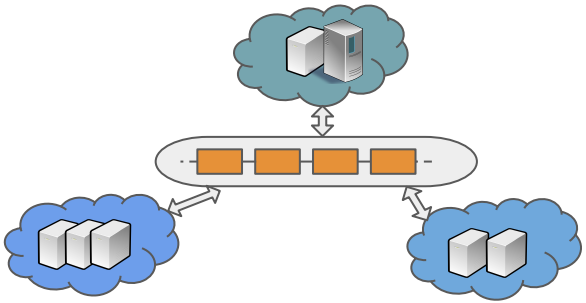
Towards a Democratic Federation for Infrastructure Service Provisioning



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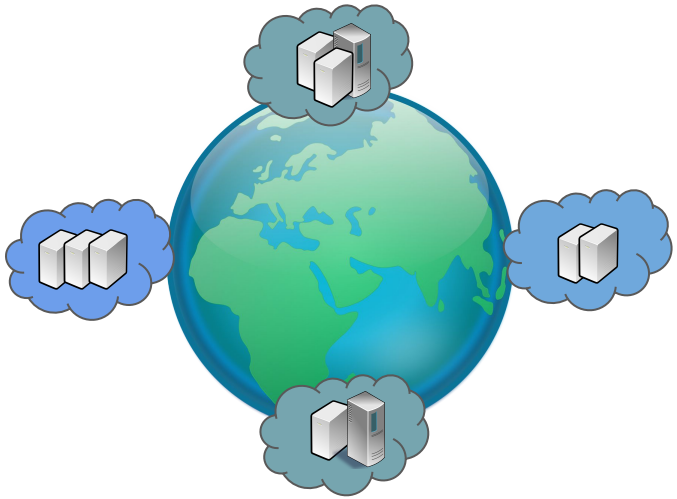
Cloud Federations

Collaboration among different **Cloud Service Providers** (CSPs), whereby they agree to mutually share their own resources for their overall benefit.



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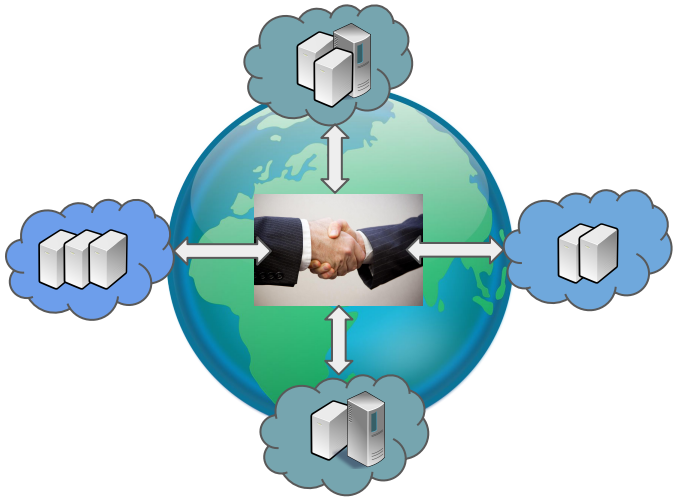


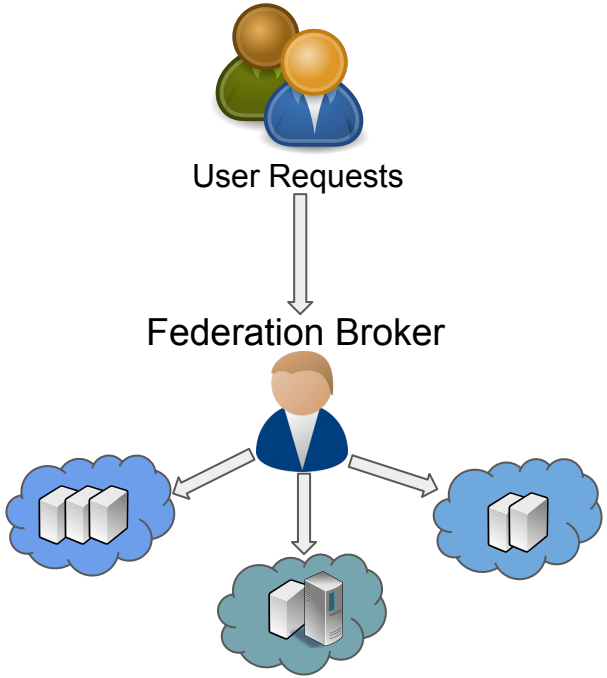
Motivation for cloud federation

- **Sharing** of computing resources.
- **Aggregation of unused resources** from different service providers.
- Bringing services closer to customers by maximizing the **geographical dispersion**.
- **Tackling data protection laws** that requires data to be stored within country’s boundary.

Existing cloud federations

Mostly **Centralized** Approach:

1. **Centralized cloud broker**



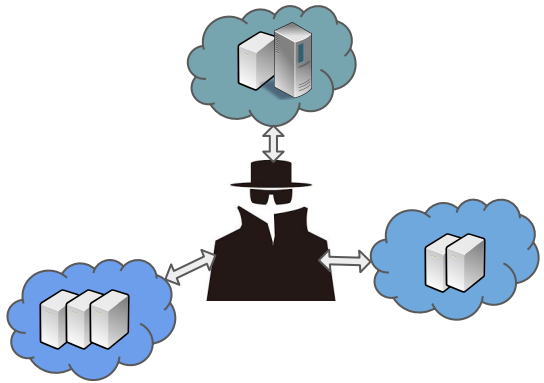
Existing cloud federations

Mostly **Centralized** Approach:

2. Centralized cloud exchange

Limitations of existing federations:

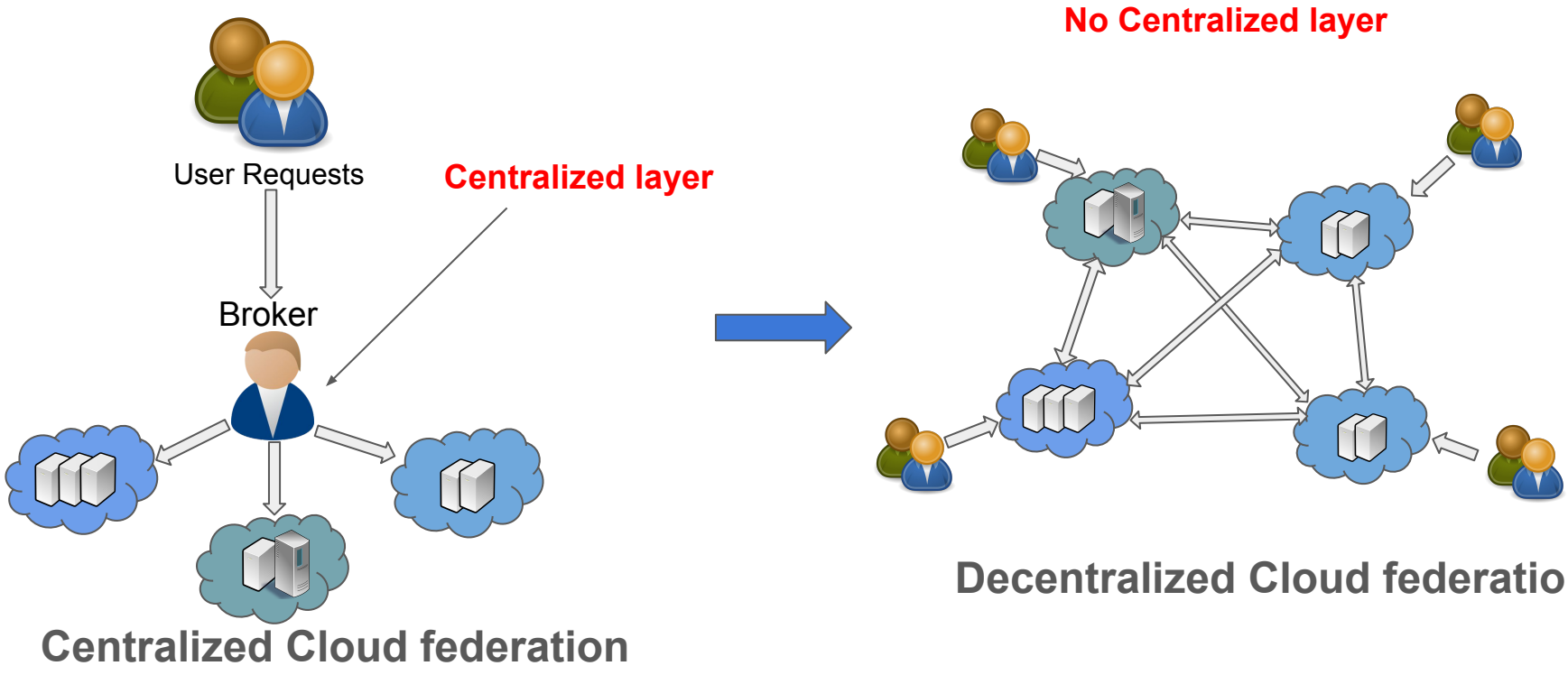
1. Profit sharing with central broker
2. Biasness of broker towards certain service providers
3. Price manipulation (*Broker can be malicious*)
4. Unfair dispute resolution
5. Central point of failure



Objective

Remove the central broker **and design a transparent distributed system for cloud federation.**

Centralized to Decentralized



Some related works

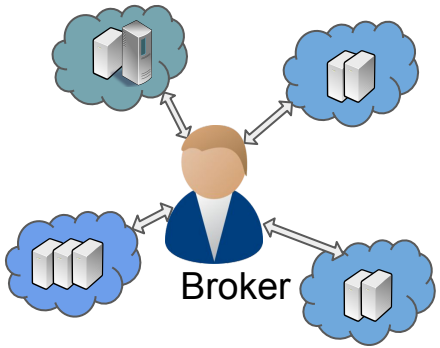
S. Kirkman	Data movement policy framework using smart contracts[1]	Not concerned with multiple CSPs
Sukhodolskiy et al.	Blockchain-based access control system for cloud storage[2]	
Zhou et al.	Blockchain based witness model for SLA monitoring[3]	
Margheri et al.	Distributed infrastructure for democratic cloud federations[4]	Public Blockchain

[1] S. Kirkman, "A data movement policy framework for improving trust in the cloud using smart contracts and blockchains," in IEEE IC2E, 2018, pp. 270–273.
[2] I. Sukhodolskiy and S. Zapechnikov, "A blockchain-based access control system for cloud storage," in IEEE EIConRus, 2018.
[3] H. Zhou, X. Ouyang, Z. Ren, J. Su, C. de Laat, and Z. Zhao, "A blockchain based witness model for trustworthy cloud service level agreement enforcement," in IEEE INFOCOM, 2019.
[4] A. Margheri, M. S. Ferdous, M. Yang, and V. Sassone, "A distributed infrastructure for democratic cloud federations," in IEEE CLOUD, 2017, pp. 688–691.

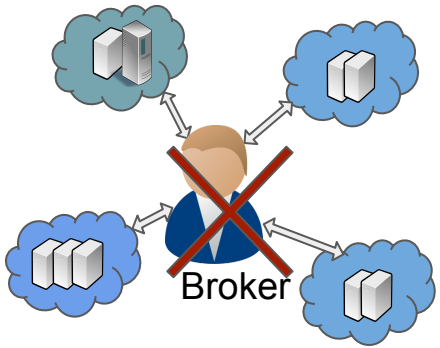
Challenges

- A decentralized platform for exchange of infrastructure resources (VM) must be developed.
- The system must allow coordination between service providers while enforcing FLA, without the help of any broker.
- Cloud functions such as VM Placement and VM Migration needs to be coordinated over the decentralized architecture.
- Fair ordering of transactions must be ensured

Proposed Architecture



Proposed Architecture



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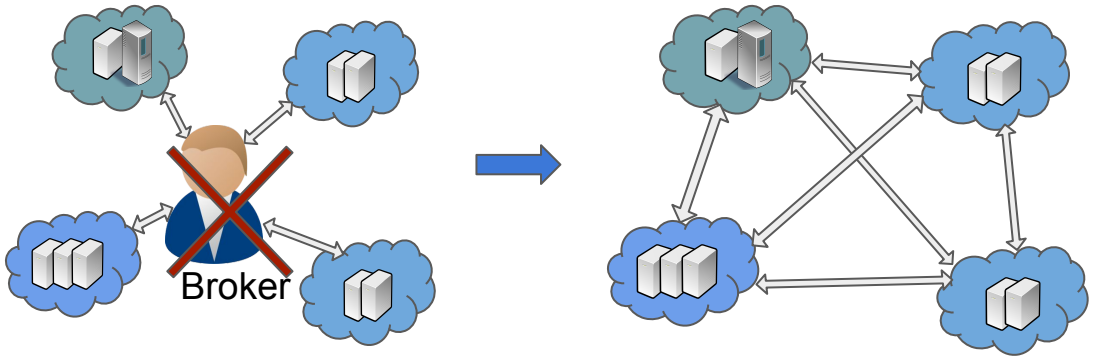
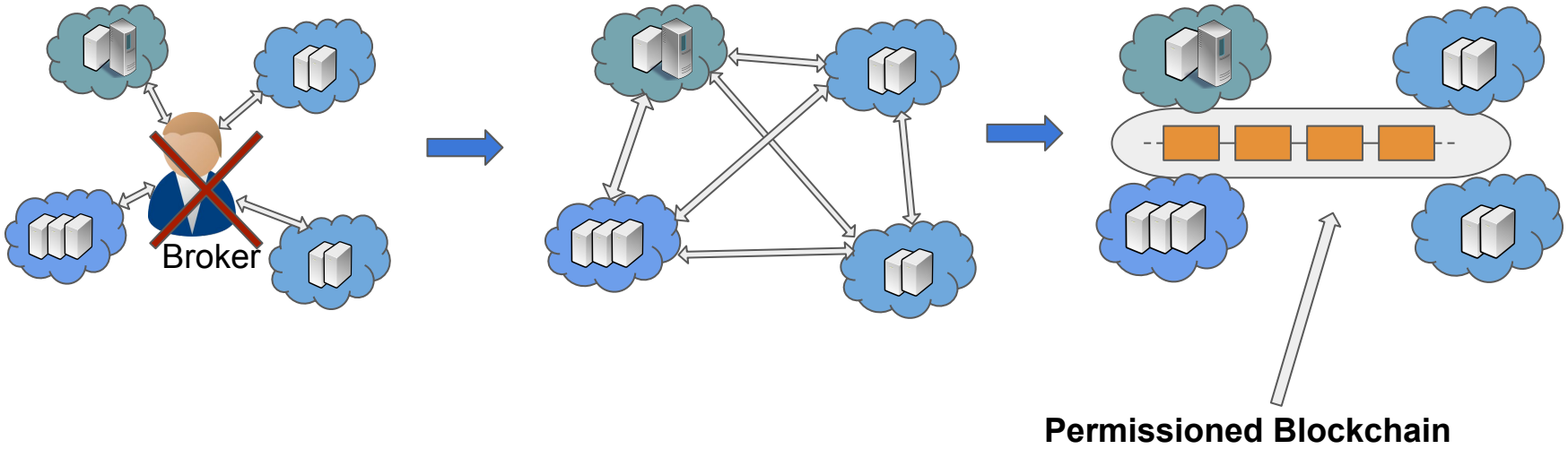


Proposed Architecture



Proposed Architecture

Permissioned blockchain based **decentralized exchange** for **democratic** cloud federations: ***CloudChain***

Proposed Architecture

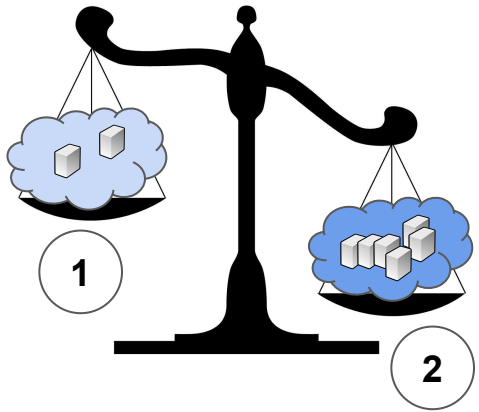
For simplicity we assume that the federation contains two types of service providers namely,

1. Demanding service providers:

   Suffer from **resource limitations** and require other members of the federation to create instances for them at peak loads.

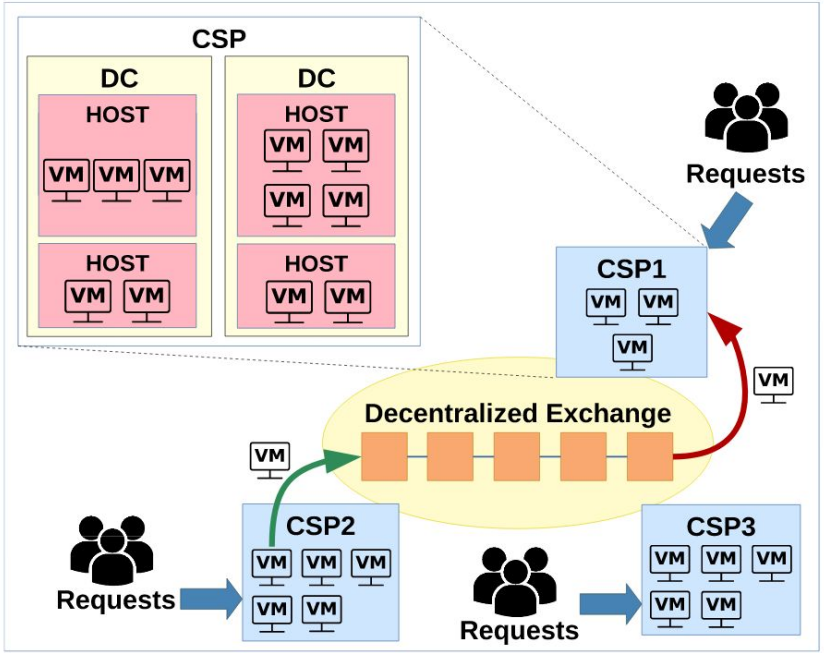
2. Supplying service providers:

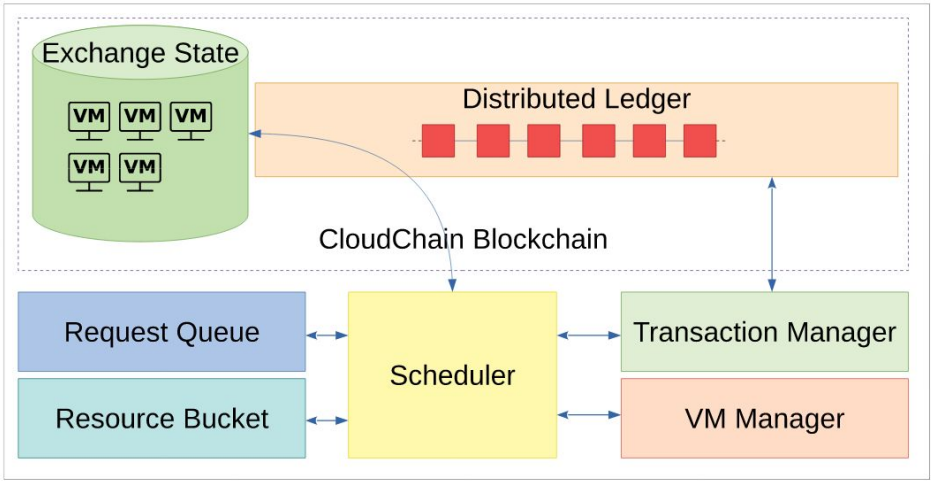
   Having **abundant resources** which goes unused.



Proposed Architecture

CloudChain





Components of CloudChain

CloudChain model overview

Components

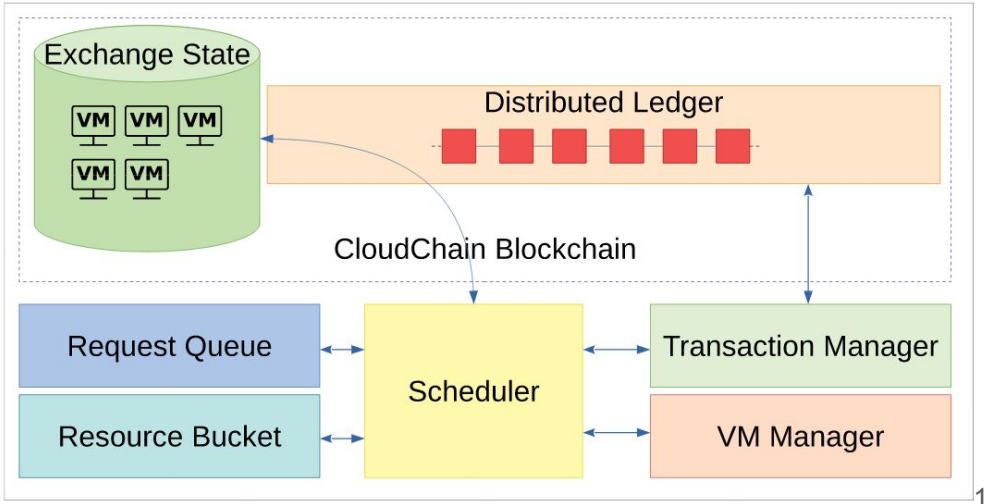
1) *CloudChain* Blockchain: Distributed Ledger & Exchange State

2) Request Queue and Resource Bucket

3) Scheduler

4) Transaction Manager

5) VM Manager



Components

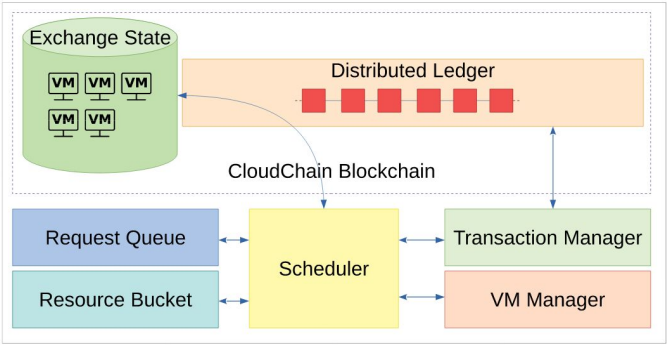
Request Queue (*ReQ)*: queue of incoming multi-tier web application requests

Resource Bucket:

Bucket of available resources, which may include both local resources and exchange resources.

1) Local resource bucket (*ResBlocal*)

2) Exchange resource bucket (*ResBexchange*)

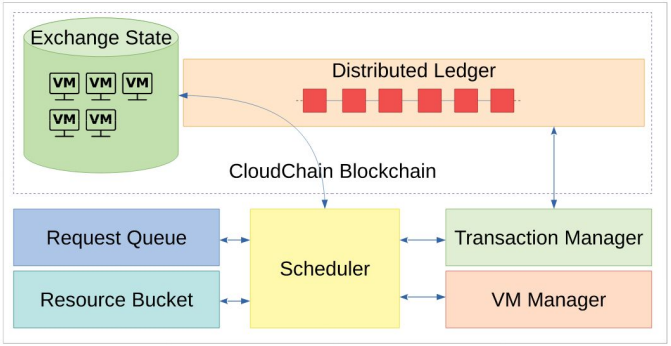


Components

Scheduler: Coordinates all the components of *CloudChain*

Transaction Manager: An interface to the *CloudChain* Blockchain.

VM Manager: Manages creation, deletion and access to VMs.



***CloudChain* Blockchain** serves as an information registry that maintains the current state of available resources and demand patterns. Thus it acts as a common marketplace where different CSPs can offer their unused or excess resources for outsourcing, and rent resources from other CSPs when required.

Exchange State

Offerings			
ID	Supplying SP	Specs	Price/BTU
o_1	Cloud 1	2 Cores, 4GB, UK	15$/Month
o_2	Cloud 2	2 Cores, 8GB, US	18$/Month
o_3	Cloud 1	2 Cores, 2GB, UK	0.16$/Day

Requests			
ID	Demanding SP	Offering Id	Duration
r_1	Cloud 2	o_1	6 Months
r_2	Cloud 3	o_2	12 Months

Associations			
ID	Demanding SP	Offering Id	Duration
a_1	Cloud 3	o_5	3 Months
a_2	Cloud 5	o_4	7 Days

CloudChain Blockchain

The high level **operations** that the CSPs can perform on the exchange are:

1) **Offer** a new resource

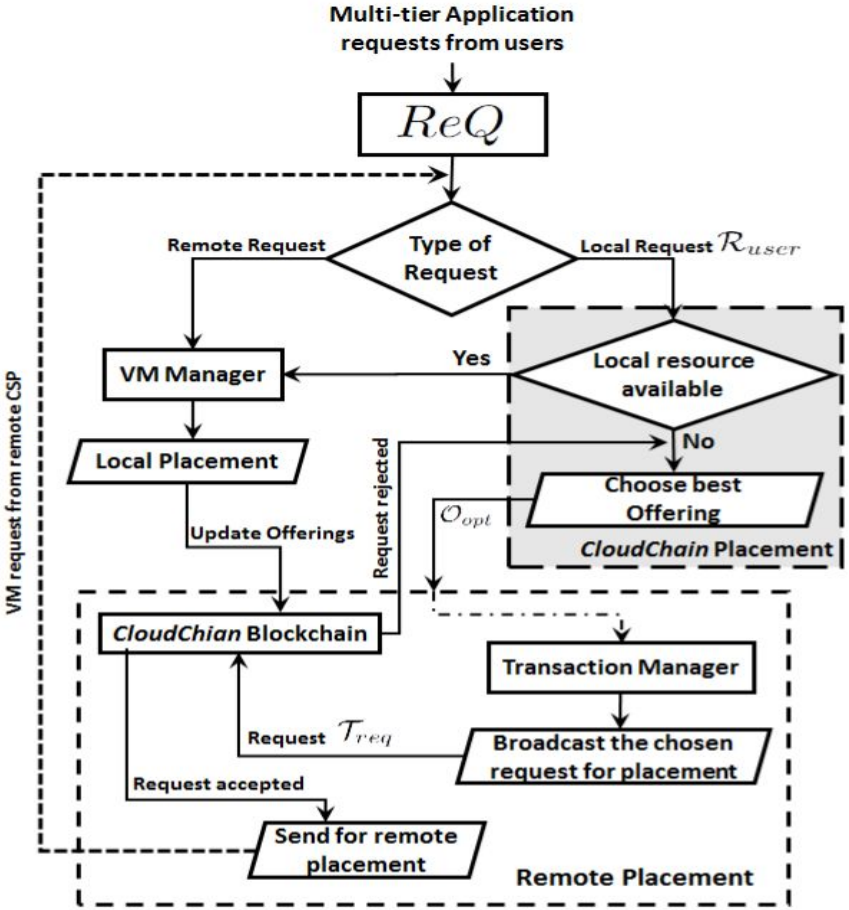
2) **Modify** an existing offering

3) **Query** for available resources offerings

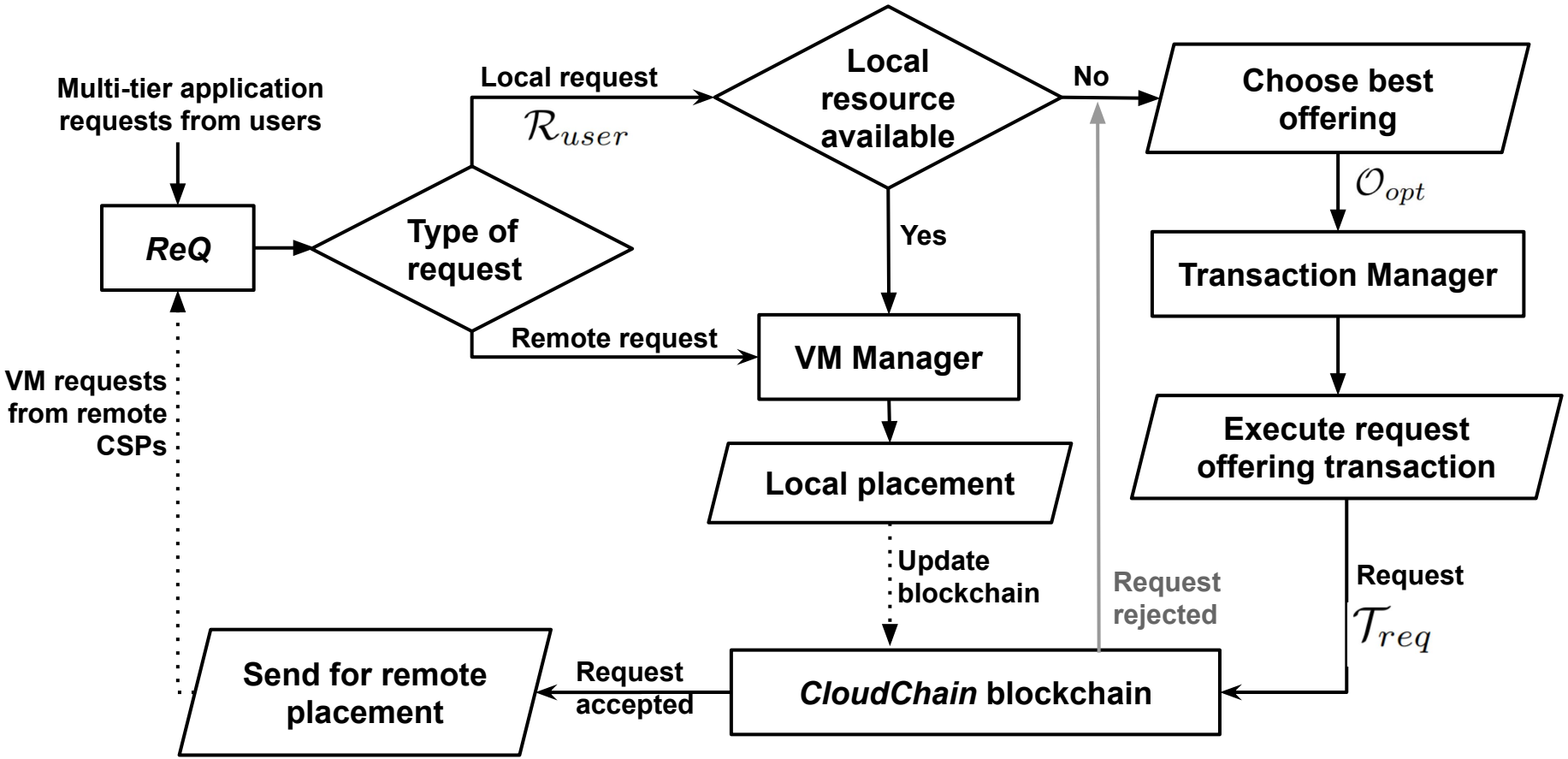
4) **Request** to rent a resource

5) **Grant/Reject** a request

System Flow


Multi-tier Application requests from users
ReQ
Type of Request
Remote Request
Local Request $\mathcal{R}_{user}$
Local resource available
Yes
No
VM Manager
Local Placement
Update Offerings
Request rejected
Choose best Offering
$\mathcal{O}_{opt}$
CloudChain Placement
VM request from remote CSP
CloudChian Blockchain
Transaction Manager
Request $\mathcal{T}_{req}$
Broadcast the chosen request for placement
Request accepted
Send for remote placement
Remote Placement

System Flow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Transaction Manager
Execute request offering transaction
Request
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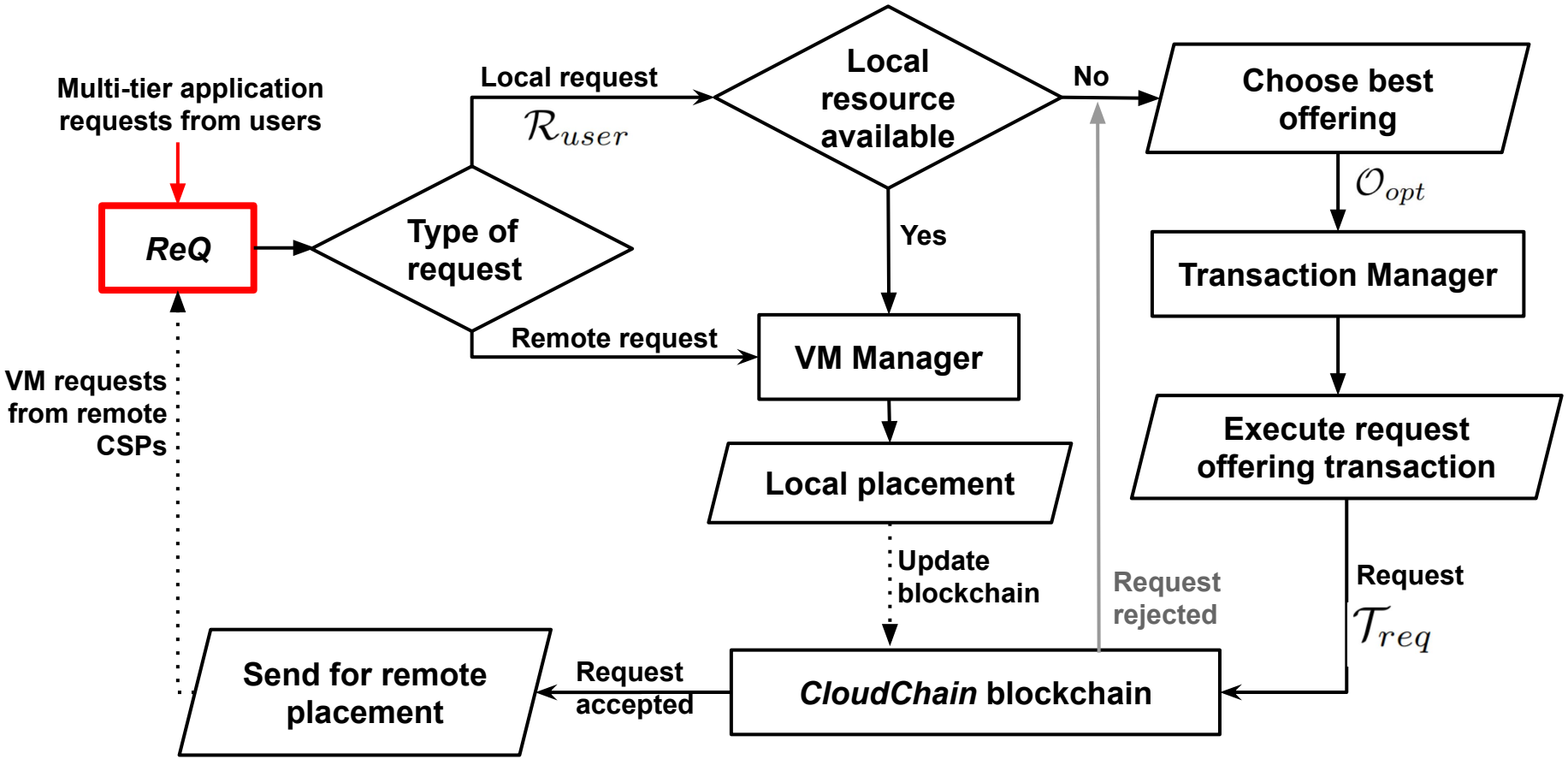
VM Manager
Local placement
Update blockchain
Request rejected
CloudChain blockchain
Request accepted
Send for remote placement
VM requests from remote CSPs

System Flow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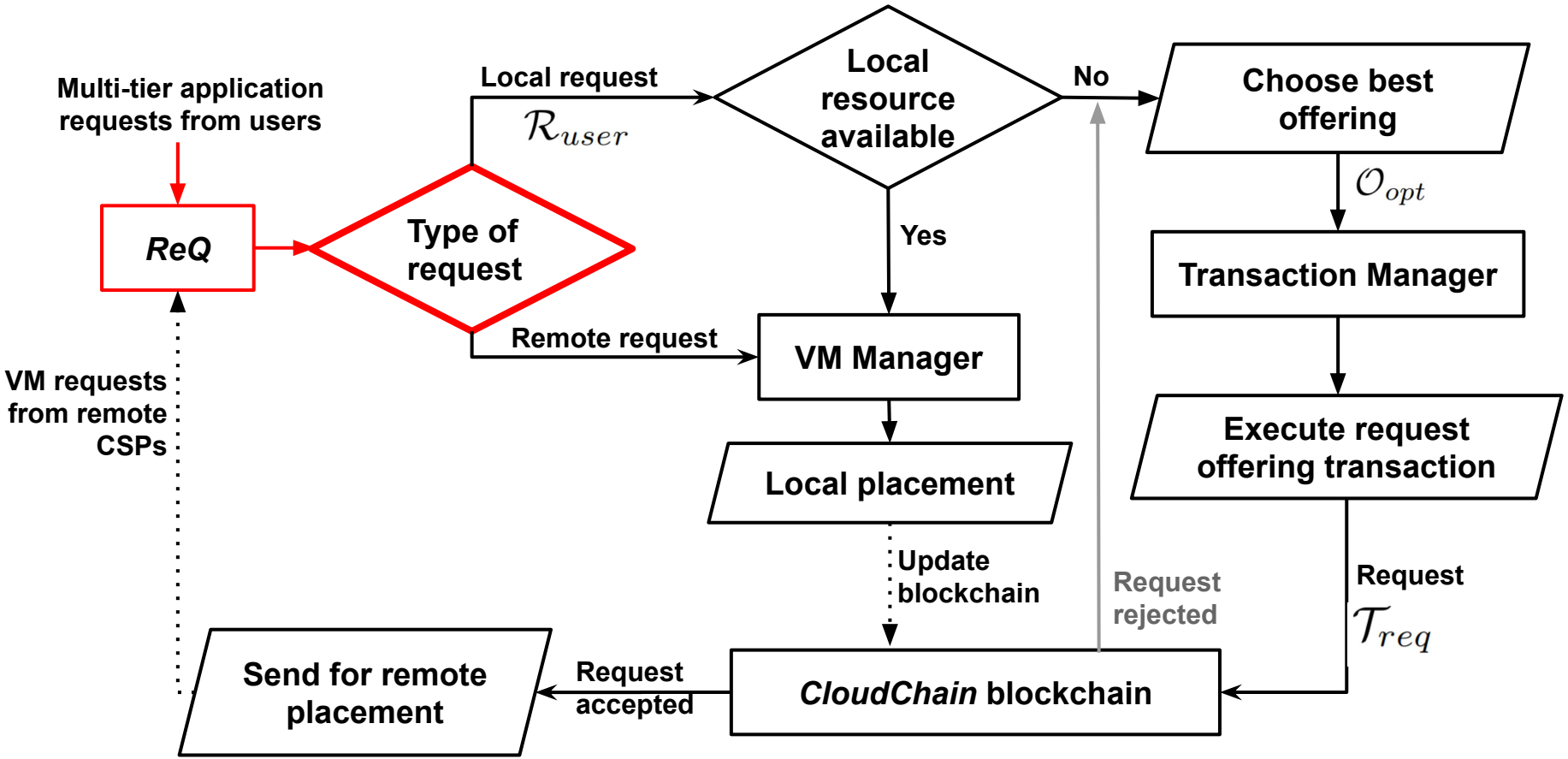
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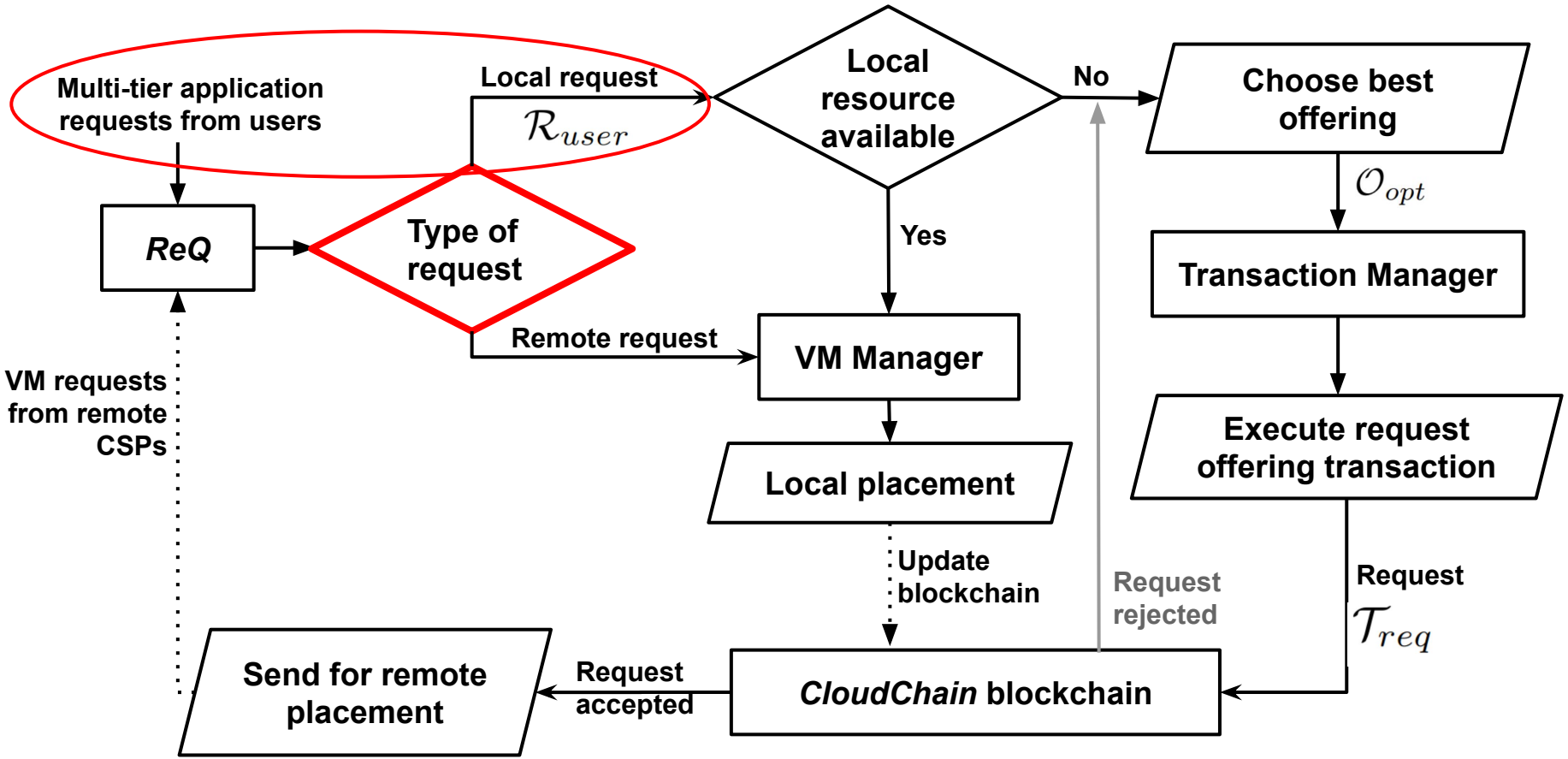
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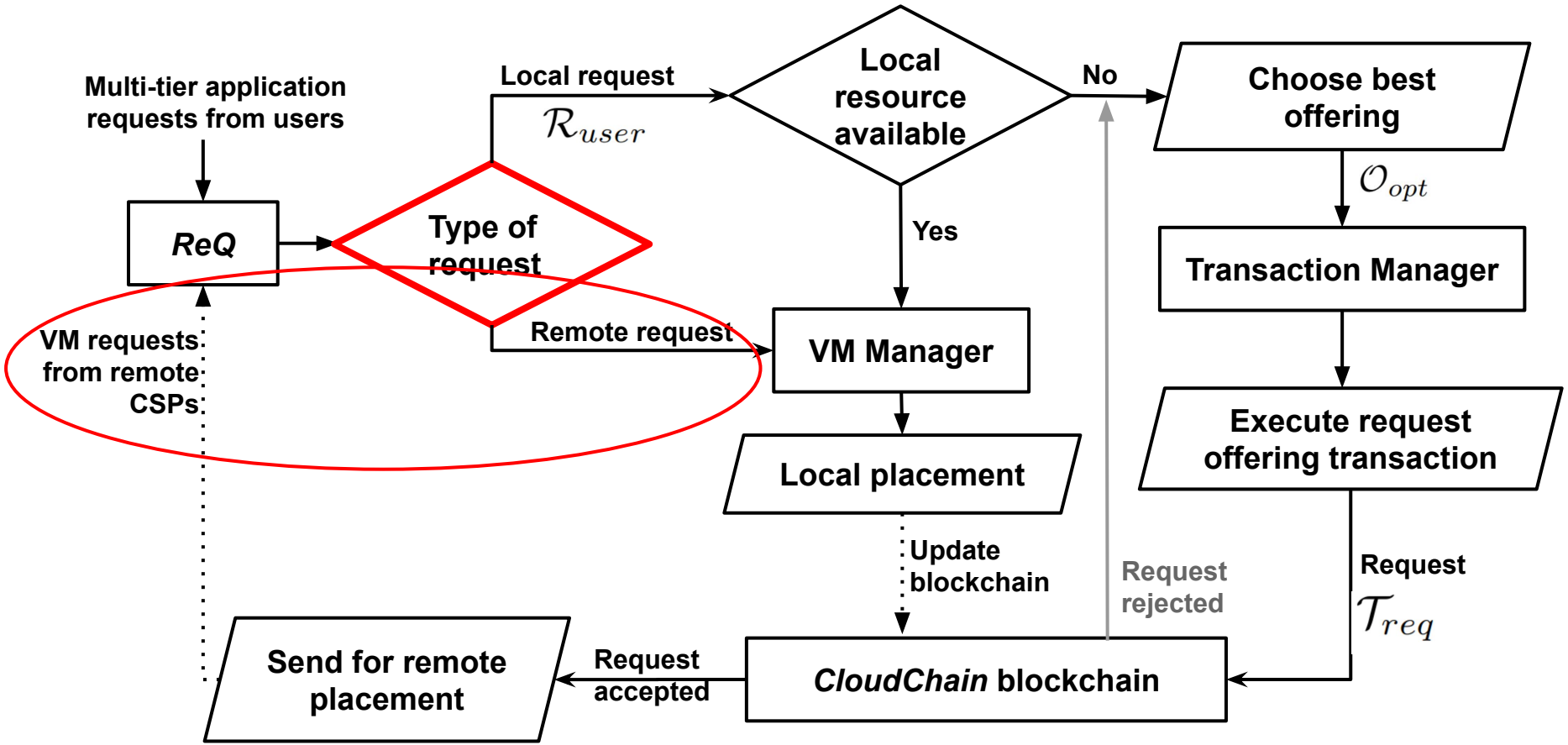
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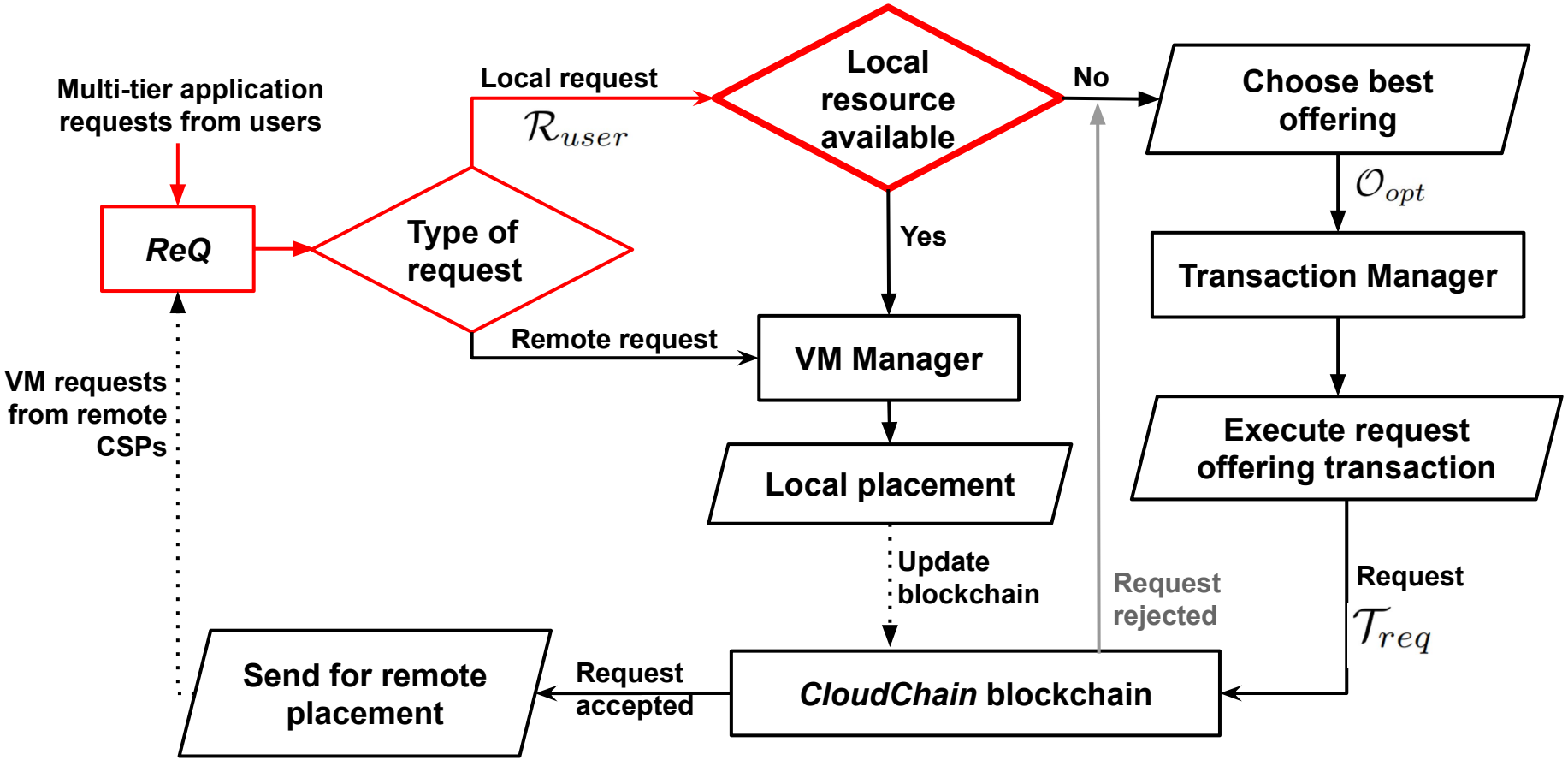
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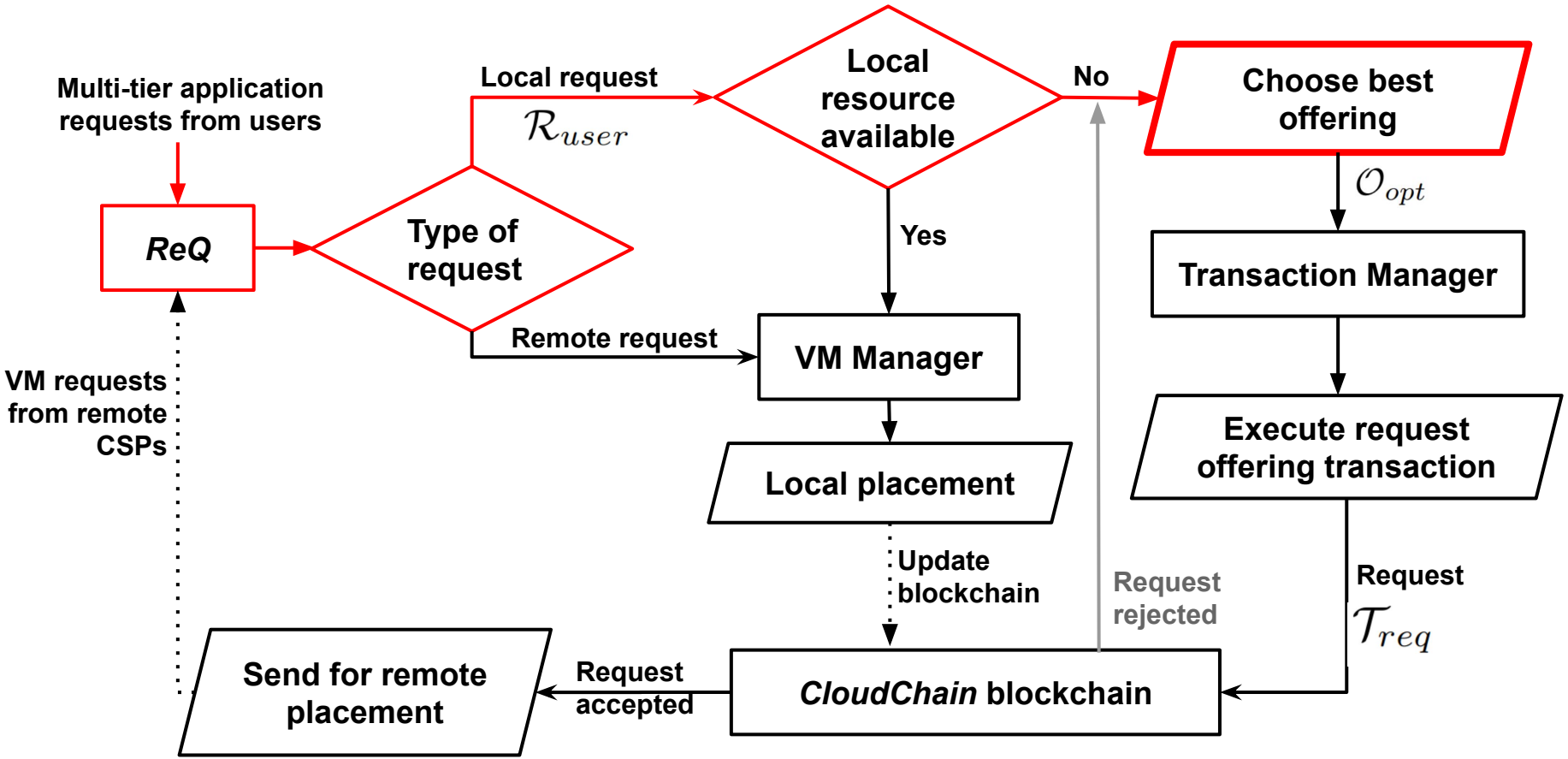
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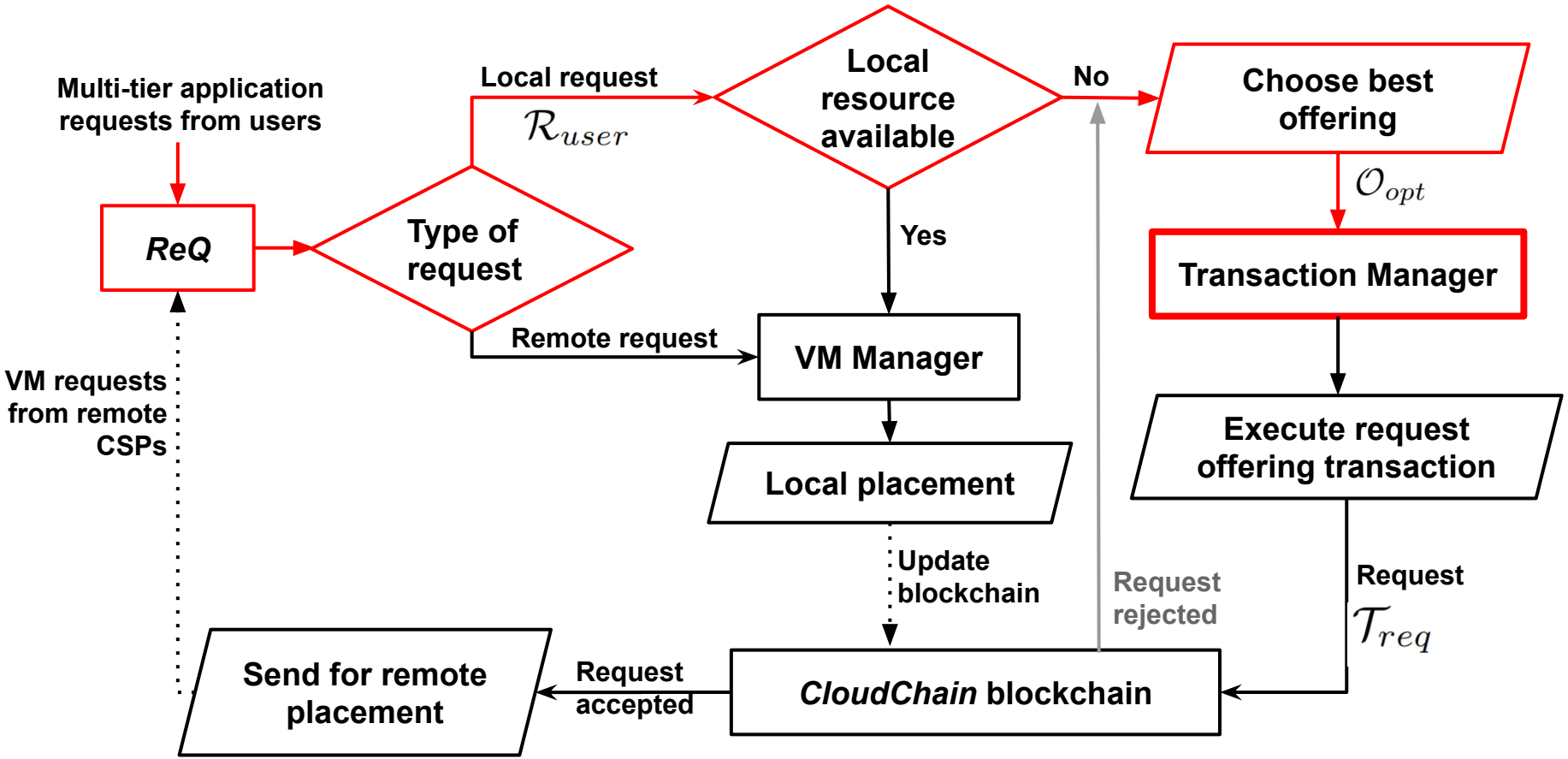
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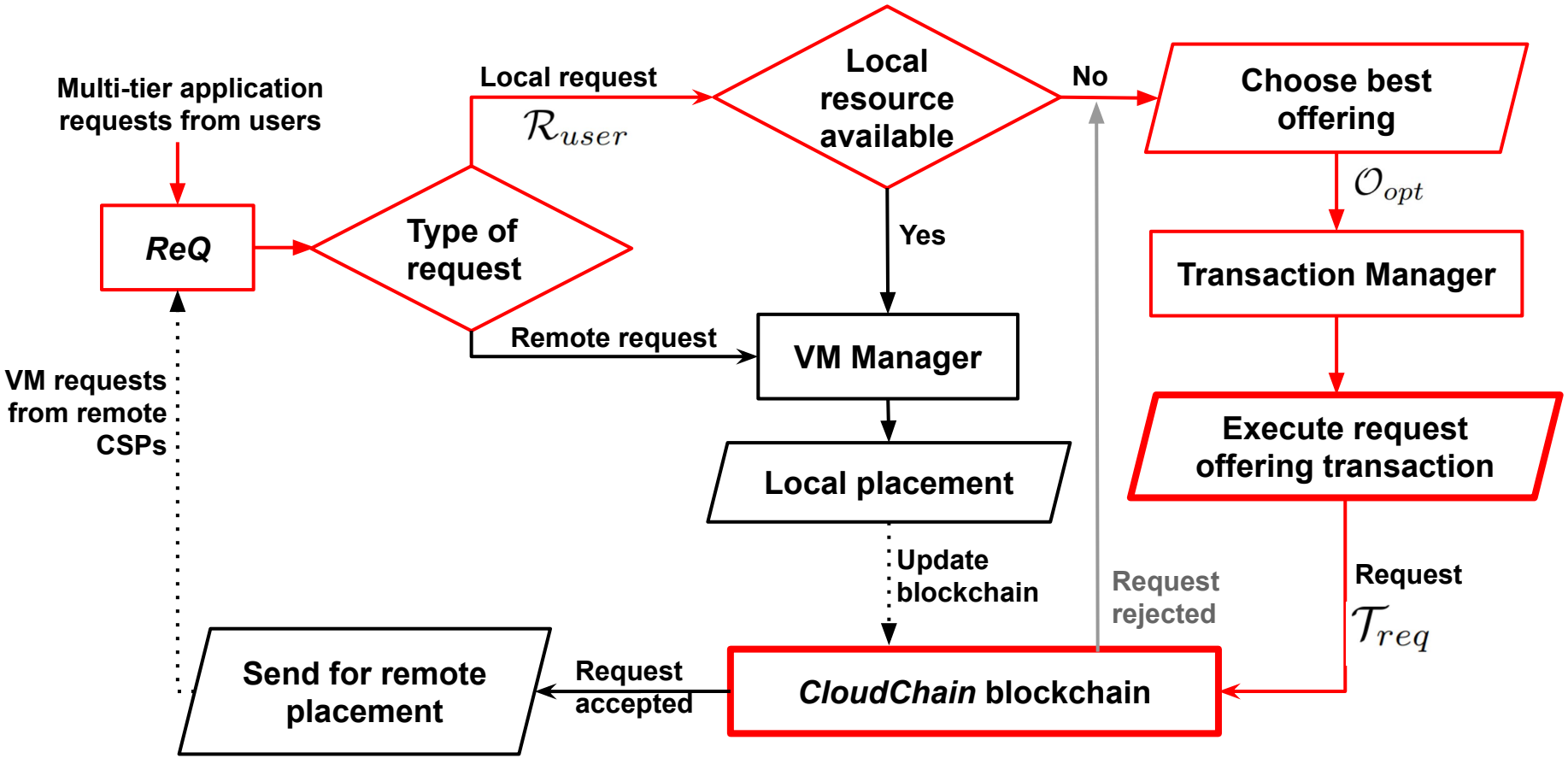
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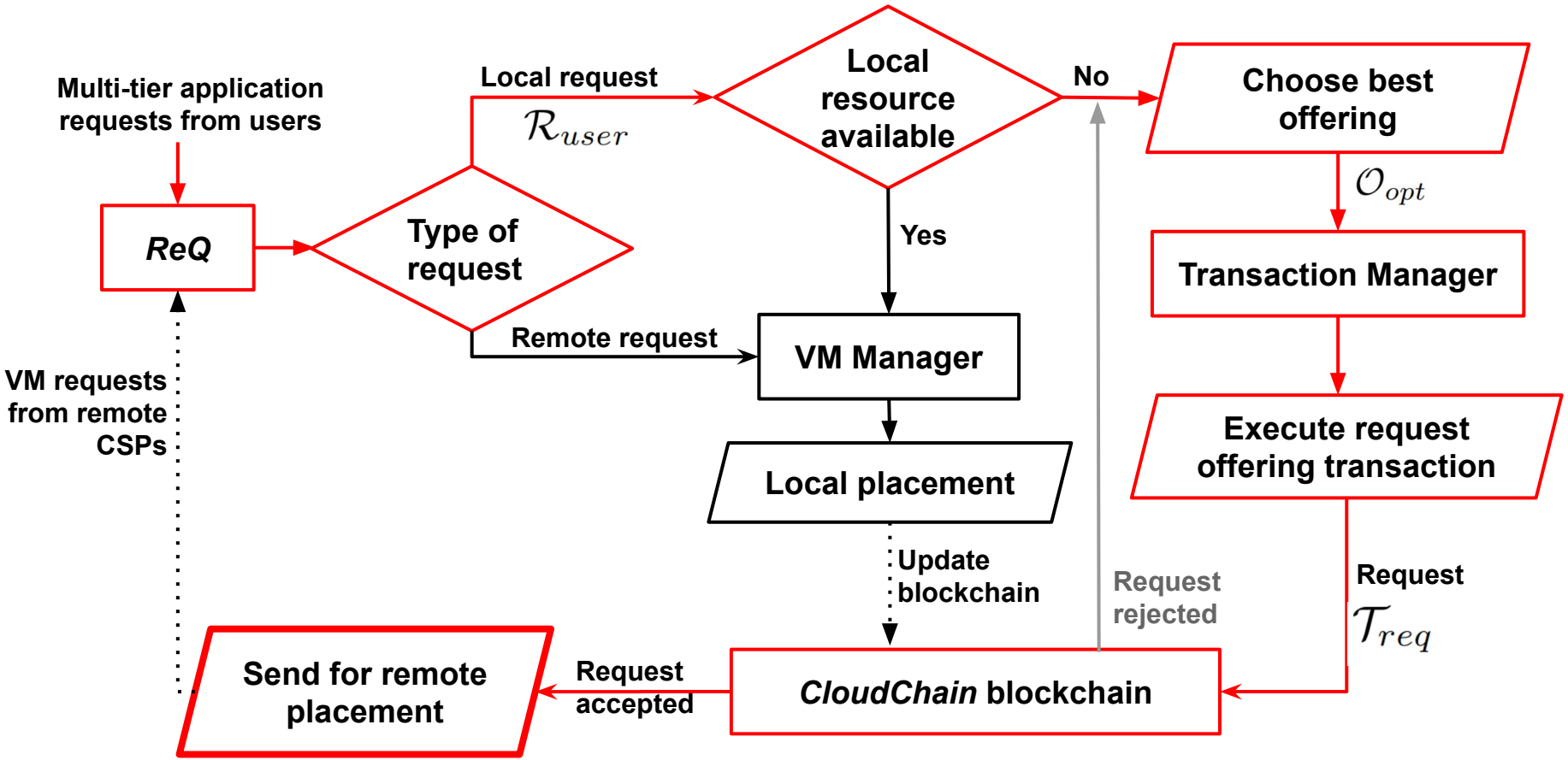
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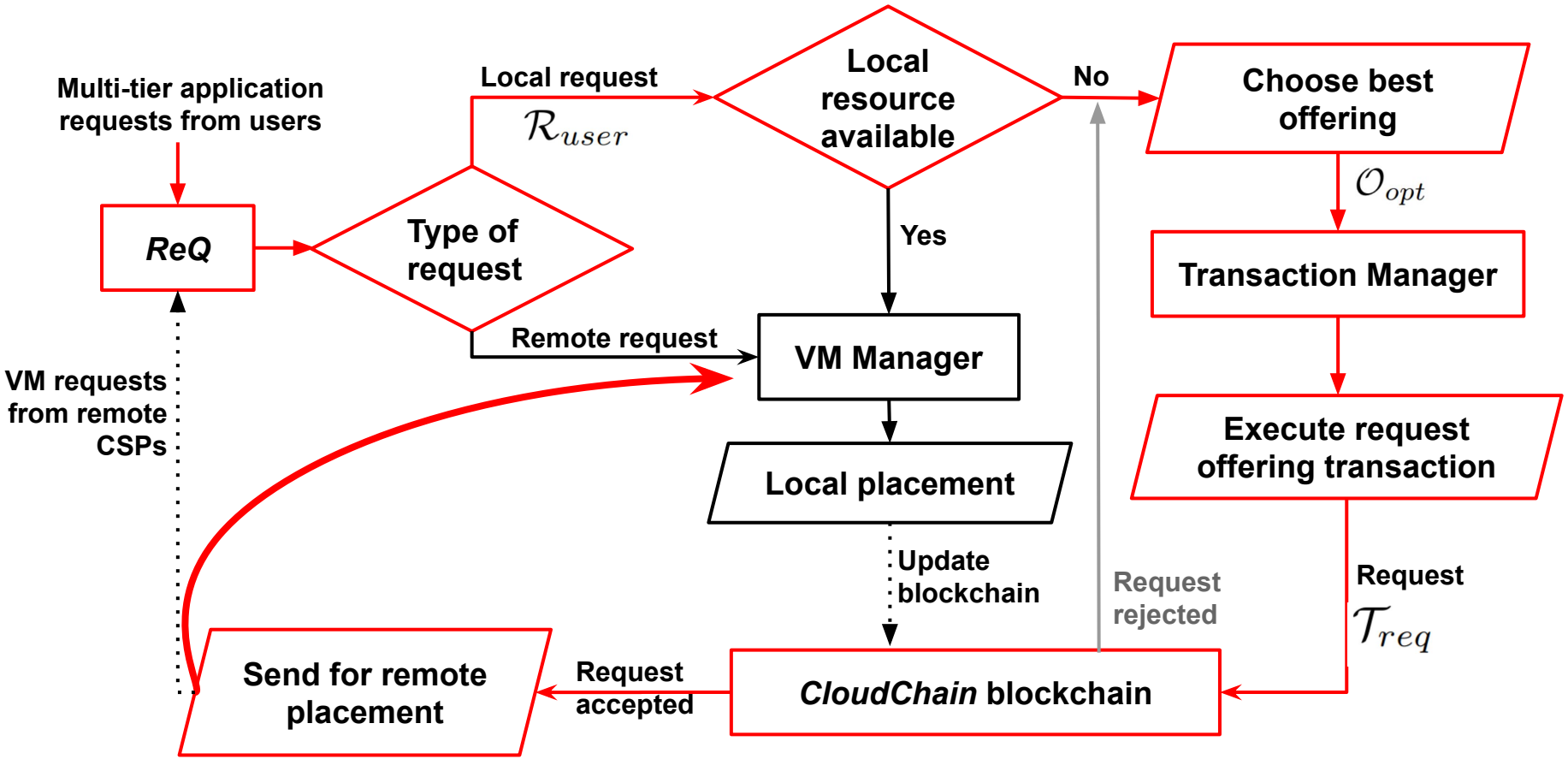
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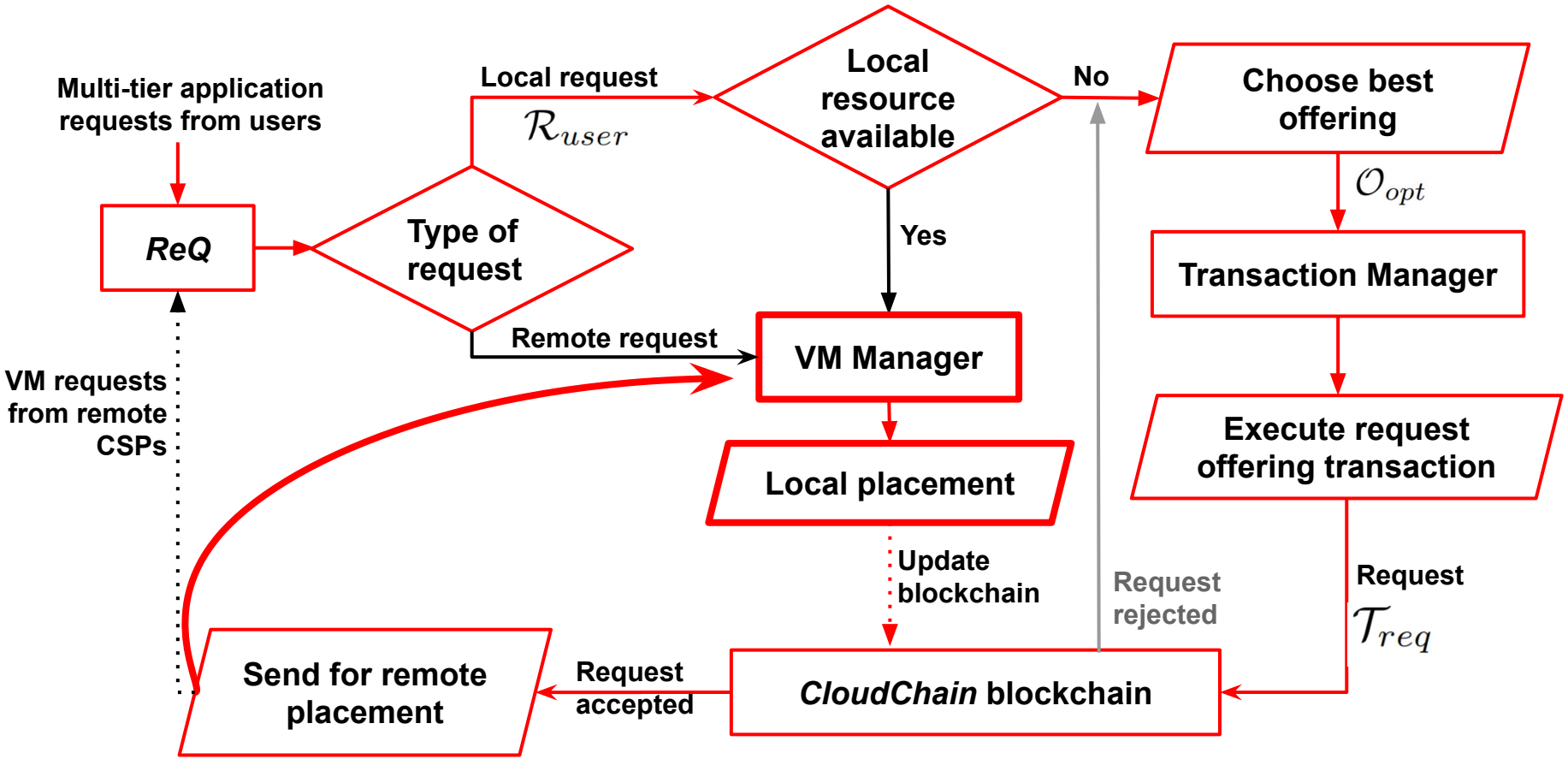
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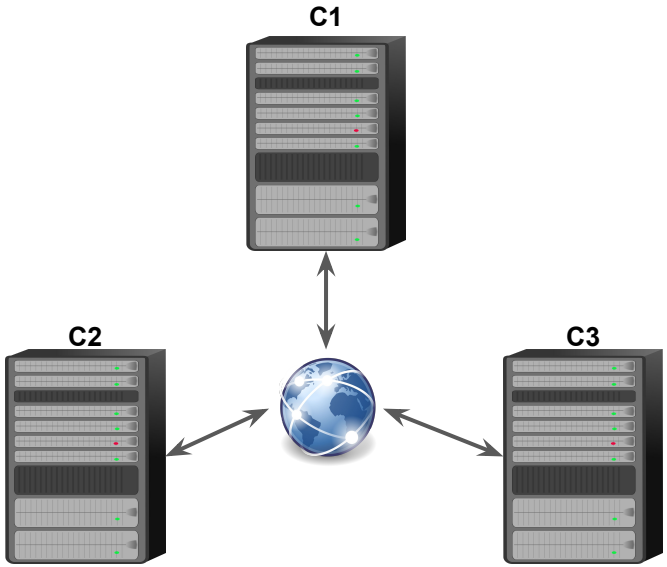
Implementation Details

Testbed Setup:

- 3 Hosts, each acting as a cloud connected over the network.



Testbed Parameters.

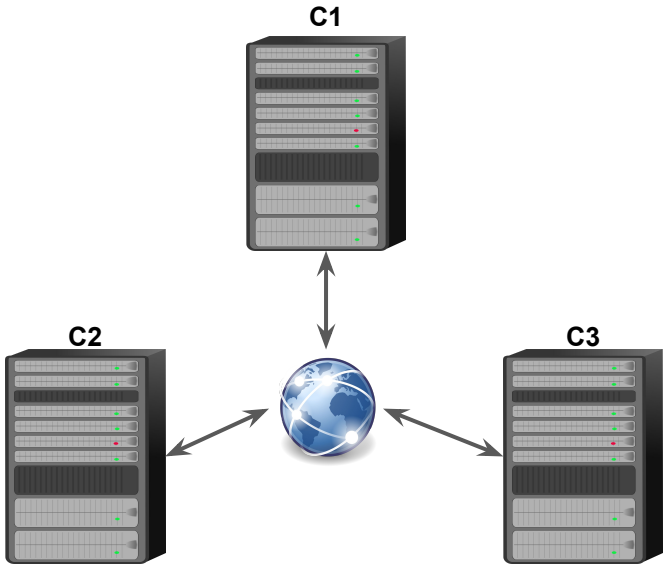
Category	Value
Number of CSP	3
Number of DC per CSP	3
$\mathcal{C}_1$ Config	2.7 GHz, Intel Xeon(R) 48 core, 256 GB Memory
$\mathcal{C}_2$ Config	3.2 GHz, Intel Core i5 4 core, 20 GB Memory
$\mathcal{C}_3$ Config	2.7 GHz, Intel Core i3 4 core, 8 GB Memory
Containerization	Docker 18.06
Language used	Go 1.10, Python 2.7

Implementation Details

Testbed Setup:

- 3 Hosts, each acting as a cloud connected over the network.

- Hyperledger fabric for blockchain (v1.3.0)

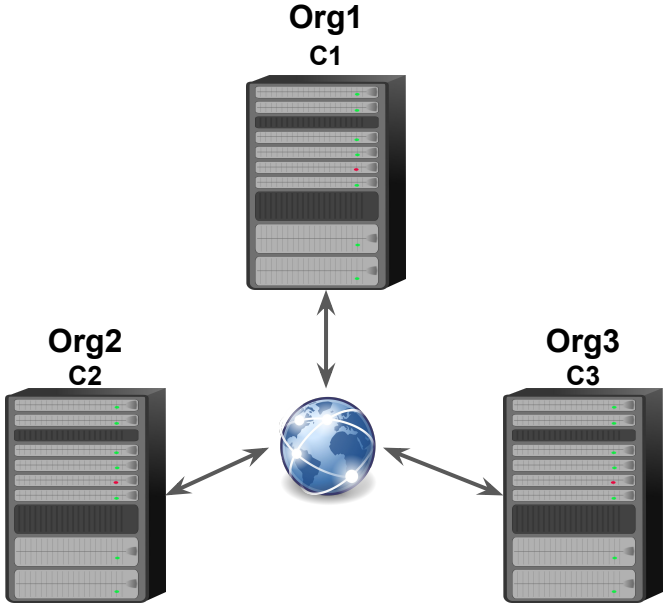


HYPERLEDGER FABRIC

Implementation Details

Testbed Setup:

- 3 Hosts, each acting as a cloud connected over the network.
- Hyperledger fabric for blockchain (v1.3.0).
- Each cloud belongs to a separate **organization**, and runs a **peer.**

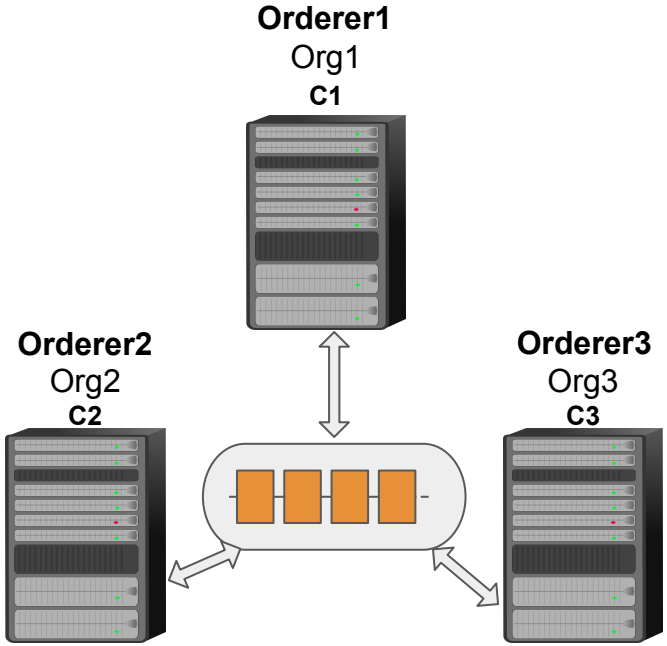


HYPERLEDGER FABRIC

Implementation Details

Testbed Setup:

- Each cloud runs its own **orderer**.

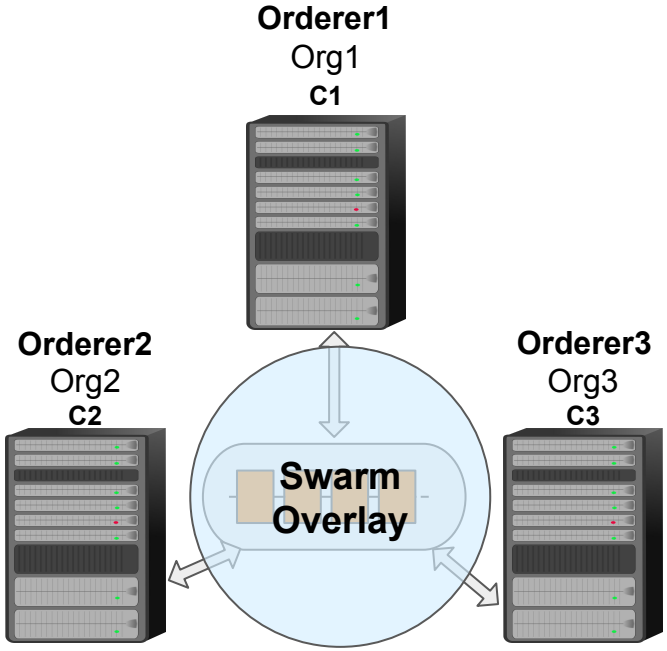


HYPERLEDGER FABRIC

Implementation Details

Testbed Setup:

- Each cloud runs its own orderer
- Create a **docker swarm**.
- Create **overlay network**.

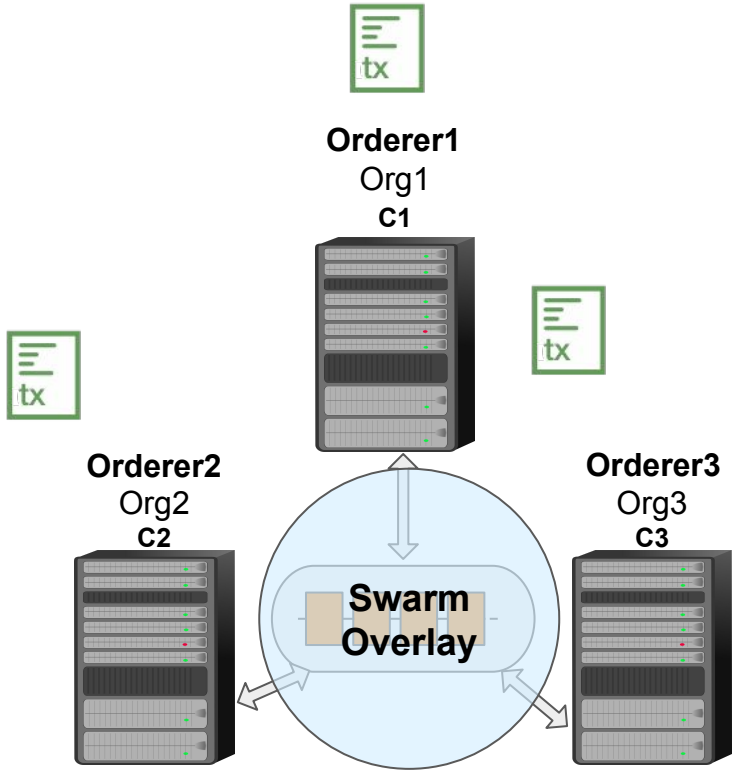


HYPERLEDGER
FABRIC

Implementation Details

Testbed Setup:

- Each cloud runs its own orderer.
- Create a **docker swarm**.
- Create **overlay network**.
- **Chaincodes** for *CloudChain* logic.

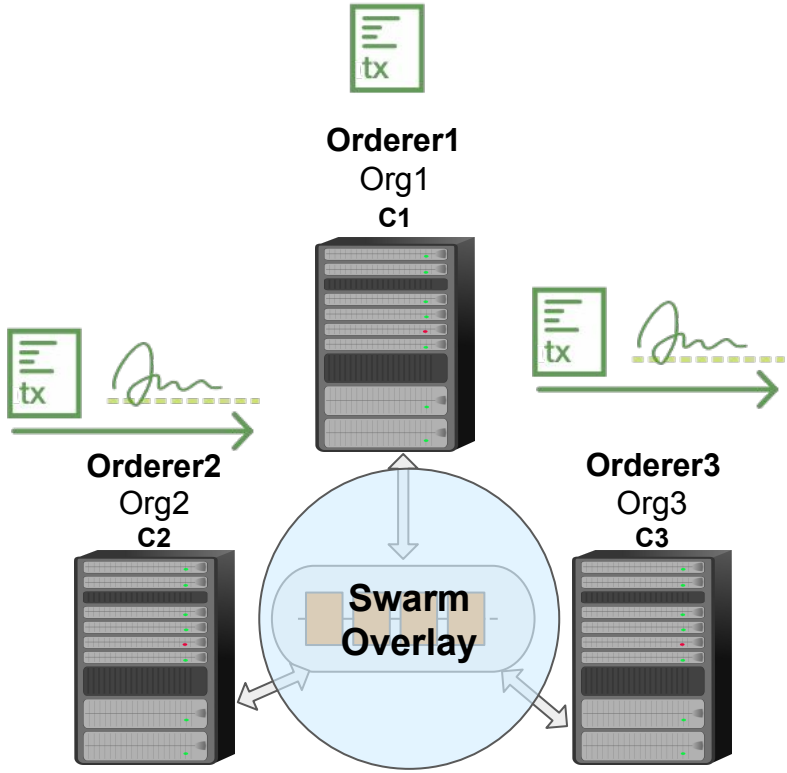


HYPERLEDGER
FABRIC

Implementation Details

Testbed Setup:

- Each cloud runs its own orderer.
- The orderers use **BFT** protocol.
- **Chaincodes** for Cloud Exchange logic.
- **Endorsement policy** requiring the endorsement of the concerned demanding SP, supplying SP and the majority of other endorsing peers.

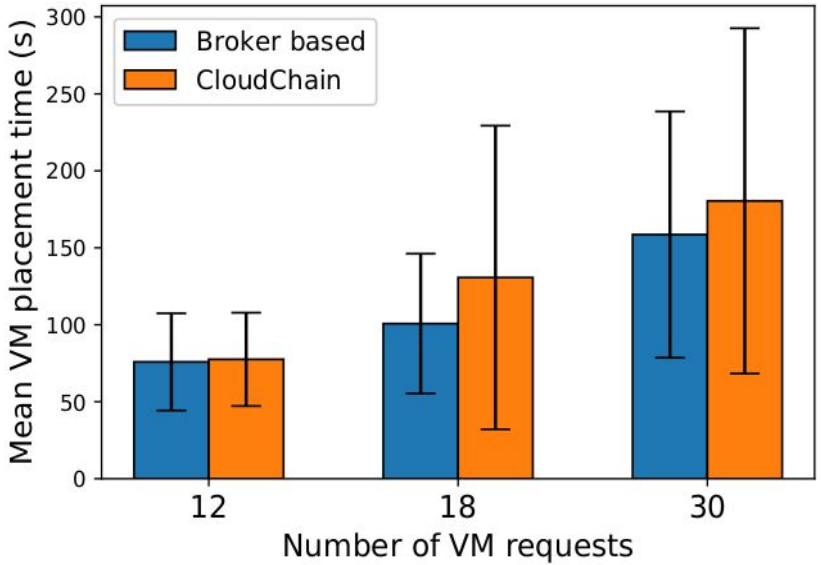


HYPERLEDGER
FABRIC

Results

- Mean VM placement time in broker based federation and *CloudChain*
- Three scenarios
- Each CSP receives 4, 6, and 10 VM requests in first, second and third scenarios respectively.
- In case of broker based federation all the requests arrive at the broker first.

Mean VM placement time

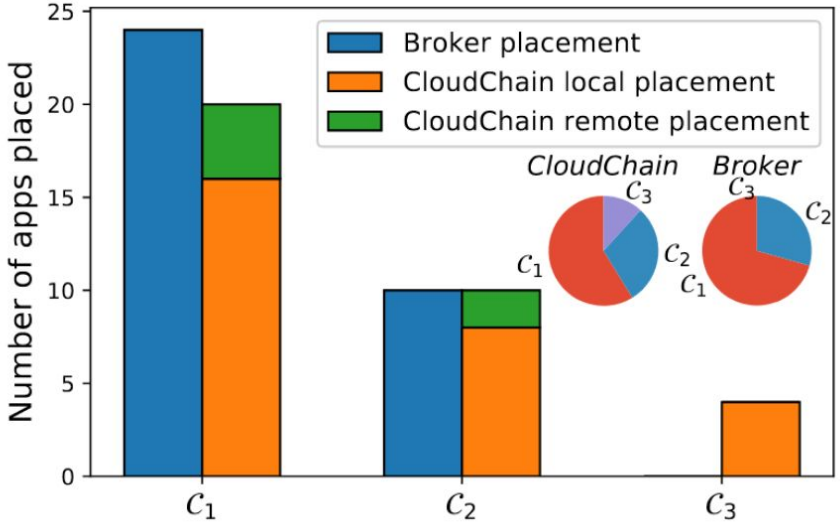


Very little compromise in performance

Results

- 34 multi-tier application requests
- *C1*, *C2* and *C3* receiving 16, 8 and 10 requests respectively.
- In case of broker based federation, all requests arrive at the broker

Distribution of user requests across different CSPs



C3 is starved in case of broker based system

***CloudChain* shows fair distribution**

Conclusion and Future work

***CloudChain* over Federation brokers:**

- Decentralized
- Transparent
- Autonomy
- Immutable
- Fairness

Conclusion and Future work

Future work

- Support for live VM migration
- FLA monitoring

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