Ruteo - Capacidad

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Capítulo 1

Routing Problems

1.1. Online Route Assignment

Given

- $G = (V, E)$: Graph that represents the topology.
- $M = |V|$: Number of vertices.
- W_{ij} : Cost of (i, j) edge.
- s : Source vertex $s \in V$.
- d : Destination vertex $d \in V$.

Variables

- x_{ij} : Binary, one iff the path cross (i, j) edge from i to j, zero otherwise.

Formulation

- Minimize:

$$z = \sum_{i=1}^{M} \sum_{j=1}^{M} W_{ij} x_{ij}$$

- Subject to:

$$\sum_{j=1}^{M} x_{ij} - \sum_{j=1}^{M} x_{ji} = \begin{cases} 1 & \text{if } i = s \\ -1 & \text{if } i = d \\ 0 & \text{otherwise} \end{cases} \qquad \forall i \in \{0, 1, ..., M\}$$

$$x_{ij} \in \{0, 1\}$$

1.2. Offline Route Assignment

Given

- $G = (V, E)$: Graph that represents the topology.
- $M = |V|$: Number of vertices.
- K : Number of flows.
- W_{ij} : Cost of (i, j) edge.
- s^k : Source vertex $s \in V$ of flow k.
- d^k : Destination vertex $d \in V$ of flow k.

Variables

- x_{ij}^k : Binary, one iff the path of flow k cross (i, j) edge from i to j, zero otherwise.

Formulation

- Minimize:

$$z = \sum_{k=1}^{K} \sum_{i=1}^{M} \sum_{j=1}^{M} W_{ij} x_{ij}^k$$

- Subject to:

$$\sum_{j=1}^{M} x_{ij}^k - \sum_{j=1}^{M} x_{ji}^k = \begin{cases} 1 & \text{if } i = s^k \\ -1 & \text{if } i = d^k \\ 0 & \text{otherwise} \end{cases} \qquad \forall i \in \{1, ..., M\} \quad \forall k \in \{1, 2, ..., K\}$$

$$x_{ij}^k \in \{0, 1\}$$

1.3. Online Route and Capacity Assignment

Given

- $G = (V, E)$: Graph that represents the topology.
- $M = |V|$: Number of vertices.
- W_{ij} : Cost of (i, j) edge.
- C : Capacity demanded.
- C_{ij} : Capacity of edge (i, j).
- s : Source vertex $s \in V$.
- d : Destination vertex $d \in V$.

Variables

- x_{ij} : Binary, one iff the path cross (i, j) edge from i to j, zero otherwise.

Formulation

- Minimize:

$$z = \sum_{i=1}^{M} \sum_{j=1}^{M} W_{ij} x_{ij}$$

- Subject to:

$$\sum_{j=1}^{M} x_{ij} - \sum_{j=1}^{M} x_{ji} = \begin{cases} 1 & \text{if } i = s \\ -1 & \text{if } i = d \\ 0 & \text{otherwise} \end{cases} \qquad \forall i \in \{0, 1, ..., M\}$$

$$C(x_{ij} + x_{ji}) \leq C_{ij} \qquad \forall (i, j) \in E$$

$$x_{ij} \in \{0, 1\}$$

1.4. Offline Route Assignment

Given

- $G = (V, E)$: Graph that represents the topology.
- $M = |V|$: Number of vertices.
- K : Number of flows.
- W_{ij} : Cost of (i, j) edge.
- C^k : Capacity demanded by flow k.
- C_{ij} : Capacity of edge (i, j).
- s^k : Source vertex $s \in V$ of flow k.
- d^k : Destination vertex $d \in V$ of flow k.

Variables

- x_{ij}^k : Binary, one iff the path of flow k cross (i, j) edge from i to j, zero otherwise.

Formulation

- Minimize:

$$z = \sum_{k=1}^{K} \sum_{i=1}^{M} \sum_{j=1}^{M} W_{ij} x_{ij}^{k}$$

- Subject to:

$$\sum_{j=1}^{M} x_{ij}^{k} - \sum_{j=1}^{M} x_{ji}^{k} = \begin{cases} 1 & \text{if } i = s^k \\ -1 & \text{if } i = d^k \\ 0 & \text{otherwise} \end{cases} \qquad \forall i \in \{1, ..., M\} \quad \forall k \in \{1, 2, ..., K\}$$

$$\sum_{k=1}^{K} C^k (x_{ij}^{k} + x_{ji}^{k}) \leq C_{ij} \qquad \forall (i, j) \in E$$

$$x_{ij}^{k} \in \{0, 1\}$$

1.5. Online 1+1 Route and Capacity Assignment

Given

- $G = (V, E)$: Graph that represents the topology.
- $M = |V|$: Number of vertices.
- W_{ij} : Cost of (i, j) edge.
- C : Capacity demanded.
- C_{ij} : Capacity of edge (i, j).
- s : Source vertex $s \in V$.
- d : Destination vertex $d \in V$.
- B : A big number $(B \geq \sum^{ij} W_{ij})$

Variables

- x_{ij}^{k} : Integer, the number of paths from s to d that cross edge (i, j) from i to j.

Formulation

- Minimize:

$$z = \sum_{i=1}^{M}\sum_{j=1}^{M} Bj_{ij} + \sum_{i=1}^{M}\sum_{j=1}^{M} W_{ij}x_{ij}$$

- Subject to:

$$\sum_{j=1}^{M} x_{ij} - \sum_{j=1}^{M} x_{ji} = \begin{cases} 2 & \text{if } i = s \\ -2 & \text{if } i = d \\ 0 & \text{otherwise} \end{cases} \qquad \forall i \in \{0, 1, ..., M\}$$

$$C(x_{ij} + x_{ji}) \leq C_{ij} \qquad \forall (i,j) \in E$$
$$j_{ij} \geq x_{ij} + x_{ji} - 1 \qquad \forall (i,j) \in E$$

$$x_{ij} \in \{0, 1, 2\}$$
$$j_{ij} \in \{0, 1\}$$

1.6. Online 1+1 Route and Capacity Assignment

Given

- $G = (V, E)$: Graph that represents the topology.
- $M = |V|$: Number of vertices.
- W_{ij} : Cost of (i, j) edge.
- C : Capacity demanded.
- C_{ij} : Capacity of edge (i, j).
- s : Source vertex $s \in V$.
- d : Destination vertex $d \in V$.
- B : A big number ($B \geq \sum^{ij} W_{ij}$)

Variables

- x_{ij}^{k} : Integer, the number of paths from s to d that cross edge (i, j) from i to j.

Formulation

- Minimize:

$$z = \sum_{i=1}^{M}\sum_{j=1}^{M} Bj_{ij} + \sum_{i=1}^{M}\sum_{j=1}^{M} W_{ij}(x_{ij} + y_{ij})$$

- Subject to:

$$\sum_{j=1}^{M} x_{ij} - \sum_{j=1}^{M} x_{ji} = \begin{cases} 1 & \text{if } i = s \\ -1 & \text{if } i = d \\ 0 & \text{otherwise} \end{cases} \qquad \forall i \in \{0, 1, ..., M\}$$

$$\sum_{j=1}^{M} y_{ij} - \sum_{j=1}^{M} y_{ji} = \begin{cases} 1 & \text{if } i = s \\ -1 & \text{if } i = d \\ 0 & \text{otherwise} \end{cases} \qquad \forall i \in \{0, 1, ..., M\}$$

$$C(x_{ij} + x_{ji} + y_{ij} + y_{ji}) \leq C_{ij} \qquad \forall (i,j) \in E$$
$$j_{ij} \geq x_{ij} + x_{ji} + y_{ij} + y_{ji} - 1 \qquad \forall (i,j) \in E$$

$$y_{ij} \in \{0, 1\}$$
$$x_{ij} \in \{0, 1\}$$
$$j_{ij} \in \{0, 1\}$$

1.7. Offline 1+1 Route Assignment

Given

- $G = (V, E)$: Graph that represents the topology.
- $M = |V|$: Number of vertices.
- K : Number of flows.
- W_{ij} : Cost of (i, j) edge.
- C^k : Capacity demanded by flow k.
- C_{ij} : Capacity of edge (i, j).
- s^k : Source vertex $s \in V$ of flow k.
- d^k : Destination vertex $d \in V$ of flow k.
- B : A big number ($B \geq K \sum^{ij} W_{ij}$)

Variables

- x_{ij}^k : Integer, the number of paths from s^k to d^k that cross edge (i,j) from i to j.

Formulation

- Minimize:

$$z = \sum_{k=1}^{K} \sum^{(i,j)\in E} Bj_{ij}^k + \sum_{k=1}^{K} \sum_{i=1}^{M} \sum_{j=1}^{M} W_{ij} x_{ij}^k$$

- Subject to:

$$\sum_{j=1}^{M} x_{ij}^k - \sum_{j=1}^{M} x_{ji}^k = \begin{cases} 1 & \text{if } i = s^k \\ -1 & \text{if } i = d^k \\ 0 & \text{otherwise} \end{cases} \qquad \forall i \in \{1, ..., M\} \quad \forall k \in \{1, 2, ..., K\}$$

$$\sum_{k=1}^{K} C^k (x_{ij}^k + x_{ji}^k) \leq C_{ij} \qquad \forall (i,j) \in E$$

$$j_{ij}^k \geq x_{ij}^k + x_{ji}^k - 1 \qquad \forall (i,j) \in E$$

$$x_{ij}^k \in \{0, 1, 2\}$$