Analysing the Applicability of a Multi-Criteria Decision Method in Fog Computing Placement Problem

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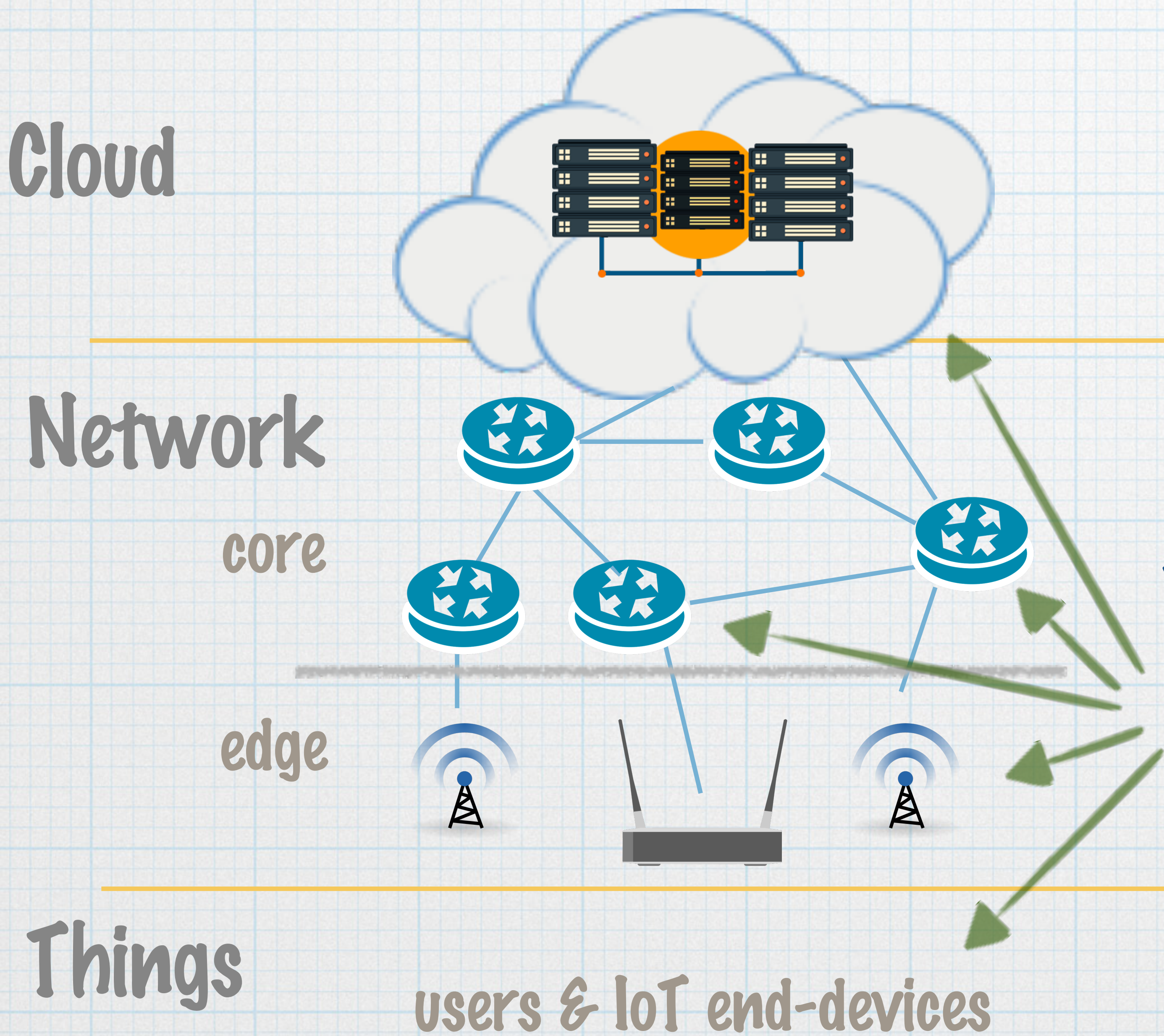
Fog Computing

rchitecture that distributes computing, storage, and networking closer to users, and anywhere along th

OpenFog Consortium - Definition



Where do we allocate services along the continuum ?

+ Not trivial
+ Dynamic
+ Complex Decision

Fog Computing Placement Problem (FCPP)

a challenging problem:

* **Influences** on the functional and non-functional requirements.
* **Depends** on multi-criteria satisfaction, i.e. latency, temporal availability, power consumption, costs, application packaging, resource utilisation, scaling possibilities, network congestions, software compatibility, user preferences, licenses, redundant links, geographical distribution, migrations, application composition, & son on.

NP-hard problem

Our approach

Other approaches try to find the most optimal allocation: a **lot of resources, slow process, and global-&-static vision of the ecosystem**

To address this problem:

* Our objective is to find the **placement of a service that satisfies the higher number of criteria**,
  * This decision concerning diverse and, often, opposite criteria
* This process can be applied
  * multiple-times / dynamically
  * performed on fog-nodes

We use **multi-criteria decision aiding discipline (MCDA)** metho

MCDA

* MCDA is an activity which helps **making decisions** mainly in terms of choosing, ranking or sorting the actions.

* The ingredients of MCDA are a finite or infinite set of actions (alternatives, solutions, courses of action, ...), at least two criteria, and, obviously, at least one decision-maker (DM).

* (MCDA) **A decision** "is a binary relation S defined on the set of potential actions *a* such that aSb **if there are enough arguments to decide that** a **is at least as good as** b, whereas there is no essential argument to refute that statement."

* Main outranking family methods are: PROMETHEE and **ELECTRE: I, Iv, IS, II, III, IV, SS, TRI**

ELECTRE III ingredients on FCPP (1°)

* To "aSb" two possible allocations, we need to evaluate them in terms of m criteria ($g_1, g_2, ..., g_m$), ie. **latency**
* Given a criterion (g_i), the alternative a is considered better than alternative b when $g_i(a)>g_i(b)$

```
if eval_latency(alloc_a) > eval_latency(alloc_b) then
   alloc_a better than alloc_b in terms of latency
```

* but in this **decision**, we need to manage with some uncertain threshold of preference and indifference values for each criterion

ELECTRE III ingredients (2°)

a is at least as good as b

1° Concordance Matrix :

indifference

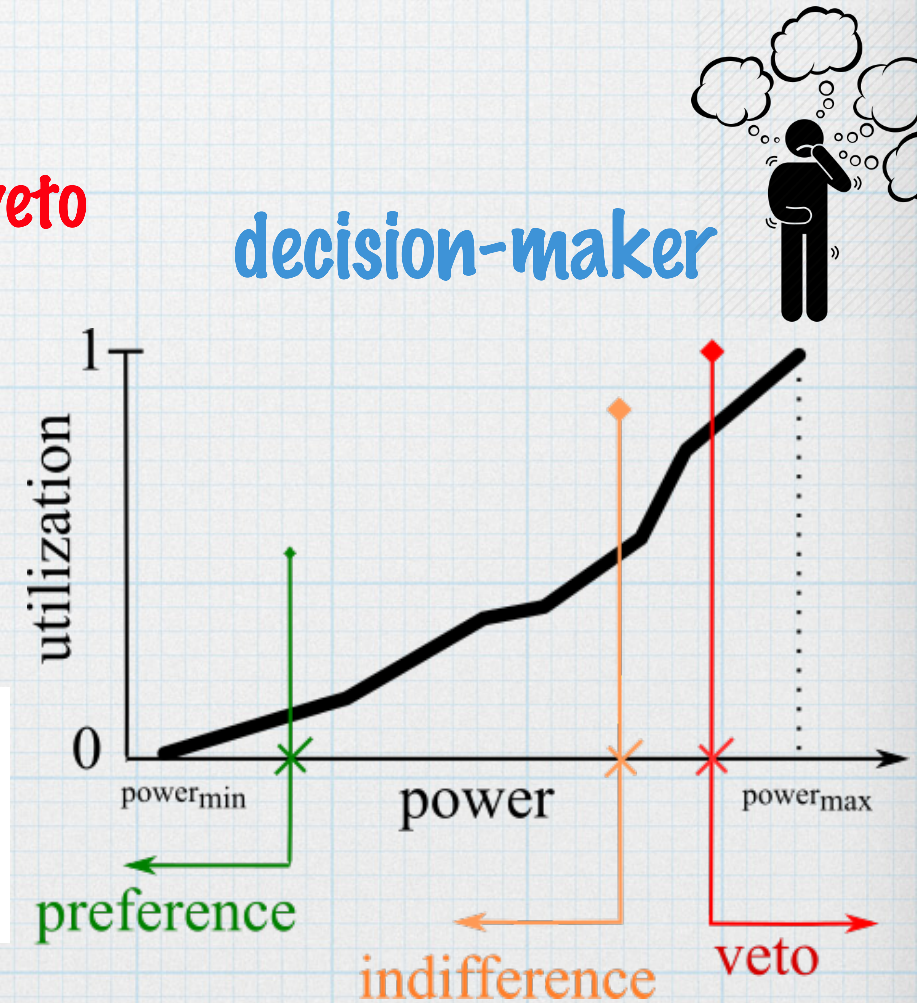
preference

$$C_i(a,b) = \begin{cases} 1 & \text{if } g_i(a) \geq g_i(b) - q_i(g_i(a)) \\ 0 & \text{if } g_i(a) \leq g_i(b) - p_i(g_i(a)) \\ \frac{p_i(g_i(a)) + g_i(a) - g_i(b)}{p_i(g_i(a)) - q_i(g_i(a))} & \text{otherwise} \end{cases}$$

2° Discordance Matrix :

veto

$$d_i(a,b) = \begin{cases} 1 & \text{if } g_i(a) \geq g_i(b) - v_i(g_i(a)) \\ 0 & \text{if } g_i(a) > g_i(b) - p_i(g_i(a)) \\ \frac{g_i(b) - g_i(a) - p_i(g_i(a)}{v_i(g_i(a)) - p_i(g_i(a))} & \text{otherwise} \end{cases}$$



3° "aSb == a outranks b":

$$S(a,b) = \begin{cases} C(a,b) & \text{if } g_i(a) \geq g_i(b) - v_i(g_i(a)) \\ C(a,b) \prod_{i \in K} \frac{(1 - d_i(a,b))}{1 - C(a,b)} & \text{otherwise} \end{cases}$$

Experiment

decision-maker

* We compare our Electre III-based approach with a simple weighted average in six different cases according with the necessities of a DM

Case	Hop count	Latency	Power	Cost	D.Penalty
A	3	3	3	3	3
B	**1**	4	3	3	3
C	4	**1**	3	3	3
D	4	4	**1**	3	3
E	4	4	3	**1**	3
F	4	4	3	1	**1**

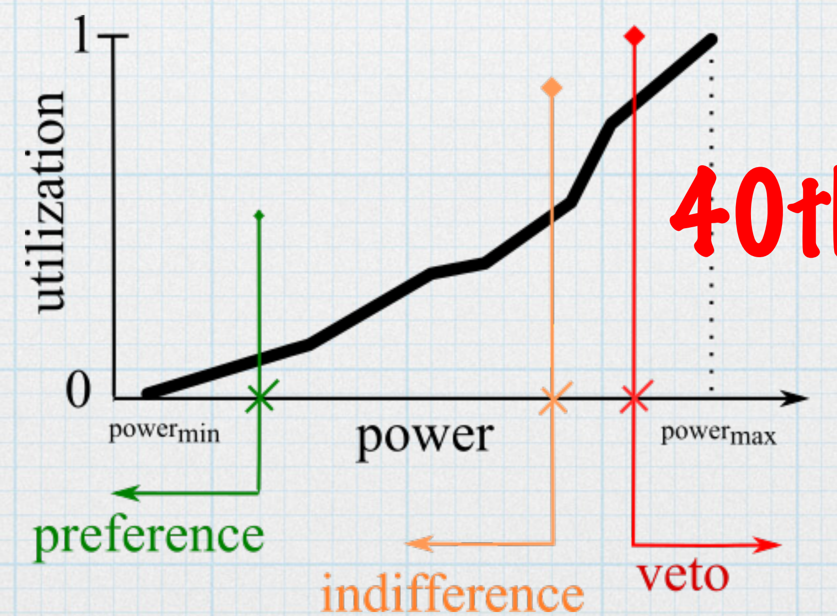
* The idea is to determine if all the cases reflect the importance of each decision

on %-values

* Preference, Indifference and Veto thresholds are chosen dynamically according with all possible values in each allocation for each criterion.

10th percentile / 3

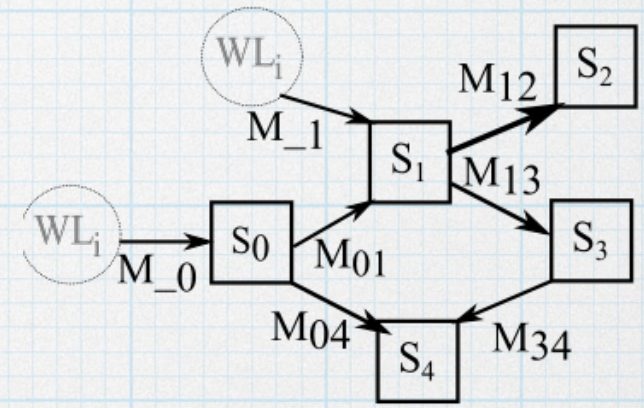
20th percentile



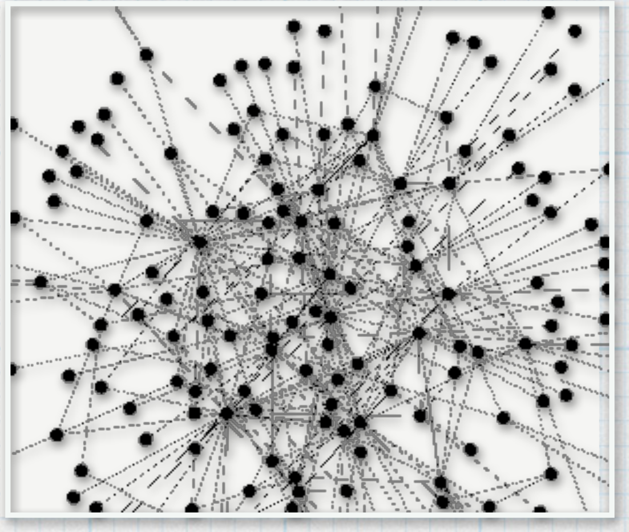
40th percentile

Modelling a dynamic Scenario

* **5 Criteria:** Latency, Hop count, Energy consumption, Cost, and Deployment penalty
* **10 Applications** set up by a composition of 10 avg. services (modeled as a Directed Acyclic Graph model)
* **40 Users**, where their arrivals follow an exponential distribution
  * In each User's service invocation, -> **ALLOCATION PROCESS**



* **Network infrastructure**: a graph
  * Generalized Linear Preference (GLP) (aSHIIP tool): **200 nodes**
  * All nodes are Fog nodes
  * IPS = random (50: 1000)
    PR links = r(10: 90)
    BW links = r(100: 1000)
  * Power min = r(30: 50) & max = r(400: 1000)
  * Cost depends on degree level, 0-4 degree value are "cheaper" & >4 degree value are "expensive"

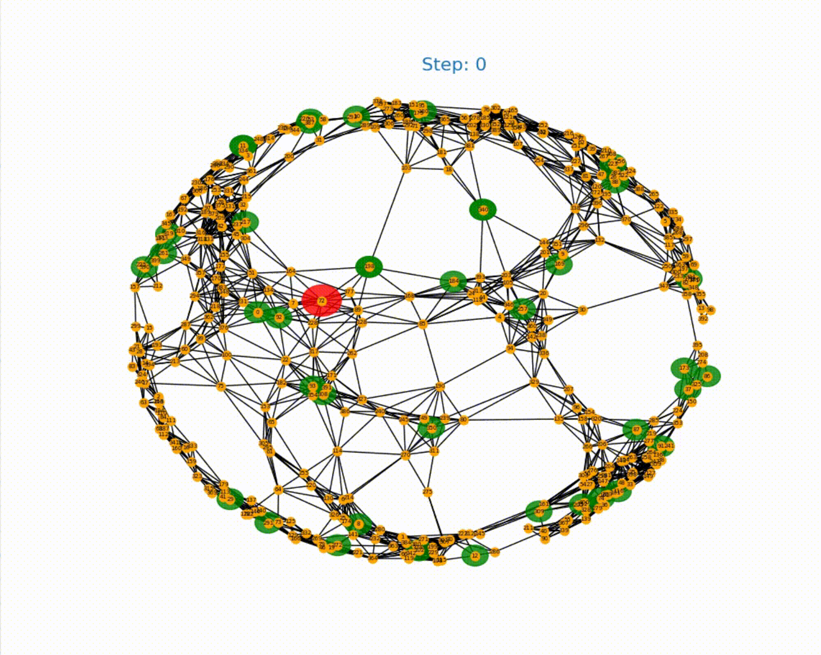


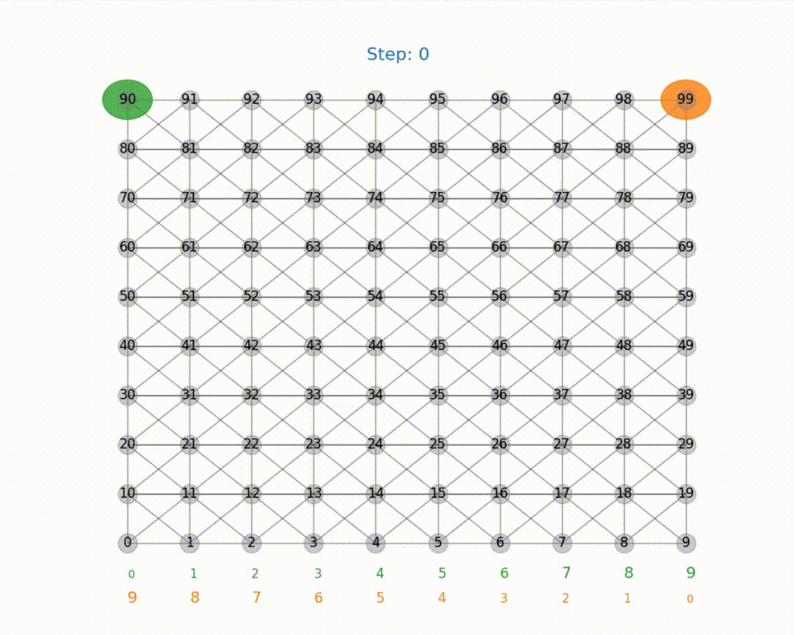
tools

* Yet Another Fog Simulator
  * Python & Free software
  * Infrastructure -> Complex Network theory
  * Dynamic movement of "things/users", services and other events.

YAFS

https://github.com/acsicuib/YAFS

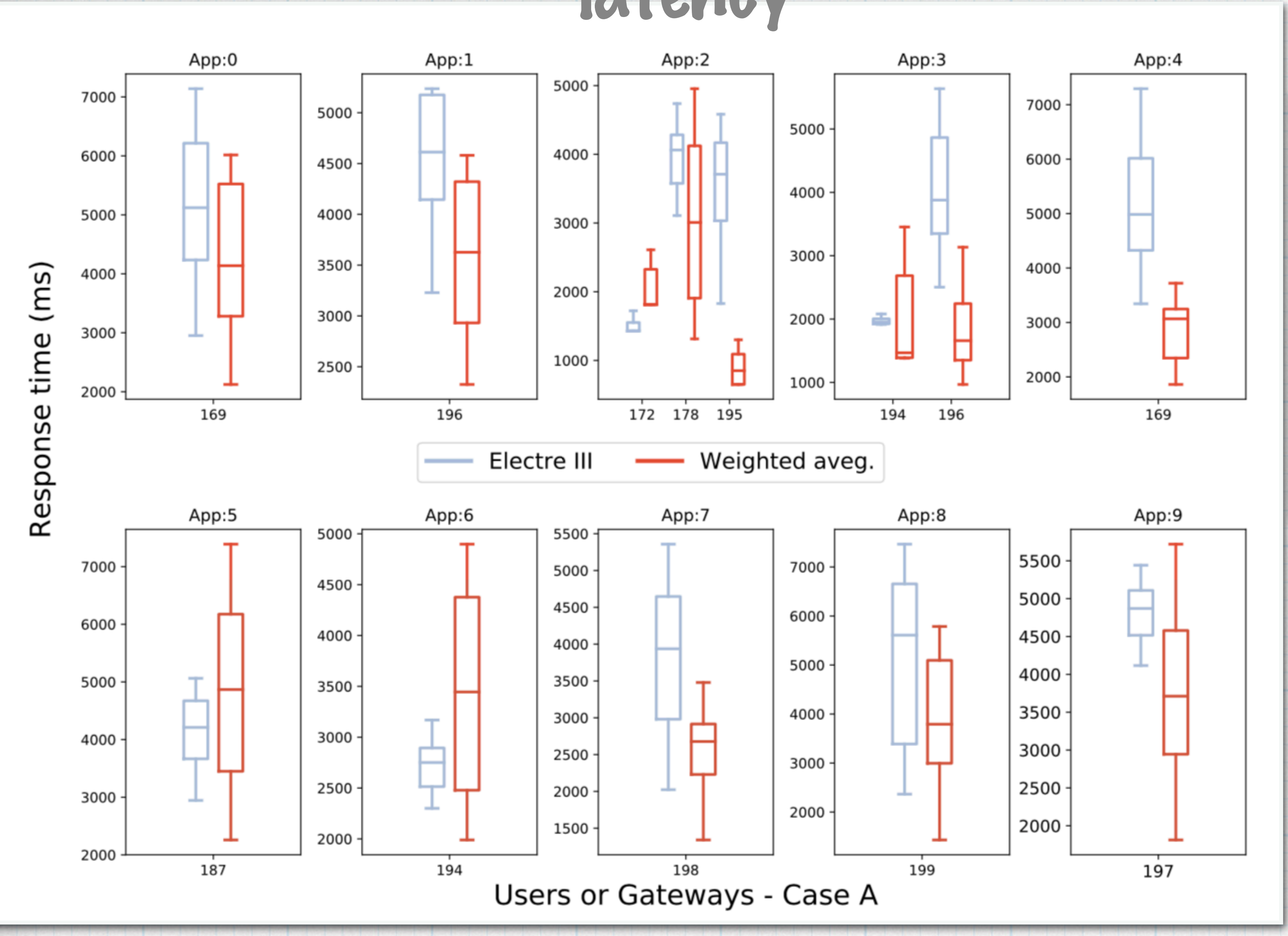




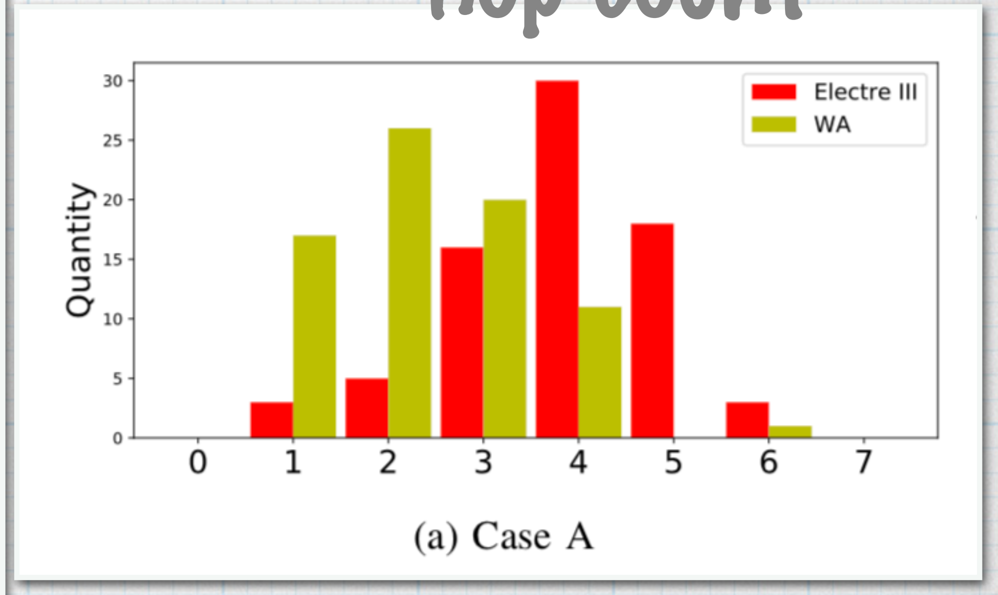
Results

Case	Hop count	Latency	Power	Cost	D.Penalty
A	3	3	3	3	3

latency

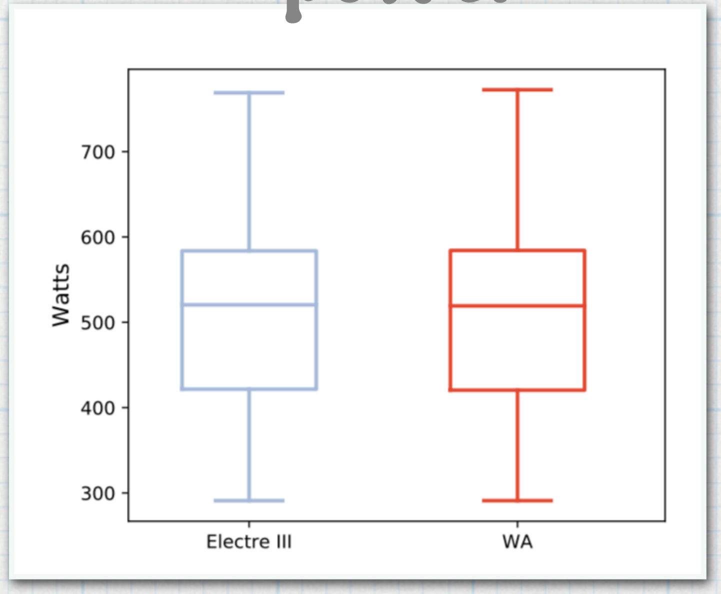


hop count



(a) Case A

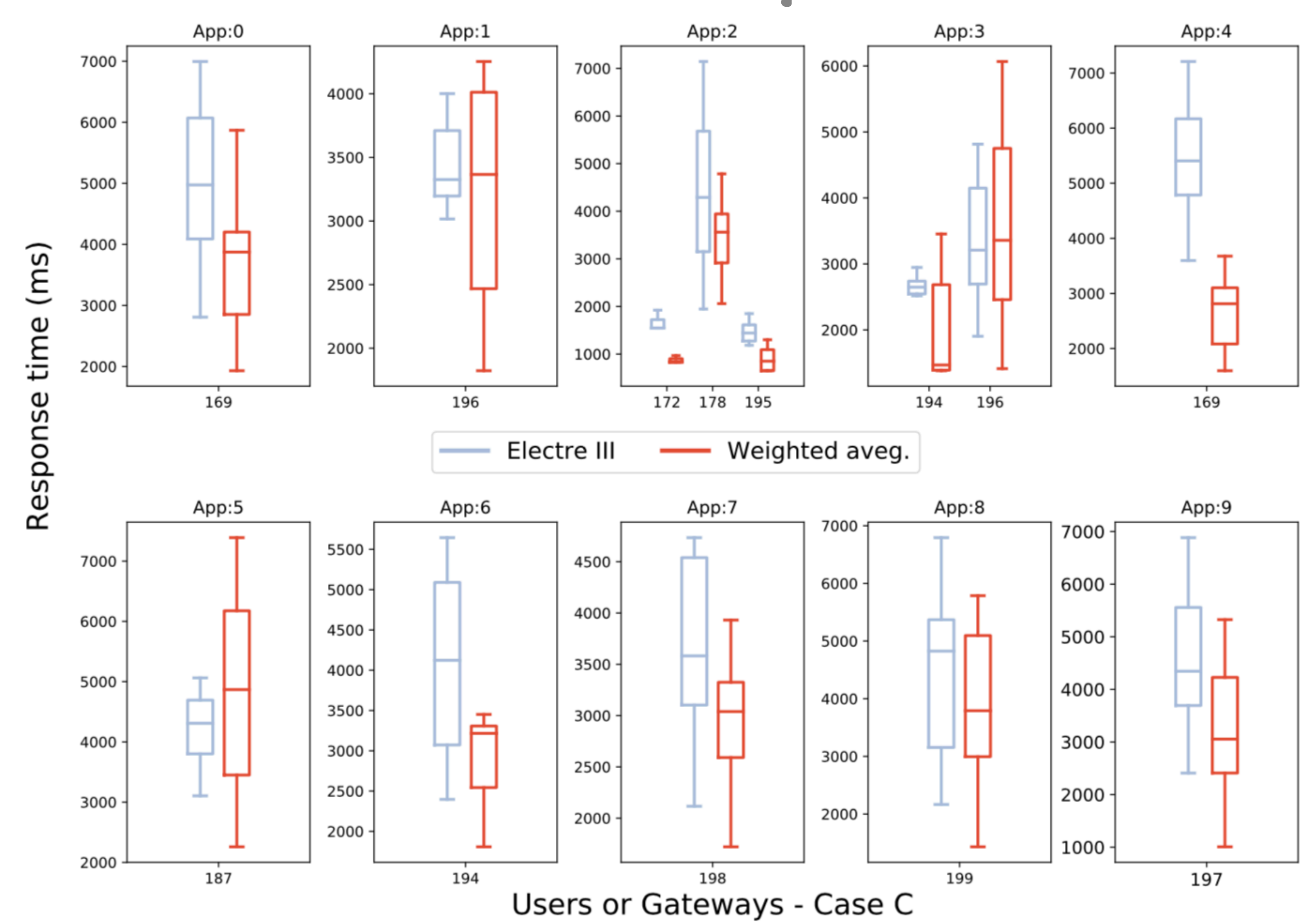
power



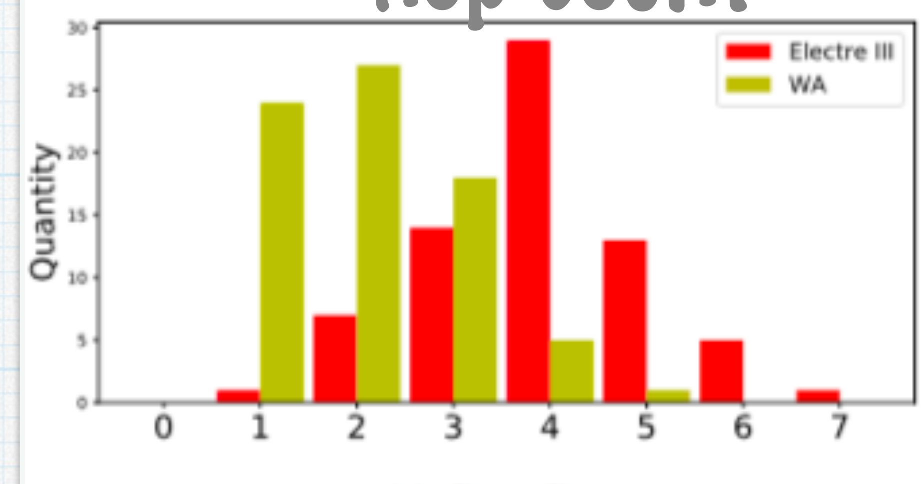
Results

Case	Hop count	Latency	Power	Cost	D.Penalty
C	4	**1**	3	3	3

latency

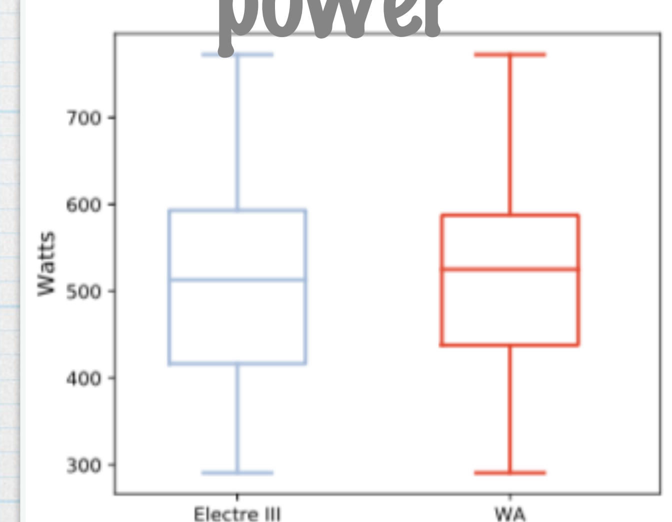


hop count



(c) Case C

power



(c) Case C

Discussion & Conclusions

* EXPLORATORY WORK -> Results are limited!
* The WA gives more importance to a specific criteria without considering the rest (obvious)
* **ELECTRE III method preserves the decision maker.**
* Not significative results due to a uniform definition of the infrastructure. there are no polarized situations
* A WA is computationally less cost than this ELECTRE III method.

Conclusion:

* MCDA methods can aid to find allocation with multiple and contradictory criteria; a powerful and flexible tool to incorporate more detailed criteria: hardware configurations, budgets, user preferences, and so on.
* As future work, we need to do MORE EXPERIMENTATION: from 2 to n-criteria, and comparing with more optimisation solutions

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Thank you for your attention

Any question?

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YAFS https://github.com/acsicuib/YAFS