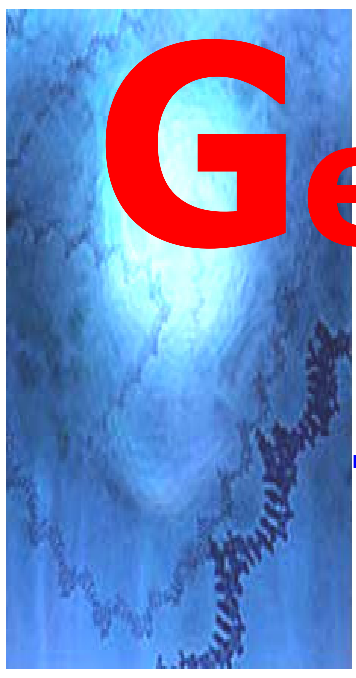


Gene Game

A modeling framework based on an extension of Game Theory to analyze the Dynamic of Regulatory Networks

Matthieu Manceny, Franck Delaplace. http://www.lami.univ-evry.fr/~delapla/fm/

Why use the Game Theory ?

Game theory describes interactions between several players or *agents* where the outcome depends on strategic interplays.

Molecular interactions of living organisms are primary governed by ***evolution pressure*** which selects process according to the adaptation of the organism to the environment. Well adapted agent survives. ***The adaptation can be figured out by the ability of an agent to fit to environmental variations by appropriate response***.

Model

The adaptive capability of an organism is usually modeled by finding the optimum of an objective cost or fitness function. Such a function is called the *payoff function*.

Modeling the behaviors of interacting agents in light of evolution pressure must be viewed in two folds by taking in consideration that ***the environment of a individual is itself composed of other individuals who are subject to the same forces of natural selection***.

Thus, the adaptation of any agent is modeled by a maximal outcome while considering that the other agent also maximize their outcomes. In game theory, this process corresponds to the definition of *Nash equilibrium*.

Strategic games

Strategic game is a model of interplays where each agent chooses its plan of action (or strategy) once and for all, and these choices are made simultaneously.

Moreover, each agent are rational and perfectly informed of the payoff functions of other agents.

Normal representation

A strategic game is perfectly defined by the 3 following data :

- the set of players or ***agents***,
- for each agent, the set of its available ***strategies***,
- for each agent, its ***payoff function***, that is the utility the player gets as a result of each possible combination of strategies.

For a 2-players game, these data are usually represented in a tableau ($\mathcal{A}$ for agents, s for strategies and p for payoffs).

		$\mathcal{A}_2$	
		s_2^1	s_2^2
$\mathcal{A}_1$	s_1^1	$p_2(s_1^1, s_2^1)$ $p_1(s_1^1, s_2^1)$	$p_2(s_1^1, s_2^2)$ $p_1(s_1^1, s_2^2)$
	s_1^2	$p_2(s_1^2, s_2^1)$ $p_1(s_1^2, s_2^1)$	$p_2(s_1^2, s_2^2)$ $p_1(s_1^2, s_2^2)$

Nash equilibrium

Nash equilibrium captures the ***steady states*** of the play of a strategic game in which each agent holds the rational expectation about the other players behavior.

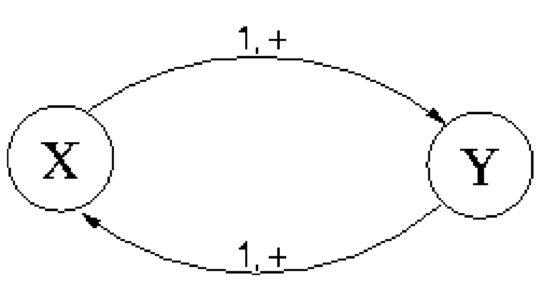
In other words, ***no agent can unilaterally deviate from a Nash equilibrium, without decreasing its payoff***.

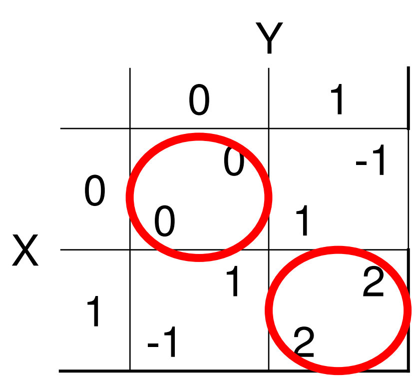
Application to Genes Networks

Positive Elementary Circuit

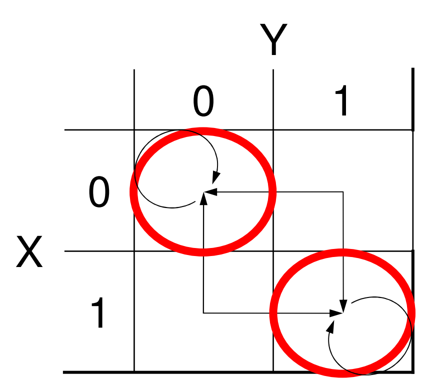
Game Theory model

René Thomas' Model





2 Pure Nash equilibria:
(x = 0 , y = 0) and (x = 1 , y = 1)

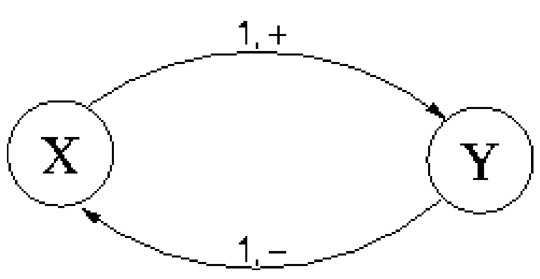


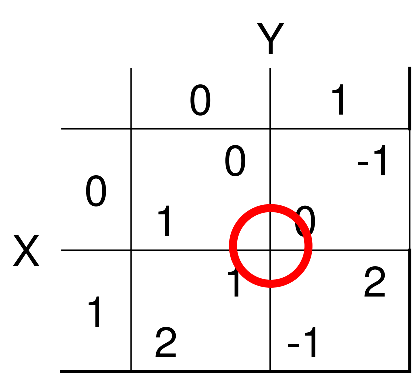
2 regular steady states

Negative Elementary Circuit

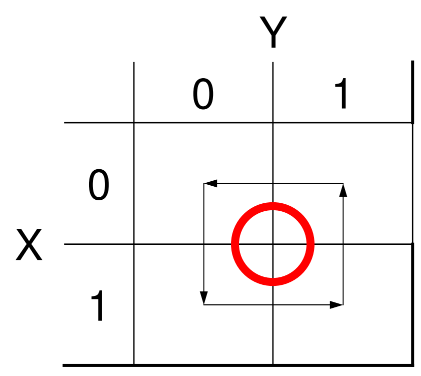
Game Theory model

René Thomas' Model





No Pure Nash Equilibrium but
1 Mixed Nash Equilibrium:
(x = 0.5(0) + 0.5(1) , y = 0.5(0) + 0.5(1))



1 singular steady state

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2x2 Game example: The Battle of Sexes

A wife and her husband are deciding where to go on Saturday afternoon.

Each of them can choose to go to a football match or to go to the shopping center.

None of them derive any pleasure from going out without the other, but the husband would prefer meeting at the football match, whereas the wife would prefer meeting at the shopping center.

The following tableau shows the payoffs associated to each of the four possible situations.

		Wife	
		(football)	(shopping)
Husband	(football)	1 3	0 0
	(shopping)	0 0	3 1

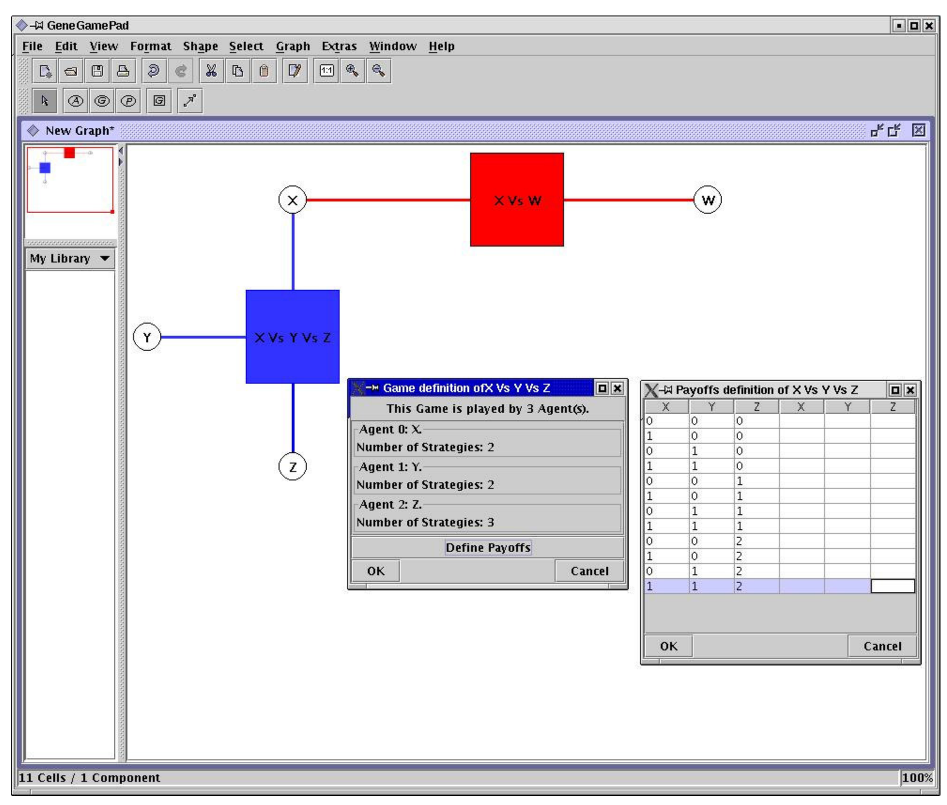
2 equilibria emerge from the tableau: the two husbands go out together, either to go to the football match or to go shopping.

Games Network

Games Network is an extension of game theory, where ***an agent can play several games simultaneously***.

In other words, a Games Network consists in a set of classical games (in sense of game theory) where the players of the different games can be the same.

G-Net Pad is a platform we have developed to model strategic games networks and compute their Nash equilibria.



Not only Strategic Games but:

Bayesian Games,
Repeated Games,
Games with communication,
Bargaining,
Coalitional Games,
Evolutionary Games...