Peer-to-Peer Bargaining in Container-Based Datacenters

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IPTPS 2010, San Jose, CA, USA

Container-Based (Modular) Datacenters

Low resource utilization!

Improve Utilization

Virtualization Technology

- Server virtualization techniques
- Storage virtualization techniques

A right direction, but not enough!

- Component failures are the norm, rather than the exception.
- Failures in different resource dimensions in distinct containers may follow their own degradation distributions.

Our Contribution

The application of Buffet Principle when launching application instances

VM migration across the boundary containers in a peer-to-peer fashion through bargaining in a local trading market

Applying the Buffet Principle

Aggressively use all available resources

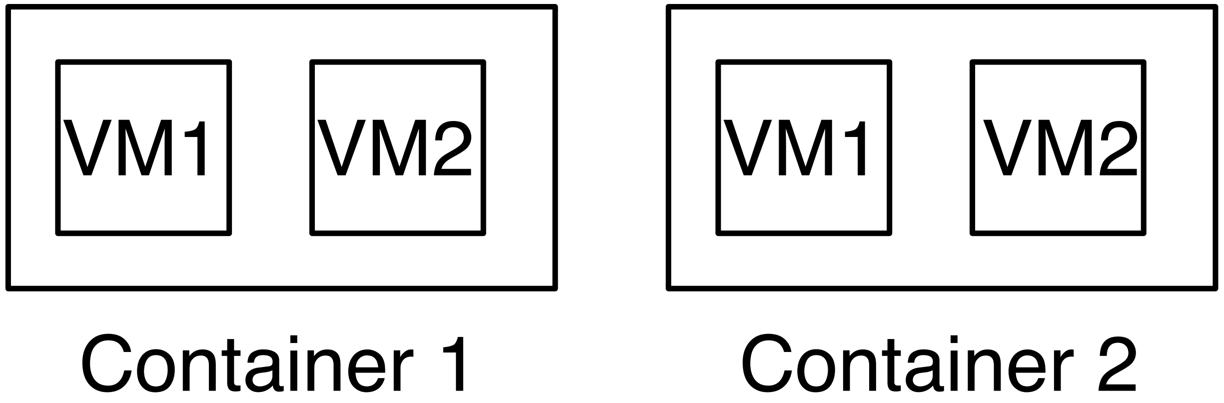
Buffet Principle: resources should be utilized as long as the marginal cost is lower than the marginal benefit.

In our context: simply let each container accommodate as many application instances as it can to saturate nearly all of its available resources, with respect to either bandwidth, CPU, or storage space.

VM Migration Algorithm

The benefits of VM migration

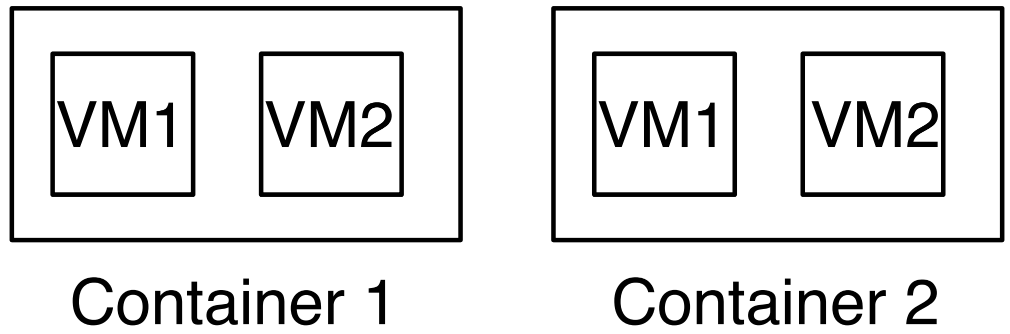
Resources	Container 1/2	VM1	VM2
CPU (MIPS)	6	3	1
Storage Space (GB)	6	3	3
Bandwidth (Mbps)	6	1	3



Resource utilization ratio: 76%

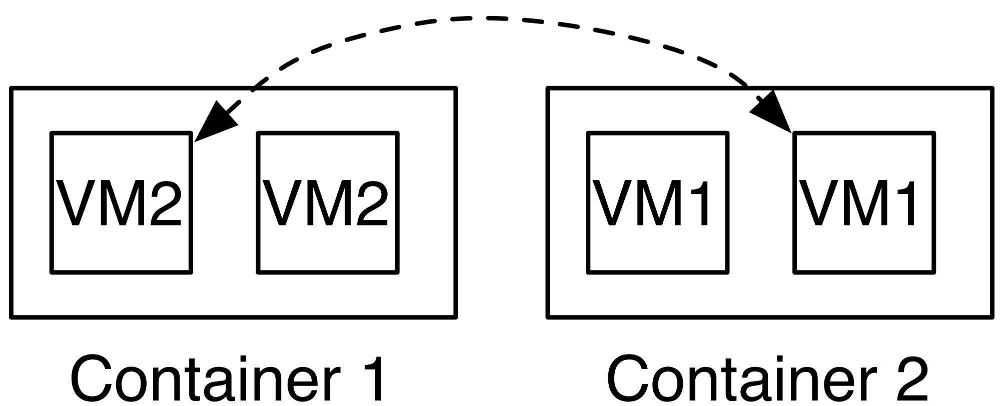
VM Migration Algorithm

CPU: -3 MIPS



Bandwidth: -3 Mbps

Without VM migration: utilization ratio 44%



With VM migration: utilization ratio 87%

System Model

Containers:

Container set: $\mathcal{N}$, for every container $i \in \mathcal{N}$,

Available storage space: $C_i(t)$

Available bandwidth: $U_i(t)$

Available CPU computing: $P_i(t)$

VMs:

Application instance set: $\mathcal{M}$, for every $k \in \mathcal{M}$,

Required storage space: s_k

Required bandwidth: r_k

Required CPU computing: cl_k

Lazy Response

Algorithm trigger: the imbalance of resource utilization ratios in different dimension alters over a threshold $\sigma_{threshold}$

At time t, the utilization ratios of each container i:

$$
\begin{aligned}
r_i^s(t) &= \frac{\sum_{k\in\mathcal{M}} I_i^k(t) s_k D_i^k(t)}{C_i(t)} \\
r_i^b(t) &= \frac{\sum_{k\in\mathcal{M}} I_i^k(t) r_k D_i^k(t)}{U_i(t)} \\
r_i^c(t) &= \frac{\sum_{k\in\mathcal{M}} I_i^k(t) cl_k D_i^k(t)}{P_i(t)}
\end{aligned}
$$

The standard deviation: $\sigma_i^r(t)$

Trigger: $\sigma_i^r(t) > \sigma_{threshold}$

Nash Bargaining Solution

Pareto efficient solution to a two-player bargaining game

Player Selection Principle

- Check out the dimension in which its resource utilization is the highest
- Chooses the container with the lowest resource utilization ratio in this dimension

Relaxed Nash Bargaining Solution

Relax the Pareto optimality property

Whenever comes a "win-win" situation within resource constraints, i.e., the exchange of commodities leads to an increase of both players' utilities:

$$
\begin{aligned}
u(i) - u(d) &= \sum_{k \in \mathcal{M}'_i} V_i^k(t) - \sum_{k \in \mathcal{M}_i} V_i^k(t) > 0 \ \text{AND} \\
v(j) - v(d) &= \sum_{k \in \mathcal{M}'_j} V_j^k(t) - \sum_{k \in \mathcal{M}_j} V_j^k(t) > 0,
\end{aligned}
$$

the trade is done.

Experimental Evaluation

Bargaining overhead

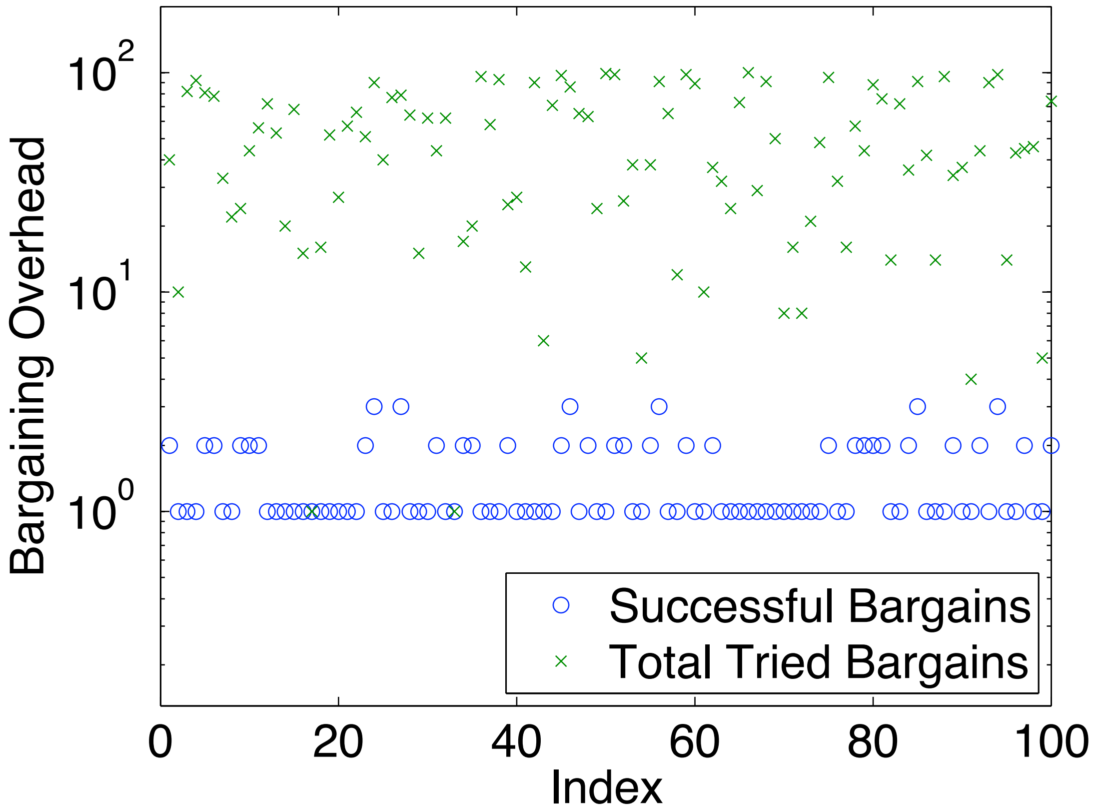


Fig. 5. The communication and transmission overhead of bargain.

Conclusion

A new application placement strategy based on Buffet Principle, which advocates to use the resources aggressively

A VM migration algorithm in a peer-to-peer fashion regulated by bargaining behaviours between containers.