Decentralized decision power and information sharing in horizontal logistics collaboration

Antón de la Fuente Suárez-Pumariega

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Maastricht University

Agenda

1. Introduction
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. Conclusions

Introduction

Horizontal logistics collaboration

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  - Centralized $\rightarrow$ Central planning.
  - Decentralized $\begin{cases} \text{Auction-based.} \\ \text{Non auction-based.} \end{cases}$

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The network design - multicommodity flow problem

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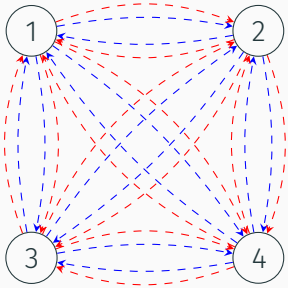
Commodities:

	Origin	Terminal	Size	Revenue
k^1	1	2	1	10
k^2	1	4	1	10
k^3	3	1	1	10
k^4	2	4	1	10

Edges:

	Capacity	Activation cost
$\forall$ edge	2	5



Original network.

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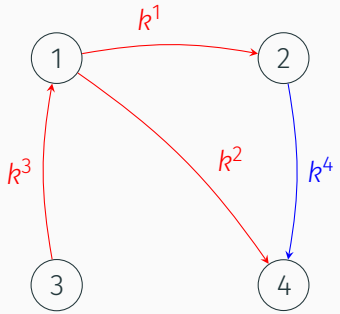

Solution without cooperation.

The network design - multicommodity flow problem

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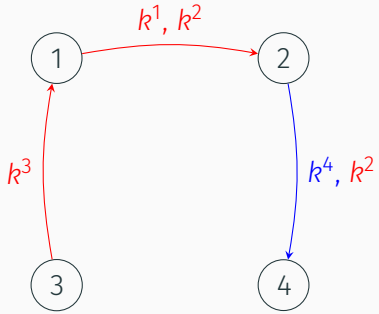

Cooperative solution.

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)

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- 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)

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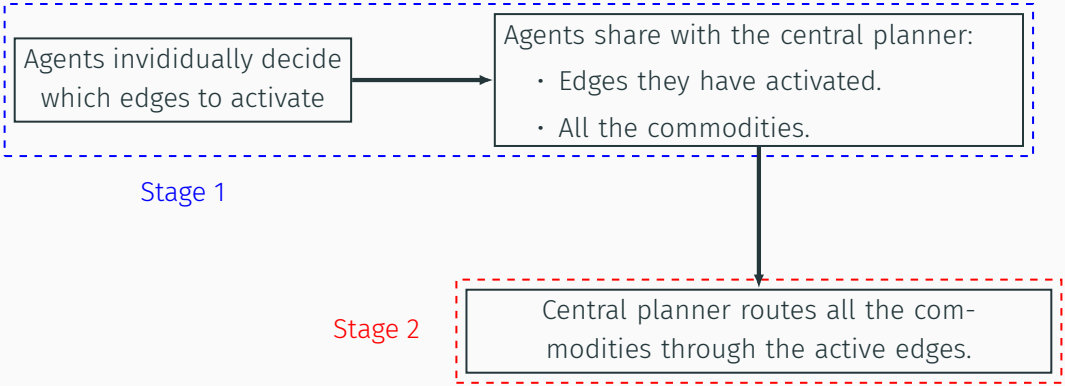

Three systems with central authority

Residual cooperation system (RCS)

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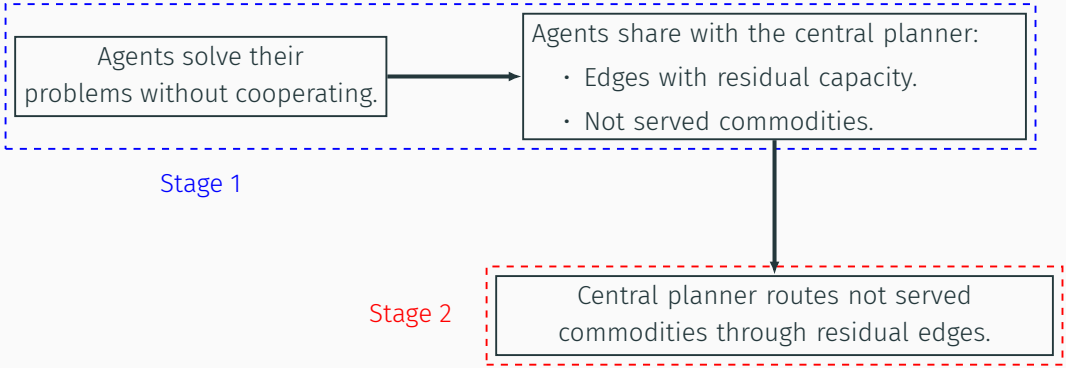


Fully Decentralized Iterative Cooperative System

Fully Decentralized Iterative Cooperative System

Some characteristics:

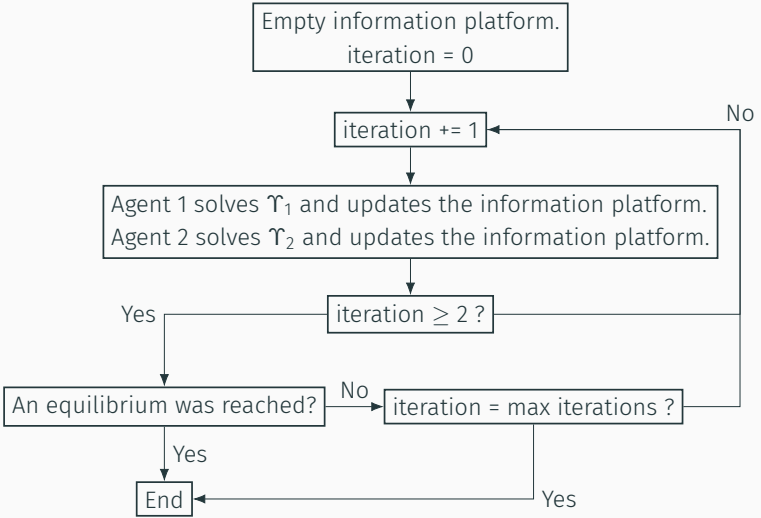
- Developed only for two agents.
- There is NOT a central authority with decision power, but only an information platform.
- Agents exchange information and make decisions in an iterative process.

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

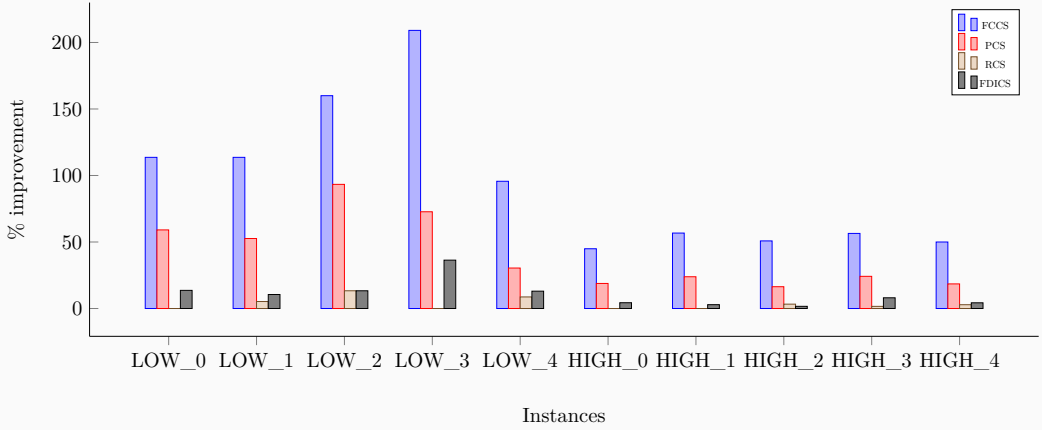


Computationally results

Instances

- Instances with 2 and 5 agents.
- Graph with 7 nodes.
- Complete graph for all the agents.
- All the parameters selected from uniform distributions.
- Instances with edges with LOW or HIGH capacity.

Results: Instances with 2 agents



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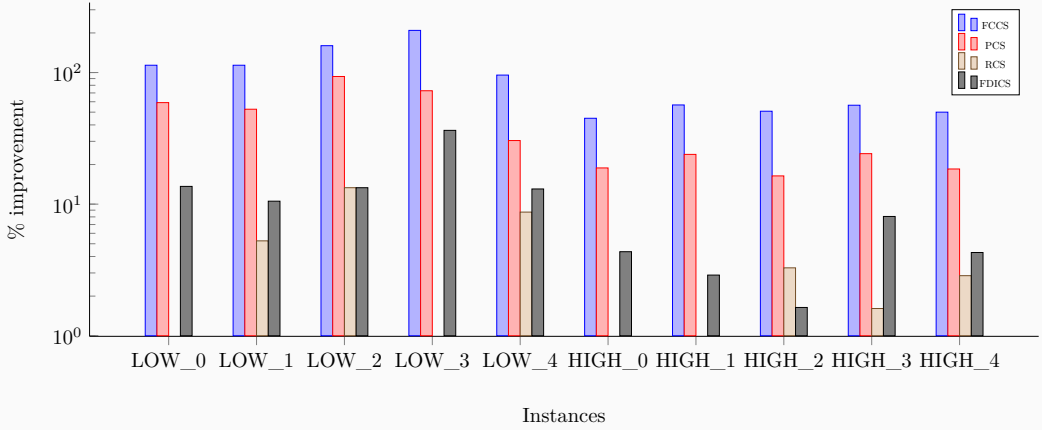

Results: Analysis of order relevance in FDICS

	Total payoffs		% Dif.	Nº iterations		Dif.
	Order:1-2	Order:2-1		Order:1-2	Order:2-1	
2_low_0	25.0	25.0	0.00	4.0	3.0	1.0
2_low_1	21.0	21.0	0.00	3.0	3.0	0.0
2_low_2	17.0	17.0	0.00	3.0	3.0	0.0
2_low_3	15.0	15.0	0.00	4.0	4.0	0.0
2_low_4	27.0	26.0	3.70	3.0	3.0	0.0
2_high_0	73.0	72.0	1.37	3.0	3.0	0.0
2_high_1	70.0	69.0	1.49	3.0	3.0	0.0
2_high_2	65.0	63.0	3.08	3.0	3.0	0.0
2_high_3	68.0	67.0	1.47	4.0	4.0	0.0
2_high_4	74.0	73.0	1.35	3.0	3.0	0.0

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- In terms of solution quality: FCCS > PCS > FDICS > RCS.
- Relevance of amount of information shared and decision power allocation.
- Extension of FDICS to more agents might be interesting.

Thank you for the attention.