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On the Influence of Fog Colonies Partitioning in Fog Application Makespan

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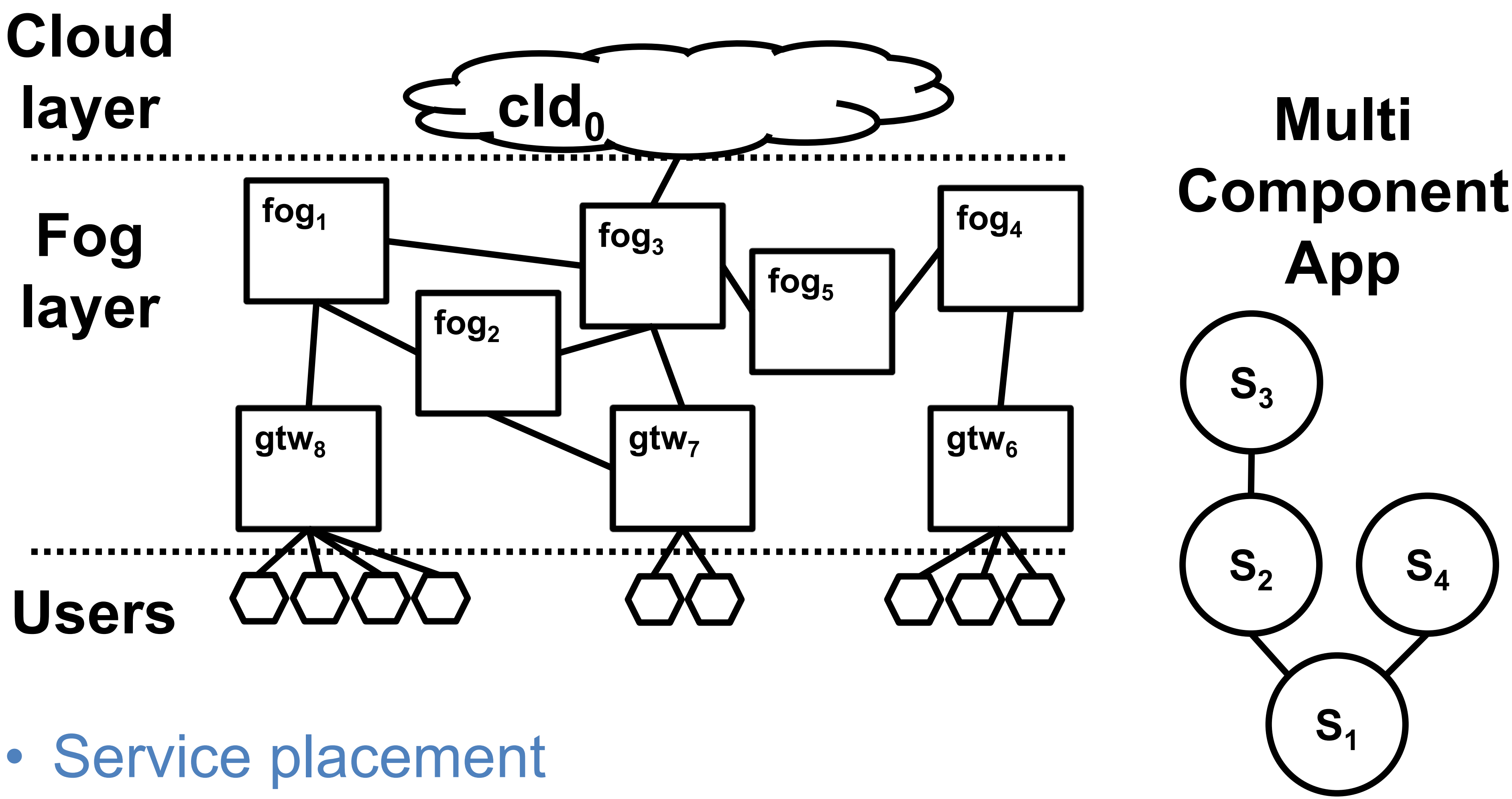
Fog Application Placement Model



- Service placement
- Colony organization (Skarlat et al., 2017)

Introduction

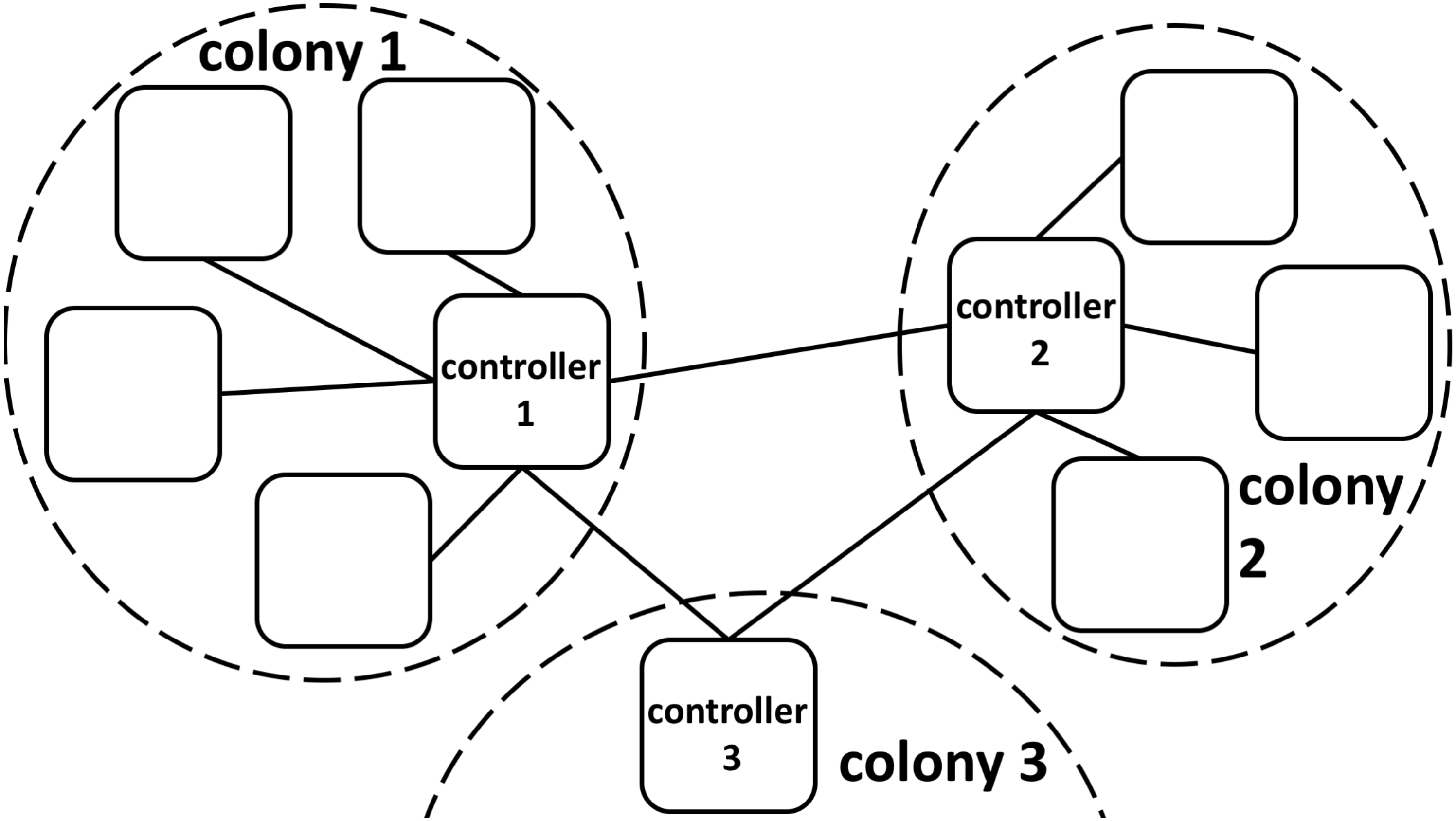
- Domain
  - Fog Computing
  - Service placement problem
  - Fog colonies [1]

- Objective → Minimize network latency/makespan

- Decision variable → Fog colonies definition

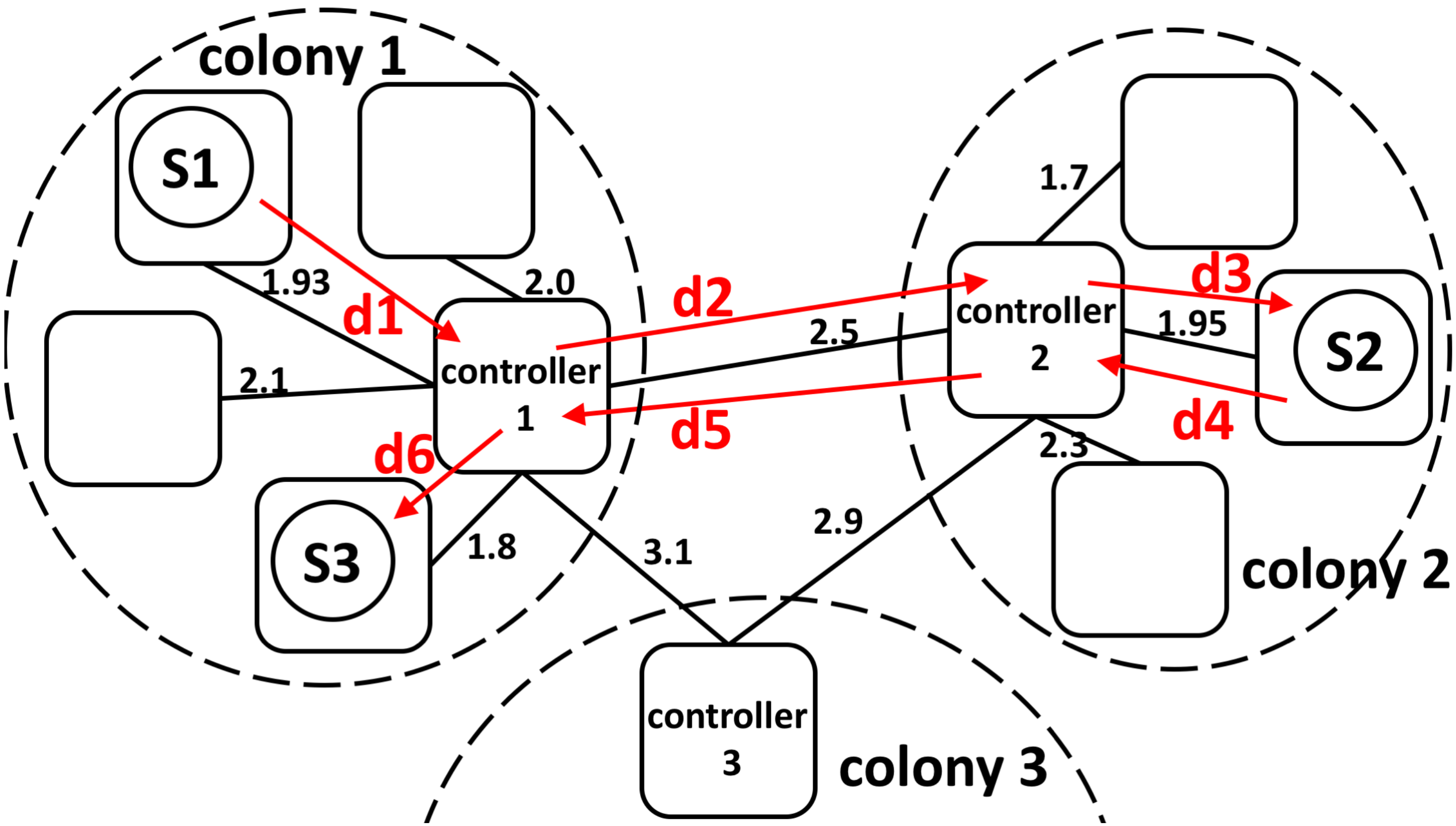
- Tools → Complex Networks Metrics
- Solution → Centrality indices

Colony-based organization



[1] O. Skarlat, M. Nardelli, S. Schulte, M. Borkowski, and P. Leitner, “Optimized iot service placement in the fog,” Service Oriented Computing and Applications, Oct 2017.

Colony-based organization



$$d1 + d2 + d3 + d4 + d5 + d6,$$

$$1.93+2.5+1.95+1.95+2.5+1.8 = 12.63$$

Colonies optimization

- Organization of the fog colonies directly influences in three main aspects:
  - (a) the network communication time between the controllers and their subordinated devices
  - (b) the network communication time between controller devices
  - (c) the resource capacity of the fog colonies.

- Optimization of (a) and (b) by determining the organization of the colonies :
  - number, size, controller devices and subordinated devices of each controller

Colonies optimization

- (a) the network communication time between the controllers and their subordinated devices
  - Intra-cluster distance
  - Average distance controller-subordinated
  - Average for all the colonies

$$IntraDist_{Res(F)} = \sum^{f^j \in Res(F)} \frac{D(f^j, F(f^i))}{|Res(F)|}$$

$$\overline{IntraDist} = \sum^{\forall Res(F)} \frac{IntraDist_{Res(F)}}{colony\ number}$$

- (b) the network communication time between controller devices
  - Closest Neighbord Distance
  - Distances controller-closest controller
  - Average for all the colonies

$$\overline{ClosestNeighDist} = \sum^{\forall Res(F)} \frac{D(F, neighbor(F))}{colony\ number}$$

Fog colony partition algorithm

- We propose to use centrality indices to select the controller devices of the fog colonies:
  - (i) model the network topology as a complex weighted network;
  - (ii) calculate the value of the centrality/clustering index of each node;
  - (iii) select the first k nodes with the highest indices, where k is the number of fog colonies to be created;
  - (iv) partition the fog devices into colonies by subordinating each devices to its closest controller device.

Algorithm 1 Pseudo-code of the fog colony partition algorithm.

Function: ColonyPartition()
Input: network topology G, number of colonies K
Output: fog colonies partitions Res()

nodesValues = CalculateCentralityIndex(G)
ordered = sort(nodesValues)
controllers = ordered[0..K]
for all f^i **do**
    closestF = null
    for all $F \in$ controllers **do**
        if $D(f^i, F) < D(f^i, closestF)$ **then**
            closestF = F
        end if
    end for
    Res(closestF) = Res(closestF) $\cup f^i$
end for
return Res()

Research questions

- RQ1. Does the size of the architecture (and colonies) influence in the intra colony and closest neighbor distances?
- RQ2. Is there any difference in the intra colony and closest neighbor distance between different centrality indices? Does anyone obtain better results than the other indices?
- RQ3. Does the network topology influence in the distance indicators? Does anyone obtain better results than the other indicators?

Experimental evaluation

- 3 network topologies
  - Lobster, Euclidean, Barabasi-Albert
- 6 centrality indices
  - Betweenness, Degree, Generalized Degree, Closeness, Eigenvector, Clustering
- 2 experiment sizes
  - 400 and 1000 fog devices
- Colony sizes
  - Ranged from 1 to 100

Results

(a) Lobster topology

(b) Random Euclidean topology

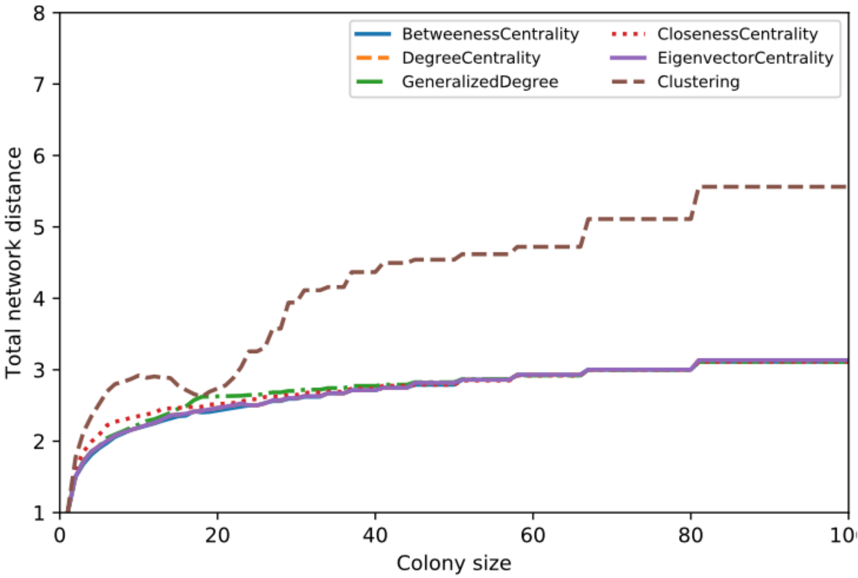
(c) Barabasi-Albert topology

- Fog colony formation for the case of 400 nodes and colony size of 20 nodes

Discussion RQ1

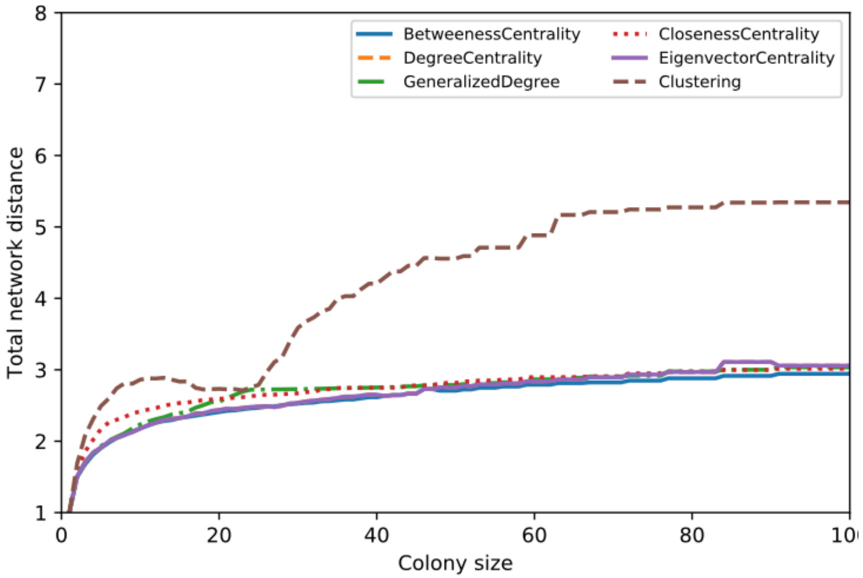
- RQ1. Does the size of the architecture (or colonies) influence in the intra colony and closest neighbor distances?

400 nodes



(a) Barabasi-Albert network topology

1000 nodes

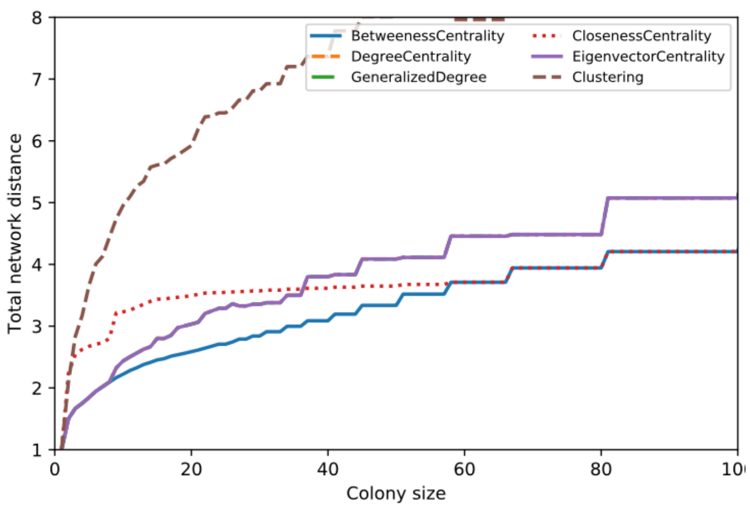


(a) Barabasi-Albert network topology

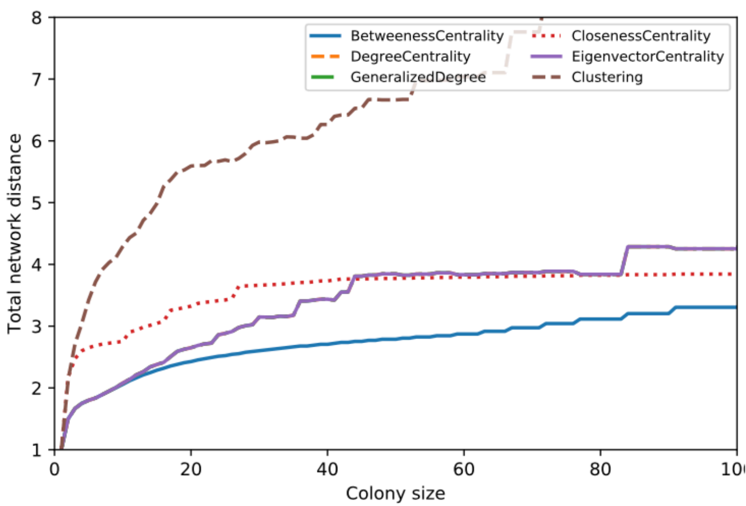
- Differences in network distances between experiment sizes: 2% for the Lobster, 5.5% for the Random Euclidean, and 1.5% for the Barabasi- Albert.

Discussion RQ1

- Network distance increases as colony size increases (differences higher than 150%) for colony sizes up to 10/20 devices
  - Best case → small colonies ????
  - Resource capacity of the colony should be consideres



(c) Lobster network topology

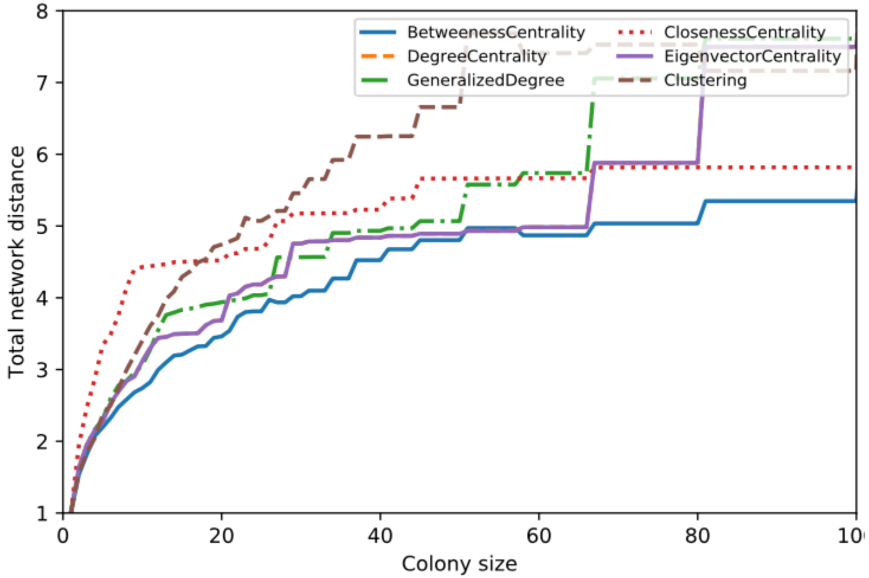


(c) Lobster network topology

Discussion RQ2

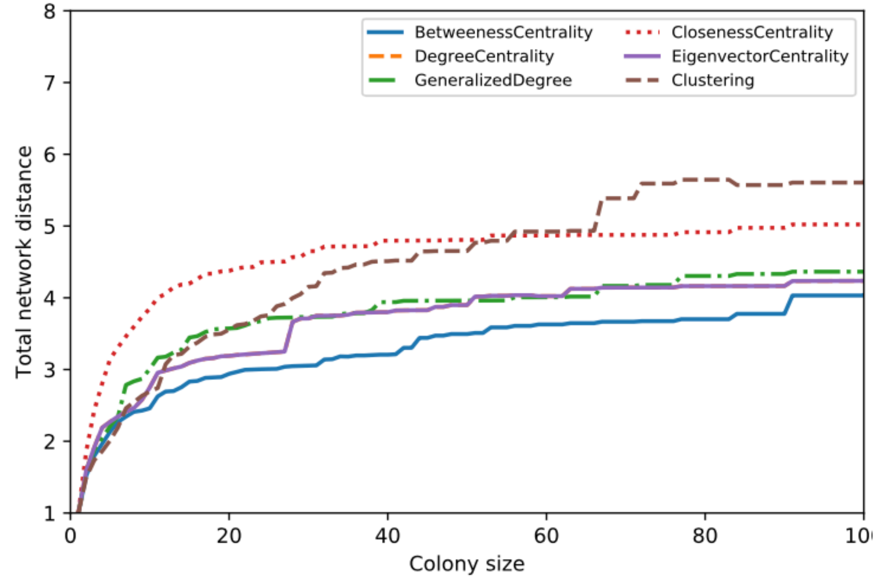
- RQ2. Is there any difference in the intra colony and closest neighbor distance between different centrality indices? Does anyone obtain better results than the other indices?

400 nodes



(b) Random Euclidean network topology

1000 nodes



(b) Random Euclidean network topology

- Betweenness centrality resulted in the index with smallest network distances, independently of the number of colonies and the network topology.

Discussion RQ3

- RQ3. Does the network topology influence in the distance indicators? Does anyone obtain better results than the other indicators?

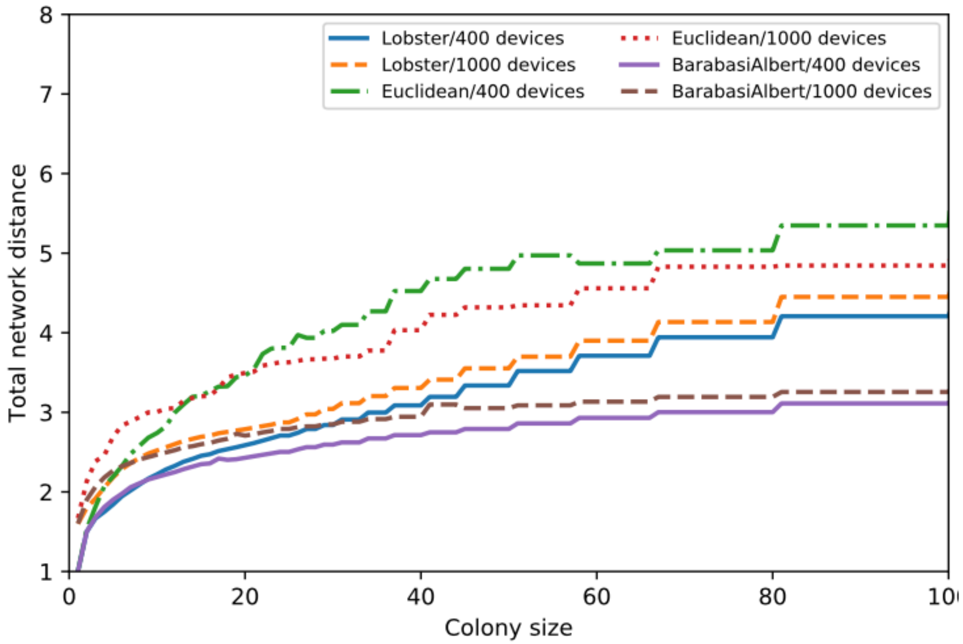


Fig. 5. Comparison of the results considering the colony size between network topologies and architecture size for Betweenness centrality.

- Barabasi-Albert topology obtained the lowest network distances and, on the contrary, Random Euclidean obtained the worst results.

Conclusions and Future works

- Fog colonies behave better if they are applied in a Barabasi-Albert network topology
- Betweenness was the centrality with the best behavior
- The increase of the network distance is negligible for colony sizes of more than 10/20 devices

- Future works:
  - Additional indicators to consider the resource capacity of the colonies
  - Combination of fog service placement optimization policies and colony partitioning strategies
  - Definition of dynamic colony partitioning framework

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Thank you!!!!
Q & A

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