Development of Data Centre Design by Improving its Cooling Performance

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ABSTRACT

Data centre are rooms or facilities used to house and protect computer systems and vital information that being stored on servers located inside the main 'hall' of data centre. Research was conducted in the purpose of taking a measurement to see on how to make an improvements to its cooling performance. The research site with existing condition of 100m2 facility consuming 1900MWh of electricity per annum and retrofitted original office space with no changes to existing façade or building cooling system. The method used was to improve heat-transfer performance by increasing the log-mean temperature difference (LMTD). LMTD describes the difference between the temperatures of the air passing across the coil fins and the water flowing through the coil tubes. Based on the data taken using a vane anemometer to measure the flow and temperature of the CRAC unit, the results indicates that by plotting a graph of log mean temperature difference versus variation of temperature, the result intersect at LMTD of 7.3. Data also indicates that, the key to designing a data centre are dependent on business model and the availability or uptime that we can get from dividing the Mean Time Between Failures (MBTF) with Mean Time Between Failures (MBTF) + Mean Time to Repair (MTTR). Using this formula, in maintaining the availability, redundancy and fault tolerance must be taken into account. Based on the Log-Mean Temperature Difference versus variation of temperature result, it proofs that by improving the data centre room conditions would have higher potential of increasing the cooling performance than the improving of HVAC unit.

Keywords:
Data centre design, Data centre availability and reliability, Space and design consideration, Energy efficient design

1. INTRODUCTION

Since the advent of the first computer, everyday life has become ever reliant on this technology to automate and make day to day tasks easier. In fact, data centres have become so integrated into society they have become invisible to the user.

When thinking about where computers are used, it can be seen that most activities do have a computer system somewhere in the process. Tasks such as making a purchase at the local supermarket using EFTPOS; or making a telephone call; then again, using the internet to find out what news is occurring around the world.

Each of these activities uses, in the background, a computer infrastructure called a DATA CENTRE.

The data centre is the core of all financial, telecommunications, and internet organisations to name a few. Without the data centre, these organisations would not be able to provide the services that their clients have grown accustomed to.
The data centre is a specialised facility in which computer systems are housed. It is not enough to just provide a standard building. Essentially, personal details and potentially sensitive information is stored in data centres. The organisations which hold this information should have a duty of care to their clients and users to securely hold and maintain their records and information. As such the data centre facility must be secure.
It is also important that the computers housed in the data centre be available at any time of the day. This is so clients and users can have access to their information where ever and whenever they need it. Therefore, to provide this 24/7/365 service, the data centre cannot just rely on the electricity company to prove an uninterrupted power supply. As part of our studies in the design and development of data centres, the task of testing was undertook on an existing facility of 100m2 facility consuming 1900MWh of electricity per annum and retrofitted original office space with no changes to existing façade or building cooling system at Victoria University's Footscray Park Campus and to take measurements of the temperatures and air velocities at a number of key location within the facility.

2. METHODOLOGY

The experiment was conducted in Victoria University Footscray Park Data Centre. Figure 1 shows the layout for the present study. The floor area is $42m^2$, equipped with 33 heat-dissipating racks, 4 CRAC units, and 3 UPS units. Table 1 describe the experimental conditions; heat loads in different racks and air velocity from different CRAC units supply. Three CRAC units are active during the experiment that supplies downward cooling airflow through the raised floor plenum acting as one big CRAC units to cool down the entire facility.

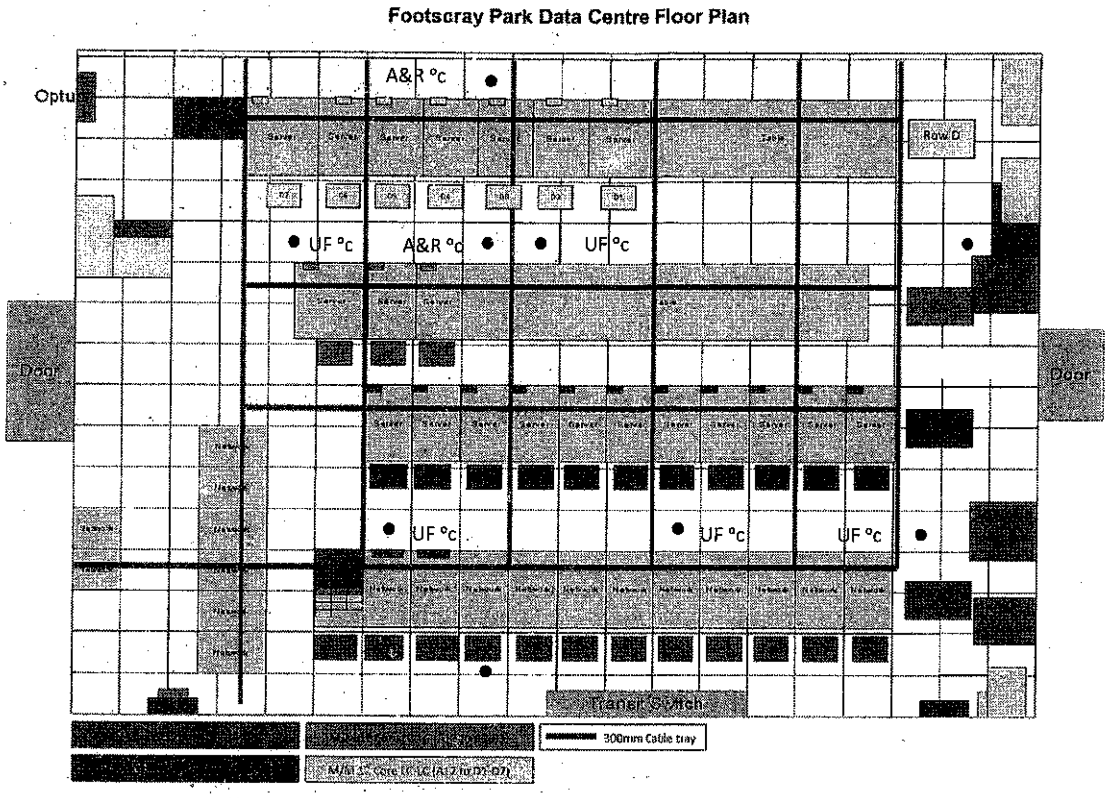


Figure 1: VU Footscray Park data centre floor layout

The dotted points are where all the measurements are taken during the experiment.

EXPERIMENT METHOD:

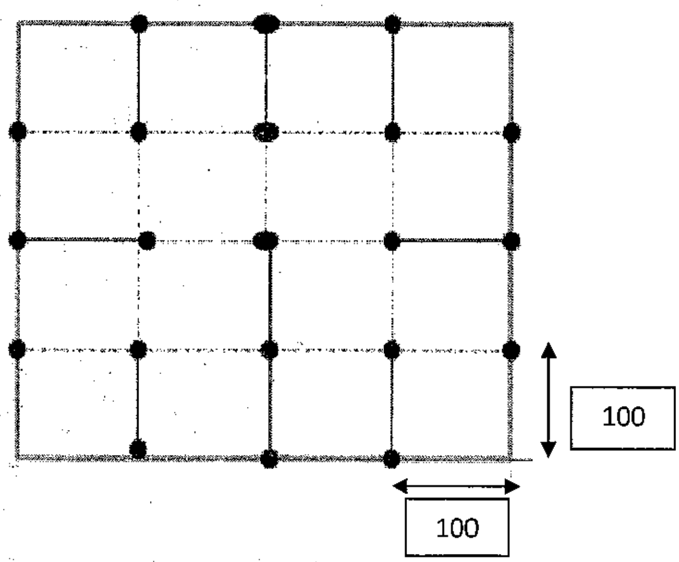


Figure 1: Thermocouple-based temperature measurement grid. All units are in mm.

1. The ambient temperature was measured in the middle of the room.
2. The temperature from the CRAC supply was measured from a three different spot.
3. Measured return grill temperature at three different spot.

4. Placed the layout grid at the designated racks. Take the measurement based on the grid.
5. Take air velocity for each racks and each point taken in process number 1 to 3.

3. RESULTS AND DISCUSSIONS

Table 1: Experimental condition result

RETURN AIR TEMPERATURE

RETURN AIR GRILL	TEMP (°c)
R.A-1	22.0
R.A-2	22.1

AMBIENT TEMPERATURE AT ROW D

SECTION	TEMPERATURE (°c)
COLD AISLE	21.9
HOT AISLE	25
MIXING	22.5

UNDERFLOOR / SUPPLY

[redacted]

[redacted]		
FRONT OF SUPPLY	TOP	10.9
	MIDDLE	10.9
	FLOOR	11.1
AIR VELOCITY	5.7 m/s	

[redacted]		
MIDDLE OF SUPPLY	TOP	16.9
	MIDDLE	17.2
	FLOOR	15.6
AIR VELOCITY	3.4 m/s	

[redacted]		
FARTHER OF SUPPLY	TOP	14.6
	MIDDLE	14.5
	FLOOR	15.1
AIR VELOCITY	2.8 m/s	

[redacted]

[redacted]		
FRONT OF SUPPLY	TOP	14.2
	MIDDLE	12.7
	FLOOR	15.6
AIR VELOCITY	6.0 m/s	

[redacted]		
MIDDLE OF SUPPLY	TOP	19.7
	MIDDLE	19.7
	FLOOR	18.9
AIR VELOCITY	4.0 m/s	

[redacted]		
FARTHER OF SUPPLY	TOP	21.0
	MIDDLE	20.8
	FLOOR	20.6
AIR VELOCITY	3.3 m/s	

READING AT THE FRONT OF THE RACK
SERVER RACK D3

[redacted]		
FRONT OF SUPPLY	TOP	23.3
	MIDDLE	23.2
	FLOOR	23.2
AIR VELOCITY	1.5-2.0 m/s	

READING AT THE BACK OF THE RACK
SERVER RACK D3

[redacted]		
FRONT OF SUPPLY	TOP	25.7
	MIDDLE	26.1
	FLOOR	25.9
AIR VELOCITY	-	

READING AT THE FRONT OF THE RACK
COMMS RACK A9

[redacted]		
FRONT OF SUPPLY	TOP	22.7
	MIDDLE	22.5
	FLOOR	22.5
AIR VELOCITY	-	

READING AT THE BACK OF THE RACK
COMMS RACK A9

[redacted]		
FRONT OF SUPPLY	TOP	23.5
	MIDDLE	23.9
	FLOOR	24.2
AIR VELOCITY	-	

SITE ANALYSIS

Dynamic of Heat Transfer

The performance of current cooling system was measured by the application of the Log-Mean Temperature Difference (LMTD) value. LMTD describes the difference between the temperatures of the air passing across the coil fins and the water flowing through the coil tubes.

The following equations quantifies the heat-transfer process:

$$\mathbf{Q = U \times A \times LMTD}$$

Where,

Q = amount of heat transferred, (W)

U = heat-transfer coefficient, ($W/m^2 \cdot K$)

A = effective surface area for heat transfer, (m^2)

LMTD = log-mean temperature difference across the coil surface, (° C)

The most effective way to improve heat-transfer performance is to increase the log-mean temperature difference (LMTD).

$$\mathbf{LMTD = (TD_2 - TD_1) / Ln . (TD_2 / TD_1)}$$

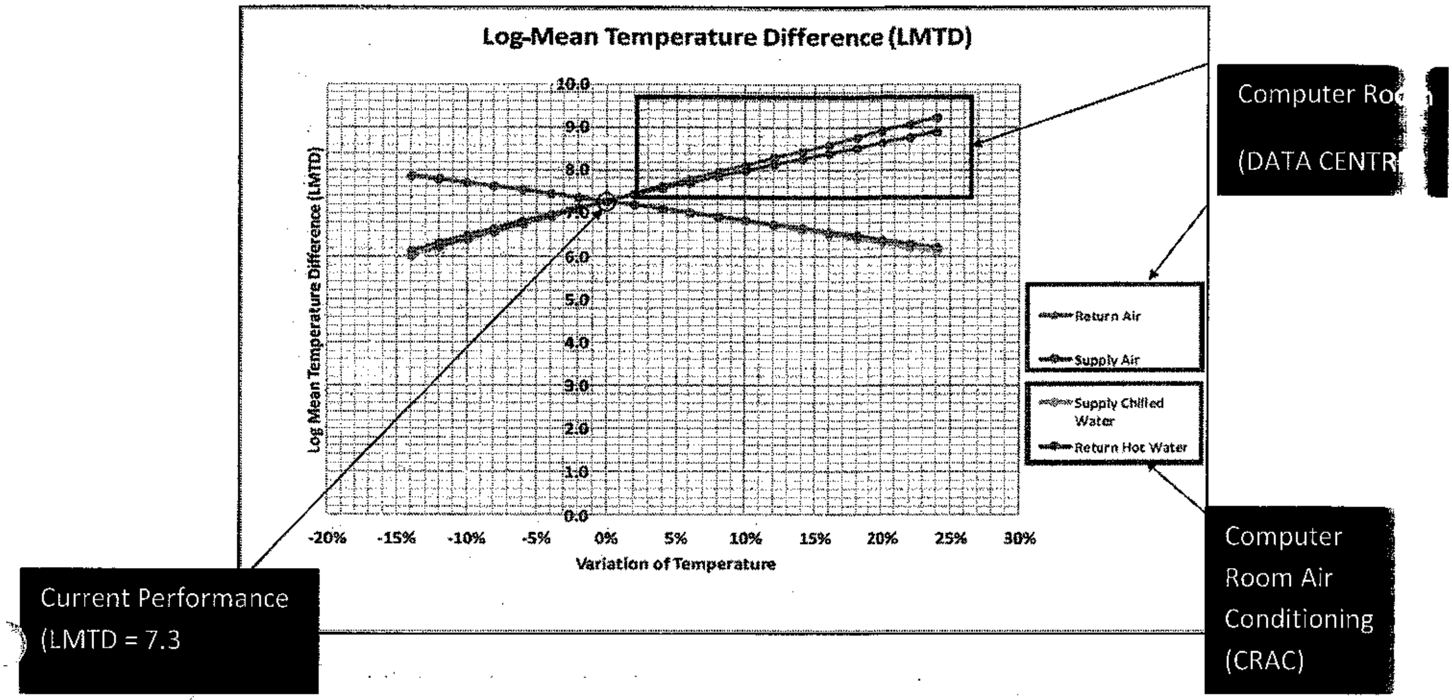
Where,

TD_1 = leaving-air and entering-water temperature difference at the coil, (° C)

TD_2 = entering-air and leaving-water temperature difference at the coil, (° C)

Room condition:

ENTERING AIR TEMPERATURE (RETURN AIR) (°C)	24
LEAVING AIR TEMPERATURE (SUPPLY AIR) (°C)	10
ENTERING WATER TEMPERATURE (CHILLED WATER) (°C)	6
LEAVING WATER TEMPERATURE (HOT WATER) (°C)	12



Summary

The graph proofs that improving the data centre room conditions would have higher potential of increasing the cooling performance than the improving CRAC unit.

4. CONCLUSIONS

Overall, this research has provided an overview of requirements that must be considered at an early stage of design. It is clear that, when it comes to building a reliable data centre and maximising the investment, various design issues must be studied and resolved early in the building development process. The process should involve coordinated efforts across a number of areas of expertise including mechanical, electrical, architectural and other building services.

To achieve satisfactory outcomes, each of the components of the data centre and its supporting systems must be carefully planned, designed and implemented to work together to ensure reliable performance of discrete data centre resources while also taking into account future requirements and provision for expansion. Neglecting any aspect of the design can render the data centre vulnerable to cost failures, early obsolescence, and intolerable availability. There is no substitute for careful planning and the following the guidelines set in the specified standards.

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