Capacity of Distributed SDC Resources

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Distributed SDC Resources

How to characterize capacity to enable efficient use of distributed SDC resources belonging to different coalition members?

Resource Capacity

Consider a system (SDC slice) with multiple and distributed resources running multiple tasks

- K types of resources
- N servers: normalized capacity $c_{n,k} = 1, \forall n,k$
- M tasks: random resource requirements $X_{m,k}$
  - Requirements of different resources for a given task are independent with each other
  - Occupancy of resource type k on server n, $\rho_{n,k} = \sum_{m=1}^{M} X_{m,k} I_{m,n}$ where $I_{m,n}$=1 if task m is assigned to server n, and 0 otherwise

Definition of resource capacity: The maximum number of tasks M that the system can serve simultaneously, so that the overload probability is no more than a small value ε:

$$\Pr\left\{\bigcup_{k=1}^{K}\bigcup_{n=1}^{N}\left(\rho_{n,k} \geq 1\right)\right\} \leq \varepsilon$$

✓ **Capacity of distributed resources can be used to assist scheduling or admission decisions of distributed analytics**

Main Analytical Results

Let $\mu^{\max}$ and $\left(\sigma^{\max}\right)^2$ denote the maximum mean and variance among all required resources for all tasks. We consider 3 assignment policies for scenarios with different resource monitoring overheads.

Random Assignment (RAND)

Assign M tasks to N servers randomly:

$$M \leq \frac{N\left(\log\frac{\varepsilon}{NK} + \theta\right)}{\exp\left(\mu^{\max}\theta + \left(\sigma^{\max}\theta\right)^2/2\right) - 1}$$

Power of d Choices Assignment (PODC)

For each task, randomly choose d servers and assign it to the least loaded one among them:

$$M \leq \frac{N\log\frac{\varepsilon}{NK} + N\theta}{\mu^{\max}\theta + \left(\sigma^{\max}\theta\right)^2/2} - \frac{N\log\log N}{\log d}$$

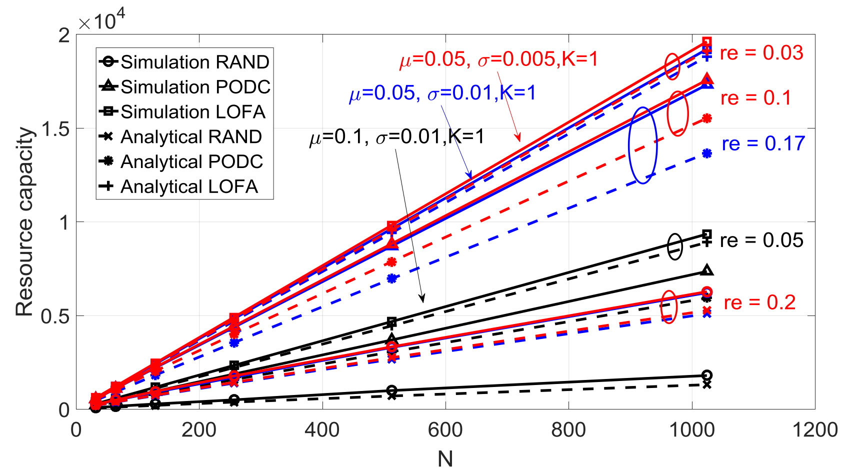
Least Occupancy First Assignment (LOFA)

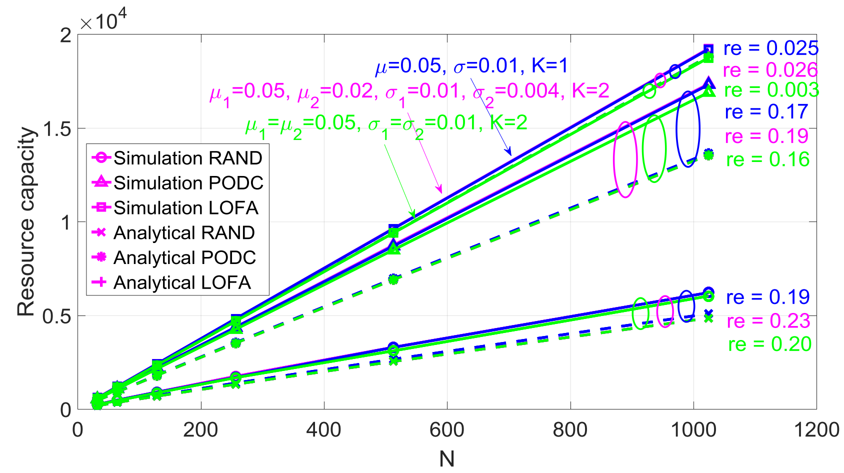
Assign each task to the server with the least occupancy (loading):

$$M \leq \frac{\log\varepsilon + \left(N - N\mu^{\max}\right)\theta - \left(N\sigma^{\max}\theta\right)^2/2}{\mu^{\max}\theta + \left(\sigma^{\max}\theta\right)^2/2} + 1$$

- *Gaussian distributed resource requirements are assumed in the above expressions*
- *We can find the optimal θ^* to obtain the better upper-bound for M*
- *The bounds above are sufficient conditions for guaranteeing ε*
- *The analysis also allows other distributions*

Numerical Results





Tightness of resource capacities with different μ, σ, K ($\varepsilon = 0.01, d = 2$), "re" stands for mean relative error