Assessing Connectivity Disruption in Interaction Graphs

A. Zakroum[1,*], R. Interdonato[1,*], P. Degenne[1,*], D. Lo Seen[2,*], M. Roche[1,*]
[1] *CIRAD, UMR TETIS, F-34398 Montpellier, France.*
[2] *CIRAD, UMR TETIS, F-97455 Saint-Pierre, La Réunion, France.*
[*] *TETIS, Université de Montpellier, AgroParisTech, CIRAD, INRAE, Montpellier, France.*

Context and motivations

- Ocelet[a] is a domain-specific language for modeling spatial dynamics. It uses ***interaction graphs*** to represent interactions between entities in an agent-based modeling framework. The graphs' state evolves over time through interactions occurring on its edges.
- A networks' structure holds insights about the phenomena they model.
- Understanding networks perturbation events is key to assess their robustness.
- In this work we attempt to construct a **framework** under which the **impact of connectivity disruption** is assessed at the **local** scale.

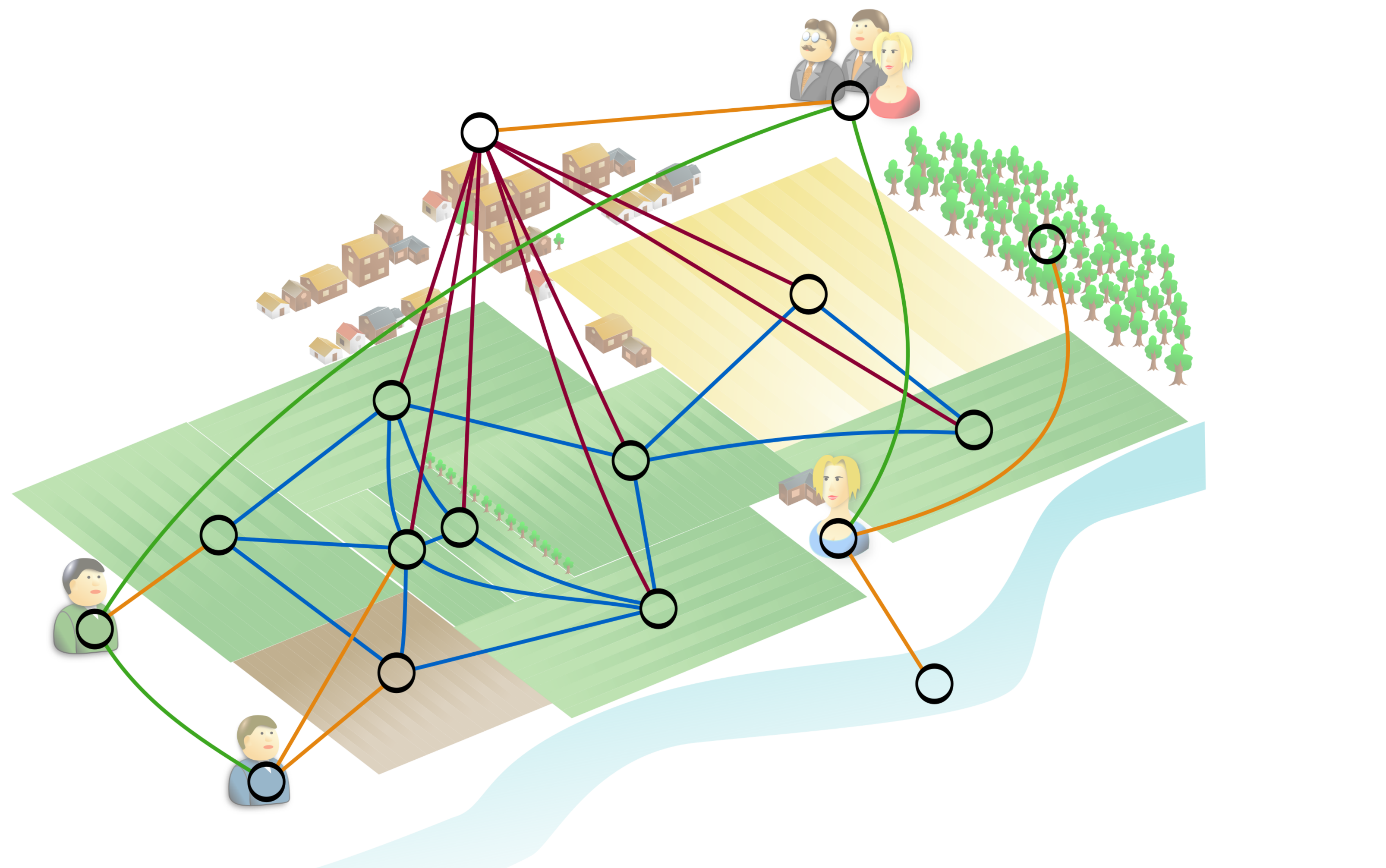


Figure 1: An interaction graph[a]. Entities are of multiple types : agricultural plots, farmers, citizens, decision makers.

[a] Degenne P, Lo Seen D, 2016. Ocelet: Simulating processes of landscape changes using interaction graphs. SoftwareX. http://dx.doi.org/10.1016/j.softx.2016.05.002

Framework

Vulnerability Profiles:

- Probability of failure $q \in (0,1)$.
- For $e \in E \underset{\text{paired}}{\leftrightarrow} W \sim \mathcal{B}ern(q)$.
- ***Impact function*** Measures impact of perturbations on nodes.

$$f_G(u;q) : V \longrightarrow \mathbb{R}_+$$

- ***Vulnerability Profile***

$$\mathcal{V} : (\ \cdot\ ; p) \longmapsto \int_0^p \mathbb{E}\left[f_G(\ \cdot\ ; q)\right]\, \mathrm{d}q$$

Experimental setup:

1. Set $q = q_1 < \ldots < q_k \in (0,1)$.
2. For each q_i, disconnect the graph N times.
3. Compute for all q_i

$$\overline{f_G}(\ \cdot\ ; q_i) = \frac{1}{N} \sum f_G(\ \cdot\ ; q_i)$$

4. Compute $\mathcal{V}(\ \cdot\ ; p)$.

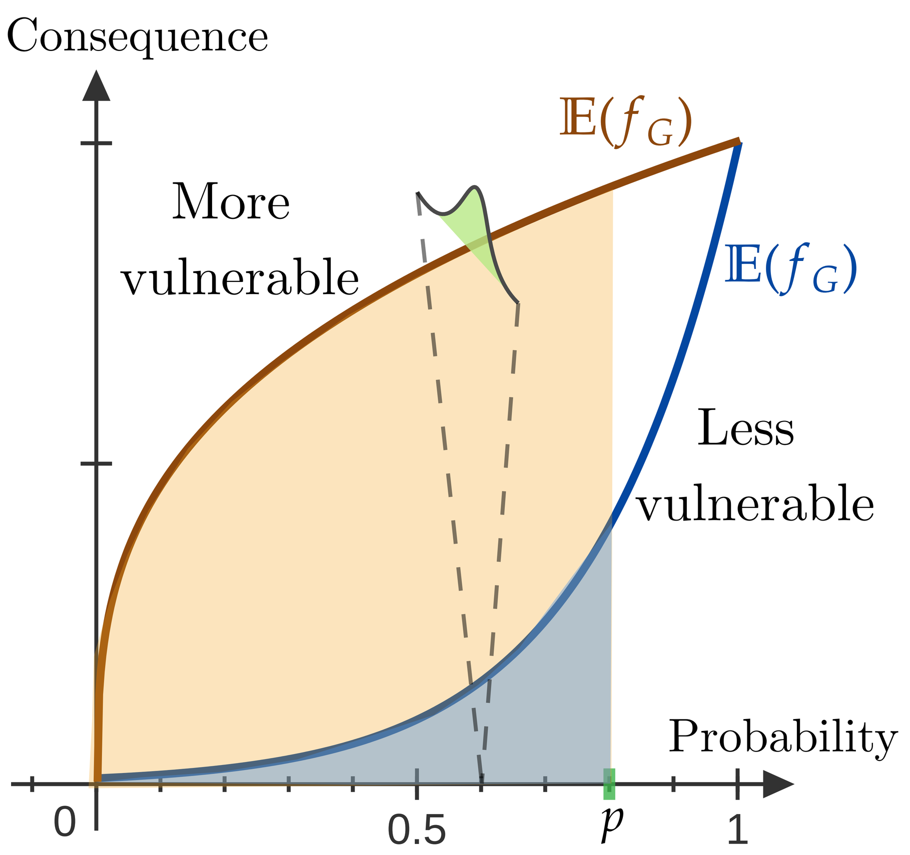
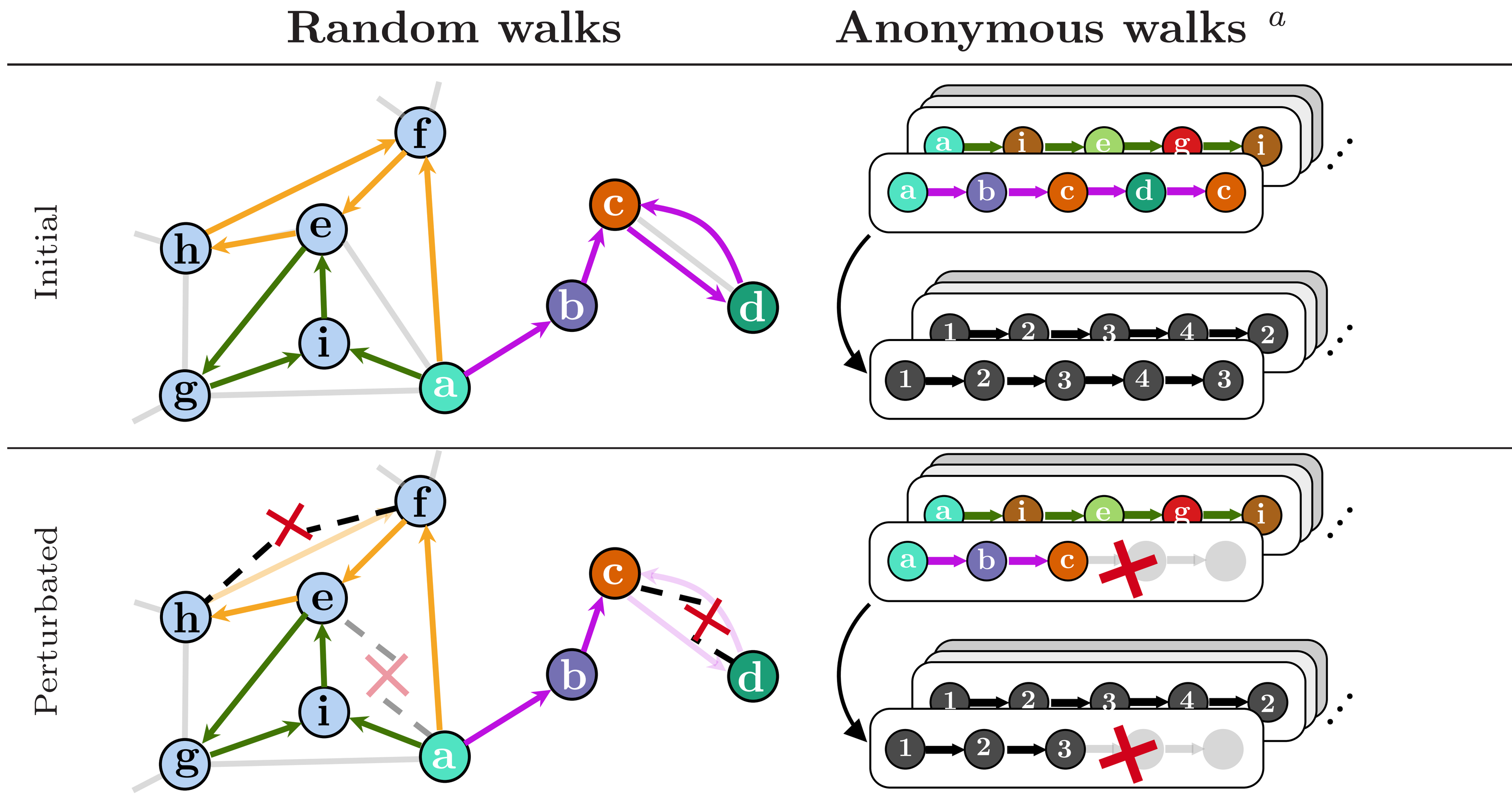


Figure 2: Illustration of a spectrum of vulnerability profiles.

Application on embeddings

	Random walks	Anonymous walks [a]	Embedding
Initial			For all $u \in V$, $q \in (0,1)$ $h_u^l = \left(p(w_1^l),\ \ldots,\ p(w_\eta^l)\right)$ $\boldsymbol{\eta}$ **:** No of **all** anonymous walks of length $\boldsymbol{l}$. $\boldsymbol{p(w_i^l)}$ **:** $\sum_{r \to a_i} \prod_{e \in r} p_e$
Perturbated			$g_u^l(q) = \left(p'(w_1^l),\ \ldots,\ p'(w_\eta^l)\right)$



Impact f_G: distance between the two embeddings

$$d(\ h_u^l\ ,\ g_u^l(q)\ ).$$

[a] Ivanov S. et al, 2018. Anonymous walk embeddings. Proceedings of the 35th ICML, PMLR 80:2186-2195.

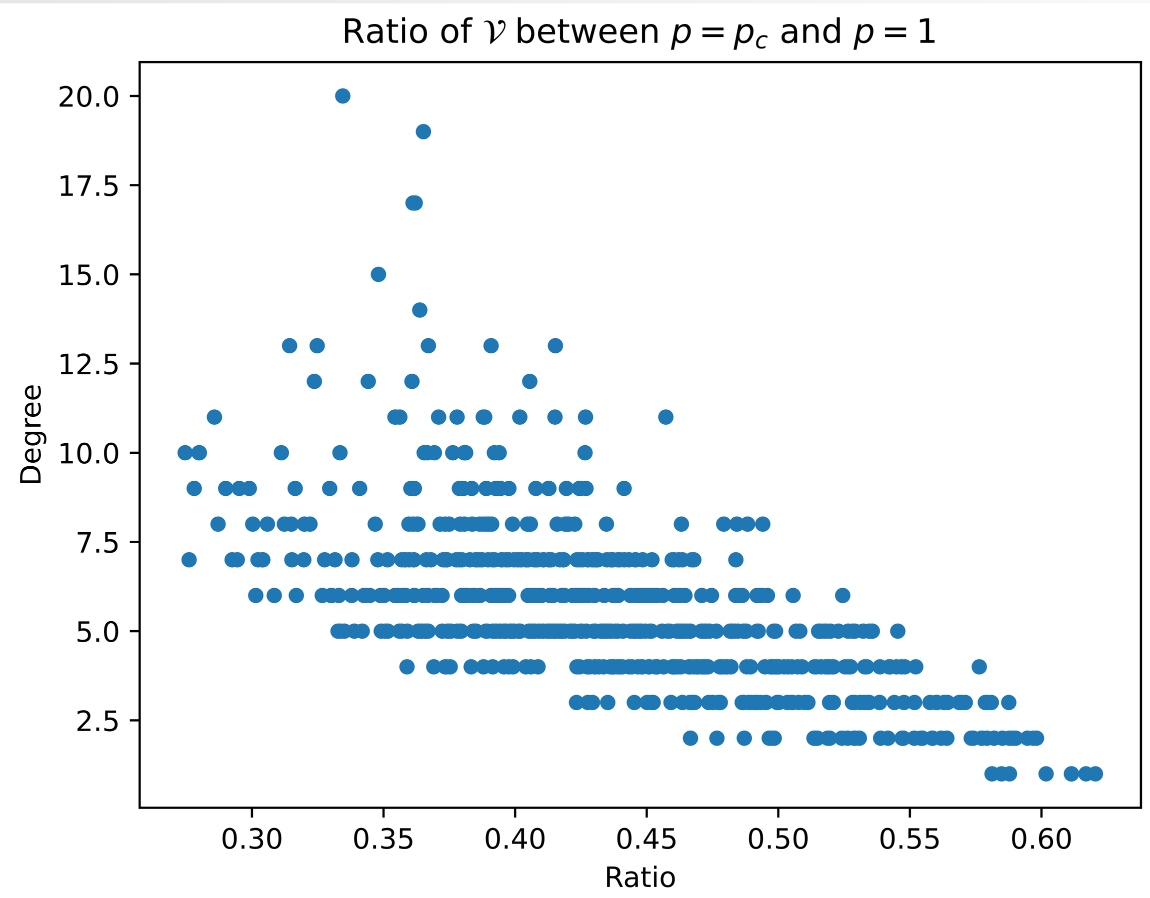
Experiments and preliminary results

Data: Network of yeast propagation in agricultural plots(nodes).
Edges are based on distances ($< 50m$)

Nodes	Edges	Density	Avg. deg.	Clust.
677	1891	0.0082	5.58	0.52

Walk length: 6 **N experiments:** 100
Sampled walks: 7266 per node (Ivanov et al.)
Percolation treshold: $p_c \sim 0.7$
Impact func.: Cosine distance in the embedding space.

$$f_G(u;q) = 1 - \cos(h_u^l, g_u^l(q))$$



Interpretation and conclusion

Anon. walks: Capture *(i)* the reachability of the plots and *(ii)* the local structure around them.
Distance: The yeasts' capability to spread (w.r.t to its init. potential) after perturbations.
Experiments: The lower the degree, the higher the variation of the vulnerability profile
Perspectives: Investigation of the links between the vulnerability and the networks' characteristics

Acknowledgements

This work is supported by the Central African Forest Initiative and the Agence Française de Développement in the context of the project "Sustainable Land Use Program of Congo".

Contact and references