Prospect of Reduction of the GreenHouse Gas Emission by ICT in Africa

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Abstract. In recent year, reducing global warming is becoming one of the most challenging research topics in Information and Communication Technologies (ICTs) because of the overwhelming utilization of electronic devices and of Petroleum products.

Current solutions mainly focus on energy efficiency for saving power consumption by virtual machine consolidation on one hand, and on the on the other hand, by minimization of the consumption of petroleum products through Teleservices. The latter that must be used via data center whose we try to reduce energy consumption.

In this paper, we propose a dynamic consolidation method of virtual machines (VMs) using the alive migration and the switching of nodes idle and allowing to the suppliers of Cloud to optimize the use of the resource and to reduce the energy consumption. Furthermore, we show how Teleservices can participate in the reduction of the emissions of greenhouse gases in Africa.

Keywords: Global warming · ICT · Petroleum products · Data center · Consolidation · Teleservices · Carbone dioxide · Virtual machine

1 Introduction

For several decades, the man has been at the origin of a vicious circle, having grave environmental consequences: the atmospheric pollution due to Green House Gas emissions (GHG) favours the degradation of lands, which, in his turn, stresses the phenomenon. Furthermore, nowadays, cloud computing has become a popular computing paradigm for hosting and delivering services over the Internet [1]. Indeed, the Cloud computing model leverages virtualization of computing resources, allowing customers to provision resources on-demand on a pay-as-you-go basis [3]. In a prospect of a reduction of the capital cost of IT infrastructures and computing software, the cloud seems necessary. The proliferation of Cloud computing has resulted in the establishment of large-scale data centers containing thousands of computing nodes and consuming enormous amounts of electrical energy. In this regard, power management in cloud data centers is becoming a crucial issue since it dominates the operational costs. Moreover, the power consumption in large-scale computer systems like clouds based on the trends from

R. Glitho et al. (Eds.): AFRICOMM 2015, LNICST 171, pp. 113–122, 2016.
DOI: 10.1007/978-3-319-43696-8_13

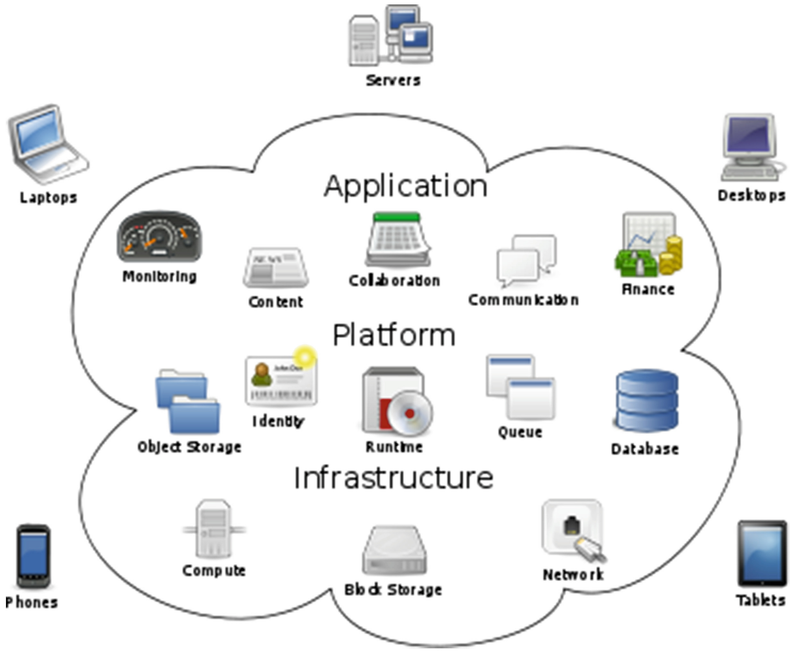

Fig. 1. Cloud computing model [14].

the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) [4], it has been estimated that by 2014 infrastructure and energy costs would contribute about 75 %, whereas ICTs would contribute just 25 % to the overall cost of operating a data center [5] (Fig. 1).

On one hand, the emergence of cloud computing has made a tremendous impact on the ICT's industry over the past few years, where large companies such as Amazon, Google, Salesforce, IBM, Microsoft, and Oracle have begun to establish new data centers for hosting cloud computing applications in various locations around the world in general and in particular in Africa, to provide redundancy and ensure reliability in case of site failures. On the other hand, Teleservices offer a solution in the reduction of the emissions of greenhouse gases, because allowing to limit the motorized movements which have the effect of increasing the atmospheric pollution.

In this paper, we are interested in a raising awareness in a usable of the Teleservices, which allows to reduce enormously CO_2 emissions in an African context or remains a means of not economic transportation in term of consumption of petroleum products. This solution does not cancel these emissions, that is why we suggest mutualizing the servers of the operator of telephony on one data centers. We also propose a solution of consolidation of the latter with the aim of reducing the energy consumption.

The remainder of this paper is organized as follows. Section 2 presents the related work. Section 3 gives an overview onto virtual machines consolidation principle. Section 4 shows our technical of reduction of energy consumption by consolidation algorithm's of data centers. Section 5 presents the impact of the Teleservices on greenhouse gas emissions. Section 6 concluded our study and presents our perspectives.

2 Related Work

Several issues about green ICT and energy reduction in modern cloud computing systems are receiving huge attention in the research community. Several other efforts have been made to build energy consumption models, develop energy-aware cost, manage workload fluctuation and try to achieve an efficient trade-off between system performance and energy cost. Furthermore, most of the research agrees that the main reason of the climate changes is the green house effect caused by Green House Gases where carbon dioxide is a key factor. It is a challenge that not only jeopardizes the sustainability of our planet; it poses significant, long-term threats to the global economy. Among the main power consumption industries, Information and Communication Technology (ICT), with its annual growing rate of 9 % [6], contributes approximately two per cent to the global GHG emissions, and this amount will almost double by 2020 [7]. One of the first works, in which power management has been applied in the context of virtualized data centers, has been done by Nathuji and Schwan [8]. The authors have proposed an architecture of a data center's resource management system where resource management is divided into local and global policies. At the local level the system leverages the guest OS's power management strategies. The global manager gets the information on the current resource allocation from the local managers and applies its policy to decide whether the VM placement needs to be adapted. However, the authors have not proposed a specific policy for automatic resource management at the global level. Kusic et al. [9] have defined the problem of power management in virtualized heterogeneous environments as a sequential optimization and addressed it using the Limited Lookahead Control (LLC). The objective is to maximize the resource provider's profit by minimizing both power consumption and SLA violation. Energy management techniques in cloud environments have also been investigated in the past few years. In [10] described how servers can be turned ON/OFF uses Dynamic Voltage/Frequency Scaling (DVFS) approach to adjust servers's power status. The power modelling techniques have been proposed by several authors. The power consumption model proposed by Buyya et al. [11] observed a correlation between the CPU energy utilization and the workload with time. Bohra et al. [12] also proposed a power consumption model that observed a correlation between the total system's power consumption and component utilization. The authors created a four-dimensional linear weighted power model for the total power consumption. The power modelling techniques for the physical infrastructure (power and cooling systems) in data centers, proposed by Pelley et al. [13]

is most relevant for us. They worked out first models which try to capture a data center at large.

Besides, the digital book represents only 6.4 % [14] of the sales of books in France and yet more weak in Africa today, a figure however in constant increase. Moving forward the argument of the dematerialization of cultural property, as in a time the MP3 was able to go out of fashion our CD, the digital book boasts of reducing the paper needs, and thus of helping in the fight against the deforestation. With the introduction of the Internet and the increasing amount of services are being provided electronically, eBooks and eReaders are gaining momentum and will significantly change the book industry [15]. Chowdhury [19] opines that the production and distribution costs of digital knowledge products are negligible compared to the environmental costs of production and distribution of printed knowledge products. Fat Knowledge [20] agrees with the above statement saying that the eBooks are better for the environment than their paper brethren and presumes that reading the physical version of the New York (NY) Times for a year uses 7,300 MJ of energy and emits 700 kg of CO_2 and reading it on a Kindle (digital version) uses 100 MJ of energy and emits 10 kg of CO_2 thereby reducing about 70 % of CO_2 emission. These figures clearly show that electronic media can be a safe and better alternative but the dark face of technology also needs to be understood as indicated by below mentioned studies.

In summary, we want to show that the frame of we consist in saying that ICT's deployment can have both a positive and negative impacts on GHG emissions. It may enable GHG emission reduction in a variety of sectors and through many different channels by playing a significant role in reducing the remaining 98 % in particular by enabling smart energy efficiency and providing a substitute for the physical transport of goods and people. But we must also face the challenge of using ICTs to help other industries such as paper-maker or cloud promoters's to realize greener objectives, whether self-imposed or externally regulated.

3 Virtual Machines Consolidation Principle

3.1 Consolidation's Aims

Consolidating disparate data centers into large scale shared premises logically reduces the net environmental impacts. But it is worthwhile to review the ways in which these benefits are realized in practice. Its purpose is:

- Reducing total infrastructure allocation,
- Leveraging multi tenancy,
- Maximizing utilization rates,
- Improving the data center efficiency.

3.2 Migration's Cost

Consolidation principle is associated with the virtual machine migration. In this section we apply competitive analysis [21] to analyze a sub-problem of the problem of energy and the performance service efficient dynamic consolidation of

VMs. There is a single physical server, or a host and M VMs assigned to this host. In this problem the time is discreet and can be divided into frames of time N, when frame every time is 1 s. It is calculated as $C_p t_p$, where C_p is the cost of power (i.e., energy per unit of time), and t p is a time period. The resource capacity of the host and resource usage by VMs are characterized by a single parameter, the CPU performance. The VMs experience dynamic workloads, which means that the CPU usage by a VM arbitrarily varies over time. The host is oversubscribed, i.e., if all the VMs request their maximum allowed CPU performance, the total CPU demand will exceed the capacity of the CPU. We define that when the demand of the CPU performance exceeds the available capacity, a violation of the SLAs (Service-Level Agreement) established between the resource provider and customers occurs. An SLA violation results in a penalty incurred by the provider, which is calculated as $C_v t_v$, where C_v is the cost of SLA violation per unit of time, and t_v is the time duration of the SLA violation. Without loss of generality, we can define $C_p = 1$ and $C_v = s$, where $s \in \mathbb{R}+$. This is equivalent to defining $C_p = 1/s$ and $C_v = 1$. At some point in time v, an SLA violation occurs and continues until N. In other words, due to the over-subscription and variability of the workload experienced by VMs, at the time v the overall demand for the CPU performance exceeds the available CPU capacity and does not decrease until N. It is assumed that according to the problem definition, a single VM can be migrated out from the host. This migration leads to a decrease of the demand for the CPU performance and makes it lower than the CPU capacity. We define n to be the stopping time, which is equal to the latest of either the end of the VM migration or the beginning of the SLA violation. A VM migration takes time T. During a migration an extra host is used to accommodate the VM being migrated, and therefore, the total energy consumed during a VM migration is $2C_pT$. The problem is to determine the time m when a VM migration should be initiated to minimize the total cost consisting of the energy cost and the cost caused by an SLA violation if it takes place. Let r be the remaining time since the beginning of the SLA violation, i.e., $r = n - v$.

4 Consolidation's Model of Data Centers

4.1 Approach's Model

In this section, we propose a new approach allowing to make a reliable strategy of consolidation in cluster of data centers. This approach uses a Poincaré disk model that is a unit's ray disk centred to origin, in which, we can consider an hyperbolic tree. We present here, the hyperbolic AntTree algorithm applied to hyperbolic plane that is based on the self assembly behaviour observed in certain species of ants, where the living structures are used as bridges or auxiliary structures to build the nest. In this model, we refer to points by using complex coordinates. We can find in the literature all the necessary information to understand the hyperbolic plane [2]. The structure is built by using an incremental process in which ants joint a fixed support or another ant for assembling. The Hyperbolic

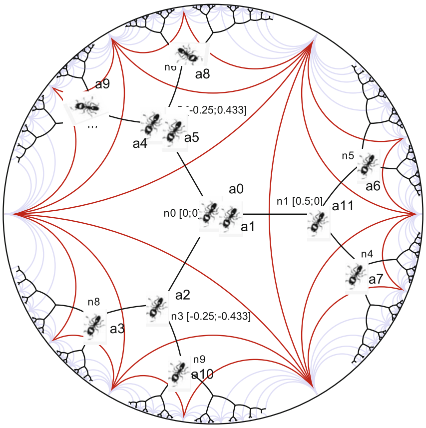

Fig. 2. Hyperbolic AntTree in Poincaré disk model.

AntTree builds a tree structure representing a hierarchical data organization which divides the whole of the data center. Each Ant represents a single datum from the data center and it moves in the structure according to its similarity to the other ants already connected to the tree under construction.

Each node with which we associate a virtual coordinates in the hyperbolic tree structure represents a set of Ants (Ants a4 and a5 is associated to node n2 in Fig. 2) and each ant represents a single datum of data center. The key aspect in AntTree is the decision about where each Ant will be connected to the data center.

Each ant with which we associate an identifier to be connected to the hyperbolic tree represents a datum to be classified. Starting from an artificial support called n0 (containing ants a0 and a1), all the ants will be incrementally connected either to that support or to other already connected ants. This process continues until all ants are connected to the structure, i.e., all data are already clustered. Each ant identifier's is used to compute the location in the hyperbolic tree [22].

4.2 Algorithm of Connection to the Tree

In Algorithm 1, we can consider a system of N data centers, hyperbolic AntTree degree is d and depth is p. Every resource is mapped in key of 256 bits then subdivided into r sub-keys of k bits. One sub-key randomly is chosen and used to determine a point on the edge of the circle of ray 1. Then the resource is stored in the closest data center to the point calculated according to [22].

4.3 Algorithm of Migration on the Tree

Resources migration's in hyperbolic tree uses a Greedy AntTree Colony Forwarding (GATCF) algorithm, the mechanism of which is described in the Algorithm 2.

Algorithm 1. Connection algorithm in hyperbolic AntTree

```
function CONNECTPROCESS(PrimeDataCenter AntDatum) return 0
    AntID ← AntDatum.GetID()
    Key ← Hash(AntID)
    for A doll r ∈ R_Circular
        d ← P_Max
        i ← 1
        SubKey[r] ← Randomly(Resource_Subkey(Key)[r])
        TgDataCentAddr[r] ← DataCenter_Addr(SubKey[r])
        TgDataCent ← GetTg(TgDatCentAd[r])
        if route(AntID, TgDataCent) then
            i++
            put(AntID, Datum)
        end if
        d−−
    end for
    return 0
end function
```

Thus, every dated center containing a resource to make migrate question the root data center (coordinates(0;0)) to find the data center of the destination towards where to send the resource. Afterward, every data center containing the resource estimates the smallest hyperbolic distance's [22] which separates his data center neighbour of data center destination and forwards it step by step to the destination as described the Algorithm 2.

Algorithm 2. Migration in hyperbolic AntTree.

```
function GETNEXTHOP(DataCenter, AntDatum) return DataCenter
    w = AntDatum.destinationDataCentCoords
    m = DataCent.Coords
    d_min = argcosh(1 + 2 |m−w|^2 / ((1−|m|^2)(1−|w|^2)))
    p_min = DataCenter
    for all neighbor ∈ DataCenter.Neighbors do
        n = neighbor.Coords
        d = argcosh(1 + 2 |n−w|^2 / ((1−|n|^2)(1−|w|^2)))
        if d < d_min then
            d_min = d
            p_min = neighbor
        end if
    end for
    return p_min
end function
```

5 Teleservices as Way of Reduction of the Global Warming

To know an enemy is essential to be able to face him. In the search to decrease the carbon footprint of the human activity he is before any necessity to know his importance.

Nowadays, advent of ICTs generally in the world and more particularly in Africa has allowed to reduce in a considerable way the time puts to realize certain activities as well as the average partners. Indeed, the development of Teleservices allows us to realize the payments of electricity bill among others without having to move and consequently without burning with any fuel which participates actively in the greenhouse gas emission. It is, for example important to note that one liter of gasoline, diesel frees respectively 2.28 kg and 2.67 kg of $\mathrm{CO_2}$ [17]. Besides, respectively 57 g and 7.6 g of CO_2 are emitted for 1 min of communication, respectively, for a USSD (Unstructured Supplementary Service Data) transaction's [16]. A study led in 2007 show that 2 % of the emission of CO_2 is attributable in ICTs against 40 % for petrol [18]. CO_2 emissions bound to Teleservices is thought of the main part side server (at the operator of telephony). Indeed, every query of call or USSD requires the execution of an energy-consuming process and consequently source of greenhouse gas emission. The study made in the Sect. 4 shows how we can reduce this consumption by the use of data to center that we could strengthen with the algorithm of hyperbolic AntTree. This study suits well in Africa, which has some more of solution of Teleservices to be developed to participate, so in the fight against the global warming.

6 Conclusion and Future Work

Our study allowed us of shown one of the contributions of ICTs in the reduction of greenhouse gas emissions. So, the use of Teleservices contributes to reduce the atmospheric pollution by petroleum products with one against unimportant part. Of more the use of data centers by the operators of telephony as well as the application of the solution of consolidation of the latter assure a low consumption of energy and participle at the same time to reduce the global warming. The African continent being emergent in general in term of presence of Teleservices, we say that the development of the latter are opportunity which is offered to reduce the vehicle movements which engenders a cost mattering regarding emission of CO_2. In ours future works, we plan to make an in-depth study on the statistics in term of presence of Teleservices in Africa and to proceed to a simulation of our algorithm of consolidation of data centers based on the hyperbolic AntTree.

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