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BCube and DCell Topology Data Center Infrastructures Performance

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Abstract. Data Center (DC) quality is if it can provide optimal service. Optimal service means that the access provided should be free from interference. Interference can come from outside the system or from within the system itself. One of the variables used to measure the performance of data center architecture is a routing protocol. Routing Information Protocol is a variable to measure performance on BCube and DCell topologies. Testing is done using a simulator that can produce information architecture that has the best performance when communicating from the server to the client. BCube is a server-centric network structure, while DCell is a recursively defined architecture. This study was conducted to compare the two data center topologies with experimental methods. The results show that DCell has a better speed in data transmission. However, when viewed from the side of security and integrity of BCube delivery much better, this is because BCube is able to send data completely without any failure or inhibition in the delivery.

1. Introduction

One of the phenomena that occurred in the era of information technology is the growth of data is very significant. This happens since the possibility of the process of convergence of media information, so that impact on the development and increase the volume and type of data continuously. Start data that only in the form of text, image data in the form of images or photos, then data in the form of video, up to the data derived sensing system. These conditions then encourage the emergence of terminology in the world of Information Technology (IT) is today known as big data.

The data center can provide the organizational capability and support to operate at all times and as needed. Information technology resources that can be covered in the data center include mainframes, web servers, application servers, file servers, print servers, messaging servers, application software, operating systems, storage, and network infrastructure[2]. Applications stored in the data center can be internal or external. Network-based applications can include IP telephony, video streaming, IP video conferencing, and so on [6].

Currently, many data center infrastructure architectures have been developed, among them are: the canonical tree, folded Clos tree, DCell, and BCube. Canonical tree and folded Clos tree is a conventional data center infrastructure architecture, while DCell and BCube is a modern infrastructure architecture [14]. To measure the performance of the two data center architectures which one is better. So researchers analyze between BCube and DCell to see from the data delivery side, which is faster between the two. So that researchers can get better results to use BCube or DCell. The purpose of this study is to determine the performance of data rates between BCube and DCell in which data delivery is better used with the help of RIP routing. Routers are used in networks based on TCP/IP protocol technology, to extend from LAN network to WAN and MAN networks. An example of a LAN network by a router is expanded into an internet-based network [9].

Routing is the process of selecting a path that a packet takes on a computer network to send network traffic. In this routing process, a network is represented as a weighted graph where each interconnection between points within a network has a certain weight or value. These values can be bandwidth, network delay, hop count, path cost, load, reliability, and communication costs. Each router must find the route with the lowest cost [3]. RIP (Routing Information Protocol) is a dynamic routing protocol. RIP is included in protocols with distance-vector routing algorithms (calculated based on the shortest distance between nodes) [8]. Distance vector is a very simple algorithm, where iteration continues until there is no information exchange between routers until iteration stops by itself) [13]. Routing Information Protocol (RIP) is a distance vector protocol that uses a jump count in its measurement. After updating the routing table, the router will immediately start updating the transmission to all network routers. This update is completely independent of regular updates[13].

2. Literature Review

2.1. Data Center

A Data Center is central storage, both physical and virtual for storage media, management, and scattering of data and information organized around a particular body of knowledge or pertaining to a particular business. For example, the National Climatic Data Center (NCDC) is a common data center that takes care of the world's largest archive of weather information [15]. Location determination for the data center requires that the location be expandable. A data center can occupy one room of a building, one or more floors, or entire building [15]. Location considerations are the most important requirements that must be met to anticipate the ever-increasing need for IT, especially hardware increments. In TIA Standard 942 it is required that the data center location is free from the interference of electronic equipment that may cause electromagnetic interference [11].

Data Center which literally means the data center is a facility to place computer system and related equipment, such as data communication system and data storage. Based on the type of service, generally the development of data center are grouped into two, namely: (1) internet data center (internet data center), only to support applications related to the internet, (2) business data center, to support all the functions that allow various business models to run on internet services, intranets or both. Therefore, the information required is handled by a system capable of managing data well, both storage capacity, data security, network infrastructure and information recovery system [4]. The relationship between the data center with the research to be conducted is the researchers will measure the speed of data transfer on the data center topology that is BCube and DCell.

2.2. Data CenterArchitectures

Mathematics The data center is a facility to place the computer system and related components [6]. The Data Center Architecture of a data is currently capable of handling up to 100,000 hosts with approximately 70% of execution of communications executed internally. This presents a challenge in designing the architecture of the interconnection network and its communication protocol. At the data center scale, conventional architecture often occurs due to physical bottleneck and cost limits of network devices used. Specifically, the availability of 10 Gigabit Ethernet components can overcome the limitations as it offers greater capacity but is still too expensive. The data center architecture itself widely used today is the three-tier architecture. This architecture consists of layers (1) access, (2) aggregation, (3) cores. Some data centers exist that still use the two-tier architecture where the two-tier computing server architecture (S) is arranged into the rack form a tier-one network. In a tier-two network, switches in Layer-3 (L3) provide full mesh connectivity using 10 GE links. In the next development with the availability of a link with a capacity of 100 GE, the three-tiered data center architecture is developed, which is basically the same as the three-tier architecture, but its link capacity is ten times that of the three-tier architecture for the link capacity between core and aggregation to 100 GE, between aggregation and access to 10 GE while between access with 1 GE fixed server. The biggest challenge that arises in the data center is the rising cost of consumption for power. As Filani explains in his paper, in the last decade the cost of power and data center cooling has increased by 400% and the trend will continue to increase. In some cases, power consumption accounts for 40-50% of the total operating costs of the data center [5].

2.3. BCube and DCell

BCube is a server-centric network structure. There are two types of devices that make up the BCube-server structure with multiple network ports and mini-switches connecting servers on different layers, server-centric network structures, where servers with multiple network ports connect to multiple layers of COTS mini switches (off-the-shelf). Servers in DCell have multiple ports each server connected with one mini-switch and with many other servers via link communication. DCell is the basic building block for building a larger DCell [10]. of research data were analyzed by using Rasch models [17], which used the Winstep Version 3.72 software [18]. In addition, network psychometrics analysis was performed using JASP Version 0.8.6.0 [19]. Research data can be accessed in open source through the Open Science Framework [20].

Asghari et al (2016) they conducted research on virtualization networks that enabled computing networks and data center providers (DCs) to manage their network resources flexibly by using software that runs on a physical computer [1]. In this paper, they discussed the problem of classical DC network topologies in virtual environments and investigated a set of DC topology networks with the ability to provide dynamic structures according to the level of service required by active traffic in virtual DC networks. In his study, Asghari et al (2016) proposed three main approaches to modify BCube's classic a topological structure as a topological benchmark, and investigate the structural and maximum features associated with an interconnected bandwidth that can be achieved for different routing scenarios [1]. Finally, they run an extensive simulation program to examine the performance of a modified topology proposed in a simulated environment that takes into consideration analysis failures and also traffic congestion. These simulated experiments were tailored to their research objective of demonstrating the proposed modified topology efficiency compared to the classical BCube in terms of bandwidth availability and failure of endurance. The results derived from the study of Vahid et al., Are Horizontal and BCube-Hybrid Topologies provide good performance, even in some cases, Horizontal-BCube has shown slightly better performance. If viewed from the flexibility Hybrid-BCube provides a better topology. So it can be concluded that this topology is the first choice in designing the physical layer of the DC network [12].

Guo et al also conducted a study related to BCube which is about a new network architecture for the delivery of modular data center-based containers (MDCs) [7]. By installing a small number of network ports on each server and using COTS motion as crossbars, and placing serverside routing intelligence, BCube forms a server-centric architecture. In his study showed that BCube significantly accelerates the one to traffic patterns and provides high network capacity. The BSR routing protocol further allows graceful performance decline and meets the specific requirements of MDCs.

Similar research on Bcube and DCell is also done by Fung Po Tso et al. They do research in server-centric DC architecture, the servers are both end-hosts and delivery nodes for the most representative multi-hop communication [16]. Both BCube and DCell come with custom routing protocols to make use of the topological properties. A high-level DCell is built from low-level DCells (DCellk, k 0) recursively. DCell0 is a building block for building larger DCells. It has server n and mini-switch and all servers in DCell0 are connected to mini-switch. And then DCell1 is built using n + 1 DCell0. In DCell1, each DCell0 is connected to all other DCell0 with one link. This procedure is repeated to create higher-level DCells. By comparison, BCube on n server is connected to the port switch. BCube1 consists of n BCube0 and n-port switches. Name BCube a server in a BCube using array1 address. If the address of the two array servers is different from one digit means that two servers connected to the same level will switch digit. The prominent competitive advantage of server-centric architecture is manageability because the entire DC fabric is built from the server and a minimal set of network switches. Architecture, intelligence can be placed on the server to implement services in the network such as traffic aggregation, caching as well as in-package inspection and so forth. However, server-centric architectures are essentially different from traditional network designs and so are not trusted or complex to update. In promoting server-centric architectures, they must offer significant competitive advantages including outstanding in overall cost reductions increased security and resilience.

3. Research Methodology

This research uses the experimental method with the following steps in Figure 2 below. This study begins by preparing the equipment used for the BCube and DCell topology. Equipment used among them Management Switch and Server. The second phase is to install the equipment used. Installation is done on the Server in the form of an operating system and configuration of each test equipment. An overview of BCube and DCell topology testing can be seen in Figure 1.

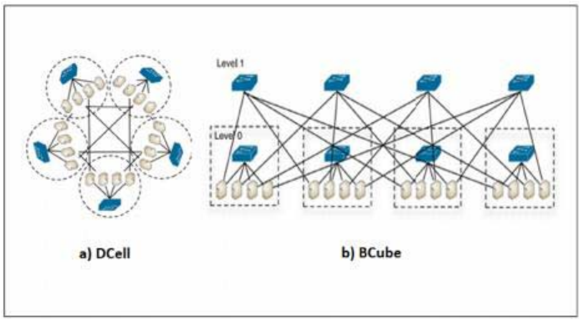

Figure 1. Topology Test of DCell and BCube

After all the equipment is installed and configured, the following stages are comparing the performance of BCube and DCell topology using Routing Information Protocol as a test variable. Speed in the process of routing and data transfer in topology to the parameter used to determine the best topology. The end of this experiment is done by recording each measurement result and providing recommendations for each test.

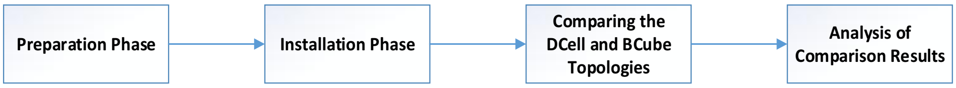

Figure 2. Experiment Research Phase

4. Results and discussion
Measurement is performed on all servers from Topology BCube and DCell. The test results of data transfer on BCube and DCell topology by using Routing Information Protocol as routing can be seen as follows:

4.1. Result of Measurement on BCube Topology
The result of data center infrastructure performance measurement using BCube topology is shown in table 1. Measurement results show that trials are performed with different ports and switches with the same delivery capacities. The test results show that speed performance in data transfer has a different time. The best and fastest performance when transferring data is on switch 3 and server 4 on F0/0. Server 4 F0/0 in Switch 3 to PC 0 with delivery capacities 5571584 bytes get result 17,087 bytes/sec and takes time 74.712 secs to complete data delivery. Test results for all servers are shown in table 1.

The results of measurements made on the BCube topology show that the fastest performance of the entire server is on the switch 4 switch server 3 on F0/0, it can be proved by the time required to complete the data transfer and the amount of data capacity capable of sending to the PC. The occurrence of speed performance in data transmission is because of the relationship between the server and the PC does not require many switches that must be passed, so it affects the data delivery ow nets. The distance between the server and the PC is what affects the speed difference in data transmission. The closer the PC and server are, the faster the data is sent.

Table 1. Results of BCube Topology Measurement on Server 0-7

Switch	Server	Capability	Speed Transfer
Switch1	Server 0 F0/0	210.731 secs	6058 byte/sec
Switch0	Server 0 F1/0	227.245 secs	5617 byte/sec
Switch1	Server 1 F0/0	78.174 secs	16.982 byte/sec

Switch2	Server 1 F1/0	78.224 secs	16.315 byte/sec
Switch1	Server 2 F0/0	96.402 secs	13.242 byte/sec
Switch4	Server 2 F1/0	80.143 secs	15.929 byte/sec
Switch1	Server 3 F0/0	77.091 secs	16.538 byte/sec
Switch6	Server 3 F1/0	78.614 secs	16.239 byte/sec
Switch3	Server 4 F0/0	74.712 secs	17.087 byte/sec
Switch0	Server 4 F1/0	76.161 secs	16.762 byte/sec
Switch3	Server 5 F0/0	80.143 secs	15.929 byte/sec
Switch2	Server 5 F1/0	78.621 secs	16.237 byte/sec
Switch3	Server 6 F0/0	76.921 secs	16.596 byte/sec
Switch4	Server 6 F1/0	78.169 secs	16.331 byte/sec
Switch3	Server 7 F0/0	79.166 secs	16.125 byte/sec
Switch6	Server 7 F1/0	80.358 secs	15.886 byte/sec

4.2. Result of Measurement on DCell Topology
The results of measuring the performance of data center infrastructure using DCell topology are shown in Table 2 The measurements are performed with different switches and servers with the same shipping capacities. The test results show that speed performance in data transfer has a different time. The best performance and fast when transferring data is on server 0 switches 0 on F0/0 because the switch has a closer distance to the server. The data transfer rate from Server 0 F0/0 in Switch 0 to PC 0 with 5571584 bytes delivery capability gets 18,018 bytes/secs and takes 70,851 secs to complete the data transmission. The overall measurement results are shown in Table 2.

Table 2. Results of DCell Topology Measurement on Server 0-7

Switch	**Server**	**Capability**	**Speed Transfer**
Switch0	Server 0 F0/0	70.851 secs	918.018 bytes/sec
Switch0	Server 2 F1/0	74.076 secs	17.233 bytes/sec
Switch0	Server 3 F0/0	74.904 secs	17.403 bytes/sec
Switch0	Server 4 F1/0	76.078 secs	16.780 bytes/sec
Switch1	Server 5 F0/0	70.809 secs	18.029 bytes/sec
Switch1	Server 6 F1/0	74.379 secs	17.168 bytes/sec
Switch1	Server 7 F0/0	75.049 secs	17.045 bytes/sec
Switch1	Server 8 F1/0	76.025 secs	16.742 bytes/sec
Switch2	Server 9 F0/0	71.203 secs	17.929 bytes/sec
Switch2	Server 10 F1/0	73.665 secs	17.330 bytes/sec
Switch2	Server 11 F0/0	74.647 secs	17.102 bytes/sec
Switch2	Server 12 F1/0	75.082 secs	17.002 bytes/sec
Switch4	Server 13 F0/0	73.976 secs	17.257 bytes/sec
Switch4	Server 14 F1/0	73.564 secs	17.353 bytes/sec
Switch4	Server 15 F0/0	72.393 secs	17.634 bytes/sec
Switch4	Server 16 F1/0	101.063 secs	12.631 bytes/sec
Switch3	Server 17 F0/0	70.525 secs	18.101 bytes/sec
Switch3	Server 18 F1/0	73.817 secs	17.294 bytes/sec
Switch3	Server 19 F0/0	77.098 secs	16.558 bytes/sec
Switch3	Server 20 F1/0	75.885 secs	16.823 bytes/sec

DCell measurements were performed using 2 ports ie F0/0 and F1/0, but the researchers only succeeded on F0/0. The researcher analyzes that failure on F1/0 because F1/0 is used as the default port to forward traffic to the outside network otherwise it is used as a subnet. Default gateway configuration on the port is not significant because F1/0 is only able to distribute data but can not transfer data.

4.3. Comparition of Performance BCube and DCell Topology

The performance comparison of Bcube and DCell topologies is shown in table 3 and table 4. The results of the measurements can be seen as follows:

Table 3 describes the experiments with different data capacities. The test is done by taking the farthest distance from the switch 1 server 0 F0/0 to PC 0. Delivery capacity 33551768 get 3354 bytes/sec results with time 1051.34 secs. The data transfer capacity of 16599160 gets result5765 bytes/sec with 644,177 secs. While the shipping capacities 3117390 get 19223 bytes/sec with 162,165 secs. With the above results, shows that the amount of data capacity affects the speed of transferring data.

Table 3. Results of BCube Topology Measurement on Server with Data Capacity

Switch	**Server**	**Data Capacity**	**Capability**	**Speed Transfer**
Switch1	Server 0 F0/0	33551768	1051.34 secs	3354 bytes/sec
Switch1	Server 0 F0/0	16599160	644.177 secs	5765 bytes/sec
Switch1	Server 0 F0/0	3117390	162.165 secs	19223 bytes/sec

Table 4. Results of DCell Topology Measurement on Server with Data Capacity

Switch	Server	Data Capacity	Capability	Speed Transfer
Switch4	Server 15 F0/0	33551768	814.074 secs	4328 bytes/sec
Switch4	Server 15 F0/0	16599160	394.076 secs	9425 bytes/sec
Switch4	Server 15 F0/0	3117390	70.568 secs	44174 bytes/sec

Table 4 describes experiments with different data capacities. The test is done by taking the farthest distance from the 4 server switch 15 F0/0 to the PC 0. The shipping capacity 33551768 gets 4328 bytes/sec with 814,074 secs. The data transfer capacity of 16599160 gets 9425 bytes/sec with 394,076 secs. While the shipping capacities 3117390 get 44174 bytes/sec results with time to 70,568 secs. With the results above, shows that the amount of data capacity affects the speed of transferring data.

From the Test Topology, BCube and DCell above make a comparison chart as in Figure 3. From the graph above it is concluded that DCell performance is better than BCube. DCell is more capable of sending data faster because of the relationship between the distance between the server and the PC is not too far away or it can be said that the passing switch to transmit data is not too much so that DCell is faster in data delivery than Bcube which has many switches and routes passed to transmit data on the PC even further so that data transmission is longer.

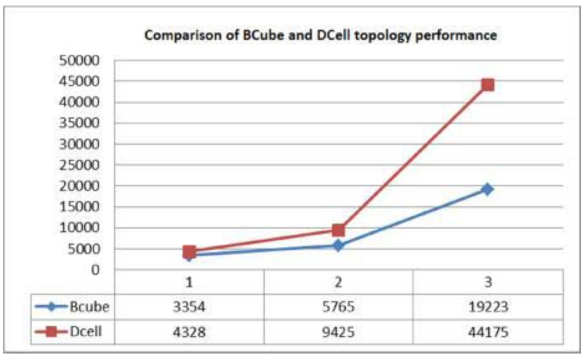

Figure 3. Comparison of BCube and DCell Topology Performance

5. Conclusion
From the research that has been done can be concluded that the speed of data transfer between BCube and DCell shows DCell better and faster in transferring data from server to PC. This can happen because, in terms of relationship and distance DCell has a direct relationship between PC and Server, whereas, in BCube other than the distance PC with server enough to have a long-distance, the relationship between the PC with the Server must go through many switches. However, if you want to see in terms of integrity in data transmission then BCube much better. BCube is better able to send data completely without any failure.

6. References
[1] Asghari, V., Moghaddam, R.F. and Cheriet, M., 2016. Performance analysis of modified BCube topologies for virtualized data center networks. Computer Communications, 96, pp.52-61.
[2] Al-Fares, M., Loukissas, A. and Vahdat, A., 2008, August. A scalable, commodity data center network architecture. In ACM SIGCOMM Computer Communication Review (Vol. 38, No. 4, pp. 63-74). ACM.
[3] Abu-Libdeh, H., Costa, P., Rowstron, A., O'Shea, G. and Donnelly, A., 2010. Symbiotic routing in future data centers. ACM SIGCOMM Computer Communication Review, 40(4), pp.51-62.
[4] Ebrahimi, K., Jones, G.F. and Fleischer, A.S., 2014. A review of data center cooling technology, operating conditions, and the corresponding low-grade waste heat recovery opportunities. Renewable and Sustainable Energy Reviews, 31, pp.622-638.
[5] Filani, D., He, J., Gao, S., Rajappa, M., Kumar, A., Shah, P. and Nagappan, R., 2008. Dynamic data center power management: Trends, issues, and solutions. Intel Technology Journal, 12(1).
[6] Greenberg, A., Lahiri, P., Maltz, D.A., Patel, P. and Sengupta, S., 2008, August. Towards a next-generation data center architecture: scalability and commoditization. In Proceedings of the ACM workshop on Programmable routers for extensible services of tomorrow (pp. 57-62). ACM.
[7] Guo, C., Lu, G., Li, D., Wu, H., Zhang, X., Shi, Y., Tian, C., Zhang, Y. and Lu, S., 2009. BCube: a high performance, server-centric network architecture for modular data centers. ACM SIGCOMM Computer Communication Review, 39(4), pp.63-74.
[8] Hedrick, C.L., 1988. Routing information protocol (No. RFC 1058).
[9] Irwansyah, E. and Moniaga, J.V., 2014. Pengantar Teknologi Informasi. deePublish.
[10] Junhao, Y. and Aili, L., 2012, June. Research on the application of virtualization technology in high performance computing. In Electrical & Electronics Engineering (EEESYM), 2012 IEEE Symposium on (pp. 386-388). IEEE.
[11] Krone, A.D.C., 2008. Tia-942: Data center standards overview. ADC Telecommunications, Berlin.
[12] Kappagantula, S.K., 2018. Virtualization of Data Centers: Case Study on Server Virtualization.
[13] Marina, M.K. and Das, S.R., 2001, November. On demand multipath distance vector routing in ad hoc networks. In Network Protocols, 2001. Ninth International Conference on (pp. 14-23). IEEE.
[14] Tso, F.P., Jouet, S. and Pezaros, D.P., 2016. Network and server resource management strategies for data center infrastructures: A survey. Computer Networks, 106, pp.209-225.
[15] Telecommunication Industry Association. Standards and Technology Dept, 2005. Telecommunications Infrastructure Standard for Data Centers. Telecommunication Industry Association.