Games Networks

A game-theoretical approach to deal with modularity in complex systems

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Motivations

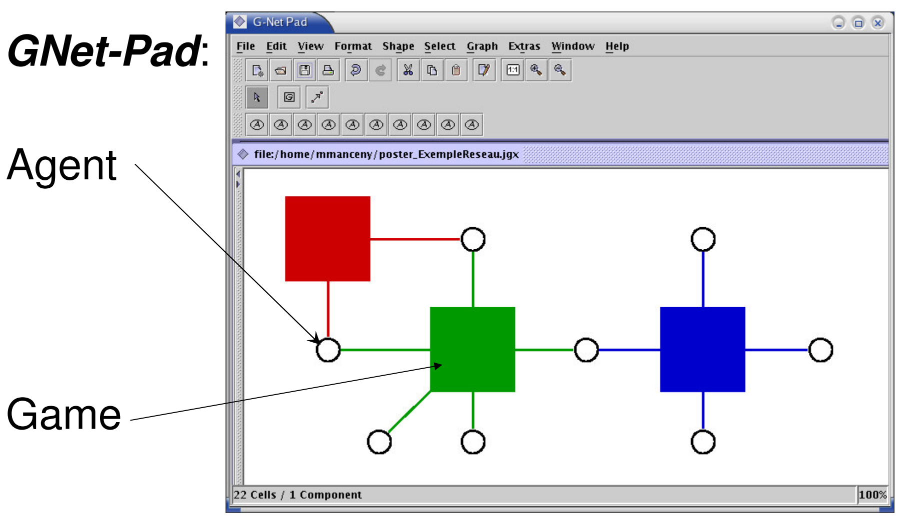
To model interactions in complex systems, we investigate an extension of game theory named **games networks**. Basically, games networks aims at providing a **modular view of complex systems** by emphasizing the locality of interactions. The issue is to understand the organization of interactions as a **composition of "basic building blocks"** (B^3). In the model, **blocks are games** and represent tight interactions between players. Such games are considered as **elementary modules**. We propose an algorithm to automatically split any game to an equivalent games network with B^3. Games networks have been applied in **molecular network analysis**. According to first experiments, B^3 decomposition appears to divide networks in two kinds of B^3: The first ones represent signal "**transmitters**" whereas the second ones represent regulatory nodes which play a critical role in the "**control**" of biological system dynamics.

Game theory

- ✓ Theory of ***interacted decision***
- ✓ Used to study situation where agents take decisions
- ✓ The choice of each agent ***depends on, and influences***, choices of other players
- ✓ Steady states ≡ Nash equilibria

Games networks

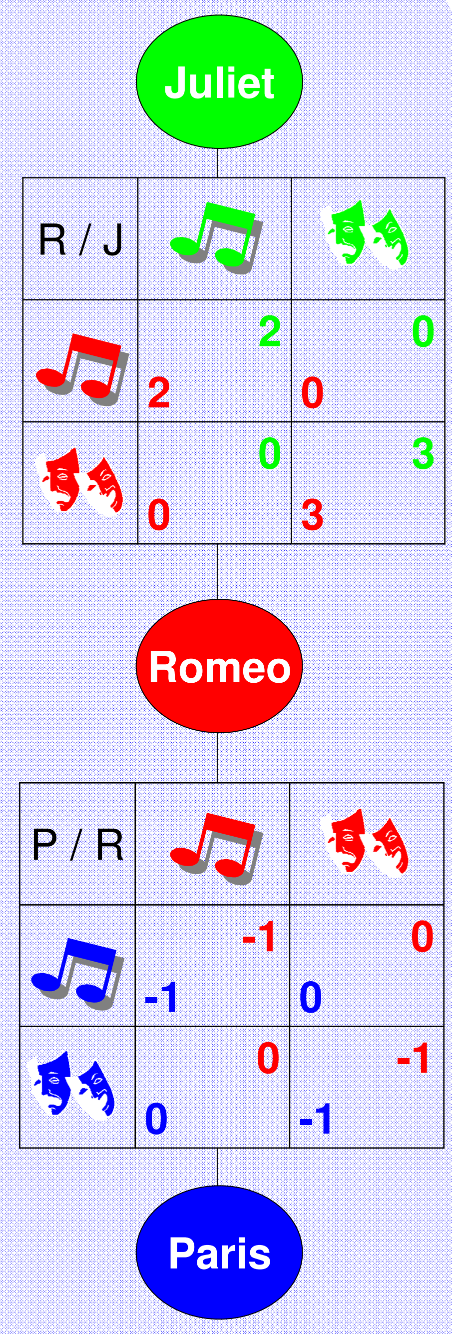
- ❖ ***Modular extension*** of game theory
- ❖ A player can be ***involved in several games simultaneously***
- ❖ ***Static analysis of the dynamics***
- ❖ Compute ***steady states*** for one game / for the whole network
- ❖ ***GNet-Pad***:



An example: Romeo, Juliet…

Romeo **and** ***Juliet have a date.*** Unfortunately they do not remember where the appointment takes place. They only know they can go either to ***theatre*** or to ***opera***…

Count Paris, the promise husband of Juliet, is in town. He ***does not want to meet Romeo***, and reciprocally.



… and Paris

Nash equilibria

- ✓ Central concept
- ✓ Steady states of a game where agents are ***rational*** *(they aim at maximizing their payoffs)*
- ✓ ***No agent can unilaterally deviates from a Nash equilibrium without decreasing its payoff***
- ✓ Two Nash equilibria between Romeo and Juliet: ***they go out together***, either to theatre or to opera

Global Equilibria

- ❖ Equilibria at the scale of the whole network
- ❖ Principle of single strategy: an agent which is involved in several games must ***play the same strategy*** for all the games
- ❖ Global equilibrium = ***composition of Nash equilibria*** from each game of the network
- ❖ Two global equilibria between Romeo, Juliet and Paris: ***Romeo and Juliet go to theatre and Paris to opera***, or ***Romeo and Juliet go to opera and Paris to theatre***

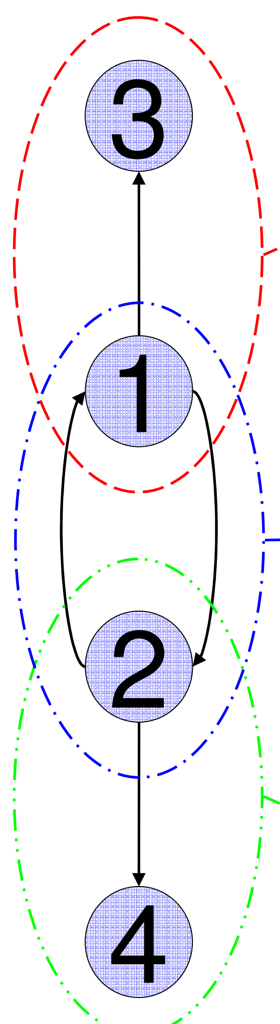
Elementary modules

- ❖ Several games networks can ***represent the same situation***
- ❖ Two games networks are ***equivalent*** if they have the ***same global equilibria***
- ❖ Find a normal representation where the ***elementary interactions*** are underlined
- ❖ Games networks with ***games as small as possible*** (in sense of number of agents participating to the game)
- ❖ ***Dependence between agents***: agent A is dependent on agent B if A's payoffs are altered by B's strategies

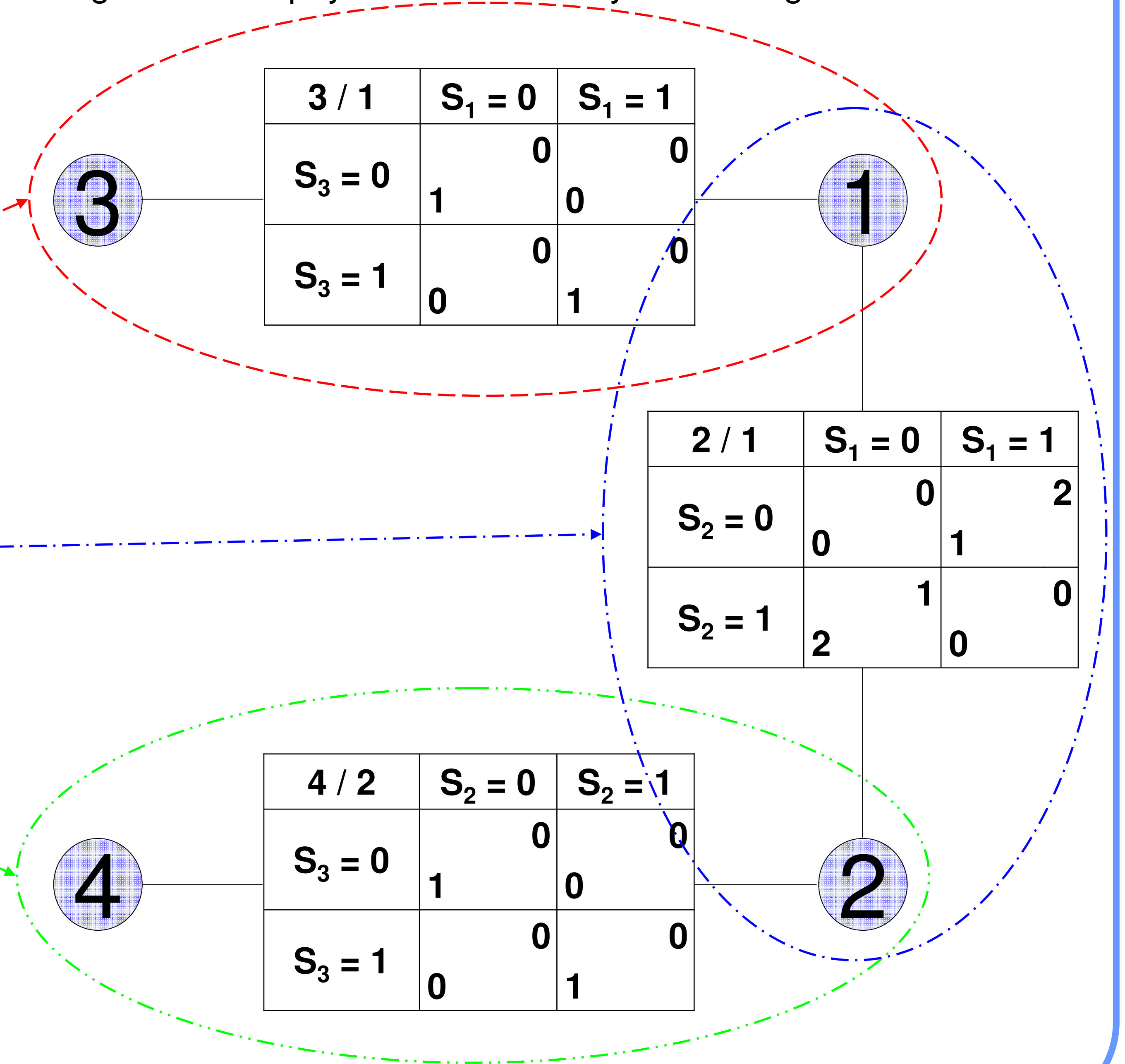
Agents 1, 2, 3, 4

Strategies				Payoffs			
S_1	S_2	S_3	S_4	u_1	u_2	u_3	u_4
0	0	0	0	0	0	1	1
0	0	0	1	0	0	1	0
0	0	1	0	0	0	0	1
0	0	1	1	0	0	0	0
0	1	0	0	1	2	1	0
0	1	0	1	1	2	1	1
0	1	1	0	1	2	0	0
0	1	1	1	1	2	0	1
1	0	0	0	2	1	0	1
1	0	0	1	2	1	0	0
1	0	1	0	2	1	1	1
1	0	1	1	2	1	1	0
1	1	0	0	0	0	0	0
1	1	0	1	0	0	0	1
1	1	1	0	0	0	1	0
1	1	1	1	0	0	1	1

Starting game



Dependence graph



3 / 1	$S_1 = 0$	$S_1 = 1$
$S_3 = 0$	1 / 0	0 / 0
$S_3 = 1$	0 / 0	1 / 0

2 / 1	$S_1 = 0$	$S_1 = 1$
$S_2 = 0$	0 / 0	1 / 2
$S_2 = 1$	2 / 1	0 / 0

4 / 2	$S_2 = 0$	$S_2 = 1$
$S_3 = 0$	1 / 0	0 / 0
$S_3 = 1$	0 / 0	1 / 0

Games network with elementary modules