Multi-objective Optimization

Features:

- Distributed Data Flow
- Fog nodes mobility
- IoT devices mobility
- Migration support
- Partitioning techniques
- Data placement optimization
- Migration Optimization

Variables:

- QoS
  - latency
- Cost
  - CPU
  - RAM
  - MEM
  - BW
- Energy
  - busyPower
  - idlePower
- Bandwidth

Static optimization

Notations:

- N fog nodes $S = \{s_1, ..., s_n\}$
- M users $U = \{u_1, ..., u_m\}$

- C^{MIPS} = matrix $N \times 1$ representing the MIPS capacity of each fog node
- C^{MEM} = matrix $N \times 1$ representing the memory capacity of each fog node
- C^{STRG} = matrix $N \times 1$ representing the storage capacity of each fog node
- C^{BW} = matrix $N \times 1$ representing the bandwidth capacity of each fog node

- a^{MIPS} = matrix $1 \times N$ representing the MIPS price of each fog node per unit
- a^{MEM} = matrix $1 \times N$ representing the memory price of each fog node per unit
- a^{STRG} = matrix $1 \times N$ representing the storage price of each fog node per unit
- a^{BW} = matrix $1 \times N$ representing the bandwidth price of each fog node per unit
- a^{bPw} = matrix $1 \times N$ representing the busy power consumption of each fog node per unit
- a^{iPw} = matrix $1 \times N$ representing the idle power consumption of each fog node per unit

- x^{MIPS} = matrix $M \times 1$ representing the MIPS needed for each application's module
- x^{MEM} = matrix $M \times 1$ representing the memory needed for each application's module
- x^{STRG} = matrix $M \times 1$ representing the storage needed for each application's module
- x^{BW} = matrix $M \times 1$ representing the bandwidth needed for each application's module

- B = matrix $N \times M$ representing the solution of the problem (mapping between modules and nodes)
- D = matrix $M \times M$ representing the dependencies between modules ($D_{ij} = 1$, if i sends data to j)
- S = matrix $M \times M$ representing the NW tuple size sent between modules ($S_{ij} =$, sum of tuple sizes sent from i to j)
- L = matrix $N \times N$ representing the latency between each two nodes (result from dijkstra method)
- Bw = matrix $N - 1 \times N \times N$ representing the bandwidth between each two nodes (result from dijkstra method)
- e = matrix $1 \times N$, with all cells to 1

Problem formulation:

The cost function is mainly characterized by two components: Operational Cost and Service Quality Cost.

Operational Cost (C_O) is characterized by the resources allocated in each fog node to support all users' computations, namely: CPU, memory, storage, bandwidth.

$$C_O = a^{MIPS} Bx^{MIPS} + a^{MEM} Bx^{MEM} + a^{STRG} Bx^{STRG} + a^{BW} Bx^{BW}$$

Energetic Cost (C_E) is characterized by the busy/idle power in each fog node to support all users' computations.

$$C_E = (a^{bPw} - a^{iPw}) \times ((Bx^{MIPS}) \ ./ \ C^{MIPS})$$

Quality Cost (C_Q) is characterized by the total latency (sense-process-actuate).

$$C_Q = e[(BDB'). * L + \sum_{i=1}^{N-1} ((BSB'). * Bw_i)]e'$$

Final problem:

$$\begin{aligned}
\underset{B}{\text{minimize}} \quad & C = \alpha C_O + \beta C_E + \gamma C_Q \\
\text{subject to} \quad & Bx^{MIPS} \leq C^{MIPS}, \\
& Bx^{MEM} \leq C^{MEM}, \\
& Bx^{STRG} \leq C^{STRG}, \\
& Bx^{BW} \leq C^{BW}, \\
& B_{i,j} \in \{0,1\}, \forall i \in [0,N], \forall j \in [0,M], \\
& \sum_{i=1}^{N} B_{i,j} = 1, \forall j \in [0,M]
\end{aligned}$$