A Novel Structure and Route Algorithm for hybrid DCN Network Based on ExCCC-DCN

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二等奖

Abstract

With the rapid development of data center network (DCN) technology, researchers have cleverly combined wireless connection and wired DCN to form a new structure, hybrid data center network (HDCN). Exchanged Cube-Connected Cycles (ExCCC) has high scalability and relatively low construction cost and operation energy consumption, which is very suitable for the deployment of large-scale data center. In this paper a novel hybrid ExCCC-DCN structure is proposed by combining the communication characteristics of 60GHz millimeter-wave technology. The transformed hybrid network not only inherits the original structural characteristics of ExCCC-DCN structure, but also effectively reduces the network data traffic and improves the network throughput. We divide the hybrid ExCCC-DCN into several units (pods), and propose a new cluster-based multicast routing algorithm. Comparative experiments prove that the algorithm can effectively reduce the number of multicast links and improve the data throughput during multicast communication when constructing a multicast tree.

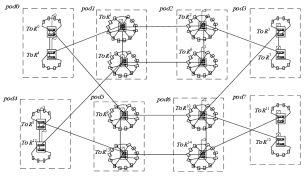
Introduction

Our focus is on wireless technologies suitable for use in data centers. Such technologies should first have a high data transmission rate to meet the huge data flow in the data center, then be stable and reliable to ensure the normal operation of the data center, and finally, the cost should not be too high for large-scale application. Combining these characteristics, researchers began to pay attention on millimeter wave communication technology. Currently, there are two kinds of millimeter wave communication technology that attract the most attention, one is 5G cellular mobile communication technology, the other is 60GHz millimeter wave technology. And 60 GHz millimeter wave technology in a long period of time are not widely used, this is mainly for two reasons: one is the most scenarios people reach so high to the requirement of network speed, the second is due to 60 GHz millimeter-wave wavelength is only 5 mm, its diffraction ability is very weak, so as long as there is a wall block signals will not the past. However, 60GHz millimeter-wave is very suitable for the data center, because the data flow in the data center is very large, and the ultra-high transmission rate of 60GHz millimeter-wave can make the best use of everything. Secondly, in the data center, we can use beam shaping technology to make the signal directional transmission in a very small angle. In this way, as long as there is no obstacle in the transmission direction with a small Angle, the normal communication of 60GHz MMW can be ensured. With beamforming technology, we can use the cheap angular antenna to send and receive wireless signals. Therefore, In this paper, 60GHz millimeter wave technology will be used for hybrid transformation of ExCCC-DCN.

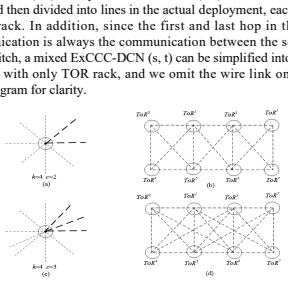
Hybrid EXCCC-DCN topology

Since all the servers in ExCCC-DCN are connected to the edge parallel to cycle-edge, we consider to put the switches in each cycle into a Rack when we mix ExCCC-DCN. Such a Rack is called TOR(Top of Rack).Then using the three dimension hierarchies beam informs technology to 60GHz millimeter wave antenna is installed in the top of the rack, and the antenna can adjust its direction and angle in 3D space, similarly equipped with antenna frame can set up a wireless connection within the scope of the communication each other, considering the effective 60GHz millimeter wave communication distance of only 10 m, R = 10 m. In this way, the wireless coverage within the communication range R can be realized.

We preliminary get a mixed ExCCC-DCN model, but in order to facilitate the deployment and performance analysis, we will modified hybrid ExCCC-DCN divided into k units (pod), and define the distance between the frame within the same cell of no more than 10 m, and the distance between the adjacent cells on the horizontal and vertical direction is not more than 10 m, after a mixed ExCCC-DCN (1, 2) as shown in Fig. 1.



As can be seen from Fig. 1, the hybrid ExCCC-DCN (1,2) is divided into 8 units, and these units are evenly arranged in two lines, plus each unit has two TOR racks, so the whole hybrid ExCCC-DCN (1,2) in the actual deployment can be divided into 4 lines, 4 TOR racks per line. In fact, since the hybrid structure inherits the structural features of ExCCC-DCN (s, t), the hybrid ExCCC-DCN (s, t) can be divided into k cells, and then divided into lines in the actual deployment, each line has a TOR rack. In addition, since the first and last hop in the actual communication is always the communication between the server and TOR switch, a mixed ExCCC-DCN (s, t) can be simplified into an array diagram with only TOR rack, and we omit the wire link on the rack array diagram for clarity.



For example, in Fig. 2, if the server in the upper left corner of ExCCC-DCN (1,2) wants to communicate with the server in the lower right corner, then one possible path to communicate completely according to the wired link is: source node—1000;0—1001;0—1001;1—1011;1—1011;2—1111;2—1111;0—1110;0—1110;1—0110;1—destination node. However, this path can be shortened immediately by establishing a wireless connection. The new path can be: source node —TOR0—TOR9—TOR10—TOR15—destination node. If the source node wants to send 10MB of data to the destination node, then the entire routing process forwards 100MB of data through the first path of communication, while only 50MB of data is forwarded through the second path of communication. This reduces network traffic by 50% and effectively reduces congestion. We call this traffic reduction caused by wireless communication wireless gain .

Hybrid ExCCC-DCN multicast routing algorithm

/* Input: S=ToR_{src},D={ToR^{i}_{recv}}, G_r ,G_w */
/* Output: Multicast tree Tc */

1 $H=[S \cup D]$, $T_c^w=\varnothing$, $M=\varnothing$;
2 Divide H into connected clusters;
3 For each connected cluster H_i of H do;
4 T_i =minimum spanning tree of H_i;
5 $T_c^w=T_c^w \cup T_i$;
6 Select $v_j \in T_i$;
7 $M=M \cup \{v_j\}$;
8 Build a multicast tree T_c in $G_r^{new}[M]$ via ESM;
9 $T_C=T_c^w \cup T_c^r$;

Analysis of hybrid ExCCC-DCN experimental results

In this section, the performance of Cluster algorithm will be analyzed through simulation experiment, which is carried out under 64-bit Windows 10 with the help of Java and MATLAB. In ExCCC-DCN (4, 5), there are 5632 switches and 61,952 servers. Meanwhile, in order to test the performance of Cluster algorithm, the experiment firstly generates 10 multicast group, Then it is compared with ESM algorithm under uniform distribution and power law distribution.

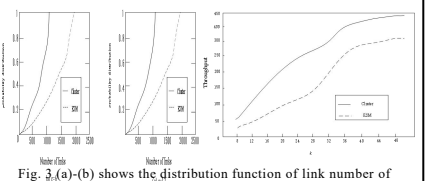


Fig. 3. (a)-(b) shows the distribution function of link number of multicast tree constructed by Cluster algorithm and ESM algorithm under the uniform distribution of ExCCC-DCN(4,5). It can be seen that the multicast tree constructed by Cluster algorithm effectively reduces the number of links and has shorter routing hop number, indicating that this algorithm has better multicast performance under the same network environment.

It can be seen from Fig. 3 that the average throughput of the multicast tree constructed by Cluster algorithm in a multicast group of the same size is always higher than that of the ESM algorithm, indicating that the Cluster algorithm effectively improves the wireless gain of 60GHz millimeter-wave, which is in line with the expected goal of this section.

Conclusion

In this paper, a data center network based on ExCCC-DCN hybrid is designed, and a data center with both wired and wireless links is formed by installing a 60GHz millimeter-wave antenna on the top of the rack of each cycled edge connected switch. Thus, the throughput of the network is further improved and the data flow of the network is effectively reduced. Then a multicast routing algorithm based on cluster is designed, and the wireless gain analysis of the algorithm when building multicast trees with hybrid ExCCC-DCN is given from the mathematical point of view. Finally, the performance of the multicast algorithm in reducing the number of links in the multicast tree and improving the throughput of the network is analyzed experimentally.

Main references

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