Identify Competition in Non-Explicit Competition Networks with a Case Study in Politics

Jose Ramirez-Marquez

Stevens Institute of Technology

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Jose Ramirez-Marquez & Denisse Martinez-Mejorado

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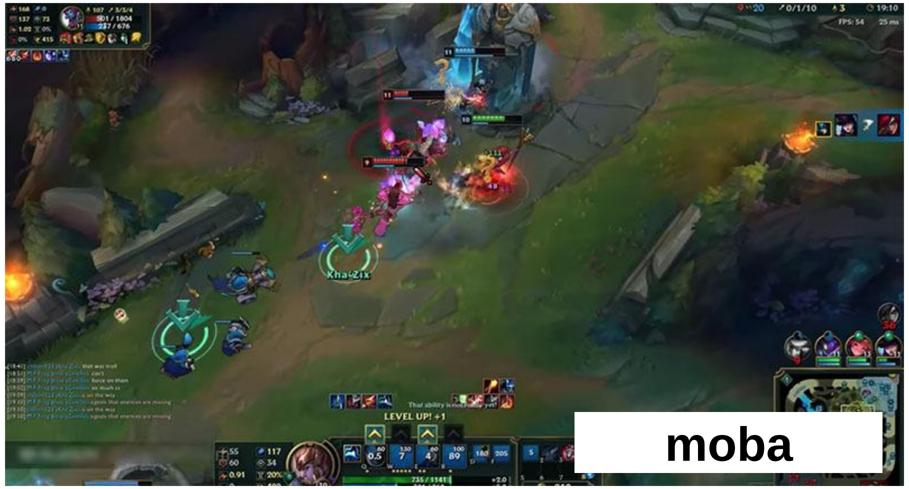
Competing organizations

Organizations that compete against each other and are dependent on the performance of its opposing organizations.

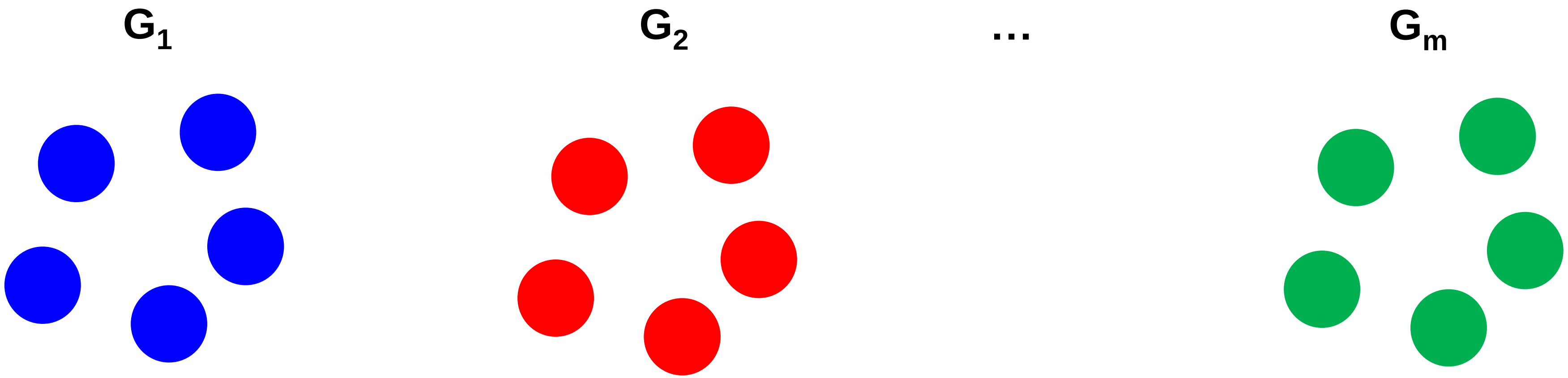


Technical definition of competition networks

We posit that competition networks are co-dependent on the performance of other networks in a common competition environment.

A competition network has a collection *T* of *m* competitors

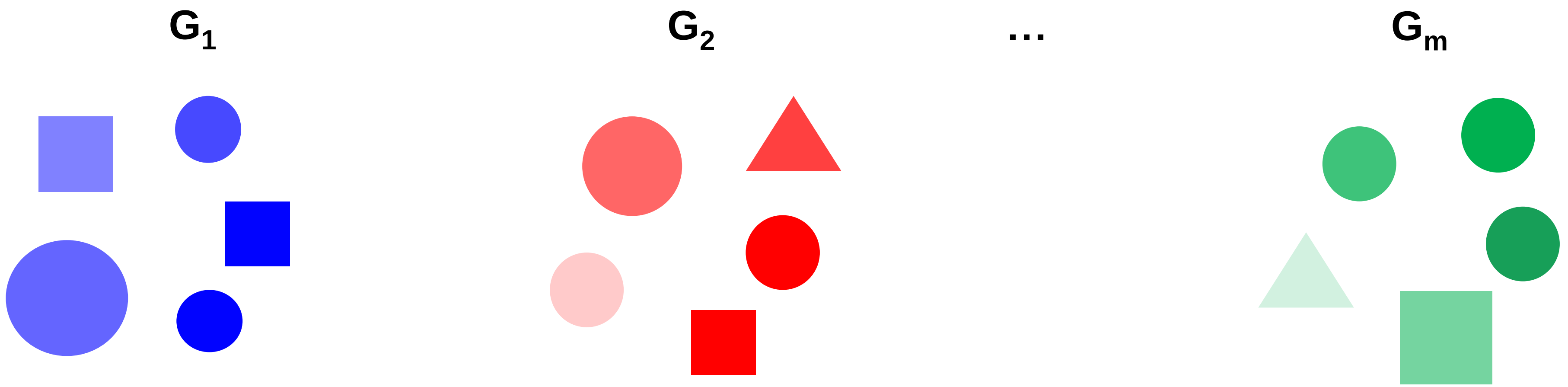
$$\underline{T} = \{t_1, t_2, \ldots, t_m\}$$



Node's attributes

$$\underline{F}\,(x_{l(i|j)}) = \{f_1(x_{l(i|j)}),\ldots,f_n(x_{l(i|j)})\}$$

where $f_n(x_{l(i|j)})$ is the function mapping the n^{th} attribute of actor *l* in graph $\underline{X}_{i|j}$.

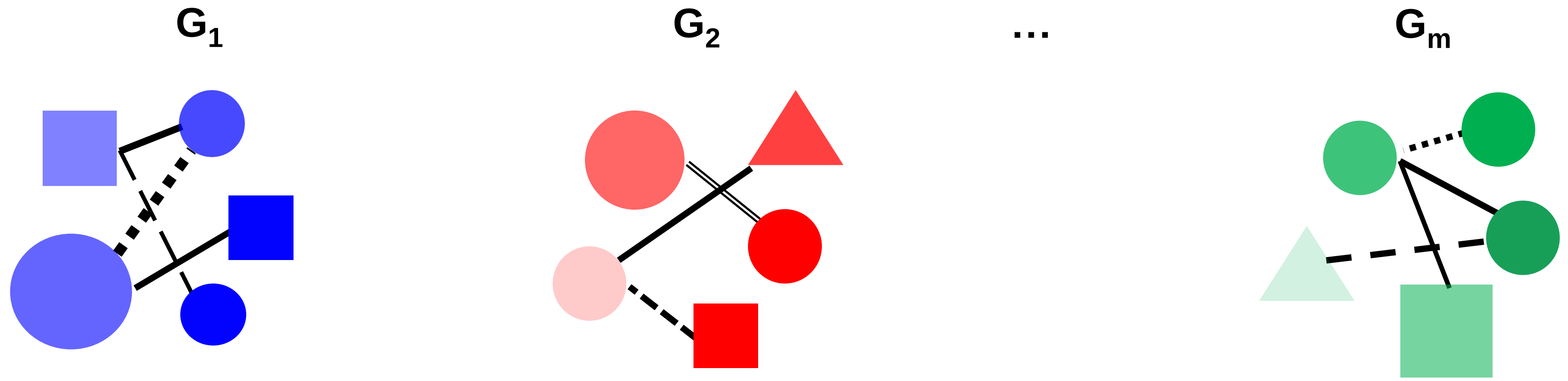


Inner arcs

$$\underline{A}(i|j) = \{a_{1,2}^{i|j}, \dots, a_{1,k}^{i|j}, a_{2,1}^{i|j}, \dots, a_{2,k}^{i|j}, \dots, a_{l,1}^{i|j}, \dots, a_{l,k}^{i|j}, \dots, a_{k,1}^{i|j}, \dots, a_{k,k-1}^{i|j}\}$$

$a_{l,o}^{i|j}$ is an element of vector $\underline{A}(i|j)$ if for any *r*,

$$g_r(a_{l,o}^{i|j}) > 0$$

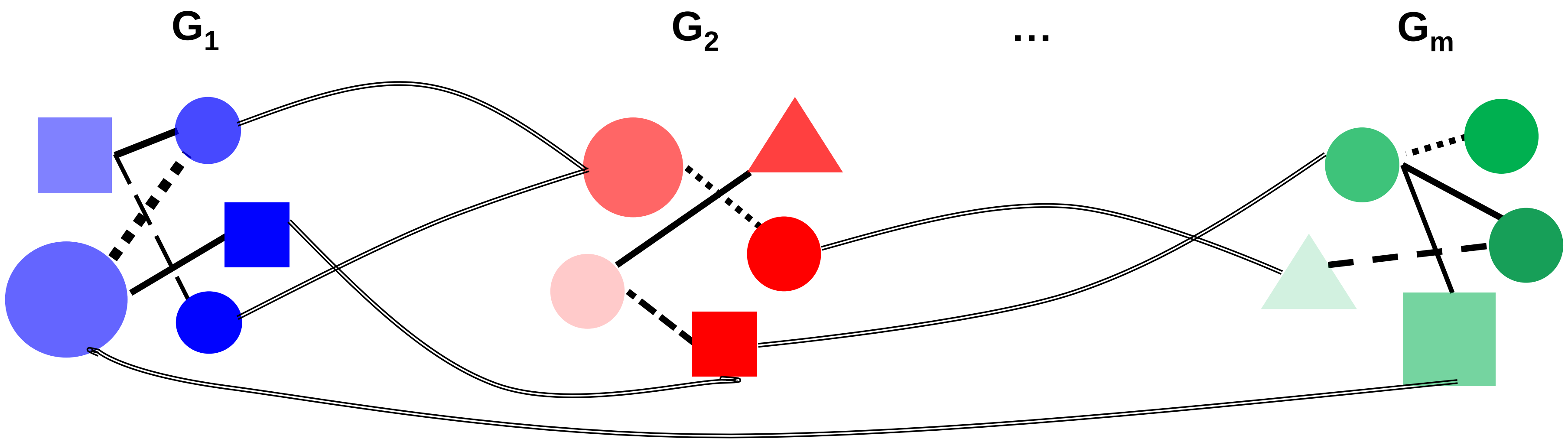


Outer arcs

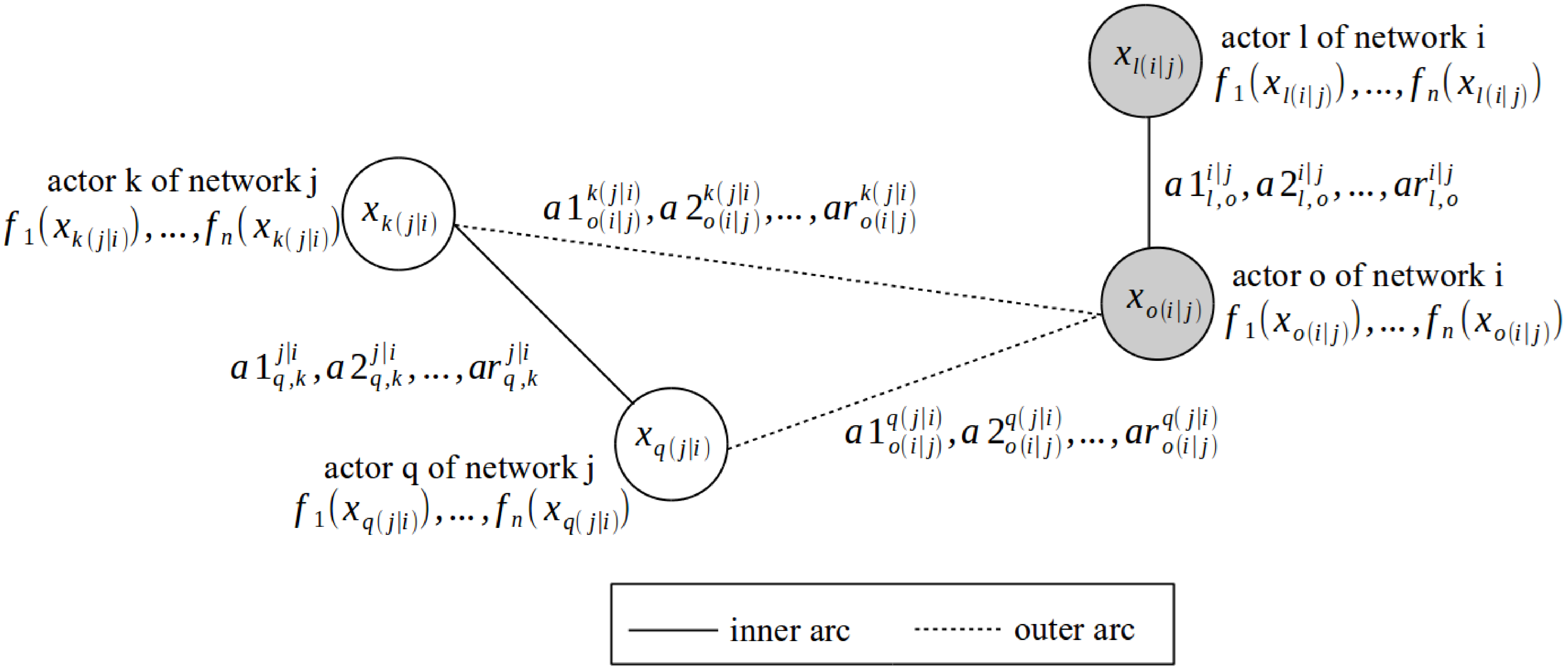
$$\underline{A}^{l(i|j)}_{q(j|i)} = \{a^{2(i|j)}_{1(j|i)},\dots,\ a^{k(i|j)}_{1(j|i)},\ a^{1(i|j)}_{2(j|i)},\dots,\ a^{k(i|j)}_{2(j|i)},\dots,\ a^{1(i|j)}_{l(j|i)},\dots,\ a^{k(i|j)}_{l(j|i)},\ a^{l(i|j)}_{k(j|i)},\dots,\ a^{k-1(i|j)}_{k(j|i)}\}$$

where $a^{i|j}_{l,o}$ is an element of vector $\underline{A}^{l(i|j)}_{q(j|i)}$ if for any *r*',

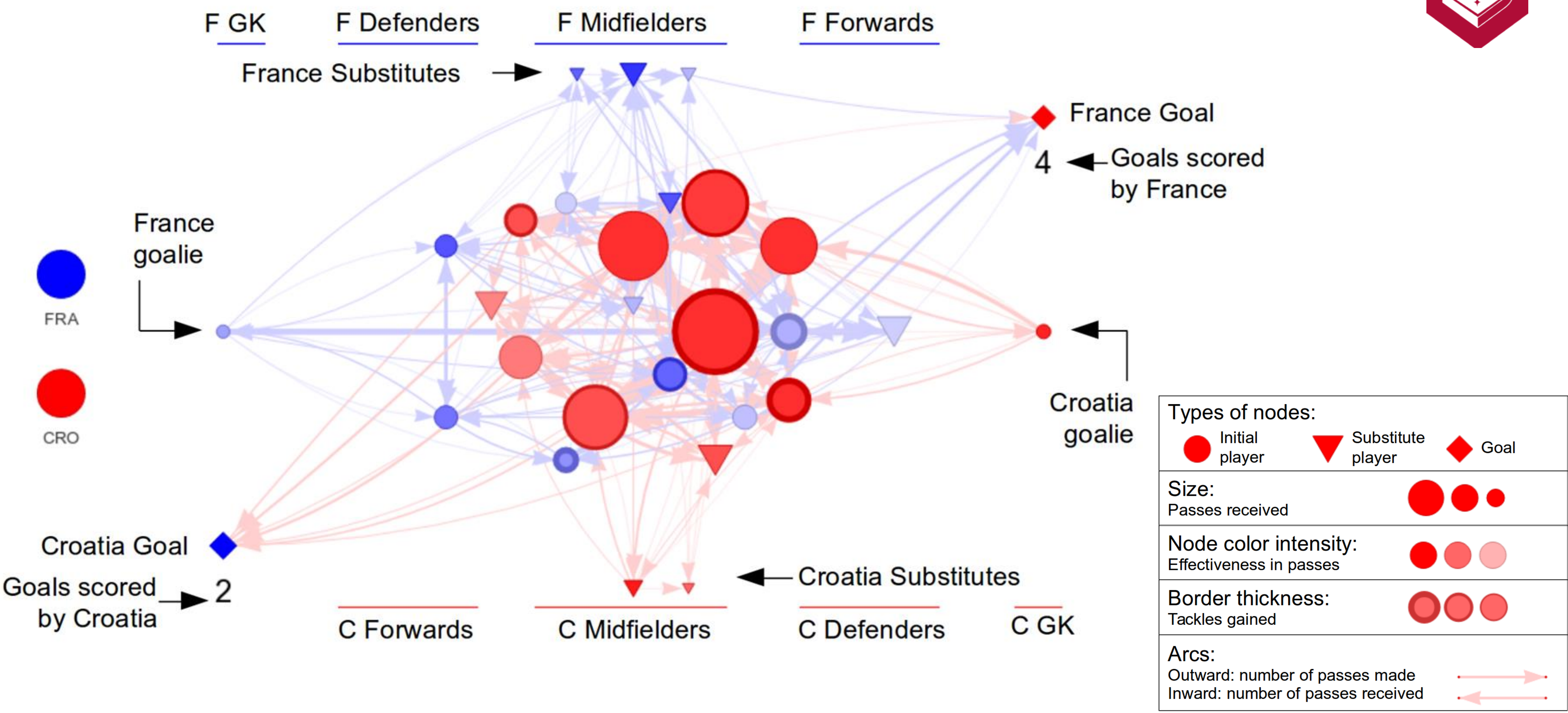
$$g'_r(a^{l(i|j)}_{q(j|i)}) > 0$$



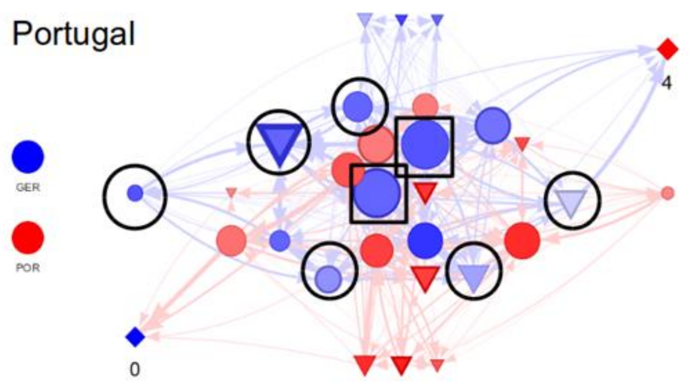
Competition Networks visualization

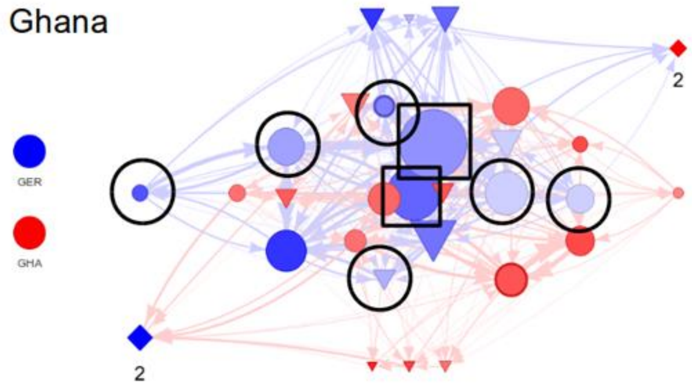


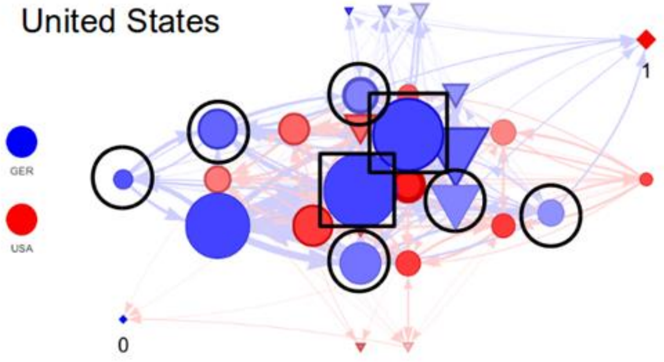
FIFA World Cup 2018 - Final match

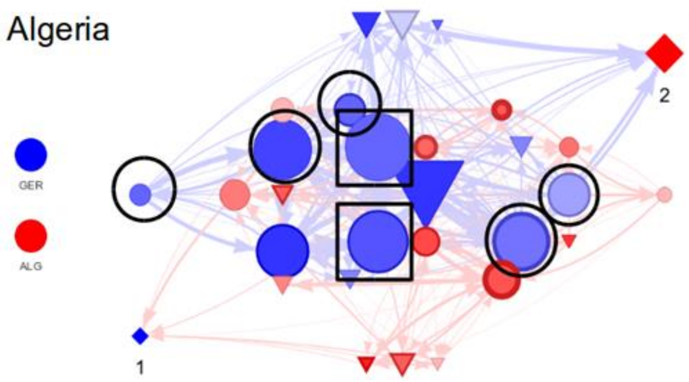


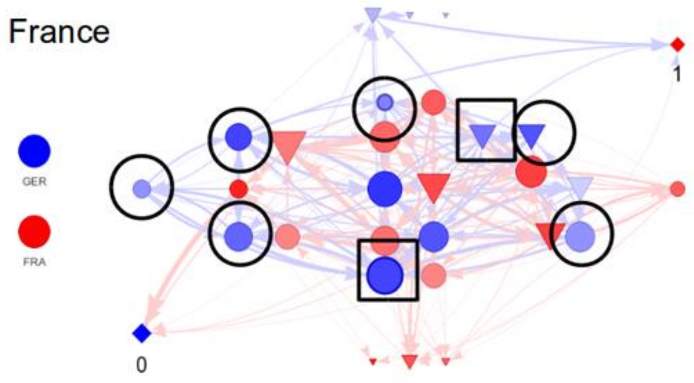
High performance teams - Germany 2014

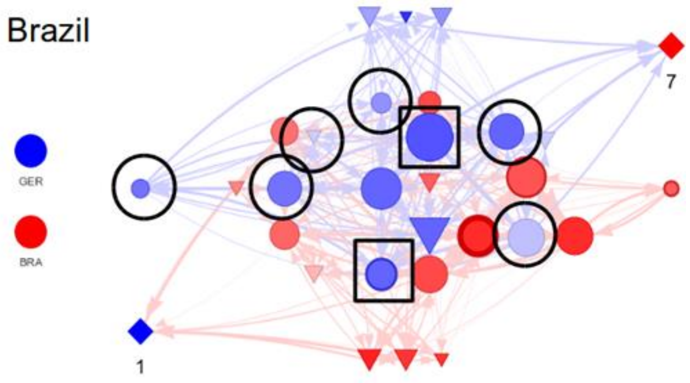


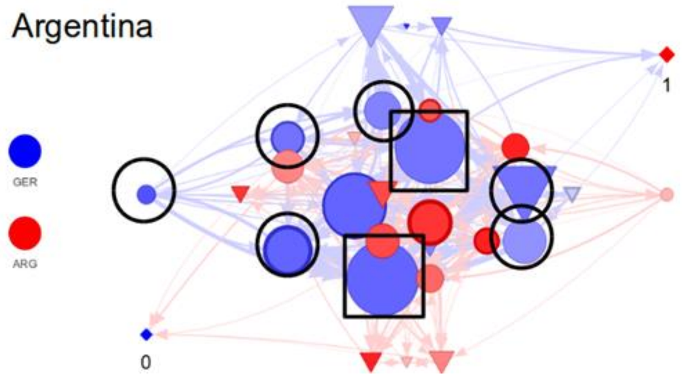












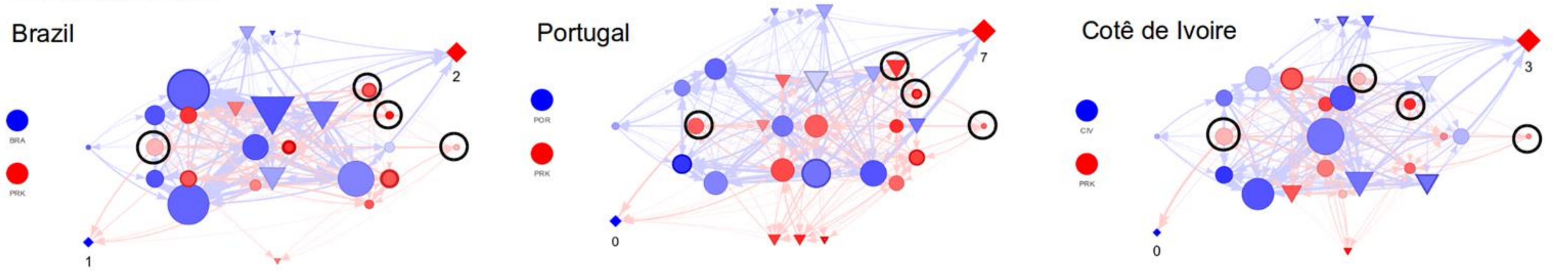
- Germany bigger blue nodes midfield and defense
- Match against France less passes

Top receptors of the ball in midfield: (16) Lahm & (18) Kroos

Regular players: (1) Neuer, (4) Hoewedes, (5) Hummels, (8) Oezil, (13) Mueller, (20) Boateng

Low performance teams

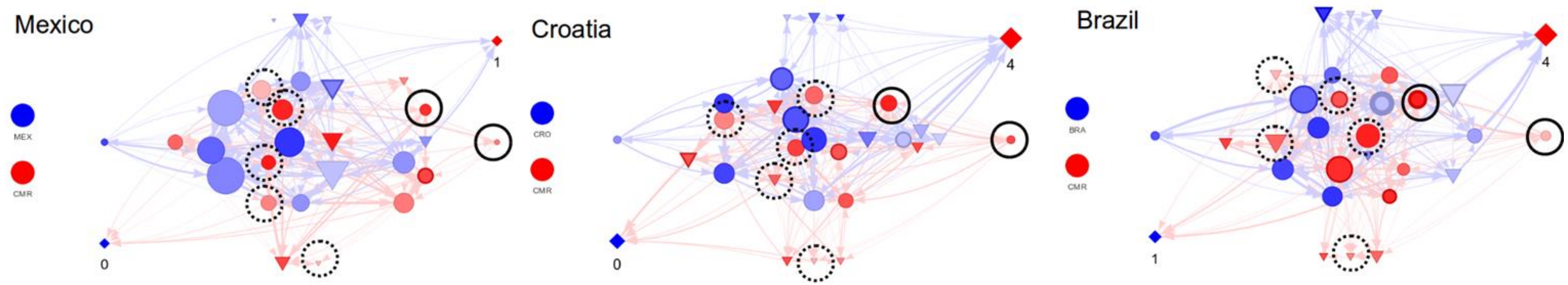
North Korea 2010



- Less passes
- No key player
- Low effectiveness in passing dist.
- Same players, maintained position:

(1) Ri, (2) Cha, (9) Jong, (13) Park.

Cameroon 2014

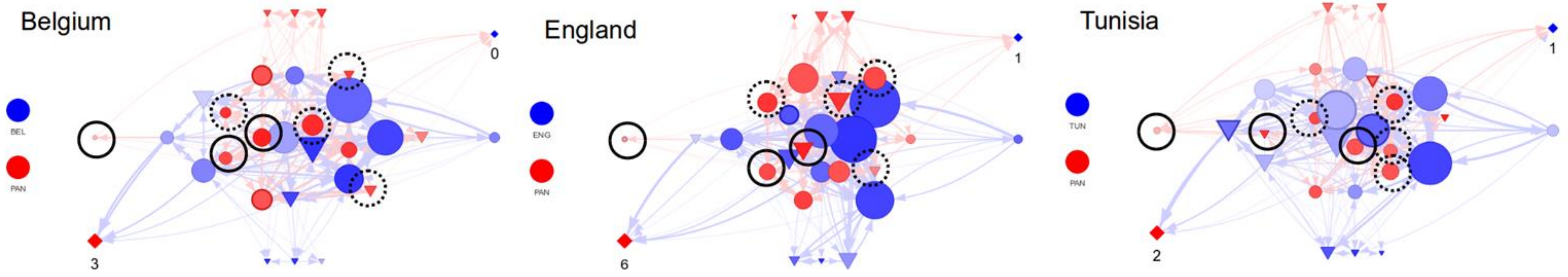


- Less passes
- No key player

Regular players & same position: (16) Itandje, (3) Nkoulou

Regular players: (8) Moukandjo, (13) Choupo Moting, (15) Webo, (17) Mbia, (18) Enoh

Panama 2018



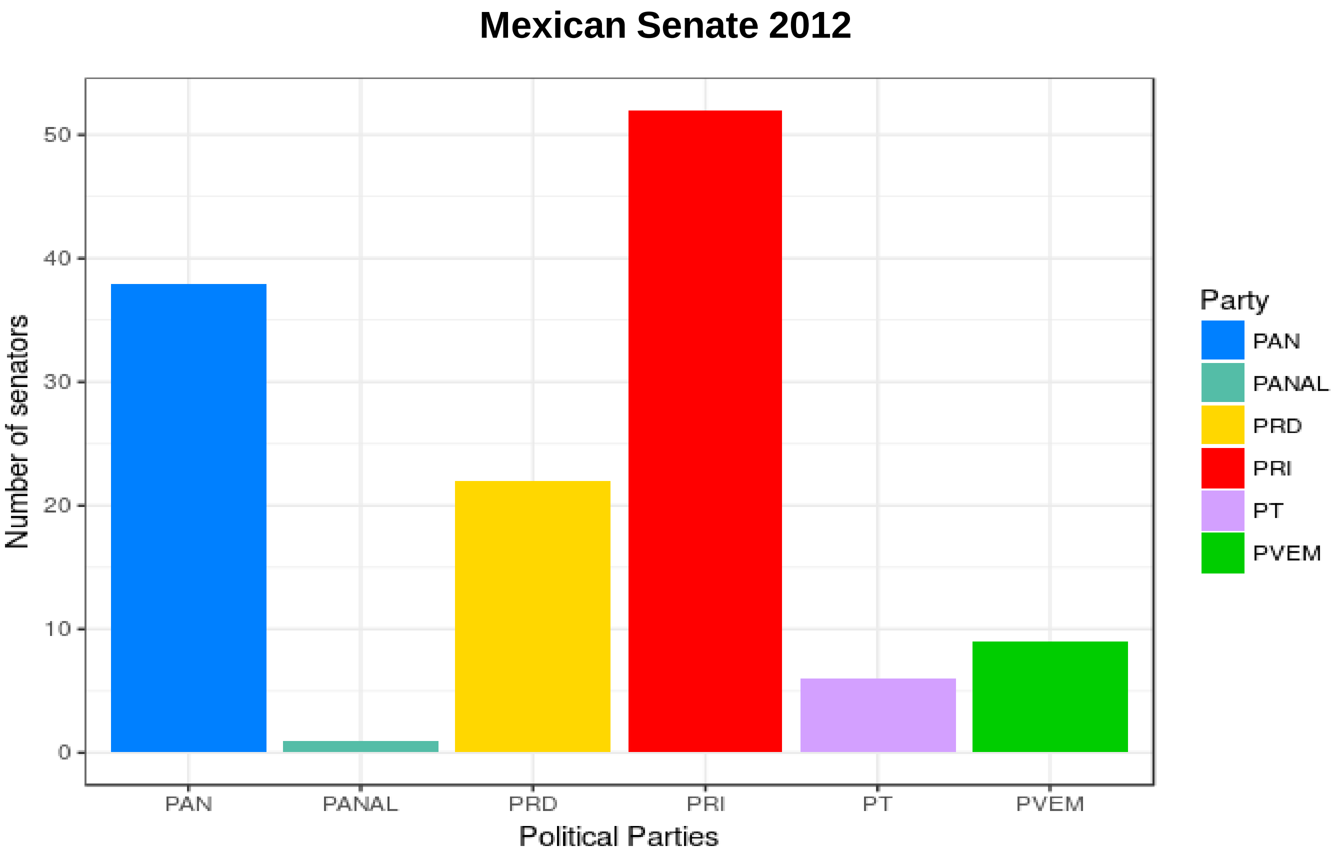
- Less passes, high effectiveness
- No key player

Regular players & same position: (1) Penedo, (5) Torres, (6) Gomez

Regular players: (4) Escobar, (8) Barcenas, (20) Godoy, (21) Rodriguez

Identify competitors when these are not explicitly defined

Politicians must form majorities to approve or not a bill



Identify competition through collaboration

The α threshold is the level of cooperation among the non explicitly defined actors in a competition environment, which each of them participates through actions or decisions that impact the competition output.

When multiple competition actions or events are considered, the outer arcs are defined as:

$$g'_r(a_{q(j|i,\dots m)}^{l(i|j,\dots,m)}) = \begin{cases} 1 & \text{if association threshold between actor } l^{i|j,\dots,m} \text{ and actor } q^{j|i,\dots,m} \geq \alpha \\ 0 & \text{otherwise} \end{cases}$$

outer arcs

One approach to estimate α is as follows:

$$\frac{1}{z}\sum (a_{q(j|i,\dots m)}^{l(i|j,\dots,m)}) \geq \alpha$$

cooperation threshold

where *z* is the number of competition actions in one or multiple competition events.

Senators competition network

Mexican Senate 2012-2015

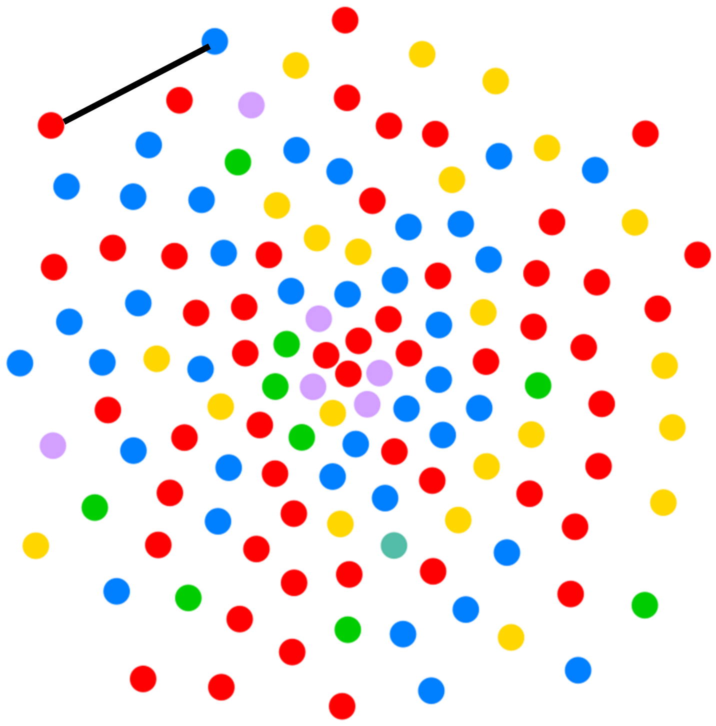
For each bill: 128 graphs of size 1

- Represent different population
- Each vote worths same

Nodes attributes:

- type of senator (elected by popular vote of not)
- senator's political party
- vote of the senator
- node degree
- senator's age
- avg. years of education of the state the senator represents
- % state participation in GDP of the state the senator represents

Outer arc exists if they vote same at least α%



Visualization guide

Node's shape:
senator elected by popular vote
senator not elected by popular vote (*plurinominales*)

Node's size: node's degree

Node's color:
Bill: type of vote
In favor
Abstention
Against

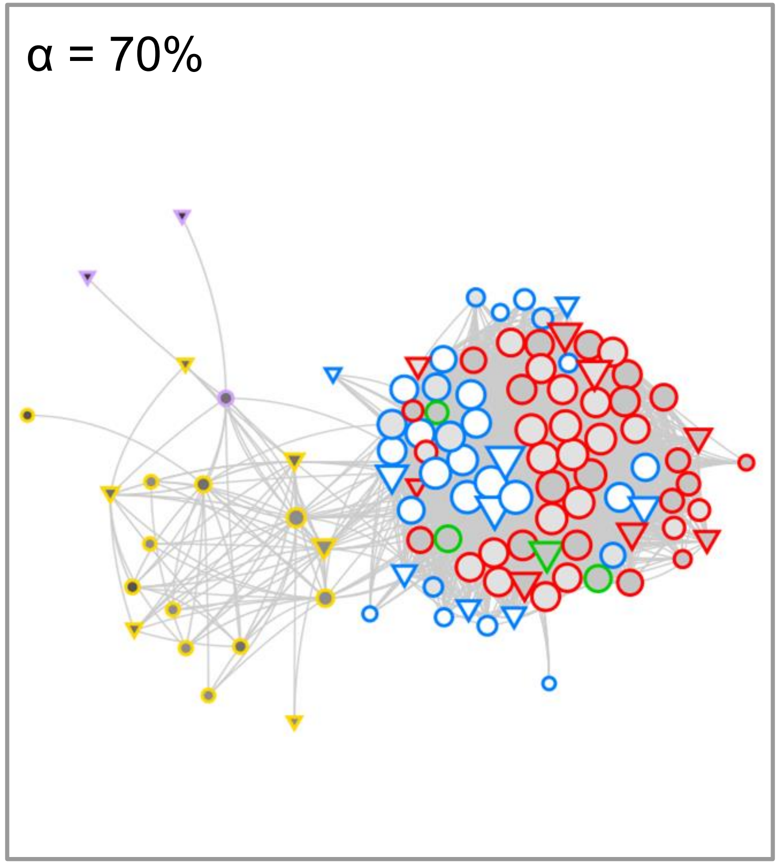
Period: percentage of votes in favor on a scale from white to black.
In favor (white)
Against (black)

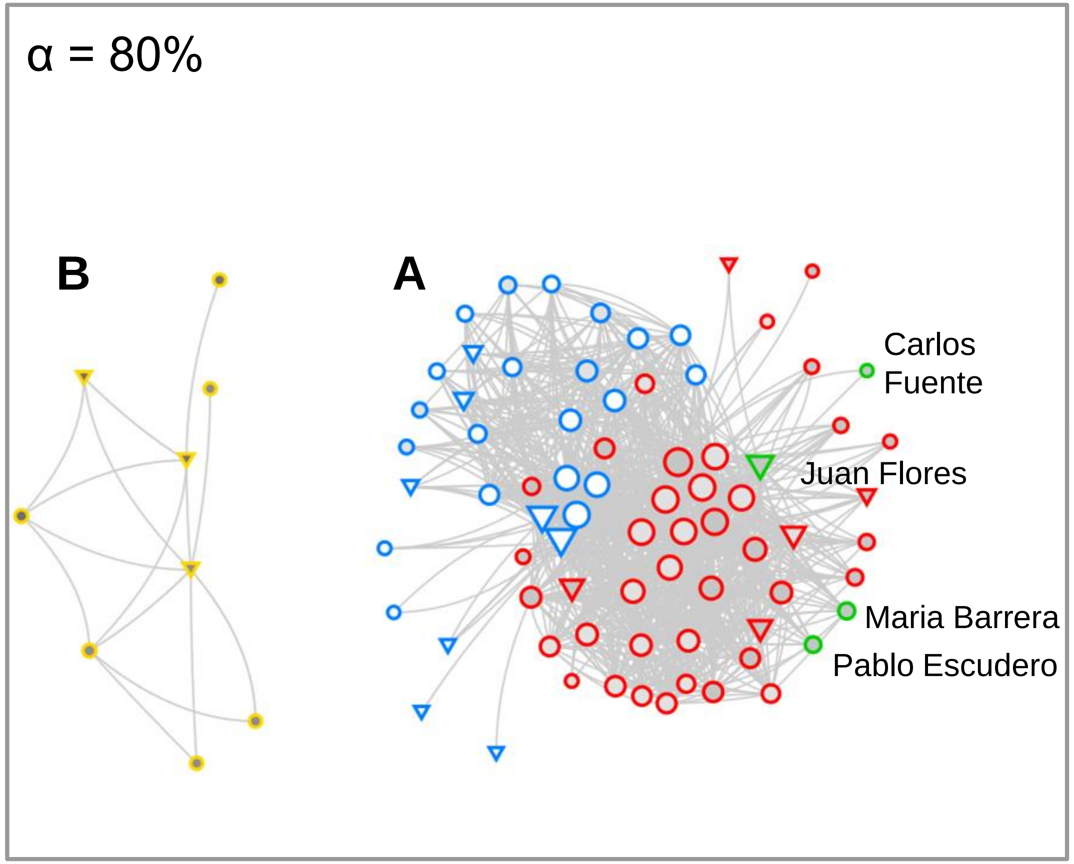
Node's border color: senator's political party
PRI PAN PRD PVEM PT PANAL

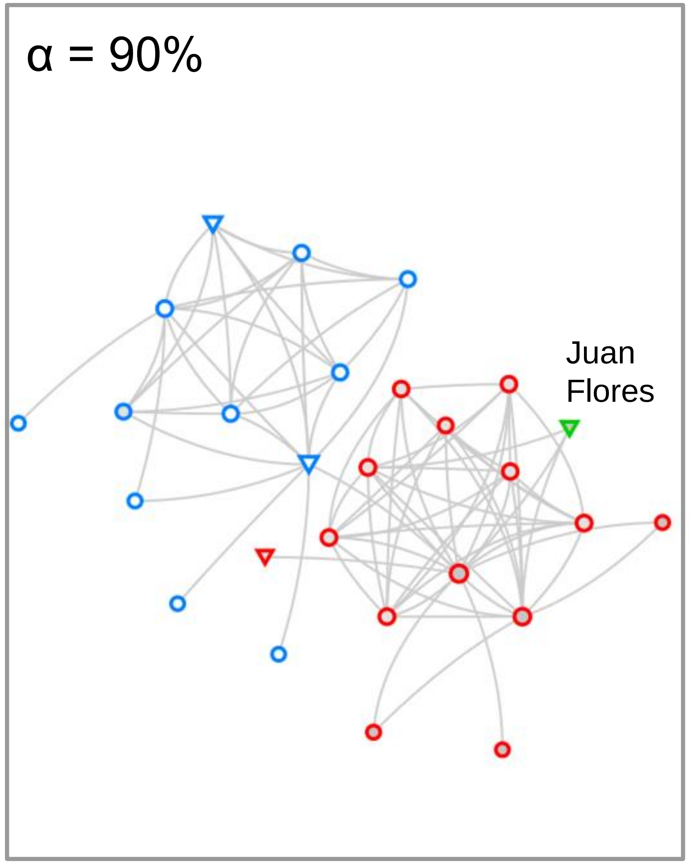
Bidirectional arc:
Bill: senators vote same way
Period: if cooperation threshold between senator $l^{i|j,\ldots,m}$ and senator $q^{j|i,\ldots,m} \geq \alpha$.

1st yr, 1st ordinary period

https://research00.shinyapps.io/vis_senate_mexico

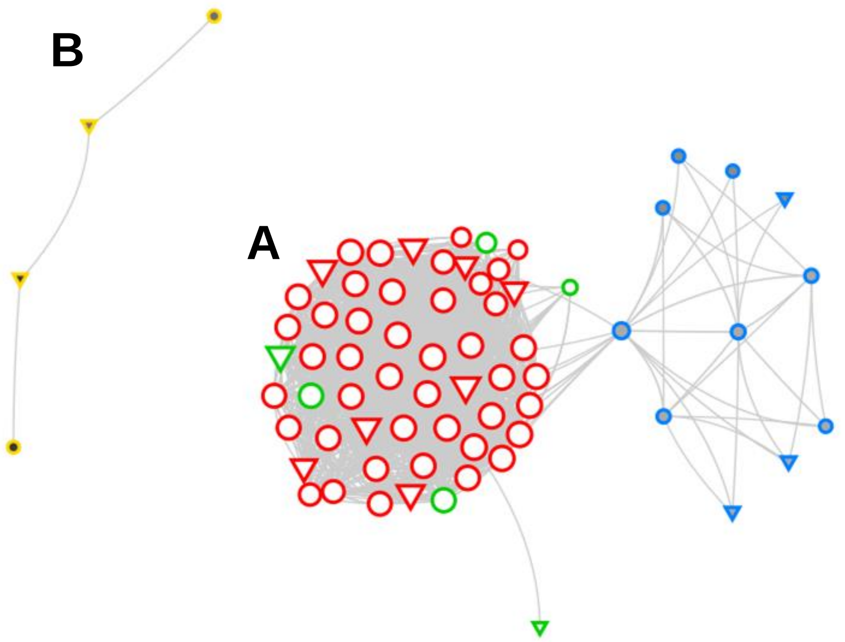




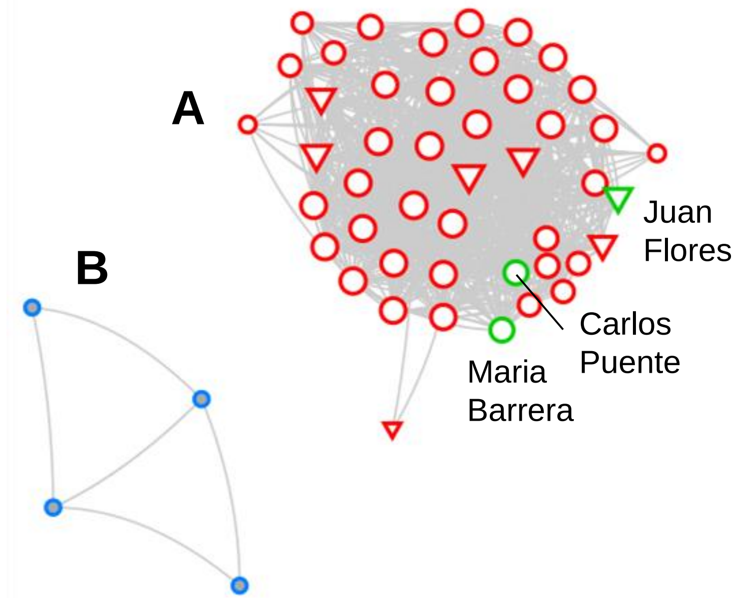


2nd yr, 1st ordinary period

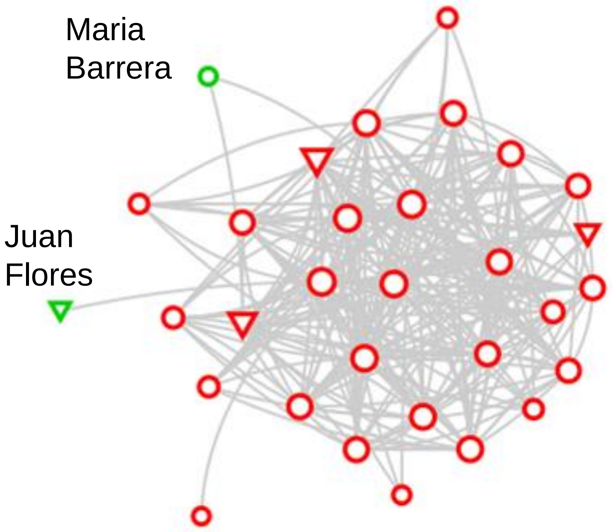
α = 70%



α = 80%

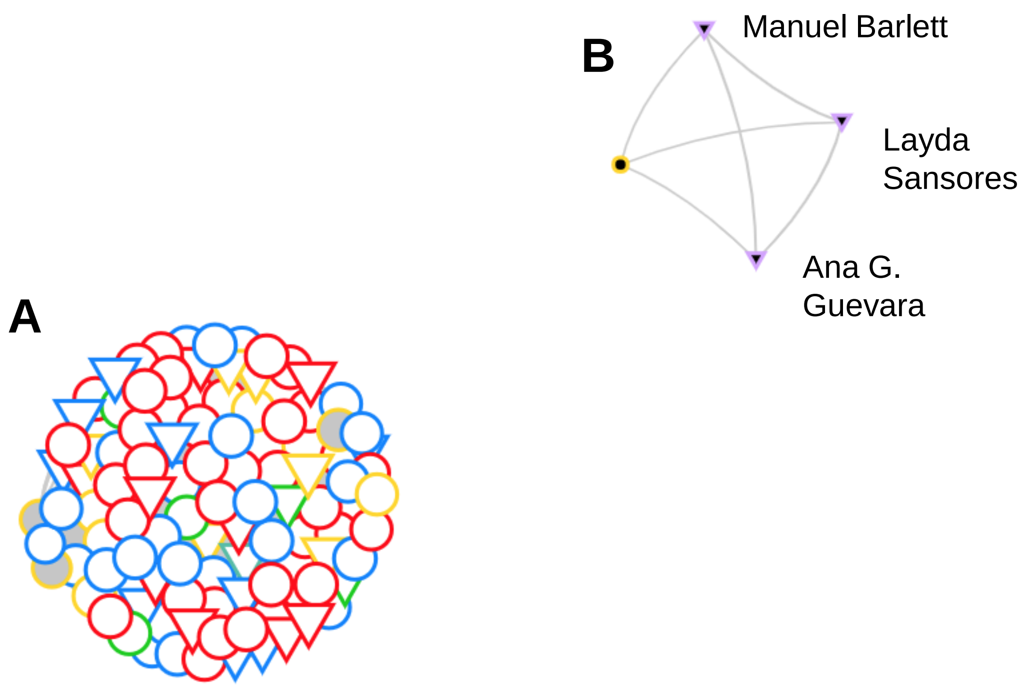


α = 90%

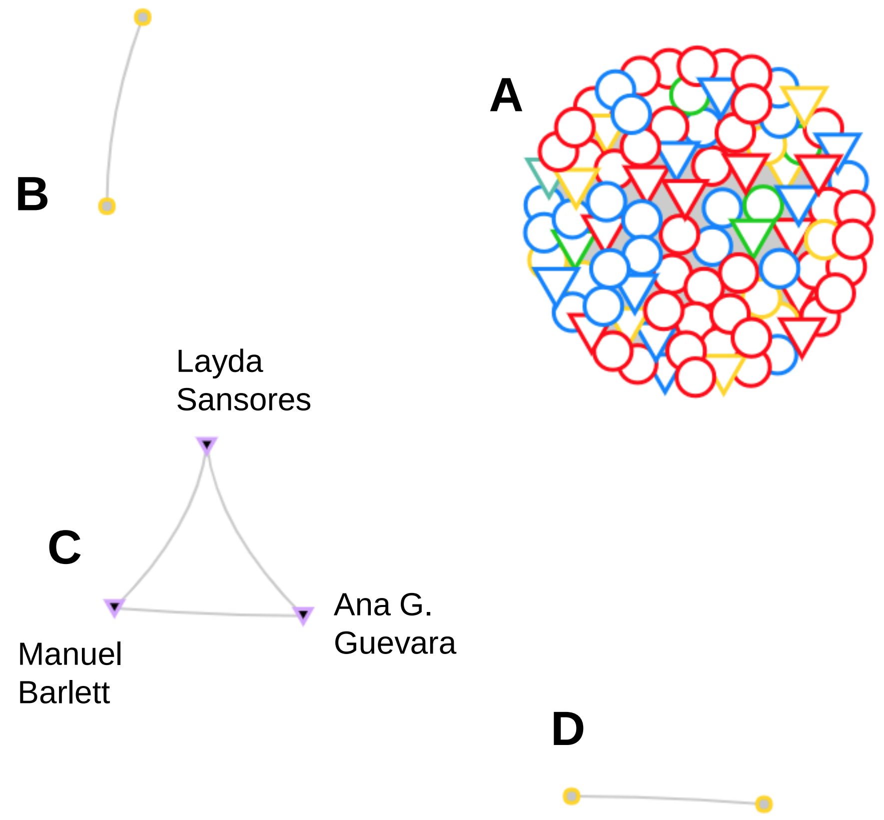


2nd yr, 1st extraordinary period

α = 70% and 80%



α = 90%



Conclusion

- Evolution of networks. Opposition groups formed by senators from PRD (yellow) and PT (purple). While the parties PRI (red) and PVEM (green) cooperate in more bills, and PAN (blue) was an occasional rival.

- As shown, the α cooperation threshold delineates the competition networks and therefore the composition of the networks.

- The visualization helped to identify actors' characteristics like their political affiliation, showing which political parties usually worked together. The percentage of votes in favor showed in the node's color illustrated the level of opposition among actors in each network.

Conclusion

- Network approach to identify competitors when these are not explicitly defined:
  - The α cooperation threshold delineated the networks.
  - Identified clusters inside networks.

- Visualization framework:
  - Composition and evolution of networks, relevant actors.

- This framework can be applied to other competition environments were collaboration and competition are present. For example defense, security, e-sports, politics, multi-player video games.

STEVENS
INSTITUTE of TECHNOLOGY
THE INNOVATION UNIVERSITY®

stevens.edu

Jose Ramirez-Marquez
jmarquez@stevens.edu

Technical definition of competition networks

We posit that competition networks are co-dependent on the performance of other networks in a common competition environment.

A competition network has a collection *T* of *m* competitors

$$\underline{T} = \{t_1, t_2, \dots, t_m\}$$

m competitors

Where $\underline{X}_{i|j\dots m}$ is the graph generated for competitor *i* given competitors *j,…,m*. In an event, competitors perform at the same time generating their corresponding graph

$$\underline{X}_{i|j\dots m}, \underline{X}_{j|i\dots m}, \dots, \underline{X}_{m|i\dots m-1}$$

In the simplest case of 2 competitors, *i* and *j*, each graph has a vector *k* nodes (actor and node are used interchangeably moving forward)

$$\underline{X}_{i|j} = \{x_{1(i|j)}, \dots, x_{k(i|j)}\}$$

graph X i|j

Where $x_{l(i|j)}$ is understood as actor *l* in graph $\underline{X}_{i|j}$.

Each node $x_{l(i|j)}$ has a vector of attributes

$$\underline{F}(x_{l(i|j)}) = \{f_1(x_{l(i|j)}),\ldots,f_n(x_{l(i|j)})\}$$

nodes attributes

where $f_n(x_{l(i|j)})$ is the function mapping the n^{th} attribute of actor *l* in graph $\underline{X}_{i|j}$.

The actors (nodes) inside each graph have a potential vector $\underline{A}(i|j)$ of inner arcs $a_{l,o}^{i|j}$ connecting actor *l* and *o* in graph $\underline{X}_{i|j}$

$$\underline{A}(i|j) = \{a_{1,2}^{i|j},\ldots,\ a_{1,k}^{i|j},\ a_{2,1}^{i|j},\ldots,\ a_{2,k}^{i|j},\ldots,\ a_{l,1}^{i|j},\ldots,\ a_{l,k}^{i|j},\ldots,\ a_{k,1}^{i|j},\ldots,\ a_{k,k-1}^{i|j}\}$$

inner arcs among nodes in graph X i|j

and $a_{l,o}^{i|j}$ is an element of vector $\underline{A}(i|j)$ if for any *r*,

$$g_r(a_{l,o}^{i|j}) > 0$$

where $g_r(a_{l,o}^{i|j})$ is the r^{th} attribute function for inner arcs in graph $\underline{X}_{i|j}$ between nodes *l* and *o*.

Also, competition graphs are potentially connected through outside arcs $a_{q(j|i)}^{l(i|j)}$ where actor *l* in graph $\underline{X}_{i|j}$ is connected to actor *q* in graph $\underline{X}_{j|i}$.

$$\underline{A}_{q(j|i)}^{l(i|j)} = \{a_{1(j|i)}^{2(i|j)},\dots, a_{1(j|i)}^{k(i|j)}, a_{2(j|i)}^{1(i|j)},\dots, a_{2(j|i)}^{k(i|j)},\dots, a_{l(j|i)}^{1(i|j)},\dots, a_{l(j|i)}^{k(i|j)}, a_{k(j|i)}^{l(i|j)},\dots, a_{k(j|i)}^{k-1(i|j)}\}$$

outer arcs between competing graphs

where $a_{l,o}^{i|j}$ is an element of vector $\underline{A}_{q(j|i)}^{l(i|j)}$ if for any *r'*,

$$g'_r(a_{q(j|i)}^{l(i|j)}) > 0$$

where $g'_r(_{q(j|i)}^{l(i|j)})$ is the r'[th] attribute function for outer arcs in competition graphs $\underline{X}_{i|j}$ and $\underline{X}_{j|i}$ between competing nodes *l* and *q*, respectively.