MULTI-CRITERIA APPROACH OF DATA CENTER RESOURCES RELOCATION

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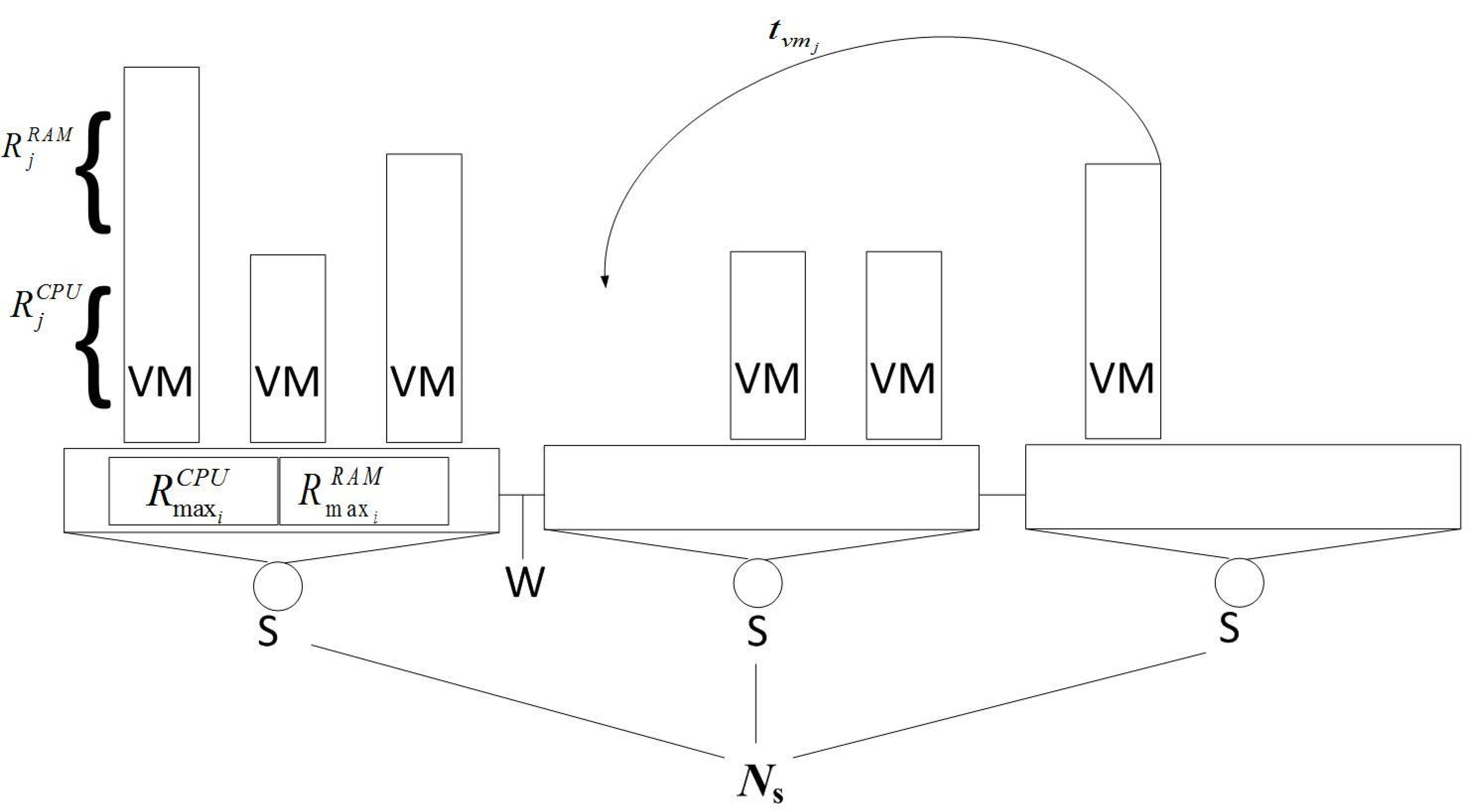
Purpose

Decreasing the total power consumption of data center servers

Problem definition



There are

Computer network data center (DC) with multiple servers S,

and number of servers - N_s.

$P\max_i$, $P\min_i$ - The maximum and minimum power consumption

$R_{\max_i}^{CPU}, R_{\max_i}^{RAM}$ - available resources (the number of cores of processors, RAM)

P_i, - consumption of the server, W - bandwidth of network links

N_{vm} - consumption of the number of virtual machine (VM)

matrix X - placement of VMs,

R_j^{CPU}, R_j^{RAM} - the amount of resources required for each j-th VM

Q_j^{CPU}, Q_j^{RAM} - current load of resources

$V_i(Q^{CPU}, Q^{RAM})$ - the function of the dependence of the transmitted amount of data from the current load of resources

α_i - the threshold consumption ratio of potential power, β_i - the ratio of the time of VM migration, γ - the ratio of the amount of redistributed servers

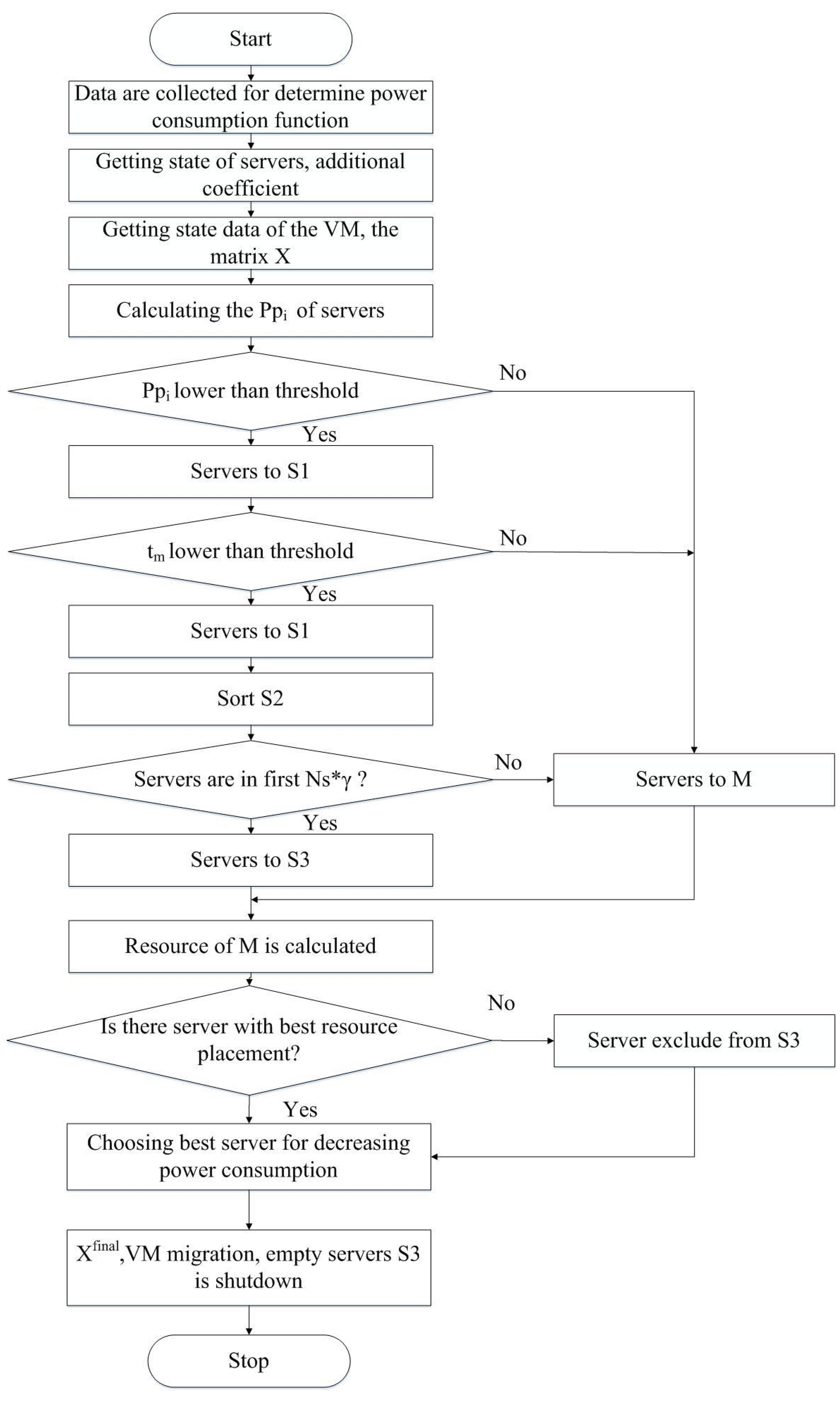
t_{vm_j}- limit VM migration time

The considered problem can be formulated as below. There are multiple servers $s_i \in S$ $(i=\overline{1,N_s})$ each of which is specified by the parameters $P\max_i$,$P\min_i$,P_i, $R_{\max_i}^{CPU}, R_{\max_i}^{RAM}$ multiple virtual machines $VM_j \in VM$ $(j=\overline{1,N_{vm}})$ each of which is specified by the parameters $(R_j^{CPU}, R_j^{RAM}), (Q_j^{CPU}, Q_j^{RAM}), t_{vm_j}$.

Required:

matrix **X** => matrix $\mathbf{X}^{\mathbf{final}}$

Method



Method for solving the problem is based on the the heuristic procedure "Orderly search of options in the field of admissible solutions"

Static stage

Power consumption Pi are collected with all possible server load resource (Q_j^{CPU}, Q_j^{RAM}) Result: $P_i(Q^{CPU}, Q^{RAM})$

Dynamic stage

1.The monitoring system collects data about the reservation of each VM resources, actual resource load, SLA for each VM. The location of

each j-th VM on the i-th server is in a matrix X, where x_{ij} is a binary variable

$$x_{ij} = \begin{cases} 1, & npu\ VM_j \in S_i \\ 0, & npu\ VM_j \notin S_i \end{cases}$$

also: $\sum_{i=1}^{Ns}\sum_{j=1}^{Nvm} x_{ij} = N_{vm}$

2.For each i-server of the set **S**: $P_{p_i} = P_{\min_i} + \sum_{j=1}^{Nvm} P_i(R_{vm_j}^{CPU}, R_{vm_j}^{RAM}) \cdot x_{ij}$

3.The servers will disable $(P_{p_i} = P_{\min_i})$

Then check: $P_{P_i} \le P_{\min_i} + \Delta\alpha_i$, where $\Delta\alpha_i = (P_{\max_i} - P_{\min_i}) \cdot \alpha_i$

Then the server is added to the set **S1**

4.For each server of set **S1**, the condition is checked: $\frac{V_i(Q_{vm_j}^{CPU}, Q_{vm_j}^{RAM})}{W} < t_{m_j} \cdot \beta_j$

Then **S2** is formed

5. **S2** is sorted by $P_{\min_i}$ and $\frac{P_{P_i}}{P_{\min_i}}$

Then **S3** is formed by $N_s \cdot \gamma$

The remaining servers are added to M: **M** = **S** – **S3**.

6. Equations are calculated:

$$R_{ocm_m}^{CPU} = R_{\max_m}^{CPU} - \sum_{j=1}^{Nvm} R_{vm_j}^{CPU} \cdot x_{mj}$$

$$R_{ocm_m}^{RAM} = R_{\max_m}^{RAM} - \sum_{j=1}^{Nvm} R_{vm_j}^{RAM} \cdot x_{mj}$$

Then, to migrate all VMs from the server k of the set **S3** to the server m of the set M, the following conditions must be fulfilled:

$$\begin{cases} R_{ocm_m}^{CPU} > \sum_{j=1}^{Nvm} R_{vm_j}^{CPU} \cdot x_{kj} \\ R_{ocm_m}^{RAM} > \sum_{j=1}^{Nvm} R_{vm_j}^{RAM} \cdot x_{kj} \\ \sum_{j=1}^{Nvm} P_m(R_{vm_j}^{CPU}, R_{vm_j}^{RAM}) \cdot x_{mj} < P_{\min_k} + \sum_{j=1}^{Nvm} P_k(R_{vm_j}^{CPU}, R_{vm_j}^{RAM}) \cdot x_{kj} \end{cases}$$

7. The k-th server VM is migrated to the server m if the minimum value $\sum_{j=1}^{Nvm} P_m(R_{vm_j}^{CPU}, R_{vm_j}^{RAM}) \cdot x_{mj}$

Then server k is shutdown. Server k is excluded from **S3**. Similarly, the remaining servers of set **S3** are checked.

The result of migrations is contained in the matrix $\mathbf{X}^{\mathbf{final}}$

Conclusions

The method allows to reduce the power consumption of the DC an amount:

$$P_{DC} - \sum_{k=1}^{Nds} P_{\min_k} - \sum_{k=1}^{Nds}\sum_{j=1}^{Nvm} P_k(Q_{vm_j}^{CPU}, Q_{vm_j}^{RAM}) \cdot x_{kj} + \sum_{m=1}^{Nds}\sum_{j=1}^{Nvm} P_m(Q_{vm_j}^{CPU}, Q_{vm_j}^{RAM}) \cdot x_{mj}^{final}$$