

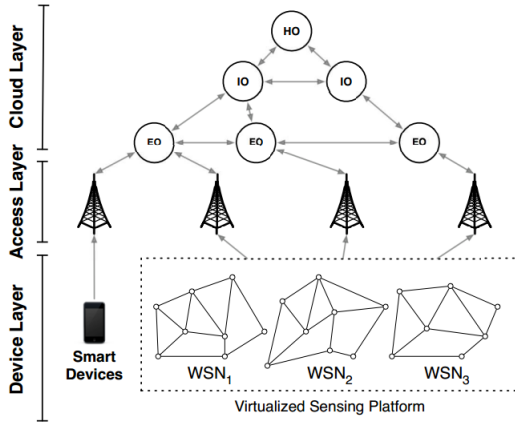
Progress

- ▶ Study about network flow problem: max flow, min-cost flow, multi-commodity flow problem and use python to solve some example in about 2 weeks
- ▶ Implement the smart city simulation of the second paper in about 2 weeks

PuLP

- ▶ PuLP is a library for the Python scripting language that enables users to describe mathematical programs
- ▶ PuLP has focused on supporting linear and mixed-integer models.
- ▶ It supports a wide range of both commercial and open-source solvers, and can be easily extended to support additional solvers: CPLEX, Gurobi, CBC, GLPK...

Smart city architecture



(a) Smart city architecture. The device layer is composed of smart devices, which provide live video streams and request augmented videos, and 3 WSNs collecting environmental information around the city.

Formulating the mathematical program

Decision Variables:

- ▶ $pr_in[u][o] \in \{0, 1\}, u \in V, o \in O$
- ▶ $pr_out[u][o] \in \{0, 1\}, u \in V, o \in O$
- ▶ $tr[u][v][o] \in \{0, 1\}, u \in V, o \in O$

Formulating the mathematical program

Objective function:

$$\begin{aligned} & \sum_{\substack{u \in V \\ o \in O}} pr_in[u][o].obj[o].complexity[o].user \cdot \frac{1}{node_e[u]} \\ \text{minimize} \quad & + \sum_{\substack{u \in V \\ v \in V \\ o \in O}} tr[u][v][o].obj[o].link_e[u][v].user \end{aligned}$$

Formulating the mathematical program

Constraints:

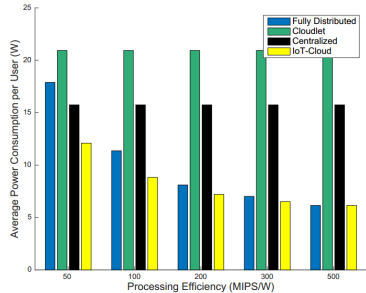
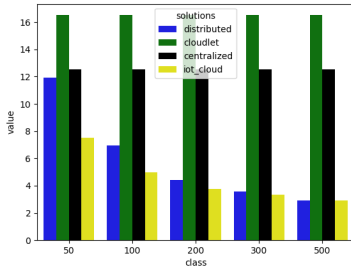
- ▶ Generalized flow conservation constraints
- ▶ Source constraints
- ▶ QoS Constraints
- ▶ Capacity constraints

Formulating the mathematical program

Data needed for the objective function and constraints

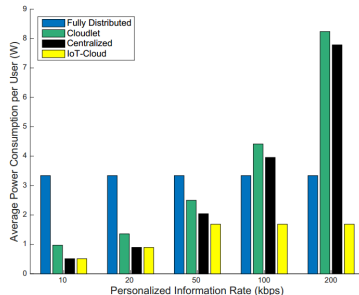
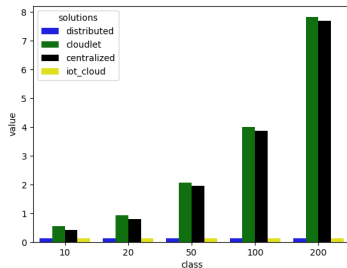
- ▶ Demand: Device request final information object
- ▶ Supply/Sensing
- ▶ Information objects dependencies
- ▶ Node capacity, node efficiency, link capacity, link efficiency, object bitrate

Smart city simulation



Augmented Reality Service in Smart city with device efficiency = [50, 100, 200, 300, 500]

Smart city simulation

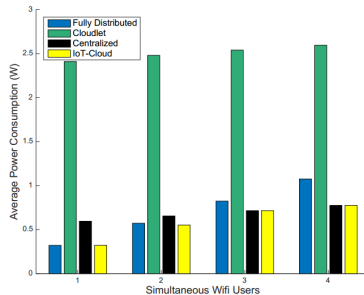
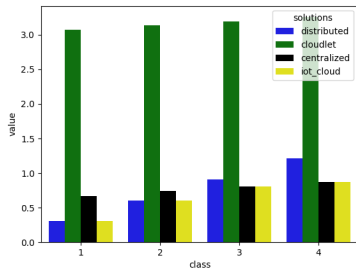


City monitoring service

2 wifi and 2 4g users simultaneously request the service

personalized information rate = [10, 20, 30, 50, 100, 200]

Smart city simulation

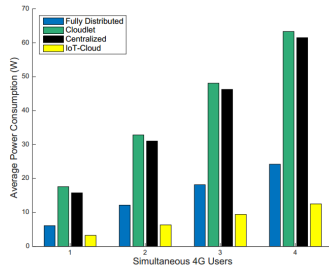
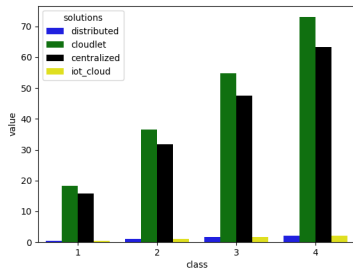


City monitoring service

Number of users = [1, 2, 3, 4]

Using wifi connection

Smart city simulation



(b) Simultaneous 4G users

City monitoring service

Number of users = [1, 2, 3, 4]

Using 4G connection

Missing information

- ▶ sensing cost
- ▶ how many sensors in a WSN
- ▶ bitrate of intermediate information objects