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Overview of wireless Data centre

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Abstract:

The data center is a cluster of servers, whichusually contains tens or even hundreds of thousands of servers. The huge number of servers determines that its performance is closely related to its interconnection mode.As the foundation of data centers construction, the network structure of data centers has great influence on its performance and capacity. However, most of the current data centers network topology is mainly wired structure, and there are some disadvantages such as complex wiring, high maintenance cost and slowlycooling. Therefore, people propose to use wireless as the backup of wired or completely replace wired to improve the performance of data centers networks.This paper mainly summarizes the wireless communication technology in wireless data centers and the design of wireless data centers networks topology structure, which provides useful reference value for future research on wireless data centers.

Keywords —**Wirelessdata center, Wireless communication technology,Wirelessdata centernetwork topology.**

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I. INTRODUCTION

In the era of explosive growth of data, in order to better store and transmit these data, many IT companies need to buy a large number of dedicated servers. However,with the growing number of internet users, the scale of the internet is also expanding, and the expansion speed is almost exponential. As a result, the demand for data storage is growing, and data centre is produced in this context[1-3]. Data centre is an integrated ICT application environment formed by big data concentration,which is the key equipment of data transmission, data calculation and data storage. It's a complex set of facilities that includes not only computer system and other supporting equipment (such as communication and storage system), but also redundant data communication connection, environmental control equipment, monitoring equipment and various safety devices. The network topology based on this is called data centrenetworks(DCNs)[4].

The data centre can be seen as a large interconnect ofcommodity computing and storage devices. To support thelarge scale of enterprise applications, the data centre networks design requires careful consideration of performance,resilience, scalability as well as flexibility[5].

With the development of cloud computing,data centres are becoming increasingly popular fora wide variety of applications such as search, gaming,email andso on [6]. However, when building a data centre network, a variety of cables such as copper cables, unshielded twisted pairs, andoptical fibres are usually used to form a complete system. However, when too many types of cables are used, it will increase the difficulty and cost of maintenance, overhaul and management[7-8].In addition, the wiring and connection of cables will reduce the space utilization rate of the

computer room, and it will also emit a lot of heat in the process of data transmission for a long time.Therefore, if the network wiring is unreasonable or the cooling system is not cooled enough, it will also cause serious consequences[9]. The complex wiring issues in data centre have motivatedus to consider a wireless solution for data centre which meets thedesign goals of a typical data centre network while providing theadditional benefit of flexibility in the network.

II. WIRELESS DATA CENTER

To meet the challenge of traditional data centre, some scholars have begun to study wireless data centre. In this chapter, we will introduce the motivation for moving to the wireless data centre and the metrics for measuring the wireless data centre.

A. Motivation for Wireless Data CentreNetworks

As we know, more and more data centres are being built to support the expansion of cloud applications. As a critical infrastructure,DCNsnot only need to be expanded to accommodate a large number of servers, but also need to provide sufficient bandwidth for various applications.At present,DCNs are typically constructedbased on a hierarchical topology [10]. As shown in Fig. 1, servers are arranged in racks, and a Top-of-Rack switch (ToR) connects allthe servers ina rack. These rack, and the switches of theaggregation and core layers in a DCN form amulti-root tree. Since there are only a few switches at the core layer as root nodes, these root nodes will obviously become hot nodes when the north-south traffic increases, especially the core layer switches require expensive high-end switches to ensure the stable operation of the entire network. It is undoubtedly increased the construction cost of the entire data centre networks.

According to the analysis of DCNs traffic distribution, we found that only a few servers generate a lot of traffic, and the traffic matrix is generally sparse [11]. In addition, because the traffic distribution of DCNs is highly dynamic, the link is not always fully utilized. At any time, about 60% of core links and edge links are active, while the utilization rate is much lowerfor aggregation links, with 95% of utilization being less than 10% [12].These data indicate that the oversubscription is mainly caused by the high burst of traffic from hot servers.

Although these approaches are effective tosome degree, it is difficult to avoid the high load of the core switch in the tree-based topology, and the server-based data forwarding efficiency is low, which limits the performance of the server-centric structure.Fundamentally, it is necessary to establishmore linksto increase the capacity for hot servers.In order tosolve these challenges, it is imperative to designnovel approaches that are able to flexibly provideadditional capacity for hot servers and can easilybe realized with current hardware technologies.That is why we turn to wireless.

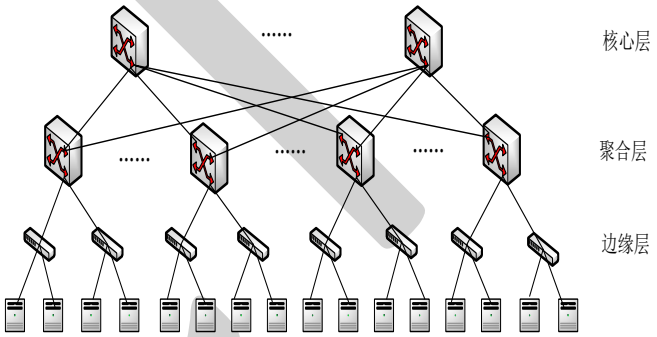


Fig. 1Multi-rooted tree structure

B. Wireless Data Centre Network Metrics

When we research the wireless data centre network, the degree of network nodes and the node coverage within one hop are two important properties that can be used as metrics. In a wireless data centre network, the degree of a network node has always been an important reference indicator to measure the communication capability of a node. It represents the number of other nodes that can establish a connection with a sending node within the wireless communication range. Therefore, if the degree of the network node is relatively high, it is considered that the node can have higher flexibility. In this way, it can form more network flows with other nodes in the data centre network, thereby improving the performance of the entire data centre network in terms of network performance. The node coverage rate within a hop is the ratio of the number of nodes that can be directly connected to the sending node to all the nodes in the

communication range, which mainly reflects the solution to signal blocking that a topology can achieve by reasonably allocating the positions of racks and antennas ability. In other words, the higher the node coverage within a hop, the lower the frequency of signal blocking.

III. WIRELESS COMMUNICATION TECHNOLOGYB

The wireless datacentre is based on the recently released IEEE 802.15.3c wirelessnetworking standard in the 60 GHz ISM band [13]. The standardsupports multi-Gbps data rates and enables the transceivers to setup point-to-point links with each other, which makes it suitablefor data centre interconnects. What people call the wireless data centre network structure now is to use wireless technology to complete the design and deployment of the data centre network. Next, we will introduce key technologies in wireless data centre in this chapter.

A. Flyway Technology

Flyways [11] is proposed by Kandal et al,it improves the connectivity in the data centre by increasing the number of wireless connections, and uses wireless communication technology to solve the problem of overheating of some nodes in the data centre. We call the 60GHz millimetre wave wireless transmission technology a milestone in data centre applications. Flyways structure uses the existing wired network foundation to realize wireless connection between cabinets by placing antennas at the top of each cabinet. It needs to place a number of circles with fixed size in a square area to ensure that any three racks will not be in the same line, which can alleviate the overheating problem of nodes in the wired data centre network to a certain extent. However, when some of the racks fail, maintenance and re deployment will bring great trouble.

B. 60GHz MillimetreWave Technology

Users' unlimited access to data and information promotes the development of wireless communication technology. At present, the wireless communication technology using millimetre wave is developing rapidly,among them, the 60GHz frequency band has attracted the attention of researchers. 60GHz millimetre wave technology refers to the wireless communication technology whose carrier frequency is between 57GHz and 66GHz. The 60GHz band can be used without permission in many countries.Compared with the 2.4GHz and 5GHz band, it has more unique features, and these properties are difficult to be reflected in other wireless communication systems [14-16]. Because the transmission mode of signal in the air is electromagnetic wave,no matter what form of wireless communication technology, there is a corresponding working frequency.For example, Bluetooth technology and Wi-Fi technology work at 2.4GHz, and different communication frequency means different electromagnetic wavelength.For communication frequency around 60GHz, its communication wavelength is about 5mm.Because of its small wavelength, 60GHz millimetre wave has strong directivity, and its spectrum resources as high as 9GHz enable it to provide several Gbps transmission rate, which is dozens of times of other wireless transmission technologies.

In addition to the high transmission rate, the 60GHz millimeter wave has a strong anti-interference ability, there are two reasons: one is the strong directivity of millimeter wave signal and its ultra wide spectrum resources, so the probability of interference of different millimeter wave signals is very small even in a very small range;the other is the 60GHz millimeter wave is much higher than the working frequency of the main wireless communication technology currently used, so theinterference between different communication systems is also very small.

C. Three Dimensional HierarchicalBeamformingTechnology

Beamforming technology[17-18] is a signal processing technology that uses sensor array to transmit and receive directional signals, which can also be called beamforming. It can be used flexibly, that is, it can be used at the transmitter and receiver. Its main working principle is to adjust the output of the antenna array element through the wave interference technology and the characteristics of the space channel, so as to produce strong directional radiation and make the main lobe of itsdirection point to the reasonable position of the receiving end for directional propagation.

Due to the short wavelength of 60GHz millimetre wave, its signal will be sharply attenuated with the increase of transmission distance, and may be blocked during transmission[19]. General wireless signal can avoid obstacles by diffraction in transmission, but for 60GHz millimetre wave wireless signal, diffraction is very weak, or even negligible. In practical application scenarios, when the diameter of the obstacle is larger than 2.5mm, it can block or reverse the 60GHz millimetre wave wireless signal, resulting in the decline of transmission rate. In order to effectively deal with the problem of signal blocking, we can carefully place the antenna on the top of the rack through the two-dimensional beamforming technology,or gracefully realize the three-dimensional beam forming with the help ofmetal reflector[8]. The most common three-dimensional beamforming technology is to install a metal mirror at a certain distance from the top of the rack on the basis of two-dimensional beam forming to reflect the millimetre wave signal, so as to realize the communication between frames by reflection. This technology usually uses the ceiling as the reflector in practical application.3D beamforming [20-22] can significantly reduce the effective communication range of the signal on the horizontal plane, especially when the ceiling used for reflection is very far away from the antenna on the top of the rack. In order to effectively solve the above problem, some researchers proposed to install the 60GHz millimetre wave antenna on a rotatable bracket, for example, Li Yang [23] proposed a scheme to realize millimetre wave signal transmission in three-dimensional space by setting different rack heights.

D. Massive MIMO Technology

Multiple input multiple output antenna (MIMO) plays an important role in the current wireless technology. MIMO technology means that the transmitter has multiple input antennas and the receiver has multiple output antennas. Compared with SISO (single input single output), SIMO (single input multiple output) and miso (multiple input single output) systems, MIMO antenna systems reduce errors and improve data rate and channel capacity. In 2010, scientists at Bell Labs first put forward the concept of massive MIMO. Massive MIMO technology [24-25] refers to a communication mode in which there are a large number of antennas at the transmitter of the base station, while the receiver uses a single antenna to receive signals. Massive MIMO technology evolved from MIMO technology, but there are many differences. First of all, the number of antennas in traditional TDD network is generally 2 antennas, 4 antennas, etc., and the number of channels is also small; however, massive MIMO technology has a largenumber of antenna support, and the channel capacity and quality are also steadily increased. Secondly, the dimensions of signal coverage are different. Simple MIMO technology is also known as 2D-mimo technology,in practical applications, the signal can only move horizontally, but it is impossible to move vertically. However,the radiation state of the signal is more like an electromagnetic beam, which can make good use of the horizontal and vertical space fields. Therefore, the functions of massive MIMO technology and 3d-mimo technology are similar.

IV. WIRELESS DATA CENTRE NETWORK STRUCTURE

In this section, we will introduce several wireless data centre network topologies.

A. Graphite Structure

Most of the existing wireless data centre network topologies are designed by placing the antenna on the top of the rack at the same level. However, this design method can only provide a small number of wireless connections, or it needs to reduce the transmission distance with the help of the reflection of the ceiling. Compared with the existing structure, Li Yang proposed a graphite structure, which uses the three-dimensional hierarchical beam forming technology to fix the horn antenna on a bracket that can be adjusted up and down, and adjust the antenna direction and position to the appropriate position, so as to realize the barrier free data transmission between the two antennas. Through the use of three-dimensional hierarchical beamforming technology, data transmission can be carried out between the same layer and between different layers of the antenna. The bracket which

can be adjusted up and down can avoid the obstruction of the bracket itself to the data transmission, and by adjusting the position of the bracket, the signal blocking of the antenna at the lower layer can be avoided during data transmission. In order to reduce the occurrence of signal blocking and further improve the network connectivity, the antenna direction and bracket position for data transmission are adjusted by deploying antennas at different heights. The antenna arrangement of graphite structure is shown in Fig.2:

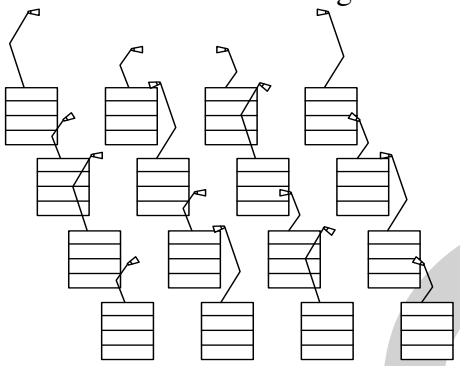


Fig.2Antenna deployment

B. Graphite Structure

The basic unit of spherical mesh network structure is spherical mesh network unit, which is composed of rack array. The distance from the top left node to the bottom right node is the maximum transmission distance of 60GHz signal (10m), which indicates that any two nodes in the cell are in the communication range. Because all the points in the element are on the spherical surface, according to the knowledge of geometry, we know that any three nodes in the element are not in a straight line, so there will be no signal blocking when data transmission between nodes. The spherical mesh network structure is shown in Fig. 3:

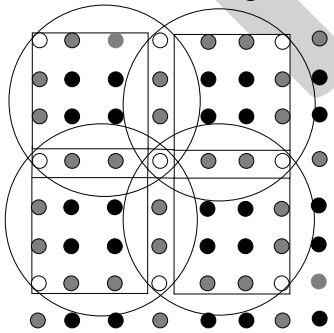
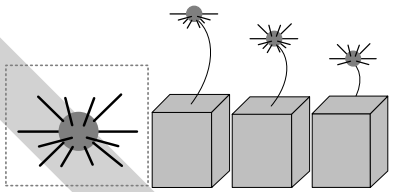


Fig.3Spherical mesh network structure

C. Comb Structure

Comb structure is a new type of wireless data centre network topology. Its network topology is very similar to comb model, so it is named comb structure. Compared with graphite structure, its innovation lies in increasing the number of antennas on the wireless transceiver and deploying the structure on different planes, which can greatly reduce the occurrence of signal blocking, shorten the routing path and increase the network connectivity. As shown in the Fig.4, the wireless transceiver consists of three different heights of wireless transmission antennas: high, medium and low.



(a)Wireless transceiver(b)High(c)Medium(d)Low

Fig.4 Wireless transceiver and rack

To a great extent, the wireless data centre network structure solves the problems of complex wiring, high maintenance cost, and slow cooling speed that exist in the traditional data centre network structure. It provides new ideas for building data centre and improves data centre network performance.

V. CONCLUSIONS

Through the summary of wireless communication technology and several network topologies in wireless data centre network, we can see that the development of wireless data centre has been in continuous progress, especially when 60GHz millimetre wave communication technology has been used, researchers began to widely apply it in the construction of wireless data centre, which not only alleviates the network in wired data centre network to a certain extent The problems such as insufficient network bandwidth and overheated nodes also bring technological breakthroughs to wireless data centre, which makes the wireless data centre gradually enter the public's view. Next, we can continue to build a good performance wireless data centre network topology, and the existing wired data centre network structure can be mixed transformation, research its nature and routing

algorithm, to lay a good foundation for cloud computing.

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