# Unleashing the Cloud Potential: Energy Efficiency through Resource Sharing.

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## 1 Introduction to the cloud sharing system

Cloud computing has transformed numerous sectors of businesses, governments, and individuals' lives with its benefits of processing power, resource simplicity, scalability, and accessibility. Predictions anticipate a significant upsurge in global data traffic by 2025, driven by an increase in demand for cloud computing [3]. Although cloud computing is energy-efficient compared to private computers, it is still wasteful [1]. Data centers often underutilize servers, which continue to consume considerable amounts of energy even when idle [2]. The inefficiency originates in the overstocking of computers due to consumer behavior and service-level buffering.[1]

To face this problem, we propose a cloud sharing system to enhance resource efficiency. The system's framework is formulated as a mixed integer bilevel problem, which features two distinct follower types representing the different types of customers in the public cloud, namely, *long-term consumers* with monthly subscriptions and *short-term consumers* who seek on-demand access. The cloud service manager's (CSM) goal, operating as the leader, is to incentivize long-term consumers to share their resources through rewards to allocate short-term consumers without requiring new resources.

## 2 The cloud sharing model

The proposed model is a mixed-integer bilevel problem with continuous linking variables and nonlinear objective functions at both levels. The problem is composed of two types of consumers that interact with the CSM.

### 2.1 Followers' problems

#### 2.1.1 Long-term consumers

Individuals who own virtual machines (VMs) have the opportunity to get rewards from their unused resources through the cloud sharing system. The CSM incentivizes this behavior by offering monetary rewards for lending. The decision to lend is influenced by the opportunity cost of not using the VM for personal purposes. Thus, lenders are motivated to strike a balance between maximizing their gains through lending and retaining access to their VMs.

[1]For definitions on Public Cloud terms, you can access this https://help.ovhcloud.com/csm/en-public-cloud-compute-glossary?id=kb$_article_view&sysparm_article = KB0050915page$.

### 2.1.2 Short-term consumers

When a short-term consumer enters the cloud system, they must decide to either borrow a VM of a certain flavor or exit. This decision is guided by their maximum budget, the upper limit they're willing to spend for running tasks. This budget also reflects the potential cost of not using the service. The cost to the user is based on the CSM's pricing for a specific VM flavor at a particular time. The consumer's goal is to minimize expenses by selecting the most cost-effective option from the available choices.

## 2.2 Leader's problem

The CSM operates with the objective of maximizing profits of the cloud sharing system. It encourages the leasing of VMs by offering rewards to long-term consumers and sets prices for short-term consumers to access different VM flavors.

A series of constraints have to be considered to ensure the integrity of the cloud:

- **Pricing:** The CSM sets uniform prices for all consumers based on demand and availability, within limits for each VM flavor. This ensures fairness and market competitiveness.
- **Allocation:** Short-term consumers are allocated to only one physical machine (PM) for the duration of their usage.
- **Reallocation:** When long-term consumers who have previously shared their VMs return to the system, they are not necessarily assigned to the same VM. They can be reallocated to any VM of the same flavor, which can be on a different PM.
- **Capacity:** There is a limit on the number of idle VMs of each flavor at each time slot and PM. There should always be enough VMs available to allocated users without overwhelming the system with unused resources.
- **Energy:** The CSM has to consider the energy consumption, which is the highest expense for cloud service providers (CSP). The energy consumption for each PM is modeled as a logarithmic function of the workload.

# 3 Conclusions and future work

Our research introduces a unique approach by viewing cloud pricing as a bilevel problem, a perspective not previously explored in the classical cloud models. The nature of our model, which includes nonlinear interactions between leader and follower variables and a multitude of binary variables, to efficiently solve this problem we need the application of decomposition approaches.

Future work will expand our model to include user responses to quality of service variations. In a cloud sharing systems, service quality could change significantly thought time, influencing user decisions.

# References

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