

The complex networks to understand the world around us

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Outline

What is a network ?

Why to use networks ?

Why to detect communities in networks ?

- The community detection problem

- Mobile phone communications in France

- Image segmentation

Conclusion

What is a network ?

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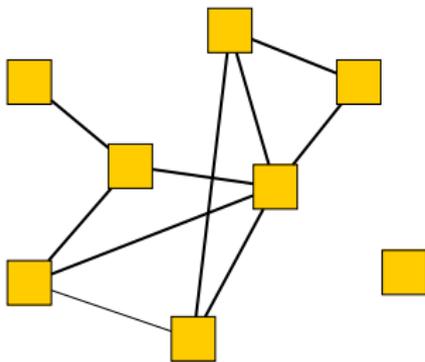
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A **network** is a set of points joined by lines.

Example



A point is called a **node**.

A line is called an **edge**.

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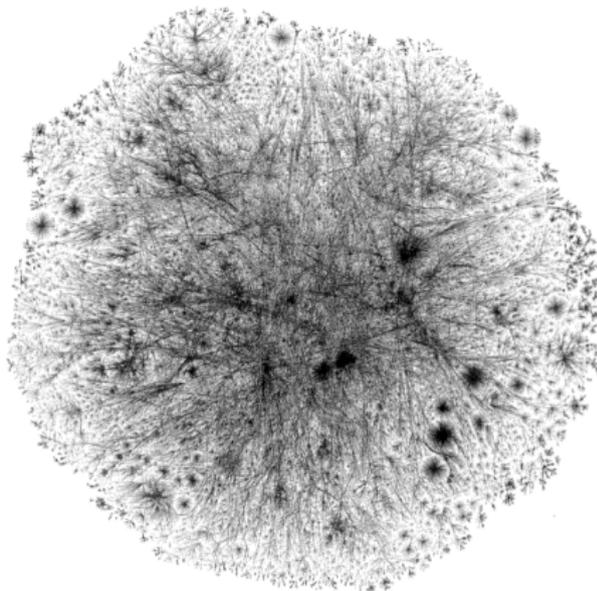
Why to use networks ?

Networks allow to model systems with interacting agents.

The structure of the network is fundamental for the understanding of the underlying system.

Examples

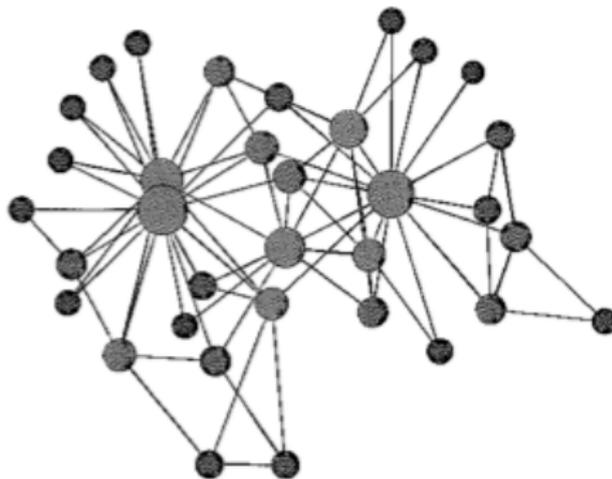
- *Technological networks*
 - *Internet*



M.E.J. Newman, Networks : an introduction, Oxford University Press, Oxford UK, 2010, page 5.

- *Telephone networks*
- *Transportation networks*

- Social networks
 - Friendship network between members of a club



M.E.J. Newman, *Networks : an introduction*, Oxford University Press, Oxford UK, 2010, page 6.

And so many others ...

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Community detection :

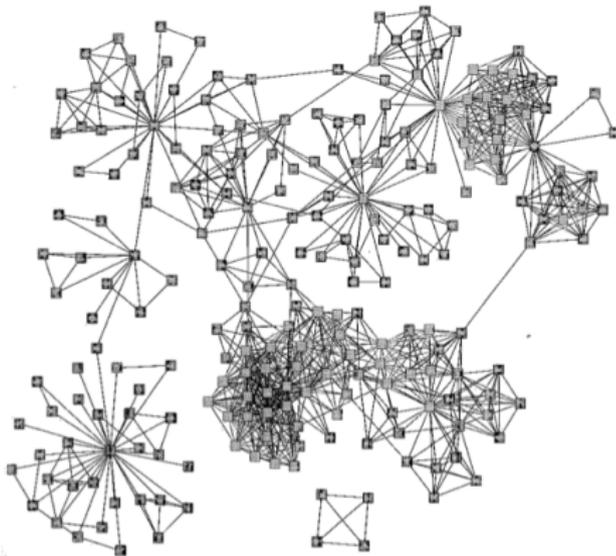
Partitioning the nodes of the network into groups, called communities, with many edges within the communities et few links between them.

Utility :

Revealing the structure and the organisation of the network.

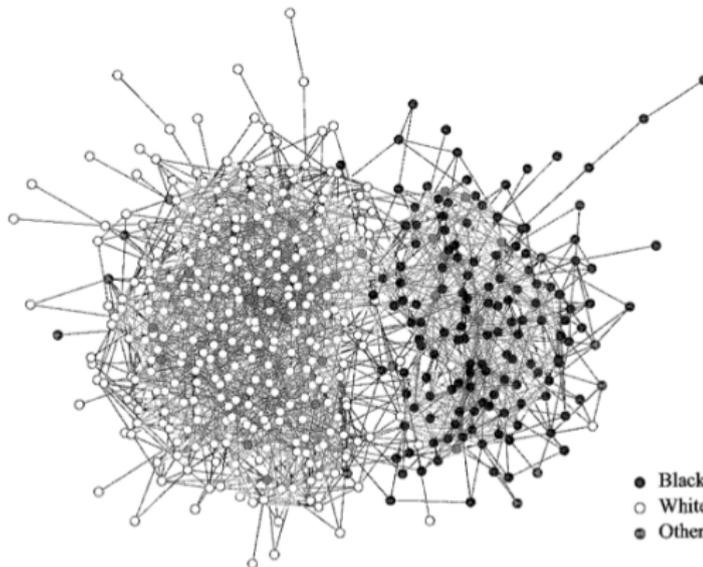
Examples

- *Network of coauthorship in a university department*



M.E.J. Newman, Networks : an introduction, Oxford University Press, Oxford UK, 2010, page 355.

- Friendship network at a US high school



M.E.J. Newman, *Networks : an introduction*, Oxford University Press, Oxford UK, 2010, page 221.

How to detect communities in networks ?

1. Defining an objective function (ex : the modularity)
2. Developing heuristics to optimize it (ex : Louvain method)

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Motivation :

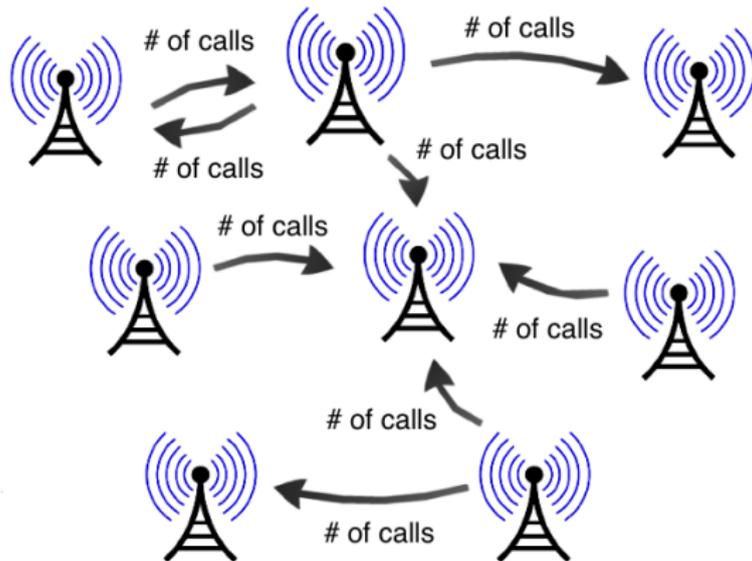
- highlight the pattern of mobile phone communications in France
- from the observations, the operator could adapt its mobile phone contracts

In practice :

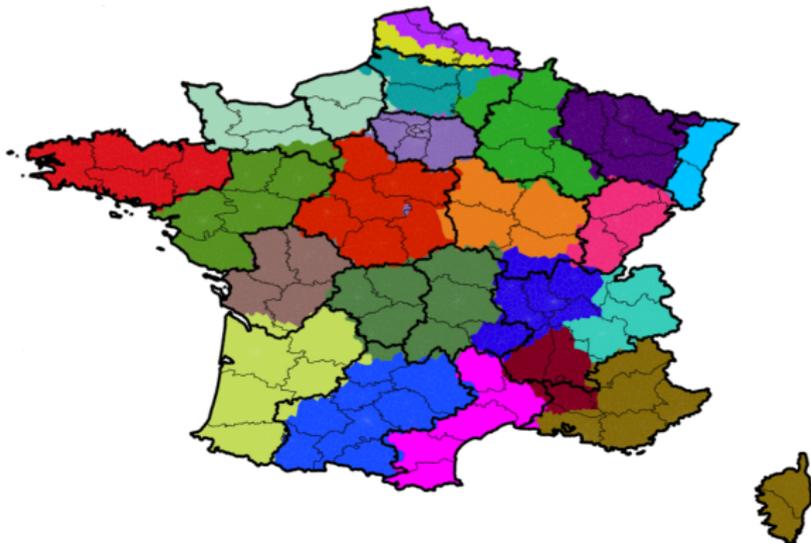
- 18 000 towers
- 2 billion links
- 6 month period
- only calls from/to same operator (no text message)



Graph construction :



Results of community detection :



Observation : almost perfect correspondance between the detected communities and the regions in France.

This observation is quite **unexpected** because :

- everybody speaks french
- no political or geographical border

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Many applications of image segmentation :

- discovering abnormal shadows on a scan for tumor detection
- detection of people or objects from images of surveillance cameras

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Graph construction :

- a node = the position of a pixel of the input image
- a weighted edge represents the similarity between a pair of pixels

Results :



Input Image



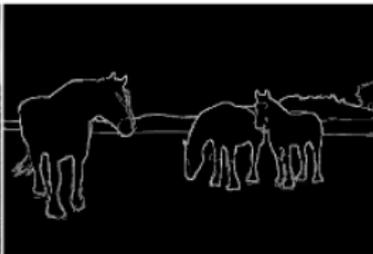
Human Benchmark



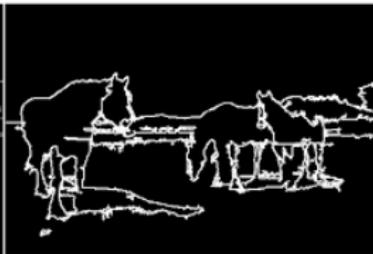
Detected communities



Input Image



Human Benchmark



Detected Communities

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Conclusion :

- Networks allow to model systems with interacting agents
- The structure of the network provides information about the organization of the underlying system
- Communities provide information about the structure of the network
(Many applications : image segmentation, ...)

Thank you for your attention !