

## Big Data using Cloud Computing - Opportunities for Small and Medium-sized Enterprises

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### Abstract

Big Data has been listed as one of the current and future research frontiers by Gartner. Large-sized companies are already investing on and leveraging big data. Small-sized and medium-sized enterprises (SMEs) can also leverage big data to gain a strategic competitive advantage but are often limited by the lack of adequate financial resources to invest on the technology and manpower. Several big data challenges still exist especially in computer architecture that is CPU-heavy but I/O poor. Cloud computing eliminates the need to maintain expensive computing hardware and software. Cloud computing resources and techniques can be leveraged to address the traditional problems associated with fault tolerance and low performance causing bottlenecks to using big data. SMEs can take advantage of cloud computing techniques to avail the advantages of big data without significant investments in technology and manpower. This paper explores the current trends in the area of big data using cloud resources and how SMEs can take advantage of these technological trends. The results of this study will benefit SMEs in identifying and exploring possible opportunities and also understanding the challenges in leveraging big data.

**Keywords:** Big data, cloud, SMEs, technology, trends

### INTRODUCTION

Big data has been listed as one of the current and future research frontiers by Gartner (Chen & Zhang, 2014). Companies, both large and medium-sized as well as small-sized companies can leverage big data to gain a strategic competitive advantage. However, several big data challenges still exist especially in computer architecture that is CPU-heavy but I/O poor (Chen & Zhang, 2014). Cloud computing eliminates the need to maintain expensive computing hardware and software (Hashem et al., 2015). Cloud computing resources and techniques can be leveraged to address the traditional problems associated with fault tolerance and low performance causing bottlenecks to using big data (Chen & Zhang, 2014). According to Assunção et al. (2015), the area of big data using cloud resources is moving at a rapid pace. Small- and Medium-sized businesses (SMEs) often lack the resources to invest significantly on technology needed to leverage big data. SMEs can take advantage of cloud computing techniques to avail the advantages of big data without significant investments in technology and manpower.

## LITERATURE REVIEW

### Big Data

Several definitions of big data exist in the literature. The multi-V model with four V's is often used to describe big data, namely, Volume, Velocity, Variety, and Veracity (Amerland, 2013). Some researchers have added a fifth "V" for Value (Baro, Degoul, Beuscart & Chazard, 2015). Volume is one of the key characteristics of big data as large amounts of data are now available because of which it is nearly impossible to set a threshold for defining the volume of big data. Rainer et al. (2013) provide some statistics to increase the huge volume of data that is produced on a daily basis. According to Rainer et al. (2013), Google was processing more than 24 million petabytes every day, Facebook members uploaded more than 10 million new photos every hour and the number of clicks on the like button totaled to more than 3 billion per day. The current data rate is estimated at 2.5 Exabytes of data every day, with each Exabyte approximately around 1,000,000 Terabytes (Bello-Orgaz, Jung, & Camacho, 2016). The sources of this data varies from a wide range of data sources, including sensors transmitting weather-related data, data generated from social networking sites such as Facebook and Twitter, and sites where digital content is shared such as YouTube (Bello-Orgaz, Jung, & Camacho, 2016).

After volume, variety is the next important characteristic of big data as different data sources make up big data. Big Data encapsulates data from several sources, including the traditional enterprise data, machine-generated sensor data, social data, and data from images captured from billions of devices (Rainer et al., 2014). According to Baro et al. (2015), big data can deviate from traditional structured data and could assume many forms including semistructured data such as XML or unstructured flat files that are not compliant with traditional data formats. The variety dimension also brings forward several challenges related to integrating diverse data sources into a common representation apart from several data cleaning problems as data in different sources is represented in different and incompatible ways (Knoblock & Szekely, 2015).

Velocity refers to not just the frequency at which data is generated but also includes the frequency at which the data is delivered and processed (Baro et al., 2015). Velocity is an important component of big data as customers expect to receive information on demand and expect real time updates in the data (Walker, 2015). According to Bello-Orgaz, Jung and Camacho (2016), some of the challenges related to velocity include the

Introduction of previously stored legacy collection of data and different forms of streamed data from multiple sources. Veracity refers to the level of trust and reliability associated with the data given its source (Assunção et al., 2015). According to Jamil et al. (2015), data veracity has four components, namely, trustworthiness, availability, accountability, and authenticity.

The fifth dimension of big data, value, refers to the monetary worth that employing big data technology can provide to a company. As with any other technology, not every company stands to benefit from deploying a new technology. An in-depth analysis of the benefits of the technology, its relevance, and alignment of deployment of this new technology with the strategic business objectives of the company needs to be conducted. Big data provides the ability to companies to analyze data and have a better understanding of the several key areas, including customer behavior, offer customized services and gain insights into issues to which they had no access before (Assunção et al., 2015). Several instances of failure of new technology initiatives in companies exist which demonstrate that new technologies cannot succeed unless there is a strategic alignment between the business and the technology objectives.

### Cloud Computing

Cloud computing allows the delivery of computing as a service rather than as a product (Kumar, 2013). Companies adopting for cloud computing can benefit from shared resources, software, and information resulting in lower costs and higher availability and scalability. Cloud computing allows on-demand network access to computing resources provided by an outside entity. Cloud computing allows virtualization of resources, including processing, memory, storage, and network with the Web through the internet (Hsieh, Li & Yang, 2013). User applications can run on a virtual machine monitored by the cloud and the users are given access to the computing resources at relatively lower costs along with the flexibility of high scalability (Hsieh et al., 2013).

Cloud computing facilitates providing accessible, modular, and highly customizable solutions (Depeige & Doyencourt, 2015). Some of the key characteristics of cloud computing include agility, device and location independence, high availability, increased peak-load capacity, improved performance, scalability, low cost solutions, and easier maintenance (Depeige & Doyencourt, 2015; Hsieh et al., 2013; Kumar, 2013). Nekvapil (2015) adds additional characteristics of cloud computing include on-demand self-service, broad network access, resource pooling, elasticity, and measured service.

There are three primary cloud computing service models, namely, Software-as-a-Service (SaaS), Infrastructure-as-a-Service (IaaS), and Platform-as-a-Service (PaaS). SaaS allows cloud users to access and execute applications on the cloud infrastructure managed by the cloud provider (Branch, Tjeerdsma, Wilson, Hurley & McConnell, 2014). PaaS allows cloud users to deploy applications on the infrastructure provided and managed by the cloud provider. In all these three service models, the users do not have access to the underlying cloud infrastructure; the access is controlled and managed by the cloud provider (Branch et al., 2014). However, cloud users can be granted the ability to manage the underlying infrastructure of the cloud provider through IaaS. Sharma (2016) suggests that Database-as-a-Service (DBaaS) should be added as another cloud computing service model. Big data using cloud computing could be part of such a service model. Sharma (2016) gives the examples of providers who already use this model such as Amazon RDS and Microsoft Azure. The advantages of DBaaS service model is that it offers a shared and consolidated platform for provisioning database services along with flexibility in scaling back database resources coupled with pay-as-per-use mechanism for using database services.

There are four key cloud computing deployment models, namely, private cloud, community cloud, public cloud, and hybrid cloud (Nekvapil, 2015; Kumar, 2013). Private clouds allow the cloud infrastructure to be deployed exclusively for use by a single organization. Private clouds are suitable for organizations that require highest level of control over security and privacy (Assunção et al., 2015). SMEs would typically not require a private cloud. Private cloud would typically be suitable for large companies that can use this type of cloud infrastructure to share services and data across different departments in the organization.

Community cloud deployment on the other hand allows the cloud infrastructure to be used by a specific community of organizations or consumers sharing common concerns. Community clouds can be viewed as an intermediate form balancing the other two extremes of private and public clouds. Community clouds could be managed and hosted internally or externally by a third party (Kumar, 2013). Public clouds are open for general public and the infrastructure is open for the public. In a public cloud resources are provisioned dynamically to general public on a fine-grained self service basis and service is provided through web services or other alternative forms (Kumar, 2013). Public clouds can be deployed off-site over the Internet and are available to the general public. The advantage of public clouds is that they offer high efficiency and resources at low cost (Assunção et al., 2015). This type of cloud infrastructure could be quite useful for SMEs which often have limitations with budget and manpower. Public clouds could be beneficial for SMEs as the analytics and data management services are offered by the cloud service provider which is also responsible for the quality of service (Assunção et al., 2015).

Hybrid clouds as the name suggests allows a combination of the other three cloud deployment models bound together by proprietary technology allowing application portability. Hybrid clouds could be suitable when private clouds could need certain resources from public clouds. Assunção et al. (2015) give the example of a scenario when customers can develop and deploy analytics using a private environment and in this process benefiting from elasticity and higher degree of security associated with private clouds. This type of infrastructure could be beneficial for medium-sized companies which do not have the same level of scarcity of resources as small-sized companies but at the same time cannot afford investments that large-sized companies can.

### **Big Data using Cloud Computing – Current Trends**

The usage of big data offers companies the unique opportunity to achieve a sustainable competitive strategic advantage provided companies use the right mix of big data analytics to discover relationships and patterns that could not be discovered otherwise. Also, the complexity associated with big data including volume and variety make it quite complex for traditional data processing platforms to process big data (Vajjhala, Strang, & Sun, 2015). However, not all companies can take afford the investments that big data technology requires both in terms of financial and human resources. In such

scenarios, cloud computing provides a robust alternative as the burden of providing and maintaining expensive computer resources shifts to the cloud service providers (Sharma, 2016).

According to Tian and Zhao (2015), cloud computing and big data are complementary to each other and some of the big data problems can be resolved with cloud computing techniques and solutions. Cloud storage offers a robust, distributed, scalable, and fault tolerant infrastructure that can match the processing power associated with parallel and distributed processing models (Sharma, 2016). Assunção et al. (2015) state that cloud computing not only provides infrastructure and tools for big data but could also provide a business model that can be used in big data analytics, for instance either Analytics as a Service (AaaS) or Big Data as a Service (BDaaS). The scalability of clouds is possible because of the virtually unlimited resources in terms of processing power and memory (Krämer & Senner, 2015). The availability of commodity hardware, which include large data centres allows storing of big data and also perform complex computations associated with big data analytics.

Several researchers agree that cloud computing infrastructure can be used for effective big data storage and analytics (Fazio et al., 2015; Hashem et al., 2015; O'Driscoll, Daugelaite & Sleator, 2013; Sharma, 2016). Fazio et al. (2015) state that at an IaaS level, big data can leverage the storage capabilities of clouds and can rely on the computations inside the virtual machine. Hashem et al. (2015) states that big data and cloud computing are conjoined as big data provides the users with ability to use commodity computing to process distributed queries and cloud computing provides the underlying engine through the use of distributed data-processing environments, such as Hadoop. MapReduce is another example of big data processing in a cloud environment. Hadoop is an open source implementation that includes MapReduce and the Hadoop Distributed File System (HDFS) is based on strategy of co-locating data and processing to significantly improve the performance (O'Driscoll et al., 2013). Hadoop is optimized for big data processing using the MapReduce approach.

Hashem et al. (2015) illustrate several cases of how researchers have used cloud computing infrastructure and technology for big data projects. The cases include use of cloud computing in genome informatics and mining Twitter in cloud. Both these cases provide adequate illustration how cloud infrastructure can be used to solve some of the problems associated with complex big data analytics. Diaz et al. (2016) give the example of OpenNebula, an IaaS cloud platform providing an open source solution for management of virtualized data centres with private, public, and hybrid IaaS clouds. OpenStack is another IaaS platform which could also be used for big data analytics using the cloud computing infrastructure.

One of the key bottlenecks associated with the use of cloud computing for big data relates to the issue of rate of data transfer, both in and out of the clouds (O'Driscoll et al., 2013). The data transfer speed associated with networks, especially in developing countries has not advanced at the same rates as processing and data storage capabilities. This difference in networking infrastructure and data transfer capabilities is likely to pose significant problems while using big data with cloud computing infrastructure. Some of other technology-related challenges relate to using technologies such as Hadoop. According to O'Driscoll et al. (2013), programming Hadoop required high level of Java programming expertise apart from the complexities associated with visualizing the big data analytics.

### **Small- and Medium-sized Enterprises (SMEs)**

SMEs form a significant proportion of the number of firms in most countries, for instance in Europe more than 99% of the firms are SMEs (Vajjhala, 2013). SMEs also contribute significantly to the gross domestic product (GDP) and act as sources of innovation and job creation. Although several different definitions of which companies could be categorized as SMEs exist, one of the most commonly referred to definition is the definition stated in the European Union recommendations. According to this definition, companies that have a staff headcount of less than 250 staff members and having either a turnover of less than 50 million Euros or having a balance sheet total of less than 43 million Euros (European Commission, 2016). Small-sized companies on the other hand have a staff turnover of less than 50 members and have either a turnover less than 10 million Euros or a balance sheet total of less than 10 million Euros (European Commission, 2016). Micro-sized companies include companies with a staff headcount less than 10 and either having a turnover or balance sheet total of less than 2 million Euros (European Commission, 2016). Micro-sized enterprises were not considered for this study as their staff headcount and size makes it hard for them to avail advantages of big data using cloud computing, however these enterprises might benefit from big data analytics which could be a direction for future research.

Several researchers have found positive correlation between growth and innovation. According to Love and Roper (2015), SMEs which have previous innovation experience are likely to export more and generate growth from these exports as compared to non-innovating SMEs. Because of their relatively smaller size, SMEs benefit from rapid decision-making, willingness to take risks and flexibility in responding to market opportunities. These advantages balance some of the disadvantages of SMEs, including resource constraints that inhibit the innovation capabilities of SMEs. Some of the enablers for SMEs gaining a strategic competitive advantage and improving their innovation capabilities, include ability to develop unique products and the flexibility in adopting new technology. Lin and Lin (2016) emphasize that the performance of the SMEs depends on how effectively the SMEs utilize the scarce resources and how effectively they utilize their external network relationships with other SMEs and entities.

### **Big Data using Cloud Computing – Opportunities and Challenges for SMEs**

According to Bhat and Quadri (2015), proper analysis of big data combined together with drawing correct correlations can help in innovation, higher productivity, and profitability for companies. An organization intending to adopt big data technologies typically needs to acquire expensive software licenses, deploy expensive infrastructure and have trained and experienced manpower to take use these technologies effectively (Assunção et al., 2015). According to Frizzo-Barker et al. (2016), several digitally-savvy organizations are using big data in several strategic ways, though majority of the large- and medium-sized companies are struggling to integrate big data into their organizational cultures. states three reasons for SMEs to adopt big data technology implementations using cloud computing, including hardware cost reduction, processing cost reduction, and ability to test the value of big data. SMEs with limited resources might find it quite difficult to adopt big data technology implementation in-house. In such situations, cloud computing might allow SMEs to adopt big data as they could benefit from the low cost and reliable cloud computing infrastructure.

Cloud computing allows on-demand network access to computing resources provided by an outside entity (Purcell, 2013). Since computing capacity required for analyzing large data sets varies based on the amount of input data and the type of analysis, this characteristic of big data is ideally suited to the pay-as-you-go cloud computing model, where applications can easily scale up and down based on demand. As requirements change, organizations can easily resize their virtual resources (horizontally or vertically) to meet their demands, in a relatively short amount of time, and without having to wait for additional hardware (AWS, 2016). Finally, cloud providers, such as Amazon<sup>1</sup>, provide a variety of SaaS big data services, helpful in activities from capturing and storing data, to processing and analysing it.

The advent of cloud computing has decreased the costs and resource usage for companies and also allowed them to deploy solutions with flexibility. However, concerns related to cloud computing include challenges associated with privacy, performance, reliability, and data security (Depeige & Doyencourt, 2015; Kumar, 2013). Cloud computing have of late been under the scanner following reports of privacy violations. The cloud computing model is often criticized for allowing possibilities of privacy violations as companies holding the control of cloud services and infrastructure could monitor the communication and data either legally or illegally. SMEs will have weigh the advantages with the potential risks before adopting the cloud infrastructure for big data related storage and analytics.

Security and privacy issues are a key challenge for big data applications using cloud computing. Concerns about lack of trust in the service provider, insufficient knowledge about service level agreements (SLAs), and possibility of attacks on distributed locations are some of the challenges that are hindering the adoption of cloud computing infrastructure (Botta et al., 2016). A key challenge associated with the use of cloud computing infrastructure is fault tolerance dealing with the ability of the cloud to detect and recover without any damage to the final output (Cheraghlou et al., 2016). Some of the practical difficulties associated with cloud computing technology include issues involved with interoperability and portability (Branch et al., 2013). Interoperability between cloud platforms in the context of communication is still an issue as multiple independent APIs that are used for communication between multiple clouds cause barriers in combining the functionality of these multiple clouds (Branch et al., 2013). Yet, in another study (451 Research, 2016), it was concluded that the cloud itself does not represent a major challenge in big-data deployments for the surveyed companies. Instead, difficulties

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<sup>1</sup> <https://aws.amazon.com/big-data/>

encountered in usual on-premises deployments, such as lack of big-data skills, value perception and resistance from owners, were considered as more challenging.

## RESEARCH METHODOLOGY

The aim of this paper is to explore the current trends in the area of big data using cloud resources and how SMEs can take advantage of these technology trends. Bearing this as the central focal point, three research questions were framed to assist in accomplishing this aim:

*RQ1: What are the current trends in the area of big data using cloud computing?*

*RQ2: How can SMEs benefit from using big data using cloud computing?*

*RQ3: What are the technical challenges of using cloud computing in the processes of generation, acquisition, storage, and analytics of big data?*

*RQ3: What are the risks of using big data using cloud computing for SMEs?*

In this study, a comprehensive literature review of big data, cloud computing as well as big data using cloud computing resources has been conducted by searching online computer databases as illustrated in Table 1. Several key databases, including IEEE, Science Direct, Proquest, EBSCO, and ACM Digital libraries were explored. Some of the keywords used for exploring literature to answer the first research question, include “big data using cloud computing”, “current trends in cloud computing”, and “current trends in big data using cloud computing”. Several articles were found illustrating some of the current trends in the area of big data using cloud computing. The search was limited to articles published in 2015 and 2016. Some of the key articles that were cited in this study include the work of Assunção et al. (2015), Tian and Zhao (2015), Hashem et al. (2015), and Díaz et al. (2016).

The second research question involved identifying how SMEs could benefit from using big data technology using cloud computing infrastructure. Articles that were studied to answer this research question included articles identifying the key enablers on how SMEs could innovate and grow. One of the key factors identified during this search was the use of new technologies by SMEs. Several researchers identified the links between use of new technologies and innovation in SMEs. However, resource constraints often inhibit SMEs from investing on new technologies. Cloud computing technology could be a solution in such as case as SMEs can benefit from the low cost solutions offered by cloud providers and also do not have to invest on in-house solutions which are relatively expensive.

The third research question involved identifying the technical challenges of using cloud computing in the processes of generation, acquisition, storage, and analytics of big data. The fourth research question involved identifying factors that could be perceived as potential risks and challenges associated with the use of cloud computing infrastructure for big data problems by SMEs. This research question first involved identifying the risks and challenges associated with the use of cloud computing infrastructure for resolving some of the big data problems. After these factors were identified, the study narrowed down to identifying the key factors that would be applicable from the perspective of SMEs.

Table  
*Summary of Literature by Search Topic and Database*

Search term	ProQuest	EBSCOhost	ACM Library	Digital	Sciencedirect
Cloud computing	2,319	1,837	1,214		1,380
Big data	1,838	1,723	1,249		1,181
Big data using cloud computing	870	679	718		625
SMEs using big data	704	560	434		591
SMEs using cloud computing	715	803	575		325

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Big data using cloud computing challenges	408	410	465	506
Big data using cloud computing opportunities	576	768	342	458

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## DIRECTIONS FOR FUTURE RESEARCH

The focus of this study was on identifying the current trends in the areas of big data using cloud computing and also exploring how SMEs can benefit from using big data using cloud computing. The research methodology involved an extensive study of literature on the key research theme of identifying how SMEs can benefit from adopting big data technologies using cloud computing infrastructure. Researchers could explore further identifying the key managerial and leadership challenges involved in adopting the big data technologies using cloud computing infrastructure. This paper identified the key technical challenges for SMEs in using cloud computing infrastructure in the processes of generation, acquisition, storage, and analytics of big data. Future studies could explore the managerial and leadership aspects involved in such an implementation strategy. Researchers could also explore the extent to which SMEs are currently using big data technologies, and if adoption of big data technologies in SMEs has been successful. Researchers could then identify the factors that contribute to the success or failure of big data initiatives using cloud computing infrastructure in SMEs. Future research could also include case studies identifying individual cases of SMEs which have attempted to implement big data technology using cloud computing infrastructure.

## CONCLUSION

SMEs are the growth engine for most of the economies as they contribute significantly to the employment generation and also form a large chunk of the number of enterprises. The growth of economies depends to a large extent on the growth of SMEs and the growth of the SMEs is dependent on the ability of these enterprises to innovate. A key enabler of innovation in SMEs is the ability of these enterprises to adopt new technologies and use them as a source of innovation. Big data is a key technology that has the potential of helping managers in these enterprises access knowledge through analytics that was not previously available to a large number of companies. However, big data analytics is a complex process demanding experienced staff having knowledge of big data analytics and data science apart from significant investment in big technology-related infrastructure. Resource-constrained SMEs might find it difficult to find the appropriate human resources, in such a case cloud service providers with access to adequate human resources and technology could provide a viable alternative to SMEs seeking to take advantage of the big data technology. Cloud computing provides a robust alternative to SMEs shifting the burden of providing and maintaining expensive infrastructure to cloud service providers. Cloud computing infrastructure and resources provide a unique opportunity for resource-constrained SMEs to leverage big data not only to innovate but also gain a sustainable strategic competitive advantage. A few bottlenecks associated with using cloud computing infrastructure for big data include, the issue of rate of data transfer in and out of the clouds, security issues as the cloud computing provider handles key tasks, and sophistication involved in use of these technologies.

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