A Novel Parking-Based Management System in Smart City Vehicular Datacenters

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Abstract

Researchers have shown that most vehicles spend the majority of their time parked in parking garages, lots, or driveways. During this time, their computing resources are unused and untapped. This has led to substantial interest in Vehicular Cloud, an area of research in which each vehicle acts as a computation node. The main difference between traditional cloud computing and vehicular cloud computing is the availability of nodes. In traditional clouds, nodes are available 24/7, while in vehicular clouds, nodes (vehicles) are only available while parked in parking lots. This creates a dynamic environment as vehicles enter and exit parking garages at random. In this paper, we present a novel framework called ADAM (Auction-based Datacenter Management) for Vehicular Cloud. It uses auction and market design approaches and makes the following contributions: (1) integration of software agents that can search, bid, price, and allocate jobs on behalf of stakeholders, (2) formulation of a truthful auction-based job management system that unifies job allocation, scheduling, and pricing strategies, and (3) simulation studies demonstrating substantial performance benefits. The results of our simulations show that the proposed interactive agents enable efficient processing of large amounts of data, leading to cost savings for stakeholders, reducing the load on conventional clouds, and improving the utility of parked vehicles and parking facilities.

Clouds in Vehicular Networks

Vehicular cloud: Enables real-time data sharing, edge computing, and content distribution among vehicles and with the cloud for applications such as autonomous driving and V2I communication.
Roadside cloud: Processes data from nearby vehicles for localized services such as traffic information and weather alerts.
Central cloud: Stores and processes data from numerous vehicles in a central location for real-time analytics and coordination of services.

Datacenter – A Parking-Based Cloud

- Olariu et al. through a series of researches introduced a novel concept - Vehicular Cloud Computing.
- In this vision, a Vehicular Cloud (VC) is a network of vehicles in parking lot(s) that can provide computation services to users such that each vehicle becomes a computation node.
- Major applications of such VC include:
  - Datacenter at an airport
  - Data cloud in a large parking lot
  - Datacenter at a mall
- We focus on this type of VC, i.e., a cloud made up of parked vehicles in a large parking lot. We call it a Datacenter (DC).

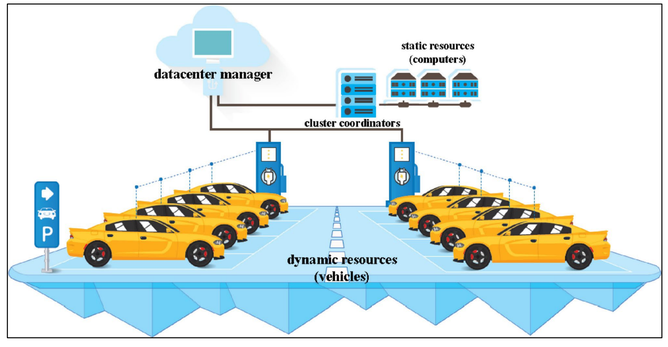


Illustration of vehicular datacenter model [3].

Problems in a Datacenter

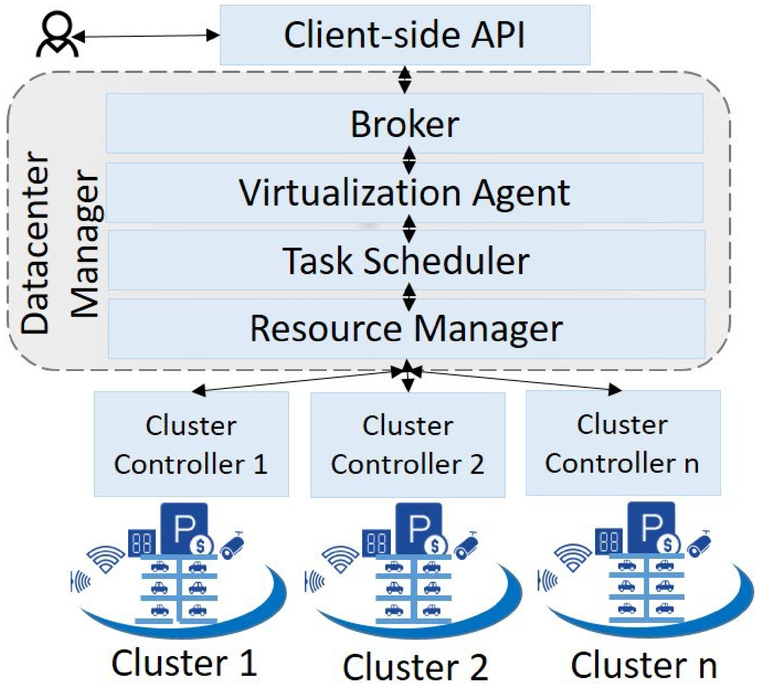
The dynamic nature of car's arrival and departure in a datacenter proposed by Olariu et al. can introduce several issues, including: 1) Resource allocation, 2) Data management, and 3) Maintenance.

Our Contributions

- Developed a concept for integrating software agents that can search, bid, price, and allocate jobs on behalf of stakeholders.
- Formulated an auction-based job allocation strategy that achieves substantial performance benefits.
- Conducted simulation studies to demonstrate the effectiveness of our economics.
- Proposed ADAM, a priority-based recurrent reverse auction.

Auction-based **D**atacenter **M**anagement

Architecture of a Datacenter



Nomenclature

Jobs	Tasks or jobs that are requested to be processes at a DC
Resources	The parking spaces
Nodes	Reserved vehicles at a datacenter (DC)
Local Agent (LA)	A software agent hosted in a parker's vehicle
Parker's Agent (PA)	A software agent hosted in cloud that act on behalf of a bidder
Job's Agent (JA)	A software agent hosted in cloud that act on behalf of the job owner
Pricing Agent (PiA)	A software agent hosted in cloud that act on behalf of the auctioneers (the parking platform)

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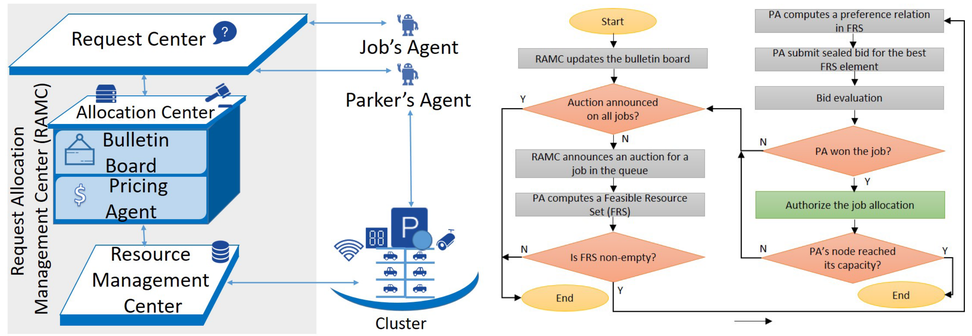
Framework and Workflow



Simulation

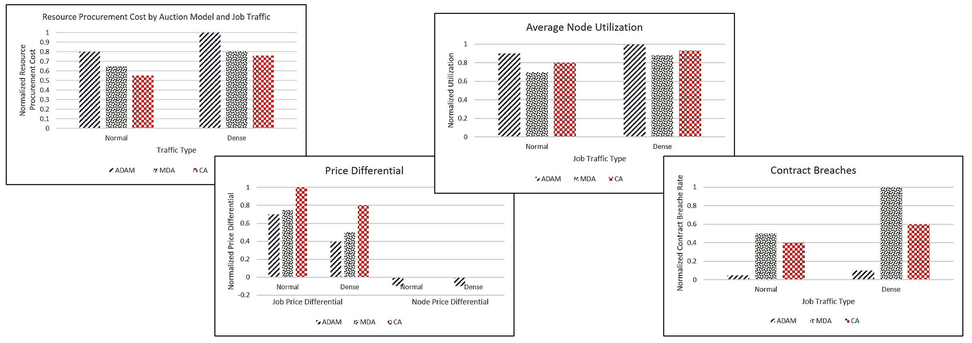
We used a well-known network simulator called Arena in a large area.

Important metrics that were recorded:
- Resource Procurement Cost ($)
- Job Price Differential
- Node Price Differential
- Contract Breach Rate
- Average Node Utilization Rate

Parameter	Setting
Parking capacity of DC	2,000 vehicles
Number of jobs per day (Normal)	7,500
Number of jobs per day (Dense)	15,000
Range of job processing time (float)	[0.1 - 23.9] hr
Range of maximum price (float)	S[1-10]
Simulation end condition	All jobs auctioned / no bidders

The proposed framework was compared with (1) Monetary Dutch Auction (MDA) model, an open descending auction for jobs with no FRS, no preference relation on elements of the FRS, and no PCR, and (2) Combinatorial Auction (CA) model.

Results



Conclusion

In a parking-based Vehicular Cloud (VC), also known as a datacenter (DC), each vehicle serves as a computation node. Unlike traditional clouds, nodes in a DC are not constantly available. The dynamic environment created by vehicles entering and exiting parking garages randomly contributes to this. In this paper, we formulated a novel framework called ADAM (Auction-based Datacenter Management) for VCs. The framework is based on auction and market design approaches and includes sophisticated software agents capable of tasks such as lookup, negotiation, pricing, and bidding. Simulation results demonstrated that the proposed interactive agents allow for efficient processing of large amounts of data, leading to cost savings for stakeholders, reducing the load on conventional clouds, and improving the utility of parked vehicles and parking facilities.

References

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