Final Report for Project 3: Wireless Technologies In Data Center Networks

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June 21, 2014

1. Background

When we think of data center,we can imagine a scenery where there are many cables and hot machines surrounding us,which makes us feel dizzy!

Traditional data center networks (DCN) is like the picture below.

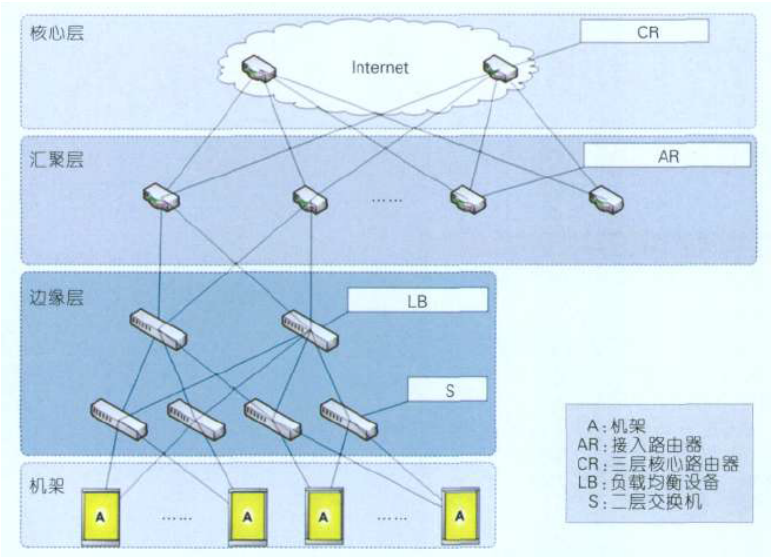

Figure 1: structure of traditional DCN

It has three layers:the core layer, the aggregation layer, the edge layer. In every layer,there are many switches connecting each other. The computer severs are connected with the edge layer,as you can see from the picture.

Many efforts have been made in the research of performance of DCN. In traditional DCN, some routes in the whole system is quite busy, which means that the route from one switch to another switch is hot. Below is a picture showing the distribution of hot routes in the system.The darker the point is, the busier the route gets. We can see that,as a result of those hot points, the performance of the system is limited.

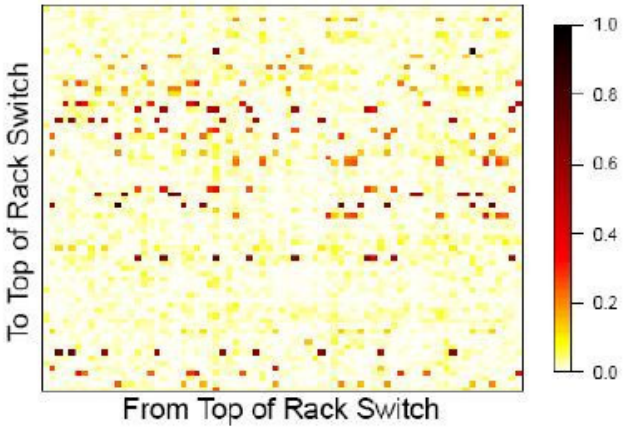

Figure 2: distribution of hot routes

Comparing to wireless technologies, wired DCN have many disadvantages.There are many cables in the data center,costing too much space in the rooms. We may spend more money and more energy purchasing and managing the system. Whats more, when something terrible happens abruptly, its hard to manage and adjust the system.

2. DCN with wireless technology

It comes naturally that, we ought to take wireless technologies into consideration. Wireless technologies have faster transmission speed,and it costs less energy. In addition, wireless facilities can be changed and managed quickly and conveniently than wired ones.

When considering the wireless technologies, 60 Ghz is involved. It has high directivity. 99.9% beam is concentrated in the range of 4.7 degrees. It has high transmission rate. Enough bandwidth makes its speed goes beyond 1 Gbps. The radius of it spreading is short. Wireless signals fade rapidly because the oxygen atom absorbs this band. As a result, the transmission range is about 10 m.

We can put 10 servers (dark blue) in a row and put the rows like the picture in Figure 3.

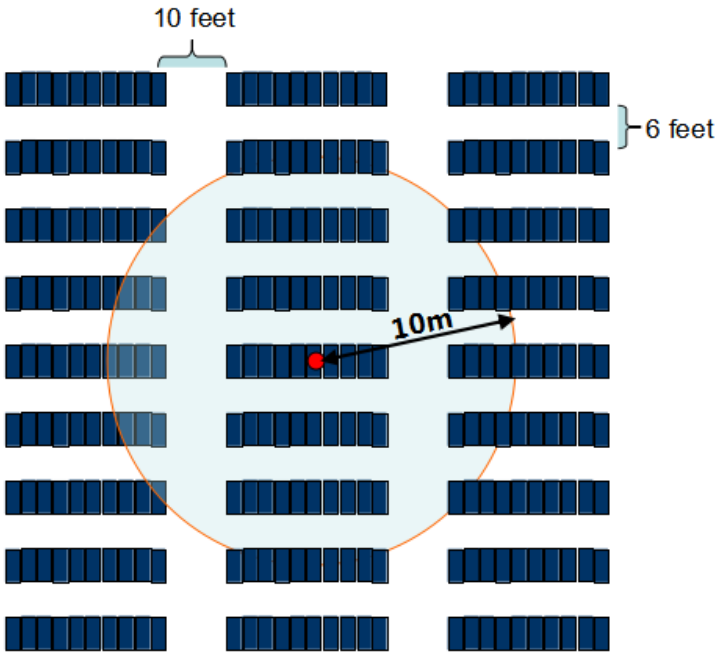

Figure 3: signal propagation if 10 servers in a row

we can see that, the signal from a server goes through 10 meters and can cover 17 rows of servers. It seems enough for our common use.

When we are applying wireless technologies in the DCN, beam forming and directional antenna cant be ignored. When we send signals from one rack to another rack, we want the signal to transmit in a line directly to the target rack in a certain direction. So we can use a kind of small directional antenna .

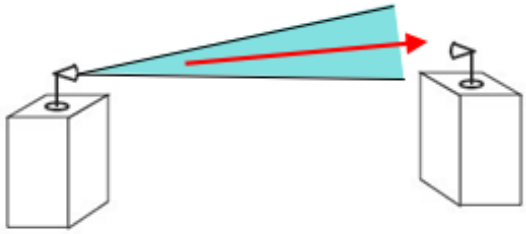

Figure 4:signal transmitted in a certain direction

Several years ago, some professional researchers proposed that, if we want to build a fully-wireless DCN, the rack must be designed like a cylindrical in Figure 5.

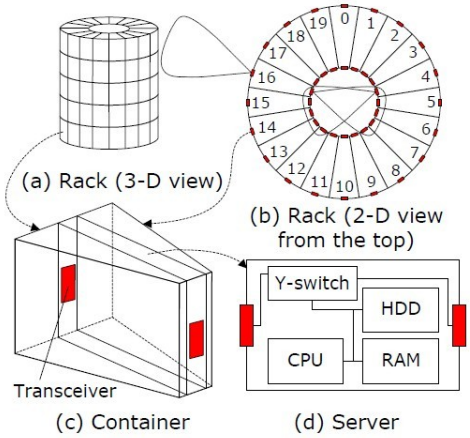

Figure 5: fully-wireless DCN designed by researchers

It may be a little hard for us to study, so we just pay attention to some details.

Referring to the Figure 6, previously,if we want to transmit signals from rack 1 to rack 3, we firstly need to transmit the signal to rack 2 and use the other antenna on rack 2 to transfer the signal to rack 3. Its speed is limited so it is time-consuming.

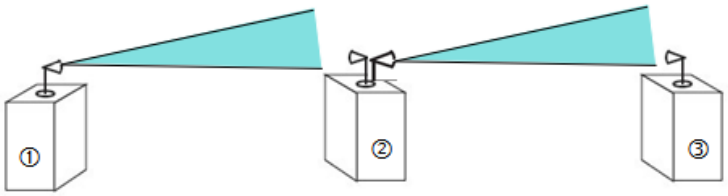

Figure 6: signal transmission between three racks

To overcome the problem of being time consuming, we can use the ceiling to reflect the signal.Please refer to the figure below.

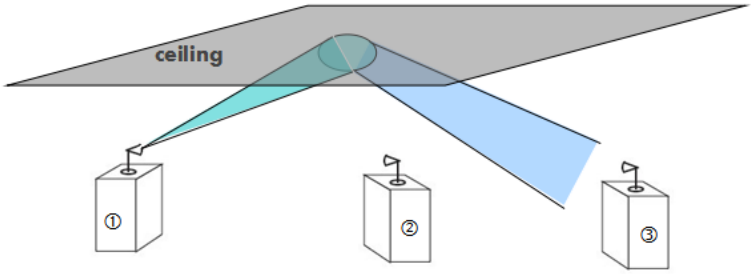

Figure 7: using the ceiling to reflect signals

We can send the signal from rack 1 to the ceiling above the machines and the signal will be reflected to rack 3. This idea costs less and its faster.

Now assume that, we have a data center structure like Figure 8. It is too time-consuming if we want to transmit signals from rack 1 to rack 4 rack by rack. Actually we can put some small rectangular boards (like that in this picture) on the racks. We just send the signal to the second board and the board will reflect the signal to rack 4,finishing the task. This idea can save much time and improve the performance. Anyway, these schemes perform better than wired data center.

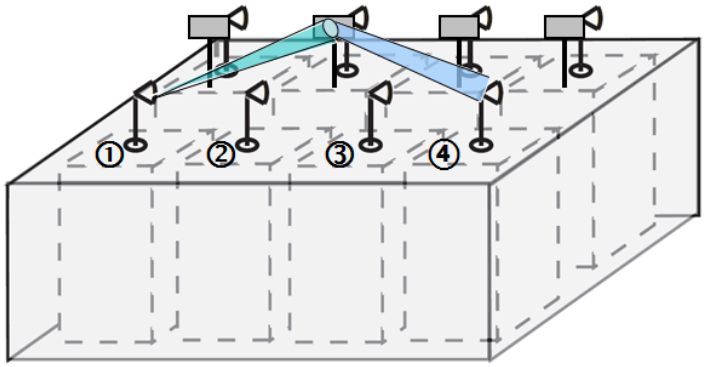

Figure 8: using the small board on the racks to reflect signals

Contents discussed above are just some simple ideas. There are still some questions waiting to be answered. How is the performance of wireless technology? How to realize there ideas? How to optimize the communication?.....
Unfortunately, I did not do any simulation about their performance because I did not have enough time.

3. future work

As there are still too many misteries involved in the wireless technologies in DCN, it needs more effort. The future work will concentrates in two aspect:the structure design, which pays attention to hardware optimization, for example,topology and facilities design; and communication optimization, which pays attention to software performance,for example, the route and channel allocation.