Social Networks & Recommendation Systems

VIII. Hierarchical, layered and temporal networks.

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MSc program in Data Science has been developed
as a part of task 10 of the project
„NERW PW. Science - Education - Development - Cooperation”
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Before classes

Exercises:

Look in known repositories for examples of networks which are:

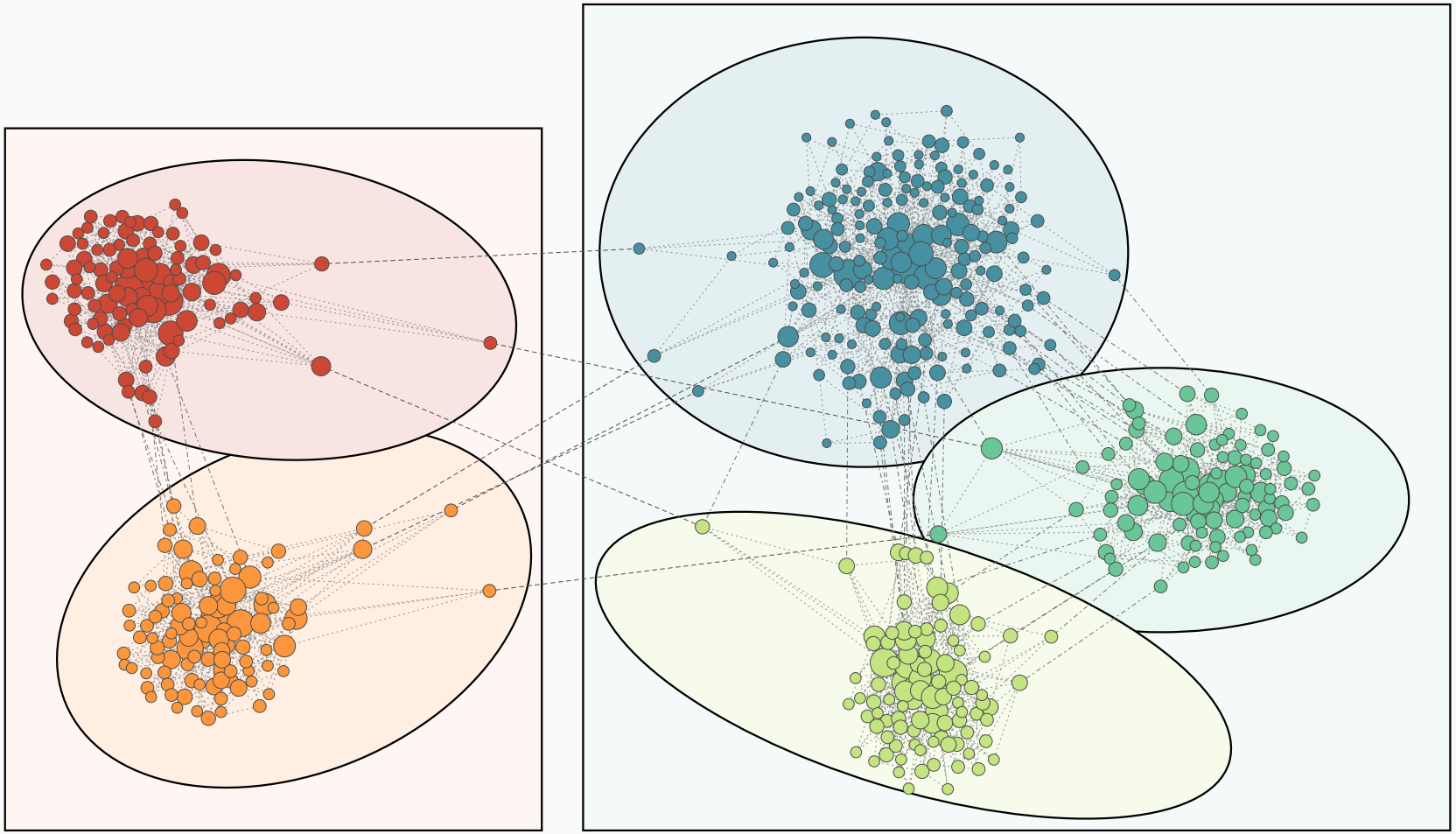
- hierarchical,
- layered,
- temporal (i.e. time-dependent).

Read

- `www.ams.org/journals/notices/201811/rnoti-p1419.pdf`
- `www.ztm.waw.pl/pliki-do-pobrania/dane-rozkladowe/`

Lecture

Hierarchical networks



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- a system in which people or things are arranged according to their importance,
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Both can be of network science importance:

- directed graphs (trees),
- social or political networks...

The origins of the idea of hierarchy

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Networks apply everywhere!

Even in theology.

Review of hierachical networks

The hierarchical structure have, among others

- Internet web (on the level of autonomous systems),

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Potential sources of hierarchy:

- logical order,
- Matthew effect,
- position in the network structure (by definition).

How to detect hierarchies?

Local clustering coefficients scalling

It is assumed that the indicator of the hierarchy of the network is

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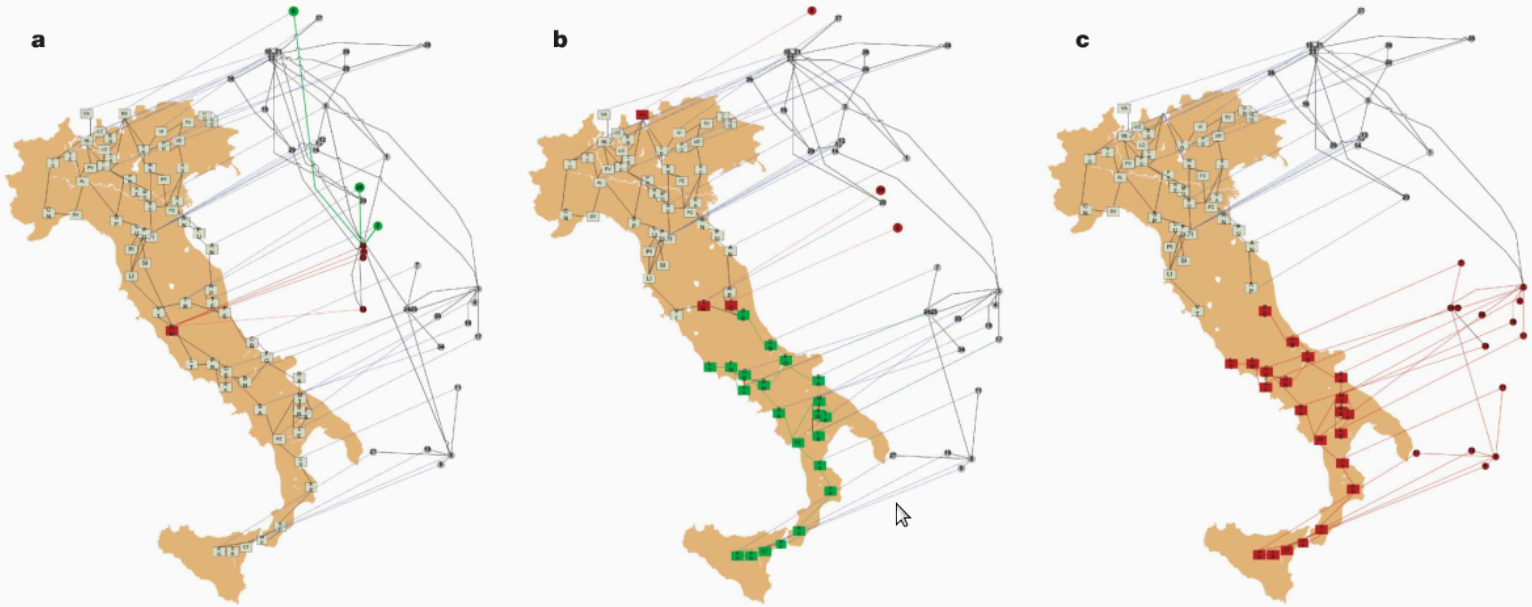
Hint:

Look for networks where edge costs are significant.

Layered (coupled, dependent) networks



Interdependent power and Internet networks [S.V Buldyrev i in. Nature **464**, 1025–1028, (2010)]

Buldyrev et. al.

Why is it worth knowing the theory of percolation...

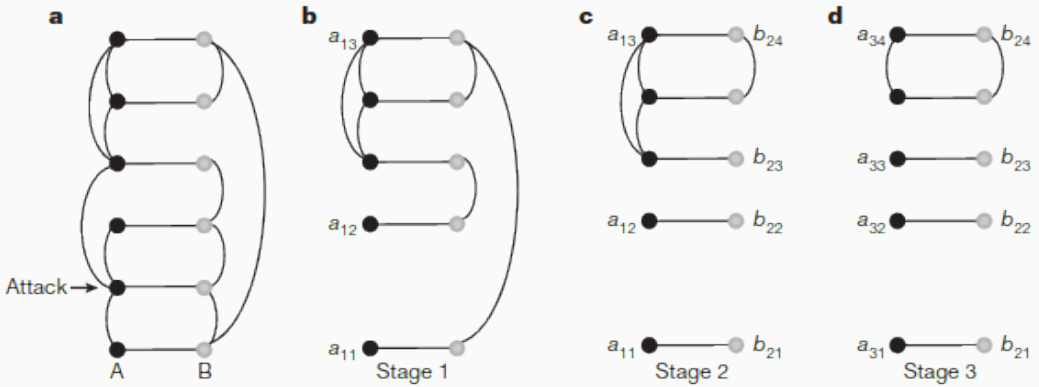


Figure 2 | Modelling an iterative process of a cascade of failures. Each node in network A depends on one and only one node in network B, and vice versa. Links between the networks are shown as horizontal straight lines, and A-links and B-links are shown as arcs. **a**, One node from network A is removed ('attack'). **b**, Stage 1: a dependent node in network B is also eliminated and network A breaks into three a_1-clusters, namely a_{11}, a_{12} and a_{13}. **c**, Stage 2: B-links that link sets of B-nodes connected to separate a_1-clusters are eliminated and network B breaks into four b_2-clusters, namely b_{21}, b_{22}, b_{23} and b_{24}. **d**, Stage 3: A-links that link sets of A-nodes connected to separate b_2-clusters are eliminated and network A breaks into four a_3-clusters, namely a_{31}, a_{32}, a_{33} and a_{34}. These coincide with the clusters b_{21}, b_{22}, b_{23} and b_{24}, and no further link elimination and network breaking occurs. Therefore, each connected b_2-cluster/a_3-cluster pair is a mutually connected cluster and the clusters b_{24} and a_{34}, which are the largest among them, constitute the giant mutually connected component.

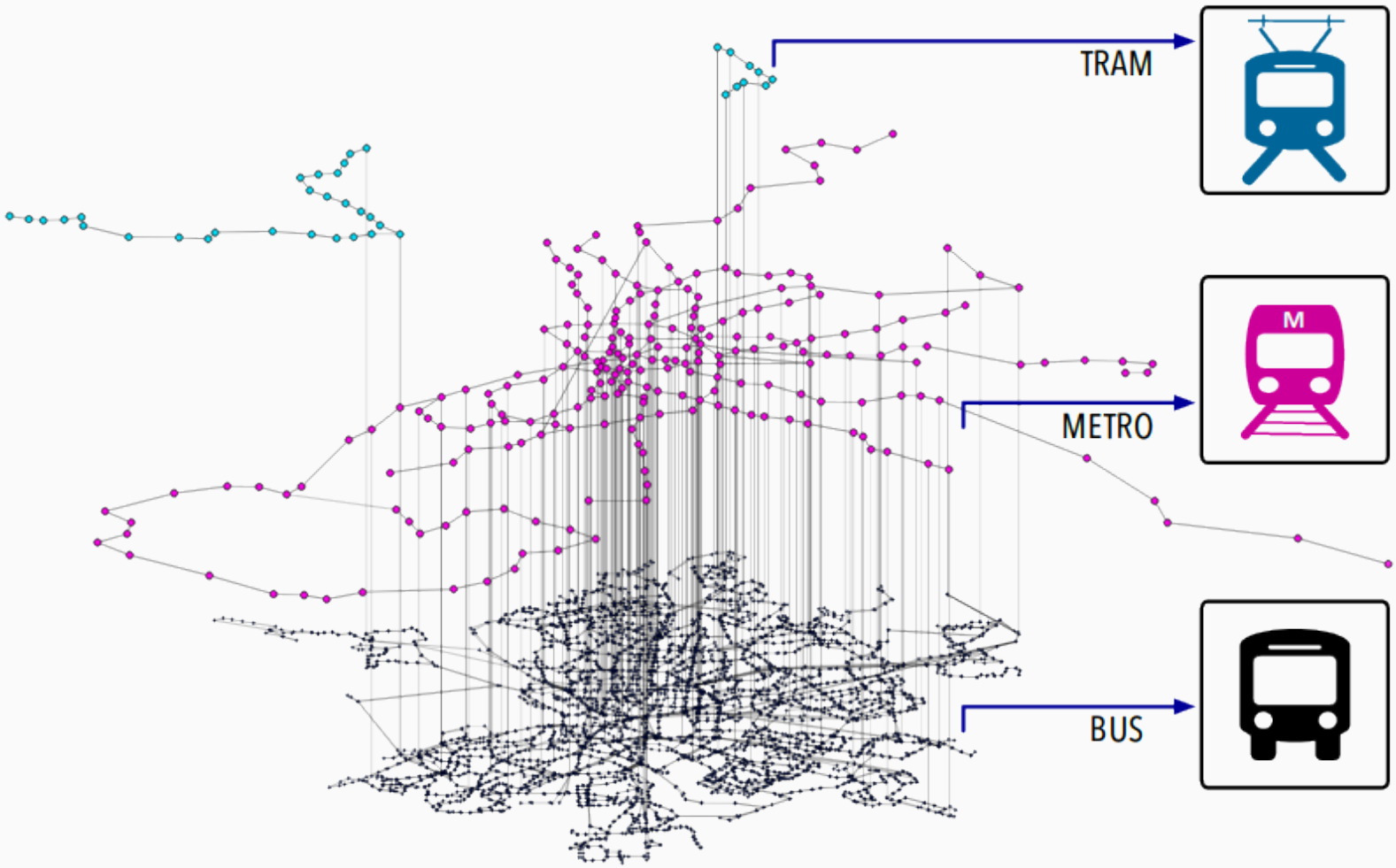
What are layered networks?

Generalization of classical graphs

where every layer (i.e. classical graph, set of the relations) corresponds to a different type of interaction:

- transportation networks,
- social networks,
- other socio-economics (or ecological) networks.

Layered networks



A. Aleta and Y. Moreno, Annual Review of Condensed Matter Physics 10:1, 45-62, (2019)

Temporal networks

Definition

Temporal networks are networks that change their structure over time.

Potential applications:

- time-varying phenomena modeled by networks (we'll cover in a moment),
- evolving networks (e.g. BA networks and their modifications),
- co-evolving networks (dynamical processes on networks + varying network structure).

Summary

Question before next classes:

What do you know about stochastic processes?

Thank you for your attention!

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