Datacenter Simulation and Study of Malware Intrusion / Energy Efficiency in Datacenters

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Approval

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ABSTARCT

Cloud computing has emerged as the leading technology for delivering reliable, sustainable, and scalable computational services, which are presented as Software, Infrastructure, or Platform as services (SaaS, IaaS, PaaS).With the rapid pace of adoption of Cloud computing there is an increased dependence on Datacenters. The design and analysis of such large/complex distributed systems often suffers from the lack of availability of an adequate physical infrastructure. In such case, simulators provide a crucial role. Simulators permit system designers to study a problem at several different levels of abstraction. The primary objective of this thesis is to develop a generalized and extensible simulation framework that enables seamless modeling, configuration of datacenter equipment which allows the study of task allocation techniques and effects of malware intrusion on datacenter energy consumption. Datacenter management is a field new to students and researchers; a great deal of effort is usually required for understanding the core concepts involved. In an effort to minimize this effort; a generic datacenter simulator has been developed with basic features of networking/ configurations of equipment, task management and scheduling.

CERTIFICATE OF ORIGINALITY

I hereby declare that this submission is my own work and to the best of my knowledge. It contains no materials previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any degree or diploma at SEECS-NUST or any other education institute, except where due acknowledgment, is made in the thesis. Any contribution made to the research by others, with whom I have worked at SEECS-NUST or elsewhere, is explicitly acknowledged in the thesis.

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Firstly, I would like to express my endless gratitude to Allah Almighty (SWT) for his abundant blessings. Without his guidance, affection and love it was really impossible for me to accomplish anything in life. He is the creator who helps me in the dark hours of my life. He is the only one who enlightens the way when things seem impossible to me, he comforts me when i feel agonized, he guides me when I was about to deviate.

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Dedicated to my Parents and Siblings

For their love, kindness, sacrifices, and encouragement

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CHAPTER 1

1. INTRODUCTION

The next generations of datacenters are powered by Clouds which expose them as a network of virtual services such as databases, application logic, user-interface, and virtual machines. This aids users to access and deploy applications from anywhere in the world on demand at competitive costs depending on their Quality of Service (QoS) requirements. It saves small and medium IT companies the trouble of buying their own server equipment and managing services themselves. The most common Cloud-based applications are 1) social networking, 2) content delivery, 3) web hosting, and 4) real time instrumented data processing. Each of these application types has different composition, configuration, and deployment requirements. Quantifying the performance of scheduling and allocation policies in a real Cloud environment for different application and service models under different conditions is extremely challenging because: (i) Clouds exhibit varying demand, supply patterns, and system size; and (ii) users have heterogeneous and competing QoS requirements. The use of real infrastructures such as Amazon EC2, limits the experiments to the scale of the infrastructure, and makes the reproduction of results an extremely difficult undertaking.

Datacenters can consume energy as much as that of a medium sized town. Due to enormous consumption of energy, Datacenters have a large and growing carbon footprint. Typically a major portion (over 70%) of the energy consumed in Datacenters is wasted and dissipated. After conducting a yearlong Survey, New York Times published a report [1] in which they claimed that most datacenters, by design, consume vast amounts of energy in an incongruously wasteful manner. Worldwide, the digital warehouses use about 30 billion watts of electricity, roughly equivalent to the output of 30 nuclear power plants. Online companies usually run their facilities at maximum capacity, round the clock, whatever the demand. Therefore, they can waste up to 90 percent or more energy they pull off grid. According to Mckinsey study, commissioned by a newspaper that found across several industries, that the average server used only 6 to 12% of the available CPU cycles and another information week report reflects utilization of only 7%- 15 % of the CPU cycle. Such practices reflects IT managers fear of downtime. The business owners could afford extra electricity, but couldn’t afford to go off air for a few hours. With the introduction of virtualization almost half to two-third of the number of physical servers formally in use are now gone. Colombia, Sportswear during the process of virtualization of its servers observed that the services provided by 300 servers was shifted to only 65 server by utilizing 80% of the CPU cycles of those 65 servers as mentioned in [2].

With the rapid pace of adoption of Cloud and utility computing there is an increased dependence on Datacenters and cloud computing paradigm has recently gained the attention of various communities including researchers, businesses, consumers and government organizations. The design and analysis of such large/complex distributed systems often suffer from the lack of availability of an adequate physical infrastructure. In such case, simulators provide a crucial role in both industry and academia. Consequently, the user may explore the merits of alternative designs and study behavior of different applications hosted on servers without actually physically building the systems. By investigating the effects of specific design decisions during the design phase rather than the construction phase, the overall cost of building the system diminishes significantly. Simulators permit system designers to study a problem at several different levels of abstraction. In this work we provide students, researchers, industry professionals and even a novice user with a simulation platform where they can easily create, design and configure a datacenter and gain knowledge about configuration of equipment used in datacenters like servers, switches etc. Our aim is to enhance the understanding of user about working of datacenter.

Keeping fore mentioned in view we have developed a web based, user friendly and flexible datacenter simulation platform specifically to help students, researchers and professionals to understand the core concept of datacenters. Our simulator will assist its users in creation/ configuration of a platform that will assists its users in creation/ configuration of a datacenter, using different scheduling algorithms to execute tasks and study their state in terms of MIPS and RAM acquired by a particular node and whole datacenter. A special module for simulating workload in datacenter when it's infected with a malware has also been developed to enhance understanding of users in subject field. Infection of a malware or denial of service attack makes certain changes in a datacenter. Studies of these changes are visible to user at the time of execution of tasks on infected servers using different scheduling algorithms and its effects on the execution capability of servers.

We will start our research paper with by providing readers a brief introduction and background knowledge about datacenters, simulators, datacenter networking architectures, green engineering techniques and effects of energy efficiency in malware infected/neutral environment using different schedulers. Section 4 of the paper will provide details regarding underlying architecture including Entity relationship diagram (ERD) and System Implementation flow which will lead to objectives for the development of the simulator and educational modules. Last portion of the paper will brief readers about tools and technologies that were used to develop the simulator, evaluation of the system, conclusion and future work.

To test and evaluate the simulator we uploaded it on World Wide Web (www) and provided access to a class of post graduate students to create/configure their own datacenters, simulate workloads, study effects of different schedulers on energy and processing power utilized by datacenter. Result of survey conducted after the lab showed drastic improvement in core concepts of students and researchers about how servers and switches are configured / networked, how tasks are allocated/ executed, how energy is consumed in datacenter and what are factors effecting energy consumption of datacenter and what impact does malware infection or distributed denial of service attack have on energy utilization and processing capabilities of datacenter. Further results of different simulation schedulers lead them to better understanding of the effects of scheduling algorithms and their tradeoffs with respect to energy utilization and processing capabilities of a datacenter.

CHAPTER 2

2. BACKGROUND

Datacenters are usually made up of either three tiers: *Access*, *Aggregation* and *Core* as seen in figure 1 or two tiers: Access and *Edge* for smaller setups. All devices between these layers are inter-connected. The bottom or Edge layer consists of the servers, above which is the distribution layer which is a mesh up topology of switches responsible for interconnection of everything between the Edge and the Core. Two tier architectures are for small setups supporting up to 8K servers at most, and therefore three tier architectures are more prevalent. The three and two tier architectures have been designed to fulfill the requirements of a highly redundant and fault-tolerant datacenter where recovery, backup, protection and management of company and customer data is of primary concern in Cloud-based environments. The reader may note that the switching fabric plays a very dominant role in this DCN architecture and therefore choosing the right switching equipment and differentiation between small commodity switches and expensive non commodity switches can make a lot of difference. Unfortunately with very large diversity in vendors' networking equipment, network planners end up with over provisioned links and switches for peak network loads and no support for power throttling. Moreover the switch and server topology (DCN architecture) may also be varied so that this strict three or two tier connectivity is avoided. For instance in some recent architecture's [3] [4] dual-ported servers are used instead of switches that can reduce the need for hardware switches and have profound effect on overall energy-consumption.

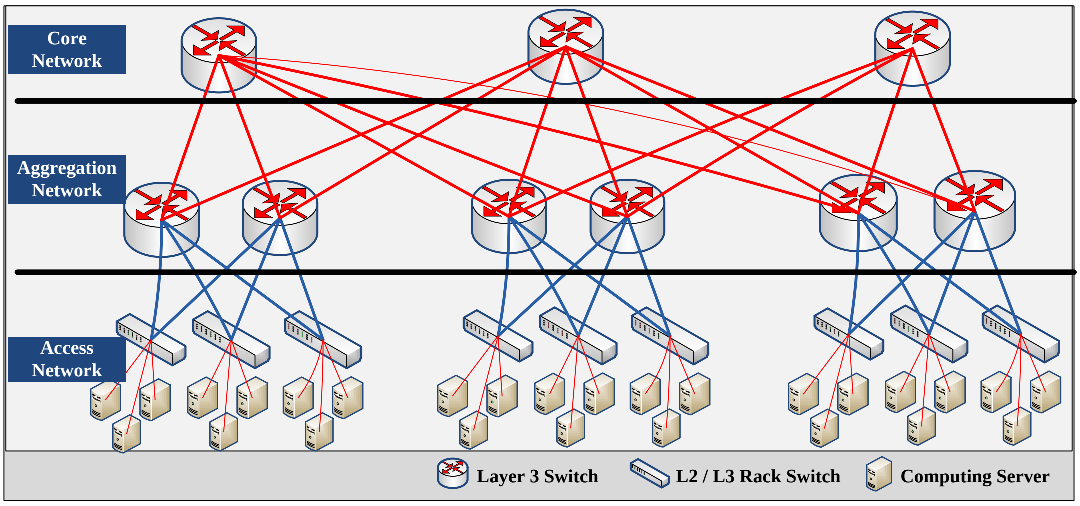


Figure 1: A Simple 3-Tier Datacenter Architecture

The next generation of datacenters is powered by Cloud which exposes them as a network of virtual services such as databases, application logic, user-interface, and virtual machines. This aids users to access and deploy applications from anywhere in the world on demand at competitive costs depending on their Quality of Service (QoS) requirements. It saves small and medium IT companies the trouble of buying their own server equipment and managing services themselves. The most common Cloud-based applications are 1) social networking, 2) content delivery, 3) web hosting, and 4) real time instrumented data processing. Each of these application types has different composition, configuration, and deployment requirements. The cloud usage model has made the task of the datacenter network planner even more complex especially from the perspective of Green Traffic Engineering. Quantifying the performance of scheduling and allocation policies in a real Cloud environment for different application and service models under different conditions is extremely challenging because: (i) Clouds exhibit varying demand, supply patterns, and system size; and (ii) users have heterogeneous and competing QoS requirements. By identifying the usage patterns of clients, management applications can be used to shutdown, hibernate or use some other mechanism to minimize the overall energy utilization of a datacenter. Cloud service providers such as Amazon EC2 partition the datacenter network into different zones where each zone is pre-configured and optimized for a particular workload requirement such as content delivery or data-processing etc. While such network segregation can aid in planning for power conservation it is also security vulnerability. Hackers have devised techniques commonly referred to as Cloud Cartography which involve instantiating Virtual Machines with the same workload characteristics as that of the victim's. The cloud scheduling service with high probability co-locates the hackers and the victim's VM on the same IP network segment or sometimes even the same physical host allowing the hacker's VM to observe the victim VM's memory and disk usage via covert channels. To grasp better understanding of these concepts it is not possible for students and researchers to setup their own datacenters and observe its working and mechanisms involved in its configuration therefore there is extreme need of some simulation platform that is readily available, user friendly and flexible to the extent of their usage.

we have detailed three categories of green engineering techniques for datacenter planning: 1) solutions that require changes to core switching firmware requiring vendor support 2) services and task provisioning and 3) solutions that require changes to the network architecture and topology and as shown in **Error! Reference source not found.**.

Energy Saving Options at Device Firmware Level	**Energy Efficient Task Provisioning**	**Selection of Energy Efficient DCN Architecture and Topology**
Keeping devices in sleep mode	Data Based	Fat Tree
Power Consumption Models	Communication	VL2
Dynamically Adapting Rate of Network ports	Computation	DCell
Dynamically Select and Control group of switches and links	Computer	BCube
		CamCube

Table 1: Categories of Green Traffic Engineering Solutions

A brief introduction regarding these concepts is available in the following sections.

2.1 Energy saving options at device firmware level

A major portion of energy is utilized by always on network devices. However, if network equipment that allows Device Level Sleeping is purchased, then these switches are able to enter a deep sleep mode while continuing to maintain network links thus ensuring the ability to wake up in response to a network request. In such a sleep state, edge devices may require a longer wakeup time which can be negotiated using link level discovery protocols (LLDP) defined in the standard IEEE 802.1AB. This standard is already widely supported by networking equipment and so it does not place extra burden on the system to add wake time negotiation. By managing fan speeds and monitoring energy efficiency DCN administrators can calculate the tradeoff between energy utilization and work done.

The power provisioning and management capabilities of early-generation Power over Ethernet (PoE)-a family of standards that provides both data and power connections in one cable promises to reduce AC draws of all networking devices involved. In very early PoE the power transmission to a Powered Device (PD) such a switch from the Power Sourcing Equipment (PSE) used to be rudimentarily controlled up to 13W. Lately the IEEE 802.3at standard has increased this power limit to 25W with much finer grained management features. With variations in demand and supply, boosted power for PoE systems is an

important feature. If the PSE is designed with an assumption that all ports constantly supply the maximum power to PDs then the PSE power conversion will operate at low efficiency. Using the sophisticated control and negotiation of power modes, the PSE can improve its power conversion for the specific power demands at any point in time. Furthermore, PSEs may benefit from more efficient design if there is no need to supply maximum power on all ports continuously.
Background knowledge about domain concepts of task scheduling and energy efficiency In this section we describe the very basics of research and development work that has been carried out by us. This is followed by a brief description of different modules and plugins that we have developed and will be explained throughout the paper.

2.2 Energy Efficient Task provisioning techniques

Servers utilize large amounts of power and usually dominate the overall energy cost of Datacenters. Even if a server is kept idle it still utilizes 66 percent of its maximum power consumption. In datacenters providing Cloud Computing services, the users via Cloud brokers depending upon their traffic flow over the Cloud, specify QoS requirements. This is helpful for efficient utilization of resources in the datacenter and boosts performance as per QoS requirement for transmission of user data (e.g. audio, video, textual etc.) and other traffic (e.g. management alerts, security related messages etc.). Clouds offer different services ranging from storage of user data in encrypted form, fast retrieval of that data, provision of virtual machines, to migration of active virtual machines from one server to the other without any loss of user data. The QoS offered by these services is dependent on the specifications of the servers they are hosted on. Some servers perform computationally intensive tasks efficiently, while others are suitable for fast and reliable communication.

The focus of energy efficient task provisioning is to efficiently utilize the minimum number of servers required to meet the quality of service (QoS) requirements and intelligently distribute running applications and services (henceforth called as tasks) among available servers to minimize the energy usage. Tasks can usually be segregated into broadly four categories depending upon their workload 1) processing and computation intensive e.g. scientific applications and long-running simulations 2) communication intensive e.g. video hosting 3) balanced tasks which utilize resources from all the categories e.g. GIS applications and 4) storage intensive e.g database centric and logging applications. Efficiently detecting the tasks’ nature and deploying their combinations intelligently on servers optimized for energy consumption of particular workload types can yield maximum benefit from available resources. There is increasing the case where a datacenter facility originally not planned for large workloads faces high customer demand but cannot be further extended due to limited power available. In this case if resources are allocated to clients based on the fore mentioned attributes the same servers can end up managing more load. Some strategies for energy efficient task provisioning are provided in the subsections below

2.3 Co-Location of Tasks Utilizing Non-Overlapping Server Resources

Computation intensive tasks are services that demand high CPU utilization for solving advanced scientific or simulation based problems on high performance computing servers. While these tasks require high processing power they add little load to the datacenter network. On the other hand communication biased tasks utilize very small fraction of processing power of servers but demand more bandwidth from the network for providing attractive data transfer rates for file or video sharing like services. Such servers are mostly involved in managing I/O controllers in transferring video streams from storage to the client's machine and CPUs remain under-utilized. Intelligent mapping and coupling of diverse CPU vs I/O bound tasks (example shown in Figure 2) can free up both servers and routers that can consequently be kept on low power mode to increase the overall energy efficiency.

2.4 Offload Storage Centric Tasks to Dedicated Storage

Storage centric tasks mostly include database centric and backup services in which data needs to be backed up at regular intervals. Different backup policies may exist keeping in context the QoS requirements. An important network design consideration is to replace multiple Network Attached Storage (NAS) servers with a dedicated Storage Area Network (SAN). Migrating data to a SAN has an energy conservation advantage where a few SAN controllers replace multiple servers. SAN hardware typically allows power-down of RAID arrays and tape drives when data backup is not required which is typically not possible with server centric storage

2.5 Network Wide energy aware routing

Network wide energy aware routing aims to save energy from richly connected Datacenter network devices from a routing perspective. It encourages the use of utilizing a minimum number of network devices keeping in perspective the QoS requirements. During the planning process the network throughput termed as basic routing is first computed according to the currently routed traffic patterns on all datacenter switches. In the next step switches are gradually removed from the basic routing, until the network throughput decreases to a predefined performance threshold

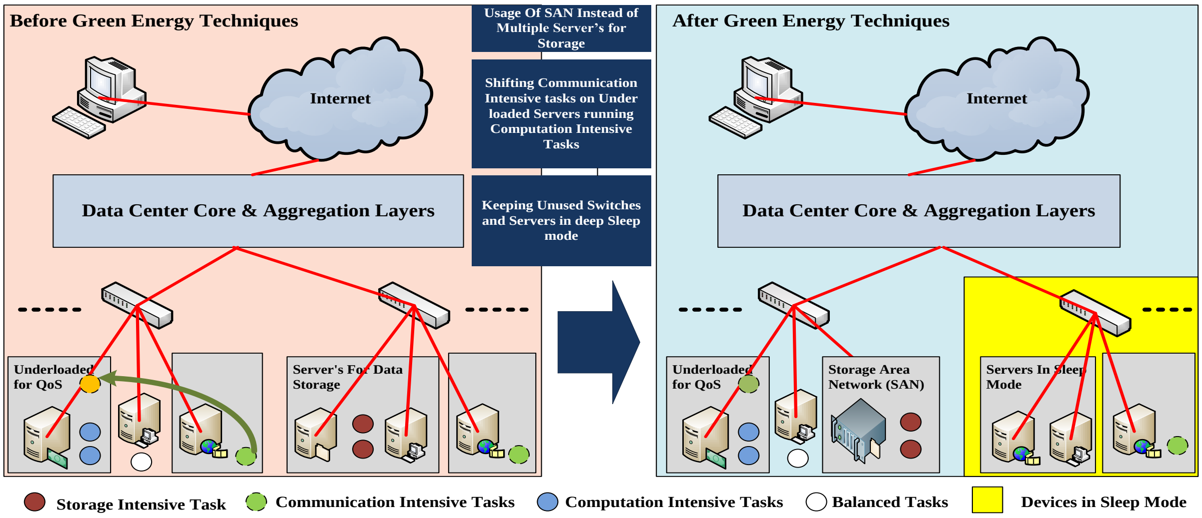


Figure 2: Energy Efficient Task Provisioning Example Scenario

Researchers at KTH Royal Institute of Technology, Sweden to minimize the energy utilization in Networks, originally presented this scheme called Green traffic engineering for future core networks. It addresses the problem faced in traditional networks by allowing network traffic to be diverted to multiple paths and by using intelligent routing decisions to yield maximum performance for the least amount of power.

There is always a tradeoff between efficiency and energy consumption and good network planning will try to achieve a middle ground. We have demonstrated various Green Traffic Engineering techniques based on intelligent task provisioning in Figure 2. The techniques under consideration include combining of multiple services to maximize the utilization of server equipment so that left-over devices are put to deep sleep. Similarly usage of SAN over server based storage helps conserve energy

CHAPTER 3

3. RELATED WORK

Modelling of power consumption in computer systems has been done at various granularity levels, starting from large datacenter to individual components of a system either through real measurements, estimations from performance counters or using a combination of both. Existing datacenter simulators available but some expertise are required in the configuration and management of datacenters therefore it is difficult for students who are new in this field to explore and pursue in field of datacenters simulation. To address this issue we have developed a generic architecture of a datacenter simulator to make students understand about the actual working and configurations of datacenters. A new concept of simulating malware intrusion in datacenters has also been implemented in WebSim. Malware Intrusion helps students get insights and effects of Malware on different components of datacenter.

WebSim equips user with the provision of designing a model of real datacenter in a simulated environment and conduct experiments on it for the purpose of either understanding the behaviour of system or evaluating various stages (within the limits imposed by a creation or a set of criteria) for the operation of the system. Core benefits of datacenter simulator include designing and configuration of datacenter network and processing equipment and getting practical feedback from them after execution of different tasks when designing real world systems. WebSim is an open source event driven simulator specifically for research in the field of malware intrusion/ energy efficiency and its effects on working and resources of datacenter. Understanding principal concepts behind Datacenter designing, task management, app deployment in cloud, network planning, datacenter security, observing effects of malware intrusion in datacenter and meeting Quality of Service requirements in datacenter should be well understood by IT professionals. Students, researchers, professionals and cyber security experts who work in datacenters need to be aware of these terminologies and their importance in datacenters. To address this concept our platform provides a practical and simulated pathway for a user in understanding these key terminologies and their importance in datacenters.

3.1 Energy Centric attributes in Datacenters

Datacenter modeling and simulation is a key to understanding performance and energy tradeoffs when designing management policies such as DVFS and workload consolidation. Many datacenter simulators are available, with varying capabilities and limitations that enable researchers to develop and test innovative energy-saving algorithms. Energy consumption of communication fabric can be reduced [2] via a combination of green traffic engineering techniques such as 1) scaling down communication speeds, 2) deploying power consumption models, 3) dynamically adapting rate of network ports, 4) keeping the devices in sleep mode and 5) by efficient mapping of applications/services running in Datacenters. The authors of [2] demonstrate energy savings of up to 75% that can be achieved by traffic management and workload consolidation techniques. Unfortunately most of the networking devices in use today are not energy compliant and therefore do not support the above listed techniques. As a consequence DCN power consumption largely depends upon efficiently mapping of services on available resources to yield the maximum benefit. WebSim primarily teaches three grey areas which include keeping devices in sleep mode, intelligent mapping of applications/services running in datacenters and senerios in which a datacenter is infected with a malware.

A substitute of wasting resources is efficiently hosting different applications and services depending upon their requirements and processing attributes. Lack of efficient utilization of available resources may result in good quality of service but can ultimately be an overhead on profits generation and energy utilization. WebSim provides a generalized and extensible framework that enables seamless modelling of services and communication processes of emerging Cloud computing infrastructures and with slight modifications it can be ready to use with any datacenter model.

3.2 Effects Malware Infection on Energy / Processing Capabilities of Datacenters

WebSim provides a platform for IT professionals and Higher Management to impart them knowledge about designing and working of datacenters. It also familiarizes them with the process of malware intrusion in datacenters and its effects on running tasks in datacenters. Malware intrusion is phenomenon in which a malicious piece of code is injected in datacenter with the intent of damaging/disrupting the services of datacenter. WebSim provides its user with the malware intrusion interface where one can study the effects of a particular malware on working of his datacenter and decrease in quality of service of datacenter. Tasks are allocated to left over resources of a particular server and user if provided with the statistical analysis of damages to Quality of Service made by a particular malware. Statistical analysis also help user in repair and maintenance of left over resources in datacenter and to study the effects of Malware intrusion in terms of Energy utilization in datacenter.

Main objective of our research was to impart knowledge and importance of these fore mentioned techniques to the students and researchers especially green engineering techniques so that carbon emission footprint can be reduced and more individuals can be motivated towards making this world a green and better place by taking small steps. To fulfil our objectives it was necessary to develop an easily accessible and flexible datacenter simulator that can help as an educational tool for students.

3.3 DCN Architectures and their effects on energy utilization

Current DCN architectures vary significantly in their topology preferences e.g. building networks entirely out of switches or using a combination of switches and servers. In this section we examine the abilities of different DCN architectures, their ability to design a switch centric, server centric or hybrid network depending upon the need of Datacenter and finally their energy needs. Table 2 provides an overview of structuring of some currently used DCN architectures.

Switch Centric DCN's	Hybrid DCN's
Switch Centric DCN's use Switches as packet routing and switching devices while servers are treated only as Senders/Receivers. Some Examples are:- • **FAT Tree** • **VL2**	Combination of Servers equipped with multiple NIC's and switches is used to intelligently manage traffic of Datacenters. Some Examples are:- • BCube • DCell • CamCube

Table 2 : Classification of DCN Architectures

3.3.1 VL2

VL2 is datacenter network architecture [5] with the goal of allocating resources in a flexible way. To cope with high divergence and volatility of datacenter traffic environment, VL2 makes use of Valiant Load Balancing to do goal-independent traffic distribution across several transitional nodes.VL2 uses IP routing and forwarding mechanisms that are already existing in product switches: equal-cost multi-path (ECMP) forwarding, link-state routing, IP multicasting, and IP any casting. It utilizes Open Shortest Path First (OSPF) to retain the layer-2 topology, but not to distribute end users' information. In this way, switches do not need to track the rapidly changing users' information.

In VL2, any server can be assigned to any service since all servers belonging to a service share a single addressing space regardless of their physical location, for quick expansion and reduction of server pools, and for speedy relocation of VMs. In VL2, application-specific addresses (AAs) are apart from location-specific addresses (LAs) due to usage of a unique addressing scheme. Also, name-locator mappings are preserved by using a scalable, trustworthy directory system. A VL2 agent provides a thin layer operating in the network stack on each server which invokes the resolution service of directory system. Network cabling infrastructure is one major player in the consumption of energy as shown in Figure 6. In general, switch-to-switch links are faster than server-to-switch links. The authors of [6] take advantage of this behaviour by using 1G server links and 10G switch links in design of VL2. Moreover they claim that the upcoming design will be using 10G server links and 40G switch links which will lessen the required amount of cabling for implementation of Clos topology, thereby consuming less amount of energy

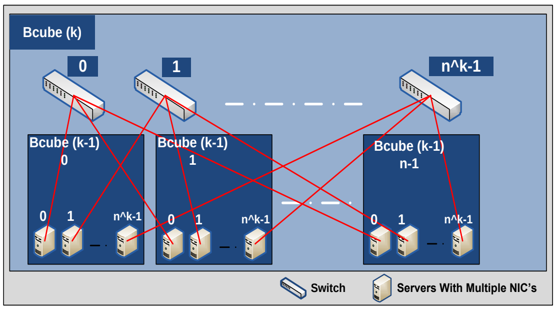


Figure 3: BCube DCN Architecture

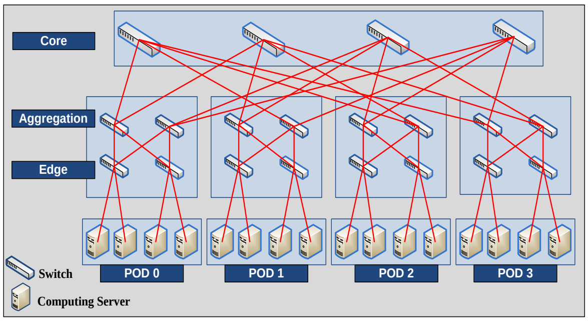


Figure 4 : Fat Tree Architecture for DCN's

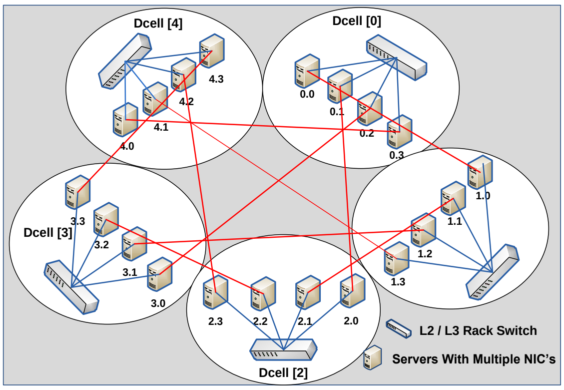


Figure 5 : DCell DCN Architecture

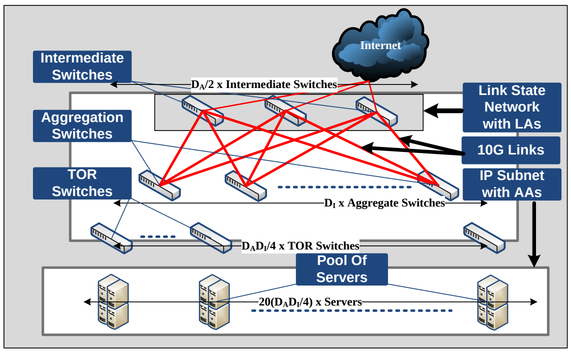


Figure 6 : VL2 DCN Architecture

3.3.2 Fat Tree

The basic model of Fat tree DCN architecture (Figure 4) consists of a routing and switching tree with progressively more expensive and specialized equipment moving up the hierarchy. The main objectives of this architecture [7] are to 1) provide arbitrary hosts with sufficient bandwidth to communicate with any other host in the network, 2) to cut the cost of DCN by using cheap off the shelf switches as the basis of large scale Datacenter Networks and 3) to provide backward compatibility. This architecture usually uses 48-port GigE switch at the edge of the tree and 128-port GigE switches for higher levels of communication hierarchy.

The cost of building networks interconnect for a large cluster greatly effects design decisions. Today, the price differential between commodity and non-commodity switches provides a strong incentive to build large-scale communication networks from many small commodity switches rather than fewer larger and more expensive high-end switches which can consume thousands of kilowatts of energy. To tackle that issue the authors have devised to use cheap net gear switches because they do not have requirement of 10G uplinks. Use of these switches with low speed links and less heat dissipation saves overall power. Authors of [8] also claim that by using this architecture datacenters can have 56.5% less power consumption and 56.6 % less heat dissipation.

3.3.3 DCell

The DCell [4] architecture consists of three major components, namely; 1) Scalable network structure, 2) efficient, distributed and fault-tolerant routing, and 3) an incremental upgrade scheme. Malfunctions such as server/link/rack failures are handled by fault-tolerant routing, and upgrade scheme helps to expand the size of a Datacenter Network progressively. DCell makes use of mini-switches and multi-port servers to scale-out recursively. It uses bidirectional communication links between servers that are connected via mini-switches. Many low-level DCells are combined to form a high-level DCell. Servers forward packets using multiple ports by exploiting routing infrastructure. DCell capacity can be increased by recursive scaling and by building complete graphs.

In DCell architecture, multiple servers are interconnected in a recursive fashion. A large number of links are used to connect every server to various stages of DCells while not using any core routers/switches. Such a large quantity of cabling requirements increases the energy consumption to a large extent. Moreover, DCell uses multi-port servers thereby boosting the energy requirements. One suggested and obvious solution to mitigate this problem is to shut down ports that are not in use, but this will affect the scalability of DCell architecture which lies in usage of a large number of communication links which ultimately require active ports. So it could be a performance/energy tradeoff in that if we try to save energy by keeping the ports down as suggested by [6] , we will lower our capability to scale out the network and hence degrade the performance.

3.3.4 BCube

BCube is a high performance and robust network architecture specifically designed for shipping container based, modular datacenters (MDCs). MDCs are used by modern datacenters in which servers are connected to mini switches and then packed in a container so that they can easily be shipped and attached to any datacenter. In BCube [3], servers with multiple NIC's are connected to multiple layers of commodity of the shelf switches as shown in Figure 3. It provides multiple short paths between any pair of servers which helps in moving live VMs in a robust and efficient manner. The main feature of BCube is efficient management of one-to-one, one-to-all and all-to-all network traffic. In one to several traffic transmissions the same set of data is needed to be simultaneously replicated to all servers. One-to-all connection is needed in which a server transfers one copy of data to all servers. There are also services that require simultaneous transmission of data to all servers for which all-to-all pattern is required.

BCube is a MDC based hybrid DCN architecture in which both servers and switches are needed for building a network topology. The main benefit of MDC's is to shorter deployment time, higher system and power density, and lower cooling and manufacturing costs. BCube uses more wires and switches than mini-switches and according to [6] the power consumption and cost of BCube nearly equals the cost of Fat Tree architecture. According to closer examination of BCube reveals that as a point in the design space of hybrid architectures, BCube skews more energy toward the "switch heavy" end of the spectrum in the sense that that switches take on a greater share of the job of packet forwarding than do the servers. BCube acts as one of the most energy efficient architectures and its power consumption gradually increases with increased network load

CHAPTER 4

4. SYSTEM ARCHITECTURE & IMPLIMENTATION FLOW

WebSim has been developed to run on www so that it can be accessed anywhere in the world from web browser of any smartphone, tablet, laptop or a desktop PC. Due to its deployment on the www it has been developed using a three tier architecture which includes presentation layer that is responsible for providing graphical user interface to the user to access the simulator. Presentation layer communicates directly with the data/ Application logic layer which is responsible for maintaining and processing all the logic/ algorithms that are working behind the scenes to provide a user friendly interface to the user. Base layer is termed as a database layer provides access to data base that is present against account of an authenticated user. This data is utilized to construct datacenters, workloads and to keep other features that are mandatory for working on the simulator. Pictorial representation of three tiers is shown in Figure 7.

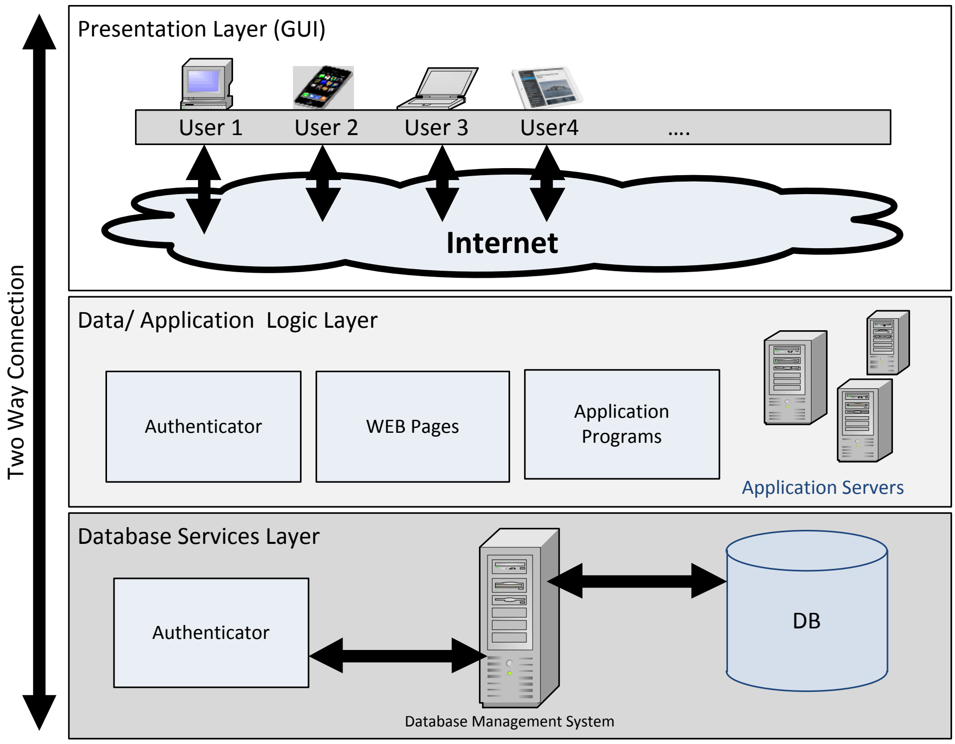


Figure 7: System Architecture Model

Prime objectives that were taken into consideration during development were to provide ease of access and user friendliness to the user.

Entity relationship diagram (ERD) of the database schema that is present in the bottom most layer of the simulator is represented in figure 8.

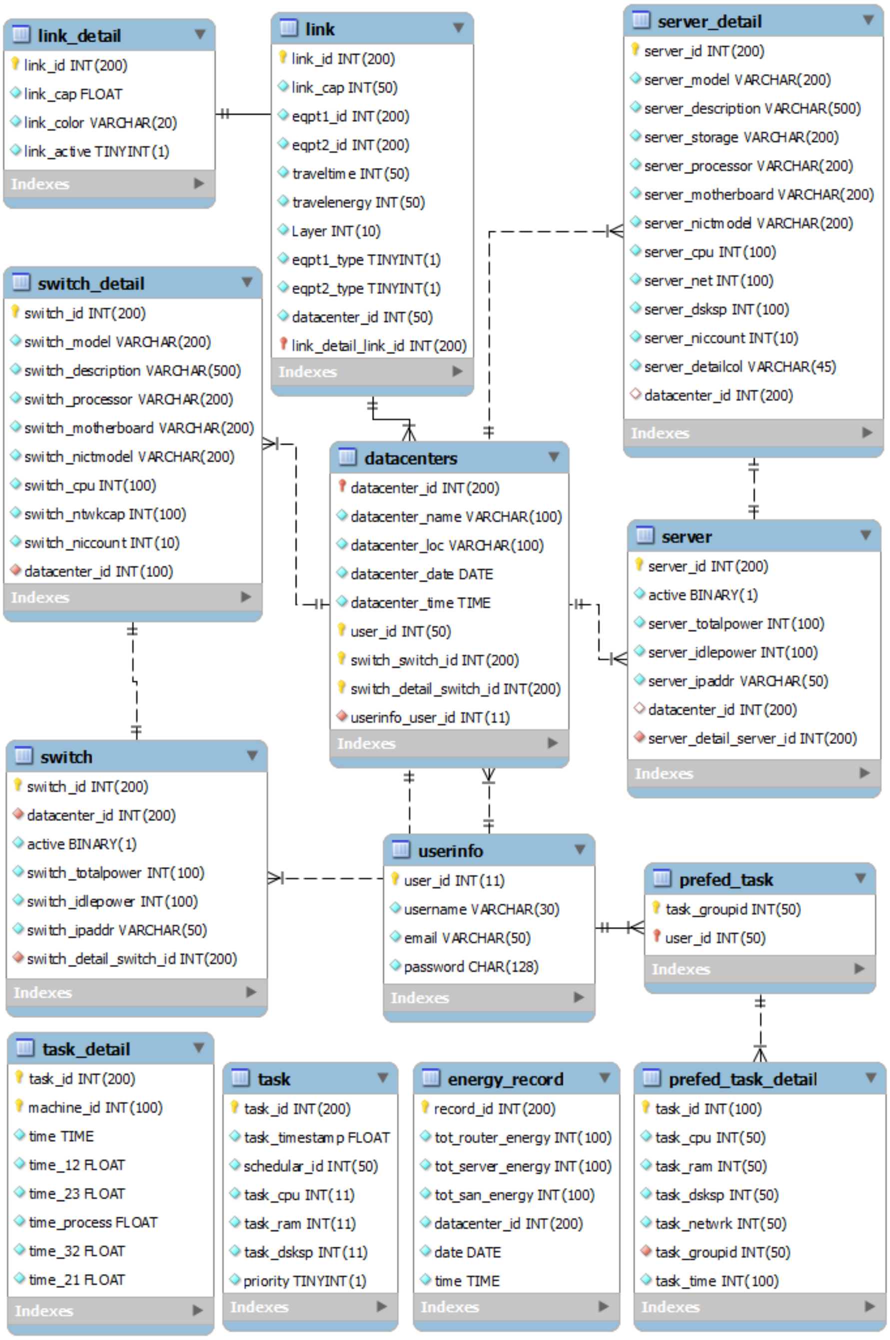


Figure 8 : Entity Relationship Diagram (ERD)

This database is accessed after authentication by authenticator by of MySQL database management system. For writing, updating or delete records from the database a secure authentication system is used to provide secure access to the users of simulator. This database contains all the data and metadata including registered users credentials that are necessary to run the simulator.

Table	Description
Userinfo	Stores usename, password, email and assigns a unique identifier to each user
Datacenters	Stores information name, ID, location, userid of each datacenter
Switch	Stores frequently used attributes of switches
Switch_detail	Stores detailed information about switches including their state, configurations etc
Server	Stores frequently used attributes of server
Server_detail	Stores detailed information about server including their state, configurations etc
Link	Stores frequently used information about the link
Link_detail	Stores detailed information and physical attributes of the link
Energy_record	Stores logging information for later use including simulation results for a particular user
Prefed_task	Stores information regarding a group of tasks that are defined by user for simulation
Prefed_task_detail	Stores information regarding attributes of each workload

Table 3 : ERD Tables description

Underlying database architecture of the WebSim consists of 13 tables that are using MySQL database architecture for storing and querying stored information

To understand working of the datacenter simulator it is mandatory to understand the system flow / logic implemented behind the system. Logic layer act as a backbone of the system, slight modifications in this layer can provide you the flexibility to use it with other datacenter architectures. For testing purposes we uploaded the project to a directory in our lab Webserver. When an authenticated user logs into our system following hierarchy is displayed in the form of webpages where Datacenters displays a list of datacenters available in a user's account. "Exec_sim.php" module represents a panel for execution of simulation on different schedulers, servers/ switches pages redirects the user to a panel responsible for display list of respective equipment in all the datacenters of a particular user and their configurations. Networking terminal diverts user to Network Management Center and Managetask is used for redirecting user to task manager where he configures tasks that are to be executed during simulation. Wizard and "createnewdatacenter.php" are the two modules responsible for helping a new user in creating and configuring datacenters.

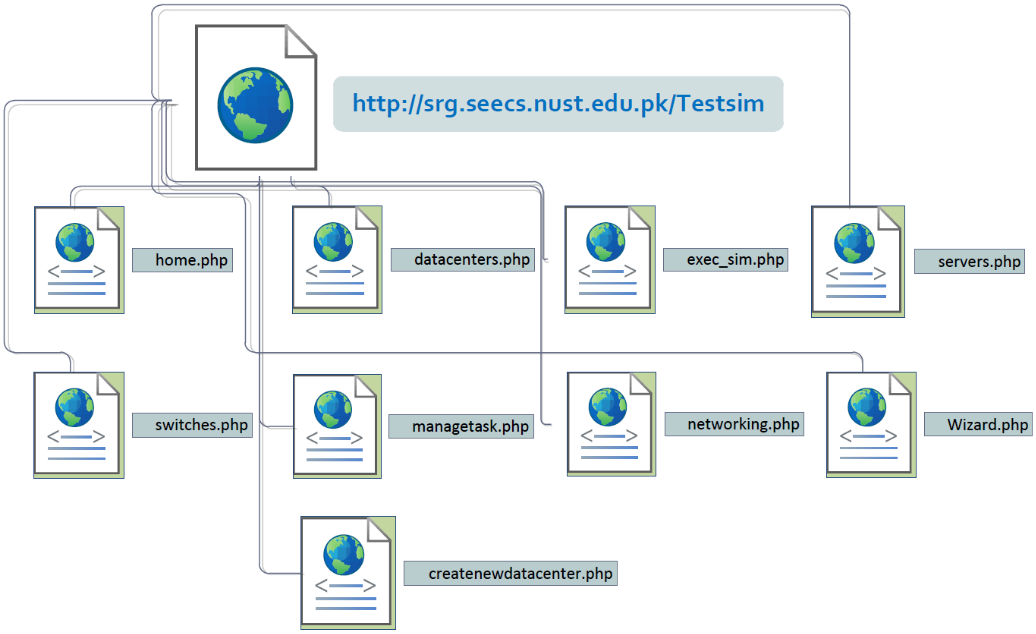


Figure 9 : System Implementation flow for authenticated users

All these modules have been further elaborated in the coming chapters of the research paper.

CHAPTER 5

5. SIMULATOR OBJECTIVES & DEVELOPED EDUCATIONAL MODULES

The simulator has been developed to give its users insight about datacenters and its associated infrastructure. Currently several open source and paid datacenter simulators are available in the market. There is an adequate need of improvement among them to provide a user friendly and meek educational tool where they can create their own datacenter in a virtualized environment, add/ configure different equipment's necessary for setting up a datacenter, configure their own network and create their own set of tasks, execute them in a simulated environment and study the results of their simulation. It not only gives students an insight about theoretical perspective of cloud computing but also enlighten upon the core concepts involved in setting up and utilizing resources available in an actual datacenter. In addition to this it provides different schedulers for execution of different tasks and comparison of their results can lead a student to study energy tradeoffs on single server and among the complete datacenter which teaches the student about the concepts of green energy that very few changes among task allocation can make a huge difference in large scale datacenters. Another Simulation with malware injection module has specifically been integrated to elaborate the disaster that is caused when a malware intrudes and occupies certain resources of datacenter that what difference in energy is made and how much task execution is delayed. This module can also be used to enlighten the concept of recovery in case of malware infection by studying the availability of free resources in case of malware intrusion and by using workload consolidation infected systems can be separated of from the main systems and recovery process can be started on these systems while other remain working to ensure the QOS requirements. Main objectives of our simulator are to provide an online platform to students and researchers where they can work in teams:-

- Create own datacenters, add/ configure eqpt and setting up different attributes associated with their functioning
- Internetwork different devices, servers and switches present in the datacenter.
- Execute simulation in different scheduling environments
- Management of varying workloads
- Studying simulation results to check overall datacenter and eqpt based energy utilization of different schedulers.

- Effects on energy utilization and performance in during Malware intrusion in datacenter
- Estimation of resources required to revive datacenter in case of Malware Intrusion
- Comparison of Energy Utilized by Various Simulation modules

To facilitate the learning of students, researcher and industry professionals we have created various educational modules related Datacenters in a simulated environment. Following modules have been developed in our simulator.

5.1 Creation/ Configuration of Datacenter

Datacenter wizard is a tool specially designed for introducing a novice user with a simulation platform where he can easily create, design and configure a datacenter and gain knowledge about configuration of equipment used in datacenters like servers, switches etc. This wizard provides students and researchers with a step by step procedure in which eqpt newly created datacenter after being configured is linked with each other with the help of Network management center. Once the network is established these configurations are saved and user if forwarded to a Task Manager where he can create his own set of tasks that will be fed as an input to the simulator while running the simulation. These parameters which include various attributes related to tasks and their arrival time in simulation are saved permanently for the future use of user. Once everything is configured user is forwarded to a Datacenter control center where all his datacenters are visible and different controls regarding networking, add/remove eqpt, datacenter deletion links and simulation execution are present. These modules will be elaborated in the coming portion of the paper.

5.2 Internetworking of equipment present in Datacenter

Different DCN architectures are available for internetworking of devices present in datacenter. The main purpose behind developing a Network management center in WebSim is to accumulate students with the practical information regarding datacenter networking. We have developed a Network management center with both text based and GUI based integrated interface for the users. Network controller with a generic base has been developed keeping in view the advancements in the field of networking. Currently we have integrated 3-tier architecture for datacenters networks. Most commonly used Datacenter Architecture is a 3-Tier Datacenter in which three layers of Switches and Servers are present. Top two layers constitute only switches and in the last layer Top of the Rack switches and servers are present. User can create new links by selecting two devices (servers or switches) from the list of available devices and providing other information about the link which includes link Cap, travel time, travel energy and layer on which the link is to be established. Each link here will represent a physical medium that connects two nodes with each other. Links after creation can be updated or removed as done in real environments. Important terminologies involved during networking are as follows:-

- Layer 1:- Represents the bottom most layer of datacenter in which servers and TOR switches are present.
- Layer 2:- It is the middle layer that provides connectivity between Layer 1 and Layer 3 of the datacenter
- Layer 3:- It is the outermost layer of switches that is connected with the outer world i.e. Internet
- Link capacity:- Represents max transmission rate of the link. It is usually the max attainable value which is 1G or 10G.
- Travel time:- It is time required per request to travel between two nodes within the attainable rate
- Travel energy:- It is the approx. energy consumed by both nodes when they communicate with each other

These parameters give brief to readers about the terminologies that are considered while setting up a network of datacenter. After slight modifications system can be used to internetwork devices using different DCN architectures. Default configuration of the simulator uses 3-tier DCN architecture for networking

5.3 Management of varying workloads

Workload management module has been developed to manage tasks in a group that are assigned to a datacenter during execution of simulation. Using this manager where students can create, configure and modify their own set of tasks. These tasks will be further used by them as an input to different datacenter simulation modules. Major parameters that are required during configuration of tasks is its processing requirements, memory requirements, network bandwidth requirements and arrival time of tasks. Arrival time of tasks has been taken in seconds to make it easy to understand for students. These pre-fed tasks are saved permanently with the user account and can be used by student for simulation on any newly created or preconfigured datacenter.

5.4 Simulation in different scheduling algorithms

Simulation module is the main module in datacenter simulator which is of keen importance for students and researchers because it imparts introduction to students and researchers about the task execution, interactions of different modules in the datacenter when a workload is assigned to a set of servers for execution. Task configured in Task manager are assigned to a particular datacenter from a very user friendly interface in datacenter control center. If any new changes are to be made to datacenter they are available in datacenter control center. When a particular task or set of tasks is assigned to a datacenter its attributes are loaded into a stack for execution. Each task is loaded with its preset attributes which include MIPS requirement, RAM requirement and Arrival time of the task. Resources available in datacenter are then loaded into the stack for execution. These resources also include some servers which have a particular load limit that they can handle. This limit is calculated by taking into account the simulation time and processing / storage capabilities of a server. Once tasks and datacenter is loaded and ready final and initial time stamps calculated for a particular simulation process are calculated and displayed. With everything up and running the system is than available for simulation.

Simulation process is started by keeping in view two main stacks; one is of available resources and other of the tasks that are to be executed. As the clock of simulation starts ticking server with idle state are activated and queue of tasks is constantly monitored with respect to the time of arrival of a particular task. Upon arrival of tasks available servers are checked and tasks are assigned to appropriate server. The whole process is visible to the user via a simple web interface that is designed to keep users informed about the whole simulation process. This process continues until the last task is loaded and assigned to available servers or time of simulation runs out, In that case an error message showing time required to complete the task is displayed and user is requested to increase the simulation time to complete the remaining tasks. At the end of simulation complete energy utilized by each server in idle state and execution state is displayed which gives user an overview about the usage of energy while tasks are executed. This value for energy is different for different vendors so it is preconfigured by user while adding servers and switches to the datacenters. The concept of green simulation in datacenters has also been integrated which is applicable to modern servers whose energy is increased from idle state to maximum state as soon as a servers task load increases. Four different simulation modules have been integrated to deepen the knowledge of students and researchers about datacenters, cloud computing and malware intrusion in datacenters. Simulation in cloud environment, is a calculator like module has specifically been integrated into the WebSim to enlighten the very basic concept used in cloud computing in which one huge task can be allocated to multiple servers. This module depending upon the selected datacenter provides user with the time and energy required for execution of a particular task keeping in consideration all the parameters associated with task including required MIPS, RAM and network requirements.

5.4.1 Learning simulation using first come first serve scheduling

This module helps students and researchers to select a particular set of tasks having attributes like MIPS, RAM, Network and other requirements including arrival time of tasks in seconds. These tasks are required and managed by a particular user according to own requirements. Simulation is executed for the time period defined by user in seconds. Step by step logs of the execution of simulation and allocation of tasks to specific resources is maintained and shown to user which leads to the final calculation of energy consumed by servers while execution of tasks. This module uses a scheduler which during execution of simulation constantly monitor for arrival of any tasks and upon arrival tasks are allocated to first available server and servers state is changed to active. Active state depicts that server is currently dealing with assigned tasks and no more tasks are assigned to that server until the task is executed and state is changed i.e. it is again available for execution. Same procedure is followed for all the tasks that are loaded in queue until servers are full or time of simulation runs out. The end result of this simulation shows total energy consumed by datacenter using subject current scheduler and its individual components. The average energy taken by server during this simulation is idle energy value when a server is not working on a particular task and during that time the server works on a particular task its value is taken as maximum defined by equipment vendor.

5.4.2 Learning simulation using green scheduling

Energy efficient simulation in datacenter has been integrated to introduce the concept of green datacenters among students and researchers so that they can understand the impacts on energy utilized by datacenter when different equipment’s and schedulers are used. Due to the importance of green energy and to save carbon footprint there is a drastic need among researchers to understand the impact on global climate that is made by slight negligence or lack of awareness about small steps that can have a huge impact towards betterment of this world. This module covers the perspective of efficient utilization of available resources to yield maximum output from them. In the simple simulation once a task is assigned to a server it is executed upon it with max power utilization value. This phenomenon was applicable to power supplies that were available in the market during the last decade. Most of the datacenters are still sticking with the old technology and most of the focus of datacenters is towards meeting quality of service requirements and energy efficiency is usually not on top of the list while setting up or upgrading a datacenter. Our module will help professionals and students to understand that using modern and energy efficient technology they can contribute a lot towards green environment keeping their quality of service in line with the requirements.

Keeping fore mentioned concept in view Energy Efficient datacenter simulator takes input in the form of set of tasks that are preconfigured by user in the task manager, any of the datacenters that are configured by the user and time duration for which the simulation has to be executed. Initial procedure for setting up the simulation is same for the one that is used in simple simulation. Set of servers are loaded in a stack and queue of tasks that are to be executed is maintained by the server. Starting and ending time stamps are calculated and when initial timestamp is reached simulation process is started. During simulation process difference between idle power consumption of server and max power consumption is divided by total processing power of the server. Processing power is combination of both memory and processor max capability. This value gives us a reliable estimate of about how much power will be utilized by a particular server that is equipped with variable power supply that do not remain on max power utilization mode when a server is exceeding a small task, but their power consumption gradually increases with the increase in work load. Same concept has been integrated in this module where power consumption of individual servers and of the whole datacenter is calculated keeping the modern device architecture as basis. The values of Energy utilization obtained by servers and datacenters during energy efficient simulation can also be compared to the values obtained during simple simulation using same datacenters and Workloads. A drastic change in energy values is observed when both results are compared which showers light on the actual idea for which research & development has been conducted.

5.5 Analysis of the effect of malware infection on datacenter energy in Infected Datacenter

Cyber security, threat management and malware intrusion are being widely used by hackers around the world to disrupt the services running in datacenters. With the advancements in cloud computing datacenters are becoming the primary source of information which includes access to academic documents, forums, social networks, email servers, health records etc. It is necessity of time that there server should be up and running round the clock. To meet this goal it is recommended that young graduates should get a grasp of practical working of datacenters before entering into the professional world. Our main focus regarding cyber security during development of simulation platform was to educate students and researchers about the very basic attacks on datacenters like denial of service or distributed denial of service attack. During these attacks resources available in datacenter are occupied by a malware and service connectivity to legitimate user is disrupted and quality of service is not maintained. Major signs of such malware intrusion are easily visible because there is usually a drastic change in processing capabilities, extended utilization of RAM and increase in rate of network traffic etc.

To study the impacts of such malwares and attacks in datacenters we have integrated two modules in our datacenter simulator one with scheduling of workloads with first come first serve basis and the other with green datacenter scheduler.

5.5.1 Learning simulation in infected datacenter

Simple simulation in infected datacenter is plugin that uses scheduler which assigns the workloads on first come first serve basis but the major difference lies when user configures parameters of malware that infected the datacenter. These parameters will be available to user if a known malware or attack hits the datacenter. This simulation module can also help students and researchers to create a sample datacenter and study trends and effects of different attacks on datacenters. Input parameters of infection are of prime importance in this case as during simulation these parameters impact available resources and its effect is observed in all active resources present in datacenter.

The simulation procedure of malware infected datacenter is near similar to the one used in other simulations with addition of percentages to which resources of datacenter are effected. Effected resources may include utilization of processing power of servers, memory occupied by payload or attack etc. After the selection of particular set of tasks and simulation time these values are visible to user and their effect is depicted throughout the datacenter. Once the initial and final timestamps are calculated based on input by the user simulation of tasks and their mapping on servers is started. Output values of this simulation clearly indicate the effect of malware or attack on datacenter by showing increase in processing and memory requirements which in the end lead to more utilization of Energy.

5.5.2 Learning simulation in Infected Datacenter with Green Scheduler

Energy efficient simulation of datacenters is slightly different from the simple simulation because it uses an energy efficient scheduler for simulation. This simulation module works on same principles and hierarchy, first the input consisting of simulation time, percentage of malware intrusion and set of tasks is selected by the user. The input is forwarded to a green scheduler who processes the request of user and simulation process is completed. The results of this scheduler give indicators to the user regarding the increase in energy utilization by the equipment in datacenter because of resource occupation by the malware or cyber-attack. These results can provide valuable information to the user when compared with the output of other simulations because it introduces core concepts of processing/ allocation of tasks, energy utilization and effects of malware or denial of service attacks in three tier datacenter architecture.

Chapter 6

6. TOOLS AND TECHNOLOGIES

In order to develop an open source datacenter simulator we choose to use most widely used and freeware software Appserv which is combination of MY SQL server, apache server and PHP server. My SQL server was used to provide a robust and reliable architecture underneath the simulator so that it can handle queries efficiently when multiple users signup and perform simulations simultaneously. PHP was used as a coding language and complete user manuals were created during this project to educate users of simulators on setting up simulator on their local machines. A simple Pentium 4 system with 1 GB RAM and 80GB hard drive can do the job for a single user. Software's for setting up the My SQL server and PHP scripting engine mandatory for setting up simulator on Linux and MAC OS are also freely available while it can be set up on any webserver that supports PHP and MySQL. If someone wants to access this project using web service it can be accessed from any web browser running on smartphones, Laptops, PC or any other end user device. Detailed User manual for configuring / Installation of Simulator and prerequisites is available in last section of this paper.

Chapter 7

7. EVALUATION

WebSim was provided to some programmers, postgraduate students and industry professionals and after completing the lab exercise, a detailed survey was conducted to get feedback from user regarding the simulator and its effects in fulfilling their objectives. Users were introduced to URL of the website where the simulator was placed for testing and evaluation purposes. Every user registered for a new account and after successful generation of username and password; authenticated users were redirected to the home of datacenter simulator. For pre evaluation exercise a simple topology with two switches one with layer 1 and other with layer 2 was selected which was further connected to two more top of rack switches. In each rack two servers were placed and tasks were simulated on these servers later on. Upon successful authentication every user was able to access the Datacenter Control center where there were no datacenters present. Using datacenter wizard datacenter identified by a particular identifier was created by users. Further the above mentioned topology was implemented where new servers and switches of different types were added. Students were familiarized with various different configuration options like Model, Processor, Network interface Cards, Network Capacity of Node, Processing power in MIPS, RAM, IP Address, Status (Active / Inactive), Total Power Cons while processing a task and Idle Power Cons when no task is allocated to it. Once users were done with configuration of equipment they were sent to datacenter network manager where the newly added equipment against a particular datacenter was visible. This equipment was then internetworked and a 3-Tier datacenter network topology was followed. At this point it needs to be made sure that you are performing following a legitimate 3-Tier architecture because for now simulator is only equipped with 3-Tier topology support.

Once datacenter is completely configured than Task Manager played its role by providing an interface to users to add multiple tasks, their attributes and their entering time they were available to users in the main datacenter control center. Through datacenter control center tasks were simulated on five different types of modules for simulation. With sample topology and workloads different answers were obtained by the users which gave them an overview of the difference in energy consumption when same workload was processed with a datacenter using green energy techniques and other using simple scheduler on old systems. This enlightens the importance of newly built energy efficient equipment by various vendors around the world, importance of task schedulers in datacenters and shows that how too much energy is wasted in datacenters while it can be avoided keep up to mark quality of service at the same time. Table 1 shows the survey results of the post graduate students who have who experience of working with multinational organizations, software houses, datacenters, IT firms and some have no link to this field. Therefore this exercise involved all type of technical people and some of them were not remotely aware of the concepts regarding Green energy and effects of malware intrusion.

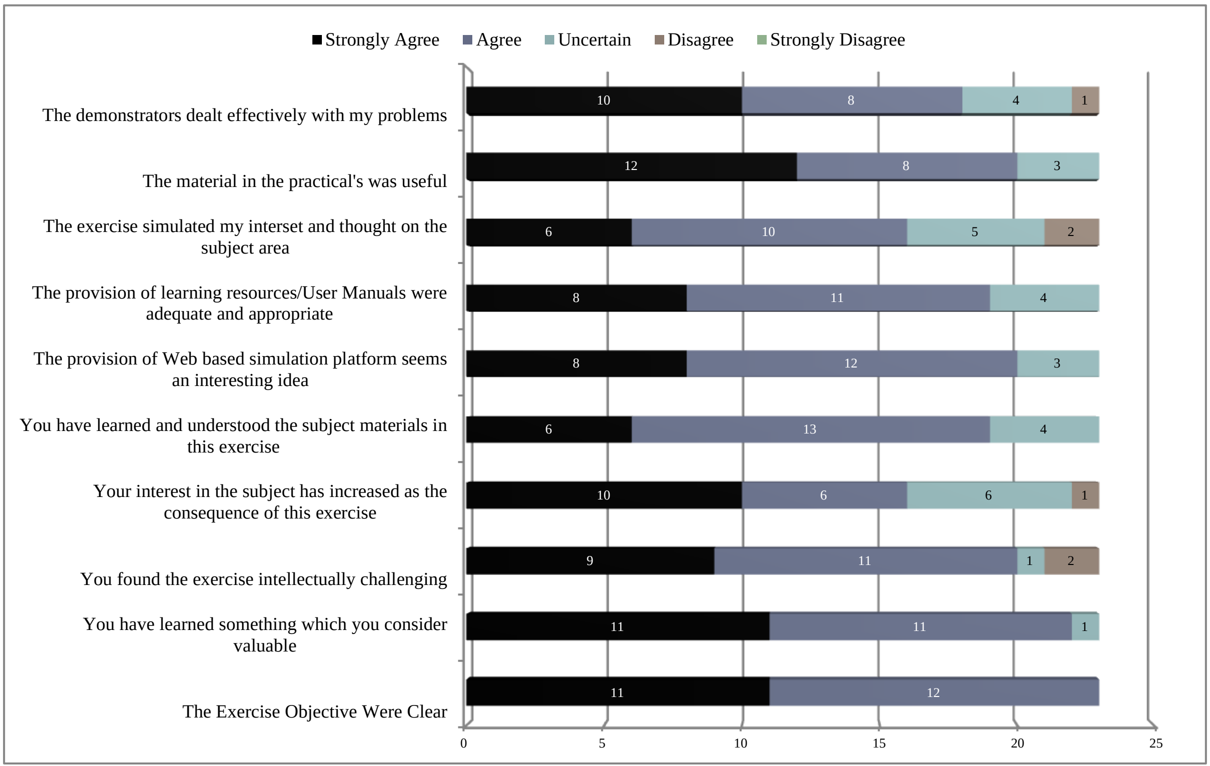


Table 4 : Key Survey Results from Post Graduate IT Students

Second portion of this evaluation exercise was related to simulation of tasks in a datacenter that is infected with a malware of a denial of service attack on that datacenter is progress which is eating up resources of the datacenter. Show graphical form of result. Same set of tasks were simulated on these infected datacenters using two different schedulers. The users took keen interest in comparing the simulation results of these infected datacenter that how a simple malware that is eating up resources in a datacenter impact on the energy utilization of servers and that of the whole datacenter. Students were also made aware that these schedulers can also be used to check the maximum needed servers in datacenter with the current task load and remaining server can be cut off from the main datacenter for malware scanning purposes and once cleaned they can again be connected to the main terminals while remaining are cleansed from malware. When results of all the simulation modules were available to the users they were clearly able to understand that how tasks arrive and are allocated to servers based on their processing capabilities and how their energy is utilized and dissipated.

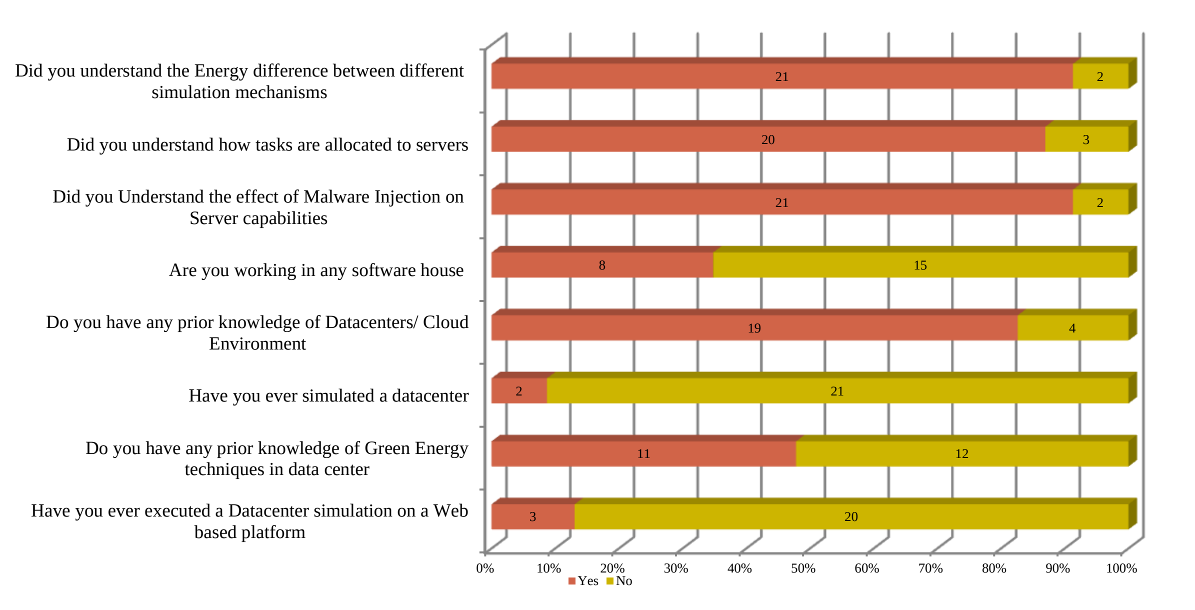


Table 5 : Key Survey Results from Post Graduate It Students

Feedback as shown in Table 2 depicts that practical lab exercise of WebSim improved the concepts of attendees in following areas.

- How tasks are allocated and executed on servers
- Effect of Malware Injection on Server capabilities
- Energy mappings of different simulation mechanisms

Chapter 8

8. CONCLUSION AND FUTURE WORK

In this thesis we have presented a number of Green Traffic Engineering techniques for planning datacenter networks from the perspective of energy conservation. These techniques range from energy saving options at the firmware level to intelligent task provisioning according to workload characteristic at the software and firmware level. Finally we showed that the actual architectural makeup of the network can affect the overall power consumption in subtle ways. New network architectures are continually being adopted such as Software Defined Networking (SDN) based network fabrics are becoming popular in which the control plane is separated from the data and implemented in software. While this technology promises features such as fine grained control of energy-saving measures in SDN compliant switches the software based control plane will affect the overall energy consumption in complicated ways. In summary planning the energy requirements of datacenter networks is a complex task but it is going to be a foremost consideration in the years to come.

With the achieved goal of promoting better techniques for understanding Datacenters, cloud computing, distributed computing and their energy utilization in simple / Malware Infected environment; it can be further explored to contribute more for providing green environment in existing and newly established datacenter infrastructures. Our work can further be utilized into many useful applications by adapting these techniques in real datacenters and by doing further developments in websim to educate students and researchers about different workload consolidation techniques in datacenter networks. The most significant contributions that can be done by including scripts regarding other DCN architectures like BCube, DCell, Camcube etc and by simulating real datasets of malwares and workloads to educate students about their impacts on datacenters.

Annex – “A”

SCHOOL OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE, NUST

WebSim USER GUIDE

Objective of this document is that user will understand and learn practical implementation of 3-Tier Datacenters in a simulated Environment and to study Execution/ Energy utilization of tasks of servers

Step 1: Installing/Configuring Appserv

Detailed Procedure for Installing and Configuring Appserv is att at Flag'A'.

Step 2: Importing/Configuring Simulator

After Completion of step 1 your system will be working as a server. Now you have to download and configure the php and Database files. Follow the following procedure for setting up Dsim on your own PC.

1. Download file named "**Dsim_ver_xx.zip**" from the specified server.
2. Extracting Zip file will create two folders "**cloud**" and "**Datacenter**" in your current directory.
3. Move "**cloud**" folder in "**AppServ\www**" folder in your computer. This path will be in the installation directory of Appserv (*Default Path: C:\AppServ\www*).
4. Move "**Datacenter**" folder in "**AppServ\MySQL\data**" folder in your computer. This path will be in the installation directory of Appserv (*Default Path: C:\AppServ\MySQL\data*).
5. After copying the cloud folder in respective directory, open "**connection.php**" file and change predefined login credentials with your own MYSQL server login credentials defined in step1.

   In this line ($connect=mysql_connect("localhost","root",**"Password"**);), type your own password
6. Open your Web browser and Type http://localhost/cloud. If everything goes right you be able to see the home page of simulator in your browser window.

Step 3: Walkthrough Using an Example

Examples and Sample Datasets are att at Flag'B'.

Preparing package for installation:

Download AppServ 2.5.10 program from http://www.appservnetwork.com . This version will provide Apache, PHP, MySQL integrated environment.

AppServ Step by Step Installation:

1. ***Executing Installation:*** Double Click appserv-win32-x.x.x.exe to install AppServ on your computer.

Figure 10 : AppServ executable welcome screen

2. ***License Agreement*** **:** AppServ distribution under GNU/GPL License.
   a. Agree for this license click Next to go to next step.

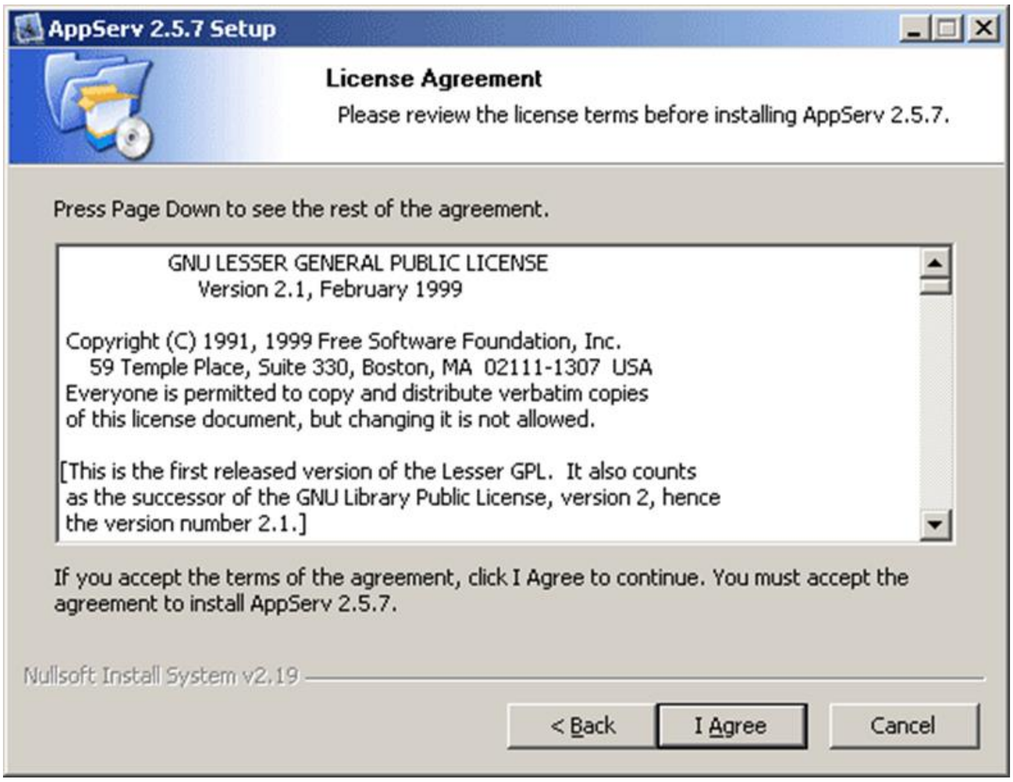


Figure 11: GNU/GPL License Agreement screen

3. ***Choose Install Location:*** AppServ default location is C:AppServ. If you need to change destination click Browse botton to change your destination for AppServ program and then click Next to go to next step.

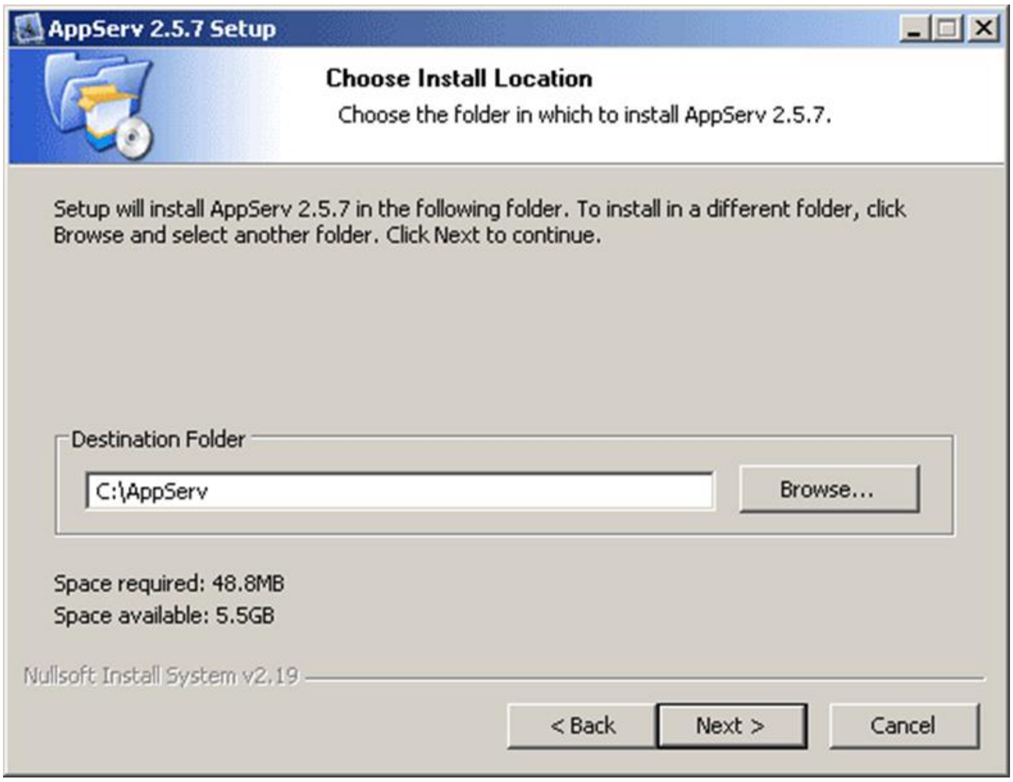


Figure 12 : Choose Install location screen

4. Select Components : AppServ default package components it's checked all package.

If you need to choose some package to install. You can click at check box.

- Apache HTTP Server is a Web Server.
- MySQL Database is a Database Server.
- PHP Hypertext Preprocessor is a PHP Programming processor.
- phpMyAdmin is a MySQL Database control via WWW.

If you complete choosing it click Next to go next step.

Figure 13 : Package component selection screen

5. Apache Configuration : This screen for specify Apache configure.

Server Name You must specify Server Name (**root / localhost)**

Admin Email You must specify Admin Email (**Any Email Of your Choice)**

HTTP Port You must specify HTTP port for Apache Web Server.**(80)**

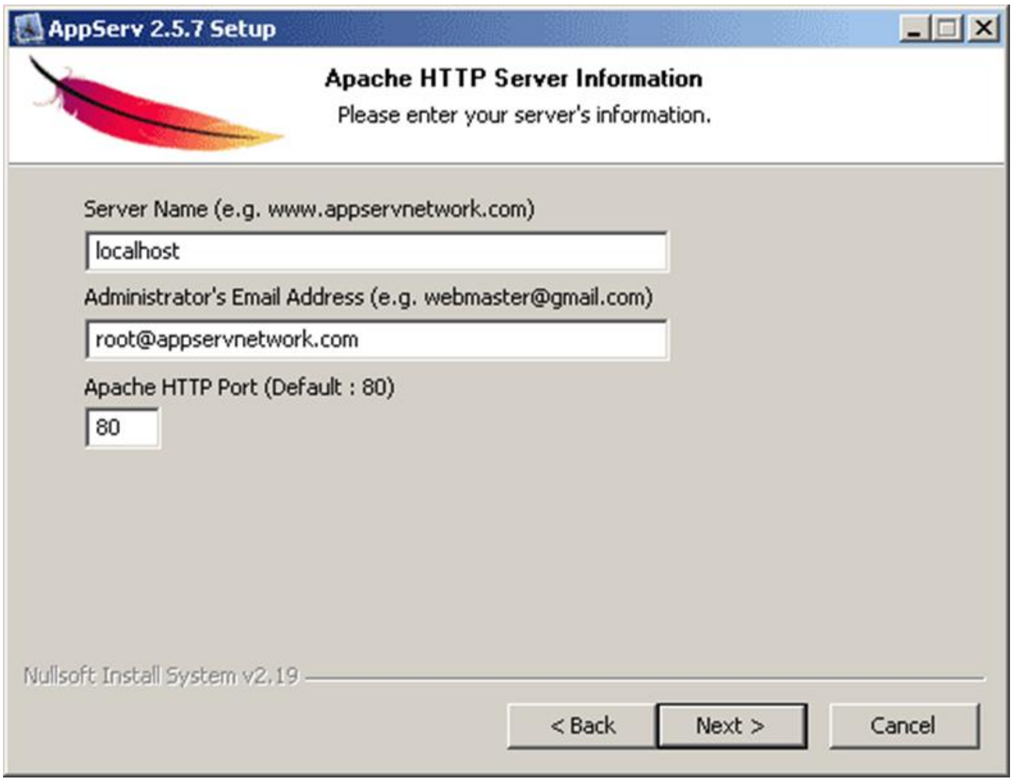


Figure 14 : Apache Web Server configuration screen

6. MySQL Configuration:

Root Password You must enter root password for MySQL Database. Default user for this password is root. This will be required for establishing connection with the Database server.

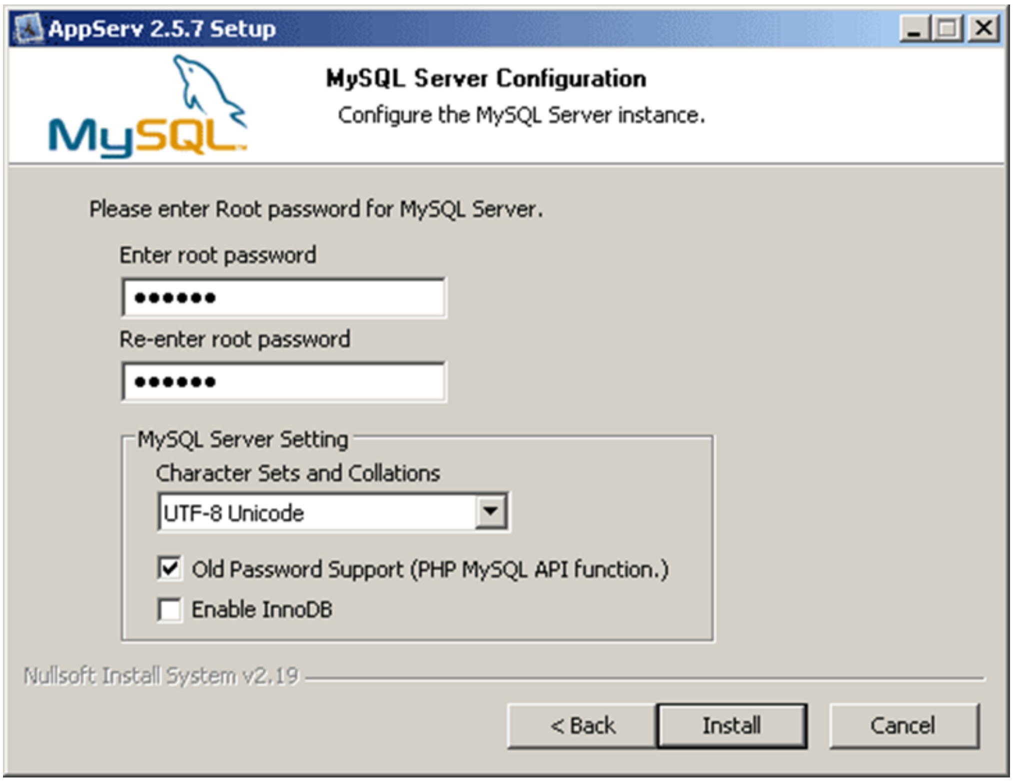


Figure 15 : MySQL Database configure screen

7. Complete AppServ setup : Setup ask for start Apache and MySQL immediately.

Click Finish to end this setup and AppServ prompt to use.

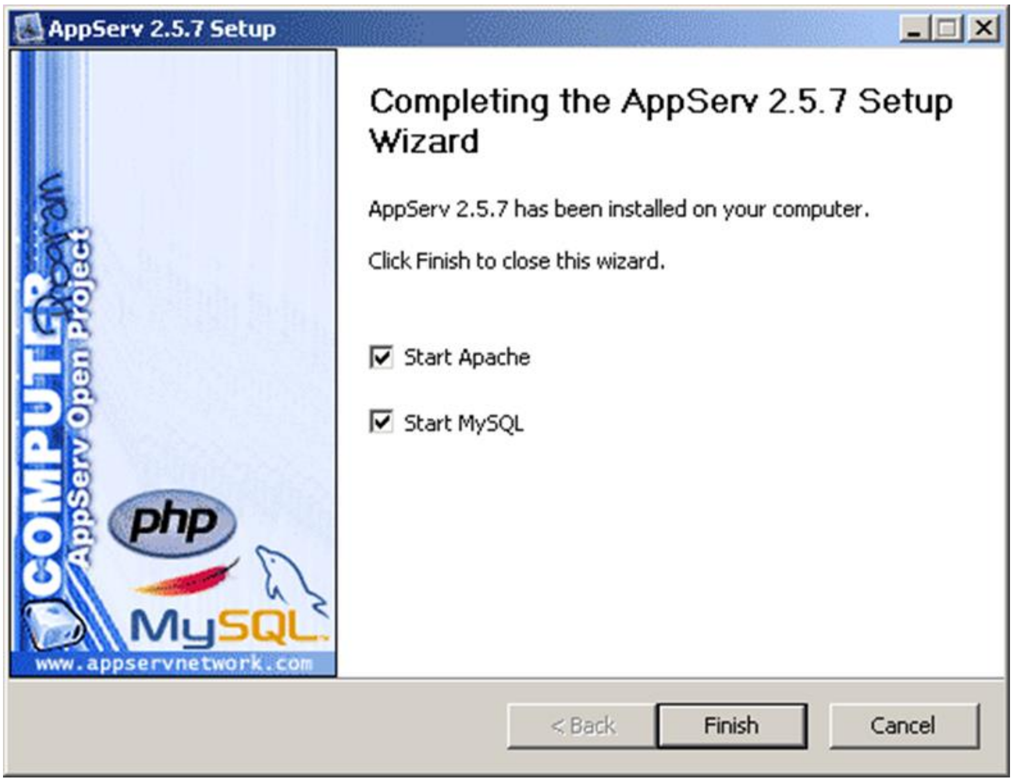


Figure 16 : Complete AppServ setup screen

Walkthrough Using a Sample Topology

Introduction

With the rapid pace of adoption of Cloud computing there is an increased dependence on Datacenters. In the early years Datacenters were primarily planned with performance and reliability point of view. However performance typically comes at the cost of increased power consumption and same is the case with security. With growing need or Datacenters, there is drastic need of a platform where one can view the entire datacenter and study the energy utilization in a simulated environment. Most commonly used Datacenter Architecture is a 3-Tier Datacenter in which three layers of Switches and Servers are present. Top two layers constitute of only switches and in the last layer Top of the Rack switches and servers are present.

Sample Topology

We will implement and study the results of simulation on the following 3-Tier topology

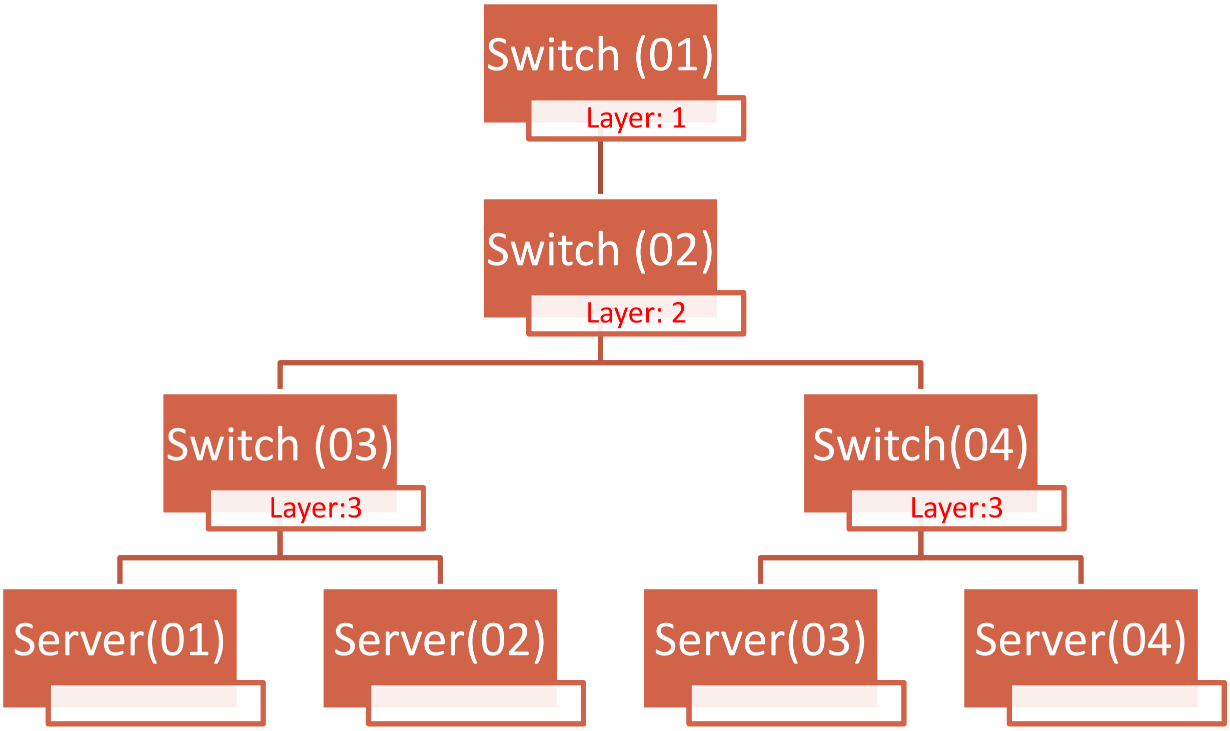


Figure 17 : Sample Datacenter Topology

Sample Topology (Walk Through)

Step:1

- **Go to URL** i.e. http://srg.seecs.nust.edu.pk/Testsim or http://localhost/cloud (In case of local server), from here you will be redirected to home page of the DSim.

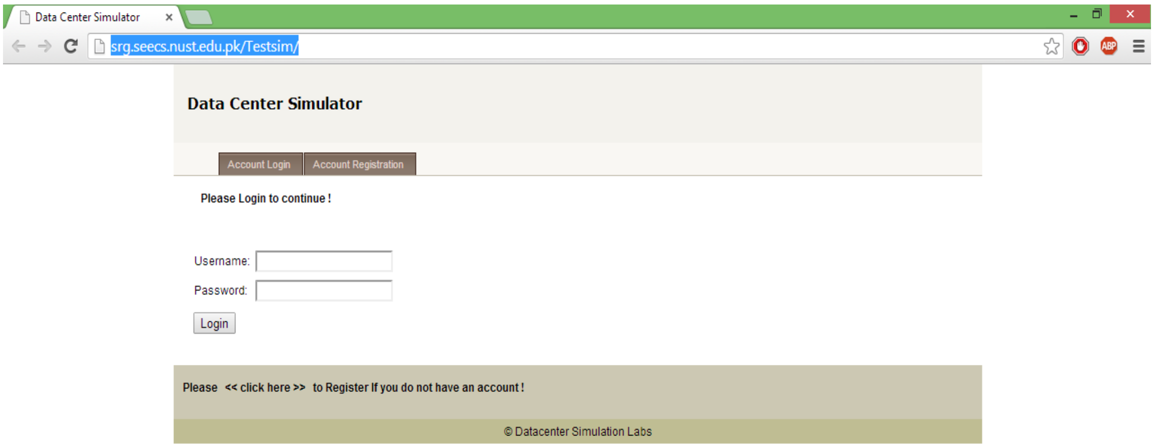


Figure 18 : Index of WebSim

- Here you'll have to enter your existing credentials or click on << **Click here** >> to register for a new account.
- Once done with registration you will get the following message "Your account has been created, please login to continue!"
- Now Enter the Username and Password of your newly created account to view the admin panel of the simulator.

Figure 19 : Menu Bar of the WebSim

- Clicking on each of the Menu Tabs takes you to their fol respective pages.

S.No	Menu Name	Description
1	**Home**	Takes user to the home page of the Website
2	**Datacenters Control Center**	Enlists Current datacenters and provides user with a list of controls
3	**Run Simulation**	This Tab includes various simulation options once your Datacenter is created
4	**Server**	Enlists Servers present in all the datacenters of Current user
5	**Switches**	Enlists Switches present in all the datacenters of Current user

6	**Manage Tasks**	Responsible for updating/listing predefined tasks list
7	**Networking**	Gives functionality to make changes to Networks within the datacenters
8	**Create New Datacenter**	Takes user to Form from where he can add new Datacenters
9	**Wizard**	For beginners to follow instruction in step by step manner from User Guide.

Table 6 : Menu Detail

Step: 2

- **Click "Create New Datacenter"** in the main menu and fill out the form for creating new datacenter.

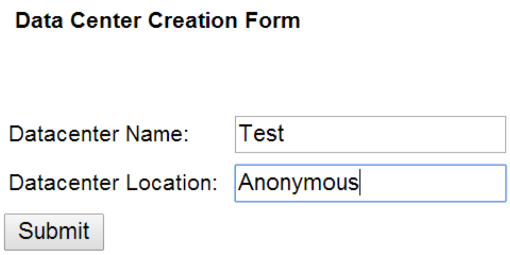


Figure 20 : Datacenter creation panel

Step: 3

- To view your newly created datacenter **click "Datacenter Control center"** Tab in the main menu

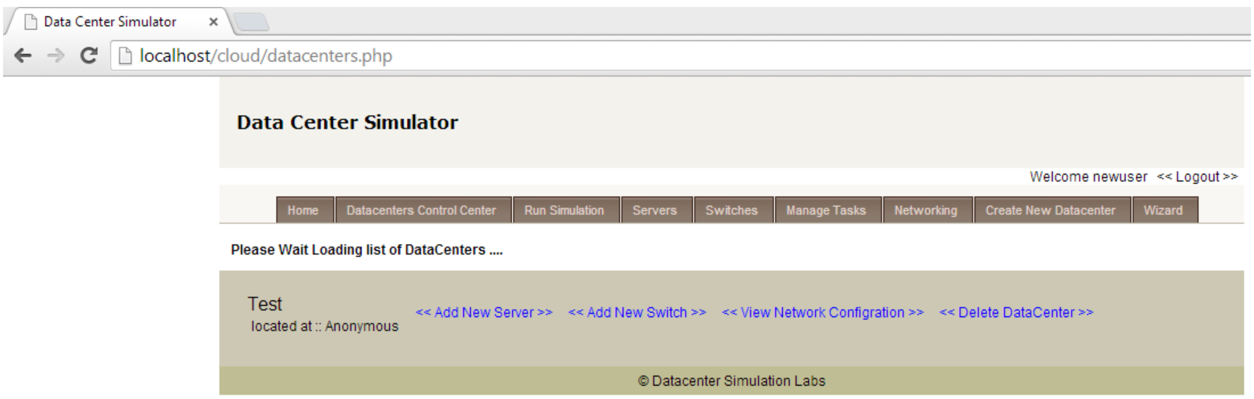


Figure 21: Enlisting of Existing Datacenters

Step: 4

- Click on the name of your newly created datacenter, you will see an empty Datacenter. Now your task will be to configure switches, servers and topology for your datacenter.

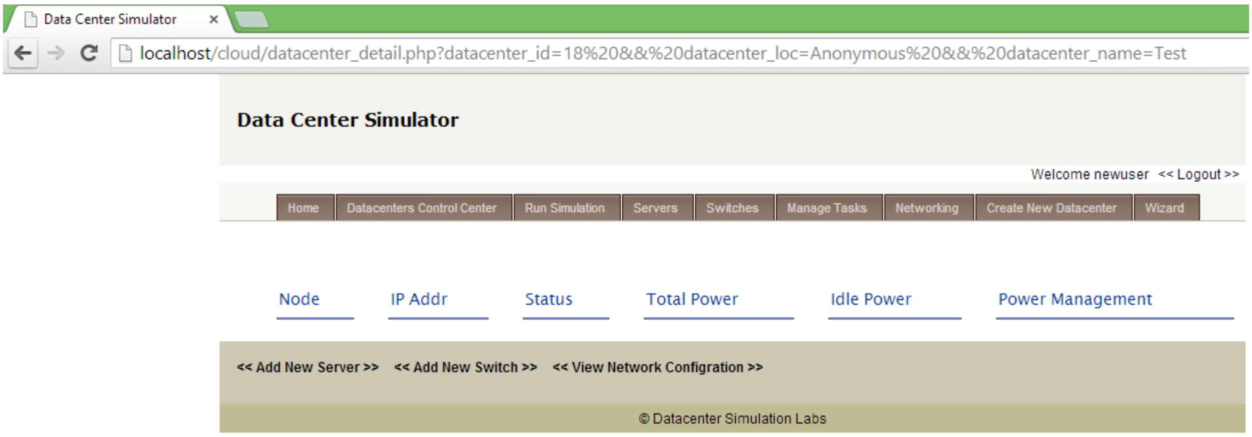


Figure 22 : Newly Created Datacenter Panel

- Important terminologies used in fore mentioned page are as follows:-

S.No	**Menu Name**	**Description**
1	**Node**	Represents individual Nodes i.e Switches and Servers present in Datacenter
2	**IP Addr**	It represents IP address allocated to a particular node
3	**Status**	Status of Node represents whether it is active or Inactive
4	**Total Power**	Represents power consumed by a particular node while it is working on a particular task
5	**Idle Power**	It is total power consumed by a server in idle mode
6	**Power Management**	Power management displays certain hyperlinks that can be utilized for any addition of any one click controls related to a particular node.

Table 7 : Attributes representing nodes in datacenters

Step: 5

- **Click on << Add new server >>** to add “4” new Servers in the datacenter. **It is necessary to input a unique IP addr every time you add a new server.**
- Important terminologies used in << **Add new server** >> page are as follows:-

S.No	**Terminology**	**Description**
1	**Equipment Model**	Represents make and model of the server
2	**Equipment Description**	Any comments that you would like to add
3	**Equipment Processor**	Make and Model of server Processor
4	**Equipment NIC's**	Make and Model of server NIC’s
5	**Equipment Network Cap**	Total Network capacity of the server
6	**Equipment CPU**	Processing power of the server in MIPS
7	**Network Interfaces**	Network Interface Cards attached to the Server.
8	**RAM**	RAM attached in the server in MB’s
9	**Equipment IP Address**	It represents IP address that is to be allocated to a particular server
10	**Equipment Status**	Status of Node represents whether it is active or Inactive
11	**Equipment Total Power Cons**	Represents power consumed by a particular node while it is working on a particular task
12	**Equipment Idle Power Cons**	It is total power consumed by a server in idle mode

Table 8 : Attributes for addition of a new server

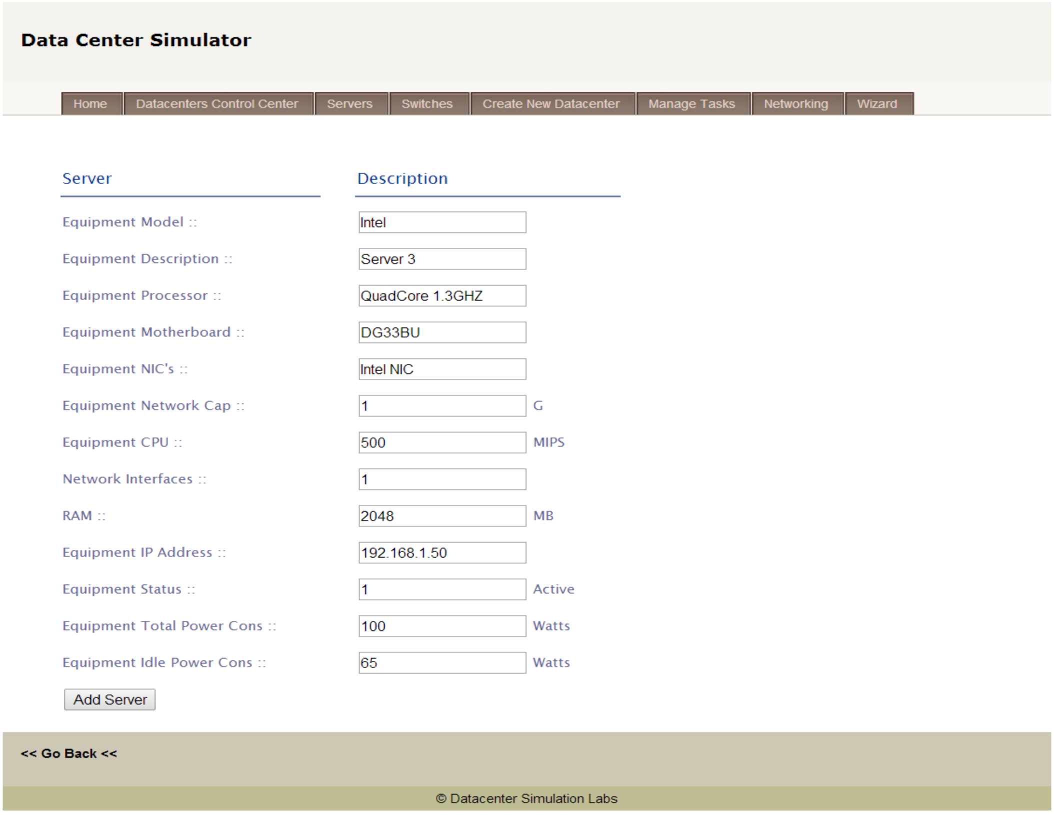


Figure 23 : Server Addition

- Now **Click on** << **Add new switch** >> to add "4" new Switches in the datacenter. **It is necessary to input a unique IP addr every time you add a new switch.**

- Important terminologies used in << **Add new Switch** >> page are as follows:-

S.No	**Terminology**	**Description**
1	**Equipment Model**	Represents make and model of the switch
2	**Equipment Description**	Any comments that you would like to add
3	**Equipment Processor**	Make and Model of switch Processor
4	**Equipment NIC's**	Make and Model of switch NIC's
5	**Equipment Network Cap**	Total Network capacity of the switch

6	**Equipment CPU**	Processing power of the switch in MIPS
7	**Network Interfaces**	Network Interface Cards attached to the switch.
8	**Equipment IP Address**	It represents IP address that is to be allocated to a particular switch
9	**Equipment Status**	Status of switch represents whether it is active or Inactive
10	**Equipment Total Power Cons**	Represents power consumed by a particular switch while it is working on a particular task
11	**Equipment Idle Power Cons**	It is total power consumed by a switch in idle mode

Table 9 : Attributes for addition of a new server

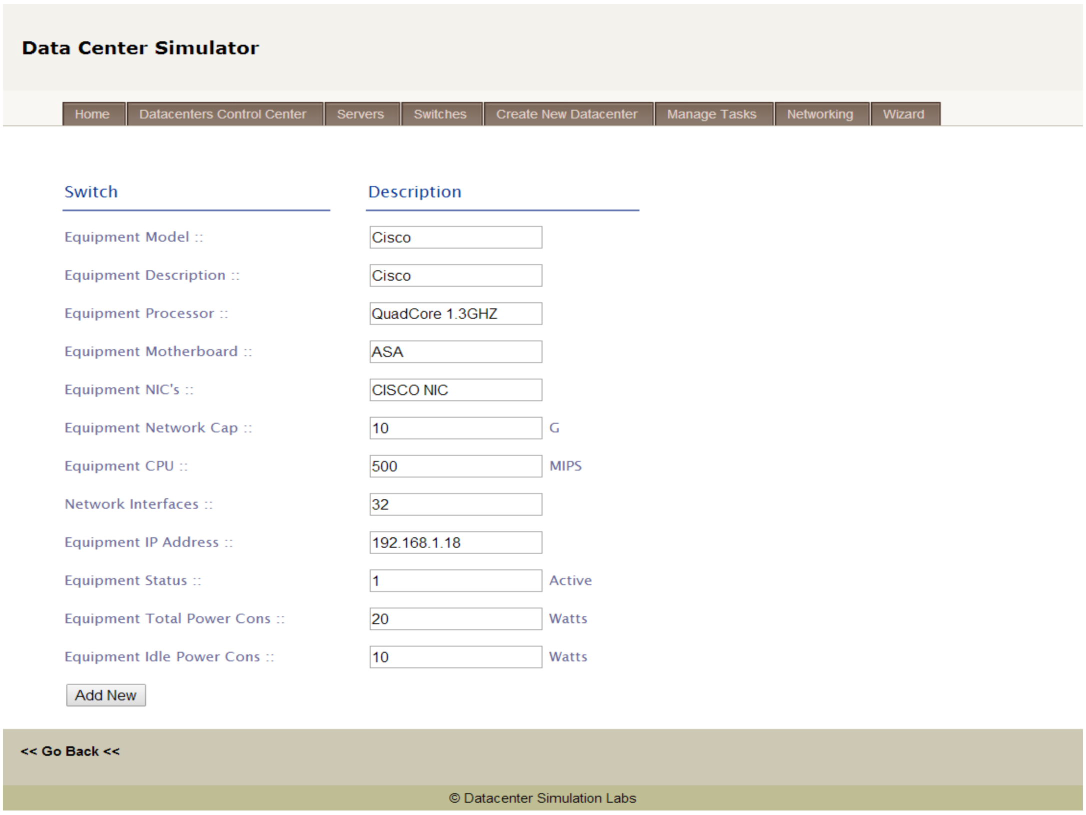


Figure 24 : Switch Addition

- After Adding servers and switches your Equipment base will look like

Node	IP Addr	Status	Total Power	Idle Power	Power Management
Server (62)	192.168.1.4	Active	100 Watts	65 Watts	
Server (61)	192.168.1.3	Active	100 Watts	65 Watts	
Server (60)	192.168.1.2	Active	100 Watts	65 Watts	
Server (59)	192.168.1.1	Active	100 Watts	65 Watts	
Switch (50031)	192.168.1.53	Active	20 Watts	10 Watts	
Switch (50030)	192.168.1.52	Active	20 Watts	10 Watts	
Switch (50029)	192.168.1.51	Active	20 Watts	10 Watts	
Switch (50028)	192.168.1.50	Active	20 Watts	10 Watts	
Switch (50032)	192.168.1.54	Active	20 Watts	10 Watts	

Figure 25 : Datacenter control center

Step: 6

- Once you are finished adding equipment in datacenter click on **“Networking”** Tab to configure this newly added Equipment in the Datacenter or click on **“Change Network Configuration”** link present in the bottom of the page after your newly created datacenter

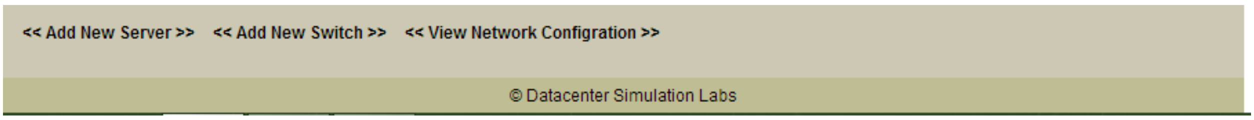


Figure 26 : Networking Menu

Step: 7

- You have to implement 3-tier architecture that was shown in the beginning of handout. Each link here will represent a physical medium that connects two nodes with each other. Links after creation can be updated or removed as done in real environments. Important terms are as follows:-

S.No	**Menu Name**	**Description**
1	**link ID**	Id assigned to a particular node
2	**Eqpt1 Id**	From this drop down you will select the starting end of your Link. Top down hierarchy is followed here i.e. starting node of Layer2 will terminate at ending node of Layer 1.
3	**Eqpt2 Id**	From this drop down you will select the terminating end of your Link. Top down hierarchy is followed here i.e. starting node of Layer2 will terminate at ending node of Layer 1.
4	**Layers/Tiers of Datacenter**	
	Layer 1	Represents the bottom most layer of datacenter in which servers and TOR switches are present.
	Layer 2	It is the middle layer connecting Layer 1 and Layer 3
	Layer 3	It is the layer of switches that is connected with the outer world i.e. Internet
5	**Link capacity (Link Cap)**	Represents max transmission rate of the switch
6	**Travel time (Traveltime)**	It is time required per request to travel between two nodes and
7	**Travel energy (Travelenergy)**	It is the energy that is required to for both mediums to communicate with each other

Table 10 : Frequently used terminologies in networking

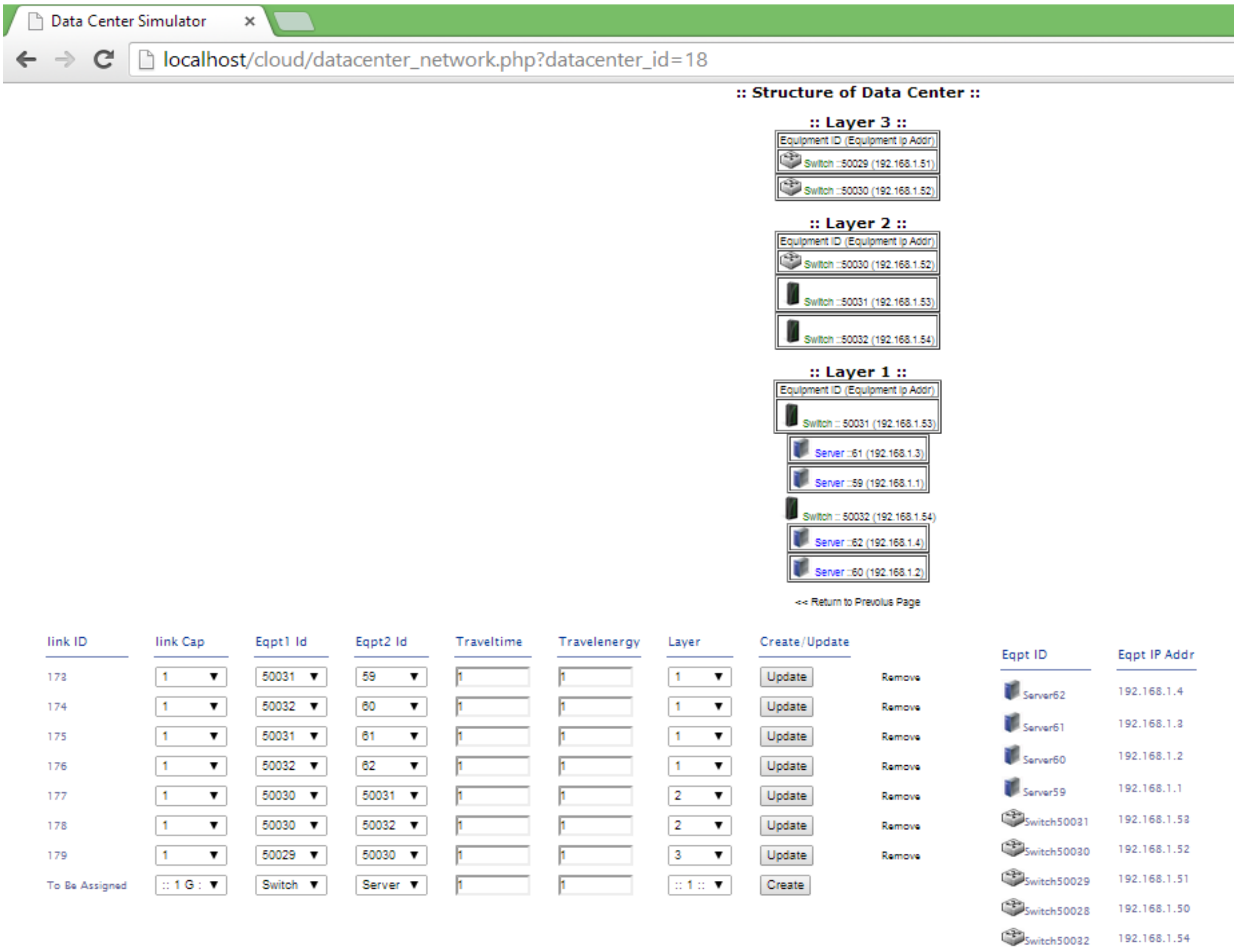


Figure 27 : Network management of datacenter

Step: 8

- Now click on the **Manage Tasks** Tab in the main menu
- If you don't have any simulation group already made, click on << **Click Here**>> tab in **To Create a New Group of Tasks , << Click Here >>**

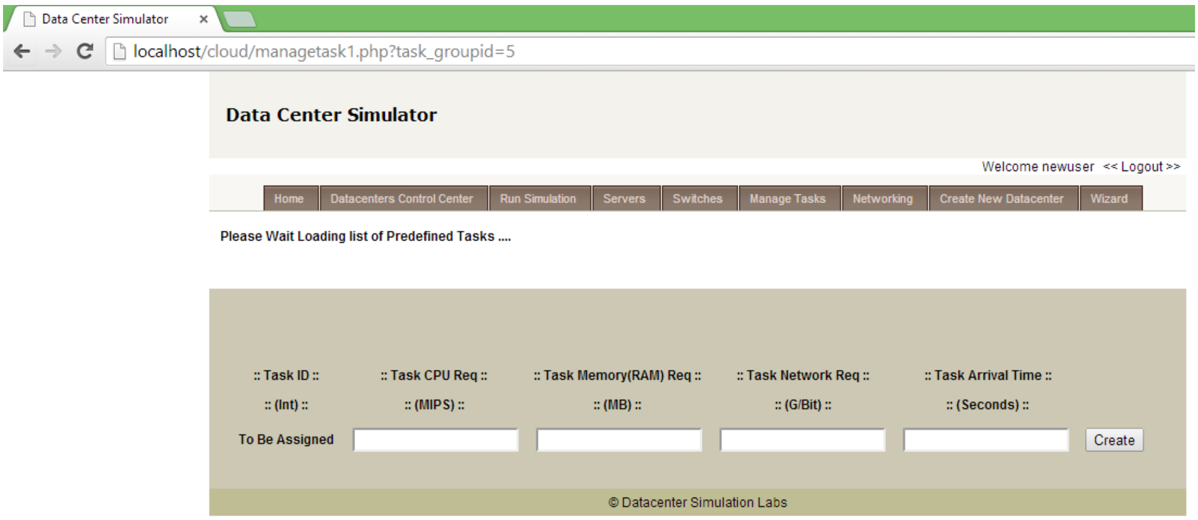


Figure 28 : Workload Management Panel

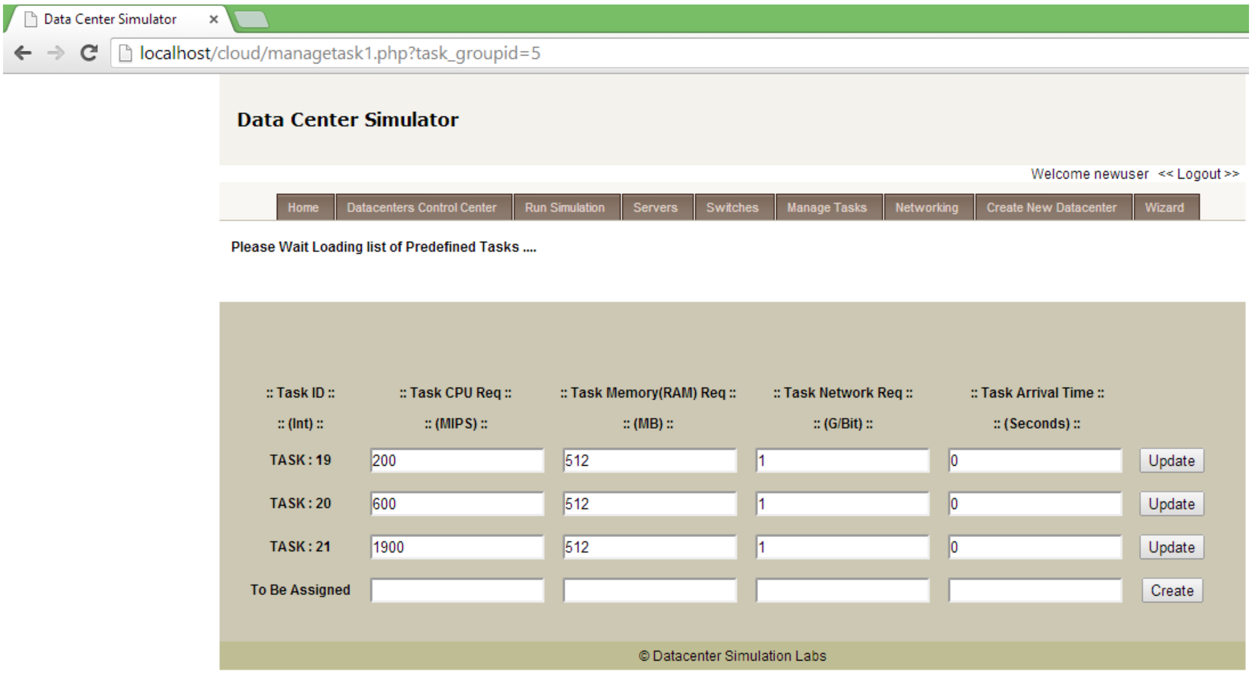


Figure 29 : Workload Creation/Update Panel

Step: 9

- Now from "Run Simulation" tab we will select our newly created datacenter and execute will execute tasks in the simulated environment to check energy conservation on avail servers.
- We have four different simulation environments; we will execute them one by one.
- Here you can view the same prefed task parameters that you updated in Mange Tasks tab. **Click the *Submit* button**.

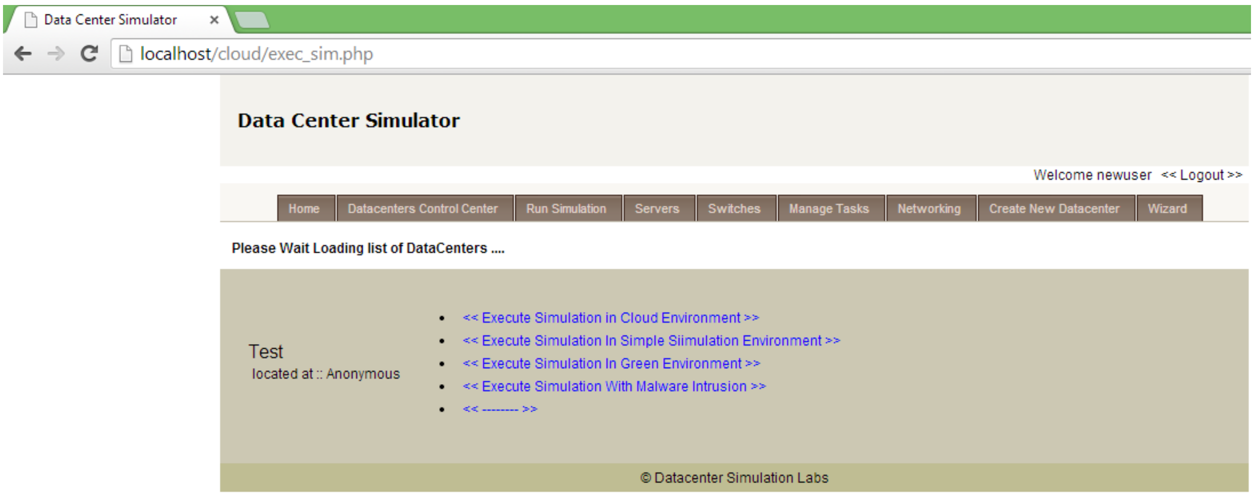


Figure 30 : Datacenter simulation panel

- After clicking a particular simulation you have to **select a particular Group that you added from Task Manager** and want to use for Executing simulation. Here you'll also enter the **time in seconds** for which you have to run the simulation.

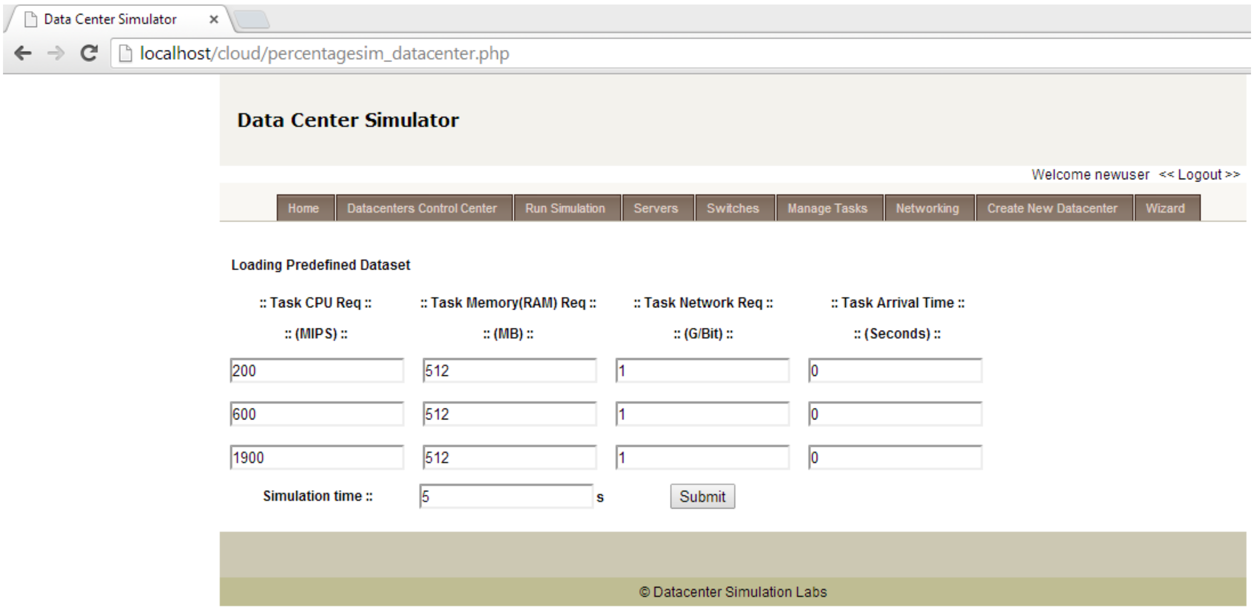


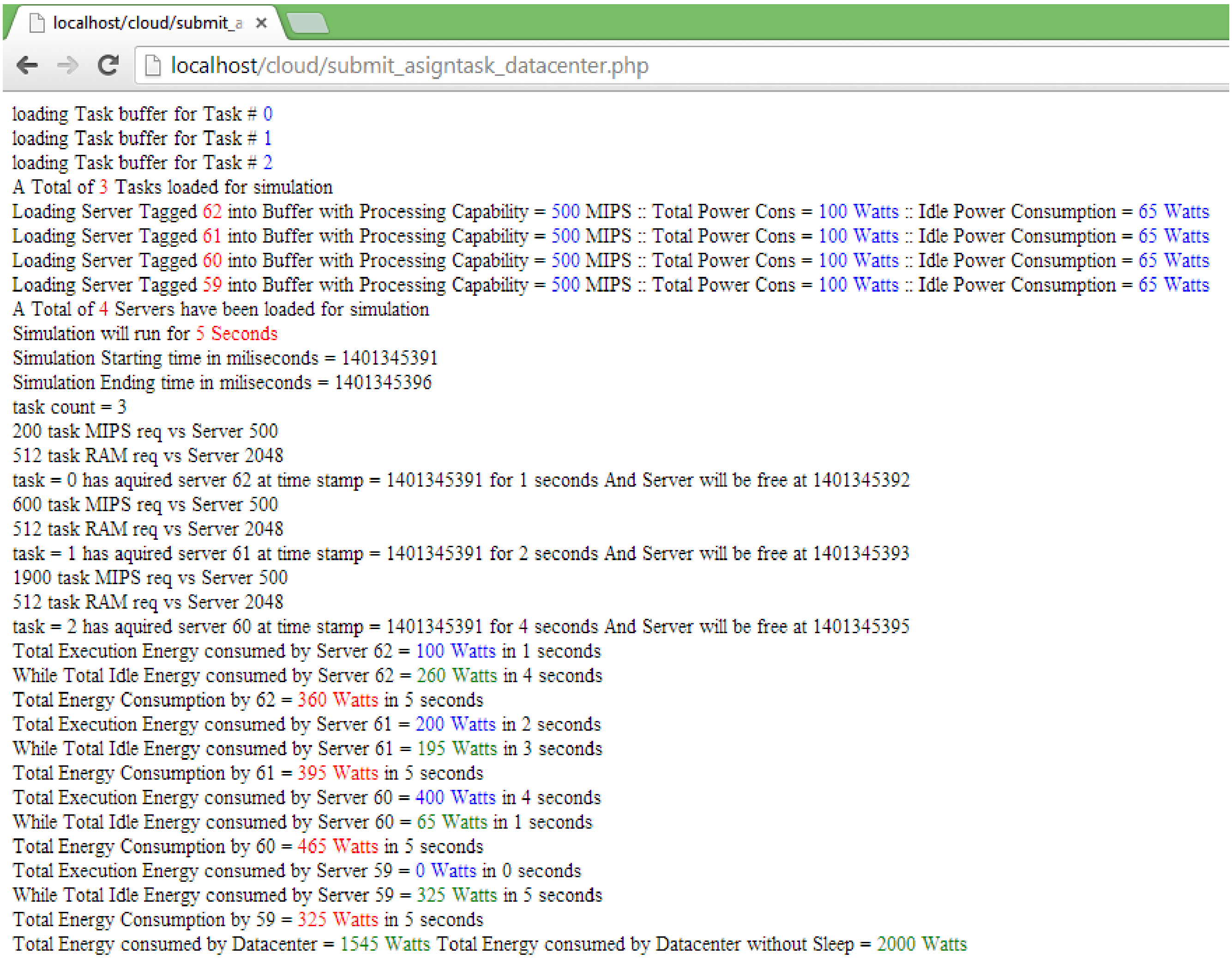
Figure 31: Task simulation parameters

Results

Here you will view the results of your simulation in the following hierarchy

1. Tasks will be loaded in buffers for simulations
2. Servers along with their capabilities will be loaded into buffers.
3. Simulation starting and ending timestamps will be calculated prior to running simulation.
4. Comparison of characteristics associated with Servers and Tasks will be done and respective task will be allocated to the server.
5. In the end individual as well as collective energies consumed by the servers will be calculated.

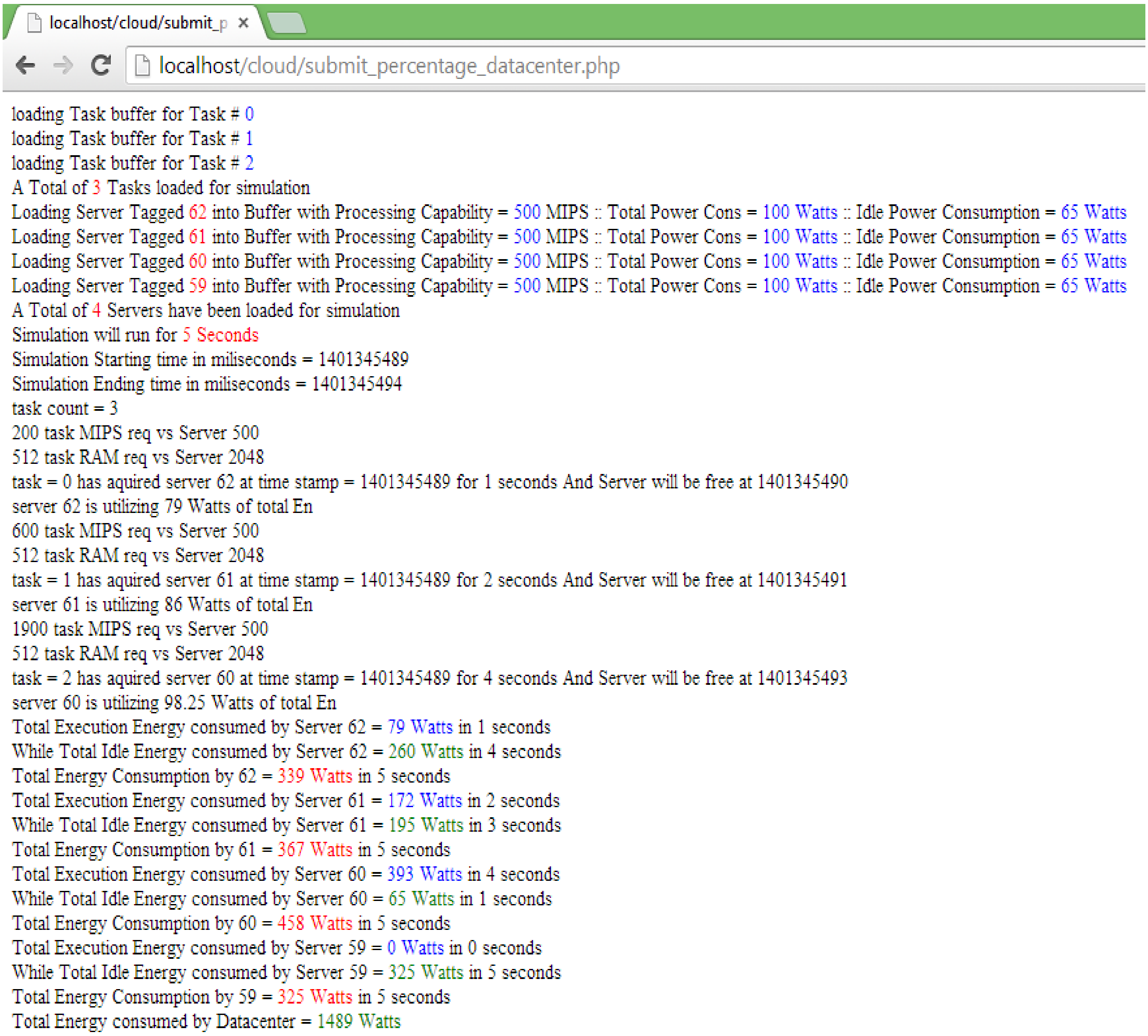
Simulation Environment 2: (FCFS Scheduling)



loading Task buffer for Task # 0
loading Task buffer for Task # 1
loading Task buffer for Task # 2
A Total of 3 Tasks loaded for simulation
Loading Server Tagged 62 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
Loading Server Tagged 61 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
Loading Server Tagged 60 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
Loading Server Tagged 59 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
A Total of 4 Servers have been loaded for simulation
Simulation will run for 5 Seconds
Simulation Starting time in miliseconds = 1401345391
Simulation Ending time in miliseconds = 1401345396
task count = 3
200 task MIPS req vs Server 500
512 task RAM req vs Server 2048
task = 0 has aquired server 62 at time stamp = 1401345391 for 1 seconds And Server will be free at 1401345392
600 task MIPS req vs Server 500
512 task RAM req vs Server 2048
task = 1 has aquired server 61 at time stamp = 1401345391 for 2 seconds And Server will be free at 1401345393
1900 task MIPS req vs Server 500
512 task RAM req vs Server 2048
task = 2 has aquired server 60 at time stamp = 1401345391 for 4 seconds And Server will be free at 1401345395
Total Execution Energy consumed by Server 62 = 100 Watts in 1 seconds
While Total Idle Energy consumed by Server 62 = 260 Watts in 4 seconds
Total Energy Consumption by 62 = 360 Watts in 5 seconds
Total Execution Energy consumed by Server 61 = 200 Watts in 2 seconds
While Total Idle Energy consumed by Server 61 = 195 Watts in 3 seconds
Total Energy Consumption by 61 = 395 Watts in 5 seconds
Total Execution Energy consumed by Server 60 = 400 Watts in 4 seconds
While Total Idle Energy consumed by Server 60 = 65 Watts in 1 seconds
Total Energy Consumption by 60 = 465 Watts in 5 seconds
Total Execution Energy consumed by Server 59 = 0 Watts in 0 seconds
While Total Idle Energy consumed by Server 59 = 325 Watts in 5 seconds
Total Energy Consumption by 59 = 325 Watts in 5 seconds
Total Energy consumed by Datacenter = 1545 Watts Total Energy consumed by Datacenter without Sleep = 2000 Watts

Figure 32 : Simulation results with FCFS scheduling

Simulation Environment 3: (Green Engineered Scheduler)



localhost/cloud/submit_percentage_datacenter.php

loading Task buffer for Task # 0
loading Task buffer for Task # 1
loading Task buffer for Task # 2
A Total of 3 Tasks loaded for simulation
Loading Server Tagged 62 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
Loading Server Tagged 61 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
Loading Server Tagged 60 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
Loading Server Tagged 59 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
A Total of 4 Servers have been loaded for simulation
Simulation will run for 5 Seconds
Simulation Starting time in miliseconds = 1401345489
Simulation Ending time in miliseconds = 1401345494
task count = 3
200 task MIPS req vs Server 500
512 task RAM req vs Server 2048
task = 0 has aquired server 62 at time stamp = 1401345489 for 1 seconds And Server will be free at 1401345490
server 62 is utilizing 79 Watts of total En
600 task MIPS req vs Server 500
512 task RAM req vs Server 2048
task = 1 has aquired server 61 at time stamp = 1401345489 for 2 seconds And Server will be free at 1401345491
server 61 is utilizing 86 Watts of total En
1900 task MIPS req vs Server 500
512 task RAM req vs Server 2048
task = 2 has aquired server 60 at time stamp = 1401345489 for 4 seconds And Server will be free at 1401345493
server 60 is utilizing 98.25 Watts of total En
Total Execution Energy consumed by Server 62 = 79 Watts in 1 seconds
While Total Idle Energy consumed by Server 62 = 260 Watts in 4 seconds
Total Energy Consumption by 62 = 339 Watts in 5 seconds
Total Execution Energy consumed by Server 61 = 172 Watts in 2 seconds
While Total Idle Energy consumed by Server 61 = 195 Watts in 3 seconds
Total Energy Consumption by 61 = 367 Watts in 5 seconds
Total Execution Energy consumed by Server 60 = 393 Watts in 4 seconds
While Total Idle Energy consumed by Server 60 = 65 Watts in 1 seconds
Total Energy Consumption by 60 = 458 Watts in 5 seconds
Total Execution Energy consumed by Server 59 = 0 Watts in 0 seconds
While Total Idle Energy consumed by Server 59 = 325 Watts in 5 seconds
Total Energy Consumption by 59 = 325 Watts in 5 seconds
Total Energy consumed by Datacenter = 1489 Watts

Figure 33 : Simulation Results with Green Scheduling

Simulation Environment 4: (Malware Intrusion with FCFS Scheduling)

- In the fourth scenario consider a Malware Intrusion in your Datacenter, due to which processing and memory capabilities of your datacenter are affected. When you configure the Percentage with which you datacenter servers have been affected you can study the results of malware intrusion on Energy of your datacenter.

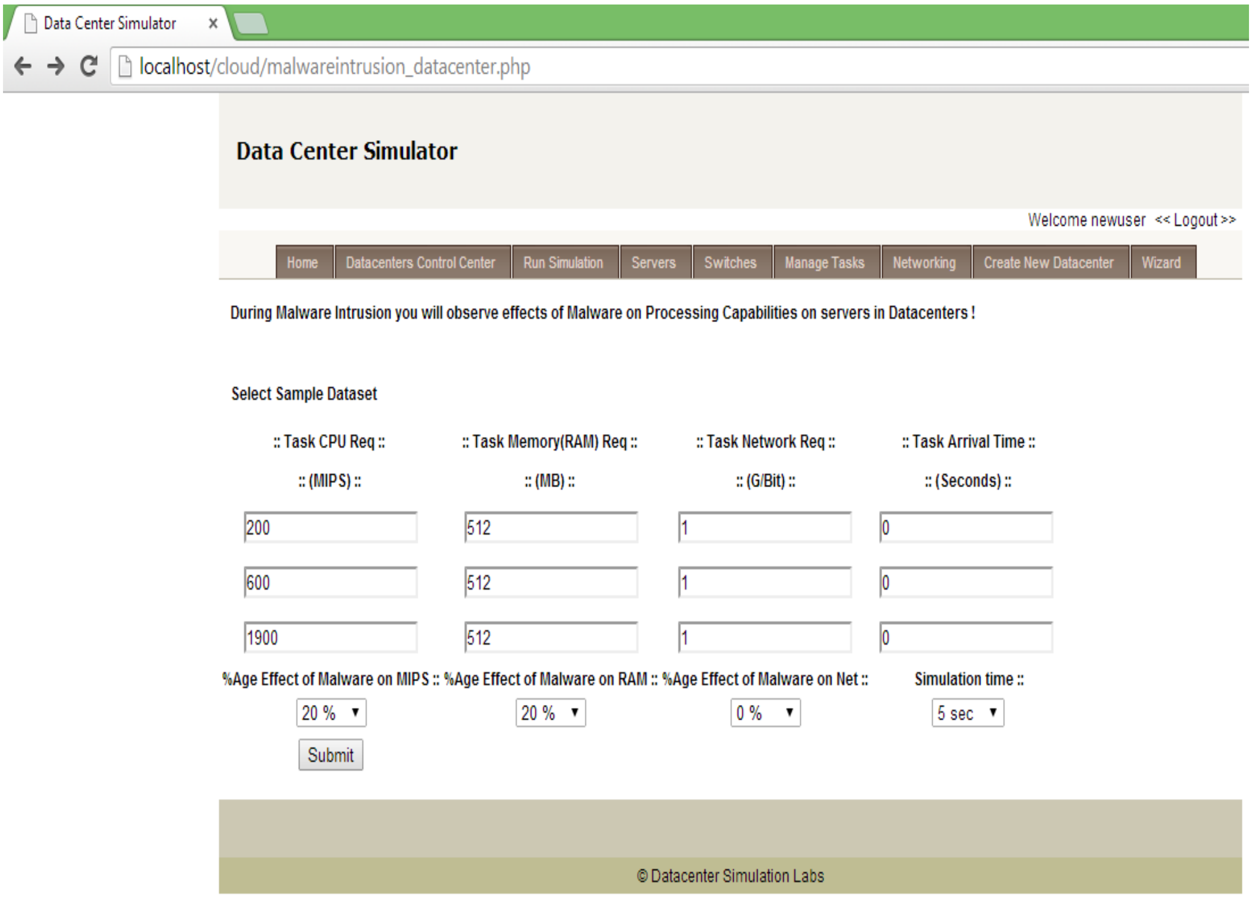
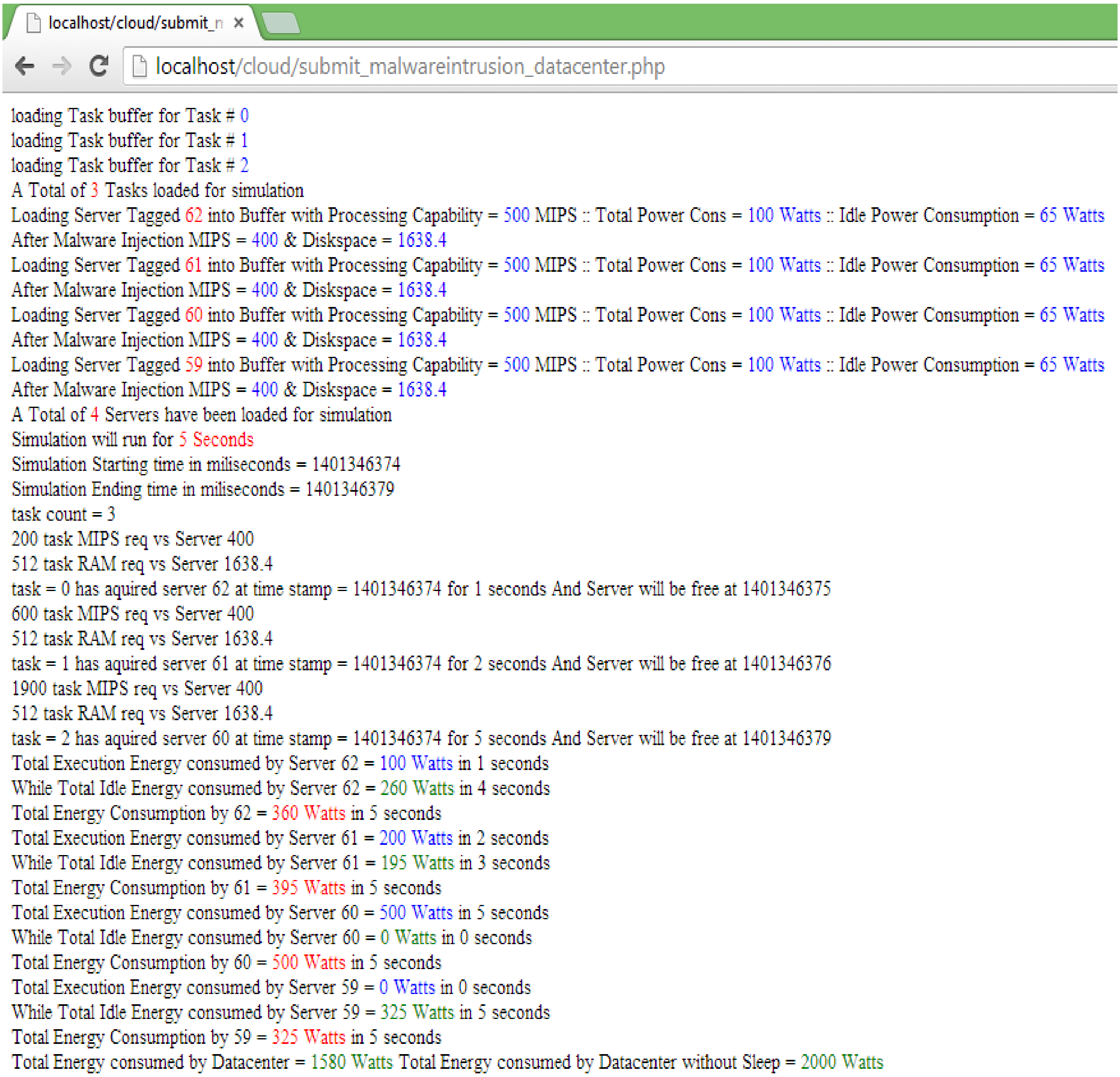


Figure 34 : Configuration for Malware Intrusion



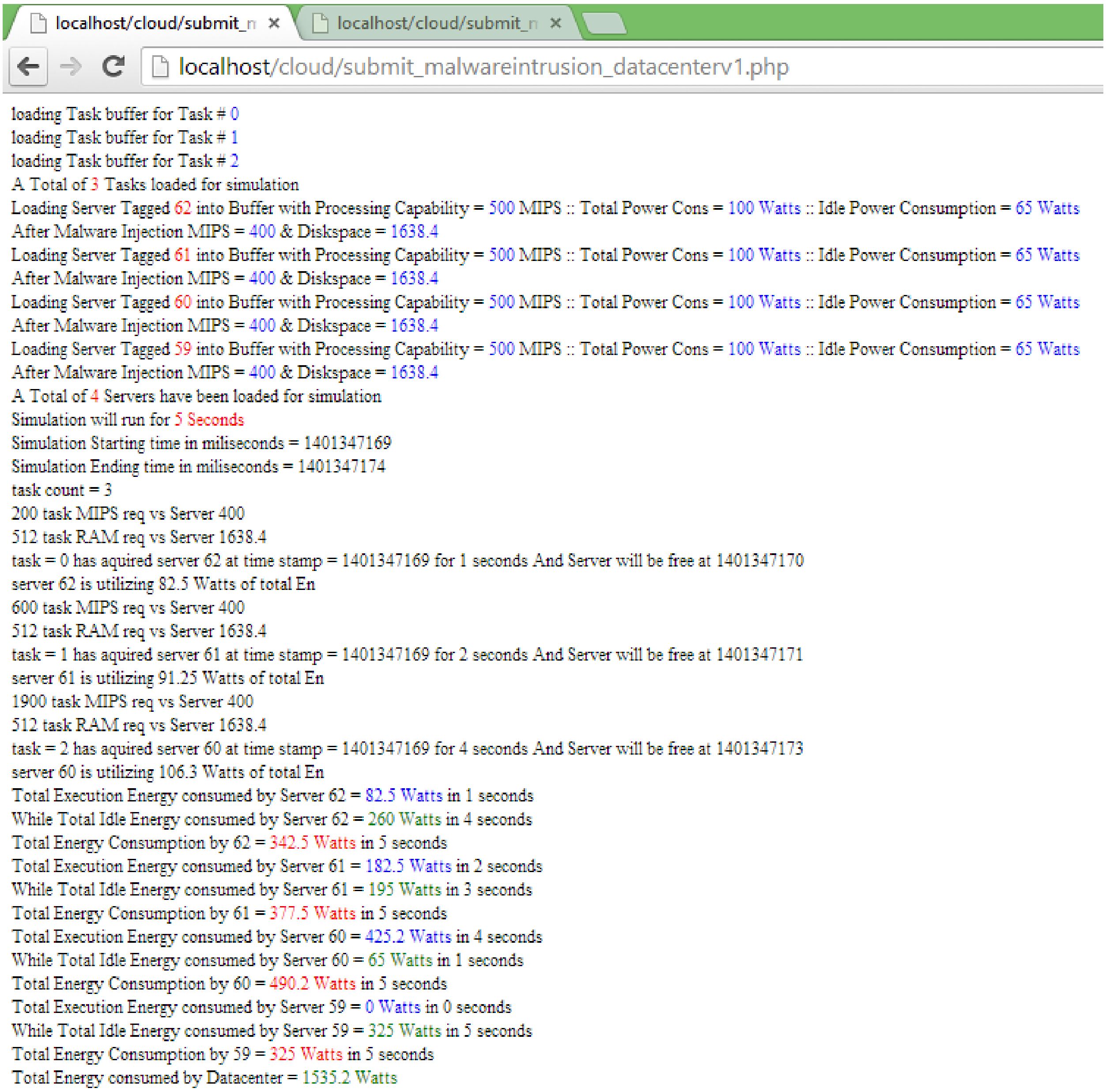
localhost/cloud/submit_n

localhost/cloud/submit_malwareintrusion_datacenter.php

loading Task buffer for Task # 0
loading Task buffer for Task # 1
loading Task buffer for Task # 2
A Total of 3 Tasks loaded for simulation
Loading Server Tagged 62 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
After Malware Injection MIPS = 400 & Diskspace = 1638.4
Loading Server Tagged 61 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
After Malware Injection MIPS = 400 & Diskspace = 1638.4
Loading Server Tagged 60 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
After Malware Injection MIPS = 400 & Diskspace = 1638.4
Loading Server Tagged 59 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
After Malware Injection MIPS = 400 & Diskspace = 1638.4
A Total of 4 Servers have been loaded for simulation
Simulation will run for 5 Seconds
Simulation Starting time in miliseconds = 1401346374
Simulation Ending time in miliseconds = 1401346379
task count = 3
200 task MIPS req vs Server 400
512 task RAM req vs Server 1638.4
task = 0 has aquired server 62 at time stamp = 1401346374 for 1 seconds And Server will be free at 1401346375
600 task MIPS req vs Server 400
512 task RAM req vs Server 1638.4
task = 1 has aquired server 61 at time stamp = 1401346374 for 2 seconds And Server will be free at 1401346376
1900 task MIPS req vs Server 400
512 task RAM req vs Server 1638.4
task = 2 has aquired server 60 at time stamp = 1401346374 for 5 seconds And Server will be free at 1401346379
Total Execution Energy consumed by Server 62 = 100 Watts in 1 seconds
While Total Idle Energy consumed by Server 62 = 260 Watts in 4 seconds
Total Energy Consumption by 62 = 360 Watts in 5 seconds
Total Execution Energy consumed by Server 61 = 200 Watts in 2 seconds
While Total Idle Energy consumed by Server 61 = 195 Watts in 3 seconds
Total Energy Consumption by 61 = 395 Watts in 5 seconds
Total Execution Energy consumed by Server 60 = 500 Watts in 5 seconds
While Total Idle Energy consumed by Server 60 = 0 Watts in 0 seconds
Total Energy Consumption by 60 = 500 Watts in 5 seconds
Total Execution Energy consumed by Server 59 = 0 Watts in 0 seconds
While Total Idle Energy consumed by Server 59 = 325 Watts in 5 seconds
Total Energy Consumption by 59 = 325 Watts in 5 seconds
Total Energy consumed by Datacenter = 1580 Watts Total Energy consumed by Datacenter without Sleep = 2000 Watts

Figure 35 : Simulation results with malware injection & FCFS scheduling

Simulation Environment 5: (Malware Intrusion with Green Scheduling)



loading Task buffer for Task # 0
loading Task buffer for Task # 1
loading Task buffer for Task # 2
A Total of 3 Tasks loaded for simulation
Loading Server Tagged 62 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
After Malware Injection MIPS = 400 & Diskspace = 1638.4
Loading Server Tagged 61 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
After Malware Injection MIPS = 400 & Diskspace = 1638.4
Loading Server Tagged 60 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
After Malware Injection MIPS = 400 & Diskspace = 1638.4
Loading Server Tagged 59 into Buffer with Processing Capability = 500 MIPS :: Total Power Cons = 100 Watts :: Idle Power Consumption = 65 Watts
After Malware Injection MIPS = 400 & Diskspace = 1638.4
A Total of 4 Servers have been loaded for simulation
Simulation will run for 5 Seconds
Simulation Starting time in miliseconds = 1401347169
Simulation Ending time in miliseconds = 1401347174
task count = 3
200 task MIPS req vs Server 400
512 task RAM req vs Server 1638.4
task = 0 has aquired server 62 at time stamp = 1401347169 for 1 seconds And Server will be free at 1401347170
server 62 is utilizing 82.5 Watts of total En
600 task MIPS req vs Server 400
512 task RAM req vs Server 1638.4
task = 1 has aquired server 61 at time stamp = 1401347169 for 2 seconds And Server will be free at 1401347171
server 61 is utilizing 91.25 Watts of total En
1900 task MIPS req vs Server 400
512 task RAM req vs Server 1638.4
task = 2 has aquired server 60 at time stamp = 1401347169 for 4 seconds And Server will be free at 1401347173
server 60 is utilizing 106.3 Watts of total En
Total Execution Energy consumed by Server 62 = 82.5 Watts in 1 seconds
While Total Idle Energy consumed by Server 62 = 260 Watts in 4 seconds
Total Energy Consumption by 62 = 342.5 Watts in 5 seconds
Total Execution Energy consumed by Server 61 = 182.5 Watts in 2 seconds
While Total Idle Energy consumed by Server 61 = 195 Watts in 3 seconds
Total Energy Consumption by 61 = 377.5 Watts in 5 seconds
Total Execution Energy consumed by Server 60 = 425.2 Watts in 4 seconds
While Total Idle Energy consumed by Server 60 = 65 Watts in 1 seconds
Total Energy Consumption by 60 = 490.2 Watts in 5 seconds
Total Execution Energy consumed by Server 59 = 0 Watts in 0 seconds
While Total Idle Energy consumed by Server 59 = 325 Watts in 5 seconds
Total Energy Consumption by 59 = 325 Watts in 5 seconds
Total Energy consumed by Datacenter = 1535.2 Watts

Figure 36 : Simulation results with malware injection & green engineering

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