Finding Criminal Groups in Suspect Networks Using a Steiner Tree Approach

Fredy Troncoso[a] Richard Weber[b] Alex Barrales-Araneda[a]

[a]Departamento de Ingeniería Industrial, Universidad del Bío-Bío
[b]Departamento de Ingeniería Industrial, Universidad de Chile

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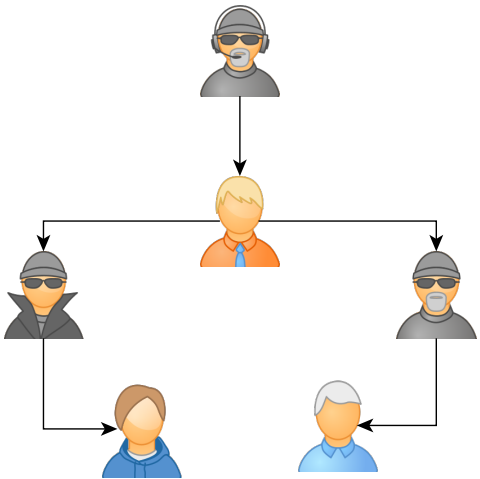
Outline

1. A criminal group is defined as a structured group formed by two or more people that is characterized by serious criminal activity over time, with high internal cohesion and a hierarchical and specialized structure[2]
2. The structure of a criminal group is given by the relationships between its members and is fundamental for the success of its operations.[1]



1. The STP in graphs is a combinatorial optimization problem that has been widely used in network design, integrated circuit design, localization problems, machine learning, systems biology, and bioinformatics[3].
2. The STP seeks a tree that interconnects a set of nodes S called terminals at a minimum cost.

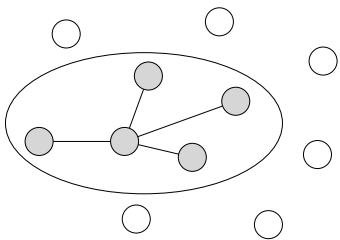
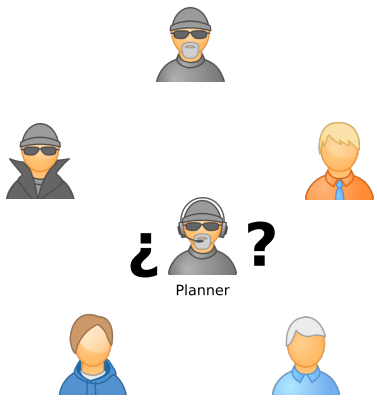
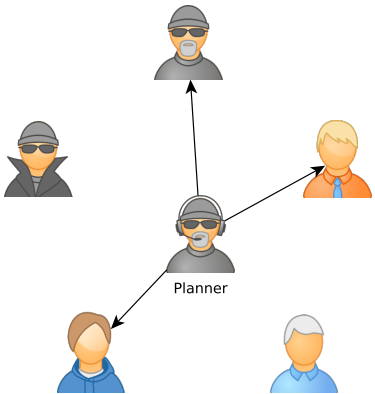


Figure: Figure ? $|S| = 4$

1. The search for association can be seen as the process by which a criminal planner s plans a group crime by choosing other criminals.



1. The search for association can be seen as the process by which a criminal planner s plans a group crime by choosing other criminals.
2. The planner is rational and chooses criminals with the criminal skills that guarantee that the crime is carried out with the maximum utility.



1. Criminal skills are represented by the criminal propensity *pcg* and trustworthiness through social distance between individuals d_{ij}
2. The social distance between two individuals is represented by a value between 0 and 1, where 1 represents the maximum distance between them.

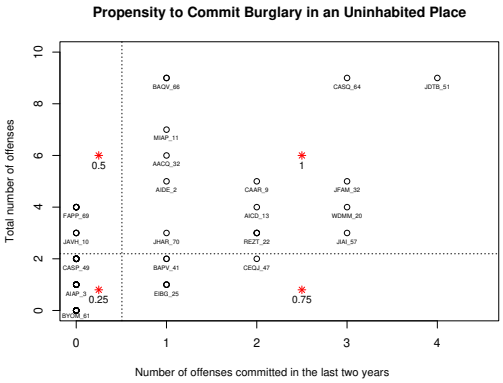


Figure: PCG values for network of 77 suspects

Objective function

- Utility function of a crime planner

$$\max U = \frac{\sum_{i \in N} pcg_i y_i}{pcg_{max} - pcg_s} - \frac{\sum_{(i,j) \in A} d_{ij} x_{ij}}{d_{max}}$$

Decision variables

$$y_i = \begin{cases} 1 & \text{Si } i \in N \text{ se encuentra en la banda} \\ 0 & \text{En otro caso} \end{cases}$$

$$x_{ij} = \begin{cases} 1 & \text{Si } (i,j) \in A \text{ se encuentra en el árbol} \\ 0 & \text{En otro caso} \end{cases}$$

$f_{ij} =$ Flujo a través del arco $(i,j) \in A$

Restricciones

- Asignación de vértices:

$$\sum_{i \in N} x_{ij} = y_j \qquad \forall j \in N \setminus \{s\} \qquad (1)$$

- Conservación de flujo:

$$\sum_{i \in N} f_{ij} - \sum_{i \in N} f_{ji} = y_j \qquad \forall j \in N \setminus \{s\} \qquad (2)$$

- Asociación del Flujo:

$$f_{ij} \leq (|N| - 1) x_{ij} \qquad \forall (i,j) \in A \qquad (3)$$

- Propensión máxima:

$$\sum_{i \in N} pcg_i y_i \leq \varphi pcg_{max} \qquad (4)$$

- Dominio de las Variables:

$$f_{ij} \geq 0 \qquad \forall (i,j) \in A \qquad (5)$$
$$x_{ij} \in \{0,1\} \qquad \forall (i,j) \in A \qquad (6)$$
$$y_i \in \{0,1\} \qquad \forall i \in N \qquad (7)$$

The Public Prosecutor's Office of Chile Dataset

- The criminal network was provided by the criminal analysis unit of the Public Prosecutor's Office of Chile.
- The database consists of 1,666 crimes and 77 suspects.

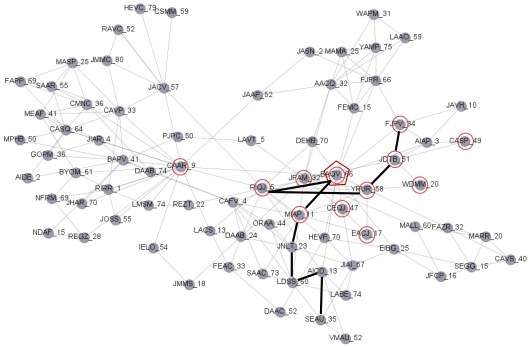


Figure: The network of 77 suspects.

Results

1. R1
2. R2
3. R3

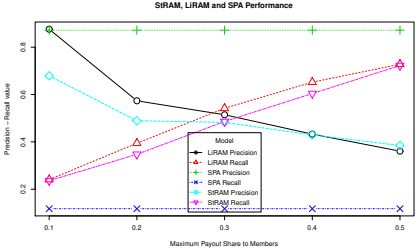


Figure: Precision and Recall to StRAM, LiRAM and SPA.

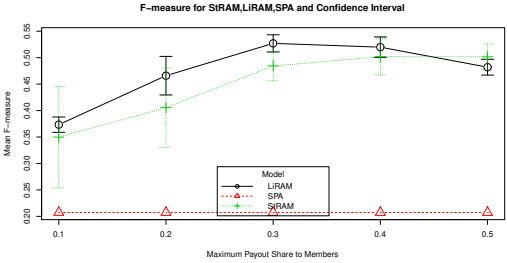


Figure: F-measure to StRAM, LiRAM and SPA

Results

1. R1
2. R2
3. R3
4. R4
5. R5

Table: Results to statistical tests for different values of φ.

Results to Statistical Tests					
	Maximum Payout Share to Members P-value				
Test	$\varphi = 0.1$	$\varphi = 0.2$	$\varphi = 0.3$	$\varphi = 0.4$	$\varphi = 0.5$
Shapiro-Wilk (LiRAM data)	0.0000000034111	0.0021649	0.0027877	0.0117392	0.2396275
Shapiro-Wilk (StRAM data)	0.02501584	0.00374289	0.00201161	0.04011305	0.00056471
Levene	0.00006102	0.1438	0.05163	0.03224	0.03611
Kruskal-Wallis	0.8504	0.4327	0.07577	0.6481	0.2407

Conclusions

1. C1.
2. C2.
3. C3.
4. C4.

Future Work

1. FW1.
2. FW2.
3. FW3.
4. FW4.

References I

[1] Carles Ortolà Boscà. Así son las redes terroristas más eficientes según las matemáticas. *Global strategy reports*, 1(53), 2020.

[2] Frank E. Hagan. "organized crime" and "organized crime": Indeterminate problems of definition. *Trends Organ Crim*, 9:127–137, 2006.

[3] Ivana Ljubić. Solving steiner trees: Recent advances, challenges, and perspectives. *Networks*, 77(2):177–204, 2021.

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Space for images

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