

ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE
ENGINEERING AND TECHNOLOGY

**Quality of Service Trade-offs Between Central Data Centers
and Nano Data Centers**

M.Sc. THESIS

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Department of Computer Engineering

Computer Engineering Programme

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**Merkezi Veri Merkezleri İle Dağıtk Nano Boyutlu Veri
Merkezleri Arasındaki Servis Kalitesi Ödünleşmeleri**

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FOREWORD

This master thesis is written under Asst. Prof. Dr. Tolga Ovatman supervision, Istanbul Technical University. The intent of this thesis is giving a replacement properties of current data centers topology by qualifying better quality of services, as nano data centers.

I take this opportunity to express gratitude to my advisor for his help and support. I also thank my parents for the unceasing encouragement, support and attention. I am also grateful to my friends who supported me. I also place on record, my sense of gratitude to one and all, who directly or indirectly, have lent their hand in this research.

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Farzaneh AKHBAR

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ABBREVIATIONS

NDC	: Nano Data Center
CDC	: Central Data Center
VoD	: Video on Demand
EC	: Energy Consumption
CA	: Cloud Analyst
P2P	: Peer to Peer
MC	:Memory Capacity
PRS	: Processor Speed
BW	: Band Width
QoS	: Quality of Services
ISP	: Internet Service Provider

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Quality of Service Trade-offs Between Central Data Centers and Nano Data Centers

SUMMARY

We all know progress speed of technology is really fast and every day we encounter several new topics. Cloud computing is one of the recently emerging technologies in computer science. However cloud computing is almost new, There are lots of gaps that need attention. In our research we decide to consider data centers' performance in cloud computing infrastructure. Huge amount of data is one of the serious problem in today's world. This rising amount of data cause lack of management and current configuration of data centers could not satisfy consumer's requests. We decide to investigate the performance of a specific kind of distributed approach instead of current centralized approach, to check if they could give better quality of services. For our experiment we use CloudAnalyst simulator which written in java and built on CloudSim (Buyya et al., 2009, p. 1265). By replacing a central data center with Nano data centers, we start to check their performance in comparison of central data center. Changing different properties of data center include: memory capacity, processor speed, bandwidth and number of user bases whom send requests to their local data center, we compare central and nano data center performance on different aspects like response time and performance cost, since these two factors are the most important factors we need them to be desirable. By interpreting our charts we show that our nano data centers works much better than central data centers. Finally we try to get some threshold point which our nano data center could give their best quality of services in.

Actually we changed different properties of data center to find best point value that in which Nano data centers could reach their best performance and give better quality of services to their requests. However some properties has no impressive effect on response time or performance cost we try to do experiment more on those which act differently, like memory capacity. Also we conduct our experiments with some kind; of proportions between resources to obtain relativistic results. Finally we combine results of different properties two by two in one chart to show points which data centers give better quality of services with considering more than one properties. These kinds of analyses could be beneficial when for example we have a boundary for changing data centers' categories and by referring to our charts could decide more precisely about constructing data center properties.

Merkezi Veri Merkezleri ile Dağıtık Nano Boyutlu Veri Merkezleri Arasındaki Servis Kalitesi Ödünleşmeleri

ÖZET

Hepimiz farkındayız ki günümüzde teknoloji hızla gelişmektedir ve kişilerin gün geçtikçe yeni teknolojik yapılarla karşı karşılaşmasına sebep olmaktadır. Bulut bilişimö web uygulamalarının geliştirilmesi ve zenginleştirilmesinde kullanılan en iyi ve yeni teknolojilerinden birisidir. Son yüzyılda, dünyanın dört bir yanındaki internet kullanıcıların büyük bir kısmı bir veya birden fazla internete bağlı cihaza ve bu cihazlardaki çeşitli programlara sahiptirler. Bu uygulamaların vasıtasıyla üretilen veri hacminin çok büyük bir seviyede olduğundan dolayı ve bunun yanında düşük kalitede veri yönetimi metotları kullanılmaması neticesinde servis sunucular yavaş, veya kesintili çalışabilirler ve bu düşük servis kalitesi müşterilerin memnuniyetini ve müşteri sayısını azaltabilir. İnternet tabanlı teslimat oluşturucuları günümüzdeki altyapılarda düşük kalitede olan servislerin en önemli sebeplerinden bir tanesidir. Kullanıcılar herhangi bir servis isteği oluşturduklarında o servis isteği internet üzerinden sunuculara ulaşır ve sunucu isteği işledikten sonra ona uygun servisi sağlar. Bu işlem zaman alır ve zaman alıcı olmasından dolayı sunucunun servis sağlamasında gecikmelere neden olur. Biz bu çalışmada isteklerin ve servislerin, kullanıcı ve sunucuya ulaşmaları için daha kısa bir mesafe hareket etmelerini ve böylece servislerin daha kaliteli bir şekilde sunulmalarını amaçlıyoruz. Bunun için veri merkezlerini yerel çevrelere taşımayı ve kullanıcıların daha hızlı ve daha az enerji harcayarak servislere ulaşmalarını hedefliyoruz.

Bulut bilişimin kendi içerisinde barındırdığı ve belli düzeyde geliştirilmesi gereken kısımları mevcuttur. Bu çalışmada bulut bilişimin alt yapısında bulunan veri merkezinin performansı değerlendirilmiştir. Veri miktarının büyüklüğü günümüzün bu alanda en büyük sorunlarından bir tanesidir. Veri miktarındaki artış, yönetim boşluğuna sebep olmakla birlikte veri merkezinin güncel konfigürasyonunun tüketici memnuniyetini karşılamamasına neden olmaktadır. Bu sebepten ötürü bu çalışmada güncel veri merkezi konfigürasyonlarının yerine bir takım dağıtılmış veri merkezlerinin performansı hizmet kalitesini artırmak amacıyla inceleme yoluna gidilmiştir.

Yapılan bu çalışmada JAVA programında yazılan ve CloudSim üzerinde inşa edilmiş olan CloudAnalyst simülatörü kullanılmıştır. Mevcut veri merkezi nano düzeydeki veri merkezlerinin değiştirilmesi yoluna başvurulmuş ve yeni düzenin eski sistemle kıyaslanması sağlanmıştır. Değişen veri merkezinin özellikleri ise şu şekilde sıralanabilir: Hafıza kapasitesi, işlem hızı, bant genişliği ve bununla birlikte yerel merkezlerine istek gönderen tüketici sayısındaki değişimdir. Bu çalışmada ayrıca tüketici memnuniyeti etkileyen en önemli iki faktör olması sebebiyle eski sistemin ile geliştirilmiş nano düzeydeki yeni sistemi performans açısından ve sistemlerin kurulum maliyetleri açısından zamana bağlı olarak farklı grafikler

üzerinde gösterilmiştir. Bu grafikler bu açıdan değerlendirildiğinde nano düzeydeki veri merkezlerinin mevcut sisteme göre daha etkili çalıştığı gözlemlenmiştir. Sonuç olarak nano düzeyde veri merkezlerinin en iyi hizmet verdiği eşik değerleri tespit edilmiştir.

Bu çalışmada yapılmış olanlar, özünde Nano servislerinin kullanıcılar için en iyi performansı sağlamaları ve kullanıcılar tarafından oluşturulan isteklere en iyi bir biçimde hizmet sunmaları için onların yukarıda belirlenen özelliklerini değiştirerek en iyi çalışacakları duruma gelmelerini sağladık. Ancak bazı bu özelliklerin değiştirildikleri zaman etkileri tepki süresi ve performans maliyeti üzerinde çok düşük bir seviyede olduklarından dolayı bu çalışmada bizim için bellek kapasitesi ve buna benzer olan ilginç ve etkili davranışları olan özellikler daha önemli olmaktadır. Bu sonuçlar çeşitli sistemlerdeki farklı yapılandırma ihtiyaçlarına göre farklı miktarlarda kullanılabilir olacak. Sonunda ise farklı özelliklerin sonuçlarını bir grafikte göstererek veri merkezlerinin hangilerinin kullanıcılar için daha kaliteli servisler sunduğunu grafikteki noktaları kullanarak göstermeye çalışıyoruz. Bu grafikler bazı durumlarda, özellikle veri merkezlerinin kategorilerinin sınırlı bir biçimde değiştirilebilir oldukları zaman onların özelliklerinin daha hassas bir şekilde belirlenmesine yardımcı olurlar. Veri merkezlerinin kalitesi aslında oluşturucuların kalitesinde olması gerekmektedir. Veri merkezlerinin kullanıcı isteklerine istenen kalitede cevap vermeleri için özelliklerinin, konumu ve algoritmasının ayarlanması gerekmektedir. Kaliteli kablolar, güç dağıtım üniteleri soğutma sistemleri ve benzeri şeylerin sadece bir servis sunucusunun veri merkezi kurulumu konusunda sorunsuz olduğu zaman etkileyici olurlar.

Örnek olarak NDCs'in performansını gerçekten anlamamız için bu konuya herkesin bildiği ve kolayca anladığı bir biçimde yaklaşmamız gerekmektedir. İçinde bulunduğumuz yüzyılda herkesin evinde, masasında ve hatta cebinde interneti bağlı olan cihazlar bulunmaktadır. Laptop, bilgisayar, TV ve tablet gibi cihazlar. Tüm bu cihazlar sürekli veri üretiyorlar ve CDC'lerdeki yönetim eksikliği ve aşırı derecede karmaşıklık performansın sorunlu olması ve garanti olmamasına sebep olur. Günümüzdeki veri merkezleri sunucuları yönetmekte sıkıntı yaşamaktalar. Bir kullanıcının isteklerine kaliteli bir servis sunulması için düzgün bir şekilde planlama gerekmektedir. Sistemdeki herkesin ve her şeyin birbiri ile uyumlu bir biçimde çalışabilmesi gerekmektedir. Veri merkezlerinin ömrü boyunca sunuculardaki bazı bilinen sıkıntılar onların yapılmasında zorluklara neden olabilir. Mühendislik tasarımı ve yapılandırması, donanımların ömrünün bittiğindeki operasyonlar, donanımların tamiri ve güncellenmesi bu problemlerin bazılarıdır. Dikkate alınması gereken başka sıkıntılar ise, bazı durumlarda kullanıcılar veri merkezleri alanında uzman olmayan bir firmayı tercih edebilirler veya kurucuların veri merkezi sistemlerini bilmiyor olabilirler. Bu bir sürekli olan kalite kontrolü meselesidir. Ayrıca buradaki söylenen problemler sıkça yaşanan problemlerdenler. Bunlarla karşılaşmak aslında her türlü kullanıcı ile çalıştığınız zaman mümkündür. Bazı büyük firmalarda çalışanlar arasındaki iletişim seviyesi çok düşük olur veya küçük bir firmada sizin isteklerinizi karşılayacak kaynaklar bulunmayabilir. Bu yetersizlikler çoğu zamanlarda kullanıcıların internet servisleri kalitesinden memnun kalmamalarına sebep olur ve internet servisi sunucuları servis kalitesinin garantilenmesi için hiçbir şey yapamazlar.

Bunun da asıl nedeni ise günümüzdeki kullanılan topoloji ve veri merkezlerinin modelidir. İnternet tabanlı servislerin enerjiyi yetersiz kullanmaları ve kalite kontrolünün zorlaşması ve kişiselleştirmede sorun yaşamalarına da dikkat etmemiz lazım.

1. INTRODUCTION

Cloud computing is one of the recently maturing technologies that could help today's web based applications in a way, they could reach better quality of services. In recent decade, every internet user has several instruments that use a different application. These applications produce data in large amount, so rising amount of data cause lack of management and customers at most of the time are unsatisfied by their internet services provider. Internet based delivery approach is the biggest reason of low quality of services in current infrastructures. Every time a consumer send a request, it goes through the internet to a server and data center for getting an appropriate response and back to the consumer via internet. This procedure takes time and cause latency in receiving response. We try to increase quality of services by decreasing the distance every request pass to get response from data centers. We transfer data centers to local environment of user bases till users access their needs with low latency and less energy consumption. Although cloud computing is almost a newborn technology; it is continuously getting more mature over time as the challenges retaining the concept evolving (Zhang et al. 2010). Challenges like energy efficient computing in cloud environments and optimal resource management is heavily studied while new concepts like nano data centers(NDC) are proposed as well through time. NDC concept is based on the idea of distributing the computing power of central data centers(CDC) among the customers of the computing services by using relatively less powerful computing devices at customer site. However, CDC should manage requests of different servers, NDC could consent request of their local users, which are in edge of their networks, for example their homegates or set-top-boxes (Adami et al. 2013). The basis drive in the development of NDC is the thriving towards pertaining QoS issues where continuous low latency is an important parameter to improve. Even more importantly, inducing the cost to setup and maintain a large CDC may increase the cost of services. In this paper we show that

distributed data centers as a new version of data centers have advantages in contrast to current CDC in cloud based infrastructures. We use CloudAnalyst simulator to study the behaviour of data centers in both central and distributed topologies. After that we present the trade-off between data center properties: memory capacity, computing costs and latency under different configurations of data centers to study if they can be used in the decision process of migrating to a distributed NDC approach. Finally, we take into consideration parameters like the number of user bases: cumulated areas of incoming user traffic and the ratio between CDC's memory capacity and a single node's capacity in the distributed nano network.

2. LITRATURE REVIEW

Since cloud computing is a modern technology, recently a lot of studies on different aspects have performed. In these studies data centers play an important role, always attaining big attention. Majority of articles which exist in literature consider only energy consumption of data centers in their studies. In this study we try to find some thresholds to adjust different characteristics of our nano data centers as a replacement for current central ones. For example, Ning Liu et al suggested an optimization model for energy consumption (Liu N. et al. 2013). They used greedy algorithm for allocating tasks to different open server and maintained the response time and energy consumption and compared results with the results of random task scheduling in internet. Their results show greedy task scheduling gives less energy consumption and at the same time less response time. Another research proposed genetic algorithm based approach, namely GABA for virtual machine online reconfiguration in large scale cloud computing data centers with aim of energy efficiency. In the study by Lin Yuan et al. GABA algorithm is suggested to conserve consumption energy by decreasing the number of physical machine which should be turn on when tasks get arrived in cloud based infrastructures (Mi, H. et al. 2006). Moreno and Xu suggested Nano data center again for energy conservation in a way that data centers be located at the edge of the network, like home gateways or set-top-boxes, and cooperate in a peer-to-peer manner (Moreno. et al. 2011). Vytautas Valancius et al. applied NDC in video on demand (VoD) services in cloud computing environment and verified energy utilization in traditional current centric data centers and the new version of data centers, NDC (Adami. et al. 2013). In this study NDC utilized ISP-controlled home gateways to provide computing and storage services and adopts a managed peer-to-peer model to form a distributed data center infrastructures. By developing energy consumption pattern with using a large set of empirical VoD access data in traditional and in NDC data centers they demonstrated, even under the most pessimistic scenarios, NDC saves at least 20% to 30% of the energy compared to traditional

data centers. In the study, it is claimed such kind of energy savings is result of cooling costs avoidance, or reduction of network energy consumptions.

He et al. (2009), investigate nano data center from another aspect and studies the feasibility of providing peer-to peer live streaming application with quality and delay comparison of traditional television broadcast which use nano data centers. It uses peer to peer communication in nano data center for sending and receiving data back and forth among each other. In this article Jiayue He et al. try to find the model which nano data center could get data from their neighbours; Because every NDC are not always on or ready to prepare their requests, but in such situations NDCs could negotiate with other neighbourhood partners and ask them to process their requests request (He et al. 2009). shows the best way which NDC could get services from a peer to peer communication in different situation, is, when slept NDCs send their received request to near on peers. In this research, on and off NDCs considered just like a tree with clusters and solution are suggested by giving order to these clusters as NDCs, to ask service. Toataly, branching architecture over nano data centers as a novel architecture in this article include three parts: initial tree construction, tree reconfiguration as users switch between content streams, and flow control to handle temporary network congestion (from background traffic) and continuity of data delivery.

As mentioned before majority of researches in nano data center are related to energy consumption investigation. Fatemeh J. et al. (2014), in their research give an end to end energy consumption model for NDCs till the amount of consumption decrease and data centers reach better performance. In this model their considered centralized counterpart, which control and set jobs for their nano data center that, individually are independent and should respond to request based on what a centralized supporter forced way. In their study, the energy consumption in a central data center, is modelled by dividing energy through three elements including: energy consumption when users access response of their requests from a data center. This energy is which consumers use in last part of receiving their response. Secondly,

transmission energy consumption when the requests or response pass a path from users to servers, switches or even through cables. Finally energy consumption by data centers itself when try to handle a request inside their construction. . Actually their goal is, decrease distant between data center and user to save energy wasted in paths when service demands or prepare answer transmit in internet (Jalali et al. 2014).

In Zhang et al. (2010) authors give a survey about cloud computing with the aim to provide better understanding of gaps or lacking parts in cloud computing. No up-front investment, low operating cost, highly scalable and easy access are important properties which estate for cloud computing applications in this search. In high scalability characteristic of cloud computing infrastructure, data centers are mentioned as a resource which give flexibility to clouds. Because cloud computing can be seen as a service model, which give ability to the common resources in internet like networks, server, storage, application and services to satisfy their consumers with minimum management striving or little internet service provider challenges. Also in this case the speed is high in a desirable level.

Based on this research, a data center can be seen as a very powerful computing machine in internet having an important and fundamental role in cloud computing. Data centers reach their power by ownership of different part like: servers, switches and routers. An appropriate topology of data centers in internet could, change data center performance in a better way, especially when we have distributed computing infrastructures. Scalability and resiliency are two other prominent factor which should be considered in data centers, based on this survey.

Among all the literature about data center in Cloud computing infrastructure, our works is completely a novel research, because most of them are about energy consumption (EC) (Mi et al. 2010). In such kind of research people try to give models, algorithms or ways which decrease EC. In our research we try to fine tune data center properties by allocating proper characteristics. By assigning appropriate data center properties cloud infrastructure could give better quality of services.

3. BACKGROUND

The cloud technology cause elimination of subjects that services, programs or application runs on end users. By adding cloud to internet all the computation which was done in end users devices now is done in clouds and a cloud could give a software as a service to it's users who want to access. Using cloud facilities for processing the requests by physical instruments of cloud cause clouds giving also platform as a service to their users. Providing infrastructure means clouds give a flexibility to users all over a cloud to add, eliminate or switch from one service or application and access to other programs and services on other clouds.

One of the main concepts of cloud computing is providing almost unlimited resources for a given service, automatically and dynamically. To provide those resources, the complete cloud computing architecture must be built with efficient tools and support business continuity throughout its compute, network, and storage resources. In all of these procedures data is the main concern and data centers should have the ability to guarantee flexibility and performance of cloud infrastructures. Business resilience and data Recovery are core capabilities of the data center IT infrastructure. The emergence of cloud computing has further highlighted the need for extremely robust network resilience strategies that address security, availability, and virtual machine mobility while maintaining the flexibility and agility of a cloud model (Papagianni et al. 2013).

The challenges of supporting business continuity in a cloud environment are not limited to a physical area or data center. The elasticity and flexibility of the network architecture must be addressed as well. Therefore, the compute, storage, and network components used for cloud computing may not reside in the same physical location. These resources could be spread over multiple locations and interconnected using a

transparent transport mechanism that maintains security and end-to-end segmentation.

3.1 Purpose

In this chapter we are trying to give some information about current situation of data centers in cloud computing infrastructures and discuss about problem which today's big amount of data make in cloud computing. Giving some background about central data centers and disadvantages they cause in clouds is another purpose of this section. Actually disadvantages of central data centers make researchers to think about ways, which could give better quality of services. Distributed data centers are result of concerns about data center performance of internet service provider. We will discuss how distributed data centers or nano data centers could manage requests response with better performance like low latency or less cost. In other mean, this part describes the process and components required to connect the network, storage, and compute resources in distributed data centers instead of central data center for cloud computing.

3.2 Contemporary Data Centers and Their Problems

We all know most the applications, software and platforms are extended in just few previous decades. With huge amount of data, data center lack the quality of services and make a need to innovate new technologies for managing data in large size. This situation results in center being unable to meet today's needs. With all these reasons we need new technology to help us managing data in huge amount. A new approach to data centers in could need to qualify for high amount of demand in computation and storage.

3.3 Inefficiency of Current Data Centers and Improvement Ideas.

Cloud and virtualization has become crucial for the modern data center as new technologies need improvements in density, efficiency and management. There is

clear growth in both virtualization and cloud services all over the world (Mi et al. 2010). In fact, a recent reports, cloud computing will become the bulk of new IT spending by 2016.

In the world, cloud services revenue is projected to have a five-year projected compound annual growth rate across all segments of the cloud computing market. Segments such as Software as a Service (SaaS) and Infrastructure as a Service (IaaS) have even higher projected growth rates (Hou et al. 2010). Cloud computing continues to grow at rates much higher than IT spending generally. Growth in cloud services is being driven by new IT computing scenarios being deployed using cloud models, as well as the migration of traditional IT services to cloud service alternatives (Hou et al. 2010).

With so much new cloud data traversing the data center and the increased number of users utilizing cloud services, what will the next-generation data center resemble is an important question.

The software-defined data center: Think of this as the logical layer within the data center. Security, storage, networking and even the data center now incorporate the software-defined technologies realm. This logical layer allows for even greater control of both physical and virtual resources. In this layer solid platforms help control many new aspects of cloud computing and the next-generation data center. Multi-layered data center control: The data center is hosting a number of different systems. With that in mind, the control layer must be extremely diversified. This management console now integrates into APIs to span an ever-growing data center footprint. New integrations allow for big data control, data manipulation, and even resource allocation. The networking component allows administrators to do some pretty amazing things with their cloud model. Now, with direct integration with OpenFlow, NDC allows for greater levels of multi-tenancy and cloud scaling by adopting various software-defined networking technologies (Buyya et al. 2014).

The data center operating systems: The spanning data center needs a spanning

Control layer. Already, global data center providers are deploying data center operating control layers which manage policies, resources, users, VMs, and much more. Most of all, you're creating a proactive management infrastructure capable of greater scale. For example, IO and their IO.OS environment helps control many of the absolutely critical components – from chip to chiller. The great part is that this layer has visibility into every critical aspect that a data center has to present.

Infrastructure agnosticism. To be completely honest, the future data center will not care which hypervisor, storage layer, or server platform is running. Layered management tools will be able to pool resources intelligently and present them to workloads. This type of infrastructure and data center agnosticism will allow administrators to scale better and create more powerful cloud platforms. By connecting with major control plains and interfacing with solid APIs, the cloud computing concept and everything beneath it can be better abstracted (Laoutaris et al. 2008). Data center automation (and robotics): The next-generation data center will revolve around better workflow orchestration and automation services. Resources will be provisioned and de-provisioned dynamically, users will be load-balanced intelligently, and administrators will be able to focus on providing even greater levels of efficiency. Know what else the next-gen data center might have more of Robotics. Big robotics makers are already developing smaller, smarter and much faster robotics. (Kliazovich et al. 2010).

There's really no question that data center technologies are quickly progressing. New ways to integrate at the API layer, improved methods of optimization, and overall density are all impacting data center platforms. It doesn't stop here though. Trends show that more users are utilizing IT consumerization to process even more through the cloud. This means that data centers will have to evolve even more. Our NDC try to reach some of advantages which next generation of data center should have.

3.4 Difficulties and Challenges in Central Data Center Management

The rapid progress of applications, software, platforms and various technologies through cloud computing over more than a decade make data center to enter a new

generation. With this improvement current traditional data center which works in central mode encounter with different challenges including below:

- By taking advantages of central data center of existing systems innovate new architecture and topology to be adapted with new worlds demands to supply all various industry.
- As a new and unexamined replacement of data center carry the risk in high level. Problems which could be faced like: high cost of replacement, high energy consumption, rate of latency in response time, capable of adopting with other technologies or platform and resource utilization.
- The latency of requests response is another important element we have to consider during data center progress. Because every function, account and deployment has it's boundaries and constraint, data center construction should be supply all of the limits of application. As distance between users and processors is dominant reason of latency new replacement should decrease this distance between physical resources. (Buyya et al. 2009).
- The difficulty of way of communication between users and other processors cause inflexibility and reduce scalability. Central data center which used in today's cloud computing application and infrastructures has such kind disadvantages which should be eliminate in new replacements (Sravan et al. 2011).
- With considering above items we conclude, internet service provider and everybody who involved should consider new generation of data center in a way they could support new and future needs in a better way and their operation be adaptable when extension of technologies happen in networks. Solution for more than two end user should be as simple as when two end user contact point to point. By growing internet infrastructure users going to be distributed every day more than before all around the different

places in geographical places all around the world. The novel data center have to be transparency and able to have new parts if the users or provider later want to insert or remove some extra capabilities to it, in the cloud to provide additional compute resources without changing the existing interfaces and regardless of the status of the other connections (He et al. 2009).

All existing opportunities for data centers should be transferred in to cloud networking procedures. Clouds traffic should be controlled in a way could use better configuration of various properties like bandwidth. The applications has not an ability to migrate among physical instruments and be used by different platform even in their local environments or virtual machines. These disadvantages makes trouble when we have traffic or software extend during improvement, specially we have different users in different geographical places around the world or outside the local boundary when distance becomes more than physical instruments support.

3.5 Nano Data Centers

In fact the quality of a data center could be as good as it's constructor. Some body adjust it's properties, location place of it and the algorithm responses the requests of user bases. Great cables, good networks, power distribution units, cooling equipment and all other physical instrument only could affect the data center performance that, an internet service provider know how data center should be construct in a special environment.

In NDCs case, if we realize the performance of NDCs we can look to the subject in a way that everybody knows. In today's modern century every internet consumer has multiple entertainment devices. Laptops, gateways, computers, TVs, set-top boxes and tablets. All of these equipments keeping on producing data in every second and CDCs cause lack of management, too much complexity and no quality guarantee (Valancius et al. 2009). Current Data centers have trouble managing providers. It's important that proper planning and communication take place and everyone works together and gets you what you need.

Internet-based service delivered over the top is energy inefficient and makes content quality hard to control and personalize. Services delivered by cloud limit the way consumers could manage services in quality leading to an inferior overall experience. In this point NDCs use the power of the crowd to deliver services in a managed peer to peer the local environment gateway which is always on and could become the center of the home digital life. In contrast with CDCs, NDCs in home gateways could become a service hosting device and manage the quality of experience and allow flexible service portfolio deployment. In all NDCs architecture could save energy consumption compared to internet-based delivery into eliminates most set top boxes in home. Imagine by NDCs all remote in a special environment replaced by a single tablet. By this topology we could check the quality of services in data center while performing another action. With NDCs consumers could enjoy better viewing experience by receiving content from neighbour's gateway. So with NDCs new advantages could be reached. Advantages include quick startup delay, robustness to failure and high quality.

Focusing on user experience, NDCs could provide user-centric services. For example, roaming users can enjoy excellent services when using applications. In NDCs, integrated service automation with the intelligent network channel ensure the quality of service and provide stable services. Also, using different kinds of data separation deployment mode and data recovery system ensure the reliability and sustainability of the data center. Uses optimal resource scheduling and deployment as a target, is another advantage of NDC. Integrates dispersed computing, storage, and network physical and virtual resources to construct a unified and logical cloud resource pool, make NDCs to maximizing resource reuse rates. NDCs, implement proper service deployment, sends intelligent and unified resource requests, and performs scheduling across nodes, thereby achieving the maximum energy efficiency ratio. Supports multiple flexible and efficient resource management modes, including direct service release modes, such as the hosting mode and indirect service modes, are other NDCs abilities. All in all, NDCs could be a good replacement for CDCs because, there are high requirements for CDCs due to new economic and environmental constraints on services. The goal of the NDCs, as a good replacement of CDCs, is to consolidate

traditional data center, introduce innovative technologies, maintain existing services, and exploit new opportunities.

4. SIMULATION ENVIRONMENT

In contrast with traditional data centers that provide services for a large variety of consumers, NDC supply just local consumers. Since cloud computing developed with the aim to serve as needed, equipment in cloud based infrastructure, should have enough facilities to resolve the requests they take and this may cause data centers and virtual machines over provision. In all, Disadvantages of traditional data centers include majorly three factors (Valancius et al. 2009): 1) over-provisioning, 2) height cost of heat dissipation and 3) increased distance to endusers. In this paper we show how NDC could overcome these three factors in best. Actually our aim is to find a threshold could guarantee privilege of NDC in comparison of CDC, while NDC get maximum proficiency. We simulate the performance of traditional DCs and Nano ones (Wickremasinghe et al.2010). We use Cloud Analyst simulator in Java with Intel Core i7-3537U-2.0GHz. During the paper we show response time and performance costs in both traditional and NDC, and compare them to prove that NDC works more better than the current CDC and reach the saturation points in which NDC give their best QoS. We show results as performance cost and response time in charts.

4.1 Cloud Analyst Simulator

Cloud Analyst simulator (CA) have written in java (Buyya et al. 2009). CA built on Cloudsim, which is a toolkit for modeling and simulation of cloud computing environment and evaluation of resource provisioning algorithms and studying the data center's response time patterns (Wickremasinghe et al. 2010). In CA whole worlds considered as 6 different regions. These regions could hosts data centers and user bases. For studying the traditional data centers as CDC, we define a data center in central region and distribute users in all

around regions but for NDC we define one data center for every user. The topology of CDCs in our simulator, model the configuration of CDCs in real world. We put a data center in central region of simulator for investigate CDCs performance, because



Figure 4.1: Cloud Analyst Regions.

current central data centers receive tasks from lots of consumer and different machines all over their environment, so by placing a CDC in central region we try to force that data center to get task from all user bases in all regions around to act like real central data centers. For modeling NDCs, we try to put users in shortest distance, by placing them in the same region as a NDC data center is in. NDC could communicate peer to peer to get their required data instead they send their requests via internet to the servers and waste lots of time and energy during their transfer.

4.2 Peer to Peer Communication in Nano Data Center

P2P is some kinds of contradiction with client/server communication. Although users or computers in client/server have a singular role of client or a server, in P2P every user could be as a server or client. A server share its resources with all other client users. This server is central in client/server model, however its in decentralized in P2P. In fact all user could share their resources with each other and even could do their client or server role simultaneously.

P2P affect internet traffic by its specific way of managing the requests from users. For example in P2P many request could be responded in parallel. Most P2P programs are beneficial on media sharing. P2P communication has some disadvantages which it

violate application privacy and copyright, because peer to peer communication could give permission to users to rule many setting of one procedure. In P2P many users could send request to access one application or software Simultaneously, in this situation and end user could refuse to give access to an special software but sometimes end users have little safety and other user in another side could control the permission and easily access what it want. But totally P2P improve music and movie industry profits and changed how people thought about acquiring and consuming media.

Our NDCs work by simply crawling peer-to-peer file sharing networks and gathering information about who is uploading and downloading files, similar to the way a search engine navigates the Web. These are the same techniques the distributed data center use. There is no harm in running your corporate IP addresses through a NDC to see what information related to P2P activity it might uncover. However, if your IP addresses appear in the local database, you probably already know about it.

Among customer demands in internet, video sharing is pervasive. Most companies lack capabilities for business collaboration, either internally or externally with business partners. That's rapidly changing. NDCs based on data gathered from more than their local end-user organizations, found that more than half CDCs, already have an enterprise platform for video capture and streaming.



Figure 4.2: Peer to Peer Communication in Nano Data Center (Url-1).

With this simulator we could change different data center’s configurations and user bases properties. Figure 4.1 shows regions distribution in Cloud Analyst simulator. UB1 near R2 shows we have one user in region 2 and DC1 close to R0 shows there is one data center in region 0. We show the result of our investigation for different configuration of data centers and user bases. By these results we can determine which configuration make NDC work better. Results are in forms of the response time in millisecond and performance cost. In Table1 there are the characteristics of our CDC. These characteristics are default in our cloud analyst simulator. In fact these values are the average amount of specification we need in our data centers totally (Zhang et al. 2010). Below amount are the average values which guarantee satisfying quality of services in a normal size data center with small task of video demand or such kind of tasks (Qusterhout et al. 2011), (Ahmed et al. 2014).

Table 4.1: Properties of CDC.

Central Data Center	
Band Width(Mb/s)	1000000
Memory Capacity(Mb)	204800
Processor Speed(MHz)	10000

5. SIMULATION RESULTS AND EVALUATION

For next step at first we consider bandwidth fluctuation. As shown in Figure 5-1, we consider bandwidth between 1Mbps and 25Mbps and in all examination with different bandwidth our nano data centers has 1 GB memory capacity and 1G GHZ of processor speed. As we expected, by increasing the bandwidth amount response time decreases. We can see behavior of the lines almost are linearly and the same for all sizes of bandwidth. Also we can see when the number of user bases exceeds the 100, response time going to stay constant near the 50 ml second. This happening has different reason, one of them is, by increasing amount of bandwidth requests get an opportunity to pass , paths faster and other reason is by increasing number of user bases, every local nano data center obtain a chance to send it's requests to other nano data centers in neighborhood, so NDCs could process more requests in less time.

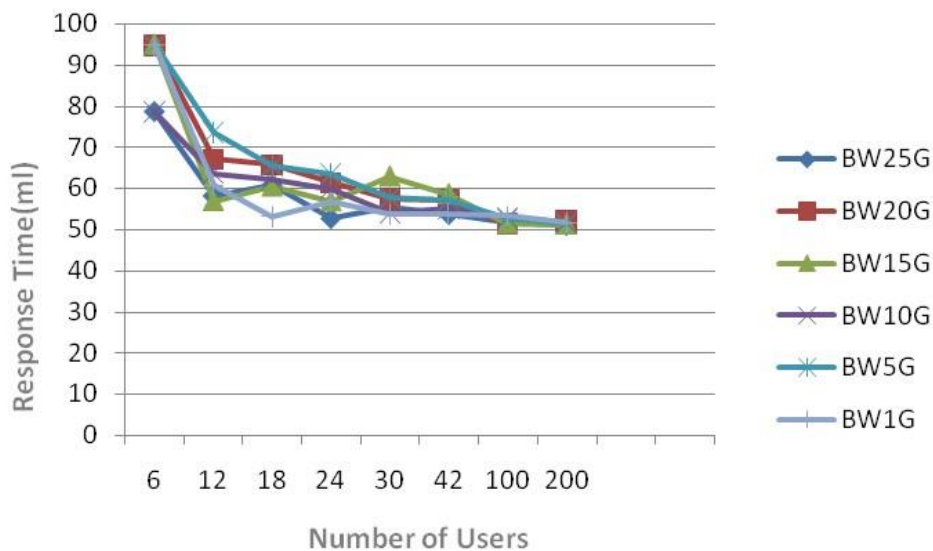


Figure 5.1: NDC Bandwidth effect on response times.

Figure 5.2 demonstrates pattern of response time when we change the amounts of processor speed. The amounts interval is between 2 and 6 GHz and we have 1G of memory capacity and 1000Mbps of bandwidth in all cases. Although response time for different amounts of processor speed at first act differently but as the number of

user bases increase it goes to be constant again near 50 ml second. So based on our purpose, like: network structure or the number of user bases; we could select the bandwidth size. Then we start investigate the memory changes effects on response time behaviour. While memory capacity changes, processor speed has 1GHz and bandwidth amount is 1000Mbs.

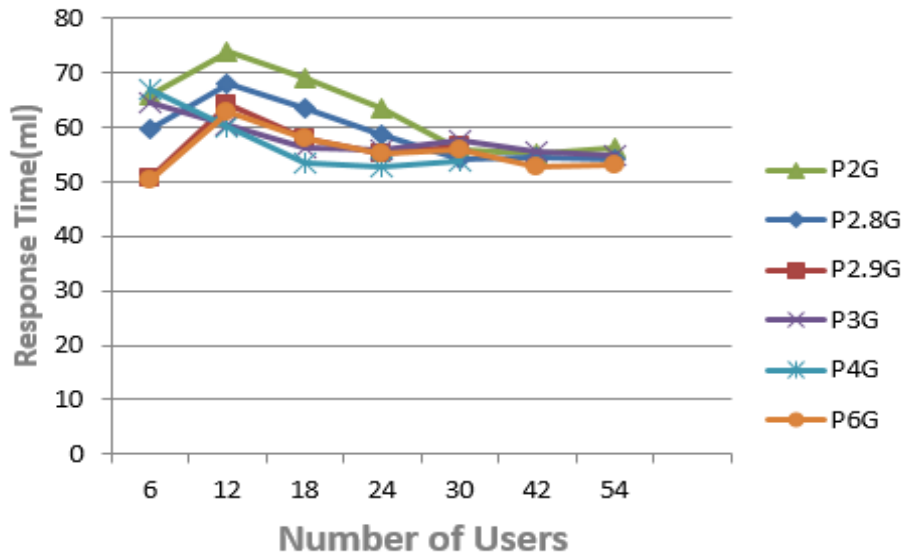


Figure 5.2: NDC Processor speed effect on response times.

We can see from Figure 5.3, after we increase NDC’s memory storage capacity more than 1 GB, response time show the constant behaviour, with 50 mls value. It means, with this threshold we will have no concern about response time fluctuations and guarantee the average response time for consumer whose their data centers has this amount of memory capacity in their local data center. In other mean with help of these results we can design local Data center that provides lower response time. Also, inform us, assigning more than 1GB of memory capacity has no benefit for nano data center performance because it will not affect response time in a good way, so increasing amount of memory is useless.

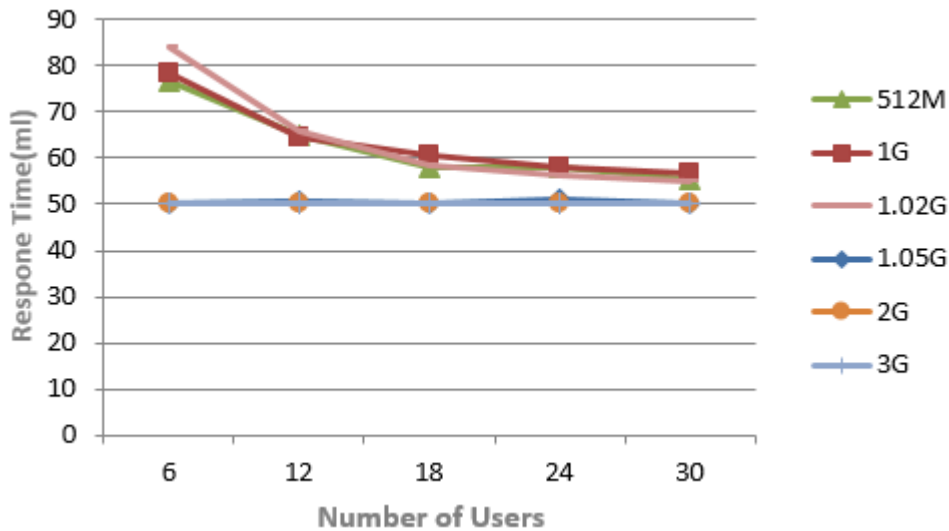


Figure 5.3: NDC memory storage effect on response times.

5.1.1 Worst Case of Response Time in Central data Centers and Nano Data centers

Up to this point we examine bandwidth, processor speed and memory capacity that are the most important properties in data centers. For demonstrating how the behavior of distributed NDC and central ones are different, we collect the maximum response time value in NDC and CDC for all three properties that we have examined for different user bases in Table 5.1. In this way we can see the difference between NDC and CDC response times. As we can see there is a significant difference between response time values of NDC and CDC.

For CDCs the worst amount of response time is, almost near 300 millisecond, but as you can see for NDCs is, 95 millisecond is the highest case. The difference is more than 200 ml second and it is really much. For example consider when one customer demand is video, what a better quality he or she could have with this amount of difference in response time. Any other request from data centers could affect by using NDCs in cloud infrastructure application and all this make we consent, NDCs are really good replacement of current central data center. In current internet application, when a request has sent via internet it should pass a long path to deliver to a server, but because servers are in different geographical places in the world, the time long one request back and forth takes lot and also cost much.

Table 5.1: Comparison of CDC and NDC Response Times.

# of Users	CDC Response Time	NaDa Band width	NaDa Mem. Cap.	NaDa Proc. Speed
		Worst Case Response Time		
6	309.89	94.86	84	65.8
18	308.36	65.5	58.38	69.01
30	308.68	57.72	54.96	55.7
100	307.95	51.52	50.42	52.49
500	309.01	50.98	50.12	50.23

This table show obviously how NDCs could be a good replacement for CDCs. We see even for every number of user bases NDCs act in a better way. If we look to the table more precisely we will see number of user bases is an important factor for construct a replacement. However in all cases our NDCs work better than CDCs, but there are also distance between NDCs response times in different cases. For example in bandwidth properties, for 6 number of user bases we have response time near 95 ml second and this amount decrease when we have 500 user bases.

Paying attention to use NDCs for how many of user bases could be very beneficial, because as you can see NDC have different performance for various number of user bases. If somebody, for example internet service developer or everybody who may concern about data center performance, want to replace a CDC with our NDCs and almost 40 ml second could be important for her or him, so he/she should consider the NDC for more than 6 user bases because as you can see in the table there is difference between response time of 6 user bases and all other number of user bases which are more than 6. This difference is not even for one properties but for all of characteristics which we investigate in this research, so it shows maybe our NDC have better performance for more than 6 number of user bases.

Consider the situation which you have boundary on your processor speed and you can assign all other properties like memory capacity and bandwidth as much as it be

needed in the new topology which is a replacement for previous central topologies.

In this case maybe you can allocate NDC for any number of user bases you want, because based on table 5.1 there is not much distance between all of number of user bases. Among three different properties, bandwidth has a biggest distance in response time for more than 6 number of user bases, but even if we want to have a NDC for 6 user bases, because today's bandwidth are cheaper so we can increase bandwidth if instead of increasing number of user bases.

Majority part of the problems we are encountered in today's network, is result of latency in internet infrastructure like data center, servers or maybe application and software. Lack of management cause performance latency. With current topologies and construction, internet service provider could not satisfy user's request. In addition cost of going back and forth of requests from every end user to processors , servers or data center is high, so today's world need some management ,which decrease cost and latency in a impressive level till demands like video request reach their end users in minimum time and cost. For this goal new technologies should eliminate extra and unnecessary path which will increase quality of services. We try to solve such kind of problems in this research by suggesting NDCs.

Although we think latency of request response could be diminish by increasing amount of bandwidth but packets queue, where packets of data delayed in internet is dominant reason of latency. There are lots of effort to extend bandwidth capacity with more powerful cables, but we should pay attention to the issue that increasing bandwidth singularly could not solve latency and performance problems, unless management lacks be considered. By traffic growth during the everyday via internet service customers or data producers, we should have a network could supply huge users and their requests and also data has made. New technologies should be scalable and include algorithms to manage huge amount of data. We could not build infinite bandwidth like everywhere. It will need high rate of costs, time lots of aspect to be considered during construction of new adjustment. Service provider involve to extend new technologies based on cloud till could reach better

performance with least of challenges. Nevertheless, virtualization and mobile network could support needs in a good level and make, but those could not satisfy scalability. Even if we look at one customer data production rate, we will facing with a linear chart statistically but again rising amount of data in internet totally could not be realized. All in all, with todays of technologies worries about bandwidth amount could be order in last of matter of worries.

NDC could be one of those new technology which have ability to satisfy today's huge internet world demand and solve the problems we have expressed till here. Improvement in architecture and technical effort in network between contents and application provider to make better quality of services has high priority for data management. Novel solution for ordering different properties of internet facilities like bandwidth for customer and other service provider are other important subjects which need to be considered carefully. Separating software and hardware dependencies in all new born technologies should be applied, because in todays world users in all around the world need to access their requests in minimum time and cost so if request response be corresponded to physical facilities, quality of services will decrease and we try to adjust our NDCs characteristic based on all these issues.

5.1.2 Comparison of NDCs and NDCs with Memory Capacity Proportion

Between the characteristic we have checked, memory capacity has some kind of exception; because after a point response time become a horizontal line for all different number of user bases. These all lead us to consider the memory capacity proportion of traditional data center on our NDC, till we explore more precisely point of memory storage value which NDC gain their best performance and could be substitute with traditional data centers in best way. Maybe proportion comparison could help more, because the central datacenter which will be replaced with NDC could have different memory storage amount in different places, depends on network structures or some other parameters.

Actually, In this case using proportional value has lots of advantages, because the majority of qualifying analysts state that the proportional analyst is the most

appropriate kind of data interpretation system for stimulating results features which have no alternative. The main advantage of proportional is that we can rely to our results in a way that they will be independent from individual cases and easily and quickly compute the amount of our goal. But this time we pay attention to the performance cost values, because we knew how response time fluctuations act, based on Figure 5.3.

Figure 5.4 presents performance cost pattern of NDC memory capacity on CDC memory capacity. There may be other interpretations for this chart; for example for different number of user bases after almost 0.04 point, we see horizontal constant response time. In deed for one CDC substitution we could consider the NDC with memory capacity that make this proportion, till NDC get the best quality and service. Another amassing thing in Figure 5.4 is, lines are close to each other after number of user bases increase more than 20, and this shows, as the numbers of NDC consumer increase, response time going to be close to each other and it could give us more opportunity to choose the user base number to ascribe local data center as a NDC.

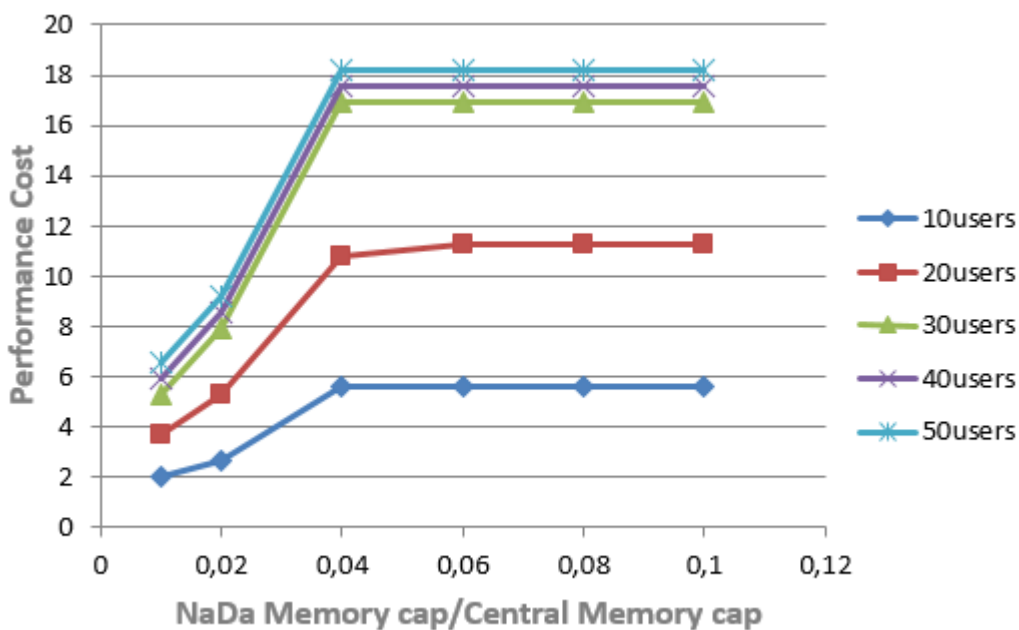


Figure 5.4: The effect of memory capacity ratio on performance cost with respect to small number of users.

In Figure 5.4 we consider 640 GB for our central data center until, being sure that the 0.04 points for memory proportion is a correct point. For guarantee our results we repeat investigation with more number of user bases. We increase number to 1800 users, although this amount maybe be extra for a NDC, but in comparison with millions customer who send requests to traditional data centers could considered as a normal number. You can find consequences in figure 5.4. We can see again lines go to be horizontal after some point. However this point descent to lower point of 0.02 but again proportion of 0.04 is a common point with lower number of user bases. Based on the need like application which is used by users, internet topology, geographical position or other limits which internet service provider facing like low space for saving or even taking back up for their data could use 0.02 amount of proportion, but if want to unanimous on one common point among all various user bases number, Actually 0.04 is that independent point for NDC. It is important to mention, in this case we allocate 640 Mb of memory capacity for central data center and apparently NDCs memory capacity's proportion is based on this value.

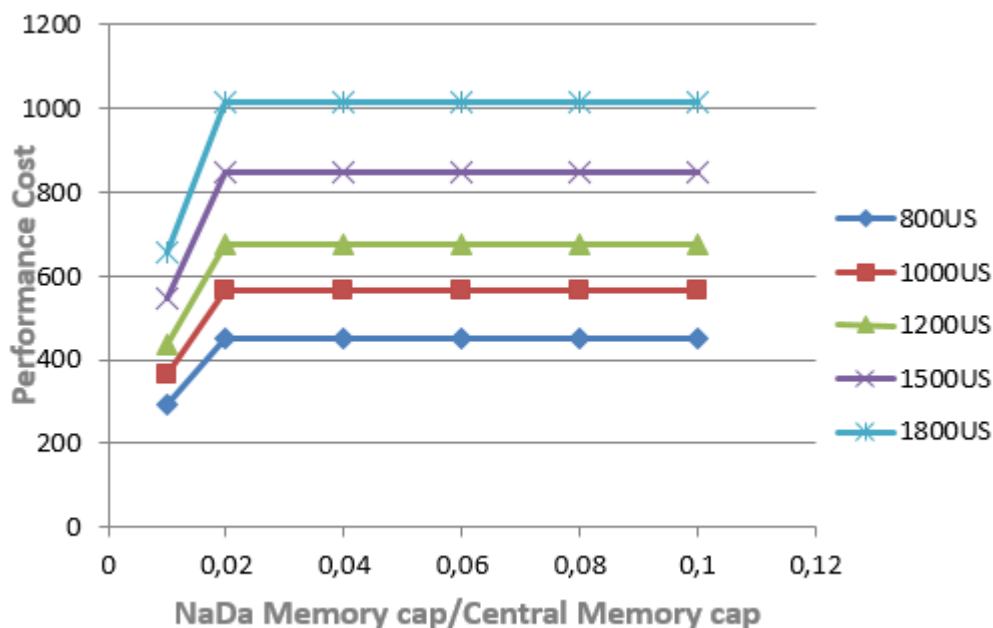


Figure 5.5: The effect of memory capacity ratio on performance cost with respect to big number of users.

Because the examination with upper number of user bases have a starting point of different amount with lower number of user base, we prefer to repeat the

simulation with different central data center. This time we consider 6400 Mb memory capacity for CDC. Figure 5.7 shows the results. The lines have interesting behaviour just like the behaviour of previous case which CDC have 640 Mb of memory capacity and again 0.04 point show a threshold for NDCs. In CDC with 10 times of memory capacity and NDCs with different proportion of this amount again we reach the same threshold. This guarantee the behaviour of our NDCs in different case.

Hence for both data center with 640 Mb and 6400 Mb NDCs with 0.04 proportion, which in first case have 2560 Mb and in second case have 25600 Mb and all more amount of memory capacity will have the same performance cost and this let us to adjust a new distributed topology of data center with determined amount of memory capacity values. The other data center configurations are available in table 5.2. Again I want to mention if we have boundary on allocating memory capacity in our environment and for example 0.04 proportion is expensive or unavailable, instead of considering this amount of memory capacity we can negotiate with other characteristics to reach better QoS. Negotiation could be like use more bandwidth or processor speed or even change the number of user bases. All of mentioned changes is explained in this research and ISP and anybody who may Concern could use our thresholds to construct better data center topology. Look at our comparison in figure 5.9, which performance cost and response time of different number of user bases combine on one chart to give a better view to users, so based on aims people could do some negotiation between response time and performance cost.

Table 5.2: Basic Configuration of CDCs & NDCs in Memory Capacity Proportional Investigation

	CDC	NDC
Total Proc Speed of Each DC	10000	1000
BW	1T	1G
Total Ram of Each DC	640/6400 Mb	changing
Req Per Hour	60	60

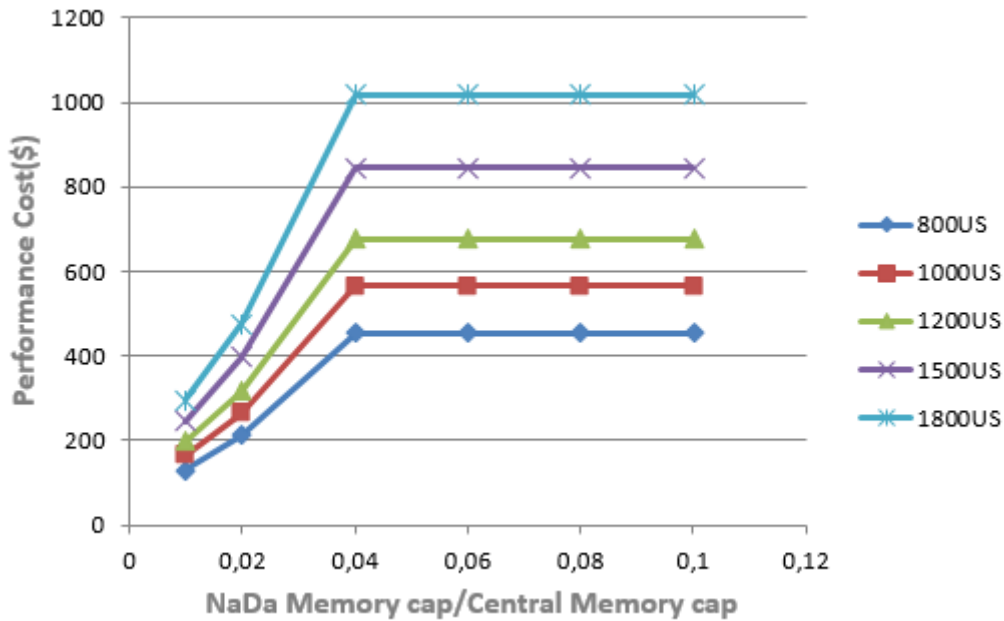


Figure 5.6: The effect of memory capacity ratio on performance cost with respect to small number of users.

5.1.3 Data Size in NDCs and NDCs

Data size is another important factor that affect data center performance drastically. Hence we choose data packet size for our next investigation. We start to verify the effect of transferring data in different size between user bases and data centers in different CDC and NDC, so we consider three different data packet size fro CDC and NDC. You can see other properties of CDC and NDC in table 5-3.

Table 5-3: Basic Configuration of CDCs & NDCs in Different Data Packet Sizes Investigation.

Basic Configuration		
	CDC	NDC
Total Ram of Each DC	200G	1000M
Total Proc Speed of Each DC	10000	1000
Number of Users	changing	changing
Req Per Hour	60	60
Data Size	changing	changing
BW	1T	1G

Figure 5.7 shows average response time of CDC and NDC. As we can see in the chart, for all three, 0.5, 1 and 1.5 MB data packet sizes, response time has less amount for NDC in comparison with CDC. Although, NDCs' response time has smaller amount than CDC, but we except performance cost be more for NDCs.

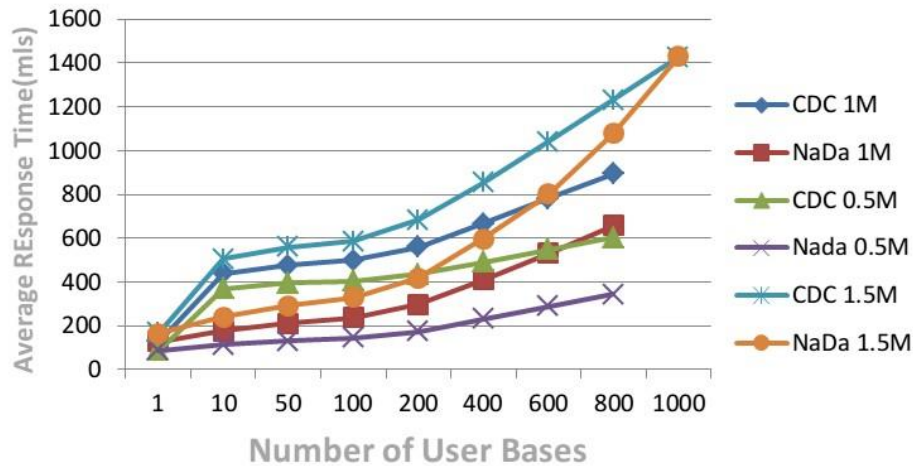


Figure 5.7: NDC and CDC Response Times for Different Data Sizes.

So we start check it, and surprisingly we realize performance cost of all CDCs and NDCs have the same amount for different data packet sizes. Our results in this part is very important, because there are previous research which shows distributed data centers have higher cost in comparison with central ones. They believe in because in distributed data centers, every adjustments or any other related work like: data recovery, security management, taking backup and many others have to be done in multiple times, NDCs could not be affordable as a replacement for CDCs. But as you can see based on our results in figure 5.8, distributed data centers have the same cost with central ones. We distribute data centers in different geographical places, in cloud network infrastructures, and they communicate in peer to peer form, to could simulate a real topology. By considering all these situations again we get same performance cost for NDCs and CDCs. It is an important consequences because, it is a contravention with some previous researches which exist in literature, so our research is a good prove of NDCs privileges.

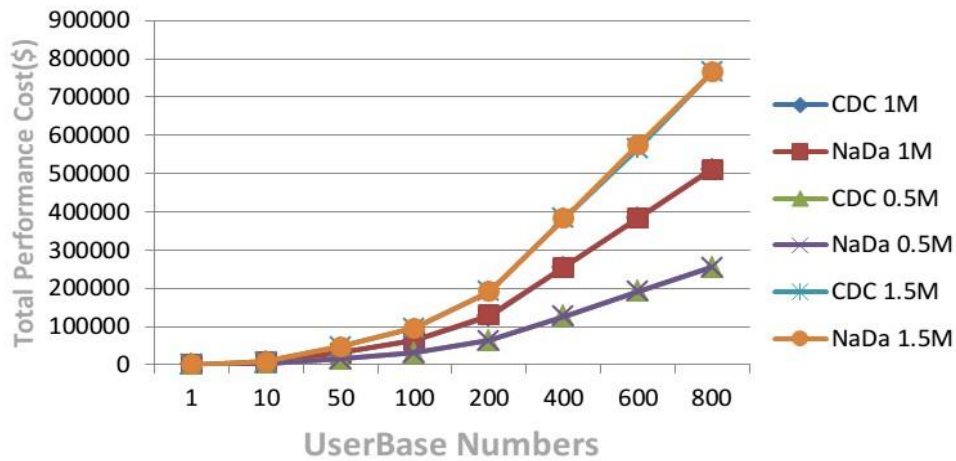


Figure 5.8: NDC and CDC Performance Cost with Different Data Sizes.

When we consider both figure 5.7 and 5.8, we realize, in all three cases with different data packet sizes, NDC have better proficiency than, the CDC. Less response time with equal performance cost really satisfying to substitute NDC with current traditional central ones. Finally for having the better perspective of how our research could help construct the NDC for replacing with CDC, we put the results of performance cost and average response time in one chart together, till we could have better comparison. Because user bases number and memory capacity both are important properties, our combination done with these two characteristic. At Figure 5.9 and Figure 5.10 we have results of them, respectively. As we can see for 1.5MB data packet sizes, response time line and cost line intersect with each other at one point which belong to 300 number of user bases, so based on our aim, if less response time is more important for us or less performance cost is determinative, we could replace a CDC with nano one for apparent number of user bases we reach in our charts and get best proficiency. In Figure 5.10, we repeat the combination with performance cost and response time vs. the proportion of memory capacity of nano data center on memory capacity of CDC for 50 user bases. The intersection of response time and performance cost happen at 0.02 proportion amount. So we can decide about priority of less response time or performance cost and choose amount of nano data centers' memory capacity. For example, if we need to have less response response time in contrast with performance cost, NDCs memory capacity should

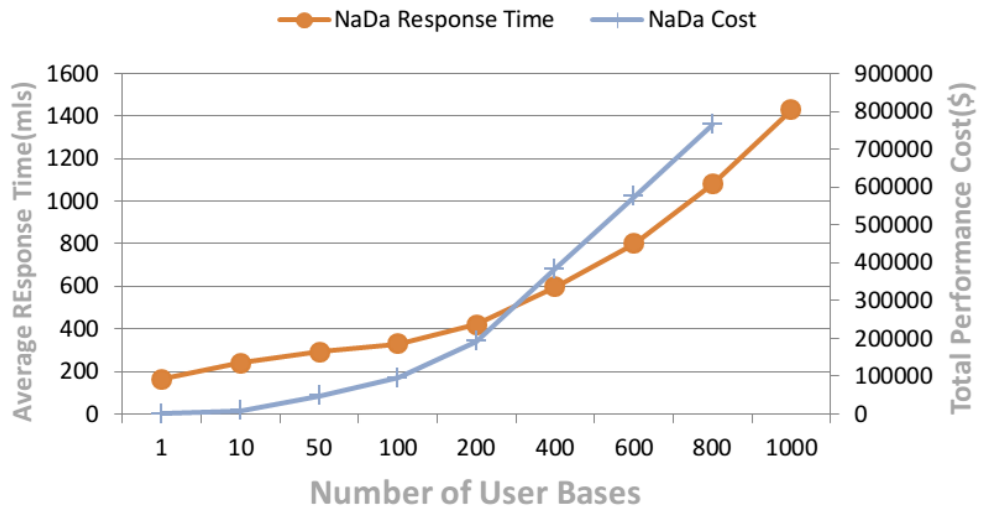


Figure 5.9: Average Response Time and Performance Cost vs. User Base Numbers

have 0.02 or less ratio of CDC memory capacity, because response time line is under the performance cost line after 0.02 ratio. In our studies we examine distributed data centers as nano data center to find the properties to construct

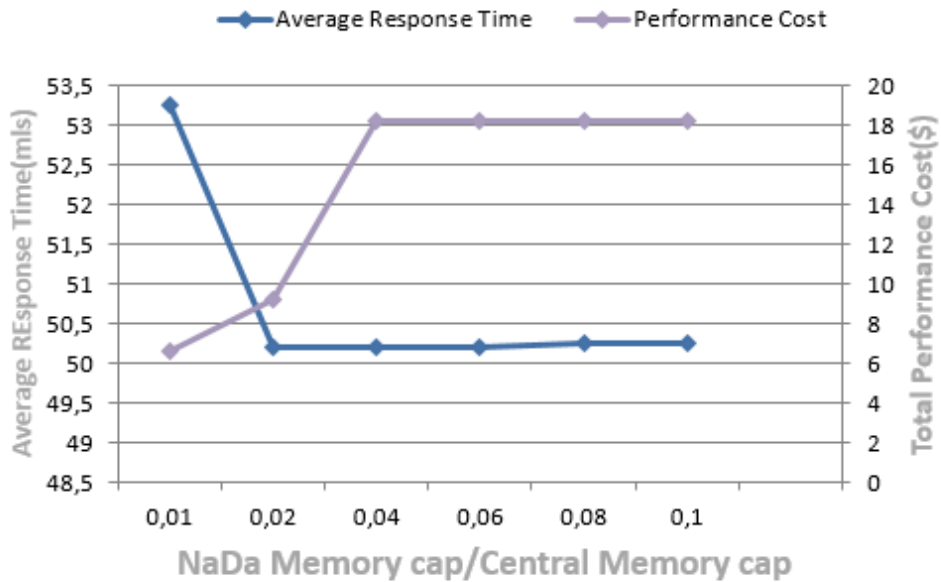


Figure 5.9: Average Response Time and Performance Cost vs. Memory Capacity Ratio.

nano data center as a good replacement for central data centers. We find response time and performance cost for different properties amounts like memory capacity, bandwidth, processor speed and user bases. For example our research shows for more than 1 Gigabyte memory capacity response time will not change. This approach could help people who concern with data centers performance to construct needed data center in a way they could reach maximum quality of services in different cloud architectures.

6. CONCLUSIONS AND FUTURE WORK

We demonstrate NDCs have better quality of services even in worst case. We reach threshold points for different properties of NDCs, include: memory capacity, bandwidth and processor speed. Our result shows 1GB of memory could mention as a threshold for this properties. 0.04 become a saturation point for NDCs memory proportion. In this research we reach 200 number of user bases and 0.02 ratio of NDCS' memory capacity as negotiation points for ascribing priority to response time or performance cost to decide which amount of memory or number of user bases could give us our intended aim. So, we show how NDC could have its maximum quality of services in these points. We also show Our NDCs performance while giving services to different number of user bases. In all of our simulations every NDC could ask services from any other NDC in it's neighborhood, in peer to peer form. We admit that our investigation do not reach a significant effect for processor speed and bandwidth. Although, 50ml second of response time obtained for different amount of these properties after some special values for both, of course, but because these values could not be applicable for real NDCs, hence we could not consider them as a saturation point.

Trying other ways of communication between neighbor data centers could be considered as a next level of performance investigation. In addition, our studies can be extended by using a real cloud based architecture for experiments. Searching ways of how our suggested NDCs could help the industry for more financial profit and improvement, also, could be another charming spark to use this approach. Web application providers could adopt their products based on our new thresholds for NDC till get better QoS and reach more profit. Our studies show that still there are gaps in cloud computing structures and shows we could prepare data centers in a distributed way. Our threshold can be used almost in all of the applications which implemented in internet. ISP Provider or who want to adjust the data centers characteristics could consider our work to reach the better

performance and QoS. The thresholds in this study give hints for adjusting the properties of the NDCs which will replace CDCs, till we could get maximum performance by having the minimum response time of task delivery or less performance cost. As still there are not any satisfactory results for processor speed and bandwidth amounts, experiment on increased number of DC or NDC to further analyze on the effect of BW and PS could be the subject of future researches. We can also, do more complicated analyses on cost effective of NDCs or repeat the same investigation with another simulators for more accuracy.

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PUBLICATIONS/PRESENTATIONS ON THE THESIS

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