Microsoft Research

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# Filo
## consolidated consensus as a cloud service

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# Consensus

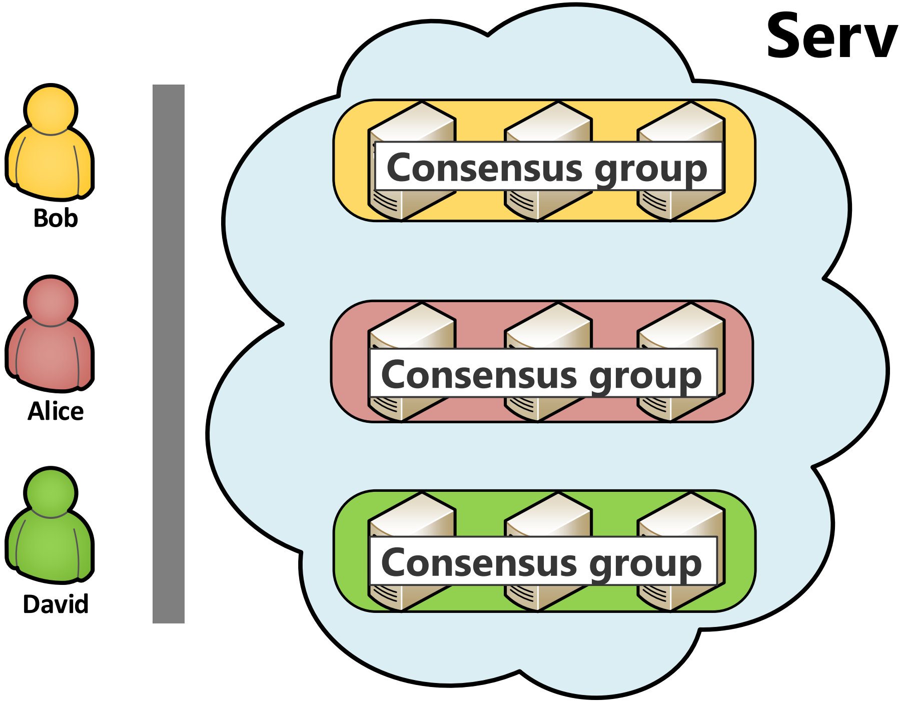
- Enables a set of distributed processes to **reach agreement**
    - Leader election, Membership
    - Coordinating access to shared objects
    - ➢E.g., Paxos, Chain Replication, Two-Phase commit

- Many distributed systems need consensus

**Many distributed systems are moving to cloud**

How to implement consensus in a cloud environment?

# Isolated consensus

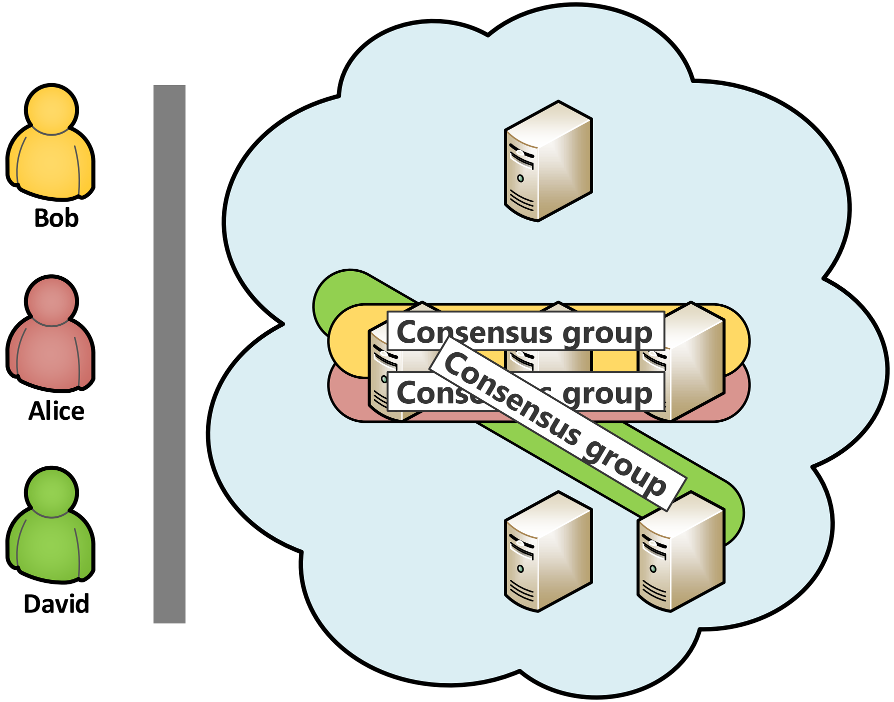


**Servers are dedicated to tenants**

**Underutilized Servers**

**$**

# Our Goal: Consolidated Consensus

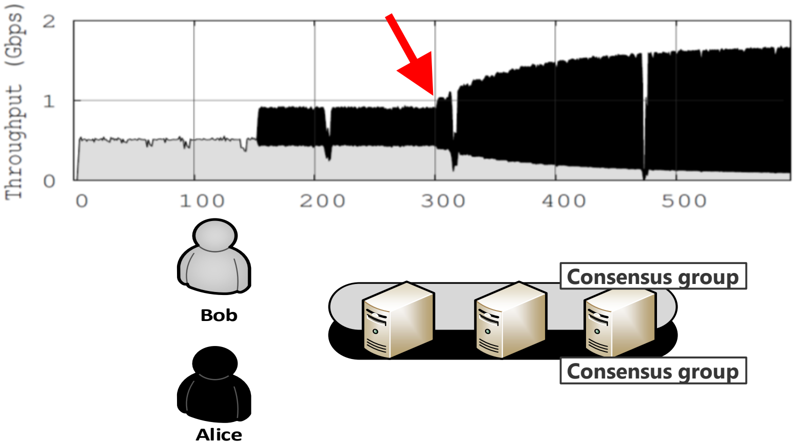


- ✓ Lower $
- ✓ Efficient server utilization
- ✓ No management hurdles

# Challenges with Consolidated Model

- Multi-tenancy
  - Performance isolation
  - SLA Guarantees: (requests/sec)
    - Users may misestimate their SLA

- Maximise resource usage on servers
  - CPU, Network, Storage



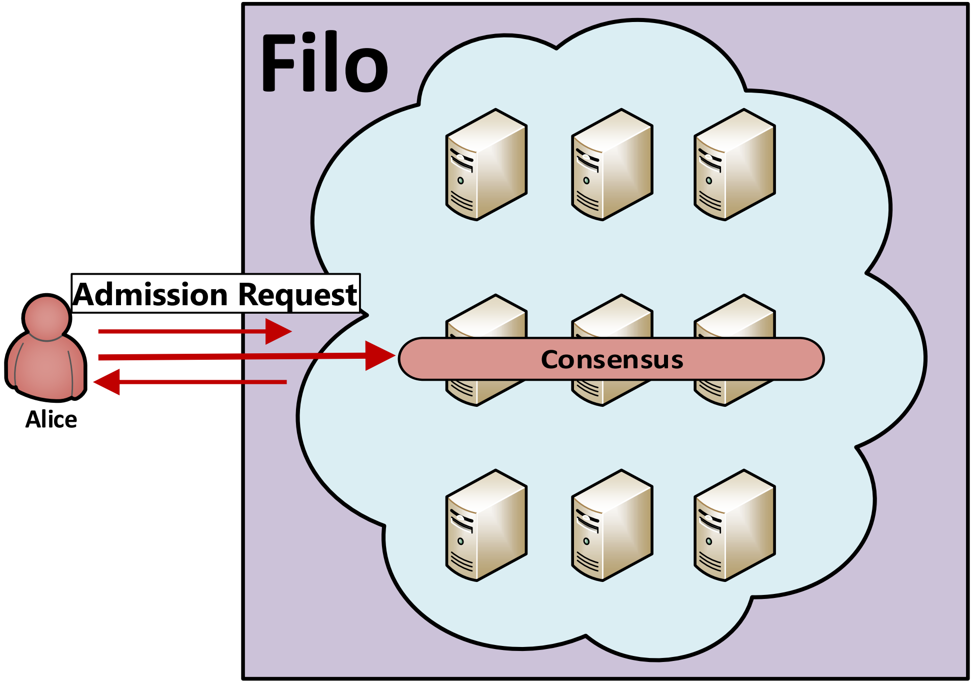
- How to isolate performance **and** maximize resource usage?
  1. Translate SLAs to raw resource usage

     e.g. 10K requests / s ➔ (10% CPU, 10K disk I/O, 80Mbps)
  2. Monitor and adjust resource usage

# Filo

1) Provides consensus as a shared multi-tenant service
2) Isolates Performance
3) Guarantees a minimum SLA
4) Optimizes resource usage

# Filo at a high level

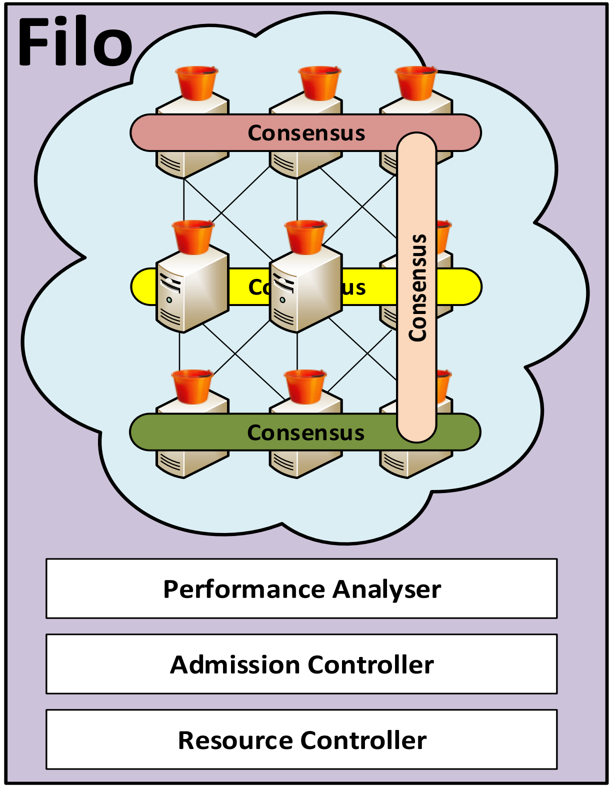


## Admission Request

1. Durability mode
   disk or memory
2. Replication degree
   3, 5, 7
3. Request size
   in bytes
4. Throughput SLA (High-level)
   in requests / second

# Filo

1. Performance Analyser **initialization**
2. Admission Controller
   1. SLA Translation
   2. Placement
3. Resource controller

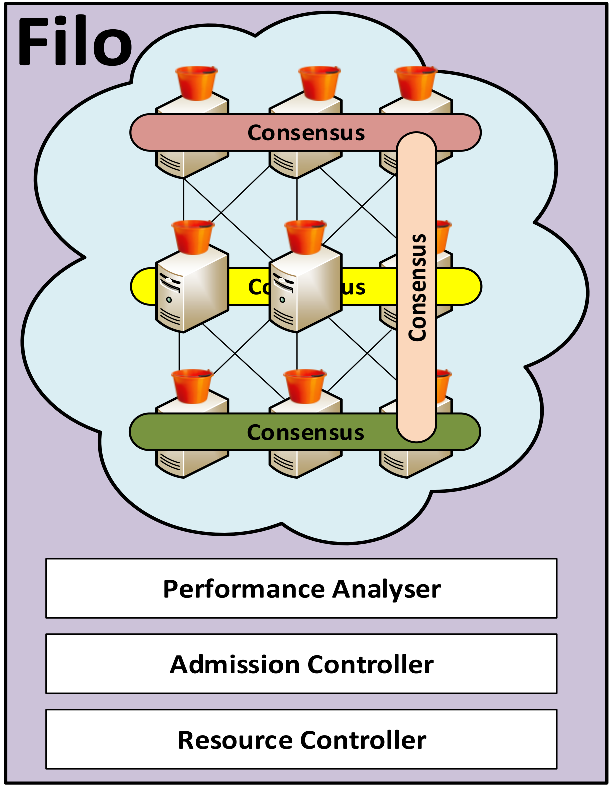


# Filo

1. **Performance Analyser**

2. Admission Controller
    1. SLA Translation
    2. Placement

3. Resource controller



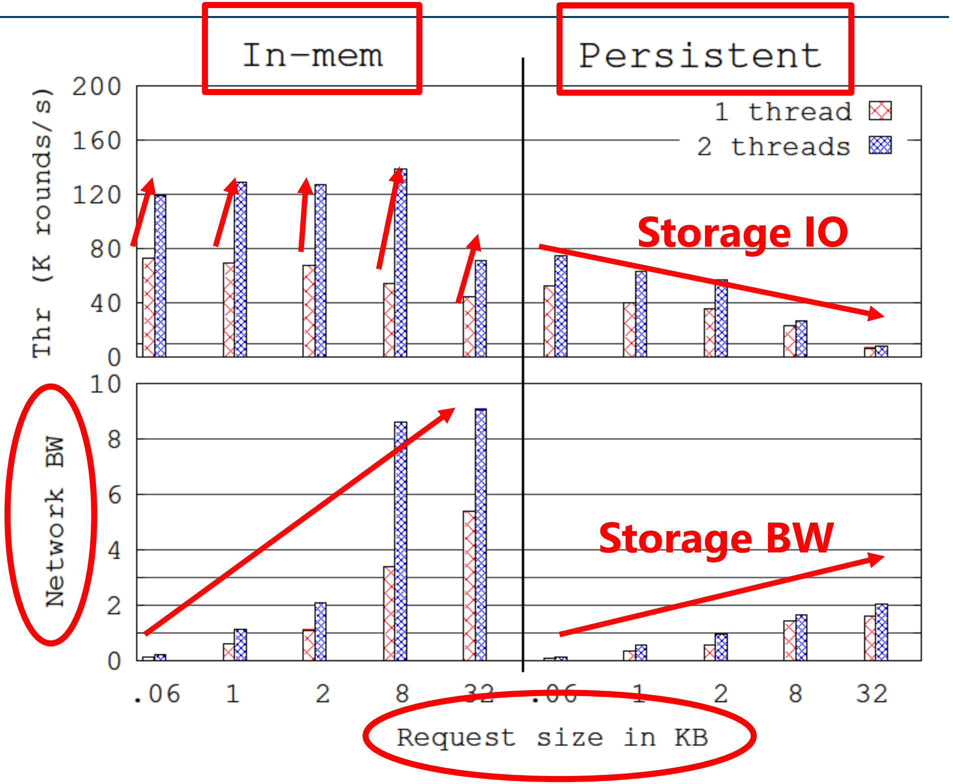
# Performance Analyser

- Generates **performance profile**
  - Similar to [Quasar-SIGPLAN14], [Bazaar-SoCC12], [Matrix-ICAC14].

    Large space to explore

1. Control SLAs
2. Translate high-level user SLAs to resource costs

- **Chain Replication** [OSDI-2004]
  - Or any other (e.g., Paxos)



In-mem

Persistent

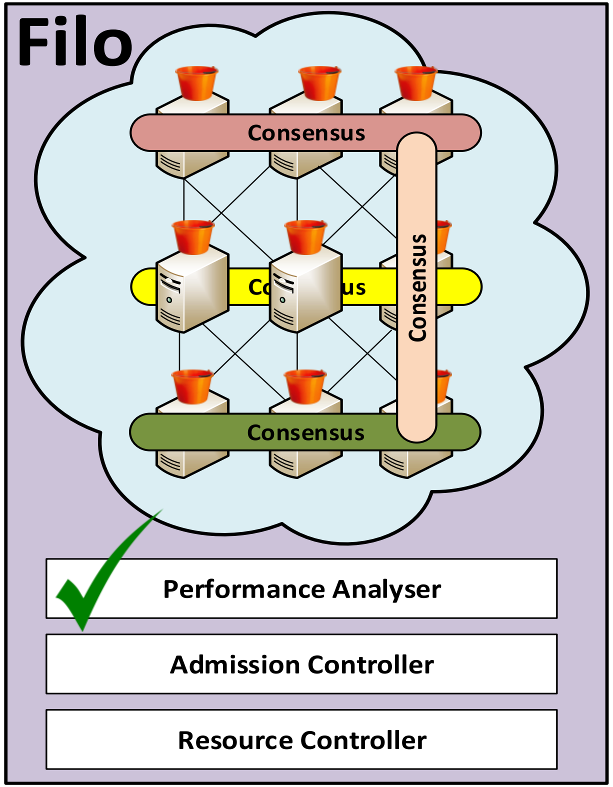
Storage IO

Storage BW

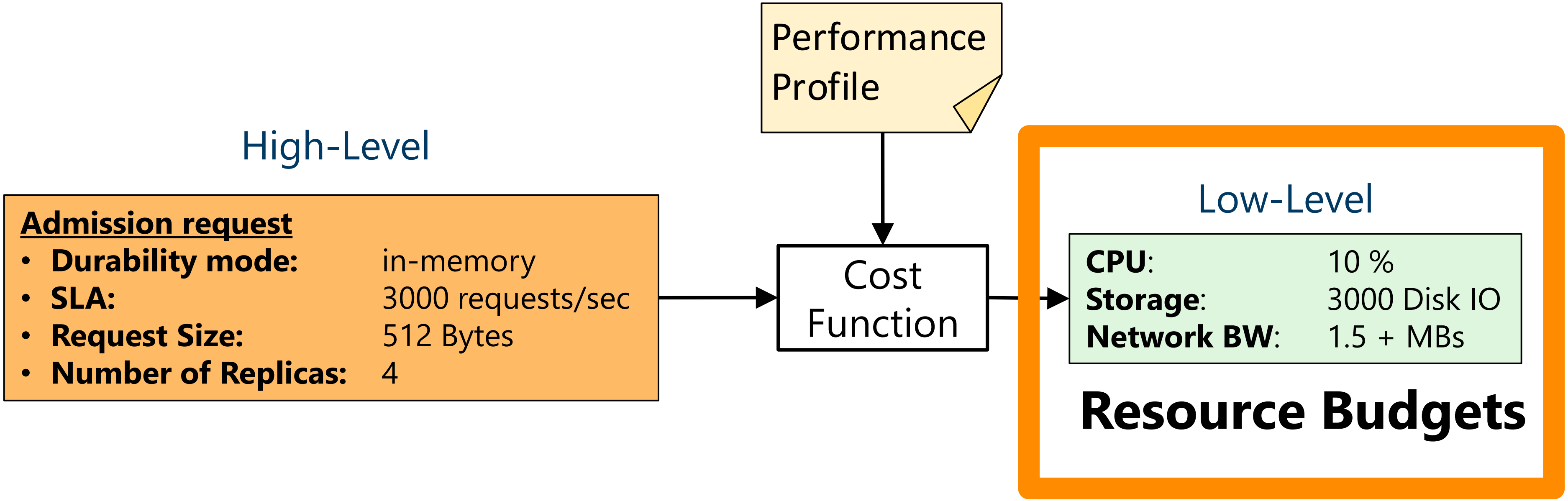
**Performance Profile**

# Filo

1. Performance Analyser
2. **Admission Controller**
    1. **SLA Translation**
    2. Placement
3. Resource controller



# SLA Translation



High-Level

**Admission request**

| | |
|---|---|
| • **Durability mode:** | in-memory |
| • **SLA:** | 3000 requests/sec |
| • **Request Size:** | 512 Bytes |
| • **Number of Replicas:** | 4 |

Performance Profile

Cost Function

Low-Level

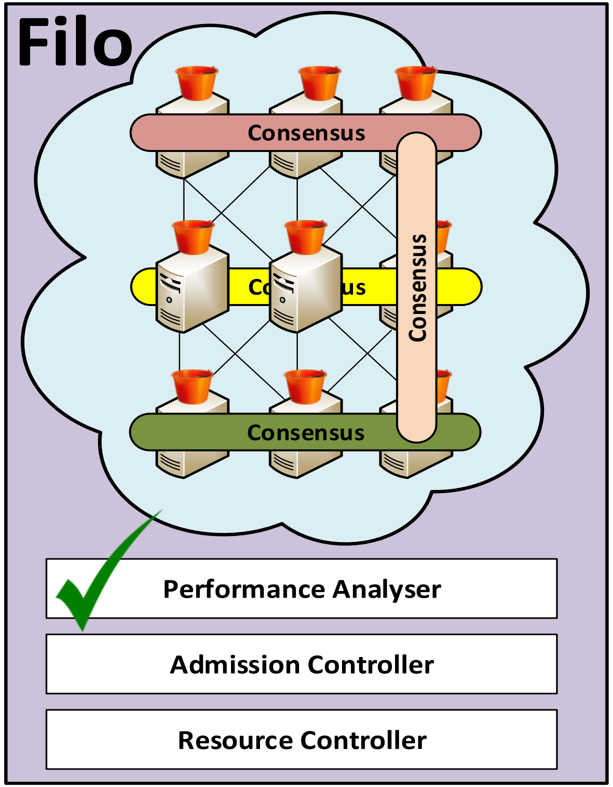
| | |
|---|---|
| **CPU**: | 10 % |
| **Storage**: | 3000 Disk IO |
| **Network BW**: | 1.5 + MBs |

**Resource Budgets**

- Tenant is not limited to 512-B requests

# Filo

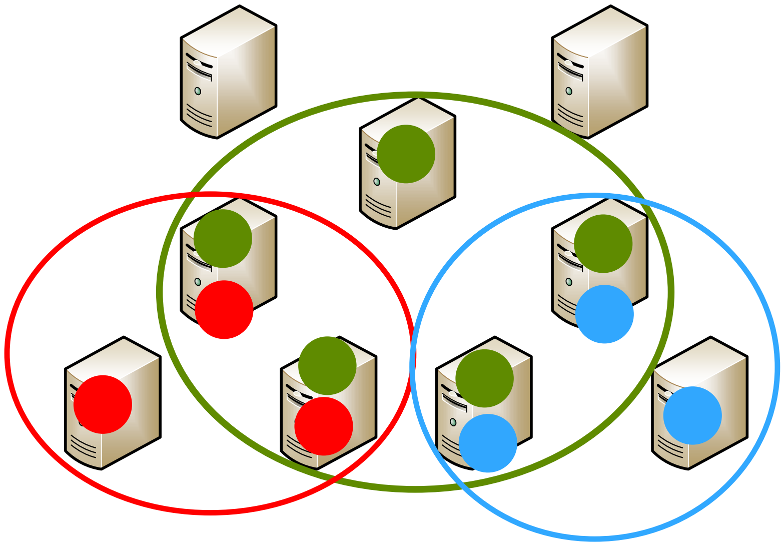
1. Performance Analyser
2. **Admission Controller**
    1. SLA Translation
    2. **Placement**
3. Resource controller

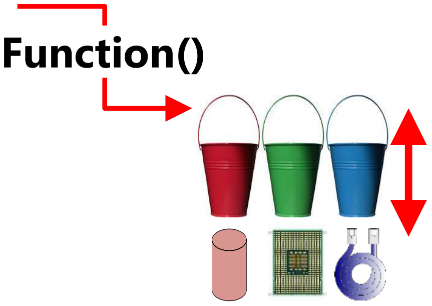


# Placement

- Multi-Resource Bin-Packing
  - Greedy approach
  - Respecting objectives and constraints:
    - **Replicas of a consensus group on distinct servers**

Replica ○





**Request**

**CostFunction()**

**Resource Budget**

Storage IO CPU Network BW

# However:

## Tenant demand may be higher/lower than Resource Budget

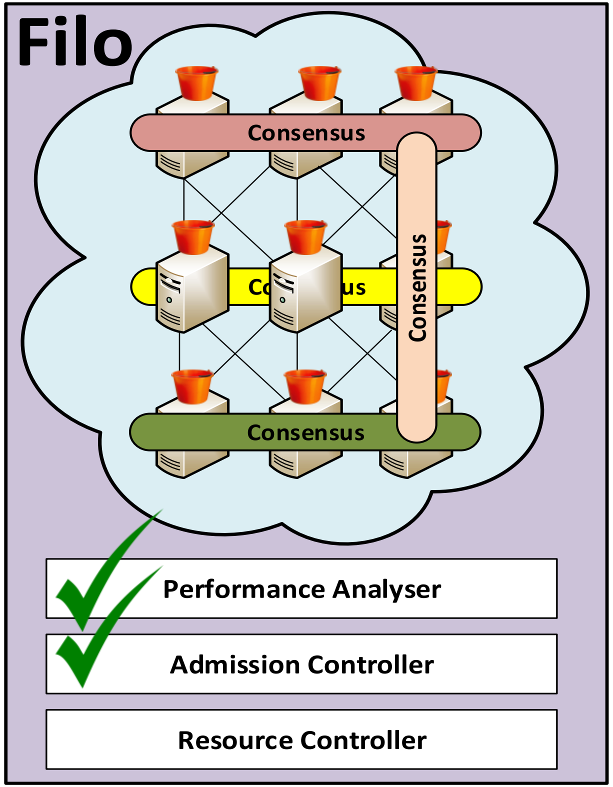
Can we change Resource Budget at runtime ?
Without violating others SLAs?

# Filo

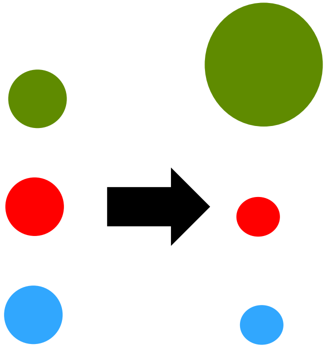
1. Performance Analyser

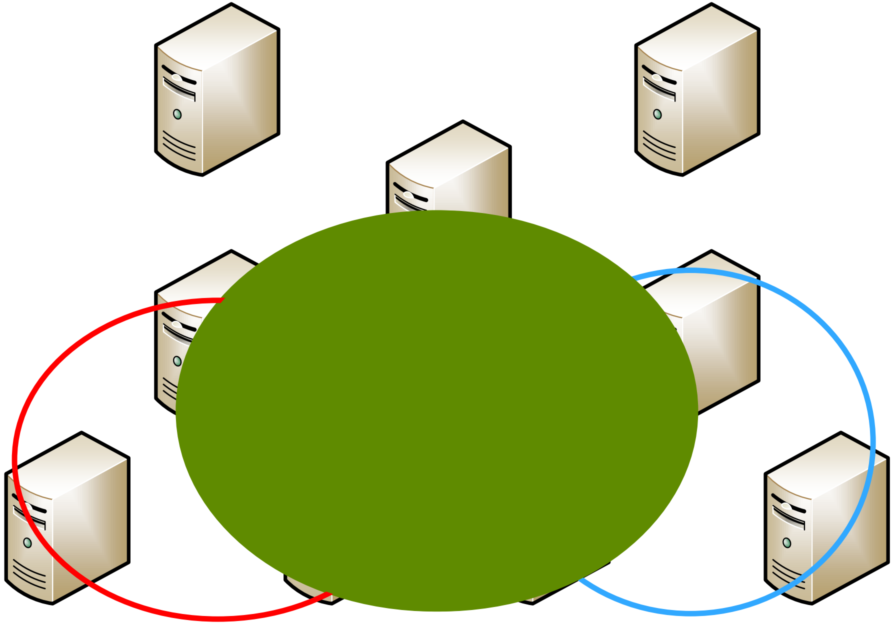
2. Admission Controller
   1. SLA Translation
   2. Placement

3. **Resource controller**

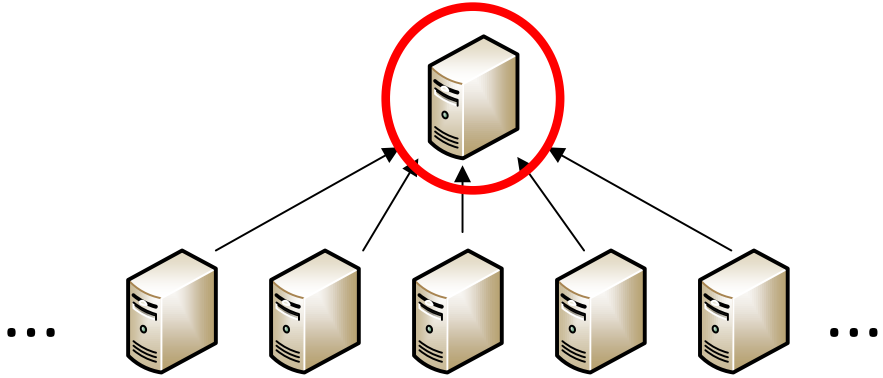


# Resource Usage at Runtime





# Centralized Resource Controller

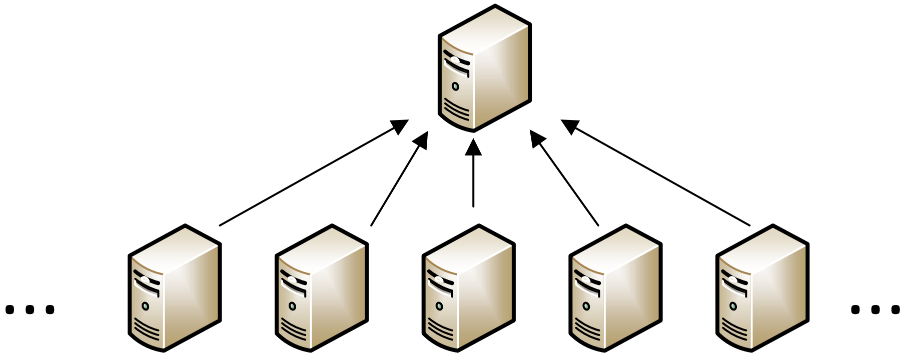


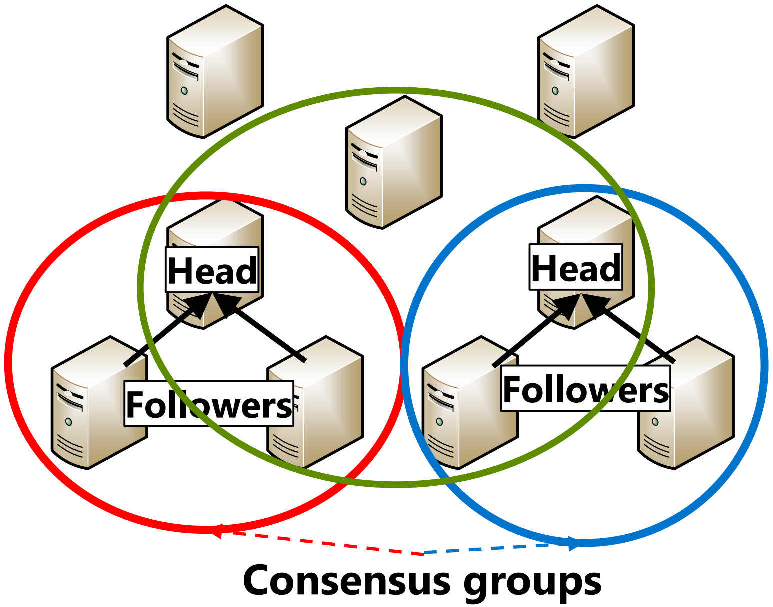
| Tenant | Granted Extra Requests |
|---|---|
| **Alice** | 10 extra requests/sec<br>Size: 512 B |
| **Bob** | 5 extra requests/sec<br>Size: 8KB |
| … | … |

**Optimal resource usage but Slow**

- Polynomial with # tenants
- Collect all information centrally

# Distributed Resource Controller





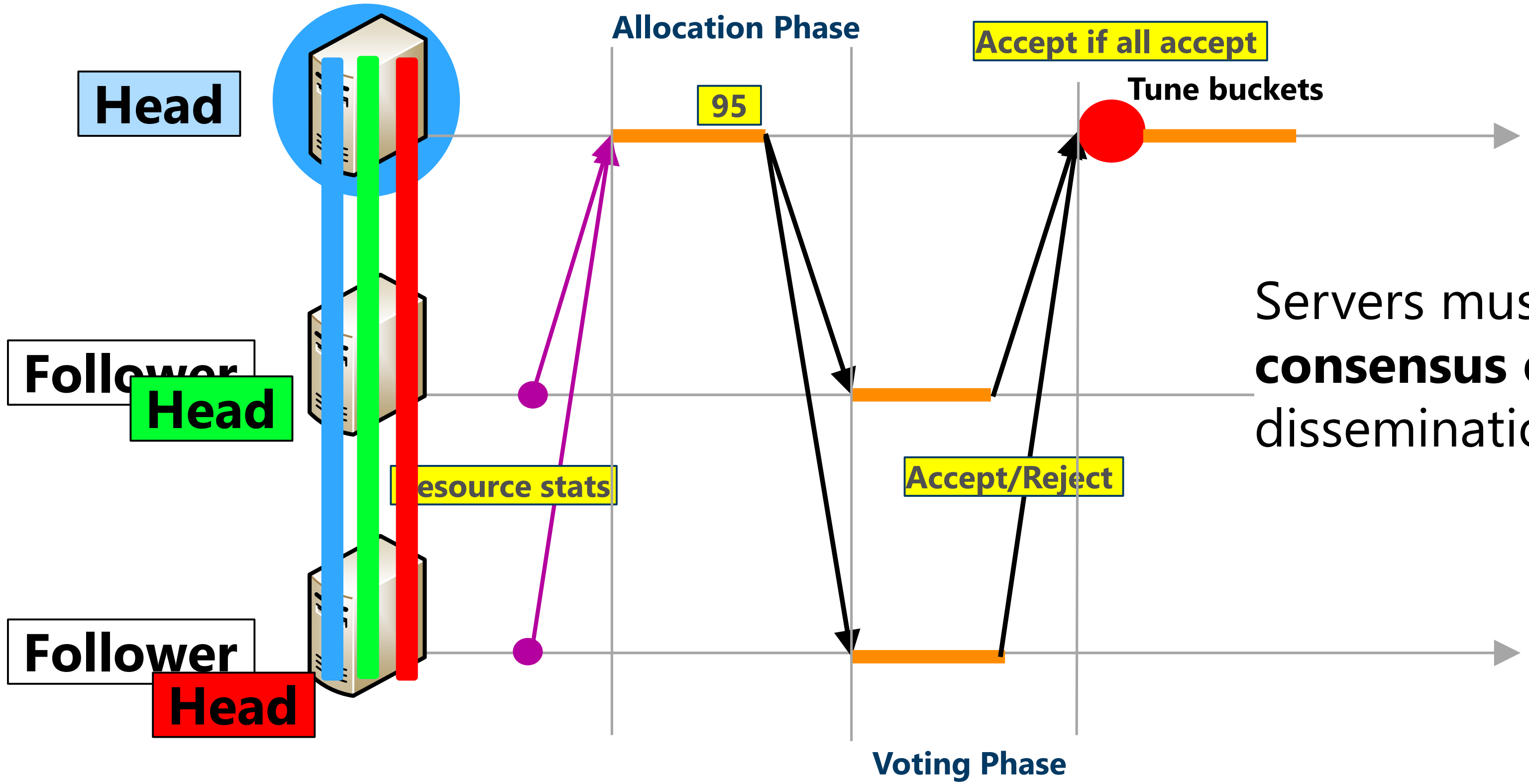
Slow computation
High resource usage

Faster computation
resource usage?

# Head-DRF

Dominant Resource Fairness [NSDI-2011]

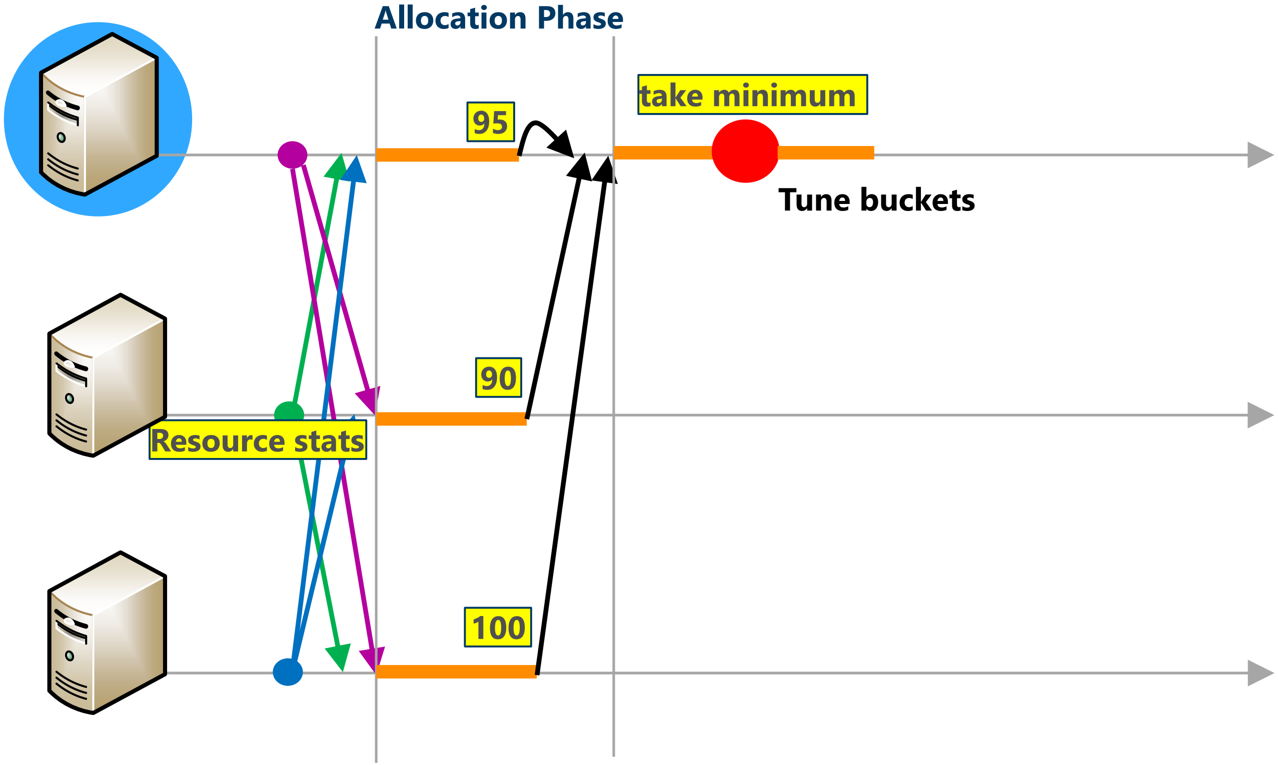
**Alice: 200 extra requests**



Servers must have **consensus** on resource dissemination

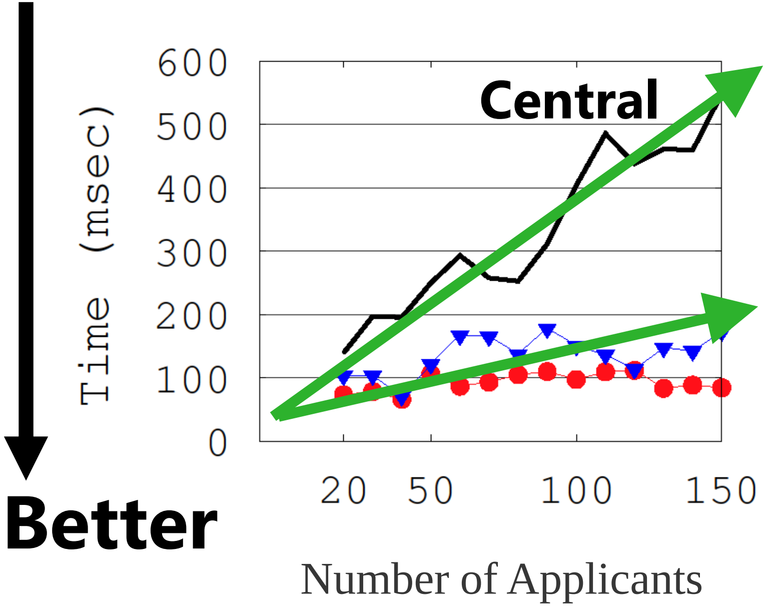
# ALL-DRF

Alice: 200 extra requests



# Evaluating Resource Controller

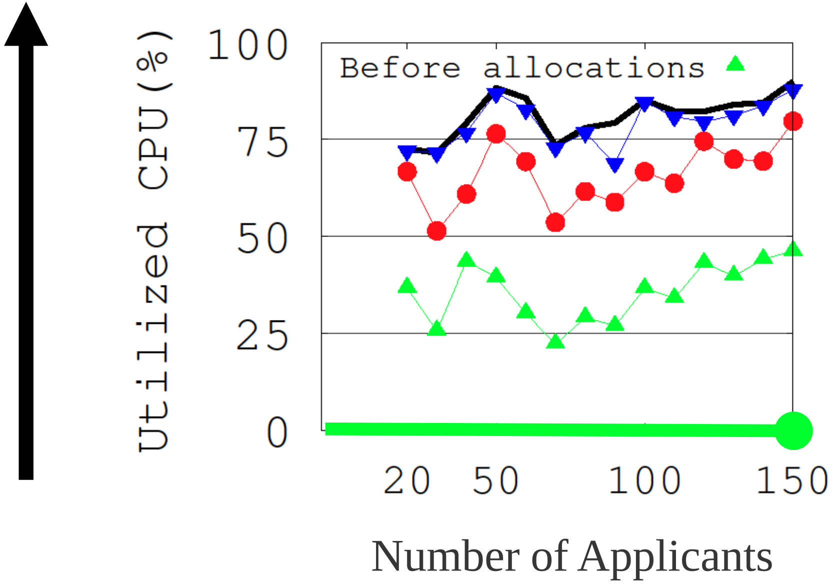
**Head-DRF** ● **All-DRF** ▲



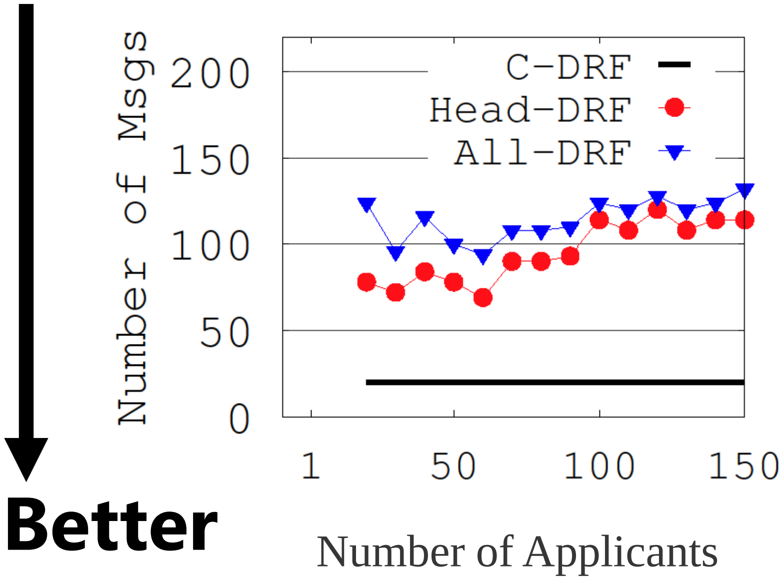
**Better**

## Maximize resource usage

**Better**



# Message Complexity



- ➢ Overhead is affordable given the many number of msgs exchanged for the service itself

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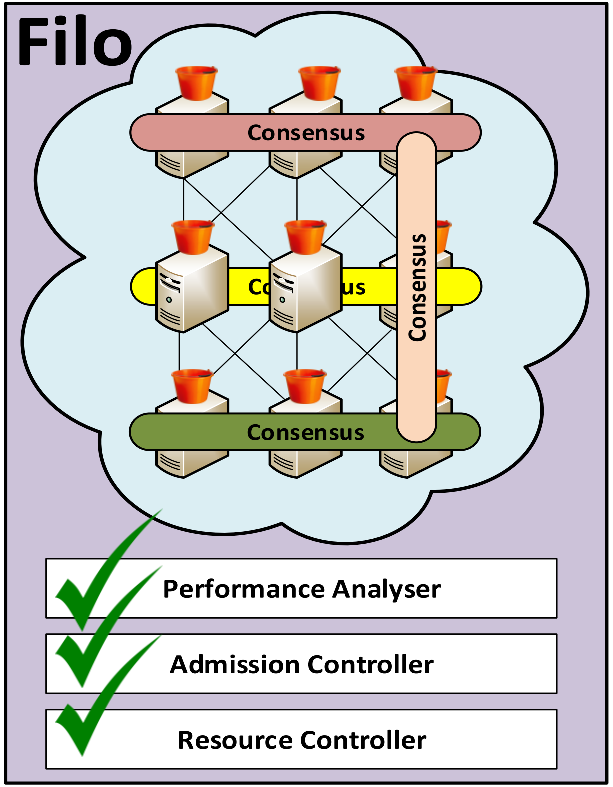
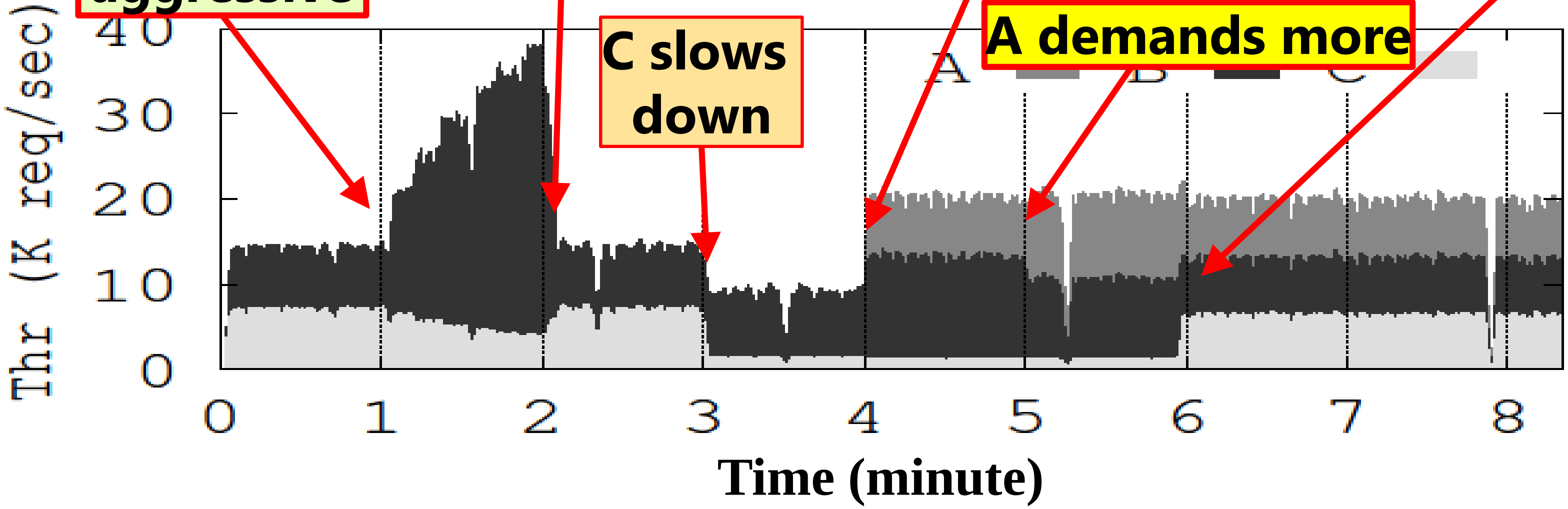


# Testbed

- 10 Dell servers each with 10-core Intel Xeon
- 10 Gbps Mellanox ConnectX-3 NIC
- 128 GB RAM
- Hyper threading enabled
- 2 HDDs
- Hierarchical Switches

**A**-SLA: 6.5 K reqs/sec ▓
**B**-SLA: 6.5 K reqs/sec ■
**C**-SLA: 6.5 K reqs/sec ░
Request size: 1 KB
Async disk IO

# Filo



**B becomes aggressive**

**Enable rate limiters**

**C slows down**

**Enable Resource controller**

**B demands more**

**A demands more**

**C restores speed**

# Conclusions

- First system to provide consensus as a multi-tenant cloud service
  - A cheaper and convenient alternative for users
  - First distributed resource controller using DRF

Filo