Tactical Level in SARNET

Overview and Transitions between Equilibria

SNE, The University of Amsterdam, The Netherlands

The Goals

We aim to

- Study and use the alliance
- Improve and reorganise cooperation
- Implement the strategies

These topics inspire the following

1.
2.
3.

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    2. Whom to ask for help?
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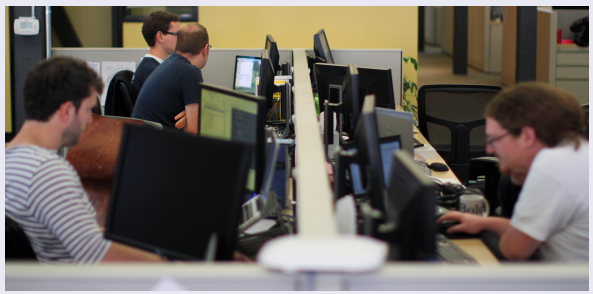

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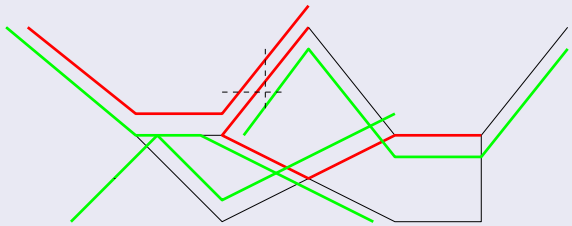
3. Implementing the strategy
    1. Filtering flows
    2. Deleting links



    3. Measuring the efficiency of defence

Achieved Goals

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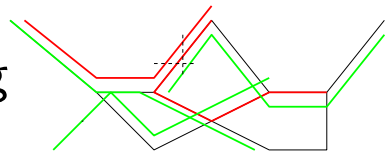

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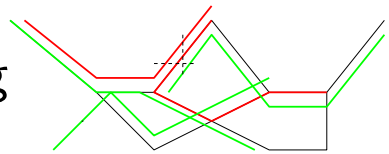

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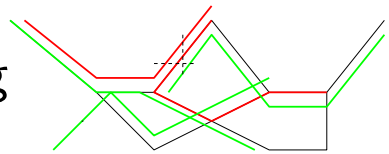

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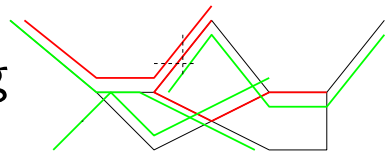

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Solutions, Transitions and Efficiency - Introduction

We study how lack of coordination (domains, etc.) influences efficiency

Definition

A game $(N, S = S_1 \times \ldots \times S_N, u_1, \ldots, u_n)$ *consists of a set of players* $N = \{1, \ldots, n\}$, *strategy sets* S_i *and utilities* $u_i : S \to \mathbb{R}$.

Definition

Strategy profile $s_1 \in S_1, \ldots, s_n \in S_n$ *where no one can unilaterally improve her own utility is called a Nash equilibrium.*

(Nash) equilibria suffer from

- Strong belief assumptions
- Non simultaneous change (rules, democracy, marriage, traffic)
- *Lack of coordination*

Solutions, Transitions and Efficiency - Plan

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- Strong belief assumptions
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- *Lack of coordination*

No theoretical modelling of using various solutions simultaneously

$\Rightarrow$ We

1. formally model a
   1. a transition
   2. a limited transition
   3. a stable transition
2. bound efficiency

Definition

Given $D \subseteq S$, a transition is any profile $s = (s_1, \ldots, s_n) \in S$ such that for each $i \in N$, there exists a solution $d(s, i) = (d_1, \ldots, d_n) \in D$, such that $s_i = d_i$.
Denote the set of all the transitions to be $T(D) \subseteq S$, the transition set.

Solutions, Transitions and Efficiency - Model - Transition

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A limited transition, m-transition, is a transition where players "confuse" among at most m solutions. Denote $T(D, m)$.

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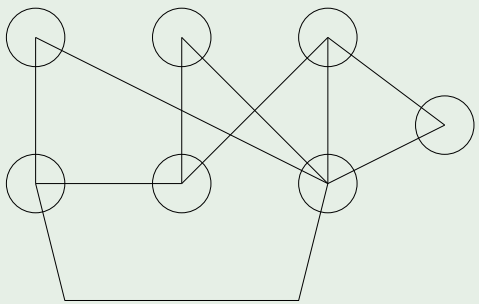
A stable transition is a transition, where no improvement is "straight-forward".

Model - Refinement to Stable Transitions - Motivation

Disallow transitions that can be easily improved

Coordination game on graphs, where any node chooses in $\{r, b\}$:



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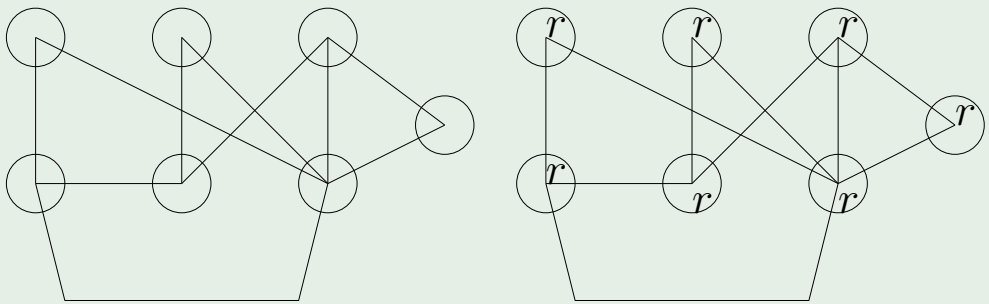

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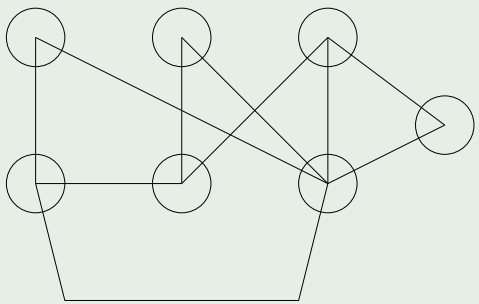

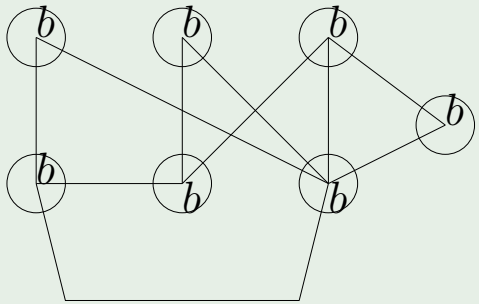

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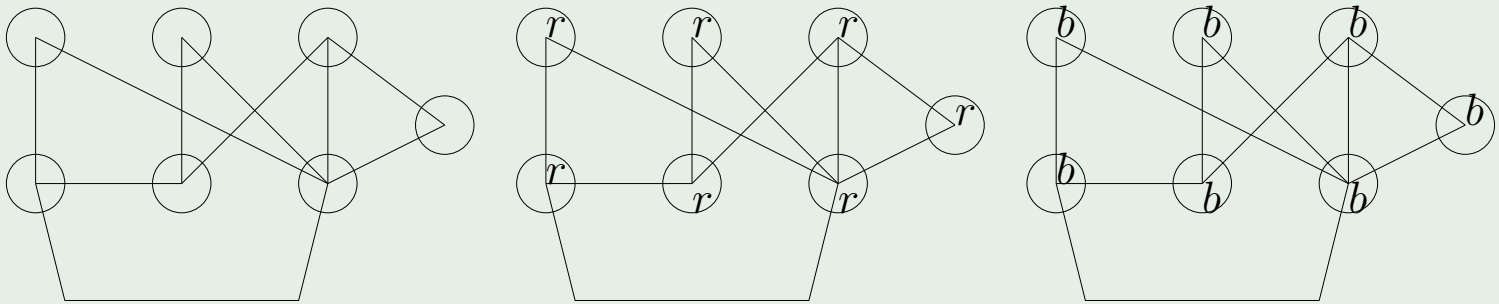

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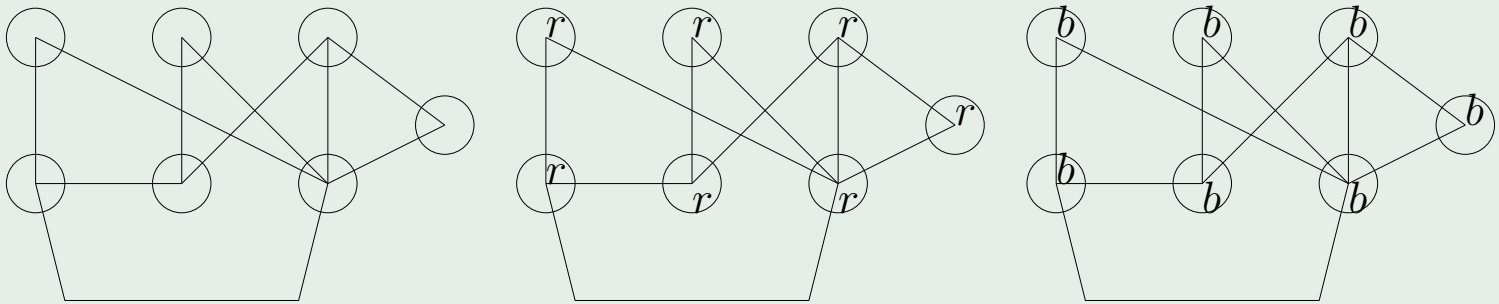

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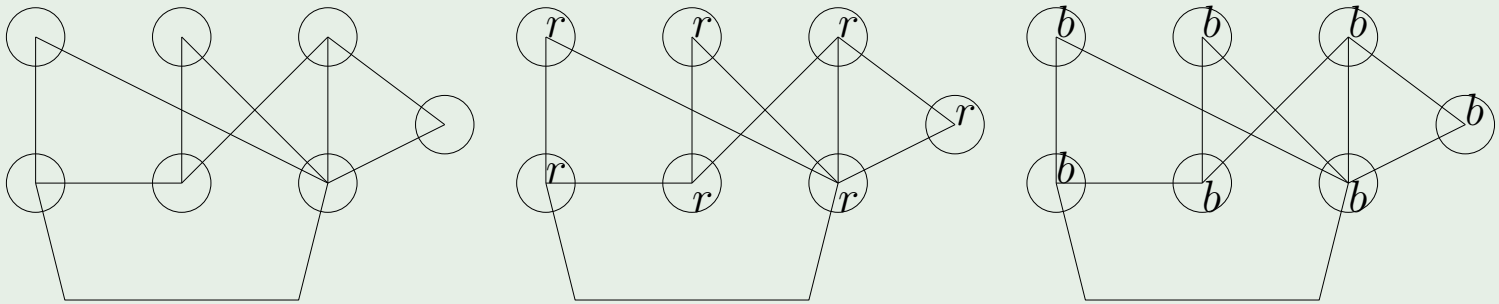

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Disallow transitions where a player can increase her utility, regardless the others' unilateral improvements

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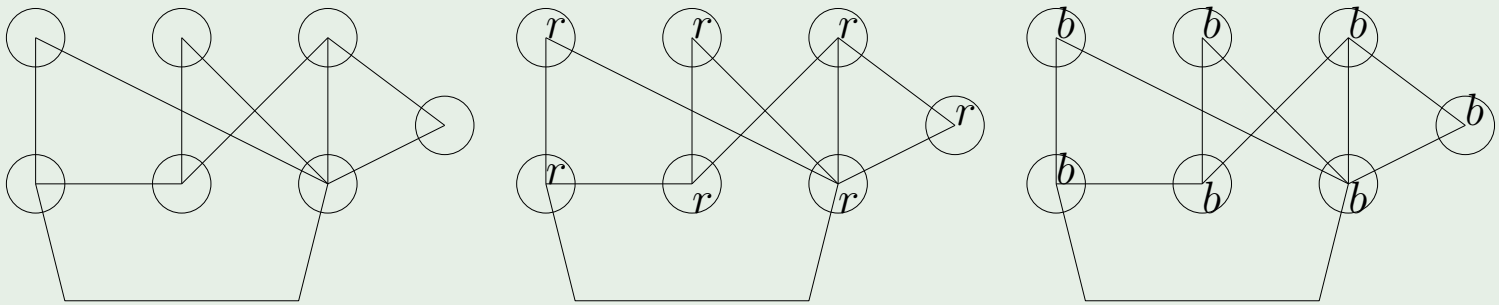

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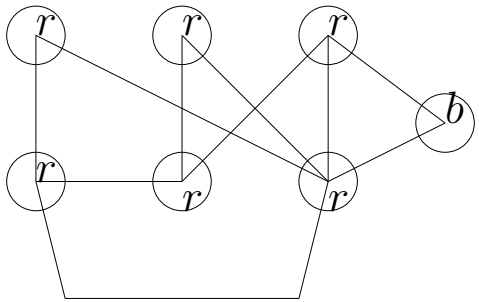

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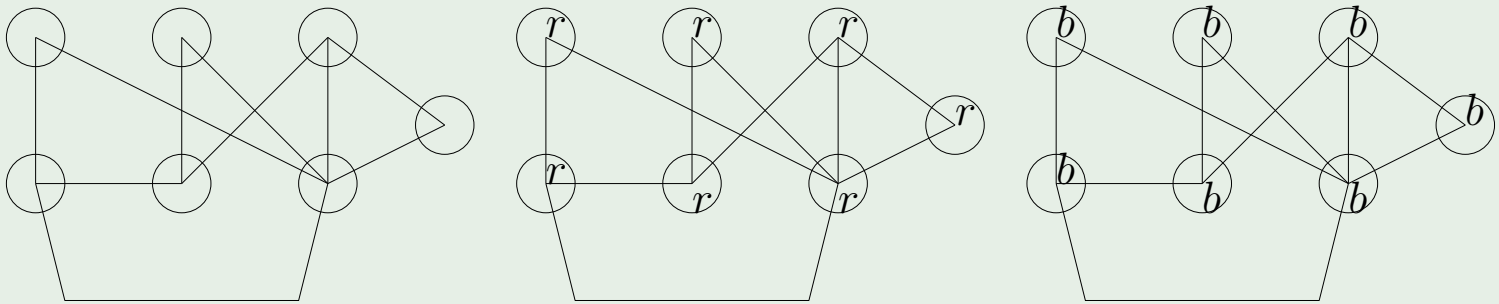

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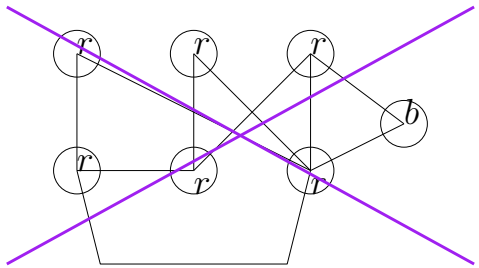

Definition

The social welfare is the sum of the utilities, i.e.

$$\mathrm{SW}(s) \triangleq \sum_{i \in N} u_i(s)$$

Definition

We look at

$\mathrm{PoA} \triangleq \frac{\min_{s \in D} \mathrm{SW}(s)}{\max_{s \in S} \mathrm{SW}(s)}$ *and* $\mathrm{PoS} \triangleq \frac{\max_{s \in D} \mathrm{SW}(s)}{\max_{s \in S} \mathrm{SW}(s)}$.

$\mathrm{PoTA} \triangleq \frac{\min_{s \in T(D)} \mathrm{SW}(s)}{\max_{s \in S} \mathrm{SW}(s)}$ *and* $\mathrm{PoTS} \triangleq \frac{\max_{s \in T(D)} \mathrm{SW}(s)}{\max_{s \in S} \mathrm{SW}(s)}$.

$m - \mathrm{PoTA} \triangleq \frac{\min_{s \in T(D,m)} \mathrm{SW}(s)}{\max_{s \in S} \mathrm{SW}(s)}$ *and* $m - \mathrm{PoTS} \triangleq \frac{\max_{s \in T(D,m)} \mathrm{SW}(s)}{\max_{s \in S} \mathrm{SW}(s)}$.

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Solutions, Transitions and Efficiency - General Bounds

The price of anarchy can only become worse, when the set grows.
We provide opposite bounds based on how the individual utilities depend on coordination and how the total utility depends on the individual ones.

Solutions, Transitions and Efficiency - Constant-Sum and Potential Games

These are intuitively opposite kinds of games

Constant-sum

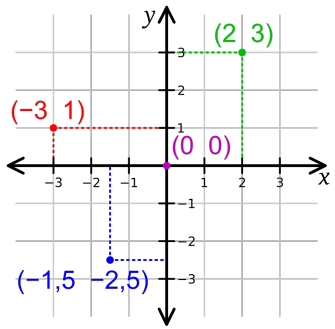
Constant-Sum games have PoTA $= 1$.

Potential

$m -$ PoTA $\geq$ PoA $/m$, and this is tight.

Solutions, Transitions and Efficiency - Constant-Sum and Potential Games - Decomposition

Using "Flows and decompositions of games: Harmonic and potential games" by Candogan et al., we treat general games.



Solutions, Transitions and Efficiency - Routing Games

1. routing games
2. equilibrium flow
3. price of anarchy

Definition

A transition as a feasible flow that is positive only where there is an equilibrium with a positive flow

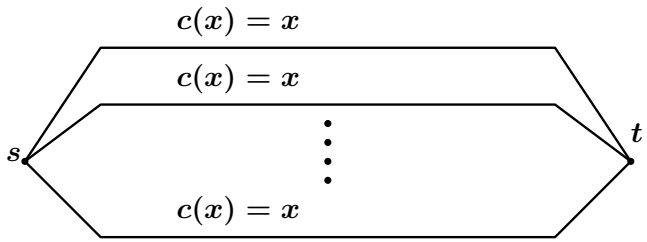


Figure: Having n parallel edges with $c_e(x) = x$ each.

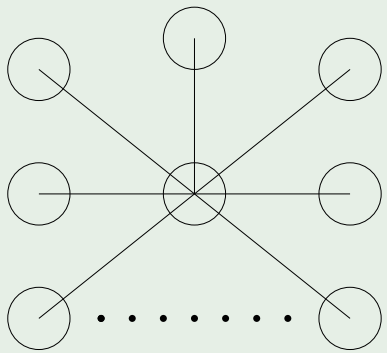
We tightly bound the efficiency of transitions

Solutions, Transitions and Efficiency - Coordination Games

Consider coordination games with colours $\{r, b\}$ for everyone

Good Restriction

For the star topology with $n-1$ leaves, the only stable transitions that are not NE colour the cetre in r and $\left\lfloor \frac{n-1}{2} \right\rfloor$ leaves in r and the rest $\left\lfloor \frac{n}{2} \right\rfloor$ leaves in b, or fully switching between r and b.



Theorem

PoSTA $\geq \frac{1}{2} - \frac{|N|}{2|E|}$, PoA $\geq 1/2$, *and these bounds are tight.*

Help in Defending against Attacks - Conclusions

1. Modelling lack of coordination
2. General efficiency bounds are appalling $\Rightarrow$ coordinate
3. The bounds are optimistic for
   - certain routing games
   - constant-sum
   - limited transitions in potential games
   - stable transitions in coordination games (the denser, the better)
4. Removing non-equilibria stable transitions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And SARNET?

Solutions, Transitions and Efficiency - SARNET

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Nash equilibria

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Superrational equilibria

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Superrational equilibria

1. Hofstader's superrational equilibria predict everyone will comply

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Superrational equilibria

1. Hofstader's superrational equilibria predict everyone will comply
2. $\Rightarrow$ Confusing NE and superrational allows for all the possible profiles!

Future Work

- When using *trust and smart policies*, what are the transitions?
- Further requirements/probabilities on transitions (SARNET)
- Is the given profile a (limited, stable) transition?

Thank You!