

A GRAPh-based Model (GRAM) for multi-risk assessment in complex systems

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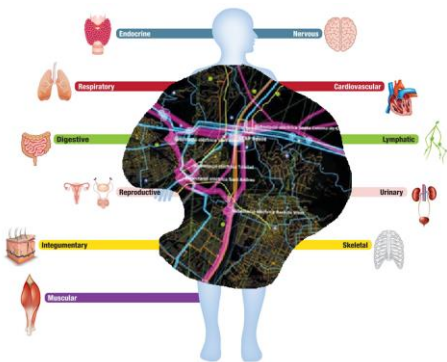
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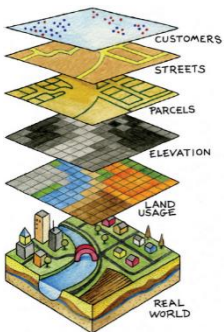
Workshops



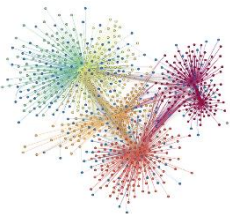
**Systems
perspective**

from
COMPLICATED to COMPLEX





**GIS
LAYERS**



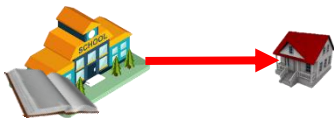
**GRAPH:
nodes &
links**



Identify the **relevant typologies** of exposed elements

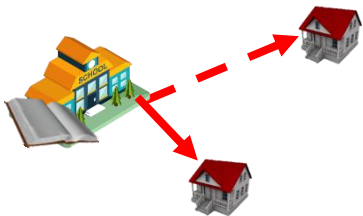


Define the **connection** between typologies

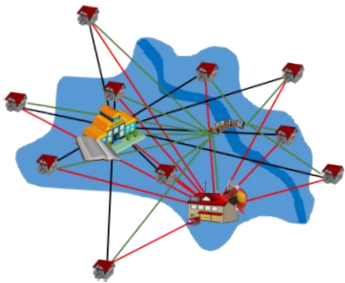




Define the **rules**
between elements



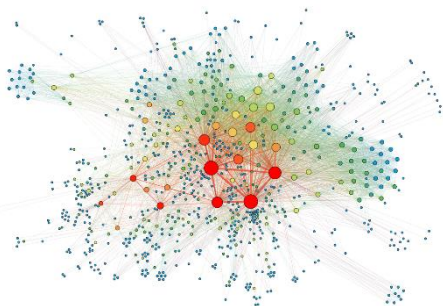
Build the **graph**



Analysis



STATIC



Hub



Authority

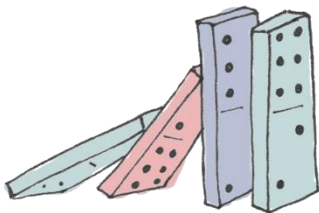


Closeness

Analysis



Dynamic

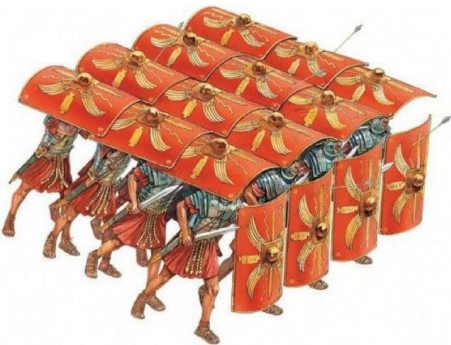


More orders



Nodes & links affected

Is the whole equal to
the sum of its parts?





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Download the full poster [here](#)

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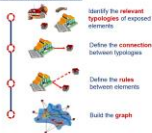
Scienze Universitarie Superiori IUSS Pavia, correspondence to: marcello.arosio@iusspavia.it



CONTEXT & AIM

A paradigm shift in risk assessment is necessary: from a reductionist to a **holistic approach**¹. We propose a new approach based on Graph Theory to obtain a deeper knowledge of the exposed system and better understand its risk mechanisms, including **indirect impacts** and cascade effects. Some preliminary results from a case study in **Mexico City** are presented.

GRAPH CONSTRUCTION



Map of nodes and the services provided among them

Graph of major services in the Federal District of **MEXICO CITY**: approximately 8.8 million people live in one of the most hazard-prone cities in the world.²

GRAPH PROPERTIES

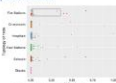
Hub property of a node is proportional to the sum of authority of nodes pointing to it.

The larger icon sizes in the figure **can generate** a large indirect impact into the network³.



Map of hub values categorized by services

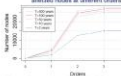
It is important to study the **outliers of hub** values because they show which are the elements in the graph that, in case of potential failure, can have a large impact on the network.



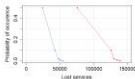
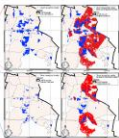
Exploits of hub value for different typologies of service providers

IMPACTS: DIRECT vs INDIRECT

Evolution of cascading effects of affected nodes at different orders



The graph at **order n** is obtained by removing the nodes affected in the previous order.



The total impact (red) shows a much higher curve compare the direct impact (blue).

WHAT IS THE ROLE OF CONNECTIONS IN RISK ASSESSMENTS?



REFERENCES
¹ Arosio M., Liu Y. and Frances T. (2014) A Complexity Framework for Modeling Disaster-Resilient Management. Journal of Contingency and Crisis Management, 7(1), 1-12.
² Carrillo G., Dickson S., Llanos C. and Figueiredo R. (2014) Urban risk assessment through GIS complexity and network theory.
³ Figueiredo R., Llanos S., Martins M., Arosio M. and Frances T. (2014) Complex...

¹ Arosio M., Liu Y. and Frances T. (2014) A Complexity Framework for Modeling Disaster-Resilient Management. Journal of Contingency and Crisis Management, 7(1), 1-12.
² Carrillo G., Dickson S., Llanos C. and Figueiredo R. (2014) Urban risk assessment through GIS complexity and network theory. International Journal of Geographical Information Science, 28(12), 2173-2191.



Thank you for your
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