International Journal of Engineering & Technology, 7 (3.4) (2018) 113-117

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Cold LOGIK and RDHX Solution for Data Center Energy Optimization

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Abstract

In all types of data center, keeping the right temperature with less cost and energy is one of important objective as energy saving is crucial in increased data driven industry. Energy saving is global focus for all industry. In Information technology, more than 60% of energy is utilized in data centers as it needs to be up and running. As per Avocent data center issue study, across globe more than 54% of data centers are in redesigning process to improve their efficiency and reduce operational cost and energy consumption. Data center managers and operators major challenge was how to maintain the temperature of servers with less power and energy. When the densities of data center energy nearing 5 kilowatts (kW) per cabinet, organizations are trying to find a way to manage the heat through latest technologies. Power usage per square can be reduced by incorporating liquid-cooling devices instead of increasing airflow volume. This is especially important in a data center with a typical under-floor cooling system. This research paper uses Rear-Door Heat eXchangers (RDHx) and cool logic solutions to reduce energy consumption. It gives result of implementation of Cold Logik and RDHx solution to Data center and proves that how it saves energy and power. Data center has optimized space, cooling, power and operational cost by implementing RDHx technology. This will enable to add more servers without increasing the space and reduce cooling and power cost. It also saves Data center space from heat dissipation from servers.

Keywords: *Data Center Optimization, Cold logic, RDHx, Rear Door Heat exchanger, energy saving, power saving, green computing.*

1. Introduction

In 2005, Telecommunication Industry Association (TIA) published ANSI/TIA-942 telecommunications infrastructure standard for data center [1]. This standard is amended further four times in 2008, 2010, 2014, and recently in 2017. Based on these standards, Uptime Institute classifies data centers into 4 standard types. Table (1) gives details of these 4 tiers and its requirements

Table 1Data Center Tier Description

Tier	Requirements
I	This is the typical server room maintained by internal IT team of organization Single uplink and servers. Non redundant capacity of components. No UPS / Generator or optional. 99.671% availability. 28.8 our downtime / year
II	Tier I + UPS / Generator Redundant capacity or components 99.741% availability. 22 hour downtime / year
III	Tier II + Concurrently maintainable Generator and UPS systems Duel powered equipment with multiple uplink 99.982% availability. 1.6 hours downtime / year
IV	Tier III + 100% fault tolerant of all components including uplinks, storage, Heading ,Ventilation and Air Conditioning (HVAC) system 99.995% availability 0.4 hours downtime / year

In addition to these 4 tier, the German Data center Star Audit program uses an auditing process to certify five levels of "gratification" that affect data center criticality which is not acknowledged by any standards.

The Fourth Industrial Revolution (4IR) is described as a range of new technologies cut across social networking, Internet of Things (IoT), Artificial Intelligence (AI), virtual reality (VR), augmented reality (AR), cloud computing, mobility, self-driving vehicles and bio-technology revolution. 4IR generates more data than ever and it is mandatory to manage these data as per business requirement and need. To maintain these data, Data center plays major role and it is important to ensure data center are up and running all time. Ken Brill, father of data center predicted that rate of computational increase is greater than the rate of increase of power (Moore's Law). He also mentioned that the increasing amount of heat resulting from adding more transistors onto a chip requires advanced technologies to control the heat and maintain temperature of data center. The chief executive officer of Google remarked, "What matters most to the computer designers at Google is not speed but power, low power, because data centers can consume as much energy as a city" [2].

As per report from U.S. Department of Energy-led Center of Expertise for Energy Efficiency in Data Centers, U.S. data centers consumed 1.8 percent of the country's total energy consumption. This will go up with the increase of 4IR technology revolution. The report Emerging Trends in Electricity Consumption for Consumer ICT determined that data centers and networks will be the highest growth segments in energy consumption. As per, Emerging Trends in Electricity Consumption for Consumer ICT, in the last 5 years, energy consumption is increasing for maintaining networks and managing data center. Figure (1) shows the comparison of energy consumption between 2012 and 2017

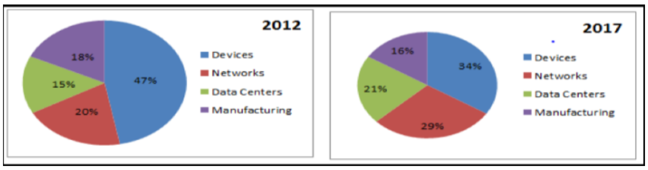

Figure 1Energy Consumption between 2012 and 2017

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) have done more research on finding suitable area for keeping IT Equipment (ITE). ASHRAE Technical Committee 9.9 (TC9.9) guidelines are based on server inlet temperature and not as per internal server temperature, room temperature or server exhaust temperature. The lifespan is server will come down when it functions in high temperature and duration of exposure. It suggests that it is not necessarily that ITEs are not kept in cooling condition throughout the year, it can be exposed to heat for more hours each year. To maintain the temperature of data center, the cooling process can be divided into following steps

1.1 Server Cooling:

In Data center, ITE generate more heat as it uses electricity, meaning server components are changing the state of energy from electricity to heat. Heat transform from electrical component to air within the server. Fan inside server is facilitating this heat transfer. Some system uses liquids to absorb and carry heat generated from ITE.Figure (2) gives standard air flow path through server equipment as per ASHRAE standard nomenclature [3]

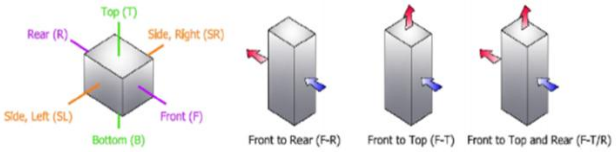

Figure 2ASHRAE standard nomenclature for air flow paths through server equipment

1.2 .Space Cooling:

In previous generation data center, heated air comes from server is mixed with open air and eventually moves to Computer Room Air Conditioner (CRAC) or Computer Room Air Handler (CRAH). CRAC and CRAH use refrigerant and chilled water as cooling coil respectively. Figure (3) shows the system architecture of CRAC and CRAH

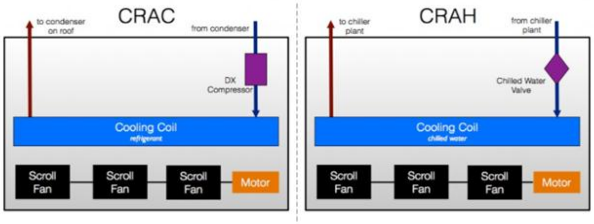

Figure 3System Architecture of CRAC and CRAH

1.3 Fluid Conditioning:

Tempering and returning fluid to the white space, to maintain appropriateconditions within the space. This research paper uses Cold Logik and RDHx as solution to save energy and power of data center and improves efficiency

1.4 Heat Rejection:

Once heat air is removed from free space in data center, it must be rejected to heat sink. The heat sink can be atmosphere or any other systems. Some of well-known system are:

- CRAC or CRAH systems
- Pumped liquid and cooling tower
- Direct Evaporative Cooling (DEC)
- Indirect Evaporative Cooling (IEC)

2. Literature Review

For effective Internet services without any disruption, Data center must provide reliable infrastructure and capable of supporting more users. To ensure the servers are up and running, it requires more power, increased operational costs. About 70% of budget is utilized for Servers and expenses towards maintaining temperature. Brandon Heller et all, present ElasticTree, a network-wide power manager, which dynamically adjusts the set of active network elements, links and switches to satisfy changing data center traffic loads [5].

In Data center, it is essential to have right power consumption models to optimizing energy-efficient operations and saving operational cost. Miyuru Dayarathna et all, survey the techniques used for energy consumption modelling [6]. They conduct an in-depth study of the existing data center power modelling, covering more than 200 models. The team organize these models focusing on hardware-centric and software-centric power models. In hardware-centric approaches, they covered from the digital circuit level and move on to energy consumption models at the hardware component level, server level, data center level, and finally systems of systems level. In software-centric approaches, they investigate power models developed for operating systems, virtual machines and software applications.

Power consumed in data centers is having huge impacts on environments. There are several approaches followed to reduce power consumption and save energy while keep the desired quality of service or service level objectives. In server consolidation approach, Virtual Machine (VM) technology has been widely applied in data center environments to host multiple virtual servers on base server [7]. Liang Liu et all did research on how to save energy using VM and present the GreenCloud architecture, which aims to reduce data center power consumption, while guarantee the performance from users' perspective. Green Cloud architecture enables comprehensive online-monitoring, migration and optimization through VM. To verify the efficiency and effectiveness of the proposed architecture, they took an online real-time game, Tremulous, as a VM application and the results show that they can save up to 27% of the energy when applying Green Cloud architecture

Cloud, green, grid and computing are more of commercial for few organizations. Only very few are succeed and able to produce stable products on this area. Vendors and consumers are keen to optimize the services offered through cloud data centers as much as possible. There are various methods which help to bring down rise in temperatures of servers in cloud data center infrastructure. Sahana et all, approached the problem in a new light—concentrating on server utilization to regulate the temperature [9]. They introduced Mean Utilization Factor concept that allows detecting and regulating the amount of cool air that is to be channelled in and around the servers within a cloud data center to bring down the operating temperature

3. Problem Statement

Data center managers are expected to do more than ever including managing heterogeneous data sources, rapid growth in data volume and managing mission critical applications. They are also able to meet challenging service level agreements (SLA) and implementing green computing business initiatives. They are also expected to do less including reduced man power, less budget and saving energy and power consumption. 4IR revolution gave more opportunities to industries and several tools and systems are available with improved processes. By leveraging these technology improvements, Data centers are driving towards improved data storage and server utilization, manage physical and virtual environment and reduce capital and operational expenses.

This research focuses on possible ways to

- Providing an cost effective and efficient DC to support the on-going Business
- Adding more devices in the existing space
- Reduction in cooling cost
- Reduction in power cost
- Reduction in overall operational cost

Threat and Opportunity analysis is done with the existing infrastructure and available devices and what will happen if no changes are made in the current data center. Table (2) gives threat and opportunities matrix for both long and short term

Table 2Threat and Opportunities for short and long term

	Threat (if no changes are made)	**Opportunities (if changes are made)**
Short Term	• Cooling issues will be continued in Data center • Additional devices cannot be deployed • Business demand cannot be met • Delay in project delivery lead to customer escalation	• Able to host additional servers • Business demand can be met • Operational cost will be reduced
Long Term	• The cooling provided is not sufficient which causes hotspots in the Data Center & occasional performance issues. • There is no capacity to install the IT hardware since there is a cooling capacity and space constrain. • Addition of Precision Air Handling Unit (PAHU) type cooling units & racks are not possible as there is no space.	• Rack utilization would improve thereby can host more servers • Close coupled cooling improves efficiency tremendously • Able to generate energy saving from day1 & also simultaneously have improved cooling in the DC • The high density RDHx cooling units will give triple the current cooling capacity

4. Proposed Solution

This research paper focuses on adding additional servers in the existing rack where data center has cooling issues due to which unable to add additional severs. This data center has 190+ devices including firewall, routers and servers in 25 racks placed in 990 square feet. In this data center, there is no space to install new racks and new devices. Even Precision Air Handling Unit (PAHU) will not sustain to provide the cooling on adding new devices like server, Network, EMC Storages which will dissipate British Thermal Unit (BTU). To install new server rack, it takes 1124 minutes of cycle time which should be reduced to support ongoing deliverables and business units.

1.1. Lean Analysis

After analysing various solutions to save energy and power, it is decided to implement RDHx to resolve existing problem. Table (3) gives analysis performed on identified problem, improvement and benefit after installing RDHx.

Table 3Lean Analysis for Energy efficiency

Operation	**Problem**	**Implemented Solution**	**Result**	**Waste Reduction**
RDHx Implementation	Existing cooling method is not efficient which causes hotspots in the Data Center & occasional performance issues Space Crunch due to which unable to host additional rack Increased Operational Cost	Proposed RDHx and Cold logic solution will help to host minimum 16 servers and 22 network devices Reduce energy consumption of chiller and PAHU unit Decrease Space requirements	Would result in reduction in the cooling cost and power cost Reduced the overall operational cost Consolidation of computing equipment into the existing racks Increasing valuable floor space or enabling expansion	Cooling leakages and inefficiency is arrested Space Crunch is arrested Power Usage Efficiency will be achieved Efficiency of the Chiller would be increased

1.2. High Energy Consumption and Operational Cost

While analyzing reason for increased cost and high energy consumption, it is observed that major expenses came from ensure availability of servers, energy and space, machine maintenance cost and man power. Figure (4) provides outcome of root cause analysis of higher cost.

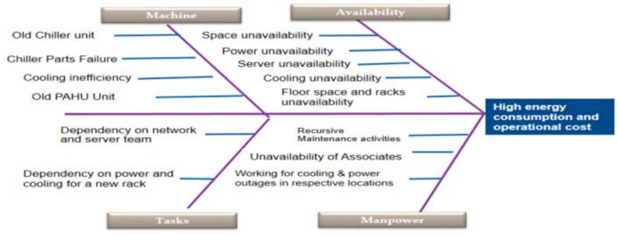

Figure 4Root Cause Analysis for High Energy Consumption and Operational Cost

1.3. Working Principle of RDHx and Cold Logic Works

By implementing RDHx cooling technology, without increasing space, can add more servers in each rack. Heat disputation from the servers will not affect the DC area through this solution. RDHx devices can eliminate chiller energy because they can use treated water from a plate-and-frame heat exchanger connected to a cooling tower. These inherent features of a RDHx help reduce energy use while minimizing maintenance costs

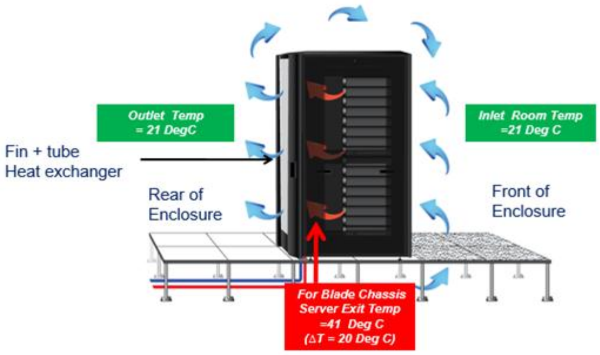

Figure 5How RDHx and Cold logik works

Figure (5) demonstrates how RDHx works in data center.

- Inlet and outlet temperature remains the same Rear Door Heat Exchanger (RDHx) & Cold Logik replaces existing rear door of Data Center Racks.
- Chilled water in RDHx circulates through heat exchanger from supply connections.
- Once RDHx is installed, it doesn't require direct electrical energy to operate.
- Equipment exhaust air passes through coil and is cooled before re-entering the room.
- Heat is rejected from room through return water connection.
- RDHx & Cold Logik provides 100% sensible cooling.
- No condensation, no need for reheat or humidification.
- CDU creates a fully isolated, temperature controlled secondary loop
- Chilled water source - city water, building chilled water, packaged chiller and central return CRAC water.

1.4. Thermal Image Comparison

The improvements on air temperature in data center are compared with thermal image picture which is used for capturing heat energy into visible light. Figure (6) has picture taken from normal camera, thermal picture of before and after RDHx implementation.

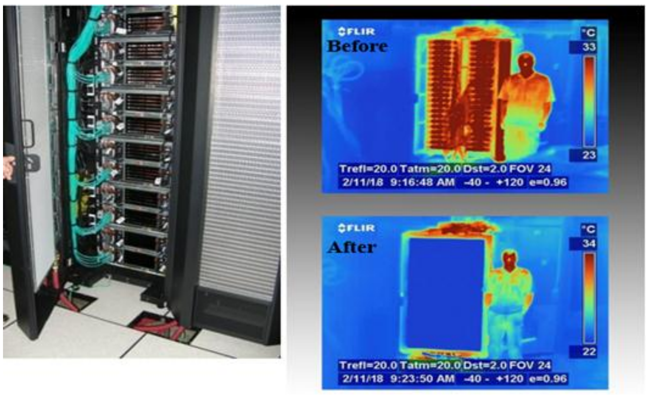

Figure 6Thermal Image taken on a 23 KW Cabinet

5. Execution Approach

Whenever there is a change in Data center, it is important to ensure that there will not be shut down for longer duration and there will not be any impact on regular operations including development and support activities. After implementation, efficiency and cost analysis to be done in all major areas including consolidation and utilization of servers, space management and energy consumption and reduction in man power

5.1 Precision Air Handling Unit (PAHU) maintenance

This data center has more than 190 devices which are handled by 7 users. Time and effort consumed for PAHU activities are reduced by 64% as per sample data from 5 different users. The activities performed by users and time taken for each activity.

Table (4) and Table (5) are time consumed by different users before and after implementation of RDHx. This table didn't consider idle time between activities and considered only active duration in minutes. Average time consumed for completing all activities is reduced from 771 minutes to 492 minutes which is more than 64%.

Table 4Pre Implementation Time and Motion study for PAHU activities

	Pre Implementation Time (in Minutes)						
Activities / User	**1**	**2**	**3**	**4**	**5**	**Total**	**Average**
Ensure the Application, Databases down	155	175	150	185	195	860	172
After confirming with the Application owner proceeding with the servers shut down	120	100	115	95	85	515	103
SAN Switch Post disable	8	7	5	9	6	35	7
Network devices Port disable	10	7	8	6	10	41	8
PAHU maintenance Activity	215	210	205	200	210	1040	208
Network devices Port enable	5	7	6	9	5	32	6
SAN Switch Post enable	4	3	7	5	3	22	4
Servers powered on	90	85	95	90	88	448	90
Start application, databases, verification	155	175	150	185	195	860	172
Total Time	**762**	**769**	**741**	**784**	**797**	**3853**	**771**

Table 5Post Implementation Time and Motion study for PAHU activities

	Post Implementation Time (In Minutes)						
Activities / User	**1**	**2**	**3**	**4**	**5**	**Total**	**Average**
Ensure the Application, Databases down	75	70	80	85	75	385	77
After confirming with the Application owner proceeding with the servers shut down	85	80	75	90	70	400	80
SAN Switch Post disable	8	7	5	9	6	35	7
Network devices Port disable	10	7	8	6	10	41	8
PAHU maintenance Activity	115	110	105	100	110	540	108
Network devices Port enable	5	7	6	9	5	32	6
SAN Switch Post enable	4	3	7	5	3	22	4
Servers powered on	90	85	95	90	70	430	86
Start application, databases, verification	115	125	110	105	120	575	115
Total Time	**507**	**494**	**491**	**499**	**469**	**2460**	**492**

5.2 Energy and Consumption Comparison

In this section, analysis on how electricity consumption is saved before and after implementation of this cooling technology. This comparison assumes that there is no additional load during this analysis. Table (6) shows comparison power consumption (in Watt) before and after implementation for 12 months. From this data, it is clear that 11.5% power saved in a year.

Table 6Power consumption (in Units) for 12 months

Month	**Pre Implementation**	**Post Implementation**	**Diff**
Mon 1	536932	416880	120052
Mon 2	548304	428202	120102
Mon 3	486292	453766	32526
Mon 4	434992	423244	11748
Mon 5	436572	429380	7192
Mon 6	465870	449716	16154
Mon 7	421114	396770	24344
Mon 8	414672	395994	18678
Mon 9	430192	339054	91138
Mon 10	388370	326307	62063
Mon 11	367930	313302	54628
Mon 12	363762	318778	44984
Total	5275002	4691393	603609

6. Conclusionand Future Work

This paper presents implementation of RDHx cooling strategy combined with cold logik to reduce energy and power consumption and reducing operational expenses. By implementing RDHx, cooling cost, power cost, operational cost and effective utilization of spaces can be achieved in any data center. There is no need to shutdown data center for this migration process. After installing RDHx, PAHU and PAU can be switched off completely which is direct cost savings on cooling. Due to increased inlet water supply, the efficiency of chiller unit is improved. Hotspot free Data center is possible by implementation of RDHx and HOT and COLD tile is not required. These are prime reasons for saving data center operational cost.

4IR generates more data and lead to technology advancement faster than expected ration. More money and too much time are spent on 4IR to standardize and prove technologies in market. Among all challenges, few well established technologies influences the industry to save cost, energy and power in Data center. RDHx and cold logik are one among simple and inexpensive which is suitable for Tier 4 data centers. For next few years, there will not be much advancement technologies to transform data centers. Some improvements are expected to save power and energy efficiency in next generation data center through below approaches

- More efficiency on power distribution and combined cooling technologies including free cooling
- Right selection of tier and place for data center which support zero downtime
- Realistic target for data center power usage target.

Transform towards elevated data center temperature

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