Decentralized decision power and information sharing in horizontal logistics collaboration

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Agenda

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2. The network design - multicommodity flow problem
3. Allocation rule
4. Three systems with central authority
5. Fully Decentralized Iterative Cooperative System
6. Computationally results
7. Discussion

Introduction

Horizontal logistics collaboration

- Central planning
- Decentralized systems
  - Auction-based
  - Non auction-based

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The network design - multicommodity flow problem

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Commodities:

	$o(k)$	$t(k)$	d_k	r_k
k^1	1	2	1	10
k^2	1	4	1	10
k^3	3	1	1	10

Edges:

	q_e	c_e
$\forall e \in E$	2	5

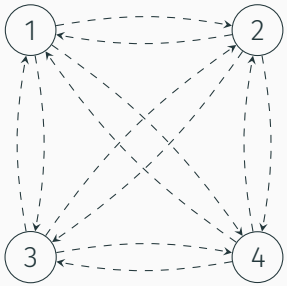

Figure: Original network.

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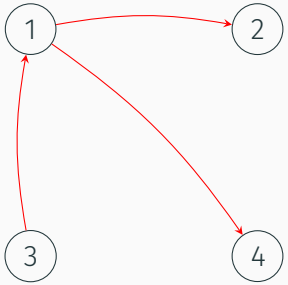

Figure: Design of the network.

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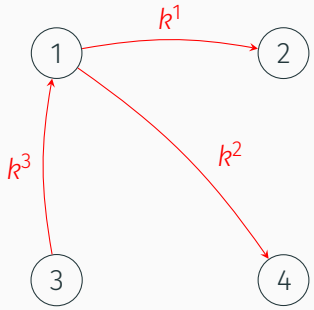

Figure: Route the commodities.

The network design - multicommodity flow problem: ILP

- We model the problem as an ILP, $\boldsymbol{P_i}\ \forall i \in N$.

$$P_i: \quad \max \sum_{k \in \Theta^i} \sum_{e \in \delta^+(t(k)) \cap E^i} f_e^k \cdot d_k \cdot r_k - \sum_{e \in E^i} u_e \cdot c_e \tag{1}$$

- Subject to different constraints

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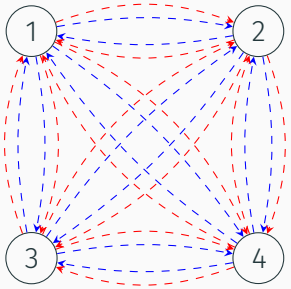

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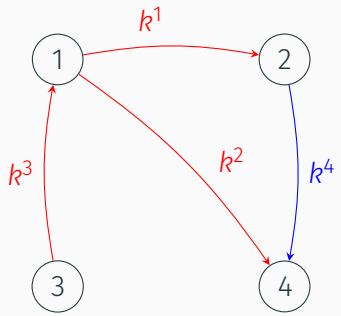

Figure: Solution without cooperation.

The network design - multicommodity flow problem

Commodities:

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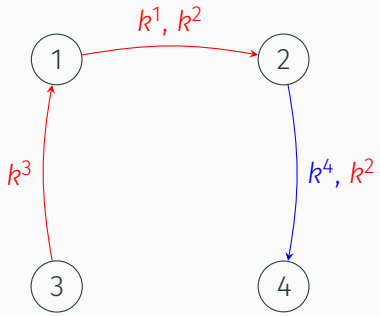


Figure: Cooperative solution.

Allocation rule

Allocation rule

1. The revenues generated by any served commodity are allocated to its owner.
2. The activation cost of any active edge is paid by its owner.
3. The price of using an unit of capacity on an edge $e \in E$ owned by agent $w(e)$ for any other member of the coalition, $i \in N \setminus \{w(e)\}$, is equal to $\frac{c_e}{q_e}$.

Three systems with central authority

Three systems with central authority

- A central authority with certain decision power.
- Agents have to share certain amount of information to cooperate.
- 3 systems:
  - Fully centralized cooperation system (FCCS),
  - Partial cooperation system (PCS),
  - Residual cooperation system (RCS).

Three systems with central authority

Fully centralized cooperative system (FCCS)

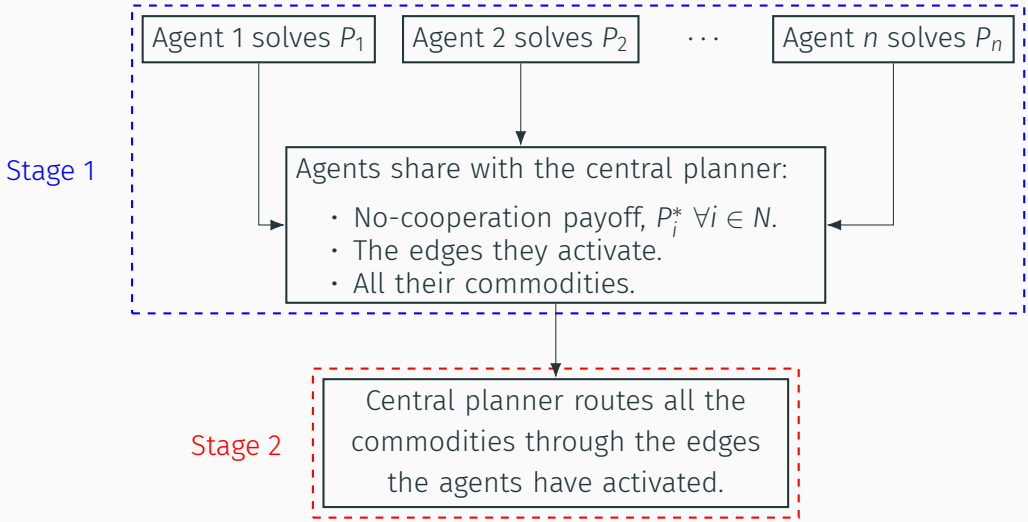
Fully centralized cooperative system (FCCS)

- A central planning system $\Longrightarrow$ Central authority with full information and all the decision power.
- Commodities and edges of all the agents are aggregated into a single bigger problem.
- Final profit allocation must be individually rational.

Three systems with central authority

Partial cooperative system (PCS)

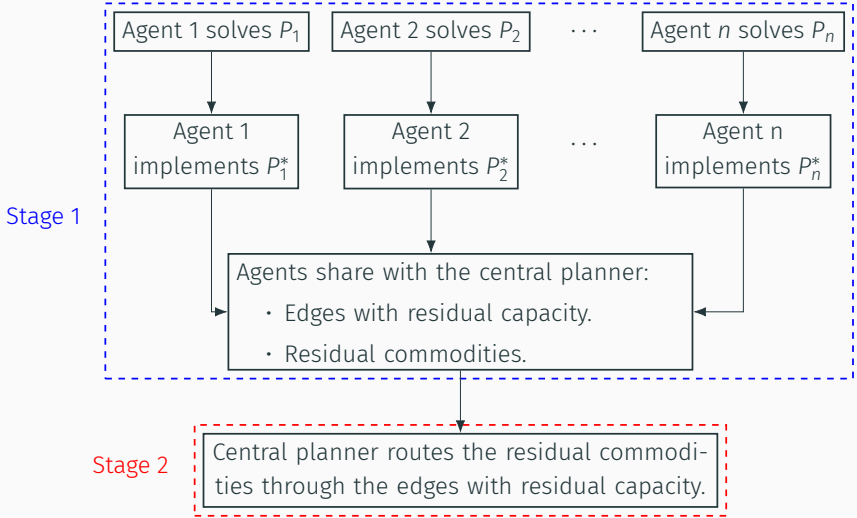
Partial cooperative system (PCS)



Three systems with central authority

Residual cooperation system (RCS)

Residual cooperation system (RCS)



Fully Decentralized Iterative Cooperative System

Fully Decentralized Iterative Cooperative System

Some characteristics:

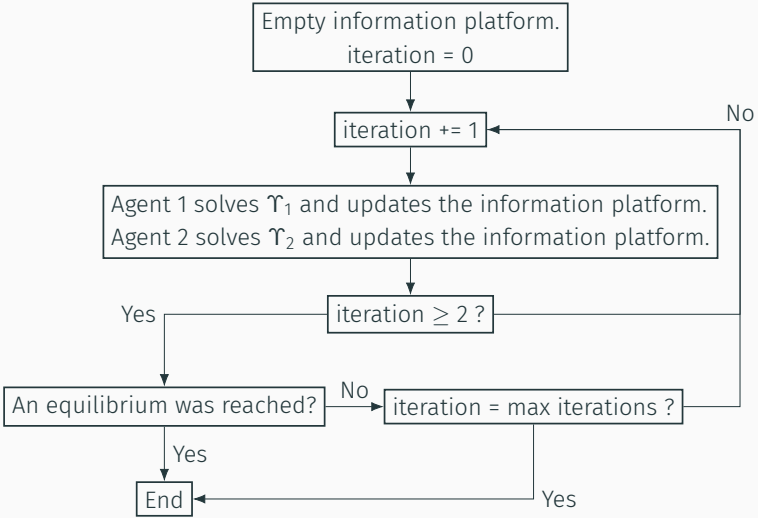
- Developed only for two agents.
- There is NOT a central authority with decision power, but only an information platform.
- Agents exchange information and make decisions in an iterative process.

Information platform

An agent can share in the information platform:

1. Which edges he is planning to active leaving residual capacity on them.
2. Which edges previously shared by the other agent he would like to use, indicating:
   - The capacity he would like to use in each edge.
   - Which “combinations” of that edges he requires for each commodity, as well as the size of that commodity.

Fully Decentralized Iterative Cooperative System

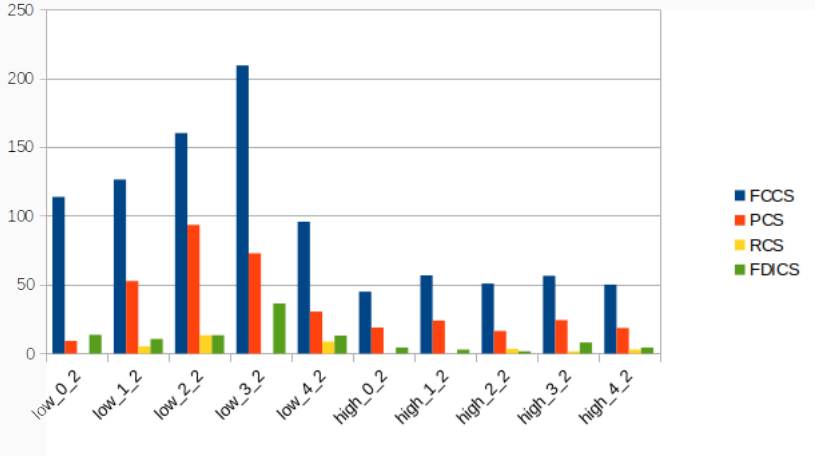


Computationally results

Instances

- Instances with 2 and 5 agents.
- In all, graphs with 7 nodes.
- All the parameters selected from uniform distribution.
- Instances with edges with LOW or HIGH capacity.

Results


250
200
150
100
50
0
low_0_2
low_1_2
low_2_2
low_3_2
low_4_2
high_0_2
high_1_2
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high_3_2
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FCCS
PCS
RCS
FDICS

Discussion