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Optimal design of heat dissipation based on the first seabed data center in China

Yujian Tang[1], Xinyu Ye[2], Zhixin Qi[3]

[1]School of computer and communication, Lanzhou University of Technology, Lanzhou 730050, China

[2]College of digital media, Chongqing College of Electronic Engineering, Chongqing 401331, China

[3]College of oceanography and space informatics, China University of Petroleum, Qidao 266580, China

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Abstract: In recent years, with the rapid development of big data and cloud computing technology, large Internet companies have taken the ocean with natural heat dissipation advantages as the location of data centers. However, there are still many complex factors to consider in the construction of data centers in seawater. This paper is based on the background of the first submarine data module in China.

1. Introduction

With the development of big data and cloud technology, algorithm and computing power have become two major factors restricting the development of technology, and the biggest factor restricting computing power is the number and operation ability of servers. The construction of big data center on land needs to occupy a large amount of land resources, and needs to consume a large amount of electric energy and cooling water resources, which to a certain extent increases the construction cost and pollutes the environment.

As a result, some companies turned their bases to the ocean of natural cooling water.

2. Modeling and Solving

2.1 Problem analysis

The problem requires us to evaluate the maximum number of servers in a single container shell considering only the heat dissipation of the server. Here, we solve the problem from two angles.

First, only consider how many servers can be placed in a data center container. We can not divide the volume of a single server directly by the volume of the data center container, because the shape of the server is fixed, and there must be a gap with the inner wall of the container when placed. Therefore, we must place the server according to the fixed volume of the container to find the maximum placement mode, so as to maximize the number of servers in this placement mode.

Second, only consider how many servers can be placed when the data center container reaches the minimum heat dissipation requirement. The cooling of solid in liquid mainly includes natural convection and forced convection.

2.2 Model building

Based on the above analysis of problem 1, we establish the maximum programming model.

$$\begin{cases} N = \min(n_1, n_2) \\ n_1 = n_{max}^1 \\ n_2 = n_{max}^2 \end{cases} \tag{1}$$

n_1 Represents the maximum number of servers placed without considering heat dissipation, n_2 Represents the maximum number of servers placed when heat dissipation is considered, N Represents the number of servers reasonably placed in two cases.

2.3 Model solving

2.3.1 The maximum number of servers placed without considering heat dissipation

In order to reduce the error of data calculation, we use computer aided drawing CAD software to simulate the calculation.

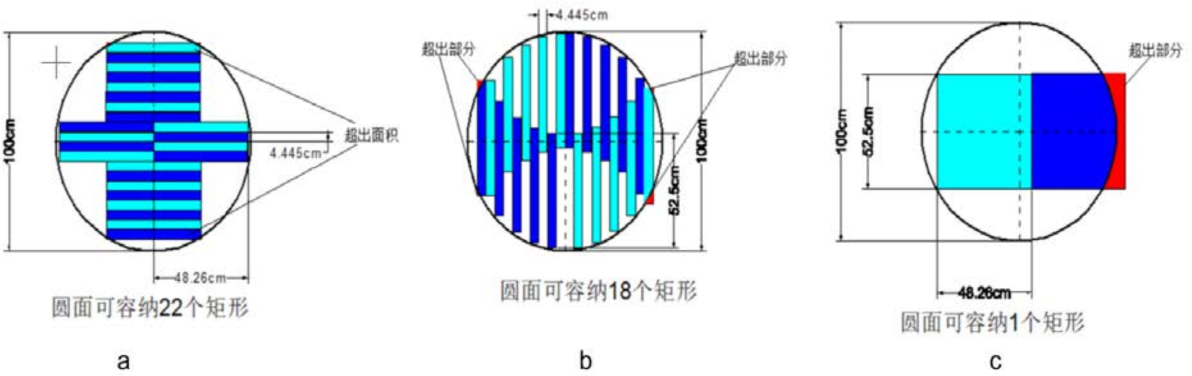

Figure 1: CAD Simulated server placement

1. Server length is consistent with container length, as shown in Figure 1(a)

In the direction of length: $12 \div 525 \times 10^{-3} \approx 22$

After CAD simulation, the number of rectangles can be placed in the section circle: 22

$$n_1^1 = 22 \times 22 = 484$$

2. height of the server is consistent with the length direction of the container, as shown in Figure 1(b).In the direction of length: $12 \div 482.6 \times 10^{-3} \approx 24$

After CAD simulation, the number of rectangles can be placed in the section circle: 18

$$n_2^1 = 24 \times 18 = 432$$

3. The width of the server is consistent with the length of the container, as shown in Figure 1(c).In the direction of length: $12 \div 44.45 \times 10^{-3} \approx 269$

After CAD simulation, the number of rectangles can be placed in the section circle: 1

$$n_3^1 = 269 \times 1 = 269$$

In summary, the maximum number of servers placed without considering heat dissipation is 484.

2.3.2 Consider only the maximum number of servers placed during heat dissipation

1. Two modes of convection

Forced convection: a heat transfer method that uses some fans, heating (or refrigeration) equipment, specially designed air ducts (or pipes) to flow air in a particular environment.

Natural convection: the heat transfer mode of flow caused by the uneven temperature field or concentration field of the fluid, which is not driven by external forces such as pumps or fans.

Comparing the two heat transfer modes, we find that because the data center container is suspended in the sea water, there is no machine external force on it. Therefore, the effect of forced convection in this environment is not obvious. We can reasonably ignore forced convection and only consider the cooling mode of natural convection.

2. Application of heat transfer knowledge

(1) Newton's cooling law

$$q = h \Delta t \tag{2}$$

$$\Delta t = |t_w - t_f| \tag{3}$$

The q represents the heat flux, the h represents the convection heat transfer coefficient, the △t represents the temperature difference, the t_w represents the temperature of the heat transfer object, the maximum operating temperature of the server is 80℃, t_f the temperature of the heat transfer object.

$$\phi = qS \tag{4}$$

The φ represents the heat transfer power and the S represents the heat transfer area, which is calculated according to the cylindrical surface area.

(2) Simplified calculation [1] of convection heat transfer coefficient

$$h = \frac{1}{\sigma/\lambda + 1/\alpha} \tag{5}$$

σ represents the thickness of the heat transferred object, assuming that the thickness of the container is 0.01 m; λ indicating the thermal conductivity of the heat transferred object, assuming that the material of the container is aluminum alloy with a thermal conductivity of 237 w/(m k);α represents the internal surface convection heat transfer coefficient, where the air convection heat transfer coefficient is 15 w/(m 2 k).

(3) Calculation of the number of servers

$$n_2 = \frac{\phi}{Q} \tag{6}$$

Through the calculation of (1-6) formula, it is concluded that the maximum number of servers placed only considering heat dissipation is 392.

2.3.3 Consider maximizing placement and maximum heat dissipation

After calculating from formula (1), it can be concluded that up to 392 1 U servers can be placed in a single container shell.

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