

# Collective intelligence: Analysis and modeling

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# Outline

- 1 Introduction
  - Context
  - Motivation
- 2 Proposal
  - Approach
  - Wiki-ITRB
  - Model
- 3 Results
- 4 Discussion and future work
  - Discussion
  - Future work

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# What is collective intelligence?

The capacity of a collective system to evolve towards higher order complexity through networks of individual capacities.

# Organization around knowledge

Understand new forms of knowledge production:

- Wikipedia: Collective encyclopedia.
- Crowdsourcing: Problem-solving and production network.
- Open Government.
- Crowdfunding: Funding network.

An attempt to measure the collective intelligence.

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# Analysis of structural properties of networks

## Measurements:

- Clustering coefficient.
- Average path length.

## Networks:

- Data from the activity Wiki-ITRB at the course PeSO at the Universidad de Los Andes, Bogotá, Colombia.
- An agent-based model of collective intelligence based on wiki systems.

# Wiki-ITRB

- The purpose of the Wiki-ITRB is to collectively write ITRB (Informe Técnico de Revisión Bibliográfica—Technical Reports of Literature Reviews) documents.
- Students participated in the writing and modification of several documents and each one decided to be the author of a subset of documents, which she or he edited and evaluated.
- The participation of students in the Wiki-ITRB is stored up over time.
- A network from the aggregation of connected authors via co-authored documents over time is constructed.



# Agents

## People:

- Agent edition capacity.

## Documents:

- Selection's probability.
- Total edits.

At the beginning of the simulation, every document has the same probability, 1 per total number of documents. And every agent have the same agent edition capacity.

# Description

Each time unit goes as follows:

- One person is selected randomly.
- The person edits as many documents as agent edition capacity indicates.
- The documents edited by the person are chosen according to documents' probability.
- Every document edited increases by 1 its total edits.
- Probabilities of every document are updated including the edits made by the person.

At the end it is constructed a network of co-author editions, where an edge connects two people who have made editions to the same document.

# Experimental design

The probability of connection between two agents, given a determined number of agents, depends on the simulation time and the agent edition capacity.

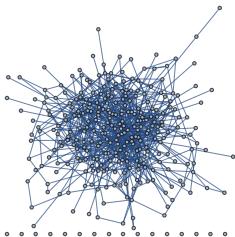
- Total agents (**A**):  $[10^1 - 10^3]$
- Time simulation (**T**):  $[2 * A - 10 * A]$
- Agent edition capacity (**K**):  $[1 - 10]$

Each simulation was run 80 times.

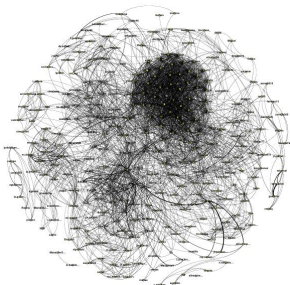
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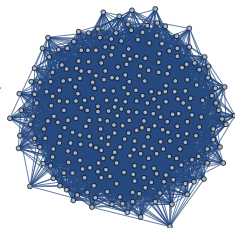
# Networks



(a)  $T=1500$  and  $K=3$



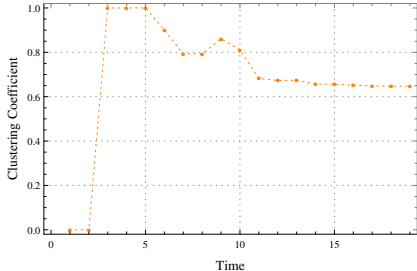
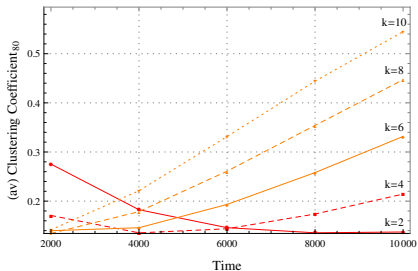
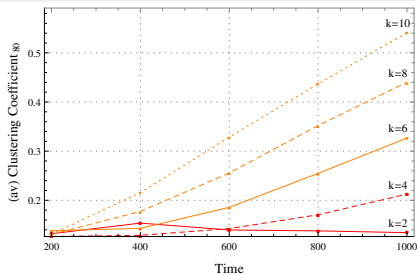
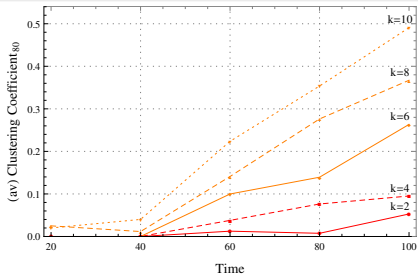
(b) Wiki-ITRB



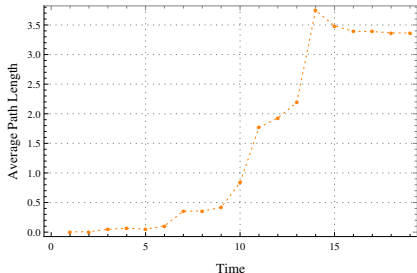
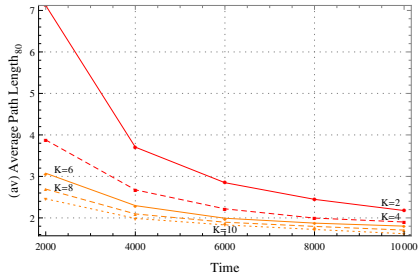
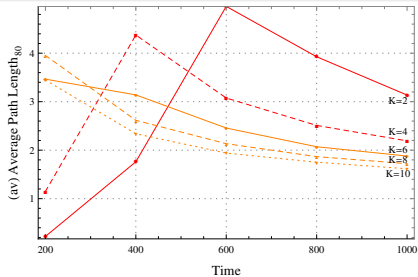
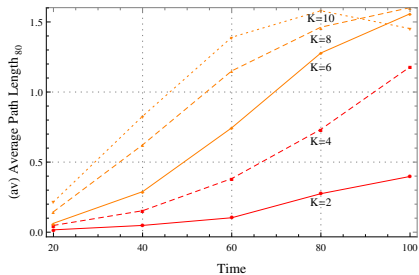
(c) Probability = 0.1

**Figure:** Networks with 300 nodes. Results from the model (a), the Wiki-ITRB (b) and a random graph with Bernoulli distribution (c).

# Clustering coefficient



# Average path length



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# Discussion

- It was constructed a framework to study networks resulting from interaction rules at a micro level. It allows for the study of collective intelligence based on a network science approach.
- The proposed model reproduces the behavior observed in the PeSO course; this behavior is also described for small world networks. From this, we interpret that collective intelligence emerges from cumulative dynamics.

# Discussion

- Both the clustering coefficient and the average path length have consistent values in terms of individual edition capacity ( $K$ ) and time units ( $T$ ), where neither could be too large or too small. Higher values of  $T$  implies that a lot of agents have connections and the small world structure disappears. Smaller values of  $K$  implies there is not growth over time and, therefore there is not a self-organized system.

# Future work

- In-depth study of the proposed model: distribution of agent edition capacity ( $k$ ) and the computation of other measurements such as Small-World Characteristic  $Q$  and robustness.
- The model presented here is an accumulative system, where there is no loss of information (no loss of nodes or edges). It is proposed that in future work, a less accumulative system should be examined.
- It is necessary to develop a better understanding of collective intelligence in order to investigate how teaching methodologies in higher education can be designed to develop collective thinking.

# Thank You

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