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Controllability analysis of second-order multi-agent systems with directed and weighted interconnection

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Introduction

- We consider the controllability problem of second-order multi-agent systems with directed and weighted interconnection and aim to obtain easy-to-verify criteria for controllability checking in terms of the interaction weights.
- A very simple necessary and sufficient condition regarding the weighting scheme is obtained in this scenario.
- A type of topology is concerned with a more general graph that can be reduced to a directed tree by contracting a cluster of nodes to a component.

The topology investigated in this work

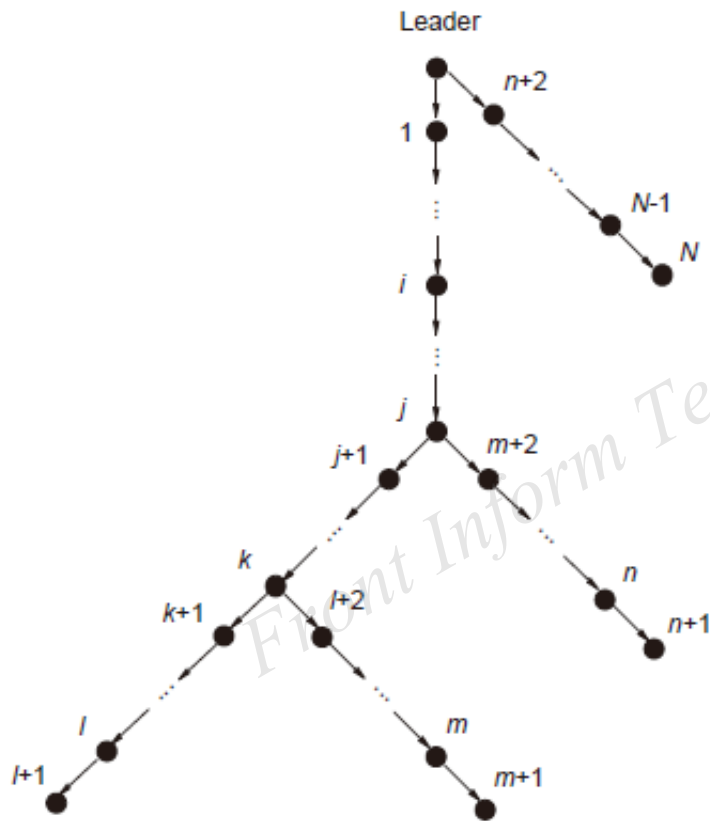


Fig. 1 A directed tree

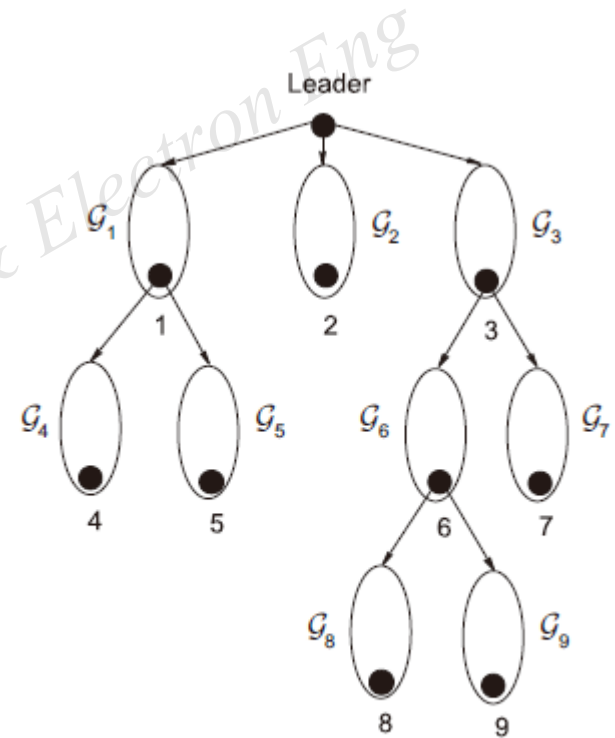


Fig. 2 A contracted tree

Main results

- For a directed tree, choosing different weights for agents at different branches, the controllability can be ensured.
- A contracted tree is controllable if and only if
 - Every subgraph is controllable.
 - The components in different branches have different eigenvalues.

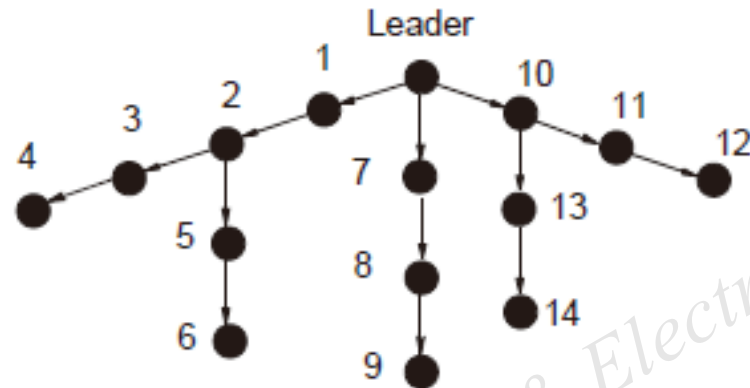


Fig. 8 Example 1: a directed tree

- Choosing different weights for agents at different branches, the system is controllable.
- On the other hand, choose $w_{12} = w_4$ the system is not controllable.

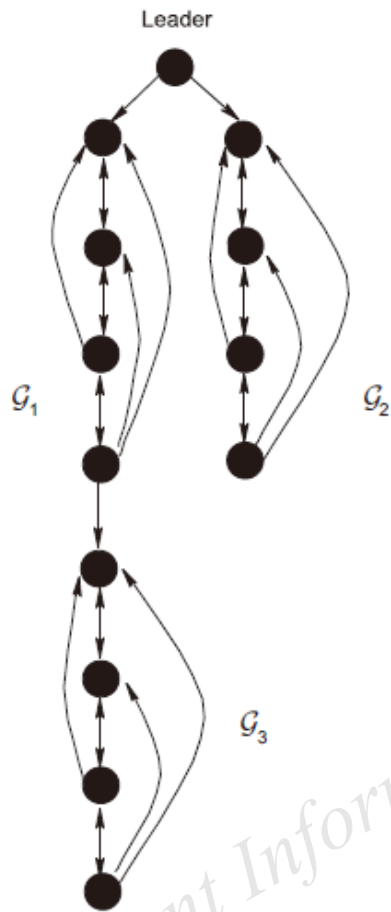


Fig. 9 Example 2: a contracted tree with feedback arcs

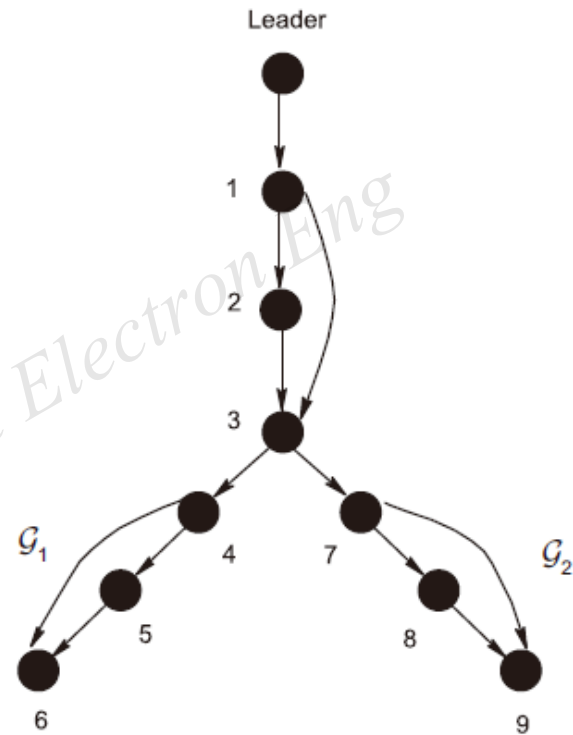


Fig. 10 Example 3: a contracted tree with feedforward arcs

The above two examples also show that the results of this work are correct.

Conclusions

- This article investigates the controllability problem of second-order multi-agent systems over directed trees and contracted trees.
- Necessary and sufficient controllable conditions are obtained, which are easy to be verified.