Current Trends in Biomedical Engineering & Biosciences
ISSN: 2572-1151

Juniper Publishers
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Opinion
Volume 11 Issue 3 - January 2018
DOI: 10.19080/CTBEB.2018.11.555813

Curr Trends Biomedical Eng & Biosci

Cloud Computing and Internet of Things in Biomedicine

Ehsan Sheybani*

Giti Javidi University of South Florida, USA

Submission: November 11, 2017; **Published:** January 24, 2018

***Corresponding author:** Ehsan Sheybani, Giti Javidi University of South Florida, USA, Email: sheybani@sar.usf.edu

Opinion

Biomedicine has already felt the impact of big data in the form of patient data, imaging systems, patient monitoring devices, biomedical communication systems, etc. These big datasets from different sensors are stored in databases and eventually used in conjunction with data analysis packages to make biomedical scientific and engineering decisions. However, the effect of big data on this strategy has been to sway it more and more toward using external resources and distributed facilities. Today's biomedicine has an increasing reliance on cloud and cloud computing for its storage and analytical needs and on internet of things (IoT) for sensing and data acquisition. This new environment has given the modern biomedicine a deeper and broader reach. Moreover, as the Internet of Things (IoT) becomes more widespread, high-speed data processing, analytics and reduced response times are becoming more critical than ever. To meet these requirements through the current centralized, cloud-based model new algorithms have been developed to enhance and complement cloud's computational capabilities. In this article, we will highlight cloud vs. cloud computing, its advantages, and its current applications. We will also discuss how cloud computing can help biomedicine deal with current and future challenges of the growing network of sensors in IoT including ensuring that the infrastructure is better equipped to handle the big data.

The amount of data analyzed on sensor devices that constitute the IoTs is approaching 40% of the overall data transactions, which is a serious challenge to the integrity of quality of service (QoS). With the advent of cloud computing, as a distributed architecture between the cloud and the data, many of the challenges can be alleviated by extending the functions of the cloud computing closer to the IoT devices by only pushing relevant data to the cloud. Cloud computing is an intermediate layer that extends Cloud layer. Cloud computing architecture moves computing to the edges, away from the centralized data centers and cloud solutions.

Cloud computing is a highly virtualized platform that provides compute, storage, and networking services between end devices and traditional Cloud Data Centers, typically, but not exclusively located at the edge of network [1-3]. Therefore, data can be processed locally in smart devices rather than being sent to the cloud for processing.

Cloud provides data, computation, storage and application services to end-users, however, the idea of cloud computing should be to place transactions and resources at the edge of the cloud, rather than to establish channels for cloud storage and utilization. This will reduce bandwidth by not sending every bit of information over cloud channels, and instead aggregating it at a certain access point. It will also eliminate latency and numerous hops, lower the costs, improve efficiency and support mobile computing and data streaming.

In many cases, cloud and cloud computing can complement each other. A good example is a smart lighting system which operates based on movement. When motion is detected, data needs to be processed to affect the outcome that the lights are turned on. When no motion is detected for a period of time, a decision needs to be made that the lights should now be turned off. This data and resulting decisions are best processed at the edge. On the other hand, the company running the smart lighting system may also want to monitor energy efficiency and the duration of time the lights were on. The data which provides this "bigger picture" of how the smart lighting is being used would require data to be assembled and processed by a reporting system run in the cloud. As another good use case, consider an example of smart vehicles where cars could collect information about road conditions. These smart vehicles can send the collected information to alert the other drivers on the same road, but also to a central cloud server when connected to the WAN to warn other drivers on other roads/highways and recommend to others to avoid that route. A great example of this is Waze, a wildly utilized crowdsourced driving application that people use for real-time traffic information, warnings about hidden police, and information about how to get around congestion. Drivers provide their location information (on their mobile device) in exchange for information that will enhance their own experiences. So each mobile device sends real time information to the main information hub, which processes all of the data and then sends personalized messages back to every device that is connected.

Table 1: Cloud vs. Cloud Computing.

Cloud	Cloud Computing
High Latency	Low Latency
Servers are within Internet	Servers are on the edge of the network
There is no user-defined security	There is user-defined security
Prone to attack	Safe from attack
Multiple Hops	Single Hop
No location awareness	Location awareness

Cloud computing should be a computing layer closer to the sensor layer, where the sensors and actuators reside and provide computing, networking, and storage services. The nodes in this layer can be deployed anywhere with a network connection close to the smart devices where actual data generation or end outcome takes place; i.e., in a vehicle. To accommodate the services, and address the requirements of IoT systems, this layer offers several advantages. One of the immediate benefits of cloud computing layer over the cloud is its proximity to the sensor layer. Another advantage is the location-awareness which is due to the large-scale geographical distribution of the devices that make up this layer. This will, in turn, offer communication latency. The combined benefits of location-awareness and large-scale geographic distribution support the mobility requirements of devices or "things" at the sensor layer. Also, the close proximity of the layer to the nodes provides real-time interaction with the sensors and actuators in the sensor layer. Cloud computing offers additional security to endure safe and trusted transitions, provides affordable scaling under a shared infrastructure, offers real-time processing and cyber-physical system control, and increasing efficiency by pooling of unused local resources from participating end-user devices. Some differences are shown in Table 1.

With this new proposed architecture, cloud computing can provide computing, networking, and storage services to IoT sensors in biomedicine or other platforms. Consider a system which performs data processing to learn a certain pattern. In this case, the workload can be distributed in such a way that localized patterns can be identified in the cloud computing layer while the generalized patterns are only available in the cloud. This load sharing will increase the computing power of data. The proximity of the layer makes it an ideal way to handle events to react in real-time and enhance the reliability of the system.

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 How to cite this article: Ehsan S. Cloud Computing and Internet of Things in Biomedicine. Curr Trends Biomedical Eng & Biosci. 2018; 11(3): 555813. DOI: 10.19080/CTBEB.2018.11.555813.