only authorized users.
2. Encryption of data to ensure validity and authenticity.
3. Collaborative threat detection using big data analytics.
4. Obscuring data within the cloud to hide from eavesdropping.
5. Secure storage and retrieval of data within the cloud.
6. Watermarking data to ensure authenticity. Cloud Computing Adoption Framework (CCAF) integrates three major security technologies: firewall, identity management, and encryption.

These concepts have been shown to efficiently and effectively detect and prevent security attacks. This concept was able to detect and block almost all Trojans and viruses within a very short period of time and was able to do this without reporting any false positives.

9. CONCLUSION

As can be seen above, cloud computing has a very wide variety of topics. These can include everything from Mobile Cloud Computing to network infrastructure. It is a very new topic which is developing rapidly. For this reason, there is still a large amount of research that is required in any of these fields. Some of the major fields are MCC, APIs, infrastructure, and security. Possible further research can include guidelines on how to optimally write applications/ interfaces/ protocols for MCC making use of the cloud for processing. Heterogeneity and energy awareness algorithms in MCC could provide an opportunity for further research. Further research in APIs can be done in the design to enable multi-cloud solutions or in the abstraction of APIs implementations. The use of SDN and NFV provides a wide variety of future research regarding cloud platforms to be used in MCC and other cloud solutions as well. Finally, security has many unanswered questions and many of the current security solutions do not fully ensure all security requirements.

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