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Cloud Computing Enabled Data Center Infrastructure Development and Deployment by IT Firms

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Abstract: Cloud computing has become an active area of research over the last decay to date. It is the collection of inter-networking of computers that are dynamically and seamlessly provisioned as resources based on end-user demand. Presently, researches in cloud computing are mainly based on its architectural framework, utilization of algorithms to manage its computational and storage resource provisioning to end-users, and the integration of cloud with fog computing as well as the Internet of Things. Despite the increasing rate of deploying cloud in various aspect of human endeavor (e.g. health, manufacturing, smart cities, and agriculture, etc.), little or no attention have been given to the Information Technological (IT) industrial firms that develop and deploy cloud data center platforms. Therefore, this research paper aims to investigate the aforementioned issue as part of its contribution to the systematic literature review. Hence, to support researchers who are determined to explore this research area. The main objective of this paper is to systematically identify and analyze the existing IT firms, capable of developing and deploying cloud data center platform to companies and Cloud Service Providers (CSPs) concerning their functionalities, capabilities in terms of the level of expertise and experience. The grounded theory research methodology is adopted to systematically actualize the research aim which is based on five steps namely the background information about cloud computing, collecting useful information from potential IT firm's websites and conducting a semi-structured interview on their personnel. Thereafter, the retrieved information is ordered using the triangulation technique to speed up the analysis phase. Also, current challenges as stated by some IT firm personnel are presented in this research paper and end with concluding remarks.

Keywords: Cloud Data Center Infrastrucure, Grounded Theory Methodology, Triangulation Method, Comparison Determinant

1. INTRODUCTION

Computing is revolutionizing the way humans interact and perform their daily activities at home, offices and business environments. An individual can carry out his responsibilities assigned to him in the office from home. Humans can communicate with friends or business partners dynamically, goods and services can be purchased at any time anywhere across the globe. These activities are possible due to the advancement of high-speed bandwidth network communication and the internet. In the eighties and nineties, the internet is only known for presenting information on web pages, developed mainly with the use of Hyper Test Make-up Language (HTML) codes. Presently, music and video clips can be accessed from the internet, as well as live streaming of conferences and interactions between corporate bodies or individuals. Also, clients can have direct access to the organization's back-end system (Database) for business transactions via the internet.

Computing has drifted away from exorbitant upfront capital intensive purchase of Information Technology Infrastructures (IT) at business sites to the rendering of IT services via the internet, over the last ten years. This is due to the delivering of IT Infrastructure as a service(s) by making the physical system components pervasive to end users while they are being utilized [1]. Also, paving the way for the availability of hardware and software resources "to access, anytime anywhere via the internet" [2]. End users only pay for services based on their opted service utilization on a pay-as-you-go basis [3]. These IT services include access to storage facilities, computational processing power, high-speed network facilities, data and information residing on multiple servers across the globe. Cloud computing provides the enabling environments for these services to be accessed by organizations and individuals. It is deemed to be the latest technology with the potential to transform how the World Wide Web and information systems operate seamlessly for information retrieval [4].

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Previous research works in cloud computing mainly focus on the implementation of algorithms and approaches used for managing cloud resources for efficient and reliable delivery of services to end users. Besides, a significant number of review has been presented by various researchers on Cloud Service Providers (CSPs) and its challenges. This research paper investigates the IT firms that are responsible for the development and deployment of Cloud Data Centre Infrastructure (CDCI) to both cloud providers and private organizations across the globe. Presently, there are very few or limited researches in this area to the best of our knowledge, which motivated the research under study. Our research contributions are listed as follows;

- We investigate and identify the IT firms that specialize in the implementation and deployment of CDCI across the globe.
- We analyzed their capabilities of providing cloud data center infrastructure while highlighting the services they render to the public.
- We ascertain the possible and preferable IT firm(s) that can render and facilitate the development and deployment of CDCI to prospective clients (business organizations and cloud service providers).
- Several research challenges and improvements are presented as stipulated by the IT firms, paving the way for future research directions.

It is imperative to investigate IT firms that can effectively and efficiently develop a robust and workable CDCI. Thus, clients such as cloud providers and private/public organizations will not be at a loss in the short term, due to incessant fault emanating from the newly acquired CDCI services. Therefore, it will enable private organizations and cloud providers to choose a reputable and reliable IT firm that can offer them the desired cloud data center platform, which will be of great benefit on both a short and long-term basis.

The rest of this paper is structured as follows. Section 2 presents a brief discussion on grounded theory methodology, detailing what it entails and how it can be utilized to actualize the research goal under study. Section 3 presents the background information of cloud computing followed by Section 4, detailing how data was collected using online techniques and semi-structured interviews. Section 5 presents data ordering and analysis. Data ordering was done using a triangulation technique to facilitate the analysis of data obtained during the data collection exercise. Also, a detailed analysis of potential IT firms about the cloud services they offer based on the development and deployment phases. Section 6 presents a comparative determinant to determine the most reliable IT firm(s) that has the expertise and potential to implement and deploy CDCI services. A brief discussion on current challenges and concluding remarks are presented in Section 7.

2. GROUNDED THEORY METHODOLOGY

Grounded theory dated back in the 1960s, developed by Barney Glaser and Anselm Strauss in the Chicago school of interactionism. Grounded theory is mainly used by social science students to conduct research. According to [5], graduate students in social sciences were being trained to confirm the ideas of early theorist but not encouraged to generate theory themselves. Hence, it resulted in the delay in obtaining optimal ideas and failure to understand the attributes and diversity of social life. The last decade has witnessed academic researchers and scholars in computer science, adopting the concept of ground theory to conduct research. This is because it inductively derived from the study of the phenomenon that it presents. In other words, "it is discovered, developed, and provisionally verified through systematic data collection, analysis, and theory stand in a reciprocal relationship with each other" [6]. There are five major analytical stages of creating a grounded theory which include literature review or background information, data collection, data ordering, data analysis, and theory comparison.

Grounded theory methodology and its stages will be adopted to actualize the research aim under study. There are three main elements of the grounded theory which are categories, indicators, and concepts. The concept is the basic units of the analysis due to its derivation from conceptualization of data, not the actual data per se, that theory is developed, which cannot be built with actual raw data gathered during the investigation [7]. It means that raw data or information gathered are identified as indicators, which are represented with conceptual labels called concepts. For instance, an interviewee or a respondent may say lack of internet connection and another respondent may say lack of broadband connection. Comparing both responses shows that both phenomena and indicators are the same, and this can be labeled as a "connection barrier", denoting concept. Comparing data or information gathered and naming similar phenomena with the same term enables the theorist to build up the basic units to formulate the theory [8].

The category in grounded theory involves the grouping of putatively similar but not identical concepts under a more abstract heading [5]. This means that category is higher in abstract than the concepts they represent. Hence, a category is the basis for developing a theory as they provide the way by which theory can be formed. This can be illustrated by continuing with the aforementioned example. Also, to the concept labeled as 'connection barrier', the analyst might create other

concepts such as political barrier, economic barrier, and social barrier. During coding, the analyst may notice that these concepts generated are dissimilar in form but seems to represent activities aimed toward a similar process such as barriers of setting up electronic infrastructure in a particular region or country. These concepts can, therefore, be grouped under a more abstract heading, i.e. Category; "challenges preventing the creation of an electronic infrastructure". Indicators which are also called propositions are another element of grounded theory that indicated a generalized relationship between concepts and its category as well as between discrete categories [6]. In a situation where indicators cannot be classified into the concept, they are connected directly to the category.

3. BACKGROUND INFORMATION

Cloud computing was envisioned in the year 1959 by John McCarthy when he noted that there is a need for time-share computers. Enabling the sharing of computing resources between two or more users through the means of multi-tasking and programming at the same time. In the year 1961, he suggested that computers should become a utility similar to telephone services. Thus, led to Douglas Parkhill to base his research on the feasibility of utility computing and thereafter published a book titled, "Challenges of the Computer Utilities" in the year 1966. The outcome of his research stipulated that utility computer cannot be feasible due to the absence of network infrastructures. However, his research outcome was dented in 1995 when Amazon started selling books via the internet [9].

Salesforce.com in the year 1999, provides software services on the World Wide Web (Internet platform) which is only accessible on payment basis. In the year 2004, Google started offering free email services, enabling end users to send messages to their loved ones irrespective of their geographical location across the globe. Thereafter, Amazon introduces the Elastic Cloud Computing (EC2) that allows multiple users to pay and make use of applications dynamically on demand via the internet [10]. That same year Google started rendering their applications to end users such as the GoogleApps with 2-gigabyte free disk space residing on their infrastructure via the internet [11]. In the year 2010, Microsoft started providing a cloud service called Azure, which allows end users to store data, run their applications and host sites. In the following year, IBM introduces a smart cloud which provides services such as email, collaboration and instant messaging, Web Meetings, application for preparing documents and mobile phone platforms.

Cloud computing is a style of computing where scalable and flexible information technology (IT)-related capabilities are provided as a service to the external customer by using internet technologies [12]. In simple words, Information technology resources such as computing power, servers, network communication, storage and applications are provided as cloud services, which are accessible by end-users over the internet. The research work conducted by [13] suggested that cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned with minimal management intervention or service provider interaction. This means that cloud computing provides the flexibility to have efficient access to various computing resources on a pay-as-you-use basis without considering where these resources are located, and the "upfront purchase of an over-provisioned infrastructure" [14].

The Research study in [15], envisages that cloud computing allows for pay-per-use or charge-per-use access to applications, software development, deployment environments, and computing infrastructure. Furthermore, it delivers enhanced and efficient computing through a shared pool of seamlessly scalable resources. The term 'Cloud Computing' refers to the computing paradigm using a virtual private network (VPN) services whose environment is dynamic, reliable, and cost-effective with guaranteed quality of service [16]. It tends to offer effective and efficient computing resources as services that are residing on a private network infrastructure that is affordable and resilient. Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

A. Cloud computing services

Cloud computing offers three basic services that are provisioned by various service providers. Each of these services relies upon one another to actualize their functionalities effectively. Also, they serve different purposes for targeting various end-users, as they share a collective business model. These include Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Application as a Service (PaaS). According to [17], Infrastructure as a service (IaaS) is sub-divided into two main components namely, Compute and resource clouds. Compute cloud offers access to computing resources such as the processing power of multiple servers, hypervisors, and utilities. A hypervisor is a system software used for virtualization to enable multiple operating systems to run simultaneously on a host computer. End users buy the resources, instead of having to set up servers, software, and data center space themselves, thus get billed based on the resources consumed [18].

Platform as a Service (PaaS) provides programming and execution platforms to multiple users across the globe. It enables users to create applications using

programming languages and Application Programming Interface (APIs) supported by the service provider [19]. End users are not permitted to have control over the core cloud infrastructure (e.g. Servers, operating systems, and storage). However, they have the privilege to deploy and to host an application environment for configuration purposes. On the other hand, Software as a Service (SaaS) is "presented as a web-based application interface where services and complete software applications are delivered over the internet and are accessed via a web browser" [1]. It is targeted to end-users which demands the services of applications, such as Google documents and Microsoft word to process information. Other services provided by cloud computing are Collaboration and Consulting services. Collaboration is made up of a set of applications that tends to focus totally on social networking applications such as Whatsapp, Skype, and Facebook. It also provides the enabling platform for collaboration and sharing of ideas from multiple users across the globe. On the other hand, consulting services provide consulting and integration services such as Appirio, Moomi and OpSource [20].

B. Types of Cloud Computing

Four main types of cloud computing are accessible to end-users' demand. These include private, community, public and hybrid cloud. Each of them has its distinct characteristics and how they can be accessed. A private cloud is owned and used by a single organization or institution. Its resources are utilized internally, maintained in-house and solely accessible by internal users within an organization [19]. In the case of a public cloud, the infrastructure and other cloud services are made available to the general public over the internet [1]. Therefore, multiple end users across the globe can gain access to the cloud simultaneously at any time irrespective of their geographical locations. Access to resources on a public cloud is through the internet [21]. The infrastructure is mostly controlled and maintained by CSPs who render cloud services to potential customers by the pay-per-use method.

A community cloud provides cloud computing resources to two or more organizations that have mutual interest. The research conducted in [20] envisages that it provides an infrastructure that is shared by several organizations, supporting a specific community with shared concerns. The infrastructure may be maintained and managed by a participating organization or an external body situated on or off the premises of these organizations. A good example of a community cloud is that of educational cloud that is set up by a group of Academic institutions, for the sharing of academic information resources and conducting experiments. Hybrid Cloud is mainly composed of two or more private, public or community clouds. Though, they remain independent but are confined together by a standardized technique that allows data and application movement such as cloud bursting for load-balancing across the network of clouds [22].

C. Cloud Architectural Model

The data center is the enabler of cloud computing infrastructure. It is made up of storage facilities such as racks of servers, Ethernet switches, routers, and diverse system software ranging from security, network management, distributed to virtualization software. Setting up a data center network architecture is a complex task, therefore requires the expertise that has the technical skills and potentials. This is because application performance and throughput enormously depend on the data center network infrastructure. Also, scalability and reliability features need to be considered when setting up a data center. Presently, the layered approach is proven to be the possible solution for designing a formidable cloud-enabled data center. There are three basic layers involved in the design of data centers which include Core, Aggregation and Access or Fabric. The layers depend on each other to perform their assigned function properly.

The core layer provides connectivity to multiple aggregation switches and provides a resilient routed fabric with no single point of failure [20]. The responsibility of the router(s) is to leverage data traffic that goes out and into the data center. Also, it interconnects the data center network to a wide area network such as the internet. The aggregation layer merges switches, providing information about locations of servers on the network (i.e. servers connected to the specific switch). Also, avoiding overloading by making sure that all servers on the network have a fair share. The fabric layer consists of servers and switches. Ethernet switches are utilized to connect servers for information sharing and communication. Servers connected to a switch is regarded as a network. Furthermore, Distributed software applications are installed on the data center network to enable the provision of cloud services. Also, to enable the high intensive computational task to be executed on the cloud-enabled data center. A distributed software or middleware application called MapReduce was introduced by Google to enable clusters of servers residing in the data center to perform intensive computation tasks. When a task is submitted to the MapReduce, it pushes the task to a master server which splits the task into smaller subtasks and dispatches them to available servers on the same network to execute. The worker servers return the completed task to the master server. The major drawback of MapReduce is that, if the master server crashes, the assigned task will not be executed. Presently, the virtualization middleware application is installed on clusters of servers in the data centers due to the limitation of MapReduce. In virtualization, the computing power or storage space of a

server is divided into sub-sections called virtual machines, enabling the high intensive computational task to be executed. Also, a server can process two or more tasks simultaneously. Peradventure, if the initiated server is unable to process a specific task, it is transferred automatically to another server within the same network on the data center to be executed.

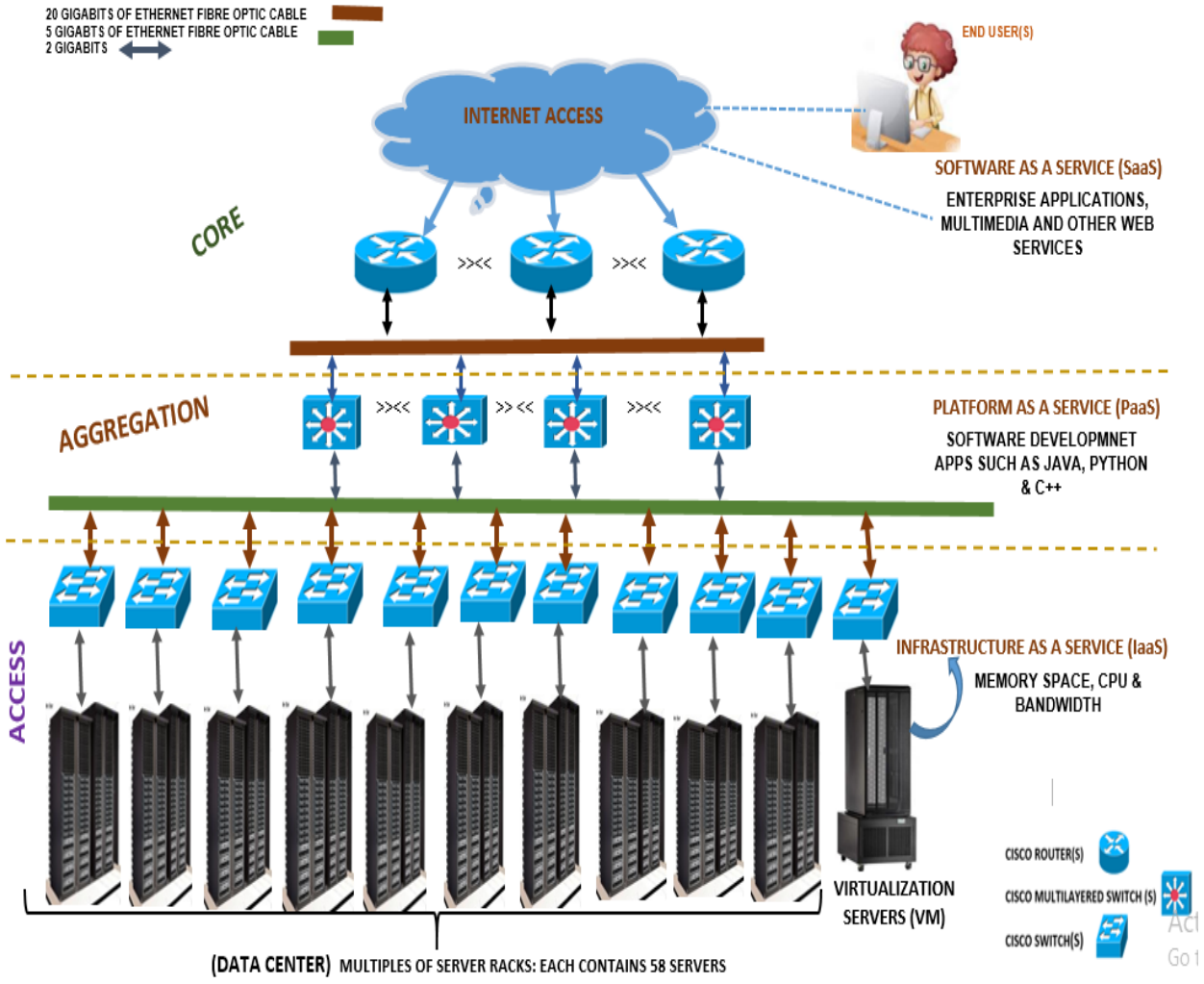

Figure 1. Cloud Computing Architecture

4. DATA GATHERING

Data was collected using an online survey and semi-structured interview via Skype. Google Search Engine was used to search for credible websites belonging to IT Firms across the globe. Seventy IT firms were initially discovered has the search results. After which a phone call was put across to them and they obliged our request for an interview via Skype. Questions were fed to them in regards to the cloud services they offer to the general public concerning cloud data center development and deployment. Most responses retrieved from the IT Firm personnel tally with the information on their websites.

Table 1. DATA COLLECTION

S/N	SHOWING IT FIRM NAME, NUMBER OF BRANCHES AND PARTNERS			
	IT Firm Name	**Facts Information**	**No. of Branch Offices across the Globe**	**No. of Partners Across the Globe**
1	Redapt	Assist organizations to configure and build their data centers. Other services include Cloud-Native Architecture, DevOps Tooling, Data Storage, Computer Performance and Networking.	1	41
2	Riverbed	Provides application solutions for IaaS, SaaS, and PaaS on cloud dater center. Other services include, Application Migration, Optimize Application Performance, Speed Application Development, and Simplify Network Build-out.	30	4
3	LogicOne	Expertise includes Network Infrastructure, Storage & Data Management, Data Centre Virtualization, Desktop Virtualization, Unified Communications & Collaboration, Application Development, Hybrid Cloud Computing, and Data Centre Infrastructure.	7	7
4	Netcon Technologies	Cloud Data Centre Services includes Data Centre Design, Migration & Revamping of Data centre, Data centre energy audits, Data centre certification, Turnkey implementation and Cloud implementation.	1	9
5	RagingWire	Services and solutions include designing and implementing dedicated entrances, access controls, and electrical panels, fabricate custom cages for multi-rack deployment, network design, cable management planning, and installation.	25	
6	CISCO	Specializes in building secure hybrid clouds and data center infrastructure. Also the provision of applications such as Data Centre Network Manager (DCNM) and Dynamic Fabric Automation (DFA) etc.	79	13
7	IBM	Specializes in building secure hybrid clouds and data center infrastructure. Also the provision of applications such as Data Centre Network Manager (DCNM) and Dynamic Fabric Automation (DFA) etc.	212	97
8	Akamai Technologies	Specializes in Datacenter networking applications, ensuring reliability and security. Applications packages on offer include internet Transport Optimization, SaaS & Cloud Acceleration, Secure Web Gateway, Network Onramps, Cloud Management, and Orchestration.	28	22
9	Schneider Electric	Provides physical infrastructure such as uninterrupted power, cooling networking facilities on-premise, Data Centre Software, Prefabricated Data Centre Modules, Security and Environmental Monitoring Surge Protection.	105	78
10	Panduit	Facilitate the development of cloud-enabled data centers, providing components such as Cabling Systems, Fabre optics, Power Distribution, environment monitoring, wire routing, protection and insulation, racks and enclosures, cable routing and pathways and datacentre management software.	1	14
11	Corning	Provides facilities for data center development such as Cabinets, cable, connectors indoor Preterminated System, fiber optics, outdoor preterminated systems, racks & racks mounted housings, broadband coaxial connectors, microwave connectivity.	27	27
12	Intel Corporation	They Manufacture communication network infrastructure facilities such as the gigabit server adapters, controllers, switches, Servers, Wireless software such as Intel data center manager for the configuration of Cloud-enabled Data Centre Infrastructure.	65	4
13	Vmware	Implemented Datacenter Virtualization and cloud infrastructure Products such as server virtualization software and recovery manager software.	22	17

Table 1. Shows the name of IT Firms considered for this research together with the services they renders with respect to the development and deployment of CDCI and their branch offices as well as their business partners across the globe.

A thorough screening was done on information obtained from each IT Firm's website as well as during the interview session. Hence, to ascertain their credibility and relevance in regards to the research goal. This was actualized by sampling the number of branch offices owned across the globe by each IT firm, which symbolizes their relevance in the market and the volume of the audience (clients) that patronizes their services. Resulting in further scaling down the number of IT firms to thirteen. The data obtained from each selected IT firm's website were arranged in a tabular form. As depicted in table 1.

5. DATA ORDERING AND ANALYSIS

This section describes how the information retrieved during data gathering exercise is ordered using the triangulation technique to facilitate and speed up analysis.

A. Triangulation Technique

Indicators were generated from data obtained and grouped to form concepts, which are analyzed qualitatively as the key outcomes of our investigation. Thus, leading to the actualization of the category (theory-IT firms that specializes in the design, implementation, configuration, installation and deployment of Cloud-enabled Data Centre). Keywords from data gathering were used as indicators and were grouped according to their similarities.

According to [5], category involves the grouping of putatively similar but not identical concepts, while concepts involve the grouping of putatively similar but identical indicators. See Figure 2 for more insight into how the data ordering technique was actualized. In a nutshell, the utilization of the triangulation technique is very important as it denotes the entire structure of the methodology, showing how its components (Indicators and concepts and categories) are inter-related to form the new theory. IT firms are indicated as concepts in this research because they are the major objectives investigated, leading to the research goal. Therefore, information gathered about each IT firm was tagged as indicators, showing their features and services they render in the proliferation and deployment of CDCI. The triangle technique is a bottom-up approach in the form of a conventional triangular shape.

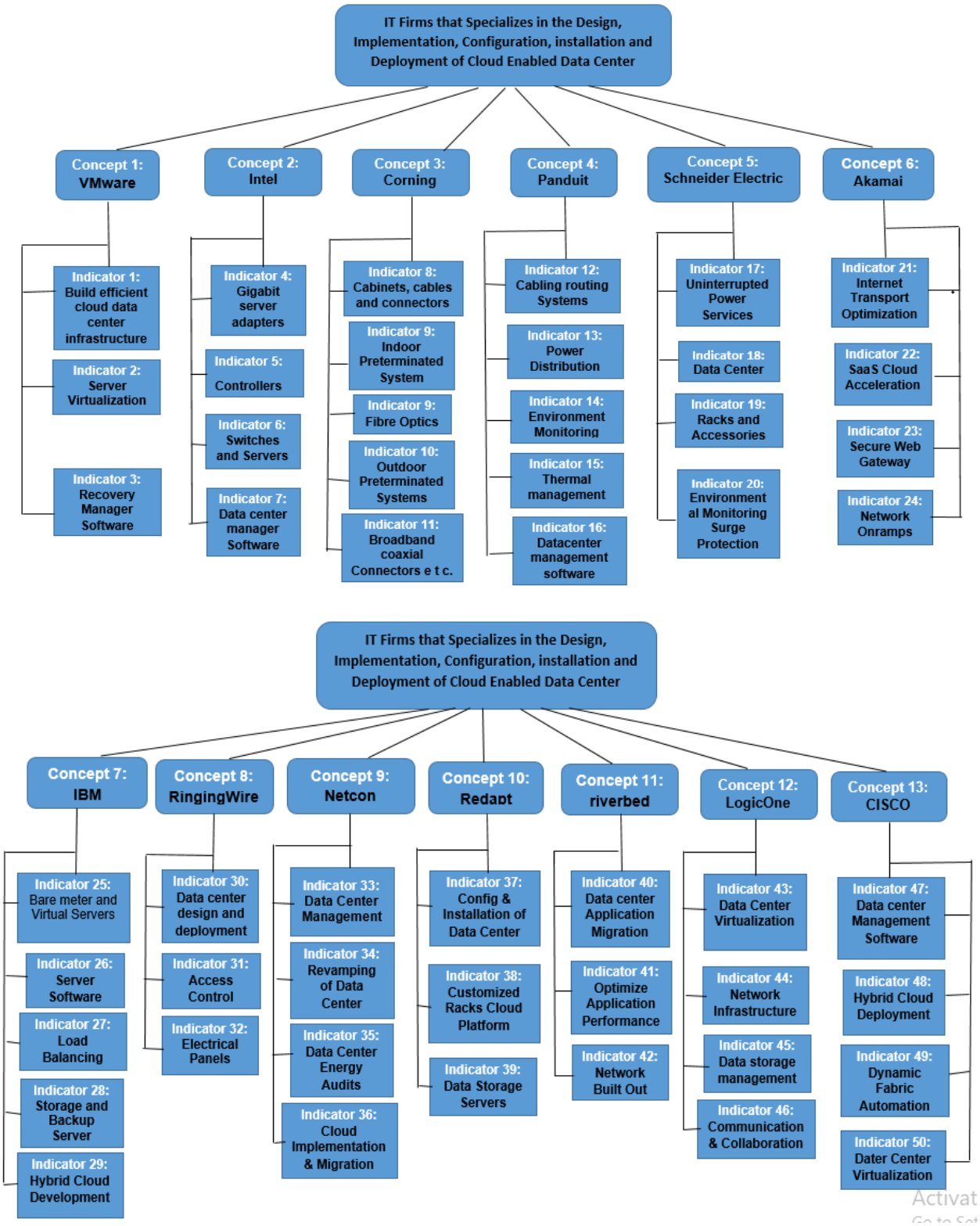

Figure 2. Triangulation Ordering Technique

Investigation shows that there are significant IT firms that implement cloud data center infrastructures, for CSPs and business organizations across the globe. Most of them are into the development of hardware components such as servers, cabling (fiber optic and twisted pair), routers, cooling units, and switches. While others are into the implementation of distributed management and security system software as well as enabling the virtualization of a cloud data center. The investigation also shows that some of the IT firms that produce both hardware and software components embark on the installation and configuration of cloud data centers for CSPs and business organizations.

Redapt is an IT firm that deals with System integration and cloud adoption services. It was established in the year 1996 by Rick Cantu and David Cantu, based in the United States of America [23]. Its major responsibility is to help organizations configure and develop their data center. Hardware such as servers, routers, switches, and network bandwidth are configured as well as applications to run the cloud. Redapt also confides in prospective clients on what they intend to actualize in their data center and make an order for necessary components from hardware vendors and alike. After this, they embark on setting up the components into customized racks. Other operations of Redapt include Configuring and developing a cloud-native architecture, development of operations tooling, data storage, compute performance and network deployment.

Riverbed Technology is another IT firm that specializes in applications that run on the data centers for performance enhancement by discovering, troubleshooting, and resolving cloud virtualization issues effectively and efficiently. It was founded in the year 2002 by Jerry Kennelly, based in Francisco, United States of America [24]. Investigation shows that Riverbed Technology implements a tool called APM/NPM that can monitor the performance of applications, databases, middleware, servers, and networks that make up the data center. It also develops cloud-based applications to meet the demand of end-users and enabling organizations to achieve their business objectives. Also, it builds seamless network connectivity across the data center enterprise and public cloud.

LogicOne assists private and public organizations to adopt data center infrastructure. It was established in the year 1992 by Kevin Hall. The firm is based in Kittery, United States of America. Its major responsibilities are to design and render services to optimize existing cloud data center performance. They also handle complete virtualization processes of cloud data centers and the deployment of sophisticated system software technologies "to help keep businesses competitive in the modern cloud era" [25]. They also assist companies in "building converged Infrastructure solutions that combined compute storage and networking into a single module with unified management capabilities" [25]. Other services which it renders to organizations include the design and implementation of hybrid cloud computing, network infrastructure, storage and data management, desktop virtualization, unified communications, and collaboration.

Netcon Technologies is another IT firm that provides solutions to organizations in realizing the implementation of the data center. It was founded in 2007 by Mahalingam Ramasamy, based in Nava, India. It specializes in the design and implementation of data centers for small to national or multi-international organizations. They also provide an end-to-end data center to build solutions from civil to advanced software-defined and cloud IT [26]. Their data center implementation services include data center design, data center project management, migration, revamping of the data center, data center energy audits, data center certification and turnkey implementation of the data center services.

RagingWire IT firm is responsible for the design and construction of customized cages for multi-rack deployment. Established in the year 2000 and co-founded by Douglas S. Adam. The firm develops and manages racks including the latest color-coded racks, and design data centers with the capability of eight to ten-foot racks [27]. Furthermore, it is involved in network design and cable management planning as well as installations. Other services include dedicated vaults and private suites, custom cages, cabinets, and backup services.

Cisco Devnet is a formidable IT firm that is highly involved in the implementation of data center infrastructure components. It was established in the year 1984, by Sandy Lerner and Leonard Bosack, based in the United States of America. It has offices in seventy-nine countries across the globe. They are mostly in the implementation of secured hybrid clouds for prospective organizations. Hence, enabling the organizations to connect and extend their private cloud to CSPs platforms such as Amazon and Microsoft Azure. It newly developed Intercloud Fabric (data center), enables CSPs to efficiently offer hybrid cloud without building or adding their own Application Programming Interface (API). Thus, it integrates with the CSPs environment, enabling on-boarding of workloads from the enterprise to the CSPs cloud. Furthermore, the Cisco Datacentre Network Manager (DCNM) is a system management software, which is developed to monitor and troubleshoot the data center network infrastructure [28]. It monitors data traffic through routers and switches to the storage database on the data center. Dynamic Fabric Automation (DFA) system software is also implemented to enhance network efficiency and flexibility. Furthermore, it optimizes data center infrastructure by providing

automation across the virtual and physical environment of the data center.

IBM is another well-known IT firm in the world that is into the deployment of IT products such as Hardware and Software components. Founded in the year 1911, by Charles Ranlett Flint, based in New York, United States of America. It has offices and branches in well over two hundred countries in the world. IBM specializes in the development of hardware for setting up data centers for CSPs and organizations. Hardware includes bare meter servers, virtual servers, powerful servers, and server software. Also, the provision of networking capabilities such as load balancing, Network appliances and content delivery in the data center. IBM also provides a storage file, storage server Backup as well as security components such as firewalls and security virtualization. Presently, IBM develops and deploys a hybrid cloud called Bluemix to CSPs and business organizations [29].

Akamai Technologies is an IT firm that provides networking capabilities for data center infrastructure. It was established in the year 1996 and co-founded by Dr, Tom Leighton, and Danny Lewin. Headquartered in Cambridge Ma, United States of America, having branch offices in twenty-eight countries. Akamai Networking software platform ensures application and network high performance based on security and reliability. It enables CSPs or vendors to upgrade their existing services to hybrid networking requirements. It has a feature that monitors routers for the optimization of forwarding error correction to ensure reliability and high-throughput packet distribution over the internet. It also provides the "Cloud Management Orchestration Application Programming Interfaces (APIs) framework for rapid service provisioning, real-time visibility, technical support integration and all aspects of building workflow" [30].

Schneider Electric is another IT firm that provides physical infrastructure for setting up a data center. It was established in the year 1836 by the Schneiders brothers in Creusot, France. It started fortifying its positions in the provisioning of critical power and smart grid applications as well as software provisioning in the year 2010. It facilitates the development and deployment of power, cooling networking facilities for data centers on-premise. It also models data center modules, developing racks and tools for "environmental monitoring surge protection and power conditioning, as well as providing an uninterrupted power supply for data centers" [31].

Panduit IT firm assists in the development of cloud-enabled data centers for hybrid, public and private cloud infrastructure. It was founded in 1995 by Jack E. Caveney. Headquartered in Illinois, United States of America. It specializes in the provisioning of cabling systems such as fiber optics, power distribution, and environmental monitoring. Also, the provisioning of wire routing, protection, and insulation, cabinets, thermal management, racks and enclosures, cabling routing & pathways and data center management software [32].

Corning is another IT firm that specializes in the installation of data center components. It was founded by Wendell P. Weeks, in the past 165 years. They facilitate the efficient installation of data center components for organizations that want to adopt or upgrade their existing IT infrastructure into cloud infrastructure. Components such as "cabinets, cables, connectors, indoor terminated system, fiber optics, outdoor preterminated systems, racks, and racks mounted housings, broadband coaxial connectors and microwave connectivity" [33], are provided to facilitate the development of data centers.

Intel Corporation has been in the lead, pioneering the growth of data center development. It was co-founded by Robert Noyce and Gordon Moore in 1968. They are into the production of communication network infrastructure components. These components include gigabit servers adapters, controllers switches, servers, wireless software such as Intel data center manager. The data center management software suite, reduces operational costs, thereby optimizing the monitoring and absolute control of remote management design [34]. Intel recently alerts the public about their newly invented world's first hybrid silicon photonics. Its function is to enable future data center bandwidth by enhancing network speed from the present hundred gigabit (100G) to four hundred gigabits (400G).

Vmware is also into the manufacturing of IT components that aids the setting up of data centers for cloud infrastructure purposes. Its branch offices span over twenty-two countries across the globe. It was co-founded by Dr. Daine Greene, Dr. Mendal Rosenblum, Scott Devine, Dr. Edward Wang, and Edouard Bugnion. Its main area of specialization is the provisioning of data center and cloud infrastructure virtualization. Products produced for the facilitation of data center virtualization include server virtualization software and recovery manager software. Also, in the production of cloud infrastructures software-defined services such as policy-based self-service provisioning and automated management [35].

C. Exclusion/Inclusion of IT firms provisioning of CDCI

Some of the IT companies that provide CDCI which are excluded from the study has limited relevance and minimum patronage across the globe. This is due to their limited branch offices and network partners across the world. Most of them have just one or two branch offices with no network partners across the globe. While some of them only have few branch offices locally in their respective country of origin. However, excluding them from our current research study limits their chances to be recognized globally. Thus, clients are denied having

information about their potentials in rendering CDCI. On the other hand, some of the IT firms included in the current study, may not be well-regarded IT companies that provide CDCI. Notwithstanding, they were selected due to the level of relevance and high patronage from the general public, in regards to the number of branch offices and network partners they have at present. IT firms in this category provide some or all the system components required, with limited expertise in the implementation and deployment of CDCI. The limitation is that clients who intend to set up CDCI may spend more capital (money) and also likely to experience a delay in service delivery. This is because some IT firms in this category always present themselves as a consultant to the clients, by contacting an IT firm that is involved in the development and deployment of CDCI. A conflicting interest may arise, as the former (IT firm consultant) would like to provide the entire system components at a rate which may not go down well with the letter (actual IT firm). Thus, will slow down the pace in the implementation and the deployment of CDCI.

6. COMPARISON DETERMINANT

A comparative determinant was carried out on IT firms to predict their potential, in the development and delivery of cloud data center infrastructure. It was achieved using the mathematical formula below;

$$C_{(I1...Ii)} = (B_{(n1\ldots Nn)}/P_{(x1\ldots xx)}) * 100 \quad (1)$$

The symbol C indicates firm name while its subscript (I_1….Ii) represent the number of firms under consideration. The symbol B indicates branch offices located in different countries across the globe that belongs to a particular IT firm, while its subscripts (n_1…N_n) represent the total number of branch offices owned by a firm. That of the P symbol is used to represent the partners of a specific IT firm across the globe while its subscript indicates the total number of partners. Figure 3 depicts the number of branch offices owned by each IT firm across the globe, while the number of IT firm partners across the globe is denoted in figure 4.

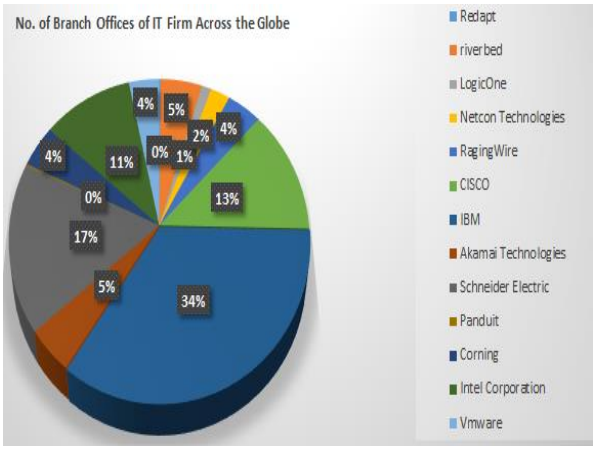

Figure 3. Depicting the No. of Branch offices owned by an IT firm

Figure 4: Denote the No. of IT firm's business Partners Globally

The utilization of the mathematical formula shows that Riverbed Technologies has the highest impact factor which is graphically represented in figure 5. It indicates that Riverbed Technologies has an edge over other IT firms to develop and deploy reliable CDCI to CSPs and organizations. However, Riverbed Technologies relies on its partners such as SAS, SAP, Cloudera, and Vmware to provide optimal CDCI development solutions just has other IT firms do.

The fact that reverbed Technologies has the highest impact factor in our research, does not render other IT firm incompetent in the development and deployment of CDCI. It only stipulates that riverbed has the cutting edge over its competitors in the delivery CDCI services. However, information gathered during the investigation shows that Redapt and LogicOne IT firms possess the technical expertise in configuring and installation of the cloud data center at the organization's premises.

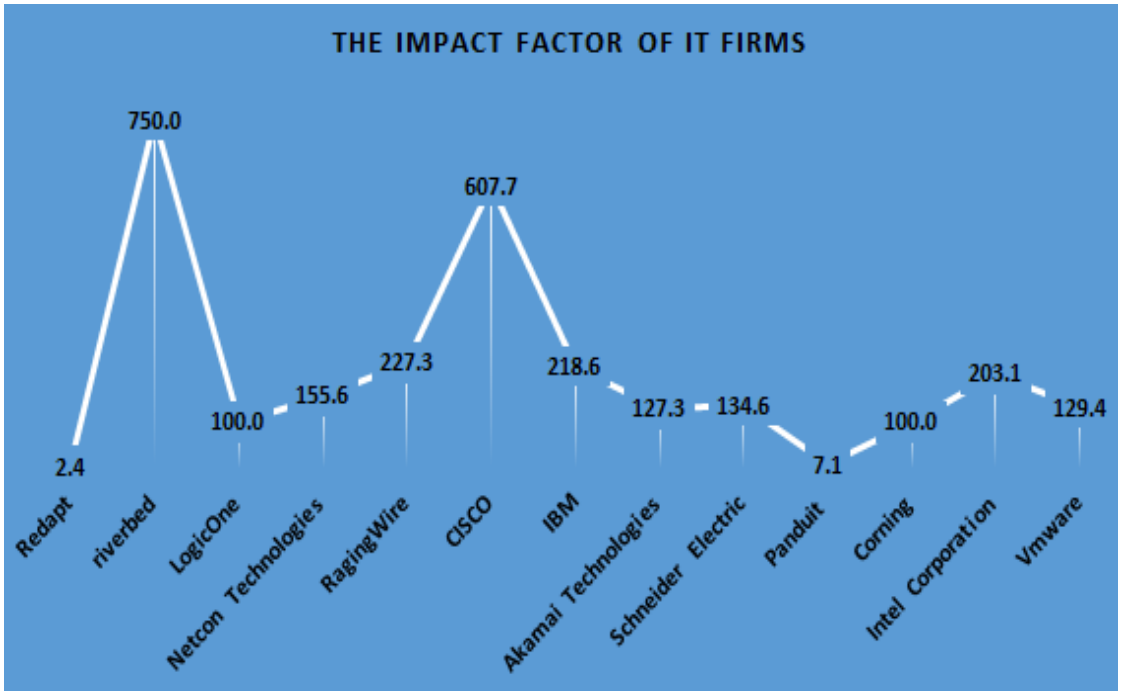

Figure 5: Comparative determinant Impact Factor for each IT Firm

But they do not manufacture the hardware components such as cooling units, servers, and racks, needed for the installation and configuration. IT firms such as Cisco, Intel, and Schneider have the technicality to manufacture Hardware and Software components in the realization of CDCI. Others are involved in the manufacturing of hardware and software components as well as delivery, configuration, and installation services to prospective CSPs and organizations.

A. The Limitations/Assumption of the Impact Factor

The impact factor of each IT firms under consideration was achieved by utilizing the mathematical expression as indicated in equation 1. We assume that the weighting values of branch offices and the network partners vary over time. Also, the number of branch offices owned and the number of network partners across the globe determines their relevance and patronage from clients. However, the weighting values of branch offices and network partners for each IT company (as indicated in table 1) are subject to change in the future. This may be due to inconsistency in the delivery of effective and efficient services, as well as conflicting business interests with their respective network partners.

B. The Implications of Impact Factor on Future CDCI

IT firms who only deals with the manufacturing of the CDCI system components will be compelled in the future to venture into its deployment. Deployment phase involves the configuration and installation of the system components at the premises of potential business organizations. Also, for maintenance and troubleshooting of existing CDCI at organization premise. This will enhance their level of relevance and attract more clients across the globe. On the other hand, IT firms who are restricted to the deployment of the CDCI service will be tempted to venture into the manufacturing of its system components. Thus, to reduce system components purchasing cost and speed up the deployment process of the CDCI to meet the stipulated deadline. This will give them the cutting edge over their contemporaries in the development and deployment of CDCI infrastructure across the globe in the future.

It will also compel IT firms that are presently operating locally in the development and deployment of CDCI, to strategize on how best to render effective and efficient service beyond their current boundaries. Thus, to gain more relevance and patronage across the globe in the future. One crucial strategy is to partner with other reputable IT firms that are globally recognized and to set up modalities to resolve any unforeseen conflicting business interests with their partners. Consequently, it will enable potential business organizations who intend to set up a Cloud infrastructure, to evaluate the services of the IT firms based on their relevance and competency. Given them the choice of IT firm that can eventually develop and deploy CDCI effectively and efficiently, to suits their business needs at an affordable cost.

C. Recommendations

Organizations that intend to embark on the adoption of cloud data center infrastructure should do a thorough feasibility study. Thus, to determine if the value to be achieved in setting up cloud infrastructure is more than the cost of setting it up. The outcome of the feasibility study will influence management decision to either adopt or not to embark on the adoption of cloud data center infrastructure. However, if the decision is to adopt, IT firms that manufacture Hardware and software components, as well as having the technical expertise at their disposal in configuring and installation is recommended. Thus, private organizations and CSPs have the opportunity to make a good bargain regarding the cost of adoption and technical support during and after adoption. However, the IT firms depicted in this research article has the technical expertise and the capacity to develop and deploy cloud data center infrastructure to prospective CSPs and private organizations.

7. FUTURE CHALLENGES AND CONCLUDING REMARK

The future challenges are listed as follows;

- According to riverbed technologies, legacy networks are an obstacle to the successful development and deployment of CDCI in the business premise. However, they tend to improve their services in the future by implementing SD-WAN. A survey carried out by riverbed shows that about 98% agreed that in the next two years, SD-WAN will be important to the next-generation networks. Thus, providing the enabling resources to manage cloud and hybrid networks. The complexity of managing multiple cloud services from different cloud providers is another imminent challenge as cited in [33].

- Cisco envisages launching the development of Mid-Band Spectrum for speeding up network communication, to be released for commercial use in the next two years [36].

- Akamai technologies stipulated that third-party access to private cloud networks is a challenging security issue that needs to be addressed. RagingWire IT firm tends to render data center colocation pricing in their future work. A platform that will enable clients to compare services render by multiple cloud providers before they signup.

In conclusion, investigation shows that numerous IT firms develop and deploy CDCI across the globe. However, business organizations are posed with the challenges of choosing the preferable IT firm that can render the aforementioned services to suit their business objectives at an affordable cost. In this article, we present background information on cloud computing, detailing its emergence, the types of cloud platforms and the services it has in the offer, as well as architectural design, depicting the various system components of cloud computing. Followed by a brief discussion on ground theory methodology, deployed to actualize the research under study. Therefore, the outcome of the research shows that seventy IT firms have the potential in the development and deployment of CDCI. Out of which thirteen of them were selected based on the magnitude of their market (services) coverage and relevance, by the number of branch offices and partners they possess across the globe. Thus, to alleviate the challenges of making the right choice of IT firm when considering setting up CDCI. Furthermore, Riverbird IT firm happens to have the highest impact factor than other IT firms as depicted in this research. Because it is not only involved in the development and deployment of CDCI but also manufacture its system components. The current challenges and future improvements have stipulated by the IT firms are briefly discussed in this article, which paves the way for future research directions.

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