AFAM: A Fair Allocation Model for Cloud-Datacenter Networks

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ABSTRACT

Cloud-**D**atacentere **N**etworks (CDNs) have rapidly emerged as a leading solution for almost every technological aspect of life. Indeed, the theme of Cloud Computing and its provided services can nowadays be considered as a fourth utility beside the traditional essential utilities of electricity, water, and gas. Putting such technology in the same basket with the aforementioned three utilities triggers the common challenge they all face. True, the challenge of efficient resource utilization. CDNs provide *virtual network infrastructures* in the theme of *services*. Such services serve both enterprise and individual clients, those that are called service tenants who lease the cloud resources in the forms of services. Resource utilization in CDNs is challenging, and those tenants who lease the network resources play a substantial role in such challenge. This comes through resource exaggeration where service-tenants may ask the CDNs for resources that exceeds their real needs. In CDNs, extra resource requirements may necessitate *expensive* updates in the infrastructure. Such updates may require changes in the *network topology* and the *network assets*. With the absence of utilization incentives, service-tenants will not stop exaggerating their resource requirements. Therefore, in this work, the process of resource allocation in CDNs is managed through **A** **F**air **A**llocation **M**odel (AFAM) that deploys the *Vickrey-Clarke-Groves* (VCG) and *auction* mechanisms to provide for efficient allocation and tenant selection shemes. AFAM proposes a *fair* allocation model that follows a *non-linear pricing policy* for the allocated cloud resources. Through VCG, part of the charged cost in AFAM is referred to as a *transfer*. This transfer value refers to the inconvenience that each service-tenant causes to the whole system (i.e. the whole CDN) by being among its service-tenants. The transfer is introduced to *encourage* service-tenants not to exaggerate their reveals, and instead, be truthful. Simulation results show that such truthful reveals allows the delivery of higher profit gains and better utilization rates.

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Cloud-Datacenter Networks; Service Allocation; Virtual Datacenter Networks; Vickrey-Clarke-Groves

1. INTRODUCTION

The theme of cloud-based computing have emerged in the last few years as a promising approach that touches almost every technological aspect of life. Advancements in computer and telecommunication technologies influenced the peoples' life-style. Indeed, with such smart era of Big-Data and Cloud-Computing, our technological preferences got different [1]. The world witnesses a huge shift from traditional in-office networking infrastructures toward cloud-based topologies that are built and managed by third-party providers. Cloud-Datacenter Networks (CDNs) lease its computing resources to the cloud-clients (i.e. tenants) in the form of *services*. Services may vary, it come in the form of: (1) software (i.e. software as a service), (2) infrastructure (i.e. infrastructure as a service), and (3) platforms (i.e. platform as a service). For those cloud-clients, such theme of service provision provides for a peace of mind, truly, performance and reliability are almost always guaranteed. Moreover, using such CDNs breaks any physical restrictions that limit the clients mobility options.

Through CDNS, clients can lease a whole **V**irtual **D**atacenter **N**etwork (VDN) (i.e. a network infrastructure) that can be accessed remotely anywhere worldwide with no physical ties. All what they need is a sufficient internet connection. CDNs are *rich* in resources, however, its resource are *still limited* [2]. Accordingly, with such limits of resource availability, those service-tenants who like to expand their VDNs capacities beyond the physical capacity of the currently hosting CDN may find themselves obliged to **migrate** [11] to other new CDN that provides their infrastructural requirements. Such migration processes need to be carefully *managed* by both: (1) The migrating VDN service-tenants, and (2) the new CDN providers who offer hosting service to the migrating VDNs.

CDN structures are many, however, they all come with bounded *resource capacities* and narrow *scale* limits [1]. Hence, the issue of resource utilization is such environments is considered as *a must*. Efficient models of network management are those who deliver high performance and profit targets. This mainly starts with how the available network resources are being utilized, and how they are leased to their tenants.

In this context, when studying the migration of a VDN from one physical location to another, great attention must be made towards the issues of how to efficiently utilize the hosting CDN physical resources. This not only allows for better profits for the host CDN operators, but also, it allows for *lower service prices* being offered to the migrating VDN operators. Again, tenants *truthful resource requirements* represent a key to an efficient utilization algorithm in such allocation scenarios. Having such truthful information requires special strategies to be deployed. However, once gathered, optimal network performance can be easily achieved for all, cloud providers and service-tenants.

2. PROBLEM STATEMENT

The proposed structures of CDNs are many [7] [6] [10], each provides for different sorts of services. Such services may vary in price, bandwidth capacity, scale options, complexity, and many other attributes. Hence, those service-tenants (i.e. the migrating VDNs) who reveal exaggerated requirements for their leased infrastructures may mislead the business of the CDNs providers. Indeed, requirements of the VDN tenants come in the form of services, however, from an architectural perspective, such requirements are implicitly translated to switching capacities, number of ports per switch, bandwidth capacities, memory space, clock cycles, and others. Costs of such resources can greatly impact the cost of the offered services, indeed, the prices of commodity switches totally differ from those high-level ones. Accordingly, at the end of the chain, it is the end-user who is going to pay for such mess in resource allocation. So, it is worth to tackle such management issues at these high layers of resource allocation, in a way to provide those end-users with their required services by reasonable price-units.

The authors of [9] proposed an allocation model that attempts an auction scenario played by a cloud-service provider and a set of network clients (i.e. the service-tenants). In which, the allocation process follows a multi-stage uniform price sealed bid approach to allocate the services among the bidders. The allocation function is formulated based on the bidders' resource requests and the offered bid prices. As long as there is enough bandwidth to provide, the model chooses those bidders who offered bid prices higher than a predefined *market clearing price*. However, to accommodate for more requests, those chosen bidders *may not receive the full amount of resources* they requested. Instead, the allocation is for portional amounts only! This was motivated with the claim that such allocation scenario can maximize the provider's profit. We believe that the aforementioned proposal suffers from the following:

- Considering the **market clearing price** as a sale price-unit does not guarantee high profits. According to their proposal, the market clearing price is the price-unit offered by the lowest winning bid received in the allocation auction. Selling in such price may not only provide for low profits, instead, it *may impose losses* for the cloud-providers [8].

- Competition in such allocation environments is truly required. Hence, the absence of a real competition among the service-tenants leaves no incentives for truthful reveals of service resource requirements. Normally, for a bidder to win an auction, it offers a competing bid that beats all other offers. In such allocation scenarios, this means high price-units for the auctioned resources. To do so, tenants need to be *truly **willing to pay*** their offered bid price-units, and not rely on paying a market clearing price. For a bidder to be truly *willing to pay* its offered price, it must be sure about its real need for the auctioned amount of resources. Otherwise, the offered price-unit is mostly not reasonable (i.e. low price-unit offer). Indeed, those bidders who are not sure about their real need to the whole amount of resources being requested will never tend to offer a reasonable price that covers them all. In the proposal of [9], the offered price-units do not necessarily reflect what the bidders are *willing to pay*. Indeed, offered prices mean nothing as long as the tenants will end up paying that clearing price value! Therefore, we can claim that service-tenants do not have a true motivation for truthful price reveals.

- Customers' satisfaction need always to be guaranteed, especially in such cloud-based environments that were essentially proposed to provide for efficient service levels in reasonable costs. Service efficiency comes with customer satisfaction being guaranteed. Otherwise, efficiency is not considered to be met. The proposal of [9] allows partial allocations for the tenants' requests. Those tenants, and *especially who were truthful in the beginning and asked for the exact amount of resources they really need*, and receive partial allocations will be definitely not satisfied by their allocation, as such allocations may break their anticipated service levels.

In this work, we are proposing **A F**air **A**llocation **M**odel for Cloud-Datacenter Networks (AFAM). In which, we consider deploying an *auction mechanism* for the allocation process of CDNs resources among a set of migrating VDNs operators. Therefore, the allocation process will be through auction scenarios where the competition for CDNs resources will be according to the submitted bids of the VDNs operators. However, although the auction mechanism may enhance the satisfaction and profit rates of the cloud-providers, but still it will never solve the problem of tenants' exaggeration. Therefore, AFAM also proposes a mechanism that governs revealing the tenants' truthful resource requirements under the threat of punishment. In AFAM, we deploy the well known *Vickery - Clark - Glove* (VCG) truth-telling mechanism [13] to calculate the inconvenience each VDN operator causes to the whole network, according to its required resources. This inconvenience is defined in terms of the utility drop caused to the whole CDN. The result value is denoted by the *transfer*, where this transfer value will be added to the original charge of the leased resources. Consequently, *rational* VDN operators will never tend to request resources more that their real needs, as they know that they will be charged more according to the inconvenience they will cause. Briefly, **the contribution of AFAM** is a model that:

- Provides *fair* resource allocation among the VDN tenants [5]. Through which, tenants are charged *their offered bid prices* for their leased VDN resources, added to the *transfer* charge that is calculated according to the *inconvenience* they make to other tenants in the same CDN.

- Provides *fair* profit gain for the CDN providers. Through which, cloud providers get paid in a way that *suits the offered service* levels. Tenants who ask for more resource pay extra charges, such charges grow in a direct relationship with the required resources.

- Motivates *efficient utilization* of the available cloud resources. In this context, it is worth to note that extra resource requirements in a datacenter network may require *expensive* updates in the infrastructure. Such updates may require changes in the *network topology* and the *network assets*.

The reminder of the paper is organized as follows: Section 3 presents AFAM's service allocation model, followed by sample of the simulation results in Section 4. Section 5 reviews related works, and finally, Section 6 concludes the paper.

3. AFAM: A FAIR ALLOCATION MODEL FOR CLOUD DATACENTER NETWORKS

The allocation process of the *service resources at the hosting CDN* mainly depends on what the *migrating VDN operators* reveal about their service requirements. Therefore, such reveals can really shape how the resources of the CDNs are going to be utilized. Migrating VDN operators are expected to be *rational* [12]; aiming to maximize their own utilities. Hence, it is expected that they may tend to exaggerate their real resource requirements and reveal non-truthful needs. Such behavior can impose negative affects for both: (1) the *hosting CDN providers* (e.g. expensive expansion requirements, and other architectural and scaling constraints), and (2) the other service-tenants in the system (e.g. resource shortage and increasing service price-unit).

To overcome such a problem, in AFAM, we propose developing a special mechanism that can provide *financial incentives* to encourage the tenants' efficient behavior. With such mechanism, both parties are expected to be satisfied. The CDN providers can guarantee their own profit objectives while providing their tenants with satisfactory service prices.

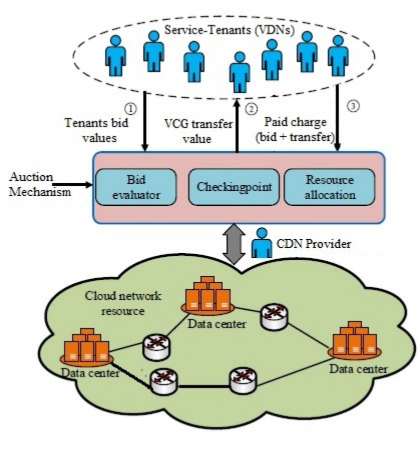

Figure 1: AFAM Allocation Process

Accordingly, to provide for *fair* competition and *fair* pricing model, the allocation process is developed as shown in Figure 1 to follow an *auction mechanism*. Through which, the operators of the migrating VDNs will be asked to reveal their required resources (i.e. CPU cycles, Memory, Disk Space, Bandwidth, ... etc), and the corresponding bid prices. It is therefore expected that service-tenants will offer different prices for the same type of resources. In Table 1, the allocation Algorithm is presented to illustrates the allocation process. The transfer value is proposed to represent the inconvenience each bidder (the migrating VDN tenant) causes to the system (i.e. the whole other tenants of a CDN) through the amount of resources it reserves. This inconvenience is calculated based on the *Vickrey-Clarke-Groves* (VCG) mechanism [13]. This create: (1) a form of competition between the service-tenants which can reduce their tendency of exaggeration, and ask for resources that really matches their *"competing"* offered prices, (2) a *fair* pricing model that charges the bidders according to (i) their *offered bid* and (ii) the *affect* of their allocation to the system. Consequently, *rational service-tenants* will not be motivated to ask for extra resource requirements that require what *exceeds* their ***willingness to pay capacities***.

3.1 Definitions and Mathematical Modeling

In AFAM, the resource allocation problem is modeled as a *game* where the *migrating VDN operators* are the players of the game. These players are assumed to be *rational*, and thus their aim is to maximize their own *utilities* according to the revealed values of their required *resources* and offered auction *prices*. A tenant's offered bid price implicitly represents the anticipated *utility-gain*, ρ_i, that the a tenant i can collect from its allocated services, and always aims to maximize. Utility-gain maximization leads to higher utility rates, where the tenant's *total utility* is represented as the aggregation of its utility-gains (ρ_i) and the system's calculated *transfer* value (τ_i). This utility function is expressed as follows:

$$Utility_i = \rho_i + \tau_i \qquad ; \rho_i \leq 0 \tag{1}$$

On the other hand, the objective of the *hosting CDN provider* is to maximize the sum of accepted bids for allocation, *while* satisfying the whole network tenants in terms of competing service-prices, availability, and reliability. provider's utility is expressed as follows:

$$U^{CDN} = \sum_{i=1}^{N} \rho_i \tag{2}$$

3.2 The Auction Model

The migrating VDN operators are expected to ask for different types of resources (e.g. CPU cycles, Memory, Disk Space, Bandwidth, ... etc), for which they will offer certain corresponding prices. For ease of presentation, and due to the length restrictions of the paper, we will limit our presentation to denote the required resources by the services s they construct, $s \in S$. Hence, for each migrating VDN operator i, the hosting CDN provider calculates the offered cost-units c_{i_s} for the required resources r_{i_s} of the different required service as follows:

$$c_{i_s} = \frac{price_{i_s}}{r_{i_s}} \tag{3}$$

where:

- c_{i_s}: represents the offered cost-unit by tenant i for the service s;
- $price_{i_s}$: represents the price offered by tenant i for the service s;
- r_{i_s}: represents the amount of resources requested to provide the service s to the tenant i..

Upon receiving all service-tenants' requests, the proposed model follows the selection algorithm presented in Table 1 to select those requests with the most profitable cost-units in accordance to the available resource capacity for allocation.

3.3 ARAAC's Allocation Algorithm

Having the tenants' bids submitted. It is only the cloud-service provider who has the privilege to read the tenants' offered bids, and is hereby authorized to make the allocation decision. The decision defines who among the bidding tenants win the allocation auction. The auction is held for *multiple rounds* t, $t \in T$, that are periodically carried out. The durations of such periods are defined according to the offered services and the market requirements.

To start the allocation process, in each round t, the cloud-service provider calls the service-tenants to submit their requests. Each bidder i is required to reveal: (1) its required service **r**esources r_{i_s} (i.e. resource units required for the migrating VDN), and (2) its offered **p**rice p_{i_s}. Having the aforementioned inputs, AFAM follows the allocation Algorithm presented in Table 1 to choose the candidate bidders for allocation.

Table 1: AFAM's Selection Algorithm

Candidate VDN Selection Algorithm for Allocation
1: **Input:** Vector of offered bids N, $\forall\ i \in N$, find (r_{i_s}, c_{i_s});
2: **Output:** Vector of **C**andidate service-tenants for allocation C;
3: **for** all $i \in N$ requires service s;
4: **find** the value c_{i_s}, **then**
5: **sort** them accordingly in N as $c_{i_s} > c_{i+1_s} > c_{i+2_s} > ... > c_{n-1_s} > c_{n_s}$;
6: **update** N;
7: **end**
8: **for** all $i \in N$;
9: **if** $c_{i_s} < C^{\star}{}_s$, **exclude** from N;
10: **else** keep in N;
11: **end**
12: **for** all $i \in N$;
13: **find** bidder $\bar{i}$, where $\sum_{i=1}^{\bar{i}} (r_i \leq \alpha_t R_t)$ and $\sum_{i=1}^{\bar{i}+1} (r_i > \alpha_t R_t)$;
14: **move** bidders from $i \rightarrow \bar{i}$ to a new vector C;
15: **end**
16: **for** all $i \in C$;
17: **find** the *transfer* value $\tau_i(\theta, r)$, then;
18: **calculate** the final charge based on $\tau_i(\theta, r)$, and offered price p_{i_s};
19: **end**

As described before, the model received the tenants bids as an input. In steps 3 to 5, it sorts the received bids in a descending order according to the offered service cost-unit values c_{i_s}, and update the set N accordingly. For those sorted bids, steps 8 to 11 show that the model will exclude any bid who has low cost-unit that does not satisfy a predefined **C**ost-unit threshold $C^{\star}$. The definition of this $C^{\star}$ value is beyond the scope of this paper. Next, it checks who among the remaining bidders in N fit within the available resource space $\alpha_t R$ to be served. Hence, in step 13, the model finds the reference $\bar{i}$ which refers to the last bidder that fit for allocation at round t. Then in 14, all those who passed the aforementioned check points are stored in a new Candidates' set called C. Finally, step 18 charges all those in C according to their $\tau_i(\theta, r)$ and offered price p_{i_s} values.

3.4 The VCG Pricing Mechanism

In the current management models, the *absence* of any incentive mechanism for the migrating VDN operators to truthfully reveal their requirements can motivate exaggeration. Particularly, in a loaded CDN, if a tenant lies or exaggerates its resource requirements, the performance of the entire CDN can be negatively affected. Hence, there is a need to develop a model that guarantees the integrity of the CDN resources, and protects it from being wasted or misused. Therefore, we propose a model that reduces the exaggeration behavior and motivates the migrating VDN operators to truthfully reveal their real resource requirements.

In AFAM, we adopted a mechanism from the *game theory* [14] which is known as the VCG mechanism to calculate what is called a *transfer* value. With such mechanism, the hosting CDN providers can enforce the migrating service-tenants *to cooperate* under the threat of *punishment*. The calculation of the *transfer* value will be in terms of the utility drop each migrating tenant causes to the other tenants in the system by consuming part of the available common resources $\alpha_t R_t$. To address the above challenge, in AFAM, we propose using the VCG truth-telling mechanism to define an "*optimal decision*" $T(\theta, R)$ that provides *fair* allocations of network resources among the migrating tenants, and computes the "*transfer*" value $\tau(\theta, r)$ that represents the inconvenience each migrating tenant causes to the other competing tenants. This transfer value is added to the offered bid price p_{i_s}, together giving the total *charge* to be paid by this new tenant, represented as follows:

$$charge_i = p_{i_s} + \tau_i(\theta, r) \tag{4}$$

Thus, the aggregated utility of a CDN is defined as:

$$u^{CDN}(T(\theta, R), \theta) = \sum_{i=1}^{C} u_i(\theta_i, r_i) \tag{5}$$

where r_i represents the amount of resources allocated to the migrating operator i according to the required service s_i. This can be calculated for each resource type r. Consequently, at each auction round t, the optimal decision should provide a map for allocating the CDN resources $\alpha_t R_t$ among the migrating service-tenants in a way that maximizes the aggregated utilities of all. The *optimal decision* is defined as follows:

$$T^{opt}(\theta, R) = arg\ max\ u^{CDN}(T(\theta, R), \theta) \tag{6}$$

The symbol θ represents the "type profile" for the migrating VDN operators which includes the utility gain per auction round t. In the following, θ_{-i} indicates the type profile of all VDN operators (i.e. tenants) except operator i. (i.e. $\theta_1, \theta_2, \theta_3, ..., \theta_{-i}, \theta_{+i}, ..., \theta_C$), and $T_{-1}(\theta_{-i}, R))$ indicates the resource allocations for all VDN operators except operator i. (i.e. $t_1, t_2, t_3, ..., t_{i-1}, t_{i+1}, ..., t_M$). Hence, the transfer value for the migrating VDN operator i is computed as:

$$\tau_i(\theta, r) = \sum_{C \neq i} u_C(t_C{}^{opt}, \theta_C) - {}_{T_{-i}(\theta_{-i}, R))}^{MAX} \sum_{C \neq i} u_C(t_C, \theta_C) \tag{7}$$

The first term represents the sum of the aggregated utilities of all other VDN operators $\in C$ given by the *optimal migrating decision* except VDN operator i, in the presence of operator i. While the second term represents the maximum sum of aggregated utilities that all VDN operators can obtain if VDN operator i does not participate in the resource allocation game. Clearly, the second term will always be greater than or equal the first term, this means that the "*transfer*" value will always be negative or zero representing no inconvenience (utility drop) caused to the other VDN operators by operator i. Accordingly, equation 4 can be reformulated as:

$$charge_i = p_{i_s} + \sum_{C \neq i} u_C({t_C}^{opt}, \theta_C) - {}_{T_{-i}(\theta_{-i},R))}^{MAX} \sum_{C \neq i} u_C(t_C, \theta_C) \tag{8}$$

According to (6), rational VDN operators should never be motivated to exaggerate their resource requirements, instead, they should reveal their truthful requirements in order to avoid any extra expenses and charges paid in accordance to the amounts of service resources being required.

4. SIMULATION RESULTS

To assess the efficiency of the proposed allocation mechanism in this work, we chose to develop the allocation methodology presented in Section 3 in MATLAB. Through which, we simulate the allocation process of a pool of 3600 units of a CDN resources among a set of a 100 competing service-tenants. The developed simulation compares the performance of *AFAM* with a *benchmark model* that considers the Market Clearing Price (MCP) strategy adopted in the proposal of [9] for allocation. However, not like that of [9], both models are assumed to provide full (no-partial) allocations. Each of the 100 tenants has a *profile* that is created by taking the mean value of 10 iterative rounds. Those rounds that randomly choose price p_{i_s} and resource unit r_{i_s} values for each tenant (i.e. bidding values). To simulate a real-life bidders' options, the model is developed to create bidding profiles of reasonable and non-reasonable price offers in regard to the required resource units.

Having the bidders' profiles generated, they are fed as input to the tested allocation models. In AFAM, the model is developed to follow the allocation Algorithm presented in Table 1. The benchmark model follows the same allocation algorithm but different pricing policy. It follows the MCP policy proposed in [9] to set the charges for the winning tenants. Accordingly, Figures 2 and 3 show the behavior of the aforementioned two models in regard to: (1) the profit rates of the CDN provider, and (2) the acceptance ratio in regard to the available resource capacities.

Figure 2 shows the resultant profits to the number of service-tenants being candidates for allocation. From the figure, we can clearly notice the gap in profit gains for both models. In AFAM, the deployed auction mechanism motivates high price offers to win the competition. Beside the VCG truth-telling mechanism that allows for a better use of the available cloud resource; this justifies the high profit gains. This is not the case for MCP, despite the fact that the bids here are also processed through the same competition environment. However, what really counts when calculating the profit gains are those *MCP-based* charges not the offered ones. In MCP, those offered bid prices do not really reflect what the bidders are willing to pay, these offers are simply used to pass the competition-based selection criteria. What is really paid is the MCP! In Figure 3, the figure examines the acceptance ratio of the studied models in regard to the number of service-tenants. Intuitively, both models will almost provide the same acceptance ratios, however, it is worth to note that the adoption of the VCG allows for higher ratios in AFAM. Indeed, VCG provides a *threat mechanism* that motivates truthful reveals of resource requirements. This means better resource utilization, and accordingly more space to accept more new tenants.

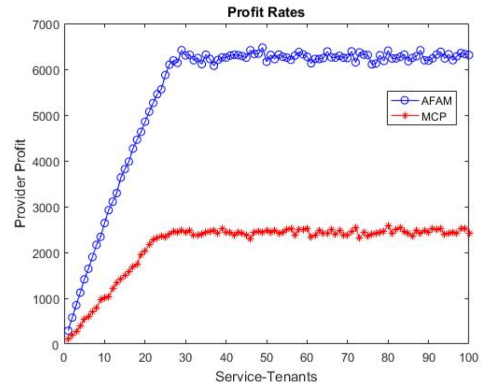

Figure 2: Profit Rates for both AFAM and MCP

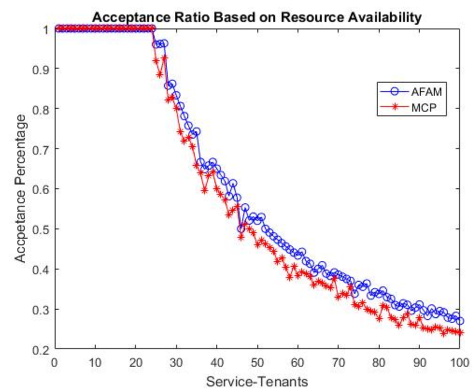

Figure 3: Acceptance Ratios for AFAM and MCP

5. RELATED WORKS

The theme of cloud-service networks enabled new a environment that boosts almost all the technological aspects we are living nowadays. A fundamental key for the high performance in such sort of networks lies in the rich resource capacities they provide. They are rich indeed, however, their capacities are still limited. To keep the high levels of performance, resource capacities need to be efficiently utilized. In the general context, several research proposals are listed in the literature. Among them we present the following. In [4], the authors proposed an allocation model for the cloud-network resources that attempts the the tenants historical resource utilization records to predict their actual current requirements. Hence, no guarantees that the tenants requests will be fully satisfied, allocation decisions are fed by historical records. Therefore, it is highly expected that tenants will receive partial/over allocations for what they have requested. In regard to the pricing issues, their proposal define the price-units in accordance to the actual allocations the tenants receive. The authors of [3] proposed a resource allocation algorithm that dealt with the problem of tenants inability to accurately determine their true resource requirements. In that proposal, the tenants have two options of resource allocations, static and dynamic. In *static* allocation, tenants' receive guaranteed resource allocations with predefined prices. In the dynamic allocation option, tenants receive *dynamic* resource allocations that follows different pricing schemes. Such proposals may truly provide for good resource utilization rates, however, this comes with a compromise in the tenants satisfaction rates. Indeed, those who do not receive their requested resources in full may not be satisfied, and accordingly affecting their willingness to pay attitude. Moreover, the scheme of static allocations may provide for *instantaneous service guarantees*, but contradicts with the goals of *resource utilization* and *fair* allocation schemes. The authors of [9] proposed an allocation model that attempts an auction scenario played by a cloud-service provider (i.e. the service-provider) and a set of network clients (i.e. the service-tenants). In which, the allocation process follows a multi-stage uniform price sealed bid approach to allocate the services (i.e. network resources) among the bidders. The allocation function is formulated based on the bidders' resource requests and the offered bid prices. As long as there is enough bandwidth to provide, the model chooses those bidders who offered bid prices higher than a predefined *market clearing price*. However, *to accommodate for more requests*, those chosen bidders may not receive the full amount of resources they requested. Instead, the allocation is for *portional amounts* only! This was motivated with the claim that such allocation scenario can maximize the provider's profit. One may ask, what about tenants satisfaction rates with such partial allocations? Moreover, we believe that the aforementioned proposal does not provide for profit guarantees, indeed, leasing the cloud resources with a predefined market clearing price may help in avoid losses, *however*, it can never guarantee profit maximization.

6. CONCLUSIONS

AFAM models the service allocation in the Cloud-Datacanter Networks (CDNs) as a game that is played by a set of service-tenants. Those who compete to win resource allocations for their Virtual-Datacenter Networks (VDNs). For this, AFAM proposes deploying the *auction mechanism* to ensure a *fair* allocation that chooses those bidders with the most *profitable* offers. CDNs are rich in resources indeed, however, they still *limited*. Therefore, to utilize the cloud resources better and provide for reliable cost-effective cloud services, the allocation model needs to *motivate truthful reveals* of the tenants resource requirements. To do so, from the game theory mechanism, AFAM proposes deploying the VCG truth-telling mechanism to incentivise revealing the tenants' true resource requirement. Through VCG, service *charges* paid by the service-tenants are calculated according to their *offered bid prices* and a *transfer value* that is influenced by the amount of requested resources. Tenants who ask for more resources may affect other tenants in the network. Accordingly, to *enforce fairness* they are required to pay high transfer values. Tenants who show a *willingness to pay* behavior to such the high transfer values represent those types of serious tenants who believe that they really need the required amount of resources to receive better levels of service or any other motives. In the contrary, tenants who just ask for extra resources for the sake of greed represent those selfish tenants who are not willing to pay the *real* cost for their lease.

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