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Power Management in the Computer Centre Under Distributed Environment

Kamlesh Kumar Verma
Department of Computer Science
Babasaheb Bhimrao Ambedkar University
Raebareli Road, Vidya Vihar
Lucknow 226025, (UP) India

Vipin Saxena
Department of Computer Science
Babasaheb Bhimrao Ambedkar University
Raebareli Road, Vidya Vihar
Lucknow 226025, (UP) India

Abstract: In the current scenario, many of the computer centres across worldwide are following the approach of distributed systems in which multiprocessors are arranged for timely run of tasks through task scheduling by means of effective networks topology. The centres contain many electrical devices which emit energy hence there is a big challenge to optimize the power consumption in the computer centre. In the present paper, a case study of computer centre is considered in which devices are arranged under distributed environment for providing better facilities to the users. Each device is examined properly along with specifications and methods are proposed for optimization of power consumption. Results are represented in the form of tables and graphs.

Keywords: Distributed Computing; Energy Optimization; Power Consumption; Step Network Topology

I. BACKGROUND

Since last few years, centralized computing is almost obsolete due to evolution of the distributed technology in which heterogeneous devices which have different configurations are well connected across the network. These devices may provide services on either on fibre optics or wireless technology both of the technology needs either Local Area Network (LAN) card or wireless LAN card. In this approach, control is not a centralized but users may access or run tasks on the server as well as on its own machine. In the present work, a well known National Knowledge Network (NKN) was established by Government of India in the computer centre located at Babasaheb Bhimrao Ambedkar University, Lucknow, India. In this network the devices are arranged according to the following figure.

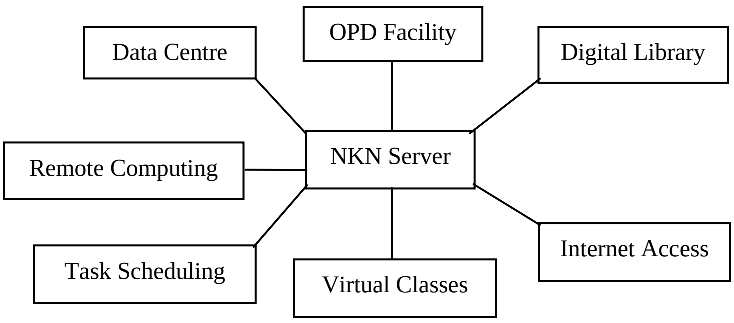

Figure1. Distributed Features of Computing

In the above technology, a router model CISCO 7609 is used to provide access to the server and through this server, users may get the services like OPD facility, online medicine treatment facility, online Examination, video conferencing, online report generation, digital library, remote computing, virtual classes, tasks computing through data centres, internet access and many more. For optimizing the performance of the above devices used for providing the said facilities to the users, a number of processors are used by means of the static step network technology as shown in the figure 2.

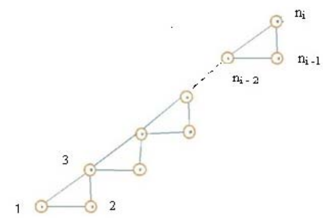

Figure 2. A Static Step Network

In the reference of figures 1 and 2, different network devices are well interconnected in the computer centre as shown below in the figure 3.

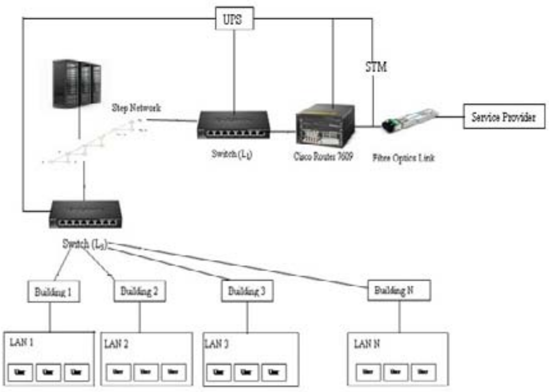

Figure 3. Interconnection of Devices in the Computer Centre of the University

The above setup has been established in Babasaheb Bhimrao Ambedkar University (BBAU), Lucknow and represented in figure 2. It is self explanatory; service provider provides the fibre connectivity to (STM). A link from STM is given to the CISCO router 7609, and then different processors are arranged through step network connected through L1 switch for distribution to the various buildings, link from servers is given to L3 switch which is used for NKN servers to the different buildings located in the BBAU campus of the University. The specifications of devices used in the computer centre are summarized below in following table 1.

Table1 Specifications of Devices used in the Computer Centre

Name of Device	Specification	Power Consumption
Router Cisco 7609	**1. Dimensions** (H x W x D) 36.75 x 17.2 x 20.7 in. (93.3 x 43.1 x 53.3 cm) **2. Power requirements:** (a)– 208 to 240 VAC (b)– 48 to -60 VDC **3. Input Current** - 30A **4.-Environmental Features**: (a) Operating temperature: 32 to 104°F (0 to 40°C) (b)Storage Temperature: -4 to 149°F (-20 to 65°C)	Power Consumption: 1300W Max (100-120 VAC).2500W Max (200-240 VAC or -48 to -60 VDC).
L1 Switch - Coriant (switchgear)7090 Series 7090-92M	**1. Dimension**: 442 x 220 x 180. **2. Model :** Coriant , hiT 7090 92G **3.Fabric Capacity**: 92Gbps **4. Hardware Protection**: Control, timing and fabric module protection for hiT 7090 240G and hiT 7090 92G.	Maximum Power Consumption = 400w
L3Switch D Link DGS-3120 , 24PC	**1.Dimensions** (W x D x H) = (440 x 310 x 44 mm) **2. Model:** DGS-3120-24PC: 24-Port Gigabit , L2 Stackable Managed, PoE Switch including 4 x Combo 1000BASE-T/SFP ports and 2 x 10 Gbps stacking ports (24 x PoE ports, smart fans), **3. Switching Capacity** -88 Gbps,	PoE = Power Over Ethernet Load (Min): 482.7 Watts (with 70W) PoE = Power Over Ethernet Load (Max): 935.1 Watts (with 740W)
Firewall Proxy HP Proliant DL580G7 (Endian Firewall Community)	**1.Dimensions:** 4u Rack, 6.94 X 19 X 27.55 Inches (17.6 X 48.3 X 70 Cm) 100lbs Max **2.Rail Kit:** Rack Rail Kit 50/60 Hz **3**. Hewlett-Packard Company, Model No. HSTNS- 2131, Server / Storage - HSTNS-2131 (HP Proliant DL580 G7) **3. Cache Memory**- 24mb (1 X 24mb) Level 3 Cache Ports: 6 Usb 2.0 Ports. **4. Processors:** 2 X Intel Xeon 10 Core Processor E7-4860 2.26ghz 24mb Smart Cache 6.4 Gt/S Qpi Tdp 130w	Maximum Power Consumption HP 1200W ,100/110-120/200- 240 Volt Current supply at per 9/9/5 amp

By the use of Table 1, different parameters are considered which are variable form time to time and a mathematical method is proposed to optimized the power consumption used in the above devices, since the power consumption is directly dependent on time hence is varied as per time variation for scheduling of the various tasks given by the users. In this work, power consumption is optimized by the mathematical technique and results are depicted in the form of table and graphs.

II. RELATED WORK

Let us describe some of the important work on the said topic from which authors are motivated to describe the power consumption methods on the computer centre of the University. Vasudevan et al. [1] have given an algorithm for theoretical based framework a penalty based Profile Matching Algorithm (PMA). This algorithm is mainly used for scaling the energy consumption during data work load in profile based application in the data centre. Mäsker et al. [2] described the smart grid–aware scheduling in data centres. An algorithm introduced for better balance energy effect in multi queue batch system and improved the scheduling algorithms for energy utilization. Shen et al. [3] have developed a stochastic model on querying theory BFGS based algorithm to optimize the trade off by searching for the data centre operators to right–size. The Stochastic Right Sizing Model (SRM) implements the algorithm on data workload in data centre. Rossi et al. [4] have used various methods for energy saving techniques. One of the methods Energy-Efficient Cloud Orchestrator e-eco is a data management system that connected with the cloud load balance during execution. The power aware approaches the e-eco the best way for finding the energy performance. Arianyan et al. [5] have developed a Dynamic Voltage and Frequency Scaling (DVFS) method for consolidation resources to propose a novel fuzzy and objective resource management solution.

Nada et al. [6] have described a scaling physical model for energy consumption. In this model, there are three different stages (i) rack inlet temperature at the time of aisle partition and aisle containment configuration. (ii) Temperature reduction increase with increase power density (iii) using aisle partitioned with raised floor improvement. Gu et al. [7] have developed a green scheduling algorithm for cloud data centre and focused on two optimization, (1) Reducing the total energy cost through scheduling of servers, and the usage of different energy sources, (2) minimizing total carbon emissions within the budget of energy cost. Shoukourian et al. [8] have given a toolset, called Power Data Aggregation Monitor (PDAM). It collects and evaluates data from all resources like information technology systems, resource management systems and applications. The goal of power DAM improves the energy efficiency of High Performance Computing (HPC). Baccarelli et al. [9] have given a queuing theory for data work load in data centre. This theory has two features (i) maximize the average workload admitted by the data cente (ii) minimize the resulting networking-plus-computing average energy Consumption. The optimization method is implemented to the resource management framework uses in admission control. Zapater et al. [10] have given a technique for energy consumption in data centre called Grammatical Evolution Techniques (GET) used as generation as a temperature model. The temperature model is used for prediction of CPU and inlet temperatures for runtime data center temperature prediction using GET. Basmadjian et al. [11] have proposed a mechanism theory to find the demand supply electricity in data centres. In this proposed mechanism, they described the power supply policies to reduction the energy consumption. Lei et al. [12] have given an algorithm for energy efficient scheduling in data centre. In this proposed algorithm, there are two types of scheduling (i) Green-Oriented scheduling (ii) Time – Oriented Scheduling. They described a multi objective energy efficiency task scheduling on a green data centre by Dynamic Voltage Frequency Scaling (DVFS) technology. Hammadi et al. [13] have explained the survey methods of architectures and energy efficiency in Data Centre Networks and proposed the Data Centre Networks (DCN) techniques as switch-centric and server centric topologies. Xu et al. [14] have described a novel energy efficient flow scheduling and routing algorithms in Software Defined Networking (SDN). In this approach, the networks link and switch works as scheduling algorithms for energy consumption are explained. Vitali et al. [15] have given a model approach for finding the energy consumption of data centre. By the use of the model efficiency of data center has increased the energy efficiency and quality of service (QoS). Brown et al. [16] have discussed the current trend of energy and energy costs of data centres and servers and given various methods, techniques, and algorithms for finding the energy consumption in data centres. Ghazisaeed et al. [17] have proposed a method of energy embedding of Map Reduce based virtual networks in data center and formulated a mixed integer disciplined convex program (MIDCP) for applying this method. This method used for solving the NP-hard problems. Cupertino et al. [18] have proposed the energy efficiency through thermal modelling in data centre and used the CoolEm All approach for evaluation and measurement. They also described resource management scheduling for workload process. Asghari et al. [19] proposed proposed the three main approaches used to modify of Bcube topology as a topology for vitualized data centre. Khani et al. [20] proposed a Mathematical analysis for distributed consolidated virtual machines for pewer efficiency in cloud data centres. Jiang et al. [21] have proposed a Mathematical model for the network flow over the network device through Integer Linear Programming (ILP). In the complex networks the heuristic approach solving the Integer Linear Programming is explained. Myoung et al. [22] have proposed an algorithm for controlling the server speed and routing scheduling. They have proposed time distribution G/G/1/PS queue and load balancing algorithm. Castro et al. [23] have given two new methods for energy consumption (i) dynamic consolidation of virtual machines for CPU in data centres (ii) dynamic consolidation of virtual machines for RAM in data centres. Arianyan et al. [24] have proposed a multi-criteria decision making method for determination of energy consumption. In this method they have applied service level agreement (SLA) efficiency in resource management. Paul et al. [25] have described a method for controlling the electricity cost during load distribution for the reduction of energy consumption. Huu et al. [26] have proposed a power scaling algorithm and energy efficiency model for data centre networks. The energy analysis model is proposed to calculate the energy saving cost in low and high transmission data packets throughput in networks. Kulshrestha et al. [27] have explained a receiver contention based mixed transmission scheme for energy consumption .the residual energy of the receivers. It considers link reliability and the numbers of neighboring nodes, the proposed approach have given energy of efficient data transmission. Zhang et al. [28] proposed optical switching technology energy consumption for data centre networks. Collins et al. [29] proposed here as energy consumption case study an examination of the abandonment of applications for energy efficiency retrofit grants in Ireland. Freire- González et al. [30] have described input-output methodologies in data centre and direct and indirect rebound effects have been mathematical analysis efficiency improvements of energy efficiency. Zhang et al. [31] have proposed design principles and architecture. They have described two methods for energy reduction (i) Open Scale Network (ii) Workload Allocation. The analysis and experimental classification of an optical switching scalable data center network architecture.

III. MATERIALS AND METHODS

In data centre, there are many devices, when are connected in series and every device consumes power itself called Local Power Management (LPM). The LPM is derived of each and every hardware configuration. The configurated devices are integrated of many embedded system, and the embedded system is connected through integrative circuits. The integrative circuits are depending on the power consumption. The different devices are represented by different formulas or (Energy) like Central Processing Unit (CPU) which varies the energy consumption represented by $P \alpha CV^2$, there are two types of energy consumption of the devices (a) dynamic energy consumption (b) static energy consumption. The dynamic energy consumption is depending over the full connectivity devices on voltage and conductance or consolidated devices. The static energy consumption is fixed over the devices. The server energy consumption is proportional to the CPU utilization. The dynamic energy consumption also depends on NP completeness problem. The energy consumption of the data centres also depends on the server and different types of servers are used to optimize the work load of the power optimization.

On the basis of above concept, a National Knowledge Network (NKN) is established by Government of India, which is a capable for providing secure and reliable connectivity. The NKN provides the research, innovation and multidisciplinary area and collaborative communication for the research area. The NKN has certain features in research area and other services as given below. It is a high-speed backbone connectivity which will enable knowledge and information sharing amongst NKN connected institutes. The services provided by NKN are shown in figure 1.

a. It is enabling collaborative research, development and innovation amongst NKN connected institutes;

b. It is facilitating advanced distance education in specialized fields like engineering, science, medicine etc;

c. It is facilitating an ultra-high speed e-governance backbone;

d. It is providing connection between different sectoral networks in the field of research;

e. It is providing OPD facility, video conferencing facility, remote computing, and digital library facility and many more.

A. *UML Activity Diagram*

The process classification in data centre is represented through Unified Modeling Language (UML) activity diagram.

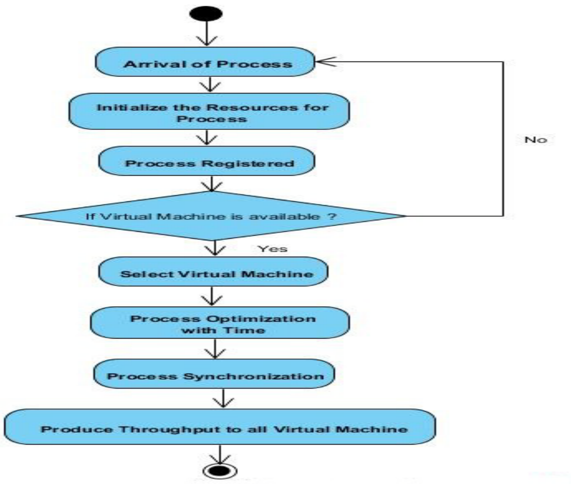

Figure 4. UML Activity for Process Classification

It is shown in the figure 4 in which flow of the information in data centre is a method of transmission. Firstly, the process of initializes incoming process at a specific time and go through for the resource analysis and process is registered in process block. Now the process entered in virtual machine and proceeded with the minimum energy cost and power utility chamber, Now then process flows in hard disks, memory, and CPU with specific time interval. Now that the same process in all virtual machine and process synchronizes throughput to all devices. Now the final process get energy cost measured with the data flow in data centre.

B. *Methods of Energy Efficiency in Data Centre*

Data centre uses the energy consumption major components. Suitable methods for efficient energy consumption are described below:

1) *Information Technology for Equipments*

The energy consumption of data delivery packets in IT components is very vast. During the period of execution process, the energy consumption of all IT equipment is consolidated consumption and individual components. These approaches are working on IT equipment with working load on CPU, hard disk, motherboard, and other electromechanical devices components.

2) *Cooling*

The cooling in data centres is mostly provided by Computer Room Air Conditioning (CRAC) units. The CRAC units works in data centre, for minimizing the energy consumption in the equipments. The air handling units is covered the distributing the air throughout the data centre using the devices like fans, filters, and cooling coils. The fans works with the server's pulls are cold air and reduce their heat. At this time the warmed air toward the ceiling and receive the CRAC unit.

3) *Electric Power Delivery*

The power delivery is performed in data centre to storage devices and network IT equipments to facilitate the storage and transmission of data. The power delivery systems provide voltage regulation, backup power, and AC/DC convertors. The power delivery of electricity is first supplied to UPS, and then Power Distribution Unit (PDU). The PDU units convert the AC voltage in to the DC voltage. The DC voltage performs as work all internal hardware devices like, CPU, memory, disk drives, chipset, and fans.

4) *Heat Removal*

The maintaining and controlling of temperature or humidity is the main feature of air conditioning systems in data centres. The all electronic devices are consumed the energy as heat delivery. The rack of blade servers requires the power up to 20-25 kilowatts.

5) *Energy efficiency*

The energy efficiency of data reliability in data centres depends on the designers and operators. The power and cooling systems in data centres must be efficient for the energy efficiency. Many software programs and hardware devices consume the power allocation and released the carbon footprint. The energy efficiency is increased by the design of device architectural and software applications.

6) *Power Vs Energy*

- The power and energy are different. Power is measured in a particular point in respect of time but the energy consumption is measured in over a period of time.
- Power is measured in kilowatts (kw) but the energy is measured in kilowatts hours (kwh).
- The highest power approached is very important aspect at any point of time for power based design, while energy consumption over a period of time is important aspect for energy based design.

7) *Performance Vs Productivity*

- The performance and productivity are distinct of the data centre. The performance of the data centre is measured as (QoS) of the networks availability and their design, while the productivity is measured as the throughput data packets in amount of quality assurance.
- If the hardware side of servers and storage are capable of the data transmission throughout the networks as called performance. While the total amount of data packets in specific time is called productivity.

8) *Code of Conduct (COC)*

The code of conduct is a action of stimulate data centre operators to reduce their energy consumption. The code of conduct is responsible for the following parameters:

- Environmental statement;
- Problem Statement;
- Scope of CoC;
- Aim and Objectives of CoC;

IV. COMPUTAION OF POWER CONSUMPTION

In the said case study, the devices are installed and consumed more energy in comparison of the others because of high power requirement by the devices, as well as cooling infrastructures. In general, it is approximate 40 times more in comparison of other office equipments installed in the building. A server takes more energy consumption during the peak hours. Let us describe, the electric power consume by the devices for which consumption of energy takes place.

A. *Electric Power Consumption*

In the university numerous devices are installed which are represented in figure 5.

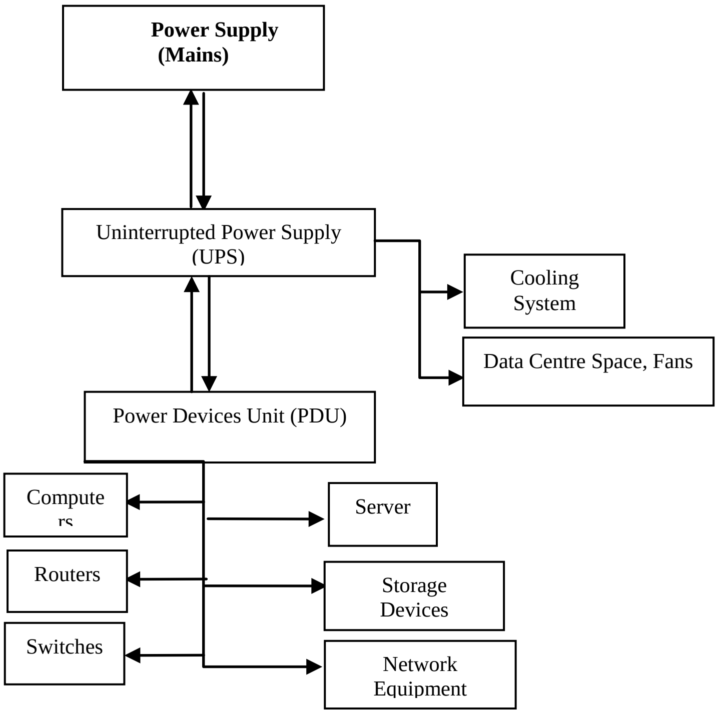

Figure 5. Power Consumption Devices

Since, these devices perform critical operation for which Uninterrupted Power Supply (UPS) equipment is designed to maintain desire electric supply. The equipment represented power as described in following table 2.

Table2. Details of Peak Power Consumption

Component	Peak Power (kW)
CPU	80
Memory	36
Disks	12
Peripheral Slots	52
Motherboard	25
Fan	10
Power Loss Supply Unit	38
Total	253

However, in some equipment it has range from minimum to maximum like CISCO router 7609 consumes power consumption from 48 watt to 60 watt, hence the range of power consumption varies from one device to other device.

B. *Heat Removal*

Temperature, varies from day to day temperature varies therefore cooling equipment are necessary for maintaining the temperature in the computer centre, generally air conditioning systems are used for maintaining temperatures in the computer centre where devices are installed.

C. *Measurement Techniques*

Various authors here designed measurement techniques for finding the consumption cost of the services related to the computer centre. The steps are given below,

- To determine the rate of energy delivery from the source to the devices;
- To determine how many units are delivered by the devices;
- To determine how many units are used for the work;

Some of the measurement techniques in the computer centre are described below:

1) Power Usage (PU)

This is a technique for measurement of the amount of power to perform effective computation in a data centre. The formula is expressed of power usage and is given below. Power allocations in IT equipments are distributed. The power is distributed in the entire devices like UPS, generators, batteries, IT devices. The power uses the distribution air cooling system and network nodes.

2) Data Centre Infrastructure Efficiency

Let us consider a power management for the router (CISCO 7609) modelled in the computer centre the router power management is given by,

$$RPM = Static\ Power\ Supply + \alpha\,(Dynamic\ Power\ Supply)$$

$$RPM = SPS + \alpha\,(DPS) \qquad (1)$$

Where α is constant, RPM is the Router Power Management, SPS is Static Power Supply, DPS is the Dynamic Power Supply. Let us apply least square method to optimize the power consumption and normal equation are given below,

$$\sum RPM = SPS + \alpha \sum DPS \qquad (2)$$

$$\sum RPM \times DPS = SPS \sum DPS + \alpha \sum DPS^2 \qquad (3)$$

Let us consider computation current supply i.e. I=30 amp. and voltage is varying from minimum value 48 to maximum value 60, and then power consumption is resolved in the following table 3.

Table 3 Computation of Power Consumption

V (Volt)	I (Amp)	P=V*I (In Watt)
48	30	1440
49	30	1470
50	30	1500
51	30	1530
52	30	1560
53	30	1590
54	30	1620
55	30	1650
56	30	1680
57	30	1710
58	30	1740
59	30	1770
60	30	1800

From the above it is observed that power is directly dependent on the voltage for management of this power, let us consider RPM is taken as P while DPS dependent on the voltage V, hence RPM depends on the V on solving (2) and (3) on the said data, it is computed as

SPS = 0, α = 30 and RPM = 30*V

This is true as per observations.

V. RESULTS AND DISCUSSIONS

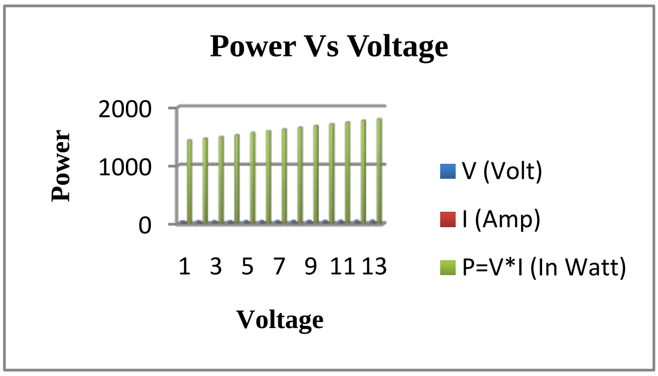

Figure 6. Representation of Power V/s Voltage

The above graph has shown the result of the relation between the power consumption and input voltage for the Router Power Management (RPM). The input voltage applied range from V_{Min} = 48 Volt to V_{Max} = 60 Volt and applied input Current is 30 Ampere. So the router power management and power measurement have described the power which is increased as voltage is increased and when the current is constant taken as 30 amp.

VI. CONCLUSIONS

From the above work, it is concluded that the UML is a powerful modeling language which is used to represent the dynamic behavior of the research problem. In the above work, a studied is done for the minimizing the power consumption in the computer centre which contains various devices emitting the energy. A least square method is used for providing the optimized results represented through graph. The same study can be extended for the other computer centre.

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