

IoT: Green Data Center Strategies

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Abstract— With the rapid development of science and technology, the world is becoming “smart”. Living in such a smart world, people will be automatically and collaboratively served by the smart devices (e.g., watches, mobile phones, computers), smart transportation (e.g., cars, buses, trains), smart environments (e.g., homes, offices, factories), etc. The volume of data that will travel around the world will increase enormously in the near future. Data center IP traffic will grow at a CAGR of 27% between 2015 and 2020 to 15.3 zettabytes(10^{21} bytes) per annum according to Cisco’s 2015 Global Cloud Index, and there will also be as many as 25 billion devices connected to the IoT generating as much as 50 zettabytes of data. Thus, an autonomous vehicle can be seen as a data centre in its own right, although connected to a control data centre for some elements of its operation and programming.

The energy use and environmental impact of data centers has recently become a significant issue for both operators and policy makers. More than 50 per cent of the power being expended is directed to powering the necessary cooling systems that keep processors from overheating. This presents, potentially, a big opportunity for the “greening” of data centers. This paper aims at studying the need of green data centers to synchronize the upcoming IoT trends and its effect on the environment, along with better energy efficient strategies.

Green data centers thus aims at reducing the carbon footprints required or generated by the computer technology.[14] For any data centre today being energy efficient is a must. PUE can provide a basis for measuring energy efficiency and is very important for creating a sustainable green data center. By reducing carbon footprints and increasing the utilization of individual servers, the goals of PUE and ROI optimization can be achieved.

Keywords-PUE, green data center

I. INTRODUCTION

Today, more than ever, data is being created on a massive level as a huge wave of connectivity dominates both home and office through a multitude of devices like wearables, smart homes, connected cars, medical devices, fitness bands, smart retail etc. Gartner predicts that the number of Internet of Things (IoT) devices will reach 26 billion by 2020. However, as the number of devices grows, so does network congestion.[1] As major businesses will begin to incorporate some element of IoT into their processes and systems, CIOs will need to focus on being able to get and use data generated by IoT cost-effectively.

The IoT revolution isn’t just going to change our applications and endpoint devices, it’s also going to significantly change how data centers operate. Today’s data centers are largely built around the concept where endpoints use client applications to access data housed within a data center. Data taken from these billions of IoT devices will be collected and analyzed in order to make decisions, perform actions or other automated processes. IoT applications will possess built-in intelligence to make predetermined decisions

based on the analysis of the data it collects. The goal for many IoT applications is to produce accurate, real-time results.

Changes in data flows and automated responses based on data analysis will dramatically change the way data centers are designed, deployed, secured and managed. Data centers already consume roughly 3% of all globally generated power and account for approximately 2% of greenhouse gas emissions – a carbon footprint equivalent to the airline industry. Data center energy consumption first came under heavy scrutiny in the early 2000s, when experts warned that the rapid growth of the Internet would drive a rise in worldwide fossil fuel emissions. Thankfully, energy efficiency improvements and innovation in renewable energy has substantially lowered the industry’s power consumption – despite the hunger for data accelerating. Data centers have been identified as one of the fastest growing consumers of energy.

All data center are plagued with thousands of servers as major components. These Servers emits Carbon foot prints thus raising the requirement of more green computing techniques.[2] Optimizing energy in Data centers is

becoming an important aspect of research. This paper aims at studying the need of green data centres to synchronize the upcoming IoT trends and its effect on the environment, along with better energy efficient technology.

II. IoT - The Internet of things

The internet of things will force enterprise data center operators to completely rethink the way they manage capacity across all layers of the IT stack, according to a recent report by the market research firm Gartner. Gartner's definition of the internet of things or IoT, as the company abbreviates it – is something that connects “remote assets” and pushes data between them and centralized management systems. Companies can integrate that data and those assets in their processes to improve utilization and productivity.

With the rapid development of science and technology, the world is becoming “smart”. Living in such a smart world, people will be automatically and collaboratively served by the smart devices (e.g., watches, mobile phones, computers), smart transportation (e.g., cars, buses, trains), smart environments (e.g., homes, offices, factories), etc. Our world consists of various “things”. As one of the enablers of smart world, internet of things (IoT) targets to connect various objects (e.g., mobile phones, computers, cars, appliances) with unique addresses, to enable them interacting with each other and with the world.[3]

There is little argument that the Internet of Things (IoT) will have a massive impact on the data centre industry. The volume of data that will travel around the world will increase enormously in the near future. Data center IP traffic will grow at a CAGR of 27% between 2015 and 2020 to 15.3 zettabytes(10^{21} bytes) per annum according to Cisco's 2015 Global Cloud Index, and there will also be as many as 25 billion devices connected to the IoT generating as much as 50 zettabytes of data.

The form of the impact is less predictable and will not be uniform but will depend on the type of data centre (enterprise, cloud, colocation or service), its specification and capacity to deal with large and variable data loads. It will also depend on the network location of the data center since the model for dealing with the coming flood of data will include ‘edge’ devices processing, curating and transmitting data close to where it is generated through networks and nodal units to a core data centre.

Thus, an autonomous vehicle can be seen as a data centre in its own right, although connected to a control data centre for some elements of its operation and programming.

III. DATA CENTER

A. What is a data center?[4]

Data centers are simply centralized locations where computing and networking equipment is concentrated for the purpose of collecting, storing, processing, distributing or allowing access to large amounts of data. They have existed in one form or another since the advent of computers.

B. Need for data center

Despite the fact that hardware is constantly getting smaller, faster and more powerful, data generation and handling also has increased along with the demand for processing power, storage space and information. A study by

International Data Corporation for EMC estimated that 1.8 trillion gigabytes (GB), or around 1.8 zettabytes (ZB), of digital information was created in 2011 [sources: Glanz, EMC, Phneah]. The amount of data in 2012 was approximately 2.8 ZB and is expected to rise to 40 ZB by the year 2020 [sources: Courtney, Digital Science Series, EMC].

A datacenter has many purposes

- Provide single location for compute infrastructure for big organizations.
- Provide hosting facilities so companies don't have to manage their own IT.
- Perform large distributed computations (Google Warehouse computing, scientific simulations).
- Provide scale-out on-demand IT services (e.g., accommodating temporary usage spikes).

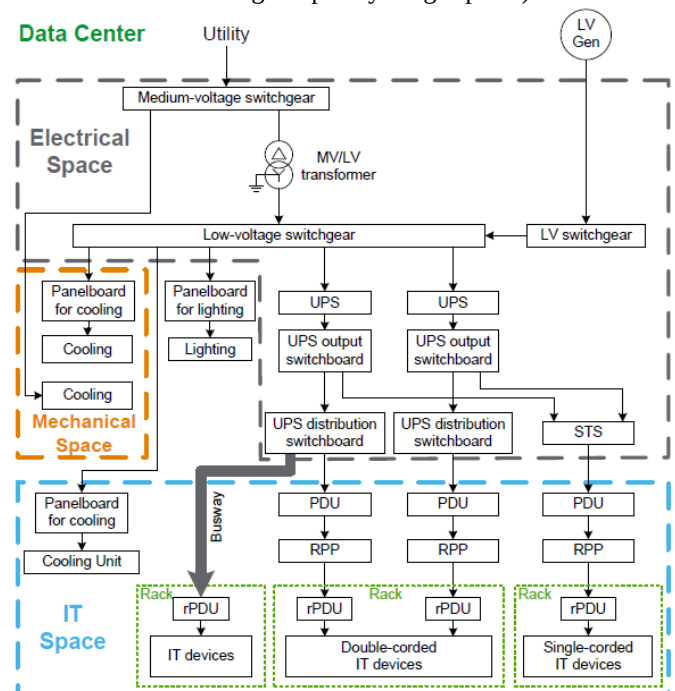


Figure 1 :Block diagram of an electrical distribution system in a data center. [5]

C. Data Centre Consists of:

- Servers (Physical machines) – With the advent of large scale operation, IT infrastructure depending on the size is referred today as “server rooms” or “data center”.
- Storage – Data center storage primarily refers to the devices, equipment and software technologies that enable data and application storage within a data center facility. Effective storage and protection of data along with enabling fast and secured access is a crucial part of the data centre.
- Network devices (switch, router, cables) - A conventional data center network comprises: servers that manage workloads and respond to client requests; switches that connect devices together; routers that perform packet forwarding functions; controllers that manage the workflow between network devices; gateways that serve as the

junctions between data center networks and the broader Internet; and clients that act as consumers of the information in data packets, Network cables to connect and transfer data and information between computers, routers, switches and storage area networks .

- Power distribution systems - “Data center needs power to run the IT equipment that they house and the power distribution systems in a data center varies according to the particular equipment installations and its use.
- Cooling systems - The electrical power used in data center generates a lot of heat, which may cause interruptions in services if the cooling of the room is insufficient. An efficient cooling system curbs the energy consumption in the data center and ensures that an excessive heat load will not cause service interruptions.

D. Electrical Distribution Equipment in Data Center Environments

This diagram (Figure 1) is only an example of an electrical architecture and attempts to include all the possible major types of equipment used and their typical location in a data center. In the real world, a typical data center electrical design has much more complexity and diversity than that in Figure 1. (Note that electrical designs are typically expressed as single-line diagrams (see side bar).)

Typically the utility supplies a medium voltage (MV) service to a dedicated data center. Then the MV is stepped down to low voltage (LV) by a MV/LV transformer located in the data center. LV power is distributed to the different electrical loads such as IT devices inside the racks, cooling system, lighting by the electrical distribution equipment. The electrical distribution in data centers is typically an alternating current (AC) three-phase system. All electrical components in the data center must be protected against over-current conditions such as overloads and short circuits.

There are many different loads in the data center, such as IT equipment, air conditioners, fans, pumps & lighting. The flow and transformation of energy from the utility/generator to the load is enabled by various types of equipment.

- Medium-voltage switchgear including MV/LV transformer : Medium-voltage switchgear is generally located in the electrical space of large-capacity data centers(i.e. greater than 1 MW IT load).
- Low-voltage switchgear/switchboard / automatic transfer switch (ATS): Typically LV switchgear/switchboard is located in the electrical room and marks the utility service entrance for data centers less than 1 MW.
- UPS system with input/output switchboard and UPS distribution switchboard: UPS systems are typically installed in the electrical space or IT space of the data center to provide uninterrupted power to the critical equipment it supports.
- Power distribution Units (PDUs) and remote power panels (RPPs) : Traditional PDUs and RPPs are located in the IT space to distribute, control, and

monitor the critical power from the upstream UPS system to IT racks

- Busway: Busway is an alternative to traditional power distribution using PDUs and RPPs
- Panelboard: Panelboards (typically rated from 1.5kVA to 75kVA) are basically a metal cabinet that house the main electrical bussing and the terminals upon which circuit breakers, neutral wires, and ground wires are installed.
- Rack PDUs (rPDUs) / outlet strips: Rack PDUs (i.e. power strips) are installed in IT racks and are powered from the mating connector of the upstream PDU or RPP and distribute power directly to IT equipment in the rack

IV. ENERGY CONSUMPTION IN A DATA CENTER

Climate change is recognized as one of the key challenges humankind is facing. The Information and Communication Technology (ICT) sector including data center which generate up to 2% of the global CO₂ emissions, a number on par to the aviation sector contribution. Data centers are estimated to have the fastest growing carbon footprint from across the whole ICT sector, mainly due to technological advances such as the cloud computing and the rapid growth of the use of Internet services.[6]

In general, the information technology (IT) sector nowadays consumes approximately 7% of the global electricity, and it is forecasted that the share will rise up to 13% by 2030 [7]. The data centre (DC) sector in particular is estimated to account for 1.4% of the global electricity consumption (1.1–1.5% for 2011 specifically), and the compound annual growth rate (CAGR) of this consumption in the period between 2007 and 2012 has been estimated as 4.4%, much higher than the projected 2.1% increase in global demand from 2012 to 2040 [6].

Furthermore, with the increasing generation of huge amounts of data by various pervasive and ubiquitous things or objects (e.g., mobile phones, sensors, etc.) on the way to smart world, the energy efficiency for DCs becomes more pressing.[8](Refer figure 2)

The average data center, according to the report, is 40 times more energy-intensive than an office building and they're only getting bigger. In terms of energy use, meanwhile, they've already hit an estimated 40GW in 2013. More than 50 per cent of the power being expended is directed to powering the necessary cooling systems that keep processors from overheating. This presents, potentially, a big opportunity for the “greening” of data centers.

The energy use and environmental impact of data centers has recently become a significant issue for both operators and policy makers. Data center represent a relatively easy target due to the very high density of energy consumption and ease of measurement in comparison to other, possibly more significant areas of IT energy use. Energy security and availability is also fast becoming an issue for data center operators as the combined pressures of fossil fuel availability, generation and distribution infrastructure capacity and environmental energy policy make prediction of energy availability and cost difficult.

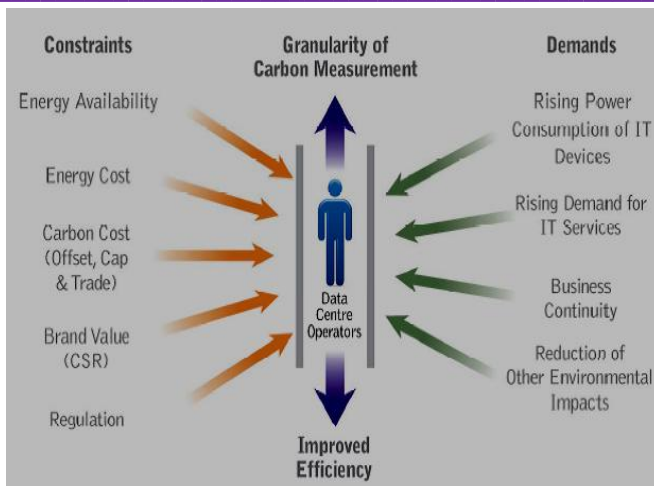


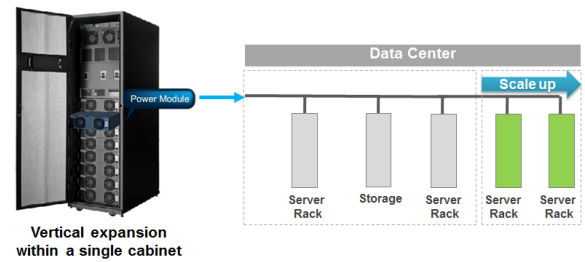
Figure 2: Demand and constraints on data center operators [9]

V. GREEN ENERGY STRATEGY

The rise of big data and Internet-of-Things (IoT) in recent years has spurred the continued construction of data centers. As data centers support billions of online users worldwide, the data centers generate large amounts of energy consumption. Tangible improvements to data centers energy efficiency must therefore be developed to realize significant energy savings. Existing data center operators must adopt high efficiency in their data center management in order to benefit both "environmentally" and "economically". Data centers are often accused of being "non-environmentally friendly" as many data centers, have still not adopted any efficiency indicators to date, so there is no standard for energy savings. [10] The top five data center green strategies are listed below. They will help improve data center energy consumption and optimize PUE:

A. Decommissioning of unused servers:

- Data centers usually have a lot of unnecessary IT equipment. 'Comatose servers' refer to servers that are still plugged into the rack but are no longer in actual use. They still take up valuable rack space, consume large amounts of energy and degrade the PUE (Power Usage Effectiveness).
- Decommissioning allows you to retire servers and/or defer purchases of new servers, thus decreasing electricity consumption and waste heat. One watt-hour of energy savings at the server level results in roughly 1.9 watt-hours of facility-level energy savings from devices inside the racks, cooling system, lighting by the electrical distribution equipment. The reducing energy waste in the power infrastructure (power distribution unit, UPS, building transformers) and reducing energy needed to cool the waste heat produced by the server.
- Apart from IT equipment audits, non-IT infrastructure such as the data center's uninterruptible power supplies (UPS) must be regularly inspected as well.
- Modular UPS allows the number of power supply modules to be increased to keep pace with data center expansion.



B. Decreasing the overall energy usage in the data center to get a HIGHER value for PUE:

- The Power Usage Effectiveness (PUE) metric was introduced by the Green Grid, an association of IT professionals focused on increasing the energy efficiency of data centers.
- There were two primary metrics introduced, PUE and DCE (Data Center Efficiency). The latter was later changed to DCiE (Data Center Infrastructure Efficiency). Both metrics measure the same two parameters, the total power into the data center and the IT equipment power.[12]

$$\text{PUE (Power Use Effectiveness)} = \frac{\text{Total power used by the data center building}}{\text{Power used of IT equipment}}$$

$$\text{DCiE (data center infrastructure efficiency)} = \frac{1}{\text{PUE}}$$

- Routine PUE measurements have to be done to monitor how data center PUE fluctuates with the seasons or other external factors. To accurately measure total power in real-time and record the actual PUE, sensors must be installed at key measurement points to record the actual power
- Using high-efficiency UPS systems and eliminating unnecessary voltage conversion stages reduces power loss.
- Implement controlled lighting systems.[11]
- Virtualization is a key strategy to reduce data center power consumption.
- Turn off servers when not in use.
- Replacing chiller or UPS systems that have been in service for 15 years or more can result in substantial savings.

C. Improving data center cooling efficiency:

- Reducing cooling requirements by organizing IT equipment into a hot aisle and cold aisle configuration.
- Positioning the equipment such that the airflow can be controlled between the hot and cold aisles and prevent hot air from re-circulating back to the IT equipment cooling intakes.
- Taking advantage of the current capacity by clearing under-floor blockages and implementing effective cable management to improving airflow management.
- Using free air or natural cooling technique to cooling the data Center.

- Turning up the thermostat wherein increasing the data center ambient temperature by 1°C was found reducing cooling costs by around 4%.
- Raising the temperature and turning off dehumidifying and reheating provides significant energy savings.
- Abiding by the The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Technical Committee 9.9 guidelines for optimal temperature and humidity set points in the data center.

D. Introduction of DCIM System

- The Data Center Infrastructure Management (DCIM) system was developed to help data center managers and operators achieve more effective and comprehensive control and monitoring of the data center.
- Low utilization in individual servers is a common problem among data centers. DCIM can increase efficiency by helping data center administrator identify comatose servers for re-assignment. It can also accurately measure asset utilization and energy consumption by the data center.

E. Use clean, renewable energy sources [13]

- Solar and wind are two of the most promising sources of green energy for data centers, as they are clean and broadly available.
- Use of two load-scheduling systems for green data centers: GreenSlot and GreenHadoop. Both systems assume that
 - a. The data center is connected to a solar array and the electrical grid, and
 - b. There are no batteries.

Their goal is to maximize the use of solar energy; brown energy should only be consumed when solar energy is not available.

VI. Conclusion

The fundamental idea of IoT is that connectivity is rapidly growing -- via the Internet -- to a wide range of embedded sensors, devices and systems. IoT embraces existing machine-to-machine communications and expands to include more analytics and consumer-oriented products. The Internet of Things (IoT) has a potential transformational effect on the data center market, its customers, technology providers, technologies, and sales and marketing models, according to Gartner, Inc. Gartner estimates that the IoT will include 26 billion units installed by 2020, and by that time, IoT product and service suppliers will generate incremental revenue exceeding \$300 billion, mostly in services.

IoT deployments will generate large quantities of data that need to be processed and analyzed in real time," said Fabrizio Biscotti, research director at Gartner. "Processing large quantities of IoT data in real time will increase as a proportion of workloads of data centers, leaving providers facing new security, capacity and analytics challenges.

Data center managers will need to deploy more forward-looking capacity management in these areas to be able to proactively meet the business priorities associated with IoT. The magnitude of network connections and data associated with the IoT will accelerate a distributed data center

management approach that calls for providers to offer efficient system management platforms. The rise of big data and Internet-of-Things (IoT) in recent years has spurred the continued construction of data centers.

Data centers are often accused of being "non-environmentally friendly" as many data centers, still need efficiency indicators for energy savings. Growing environmental awareness has highlighted the importance of "data center energy saving" as well.

Green data centers thus aims at reducing the carbon footprints required or generated by the computer technology.[14] For any data centre today being energy efficient is a must. PUE can provide a basis for measuring energy efficiency and is very important for creating a sustainable green data center. By reducing carbon footprints and increasing the utilization of individual servers, the goals of PUE and ROI optimization can be achieved.

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